Institut de Bioenginyeria de Catalunya

COLLABORATIVE IBEC INTERNATIONAL PhD PROGRAMME

Position

1. Project Title:
   Interaction of Nanomotors with Biofluids and Extracellular Matrices

2. Research project/ Research Group description

Nanomotors, self-propelled nanosystems capable of navigating complex biological environments, are emerging as transformative tools for biomedical applications. Their ability to interact with biofluids, cross biological barriers, and deliver therapeutic agents makes them highly promising for targeted therapies. However, key challenges remain in understanding how nanomotors interact with biofluids and extracellular matrices, particularly the effects of the protein corona—a dynamic biomolecular layer that forms on their surface in biological environments. This corona can significantly influence nanomotor stability, propulsion, and cellular uptake, making its study critical for optimizing nanomotor functionality.

Advanced microscopy techniques, such as STORM (Stochastic Optical Reconstruction Microscopy) and STED (Stimulated Emission Depletion), provide unparalleled resolution (10-25 nm) and multicolor capabilities to quantify the composition of the protein corona and active enzymes on nanomotor surfaces. Additionally, high-throughput microscopy enables the rapid screening of multiple conditions, correlating nanomotor motion parameters (e.g., speed, mean square displacement) with cellular interactions. These state-of-the-art tools allow for a detailed understanding of nanomotor behavior in complex biological environments, addressing key knowledge gaps in their design and application.

This PhD project, a collaboration between the Samuel Sánchez group at IBEC and the Albertazzi and Patiño groups at ICMS Eindhoven, will investigate the interactions of nanomotors with biofluids and extracellular matrices. ICMS will provide state-of-the-art facilities and expertise, using super-resolution microscopy to study protein corona formation and enzyme activity, and high-throughput microscopy to assess motor behavior under various conditions. These results will be correlated with cellular interactions, including internalization, to optimize nanomotor delivery and therapeutic efficacy.

The project aims to establish a mechanistic understanding of nanomotor interactions with biofluids and extracellular matrices, enabling optimized designs for biomedical applications. The candidate will gain expertise in nanotechnology, advanced imaging, and cellular biology, contributing to innovative solutions in precision nanomedicine.

3. Job position description

This PhD project focuses on understanding the interaction of nanomotors with biofluids and extracellular matrices, in particular the effects of the protein corona and cellular internalization. By exploring these interactions, the research aims to optimize nanomotor design and functionality for enhanced biomedical applications. The work will be carried out in collaboration with the **Samuel Sánchez group at IBEC**, specialists in nanomotor design and propulsion, and the **Albertazzi and Patiño groups at ICMS Eindhoven**, experts in advanced microscopy techniques and nanomotor-cell interactions, respectively. This project aims to establish a mechanistic understanding of nanomotor interactions with complex biological environments, leading to improved nanomotor designs for biomedical applications. The candidate will gain expertise in nanotechnology, advanced microscopy, and cellular biology, contributing to innovative therapeutic solutions.

ICMS Contribution:

ICMS will provide state-of-the-art facilities and expertise for motor characterization in vitro and in cells. Super-resolution microscopy, including STORM and STED, will quantify active enzymes and protein corona formation. High-throughput microscopy will enable systematic screening of conditions to correlate motor motion with cellular interactions, ensuring comprehensive characterization.

Objectives:

1. **Synthesis of Nanomotors and Characterization of their Interactions in Biofluids**
   The candidate will design, and optimize the surface properties of nanoparticle-based nanomotors and study how these interact with biofluids, focusing on the formation of the protein corona. This involves investigating how biofluid composition impacts nanomotor stability, enzyme activity, and propulsion. Advanced imaging techniques will be used to correlate the protein corona with motion parameters such as speed and mean square displacement as well as their collective behaviour.

2. **Surface Engineering and Protein Corona Modulation**
   The project will involve modifying nanomotor surfaces to control protein corona formation, aiming to enhance functionality and reduce off-target interactions. Techniques like STORM and STED microscopy will be used to quantify active enzymes and protein types on the motor surface with single-molecule precision (10-25 nm resolution) and multicolor capability.

3. **Cellular Interactions and Internalization**
   The candidate will explore how nanomotors interact with and are internalized by cells. High-throughput microscopy will be employed to screen multiple conditions, including variations in particle concentration, fuel levels, serum composition, and cell types. These experiments will identify optimal combinations to maximize nanomotor delivery and efficacy within cells.

Group Leader at IBEC

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Collaborators at ICMS

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