Synthesis and characterization of multifunctional smart nanomaterials

Over the past two decades nanomaterials and nanoparticles have encountered a great interest among the scientific community. This is justified by the new properties arising in a material as a result of its nanometric size. Examples are the lowering of melting point, unique optical properties related to Localized Surface Plasmon Resonance, changes of band gap energy values inside semiconductor quantum dots and changes in chemical reactivity.
On the other hand, smart materials at the macrometric scale are well studied. Materials that are designed to have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as mechanical stress, temperature, moisture, pH, electric or magnetic fields, light and chemical environment are widely investigated. Example are piezoelectric materials, shape memory materials, magnetostrictive materials, pH-sensitive polymers, temperature-responsive polymers, self-healing materials and sensors.
During my Ph.D. the idea is to combine both these research topics.

The aim of my project is to create "intelligent" and adaptive nanomaterials, venturing beyond equilibrium/static structures, that, instead, are the major part of nanomaterials studied until now. In fact, the use of systems far from equilibrium can provide interesting properties: stimuleted senzing, adaptability, self-healing, self-replication and movement.
The idea is to create responsive and nonequilibrium materials, that could use externally delivered energy to change their structures and overall functions on demand, exploiting the simple synthesis technique known for nanomaterial preparation.
The external stimuli that will be more widely investigated will be light (introducing in the materials functions that are sensitive to light, with particular regards to wavelength selective illumination and response) and changes in chemical composition (exploiting, for example, oscillating reactions if a continuous response is wanted, or introducing from the extern a time limited concentration variation, if, for example, a sensing activity is wanted).
The systems studied could find an application as:
- actuators (photo-thermal actuators, self-actuators)
- catalysts (self-repairing catalyst, catalyst with dynamically reconfigurable structures)
- sensors (allowing a controlled and cyclic uptake and release of the analyte of interest)
- systems that permit an information storage.