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RESEARCH THEMES
DOCTORATE SCIENCES AND TECHNOLOGIES OF CHEMISTRY AND MATERIALS

NOTE: In this file you can find additional information on the research themes summarized in the call November, 2023.

Summary

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Curriculum Drug Discovery and Nanobiotechnologies

1. Exploring new nanozyme functionalities and applications

Tutor: Pierpaolo Pompa

Nanozyme are nanoparticles that can mimic natural enzymes, however one single nanozyme can present multi-catalytic activity, mimicking even three or more natural enzyme altogether, with no need for specially prepared functionalization. The catalytic activity can be switched by using co-factors or specific environmental conditions. As a matter of fact, for several nanozymes new properties are yet to be found and so are their potential applications. This project aims to explore new nanozyme activities, investigate some properties recently found in our group and their potential applications in sensing, nanomedicine, and environmental remediation.

Requirements: A background in chemistry, biotechnology, physics, engineering, and related disciplines would be appreciated.

For further details concerning the research theme, please contact: pierpaolo.pompa@iit.it.

Curriculum Nanochemistry

2. Innovative nanocavities coupled to emissive nanomaterials for light-matter interaction

Tutor: Roman Krahne

We are investigating emerging nanomaterials for light emission and their integration into optical resonators to obtain nonlinear optical properties and emitting devices with novel functionalities. Towards the emitters we focus on low-dimensional metal-halide perovskites and colloidal nanocrystals that can be tailored for the compatibility with photonic cavities in size, emission wavelength and surface functionalisation. For the optical resonators we are interested metal-dielectric nanocavities and plasmonic nanosystems that can be realized either by self-assembly or top-down fabrication.

This PhD project will target the fabrication of the photonic cavities and explore different strategies for the integration of emitting nanomaterials, with the aim to discover novel approaches that can boost the performance of optoelectronic devices in light emission and photodetection.

Requirements: We are looking for highly motivated candidates with a degree in physics, chemistry, material science, engineering or nanotechnology that are keen to work in an interdisciplinary environment. Experience in nanofabrication, optoelectronic spectroscopies, and theoretical modeling are considered as a plus.

Information on the activities of the Optoelectronics Group and related publications can be found at: https://www.iit.it/it/web/optoelectronics. For further details concerning the research theme, please contact: roman.krahne@iit.it.

3. Anti-inflammatory and anti-fibrotic activity of novel organic materials based on Sulfur (II)-containing polymers

Tutor: Nicola Tirelli

Sulfur (II) organic polymers (polysulfides, polythioacetals) can effectively scavenge biologically relevant oxidants (Reactive Oxygen Species, ROS), which typically act as inflammatory mediators; therefore, their removal has anti-inflammatory [1] and anti-fibrotic [2] effects, and may also have a protective role for e.g. therapeutic proteins [3].

This project aims to utilize two classes of ROS-scavenging materials: surface-functional hydrophobic nanoparticles made of poly(propylene sulfide) and hydrophilic polymers based on poly(thioglycidyl glycerol). These two classes of materials will be employed in anti-inflammatory scenarios, specifically targeting the management of innate inflammatory activation.

The skills developed in the project will include monomer/polymer synthesis (including microfluidic-assisted scaled-up processes), nanomaterial/colloidal characterization, 2D/3D culture, and molecular biology characterization of mammalian cell lines.

Requirements: Background in chemistry (including pharmaceutical and industrial) or biomedical/materials engineering. Candidates with previous experience in cell culture and materials characterization, or polymer synthesis are a better fit to the project.

[1]. Z.Y. Turhan et al., Biomacromolecules, 24 (2023), 4478. DOI: 10.1021/acs.biomac.2c01365.
[2]. A. Siani et al., Biomaterials Advances, 153 (2023), 213537. DOI: 10.1016/j.bioadv.2023.213537.
[3]. R. d'Arcy et al., Journal of the American Chemical Society, 144 (2022), 21304–21317. DOI: 10.1021/jacs.2c09232.

For further details concerning the research theme, please contact: nicola.tirelli@iit.it.

Curriculum Science and Technology of Materials (Regione Liguria)

4. **Synthesis and electrochemical production process of sodium hypochlorite: investigation and optimization of key process parameters** (grant within PROGRAMMA REGIONALE FONDO SOCIALE EUROPEO+ 2021-2027 PRIORITÀ 2 - ISTRUZIONE E FORMAZIONE - ESO 4.6 (OS-f), with the contribution of Angelini S.p.a.)

   Tutors: Paola Riani, Maria Paola Carpanese

   The research activity will focus on the optimisation of the electrochemical process of industrial production of sodium hypochlorite, by identifying solutions to reduce environmental impact, decreasing waste production and resources consumption.

   The chemical process optimization will be aimed at reducing the risks of non-conformity of the product, to avoid the consequent generation of wastes; moreover, optimization will be studied and applied in the industrial context to move towards an automated and digital process.

   It is expected that at the end of the PhD improvements related to the process have been explored and analysed; improvements are identified and compared with other similar industrial processes available in the literature; solutions able to reduce waste disposal are identified and the efficiency of the production lines improved.

   For further details concerning the research theme, please contact paola.riani@unige.it, maria.paola.carpanese@unige.it.