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The self-assembling fungal protein Vmh2 as a versatile biointerface

Paola Giardina¹, Alfredo Maria Gravagnuolo¹, Luca De Stefano², Jane Politi², Sara Longobardi¹, Paola Cicatiello¹, Eden Morales Narváez³ and Arben Merkoçi³¹University of Naples Federico II, Italy²Institute for Microelectronics and Microsystems-Naples National Research Council, Italy³Catalan Institute of Nanoscience and Nanotechnology, Spain

Biological interfacing of nanomaterials is crucial to improve their biocompatibility, dispersibility and selectivity towards various applications in the biotechnological and biomedical fields. Proteins are suitable candidates for the bioconjugation of nanomaterials and the amphiphilic proteins called hydrophobins have been reported to self-assemble into stable biofunctional coating on a wide variety of (nano) materials. Hydrophobins are fungal proteins whose functions are mainly based on their capability to self-assemble into amphiphilic films, adhering to several surfaces. Fibrillar structures formed by class I hydrophobins share many structural analogies with amyloid fibrils, such as stability and resistance to proteolysis. We have studied the class I hydrophobin produced by the edible Basidiomycetes fungus *Pleurotus ostreatus*, named Vmh2, and evaluated its self-assembly under an array of experimental conditions to define the key factors controlling the process. This protein has been exploited as interface on different materials (silicon, glass, gold, steel and 2D materials) to develop different biotechnological applications. As an example, a Vmh2 film formed on the steel sample plate of a MALDI-TOF mass spectrometer has been used to immobilize different enzymes involved in proteomic studies, providing a simple and rapid procedure for in situ serial digestions and analysis of protein sequences, including post-translational modifications. Moreover, we have set up the production of biofunctionalized defect-free graphene by using this hydrophobin. Due to the superior hydrophobicity and stability of this protein, we have obtained high concentrated graphene dispersions upon Vmh2 assisted exfoliation of raw graphitic material. Furthermore, controlled centrifugation enabled the selection of very stable, few-layer and defect-free graphene.

giardina@unina.it

Lanthanides doped inorganic nanocrystals

Artur Podhorodecki

Wroclaw University of Technology, Poland

Over the past decade, high-quality rare earth doped nanocrystals (RENCs) have been successfully synthesized with the rapid development of nanotechnology. Several materials have been successfully applied so far as efficient matrix for RE³⁺ combinations, where the low crystal field symmetry and low phonon frequency are the main factors defining the best matrix selection. These materials have already found several potential applications in biology, medicine as well as in photovoltaics and photocatalysis, as the most common examples. However, to change their commercial potential to real devices, still several problems must be solved, where low emission quantum efficiency (EQE) and controlling their surface properties are the most important ones. The EQE is directly related with the other challenges in this field: Growth of small size <10 nm RENCs, their shape and architecture control. To solve all abovementioned problems, the correlation between technological, morphological and physical parameters is needed. This is however a difficult task because the system itself is very complicated and consists of number of correlated parameters. In this work, we will discuss synthesis and optical properties of down-shifting NaGdF₄ NCs based on Eu³⁺ emission and NaGdF₄ up-converting NCs based on Yb³⁺-Er³⁺ emission. We will discuss how to control their size, shape and core-shell architecture. Finally, based on our work on nanocrystals surface functionalization and their toxicity tests, we will briefly discuss potential use of RENCs in biology and medicine.

artur.p.podhorodecki@pwr.edu.pl