Keynote speaker

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Programmable Nanosystems: a second generation of nanomaterials

In the last years, a natural evolution is taking place at high speed, from first generation nanomaterials with structure and morphology-controlled properties to nanosystems, in which properties can be programmed by precisely locating multiple functions in space. Today we aim at building multiscale nanoarchitectures with space-dependent properties that can adapt to the environment and present dynamic and vectorial responses to stimuli.

In this exciting field, chemical synthesis routes opened the path to complex nanomaterials that mimic the complexity of those found in Nature. Current efforts are directed to produce nanosystems with well-defined functional domains that can intercommunicate to obtain an emergent behavior derived from the local structure, the mesoscale architecture and the spatial location of different molecular, polymeric, biological or nanoscale functions.

Mesoporous materials (MM) with high surface area and controlled mesopore diameter (2-50 nm) constitute a highly tuneable platform. The pore architectures and dimensions can be finely tailored, and “decorated” with a variety of molecular, bioactive or nanoscale components. Chemical routes lead to pre-programmed nanosystems, in which confinement effects, responsivity, or collaborative functionality can be imparted into the structure through the control of positional chemistry of different nanobuilding blocks.

We will present examples based in MM in which sol-gel chemistry, self-assembly and localized reactivity are the basic topological toolkit that enables their construction. The combination and feedback of synthesis, characterization and modeling leads to nanosystems with responsive and autonomous behaviour programmed in their structure at the molecular, mesoscopic and interfacial length scales. We will illustrate this concept with examples in novel catalysts, remotely activated nanoparticles, responsive optoacoustic devices or perm-selective membranes.

The chemical strategies and tools at our disposal are key to design and produce a potentially infinite variety of programmable and intelligent matter presenting controllable behaviour, with wide applicability in bioinspired catalysis, environmental sensing, renewable energy, prosthetics, soft robotics or synthetic biology.