Synchrotron techniques: the Holy Grail tool to solve the puzzle of Hierarchical Nanoporous Structures

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Abstract: Hierarchical structures made up of inorganic and organic nanobuilding blocks (NBB) are omnipresent in Nature: from bone to nacre to exoskeletons, the organization of nanomatter at different levels brings up new properties. The delicate combination of self-assembled NBB allows for novel properties tied to spatial organization of functions, such as improved mechanical properties, energy management or localized bioprocesses. In the last twenty years, synthetic chemists took examples from this “school of Nature” to produce hierarchically porous materials that present micro, meso- and macropores with functionalized surfaces.[1] These novel matrices present high surface area, mesopores with size-selective properties and a large pore network that provides high molecular accessibility. These materials find potential applications in a variety of fields such as novel catalysts, biocolloids, intelligent surfaces, nanocarriers or solar cells.[2] The complexity of these multiscale nanomaterials can only be adequately solved by combining spectroscopic and scattering techniques in order to understand the structural parameters at different length scales: from the atomic environment to long-range ordering to surface composition.[3] In addition, the use of crossed synchrotron techniques (SAXS, XAS, XPS, FTIR) in situ and operando have permitted to shed light into the dynamics of formation of these structures as well as their behavior under operation conditions. In this presentation, we will discuss several examples of the formation of mesoporous thin films and nanoparticles with functionalized surfaces and pore systems, their structural, surface and functional determination, and their evolution under solicitation, with applications in health and environment.[4] Interestingly, the use of these accurate techniques permit to develop a virtuous feedback between materials synthesis, characterization and theory, which is a sound basis for the design of future complex nano-matter.[5]

References:

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