

The chemistry of metal-organic framework nanoparticles

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Metal-organic framework (MOF) science has turned into an advanced research field recognized as a driver for the development of key technologies incorporating novel functional materials. They have proven to be useful in the implementation of various applications such as storage, separation, catalysis, sensing, and energy technologies. Beside tremendous advances in these material-oriented applications, MOF, in particular nano MOF, could, in the near future, deeply enlarge nanomaterial science and inspire new insights and leverage the field of nanomedicine.[1]

MOF nanoparticles (MOF NPs) combine the richness of bulk MOF chemistry with the surface- and size- dependent properties of the nanoworld. Bringing together these two worlds leads to an interdisciplinary field of research between chemistry, physics, materials science, and engineering. The past and still ongoing intensive development of synthesis routes of innovative functional MOF materials is currently enriched through their extension to the nanolevel. In doing so, scaling-down the MOF size could allow to tackle medical applications as diagnosis and therapy, which require nanometric dimensions to overcome several biological barriers. This is especially the case for drug delivery systems, which should be able to selectively and specifically deliver a drug to a site of interest.[1]

In this talk, we describe our research aiming at the establishment of material chemistry guidelines to engineer smart MOF nanoparticles (MOF NPs) able to unlock their potential for applications in the field of life sciences. To successfully achieve smart nanoMOFs, we aim to bring together five fields of expertise as illustrated up in the Figure. Special emphasis will be given to the characterization of MOF NPs, the MOF NPs' external surface functionalization and their biological assessment.

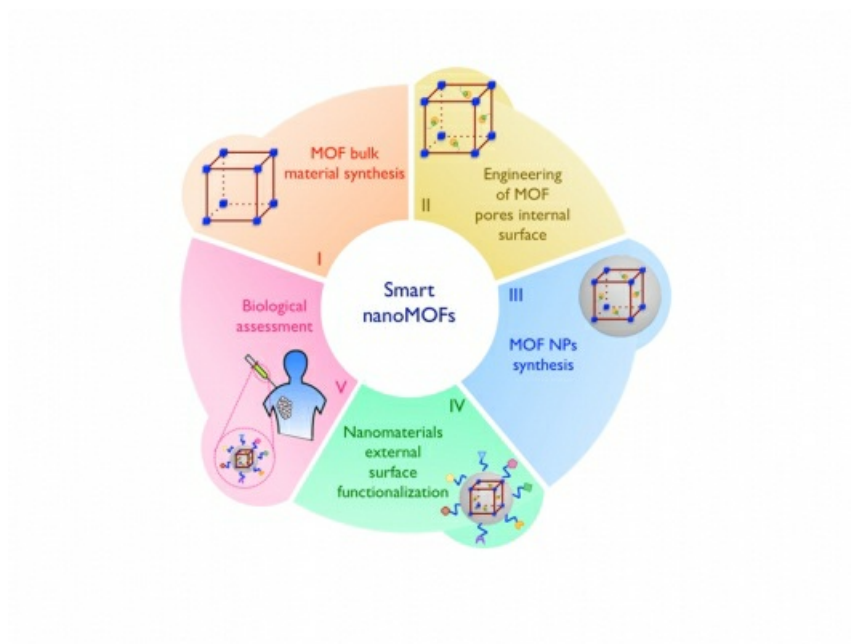
In solution, the size, more precisely the hydrodynamic diameter, and the surface charge of NPs are determined routinely via measurements of their mobility. Although NP hydrodynamic diameter is one major characterization parameter, this one is related to the external dimensions of NP and is thus not sufficient to characterize highly porous MOF NPs.[2] In the case of MOF NPs, a further fascinating layer of complexity is added by the possibility of functionalizing the internal and external surfaces differently. In this talk, we wish to describe a novel method that uses mass fluctuations at the attogram-level and with this revealing solvent accessibility of porous MOF NPs.

Furthermore, we wish to introduce two novel concepts dealing with the selective functionalization of the external surface of MOF NPs. The first concept uses the coordinatively unsaturated sites present on the MOF NPs' external surface to self-assemble functional units bearing Lewis bases, such as oligohistidine tags, which are routinely used for the purification of recombinant proteins.[3] The second concept synergistically combine the advantages of MOF NPs as nanocarriers with those of exosomes as capping system to facilitate simple drug loading, leakage-free delivery and efficient release. Last but not least, we will demonstrate the therapeutic potential of our MOF NP systems.

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