Bruface
Brussels Faculty of Engineering

ECOLE POLYTECHNIQUE DE BRUXELLES

Vrije Universiteit Brussel

Master Thesis subjects 2018-2019 proposed by
Engineering of Molecular NanoSystems Laboratory

1. Peptide aptamers functionalized Gold Nanoparticles for the detection of proteins of medical interest.

Summary: Gold nanoparticles (GNPs) are of particular interest for biomedical diagnostics and therapeutic applications because of their remarkable optical properties, ease of surface functionalization and presumed biocompatibility. Our laboratory has recently developed a GNP-based protein detection platform based on a double recognition strategy using two sets of GNPs functionalized with peptide aptamers. The selective detection of the oncoprotein Mdm2 at physiological concentration has been achieved as proof of concept. However, in order to optimise the performance of this detection platform, a model system, based on the detection of thrombin, will be thoroughly investigated. In collaboration with Prof. B. Mognetti (Physics of Complex Systems and Statistical Mechanics, Faculty of Sciences), optimal functionalization densities for the targeted dynamic range of the sensor will be determined by modelling and tested experimentally.

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2. Elaboration of micellar nanocatalysts for biomass conversion in water.

Summary: There is currently great interest in development of environmental-friendly synthetic processes and, in this context, the replacement of commonly-used volatile organic solvents by water is of prime interest. Water is a solvent with little environmental impact but its use has been limited because organic substrates are often poorly soluble in water. Micellar systems represent one of the simplest methods to achieve organic transformation in an aqueous environment. In collaboration with the University of Padova, we are investigating the potential of vanadium-based catalysts in aqueous micellar media for the hydrolysis of lignin. The work will consist in monitoring the conversion using model substrates in order to identify the key parameters to control for optimum conversion. This will entail work in the wet-lab and the set-up of HPLC and NMR protocols to characterize the systems and reactions.

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3. Study of transmembrane ion transport.

Summary: The phospholipid cell membrane is an apolar barrier for the free diffusion of charged species and ions are transported in-vivo in a controlled fashion by specialized proteins embedded within the cellular membranes. The dysregulation of these proteins are the known cause of a number of diseases of which the most well known is cystic fibrosis (deficiency in chloride transport). The design of synthetic transmembrane mobile carriers that can transport ions across lipid membranes is seen as a potential strategy for the treatment of such diseases. In collaboration with our colleagues from the Chemistry Department at the University of Bristol we are studying the transport properties of novel chloride carriers across model membranes, using NMR and fluorescence spectroscopies. The work to be undertaken during this Master's thesis will entail the preparation of stable phospholipid vesicles of controlled size (model membranes) in which carriers will be incorporated and the monitoring of chloride binding and transport under different experimental conditions. The aim is to identify the key physico-chemical parameters that control transport efficiency.

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4. Design of multivalent nanoparticles for superselective targeting of biological systems.

Summary: The selective targeting of few specific cells among vast and extremely diverse populations is a key step in the development of effective nanocarriers for drug and gene delivery. Targets can be diseased eukaryotic cells, to be distinguished from their healthy counterparts, or pathogenic bacteria often coexisting with beneficial strains, e.g. in gut bacterial flora. Our goal is to take advantage of the complexity of cell membranes and design multivalent interaction schemes that are selective against a specific combination of receptors that is likely to occur uniquely on the target cell. We plan to develop our strategy on a synthetic model system, in which liposomes, functionalized with DNA oligonucleotides, will mimic cells and nanoparticles, functionalized with the complementary strands, will serve as probes. By a careful design of the oligonucleotides grafted on the particles, designed in collaboration with Prof. B. Mognetti (Physics of Complex Systems and Statistical Mechanics, Faculty of Sciences), it should be possible to target only those liposomes expressing a defined combination of receptors at their surface.

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