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Strategies for a better control of the properties of functional ordered mesoporous hybrid nanomaterials

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Ordered mesoporous silica (OMS) materials resulting from the synergy between supramolecular templating and sol-gel processes exhibit unique porosity and surface properties, which make them highly attractive as drug delivery systems, sensors, adsorbents or catalysts , and more generally for applications in fields as diverse as human health, environment protection and sustainable energy.

Functionalization of their mesopores by organic, organometallic or biologically active functional groups can be achieved by well-controlled processes. Bringing polymer functionalities in those systems could confer new physical and chemical properties to these hybrid materials, but that remains a quite challenging task: post-functionalization routes applied on template-free porous materials hardly succeed in providing homogeneously distributed polymer chains of controlled chemical function, polymer block length and density of function.

The use of polyion complex (PIC) micelles as structure-directing agents can allow overcoming the different issues related to the preparation of polymer-functionalized mesoporous materials. Polyion complex micelles are dynamic assemblies obtained by electrostatic complexation between a double-hydrophilic block copolymer (DHBC) and an oppositely charged polyelectrolyte (PE), their formation is reversible in water as a function of parameters such as pH and ionic strength. Their use for structuring silica is highly beneficial since (1) they allow the preparation of ordered materials whose structure (2D hexagonal, lamellar, 3D spherical cubic) and pore size can be easily controlled, (2) they allow recovering and recycling the pore-generating polymers (PE) and (3) they enable the direct preparation of homogeneously distributed polymer-functionalized mesoporous structures. Another great benefit of the use of PIC micelles is that the ability to finely tune the affinity of the corona polymer blocks for silica allows the preparation of mesoporous nanoparticles of controlled colloidal size. Finally this synthesis route could be extended to the preparation or periodic mesoporous organosilicas (PMO) whose interest in biomedical applications was evidenced.

[1] E. Molina et al Langmuir 31 (47), 12839 (2015)
[2] A. Birault et al ACS Appl. Bio Mater. 1, 1787 (2018)

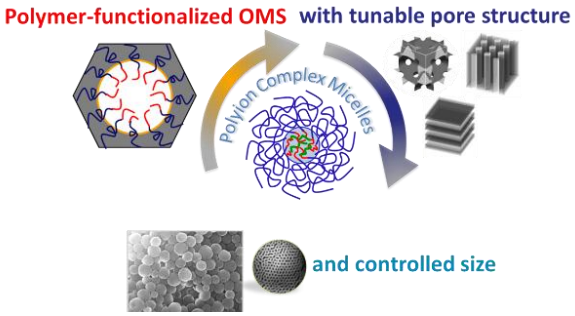

Figure 1 : Polyion complex micelles as structure-directing agents, porogens and functionalizing agents of silica