**Project title**: Biomimetic design of nanostructured composites through enzyme-assisted mineralization

**Project Description (~4000 characters, font 11 min):**

The biogenic crystallization of calcium phosphate (CaP) is a ubiquitous process that occurs in several mineralized tissues, such as bone, teeth and cartilage, and involves a variety of biochemical and chemical reactions. This issue has been hitherto continuously studied from supersaturated solutions, i.e. by adding calcium and orthophosphate ions in a homogenous phase (chemical approach). Yet, both in vivo and in vitro investigations have clearly shown the implication of enzymes, in combination with other proteins, to initiate and regulate the mineralization processes. Recently, the use of enzymes has highly motivated the development of "biomimetic" approaches for the design of mineralized nanostructures, the control of their crystallinity being the most important challenge.

The present project aims at exploring the enzyme-assisted mineralization approach, recently investigated in our lab [1], for the design of hard mineralized hybrid nano-objects. For this purpose, enzymes will be embedded in an organic matrix, containing specific (bio) macromolecules [2], and their activity exploited to initiate, in situ, CaP mineralization in the adsorbed state.

These studies will be carried out with various physical-chemistry characterization techniques allowing in particular in situ monitoring. In solution, ion-selective electrode measurements will be performed to characterize the different mineralization stages: nucleation, growth, phase transformations, etc. Visible light and X-ray scattering experiments will be undertaken to follow in real time the growth of nanostructures and the evolution of their morphologies. In the adsorbed state, high-resolution in situ atomic force microscopy (AFM) imaging will be performed on immobilized enzymes during the mineralization process. Complementary in situ characterizations, including infra-red, Raman, X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), and transmission electron microscopy (TEM), will be also used to probe the composition of the CaP compounds and their crystallinity.

This project will mainly take place at the Laboratoire de Réactivité de Surface (LRS) in Sorbonne Université and on the technical platform of the Institut des Matériaux de Paris-Centre (IMPC). Experiments on synchrotron beamlines and, alternatively, collaboration with laboratories with access to in-house equipment such as Small Angle X-ray Scattering instruments will be set up.

From materials chemistry perspective, the approach proposed in this project will provide a straightforward, yet powerful, way to design novel hard biomimeralized nanomaterials with highly ordered dimensions, and tunable crystallinity, and may be used in various biomedical applications. Moreover, it will help to provide a comprehensive understanding on the intriguing mechanism by which organisms exploit biomacromolecules to direct crystallization.

**References**
