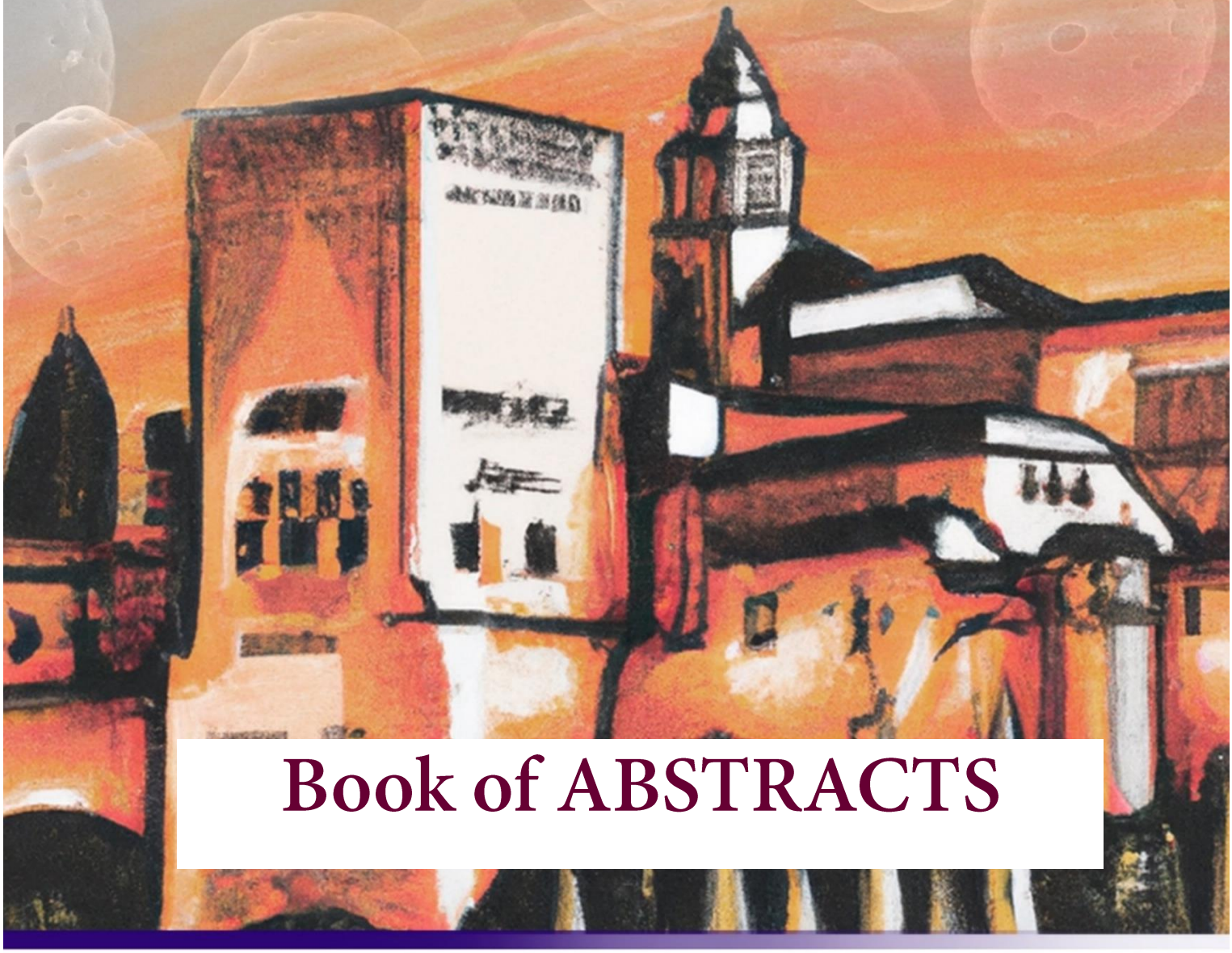
NALS 2024

Nanomaterials Applied to Life Sciences

Granada (Spain), 14-16 February 2024



Book of ABSTRACTS

UNIVERSIDAD DE GRANADA

Facultad de Ciencias

NanoMag

NALS 2024
Nanomaterials Applied to Life Sciences

Foreword

The considerable effort involved, on the part of the NALS scientific and the local committees, in organizing this international conference is only rewarded by many participants of the highest scientific level in our field and from different countries. In our opinion, both aspects are present at NALS-2024. The attendance of more than 150 researchers specialized in fields as varied as diagnosis and treatment of diseases, environmental applications, design of nanoparticles and nanodevices and the technologies involved, drug delivery and more, cannot be denied as a guarantee for the success of the conference.

Therefore, we can only thank each and every one of them for their attendance, and those who have collaborated in the organization, for their time and effort, which they have had to detract from the always absorbing research and teaching tasks. The support of the conference sponsors is also gratefully acknowledged.

We wish all participants a pleasant stay in Granada and a fruitful conference, which will continue to open new paths in the field of nanomaterials applications in health sciences. Its eminently interdisciplinary nature and the need for collaboration of scientists from different branches of knowledge justify the realization of conferences such as NALS-2024.

Thank you!

Guillermo Iglesias,

on behalf of the Organizing Committee,

Granada, February 14, 2024

GENERAL INFORMATION

The 4th International Conference on Nanomaterials Applied to Life Sciences 2024 (NALS 2024) is being organized by the University of Granada and NanoMag Lab. of the Department of Applied Physics. It will be held in the Fuentenueva Campus, Faculty of Science, University of Granada (Spain) on 14th-16th Febrary 2024.

NALS events are promoted by the NanoBioAp Cluster, which consists of more than 70 researchers from different Spanish Research Institutions. The relentless advances made in nanotechnology in recent years require multidisciplinary and cross-disciplinary approaches, from the design of new materials to their final application. NALS 2024 aims to establish synergies, foster lasting collaborations and contribute to a fruitful academia-industry link, to work together in the development of disruptive techniques and devices based on nanomaterials for applications in the fields of Medicine, Biology and the Environment, among others.

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SCOPE

- Nanomaterials for therapy: optical/magnetic hyperthermia; drug delivery; tissue regeneration; gene and cell therapies.
- Nanomaterials for detection and diagnosis: magnetic resonance imaging; magnetic particle imaging; magneto-encephalography; magnetic, optic, electromagnetic, and electrochemical sensing actuators; magnetic cell/exosome/protein pre-concentration and isolation.
- Nanomaterials for environmental applications: water and air treatment, soil remediation.
- In silico testing: computer modelling of nanomaterials and their application in medicine and biology.
- Lab on-a-chip, and organ on-a-chip.
- Metrology and standardisation of nanomaterials.
- Synthesis, functionalization, bioconjugation, and surface engineering of nanomaterials.
- Biocompatibility and toxicity of nanomaterials.
- Nanomaterials for translational applications.

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The Nals 2024 Organizing Committee would like to thank the sponsors of the conference for their support and contribution:

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The aim of NanomedCSIC Network (https://conexion-nanomed.csic.es/) is to establish a sustainable connection in the medium and long term, between research personnel from different CSIC centers around the topic of Nanomedicine, sharing information and knowledge, to maximize the CSIC effort in the area of nanomedicine and its national and international visibility. NanomedCSIC will encourage the attraction and promotion of talent, especially young people, promoting new vocations, and transmitting to society in general both advances in the subject and issues of social impact.

https://conexion-nanomed.csic.es/

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DICSA is a dynamic company with more than 35 years of experience in the distribution of scientific instrumentation and laboratory equipment, such as reagents, consumables, laboratory furniture, etc... in which we distribute to customers such as Universities, Hospitals, Laboratories, research centers, among others.

It has a highly qualified staff distributed throughout Spain, which guarantees an optimal customer service, as well as offering technical advice and extensive experience in the field of scientific instrumentation and equipment.

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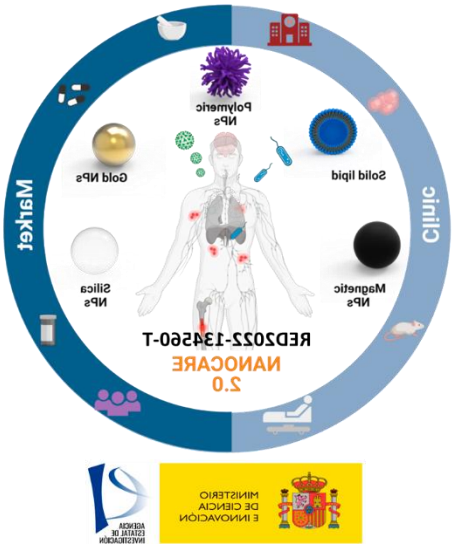

NanoCARE (https://nanocare.es/) is a thematic network for the collaborative development of nanomedicine, focused on specific challenges in cancer, atherosclerosis and infectious diseases. NanoCARE joins 14 groups working on materials for biomedicine, pharmacology, chemistry, physics, biotechnology, microbiology and medicine.

Nanomedicine impact on health is continuously growing; with Spain in a strong position and many groups leaders at international levels. On this sense, a coordinated work of these groups can boost their performance allowing new and synergistic collaborations.

NanoCARE will promote seed projects among members of the network; this will establish new collaborations or strengthen existing ones, this way we will apply to international calls from a much stronger position. Common, new, research lines will be proposed so each member can join to one or several of them, increasing the interdisciplinarity of their research and the international impact of Spanish nanomedicine. Our international impact will also benefit from our transfer to the industry of the products obtained in nanoCARE, a R+D aspect in which Spanish performance needs a boost.

NanoCARE is an opportunity of creating something new in Spain; a nanomedicine network, with the best tools for research and coordination, focused on solving specific health problems that affect society.

BIOS Technology Solutions (https://www.bios-ts.es/) is a company that offers Technological Solutions of Value to companies, of any size and sector, to make them more competitive, productive and profitable. BIOS does not offer tools, but comprehensive and innovative solutions tailored to the company's needs. With more than 15 years of experience working in

the ICT sector with public and private organisations and institutions, BIOS has been growing and evolving and has even diversified its solutions and services to other sectors, such as education.

Our main objective at BIOS is to manage all the technological needs that may arise in companies and organisations. We cover all types of hardware, software and communications systems to become your global service provider.

Nanomaterials (ISSN 2079-4991) is an international, peer-reviewed, interdisciplinary scholarly open access journal, published semimonthly online by MDPI. It publishes reviews, regular research papers, communications, and short notes that are relevant to any field of study that involves nanomaterials, with respect to their science and application. Thus, theoretical and experimental articles will be accepted, along with articles that deal with the synthesis and use of nanomaterials. Articles that synthesize information from multiple fields, and which place discoveries within a broader context, will be preferred. There is no restriction on the maximum length of the papers. Our aim is to encourage scientists to publish their experimental and theoretical research in as much detail as possible. Full experimental or methodical details, or both, must be provided for research articles. Computed data or files regarding the full details of the experimental procedure, if unable to be published in a normal way, can be deposited as supplementary material.

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Scientific Program

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Wednesday 14th February 2024

8:30-9:00	**Opening ceremony**			
Session: Magnetic materials I. Chair: Q. Pankhurst. AULA MAGNA				
9:00-9:30	R. Ibarra	**Plenary (PL1).** Thermal and ultrasonic effects due to the interaction of electromagnetic radiation with magnetic nanoparticles		
9:30-9:45	J. Alonso	**O1.** Tuning the Magnetic Response of Magnetotactic Bacteria via Culture Medium for Enhanced Hyperthermia Efficiency		
9:45-10:00	S. Caspani	**O2.** Magnetic nanostructures for biomedical applications		
10:00-10:15	C. Moya	**O3.** Unveiling the crystal and magnetic texture of iron oxide nanoflowers		
10:15-10:30	Z. Shaterabadi	**O4.** Magnetite nanorods as high-performance magnetic hyperthermia agents		
10:30-10:45	D. Villanueva-Álvaro	**O5.** Navigation control of magnetotactic bacteria under rotating and linear magnetic fields		
10:45-11:15	Coffee break (Hall Facultad de Ciencias)			
	Session: Nanotechnology and Nanodevices I. Chair: F. Giacomelli. AULA MAGNA		**Session: Cancer therapy and diagnosis I. Chair: M.P. Morales. Salón de Grados**	
11:15-11:35	M. Fanarraga	**Keynote (KN1).** Designing Fully Customizable Nanorobot for Biocompatible Navigation and Restoration of Amyloid Proteins	R.M. Sánchez-Martín	**Keynote (KN2).** Development of Active-Targeting Nanoplatforms for Cancer Diagnosis
11:35-11:50	V. Milkova	**O6.** Controlled aggregation of amyloid β peptide in the presence of homotaurine-loaded nanoliposomes	J.J Díaz-Mochón	**O12.** Nanotrackers as reagents for long-term live-cell barcoding
11:50-12:05	L. Rodríguez-Arco A.	**O7.** Design and construction of bioinspired microcompartments	N. Daviu	**O13.** Induction of Oxidative Stress by DMSA-coated IONPs trigger mitochondrial dynamic changes in breast cancer cells affecting proliferation and migration capacity
12.05-12:20	H. Shabbir	**O8.** Carbon dots, precursor and property relation with focus on toxicity	A. Cruz	**O14.** Targeting ovarian cancer nanoradiotheranostics with ligand-free 99mTc-polyurea dendrimer complexes
12.20-12:35	P. Duel	**O9.** Bio-inspired Suface Modification as a new Ultra-fast method for the Killing of common Nosocomial Bacteria	V. Paganini	**O15.** Development of a thermosensitive gel containing Curcumin-loaded nanomicelles for skin cancer treatment
12:35-12:50	Escribano-Huesca	**O10.** Immobilization of Artificial Cell-Inspired Micro-compartments for Biological Applications	A. Cepero	**O16.** LGR5 in colorectal cancer therapy, a therapeutic target for antibody-functionalized biomimetic magnetoliposomes
12:50-13:05	A. Asenjo	**O11.** Characterization of individual chains of magnetosomes by Magnetic Force Microscopy	L. García-Hevia	**O17.** Inhibition of Melanoma Metastasis through Precision Targeting Carbon Nanotubes to the tumor neovasculature
13:30-15:00	Lunch (Hall Facultad de Ciencias)			
Session: Magnetic materials II. Chair: A.V. Delgado AULA MAGNA				
15:00-15:30	Q.A. Pankhurst	**Plenary (PL2).** Some recent developments in magnetic field hyperthermia: from standards and metrology to clinical studies		
15:30-15:45	G.F. Goya	**O18.** Synthetic Magnetosomes for Dual Therapeutic Approach: Chemotherapy and Magnetic Hyperthermia		
15:45-16:00	K. Simeonidis	**O19.** An automated system for fast and sustainable synthesis of magnetic nanoparticles		
16:00-16:15	V. Salgueiriño	**O20.** Magnetically induced Thermal Effects on Tobacco Mosaic Virus-based Nanocomposites for a Programmed Disassembly of Protein Cages		
16:15-16:30	F.J. López	**O21.** Characterization techniques for nanoparticles: size distribution, concentration and interactions		
16:30:17:00	Coffee break (Hall Facultad de Ciencias)			
17:00-17:20	C. Jiménez-López	**Keynote (KN3).** Learning from nature: Biomimetic magnetic nanoparticles as platforms to combine directed chemotherapy and hyperthermia		

17:20-19:00	**Poster pitch**
19:00-20:30	**Poster and Beer Session**

Thursday 15th February 2024

	Session: Cancer therapy and diagnosis II. Chair: M.R. Ibarra. AULA MAGNA			
9:00-9:30	C. Dufès	**Plenary (PL3).** Designing tumour-targeted nanomedicines for cancer therapy		
9:30-9:50	S. Soenen	**Keynote (KN4).** On the use of bio-engineering for enhanced material properties in cancer therapy		
9:50-10:05	M.C. Ortega-Liébana	**O22.** Stimuli-Responsive Tumor-Targeting Nanocarrier for Multimodal Cancer Therapy		
10:05-10:20	J. Ruiz-Torres	**O23.** Optical studies on anisotropic Bi2S3 and hybrid Bi2S3@Au nanocomposite		
10:20-10:35	F.C. Giacomelli	**O24.** Permeability and Responsiveness Drive Performance: Linking Structural Features with Antitumor Effectiveness of Doxorubicin-Loaded Stimuli-Triggered Polymersomes		
10:35-10:50	M.C. Morán	**O25.** Active Targeting and Therapeutical Applications of Gelatin-based Nanoparticles		
10:50-11:15	Coffee break (Hall Facultad de Ciencias)			
	Session: Sensors I. Chair: F. Terán AULA MAGNA		**Session: Magnetic materials III. Chair: M.T. López-López. Salón de Grados**	
11:15-11:35	F. Wiekhorst	**Keynote (KN5).** Detecting magnetic micro- and nanoparticles by widefield magnetometry with NV centers	M.T. López - López	**Keynote (KN6).** Magnetic hydrogels: from synthesis to biocompatibility characterization
11:35-11:50	M. Alqudwa-Fattouh	**O26.** Designing Granzyme-B Activity Nanoprobes for Immunotherapy Response Evaluation	A. Gallo-Cordova	**O32.** Exploring the Microwave-assisted Synthesis of Iron Oxide Nanoparticles
11:50-12:05	M.C. Blanco López	**O27.** Nanomaterials for sensitive pathogenic bacteria determination with electrochemical biosensors	A. Jaufenthaler	**O33.** Human-sized quantitative imaging of magnetic nanoparticles with magnetorelaxometry and optically pumped magnetometers
12.05-12:20	L. Ming	**O28.** Neural networks push the limits of luminescence lifetime nanosensing	M. Jiménez-Carretero	**O34.** Combination of biomimetic magnetic nanoparticles and qPCR to magnetically concentrate and detect bacteria in liquids
12.20-12:35	P. Marín	**O29.** Magnetoelastic contactless gas sensor for real-time monitoring of breath biomarkers. A proof of concept	P. Palacios Alonso	**O35.** Exploiting the potential of AC magnetometry to display thermal conformational changes of proteins
12:35-12:50	F. Zhang	**O30.** A reliable ratiometric fluorescent nanothermometer for live cells	V. Pilati	**O36.** Superparamagnetic Mn Ferrite Nanoparticles for Highly Sensitive Lateral Flow Assays
12:50-13:05	C. Guati	**O31.** Development of an innovative Non-Enzymatic Microelectrode with Bimetallic Combination for Glucose Detection in Neutral Media	S.Calogero-Gaglio	**O37.** Effect of TAT-PLGA - DOx transported by biomimetic magnetic nanoparticles under magnetic hyperthermia and photothermia irradiation
13:30-15:00	Lunch (Hall Facultad de Ciencias)			

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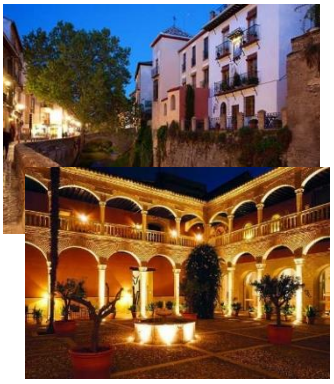
Thursday 15th February 2024

	Session: Drug Delivery I Chair: C. Dufés. AULA MAGNA		Session: Nanotechnology and Nanodevices II Chair: M.C. Blanco López. Salón de Grados	
15:00-15:15	J.A. Lirio-Piñar	**O37.** Kinetics of methotrexate release from magnetic activated carbon under external stimuli	A. González-Paredes	**O43.** Bimetallic nanoparticles for the treatment of bacterial infections associated with biofilms
15:15-15:30	A.I. Barbosa	**O38.** A sea of nano-possibilities: marine hybrid hydrogels combined with nanoparticles to treat Atopic Dermatitis	L.L. Hernández-Cubas	**O44.** Laser-Induced Graphene: Innovative Fabrication and Advanced Characterization for Biomedical Applications
15:30-15:45	K. López	**O39.** Design and optimization of an innovative lipid nanosystem for the encapsulation of a novel FXa inhibitory molecule using Green Chemistry strategies	M. Bramini	**O45.** Graphene-based materials interaction with the Central Nervous System
15:45-16:00	A. Ramos-Valle	**O40.** DNA@SiO2 spheres for versatile and efficient delivery of different DNA forms in mammalian cells	A. Rubio-Andrés	**O46.** Polyoxometalate ionic specificity effects for tuning microgel swelling and 2D interfacial self-assembly
16:00-16:15	A. Lafuente	**O41.** Multifunctional Drug-Loaded Metallic Nanodomes as a Platform for Obtaining Synergistic Therapeutic Biological Activities	F.J. Vázquez-Pérez	**O47.** Soft magnetic actuators with fast and complex motion obtained by mold casting process
16:15-16:30	F.A. Soares	**O42.** On the CD44 Express: A Journey into Precision Delivery through Engineered Milk Extracellular Vesicles	I. Adroher-Benítez	**O48.** Diffusion and interaction effects on molecular release kinetics from collapsed microgels
16:30-17:00	Coffee break (Hall Facultad de Ciencias)			
	Session: Environmental. Chair: G.F. Goya. AULA MAGNA			
17:00-17:20	M. Ferrari	**Keynote (KN7).** Superhydrophobic materials in environmental and underwater applications		
17:20-17:35	M. Fadel	**O49.** Harnessing Ultrathin Carbon-Coated Nickel Nanoparticles for Efficient Purification of Chromium and Methylene Blue from Aqueous Solutions		
17:35-17:50	E. Herrera	**O50.** Fe3O4-TiO2 nanostructures as reusable photocatalysts for water purification treatments		
17:50-18:05	T. Asimakidou	**O51.** Implementing Fe3O4-biochar based adsorbents for Cr(VI) uptake		
18:05-18:20	S. Suárez-García	**O52.** A mussel-inspired nanocoating for cost-effective and environmentally friendly CO2 capture		
18:30-20:30	**City Tour**			
20:30-	**CONFERENCE DINNER (Santa Paula Palace)**			



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Friday 16th February 2024

Session: Nanotechnology and Nanodevices III. Chair: M.L. Fernández-Gubieda. AULA MAGNA				
9:00-9:30	E. Souto	**Plenary (PL4).** Key features of lipid nanoparticles for safe use in acute and chronic diseases		
9:30-9:45	P. Maziarz	**O53.** Nanomaterials Editorial Presentation		
9:45-10:00	B. Pepió-Tárrega	**O54.** New mussel-inspired nanomaterials with antimicrobial properties		
10:00-10:15	P. Graván	**O55.** Exploring the Impact of Nanoparticle Stealth Coatings in Cancer Models: From PEGylation to Cell Membrane Coating Nanotechnology		
10:15-10:30	E. Berganza	**O56.** Biofunctionalization of 3D microstructures via dip-pen nanolithography		
10:30-10:45	D. Maestro	**O57.** CTPR390, an Hsp90-inhibiting nanoparticle, reverses fibrotic phenotype in a human model of cardiac fibrosis		
10:45-11:15	Coffee break (Hall Facultad de Ciencias)			
	Session: Drug Delivery II. Chair: M. Perduca. AULA MAGNA		**Session: Sensors II.** Chair: S.J. Soenen SALÓN DE GRADOS	
11:15-11:35	B. B. Manshian	**Keynote (KN8).** Optimized 3D human and/or animal explants for ex vivo precision cut tissue slices	S. Thompson	**Keynote (KN9).** Intracellular and Extracellular Temperature
11:35-11:50	D. Lesta-Alfeirán	**O58.** Bioadhesive and antibacterial catechol-based membranes and their applications in wound-healing and tissue regeneration	J. Rodríguez-Álvarez	**O62.** Anti-ferroelectric dark modes in plasmonic lattices
11:50-12:05	C. Tavares de Sousa	**O59.** The key parameters in phototherapy with gold nanorods combined with targeted solid lipid nanoparticles for controlled drug delivery	A. Piper	**O63.** The Cleanroom free, Cheap and Rapid Fabrication of Nanoelectrodes for Single Molecule Detection
12.05-12:20	F. Oltolina	**O60.** Innovative drug delivery system based on hyaluronic acid-functionalized biomimetic-magnetoliposomes	I. Zabala Gutiérrez	**O64.** PEGylated Ag2S nanoparticles as multifunctional biological probes
12.20-12:35	I. Clemente	**O61.** Lipid-based nanoparticles as carriers for treatment of infectious and degenerative eye pathologies	R.A. Rica	**O65.** Quantifying the temperature increase in optically trapped absorbing particles
12:35-12:50			M.A. Fernández-Rodríguez	**O66.** Microgel-laden thermoresponsive surfaces for biomedical applications
13:00-13:30	**Closing and awards ceremony:** AULA MAGNA			
13:30	**Farewell beer**			

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POSTER PRESENTATIONS

No.	Author	Title
P1	B. Colaço-Alves	Surface-enhanced Raman scattering (SERS) for dissolved carbon dioxide detection using porphyrin-coated gold nanostars
P2	J.L.Arias	Biocompatible magnetopolymeric nanoparticles for antitumor hyperthermia and photothermia therapies
P3	J.L.Arias	Reproducible formulation of poly(butylcyanoacrylate)-coated iron oxide nanostructures for biomedical applications
P4	M. Barczak	Synthesis and characterization of supramolecular peptide-based magnetic hydrogels for biomedical applications
P5	A.I. Becerro-Nieto	Effect of nanoparticles architecture on their performance as multimodal contrast agents for T1-T2 dual mode MRI and luminescent bioimaging
P6	A.B.Bonhome	Designing the internal microarchitecture for self-heating droplets via gold and magnetite nanoparticle compartmentalization
P7	A.J. Bruno	Fabrication and Sensing Applications of Laser-Engraved rGO Electrodes Decorated with Metal Nanoparticles
P8	L. Gago	The application of magnetic nanoparticle-mediated hyperthermia as a therapeutic approach to gastrointestinal cancers
P9	S. Calogero-Gaglio	Avoiding undesired effects in the interaction of nanostructures with immune cells: the Role of Oxyresveratrol
P10	M.V. Cano-Cortés	Mass Cytometry Nanodiagnostic Assay for Cancer Biomarker Recognition
P11	M.Carrasco	Conditioning of black mass of disused LIB's for the separation of its components by flotation process
P12	A.Casillas-Rubio	Upconversion luminescence lifetime modulation by excitation control
P13	A.Danana	Synthesis and functionalization of gold nanoparticles with superior x-ray attenuation properties compared to clinically used iodinated small molecular contrast agent
P14	L. De Castro Alves	Magnetic hybrid biomaterials for cyanotoxins removal from water
P15	M. del Puerto Morales	Magnetic hydrogels and primary neural cells under high-frequency magnetic stimulation
P16	M. Dhanjani	Controlled synthesis of magnetoplasmonic aggregate nanoparticles for biomedicine
P17	S. Domingo-Pelegrí	Covalent Organic Frameworks (COF) nanoparticles with optical properties as contrast agents for photoacoustic imaging
P18	S. Domingo-Pelegrí	Light-activated nanomedicines for selective intracellular delivery of camptothecin
P19	D. Egea-Benavente	Magnetic Hyperthermia Therapy mediated by Nanoparticles: search for candidates, selection of operating conditions and in vitro experiments
P20	L. Encabo	Development of a targeted PLGA-PEG nanoplatform for β-CFN volatile cannabinoid
P21	A. Fernández-Borbolla	Coating Techniques for the Obtention of Cell Membrane-Coated Nanoparticles for Tissue-Specific Therapeutics
P22	C. Lecumberri	Combined systems of magnetic photo and biocatalysts for the tertiary treatment of emerging contaminants in wastewater
P23	M.L. Fernández-Gubieda	Solar-driven antibacterial activity of Zn-Co ferrites
P24	L. Fernández-Huarte	Development of a platform for novel gene therapy vectors with renal tropism
P25	S.C. Freitas	Multifunctional Fe-Au nanostructures for biomedical applications
P26	G. García-García	Functionalized magnetopolymeric nanocomposites for antitumour magnetic hyperthermia therapy
P27	G. García-García	Magnetic core/shell nanoparticles as antitumoral agents for magnetic and photothermal therapy
P28	J. García-Fernández	Versatile and scalable nanotechnology platform for addressing personalized medicine
P29	M. Mar Gil-Díaz	Nanoscale zero valent iron increases iron availability in agricultural soils
P30	D. Jiménez-Boland	Biomimetic Cell Membrane-Coated Nanoparticles for the Targeting and Potential Treatment of Glioblastoma

P31	M.Montalbán-López	Broadening the antimicrobial spectrum of the enterocin AS-48 in combination with magnetic nanoparticles and hyperthermia
P32	M. Lázaro	Crucial role of cellular uptake in photothermal treatments using BMNPs
P33	M. Lázaro	Magnetic Activated Carbon for drug delivery
P34	A. León-Cecilla	Magnetic Semi-interpenetrating Hydrogels Based on Natural Biopolymers for Sensing and Actuating
P35	A. Márquez-López	Design of chemotherapeutic nanoparticles to target Tumor Endothelial Marker 8 receptor in solid tumors
P36	A. Medina-Moreno	Formulation of (maghemite/poli(ε-caprolactone))/polyethylenimine (core/shell)/shell nanoparticles with potential application in hyperthermia against cancer
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Plenary lectures

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Thermal and ultrasonic effects due to the interaction of electromagnetic radiation with magnetic nanoparticles

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The established understanding is that, when magnetic nanoparticles (MNPs) absorb energy within uploaded cells, biological membranes can experience physical damage due to the energy released by the MNPs [1,2]. This membrane damage goes beyond the conventional explanation of temperature increase effects. Other mechanisms, such as the generation of acoustic waves in the ultrasound region, may contribute to the observed damage. We have measured a significant increase in the amplitude of the 2nd harmonic signal in samples containing MNPs, as theoretically predicted [3]. This increase was absent in nonmagnetic nanoparticle control samples, serving as a distinctive indicator of ultrasound generation through magneto-acoustic interaction in the MNPs.

There is ample evidence supporting the impact of magnetically aligned aggregates of MNPs on heating efficiency [4]. Recent experiments have underscored the significance of magnetically aligned MNPs in ultrasound emission [5]. These findings highlight the crucial role of magnetic dipolar interaction in the magneto acoustic coupling within these systems.

These effects pave the way for the design of MNP-based nanovectors, offering new possibilities for ultrasound theragnostic applications by integrating acoustic imaging and magnetic fluid hyperthermia (MFH) treatment.

[1] L. Asín, M.R. Ibarra, A. Tres, and G.F. Goya. Controlled cell death by magnetic hyperthermia: effects of exposure time, field amplitude, and nanoparticle concentration. Pharmaceutical research, 29(5):1319–1327, 2012.

[2] B. Sanz, M. P. Calatayud, T. E. Torres, M. L. Fanarraga, M. R. Ibarra, and G. F. Goya. Magnetic hyperthermia enhances cell toxicity with respect to exogenous heating. Biomaterials, 114:62–70, 2017.

[3] J. Carrey, V. Connord, and M. Respaud. Ultrasound generation and high- frequency motion of magnetic nanoparticles in an alternating magnetic field: toward intracellular ultrasound therapy? Applied Physics Letters, 102(23):232404, 2013.

[4] Beatriz Sanz, Rafael Cabreira-Gomes, Teobaldo E. Torres, Daniela P. Valdés, Enio Lima Jr., Emilio De Biasi, Roberto D. Zysler, M. Ricardo Ibarra, and Gerardo F. Goya* "Low-Dimensional Assemblies of Magnetic $MnFe_2O_4$ Nanoparticles and Direct *In Vitro* Measurements of Enhanced Heating Driven by Dipolar Interactions: Implications for Magnetic Hyperthermia" *ACS Applied Nanomaterials*, DOI: 10.1021/acsanm.0c01545

[5] R. Marquez "Electromagnetic field-induced second harmonic ultrasound generation in Magnetic Nanoparticles" PhD Thesis (2023 presented)

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Some recent developments in magnetic field hyperthermia: from standards and metrology to clinical studies

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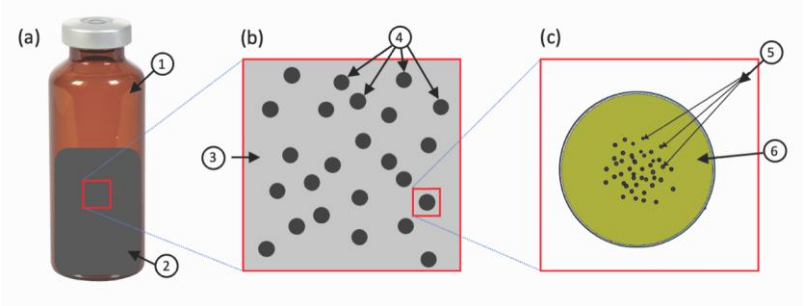
In magnetic field hyperthermia (MFH), a time-varying magnetic field $H(t) = H_o \sin(2\pi f t)$ is used to deliver thermal energy into implanted magnetic materials in the human body, for therapeutic purposes. Currently, MFH is used clinically in the treatment of glioblastoma and prostate cancer and is being tested for pancreatic cancer. It is also the subject of extensive *in vitro* and preclinical testing as researchers explore ways to optimize and use it.



Example of a magnetic fluid used in MFH. Key: 1 = glass vial; 2 = RCL Agent (magnetic fluid); 3 = supernatant of water for injection & saline; 4 = multicore magnetic nanoparticles; 5 = individual iron oxide cores; and 6 = dextran-40 matrix.

In this lecture a selection of recent examples of developments in MFH will be presented and discussed. The examples will include:

- standardisation of the terminologies used in MFH [1];
- the introduction of ISO standards on the specification of characteristics and measurement methods for magnetic nanosuspensions and nanostructured beads [2];
- a review of the safety aspects of non-specific eddy current heating associated with MFH [3];
- a multi-site inter-laboratory study and review of challenges and recommendations for MFH characterisation measurements [4];
- the evaluation of deep-tissue MFH localisation methods using pulse sequencing [5,6]; and the latest reports on an on-going clinical study of MFH for the treatment of locally advanced pancreatic cancer [7].

References

[1] J. Wells *et al.*, *J. Phys. D* **50** (2017) 383003.
[2] ISO/TS 19807-1:2019 and ISO/TS 19807-2:2021.
[3] M.K.Y. Kwok *et al.*, *Appl. Phys. Lett.* **122** (2023) 240502.
[4] J. Wells *et al.*, *Int. J. Hyperthermia* **38** (2021) 447.
[5] F.L. Tansi *et al.*, *Int. J. Hyperthermia* **38** (2021) 743.
[6] W.O. Maduasbuchi *et al.*, *Cancers* **16** (2024) 33.
[7] See https://tinyurl.com/3zfkurth, Vall d'Hebron Institute of Oncology (2023).

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Designing tumour-targeted nanomedicines for cancer therapy

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Gene therapy holds great promise for treating advanced cancers resistant to conventional therapies. However, the lack of delivery systems able to deliver therapeutic DNA selectively to tumours without harming healthy tissues presents a significant challenge. To address these issues, we are working on the design and development of novel tumour-targeted, gene-based nanomedicines for advanced cancer therapy. Several of these strategies will be highlighted in this presentation.

For example, the intravenous administration of transferrin-bearing and lactoferrin-bearing polypropylenimine dendriplexes resulted in gene expression mainly in the tumours [1-3]. Consequently, delivering the transferrin-bearing dendrimer complexed to a therapeutic DNA encoding tumour necrosis factor (TNF)α led to 90% tumour suppression of A431 epidermoid tumours over one month [1]. Similarly, this approach resulted in tumour suppression for 60% of PC-3 and 50% of DU145 prostate tumours [3]. Additionally, lactoferrin-bearing targeted dendriplexes encoding TNFα led to complete suppression of 60% of A431 tumours and up to 50% of B16-F10 skin tumours over the same period [2].

In our pursuit of a versatile delivery system capable of transporting both anti-cancer drugs and nucleic acids, we developed redox-sensitive dendrimersomes made of disulphide-linked camptothecin-bearing PEGylated dendrimers that can be used as drug and gene delivery systems for potential applications in combination cancer therapy [4-5]. Notably, these PEGylated dendrimers were found to spontaneously self-assemble into cationic vesicles. These vesicles (dendrimersomes) were able to entrap both hydrophilic and hydrophobic agents, coupled with redox-responsive sustained release of the entrapped guests. They were able to condense DNA, and increased gene expression in prostate cancer cells compared to that observed when treated with the unmodified dendrimer [4-5].

Another strategy involves the development of novel tumour-targeting gold nanocages conjugated with polyethylenimine and polyethylene glycol, along with tumour-targeting, dendrimer-bearing gold nanocages [6-7]. These nanocages led to highly promising DNA delivery to prostate cancer cells, achieving efficacy without the need for external stimulation such as photothermal therapy required for gold nanoparticles.

References

[8] S. Koppu, Y.J. Oh, *et al. J. Control. Release* **142** (2010) 215-221.
[9] L. Y. Lim, P.Y. Koh, *et al. Nanomedicine: NBM* **11** (2015) 1445-1454.
[10] N. Altwaijry, S. Somani, *et al. Drug Deliv.* **25** (2018) 679-689.
[11] P. Laskar, S. Somani, *et al. Nanoscale* **10** (2018) 22830-22847.
[12] P. Laskar, S. Somani, *et al.* Nanoscale **11** (2019) 20058-20071.
[13] J. Almowalad, S. Somani, et al. *Int. J. Nanomedicine* **16** (2021) 4391-4407.
[14] J. Almowalad, P. Laskar, et al. *Int. J. Nanomedicine* **17** (2022) 1409-1421.

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Key features of lipid nanoparticles for safe use in acute and chronic diseases

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Lipid nanoparticles are being proposed as drug delivery systems for decades. The number of published works and filled patents is increasingly growing, granting them a prominent role in formulation development for precision nanomedicine. Here we discuss the most relevant aspects (e.g., lipid concentration, particle size, surface electrical charge, time of exposure, surfactant composition) that need to be considered to classify lipid nanoparticles as efficient and safe drug carriers, both in vitro and in vivo. Examples are given with a special interest in the targeting of positively-charged drugs, as well as in dual drug loading, for the treatment of acute and chronic disease. A typical example is the brain exposure to organophosphorus compounds. Pralidoxime chloride is one of their current antidotes, acting as a reactivator of acetylcholinesterase. We have successfully shown that this water-soluble compound can be formulated in SLN for intravenous targeting to the brain effectively. Scientific evidence is also given on the safety of these carriers for dermal, ocular and oral administration of drugs.

Keynote lectures

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Designing Fully Customizable Nanorobot for Biocompatible Navigation and Restoration of Amyloid Proteins

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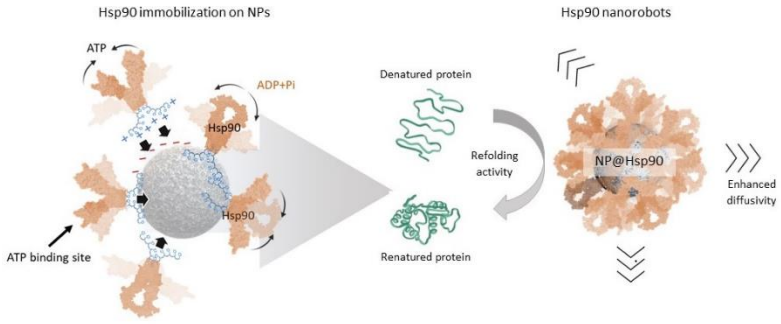
As only a small fraction of nanomedicines successfully reach their intended destination in vivo[1,2], we have long focused on using biotechnology to produce customizable protein coatings to improve nanomaterial targeting while avoiding the binding of serum proteins[3]. Aiming to add new functionalities to nanosystems of all kinds, our focus has shifted to designing nanoswimmers that can swim in biological environments.

To create a biocompatible and sustainable system powered by an "infinite" energy source, we've chosen to use motor proteins that use ATP as their fuel, since this is the universal cellular energy. With this in mind, we opted for HSP90 which undergoes a “clapping” like motion during ATP hydrolysis[4,5]. Our findings indicate that Hsp90-biohybrids can navigate through various synthetic or biological media, dependent on ATP concentration[6]. Given Hsp90's role as a molecular chaperone in restoring the functionality of damaged client proteins, our subsequent inquiry focused on whether the HSP90 nanosystems could extend their effectiveness to restoring proteins denatured by physical agents and preventing amyloid formation[7].

Our results demonstrate the remarkable efficacy of these nanosystems, which act as "nanorobots" with both swimming and protein-repairing capabilities, to efficiently inhibit amyloid formation *in vitro*. This research highlights how the fusion of biotechnology and material science is ushering in a transformative era in nanomedicine, with unprecedented prospects in healthcare and beyond. This innovation opens up a wide range of applications, from precision drug delivery to real-time protein repair and the prevention of amyloid-related diseases.



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References

[1] S. Wilhelm, et al., Nat Rev Mater 2016, 1, 16014.
[2] M. Mahmoudi, Trends Biotechnol 2018, 36, 755.
[3] E. Padín-González, et al. Nanomedicine 2020, 102268.
[4] K. A. Krukenberg, et al., Structure 2008, 16, 755.
[5] F. H. Schopf, et al. Nat Rev Mol Cell Biol 2017, 18, 345.
[6] A. Rodríguez-Ramos, et al., Mater Today Adv 2023, 17, 100353.
[7] A. Rodríguez-Ramos et. Al.. ACS Chem Neurosci 2023, 14, 2811.

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Development of Active-Targeting Nanoplatforms for Cancer Diagnosis

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Nanotechnology has made significant progress in recent years, leading to the development of various new diagnostic and therapeutic platforms, collectively referred to as theranostics. One of the key components of these platforms are polymeric nanoparticles, which have a unique set of properties, including the ability to adapt their chemical composition, size, stability, shape, and surface functionality.

Polymeric nanoparticles have the potential to effectively transport biological materials into cells without altering the cells' biological functions or causing toxicity. Additionally, these nanosystems allow for the targeted and controlled release of transported materials, avoiding toxicological problems on non-targeted cells.

The current study presents the development of novel active-targeting nanoplatforms for cancer diagnosis, focusing on two specific approaches: (1) the detection and isolation of malignant extracellular vesicles and (2) cancer cell detection based on receptor overexpression using mass cytometry. The protocols used in the study employ standard solid-phase chemistry for the controlled decoration of the nanoparticles, which were then evaluated for conjugation efficiency through various methods, including immunochemistry, BCA assay, and electrophoresis in agarose gel.

The functionalization of the nanodevices, conjugated with a specific antibody and either a fluorophore or a lanthanide, was successful. This functionalization allows for the tracking of the nanoparticles using flow cytometry or mass cytometry, respectively. The successful development of these novel active-targeting nanoplatforms represents a significant step forward in the field of cancer diagnosis and highlights the potential of polymeric nanoparticles as versatile tools in theranostics.

This research was supported by the Spanish Ministry of Economy and Competitiveness (grant number PID2019.110987RB.I00 and PDC2022.133913.I00); the Andalusian Regional Government cofinanced by European Regional Development Funds (FEDER) (PT18-TP-4160, A-FQM-760-UGR20); the FEDER/Andalusian Regional Ministry of Economy and Knowledge (CV20-77741) and the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie actions (MSCA-RISE-101007934, diaRNAgnosis). NanoChembio team are members of the NANOCARE 2.0 network (Grant RED2022-134560-T funded by MCIN/AEI/ 10.13039/501100011033.

References

[1] Delgado-Gonzalez A,et al., Anal Chem. 2022, 2;94(30):10626-10635.
[2] Cano-Cortés et al., Nanoscale. 2021, 13-6, 3500-3511.
[3] Robles-Remacho et al., Talanta. 2021 May 1;226:122092.

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Learning from nature: Biomimetic magnetic nanoparticles as platforms to combine directed chemotherapy and hyperthermia

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Magnetite formation by magnetotactic bacteria is a unique controlled biomineralization process among prokariotes. It is controlled by a set of proteins, able to interfere with the kinetics of magnetite nucleation and growth, producing crystals with unique features, very different than those produced inorganically, perfectly suited for clinical uses. Learning from this natural process, biomimetic magnetic nanoparticles (BMNPs) can be synthesized in the laboratory by using MamC, one of these magnetosomes associated proteins. Like any other protein with acidic domains, MamC controls nucleation by an ionotropic effect, but MamC presents an unique feature that has a major impact on magnetite nucleation, and this is that it exerts a template effect[1]. MamC-mediated BMNPs are composed of Fe_3O_4 and are proposed as nanocarriers for targeted chemotherapy combined with hyperthermia due to their novel properties. It is of particular interest their size (36 ± 12 nm) and surface properties, having an isoelectric point of 4.4 so they can form nanoassemblies drug-BMNPs by ionic bonding. These nanoassemblies are stable at physiological pH values, while drug is released at acidic (tumoral) pH value. BMNPs are superparamagnetic at body temperatures, but, when exposed to a magnetic field, they exhibit a large magnetic moment per particle, allowing magnetic concentration and preventing drug dissemination. BMNPs are hyperthermia agents and are cytocompatible. They can also be embedded in liposomes, further functionalized with antibodies to mediate an active targeting.

Our results with DOXO-BMNPs and liposome embedded L(DOXO-BMNP) functionalized with an antibody[2] demonstrate that these nanoformulations can be injected and concentrated at the target tumor by the apposition of a magnet. Moreover, these nanoassemblies respond to an alternating magnetic field acting as magnetic hyperthermia agents. As a result, they generate a local temperature increase that, on one hand triggers tumoral cells death, and, on the other, enhaces drug release, further intensifying cell death. Indeed, when this DOXO-BMNP nanoformulation is injected in vivo in mice model at the tumor site, and hyperthermia is generated, the combined chemo-thermal therapy mediated by these drug-loaded magnetic nanoparticles have a stronger therapeutic benefit compared to that carried out by the chemotherapeutic alone[3]. This nanoformulation and strategy are thus promising tools for translational applications in cancer therapy.

Acknowledgments

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References

[1] A. Ubago-Rodríguez et. al., *Crystal Growth and Design*, **19** (2019) 2927-2935.
[2] F. Oltolina, et.. *Int. J. Mol. Sci.*, **24** (2023) 13958.
[3] F. Oltolina, et. al. t, *Cancers*, **12** (2020) 2564.

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On the use of bio-engineering for enhanced material properties in cancer therapy

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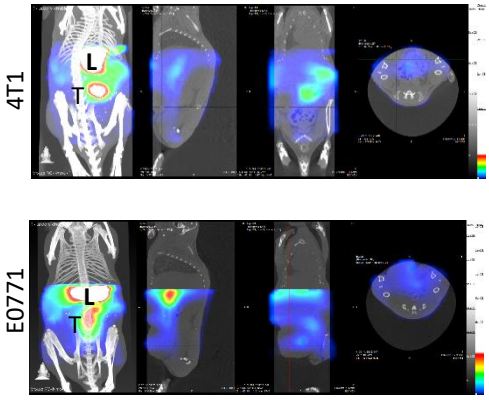
The interest in the biomedical use of nanomaterials has been quite strong for several years, yet despite the excellent preclinical proof of concept data, the clinical translation of nanomedicines has remained somewhat low. One potential issue in this regard are the uncertainties related to the biodistribution and bio-effects that nanomaterials will have upon systemic administration. In the present contribution, we aim to provide an overview of some recent examples on how developments in imaging and analysis can help to overcome some of the hurdles currently associated with biomedical research involving nanomaterials.

We will primarily focus on the use of biomimetics and biological strategies to enhance the delivery of therapeutic nanoformulations to solid tumors. Specifically, we will focus on the use of FLECT imaging in quantitatively determining nanoparticle distribution (Figure 1) and, combined with image-based flow cytometry, look at the heterogeneity of cellular particle uptake within the tumor microenvironment. Using these methodologies, we look at how different inorganic nanoparticles can influence tumor metastases levels, or how biomimetic approaches can be used to enhance therapeutic efficacy of nanoparticles loaded with gene constructs inducing immunogenic cell death.

Together with examples of novel imaging modalities and the need for fully quantitative data, we hope that this presentation will help any interested scientists in uncovering the full potential that nanomedicines have to offer.



Representative FLECT images of mice orthotopically grafted with triple negative breast cancer (TNBC tumors) and treated with fluorescently tagged formulations that end up in the liver and (L) and tumor (T), where the extent of tumor delivery was found to correlate with the level of tumor-associated macrophages.

Acknowledgments

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Detecting magnetic micro- and nanoparticles by widefield magnetometry with NV centers

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Magnetic micro- and nanoparticles are widely used in biomedical applications. Current research mainly focuses on ensemble properties in macroscopic samples, so that their magnetic properties on a microscopic scale often are hidden in the ensemble averages. However, local information of single or few numbered magnetic entities, e.g., in cellular environments, will benefit the further optimization of their performance.

The traditional approach for high spatial resolution magnetic imaging involves a scanning probe that is moved across the sample surface step-by-step. Magnetic fields are then locally quantified by magnetic force measurements, nanoSQUIDs, or recently by Nitrogen-Vacancy (NV) defects in a diamond lattice on the scanning tip. These scanning processes are however delicate, time-consuming, or destructive, and they are not optimal for time-critical or technological applications.

Widefield magnetic imaging using NV-centers in diamond allows the simultaneous monitoring of events over wider areas. The approach offers a unique compromise between resolution, sensitivity, and measurement time allowing for a relatively fast (sub-seconds to minutes) magnetic image acquisition with a large field of view and diffraction-limited resolution. These combined properties make it an ideal measurement setup for the time-resolved monitoring of magnetic nano- and microparticles in fluids. Our approach to widefield NV-based sensing uses a diamond plate containing a near-surface high NV-concentration layer with a thickness of approximately 300 nm [1].

We present magnetic imaging of magnetic microbeads and nanoparticles on the diamond surface as well as suspended in water. Optically detected magnetic resonance and longitudinal relaxation contrast imaging is performed, revealing information about the local magnetic field and GHz magnetic noise amplitudes, respectively. Fig.1 shows particle clustering visualized by both modalities. Combined with optical microscopy, complementary information on position and movement of the particles driven by external magnetic field forces as well as the fluid flow is obtained.

We demonstrate the potential and challenges of widefield NV-center magnetometry as a real-time magnetic imaging system of magnetic micro- and nanoparticles for biomedical and microfluidic applications.

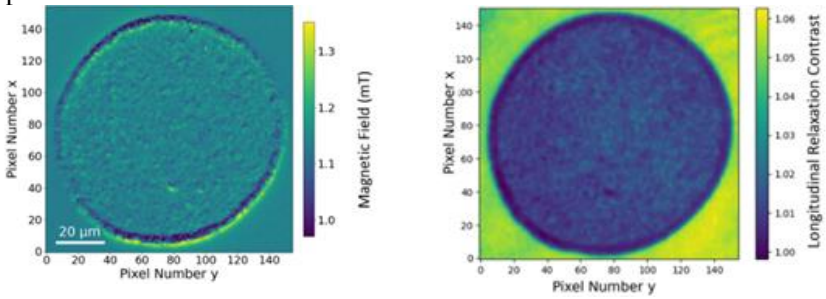

Figure 1: Left: Magnetic field component generated by magnetic nanoparticles reconstructed from the measured Zeeman splitting of the NV-center spin states. Right: Longitudinal relaxation contrast image of NV centers induced by MNP GHz noise.

References

[1] N Mathes, M Comas, R Bleul, K Everaert, T Hermle, F Wiekhorst, P Knittel, RA Sperling, X Vidal. *Nanoscale Adv.* **6**:247–255, 2024.

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Magnetic hydrogels: from synthesis to biocompatibility characterization

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Polymer hydrogels are three-dimensional, hydrophilic networks of polymer chains swollen by water or biological fluids. These hydrogels exhibit a distinctive combination of a soft, solid-like macroscopic appearance and a highly porous microscopic structure. Notably, when endowed with the requisite biocompatibility, hydrogels emulate the extracellular matrix of living tissues more effectively than any other synthetic biomaterials, rendering them versatile in biomedical applications.

Of particular interest are stimuli-responsive hydrogels, capable of reacting to external factors such as pH, light, heat, or magnetic fields. Among these stimuli, remote magnetic fields stand out as an attractive means of actuation due to their simplicity, rapid response, and safe penetration in biological environments. Achieving magnetic actuation in polymer hydrogels necessitates the incorporation of magnetic particles into the polymer network, resulting in hybrid materials known as magnetic hydrogels.

This keynote lecture will comprehensively review the significant outcomes we have attained in the field of magnetic hydrogels for biomedical applications over the past five years. The emphasis will be on elucidating the intricate relationship between microarchitecture and mechanical properties, thereby influencing the biocompatibility and temporal stability of magnetic hydrogels. The discussion will encompass diverse polymer materials, ranging from chemically cross-linked hydrogels to those based on ionic interactions between polymers. Additionally, we will delve into the impact of particle surface functionalization on the performance of magnetic hydrogels.

Acknowledgments

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Superhydrophobic materials in marine environment and underwater applications

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In sea environment the complex multi-specific biological community of bacteria, algae, fungi and ultimately higher organisms producing a biological phenomenon of accumulation and development on an interface is called biofouling. Severe problems in particular for the naval industry due to the deterioration of the surfaces, increased roughness lead to an increase of fuel consumption and, as a final result, increased material corrosion. The limitations associated can be overcome by superhydrophobic surfaces (SHS) since in this type of surfaces the combination of low surface energy and the existence of a specific surface morphology (micro-nano roughness) coexist, lead to significantly less wettable surfaces with water contact angle (CA) higher than 150° and a hysteresis lower than 5°. Protection and friction reduction in marine environment and under water applications play akey role where interactions with the aqueous environment are usually strongly to be avoided. As in the BEASTIE project underwater robots can efficiently benefit of such highly water-repellent coatings. The use of smart materials in the development of BEASTIE project is aimed to improve different behaviors, in particular the durability of the surface immersed in the environment and the efficiency of motion. Mixed organic-inorganic systems to provide self-healing properties have been prepared and their aging resistance has been evaluated as a function of the coating features. Surface characterization and on-field electrochemical studies have been carried out to test the performance in terms of fouling prevention and protection of metals in underwater conditions.

Acknowledgments
The authors acknowledge the PRIN 2022 (MUR-Ministry of University and Research, Funded by the European Union – Next Generation EU) “roBotic undErwater Autonomous Social Team for cooperative manipulation and IntelligencE (BEASTIE)” for the financial support.

NALS 2024
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Optimized 3D human and/or animal explants for ex vivo precision cut tissue slices.

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Millions of drug compounds are synthesized and tested every year. Following in-vitro and in-vivo screening of these drugs, for toxicological and therapeutic efficacy, some are translated into clinical trials. However, more than 17% of these drugs fail in phase 3 clinical trials due to safety. In order to improve and accelerate drug discovery and to better understand diseases and identify important biomarkers , there is an urgent need for reliable and reproducible methods that represent a true 3D organ. Precision-cut tissue slices (PCTS) system is an ex-vivo 3D tissue culture technique that closely resembles the organ from which it is prepared, with all the cell types present in their original tissue-matrix configuration where physiological and organ functionality details are preserved. Thus, these slices; 1) resemble the in-vivo environment, 2) are reproducible, 3) are low cost, 4) reduce the need for large number of animals for disease models fitting into the 3Rs principle (Refinement, Reduction and Replacement), and finally 5) they permit the testing in complex human systems.

Therefore, we have generated PCTSs from healthy and orthotopic lung cancer models generated in mice and validated the ex vivo model with the equivalent in vivo model. Comparison was performed using high throughput screening methods. Furthermore, in our work we were able to culture various organ specific PCTSs for an extended amount of time (21 days), thereby offering a long-term model, closely mimicking the organ which they are derived from. These were confirmed through PCR screening and histological analysis of the tissue slices. Culture conditions were further optimised following metabolomics studies. Given the high-level retainment of tissue properties, we were able to use some patient derived intestinal and ovarian cancer PCTSs to confirm the therapeutic effect different drug formulation. Patient PCTS screening results showed the high potential of this technique as a tool for personalized medicine.

Acknowledgments

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Intracellular and Extracellular Temperature.

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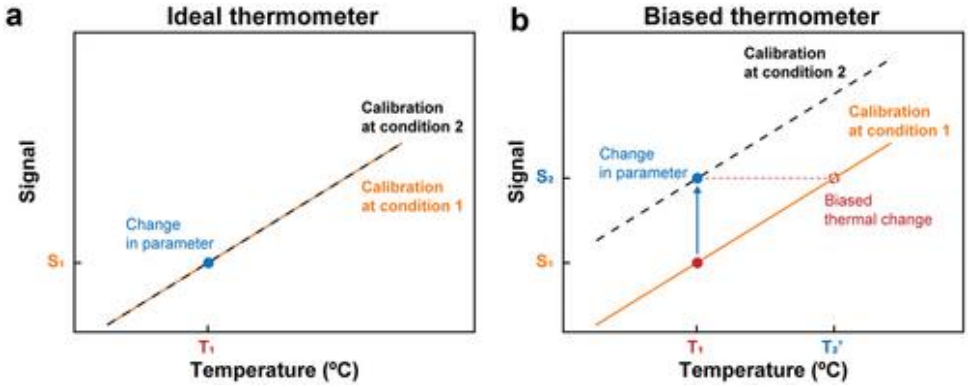
Temperature stands as a pivotal parameter in the realms of biology, medicine, and physics. Over recent years, numerous techniques have emerged to measure nanoscale intracellular temperature, with optical methods taking the lead due to their non-invasive nature, spatial accuracy, and capability to monitor real-time local temperature changes. Despite their advantages, the reliability of intracellular thermal readouts from optical methods remains a topic of ongoing discussion. This presentation addresses this debate by spotlighting cell activity as a significant bias mechanism, hindering the application of several nanothermometers for intranuclear and intracellular thermal measurements. This presentation delves into how differences observed in calibration curves, obtained in the presence and absence of cell activity, can offer insights into the existence of bias. The results and discussion presented here serve as a cautionary note to the community engaged in intracellular thermometry, urging authors to approach the issue with mindfulness. Additionally, as a parallel methodology, exploring extracellular temperature changes (where cell activity variations are absent) may uncover valuable, yet unexplored, insights into cellular processes and mechanisms. This presentation aims to contribute to the collective awareness and understanding of intracellular thermometry challenges and possibilities, fostering a conscious and informed approach within the scientific community.



Mislabeling of temperature. Comparison between a) an ideal thermometer and b) a biased thermometer

Acknowledgments (Arial 11 points)

S.T. Acknowledge Asociación Española Contra el Cancer (AECC)

References

[1] Rodríguez-Sevilla P., Spicer G., Sagrera A., Adam A., Efeyan A., Jaque D., Thompson S., *Advanced Optical Materials 11,11 2023*

NALS 2024
Nanomaterials Applied to Life Sciences

Oral presentations

(O1) Tuning the Magnetic Response of Magnetotactic Bacteria via Culture Medium for Enhanced Hyperthermia Efficiency

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Magnetotactic bacteria offer significant potential as theragnostic agents, owing to their inherent magnetic compass, chemical environment specificity, and natural motility. These microorganisms exhibit precise tracking, guided navigation to specific body regions, and activation for therapeutic responses, particularly in magnetic hyperthermia for cancer treatment [1]. In this investigation, we fine-tune the magnetic hyperthermia response of *M. magneticum AMB-1* by utilizing three distinct culture media: MSGM − W, MSGM + W, and FSM [2]. Our findings reveal that all culture media can support the growth of this species with fully developed chains of Fe_3O_4 magnetosomes, albeit with differing magnetic responses. MSGM + W medium, traditionally employed for the growth of this species, introduces 4−5% Co2+ ions into the magnetosomes, as confirmed by X-ray absorption spectroscopy and X-ray magnetic circular dichroism. This substantially alters their magnetic response, particularly at low temperatures. Conversely, FSM emerges as a promising alternative for cultivating this species. Bacteria cultured in this medium exhibit high uniaxial anisotropy, validated by magnetic simulations based on a Stoner−Wohlfarth model, resulting in elevated heating efficiency in the high-field region (> 40 mT) without the need for the standard MSGM + W. However, in the low-field region (< 40 mT), optimal heating results are achieved with bacteria grown in MSGM - W. These results underscore the critical role of culture medium in controlling and fine-tuning the magnetic response of MTB, offering the potential to select the most suitable culture medium based on specific biomedical applications.

Acknowledgments

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References

[1] M.L. Fdez-Gubieda et al. *J. Appl. Phys.* 128 (2020) 070902.
[2] D. Gandia et al. *ACS Appl. Mater. Interfaces* 15 (2023) 566.

(O2) Magnetic nanostructures for biomedical applications

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Progress in nanotechnology, particularly in the nanoparticles research field, has allowed the synthesis of nanostructures with precise morphologies and to suitably modify particles' surfaces, manipulating their characteristics for precise applications. Extensive studies have been carried out, and protocols have been developed, aiming the optimization of nanoparticles' characteristics such as composition, surface charge, shape, size, size distribution, and magnetic properties [1].

With the latest evolution and demands in nanomedicine, magnetic nanostructures (MNNs) are attracting increasing attention due to their potential to improve conventional therapeutic procedures and traditional clinical diagnostic, as well as to introduce novel approaches in biomedicine and tissue engineering [2,3,4].

Among several MNNs that have been developed, the ones that exhibit fast change of the magnetic state with the application of an external field, negligible remanence (magnetization at zero field) and coercivity (the field required to bring the magnetization to zero), are usually desired. These features are essential in biomedicine, as they prevent particles' agglomeration when dispersed in solution. Thus, this specific type of NS must combine high susceptibility and/or loss of magnetization after removal of the magnetic field, which make Superparamagnetic nanoparticles (SP-NPs), vortex state nanodiscs, high aspect-ratio nanowires (NWs), and ellipse/needle-like magnetic nanostructures very suitable in biomedical applications because of their unique magnetic properties and spin configurations [5,6,7].

In this framework, Fe NWs and ellipse/needle-like magnetite nanoparticles with different sizes and shapes have been successfully fabricated through two different bottom-up approaches, namely electrodeposition into porous anodic alumina templates and hydrothermal synthesis, respectively. Such magnetic nanostructures, after the appropriate surface functionalization, have found applications in several areas in the fight against cancer disease owing to their exclusive capability in magnetic targeting, magnetic resonance imaging, and hyperthermia [6,7].

Acknowledgments

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References

[1] [A.-H. Lu, E. L. Salabas, F. Schuth, *Angew. Chem. Int. Ed. Engl.* **46** (2007) 1222-44.
[2] S. A. Alromi, S. Y. Madani, A. Seifalian, *Polymers*, **13** (2021) 4146.
[3] S. Zhao, X. Yu, Y. Qian, W. Chen, J. Shen, *Theragnostics* **10** (2020) 6278.
[4] V. Manescu, G. Paltanea, I. Antoniac, M. Vasilescu, *Materials* **14** (2021) 5948.
[5] S. H. Bossmann, M. M. Payne, M. Kalita, R. M. D. Bristow, A. S. Perera, *Pharmaceutics* **14** (2022) 2093.
[6] S. Caspani, Magalhães, J. P. Araújo, C. T. Sousa, *Materials* **13** (2020) 2586.
[7]L. Peixoto, R. Magalhães, D. Navas, S. Moraes, C. Redondo, R. Morales, J. P. Araújo, C. T. Sousa, *Applied Physics Review* **7** (2020) 011310.

(O3) Unveiling the crystal and magnetic texture of iron oxide nanoflowers

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Magnetic iron oxide Nanoflowers (IONF) have been drawing much attention because of their superior magnetic performance compared to single-core magnetic nanoparticles.[1] Despite their large sizes, these aggregates show almost zero remanences and nearly vanishing coercivities, while preserving high saturation magnetization.[2] This seemingly effective superparamagnetic behavior has motivated their use in biomedical and environmental applications since the net magnetization can be controlled at will by an external magnetic field so that the particle agglomeration is effectively reduced. Some authors have attributed this phenomenology to the existence of some exchange coupling among the cores, leading to a super ferromagnetic state of the whole aggregate.[3] However, the effect of the crystal texture on the nearly demagnetized remnant state of these systems is still unclear. This study reports on how the local magnetic texture, originating from crystalline correlations among the cores, governs the unique magnetic properties of individual IONF in sizes ranging from 40 to 400 nm.[4] Despite size variations, all samples exhibit consistent crystalline correlations extending beyond the IONF cores. A nearly zero remnant magnetization, a persistently blocked state, and temperature-independent magnetization support the existence of a 3D magnetic texture throughout IONF. Magnetic transmission X-ray microscopy confirms nearly demagnetized states caused by magnetic texture vorticity. Moreover, micromagnetic simulations show vortex-like spin configurations with partial topological protection, stabilized by inter-core exchange coupling and demagnetizing fields at low magnetic fields (see Fig. 1). Overall, this study provides valuable insights into the impact of crystalline texture on the magnetic properties of IONF over a wide size range.

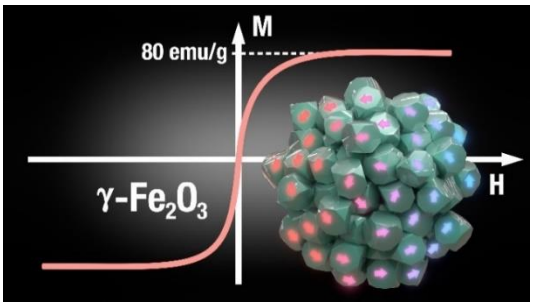

Figure 1 shows the effective superparamagnetic behavior in IONF caused by the near demagnetized state driven by the high vorticity of the core moment texture at low magnetic fields.

References

[1] Batlle, X. *et al. JMMM*. **543**, (2022), 168594.
[2] Gavilán, H. *et al*. *Part. Part. Syst. Charact*. **34**, (2017), 1700094.
[3] Bender, P. et al. *J. Phys. Chem C*. **122**, (2018), 3068.
[4] Moya, C. *et. al*. Nanoscale, in printing. DOI: 10.1039/d3nr04608g.

(O4) Magnetite nanorods as high-performance magnetic hyperthermia agents

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To date, many efforts have been made to optimize heating efficiency of magnetic nanostructures in magnetic hyperthermia therapy (MHT) by changing their size, shape, and chemical composition [1, 2]. In this regard, anisotropic one dimensional (1-D) nanostructures, owing to their unique shape-dependent properties, have recently attracted widespread attention in the MHT. In particular, magnetite nanorods (MNRs) have become one of the research hotspots as they notably exhibit higher heating efficiencies [3, 4].

In this study, a robust two-step method was employed for synthesizing MNRs, in which first $\beta - FeOOH$ NRs were synthesized by a hydrolysis method and then reduced to Fe_3O_4 NRs (Figure 1). Highly-stable and water-soluble magnetite nanorods were obtained through a ligand exchange process using polyethyleneimine (PEI). The PEI-coated MNRs were investigated as heat-generating nanoagents in the MHT. The results show an enhanced specific absorption rate (SAR) in the biologically-safe magnetic field irradiation range. The results suggest that the synthesized PEI-coated MNRs have an excellent potential to be used as high-performance nanoagents in thermal treatment of deadly diseases such as cancer and atherosclerosis.

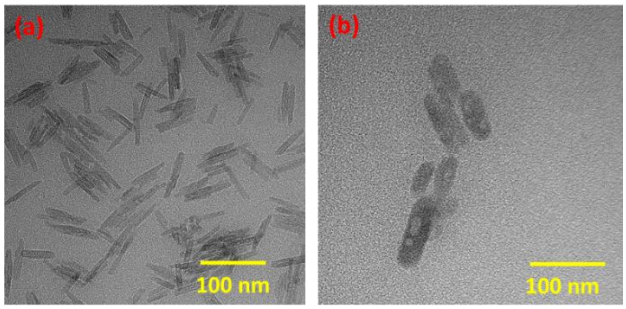

Figure1. HRTEM image of (a) $\beta - FeOOH$ NRs, and (b) Fe_3O_4 NRs

Acknowledgments

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References

[1] Z. Shaterabadi, et. al., *Ceramics International*, **49** (2023) 33934-33943.
[2] Z. Shaterabadi, et. Al., *Materials Science and Engineering: C*, **117** (2020) p.111274.
[3] R. Das et al., , The Journal of Physical Chemistry, **120** (2016) 10086-10093.
[4] M. Lázaro et. al, Polymers, **14** (2022) 4913.

(O5) Navigation control of magnetotactic bacteria under rotating and linear magnetic fields.

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Magnetotactic bacteria (MTB) are microorganisms with the ability to align and navigate along geomagnetic field lines to reach optimal regions to grow. To respond optimally to an external magnetic field, MTB biomineralize magnetic nanoparticles, called magnetosomes, that organize forming a chain. MTB features, such as self-propulsion and their capability to grow and proliferate in hypoxic regions, make them unique as bioagents for potential antitumor applications [1, 2].

The potential of MTB as nanorobots is fundamentally limited by their navigation control. [3] Trying to shed light on this matter, we set up a three-axis Helmholtz coil system, which allows us to define a precise 3D magnetic field with different time-varying configurations, such as lineal, circular, conical, etc. In addition, we have developed software algorithms for the automatic detection and tracking of MTB, applying image-sequencing techniques to the analysis of videos acquired by optical microscopy. We have worked with *Magnetospirillum gryphiswaldense* (MSR-1) strain in different biological media and under controlled flows to emulate blood flow. We are able to detect more than 18000 MTB trajectories under absence and presence of magnetic field. As an example, in **Fig.1**, we show the behaviour of MSR-1 under a rotating magnetic field with a frequency of 0.2 Hz. Under this magnetic field, bacteria describe elliptical trajectories, (**Fig.1a)**. The overall behaviour of assemble is revealed by analyzing **(Fig.1b)** the population of bacteria navigating in given direction (within ±30°). The average velocity presents a double distribution and, as expected, MSR-1 velocity is independent of flow velocity and applied magnetic field **(Fig.1c)**.

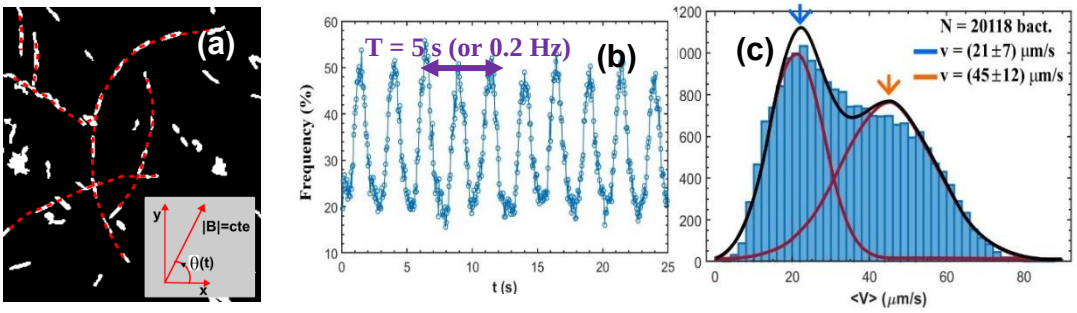

Figure 1: Swimming behaviour of MSR-1 under a rotating magnetic field of 0.1 mT with a frequency of 0.2 Hz, **(a)** Elliptical trajectories **(b)** Bacteria population over time within an arc of 30º around a given direction. **(c)** Average velocity distribution.

Acknowledgments

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References

[1] M.L. Fdez-Gubieda, *et al*. J. Appl. Phys. 128, 070902 (2020).
[2] D. Kuzajewska. Biology 9(5), 102 (2020).
[3] S. Rismani, *et al*. Small 1702982, (2017).

(O6) Controlled aggregation of amyloid β peptide in the presence of homotaurine-loaded nanoliposomes

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The kinetics of amyloid aggregation were studied by monitoring the variation of polydispersity of the mixed dispersion of Aβ peptide and composite liposomes. The liposomes were prepared from the phospholipid 1,2-dioleoyl-sn-glicero-3-phoshocholine (DOPC) and were stabilised by electrostatic adsorption of κ-carrageenan. The produced homotaurine-loaded and unloaded liposomes had a highly negative electrokinetic potential and remarkable stability in phosphate buffer (pH 4 and 7.4). For the first time, the appearance and evolution of the aggregation of Aβ were presented by the variation in the quartiles (D10, D50 and D90) in the size distribution of the particles in the dispersion.

The kinetic experiments indicated the appearance of the first aggregates almost 30 min after mixing the liposomes and peptide solution. It was registered that in the presence of unloaded liposomes, the size of 90% of the particles in the dispersion (D90) increased, while the addition of homotaurine-loaded liposomes almost did not influence the size of the fractions D50 and D90 during the kinetic experiment.

Despite the specific bioactivity of homotaurine in the presence of cell membranes, the present study reports the participation of additional inhibitory effects of the compound on the amyloid aggregation as a result of charge effects or 'molecular crowding'.

Acknowledgments

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(O7) Design and Construction of Bioinspired Compartments

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Bioinspired micro-compartments are synthetic capsules made from inanimate components designed to mimic some of the functionalities of living cells. Some examples include liposomes, polymersomes, proteinosomes, colloidosomes, and emulsion or coacervate droplets. Compartmentalisation of biomolecules within these compartments recreates the cellular environment, which enables their use as synthetic cells, for example [1]. From a more applied side, they could be used in a myriad of applications such as pollutant clean-up, micro-robot or micro-reactor technologies or incorporated within actuators and lab-on-a-chip devices. From a life science point of view they could be used in clinical diagnosis, drug delivery, complex bioassays, enzyme catalysis, etc.

Inspired by the ability of living cells to harness energy from the environment and to exploit it to support metabolic functions, we aim to provide bioinspired compartments with mechanisms for energy transduction [2]. In particular, the research of our team is focused on making bioinspired compartments sensitive to external force fields, such as electromagnetic fields. External force fields would offer advantages such as contactless spatiotemporal control of the compartments, as well as switchability and reversibility. Our approach is based on the incorporation of field-responsive nanoparticles within the compartment architecture, which also increase the compartment robustness, something very desirable for some of the applications named above.

Here I will present the latest progress of our team in the design and construction of field-responsive bioinspired compartments. In particular, I will show our latest advances on two types of emulsion droplets, namely Pickering emulsion droplets and biphasic droplets based on liquid-liquid phase separation. I will demonstrate that we can control the positioning within the compartment structure of nanoparticles of different composition (magnetite, gold, silica, carbon, etc.). The obtained micro-compartments can respond to external force fields, and are capable of higher-order functions as a result. Some of these include formation of patterns, field-induced heating of the external environment, motion and rotation, etc. I will finally show that the droplets can be used in enzyme catalysis or co-immobilised together with living cells in self-reconfigurable hydrogels showing compartment-cell communication.

Acknowledgments

We acknowledge financial support by: **(i)** Grant External Activation of Artificial Cell-Inspired Microreactors Under Force Fields. PID2019-105930GA-I00. Spanish Ministry of Science and Innovation (MICINN, 2019). **(ii)** Grant Smart droplets by design. Engineering the internal microstructure of droplets towards field-responsive reconfigurability. P20_00340. Junta de Andalucía (PAIDI, 2020). **(iii)** Grant Artificial Cell-Inspired Microreactors. Exploring their Remote Activation by Force Fields. A-FQM-258-UGR20. Fondos FEDER, Junta de Andalucía, University of Granada (2020). LRA acknowledges grant Juan de la Cierva Incorporación IJC2018-037951-I funded by MCIN/AEI/10.13039/501100011033 as well as the University of Granada.

References

[1] Dzieciol, A. J. & Mann, S. *Chem. Soc. Rev.* **41** (2012) 79.

[2] Yewdall, N., Mason, A. F. & Van Hest, J. C. M. *Interface Focus* **8** (2018) 20180023

(O8) Carbon dots, precursor and property relation with focus on toxicity

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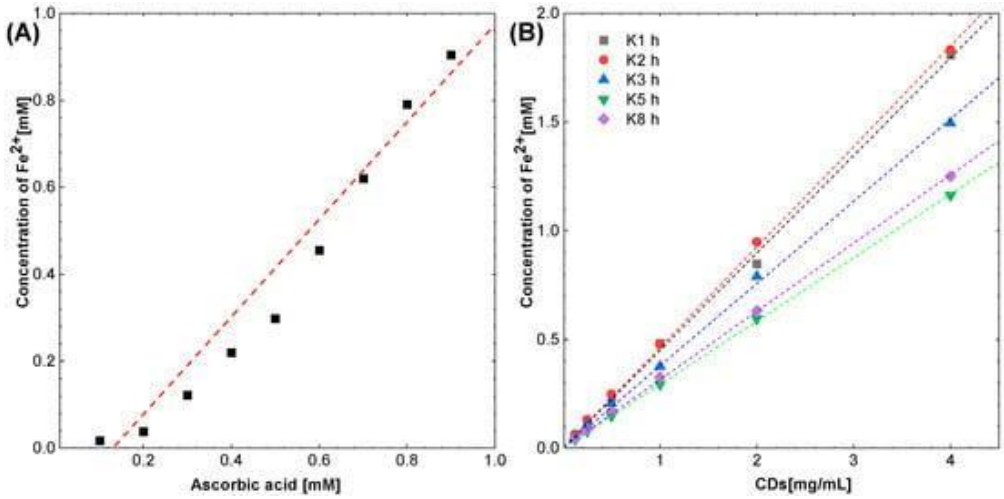
Carbon dots (CDs) are carbon-based zero-dimensional nanomaterials that can be prepared from a different organic precursors. In our laboratory we used different precursor to synthesize CDs like cherry seed ,milk and ascorbic acid. Bio-precursor based CDs shows the presence of nitrogen-based bond like C-N, C=N and -NH_2 as well as C=O and C-H which are found on each types of CDs [1]. The absorption spectra of these CDs are in the range of 280 ± 3 nm. We utilized these CDS for detection of Fe^{3+} in aqueous systems and these CDs detect concentrations up to 0.49 ppm and can be used as metal sensor based on precursor .Some of these CDs have different amount of functional group are useful for toxicity studies [2, 3].

The Presto Blue method was used to measure the toxicity of CDs for murine hippocampal cells. CDs at a concentration of 4 mg/mL were hazardous independent of synthesis time, while the toxicity was higher for lower synthesis times of 1 and 2 h. When the concentration is reduced in 1 and 2 h synthesized CDs, the cytotoxic effect also decreases significantly, ensuring a survival rate of 60-80%. However, when the synthesis time of CDs is increased, the cytotoxic effect decreases to a lesser extent. The CDs with the highest synthesis time of 8 h do not show a cytotoxic effect above 60%. The cytotoxicity study shows that CDs may have a concentration and time-dependent cytotoxic effect, reducing the number of viable cells by 40% [4].



References

[1] Shabbir, H., et al., Eco friendly synthesis of carbon dot by hydrothermal method for metal ions salt identification. Materials, 2021. 14(24): p. 7604.

[2] Shabbir, H. and M. Wojnicki, Recent Progress of Non-Cadmium and Organic Quantum Dots for Optoelectronic Applications with a Focus on Photodetector Devices. Electronics, 2023. 12(6): p. 1327.

[3] Shabbir, H., E. Csapó, and M. Wojnicki, Carbon Quantum Dots: The Role of Surface Functional Groups and Proposed Mechanisms for Metal Ion Sensing. Inorganics, 2023. 11(6): p. 262.

[4] Shabbir, H., et al., Milk-derived carbon quantum dots: Study of biological and chemical properties provides evidence of toxicity. Molecules, 2022. 27(24): p. 8728.

(O9) Bio-inspired Suface Modification as a new Ultra-fast method for the Killing of common Nosocomial Bacterias

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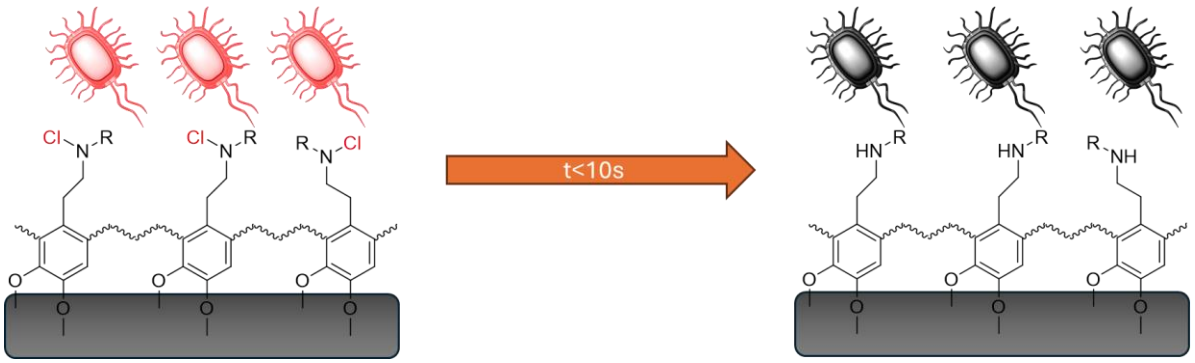
It has been shown that diseases caused by nosocomial pathogens, especially those that have developed resistance, are growing at an alarming rate.[1]

These pathogens can survive for long periods of time on non-living surfaces. Within all pathogens, survival times from days to months have been reported. Gram-positive bacteria such as Enterococcus spp., Staphylococcus aureus (including MRSA) and gram-negative bacteria such as Escherichia coli or Pseudomonas aeruginosa, can survive for months on dry surfaces. However, herpes viruses such as CMV or HSV type 1 and 2, have shown resistance from a few hours to a week. [2]

This work is based on the modification of inanimate surfaces by the deposition of bio-inspired, non-toxic polymers that maintain the physical properties of the original materials. Polymers derived from catechol and polyamines have been successfully deposited on cellulose, cotton and polypropylene surfaces, and exhibit high adhesion capacity and bactericidal properties.

The amino groups present in the polymer structure are easily modified, in the presence of sodium hypochlorite, to obtain N-chloramines. These chloramines have a much higher bactericidal activity than the original polymer, destroying 100% of pathogens in an extremely short time.



Schematic representation of Ultra-Fast Bacterial Killing using a N-Chloramine derivative polymer.

Acknowledgments (Arial 11 points)

This work was supported from grant PID2021-127983OB-C21 funded by MCIN/AEI/ 10.13039/501100011033 and by ERDF "A way of making Europe". The ICN2 is funded by the CERCA programme/Generalitat de Catalunya. The ICN2 is supported by the Severo Ochoa Centres of Excellence programme, Grant CEX2021-001214-S, funded by MCIN/AEI/10.13039.501100011033.

References

[1] R. N. Jones, *Chest.* **119** (2001) 397s-404s.

[2] A. Kramer, I. Shcwebke, G. Kampf, *BMV Infectious Diseases*, **6** (2006).

(O10) Immobilization of Artificial Cell-Inspired Micro-compartments for Biological Applications

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The design and construction of hybrid living/nonliving systems with communication between their constituent parts holds a great interest in biomedicine and biotechnology [1]. In particular, immobilization of synthetic and living cells in 3D hydrogels would enable modular assembly of soft materials with tunable architecture and functionalities [2]. In this sense, integration of multistimuli-responsive micro-compartments as synthetic cells is especially attractive in order to exert remote control over interactions with their living counterparts.

In this work, we use oil-in-water magnetic Pickering emulsion droplets (MPED) as cell-inspired micro-compartments. These are emulsion droplets stabilized by magnetite nanoparticles that confer magnetic sensitivity and thermal response under laser irradiation to the droplets. Magnetic sensitivity allows us to arrange MPED according to pre-set and sophisticated patterns by using magnetic stamps [3]. For MPED immobilization, hydrogel precursors of agarose and sodium alginate are employed. Low gelling temperature agarose hydrogels enable temperature-dependent self-reconfigurability of the microarchitecture, which can be achieved by laser irradiation. On the contrary, alginate hydrogels can resist MPED heating produced by laser irradiation.

To study communication between MPED and living organisms, MPED and yeast species *Yarrowia lipolytica* are integrated within sodium alginate hydrogels. *Yarrowia lipolytica* releases lipases which in turn act on tributyrin producing butyric acid, a nutrient for yeast population. Based on this, tributyrin-containing MPED were prepared and mixed with alginate solution, kanamycin antibiotic, and yeast inoculum. The mixture was placed onto the magnetic stamps and gelation was triggered by adding calcium chloride. After three-day incubation at 25ºC, we observe that *Yarrowia lipolytica* concentrations in tributyrin-containing MPED hydrogels outnumber concentrations found in dodecane-containing MPED samples (control experiment). Furthermore, we demonstrate that laser irradiation on the heterogeneous hydrogel samples induces heating up to 60ºC which affects yeast population concentrations, reducing or even annihilating *Yarrowia lipolytica*. These are unprecedented results of communication between colloid-stabilized artificial cells and a fungi species. In addition, the achieved functionalities of these heterogeneous hydrogels would allow control of the yeast metabolic profile or proliferation rate in a predefined and customized manner, crucially important aspects in biological applications.

Acknowledgments

This study was supported by grant External Activation of Artificial Cell-Inspired Microreactors Under Force Fields. PID2019-105930GA-I00. Ministerio de Ciencia e Innovación (MICINN, 2019), and grant Artificial Cell-Inspired Microreactors. Exploring their Remote Activation by Force Fields. A-FQM-258-UGR20. Fondos FEDER, Junta de Andalucía, Universidad de Granada (2020).

References

[1] I. Gispert, et al. *PNAS* **119** (2022) e2206563119.
[2] J. Liu, et al. *Angewandte Chemie* **59** (2020) 6853-6859.
[3] Z. Yang, et al. *Nature Communications* **8** (2017) 1564-1571.

(O11) Characterization of individual chains of magnetosomes by Magnetic Force Microscopy

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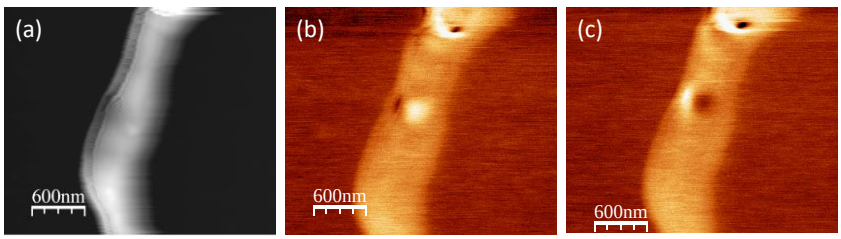
The field of Biomagnetism encompasses a broad range of topics in magnetism associated to life elements [1]. This involves the mechanism employed by various living organisms for navigation based on the Earth's magnetic field such as the magnetotactic bacteria (MTB) [2]. Despite the numerous advances and promising scenarios that biomagnetic materials disclose, challenges persist on multiple fronts including the characterization of individual elements. It's worth noting that the majority of prevailing techniques for characterizing magnetic biomaterials tend to provide an averaged collective behaviour rather than insights into the individual features. The advent of the scanning probe microscopy (SPM) leads to new opportunity for the exploration of different set of properties of biomagnetic materials such as structural, mechanical, chemical, electrical, magnetic or functional properties at the nanoscale.

This study makes use of advanced modes of Magnetic Force Microscopy (MFM) and tailored MFM probes to characterize individual magnetotactic bacteria, both in liquid environments [3] and under ambient conditions. The characterization of these elements posed a significant challenge due to the magnetosomes' low signal and the relatively large size of the bacteria. To address this, customized AFM probes were developed through various strategies [4], enhancing sensitivity in both air and liquid environments. These specialized probes were instrumental in conducting MFM measurements on magnetotactic bacteria in a liquid setting. Furthermore, employing MFM imaging under an *in situ* magnetic field provides an opportunity to gather quantitative data regarding the critical fields of these individual chains of nanoparticles, as depicted in the following figure. This approach marks a substantial advancement in the field of MFM for biological applications, enabling the detection of magnetosomes under different conditions.



Topography (a) and MFM images of an individual magnetotactic bacteria after applying (b) negative and (c) positive saturating magnetic fields.

References

[1] A. Asenjo, Europhysics News **54** (4) (2023), 20–23
[2] M.L. Fdez-Gubieda, L. Marcano, A. Muela, A. García-Prieto, J. Alonso, I. Orue, *New Trends in Nanoparticle Magnetism. Springer Series in Materials Science*, (2021) **308**. 159−179
[3] P. Ares, M. Jaafar, A. Gil, J. Gómez-Herrero and A. Asenjo, *Small*, **11** (36), (2015) 4731.
[4] M. Jaafar, J. Pablo-Navarro, E. Berganza, P. Ares, C. Magén, A. Masseboeuf, C. Gatel, E. Snoeck, J. Gómez-Herrero, J. M. de Teresa and A. Asenjo, Nanoscale,**12** (2020) 10090-10097

(O12) Nanotrackers as reagents for long-term live-cell barcoding

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Barcoding and pooling cells for processing as a composite sample is critical to minimize technical variability for multiplex technologies. Fluorescent cell barcoding has been established as standard method for multiplexing in flow cytometry analysis. In parallel, mass-tag barcoding is routinely used to label cells for mass cytometry, a cutting edge multi-parametric single-cell platform that allows the detection of nearly 60 markers per single cell. Mass cytometry comprises conventional flow cytometry and inductively coupled plasma time-of-flight mass spectrometry (ICP-MS). Mass cytometry uses metal-tagged reagents, such as metal chelating polymers instead of fluorescent-labelled reagents.

Barcoding of samples allows controlling variability between samples and fluctuations in machine sensitivity. Barcode reagents in current use label intracellular proteins in fixed, permeabilized cells and therefore are not suitable for studies with live cells in long-term culture prior to analysis. We have developed fluorescent metal-based hybrid-tag nanotrackers to barcode live cells for flow and mass cytometry dual-modal readout for diagnostic proposed. We have carried out the preparation, physicochemical characterization, analysis of efficiency of cell internalization and durability of these nanotrackers in live cells cultured over time. In addition, we have demonstrated their compatibility with standardized cytometry reagents and protocols. Finally, we have validated these nanotrackers for drug response assays during a long-term coculture experiment with two barcoded cell lines. This method represents a new and widely applicable advance for fluorescent and mass-tag barcoding that is independent of protein expression levels and can be used to label cells before long term drug studies.

References

[15] Delgado-Gonzalez A et al. Mass Cytometry Tags: Where Chemistry Meets Single-Cell Analysis. Anal Chem. 2021;93(2):657-664. doi: 10.1021/acs.analchem.0c03560.
[16] Delgado-Gonzalez A,et al., Anal Chem. 2022, 2;94(30):10626-10635. doi: 10.1021/acs.analchem.2c00795.

(O13) Induction of Oxidative Stress by DMSA-coated IONPs trigger mitochondrial dynamic changes in breast cancer cells affecting proliferation and migration capacity.

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The high metabolic and proliferation rates of cancer cells lead to an overproduction of reactive oxygen species (ROS) compared to normal cells. Dysregulation of redox homeostasis triggers pathological processes such as cancer progression, but also renders cancer cells susceptible to external stimuli that further increase ROS beyond the viable threshold inducing cell death. Therefore, some anti-cancer therapeutic approaches have been focused on modulating the ROS levels in cancer cells to achieve cell death [1]. In this context, iron oxide nanoparticles (IONPs) are potential tools to act as pharmacological agents with redox modulating capacity, as their iron core is able to convert hydrogen peroxide into a more active hydroxyl radical by reacting with iron ions through the so-called Fenton reaction [2].

Therefore, the aim of this study is to investigate the intrinsic potential of DMSA-coated IONPs to induce oxidative stress in cancer cells and to elucidate the biological adaptations or changes after ROS induction. After oxidative stress induction, cancer cells reprogrammed their mitochondrial metabolism to a less energetic state. The functionality of oxidative phosphorylation (OXPHOS) was shut down, which correlated with a decrease in ROS production by the electron transport chain (ETC). This metabolic reprogramming affected the ability of cancer cells to proliferate, as treated cells were shown to proliferate more slowly than non-IONP-treated cells. Furthermore, mitochondria are highly dynamic organelles that adapt to metabolic and oxidative stress by adjusting their ultrastructure. Therefore, we wondered whether the ultrastructure and disposition of mitochondria would also change. Mitochondria did not show any affectation on their ultrastructure, but treatment with DMSA-coated IONPs induced a change on mitochondria disposition in cells. Mitochondria in treated cells adopted an elongated and interconnected disposition after oxidative stress, compared to the spherical and individual disposition of non-treated cells, thus affecting the mitochondrial dynamics process [3]. Recent data have suggested a link between mitochondrial fission/fusion imbalance and cancer cell migration. Therefore, we wondered if affecting mitochondrial dynamics could affect cancer cell migration. DMSA-coated IONPs were shown to affect cancer cell migration as treated cells migrated at a slower rate compared to non-treated cells.

Taken together, these results highlight that DMSA-coated IONPs could be a useful anti-cancer tool, as the strong induction of ROS in cancer cells can alter their antioxidant capacity and limit their mitochondrial respiratory metabolism, thereby affecting the mitochondrial disposition. These metabolic changes have an ultimate long-term effect on the cancer cells, potentially inducing a less proliferative profile and affecting cell migration in highly metastatic cancers.

Acknowledgments

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References

[1] Perillo et al. *Experimental & Molecular Medicine* **52** (2020) 192–203.
[2] Huang et al. *Theranostics* **3** (2013) 116-126.
[3] Daviu et al. *Biomaterials* **304** (2024) 122409.

(O14) Targeting ovarian cancer nanoradiotheranostics with ligand-free ^{99m}Tc-polyurea dendrimer complexes

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In the last decades, extensive efforts have been made to prevent, diagnose, and treat cancer. As a non-invasive approach, radioimaging allows characterization and quantification of biological processes in early cancer diagnosis, specific drug delivery and follow-up of therapeutic response. Due to unique properties that combine low cost, low absorbed dose per patient, a good coordination chemistry and a short half-life time (*ca.* 6 h), ^{99m}Tc is the most used radionuclide for nuclear imaging [1]. Ovarian cancer is a silent and highly lethal disease, with only 15% of cases being diagnosed at early stages, in which early detection increases the 5-year survival rate by about 90%. Herein we demonstrated that PURE dendrimers have surface groups that behave as *pseudo* chelators suitable for a stable coordination of *fac*-$[^{99m}Tc(CO)_3]^+$. Therefore, we prepared a novel class of stable and highly hydrophilic radiolabelled dendrimers, ^{99m}Tc-PURE$_{G4}$ and folate targeted ^{99m}Tc-PURE$_{G4}$-FA$_2$, in quantitative radiochemical yield, starting from the corresponding dendrimers [2]. These encouraging results justify future studies with the therapeutic counterpart ^{188}Re to profit from the matched pair ^{99m}Tc/^{188}Re within theranostic approaches. Also, the drug loading capacity of PURE$_{G4}$ foresees other therapeutic schemes that may have a great impact in future nanoradiotheranostics.

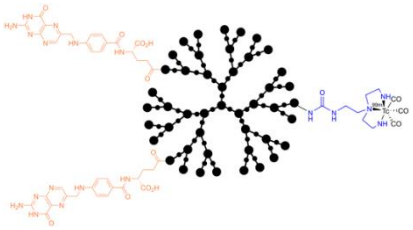

Figure 1. Coordination complex ^{99m}Tc-PURE$_{G4}$-FA$_2$. The surface of PURE$_{G4}$-FA$_2$ dendrimer (blue colour) is conjugated with folic acid (orange colour) and ^{99m}Tc.

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References

[1] P. Martini et. al., *Molecules*, 2018, **23**, 2039.
[2] A. Cruz et al., *Antioxidants*, 2020, **9**, 133.

(O15) Development of a thermosensitive gel containing Curcumin-loaded nanomicelles for skin cancer treatment

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Curcumin (CUR) is well known for its several pharmacological properties including anti-inflammatory, antimicrobial, anticancer and antioxidant activities[1], the poor solubility in aqueous medium makes it difficult to formulate this active in a patient-compliant vehicle[2]. Recently, nanostructured drug delivery systems have been proposed in the treatment of dermatological diseases for their ability to increase the solubility, stability and bioavailability of the therapeutic agent, associated with targeted administration with consequent reduction in the dose and frequency of administration and improvement in the safety profile. In this work, we have developed nanomicellar formulations based on binary mixture of surfactants able to solubilize CUR in a hydrophilic environment.
Different surfactants were investigated based on their ability to form stable nanomicelles, finally selecting Vitamin E-TPGS (TPGS) and Kolliphor ELP (ELP). A pre-formulative study and a design of experiment (DOE) were settled to evaluate the effect of the ratios of the two surfactants on both drug solubilisation and A375 melanoma cells viability. The quantitative determination of solubilized CUR in nanomicelles was carried out by HPLC analysis and the average hydrodynamic diameter (Dh) and polydispersity index (PDI) of the formulations were determined by Dynamic Light Scattering (DLS) technique. The DOE-selected nanomicellar formulation (TPGS60ELP30) was characterized by both ATR-FTIR and DSC, and its stability was monitored over time at 4°C and at room temperature, both in dark conditions and after exposure to light. Moreover, the cytotoxicity of CUR-containing nanomicelles was evaluated on melanoma cell lines overtime and acquiring images with Operetta CLS high-content imaging device. Finally, a penetration study of CUR through porcine ear skin as a model of human skin after cutaneous application of TPGS60ELP30 formulated in a thermosensitive gel was performed. Confocal microscopy was applied to investigate CUR penetration profile. Pre-formulation and DoE studies allowed the evaluation of the influence of the two surfactants used on two dependent variables and the identification of optimal conditions for the desired response. The results highlighted the crucial role of TPGS compared to ELP in inducing cell death in melanoma cells. The solubilisation of CUR appeared to be a function of the total amount of surfactants in the system: the higher the concentration of surfactants, the greater the solubilisation of CUR. Based on DoE results, a nanomicellar formulation was then designed containing the appropriate amount of surfactants and an optimal TPGS:ELP molar ratio. The ATR-FTIR analysis showed that the 1510-1630 cm^{-1} bands due to C=O and C=C stretching of CUR are still present in the spectrum of TPGS60ELP30, while they are not observable in empty nanomicelles, confirming the encapsulation of CUR inside the lipophilic core of nanomicelles. The results of cytotoxicity studies showed a remarkable time-dependent activity of the formulation in inducing cell death, with a value of cell viability at 7 and 14 hours of 50.56 ± 1.73 and 36.05 ± 2.28 % respectively, both statistically different from CUR 5μM alone at the same times (t test, $p<0.001$). Then, the good stability of TPGS60ELP30 was demonstrated both in terms of size and solubilized CUR, in the dark at both room temperature and 4ºC. Finally, confocal microscopy showed that the thermosensitive gel containing TPGS60ELP30 produced effective CUR concentrations at the target site in the skin following topical application, thus representing a potential drug delivery system for skin cancer treatment.

References

[1] Menon VP, Sudheer AR. Antioxidant and anti-inflammatory properties of curcumin. Adv Exp Med Biol. 2007;595:105-25.
[2] Priyadarsini KI. The chemistry of curcumin: from extraction to therapeutic agent. Molecules. 2014 Dec 1;19(12):20091-112.

(O16) LGR5 in colorectal cancer therapy, a therapeutic target for antibody-functionalized biomimetic magnetoliposomes

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One of the primary challenges in cancer therapy is the lack of specificity of conventional chemotherapy. Biomimetic magnetoliposomes serve as excellent chemotherapeutic delivery systems, hyperthermia agents, and active targeting agents by functionalizing their surface with monoclonal antibodies [1,2]. LGR5 receptor (*Leucine-rich repeat-containing G-protein coupled receptor 5*) is a membrane receptor that stands out as a biomarker of colorectal cancer (CRC) and appears to be related to drug resistance and the appearance of metastasis [3]. The aim of this study was to evaluate the efficacy and safety of biomimetic magnetoliposomes targeting LGR5 receptor loaded with oxaliplatin (OXA) or 5-fluorouracil (5-FU) in the targeted therapy of CRC. The *in vitro* antitumor activity of OXA- or 5-FU-loaded magnetoliposomes (with and without LGR5 functionalization) was tested on several human and murine colon cancer cell lines after synthesis and characterization of magnetoliposomes. Additionally, cell internalization was studied using Prussian Blue staining, flow cytometry, and fluorescence microscopy with the fluorophore DIO (3,3'-dioctadecyloxacarbocyanine perchlorate) vehiculated in the nanoformulations. Furthermore, an acute toxicity test was performed *in vivo* to evaluate toxicity related to iron. The results showed that nanoformulations loaded with OXA and 5-FU functionalized with the anti-LGR5 antibody showed higher cellular uptake than the non-targeted nanoformulation. The percentage of proliferation in colon cancer cell lines was reduced up to 3.2-fold of the IC_{50} value compared to that of the free drug. More evident differences were found after short exposure times (4 and 8 hours) between the targeted and non-targeted nanoformulations. Furthermore, assays conducted on MC38 cells with decreased LGR5 expression through cellular transduction (MC38-L(-)) demonstrated a decrease in the internalization of LGR5-targeted magnetoliposomes compared to the non-transduced MC38 cell line. Magnetoliposomes demonstrated excellent iron biocompatibility data *in vivo*. In conclusion, drug-loaded magnetoliposomes functionalized with anti-LGR5 antibodies could be a promising treatment strategy for targeting LGR5+ cells in CRC.

Acknowledgments

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References

[1] Y. Jabalera, et. al, Colloids Surf B Biointerfaces 183 (2019) 110435.

[2] B. Garcia-Pinel, et. al, Pharmaceutics 12 (2020) 1–20.
[3] N. Xu, et. al., Journal of B.U.ON. 26

(O17) Inhibition of Melanoma Metastasis through Precision Targeting Carbon Nanotubes to the tumor neovasculature

Lorena García-Hevia[1], Rym Soltani[2], Jesús González[1], Olivier Chaloin[2], Cécilia Ménard-Moyon[2], Alberto Bianco[2] and Mónica L. Fanarraga[1]

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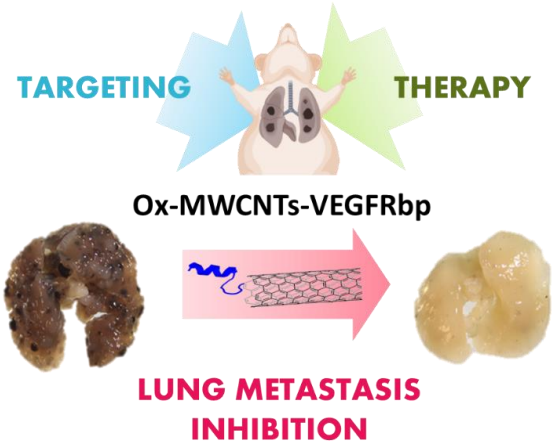
Metastasis is the process by which cancer cells spread from the primary site of origin to other parts of the body, forming secondary tumors. This complex and often aggressive progression is a major challenge in cancer management, contributing significantly to the severity and mortality of the disease. Multi-walled carbon nanotubes (MWCNTs) exhibit biomimetic interference with cytoskeletal nanofilaments upon entering tissues and cells, conferring intrinsic antitumoral effects similar to microtubule-binding chemotherapies like Taxol® [1–5]. This study investigated the potential of oxidized MWCNTs in selectively targeting vascular endothelial growth factor receptors (VEGFR). The main aim is to assess their efficacy in inhibiting metastatic growth by inducing anti-proliferative, anti-migratory, and cytotoxic effects on both cancer and tumor microenvironment cells. Our findings revealed a remarkable reduction of over 80% in malignant melanoma lung metastases after intravenous administration of the targeted biodegradable MWCNTs. Moreover, the combination of these nanomaterials with the conventional chemotherapy agent Taxol® resulted in a remarkable 90% increase in the antimetastatic effect [6]. The integrated therapeutic approach shows promising potential in combating metastatic disease, as highlighted by these findings. With nearly 60,000 deaths attributed to metastasis annually, the significance of these results becomes even more pronounced.



Acknowledgments

We thank ISCIII Projects ref. PI22/00030, PI23/00261 co-funded by ERDF/ESF, "Investing in your future", and the MELOMANES 101073025-HORIZON MSCA–2022-DN.

References

[1] L. Rodríguez-Fernández, et al. ACS Nano. 6 (2012) 6614–6625.
[2] L. García-Hevia, et al. Nanomedicine. 9 (2014) 1581–1588.
[3] L. Garcia-Hevia, et al. Curr Pharm Des. 21 (2015) 1920–1929.
[4] L. García-Hevia, R. et al. Curr Pharm Des. 21 (2015).
[5] L. García-Hevia, M.L. Fanarraga, J Nanobiotechnology. 18 (2020) 1–11.
[6] L. García-Hevia, et al. Bioactive Materials (2024).

(O18) Synthetic Magnetosomes for Dual Therapeutic Approach: Chemotherapy and Magnetic Hyperthermia

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This presentation discusses the development of a new type of synthetic magnetosomes (SMS) designed to combine chemotherapy and magnetic fluid hyperthermia (MFH), and its application to PAN02 cells as a well-established mouse pancreatic ductal adenocarcinoma model. The SMS is a magnetically-responsive, lipid-based nanosystems containing the chemotherapeutic agent cisPt. We describe the synthesis and characterization of these magnetosomes, as well as their remarkable Specific Loss Power (SLP) for heating and drug loading capacity. We found that the 'empty' MSM (i.e., without cisPt contents) have low cytotoxicity, while cisPt-loaded MSM increase the drug transport to PAN02 cells. Electron microscopy images showed that the SMS are formed by the constituent magnetic nanoparticles (MNPs) coated by a layer of lipids that, with the natural dipolar interactions of single-domain MNPs, resulted in the formation of curvilinear and spiral structures that closely resemble those produced by magnetotactic bacteria.[1] The heating capabilities of the SMS showed different behaviour compared to MNPs in gelatin-fixed samples, but a significant increase in the SLP for MNPs when moving to *in vitro* conditions resulted in a similar value of SLP≈1600 W/g ($f = 765\ kHz;\ H_0 = 29\ kA/m$). Interestingly, while SMS internalized by PAN02 cells maintained similar SLP values as in gelatin, MNPs exhibited a fourfold increase in SLP upon incorporation into the cells. The SMS showed synergistic results regarding the simultaneous *in vitro* application of MFH and chemotherapy from a single dose. Comparative analyses revealed the superior efficiency of SMS over individual doses of cisPt or MFH alone, surpassing even the cumulative effects of both treatments. We discuss the implications of such synergistic outcome.

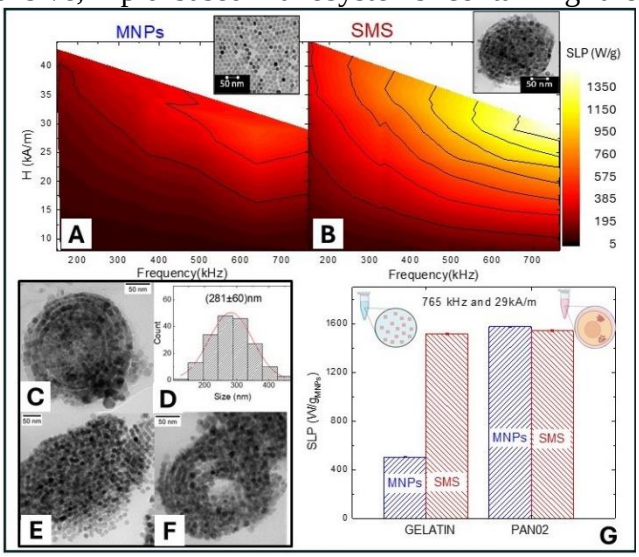

Figure 1. SLP mapping in the (f,H₀) plane for A)as prepared MNPs and B) SMS. TEM images showed SMS composed by curvilinear chains of d≈280 nm size MNPs (C-F). Panel G compares the SLP values from MNPs and SMS in gelatin and in PAN02 cells.

Acknowledgments

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References

[1] Muela, A., et al., The Journal of Physical Chemistry C, 2016. **120**(42): p. 24437-24448.

(O19) An automated system for fast and sustainable synthesis of magnetic nanoparticles

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As the demand for magnetic nanoparticles in developing biomedical and environmental applications is exponentially growing, the need to transfer laboratory knowledge into large-scale production schemes is getting more intense. At the same time, promoting methodologies which secure minimum involvement of toxic reagents, by-products and energy are in line with recent guidelines for sustainable development. An interesting alternative for the production of uniform iron oxide nanoparticles following a green route is the oxidative hydrolysis of Fe^{2+} in aqueous media through the intermediate formation of green rust [1]. This work refers to the operation of a small-sized automated system for the fast production of Fe_3O_4 nanoparticles based on the adoption of continuous oxidative precipitation of green rust in a plug-flow reactor placed inside a microwave heater. The setup was capable to provide well-defined nanoparticles within less than 5 min enabling also the direct discharge of reaction residuals at the end of the process using an attached linear magnetic separator and combined washing streams.

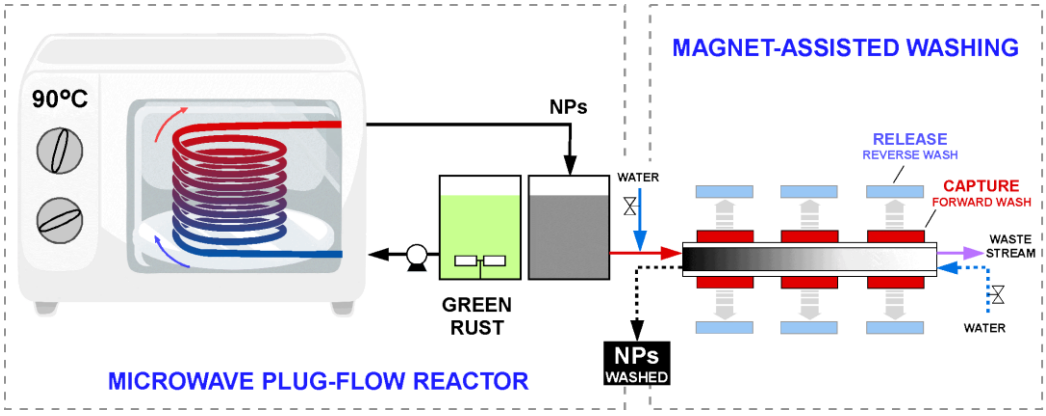

Figure 1. Continuous flow synthesis and washing of Fe_3O_4 nanoparticles through green rust precipitation using a plug-flow microwave heated reactor.

Acknowledgments

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References

[1] T. Asimakidou, A. Makridis, S. Veintemillas-Verdaguer, M.P. Morales, I. Kellartzis, M. Mitrakas, G. Vourlias, M. Angelakeris, K. Simeonidis, *Chem. Eng. J.* **393** (2020) 124593.

(O20) Magnetically induced Thermal Effects on Tobacco Mosaic Virus-based Nanocomposites for a Programmed Disassembly of Protein Cages

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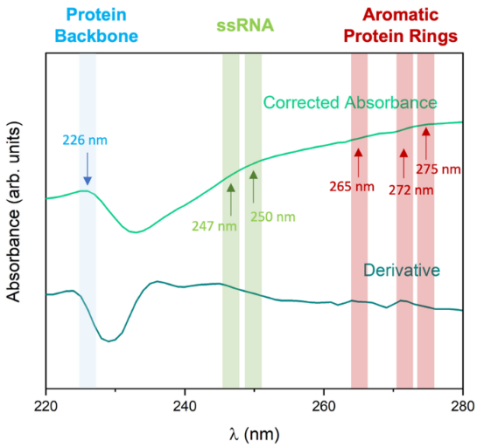
Protein cages are promising tools for the controlled delivery of therapeutics and imaging agents when endowed with programmable disassembly strategies. Here, we produced hybrid nanocomposites made of tobacco-mosaic virus (TMV) and magnetic iron oxide nanoparticles (IONPs), designed to disrupt the viral protein cages using a magnetically induced release of heat. We studied the effects of magnetic hyperthermia on the programmable viral protein capsid disassembly using 1) elongated nanocomposites of TMV coated heterogeneously with magnetic iron oxide nanoparticles (TMV@IONPs), and 2) spherical nanocomposites of polystyrene (PS) on which we deposited pre-synthesized IONPs and TMV *via* layer-by-layer self-assembly (PS@IONPs/TMV). Notably, we found that the extent of the disassembly of the protein cages is contingent upon the specific absorption rate (SAR) of the magnetic nanoparticles, that is, the heating efficiency, and the relative position of the protein cage within the nanocomposite concerning the heating sources. This implies that the spatial arrangement of components within the hybrid nanostructure has a significant impact on the disassembly process. Understanding and optimizing this relationship will contribute to the critical spatiotemporal control for targeted drug and gene delivery using protein cages.



Zero-order and first-order derivative UV/vis (corrected) spectrum of the PS@IONPs/TMV after the heat release, with a local maximum at 226 nm (shadowed in blue and associated to the protein backbone) and shoulders at 247 and 250 nm (shadowed in green and associated to nuclei acids) and at 265, 272 and 275 nm (shadowed in pink and associated to aminoacids).

References

[1] E. Tiryaki, C. Álvarez-Leirós, J. N. Majcherkiewicz, P. Chariou, M. Maceira-Campos, G. Bodelón, N. F. Steimetz, V. Salgueiriño (2024, submitted).

(O21) Characterization techniques for nanoparticles: size distribution, concentration, and interactions

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Knowledge of the properties of the materials that are the subject of our research is the key to ensuring that the results observed can be correctly interpreted and add value to them.

Nanoparticle size and concentration characterisation techniques such as DLS, NTA; fractionation techniques such as FFF or GPC/SEC or interaction measurement techniques such as ITC or DSC are some of the tools we can use in our laboratories to obtain the necessary information.

In this talk we will review all these analytical techniques, their development and range of application.

Omnisec Resolve

NanoSight NS300

Malvern Zetasizer Nano ZS

(O22) Stimuli-Responsive Tumor-Targeting Nanocarrier for Multimodal Cancer Therapy

Mari Carmen Ortega-Liebana[1,2,3*], Jose A. Laz-Ruiz[1,2,3], Juan Jose Diaz-Mochon[1,2,3], and Rosario M. Sanchez-Martin[1,2,3]

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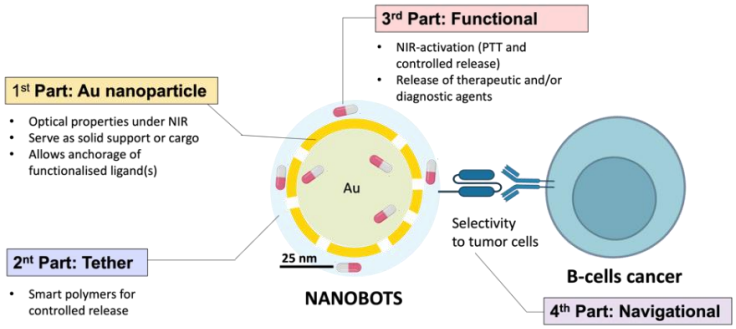
Although significant progress has been made in the development of cancer nanomedicine co-formulated with drugs, the challenges of generating a nanosystem which allows therapeutics to efficiently and selectively reach tumoral areas remain to be overcome.[1,2] Our project aims to develop an unprecedented 'track and treat' Nanobot armed with navigational ability to achieve antigen-specific targeting and controlled therapeutic agent delivery capabilities to treat B cell lymphoma. Specifically, the light-controlled thermosensitive polymer-functionalised gold(Au)-based nanodevices we present were designed to (1) track and tag tumours by recognition of a target antigen using the mimics of the single-chain variable fragment (scFv) present on the chimeric antigen receptor (CAR) T-cells, and to (2) release therapeutic agents *in situ* via NIR-controlled photothermal therapy (PTT). The first Nanobots have been successfully synthesized and characterized, and we assessed their selectivity towards target cancer cells *vs.* healthy cells, as well as their drug release and PTT capabilities upon NIR irradiation. The internalisation of the Nanobots and the combined effect of the release of an anticancer drug and PTT in the target cells were assessed in detail by viability studies, confocal fluorescence microscopy and CyTOF mass cytometry. Overall, this study advances drug delivery approaches toward clinical applicability and opens a promising avenue to design reasonable efficient NIR-activated nanomedicines.



Overview of the rational design of Nanobots for multimodal cancer therapy.

Acknowledgments

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References

[1] S. N. Bhatia et al, *Nat. Rev. Cancer*. **22** (2022) 550.
[2] R. van der Meel, *Nat. Nanotechnol*. **14** (2019) 1007.

(O23) Optical studies on anisotropic Bi_2S_3 and hybrid Bi_2S_3@Au nanocomposites

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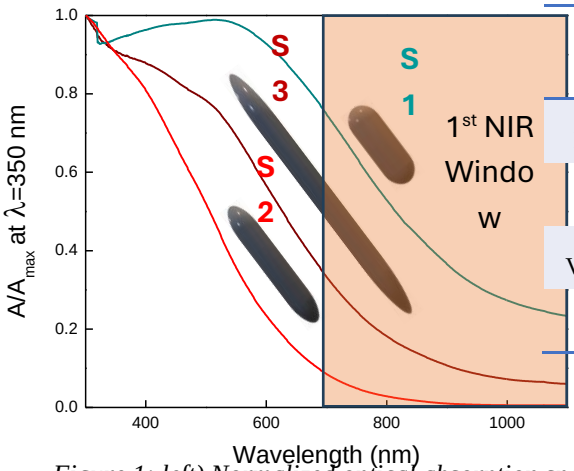
Theragnostic nanoparticles are multifunctional nanosystems that combine diagnostic and therapeutic capabilities into one single agent [1]. Although numerous types of theragnostic nanoparticles, both organic and inorganic, have been developed in the last decade for treating cancer, there is still a big gap between fundamental and applied research. In this regard, hybrid Bi_2S_3@Au nanocomposites have been drawing much attention due to their superior performance in both computed tomography and photothermal therapy [2, 3]. In this work, we synthesized three Bi_2S_3 NR samples, each with a different Width to Length ratio (W:L), two of them with similar volumes using a previously reported method [4]. We found that the general shape and bandgap is independent of their in-solution concentration through UV-vis absorption spectra, and that they follow Lambert-Beer's law. Additionally, the bandgap E_g of each sample was calculated, where no correlation to their volume was found. However, the results hint at a decrease in E_g that is related to their W:L ratio, perhaps more closely related to the width W of the NR rather than its length L. Also, in a separate step, these samples were functionalized with Au at various temperatures, Bi:Au ratios, and reaction time. The separate functionalization at room temperature for a reaction time of 30 min reproduced previous results that required 120ºC in a one-step synthesis with Bi_2S_3 NRs. These Bi_2S_3@Au nanocomposites had an increased NIR absorption compared to their non-functionalized counterparts. Finally, the anisotropic hybrid Bi_2S_3@Au nanocomposites were transferred from an organic solvent to water by the grafting of PEG-thiolate ligands onto the nanocomposite surface. The as-prepared samples show good stability in water and in phosphate buffer solution. The final objective of this study is to evaluate each sample's photothermal efficiency.



Structural properties	S1	S2	S3
Length (nm)	27 ± 9	43 ± 10	88 ± 32
Width (nm)	10 ± 3	8 ± 2	7 ± 3
Volume (nm^3)	2121 ± 2403	2055 ± 1426	3387 ± 3308
Ratio W:L	1:3	1:6	1:14

Figure 1: left) Normalized optical absorption spectra of Bi_2S_3 Nanorods with various morphologies. Right) table of nanorod dimensions for each sample.

References

[1] Xue, Y. et. al., *Cancer Biol Med.* 18, 336 (2021).
[2] Wang, X, et. al., *ACS Nano* 13 (5), 5947-5958 (2019).
[3] Cheng, Y, et. al., *Angew. Chem. Int. Ed.*, 57, 246 –251 (2018).
[4] Escoda-Torroella, M., et. al., *Phys. Chem. Chem. Phys.*, 25, 3900-3911 (2023).

(O24) Permeability and Responsiveness Drive Performance: Linking Structural Features with Antitumor Effectiveness of Doxorubicin-Loaded Stimuli-Triggered Polymersomes

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The stability of cargo delivery systems based on polymer vesicles while navigating in complex biological media is certainly a key prerequisite nevertheless, the permeability and responsiveness of the polymeric membranes are equally relevant and surely govern their efficacy. Taking into account this consideration, we herein correlate the structural features, permeability and responsiveness behavior of doxorubicin-loaded (DOX-loaded) nonresponsive and stimuli-responsive polymersomes with their *in vitro* and *in vivo* antitumor performance.[1,2] Polymer vesicles were produced using amphiphilic block copolymers containing a hydrophilic poly[*N*-(2-hydroxypropyl)methacrylamide] (PHPMA) segment linked to poly[*N*-(4-isopropylphenylacetamide)ethyl methacrylate] (PPPhA, a nonresponsive block), poly[4-(4,4,5,5-tetra-methyl-1,3,2-dioxaborolan-2-yl)benzyl methacrylate] (PbAPE, a reactive oxygen species-responsive block) or poly[2-(diisopropylamino)ethyl methacrylate] (PDPA, a pH-responsive block). The PDPA-based polymersomes demonstrated outstanding biological performance with antitumor activity notably enhanced compared to the counterparts (Figure 1). We attribute this behavior to a fast triggered DOX release at acidic tumor environments as induced by polymersome disassembly since $pKa_{(PDPA)}$ = 6.8.[1] Possibly, insufficient ROS concentration in the selected tumor model restrict or at least attenuate the rate of ROS-responsive vesicle degradation, whereas the impermeable and nonresponsive nature of the PPPhA block remarkably impact the performance of such potential nanomedicines.

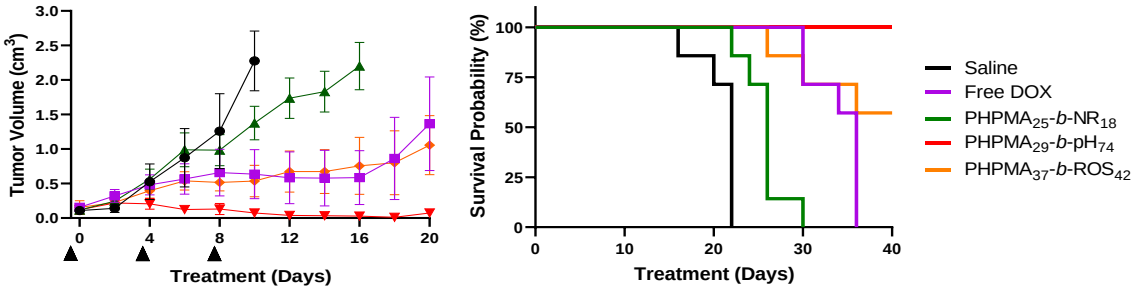

Figure 1. Tumor volume in cm³ (left) and Kaplan-Meier survival plot (right) as a function of time for mice treated with different formulations at 5 mg·kg^{-1} DOX or equivalent according to the legend.

Acknowledgments
These investigations are sponsored by FAPESP (Grants 2019/06634-8, 2021/12071-6 and 2023/00558-3), CNPq (grant 303268/2020-4) and GACR (Grants 20-15479J and 20-15077Y).

References
[1] L.J.C. Albuquerque *et al. J. Control. Release* **332** (2021) 529-538.
[2] E. Jäger *et al. Biomacromolecules* **21**, 4 (2020) 1437-1449.

(O25) Active Targeting and Therapeutical Applications of Gelatin-based Nanoparticles

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The slow progress in the therapeutic effectiveness of treating severe diseases has pointed to a growing need for a multidisciplinary approach to designing smart materials interacting with biological systems. Delivering drugs safely and efficiently to prevent and treat diseases or assist the body in healing can be achieved by designing materials whose properties can be significantly modified in response to changing conditions in their surroundings. The response of these materials can be modulated via exposure to stimuli such as stress, temperature, moisture, pH, and electric magnetic fields [1].

Recent studies in our lab have demonstrated that the gelation properties of gelatin and the strong dependence on ionization with pH make this protein an exciting candidate to be used for the effective delivery of active biomacromolecules. By using this strategy, three levels of active targeting have been achieved: i) delivering the drug to specific organelles of the target cells through the endosomal scape approach, ii) distinguishing between different cells (tumoral and non-tumoral cell lines) via the RGD–integrin recognition, and iii) promoting the selective delivery of the drug in the surroundings of a chronic wound [2-5].

This project explores the physicochemical and biological characterization of new gelatin-based nanoparticles. *In vitro* experiments have been performed to establish their biocompatibility, proliferative properties, and selective cytotoxicity upon incubation on selected cell lines in search of potential therapeutical applications.

References

[1] A. Singh, M. M. Amijipet, Stimuli-responsive drug delivery systems, Biomaterials Science Series. RSC (2018).
[2] M. C. Morán, N. Rosell, G. Ruano, M. A. Busquets, M. P. Vinardell, *Colloids Surf. B* **134** (2015) 134.
[3] M. C. Morán, J. Carazo, M.A. Busquets, *Colloids Surf. B*. **172** (2018) 646.
[4] A. Ferriol, M.C. Morán, *M.C. Mater. Sci. Eng. C* **124** (2021) 112073.
[5] M. C. Morán, C. Porredón, C. Gibert, *Antioxidants* (2024) submitted.

(O26) Designing Granzyme-B Activity Nanoprobes for Immunotherapy Response Evaluation

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Immunotherapies, including checkpoint inhibitors, are designed to amplify the immune response against cancer cells. Concurrently, there is a concerted effort to unravel the intricate interplay between cancer cells and the immune system. The overarching objective is the development of targeted therapies capable of reinforcing the body's innate defenses. However, the effectiveness of immunotherapies exhibits considerable variability, contingent upon factors such as the specific pathology, stage of the disease, and, notably, patient variability. This inherent variability in the response to immunotherapeutic interventions impacts their overall efficacy. Consequently, a rapid and accurate assessment of the applied immunotherapy's effects becomes imperative for clinicians. Such timely evaluations facilitate informed decision-making, enabling adjustments in therapy protocols, potentially including the optimization of the current treatment or transitioning to a more suitable alternative. Accordingly, we decided to design a highly sensitive nanoprobe that can evaluate the immunotherapy response based on the detection of Granzyme B (Gnz-B) which is a serin-protease secreted by immune cells to activate death pathways in cancer cells.[1] The system comprises a gold nanoparticle functionalized with a selective peptide substrate sensitive to Gnz-B and conjugated with an encrypted cholesterol molecule. All this hybrid-peptide system has been colloidally stabilized by a PEG molecule in its C-terminus. The system is able to circulate before reaching tumoral surroundings where Gnz-B is secreted by immune cells. Gnz-B cleaves the peptide and liberates the stabilizing PEG molecule, leaving the hydrophobic cholesterol molecule exposed, resulting in the precipitation of the gold nanoparticles. This precipitation allows a selective accumulation of gold nanoprobe in the tumoral mass only when the immunotherapy is working for the patient in a very short period. The nanoprobe will be detected by Computed Tomography, an implemented image technique in clinics facilitating this smart nanoprobe to a translational application. To optimize the nanoprobe, different Gnz-B specific peptide substrates, PEG molecule sizes, and sizes of gold nanoparticles were tested. Experiments in vitro were undergone by exposing the probe to Gzn-B in presence of different tumoral cell lines. Precipitation was observed and confirmed by Dynamic Light Scattering, absorbance spectroscopy, and Computed Tomography Scan. In conclusion, the nanoprobe proved to be a sensitive, fast, and non-invasive tool to detect Gnz-B presence granting the decision-makers the ability to adjust the dosage of immunotherapy, guaranteeing better survival rates and fewer immune-related adverse events.

Acknowledgments

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References

[1] Nguyen A, Ramesh A, Kumar S, Nandi D, Brouillard A, Wells A, Pobezinsky L, Osborne B, Kulkarni AA. Granzyme B nanoreporter for early monitoring of tumor response to immunotherapy. Sci Adv. 2020 Oct 2;6(40): eabc2777.

(O27) Nanomaterials for sensitive pathogenic bacteria determination with electrochemical biosensors

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Pathogens are responsible for severe food related intoxications. Conventional microbiological methods include tissue culture plate, plate count enumeration method or polymerase chain reaction. However, these require several days, skilled staff and centralized facilities. Rapid detection methods are required to meet the safety requirements for clinical and food related applications.

In this work, we have synthesized nanomaterials for the development of electrochemical biosensors for bacteria detection. We have chosen E. coli 157:H7 as a model system. This is a Shiga toxin producer strain, that could lead to severe gastrointestinal disorders or acute kidney failure. The intoxication occurs by consumption of contaminated food.

The first strategy involved the synthesis of gold nanoparticles (AuNP) coated with heterobifunctional PEG polymer. Silver was subsequently catalytically deposited on their surface. A lateral flow immunoassay was developed, including a silver enhancement protocol based on the reaction between silver nitrated and hydroquinone. The limit of detection decreased from 10^6 CFU/ml with the conventional visual detection to 2 x 10^3 CFU/ml. The test could be used to quantify E. coli in water, milk and orange juice, with high selectivity against other E. coli strains. The strips were coupled to screen printed electrodes using an in-house developed holder, to build up an electrochemical sensor for decentralized use.

For the second strategy, Fe_3O_4@Au core/shell nanoparticles were synthesized, and used as substrate for the development of an electrochemical sandwich immunoassay. Screen-printed carbon electrodes (SPCE) were used as transducers. The detection was carried out by chronoamperometry by using a secondary antibody labeled with horseradish peroxidase and TMB as co-substrate. This biosensor could be used to determine the E. coli O157:H7 strain in the linear range from 20 to 2 x10^6 CFU/mL, with a limit of detection of 20 CFU/mL in milk samples.

Acknowledgments

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References

[1] S. Bazsefidpar. E. Serrano-Pertierra. G. Gutiérrez . A. Sánchez Calvo, M. Matos, M.Carmen Blanco-López, Microchimica Acta (2023) 190:264, https://doi.org/10.1007/s00604-023-05834-8
[2] S. Bazsefidpar, M. Freitas, C.R. Pereira, G. Gutiérrez, E. Serrano-Pertierra, H. P. A. Nouws, M. Matos, C. Delerue-Matos, and M. C. Blanco-López, Biosensors 2023, 13, 567. https://doi.org/10.3390/bios13050567.

(O28) Neural networks push the limits of luminescence lifetime nanosensing

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Luminescence lifetime-based sensing relies on the analysis of changes in the decay curves of a luminescent sensor to monitor a parameter of interest. This technology is ideally suited to study biological systems due to its minimal invasiveness and remote working principle.[1] Yet, in conditions of low signal-to-noise ratio (SNR) the high uncertainty associated with the lifetime value extracted from decay curves often translates to limited precision in the readout for, e.g., short exposure times or in the presence of highly opaque media. Convolutional Neural Networks (CNNs) are emerging as a solution to several issues in luminescence sensing–thermometry above all–to ensure high spatiotemporal resolution and increased reliability.[2] U-Shaped CNNs (U-NETs) in particular, which have been proven effective in image segmentation tasks in the medical context and in image denoising,[3] show potential in overcoming the effect of noises on the performance of luminescence lifetime-based sensing.

In this work, we apply a U-NET to improve the precision of luminescence lifetime-based thermometry in conditions of extremely low SNR. To showcase this improvement, we use Ag_2S nanothermometer, we first convert luminescence decay curves into images suitable to be used as input in the U-NET. The algorithm learns the relevant features from noisy images and improve luminescence lifetime estimation under conditions of extremely low SNR (**Figure 1**) compared to traditional analysis methods of decay curve fitting and integration. Specifically, we showcase the prowess of the U-NET in improving the precision of luminescence lifetime thermometry with two experiments characterized by extreme measurement conditions: thermal monitoring of free-falling droplets and monitoring of thermal transients in suspended droplets through an opaque medium. These results broaden the applicability of luminescence lifetime-based sensing in fields including in vivo experimentation and microfluidics, while, hopefully, spurring further research on the implementation of machine learning in luminescence sensing.

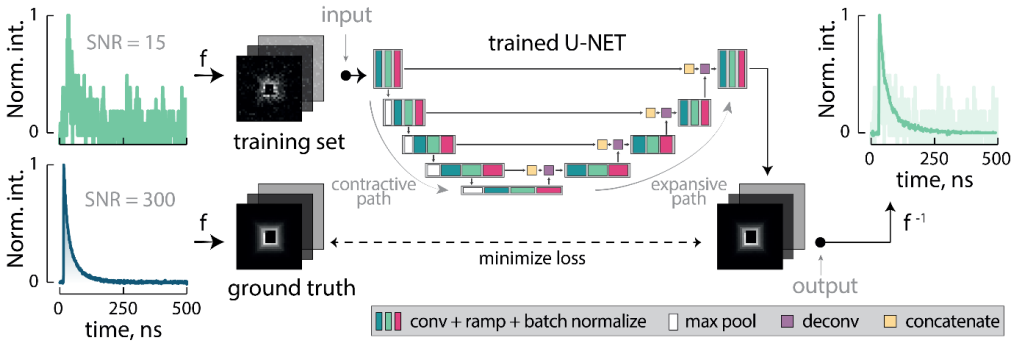

Figure 1. Flowchart representing the architecture and use of the selected U-NET.

References

[1] Y. Shen, J. Lifante, N. Fernández, D. Jaque, E. Ximendes, ACS Nano 2020, 14, 4122.
[2] L. Liu, K. Zhong, T. Munro, S. Alvarado, R. Côte, S. Creten, E. Fron, H. Ban, M. Van Der Auweraer, N. B. Roozen, O. Matsuda, C. Glorieux, Journal of Applied Physics 2015, 118, 184906.
[3] J. Gurrola-Ramos, O. Dalmau, T. E. Alarcon, IEEE Access 2021, 9, 31742.

(O29) Magnetoelastic contactless gas sensor for real-time monitoring of breath biomarkers. A proof of concept

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In the pursuit of effective gas sensors for breath analysis[1], magnetoelastic resonance-based gas sensors (MEGSs) emerge as remarkable candidates. Due to their intrinsic contactless operation, they can serve as non-invasive and portable devices. However, traditional monitoring techniques are often associated with slow detection, limiting their application in fast bio-related reactions. Here, we showcast a proof of concept for real-time monitoring of gaseous biomarkers based on magnetoelastic resonance frequency. This approach was validated using a MEGS based on Metglass 2826 MB microribbon with a polyvinylpyrrolidone (PVP) nanofiber electrospun functionalization. The device demonstrated low noise (RMS = 1.7 Hz), rapid response (<2 min), and highly reproducible reactions to humidity (Δf = 46–182 Hz for 17–95% RH), ammonia (Δf = 112 Hz for 40 ppm), and acetone (Δf = 44 Hz for 40 ppm). These analytes hold great significance in biomedical applications, especially ammonia and acetone, which are biomarkers associated with diseases such as diabetes. Moreover, the sensor's capability to distinguish between breath and regular air was validated through real breath measurements. The sensor also exhibited strong resistance to benzene, a common gaseous interferent in breath analysis[2].

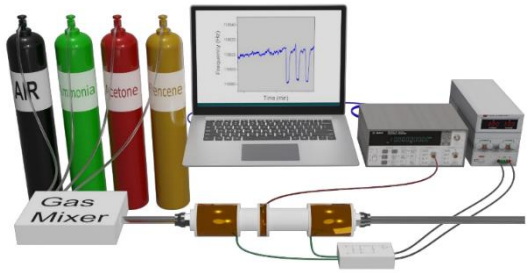

Figure 1.- Experimental setup for the real-time monitoring of magnetoelastic-based gas sensor (Ref 2)

Acknowledgments

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References

[1] Z. Wang, C. Wang, *J. Breath. Res.* **7** (2013) 037109
[2] A. Peña, J.D. Aguilera, D. Matatagui, P de la Presa, C. Horrillo, A. Hernando, P. Marín , *Biosensors* **12** (2022) 871

(O30) A reliable ratiometric fluorescent nanothermometer for live cells

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Intracellular temperature sensing plays an important role in understanding the biological reactions and physiological conditions inside live cells. A considerable amount of works about intracellular thermometer has been published.[1] Among them, fluorescence thermometers have been widely used due to their non-contact and non-invasive characteristics. However, the reliability of their intracellular thermal readouts is still a question of debate. The change in the compositional properties of intracellular medium can induce changes in the fluorescence signal that can be erroneously interpreted as thermal variations.[2] To overcome this drawback, we proposed an inert thermal probe where the fluorescent nanoparticles are encapsulated with a silica shell to isolate them from the environment.

We used the thermochromic nanoparticles as the ratiometric nanothermometer for measuring the intracellular temperature (**Figure 1a**). The fluorescent dye in nanoparticle achieves the fluorescence modulation through the solid-liquid transition of phase change materials. The phase change temperature is 38 °C, which results in a high temperature sensitivity within physiological temperature range. **Figure 1b** is the emission spectra of the suspension of nanoparticles under 20 °C to 65 °C. We experimentally demonstrated that its green-red fluorescent ratio and phase change temperature is not sensitive to pH, viscosity, ionic strength, and the physical change of the cells. The intracellular temperature calibration is consistent with the extracellular results (**Figure 1c**). The proposed ratiometric fluorescent nanothermometer is a reliable for live cells temperature sensing.

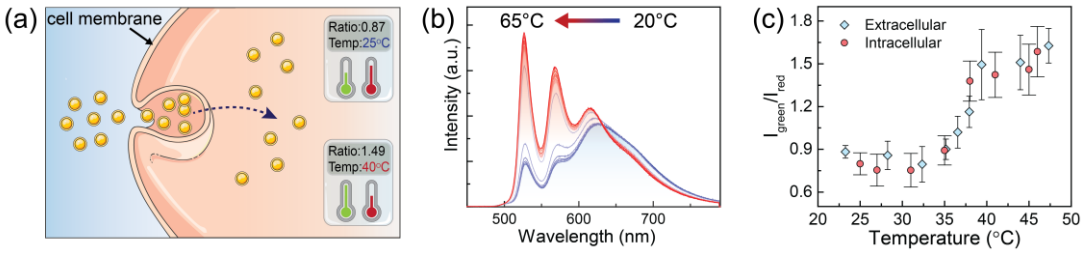

Figure 1. (a) Schematic diagram of the intercellular ratiometric nanothermometer. Yellow circles represent the nanoparticles. (b) Evolution of emission spectra with temperature from 20 °C to 65 °C. (c) Temperature dependence of the extracellular and intercellular fluorescence intensity ratio.

Acknowledgments

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References

[1] T. Bai, N. Gu, Small **2016**, 12, 4590.
[2] P. Rodríguez-Sevilla, G. Spicer, A. Sagrera, A. P. Adam, A. Efeyan, D. Jaque, S. A. Thompson, Advanced Optical Materials, **2023**, 11, 2201664.

(O31) Development of an innovative Non-Enzymatic Microelectrode with Bimetallic Combination for Glucose Detection in Neutral Media

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In this study, a novel non-enzymatic microelectrode employing a nickel-copper bimetallic combination was developed for the precise and non-invasive detection of glucose in neutral media. The electrode fabrication process utilized advanced electrochemical deposition techniques, yielding electrodes that demonstrated exceptional electrocatalytic activity towards glucose oxidation. The sensor here proposed provides a high lifespan with the needed accuracy, more than 40000 measurements were performed. Characterization studies revealed the sensor's outstanding sensitivity, and an impressively low detection limit of 0.05

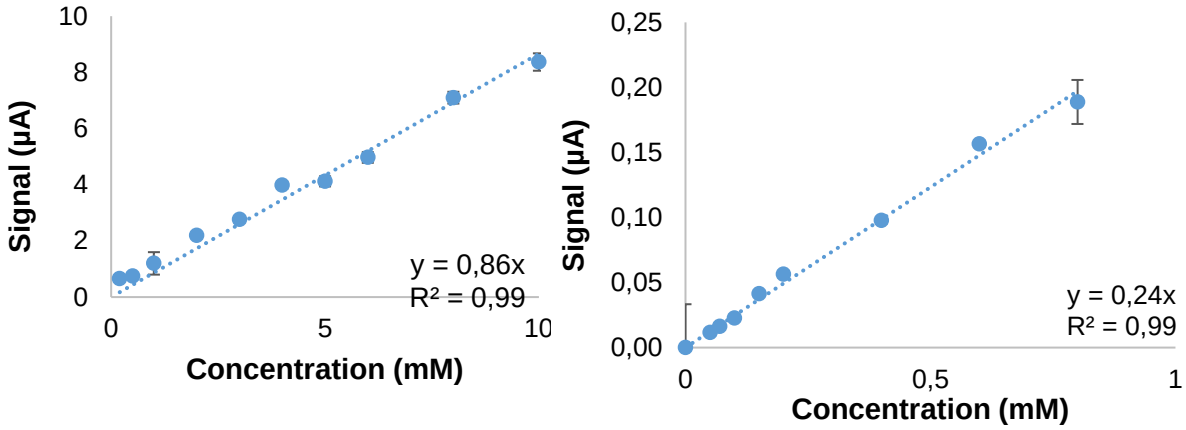

Figure.1 Linear range with microelectrode LIG/Ni/Cu in neutral media.

The electrode's performance was further assessed for selectivity, where it exhibited remarkable specificity even in the presence of potential interfering substances commonly found in neutral media environments such as sweat. In case of sweat study, the obtained deviation meets the 15% error proposed by the ISO normative. These results underscore the robust and reliable performance of the developed sensor.

The compatibility of this sensor with neutral solutions adds a significant advantage over enzymatic sensors, broadening its potential applications in healthcare and other related fields [1]. This innovation holds promise for improving accessibility to essential glucose monitoring technology on a global scale.

Acknowledgments

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References

[1] Guati C, Gomez-Coma L, Fallanza M, Ortiz I. Reviews in Chemical Engineering. 2023. doi.org/10.1515/revce-2022-0058.

(O32) Exploring the Microwave-assisted Synthesis of Iron Oxide Nanoparticles

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Microwave-assisted (MW) synthesis of iron oxide nanoparticles (IONPs) allows for controlled and reproducible processes, ensuring the fine-tuning of nanoparticle characteristics such as size, shape, and crystallinity. The accelerated reaction kinetics in MW synthesis contribute to shortened reaction times, enhancing overall productivity and therefore minimization of energy [1].

This research investigates the MW synthesis of IONPs, exploring procedures such as polyol and oxidative precipitation. In this sense, a systematic analysis of key parameters, including reaction temperature and time, heating ramp, solvent, and precursor, provided insights into their impact on the nanoparticle characteristics (Figure 1).

Within the polyol method, size modulation, from 5 to 14 nm, was achieved by diminishing the boiling point of the mixture by introducing water (3.7 % v/v) to the diethylene glycol solvent [1]. Controlled aggregation of small cores (≈7 nm) was accomplished by substituting the main solvent with a shorter carbon chain polyol (ethylene glycol) which introduces an interesting approach to produce multicore IONPs with disordered aggregation [2]. In the same way, by the addition of an amined co-solvent (N-Methyldiethanolamine) is possible to induce a crossover to a non-classical reaction mechanism leading to multicore nanostructures (≈40 nm) formed by a crystallographycally alignment of small cores, usually synthesized by solvothermal techniques [3]. Additionally, to achieve precise shape control transitioning from spheres to cubes and larger sizes (30-50 nm), the polyol media was substituted by water in an oxidative precipitation approach, enabling a rapid synthesis within a mere 3-minute reaction time.

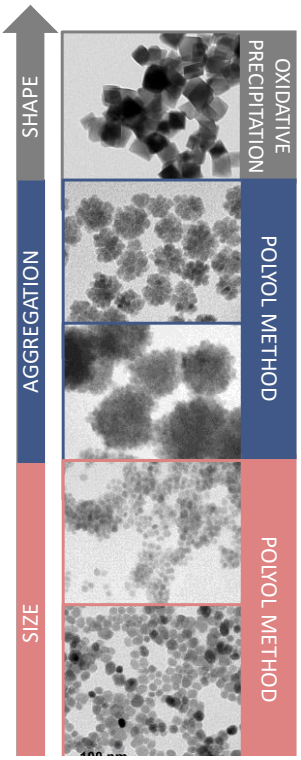

Figure 1. MW IONPs samples.

Rigorous assessments of reproducibility proved the reliability of both MW synthesis procedures across multiple batches (N=20). Finally, the successful in-situ coating of single-core particles using small molecules such as APTES, citric acid, and aminodextran was achieved in 10 min reactions.

In general, this multifaceted exploration not only enhances our understanding of MW-assisted synthesis but also opens new avenues for tailoring IONPs with precision, holding immense potential across diverse applications, from biomedicine to catalysis and environmental remediation.

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References

[1] A. Gallo-Cordova, et *al. Mater. Chem. Front.* **4** (2020) 3063-3073.
[2] A. Gallo-Cordova, et *al. Nanomaterials.* **11(4)** (2021) 1052.
[3] A. Gallo-Cordova, et *al. J. Colloid. Interface Sci.* **308** (2022) 127385.

(O33) Human-sized quantitative imaging of magnetic nanoparticles with magnetorelaxometry and optically pumped magnetometers

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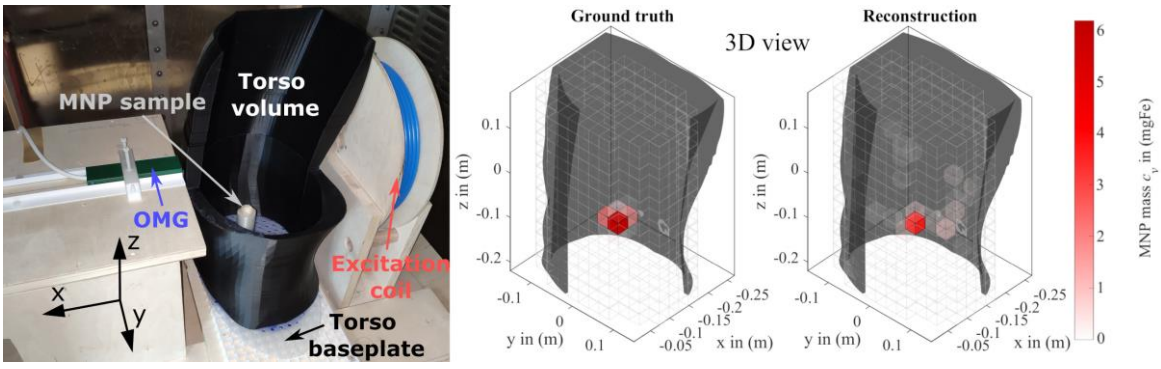
For a safe and efficient treatment, magnetic hyperthermia requires quantitative imaging of the magnetic nanoparticle (MNP) distribution in the tumor region [1]. In magnetorelaxometry (MRX), MNP are magnetized by a pulsed DC magnetic field, and the relaxation of the MNP's net magnetic moment is measured with ultra low noise magnetometers. When repeating MRX measurements with spatially different magnetization fields and multiple magnetometers, the quantitative spatial MNP distribution can be reconstructed by solving an ill-posed inverse problem.

Here we demonstrate the upscaling of MRXI to the size of a human torso. Our setup (see Fig.) is composed of a single excitation coil and an optically pumped magnetometer (OMG from Twinleaf). The system is operated inside a magnetically shielded room. The phantom mimics a pancreatic cancer and is composed of a 3D printed torso and an egg-shaped gypsum-immobilized MNP sample (Perimag®, 6.3 cm³, 12 mg Fe). In order to sufficiently magnetize distant MNP, the excitation coil is pulsed with currents ≤60 A, generating excitation fields of ≤70 mT. In consequence, (possibly) closeby MNP will be driven into magnetic saturation, requiring a nonlinear MRXI model, which we developed. The MRXI dataset was recorded by translating the phantom to 32 different positions. The coil was driven sequentially with 7 different currents, to further exploit the nonlinear model as an additional spatial encoding scheme. The voxel size was selected as 2.5 cm.

We succeeded in scaling up MRXI to the size of a human torso. Even a deeply-lying MNP source could be reconstructed well with a total mass reconstruction error of 5.2%.



Left: OPM-MRXI imaging setup, Right: ground truth and reconstruction of MNP phantom.

Acknowledgments

Financial support by the Austrian Science Fund (FWF, grant I 4357-B) and the German Research Foundation (grant WI 4230/4-1) is gratefully acknowledged.

References

[1] S. Healy et al., Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology (2022).

(O34) Combination of biomimetic magnetic nanoparticles and qPCR to magnetically concentrate and detect bacteria in liquids

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Early detection of pathogenic microorganisms in food is a crucial strategy to safeguard public health, especially when they are present in trace amounts. Numerous sensors and methods have been developed to achieve this goal, but it is necessary to further reduce the duration and detection limit of these techniques. In this sense, magnetic nanoparticles have become popular due to their large surface area, that maximizes the interaction with microorganisms; and their ability to respond to external magnetic fields, which allows to magnetically concentrate the attached microorganisms in short periods of time [1].

In this work, biomimetic magnetic nanoparticles (BMNPs) were prepared *in vitro* by chemical precipitation in presence of MamC, a magnetosome-associated protein from *Magnetococcus marinus* MC-1 [2]. This protein facilitated the nucleation and growth of magnetite crystals, and allowed to obtain magnetic nanoparticles with improved characteristics, such as the presence of functional groups on the surface which could bind bacteria through electrostatic interactions. BMNPs were used to magnetically concentrate bacteria from saline solution and milk, DNA was extracted, and qPCR was employed to specifically detect *Staphylococcus aureus* (model bacterium).

In comparison with other sensors based on the use of inorganic magnetite nanoparticles, BMNPs are more efficient materials to adsorb microorganisms, since they do not need post-production coating processes to provide functional groups on their surface. Besides, binding analysis show that both Gram-positive and Gram-negative bacteria can attach to the BMNPs and be consequently concentrated by using external magnetic fields. In addition, although the bacterial attachment is unspecific, the use of qPCR allows to discriminate specific bacteria from the concentrated bulk and detect loads as low as 10 CFU/mL in case of *S. aureus*. This system is, therefore, a faster, simpler, and eco-friendlier alternative to conventional detection methods.

Acknowledgments

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References

[1] Y. Li et al., *TrAC* **113** (2019) 74.

[2] C. Valverde-Tercedor et al., *Appl. Microbiol. Biotechnol.* **99** (2015) 5109.

(O35) Exploiting the potential of AC magnetometry to display thermal conformational changes of proteins

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The last twenty years have witnessed a remarkable increase in the variety of life sciences applications of magnetic nanoparticles (MNP). One notable case is the use of MNPs as transducers for biosensing in liquids. This benefits from changes in both colloidal and magnetic properties following the biomolecular recognition between target biomolecules and receptors attached to the MNP surface. The nature of the transduction potential relies on the variation in the magnetic relaxation process after biomolecular recognition. Consequently, the dynamic MNP magnetization cycles tightly reflect any biomolecular event influencing the Néel or Brownian relaxation. Hence, for MNPs whose relaxation mechanism is governed by the Brownian process, it is possible to precisely detect variations in their diffusion via the analysis of their alternating current (AC) magnetization cycles.

Taking advantage of this transducing methodology, we investigated the conformational changes in the monovalent variant VFP-TPR2-MMY protein, when subjected at 50ºC during different exposure times up to 120 minutes. For this investigation, we prepared and characterized MNPs bio-conjugated with receptors that specifically interact with the protein under study. The AC magnetization cycles of bioconjugated MNPs (b-MNPs) reflect diffusion changes due to the presence of biomolecules on the MNP surface. Incubation of b-MNPs and VFP-TPR2-MMY proteins also leads to b-MNP-protein complexes, whose AC magnetization cycles differ from those obtained for b-MNPs. Subsequent time exposure of the b-MNP-protein complexes to 50 ºC reveals progressive changes in their AC magnetization cycles. The modelling of such AC magnetization cycles, considering the stochastic Landau-Lifshitz-Gilbert equation and the Brownian dynamics of the particles, allows us to attribute the magnetic changes to protein conformational alterations. This was performed to correlate all observed changes in the cycles with variations in particle diffusion. Indeed, numerical methods provide a comprehensive analysis of how the conformational changes of the proteins, induced by temperature, influence the diffusion of the b-MNP-protein complex and, consequently, their AC magnetization cycles. This is possible thanks to the combination of experimental and numerical methods, showcasing the significant potential of AC magnetometry to accurately display thermal protein conformational changes, offering an alternative to existing techniques.

Acknowledgments

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(O36) Superparamagnetic Mn Ferrite Nanoparticles for Highly Sensitive Lateral Flow Assays

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Rapid diagnostic tests based on lateral flow assays (LFAs) have been frequently used as point-of-care devices for detecting several diseases. They are paper-based tests that rely on microfluidics and biorecognition to provide fast and qualitative results. Commercial LFAs are based on colloidal gold or latex labels, which can give a visual positive/negative test line[1]. However, quantifying the bio-analyte in the test line remains challenging due to difficulties in standardization regarding modifications in paper color and ambient light. Magnetic nanoparticles are promising candidates for addressing such issues and increasing the sensitivity of LFAs. In addition to the visual signal, they can be detected by a magnetic sensor. Superparamagnetic iron oxide nanoparticles (SPIONs) nanoclusters have been investigated as magnetic labels to detect and quantify histamine in wine[2], *Streptococcus pneumoniae*[3], and cancer biomarkers[4]. In this work, we propose using magnetic clusters based on citrate-coated Mn ferrite ($MnFe_2O_4$) nanoparticles as magnetic labels to increase the sensitivity of magnetic LFAs. Mn ferrite nanoparticles are soft magnetic materials with high saturation magnetization and lower magnetocrystalline anisotropy than SPIONs. Depending on their dimensions, they can be superparamagnetic at room temperature and exhibit a very high initial magnetic susceptibility and magnetic permeability. Both aspects are crucial in improving the detection signal in a magnetic radiofrequency inductive sensor [5]. We synthesized $MnFe_2O_4$ NPs by hydrothermal coprecipitation. Nanoparticles were functionalized with citric acid to achieve colloidal stability and provide carboxylic groups on the particle surface for bioconjugation with a protein of interest. Samples were characterized by XRPD, TEM, DLS, ICP, TG/DTA, and magnetometry measurements. We used the NeutrAvidin/Avidin complex as a model to study the sensitivity of the NPs for magnetic detection in magnetic LFAs. Our results show that modifying the chemical composition of magnetic nanolabels, from SPIONs to superparamagnetic Mn ferrite, increased the sensitivity of magnetic LFA due to optimizing the nanolabels magnetic properties. This would be useful for further developing highly sensitive LFAs to detect several diseases, allergens, toxins, and environmental pollutants.

Acknowledgments

This work was partially founded by the Ministry of Science and Innovation of the Spanish Government through grant PLEC2022-009490, the University Technological Institute of Asturias (IUTA) under grant SV-22-GIJON-18, and the Government of the Principality of Asturias under projects FICYT/IDI/2021/000100 and FICYT/IDI/2021/00027 3. M.S. was supported by a “Severo Ochoa” fellowship (Consejería de Educación y Cultura del Gobierno del Principado de Asturias, grant BP19-141) and by the Margarita Salas fellowship financed by the European Union-NextGenerationEU and the Plan for Recovery, Transformation and Resilience.

References

[1] Liu Y. *et al. ACS Nano* **15** (2021), 3593
[2] Moyano, A. *et al. Analytical and Bioanalytical Chemistry* **411** (2019) 6615
[3] Salvador, M. *et al. Nanomaterials* **12** (2022) 2044
[4] Moyano, A *et al*. *Sensors* **21** (2021), 3756.
[5] Lago-Cachón, D. *et al. Journal of Magnetism and Magnetic Materials* **423** (2017) 436–440

(O37) Effect of TAT-PLGA - DOx transported by biomimetic magnetic nanoparticles under magnetic hyperthermia and photothermia irradiation

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The study delves into the synergistic potential of combining targeted chemotherapy with thermal therapy, encompassing magnetic hyperthermia and photothermia. This amalgamation is facilitated by a nanoassembly comprising specialized biomimetic magnetic nanoparticles (BMNPs) laden with the potent chemotherapeutic agent doxorubicin (DOXO), ensconced within a polymeric shell of poly(lactic-co-glycolic acid) (PLGA) and adorned with TAT peptide (termed TAT–PLGA(DOXO-BMNPs)).

Notably, prior studies have utilized PLGA to encapsulate both MNPs [1] and BMNPs [2]. In a recent investigation, we demonstrated that the incorporation of PLGA and/or TAT–PLGA coating onto BMNPs enhances cellular uptake without compromising the magnetic properties critical for hyperthermic functionality. However, the potential synergy between directed chemotherapy and magnetic hyperthermia remained unexplored in that study, owing to the lack of BMNP functionalization. Additionally, the capability of TAT–PLGA-embedded DOXO-BMNPs to facilitate synergy between chemotherapy and photothermia, as an innovative means to elevate local temperatures and/or promote drug release at the tumor site, has yet to be investigated.

Our findings with the HepG2 cell line demonstrate a compelling synergistic effect between chemotherapy and thermal therapy, resulting in heightened cytotoxicity compared to soluble DOXO alone. This augmentation is ascribed to the enhanced release of DOXO facilitated by thermal therapy, coupled with the localized temperature elevation induced by BMNPs within the nanoassembly upon exposure to AMF or NIR laser irradiation.

These results underscore the potential of TAT–PLGA(DOXO-BMNPs) as a versatile platform for combining therapies against tumor cells, representing a pivotal step toward transitioning from systemic to localized treatments. This innovation holds promise for more efficacious and precisely targeted cancer therapies. Therefore, in the present study, our aim was to optimize the effectiveness of the DOXO-BMNP nanoassembly, utilizing DOXO as a model drug molecule, through various approaches. Specifically, we sought to enhance cellular uptake by embedding DOXO-BMNPs within TAT peptide-functionalized PLGA nanoparticles while concurrently combining this optimized directed chemotherapy with magnetic hyperthermia and photothermia.

Acknowledgments

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References

[1]. Takke, A.; Shende, P.. Life Sci. 2021, 275.

[2] Vurro, F. et. al. Nanomaterials 2021, 11, 766

(O38) Kinetics and Dynamics of Methotrexate Release from Magnetic Activated Carbon under External Stimuli

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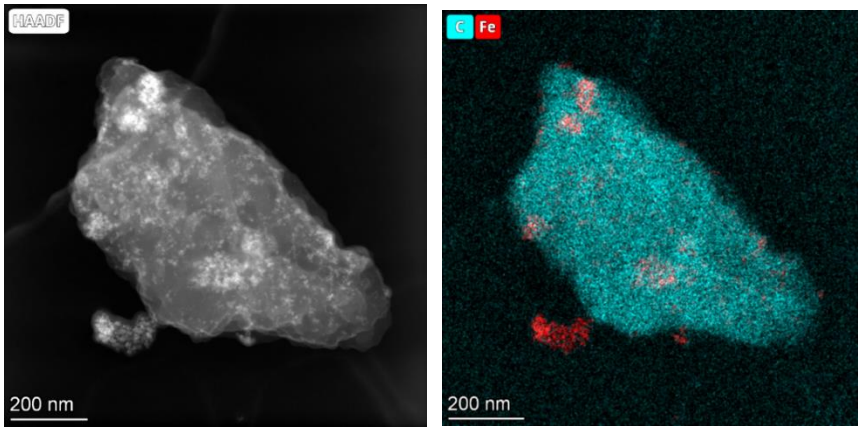
In recent decades, innovative methods have been implemented to enable controlled and localized drug release in the human body, thereby improving our response to therapy. One of these methods involves encapsulating the drug within structures that release it upon exposure to a specific stimulus. Porous carbon, due to its biocompatibility and high surface-to-mass ratio (~2000 m^2/g), can be used to adsorb drug ions released in solution.

This study explores the modification of carbon by incorporating magnetite into its structure and applying a polydiallyldimethylammonium chloride (PDADMAC) coating to its surface. The addition of magnetite produces magnetic altered carbon, MAC, particles that can respond to external magnetic fields. The PDADMAC coating adds an electrically charged layer that interacts with drug ions. The movement of carbon particles is induced by a rotating magnetic field, which facilitates the release of methotrexate (MTX) ions.

The research aims to investigate the impact of the rotation frequency of the applied magnetic field on the release kinetics of MTX, using both theoretical modelling and experimental analysis. This approach improves our understanding of the relationship between the magnetic field and the drug release process, providing insights for optimizing controlled drug delivery systems.



(Left) Image of a carbon particle modified with magnetite obtained from HRTEM. (Right) Carbon and iron distribution obtained from EDX microanalysis.

Acknowledgments

Financial support of this investigation grant TED2021-131855BI00 funded by MCIN/AEI /10.13039/501100011033 and Unión Europea NextGenerationEU/ PRTR

References

[1]Lázaro, M., et al. *Polymers* **14** (2022) 22

(O39) A sea of nano-possibilities: marine hybrid hydrogels combined with nanoparticles to treat Atopic Dermatitis

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Atopic Dermatitis (AD) is a worldwide spread and burdensome inflammatory skin disease characterized by epidermal barrier disruption, intense itch, sensitization and increased trans-epidermal water loss. The mild to moderate forms of AD are tackled with topical therapies (emollients and corticosteroids) which are still the mainstay of therapy. However, different types of nanocarriers have also been designed for AD therapy, either by the combination of different acting bioactive compounds, or by their incorporation in different delivery systems. Recently, more attention is being given to the vehicle used to deliver the drugs or bioactive compounds, in a way that their properties help to overcome the unmet clinical needs of several diseases. That is why hydrogels are rising in the field of cutaneous application, particularly for AD, since they possess high water content to treat skin dryness and reduce the water loss, improved drug delivery through an impaired skin barrier, and versatile preparation and drug-loading to represent good alternatives to regular ointments, lotions, or creams already in use [1].

In this project, hybrid hydrogels were designed to form a blend between marine polysaccharides and synthetic polymers, becoming a vehicle option to improve the AD environment. Since betamethasone is one of the mostly used corticosteroids, but present several off-target side effects,
this drug was incorporated in lipid nanoparticles to potentiate its local effect on skin layers, upon their incorporation in the hybrid hydrogel platform.

The designed nanoparticles revealed storage stability for more than two months and high drug content. The hydrogels combined with nanoparticles showed a rheological behaviour that ensures uniform spreadability and improved dispersion in skin layers. Cellular biocompatibility was also tested in fibroblasts and keratinocytes, and anti-inflammatory potential was confirmed in activated macrophages, which play a pivotal role in enhanced susceptibility to cutaneous infections like AD. *Ex vivo* pig ear skin permeation showed retention of betamethasone in skin layers just after three hours of contact, indicating a potentially maximized local effect.

These findings underscore the significance of using nanoparticles and hydrogels in the future treatments of AD and provide valuable insights on the use of natural products and the repurposing of drugs through nanomaterial science techniques for better therapeutical design.

Acknowledgments

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References

[1] A. I. Barbosa, T. Torres, S. A. Costa Lima, S. Reis, *Adv Therap*, (2021), 4(7).

(O40) Design and optimization of an innovative lipid nanosystem for the encapsulation of a novel FXa inhibitory molecule using Green Chemistry strategies

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Thrombosis, a leading cause of global cardiovascular disease-related fatalities (33% annually), represents a challenge in developing safe anticoagulants. Direct inhibition of Factor Xa (FXa) of the human coagulation system has emerged as a crucial strategy to prevent thrombosis, avoiding the activation of prothrombin (Factor II) and the subsequent generation of fibrin (FIa), giving rise to direct oral anticoagulants (DOACs). However, DOACs can lead to risks such as severe uncontrolled bleeding. For this reason, our research group synthesized a novel FXa inhibitor that could address those challenges as proven by its *in vitro* efficacy [1]. However, its elevated lipophilia hampers the clinical application potential of such a novel molecule. To overcome this, we propose using Nanostructured Lipid Carriers (NLC), colloidal carriers composed of nanoscale particles, formulated without organic solvents, and incorporating physiological lipids. NLCs enable the encapsulation of active lipid ingredients, protecting against degradation, and facilitating targeted delivery. Considering the importance of Green Chemistry strategies for developing novel nanosystems, we also used Microwave-Assisted Synthesis (MAS) for NLC formulation, which has recently demonstrated time reduction in the production process, resulting in similar physicochemical characteristics compared with traditional methods [2]. This research aimed to design and optimize a lipid nanosystem using conventional microemulsion and MAS techniques that could effectively encapsulate a new FXa inhibitory molecule. In this sense, a reproducible nanocarrier was obtained, exhibiting favorable physicochemical properties for both formulation techniques, involving sizes of 138±15 nm and 94±3 nm, polydispersity indexes (PI) of 0.168 and 0.243 and zeta potentials (ZP) of -19±2 mV and -21±6 mV respectively. Moreover, the prototypes demonstrated storage stability for over 20 weeks, physiological stability for more than 48 hours, and gastrointestinal stability until 4 hours. Once the inhibitory molecule was encapsulated, both nanosystems indicated consistent sizes around 130 nm, PI under 0.300, and a ZP around -20 mV. The efficiency of encapsulation was over 50% and was also confirmed by using ^{19}F NMR analysis. In summary, this research presents a novel and ecological approach to formulating lipid nanostructures for the encapsulation of a molecule that inhibits FXa. This method produces stable nanovehicles, offering potential solutions for overcoming the obstacles in treating thrombosis.

Acknowledgments

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References

[1] F. Santana, C. Lagos, Y. Duarte, F. Castillo, Y. Moglie, M. Maestro, N. Charbe, F. Zacconi. *Molecules.* **25** (2020) 491.

[2] K. López, A. Ravasio, J.V, González-Aramundiz, F. Zacconi. *Pharmaceutics.* **15** (2023) 1333.

(O41) DNA@SiO_2 spheres for versatile and efficient delivery of different DNA forms in mammalian cells

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Addressing genetic defects using exogenous nucleic acids presents a formidable scientific challenge. Thus, it is necessary to develop vectors capable of efficiently encapsulating, safeguarding, and precisely targeting nucleic acids in specific cells [1]. Our research focuses on the design of innovative compact silica-based particles with the capability to embed, store, and transport DNA molecules [2]. Through silica polymerization utilizing a modified Stöber reaction, nucleic acids are incorporated into the amorphous silica core, leading to the creation of spherical particles. These DNA@SiO_2 systems display impressive stability at room temperature and offer resilient protection to the enclosed DNA against various biological and physicochemical challenges. Upon cellular uptake, the amorphous silica dissolves within the cytoplasm, releasing the DNA and facilitating the process of transfection.

In our prior work, we started using plasmid DNA as genetic cargo showing long-lasting transfection and their application for sequential gene expression of two different genes in mammalian cells [3]. Subsequently, we have studied the application of DNA@SiO_2 particles for the delivery of long linear DNA, where commercially available vectors are generally limited. These particles have shown an enhanced efficiency with shorter and lineal fragments of DNA than with plasmids [4].

Based on these findings, we have initiated the application of these particles for the delivery of therapeutic oligonucleotides, specifically targeting the treatment of melanoma. The flexibility of our silica-based particles, evidenced by their efficient delivery of diverse DNA forms, makes them promising candidates for giving a boost to inorganic vectors in the field of gene therapy.

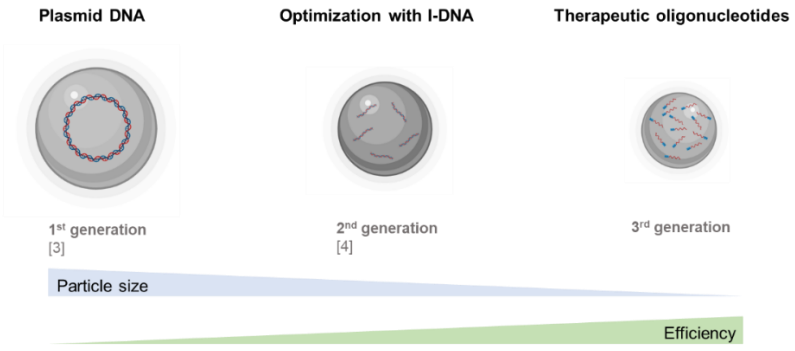

Figure 1. *Overview of DNA@SiO_2 development*

Acknowledgments

Projects PI22/00030, Grant TED2021-129248, and IDI-020-022. Project reference APG-31.

References

[1] C.E. Dunbar et al. *Science.*, **80** (2018) 357.
[2] M.L. Fanarraga, L. Marín-Cava, Patente Ref.: ES3120.
[3] A. Ramos-Valle, L. Marín-Caba, L. Garcia-Hevia, et al. *Mat. Today. Adv.*, **18** (2023) 100357.
[4] A.Ramos-Valle, H.Kirst, M.L. Fanarraga, bioRkiv, 2023.12.05.569925 (Under peer-review)

(O42) Multifunctional Drug-Loaded Metallic Nanodomes as a Platform for Obtaining Synergistic Therapeutic Biological Activities

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Multifunctional drug loaded polymer-metal nanocapsules have attracted increasing attention in drug delivery due to their multifunctional potential endowed by the drug activity and the tuneable response to physicochemical stimuli. However, chemical synthesis methods of polymer/metal capsules require specific optimization of the different components to produce particles with precise properties, being particularly complex to obtain Janus structures combining polymers and ferromagnetic and/or highly reactive metals. We have demonstrated a versatile hybrid fabrication strategy to incorporate different functional metals with optical, ferromagnetic or chemical properties on solid drug loaded nanoparticles.[1] Here, we present poly-lactic-co-glycolic-acid (PLGA) nanoparticles loaded with indocyanine green, paclitaxel, or erythromycin, that are half capped by Au, Fe, or Cu layers. Au coated nanoparticles were used for *in vivo* fluorescence imaging and synergistic photodynamic-photothermal therapy using near infrared lasers. The Fe coated paclitaxel loaded nanoparticles were used to assembly and manipulate multicellular cancer spheroids and boosted therapeutic effect *in vivo* achieving the complete eradication of tumors at ultralow drug concentration.[2] Finally, the Cu coated nanoparticles were tested for synergetic antibacterial effects. This technology can be expanded to a myriad of metals, polymers and drugs, thus the integration of magnetic, optical, and electrochemical properties in drug-loaded nanoparticles for external control and synergetic effects can be used to improve a wide range of biomedical applications.

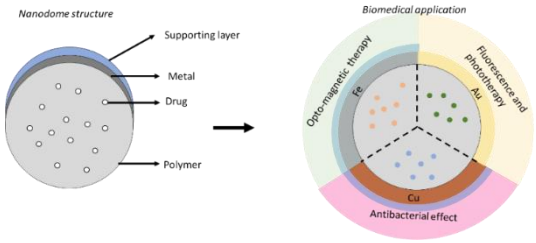

Figure 1. Scheme of the preparation and applications of the modular nanoparticles.

Acknowledgments

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References

[1] A. Fluksman, A. Lafuente, *ACS Appl. Mater. Interfaces.* **15** (2023) 50330−50343.
[2] A. Fluksman, A. Lafuente, *ACS Nano.* **17** (2023) 1946−1958.

(O43) On the CD44 Express: A Journey into Precision Delivery through Engineered Milk Extracellular Vesicles

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CD44 is a cell surface receptor that is considered a general marker for cancer stem cells and high malignancy, and it is generally inactive in normal cells [1]. Therefore, milk-derived small extracellular vesicles (sEVs) were engineered to target CD44 overexpressing cancer cells. Since hyaluronic acid (HA) is the primary ligand of CD44 [1], sEVs were functionalized with HA of different molecular weights (20-60 kDa, 250 kDa, 1000-1600 kDa) by covalent binding to surface proteins of sEVs. Uptake studies were performed with the breast cancer cell lines MDA-MB-231 (CD44+) and MCF-7 (CD44-). Confocal laser scanning microscopy (CLSM) showed that bare sEVs exhibited significantly lower uptake by both cell lines regardless of incubation time. Interestingly, different distribution patterns of functionalized sEVs in the cells at 2-hour incubation: MDA-MB-231 cells showed colocalization with cell membranes, while in MCF-7 cells sEVs were evenly distributed in the cytoplasm, suggesting different uptake mechanisms. This is confirmed by uptake pathway studies showing that blocking CD44 and inhibiting endocytosis affect the uptake of functionalized sEVs by CD44+ cells to a greater extent. A significantly higher uptake of functionalized sEVs by MDA-MB-231 cells compared to MCF-7 cells was observed at 24 h incubation (Figure 1), with sEVs-SCy5@1000-1600kDa exhibiting the highest fluorescence levels. It can be concluded that functionalization of sEVs can yield promising results in terms of selectivity to CD44+ cells, especially when high MW HA is used.

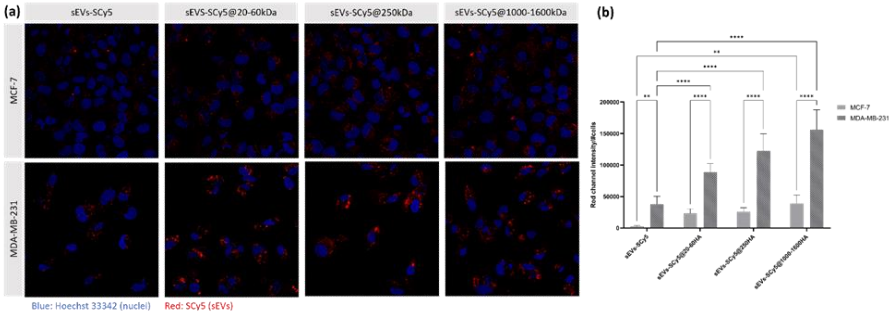

Figure 1. (a) CLSM images of MCF-7 and MDA-MB-231 cells after 24h of incubation with 10 µg/ml of sEVs; (b) Quantification of fluorescent sEVs on CLSM images.

Acknowledgments

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References

[1] Yang, C., et al., *Oncotarget* **6** (2015) 15283.

(O44) Bimetallic nanoparticles for the treatment of bacterial infections associated with biofilms

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Pathogenic bacteria typically exist only as planktonic cells for limited periods of their life cycle. However, in response to environmental signals, these bacteria can transition to form multicellular, surface-attached communities known as biofilms. Within a biofilm, bacteria are embedded in an extracellular matrix that they produce, which contributes to antibiotic resistance and facilitates the horizontal transfer of resistance genes, leading to persistent infections that are difficult to treat [1]. Given the global threat posed by antimicrobial resistance (AMR), there is an urgent need for alternative therapeutic approaches [2]. In this context, nanoparticles (NP) may present several advantages [3].

Monometallic iron oxide nanoparticles (IONP) and bimetallic zinc-iron oxide nanoparticles (Zn-IONP) were investigated for their potential activity against biofilm formation in a gram-negative pathogen, *Haemophilus influenzae*. Both types of NP were obtained through hydrothermal synthesis using iron and zinc chloride as metal sources and sodium citrate as surfactant. Several techniques (DLS, ICP-OES, FTIR, XRD) have been combined to do a full physicochemical characterization of NP and to determine their composition and crystalline structure. Finally, the ability of these NP to inhibit biofilm formation in *H. influenzae* was tested using biofilm crystal violet staining assay, whereas their ability to eradicate a mature biofilm was determined by culture and colonies counting after treatment. Toxicity of NP was evaluated in cells and zebrafish embryos, whereas biodistribution was evaluated in healthy mice.

Different bimetallic NP were synthesized with increasing amounts of zinc. All NP obtained had appropriate physico-chemical properties, and they were very stable after incubation in buffers, culture medium and serum. Regarding the composition of the organic coating, all NP were coated equally which was expected considering that the size of the nanoparticles is similar. Analyzing the ratio of occupied tetrahedral/octahedral stretching as seen in FTIR, at lower concentrations zinc occupies the octahedral positions, and as the quantity increases, it occupies the tetrahedral positions. *In vitro* tests showed that monometallic NP have little effect on biofilm formation in *H. influenzae*, whereas bimetallic NP were able to impair biofilm formation in a very efficient manner, resulting in total inhibition at the highest tested concentrations. Moreover, bimetallic NP were also more efficient in eradicating a preformed biofilm at all the tested concentrations. Toxicity studies showed a good biocompatibility profile NP. Moreover, bimetallic NP accumulate mainly in liver.
In view of these promising results, further work for a deep study of their efficacy and elucidating their mechanism of action will be carried out soon, as the NP here presented are a potential source of alternative treatments for biofilm-associated infections.

Acknowledgments
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References
[1] Kamaruzzaman, N.F., *et al*. Materials, 2018, 11(9): 1705.
[2] Global action Plan on Antimicrobial Resistance. WHO, 2015, ISBN 9789241509763.
[3] B. Malaekeh-Nikouei *et al*. Journal of Drug Delivery Science and Technology, 2020, 60, 10188.

(O45) Laser-Induced Graphene: Innovative Fabrication and Advanced Characterization for Biomedical Applications

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The continuous scientific and technological progress has propelled the creation of new materials to address various emerging needs in biomedicine. Graphene (G) stands out for its remarkable properties, including high electrical conductivity, flexibility, transparency, strength, and lightness [1]. The Laser-Induced Graphene (LIG) technique involves laser irradiation on carbon-rich materials, such as polyimides (PI), serving as precursors to obtain nanostructured graphene sheets [2]. Research confirms the significant potential of G-derived materials in interacting with cells from different tissues, facilitating the reconnection of biological structures [3-5]. This approach underscores the crucial relevance of the LIG technique in biomedical application.

In the present study, the electrical, structural, and physicochemical characterization (morphology and wettability) of substrates synthesized through LIG was conducted. Subsequently, the results of initial biological assays were examined to assess their *in vitro* biocompatibility. Our results demonstrate the ability to obtain diverse materials with desired properties in terms of conductivity, roughness, and wettability by varying laser power/speed configurations and pattern design. This flexibility provides a valuable platform for engineering materials with controlled surface and structural properties, emphasizing their immense potential in biomedical applications, especially in promoting cell-substrate interactions. Initial biological assays confirm the viability of our substrates for cell culture, where coherent cell growth is observed following the structural design on the material surface.

Acknowledgments

This work was supported by the Spanish MICIN within the framework of a National Plan Project (PID2021-124363OA-I00 and RYC2019-027692-I). In addition, the first author is supported by Connacht scholarship.

References

[1] Geim, A. K. (2009). "Graphene: status and prospects." science 324(5934): 1530-1534.
[2] Houeix, Y., et al. (2023). "Laser-synthesis of conductive carbon-based materials from two flexible commercial substrates: a comparison." Applied Surface Science: 157629.
[4] Moschetta, M., et al. (2021). "Hydrogenated graphene improves neuronal network maturation and excitatory transmission." Advanced biology 5(1): 2000177.
[4] Bramini, M., et al. (2018). "Interfacing graphene-based materials with neural cells." Frontiers in systems neuroscience 12: 12.
[5] Baldrighi, M., et al. (2016). "Carbon nanomaterials interfacing with neurons: an in vivo perspective." Frontiers in Neuroscience 10: 250.

(O46) Graphene-based materials interaction with the Central Nervous System

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The growing interest in utilizing graphene (G) and graphene-based materials (GBMs) for applications such as drug and gene delivery, biomedical imaging, and diagnostic biosensors in the central nervous system (CNS) has spurred neuroscientists to investigate the impact of GRMs on primary neural cells. Our focus has centered on characterizing the interactions of G flakes within the CNS and exploring the potential of 2D G-based supports as biocompatible scaffolds for neurological purposes. The goal is to leverage the conductive properties of graphene to regulate neural network activity closely associated with these structures. Our findings reveal that while exposure to G materials does not compromise neuronal and glial viability or blood-brain-barrier permeability, it does exert notable effects on neuronal and glial physiology. These effects encompass synaptic activity, intracellular Ca^{2+} dynamics, and astrocyte glutamate uptake [1-4]. The results suggest that G-Oxide may play a protective role in neuro-pathologies characterized by hyperexcitabilityInterestingly, our ongoing investigation is displaying a very high biocompatibility of G flakes with microglia cells, thus encouraging the future application of GBMs in neuroscience.

Additionally, we delved into the molecular and cellular mechanisms governing the interaction between 2D G-based supports and primary neurons. This exploration aims to evaluate the feasibility of employing these materials as flexible, transparent, and implantable devices for stimulating and triggering neuron excitability [5-7]. We treated monolayer graphene, grown via chemical vapor deposition (CVD), with remote hydrogen plasma to demonstrate that hydrogenated graphene (HGr) enhances cell-to-cell communication in primary cortical neurons compared to pristine graphene. This enhancement manifests through increased excitatory synaptic connections and a doubled frequency of miniature excitatory postsynaptic currents [6]. Once again, there is no sign of glial reactivity when HGr is interfaced with primary astrocytes. Furthermore, we successfully modified P3HB, an amorphous biocompatible polymer, for neuronal interfacing by incorporating GO nano-platelets into the polymer structure [7]. Finally, we are investigating laser-induced graphene 2D supports as their preparation is less time consuming and cheaper compared to CVD-G. These investigations indicate that wettability, more than electrical conductivity, is the crucial parameter to control when designing neural interfaces.

Acknowledgments
AEI RYC2019-027692-I/AEI/10.13039/501100011033; Horizon 2020 Graphene Flagship and MICIN within the framework of a National Plan Project (PID2021-124363OA-I00 and RYC2019-027692-I).

References

[1] M. Bramini et al., *ACS Nano.* 10(7) (**2016**) 7154-71.
[2] M. Chiacchiaretta, M. Bramini et al., *Nano Lett.* 18(9) (**2018**) 5827-38.
[3] M. Bramini, M. Chicchiaretta et al., *Small* 5(15) (**2019**) e1900147.
[4] V. Castagnola et al., *Nano Lett.* 23(7) (**2023**) 2981-2990.
[5] A. Capasso et al., *Adv Funct Mater* 31(11) (**2020**) 2005300.
[6] M. Moschetta et al., *Adv Biol* 5(1) (**2021**) e2000177.
[7] M. Moschetta et al., *Front Neurosci* 15 (**2021**) 731198.

(O47) Polyoxometalate ionic specificity effects for tuning microgel swelling and 2D interfacial self-assembly

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Thermoresponsive microgels are useful as emulsion stabilisers and for Soft Colloidal Lithography (SCL). The SCL uses microgels as building blocks to fabricate lithography masks with submicrometer features, usually only accessible by electron beam lithography. This technique relies on the spontaneous self-assembly of soft microgels at fluid interfaces. Understanding the mechanisms governing their self-assembly at fluid interfaces is key for those applications. In this work, we will present some recent advances on SCL developed in our team.

We will show the influence of Keggin-type polyoxometalate (POM) ions on the swelling and interfacial behaviour of pNIPAM microgels. In bulk, strong charge inversion results from POM absorption at low concentrations, such as 5·10-5 M, due to ionic specificity. We observe an interesting deswelling-swelling-deswelling trend below the Volume Phase Transition Temperature (VPTT) as POM concentration increases. When heating above the VPTT, this mechanism also produces a further deswelling of the microgel.

At the water/air interface, adding POM at a surface pressure of Π = 5 mN/m has an effect on the microgel monolayer equivalent to heating above the VPTT while compressing it in the absence of POM from 5 to 20 mN/m. If the monolayer is heated above the VPTT in the presence of POM, we achieve a further increase in the height of the deposited microgels corresponding to the further deswelling observed in bulk above the VPTT. Increasing the POM concentration above 10-5 M did not have any effect on the microgel monolayer, pointing to a saturation effect at such low concentration. Finally, the deposited monolayer in the presence of POM showed an improved performance as SCL mask, resisting better to air plasma etching [1].

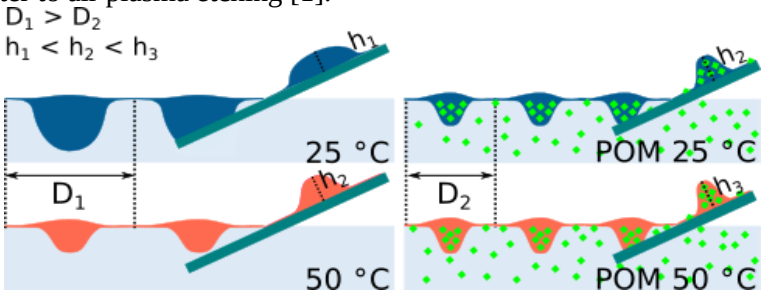

Figure 1. *Graphical abstract showing the effect of POM on microgel monolayers at fluid interfaces. Adding POM below the VPTT at low concentrations of 10^{-5} M reduces the distance between deposited microgels while increasing their height. Above the VPTT, their height is further increased in the presence of POM.*

Acknowledgments

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References

[1] Rubio-Andrés, A., Bastos-González, D., and Fernandez-Rodriguez, M. A. (2023), *arXiv preprint arXiv:2302.14010*.

(O48) Soft magnetic actuators with fast and complex motion obtained by mold casting process

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Soft magnetic actuators are soft materials able to respond to an external magnetic field by locomotion, by changing their temperature o some of their dimensions, or even by bending or twisting. Magnetic field is an attractive stimulus due to the ease of its application, fast response of magnetic actuators, and the safe penetration in biological environments [1, 2]. In this work, we studied the role of the structural organization of magnetic particles within the three-dimensional structure of an alginate hydrogel in the response of the actuators when an external magnetic field was applied. To be precise, the magnetic particles were aggregated into chains of magnetic particles, which programmed the response of the actuator. Firstly, we studied the microstructure of the different actuators using microCT techniques, obtaining structures that ranged from chains of particles with different orientational angles, to randomly distributed particles. Secondly, we studied the response of actuators with the same shape but different particle distribution using mold-casting technique to prepare the actuators, such that the actuators cured in the presence of the field with a particular shape returned to this shape when the actuation field was applied. In addition, following this technique, we developed an actuator that imitated the flapping of a butterfly's wings, with the wings having a fast response to the magnetic field of less than a one second. Finally, torsion in response to the applied magnetic field was also studied for different structures formed by the particle chains within the polymeric network of the actuators, differentiating in this work between two types of structures: i) circular structures and ii) helical structures. The experimental torsional response agreed with the prediction of a theoretical model that we also developed.

Acknowledgments

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References

[1] S. R. Goudu, I. C. Yasa, X. Hu, H. Ceylan, W. Hu, M. Sitti, *Adv. Funct. Mater*. **30** (2020) 2004975.
[2] Y. Kim, H. Yuk, R. Zhao, S. A. Chester and X. Zhao, *Nature*. **558** (2018) 274 – 279.

(O49) Diffusion and interaction effects on molecular release kinetics from collapsed microgels

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The transport of biomolecules, drugs, or reactants in stimuli-responsive polymer networks in aqueous media is fundamental for many material and environmental science applications, including drug delivery, biosensing, catalysis, nanofiltration, water purification, and desalination. The transport is particularly complex in dense polymer media, such as collapsed hydrogels, where the molecules strongly interact with the polymer network and diffuse via the hopping mechanism. In this study, we employ the Dynamical Density Functional Theory (DDFT) to investigate the non-equilibrium release kinetics of non-ionic subnanometer-sized molecules from collapsed microgel particles. The theory is consistent with previous molecular dynamics simulations of collapsed poly(N-isopropylacrylamide) (PNIPAM) polymer matrices, accommodating molecules of varying shapes and sizes [1]. We found that, despite the intricate physico-chemical properties involved in the released process, the kinetics is predominantly dictated by two material parameters: the diffusion coefficient of the molecules inside the microgel (D^*) and the interaction free energy of the molecules with the microgel (ΔG). Our results reveal two distinct limiting regimes. For large, slowly diffusing molecules weakly attracted to the polymer network, the release is primarily driven by diffusion, with a release time scaling as $\tau_{1/2} \sim 1/D^*$. Conversely, for small molecules strongly attracted to the polymer network, the release time is dominated by the interaction, scaling as $\tau_{1/2} \sim \exp(-\Delta G/k_B T)$. Our DDFT calculations are directly compared with an analytical equation for the half-release time, demonstrating excellent quantitative agreement. This equation represents a valuable tool for predicting release kinetics from collapsed microgels of non-ionic molecules.

Acknowledgments

The authors thank the financial support provided by the Junta de Andalucía and European Regional Development Fund - Consejería de Conocimiento, Investigación y Universidad, Junta de Andalucía (Projects PY20-00241, A-FQM-90-UGR20) and The Plan Estatal de Investigación Científica, Técnica y de Innovación (Project PID2022-136540NB-I00). I.A.B. acknowledges María Zambrano Grant funded by MCIN/AEI and NextGenerationEU/PRTR, and the Precompetitive Research Projects Program of the UGR Research Plan (PPJIA2022-46). J.L.M. thanks the Ph.D. student fellowship (FPU21/03568) given by Gobierno de España, Ministerio de Universidades. M.K. acknowledges financial support from the Slovenian Research Agency ARRS (contract P1-0055).

References

[1] M. Kanduč, W.K. Kim, R. Roa, J. Dzubiella, *ACS Nano* **15** (2021) 1.

[2] A. Escañuela-Copado, J. López-Molina, M. Kanduc, A.B. Jódar-Reyes, M. Tirado-Miranda, D. Bastos-González, J.M. Peeula-García, I. Adroher-Benítez and A. Moncho-Jordá, submitted to *Macromolecules* (2024).

(O50) Harnessing Ultrathin Carbon-Coated Nickel Nanoparticles for Efficient Purification of Chromium and Methylene Blue from Aqueous Solutions

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Abstract

The motivation for this work is to develop an effective method for decontaminating wastewater from industries. Water is a fundamental life-giving resource, and industrial activities frequently pose a threat to its purity. One promising approach is to use magnetic nanoparticles (NPs) exhibiting both photocalisys and adsosption functionalities, that can ve easily removed through magnetic separation. Nickel NPs have excellent catalytic activity and moderate saturation magnetization [1], necessary for efficient magnetic separation. Coating these NPs with activated carbon is an ideal strategy for this purpose thanks to its low density and large porosity.

This work focuses on producing and studying carbon-supported nickel NPs derived from nickel-organic frameworks, NiOFs (see Fig. 1). The microstructure and magnetic properties of NPs with various sizes synthesized at different carbonization temperatures were investigated [2]. Our findings indicate that by tuning the fabrication conditions of NiOFs, we can achieve excellent performance for noble metals and dye elimination from water can be achieved. In this presentation, I will discuss which are the best candidates for these purposes.

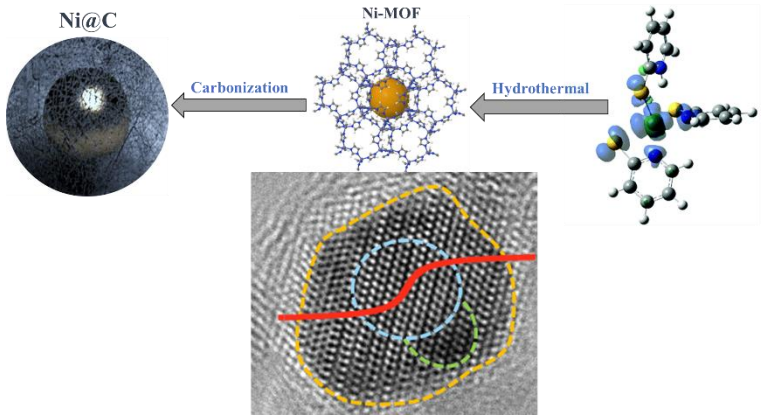

Fig. 1: Schematic of the MOF-derived fabrication of the carbon-coated Ni nanoparticles of this work

Acknowledgments

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References

[1] F. J. Martin-Jimeno, F. Suárez-Garcia, J. I. Paredes, A. Martínez-Alonso and J. M. D. Tascon, J. Alloys Compd., 2021, 853, 157348.

[2] M. Fadel, F. J. Martín-Jimeno, M. P. Fernández-García, F. Suárez-García, J. I. Paredes, J. H. Belo, J. P. Araújo, A. Adawy, D. Martínez-Blanco, P. Álvarez-Alonso, J. A. Blanco

(O51) Fe_3O_4-TiO_2 nanostructures as reusable photocatalysts for water purification treatments

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Interest in titanium dioxide (TiO_2) nanoparticles (NPs) used as photocatalysts has increased in the water cleaning sector, due to their unique characteristics such as non-toxicity, easy preparation, favourable band edge positions, multifaceted electronic properties, super hydrophilicity, etc. Core-shell magnetic photocatalysts combine the advantages of TiO_2 with the possibility of easily recovering them from treated water by applying an external magnetic field.

In the present work, we prepared core-shell magnetic nanoparticles: (A) Fe_3O_4@TiO_2 and (B) Fe_3O_4@SiO_2@TiO_2. Two different methodologies were used in the synthesis of the NPs during the addition of Titanium(IV) tert-butoxide (TBOT): a dropping method (A1, B1) and a single-step approach (A2, B2). Samples were characterized by Transmission Electronic Microscopy (TEM), X-Ray Diffraction (XRD) and Vibrating-Sample Magnetometry (VSM). Photocatalysis was tested by studying the degradation of phenol in an aqueous medium at pH 6.5. Magnetic Induction Heating (MIH) experiments (increase of temperature under AC magnetic field) were additionally performed. XRD indicates a correlation between crystallite size and the method used to introduce TBOT. Specifically, TiO_2 NPs display a crystallite size of approximately 4 nm for A1 and B1, while A2 and B2 exhibited ~~a~~ larger size of around 7 nm. TEM results show a flower type magnetic nucleus (mean diameters ranging from 220 nm to 450 nm) surrounded by spherical morphology. The samples display photocatalytic activity in the UV-Vis range, with enhanced performance of B NPs linked to the higher crystallinity degree of the anatase TiO_2 and the protective role of the SiO_2 shell. Despite the samples show similar magnetizations, enhanced MIH performance were found in samples A for high amplitudes of AC magnetic fields (> 30000 A/m). An increment of almost 20ºC for mg/mL at 311 kHz 20 kA/m (25 mT) was observed in A1 sample that could be employed in pollutant adsorption/desorption processes.

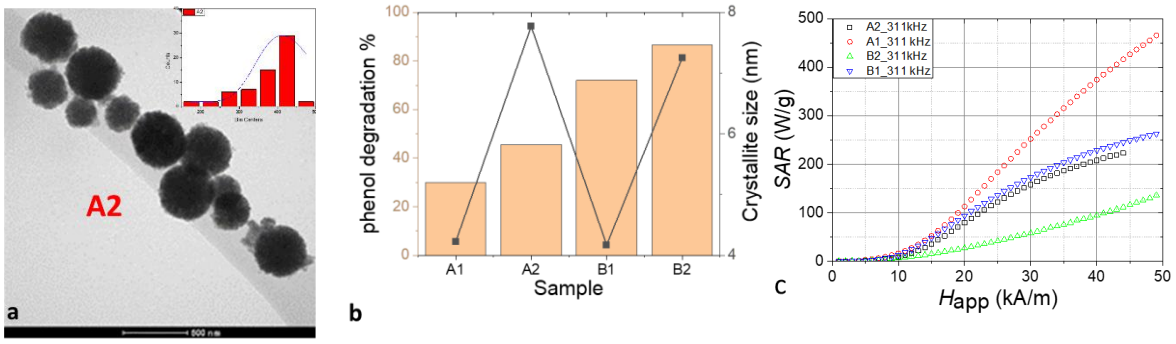

Figure 1. *(a) TEM image for A2 and its histogram, (b) phenol degradation percentage and TiO_2 crystallite size for samples A or B and (c) Specific Absorption Rate (SAR) versus amplitude of the AC magnetic field, H_{pp}.*

Acknowledgments. The research was funded by MCIN/AEI/10.13039/501100011033, grant PID2020-116321RB-C21.

(O52) Implementing Fe_3O_4-biochar based adsorbents for Cr(VI) uptake

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This work demonstrates a novel approach to develop simple, low cost and eco-friendly drinking water adsorbents for Cr(VI) removal, based on the improved performance of an active inorganic phase homogeneously distributed onto the network of different biochar matrices. For the biochar matrix, various agricultural residues including olive stone, hemp stem and sewage sludge were received after pyrolysis while for the production of the inorganic phase, Fe_3O_4 nanoparticles known for their reducing activity toward Cr(VI) to Cr(III) transformation, were synthesized. For the optimization of the Fe_3O_4 nanoparticles adsorption capacity, the role of different iron precursors including $FeSO_4$, $FeCl_2$ and $Fe(NH_4)_2(SO_4)_2$ and various counterions released by reagent compounds (Fe^{2+}, OH^-, NO_3^-), was examined. Fabrication of the examined nanocomposites was carried out by high-energy blending using 10-50 %wt. of the inorganic phase. In this way, Fe_3O_4 nanoparticles were homogeneously distributed within the structure of the biochar, providing magnetic response to the entire composite's volume. Structural characterization and morphological observations revealed the successful incorporation of the magnetic nanoparticles on biochar's amorphous structure. Nanocomposites were evaluated for their Cr(VI) uptake efficiency complying with the upcoming regulation limit (25 μg/L) for drinking water under conditions similar to those met in a typical groundwater, i.e. low concentrations (<100 μg/L), neutral pH, presence of common interfering ions. In particular, loading of 30 %wt. Fe_3O_4 nanoparticles in olive-derived biochar succeeds an increase of adsorption capacity at 3.1 mg/g_{Fe3O4}, comparing to the pure phase of Fe_3O_4 which recorded adsorption capacity at 2.8 mg/g. Finally, taking advantage of the magnetic properties of the fabricated composites, a continuous-flow water treatment unit which combines sufficient adsorption period and complete adsorbent recovery in a linear magnetic separator was designed using numerical modeling of the magnetic separation stage.

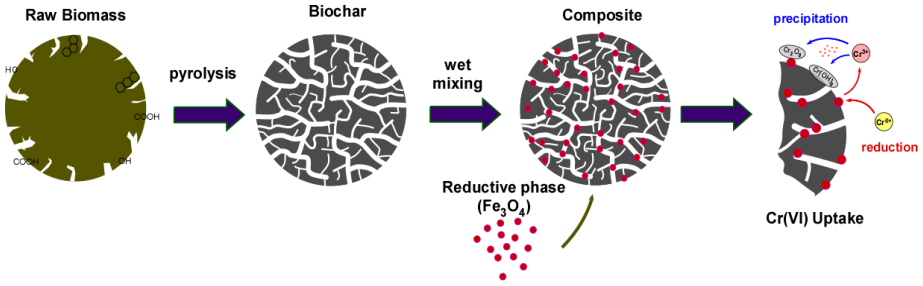

Figure 1. Synthesis route of composite fabrication

Acknowledgments

The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "2nd Call for H.F.R.I. Research Projects to support Post-Doctoral Researchers" (Project Number: 00046 MagnoSorb).

(O53) A mussel-inspired nanocoating for cost-effective and environmentally friendly CO_2 capture

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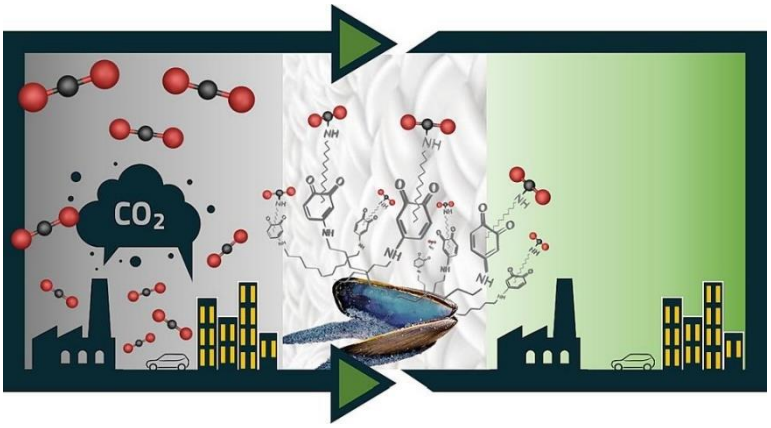
Nowadays, finding innovative technologies to efficiently adsorb/desorb CO_2 over several cycles with low energy consumption is a pressing environmental concern. We have developed a new bioionspired nanocoating based on the copolymerization of benzene-1,2-diol and hexamethylenediamine, with a CO_2 uptake of 7.28 mmol/g under humidified conditions with an outstanding chemical stability and regenerability process.[1] Further functionalization with glycidyltrimethylammonium chloride increases the uptake capacity up to 9.96 mmol/g while lowering the desorption temperature down to 50 °C for 20 min. Moreover, the coating shows strong adhesion on cotton and paper, without modifying their intrinsic permeability and mechanical properties, allowing for the recycling of fully available and environmentally friendly biomass. These results demonstrate the competitive advantages of this bioinspired coating compared with current technologies to capture CO_2 while accomplishing the resource efficiency of bioeconomy policies.



An innovative bioinspired nanocoating for CO_2 sorption.

Acknowledgments

This work was carried out with the financial support of the Italian Ministry of Universities and Research -MUR (PON R&I 2014-2020. AIM1899391-2.) in the framework of the Project AIM "Attraction and International Mobility". The authors would like to acknowledge the funding support from grant PID2021-127983OB-C21 funded by MCIN/AEI/ 10.13039/501100011033 and by ERDF "A way of making Europe". The ICN2 is funded by the CERCA programme/Generalitat de Catalunya. The ICN2 is supported by the Severo Ochoa Centres of Excellence programme, Grant CEX2021-001214-S, funded by MCIN/AEI/10.13039.501100011033.

References

[1] S. Suárez-García, I. Nicotera, D. Ruiz-Molina, C. Simari, *Chem. Eng. J.* **473** (2023) 145280.

(O54) Nanomaterial Editorial Presentation.

Paulina Mariarz. (Journal Relations Specialist in "Nanomaterials")

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Introduction to MDPI Nanomaterials: The upcoming presentation will provide insights into the development of the Nanomaterials journal, empower scholars with the knowledge of the peer-review process, and discover tailored opportunities for cooperation with our Journal

nanomaterials
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Nanomaterials (ISSN 2079-4991) is an international, peer-reviewed, interdisciplinary scholarly open access journal, published semimonthly online by MDPI. It publishes reviews, regular research papers, communications, and short notes that are relevant to any field of study that involves nanomaterials, with respect to their science and application. Thus, theoretical and experimental articles will be accepted, along with articles that deal with the synthesis and use of nanomaterials. Articles that synthesize information from multiple fields, and which place discoveries within a broader context, will be preferred. There is no restriction on the maximum length of the papers. Our aim is to encourage scientists to publish their experimental and theoretical research in as much detail as possible. Full experimental or methodical details, or both, must be provided for research articles. Computed data or files regarding the full details of the experimental procedure, if unable to be published in a normal way, can be deposited as supplementary material.

Scopes

Nanomaterials are materials with typical size features in the lower nanometer size range and characteristic mesoscopic properties; for example quantum size effects. These properties make them attractive objects of fundamental research and potential new applications. The scope of Nanomaterials covers the preparation, characterization and application of all nanomaterials.

- Nanomaterials:
- Nanoparticles, coatings and thin films, inorganic-organic hybrids and composites (i.e. MOFs), membranes, nano-alloys, quantum dots, self-assemblies, graphene, nanotubes, etc
- Methodologies:
- Synthesis of organic, inorganic, and hybrid nanomaterials
- Characterization of mesoscopic properties
- Modelling of nanomaterials and/or mesoscopic effects
- Applications: Any application of new nanomaterials or new application of nanomaterials.

(O55) New mussel-inspired nanomaterials with antimicrobial properties

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Infectious diseases related with microorganisms such as virus, bacteria or fungi outcome to be a huge health issue. In fact, multidrug resistant bacteria are increasingly becoming a public health risk as conventional antibiotics cannot provide protection.[1] According to the World Health Organization, it is estimated that more than 1.2 million deaths were directly related with bacterial antimicrobial resistance and contributed to more than 4 million deaths in 2019.[2] Thus, it is urgently needed the seek for conventional alternatives. Some of the proposed options include metallic nanoparticles such us iron oxide, gold or silver.[3] Although they possess great properties as size tunability or functionalization versatility, metallic nanoparticles often lack biocompatibility.[4] As an alternative, bioinspired polymers have also gain interest in the field. Some of them may present intrinsic antimicrobial properties as well as low toxicity for the human body.[5]

Different polyphenols and catechol-based compounds can be found in nature. These molecules possess the remarkable ability to generate reactive oxygen species (ROS), showcasing bactericidal properties as they disrupt the cellular structures of bacteria.[6] In this work, we have combined different commercially available catechol-based molecules with amines by a straightforward methodology. Interestingly, by tunning the synthetic parameters, we can obtain different materials (nanoparticles, coatings or free-standing films) with antimicrobial properties that can be exploited.

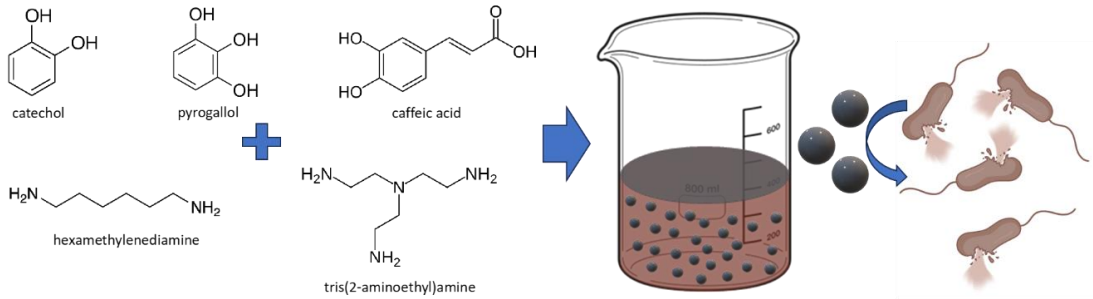

Figure 1. Formation of bioinspired nanomaterials with antimicrobial capabilities.

Acknowledgments

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References

[1] B. Kaczmarek. *Materials*, ***13*(14)** (2020) 3224.
[2] World Health Organization. (2023). Antimicrobial resistance. Retrieved from https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance
[3] S. Wahab, A. Salman, Z. Khan, S. Khan, C. Krishnaraj, S. Yun, *Int. J. Mol. Sci.* **24(19)**, (2023)
[4] R. Singla, A. Guliani, A. Kumari, & S.K. Yadav, *Nanoscale materials in targeted drug delivery, theragnosis and tissue regeneration*, (2016) 41.
[5] F. Khan, N.I. Bamunuarachchi, N. Tabassum, Y.M. Kim, *J. Agric. Food Chem.* **69(10)**, (2021) 2979.
[6] H. Li, X. Zhou, Y. Huang, B. Liao, L. Cheng, B. Ren, *Frontiers in Microbiology*, **11**, (2021)

(O56) Exploring the Impact of Nanoparticle Stealth Coatings in Cancer Models: From PEGylation to Cell Membrane Coating Nanotechnology

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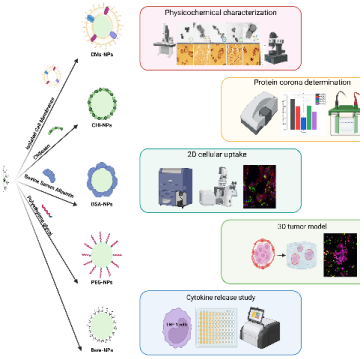
Nanotechnological platforms offer advantages over conventional therapeutic and diagnostic modalities. However, efficient biointerfacing of nanomaterials for biomedical applications remains challenging. In recent years, nanoparticles with different coatings have been developed to reduce non-specific interactions, prolong circulation time, and improve therapeutic outcomes. This study aims to compare various nanoparticle coatings to enhance surface engineering for more effective nanomedicines. We prepared and characterized polystyrene nanoparticles with different coatings of polyethylene glycol, bovine serum albumin, chitosan, and cell membranes from a human breast cancer cell line. The coating was found to affect colloidal stability, adhesion, and the elastic modulus of NPs. Protein corona formation and cellular uptake of NPs were also investigated, and a 3D tumor model was employed to provide a more realistic representation of the tumor microenvironment. The prepared NPs were found to reduce protein adsorption, and cell membrane-coated nanoparticles showed significantly higher cellular uptake. The secretion of proinflammatory cytokines of human monocytes after incubation with the prepared NPs was evaluated. Overall, the study demonstrates the importance of coatings in affecting the behavior and interaction of nanosystems with biological entities. The findings provide insight into bio-nano interactions and are important for the effective implementation of stealth surface engineering designs.



Graphical Abstract

Acknowledgments

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References

[1] Pablo Graván, Jesús Peña-Martínez, Julia López de Andrés, María Pedrosa, Martín Villegas-Montoya, Francisco Galisteo-González, Juan A. Marchal, Paola Sánchez-Moreno. *ACS Applied Materials & Interfaces, Accepted 19 december 2023.*

(O57) Biofunctionalization of 3D microstructures via dip-pen nanolithography

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Mechanical properties of the extracellular matrix can strongly influence cellular reactions. For this reason, many efforts have been devoted to the development of fabrication tools for to mimic the physiological microenvironment of living cells to build realistic in-vitro models.[1]

Three-dimensional printing has become a versatile tool for printing biomimetic scaffolds and for other biomedical applications. While direct laser writing (DLW) and similar techniques, have made impressive progress to achieve arbitrary 3D shapes, the bioactive functionalization of such microstructures remains challenging due to limitations related to the requirements that the ink needs to fulfil in order to be writable.[2] To overcome this problem, the use of Dip-Pen Nanolithography[3] -a scanning probe lithography technique where an atomic force microscope probe is used to create patterns directly on a range of substances with a variety of inks- is proposed as a post-processing strategy, as it can add the necessary functional elements (nanoparticles, biomolecules, etc.) on the surface of these 3D structures.[4] We have successfully incorporated different biomolecules (lipids, proteins, DNA) on the surface of 3D printed microstructures and demonstrated that it is a useful approach to create binding sites for cells (Figure 1).

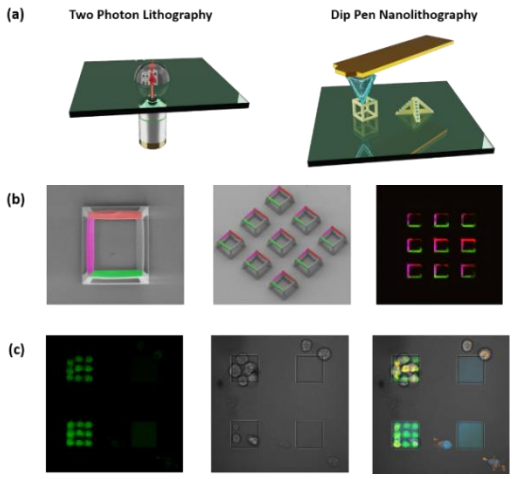

Figure 1. (a) The two techniques used to fabricate 3D cell scaffolds. (b) Polymeric scaffolds with different lipid inks selectively coating different parts of the structures. (c) Fibronectin spots patterned on squared-shaped scaffolds showing that they can selectively bind fibroblasts.

References

[1] J. L. Young, A. W. Holle, J. P. Spatz, *Exp. Cell Res.* **343**, (2016) 3.
[2] M. Hippler, E. D. Lemma, S. Bertels, E. Blasco, C. Barner-Kowollik, M. Wegener, M. Bastmeyer, *Adv. Mat*. **31**, 26, (2019) 1808110.
[3] M. Hirtz, A. Oikonomou, T. Georgiou, H. Fuchs, A. Vijayaraghavan, *Nat. Commun*. **4**, (2013) 2591
[4] G. Mathew, D. Fontana, S. Sekula-Neuner, J. Aghassi-Hagmann, E. Lemma, M. Hirtz, E. Berganza. *in preparation*. (2024)

(O58) CTPR390, an Hsp90-inhibiting nanoparticle, reverses fibrotic phenotype in a human model of cardiac fibrosis

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The combination of nanoparticles (NPs) and protein structures has emerged as a promising approach for biomedical applications, such as drug delivery, imaging, and diagnostics. In this study we investigates the therapeutic potential of CTPR390 [1], a nanoparticle that inhibits the chaperon Hsp90, in a human model of cardiac fibrosis induced by Transforming Growth Factor β (TGFβ), a key cytokine promoting fibrosis.

The 3D model used for the assays with CTPR390 is composed of a combination of matrix components and fibroblasts, referred to as Engineer Cardiac Tissue ECT [2]. This model will be subjected to an external stimulus to create a pathological condition, followed by treatment with CTPR390 a nanodrug constructed from engineered protein domains based on tetratricopeptide repeats (TPR). The response of the human cardiac model will then be analyzed at different levels.

The study demonstrated that CTPR390 effectively restores the biomechanical properties of fibrotic ECT, matching those of the control state. This compound also reduces the expression of profibrotic genes and proteins in ECT fibroblasts, indicating its ability to inhibit the fibrotic cell phenotype. At the same time, it reverses TGFβ-induced accumulation of fibroblasts on the ECT surface, suggesting its ability to modulate their behavior and decreases structured collagen production in fibroblasts from fibrotic ECT treated with CTPR390 compared to untreated ones, aligning with the observed reduction in overall collagen deposition. Application of synchrotron small-angle X-ray scattering (SAXS) supports this idea by revealing inhibition of the formation of structured and oriented collagen matrices in TGFβ-activated ECTs treated with CTPR390, technique used to study the structure of materials at the nanoscale, in this case, used to study the structure of CTPR390 and their interactions with cells and the extracellular matrix. In summary, these results demonstrate that CTPR390 emerges as a promising therapeutic agent for the treatment of cardiac fibrosis, with the potential to reverse both biomechanical and cellular alterations associated with this condition.

Acknowledgments

These findings were achieved through a collaborative effort with research teams headed by Dr. Susanne Luzt from the University of Göttingen, Dr. Cortajarena from CICbiomaGUNE and Dr. Cano Carlos Donostia International Physics Center.

References

[1] R.A. Cáceres, T. Chavez, D. Maestro, A.R. Palanca, P. Bolado, F. Madrazo, A. Aires, A.L. Cortajarena, A. V. Villar, Reduction of cardiac TGFβ-mediated profibrotic events by inhibition of Hsp90 with engineered protein, J. Mol. Cell. Cardiol. 123 (2018) 75–87. https://doi.org/10.1016/j.yjmcc.2018.08.016.
[2] G.L. Santos, S. Hartmann, W.H. Zimmermann, A. Ridley & S. Lutz, J. Mol. Cell. Cardiol. 134 (2019) 13-28.

(O59) Bioadhesive and antibacterial catechol-based membranes and their applications in wound-healing and tissue regeneration

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Biomaterial development has become one of the main research focuses towards tissue regeneration in the biomedical field. There is a prominent need for innovative materials that can act as bridge between damaged tissues, while also acting as scaffolds for drug delivery, cell therapy, and other types of precision medicine. The overall objective is promoting tissue regeneration while avoiding negative consequences such as acute rejection, cytotoxicity or chronic inflammation. Synthetic materials are no stranger to these issues, which is why materials found in nature can be an invaluable source of inspiration towards this goal.

Some strong contenders are mussel-inspired materials, based on catechol compounds, due to their strong adhesion in wet environments (Figure 1a). Using these materials, our group was able to develop and patent[1] catechol-based membranes that present several interesting qualities and show promise in this field. This technology has been validated *in-vivo* using autologous cells for cartilage regeneration in rats, resulting in great bioadhesion, high biocompatibility, and the ability to transfer cells to the damaged tissue resulting in more efficient regeneration. Currently, we are working on identifying and documenting the reach of their antibacterial capacity, complementing the *in-vitro* validation utilizing different human cell types, and validating skin regeneration *in-vivo*. Furthermore, new types of membranes are being developed in order to target different pathologies, such as the synthesis of conductive membranes towards neuron regeneration and the treatment of glioblastoma (Figure 1b).

The versatility of this technology opens up new and exciting possibilities in this field, allowing us to adapt the system based on the needs of each patient.

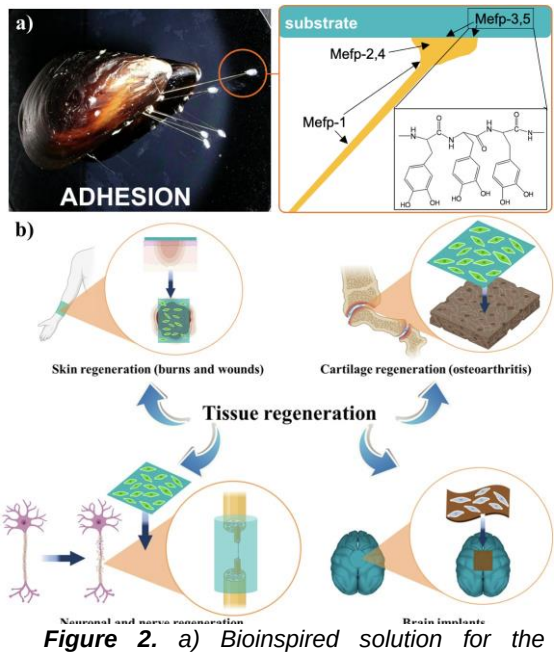

Figure 2. *a) Bioinspired solution for the formation of biocompatible and bioadhesive membranes. b) Different target tissues and pathologies for the promotion and enhancement of tissue regeneration using the developed bioinspired membranes.*

Acknowledgments

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References

[1] suárez-García, S., Saiz-Poseu, J., Ruiz-Molina, D. Catecholamine-based membrane, process for its preparation and uses thereof, WO2022258780 A1.

(O60) The key parameters in phototherapy with gold nanorods combined with targeted solid lipid nanoparticles for controlled drug delivery.

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As nanoparticle formulations move towards human clinical trials in photothermal cancer therapy (PTT), the influence of individual key parameters on the heating efficacy must be thoroughly assessed [1]. This work reports a systematic study on the heating performance of gold nanorods during exposure to near-infrared radiation, evaluating the influence of nanorods concentration, total volume, laser output power, and spot area. Interestingly, the lowest concentration tested (24 µg mL-1) showed the most promising results with a SAR (Specific Absorption Rate) value of 24.6 kW gAu-1 for the highest laser power (0.8 W), spot area (0.4 cm2) volume (1mL) [2]. The laser output power and concentration proved to be the key parameter in global heating of the sample. The cuvette´s optical path length also proved to be an important parameter given that there is a threshold concentration value beyond which no significant improvement will be observed, and the higher gold mass will play a detrimental role suppressing SAR values. After the multi-parameter exploration and the finer control of the performance in PTT, we developed a novel multifunctional nanosystem based on solid lipid nanoparticles (SLN) co-loaded with gold nanorods (AuNRs) and Mitoxantrone (Mito) and functionalized with folic acid (FA) for dual PTT and chemotherapy of breast cancer [3, 4]. Near-Infrared (NIR) irradiation (808 nm, 1.7 W cm^{-2}, 5 min) resulted in an enhanced release of the drug. The active targeting strategy was found to be successful, as shown by the greater accumulation of the functionalized SLN in MCF-7 cells. Finally, the combined effects of chemotherapy, NIR-induced drug release and PTT significantly enhanced breast cancer cell death. Overall, these results demonstrate that the developed lipid nanosystem is an efficient vehicle for breast cancer multimodal therapy.

Acknowledgments

FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) and the program Atraccion de Talento (CAM), ref. 2020-T1/IND-19889.

References

[1] A.Granja, M.Pinheiro, C.T. Sousa and S.Reis, *Biochemical Pharmacology* **190** (2021)
[2] S.Freitas et. al., *Advanced Materials Interfaces* **10** (2023), 2202214.
[3] A.Granja, C.Nunes, C.T. Sousa and S.Reis, *Biomedicine & Pharmacotherapy*, 154 (2022)
[4] A.Granja,S.Reis, Biomaterials Advances, 151 (2023) 213443.

(O61) Innovative drug delivery system based on hyaluronic acid-functionalized biomimetic-magnetoliposomes

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Nanotechnology has gained significant attention with a particular emphasis on oncology, offering novel therapeutic possibilities that may overcome limitations of conventional treatments. One appealing approach involves drug delivery systems (DDS) designed to exploit the unique properties of tumor cells or their *milieu*, mirroring the benefits of localized treatments.

Nanoparticles (NPs) represent the "magic bullet" concept, selectively delivering therapeutic molecules to tumor cells while saving healthy ones, reducing systemic exposure and adverse effects.

The most used magnetic NPs (MNPs) are the ones composed of iron oxide and obtained by synthetic chemistry. In addition, a particular type of biomimetic MNPs (BMNPs), synthetized in presence of the MamC protein from *Magnetococcus marinus* MC-1, display interesting applications in cancer therapy[1].

Recently, BMNPs covered by a lipid layer of 1,2-distearoyl-sn-glycero-3-phosphocholine, the so-called LP(BMNPs), have been used as DDS[2]. MamC protein plays a crucial role in the mineralization process of the nanocrystals[3], and it also imparts a negative charge to BMNPs, facilitating their functionalization with chemotherapeutic drugs like doxorubicin (DOXO)[4].

Among targeting agents directed against tumor associated markers, hyaluronic acid (HA) is an anionic glycosaminoglycan interacting with CD44 receptor that is overexpressed in several solid cancers and its aberrant expression contributes to tumor initiation and progression. So, the pleiotropic roles of CD44 in carcinoma potentially offer new molecular target for therapeutic intervention[5].

Herein, 14800 Da HA has been linked to an aminated phospholipid (1,2-dipalmitoyl-sn-glycero-3-phosphoethanolamine, DPPE) by reductive amination[6] and used in the production of HA-LP(BMNPs) nanoformulations. BMNPs were synthetized, functionalized with DOXO, and then encapsulated in +/-HA conjugated liposomes obtaining +/-HA-LP[(+/-DOXO)-BMNPs]. The obtained nanocomplexes were extensively chemical-physical characterized and the crystals inside the nanoformulations showed a rhombic shape, with a size lower than 200 nm, a negative ζ-potential value and their effective functionalization with the different moieties was confirmed.

In vitro biological tests were performed in red blood cells (hemolysis test) and with several cell lines of human breast cancer (MDA-MB-231 and MCF7) and human ovarian cancer cell line (A2780). Biocompatibility was analyzed by ROS production and MTT assay and +/-HA-LP(BMNPs) were not found to have cell toxicity.

The targeting ability of HA-LP(BMNPs) was evaluated on three cancer cell lines with high (MDA-MB-231), middle (MCF7) and low (A2780) CD44 expression. To this aim, the cellular interactions of the nanocomplexes were assessed and the results showed that the uptake of HA-LP(BMNPs) was significantly higher in MDA-MB-231 cells, suggesting that the interaction of HA-conjugated formulations is receptor-mediated. Moreover, incubation of LP(DOXO-BMNPs) with different cell lines exerted cytotoxic activity, increased when HA is conjugated to the nanoformulations.

These promising findings show the potential of HA-LP(DOXO-BMNPs) as magnetic DDS paving the way for the development of powerful approaches for cancer therapy.

Acknowledgments

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References

[1] F. Oltolina et al., *Cancers.* **12(9)** (2020).
[2] F. Oltolina et al., *Int J Mol Sci.* **24(18)** (2023).
[3] C. Valverde-Tercedor et al., *Appl. Microbiol. Biotechnol.* **99** (2015).
[4] A. Peigneux et al., *Part. Part. Syst. Charact.* **36** (2019).
[5] H. Xu et al., *Exp Hematol Oncol.* **9(1)** (2020).
[6] S. Arpicco et al., *C., Eur. J. Pharm. Biopharm.* **85** (2013).

(O62) Lipid-based nanoparticles as carriers for treatment of infectious and degenerative eye pathologies

Ilaria Clemente[1,2,3*], Luigi Talarico[1,2,3], Giulia Gabbricci[1,2,3], Simone Pepi[1,2,3], Claudia Bonechi[1,2,3], Gemma Leone[1,2,3], Agnese Magnani[1,2,3]

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Infectious and degenerative eye diseases play a major role among leading causes of blindness worldwide. Due to its anatomy and the direct exposure to the environment, the human eye and the related structures are particularly vulnerable to fungal and parasitic infections [1].

Fungal keratitis is a major cause of visual impairment in corneal diseases and its topical treatment is still complex, often requiring additional intervention with injections or surgery. Natamycin, a tetraene polyene which acts by binding to the main component of fungal walls i.e. ergosterol, thus blocking fungal growth, is the main antifungal drug currently employed in topical treatments. However, its low retention at the ocular surface and scarce penetration across inner ocular tissues pose significant challenges [2].

Age-Related Macular Degeneration (AMD) is the leading cause of irreversible vision loss in people over 60 years [3], characterized by massive production of vascular endothelial growth factor (VEGF), which leads to excessive choroidal neovascularization. The topical use of corticosteroids as anti-inflammatory agents has proven effective in decreasing permeability of choroidal endothelial cells and VEGF expression. Triamcinolone acetonide is an angiostatic steroid that showed efficacy against neovascularization in various eye segments, yet its poor water solubility and consequent low bioavailability limit its administration [4].

In this work, lipid nanoparticles (LNPs) are proposed as carriers for topical administration of natamycin and triamcinolone acetonide, to enhance delivery and permeation capabilities as eye drop formulations. Size, stability and surface properties of the nanosystems were characterized by Dynamic Light Scattering and Zeta potential, supramolecular structure and carrier- cargo interactions were investigated by Small Angle X-ray Scattering and Nuclear Magnetic Resonance, whereas encapsulation efficiency was assessed by High Performance Liquid Chromatography. Moreover, subsequent optimization of the synthetic procedure by using a microfluidic apparatus for better reproducibility and scalability of the nanoformulations is being carried out.

References

[1] S. A. Klotz, CC Penn, GJ Negvesky, SI Butrus, *Clin Microbiol Rev*. **13** (2000) 662-685.
[2] A. Patil, P. Lakhani, S. Majumdar, *J Drug Deliv Sci Technol* **41** (2017) 206-212.
[3] L. Talarico, S. Pepi, S. Susino, G. Leone, C. Bonechi, M. Consumi, I. Clemente, A. Magnani, *Molecules* **28** (2023) 5747.
[4] J. Li, T. Cheng, Q. Tian, Y. Cheng, L. Zhao, X. Zhang, Y. Qu, *Drug Deliv* .**26** (2019) 188-198.

(O63) Anti-ferroelectric dark modes in plasmonic lattices

Javier Rodríguez-Álvarez[1,2,*], Amílcar Labarta[1,2], Juan Carlos Idrobo[3], Rossana Dell'Anna[4], Alessandro Cian[4], Damiano Giubertoni[4], Xavier Borrisé[5], Albert Guerrero[5], Francesc Pérez-Murano[5], Arantxa Fraile Rodríguez[1,2] and Xavier Batlle[1,2].

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Here, we present a detailed study of dark and bright modes in the visible and near-infrared energy range for an inverted plasmonic honeycomb lattice by a combination of state-of-the-art Au+ focused ion beam lithography, optical and electron spectroscopy, and finite-difference time-domain simulations. The lattice consists of slits carved through an Au thin film and exhibits a plethora of resonances in the visible and near-infrared ranges.

A detailed description of the charge distribution and near-field enhancement has been provided by virtue of the good agreement between the electron energy loss spectroscopy (EELS) measurements (see Figure 1), the optical spectra, and simulations. The most remarkable result is the finding of dark modes that may be caused by antiferroelectric arrangements of the slit polarizations, giving rise to charge distributions with a unit cell two times larger than that of the original honeycomb lattice (Figure 1b and 1e). Additionally, bright plasmonic modes exhibiting hotspots far from the metal slits are also found. The studied plasmonic resonances take place within 0.5 and 2 eV energy range, indicating that they could be suitable for designing nanoscale sensing platforms based on near-field enhancement over a metallic surface. Several energies could be targeted by easily tuning manufacturing parameters such as the pitch of the lattice, thus changing the spectral position of the plasmonic resonances. The potential applications also include the coupling of those dark modes with the discrete energies that characterize the excitations of dyes and other molecules of interest.

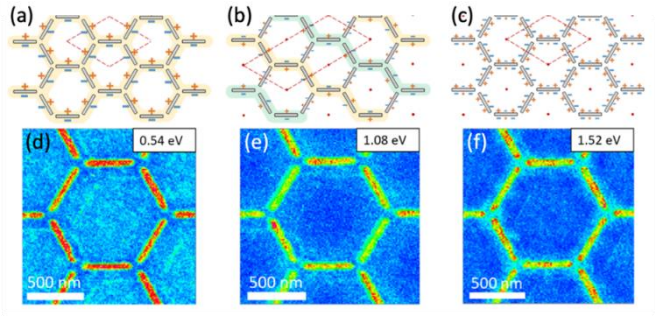

Figure 1. *Plasmonic modes measured in the lattice at three different energies. (a), (b) and (c) show schematic representations of the charge distributions associated with a bright mode and two examples of extended and local dark modes, respectively. Panels (d), (e) and (f) present the EELS mapping for each of the modes depicted in the upper panels.*

References

[1] J. Rodríguez-Álvarez, et al., *ACS Nano*, 2023, 17(9), 8123-8132.

(O64) The Cleanroom free, Cheap and Rapid Fabrication of Nanoelectrodes for Single Molecule Detection

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Nanoelectrodes have been the subject of intensive research for decades.(Arrigan, 2004) Their enhanced signal-to-noise ratios mean that they are capable of achieving unparalleled limits of detection and sensitivities.(Schmueser et al., 2013) However, their widespread adoption has been limited due to their high manufacturing costs and fabrication methods that require expensive facilities, such as cleanrooms. In this work a novel method of nanoband electrode fabrication has been developed and optimised. Using equipment and materials commonly found in laboratories around the world, the final cost of each nanoelectrode can be as low as €0.01. The electrodes have been fully characterized and their performances mimic those of other nanoelectrodes in the literature.(Piper et al., 2018; Piper and Mount, 2017) As a proof of concept these electrodes were functionalized for the detection of DNA and were found to have single molecule detection capabilities. The ability to fabricate ultrasensitive electrodes using commonplace, low-cost, laboratory equipment has the potential to revolutionize the field of biosensors.

References

Arrigan, D.W.M., 2004. Nanoelectrodes, nanoelectrode arrays and their applications. Analyst 129, 1157–1165. https://doi.org/10.1039/B415395M

Piper, A., Alston, B., Adams, D., Mount, A.R., 2018. Functionalised Microscale Nanoband Edge Electrode (MNEE) Arrays; the systematic quantitative study of hydrogels grown on nanoelectrode biosensor arrays for enhanced sensing in biological media. Faraday Discuss. https://doi.org/10.1039/C8FD00063H

Piper, A., Mount, A., 2017. Electrochemical characterisation of microsquare nanoband edge electrode (MNEE) arrays and their use as biosensors. Chemistry (Easton). University of Edinburgh.

Schmueser, I., Walton, A.J., Terry, J.G., Woodvine, H.L., Freeman, N.J., Mount, A.R., 2013. A systematic study of the influence of nanoelectrode dimensions on electrode performance and the implications for electroanalysis and sensing. Faraday Discuss. 164, 295–314. https://doi.org/10.1039/c3fd00038a

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(O65) PEGylated Ag_2S nanoparticles as multifunctional biological probes

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Abundant applications in the biomedical context have employed Ag_2S nanoparticles (NPs) as probes, demonstrating their enormous potential in the field. Ag_2S is a chalcogenide material of major interest due to its versatile structure and superior optical properties opening doors to their use as multifunctional optical probes. Nevertheless, to exploit at maximum the versatility of this material, it is necessary to highlight the extreme importance of choosing carefully the functionalization of these nanoparticles, due to the influence that surface properties have on their *in vivo* behavior.[1] Above others, PEGylation of nanoparticles is a widely used strategy that provides good stability and biocompatibility in biological environments. However, size and charge of the polyethylene glycol (PEG) chains affects the properties of the PEGylated NPs, ultimately having a significant impact on the formation of the so-called biological protein corona. The latter consists of the agglomeration of proteins on the surface of the nanomaterials when they are immersed in biological fluids, altering their physicochemical properties *in vivo*, which has been related to a decrease of targeting capabilities and cellular uptake.[2] Henceforth, a preliminary *in vitro* study of PEGylated Ag_2S NPs differing in charge, size and grafting density was carried out, in order to systematically analyze the influence that different functionalizations exert on their physicochemical and optical properties and their consequent formation of protein corona. Having clarified the foregoing, rationally selected PEGylated Ag_2S NPs were employed for such diverse *in vivo* applications as selectively targeted imaging of acute myocardial infarct, luminescence-based transient thermometry in the liver or thermal sensing for controlled brain hyperthermia. Looking more closely at one of the applications, negatively-charged PEGylated Ag_2S NPs were consciously selected for *in vivo* absolute temperature monitoring of induced inflammation in the liver.[3] Ag_2S NPs were revealed as robust and reliable lifetime-based luminescent nanothermometers *in vivo*, with remarkable thermal sensitivity (~ 3 %·ºC^{-1}) and thermal resolution (< 0.3 ºC). This opened the use of Ag_2S NPs as *in vivo* nanothermometry probes, and the intracorporeal temperature readout as a physiological and pathological diagnostic indicator.

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References

[1] J. Javidi, A. Haeri, F. Nowroozi, S. Dadashzadeh, *Pharm. Res.* **36 (3)** (2019), 46.
[2] J. Di, X. Gao, Y. Du, H. Zhang, J. Gao, A. Zheng. *Asian J. Pharm. Sci.* **16 (4)** (2021), 444–458.
[3] Y. Shen, J. Lifante, I. Zabala Gutierrez, M. de la Fuente-Fernández, M. Granado, N. Fernández, J. Rubio-Retama, D. Jaque, R. Marin, E. Ximendes, A. Benayas, *Adv. Mater.* **34 (7)** (2022)

(O66) Quantifying the temperature increase in optically trapped absorbing particles

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Micro and nanoparticles that combine multiple functionalities are sought after in biomedical applications [1-3]. In this work, we evaluate the capability of two types of assemblies that have magnetic properties thanks to the presence of magnetite that can be used as local heaters while illuminated with infrared light. Specifically, we consider microgels decorated with magnetite nanocubes [4] and nanoflowers composed of a gold core and magnetite petals [1,5]. In both cases, we evaluate their capability for light-to-heat conversion at the single particle level while they are trapped with an optical tweezers device [4,5]. In this situation, the trapped particles are in a non-equilibrium steady state called Hot Brownian Motion characterized by the temperature contrast between the absorbing particle and the bulk far from the particle, developing temperature gradients around the particle [6].

Microgels are soft systems comprised of crosslinked hydrogels that often exhibit thermoresponsiveness and collapse above a volume phase transition temperature (VPTT). The proximity of the VPTT to physiological temperatures (e.g., ≈32 °C for pNIPAM) together with their capability to carry cargo makes them very well suited to develop interesting applications, including their use as drug-delivery carriers, their potential applicability in the exploration of synthetic cell research, the design of microswimmers that move thanks to the responsiveness, and, more recently, to locally sense temperature [7]. In this work, we discuss the dynamics of a composite made of a pNIPAM microgel decorated with magnetite nanocubes that can both locally heat up and identify the surpass of threshold temperature determined by the VPTT of the microgel. Above a certain laser power, a single decorated microgel features a sharp volume phase transition, i.e., occurs at a particular power value. Since the VPTT can be modified by adding amphoteric and other functional groups to the microgel polymer network, the system can be used as a local probe tuned to keep heating under a certain threshold that might be identified as critical.

Further, we use the same technique to analyse the dynamics of multicomponent nanoparticles composed of a gold core decorated with magnetite petals [5]. In this case, we compare the temperature obtained from the analysis of the Hot Brownian motion with a local measurement of the temperature based on the photoluminescence of nanothermometers.

References

[1] C. Caro, F. Gámez, ... & M. L. García-Martín, *Pharmaceutics* **13** (2021), 416.
[2] E. Ximendes, et al., *Advanced Materials* **33** (2021) 2100077.
[3] M. Lázaro, P. Lupiáñez, J. L. Arias, M. P. Carrasco-Jiménez, A. V. Delgado, G. R. Iglesias, *Polymers* **14** (2022) 4913.
[4] M. A. Fernandez-Rodriguez, S. Orozco-Barrera, W. Sun, F. Gámez, C. Caro, M. L. García-Martín, & R. A. Rica, *Small* (2023) 2301653.
[5] E. Ortiz-Rivero, S. Orozco-Barrera, H. Chatterjee, C. D. González-Gómez, ... , R. A. Rica & F. Gámez, *ACS Nano* **17** (2023) 24961
[6] D. Rings, R. Schachoff, M. Selmke, F. Cichos, & K. Kroy, *Phys. Rev. Lett.* **105** (2010)
[7] T. Muñoz-Ortiz, I. Alayeto, J. Lifante, D. H. Ortgies, R. Marin, E. M. Rodríguez, ... & D. Jaque, *Advanced Materials* **35** (2023) 2301819.

(O67) Microgel-laden thermoresponsive surfaces for biomedical applications

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The design and fabrication of innovative platforms able to imitate specific cellular environments in which cells can properly survive, grow and replicate is of utmost interest for the future of biomedical engineering. Among the biocompatible and bioinspired materials as active components, microgels are increasingly emerging as valuable candidates for bio-applications [1]. Here, we synthesized poly(N-isopropylacrylamide) (pNIPAM) and poly(N-vinyl caprolactam) (pVCL) microgels with different crosslinking densities via precipitation polymerization. The resulting microgel dispersions were used to self-assemble microgel monolayers at water/air interfaces and deposit them on glass substrates by Langmuir-Blodgett depositions. The physico-chemical parameters of these microgel-laden substrates such as spatial distribution and maximum height were examined by Atomic Force Microscopy (AFM). We demonstrate that the microgel substrates, as well as bulk microgels do not impair cell proliferation. Specifically, both substrates demonstrated effective control for cell growth, however only pNIPAM films can be used to successfully detach cells. Interestingly, pVCL films showed high propensity to adsorb proteins, allowing their possible application in diagnostics and/or theranostics. Finally, we demonstrate the crosslinking density and thus, height and swelling ratio were a key factor to determine whether the proteins and cells could detach from the film easily.

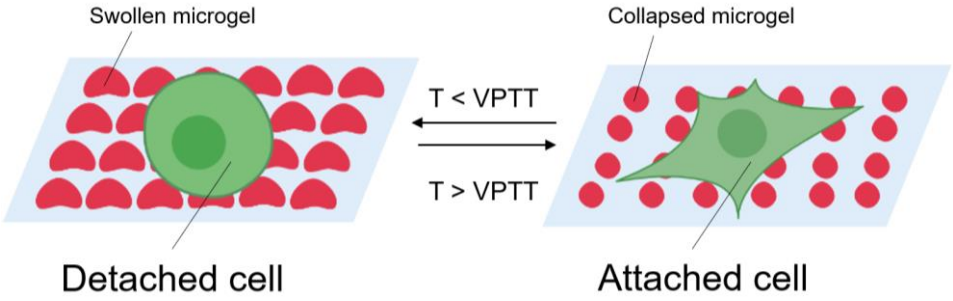

Figure 1. The thermoresponsive microgel-laden surfaces induce different cell morphologies.

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References

[1] J. Wei et al. Investigation of cell behaviors on thermo-responsive PNIPAM microgel films, Colloids and Surfaces B: Biointerfaces 132 (2015), 202–207.

Poster presentations

(P1) Surface-enhanced Raman scattering (SERS) for dissolved carbon dioxide detection using porphyrin-coated gold nanostars

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Over the recent decades, human activities have led to a substantial rise in global carbon dioxide (CO_2) emissions. The Intergovernmental Panel on Climate Change (IPCC) predicts a 1.5ºC warming by 2030, which will have profound repercussions for our water systems, such as rising sea levels and the extinction of various species [1]. The capture of this gas has become a scientific task in the past years, and as a consequence, many strategies have been developed using different systems and porous materials [1,2]. To make this strategies most effective, analytical methods with highly sensitivity and specificity for the detection of carbon dioxide in water bodies are needed.

Surface-enhanced Raman Scattering (SERS) is a promising analytical tool for this purpose, owing to its high selectivity and sensibility, being one of the most sensitive techniques currently available. Additionally, it has other advantages that hold particular significance in sensor development, as reduced time requirements, cost-effectiveness and the potential for in-situ measurements. The fabrication of highly efficient SERS substrates is intricately linked to the analytical applicability of SERS [3]. In our study, we selected gold nanostars as an optical enhancer, specifically because they highly concentrate the electromagnetic field at their tips, generating high density of hot spots in a single particle [4].

Porphyrins have been also widely investigated in the past decades. They present excellent physicochemical properties such as high internal surface areas and void volume. In addition, Porphyrins have been studied for the fabrication of different porphyrin based-materials that act as nanoreactors for the capture and conversion of CO_2 [2]. Thus, we chose 5,10,15,20-tetrakis(4-aminophenyl) porphyrin (TAPP), which is a basic pyrrole containing a macrocyclic cavity and a high number of amino groups, as chemoreceptor for the indirect SERS detection of CO_2.

In this work we first investigated the behaviour of dissolved TAPP with the gold nanostars in aqueous solution in different pH conditions by UV-vis-NIR spectroscopy and SERS. Notably, TAPP displayed an absorbance band centred at ca. 750 nm in neutral to acidic pH conditions, which was in resonance with the laser line used (785nm), leading to the phenomena of surface-enhanced resonance Raman scattering (SERRS). Understanding the behaviour of TAPP, the next step was the optimization for the detection of CO_2 in water. The identification and the potential quantification of CO_2 by SERS was performed by monitoring spectral changes of TAPP before and after CO_2 trapping. The results demonstrated this strategy to be promising for developing a fast and very sensitive method to monitor carbon dioxide dissolved in water.

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References

[1] R. Siegelman *et al.*, Nature Materials **20** (2021) 1060
[2] S.Kumar *et al., J.Mater. Chem. A.* **3** (2015) 19615
[3] J. Langer *et al., ACS Nano.* **14** (2020)
[4] I. Beceriil-Castro et al., *Analysis & Sensing* **2** (2023) e202200005

(P2) Biocompatible magnetopolymeric nanoparticles for antitumor hyperthermia and photothermia therapies

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In this work, an *in vitro* study was conducted on the photothermal and hyperthermia capabilities of magnetite/poly(butylcyanoacrylate) nanoparticles (Fe_3O_4/PBCA NPs). These NPs can generate high temperatures in response to photoluminescent and magnetic stimuli with the aim of selectively damaging cancer cells. The magnetic properties of the NPs allow for their targeted delivery to a specific area, easily combinable with other anti-tumor strategies. Biocompatibility was assessed through hemocompatibility and cytotoxicity assays.

The premise is based on the understanding that tumor cells do not survive at temperatures over ≈ 41 ˚C [1]. The hyperthermia study was conducted under conditions of high frequency (167 kHz) and low field amplitude (17 kA/m) on a dispersion of 10 mg/mL of Fe_3O_4/PBCA NPs. This resulted in a temperature increase of approximately 10°C, surpassing the mentioned threshold if starting from physiological temperature. Regarding the photothermal study, an 850 nm laser with a maximum power of 1 W was used on a dispersion of 10 mg/mL of Fe_3O_4/PBCA NPs, applying laser power in the range of 15 to 55 % of the total capacity. Results indicated that starting from 35 % of the power, the threshold of 4°C necessary to selectively damage cells was exceeded [2].

Biocompatibility of the NPs was demonstrated through *ex vivo* studies, and cytotoxicity was assessed using the MTT colorimetric method. The test was evaluated in a non-tumoral cell line and another tumoral cell line. The selected healthy cell line was normal human colon fibroblasts CCD-18, while the used tumoral cell line was the T-84 human colon carcinoma cell line. In both cell lines the relative cell viability was ≈ 100 %, so there were no evidences of cytotoxicity. To carry out the study of hemocompatibility the NPs added to anticoagulated blood samples from healthy volunteers. Hemolysis, platelet activation, complement system activation, and plasma recalcification time were measured. All the results were like those obtained in the control test, this suggesting the blood compatibility of the NPs.

Proof of concepts has been successfully done to the Fe_3O_4/PBCA NPs suggesting adequate biocompatibility and heating properties for antitumor hyperthermia and photothermia therapies.

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References

[1] Jaque D et. al. Nanoparticles for photothermal therapies. Nanoscale. 2014;6(16):9494–530.

[2] Lázaro M at. al. Combined Magnetic Hyperthermia and Photothermia with Polyelectrolyte/Gold-Coated Magnetic Nanorods. Polymers (Basel). 2022;14(22).

(P3) Reproducible formulation of poly(butylcyanoacrylate)-coated iron oxide nanostructures for biomedical applications

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In this study, a method for formulating nanoparticles (NPs) with magnetite (Fe_3O_4) cores coated with poly(butylcyanoacrylate) (PBCA) is presented. Iron oxide cores are widely used in the biomedical industry due to their magnetic responsiveness, high biocompatibility and low cost [1].

The formulation relied on surface polymerization, using oleic acid to functionalize the Fe_3O_4 cores, followed by the addition of butylcyanoacrylate monomer in a 3:4 weight ratio in acetone. Reproducibility was demonstrated with triplicate measurements, resulting in a size of 243.25 ± 24.99 nm, a surface charge of -15.92 ± 3.75 mV, and a yield of 71.82 ± 1.72 %.

The hybrid nanostructure was characterized qualitatively by measuring the electrokinetic properties of the colloids. The zeta potentials (ζ) of hybrid NPs was measured and found to be like those of pure PBCA. This conclusion was confirmed by characterizing the ζ values of hybrid NPs, PBCA, and Fe_3O_4 under varying pH and ionic concentration conditions. In both cases, it was disserved positive trend corresponding to the Fe_3O_4 NPs and a negative trend corresponding to the hybrid and PBCA NPs. Furthermore, Fourier-transform infrared spectroscopy revealed characteristic peaks of cyanoacrylates and a band corresponding to Fe-O group ≈ 500 cm^{-1} [2] for the core/shell NPs.

Magnetic properties of the Fe_3O_4/PBCA NPs were demonstrated through hysteresis loop analysis; initial susceptibility ≈ 0.732 ± 0.036 and a saturation magnetization ≈ 70 kA/m.

A reproducible methodology was developed to obtain Fe_3O_4/PBCA (core/shell) NPs characterized by an adecuate magnetic responsiveness for biomedical applications.

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References

[1] López-Viota M, El-Hammadi MM, Cabeza L, Prados J, Melguizo C, Ruiz Martinez MA, et al. Development and Characterization of Magnetite/Poly(butylcyanoacrylate) Nanoparticles for Magnetic Targeted Delivery of Cancer Drugs. AAPS PharmSciTech. 2017 Nov 1;18(8):3042–52.

[2] Arias JL, Gallardo V, Gómez-Lopera SA, Plaza RC, Delgado A V. Synthesis and characterization of poly(ethyl-2-cyanoacrylate) nanoparticles with a magnetic core. J Control Release. 2001;77(3)

(P4) Synthesis and characterization of supramolecular peptide-based magnetic hydrogels for biomedical applications

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Hydrogels can be considered as three-dimensional, hydrophilic networks of flexible polymer chains swollen by water or other fluid. Being are soft and capable of retaining large amounts of water they closely resemble living tissues. Mainly for that reason hydrogels are considered as particularly promising materials in the rapidly developing field of tissue engineering as matrices for replacing and regenerating different tissues and organs.

Short peptides are an example of hydrogelators which can form supramolecular structures as a consequence of specific and local interactions of molecules themselves. These molecules undergo self-association usually forming hierarchical structures at the nanoscale or at the macroscale [1]. Among many hydrogelators, N-(9-Fluorenylmethoxycarbonyl)-L-phenylalanine (Fmoc-FF) is one of the most frequently used.

In this study, iron nanoparticles have been modified to get hydroxyl and amine groups onto their surface. It was shown that the final properties of supramolecular magnetic hydrogels can be affected by the interactions between functionalized nanoparticles and hydrogelator molecules. DFT calculation clearly showed that attractive interactions between carbonyl group of the Fmoc-FF and protonated amine group may results in structural rearrangement of Fmoc-FF molecule.

Fig. 1. Formula of Fmoc-FF molecule (left), resulting magnetic hydrogel (center), micrograph of the hydrogel structure by ESEM microscopy; the scale bar is 2μm (right)

Those interactions and resulting rearrangements are linked with the structural and mechanical properties of the final magnetic hydrogels, while keeping their biocompatibility unchanged, when compared to non-magnetic Fmoc-FF-based hydrogel. The collected results show the important role of the surface layer of nanoparticles dispersed in the hydrogel in governing the macroscopic properties.

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References
[1] X. Yan, P. Zhu, J. Li, *Chem. Soc. Rev.* **39** (2010) 1877–1890. doi:10.1039/b915765b.

(P5) Effect of nanoparticles architecture on their performance as multimodal contrast agents for T1-T2 dual mode MRI and luminescent bioimaging

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Magnetic resonance imaging (MRI) stands out as a non-invasive technique, with high spatial resolution and detection depth, which is often used for medical diagnostics. There are two imaging modalities of MRI, involving longitudinal (T1-weighted MRI) and transversal (T2-weighted MRI) relaxation modes. Their integration (T1 T2 bimodal MRI) can overcome individual drawbacks and provide great potential for precise clinical diagnosis.[1] MRI presents however a disadvantage related with its low sensitivity, which is solved with the use of contrast agents (CAs). CAs for dual T1-T2 MRI are based in superparamagnetic iron oxide NPs (T2 contrast) with a Gd (complexes or oxide) (T1 contrast) on the NP surface. An interesting alternative to these dual T1-T2 CAs are those consisting of paramagnetic NPs based on the combination of Gd^{3+} (T1 CA) with other lanthanide ions of high magnetic moments (T2 CAs), such as Ho^{3+}, Dy^{3+}, Tb^{3+} and Er^{3+}. Their advantage with respect to the former is that the presence of these ions confers additional functionalities that make them also useful for luminescence bioimaging, and therefore gives them the ability to act as multimodal probes. Several nanoprobes based on this combination have already been published, most of them consisting of a fluoride matrix which show different drawbacks related to their low chemical stability which negatively affects their properties and their biocompatibility.

In this study, we report the synthesis of uniform NPs based on a phosphate matrix, known for its high biocompatibility, containing Gd^{3+} and Dy^{3+} ions as T1 and T2 active ions, respectively. NPs with two different architectures, co-precipitated and core-shell, were synthesised to analyse the influence of the Gd and Dy location on the magnetic relaxivity of the resultant CA. The NPs were synthesized through homogeneous precipitation in butanol, using lanthanide precursors that allow a controlled release of cations, which contributes to NPs uniformity. The coprecipitated NPs were fabricated with Gd and Dy uniformly distributed in the phosphate matrix while the core-shell NPs were fabricated from Dy phosphate cores by depositing a Gd phosphate shell on top. The core-shell architecture showed the best magnetic properties in terms of longitudinal and transversal relaxivity likely due to the spatial separation of the active ions, which avoid magnetic quenching. These NPs were successfully doped with Nd3+ ions, showing emission in the infrared region. These properties, together with their good dispersibility in water and in phosphate buffer saline make them ideal candidates as multimodal CAs for T1-T2 dual mode MRI and luminescent bioimaging.

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References

[1] M.H. Liu, J. Yan, G. et. al. *Nanoscale*, **15** (2023) 4694

[2] T. Liu, S. Li, Y. Liu, Q. Guo, L. Wang, D. Liu, J. Zhou. *J. Mater. Chem. B*, **4** (2016) 2697

(P6) Designing the internal microarchitecture for self-heating droplets via gold and magnetite nanoparticle compartmentalization

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One of the challenges in the field of droplet technology is the practical manipulation of droplets without physical contact. One potential solution to this problem would be to compartmentalize field-responsive nanoparticles within the droplet microarchitecture. Our goal here is to confine magnetite and gold nanoparticles in specific subsites within droplets not only to make them field-responsive, but also to create an asymmetric response to external fields and/or allow for field-induced reconfigurability. We select magnetite and gold nanoparticles that respond to external magnetic fields and laser irradiation, respectively. The strategy focuses on preparing water-in-oil droplets with internal phase separation and partitioning of nanoparticles in each subphase. This is achieved through mixing solutions of polyethylene glycol (PEG) and dextran as the aqueous phase of the droplets. At specific concentrations, these two polymers phase-separate resulting in Janus-shaped droplets [1]. To compartmentalize gold and magnetite nanoparticles within the PEG- and dextran-rich phases, gold nanoparticles covered with PEG-thiol polymer and magnetite nanoparticles functionalized with dextran polymer [2] are synthesized to enable preferential encapsulation within PEG-rich and dextran-rich phases, respectively. To demonstrate the response of thes e droplets to external fields, we perform experiments where heat is generated by application of alternate magnetic fields (i.e., hyperthermia) and/or laser irradiation (i.e., photothermia) to test for potential synergistic heating capability by the gold and magnetite domains within the droplet. We also observe the internal reconfigurability of the droplets induced by temperature changes, and self-healing ability by using an optical microscope. Through this approach, we have demonstrated the tunable confinement of field responsive nanoparticles within microdroplets, their response to the application of external fields, and heat-induced reconfigurability, which have the potential for application in fields such as active matter or microreactor technology.

Acknowledgments

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References

[1] C. Cui, C. Zeng, C. Wang, L. Zhang, Complex Emulsions by Extracting Water from Homogeneous Solutions Comprised of Aqueous Three-Phase Systems, Langmuir, 33, 12670-12680 (2017).

[2] Z. Shaterabadi, G. Nabiyouni, M. Soleymani, High impact of in situ dextran coating on biocompatibility, stability and magnetic properties of iron oxide nanoparticles, Materials Science and Engineering: C, 75, 947-956 (2017).

(P7) Fabrication and Sensing Applications of Laser-Engraved rGO Electrodes Decorated with Metal Nanoparticles

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Graphene oxide (GO), a derivative of graphene, has garnered significant attention in the field of material science due to its unique properties. As a two-dimensional carbon-based material, GO exhibits remarkable mechanical, electrical, and thermal characteristics. One notable advancement in the utilization of graphene oxide involves laser scribing techniques. Laser scribing techniques are employed to fabricate electrodes based on rGO, enabling the development of extensive surface area platforms that can incorporate metal nanoparticles. The synergy between rGO and metal nanoparticles yields electrodes with superior electrical properties, making them ideal for sensing and biosensing applications. This synergy arises from the laser's ability to provide energy for the reduction process and the unique properties of nanoparticle-decorated rGO. The reduction process involving exfoliation further contributes to the electrode's shape, facilitating its transfer to a suitable substrate. These electrodes are optimal for biosensing due to the presence of metal nanoparticles, which can be functionalized with bioreceptors specific to the target to be detected.

This study demonstrates the use of electrodes made of rGO decorated with gold nanoparticles to detect the concentration of an antibody, which has interest in cancer diagnostics and therapy. Capacitance is employed as a free-label electrochemical measurement approach.

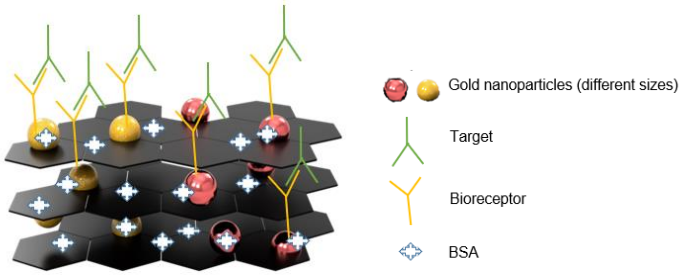

Figure 1. Schematic of the working electrode made of rGO decorated with gold nanoparticles, which has been functionalized to detect an antibody.

Acknowledgments

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References

[1] A. Scroccarello, R. Álvarez-Diduk, F. Pelle, C. Carvalho Castro e Silva, A. Idili, C. Parolo, D. Compagnone, A. Merkoçi, ACS sensors **8** (2023) 598-609.

[2] L. Zhao**,** G. Rosati**,** A. Piper**,** C. Carvalho Castro e Silva, L. Hu, Q. Yang, F. Pelle, R. Alvarez-Diduk, A. Merkoçi, ACS Appl. Mater. Interfaces **15** (2023) 9024−9033.

[3] F. Pelle, Q. Ain Bukhari, R. Alvarez-Diduk, A. Scroccarello, D. Compagnone, A. Merkoçi, Nanoscale **15** (2023) 7164-7175.

(P8) The application of magnetic nanoparticle-mediated hyperthermia as a therapeutic approach to gastrointestinal cancers

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In recent years, an increase in the prevalence and mortality of gastrointestinal cancers has been observed, mainly due to the increase of unhealthy lifestyles among other causes [1]. This, together with the limited effectiveness of current treatments, has highlighted the need to investigate new and more effective therapies that improve the quality of life of patients. In this context, nanomedicine has emerged as an alternative or complementary approach to manage cancer disease. In particular, magnetic nanoparticles may be used for both diagnosis and treatment of cancer, due to their peculiar physicochemical properties, such as their ability to increase temperature under exposure to an external alternating magnetic field (AMF) for hyperthermia therapies [2]. The purpose of this study was to demonstrate that the application of magnetic nanoparticle-based hyperthermia improves the treatment of gastrointestinal cancers. For this, an analysis of the most recent studies (2013-2023) in which magnetic nanoparticles subjected to an AMF were used as a treatment for gastrointestinal cancers, both *in vitro* and *in vivo*, was performed. The results obtained showed an improvement in treatments after the application of nanoparticle-mediated hyperthermia therapy, evidencing synergies with chemotherapy treatments [3] and increases in apoptosis values [4]. Furthermore, good biocompatibility was observed in 95% of the *in vivo* tests [5]. In conclusion, magnetic nanoformulations may increase tumor cell death in gastrointestinal cancer, becoming a promising option to improve existing treatments. In addition, more studies are required to validate these findings.

Acknowledgments

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References

[1] F Arnold, et. al Gastroenterology 2020, 159, 335-349.e15, doi:10.1053/j.gastro.2020.02.068.

[2] Farzin, A.; Etesami, S.A.; Quint, J.; Memic, A.; Tamayol, A. Magnetic Nanoparticles in Cancer Therapy and Diagnosis. Adv Healthc Mater 2020, 9, 1901058, doi:10.1002/adhm.201901058.

[3] Fernandes, S.; Fernandez, T.; Metze, S.; Balakrishnan, P.B.; Mai, B.T.; Conteh, J.; De Mei, C.; Turdo, A.; Di Franco, S.; Stassi, G.; et al. Magnetic Nanoparticle-Based Hyperthermia Mediates Drug Delivery and Impairs the Tumorigenic Capacity of Quiescent Colorectal Cancer Stem Cells. ACS Appl Mater Interfaces 2021, 13, 15959–15972, doi:10.1021/ACSAMI.0C21349.

[4] Jahangiri, S.; Khoei, S.; Khoee, S.; Safa, M.; Shirvalilou, S.; Pirhajati Mahabadi, V. Potential Anti-Tumor Activity of 13.56 MHz Alternating Magnetic Hyperthermia and Chemotherapy on the Induction of Apoptosis in Human Colon Cancer Cell Lines HT29 and HCT116 by up-Regulation of Bax, Cleaved Caspase 3&9, and Cleaved PARP Proteins. Cancer Nanotechnol 2021, 12, 34, doi:10.1186/s12645-021-00108-5.

[5] Shen, M.Y.; Liu, T.I.; Yu, T.W.; Kv, R.; Chiang, W.H.; Tsai, Y.C.; Chen, H.H.; Lin, S.C.; Chiu, H.C. Hierarchically Targetable Polysaccharide-Coated Solid Lipid Nanoparticles as an Oral Chemo/Thermotherapy Delivery System for Local Treatment of Colon Cancer. Biomaterials 2019, 197, 86–100, doi:10.1016/J.BIOMATERIALS.2019.01.019.

(P9) Avoiding undesired effects in the interaction of nanostructures with immune cells: the Role of Oxyresveratrol

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Poly(lactic-co-glycolic acid) (PLGA) nanoparticles are considered as biocompatible both by the U.S.Food and Drug Administration (FDA) and the European Medicines Agency (EMA)[1]. Nevertheless, such nanomaterials could cause some undesired effects due to unexpected "cell priming". The interaction of nanostructures with the immune cells could lead to unexpected effects, especially if microorganisms are present in the tissues of patients to whom nanoparticles are administered. In this scenario, we observed an increase in the secretion of IL-12, IL-6 and TNF-α in Dendritic Cells stimulated with R848, an event known as the "priming effect", once PLGA NPs were administrated[2]. We also assessed that bare nanoparticles induce O^{2-} production by resting monocytes and enhance the formation of this radical in β-glucan-stimulated monocytes[3]. Dendritic cells are involved in modulating the adaptive immune reaction and the inflammatory process to combat pathogenic microorganisms, while monocytes are heterogeneous cells circulating in the blood that initiate and propagate the immune response by phagocytosing pathogens and releasing chemical mediators. Oxyresveratrol is a polyphenol extracted from *Artocarpus lakoocha Roxb. heartwood*, a plant known in Thailand as 'Ma-Haad' and used in traditional medicine. The anti-inflammatory effect of oxyresveratrol is mainly attributed to downregulation of pro-inflammatory cytokine production[4]; it has also been reported as a good antioxidant, equipped with ROS scavenger activity[5]. Moreover, compared to resveratrol, the additional OH- group should increase the biological effect. We investigated if the anti-inflammatory and the ROS scavenging activity of oxyresveratrol, were able to mitigate the pro-inflammation and ROS production upon nanoparticles interaction with both Dendritic and Monocytes cells, once it was incorporate into PLGA Nanoparticles. Our finding suggests not only that the polyphenol reduce the O^{2-} during the cellular uptake of both resting and β-glucan-stimulated Monocytes but, it can also contrast the unwanted release of pro-inflammatory cytokines by Dendritic Cells, due to a synergistic effect of nanoparticles with microbial agents that could be present in the patient tissues[2,3].On the one hand the encapsulation of the polyphenol in PLGA increases its effectiveness and bioavailability and oxyresveratrol mitigates any dangerous effect especially if the nanoparticles are administered to patients with an overstressed immune system.

References

[1] Sharma, S et. al. Trends Anal. Chem. 80, 30–40 (2016).
[2] Gaglio, S. C.et. al. Nanoparticles. Molecules 26, 2106 (2021).
[3] Donini, M. et. al. Molecules 26, 4351 (2021).
[4] Wei, J. et al. Oxyresveratrol Is a Phytoestrogen Exerting Anti-inflammatory Effects Through NF-κB and Estrogen Receptor Signaling. Inflammation 40, 1285–1296 (2017).
[5] Lorenz, P., Roychowdhury, S., Engelmann, M., Wolf, G. & Horn, T. F. W. Oxyresveratrol and resveratrol are potent antioxidants and free radical scavengers: effect on nitrosative and oxidative stress derived from microglial cells. Nitric Oxide 9, 64–76 (2003).

(P10) Mass Cytometry Nanodiagnostic Assay for Cancer Biomarker Recognition

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The lack of sensitive and affordable assays for early diagnosis and recurrence of triple negative breast cancer (TNBC) is the most important obstacle to curbing its mortality [1]. In this context, liquid biopsy (LB) has emerged as an alternative to conventional tissue biopsy for cancer diagnosis. In the field of liquid biopsy, research on the detection and analysis of proteins in biological fluids as tumour biomarkers is particularly relevant. The development of innovative platforms that can detect tumour biomarkers and confer certain advantages over currently available systems is of great interest to find patterns that improve the early diagnosis of cancer [2].

In this context, this work addresses these challenges by developing a nanotechnology platform for the detection of new tumour biomarkers, implementing an innovative tool such as mass cytometry [3]. This approach will allow the development of specific, effective and easy-to-use diagnostic tests based on the use of single-domain antibodies (sdAbs) conjugated to nanosystems with high affinity and specificity against new tumour biomarkers [4]. In particular, a diagnostic tool for TNBC (with both prognostic value and predictive value for response to new therapies) is under development.

A state-of-the-art immunoassay platform based on nanoparticles has been developed. The optimization of the bioconjugation of the antibodies to the nanoparticle has been successfully carried out. A physicochemical characterisation of these sdAbs-NPs has been accomplished. The detection efficiency of tumour biomarkers and the affinity and the specificity of the VHH-metalonanoplatform has been evaluated by mass cytometry using spiked samples. Next steps will be focussed on the validation of detection efficiency using patient samples.

Acknowledgments

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References

[1] Las cifras del cáncer en España. 2023. ISBN: 978-84-09-48173-6 (SEOM).
[2] Sivapalan L, et al., Journal for ImmunoTherapy of Cancer 2023;11:e005924.
[3] Delgado-Gonzalez A,et al., Anal Chem. 2022, 2;94(30):10626-10635.

(P11) Conditioning of black mass of disused LIB's for the separation of its components by flotation process

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In the framework of lithium-ion battery waste valorization, it is necessary to address recycling as an essential activity to mitigate the environmental impact derived from these wastes. A novel and sustainable alternative for the recovery of valuable elements is the effective separation of the cathodic and anodic parts through the flotation process. Flotation is used to remove graphite (hydrophobic), from the froth, and obtain lithium metal oxides in the tailings, however, a layer is generated around the particles, which is composed of traces of electrolyte and organic binder that alters the wettability of the particles, resulting in reduced recoveries [1].The present study focuses on evaluating different variables associated with surface phenomena that affect the flotation process, its operational parameters and the effect of thermal pretreatment associated with the release of its components. To achieve this, the methodology employed starts with the discharge by chemical deactivation. Subsequently, the process of dismantling and classification of the components is carried out to obtain the "black mass" material made up of lithium metal oxides (cobalt oxide) in the cathodic part and graphite in the anodic part. Finally, the material is taken to calcination, a process prior to flotation, to effectively eliminate the traces of electrolyte and organic binder and the remaining material is characterized by measuring its electrophoretic mobility and zeta potential [2]. The results obtained cover the temperature and time ramps necessary for the decomposition of the adherent material contained in the solid matrix. When performing the characterization by thermogravimetry, a weight variation in the sample composition was evidenced in two temperature ranges. In the case of the electrolyte, it decomposes by 1.21% from 0 to 200ºC, while the organic binder undergoes a reduction of 3.75% in the temperature range from 200 to 500ºC. These results are complemented by Muffla oven tests at different times, revealing that 7.5 minutes at a temperature of 500ºC are required to achieve complete decomposition of the traces. As for the zeta potential and electrophoretic mobility measurements, it is observed that the cobalt oxide samples and graphite are stable at pH 8 or higher. However, the black mass shows an increase in potential at pH 10, indicating that, for flotation, the optimum condition should be at pH 8.

References

[1] Vanderbruggen, A., Sygusch, J., Rudolph, M., & Serna-Guerrero, R. (2021). A contribution to understanding the flotation behavior of lithium metal oxides and spheroidized graphite for lithium-ion battery recycling. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 626, 127111.

[2] Wang, F., Zhang, T., He, Y., Zhao, Y., Wang, S., Zhang, G., ... & Feng, Y. (2018). Recovery of valuable materials from spent lithium-ion batteries by mechanical separation and thermal treatment. Journal of cleaner production, 185, 646-652.

(P12) Upconversion luminescence lifetime modulation by excitation control

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Upconversion luminescence (UCL) lifetime is a fundamental magnitude in multiple applications, such as biosensing, bioimaging, and contactless temperature probing. Due to the complex energy level structure of upconversion nanoparticles (UCNPs) and the several energy transfer pathways to depopulate and repopulate ion levels, UCL lifetime cannot be directly ascribed to the decay time of the emitting levels. In fact, recent studies have shown that UCL kinetics can be modulated by changing the excitation parameters [1-6]. These results claim the necessity of reassessing UCL lifetime concept, not only from a fundamental point of view but also for its applications. With this aim, we measured the behaviour of UCL lifetime, as a result of modifying the excitation pulse width, at different laser powers. For this study, we used water-dispersed 37 nm $NaYF_4:Yb^{3+},Er^{3+}$ UCNPs coated with a protective polymer shell (PS/PMMA) [7]. Our results indicate that UCL lifetime rises with excitation pulse width, this change being more significant for higher laser powers. These results have been theoretically reproduced by using a rate equation model which allows us to predict the implications of this phenomenon in Förster resonance energy transfer (FRET) based biosensing.

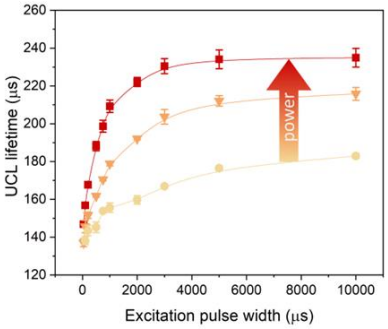

Figure 1. Experimental UCL lifetime at 540 nm of β-$NaYF_4$:Yb^{3+}_{20}, Er^{3+}_2@PS/PMMA UCNPs in water (200 μg/mL) for different excitation powers: 0.15, 0.5 and 1.7 W.

Acknowledgments

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References

[1] A. Teitelboim et al., J. Phys. Chem. C 2019, 123, 2678–2689.
[2] Y. Han et al., Angew. Chem. 2022, 134, e202212089.
[3] Y. Han, X. Zhang, and L. Huang, Chem. Eur. J. 2023, e202302633.
[4] Y. Chai et al., ACS Appl. Mater. Interfaces 2022, 14, 14004-14011.
[5] A.M. Kotulska et al., Light Sci. Appl. 2022, 11, 256.
[6] M. E. Raab et al., J. Phys. Chem. B 2021, 125, 13132−13136.
[7] D. Mendez-Gonzalez, Small 2022, 18, 2105652.

(P13) Synthesis and functionalitation of gold nanoparticles with superior x-ray attenuation properties compared to clinically used iodinated small molecular contrast agent.

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Gold nanoparticles have garnered a great deal of attention for biomedical applications. Depending on their size, shape, and local environment, gold nanoparticles can appear red, blue, or other colors. These visible colors reflect the underlying coherent oscillations of conduction-band electrons ("plasmons") upon irradiation with light of appropriate wavelengths. These plasmons underlie the intense absorption and elastic scattering of light, which in turn forms the basis for many biological sensing and imaging applications of this nanomaterial, such as biomolecule detection via surface-enhanced Raman spectroscopy (SERS) or molecular diagnostic through photoacoustic imaging.

Gold nanoparticles are also characterized by strong X-ray absorption due to their inner electrons, making them an ideal contrast agent for computed tomography (CT) imaging. In this work, we present the synthesis and surface functionalization of water-soluble, stable, and noncytotoxic gold nanoparticles with superior X-ray attenuation properties compared to clinically used iodinated small molecular contrast agents. Pharmacokinetics studies confirm a prolonged half-decay time of 11.2 hours in rats. The synthesized gold nanoparticles enable efficient and enhanced blood pool CT imaging with imaging times up to 12 hours, making them a promising contrast agent for effective CT imaging.

Acknowledgments

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References

[1] Samir El Ketara and Nancy Lee Ford 2020 Biomed. Phys. Eng. Express 6 035025Z. Chin o, ME. Noratu,

[2] Yeh, Y. C.; Creran, B.; Rotello, V. M. Gold nanoparticles: preparation, properties, and applications in bionanotechnology. Nanoscale, 2012, 4, 1871-1880.

(P14) Magnetic hybrid biomaterials for cyanotoxins removal from water

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Human activity is not the only cause of pollution worldwide, seasonal biogenic toxicity is also found to be widespread in water resources, soils and ultimately in the food chain, causing disease in animals and humans, thus producing numerous economic losses.
Cyanotoxins are secondary metabolites from cyanobacteria that are toxic to living organisms including humans and found highly dissolved in water due to the low efficiency of conventional wastewater treatment processes. Therefore, alternative innovative measurements should be implemented to avoid their biotransformation. A complementary method for toxin removal has been investigated, which consists in the use of nanostructured magnetic beads made from biopolymers, magnetic nanoparticles, activated and mesoporous carbon.
Experiments have been carried out to study the nanomaterial efficiency and pH effect in the adsorption of microcystin-LR, cylindrospermopsin, and anatoxin-A. The amount of toxin was quantified using ultra-high-performance liquid chromatography coupled to tandem mass spectrometry (UHPLC-MS/MS). The results show that activated carbon and mesoporous carbon are effective materials to capture cyanotoxins from water. This effectiveness could be owed to the pore size of the adsorbent material, since mesoporous carbon is more effective in removing higher molecular weight molecules and activated carbon with smaller ones. In addition, adsorption effectiveness is influenced by water pH, which is probably due to electrical charges.
In conclusion, the use of magnetic beads coated by activated carbon or mesoporous carbon can be an effective method of removing cyanotoxins from water and improving drinking water safety, although more studies are needed to evaluate this effectiveness in other cyanotoxins.

Acknowledgments

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(P15) Magnetic hydrogels and primary neural cells under high-frequency magnetic stimulation

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Hydrogels and magnetic nanoparticles offer a wide range of possibilities for innovative therapies in biomedicine, including those in neural regeneration, that can be stimulated using an alternating magnetic field (AMF). In this study, we have designed hybrid implants integrating natural polymers, such as collagen, chitosan and hyaluronic acid, to provide soft and flexible 3D networks able to mimic the extracellular matrix of natural tissues and iron oxide nanoparticles (IONPs) that deliver localized heat when subjected to an AMF [1, 2]. The impact of AMF stimulation on cell viability and neural differentiation was investigated using primary neural cells.

Results indicated that the exposure of primary neural cells to both polymer-coated IONPs and magnetic hydrogels preserved cell viability and neural differentiation, even at the highest tested dose (0.1 mg Fe/mL). This effect was consistent across various coating types, and notably, there was an enhancement of neuronal interconnectivity even at lower IONP doses. Incorporating IONPs into the hydrogels modulated their physicochemical properties and endowed them with responsiveness to an external magnetic field. Additionally, these materials demonstrated the ability to maintain high neural cell viability and support the formation of intricate and well-differentiated neuronal networks. When evaluated under an AMF, cell viability was slightly diminished with respect to control hydrogels magnetically stimulated, but not in comparison to their counterparts without stimulation. Neuronal differentiation under AMF was only affected on collagen hydrogels loaded with the highest dose of IONPs coated with HA, while non-neuronal differentiation regained control values. In general, hydrogels containing chitosan-coated IONPs exhibited superior performance, possibly owing to their elevated nanomechanical fluidity.

In summary, our nanocomposites allowed the formation of viable and highly interconnected neural networks. Hence, next steps will focus on the release of bioactive molecules to improve neuronal network formation and maturation and to control inflammation processes.

Acknowledgments

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References

[1] *Acta Biomaterialia*. Under review.

[2] E. Benayas, *et al. ACS Appl. Mater. Interfaces* 15 (2023).

(P16) Controlled synthesis of magnetoplasmonic aggregate nanoparticles for biomedicine

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The main objective of this work is to create hybrid nanomaterials with magnetic and optical properties of interest in biomedicine. Iron oxide nanoparticles allow non-invasive manipulation and remote actuation (using magnetic fields). They can be used as contrast agents in magnetic resonance imaging (MRI) and for magnetic heating (using AC magnetic fields) in magnetic hyperthermia. The presence of gold nanoparticles provides a surface plasmon resonance with a significant and tuneable optical absorption in the visible. These properties are useful in photothermal therapy, where localized heating is accomplished via light irradiation [1]. At the same time, SERS (surface-enhanced Raman spectroscopy) can be used for the detection of chemical and biological molecules.

Magnetoplasmonic water-soluble aggregates of nanoparticles with diameters of 14 nm (γ-Fe_2O_3) and 31nm (Au) were obtained through a new route in two steps. Firstly, magnetic NPs were obtained through Massart coprecipitation [2], followed by DMSA coating. The second step is based in a Turkevich modification where the reduction of Au^{3+} occurs simultaneously with the attachment to γ-Fe_2O_3 surface. The samples combine superparamagnetism with plasmonic properties (Fig. 1). In biomedicine, they can be used for hyperthermia (magnetically or optically stimulated), contrast enhancement in MRI, and for SERS detection. This synthesis route is simple, it allows controlling the optical properties through the amount of deposited Au and yields the product in the gram-scale.

Characterization of the size, shape, composition, relaxation times for MRI, magnetic heating, UV-vis Raman spectroscopy will be presented, as well as toxicity studies in MCF-7 cell line.

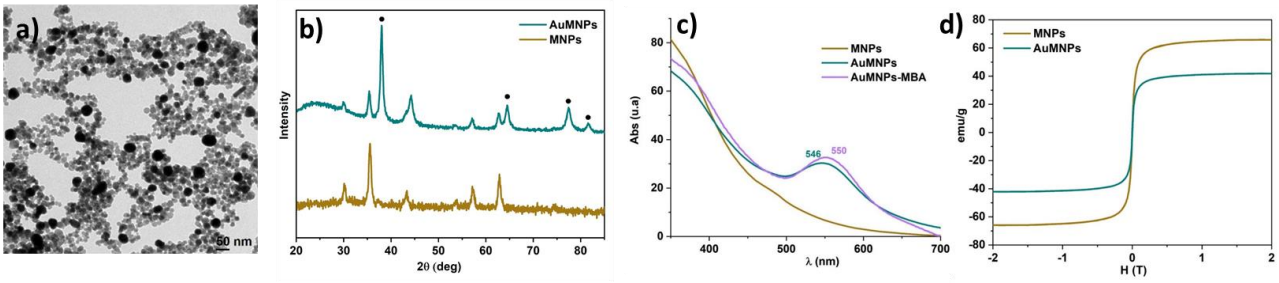

Figure 1. a) TEM images of MNPs-AuMNPs. b) Powder XRD pattern of the synthesis MNPs and AuMNPs. c) UV-vis absorption spectrum of MNPs and AuMNPs. d) Magnetic field-dependent magnetization, M(H), of MNPs and AuMNPs.

References

[1] Coelho *et al. RSC Adv*, 2017, **7,** 11223

[2] R. Massart, IEEE Trans. Magn, 1981,17,1247-1248

(P17) Covalent Organic Frameworks (COF) nanoparticles with optical properties as contrast agents for photoacoustic imaging

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Introduction: Covalent organic frameworks (COFs), have several interesting characteristics that make them very good delivery systems for bioimaging and emerged as ideal candidates for biomedicine and related fields.[1] Photoacoustic imaging allows molecular and functional imaging in any biological medium.[2] Using exogenous contrasts (typically gold nanoparticles) can improve the quality of the images obtained and be used as biomarkers for specific pathophysiological targets.[3] However, their accumulation causes oxidative stress and can lead to permanent cellular damage. In this work, we explore the feasibility and potential of utilizing two types (TAPB-PDA and LZU-1) of covalent organic framework nanoparticles (nCOFs), which are 100% organic materials, harmless to the body and biodegradable, as exogenous contrast agents for photoacoustic imaging.

Results and discussion: nCOFS and MCM-41 conjugated with ATTO532, used as references, were developed to quantify the photoacoustic response (PA) of each sample. Two experiments were conducted: (i) all samples at a concentration of 0.1 mg/mL, which is the maximum concentration of the NPAu (commercial standard) and (ii) increasing the concentration of the prepared materials within a range from 0.1 mg/mL to 5 mg/mL. While organic samples yield lower PA responses compared to the NPAu, both the organic network nanoparticles LZU-1 and TAPB-PDA, as well as the ATTO532-labeled MSNs, demonstrate significant potential as exogenous contrasts in photoacoustic imaging. They demonstrate a response level close to the reference.

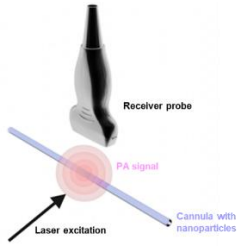

Figure 1. Schematic illustration of the experimental setup used.

Conclusions: The obtained results highlight TAPB-PDA and LZU-1 nanostructures as highly promising contrast agents in the field of photoacoustic imaging due to their extensive response, biocompatibility (as organic network nanoparticles are harmless to the organism), and wide therapeutic window. This enables an increase in the administered injected dose without side effects

Acknowledgments
Financial support from Spanish Ministry of Science and Innovation (Projects PID2022-142952OB-I00 and CEX2021-001230-S) is gratefully acknowledged.

References

[1] S. Liang, M.-H. Li, M. Qi, L. Wang, Y.-W. Yang. *Chem. Mater.* **35** (2023) 8353-8370.
[2] B. Park, S. Park, J. Kim, C. Kim. *Adv. Drug Deliv. Rev.* **184** (2022) 114235.
[3] K. Wilson, K. Homan, S. Emelianov, Nat. commun. **3** (2012) 618.

(P18) Light-activated nanomedicines for selective intracellular delivery of camptothecin

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Introduction: Stimuli-responsive systems (SRSs) have been developed to provide accurate spatial and temporal control of molecular release, limiting undesired effects on healthy tissue and maximizing therapeutic activity in the regions of interest (ROIs).[1] In particular, light-driven drug delivery systems (DDSs) are categorized into three groups: photothermal, photochemical, or systems activated by photoisomerization.[2] Within this last group, azobenzene stands out as the most commonly used photoisomerizable molecule due to its possession of two isomers, *trans* and *cis*, which can interchange reversibly through rotation around the -N=N- bond. We here propose a conceptual change by shifting photoswitching activity from the vehicle (nanoparticle) to the load (drug). The molecule to be delivered is trapped within a porous nanoparticle and its release is accomplished through a photoisomerization process.

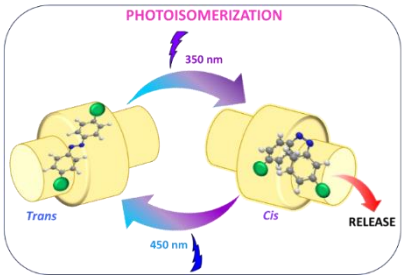

Figure 1. Schematic illustration of the *cis-trans* photoisomerization as a drug-controlled release mechanism.

Results and discussion: This proof-of-concept study was developed in three stages: (i) molecular design and synthesis of a photoswitchable CPT prodrug; (ii) tailoring the pore structure of porous silica nanoparticles for controlled prodrug loading and release mediated by UV irradiation; and (iii) in vitro validation of the DDS in several human cancer cell lines.

Conclusions: By synthesizing photoswitchable prodrugs and precisely tailoring the pore structures of mesoporous silica nanoparticles, drug loading and release was controlled through photoisomerization. The azobenzene moiety requires the use of UV light, with lower penetration in tissue efficiency, which has potential at in vivo applications over skin cancer. However, irradiation in the UVA-I spectrum has a good safety profile, and it may be possible to treat internal tumors using an endoscope particularly considering the high degree of specificity for this method.

Acknowledgments

Financial support from Spanish Ministry of Science and Innovation (Projects PID2022-142952OB-I00 and CEX2021-001230-S) is gratefully acknowledged.

References

[1] V. P. Torchilin. *Nat. Rev. Drug Discovery.* **13** (2014) 813-827.
[2] Y. Tao, H.F. Chan, B. Shi, M. Li, K.W. Leong. *Adv. Funct. Mater*. **30** (2020) 1-28.

(P19) Magnetic Hyperthermia Therapy mediated by Nanoparticles: search for candidates, selection of operating conditions and *in vitro* experiments

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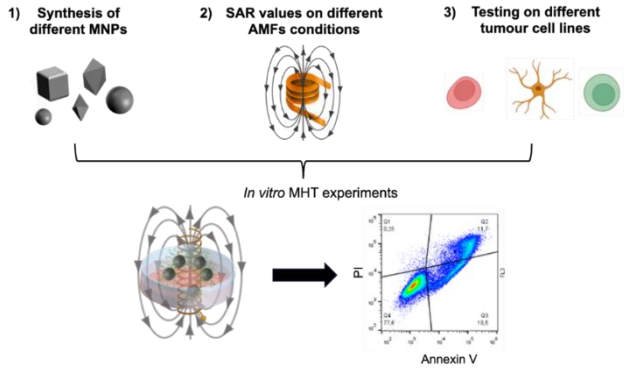
Traditional hyperthermia is often used in combination with chemotherapy or surgery in cancer treatment. Unfortunately, side effects are usually observed, mainly due to non-specific application. Therefore, magnetic hyperthermia nano-therapy (MHT) has emerged as a promising solution. MHT is based on the intrinsic ability of magnetic nanoparticles (MNPs) to accumulate in the tumour and respond to alternating magnetic fields (AMFs) by releasing heat.

There are some key parameters to achieve a successful MHT. First, the intrinsic properties of the MNPs, such as, size, shape, synthesis method or coating. Second, the equipment properties, basically, the frequency and intensity of the applied AMFs. Finally, the biological properties, which include heat tolerance of the cell line and MNPs-cell interactions.

Not all MNPs, equipment operating conditions or cell lines are good enough candidates for use in MHT, and the selection and combination of these parameters will be critical in the development of this anticancer approach. In this work, different shapes, sizes, synthesis methods and MNPs coatings were evaluated at different AMFs intensities and frequencies, based on their Specific Absorption Rates (SAR) values, a method to determine their heat release capacity. Finally, the best combination of MNP and operating conditions was tested in *in vitro* MHT experiments using different tumour cell lines, and cell death was analyzed by annexin V/PI in flow cytometry experiments.



Complete process workflow: from MNP synthesis to in vitro therapy

Acknowledgments

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References

[1] Egea-Benavente et. al *Cancers*, *13*(18), 4583.

(P20) Development of a targeted PLGA-PEG nanoplatform for β-CFN volatile cannabinoid

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Endothelial dysfunction and inflammation are key process in atherosclerosis, both of them closely related to the cannabinoid receptor type 2 (CB2). Due to CB2 possess anti-inflammatory properties, receptor agonists can be considered as a new potential treatment [1]. However, cannabinoids have unfavorable physicochemical properties, such as high lipophilicity, or low bioavailability. Therefore, new delivery systems are needed.

In this study, a novel CB2 agonist-nanoplatform has been developed as selective cannabinoid delivery system for atherosclerosis treatment, targeting VCAM-1 molecules present in the vascular endothelium [2]. β-Caryophyllene (β-CFN) is a highly volatile essential oil, making it challenging to encapsulate. The aim of this work is to optimize the formulation of this drug based on previous strategies [3].

Nanoparticles (NPs) were produced by nanoprecipitation method [4] using a mixture of PLGA-PEG and PLGA-PEG-Mal polymers and containing 30% (w/w) of β-CFN. The VCAM-1 binding peptide (VCAM-1 BP) was conjugated on NPs' surface by maleimide click reaction.

NPs exhibited a spherical morphology, with a diameter around 230 nm and a narrow size distribution (PdI ≈ 0.209). The encapsulation efficiency was EE% ≈ 36 before and EE% ≈ 12 after the peptide conjugation. Nanocarriers were successfully coupling with VCAM-1 BP (CE% ≈ 71). Additionally, to assess their stability, various cryo-preservation solutions were tested, yielding a favorable result the combination of trehalose and Pluronic® F-68.

Acknowledgments

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References

[1] S. Steffens, *Nature*. **434** (2005) 7034.
[2] K. Thayse, *Biology (Basel)*. **9** (2020) 11.
[3] MM. El-Hammadi, *Ind Crops Prod*. **164** (2021) 113345.
[4] L. Martín-Banderas, *Int J Pharm*. **487** (2015) 1-2.

(P21) Coating Techniques for the Obtention of Cell Membrane-Coated Nanoparticles for Tissue-Specific Therapeutics

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Nanoencapsulation has emerged as a recent improvement in the delivery of drugs, offering and improving stability and bioavailability, and allowing for the controlled and targeted delivery of substances to specific cells or tissues [1]. However, traditional nanoparticle delivery faces challenges such as short circulation time and immune recognition [2]. To address these issues, cell membrane-coated nanoparticles have been proposed as a promising alternative.

The production of cell membrane-coated nanoparticles involves three key stages: cell lysis and membrane fragmentation, membrane isolation, and nanoparticle coating. Before starting, source cells are decided according to the target tissue. Afterward, cell membranes are typically fragmented using hypotonic lysis in combination with homogenization or sonication. Subsequent membrane fragments are isolated through multiple centrifugation steps in which the other cellular contents are discarded. The coating of nanoparticles can be finally achieved through extrusion, sonication, or a combination of both methods.

This analysis shows the absence of a universally applicable method for nanoparticle coating, as the three stages exhibit notable differences in their procedures. Here we review ongoing developments and approaches to cell membrane-coated nanoparticles that position this technology as a promising alternative for effective targeted drug delivery and many other therapeutic applications.

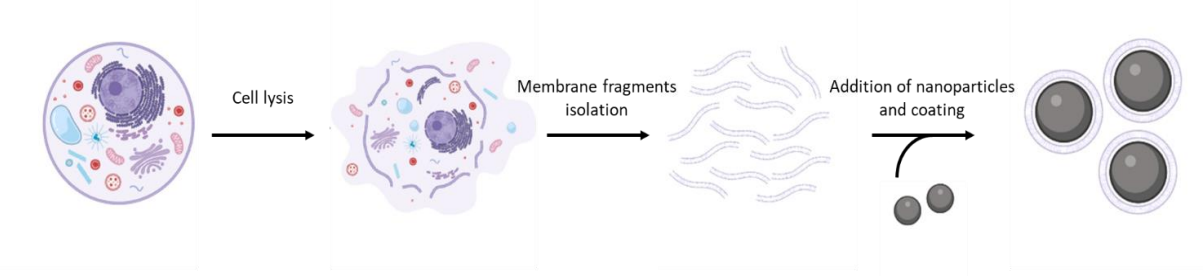

Figure 1. *General procedure of cell membrane nanoparticle coating.*

Acknowledgments

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References

[1] Barry, N.P.E.; Sadler, P.J. *ACS Nano* **7** (2013) 7
[2] Wilhelm, S.; Tavares, A.J.; Dai, Q.; Ohta, S.; Audet, J.; Dvorak, H.F.; Chan, W.C.W. Nat. Rev. Mater. **1** (2016) 16014

(P22) Combined systems of magnetic photo and biocatalysts for the tertiary treatment of emerging contaminants in wastewater

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In the last decades, activities related to the exploitation of natural resources and industrialization have had a significant impact, resulting in an increased presence of emerging contaminants (EC) in water, soil, air, and vegetation. These contaminants are not currently addressed in routine environmental control programs. However, the risks of long-term exposure associated to these compounds are well known, including prenatal mortality, diabetes, neurological or degenerative issues, and reproductive issues. These compounds include a wide range of substances, from pharmaceuticals and antibiotics to hormones, pesticides, nanomaterials, and endocrine disruptors (EDCs), among others. (1) Despite the lack of regulation, there is a growing concern regarding the presence of antibiotics in water resources, mainly because their excessive and improper use in humans and animals is leading to the development of antibiotic-resistant bacteria. World Health Organization (WHO) identifies antibiotic resistance as a major threat to global public health. It is therefore imperative, to address this socioeconomically relevant issue, focusing specifically on the removal of emerging contaminants in water, with a particular emphasis on wastewater. (2)

Therefore, one of the main challenges in the field of wastewater treatment nowadays lies in the development of innovative and efficient tertiary treatments for the removal of ECs. Among different approaches, there has been growing interest towards the development of immobilized enzyme technologies because they are more economical, effective and eco-friendly. Specifically, oxidoreductases have generated extraordinary interest attributed to their ability to catalyze reactions of a wide variety of undesirable pollutants. Immobilization of enzyme can enhance its catalytic efficiency, improve storage and operational stabilities, as well as allow enzyme recovery and reusability. (3)

In this work, engineered biocatalysts supported on magnetic substrates have been developed in order to eliminate ECs from wastewater. The developed biocatalysts are based in a magnetic magnetite core and a mesoporous zinc oxide shell, where an oxidoreductase enzyme has been immobilized through chemical interactions. Optimization of the synthetic routes of the Fe_3O_4@ZnO cores has been carried out through chemical co-precipitation method followed by a facile self-assembly synthetic procedure, obtaining magnetic nanoparticles with an average size of 15 nm, and a magnetization of 70 emu/g. The optimized nanoparticles have been used as a base for laccase immobilization by surface modification of Fe_3O_4@ZnO cores, leading to monodisperse nanostructured systems. Their catalytic activity has been analyzed in a model system evaluating EC degradation by HPLC, verifying that the activity of the biocatalyst is maintained after its recovery.

Acknowledgments

This work was supported by the project “Sistemas combinados de foto y biocatalizadores magnéticos para el tratamiento terciario de contaminantes emergentes en aguas residuales” (T3CE, PC162-PC163), funded by Innovation Department of the Government of Navarra.

References

[1] V. Geissen et al. International Soil and Water Conservation Research 3,1, (2015) 57–65

[2] https://www.who.int/es/news-room/fact-sheets/detail/antimicrobial-resistance

[3] L. Y. Jun et al., Journal of Environmental Chemical Engineering, Volume 7, Issue 2, 2019, 102961.

(P23) Solar-driven antibacterial activity of Zn-Co ferrites

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Worldwide, 844 million people lack access to drinking water and *ensure availability and sustainable management of water and sanitation for all*, is the basis of SDG 6 "Clean water and sanitation" of the United Nations. Heterogeneous semiconductor photocatalysts are proposed for developing next-generation sustainable water disinfection systems on the basis of the generation of highly reactive species under UV-Vis irradiation [1]. One of the most important current challenges in this field is the activation of the semiconductor under visible (solar) light that would enable the development of low-cost water disinfection systems.

Accordingly, the aim of the work is to explore the antibacterial performance of Zn-Co ferrites characterized by exhibiting photocatalytic activity under visible light [2, 3]. $Zn_{1-x}Co_xFe_2O_4$ (x = 0, 0.1, 0.4 and 0.6) nanoferrites were synthesized by co-precipitation method [3]. Structural and morphological characterization confirms the cubic spinel structure and their nanometer size (around 10 nm). The antibacterial performance of the NPs was evaluated on *Escherichia coli* DH5α, analysing the cultivability in a medium supplemented with the nanoparticles and compared with the evolution under visible light (both without and with nanoparticles). We first investigated the interaction between the ferrite nanoparticles and the bacteria, and observed that incubation with $Zn_{0.4}Co_{0.6}Fe_2O$ resulted in secretion of a bacterial biofilm (**Figure 1**), which might have a protective effect. Higher ratios of Co seemed to correlate with higher biofilm synthesis. Regarding the effect of the ferrites under visible light on bacterial cultivability, a light-induced decrease was detected only in the samples incubated with $ZnFe_2O$ and $Zn_{0.9}Co_{0.1}Fe_2O$. In this case, higher ratios of Zn correlated with stronger decrease in cultivability. We hypothesize that the increase in the magnetic moment of the ferrite with Co content, which results in stronger aggregation of the nanoparticles, could also contribute to their lower effect on cultivability (decrease in the effective light irradiation on the bacteria).

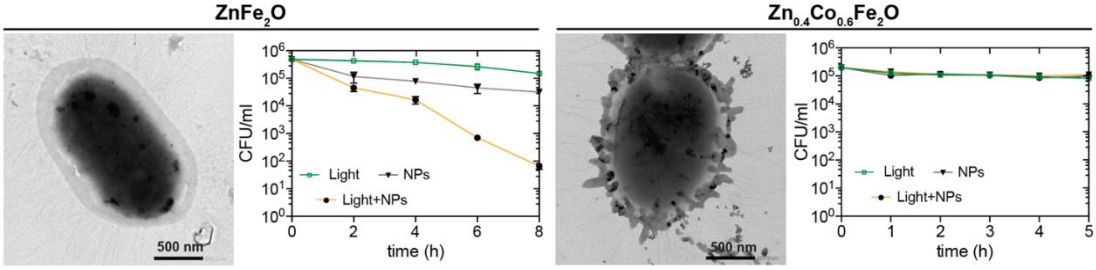

Figure 1: TEM images and cultivability of *E. coli* incubated with Zn-Co ferrites, under visible light irradiation and in the dark. Cultivability is expressed in Colony Forming Units/ml (CFU/ml), $ZnFe_2O$ were used at 20 mg/mL, and $Zn_{0.4}Co_{0.6}Fe_2O$ at 200 mg/mL.

References

[1|] S.H.S. Chan, T. Yeong Wu, J.C. Juan, C.Y. The, *J. Chem. Technol. Biotechnol*., **86** (2011)
[2] J. Revathi, M. John Abel, C. Lydia Pearline, T. Sumithra, P. Fermi Hilbert Inbaraj, J. Joseph prince, J. Allo. *Inorg. Chem. Commun.*, **121** (2020)108186.
[3] L. Cervera-Gabalda, A. Zielińska-Jurek, C. Gómez-Polo, J. Magn. Magn. Mat. **560** (2022) 169617.

(P24) Development of a platform for novel gene therapy vectors with renal tropism

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Chronic Kidney Disease (CKD) is increasingly recognized as a public health issue, estimated to affect around 10% of the population worldwide. (1) 70% of pediatric CKD and 10% of adult End-Stage Renal Disease, are attributed to defects in a single gene, representing monogenic diseases. Treatment for CKD in these cases focuses on managing symptoms and attempting to slow disease progression. Nevertheless, patients affected by genetically caused CKD may benefit from the development of gene therapy-based treatments.

Furthermore, kidney diseases are considered suitable for gene therapy due to the highly vascularized nature of the organ, facilitating easy access of therapeutic vectors to all its cells. Specifically, Polycystic Kidney Disease (PKD) is well-positioned to be the first disease for which gene therapy is developed, as it is a monogenic disease with a significant prevalence within hereditary nephropathies (1:1000-1:2500). (2)

Therefore, it is crucial to engineer vectors for the precise targeting of renal cells under various pathological conditions through the combination of nanocompounds and aptamers with the genetic material delivery properties of viral vectors. Specifically, adeno-associated viruses (AAV), which have demonstrated a high safety profile and prolonged expression of the therapeutic gene. (3)

In this study, an innovative platform has been developed with this purpose. The developed systems involve the bioconjugation of magnetite magnetic nanoparticles to genetically modified AAVs. Firstly, the synthesis and surface functionalization of magnetic nanoparticles has been optimized through the coprecipitation and thermal decomposition method of magnetic nanoparticles, resulting in particles with sizes ranging from 6 to 10 nm. These particles are stable in biocompatible solvents, exhibit spherical and cubic shapes, have high magnetization, around 80 emu/g, and demonstrate superparamagnetic behavior. The developed particles have been conjugated to the adeno-associated virus through click chemistry using DBCO-based (Dibenzocyclooctyne) molecules. The effective binding of the nanoparticles to the virus has been confirmed through SDS-PAGE. Additionally, the bioaccumulation in the kidney of the purified platform, has been demonstrated in a murine model using fluorescent microscopy.

Acknowledgments

This work was supported by the project "Creación de una plataforma para el desarrollo de vectores de terapia génica con tropismo renal" (DRONES GÉNICOS, 0011-1411-2019-000019)" funded by Innovation Department of the Government of Navarra.

References

[1] *"Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990–2015. A systematic analysis for the global burden of disease study 2015". Lancet (London, England). 2016;388(10053):1603–58.*

[2] *"Chronic kidney disease: A European perspective". Kidney International, Vol. 68, Supplement 99 (2005), pp. S30–S38.*

[3] *"Current advances in adeno-associated virus-mediated gene therapy to prevent acquired hearing loss." J Assoc Res Otolaryngol 2022;23(5):569–578.*

(P25) Multifunctional Fe-Au nanostructures for biomedical applications

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Cancer is the leading cause of death in Europe after cardiovascular disease, accounting for about 20% of deaths in the European Union [1]. One strategy followed in oncology has been hyperthermia, which consists of raising the temperature of cancer cells to 40-45ºC to reach apoptosis i.e., programmed cell death. Achieving localized and controlled hyperthermia is a pursuit that can be facilitated by functionalizable nanostructures, responsive to external stimuli such as magnetic fields or electromagnetic radiation. Gold nanostructures (Au-NS) have garnered significant attention in both academic and clinical fields due to their biocompatibility and efficient absorption of near-infrared electromagnetic radiation, attributed to surface plasmon resonance [2]. Simultaneously, magnetic nanostructures based on iron (Fe-NS) have been subject of investigation, offering diagnostic capabilities as contrast agents and therapeutic potential in magnetic hyperthermia [2]. This study aims to synergize the advantages of both materials, giving rise to multifunctional Iron-Gold nanostructures (Fe-Au-NS) that exhibit a high heating performance upon exposure to radiation and alternating magnetic fields. Fe-Au-NS were produced through the ablation of Iron and Gold targets with a femtosecond pulsed laser in liquids. This technique is particularly interesting for the development of NS-Fe-Au with complex morphologies such as the core-shell structure [3]. A thorough characterization of the Fe-Au-NS was conducted utilizing scanning electron microscopy (SEM) and superconducting quantum interference device (SQUID) techniques, providing comprehensive insights into their structural and magnetic properties. This research represents a significant step towards advancing the development of sophisticated nanostructures with dual functionality, holding promise for applications in hyperthermia-based cancer therapies and diagnostic imaging modalities.

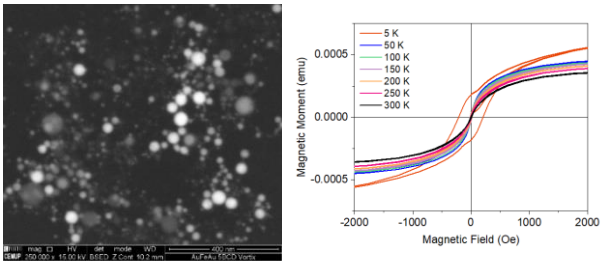

Figure 1: Nanoparticles synthesized via laser ablation of an Iron and Gold target (left); Nanoparticle's magnetization versus magnetic field measurements at different temperatures (right).

References

[1] S. C. Freitas, D. Sanderson, S. Caspani, R. Magalhães, B. Cortés-Llanos, A. Granja, S. Reis, J. H. Belo, J. Azevedo, M.V. Gómez-Gaviro, C. T. Sousa, Cancers (2023), 15, 383.
[2] S. C. Freitas, J. H. Belo, A. Granja, M. Canhota, A. S. Silva, S. Reis, H. Crespo, J. P. Araújo, C. T. Sousa, Adv. Mater. Interfaces (2023), 10, 2202214
[3] V. Amendola et. al. Journal of Colloid and Interface Science (2017) 489

(P26) Functionalized magnetopolymeric nanocomposites for antitumour magnetic hyperthermia therapy

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Among several strategies of cancer treatment, magnetic hyperthermia has recently attracted much attention due to its recently approved clinical potential. In this context, magnetic iron oxide nanosystems are of great importance among others and complex nanoplatforms are being designed for an effective therapy based in hyperthermia[1].

The main goal of the present study was to obtain magnetite/poly(ℰ-caprolactone) nanocomposites coated with chitosan and to investigate the *in vitro* antitumor magnetic hyperthermia potential.

Nanocomposites were obtained by following a step-by-step procedure[2]. Chemical co-precipitation was used for magnetite colloids synthesis. The resultant magnetite particles were embedded into a poly(ℰ-caprolactone) nanomatrix by an interfacial polymer disposition methodology. Then, coacervation procedure was selected for the magnetite/poly(ℰ-caprolactone) nanocomposites functionalization with chitosan. Resultant nanocomposites were characterized by means of dynamic light scattering and electrophoresis. Hyperthermia potential was evaluated *in vitro* using an alternating magnetic field.

Nanometric size of the nanosystem was ≈ 300 nm with a polydispersity index below 0.5. Electrophoretic study of chitosan nanoparticles and the developed nanosystem demonstrated the chitosan functionalization by showing a close similarity in the surface charge values obtained in the different pH media studied. An appropriated control over the temperature and heat flux of the magnetopolymeric nanocomposites was detected *in vitro* (minimum hyperthermia temperature ≈ 41 °C, in ≈ 30 min). Thus, the nanocomposites developed exhibited promising capabilities for efficient magnetic antitumor hyperthermia applications.

Acknowledgments

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References

[1] G. García-García, F. Fernández-Álvarez, *Polymers.* **12** (2020) 2790
[2] F. Fernández-Álvarez, C. Caro, *J. Mater. Chem. B.* **9** (2021) 4963-80

(P27) Magnetic core/shell nanoparticles as antitumoral agents for magnetic and photothermal therapy

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Hyperthermia therapy for combating tumors represent a promising cancer therapy. Magnetite-based nanoparticles are one of the most promising heating agents for clinical applications due to their biocompatibility and versatility. Specifically, they are of high interest in localized hyperthermia by means of magnetic hyperthermia and photothermal therapy[1].

The main goal of the present study was to obtain citrate-functionalized magnetite nanoparticles and core/shell magnetite-citrate/chitosan nanoparticles and to investigate their potential in magnetic hyperthermia and photothermal therapy.

Magnetite colloids were synthesis by co-precipitation method. Then, magnetite colloids were functionalized with citrate. To engineer core/shell magnetite-citrate/chitosan nanoparticles citrate-functionalized magnetite colloids were embedded into a chitosan nanomatrix[2]. Physicochemical, magnetic properties and hemocompatibility of the resultant nanoparticles were deeply investigated. Evaluation of both nanoparticles as hyperthermia agents for magnetic hyperthermia and photothermal therapy was performed using an alternating magnetic field appropriate for biomedical use and a near infrared (NIR) laser of 850 nm wavelength.

Citrate-functionalized magnetite nanoparticles and core/shell magnetite-citrate/chitosan nanoparticles showed a size of ≈ 15 nm and ≈ 325 nm, respectively. Nanoparticles composition and structure was confirmed by electrophoretic light scattering, Fourier transform infrared and thermogravimetric analysis. Saturation magnetization of functionalized-citrate magnetite nanoparticles was of ≈ 85 emu/g, which was maintained in the core/shell magnetite-citrate/chitosan nanoparticles. Heating properties of citrate-magnetite colloids and citrate-magnetite/chitosan multicore/shell nanoparticles was fully investigated resulting in a maximum SAR value of ≈ 470 for magnetic hyperthermia and ≈ 6800 W/g for photothermal therapy and a maximum SAR value of ≈ 605 for magnetic hyperthermia and ≈ 2200 W/g for photothermal therapy, respectively. Safety parenteral administration of the safety of this nanoparticle was demonstrated by hemocompatibility assays.

To conclude, citrate-magnetite/chitosan core/shell nanoparticles could find antitumor hyperthermia by combining both magnetic hyperthermia and photothermal therapies.

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FEDER/Junta de Andalucía-Consejería de Transformación Económica, Industria, Conocimiento y Universidades, Spain (Grant No. P20_00346) and Consejería de Conocimiento, Investigación y Universidad, Junta de Andalucía, Spain (Grant No, A-FQM492-UGR20) are gratefully acknowledged.

References

[1] M. Chu, Y. Shao, *Biomaterials.* **34** (2013) 4078-88

[2] F. Fernández-Álvarez, C. Caro, *J. Mater. Chem. B.* **9** (2021) 4963-80

(P28) Versatile and scalable nanotechnology platform for addressing personalized medicine

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Osteoarthritis is a degenerative joint disease that affects millions of people, being one of the main causes of pain and disability. Current therapies are limited to relieving pain and preserving joint function, but they do not cure the disease. Senotherapeutic peptides offer a promising strategy for delaying and reversing osteoarthritis progression by targeting senescent cells and the inflammatory process [1].

Recent attention has been directed towards specific peptides (YSA1/TUB1) due to their potential in osteoarthritis therapy. These peptides interfere with the activity of the marker Cx43, whose expression is increased in the articular cartilage of osteoarthritic patients, leading to senescence and dedifferentiation [2].

Our study introduces the development and optimization of sphingomyelin nanoemulsions (SNs) associated with individual and combined senolytic peptides. This aims to enhance their bioavailability, specificity, and cellular internalization. We optimized the technology for intraarticular (IA) administration, focusing on prolonging the retention times of therapeutic peptides and achieving optimal biodistribution. To achieve these goals, we introduced additional excipients such as hyaluronic acid or gelatin, forming a biocompatible hydrogel as a surface-coating for the nanoconjugates.

Positron emission tomography (PET)/computed tomography (CT) was employed to evaluate biodistribution and pharmacokinetics. PET/CT images were acquired at various time points after IA injection (2, 6, and 24 hours, 2, 7 and 14 days), allowing direct tracking of the ^{89}Zr-radiolabelled peptides loaded into SNs (PEP-SNs). The study revealed prolonged retention times of the ^{89}Zr-PEP-SNs at the target site, highlighting potential improvements in the therapeutic effects of the peptide for personalized osteoarthritis treatment.

References

[1] X. X. Zhang, S. H. He, X. Liang, W. Li, T. F. Li, and D. F. Li, *Front Pharmacol*, **12** (2021).

[2] M. D. Mayán Santos *et al.*, "Peptides for Use as Senotherapeutic Agents," Feb. 04 (2021).

(P29) Nanoscale zero valent iron increases iron availability in agricultural soils

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In the last few years, nanoscale zero-valent iron (nZVI) has been extensively tested as remediation strategy for water and soil contaminated with organic and/or inorganic pollutants. However, nZVI can provide iron, an essential trace element in crops that plays a key role in many metabolic processes. Although Fe is a relatively abundant element in the soil, the available Fe contents, which can be absorbed by plants, are remarkably low, causing deficiencies in crops, especially in alkaline soils since it precipitates as hydroxides. Nevertheless, limited data are available regarding the effectiveness of nZVI as an iron fertilizer. The objective of the present study was to evaluate the impact of nZVI application on the development of lettuce plants in two different soils.

Two agricultural soils with different physico-chemical characteristics were collected from the region of Madrid, namely an acidic soil, and an alkaline soil. Soil samples were treated with nZVI suspension (NANOFER 25S (20% Fe)) purchased from NANOIRON according to the following treatments: 0% nZVI (control), 0.5% and 5% of the nZVI commercial suspension. Five pots per treatment were included. Seedling of lettuce were transplanted and after 30 days plants were harvested, oven dried and then weighted. The content of chlorophyll, total polyphenols, flavonols and anthocyanins in leaves was monitored through the experiment. Biomass, content of nutrients and impact on ultrastructure of root cells using TEM were also studied. The analysis in soils included physico-chemical properties and iron availability.

In general, the impact of nZVI on plants depended on soil properties. Plants from acidic soils showed a better development with a significant increase of biomass and Fe content throughout the plant whereas for the alkaline soil no changes in biomass were found but an increase of Fe in aerial part was observed. The dose of 5% nZVI increased chlorophyll and total polyphenols in both soils. TEM analysis showed dark spots in the cytoplasm and cell wall of plants in the nZVI treatments which can be the nZVI since the respective EDX analysis confirmed the presence of Fe (Figure 1). Regarding soil, the treatment of nZVI induced a significant increase of pH in the acidic soil due to alkaline nature of nZVI. Iron availability increased with the dose of nZVI, especially in the acidic soils due to the greater solubility of Fe in acidic conditions. Thus, according to the obtained results, nZVI could be used as iron fertilizer although its effectiveness is conditioned by soil properties.

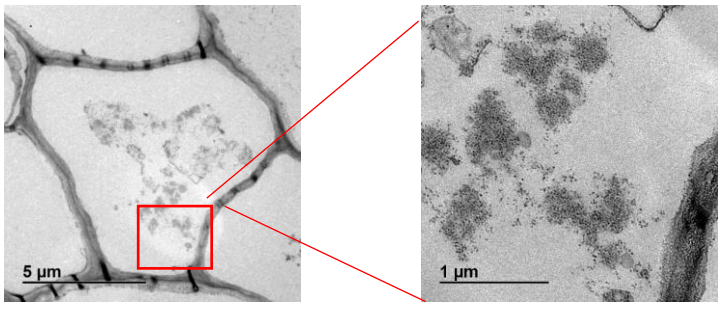

Figure 1. TEM images of root cell from 0.5% nZVI from alkaline soil.

Acknowledgments

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(P30) Biomimetic Cell Membrane-Coated Nanoparticles for the Targeting and Potential Treatment of Glioblastoma

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Glioblastoma multiforme (GBM) is the most aggressive, common, and devastating cancer of the central nervous system (CNS). Traditional GBM treatment, based on a combination of chemotherapy and radiotherapy after surgery, has not increased the 5-year survival rate of patients, which is only 5% [1]. The blood-brain barrier (BBB), a complex cellular structure that prevents the passage of hydrophilic molecules and insoluble lipids through it, is the main obstacle to the treatment of GBM. In fact, only 20% of administered temozolomide (TMZ) passes across the BBB from the blood to the brain [2]. Recently, cell membrane (CM)-coated Nanoparticles (NPs), known as nanoghosts (NGs), have emerged as potential biomimetic nanocarriers that develop a high ability to avoid the mononuclear phagocyte system, improve their half-life time, and negotiate biological barriers. Furthermore, NGs are promising in anti-cancer therapy due to their ability to target the tumour by a homologous self-recognition mechanism between the surface of cancer cells and the surface inherited from them [3]. Herein, we report a study on the synthesis and characterization of U87-MG (human GBM cell line) CM-coated NPs and their bio-interactions with GBM cells. Firstly, U87-MG CMs were isolated by a double ultracentrifugation protocol. Secondly, GBM CM-coated NPs (G-NGs) were characterized in size, surface charge, and colloidal stability by dynamic light scattering (DLS). Furthermore, G-NGs coating was visualized under transmission electron microscopy (TEM). Lastly, fluorescence microscopy and flow cytometry studies were carried out to evaluate the bio-interactions between G-NGs and U87-MG cells *in vitro*. G-NGs showed an enhanced bio-interaction *in vitro* with GBM cells thanks to a homologous self-recognition mechanism, showing promise as potential nanocarriers to target and treat GBM. Additionally, *in vitro* studies to assess the ability of G-NGs to cross the BBB by maintaining its integrity and physiological permeability are undergoing.

Acknowledgments

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References

[1] Wan, S.; Zhang, G.; Liu, R.; Abbas, M.N.; Cui, H. Pyroptosis, Ferroptosis, and Autophagy Cross-Talk in Glioblastoma Opens up New Avenues for Glioblastoma Treatment. *Cell Communication and Signaling*. **21** (2023) 115.

[2] Janjua, T.I.; Cao, Y.; Ahmed-Cox, A.; Raza, A.; Moniruzzaman, M.; Akhter, D.T.; Fletcher, N.L.; Kavallaris, M.; Thurecht, K.J.; Popat, A. Efficient Delivery of Temozolomide Using Ultrasmall Large-Pore Silica Nanoparticles for Gli-oblastoma. *Journal of Controlled Release*. **357** (2023).

[3] Li, J.; Wei, Y.; Zhang, C.; Bi, R.; Qiu, Y.; Li, Y.; Hu, B. Cell-Membrane-Coated Nanoparticles for Targeted Drug Delivery to the Brain for the Treatment of Neurological Diseases. *Pharmaceutics*. **15** (2023) 621.

(P31) Broadening the antimicrobial spectrum of the enterocin AS-48 in combination with magnetic nanoparticles and hyperthermia

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Antimicrobial resistance is a challenge for public health systems worldwide and new venues to tackle this issue are required, including the discovery of novel compounds and their effect in synergy with other treatments. Additionally, biofilms are structures in which resistance is naturally increased and more prone to appear and disseminate.

The enterocin AS-48 is a cationic head-to-tail cyclized peptide with a potent bactericidal effect against, mainly, Gram-positive bacteria. It has been broadly characterized and shows low toxicity against eukaryotic cell lines and high stability in harsh environments. Its receptor-independent mechanism of pore formation in the cell membrane is less prone to induce resistance appearance. The activity against Gram-negative species largely relies on the disturbance of the outer membrane, thus synergy with compounds altering it has been demonstrated.

Biomimetic magnetic nanocarriers (BMNPs) can be driven to bacterial cells with a magnetic field and provide high local dose of an antimicrobial. In addition, their rotation caused by the orientation in an alternating magnetic field (AMF) can increase the temperature within the therapeutic range (ca. 45 ºC). This enables a faster release of the compound and a synergy with the antimicrobial effect.

We have tested AS-48 with synthetic BMNPs inspired by bacterial magnetosomes that display a negative surface at neutral pH and have a pI of 4.8. Thus, they can adsorb AS-48 at neutral pH and release it at the cell location where the acidic pH reduces the net negative charge. With AS-48-BMNPs conjugates, we have proved fast killing of planktonic cultures of the Gram-positive bacteria tested (*Enterococcus faecalis*, *Staphylococcus aureus*, *Enterococcus faecium*) and the acid-fermenter Gram-negative *Escherichia coli*. When an AMF is applied together with AS-48-BMNPs, we achieve almost eradication of all the species tested, including the Gram-negative ones *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*.

Next, biofilms of *E. faecalis* and *P. aeruginosa* were grown and assayed using the same conditions. The combination of AS-48-BMNPs eliminated *E. faecalis* in the biofilms, whereas only a 2-log reduction was observed with *P. aeruginosa* at 45 ºC. When magnetic hyperthermia was introduced in the assay, *E. faecalis* was still fully inhibited whereas a 4-5 log reduction of *P. aeruginosa* cells was observed.

In conclusion, the enterocin AS-48 can bind BMNPs and be driven to the biofilm structure and the cell wall. There, the rotation induced by an AMF causes mechanical damage and a temperature increase that facilitates AS-48 release and killing mechanism, broadening its spectrum towards Gram-negative species. The fast and efficient killing that AS-48 causes even in biofilms represents a promising treatment for these naturally resistant infections.

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(P32) Crucial role of cellular uptake in photothermal treatments using BMNPs

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Biomimetic magnetic nanoparticles (BMNPs) have demonstrated efficacy as photothermal agents, optimizing cytotoxicity against tumour cells by playing a dual role as drug nanocarriers and hyperthermia agents [1,2].

Despite these advances, uncertainty persists about the need for internalizing BMNPs into cells and the existence of a threshold internal iron concentration to ensure the effectiveness of photothermal therapy. In this study, three scenarios of photothermal treatments were simulated to analyse the impact of cellular uptake of BMNPs in the human hepatoblastoma cell line (HepG2), evaluating cell viability following these treatments. BMNP suspensions were used, establishing protocols to obtain BMNPs exclusively intracellular (Group 1), exclusively extracellular (Group 2 and 4) or in both locations (Group 3), followed by photothermal exposure of treated cell cultures.

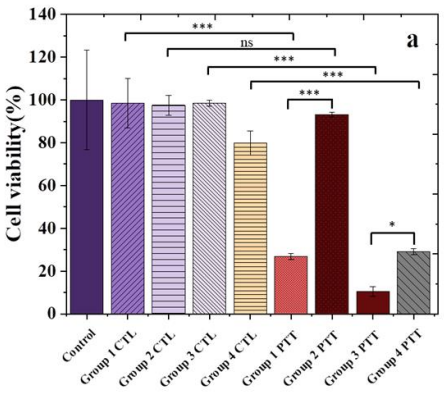

*Figure 3. HepG2 cell viability with and without photothermia treatment (0.2 W/cm2) in vitro. p-value *<0.05; ***p<0.001.*

The results reveal that, although the heating efficiency of the photothermal agent is not affected by its location, the intracellular presence of BMNPs is crucial to ensure the cytotoxic effect of the treatments, especially at low iron concentrations (Figure 1). Furthermore, it has also been shown that the concentration of BMNPs required to achieve a comparable cytotoxic effect is three times higher when BMNPs are located extracellularly compared to their intracellular location [3].

Acknowledgments

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References

[1] Jabalera, Ylenia, et al. *Pharmaceutics* 13.8 (2021): 1168.

[2] Jabalera, Ylenia, et al. "Synergistic photothermal-chemotherapy based on the use of biomimetic magnetic nanoparticles." *Pharmaceutics* 13.5 (2021): 625.

[3] Lázaro, M., et al. "The importance of cell uptake in photothermal treatments mediated by biomimetic magnetic nanoparticles." *Colloids and Surfaces B: Biointerfaces* (2023): 113722.

(P33) Magnetic Activated Carbon for Drug Delivery

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The development of localized therapies represents a significant approach to precisely target drugs or other therapeutic agents to specific regions of the body, with the aim of minimizing side effects and optimizing treatment efficacy. In this context, work is presented in which magnetic activated carbon (MAC) has been developed by incorporating commercial YP50F carbon into the magnetite synthesis process (Fig 1a). The choice of carbon is especially relevant due to its remarkable porosity, allowing efficient adsorption of ions. In addition, MAC nanoparticles have been modified by the addition of a positively charged polymer, serving as a platform for the adsorption of a drug, in this case, methotrexate (MTX) [2]. Moreover, by incorporating magnetite, they can be steered by means of magnetic fields (Fig 1b). The controlled release of MTX is carried out by stimuli such as hyperthermia and photothermia [3,4], as well as by the application of external rotating fields, which have been less studied.

The results obtained indicate a high efficiency in MTX adsorption. In addition, a significant improvement in drug release is observed when external stimuli are employed, evidencing the potential of methods such as hyperthermia, photothermia, as well as the application of external rotating fields.

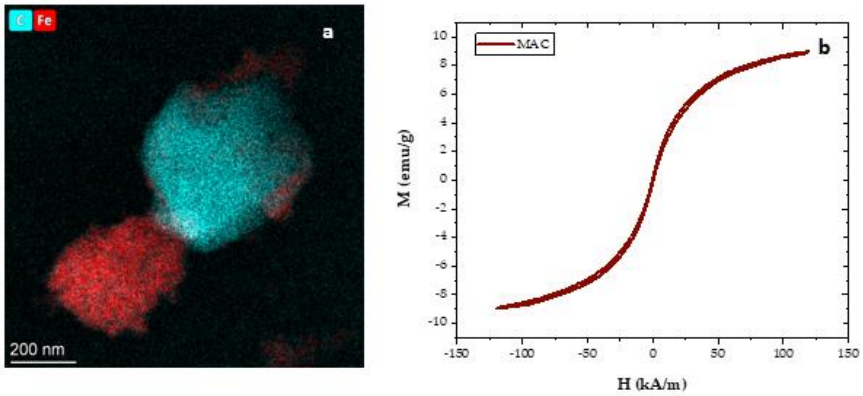

***Figure 1**. HRTEM image of the MAC sample (a). Magnetic characterization (b).*

Acknowledgments

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References

[1] Mohammadi-Samani, S., *Research in Pharmaceutical Sciences* 8.1 (2013): 25.
[2] Lázaro, M., *Polymers* 14.22 (2022): 4913.
[3] Jabalera, Y., *Pharmaceutics* 13.8 (2021): 1168.

(P34) Magnetic Semi-interpenetrating Hydrogels Based on Natural Biopolymers for Sensing and Actuating

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The design of "smart" responsive hydrogels is a growing field with applications in several different technological and biomedical areas, such as soft robots and actuators, sensors, drug delivery, tissue engineering, artificial muscles, etc. These materials stand out due to their soft nature, biocompatibility, natural response to different stimuli and wide range of mechanical properties. Among hydrogels, interpenetrating and semi-interpenetrating polymer networks are of great interest because they present the typical properties of hydrogels, alongside high values of toughness and responsiveness to more than one stimulus. The final properties of these materials depend on the polymeric networks that intertwine to form the hydrogel. This characteristic opens the possibility of total customization of the desired material regarding its mechanical properties, besides its responsiveness. In addition to that, inclusions can be added to the polymeric matrix to give even more tunability to these versatile materials.

In this work, we have developed a semi-interpenetrating hydrogel based on acrylamide, which was chemically cross-linked, and a natural carbohydrate biopolymer such as alginate or cellulose. On top of that, magnetic iron microparticles were included in the polymeric matrix, which conferred the material the ability to respond to an external magnetic field. We studied their mechanical properties under shear, tensile and compressive stress, their swelling capacity and their magnetic response. From these studies, we concluded that these hydrogels showed small values of elastic moduli while keeping a good stretchability and compressibility. They also show great swelling capacity and magnetic response. Considering all these results, we applied one of these materials as a sensor that can detect the concentration of oxygen in water thanks to the inclusion of luminescent nanoparticles. Nonetheless, the studied materials showed great properties and adaptability that make them a possible candidate for other types of applications in the field of soft robots and actuators.

Acknowledgments

This study was supported by grant PID2020-118498GB-I00 funded by MCIN/AEI/10.13039/501100011033, Spain. A.L.-C. acknowledges grant FPU19/01801 funded by MCIN/AEI/10.13039/501100011033 and "ESF Investing in your future", Spain. V.M. acknowledges VIRTUOUS project, funded by the European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie-RISE Grant Agreement No. 872181 (https://www.virtuoush2020.com/) and the Project European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie-RISE Grant Agreement "SUSTAINABLE" No. 101007702 (https://www.projectsustainable.eu/). A.L.M.-C. acknowledges funding by Plan Propio-Investigación y Transferencia de la Universidad de Granada: "Programa 9. Proyectos de Investigación para la Incorporación de Jóvenes Doctores a Nuevas Líneas de Investigación en Grupos de la UGR".

(P35) Design of chemotherapeutic nanoparticles to target Tumor Endothelial Marker 8 receptor in solid tumors

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In the search for new tumoral microenvironment markers that can overcome the limitations of conventional antitumor therapies, Tumor Endothelial Marker 8 (TEM8), alternatively recognized as Anthrax toxin receptor 1 (ANTXR1) due to its binding with this toxin, emerges as a potential candidate. This receptor has gained significant attention in recent years as an integrin-like cell surface protein that is notably enriched in the endothelium of cancer neovasculature[1] and plays a crucial role in cancer progression, angiogenesis, and metastasis[2]. As a result, it holds promise as a potential alternative to address the common limitations associated with conventional treatments for solid tumors.

In this work, we have bioengineered a TEM8 natural ligand based on the Anthrax toxin to direct chemotherapeutic nanomaterials to the tumoral microenvironment of solid tumors overexpressing this receptor. The engineered ligand was produced, purified and employed for stable electrostatic bio functionalization[3] of Doxorubicin-loaded mesoporous silica nanoparticles intended for use in *in vitro* and *in vivo* models. We show that this straightforward bio functionalization is stable under physiological conditions revealing sustained release of the drug from mesoporous silica nanoparticles (MSNs) over time, in contrast to current therapies. Subsequently, we developed a recombinant cellular model overexpressing TEM8 to validate these nanosystems in culture. Finally, we tested the chemotherapeutic nanoparticles in an *in vivo* murine malignant melanoma model induced by B16F10 malignant melanoma cell transplantation. Our results indicate that this targeting and therapeutic strategy show promise as an alternative to overcome the common limitations of conventional antitumor treatments.

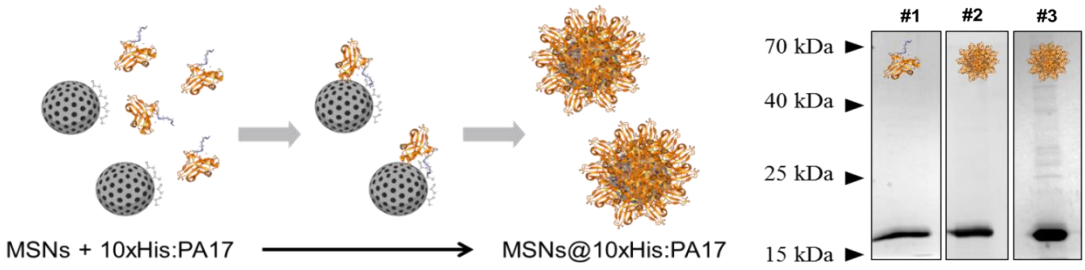

Figure 1. Scheme of MSNs electrostatic biofunctionalization. Coomassie blue stained-gel of #1 Purified 10xHis:PA17; #2 MSNs@10xHis:PA17; #3 DOX@MSNs@10xHis:PA17. In the stained gel, our protein of interest is the most abundant one bound to MSNs surface by electrostatic interactions.

References

[1] Seaman, Steven, et al. Genes that distinguish physiological and pathological angiogenesis. *Cancer cell*, 2007, vol. 11, no 6, p. 539-554.

[2] Høye, Anette M., et al. Tumor endothelial marker 8 promotes cancer progression and metastasis. *Oncotarget*, 2018, vol. 9, no 53, p. 30173.

[3] Padin-Gonzalez, Esperanza, et al. A custom-made functionalization method to control the biological identity of nanomaterials. *Nanomedicine: Nanotechnology, Biology and Medicine*, 2020, vol. 29, p. 102268.

(P36) Formulation of (maghemite/poli(ε-caprolactone))/polyethylenimine (core/shell)/shell nanoparticles with potential application in hyperthermia against cancer

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Introduction

Magnetically responsive nanoparticles (NPs) offer a promising opportunity for the application of hyperthermia as a novel approach against cancer, given that tumor cells can't survive at temperatures ≈ 41-46 ˚C. Magnetopolymeric NPs consisting of maghemite (γ-Fe_2O_3) nuclei embedded into a poly(ε-caprolactone) (PCL) matrix and decorated with polyethylenimine (PEI) are developed and evaluated for antitumor hyperthermia.

Methods

Preparation of the NPs (n = 3) was done by a solvent evaporation method [1]. Previously the iron oxid nuclei were obtained by chemical co-precipitation. Finally, surface functionalization of the γ-Fe_2O_3/PCL of the particles with PEI was done [2]. Reproducible preparation of NPs was demonstrated by determining the particle size (photon correlation spectroscopy) and by defining the effect of pH on the electrokinetics of the colloid. Finally, *in vitro* assays of hyperthermia were performed under conditions of different frequencies: 167, 150, 130, 120 and 114 kHz; and low field amplitude (17 kA/m) on a dispersion of 5 mg/mL of (γ-Fe_2O_3/PCL)/PEI NPs.

Results

(γ-Fe_2O_3/PCL)/PEI NPs of 232.9 ± 3.3 nm (PdI 0.259 ± 0.001) were produced. The dependence of the surface electrical charge of the colloids with the pH values demonstrated the formation of the nanohybrids. As well as NPs shown *in vitro* antitumor hyperthermia temperatures of ≈ 42 ˚C in every case.

Conclusions

(γ-Fe_2O_3/PCL)/PEI NPs demonstrated promising characteristics as hyperthermia nanoagents against cancer. Work is in progress to characterize these properties *in vivo*.

Acknowledgments

FEDER/Junta de Andalucía-Conserjería de Transformación Económica, Industria, Conocimiento y Universidades, Spain (Grant No. P20_00346) and Conserjería de Conocimiento, Investigación y Universidad, Junta de Andalucía, Spain (Grant No, A-FQM492-UGR20) are gratefully acknowledged.

References

[1] Garcia-Garcia G, Fernández-Álvarez F, Cabeza L, Delgado Á V., Melguizo C, Prados J, et al. Polymers. 2020;12(2790).

[2] Megías R, Arco M, Ciriza J, Saenz del Burgo L, Puras G, López-Viota M, et al. Int J Pharm. 2017;518(1-2):270-80.

(P37) Design of stable polyethylenimine-decorated magnetopolymeric nanoparticles for antitumor drug delivery

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Introduction

Conventional systemic chemotherapy involves the administration of large dosages of chemotherapeutics to obtain an acceptable antitumor effect. These high doses also induce severe toxicity. A very promising solution to this problem is the development of magnetically responsive nanoparticles (NPs) as drug nanocarriers [1]. In this work, it is described the formulation of magnetopolymeric NPs consisting of maghemite (γ-Fe_2O_3) nuclei embedded into a poly(ε-caprolactone) (PCL) matrix and decorated with polyethylenimine (PEI).

Methods

Fabrication of the NPs (n = 3) was done by a solvent evaporation method [1]. Iron oxid nuclei by a chemical co-precipitation, and post decoration with PEI [2]. Particle size and size distribution were determined by photon correlation spectroscopy. The electrophoretic properties of the NPs were characterized as a function of ionic strength. Colloidal stability was tested at room temperature and at 4 ˚C during three months.

Results

(γ-Fe_2O_3/PCL)/PEI (core/shell)/shell particles of suitable and moderately monodisperse size were obtained (≈ 230 nm). Efficacy of the PEI coating onto the γ-Fe_2O_3/PCL NPs was demonstrated by comparing the zeta potential (ζ) values of the (γ-Fe_2O_3/PCL)/PEI particles (26.2 ± 1.3 mV) with those of pure γ-Fe_2O_3 NPs (40.3 ± 1.2 mV), pure PCL NPs (-16.6 ± 1.3 mV) and hybrid (γ-Fe_2O_3)/PCL NPs (-20.4 ± 0.4 mV) as a function of KNO_3 concentration, confirmed the formation of the nanohybrids. Colloidal stability of the (γ-Fe_2O_3/PCL)/PEI NPs was demonstrated stability *in vitro*: ≈ 230 nm at t= 0 days and ≈ 240 nm (4 ˚C) and ≈ 235 nm (room temperature) at t= 90 days.

Conclusions

A reproducible methodology has been optimized to obtain (γ-Fe_2O_3/PCL)/PEI (core/shell)/shell particles with promising applications in magnetically driven drug delivery against cancer. Work is in progress to do *in vivo* assays.

Acknowledgments

FEDER/Junta de Andalucía-Conserjería de Transformación Económica, Industria, Conocimiento y Universidades, Spain (Grant No. P20_00346) and Conserjería de Conocimiento, Investigación y Universidad, Junta de Andalucía, Spain (Grant No, A-FQM492-UGR20) are gratefully acknowledged.

References

[1] Garcia-Garcia G, Fernández-Álvarez F, Cabeza L, Delgado Á V., Melguizo C, Prados J, et al. Polymers. 2020;12(2790).
[2] Megías R, Arco M, Ciriza J, Saenz del Burgo L, Puras G, López-Viota M, et al. Int J Pharm. 2017;518(1-2):270-80.

(P38) Synthesis of Magnetic Nanoparticles by the Recycling of Industrial Steel Waste and its application on CPWO

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Ensuring the reutilization of residues generated from the fabrication of products is an urgent matter to diminish the environmental impact and optimize the use of the resources [1]. Magnetic nanoparticles (NPs) can be used in diverse technological applications, being one of them addressing the pressing issue of pollutant removal from wastewater. The small size of NPs enables their easy dispersion in a liquid and, due to their large surface areas, they present a significant potential to interact with pollutants. Their magnetic properties might facilitate the NPs recovery [2].

This study shows results obtained applying a novel process that enables the transformation of steel industry residues into iron oxide NPs. The precursor was provided by CELSA Group in the form of powder with micrometer size particles. In view of the potential industrial scalability of the process, a physical method based on application of short milling times (IMDEA's self-developed "flash-milling" method [1,3]) has been used, followed by an optimized heat treatment. This route has enabled to move from a residue with a saturation magnetization (Ms) of 23 emu/g to iron oxide NPs with a Ms close to 130 emu/g after milling (10 min) and reductive annealing. The magnetic NPs obtained have been tested for the degradation of tebuconazole by catalytic wet peroxide oxidation (CWPO) [4], showing a degradation of over 75 % of the pollutant in the first minutes of reaction, and the totality of the component after 90 min. Notably, the material showed outstanding stability, with limited dissolved iron concentration at the end of the reaction (0,0098 %Fe wt.).

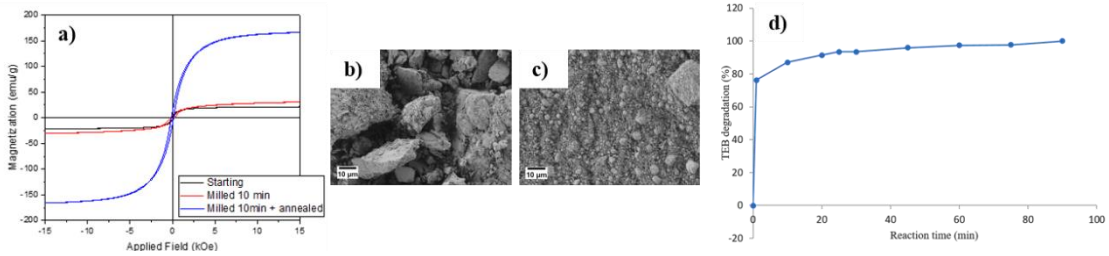

Figure 1: (a) Room temperature hysteresis loops measured by vibrating sample magnetometry (VSM) for the precursor powder and that after milling for 10 min before and after annealing. Scanning electron microscopy (SEM) images of (b) the starting powder and (c) the powder milled for 10 min. (d) Percentage degradation of tebuconazole during a CWPO process using the NPs as catalyst.

Acknowledgments
Authors acknowledge provision of the precursor material by CELSA Group and financial support through a CELSA-IMDEA Nanociencia collaboration project. IMDEA Nanociencia thanks support from the ''Severo Ochoa'' Programme for Centers of Excellence in R&D (MICINN, Grant CEX2020-001039-S), Comunidad de Madrid through NANOMAGCOST project (Ref. S2018/NMT-4321) and MINECO through the projects PID2019-105079RB-100 y el PID2022-139063OB-I00.

References

[1] A. Bollero et. al. *ACS Sustainable Chem. Eng.*, **5** (4) (2017) 3243.
[2] S.Vallinayagam e. al *J. Environ. Chem. Eng.* **9** (6) (2021) 106553.
[3] F.J. Pedrosa et. al. *RSC Adv.*, **6**, (2016) 87282.
[4] M. Munoz et. al. Appl. Catal. B: 203 (2017) 166–173.

(P39) Synthesis of starch-silver hybrid nanoparticles and their use as antimicrobial agents

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Microbial resistance to antibiotics has become a serious health problem. In recent decades, the use of silver nanoparticles (AgNPs) in antibacterial applications has been explored due to their physicochemical properties [1]. However, one of the most worrying factors in their use is the toxicological effect they may have on human health. In this sense, a coating of AgNPs could have a positive effect on their toxicity, reducing or even avoiding their effects and, in turn, increasing their antimicrobial capacity [2].

Recent studies have reported the use of starch as a stabilising agent in the synthesis of AgNPs [3, 4]. However, the use of native starch is limited and therefore a nanometric modification of starch would combine both the advantages of starch and nanoparticles [5].

The aim of this work is to develop formulations based on starch nanoparticles (SNPs) that can be used as nanocarriers of agents with antimicrobial activity, concretely silver nanoparticles.

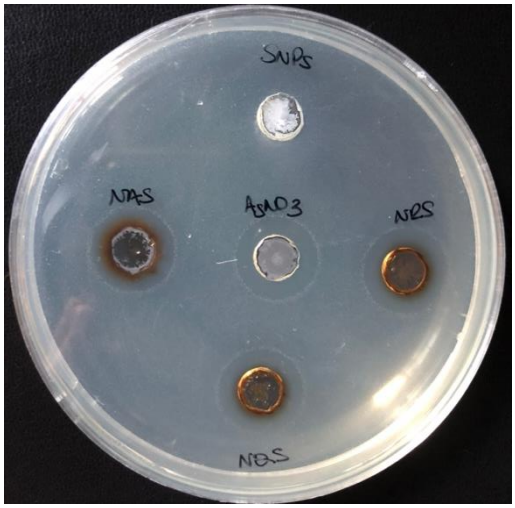

Figure 4.-Antimicrobial activity of hybrid NPs against E. coli using the agar well diffusion method. (NAS = amaranth hybrid NPs; NQS = quinoa hybrid NPs; NRS = rice hybrid NPs)

The synthesis of starch-silver hybrid NPs was carried out in two steps, combining a simple autoclave process to obtain the AgNPs and the nanoprecipitation method to obtain the SNPs under optimal conditions. Native starches of different botanical origin (amaranth, quinoa and rice) were used.

The hybrid NPs were characterised in terms of size, shape and charge by dynamic light scattering (DLS), scanning electron microscopy (SEM) and transmission electron microscopy (TEM). Fourier transform infrared spectroscopy (FTIR) analysis was used to determine the molecular structure of the NPs and inductively coupled plasma mass spectroscopy (ICP-MS) was used for the quantitative analysis of Ag. Finally, the antimicrobial activity against E. coli was determined by the agar well diffusion method (Fig.1).

Acknowledgments

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References

[1] Z. Qin, Y. Zheng, Y. Wang, T. Du, C. Li, X. Wang & H. Jiang, *Coord. Chem. Rev.*, ***449*** (2021).
[2] T. Bruna, F. Maldonado-Bravo, P. Jara & N. Caro, *Int. J. Mol. Sci.*, ***22*****(13)** (2021).
[3] J. Jung, G.M. Raghavendra, D. Kim, J.& Seo, *Int. J. Biol. Macromol.*, ***107*** (2018)
[4] S.V. Kumar et. al. *Sci. Rep.*, ***8*****(1)** (2018)
[5] D. Morán et al *Appl. Sci.*, ***11*****(10)** (2021)

(P40) Theoretical Investigation of the Role of Dipole-Dipole Interaction on the Efficiency of Magnetic Hyperthermia

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Magnetic hyperthermia is a process that converts electromagnetic energy into heat by applying an external alternating magnetic field to an assembly of magnetic nanoparticles (MNPS). Potential applications of this technique include chemical catalysis and promising cancer treatment by using MNPS as localized and selective heat sources [1]. The efficiency of magnetic hyperthermia is characterized by an observable known as the Specific Absorption Rate (SAR). It is defined as the power absorbed by a magnetic sample subjected to AC magnetic field - and therefore re-emitted by the particle- and is proportional to the hysteresis loop area and the dissipative part of susceptibility.

Several parameters are used to optimize the SAR, to control heat production, such as the amplitude and frequency of the external field, the concentration of the particles, and the volume of the nanoparticles. Many theoretical and experimental studies have shown that dipole-dipole interaction (DDI) influences the physical properties of MNPS [3], and thereby the efficiency of magnetic hyperthermia [2]. One of our aims is to clarify the role of DDI in magnetic hyperthermia processes and to study under which conditions the SAR is reduced or increased. To achieve our goal, we use two approaches, a semi-analytical method to study weak DDI for low-density nanoparticles based on perturbative calculations [4]. In addition, numerical simulations [5] make it possible to study more realistic densities (higher concentration - strong DDI) such that we can carry out a systematic study to confirm the analytical trend observed and see the limits of the analytical approach.

In the present work, we highlight the role of each physical parameter for different densities and different structures of MNPS in order to investigate their influence on the SAR. The comparison of analytical and numerical approaches, in particular the TQMC, for different assemblies of MNPS of maghemite or cobalt, in the presence or absence of an external DC field, allows us to identify the critical parameters that are in competition or in synergy for SAR optimization.

Acknowledgments

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References

[1] D. Ortega and Q. A. Pankhurst, in Nanoscience: Volume 1: Nanostructures through Chemistry, ed. P. O'Brien, The Royal Society of Chemistry, 2012, vol. 1, pp. 60-88
[2] P Tartaj, M del Puerto Morales *et al* 2003 *J. Phys. D: Appl. Phys.* 36 R182
[3] M.F. Hansen, S. Morup / Journal of Magnetism and Magnetic Materials 184 (1998) 262—274.
[4] J-L Déjardin, F Vernay, M Respaud, H Kachkachi Journal of Applied Physics, 2017, 121.
[5] V. Russier, Juan J. Alonso, I. Lisiecki, A.T. Ngo, C. Salzemann, S. Nakamae, C. Raepsaet Phys. Rev. B 102, 174410 (2020).

(P41) Soft carbon electrodes in Capacitive Energy Extraction: exploring geometry and operational parameters in Capacitive Mixing systems

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In recent years, significant research has focused on capacitive interfaces, their properties, and applications. The remarkable capacitance exhibited by the Electric Double Layer (EDL), formed when these interfaces are in contact with an ionic solution, finds application in techniques such Capacitive Deionization (CDI), involving ion adsorption, and Capacitive Mixing (CapMix). The latter is a promising technique for energy harvesting from exchanging solutions with different salinity, addressing the demands of environmental sustainability. These technologies generally utilize porous carbon electrode materials due to their properties such as their high surface area, high conductivity, and pore size distributions. The use of ion exchange membranes or the application a polymer coating to the electrode surface ("soft" electrodes) in CapMix generate a natural potential difference between the electrodes due to Donnan equilibrium without needing an external power source. Thus, the process is known as Capacitive Energy Extraction by Donnan Potential (CDP) [1, 2].

In this work, we study the use of soft carbon electrodes for CDP while we explore the influence on the efficiency and scalability of CapMix systems by parameters such as the polymer charge density, the applied current and electrode separation distance. The findings provide valuable insights into the optimization of these systems for improved energy extraction performance.

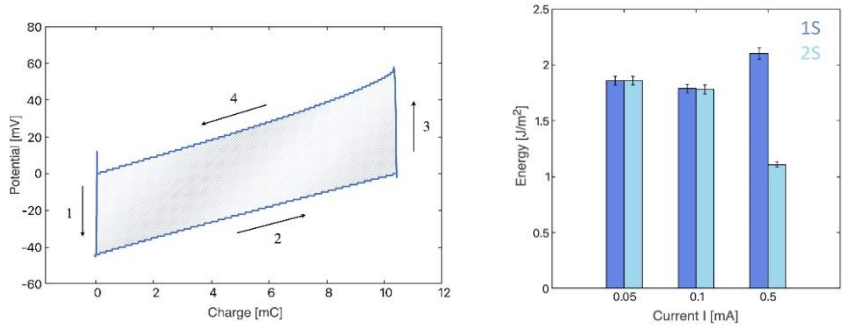

***Figure 1**: Left: Electric potential as a function of the charge. The enclosed area is the energy obtained. Right: Energy extracted as a function of the current for different separation of electrodes.*

Acknowledgments

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References

[1] M. M. Fernandez et al., *J Power Sources.* **302** (2016), 387-393.
[2] S. Ahualli et al., *Phys Chem Chem Phys.* **16**(46) (2014), 25241-25246.

(P42) Temperature Influence on the Relaxation Behavior of Immobilized Magnetic Nanoparticles

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Introduction. Magnetorelaxometry (MRX) is a promising method for monitoring magnetic drug targeting or magnetic hyperthermia. In MRX, magnetic nanoparticles (MNPs) are magnetized by an external excitation field and the relaxation of their net magnetic moment is measured after the excitation field is switched off. The relaxation amplitude, defined as the difference of measured magnetic flux densities at two points in time, is proportional to the MNP amount, allowing for their quantification. Since relaxation curves are evaluated for different MNP temperatures in hyperthermia monitoring, the influence of temperature on the relaxation amplitude is of particular interest.

Methods. An MNP sample (Perimag®, immobilized in gypsum) was positioned between an optical magnetic gradiometer (OMG, Twinleaf, USA) and an excitation coil (Fig. 1 left). The measurements were performed inside a magnetically shielded room. A background magnetic field ($B \approx 20\ \mu T$) was applied for operating the OMG. Four measurement series were carried out, whereby the MNPs had 22 °C for the first two and were heated to 38 °C for the last two. For each temperature, six different excitation flux densities and two different orientations of the background field in relation to the excitation field were applied.

Results. Our results show that the relaxation amplitude decreases with an increasing MNP temperature (Fig. 1 right). This trend is in well agreement with the literature [1]. Therefore, the influence of the MNP temperature on MRX relaxation behavior should be considered particularly when monitoring magnetic hyperthermia.

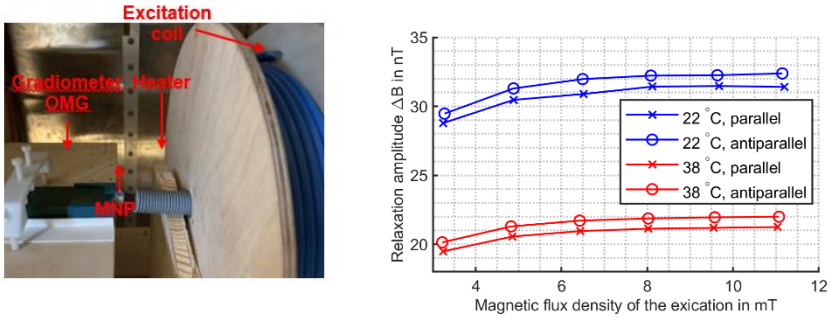

Figure 5: *Left: Measurement setup. Right: Relaxation amplitudes in dependence on the excitation flux density, the MNP temperature and the orientation of background magnetic field with respect to the excitation field.*

Acknowledgments

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References

[1] S. Arsalani, et al., *Phys. Med. Biol.* **68** (2023) 175017.

(P43) Real cell membranes in Langmuir monolayers for anticancer drug studies and model validation

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Langmuir monolayers have been frequently employed to simulate half of a cell membrane and to study their interactions with other substances, such as anticancer drugs, under controlled conditions. While lipidic models resembling cell membrane compositions are commonly used, replicating the intricate and diverse composition of cell membranes solely with lipid mixtures is challenging. Therefore, it would be convenient to start exploring the formation of Langmuir films with membranes extracted from real cells.

In this work, stable Langmuir films were created using membranes extracted from human breast adenocarcinoma cells (line MCF-7). This novel strategy maintains all the components of the membrane and rearranges them in a half membrane. Once the membranes were characterized via their surface pressure – mean molecular area isotherm and AFM images, doxorubicin anticancer drug was then introduced into the subphase while recording the changes in surface pressure and morphology to observe its effect on the membrane films.

In addition, in order to validate the use of lipidic models, Langmuir monolayers were created using lipid mixtures based on the lipidic composition of breast tumor cells found in literature. The results obtained on models with and without doxorubicin in the subphase were compared with those obtained with real membranes to determine their degree of reliability.

Acknowledgments

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References

[1] Peetla C, Bhave R, Vijayaraghavalu S, Stine A, Kooijman E, Labhasetwar. *Mol Pharm*. (2010) 7(6)Nobre T.M, Pavinatto F.J, Caseli L, Barros-Timmons A, Dynarowicz-Łątka P, Oliveira O.N. *Thin Solid Films*. (2015)
[2] W. Szlasa, I. Zendran, A. Zalesińska, M. Tarek, and J. Kulbacka. *J Bioenerg Biomembr*. (2020) 52(5)
[3] D. Matyszewska, E. Nazaruk, and R. A. Campbell. *J. Colloid Interface Sci*. (2021) 581: 403–416.
[4] Hoejholt, K.L., Mužić, T., Jensen, S.D. et al. *Sci Rep*. (2019) 9, 4758.

(P44) Superparamagnetic Nanoparticles coupled with silver and copper: growth inhibition of bacterial pathogens

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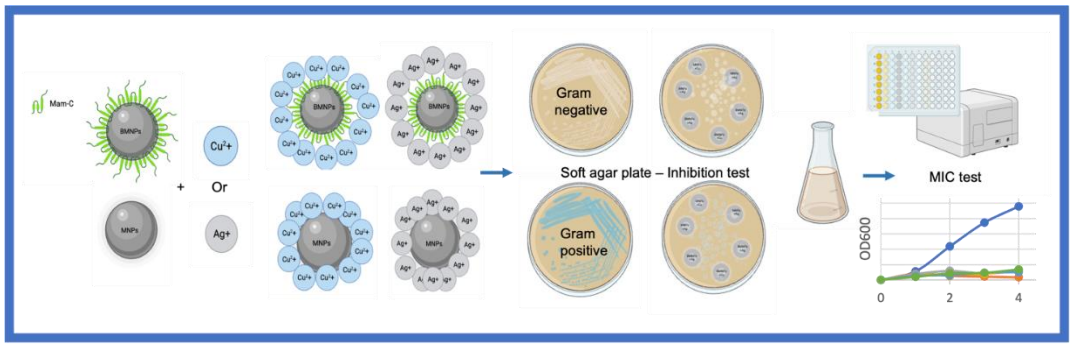
Magnetite nanoparticles are extensively applied in different fields thanks to their properties conferred by the nanoscale size. The purpose of this work is to test Biomimetic Magnetic nanoparticles and Magnetic nanoparticles, both coupled with silver or copper, against different bacterial pathogens; they were tested both against gram-positive and gram-negative bacteria. The physico-chemical characterization of the samples is obtained by Dynamic Light Scattering and ICP mass spectroscopy for both immobilized ions on both types of nanoparticles to confirm the presence of the cations, previously assessed through indirect quantitative analysis performed during the immobilization. The workflow to test the inhibition activity is reported below: the concentration of different ions was tested using soft agar plates to confirm growth inhibition and we were able to verify the formation of a distinctive halo around sample spots, confirming the exclusive inhibitory activity of our nanoassemblies when compared with superparamagnetic nanoparticles not treated with the cations. A growth curve for both pathogens was determined, and a Colony Forming Unit test was done to quantify the grown cells; Minimum Concentration Inhibitory (MIC) tests have been also performed overtime. Biomimetic nanoparticles and Magnetic nanoparticles coupled with silver or copper have different behavior depending on which bacteria is under test. Anyway, an inhibitory activity was found for both bacteria strains in presence of both ions immobilized on the nanoparticles and this will open a new antibiotic-free approach to counteract the proliferation of antibiotic-resistant bacteria.



Project workflow.

Acknowledgments

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(P45) SERS detection of saxitoxin using covalent organic polymer/gold nanoparticles composite.

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Harmful algal blooms (HABs), an excessive growth of phytoplankton, causing more than 60,000 intoxications per year. Saxitoxin (STX) stands out as one of the most prevalent toxin, found in both marine and freshwater environments. SXT is responsible for paralytical shellfish poisoning (PSP), which can potentially lead to respiratory paralysis when ingested by humans [1]. This toxin accumulates within shellfish and filter-feeding bivalves, climbing up the food chain. Providing the seafood industry with less costly, real time and *in situ* monitoring systems would help to avoid seafood contamination. Surface-enhanced Raman scattering (SERS) emerges as an interesting analytical technique due to its distinctive advantages, which include high selectivity and sensitivity, *in-situ* measurement, and time and cost reduction [2]. However, its applicability in the biotoxins detection is closely bound to the fabrication of highly efficient and flexible hybrid composites, combining a highly SERS active plasmonic enhancer with a chemoreceptor to bind/trap the biotoxin close to the plasmonic surface [3].

In this line, a family of hybrid composites were created based on a covalent organic polymer (COP), TpPa-COOH [4], with highly efficient absorption of saxitoxin and gold nanoparticles (GNPs). The SERS properties of these COP/GNPs composites were analysed using different Raman reports, which were selected through the consideration of their Raman cross-section and/or physicochemical properties, such as lipophilicity. Pararosaniline was identified as the most promising Raman reporter for the optimization of COP/GNPs composites. This reporter was successfully detected up to 10 nM. The next step is to use the composite that gave the best results with pararosaniline for saxitoxin detection.

Acknowledgments

The authors acknowledge the financial support of the project "Pacto da Bioeconomia Azul", with the reference n.º C644915664-00000026, co-funded by Component C5 – Capitalisation and Business Innovation under the Portuguese Resilience and Recovery Plan, through the NextGenerationEU Fund. This work benefitted also from financial support through the EEA grant ATLANTICLAM (PT-INNOVATION-0097) is acknowledged. L.R.-L. acknowledges funding from FCT (Fundação para a Ciência e Technologia) for the Scientific Employment Stimulus Program (2020.04021.CEECIND).

References

[1] K. D. Cusick *et al*., Mar Drugs, 2013, **11,** 991-1018
[2] J. Langer *et al*., ACS Nano, 2020, **14**, 28-117
[3] H. Lai *et al*., *J.Mater. Chem C.*, 2020, **8**, 2952
[4] T. Wang *et al*., J Hazard Mater, 2023, **452**, 131247

(P46) Trapping heavy metals by bone bioresidues

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Lead, a naturally occurring toxic metal present in the Earth's crust, has become a major source of public health concerns globally, particularly in regions where lead pipes are used for supplying drinking water. Exploring methods that incorporate environmentally friendly materials, preferably residues, with high lead retention capabilities offers an interesting approach. In this regard, chicken bone, a residue from food industry that consists mainly of an inorganic phase (nanocrystalline carbonated apatite) responsible for mineralization and an organic matrix (primarily type I collagen) that serves to shield the apatite crystals, demonstrates significance. [1][2].

Thermal treatments have the capability to alter the properties of both the mineral and the organic matrix, resulting in a material exhibiting varied porosity and/or reactivity. This opens the possibility of using bone as adsorbent and optimize its potential for adsorbing diverse compounds through the application of thermal treatment to the raw bone. When the bones are treated at 600ºC, organic matter is lost, recrystallization occurs and ions such as Mg2+ and Na+ are expelled to the crystalline surface of the apatite lattice. Considering that the combustion of more labile organic components typically takes place around 600ºC, heating up to 800ºC may be necessary for pathogen elimination and obtaining protein-free samples [3]. This calcination process creates additional microporosity in the bone. Indeed, our findings demonstrate that when calcined bones are exposed to a lead solution, a higher metal adsorption is observed compared to untreated bone. The present work focuses on the study of the lead adsorption ability of bone, serving as a proof of concept for a sustainable and environmentally friendly approach involving the recycling of bone waste for metal adsorption from aqueous samples.

Acknowledgments

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References

[1] PO. Olusakin et al., *Chemosphere* **287** (2022) 132130.

[2] A. Peigneux et al., *Ecotoxicology and Environmental Safety* **192** (2020) 110307.

[3] A. Rodríguez Navarro et al., *Crystal Growth & Design* **23.11** (2023) 7841-7852.

Bones as bacterial bioadsorbant

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Contamination of household water is a prevalent issue leading to short-term gastrointestinal illnesses. A noteworthy strategy for addressing this concern involves the formulation of methods utilizing eco-friendly materials characterized by robust bacterial retention capabilities. Chicken bone, a waste derived from the food industry, primarily consists of an inorganic phase (nanocrystalline carbonate apatite) mineralizing an organic matrix (mainly type I collagen) [1]. Through thermal treatments, alterations in both the mineral and organic components occur, resulting in a material characterized by a higher surface reactivity and increased microporosity. The methodology revolves around recycling bone waste to facilitate bacterial adsorption in aqueous samples.

Hence, bone subjected to heat treatment proves to be a effective adsorbent for various compounds and/or microorganisms. As temperature rises, bone characteristics change due to dehydration, the removal of organic components, and recrystallization of the mineral. Obtaining the unprotected bone mineral involves subjecting the bones to elevated temperatures, leading to the combustion of a majority of the organic constituents. This calcination process eradicates all pathogens as well as generates increased microporosity and a substantial surface area. Our findings demonstrate that bones calcined at 400°C placed in a bacterial culture exhibit significant adsorption capacity, providing evidence of the concept of green and sustainable technology involving the recycling of bone waste for bacterial adsorption of aqueous samples [2].

Acknowledgments

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References

[1] A. Peigneux et al., *Ecotoxicology and Environmental Safety* **192** (2020) 110307.

[2] N. Dominguez-Gasca et al., *Eur. J. Mineral* **31.2** (2019) 209-216.

(P48) Proposed mechanisms of reaction for coating maghemite nanoparticles with alkylcyanoacrylates

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Introduction: Hybrid nanospheres of maghemite (ɤ-Fe_2O_3) coated by poly alkylcyanoacrylates (PACA) are very promising for biomedical applications. Therefore, In order to understand how the ɤ-Fe_2O_3 / poly (n) butyl cyanoacrylate (PBCA) (core/shell) nanohybrid are generated, this work investigated the reactions that might occur during the process.

Methods: Coating of ɤ-Fe_2O_3 nanoparticles by PBCA was done by anionic polymerization of the BCA monomer in an aqueous phase [2], under sonication (40 kHz, 40% output) and at 2.7 > pH > 2.2 [1]. In a second phase, coated nanospheres were removed from the media by a magnet (0.4 T) and dispersed in distilled water with Kollyphor® P-188 1% (w/v) as surfactant. The final pH was 6.0 ± 0.5, so the outcome of the electrokinetic determinations were not affected by this parameter.

Results and discussion: Three different nanohybrids were formulated in three different days. The results of size and zeta potential were, respectively: 301.00 nm ± 0.15 nm, -19.00 mV ± 0.28 mV; 267.00 nm ± 1.89 nm, -22.00 mV ± 3.83 mV and 269.00 nm ± 15´95 nm, -12.90 mV ± 0.20 mV.

Conclusions: The surface of the ɤ-Fe_2O_3 nanospheres behave as a Brønsted acid depending on the pH of the medium [1]. Thus, at the tested pH, the oxygen atoms of the outer lattice of the ɤ-Fe_2O_3 create a positive charged region (O - H_2^+) that might end the PBCA polymerization by neutralization of the carbanions formed in the reaction [2]. This process may be accelerated by the hydrophobic nature of the inner part of the ɤ-Fe_2O_3 nuclei.

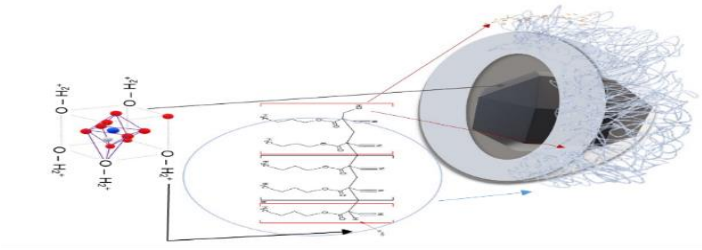

Fig. 1. *Proposed mechanism of formulation of the of ɤ-Fe_2O_3/PBCA "core/shell" nanoparticles.*

Acknowledgments

FEDER/Junta de Andalucía-Consejería de Transformación Económica, Industria, Conocimiento y Universidades, Spain (Grant No. P20_00346) and *Consejería de Conocimiento, Investigación y Universidad, Junta de Andalucía,* Spain (Grant No, A-FQM492-UGR20) are gratefully acknowledged.

References

[1] Lucas IT et. al. J Phys Chem C. 111(50):18568-76.
[2] Keller BL et,al.Polymers. 14(5):998.

(P49) Optimized formulation of maghemite/poly (n) Butylcyanoacrylate "core/shell" nanospheres with promising characteristics for antitumor magnetic hyperthermia

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Introduction: In this work, we propose a procedure, including a magnetokinetic cleaning step (MKC), for the formulation of magnetopolymeric nanoparticles. Formulation of this nanohybrid systems, consisting in a magnetic responding core of maghemite aggregates coated by a polymer which belongs to alkyl cyanoacrylates [poli (n) butylcyanoacrylate (PBCA)], is optimized to achieve a high degree of homogeneously sized nanospheres.

Methods: The coating was made by the anionic polymerization method in an aqueous phase [1], in which the maghemite nanoparticles had been previously dispersed, under sonication. The weight rate maghemite:monomer was 3:4, and in all the steps the surfactant used was Kollyphor® P-188 (1% w/v) in distilled water. After sonication, the samples were mechanically stirred at 1000 r.p.m for 60 min. The coated nanospheres were cleaned magnetically (0.4 T), removing the supernatant fluid. Those nanoparticles attracted to the magnetic field were redispersed. The colloid was then stirred mechanically (1000 r.p.m, 10 min), under the effect of a constant magnetic field (0´4 T) applied on one side of the beaker for 20 min. Measurements of size by dynamic light scattering (DLS), zeta potential by Electrophoretic light scattering (ELS) and magnetic hyperthermia measurements were done.

Results and discusion: Before applying the MKC procedure, the size of the nanoparticles was 691 nm ± 39 nm, with a Polydispersity index (PdI) of 0.63 ± 0.07. On the opposite, when following the MKC method, the size of the nanoparticles was 301.00 nm ± 0.15 nm, (PdI 0.416 ± 0.051). The zeta potential value was -19.00 mV ± 0.29 mV. For a density of 10 mg/mL, the magnetic hyperthermia (field 25 kA/m, frequency 114 kHz) test results showed a rising of ≈ 5°C in comparison to distilled water (control) in 240 s.

Conclusions: MKC method might be a promising step in the formulation of magnetopolymeric nanoparticles with antitumoral magnetic hyperthermia activity. The outcome of this work show a promising enhance of their size and homogeneity for further clinical applications.

Acknowledgments

FEDER/Junta de Andalucía-Consejería de Transformación Económica, Industria, Conocimiento y Universidades, Spain (Grant No. P20_00346) and *Consejería de Conocimiento, Investigación y Universidad, Junta de Andalucía,* Spain (Grant No, A-FQM492-UGR20) are gratefully acknowledged.

References

[1] Arias JL, Ruiz MA, Gallardo V, Delgado ÁV. Tegafur loading and release properties of magnetite/poly(alkylcyanoacrylate) (core/shell) nanoparticles. Journal of Controlled Release. 2008;125(1):50-8.

(P50) Tunable Lipid Nanoparticles as Effective Carriers for Enhanced Brain Penetration

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As of today, the scientific endeavour to treat brain pathologies has faced many inconvenient. One of the key challenges science faces is the inherent difficulty of delivering treatments to reach the Central Nervous System (CNS), primarily due to the existence of the Blood-Brain Barrier (BBB). This complex biological barrier (formed by endothelial cells, astrocytes and pericytes) surrounding the brain boasts extraordinary impermeability characteristics, strategically developed to prevent and regulate the infiltration of any biological substance in this tissue [1]. Recently, nanomaterials and, more concretely, nanoparticles (NPs), have emerged as a potential tool to overcome biological barriers when performing drug delivery therapies [1]. More concretely, lipid NPs, leveraging their distinctive physicochemical properties, prove their ability to surmount biological barriers, predominantly dictated by their size and the inherent characteristics of their constituent materials [2,3]. In this work, by using different techniques, such as dynamic light scattering, nanoparticle tracking analysis, atomic force microscopy, and rheology, we assessed the mechanical properties of biocompatible lipid NPs with different bio-mechanical properties. Herein, we manipulated the proportional concentration of olive oil and stearic acid as core components. Additionally, flow cytometry assays to evaluate the NP cellular uptake were conducted, in order to determine their capacity as drug carriers in cancer treatment. Lastly, we investigated the trespassing ability of the lipid NPs through a human BBB *in-vitro* model. Alterations in the core component proportions were found to significantly tune not only the mechanical properties of the lipid NPs but also their cellular uptake by U87-MG glioblastoma cells. Finally, these component modifications were found to impact NP performance in crossing the BBB *in vitro* model. Our findings suggest that the composition and size of lipid NPs might exert a substantial influence on their mechanical properties, leading to distinct biological performances when trying to use them as tools for specific treatments for a range of brain diseases.

Acknowledgments

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References

[1] Shankar R et. al. *Pharm Nanotechnol.* **6(2):81-93** (2018).

[2] M Li, Z Gao, J Cui. Modulation of Colloidal Particle Stiffness for the Exploration of Bio−Nano Interactions, *Langmuir* **38:6780−6785** (2022).

[3] N Dabholkar, T Waghule, VM Rapalli, S Gorantla, A Alexander, RN Saha, G Singhvi. Lipid shell nanocapsules as smart generation lipid nanocarriers, *Journal of Molecular Liquids*, **339:117– 145** (2021).

(P51) Coupled optical modes in twisted triskelia nanostructures for enantiomer detection

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Our work is focused on the design, simulation, and the manufacture of a simple 3D structure that presents large circular dichroism (CD) and polarization-selective near-field distributions in the optical range, which can be easily tuned by adjusting its geometrical parameters [1]. The building block used in this work, so-called "triskelion", shows three-fold rotational symmetry and has chiral nature (Figure 1a). Our simulations reveal that a stacking of two twisted triskelia presents a strong dichroic signal in the extinction. The arising dichroism is mainly due to two extra excitations, exhibited by the absorption at wavelengths greater than 0.7 and 1.1 μm, respectively (Figure 1b), which are not present in the single triskelion case. These extra excitations are found only for one of the light circular polarizations (Figure 1c and 1d) and show strong near field distributions between the stacked elements.

The spectral position of these two peaks can be tuned by changing either the edge-to-edge distance between the triskelia or their relative angle of rotation. This enables an accurate control of both the wavelength ranges at which the CD appears and the associated field excitations, providing a simple platform to finely control the chiral response of the system by adjusting two parameters that can be easily modified in the manufacturing process. Such a fine control of the chiral response paves the way for highly specific enantiomer detection through polarization-selective near field interaction.

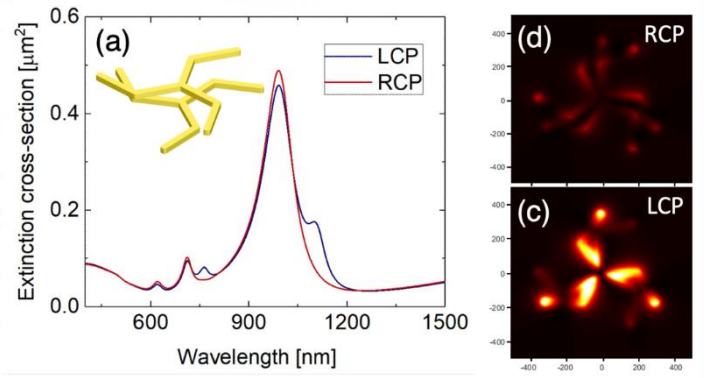

Figure 1. *(a) Extinction cross-section for right circular polarization (RCP) and left circular polarization (LCP) with a schematic depiction of the system in the inset. (b) and (c) panels show near field distributions in the plane at the middle between the two triskelia for the extra resonance at 1100 nm for RCP and LCP, respectively.*

Acknowledgments

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References

[1] J. Rodríguez-Álvarez, et al., *Scientific reports*, 2022, *12*, 1-10.

(P52) Superparamagnetic nanoprobes for magneto-inductive sensing

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Pneumonia stands as the primary cause of hospitalization in Spain, the leading infectious disease-related cause of global mortality, and a prominent contributor to child mortality (1). Accurate etiological diagnosis remains challenging, particularly in children, owing to the difficulties in accessing the infection site. To address this challenge, the NEUMOSENSOR project aims to develop a compact and portable device with optimal sensitivity and specificity for both detection of pneumococcal pneumonia in adults and children, without the need for sophisticated techniques.

The sensor utilizes superparamagnetic nanoparticles (MNPs) as detectable labels. MNPs based on iron oxides with different degrees of Mn(II) doping were produced through three distinct methods: co-precipitation, thermal decomposition, and modified polyol-mediated synthesis. Evaluation of the monocore nanoparticles revealed that those incorporating manganese, produced through co-precipitation and polyol-mediated synthesis (Fig. 1), exhibited the highest magnetic signals. In addition, the influence of the shape and nanostructure of the MNPs on the signal response has been studied preparing manganese ferrite nanoflowers (2). These particles were functionalized with polyacrilic acid to enhance biocompatibility using the protocol described by Wang et al. (3).

Particle characterization encompassed an assessment of size, surface charge, composition, and magnetic properties. Notably, consistent findings across all the synthesis methods revealed small, reproducible, and superparamagnetic nanoparticles.

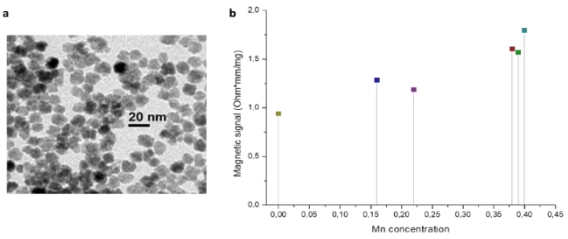

Figure 1. *a) Selected TEM micrograph of ferrite manganese nanoflowers. b) Chart showing the magnetic signal for each single-core manganese ferrite nanoparticle (increasing order of Mn concentration).*

Acknowledgments

This study was supported by Spanish Ministry of Science and Innovation (projects PLEC2022-009490 and PID2019-106301RB-I00). https://neumosensor.eu/

References

[1] Gil-Prieto R. et al. *Antibiotics (Basel).* **12** (2023) 172.
[2] Bertuit, E. et al. *ACS Nano.* **16** (2022) 271-284.
[3] Wang, W. et al. *Appl. Surf. Sci.***346** (2015) 348–353.

(P53) Physical switches to enhance the antitumoral action of magnetic nanoparticles

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The development of novel, directed antitumor therapeutic alternatives is a must. These therapies should allow going from systematic to local, thus focussing the treatment to the target, reducing the amount of the chemotherapeutic drug, preventing dissemination and, thus, reducing the undesirable secondary effects. In this context, it is well known that physical stimuli can lead to cell death, either directly (i.e., damaging cell structures) or indirectly, prompting cellular responses that end up in apoptosis (i.e., the generation of reactive oxygen species). Tumor cells have been shown to be selectively affected by local temperature increases up to 46ºC. Magnetic nanoparticles can mediate this local temperature rise, either by magnetic hyperthermia[1] or by photothermia[2]. Therefore, alternating magnetic fields (AMF) or laser irradiation in the near infrared (NIR) could be relevant to locally alter cell viability. Moreover, cell structural damages may also be caused by the rotation of a magnetic nanoparticle, and, therefore, rotation induced by AMF or by rotating magnetic fields (RMF) should also be considered. In any case, the characteristics of the magnetic nanoparticle might be important for the efficiency of these treatments. The present study analyses the effect on HepG2 tumoral cells of treatments mediated by different magnetic nanoparticles exposed to AMF, laser irradiation in the NIR (near Infrared) and RMF, with the goal of testing whether or not the size and shape of the magnetic nanoparticles are important for the efficiency of the treatment. To this end, inorganically synthetized magnetic nanoparticles uncoated (NR) or polymer coated (NR+P) and MamC-mediated magnetic nanoparticles (BMNPs) are used for comparison.

Our results show that BMNPs, NR and NR+P are different in size and morphology. NR and NR+P nanoparticles are rods of ~525 nm length, while BMNPs are elongated prismatic crystals of ~40 nm. They have different surface charge, as their isoelectric point varies from <4 for NR, 4.4 for BMNPs and 5.4 for NR+P. They are cytocompatible and a significant difference in cell internalization is observed. All nanoparticles behave as magnetic hyperthermia agents, raising the temperature of the bulk medium following upon exposure to AMF. The temperature rise increases with the intensity of the magnetic field. They are also photothermia agents, the higher the temperature rise at the higher the laser intensity power. HepG2 treated with NR+P and BMNPs and exposed to AMF show viability loss, while laser irradiation only affects HepG2 when treated with BMNPs and RMF doesn´t seem to affect cell viability. These results indicate that: (1) there are physical switches mediated by magnetic nanoparticles that can affect tumor cells viability, and (2) the size and shape of the nanoparticles are important for the efficiency of the treatment.

Acknowledgments

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References

[1] F. Oltolina et. al *Cancers*, **12**(2020) 2564.
[2] Y. Jabalera et. al. *Pharmaceutics* **13**(2021) 625.

(P54) Magnetic-induced bacterial death mediated by magnetic nanoparticles

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The design of new strategies to increase the effectiveness of antibacterial treatments is a main goal in public health prompted by the increasing generation of antibiotic resistances. This is particularly important for Gram negative bacteria, naturally resistant to many antibiotics due to the existence of the external membrane that prevents the antibiotics to reach their target. However, Gram negative bacteria have been shown to be affected by combination of a directed antibacterial therapy and hyperthermia mediated by biomimetic magnetic nanoparticles BMNPs exposed to an alternating magnetic field[1]. The aim of this work is to study whether or not inorganically synthetized uncoated (NR) or polymer coated (NR+P) magnetic nanoparticles have antibacterial activity in response to magnetic stimuli such as alternating magnetic fields (AMF) or rotating magnetic fields. MamC-mediated magnetic nanoparticles (BMNPs) are used for comparison. This study uses *Pseudomonas aeruginosa* as model Gram negative bacterium and *Staphylococcus aureus* as model Gram positive bacterium. The bacteriocine AS-48[1] was further used to form the nanoassembly AS-48-BMNPs to evaluate the effect of the combined therapy.

Our results show that BMNP, NR and NR+P have different effects inducing cell death. BMNPs, NR and NR+P magnetic nanoparticles are different in size and morphology. NR and NR+P nanoparticles are rods of ~525 nm length, while BMNPs are elongated prismatic crystals of ~40 nm. They all behave as magnetic hyperthermia agents, raising the temperature of the bulk medium following upon exposure to AMF. The temperature rise increases with the intensity of the magnetic field and reaches a maximum at a specific frequency. When NR+P or BMNPs are added to cultures of *P. aeruginosa* or to cultures of *S. aureus* and exposed to AMF, only BMNPs are able to reduce the colony forming units of *P. aeruginosa* while the rest of the treatments were bacteriostatic. When these cultures were treated identically and exposed to a rotating magnetic field, the Gram positive bacteria *S.aureus* seems to be more affected than the Gram negative bacteria. As expected, when the nanoformulation AS-48-BMNPs is tested, there is a synergistic effect of the application of the magnetic hyperthermia in combination with the antibacterial peptide AS 48 for both Gram positive and Gram negative bacteria. These results indicate that: (1) the size and shape of the nanoparticles are important for the efficiency of an antibacterial treatment, and (2) differences in the cell wall of bacteria need to be considered when designing an antibacterial treatment mediated by magnetic nanoparticles in response to alternating or rotating magnetic fields.

Acknowledgments

Financial support for this investigation by Ministerio de Economía y Competitividad (PID2019- 109294RB-100, EC2019-005930-P, PDC2021-121135.100), Instituto de Salud Carlos III (PI20- 01658), FEDER/Junta de Andalucía (P20_00346, P20_00208) and Consejería de Conocimiento, Investigación y Universidad, Junta de Andalucía, Spain (A-FQM492-UGR20, B-BIO432-UGR20, B-CTS216-UGR20) is gratefully acknowledged. Thanks also to grant TED2021- 31855BI00 funded by MCIN/AEI/10.13039/501100011033.

References

[1] Y. Jabalera, M. Montalban-Lopez, J.J. Vinuesa-Rodriguez, G.R. Iglesias, M. Maqueda, C. Jimenez-Lopez. *International Journal of Biological Macromolecules*, **189**(2021) 206-213.

(P55) Synthesis of Multiresponsive Plasmonic Microgels

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Thermoresponsive microgels are soft colloidal particles made of cross-linked polymers that swell in a good solvent. They undergo a phase transition above the Volume Phase Transition Temperature (VPTT), collapsing around 32 ºC. During the synthesis, additional features can be added to make the microgels responsive to other stimuli like pH, light, or magnetic fields. In this work, we will focus on the synthesis of microgels containing a single gold nanoparticle core [1]. This enables the possibility to induce the collapse of the microgel by light at the wavelength corresponding to the local surface plasmon resonance of the gold nanoparticle that acts as a local heater. Additionally, microgels can self-assemble at fluid interfaces, self-assembling into monolayers with hexagonal packing. The transfer of these monolayers to solid substrates while maintaining hexagonal symmetry opens up possibilities for creating ordered layers of gold nanoparticles with promising optical properties [2]. In this work, we will present recent advances from our group in the synthesis of microgels containing a single gold core. We will discuss the synthesis process, focusing on strategies to overcome challenges such as collateral synthesis of core-less microgels, difficulties in gold core encapsulation, and issues related to aggregation during synthesis. Furthermore, insights into tuning the microgel size and swelling ratio will be presented. We will also present some preliminary results on the self-assembly of gold nanostructures on solid substrates, as shown in Figure 1.

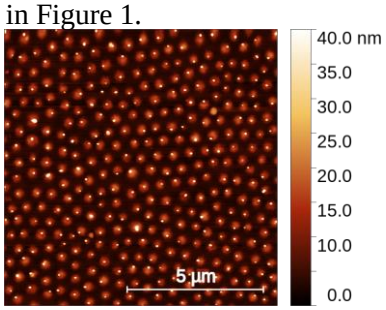

Figure 1. *Atomic Force Microscopy image of self-assembled microgels containing a gold core deposited in a silicon substrate. Bright points inside the microgels are the gold nanoparticles.*

Acknowledgments

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References

[1] Karg, M., Jaber, S., Hellweg, T., & Mulvaney, P. (2011). *Langmuir*, *27*(2), 820-827.

[2] Vinnacombe-Willson, G. A., Conti, Y., Jonas, S. J., Weiss, P. S., Mihi, A., & Scarabelli, L. (2022). *Advanced Materials*, *34*(37), 2205330.

(P56) Tailored starch-based nanocolloids for bioapplications

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Starch is a naturally abundant, biodegradable and biocompatible polysaccharide. In recent years, starch nanoparticles (SNPs) have received increasing attention due to their large surface area to volume ratio, potential surface functionalization and biocompatibility. These properties make SNPs a great candidate for the encapsulation of biocompounds for controlled release [1]. However, one of the major problems presented by these nanoparticles is their tendency to form aggregates [2]. This challenge can be addressed by encapsulating these nanoparticles in nanocapsules such as micelles, vesicles, or lipid-polymer hybrid nanoparticles, which would be versatile as there are many kinds of starch depending on their botanical source or even their chemical modification.

The aim of this work is the synthesis of colloidal systems encapsulating quinoa starch nanoparticles and their functionalisation. Four different colloidal systems were formulated, all functionalized with carboxylic acid groups on their surface: polymeric micelles, liposomes and niosomes, conformed by either phospholipids or non-ionic surfactants. Different encapsulation methods were also studied to optimise the synthesis of these sustainable nanocolloids.

Size and surface charge were determined by dynamic light scattering (DLS) and morphology and monodispersity by transmission electron microscopy (TEM), examples of which are shown in Figure 1. The molecular structure was analysed by Fourier transform infrared spectrometry (FTIR).

These systems will be susceptible to be used as nanocarriers in drug delivery or to be bioconjugated on their surface with compounds of interest (proteins or ligands) for applications such as targeted drug-release or biosensors.

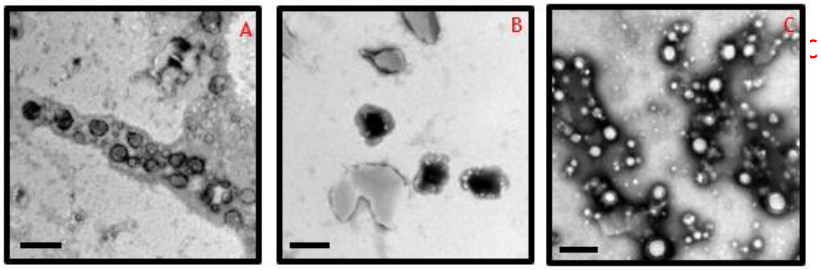

Figure 1. TEM micrographs of different quinoa starch-based nanocolloids (A: vesicles synthesised by the thin film method, B: vesicles synthesised by the ethanol injection method and C: polymeric micelles) whose membrane is composed of span 60 and functionalised with cholesteryl hemisuccinate.

Acknowledgments

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References

[1] D. Morán, G. Gutiérrez, M. C. Blanco-López, A. Marefati, M. Rayner, M. Matos. *Appl. Sci.* **11** (2021) 4547.
[2] G. Gutiérrez, D. Morán, A. Marefati, J. Purhagen, M. Rayner, M. Matos. *Carbohydr. Polym.* **250** (2020)

(P57) Uniformed-sized Fe_3O_4 NRs for application in thermal treatment

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The huge progress in nanoscience over recent years, especially in the development of multi-functional nanostructures, has opened up a promising window in nanomedicine to the treatment of deadly diseases such as cancer and atherosclerosis. In this regard, thermal treatment using heat-generating nanoagents (HNAs) which can remotely be activated by electromagnetic stimuli such as alternating magnetic field (AMF) and near-infrared laser (NIR-laser) has been of particular interest [1].

Magnetic nanorods (NRs), an important group of one-dimensional magnetic nanostructures, have recently received a lot of attention due to the proven advantages over their spherical and cubic counterparts. The unique shape-dependent properties of magnetic NRs such as adjustable aspect ratio, strong anisotropy, high surface area, and enhanced blood circulation time have made them suitable candidates for application in the nanomedicine [2, 3].

In this work, uniform-sized Fe_3O_4 NRs have been synthesized through a one-step solvothermal method (Figure 1). The NRs were investigated in terms of their heat-generating ability under AMF and NIR-laser for application in the MHT and PTT. The experimental results show the MNRs act as prominent heating agents in both modalities and can be used as excellent dual-responsive HNAs in biomedical applications.

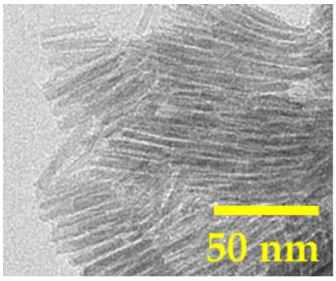

Figure 1. HRTEM image of NRs

Acknowledgments

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References

[1] F. Oltolina, A. Peigneux, D. Colangelo, N. Clemente, A. D'Urso, G. Valente, G. R. Iglesias, C. Jiménez-Lopez, M. Prat, *Cancers*, **12** (2020) 2564.

[2] M. Lázaro, P. Lupiáñez, J. L. Arias, M. P. Carrasco-Jiménez, Á. V. Delgado, G. R., *Polymers*, **14** (2022) 4913.

[3] R. Das, J. Alonso, Z. Nemati Porshokouh, V. Kalappattil, D. Torres, M. H. Phan, E. Garaio, J. Angel Garcia, Jose Luis Sanchez Llamazares, and H. Srikanth, *The Journal of Physical Chemistry*, **120** (2016) 10086-10093.

(P58) Enhanced Cancer Treatment through Triple Modality Therapy: Chemotherapy, Magnetic Hyperthermia, and Photothermia Using BMNPs Conjugated with ChoKa1 Inhibitor

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Biomimetic MamC-mediated magnetic nanoparticles (BMNPs) are emerging as powerful nanocarriers for combined cancer therapy. Their effectiveness is rooted in their superparamagnetic properties and significant magnetic moment when exposed to external magnetic fields, coupled with innovative surface characteristics imparted by the MamC protein. These nanoparticles are not only biocompatible but also function as effective photothermia agents when subjected to Near Infrared (NIR) laser irradiation.

In parallel, targeting lipid metabolism has become a pivotal approach in anticancer drug design, particularly due to the escalated synthesis of phospholipids like phosphatidylcholine in cancer cells. This is highlighted by the overexpression of the enzyme choline kinase Choline Kinase α1 (ChoKα1) in tumor tissues. Out of various synthesized ChoKα1 inhibitors, a novel compound named Fa22, characterized by its thienopyrimidium bis-biphenyl bis-cationic structure with a cyclic amine substitution, stands out for its potent inhibition of ChoKα1. Nevertheless, Fa22's application in systemic treatments is restricted due to its non-selective inhibition of choline uptake. This study illustrates how coupling Fa22 with BMNPs can facilitate targeted delivery into tumor cells, minimizing the impact on choline uptake. The Fa22-BMNP combination enhances the efficacy of chemotherapy and is further bolstered by integrating photothermia and magnetic hyperthermia. This multifaceted approach leads to reduced drug dosage and lower exposure to physical agents, signifying a leap forward in cancer treatment efficiency.

Acknowledgments

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(P59) Engineering small extracellular vesicles as targeted nanocarriers for antifibrotic therapies

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Cardiac fibrosis, characterized by the accumulation of extracellular matrix, particularly collagen, is a common protective process occurring in cardiovascular diseases which usually leads to tissue rigidity and potential fatality [1, 2]. Currently, there is a lack of antifibrotic therapies specifically targeting this process, being the use of drugs with numerous side effects the alternatives applied to reduce its impact [3]. This study proposes the use of engineered small extracellular vesicles (sEVs) as targeted nanocarriers of existing antifibrotic drugs towards activated fibroblasts, the key cells responsible of fibrosis, increasing their efficiency and reducing side effects.

In pursuit of this objective, biological nanotransporters will be engineered for their specific biodistribution, encapsulating pre-tested antifibrotic therapies. The effectiveness of this approach will be evaluated in a fibrotic model mouse and using human cardiac organoids, a 3D model that closely mimic the *in vivo* human heart function.

The *in vivo* fluorescent visualization of sEVs obtained from human cardiac fibroblasts was conducted two hours after intraperitoneal administration. This visualization highlighted the effective arrival of sEVs at the targeted organ, namely the heart. Additionally, the sEVs demonstrated the capability to reach organs associated with metabolism, such as the liver. Advancing towards the specific delivery of drugs involves utilizing genetically engineered sEVs that contain a membrane receptor for the precise targeting of activated fibroblasts. To observe the arrival of these engineered sEVs to target cells in human 3D models of the heart, confocal microscopy was employed.

In conclusion, our findings support the potential use of new generation engineered sEVs as nanocarriers, offering an approach to target specific organs and mitigate the limitations associated with systemic drug administration.

References

[1] Hinderer S, Schenke-Layland K. *Adv Drug Deliv Rev*. 146 (2019) 77-82.
[2] Rogers RG, Ciullo A, Marbán E, Ibrahim AG. *Front Physiol*. 11 (2020) 479.
[3] Umbarkar P, Singh AP, Tousif S, Zhang Q, Sethu P, Lal H. *Pharmacol Res*. 169 (2021) 105605.

(P60) Wagging Magnetic Microswimmers

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Eukaryotic cells that swim by the beating of nanoscale elastic filaments (flagella) present a promising locomotion paradigm for human-made analogues, important for the development of next-generation in-vivo treatments and for the study of collective phenomena at the low Reynolds number limit. However, constructing human-made devices with design flexibility and in large numbers remains a challenge. Here, a step toward meeting this challenge is taken by assembling such swimmers via the programmed shape and arrangement of magnetic micromodules. The method's capacity for design flexibility is demonstrated through the assembly of a variety of swimmer architectures.[1] Linking performance to design, rules are extracted informing the construction of a second-generation swimmer optimized for speed and production at scale is demonstrated through the assembly of a swimming flock to reveal four limiting cases of swimmer couplings. Dropping down an order of magnitude in scale, swimmers composed of magnetic beads anisotropically covered with made-to-order nanoscale filaments designed using the DNA-origami technique are also fabricated.[2] These swimmers move in ballistic fashion when wagged back and forth under an external magnetic field. By comparing bead dynamics at a range of bundle coverages and driving frequencies, compelling evidence is amassed to suggest that this ballistic motion is imparted by the beating of the DNA origami filaments as synthetic flagella. This proof-of-concept work opens up avenues for further made-for-purpose appendages designed using DNA self-assembly and with it ever more complex locomotion on the nano and microscale.

References

[1] Pauer, C. et al, Advanced Materials Technologies, 7 (12), 2200450 (2023).

[2] Pauer, C. et al, Advanced Materials, 2006237 (2021).

(P61) Dual-responsive magnetic nanodroplets for controlled oxygen release *via* ultrasound and magnetic stimulation

Marta Vassallo[1,2*], Simone Galati[1], Marta Vicentini[1], Jessica Petiti[1], Federica Celegato[1], Gabriele Barrera[1], Daniele Martella[1], Elena S. Olivetti[1], Alessio Sacco[1], Carla Divieto[1], Paola Tiberto[1], Adriano Troia[1], Alessandra Manzin[1]

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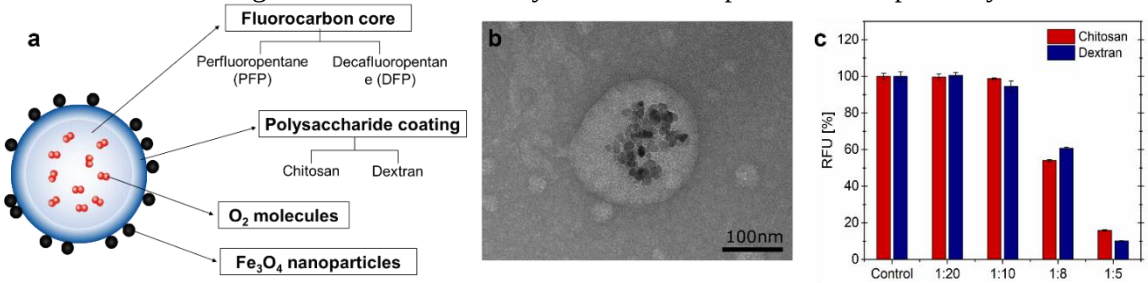
Oxygen-loaded nanodroplets (OLNDs) are liquid formulations composed of a fluorocarbon core capable of storing oxygen molecules and a polymeric coating to stabilize the nanostructure. When exposed to specific physical stimuli, such as ultrasound and optical fields, they undergo a transformation known as the vaporization mechanism, enabling the release of oxygen [1].

In this work, we explored a novel method to induce oxygen release, aiming to overcome limitations associated with conventional stimuli. Specifically, by decorating the surface of the nanodroplets with magnetic nanoparticles (MNPs), synthesized via co-precipitation method [2], we harnessed the heat released from MNPs when exposed to an alternating magnetic field. The increase in temperature allows to achieve the droplet vaporization, resulting in the release of oxygen.

Detailed characterization of the samples was conducted to assess the successful magnetic functionalization and its influence on the physicochemical properties of the nanodroplets, such as hydrodynamic diameter and colloidal stability. In addition, we evaluated the oxygen released during magnetic droplet vaporization, when exposed to an alternating magnetic field. Finally, *in vitro* tests were performed on adherent cell cultures to assess the cytotoxicity of these hybrid nanosystems.

In summary, the obtained results confirm the pivotal role of magnetic functionalization in enabling nanodroplets to release oxygen in response to a magnetic stimulus. Additionally, the study delineates the concentration range in which these nanosystems exhibit optimal biocompatibility.



***(a)** Schematic representation and (**b**) TEM image of a magnetic nanodroplet. (**c**) Cell viability assessment, expressed as a percentage of relative fluorescence unit (RFU), on A549 cell cultures after a 72-hour incubation with four incremental concentrations of magnetic nanodroplets; control refers to cells without nanodroplet treatment.*

References

[1] S. Galati, A. Troia, *Int. J. Phys. Math. Sci.* **15**, 4 (2021) 57.
[2] M. Vassallo, D. Martella, G. Barrera, F. Celegato, M. Coïsson, R. Ferrero, E. S. Olivetti, A. Troia, H. Sözeri, C. Parmeggiani, D. S. Wiersma, P. Tiberto, A. Manzin, *ACS Omega* **8**, 2 (2023) 2143.
[3] S. Galati, M. Vassallo, M. Vicentini, M. Vallino, F. Celegato, G. Barrera, D. Martella, E. S. Olivetti, A. Sacco, J. Petiti, C. Divieto, P. Tiberto, A. Manzin, A. Troia, *Nanoscale* (2024), Advance Article, https://doi.org/10.1039/D3NR04925F.

(P62) From synthesis to *in vitro* hyperthermia application of magnetite nanoparticles with different surface coating

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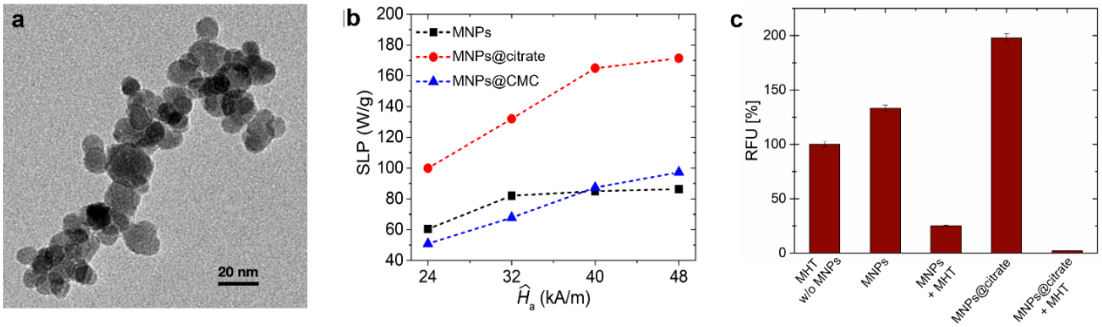
A widely investigated application of magnetic nanoparticles (MNPs) in the biomedical field is magnetic hyperthermia (MHT). In particular, MHT employs MNPs as heat mediators to produce a localized release of heat in a tumor tissue, under the effect of an alternating magnetic field. The heat deposited is responsible for an increase in temperature, which should be in the order of 4-5 °C to induce thermal stress in the target region, making it more responsive to chemotherapy or radiotherapy.

In this work, we synthesized Fe_3O_4 NPs using a co-precipitation method and employed different surface functionalization (i.e. citrate or carboxymethylcellulose) to enhance their heating efficiency. The obtained MNPs exhibit a spherical shape with a mean diameter of approximately 10 nm, and those with the citrate coating demonstrate improved dispersion. In particular, citrate-coated MNPs show the formation of smaller aggregates, resulting in an increased heating efficiency demonstrated by a specific loss power (SLP) value at 100 kHz and 48 kA/m of 170 W/g, which is 50% higher than that of the uncoated MNPs.

Moreover, we established a protocol for conducting *in vitro* studies on MHT using adherent cell cultures. The intriguing aspect of this technique lies in the utilization of MNPs that have been internalized by cells in hyperthermia treatment. Indeed, this approach involves incubating cells with MNPs and performing washes to remove excess magnetic material, leaving only the internalized nanoparticles, as observed through optical microscopy of cell cultures.

In summary, the results obtained confirm the enhanced heating efficiency of citrate-coated MNPs and their increased effectiveness in reducing cell viability when applying MHT.



***(a)** TEM image of uncoated Fe_3O_4 NPs, **(b)** SLP values of the prepared MNPs measured at different peak amplitudes of a 100 kHz magnetic field, **(c)** cell viability assessment, expressed as a percentage of relative fluorescence unit (RFU), following treatment with MNPs, with or without MHT application.*

References

[1] M. Vassallo, D. Martella, G. Barrera, F. Celegato, M. Coïsson, R. Ferrero, E. S. Olivetti, A. Troia, H. Sözeri, C. Parmeggiani, D. S. Wiersma, P. Tiberto, A. Manzin, *ACS Omega* **8**, 2 (2023) 2143.

(P63) Design, development and characterization of magnetic nanoparticle systems for advanced theranostics

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Magnetic nanoparticles (MNP) have great potential for various biomedical applications such as magnetic imaging (Magnetic Particle Imaging (MPI), Magnetic Resonance Imaging (MRI)), Magnetic Fluid Hyperthermia (MFH), magnetic targeting and magnetic drug release. Thus, MNP represent a valuable constituent in a theranostic agent. For each specific application MNP systems have to be designed and synthesized to achieve the desired function. Here, we report different continuously manufactured drug-loaded MNP systems (magnetic vesicles and protein coated single core MNP) that have been developed as theranostic tools for monitoring and controlled drug delivery and drug release. Using magnetic particle spectroscopy (MPS) as an online analytic tool MNP systems were characterised and evaluated for specific diagnostic and therapeutic applications.

Iron oxide nanoparticles were synthesized in a continuous flow micromixer setup by precipitation from aqueous, alkaline solutions of iron salts, oxidation, and stabilization [1]. MPS was used to monitor synthesis and downstream processing. In MPS a sinusoidal excitation field is applied, and the nonlinear dynamic magnetic response of the MNP is measured. The characteristic parameters A_3 (amplitude of 3rd harmonic) and A_5/A_3 (ratio of 5th to 3rd harmonics) were extracted from the MPS spectra to evaluate the performance of MNP in MPI [2], physical properties such as aggregation state, and magnetic properties to assess the expected suitability for MFH [3].

In addition to continuously synthesized single core iron oxide particles also magnetic vesicles were manufactured continuously using a micromixer controlled self-assembly of amphiphiles in the presence of MNP. These magnetic vesicles were loaded with drug and evaluated by MPS.

MPS is a powerful online analytic tool to develop and produce customized MNP systems for theranostics. Its flexible application and high sensitivity facilitate the control of the whole synthesis process from the first particle nucleation in the micromixer up to the postprocessing steps such as purification, concentration, phase transfer and quality control, thus paving the way to obtain optimized MNP for any specific application.

References

[1] N. Löwa, D. Gutkelch, E.-A. Welge, R. Welz, F. Meier, A. Baki, R. Bleul, T. Klein, F. Wiekhorst, *Nanomaterials* **10** (2020) 2277.

[2] A. Baki, A. Remmo, N. Löwa, F. Wiekhorst, R. Bleul, *Int. J.Mol. Sci.* **22** (2021) 6235.

[3] A.-N. Egler-Kemmerer, A. Baki, N. Löwa, O. Kosch, R. Thiermann, F. Wiekhorst, R. Bleul, *J. Magn. Magn. Mater.* **564** (2022) 169984.

(P64) Effects of Magnetic Nanoparticles on the Functional Activity of Human Monocytes and Dendritic Cells

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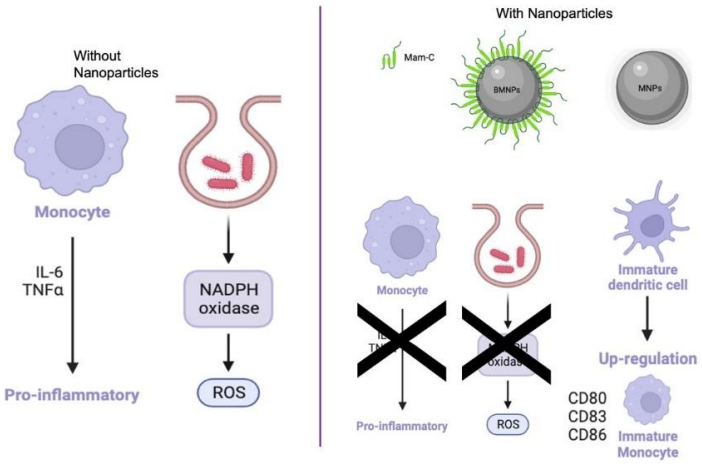
The use of nanoparticles in medicine is sometimes hampered by their potential to activate immune cells, eliciting inflammation or allergy. We investigated whether magnetic nanoparticles (MNPs) or biomimetic magnetic nanoparticles (BMNPs) affect relevant activities of human monocytes. We found that the nanoparticles neither elicited the production of pro-inflammatory mediators IL-6 and TNFα by resting monocytes (when BMNP dose < 300 μg/mL) nor enhanced their secretion induced by R848, a molecule engaging virus-recognizing receptors, or bacterial lipopolysaccharide (LPS). MNPs and BMNPs neither induced the generation of reactive oxygen species (ROS), nor affected the ROS production elicited by the NADPH oxidase activator phorbol myristate acetate(PMA) or the fungal derivative β-glucan. BMNPs, but not MNPs, caused an up-regulation of the maturation markers CD80, CD83, and CD86 in immature monocyte-derived dendritic cells (DCs), whereas both nanoparticles did not affect the LPS-induced expression of these markers. Moreover, the nanoparticles were greedily ingested by monocytes and DCs without altering their viability. Therefore, these nanoparticles are candidates for medical applications because they do not activate pro-inflammatory activities of monocytes. Furthermore, their ability to stimulate DC maturation could be used for the design of vaccines. Moreover, harmlessly engulfed nanoparticles could be vehicles to carry molecules inside the immune cells to regulate the immune response.



Effect of nanoparticles in pro-inflammatory system and DCs.

Acknowledgments

We thank Matteo Giani for assistance with flow cytometry analysis and Giulia Leo for her help with the EVOS FLoid imaging system.

(P65) Maslinic acid solid lipid nanoparticles as hydrophobic anticancer drug carriers: Formulation, in vitro activity and in vivo biodistribution

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Maslinic acid (MA) is a natural pentacyclic triterpenoid known for its inherent antitumor activity, but it exhibits low solubility in water. In this study, solid lipid nanoparticles (SLNs) of MA were prepared using Poloxamer 407 and Dicarboxylic acid-Poloxamer 407 as surfactants. Both MA SLNs are monodisperse, with sizes around 130 nm, and stable. Additionally, curcumin was encapsulated in both types of nanoparticles without altering their colloidal properties. Moreover, SLNs greatly improve the solubility of MA and Curcumin. The cytotoxicity of MA and SLNs has been evaluated in BxPC3 human pancreatic cancer cells, MCF7 human breast cancer cells, and in a human fibroblast primary cell line. MA shows higher cytotoxic effect in BxPC3 and MCF7 cancer cells than in human primary fibroblasts. Nile Red loaded MA SLNs are quickly uptaken by BxPC3 and MCF7 cells, and show different cytoplasmic distributions depending on the cellular line. The oral or intravenous administration of MA SLNs in mice does not report any toxic effect, and the intravenous administration of fluorescent MA SLNs shows a homogeneous distribution in mice, without site-specific accumulation. Results suggest the great potential of MA SLNs as nanocarriers of anticancer drugs and as promising targeted theranostic nanodevices.

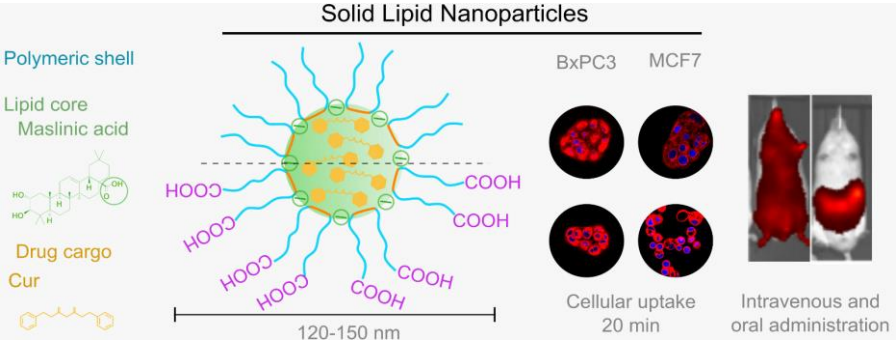

Figure 1: Graphical abstract.

Acknowledgments
The authors thank MCIN / AEI / 10.13039 / 501100011033/ FEDER for funding PID2022-140151OB-C21 and PID2022-140151OB-C22 projects.

References
[1] Aguilera-Garrido, A et. al *Biomedicine & Pharmacotherapy*, *163*(114828).

(P66) Color-tunable luminescence of Eu-doped LaF_3 particles sensitized by d-f energy transfer from a two-photon absorbing Ir(III) complex

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The surface of submicron particles composed of $Eu_{0.3}La_{0.7}F_3$ has been functionalized with a blue-emitting Ir(III) complex (**1**), specifically engineered to effectively coordinate lanthanide(III) ions via a carboxylic unit. Within this $Eu_{0.3}La_{0.7}F_3$@**1** composite, the Ir(III) complexes are randomly coordinated to either superficial La(III) ions or Eu(III) ions (forming Ir-$La_{surface}$ and Ir-$Eu_{surface}$ pairs respectively). The composite's color emission, a blend of blue (from the Ir-based complex) and red (from the Eu-based ions), can be adjusted based on the excitation wavelength. When irradiated at the peak of the excitation band in **1**, blue emission emanates from Ir-La surface pairs while red emission arises from Eu surface ions sensitized by Ir → Eu surface energy transfer (EnT). At λ_{exc} = 396 nm (peak of the Eu(III) $^5L_6 \leftarrow {}^7F_0$ absorption band), the dominant emission becomes red from inner Eu(III) ions. Furthermore, excitation of **1** is possible through two-photon absorption (TPA) due to its moderate cross-section of σ_2 = 9.4 ± 1.0 GM at 780 nm (σ_2 = 5.8 ± 0.6 GM at 800 nm). Phosphorescence Lifetime Imaging (PLIM) enables visualization of individual particle emissions, facilitating the differentiation between Ir-, $Eu_{surface}$-, and Eu_{core}-based emissions owing to their distinct emission lifetimes.

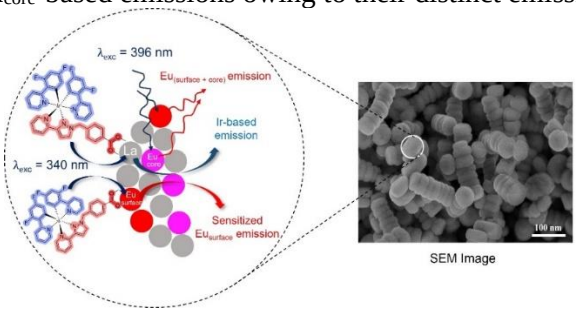

Figure 1. *Schematic model of a $Eu_{0.3}La_{0.7}F_3$@1 particle, also shown the main photophysical processes that take place as a function of the excitation wavelength.*

Acknowledgments

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(P67) Fabrication and characterization of monocyte membrane-coated lipid nanocapsules as prospective carriers for anticancer therapeutics

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Cancer remains a significant global health challenge due to its heterogeneity, and conventional treatments such as radiation therapy and chemotherapy exhibit limitations in terms of specificity and side effects. Nanotechnology, particularly nanomedicine, emerges as a promising avenue for addressing these challenges. Specifically, lipid nanocapsules offer advantages such as controlled release, subcellular size, cost-effectiveness, and low toxicity, making them ideal drug carriers. Their hydrophobic core facilitates the transport of lipophilic drugs contributing to reduced drug toxicity [1]. Despite these benefits, challenges arise in overcoming biological barriers and preventing the formation of a protein corona upon intravenous administration, leading to poor drug accumulation at tumor sites [2]. To address these challenges, bioinspired camouflage has gained attention, particularly cell membrane-camouflaged nanoparticles known as nanoghosts, that exhibit prolonged circulation time and enhanced accumulation in target tumors [3]. However, limited research has explored this direction, presenting an opportunity to investigate their potential. Monocyte nanoghosts, leveraging the unique properties of monocyte membranes, hold the potential to improve drug delivery and avoid nonspecific distribution. In this study, we have explored the use of monocyte membranes to coat biocompatible olive oil nanocapsules that will be able to deliver hydrophobic antitumoral drugs. Positively charged lipid nanoparticles, as well as negatively charged ones, were prepared and showed to be stable in culture media. Monocyte membranes were isolated and purified by ultracentrifugation and a preliminary study of coating was carried out. Preliminary results indicate successful acquisition of a cellular membrane charge, demonstrating the feasibility and potential of this novel nanotherapeutic strategy.

Acknowledgments

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References

[1] Sánchez-Moreno P, Ortega-Vinuesa JL, Boulaiz H, Marchal JA, Peula-García JM. Synthesis and characterization of lipid immuno-nanocapsules for directed drug delivery. Selective antitumor activity against HER2 positive breast cancer cells. *Biomacromolecules*, **14,** 4248-4259. (2013)

[2] Sánchez-Moreno *P* *, Buzón P, Boulaiz H, Peula-García JM, Ortega-Vinuesa JL, Luque I, Salvati A, Marchal-Corrales JA. Balancing the effect of corona on therapeutic efficacy and macrophage uptake of lipid nanocapsules *Biomaterials*;**13,** 61:266-278 (2015).

[3] Graván P, Peña-Martín J, López de Andrés J, Pedrosa M, Villegas-Montoya M, Galisteo-González F, Marchal JA, Sánchez-Moreno P. Exploring the Impact of Nanoparticle Stealth Coatings in Cancer Models: From PEGylation to Cell Membrane-Coating Nanotechnology. *ACS Applied Materials & Interfaces*. **16 (2),** 2058-2074 (2024).

(P68) Extracellular vesicles as detoxification system in microglia

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Extracellular vesicles (EVs) are membrane nanostructures secreted by cells whose cargo contains different molecules involved in intercellular communication. Recently, it has been shown that microglia can release and receive EVs and that they could actively participate in neuropathologies. In this study, we explore the role of microglial EVs in manganism, an occupational Parkinson´s like disease caused by overexposure to manganese, which is highly accumulated in the brain. For this purpose, we exposed the murine microglia BV2 cell line to high doses of manganese for 24h and we isolated EVs by differential ultracentrifugation. Transmission electron microscopy, dynamic light scattering and nanoparticle tracking analysis showed two populations of small EVs with different sizes in both unstimulated and manganese-stimulated microglia; however, the manganese stimulus increased the quantity of released EVs. We also analysed the EVs using scanning electron microscopy and energy dispersive X-ray spectroscopy, revealing an elevated amount of manganese in EVs released after manganese overexposure compared to controls, suggesting their participation in manganese detoxification in microglia. Furthermore, we evaluated the effect of these EVs on cultured murine primary microglial cells, showing a significant cytotoxic effect of manganese-loaded EVs, which was corroborated by fluorescence microscopy. This indicates an involvement of EVs in the spreading of neurodegeneration observed in manganism. These findings also demonstrate that microglia can be incubated with compounds that might be incorporated as EV cargo, suggesting a potential use of microglial EVs as drug carriers.

Acknowledgments

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(P69) Double Tailing Trap-Click Chemistry: Functionalization of nanoparticles for the preparation of miRNA-seq libraries

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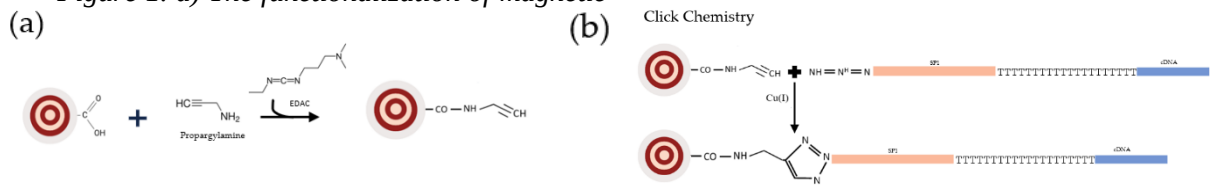
Eukaryotic cells produce small non-coding RNA molecules known as microRNAs (miRNAs) that regulate the expression of numerous genes. Dysregulation of miRNAs is linked to various chronic human diseases[1].

Accurate quantification of the entire miRNA variant repertoire in a biological sample requires the application of high-throughput sequencing methods. However, conventional bulk sequencing approaches encounter challenges when dealing with the unique chemical characteristics of miRNAs. Many variants appear overestimated and underestimated or are simply not detectable, which is mainly a consequence of linkage bias[2]. There is a compelling interest in creating novel approaches to mitigate biases inherent in high-throughput miRNA sequencing. To address this, a groundbreaking and innovative concept has been introduced, the Double Tailing Trap-Click Chemistry technology (DTT-CC). This novel approach aims to overcome the limitations posed by existing methodologies, offering a potential breakthrough in the accurate and unbiased sequencing of miRNAs.

DTT-CC methodology consists of "trapping" the miRNA molecule between two nucleotide tails (poly-T and poly-G) and then adding the adapters needed for NGS with DNA polymerase. The reaction is conducted on the surface of magnetic nanoparticles, facilitating the sequential steps and enabling the facile interchange of reagents (Figure 1). Notably, this method achieves a remarkable reduction in sensitivity by two orders of magnitude compared to traditional methodologies, where 10 ng is typically required; in contrast, DTT-CC can be performed with as little as 0.7 pg.

Figure 1. a) The functionalization of magnetic



nanoparticles involves the creation of an amide bond by reacting with propargylamine using carbodiimide. b) The conjugation of the target molecule with magnetic particles is achieved through the application of click chemistry.

Acknowledgments

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References

[1] Gebert, L. F. R. & MacRae, I. J. Regulation of microRNA function in animals. *Nat Rev Mol Cell Biol* 20, 21–37 (2019).

[2] Coenen-Stass, A. M. L. *et al.* Evaluation of methodologies for microRNA biomarker detection by next generation sequencing. *RNA Biol* 15, 1133–1145 (2018).

(P70) Non-linear Phenomena in Microchannels: PDADMAC-Coated Carbon for Enhanced Preconcentration

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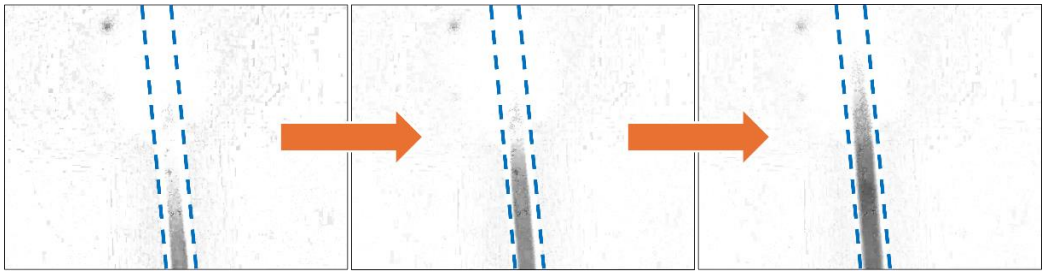
Electrochemical methods utilizing capacitive porous electrodes are increasingly popular for energy production, storage, and desalination, specifically capacitive deionization (CDI). The use of microchannels with porous activated carbon is an effective method for studying concentration polarization processes on a small scale. However, non-linear phenomena such as concentration shock waves may occur if the applied voltage is high enough. This phenomenon is seen as a region where there is an abrupt drop in concentration, spreading rapidly inside the channel. As ions accumulate outside this zone, this method is especially interesting for preconcentration in samples with low biochemicals concentrations that are difficult to detect or quantify.

The objective of this study is to qualitatively compare the concentration shock waves inside microchannels generated by bare activated carbon and activated carbon coated with polydiallyldimethylammonium chloride (PDADMAC), which creates a positively charged layer. This layer interacts with ions in the medium, trapping anions and preventing cations from entering. These constraints promote the emergence of non-linear effects at lower voltages. This is beneficial for reducing energy consumption, preventing unwanted reactions, improving the selectivity of the electrolytes used for preconcentration, and minimizing damage to biological samples or sensitive compounds.



Images taken at three different times using a fluorescent microscope of a microchannel section (between blue dashed lines). The shock wave can be seen as a dark area spreading upwards.

Acknowledgments

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References

[1] Ko, S.H., et al. *Lab Chip* **12** (2012) 21.
[2] Lin, C.C., et al. *Microfluid. Nanofluidics* **10** (2011)
[3] Lee, H., et al. *Desalination* **458** (2019)

(P71) Impact of ZVI nanoparticles on lettuce biomass and its rhizosphere microbial communities in two different soil types

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Nanoscale zero valent iron (nZVI) has been considered a promising tool for the remediation of water and soils polluted with metals, metalloids, anions and/or organic pollutants [1]. Previous studies have concluded that the addition of nZVI to polluted soils with metals or metalloids reduces their availability, decreasing soil toxicity and therefore allowing a better development of plants. However, the effect of nZVI in unpolluted soils is not totally known and can be different due to the presence of pollutants which can mask other effects caused by nZVI. Considering that bacteria and fungi are present in the rhizosphere of plants, the antimicrobial effects from nZVI exposure may have significant implications for the host plant health [2]. Despite this, studies that evaluate the exposition of nZVI at rhizosphere level (both the microbes present and the supporting host plant) are scarce. This study evaluated the impact of nZVI on lettuce plants and the bacteria and fungi in the plant rhizosphere in two agricultural soils with different characteristics.

Two agricultural soils with different characteristics (acidic and alkaline) were included. Soils were treated with nZVI suspension (NANOFER 25S (20% Fe) NANOIRON) according to the following treatments: 0% nZVI (control), 0.5% and 5% of the nZVI commercial suspension. Five pots per treatment were used. Seedling of lettuce were transplanted and after 30 days plants were harvest, oven dried and then weighted. Soil samples from the rhizosphere were collected for the analysis of microbial activity, functional diversity, enzyme activities, and community-level physiological profiling (CLPP) with Biolog EcoPlates, as well as the bacterial and fungal genetic diversity using PCR-DGGE (denature gradient gel electrophoresis).

Plants from alkaline soils did not show significant differences regarding biomass whereas a major effect was observed in plants from acidic soil, since the biomass extremely increased at 0.5% of nZVI treatment. nZVI stimulated enzyme activity in both soils. However, depending on soil type, contrasting results were observed regarding functional diversity. Shannon and richness diversity indices of CLPP were negatively impacted after nZVI treatments in alkaline soil, whereas in acidic soil an increase of diversity was observed at 0.5% nZVI dose. In relation to PCR-DGGE genetic profiles, bacterial richness significantly increased in alkaline soil, and fungal communities showed higher diversity indices after nZVI treatments in both types of soils. Canonical correspondence analysis between microbial communities structure and soil properties reveals that available Fe played a key role in the genetic structure of bacterial and fungal communities in acidic nZVI treated soils. Thus, we conclude that soil physico-chemical properties condition nZVI effects on lettuce plants and their rhizosphere.

Acknowledgments

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References

[1] X. Zhao, W. Liu, Z. Cai, B. Han, T. Qian, D. Zhao, *Water Res.* (2016) 100:245.

[2] M. Gil-Díaz, J. Álvarez-Aparicio, J. Alonso, C. Mancho, J. González, M.C. Lobo, P. García-Gonzalo, *Environ. Pollut.* (2023) 122683.

(P72) Biomimetic Magnetic Nanoparticles as carriers for antimicrobial targeted therapy

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Magnetotactic bacteria are a group of bacteria able to accomplish controlled biomineralization process, an unique property among prokariotes. They can achieve the formation of magnetite (Fe_3O_4) crystal via a set of magnetosome associated proteins which interfere with the kinetics of their nucleation and growth, giving them unique features, in contrast to those produced inorganically. One of these proteins is MamC, which allows the synthesis of biomimetic magnetic nanoparticles (BMNPs) in the laboratory mimicking the anaerobiotic conditions where magnetotactic bacteria are found. MamC has an acidic domain, which enable a controled nucleation by an ionotropic effect, but it also presents a specific structure that it exerts a template effect, facilitating the formation of the crystal[1]. MamC-mediated BMNPs present a size of 36 ± 5 nm, organic groups in their surface and an isoelectric point of 4.4. These characteristics make BMNPs perfect candidates for the assembly of drug-BMNP nanocarriers. The nanoparticles' negative charge allow them to form ionic bonds with a range of substances like antibiotics, and their superparamagnetic properties enable the development of targeted therapies against local infections. This kind of treatment could decrease the amount of antibiotic used and decrease the possibly of a systemic side effect. Previous studies with chemotherapy agents showed these nanoassemblies are feasible, maintain their magnetic and are cytocompatible. Furthermore, embedding them in liposomes help their internalization in the intracellular medium[2].

Our *in vitro* results with nanoassemblies of BMNPs with ampicillin, tetracycline and gentamicin (ABio-BMNPs) and liposome embedded L(ABio-BMNP) demonstrate that these nanoformulations are stable and maintain their magnetic properties enabling their concentration on the infection site via a magnet. Moreover, these nanocomplexes preserve the antimicrobial activity of the antibiotic. However, they tend to show a decreased activity compared to the antibiotic on its own, but they counteract this reduction with their focused activity. In addition, antimicrobial activity is enhanced by the embedding of the nanoassembly in L(ABio-BMNPs) when the antibiotic attack a processes in the bacterial interior, showing a better activity than the antibiotic by itself in the case of gentamicin against *Pseudomonas aeruginosa*.

References

[17] A. Ubago-Rodríguez, S. Casares Atienza, A. Fernández-Vivas, A. Peigneux, Y. Jabalera, Y., M. De La Cuesta-Rivero, C. Jimenez-Lopez, A.I. Azuaga Fortes, *Crystal Growth and Design*, **19** (2019) 2927-2935.

[18] F. Oltolina, A. Peigneux, D. Colangelo, (…), C. Jimenez Lopez, M. Prat, *Cancers*, **12** (2020) 2564.

(P73) Combination of immobilized AS-48 with magnetic hyperthermia against *Mycobacterium tuberculosis*

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The extensive use of antibiotics is favouring the development of multidrug-resistant (MDR) bacteria, whose infections cannot be treated with conventional therapies. Within MDR, the bacteria of the genus *Mycobacterium* are very resistant and require long-lasting treatments and the use of toxic antibiotics to deal with them [1]. As an alternative therapy, the use of the bacteriocin AS-48 has been proposed, since it has a potent bactericidal effect and is stable over wide ranges of pH and temperature. A novel approach to apply AS-48 consists of immobilizing the bacteriocin on magnetic nanoparticles and directing the nanoassemblies with magnetic fields to the site of infection [1,2]. The use of magnetic nanoparticles also allows to apply magnetic hyperthermia in order to improve the treatment's efficiency.

In this work, biomimetic magnetic nanoparticles (BMNPs) were produced by chemical precipitation in presence of the magnetosome MamC protein from *Magnetococcus marinus* MC-1. MamC controlled the nucleation and growth of the magnetite crystals, producing larger nanoparticles, with better magnetic and surface properties. The presence of MamC's functional groups in the outer layers of the crystals enabled an electrostatic interaction with AS-48 without the need of post-production coatings. The resulting nanoassemblies were applied on cultures of *Mycobacterium tuberculosis* H37Ra or human macrophages (THP-1 cell line) infected with *M. tuberculosis* H37Rv. Trials were carried out with and without the application of magnetic hyperthermia, to observe if the bactericidal effect of AS-48 was enhanced.

Results show that immobilization of AS-48 reduced its antimicrobial efficiency, in comparison with free AS-48. However, it was still very active and reached a minimum inhibitory concentration of 128 µg/mL against *M. tuberculosis*. The combined treatment of immobilized AS-48 with magnetic hyperthermia boosted the antimicrobial effect of AS-48 and allowed to eliminate infection on THP-1 macrophages in only four days, reducing both the treatment application time and the dose of AS-48 (8 µg/mL). This synergic effect was achieved due to the rotation of the BMNPs when subjected to an alternate magnetic field, which produced: a) heat; b) drug release from their surface; and c) mechanical damage on the bacterial cell wall, facilitating the contact of the bacteriocin with the cytoplasmatic membrane.

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References

[19] S. Gaglio et al., *Pharmaceutics* **14** (2022) 2744.
[20] Y. Jabalera et al., *Int. J. Biol. Macromol.* **189** (2021) 206.