Stöber Method to Amorphous Metal Organic Frameworks Coatings and Colloids

Nicola Pinna

Department of Chemistry, Humboldt University of Berlin, Brook-Taylor-Str. 2, 12489 Berlin, Germany

E-mail: nicola.pinna@hu-berlin.de

The Stöber method is a widely-used sol-gel route for synthesizing amorphous SiO_2 colloids and conformal coatings. Recently, further enrichment of this methodology has been achieved by extending it to other materials such as TiO_2 and a resorcinol–formaldehyde polymer. Nonetheless, there are still limited materials that can be synthesized by the Stöber method. Herein, by mimicking the Stöber method, we have extended the approach to metal organic frameworks (MOFs), a category of organic-inorganic hybrid materials with exceptionally customizable composition and properties. It is important to note that amorphous MOFs have demonstrated unique performances in energy storage and conversion and drug delivery applications, but achieving controllable synthesis has remained a challenge. Herein, we introduce a general synthesis route to amorphous MOFs by making use of a vapor diffusion method, which allows to precisely control the growth kinetics. Twenty-two different amorphous MOF colloids were successfully synthesized by selecting 11 metal ions and 17 organic ligands. Moreover, by introducing pre-formed core-nanoparticles (NPs), a conformal and homogeneous amorphous MOFs coating with controllable thickness can be grown on core-NPs to form core-shell colloids. The versatility of this amorphous coating technology was demonstrated by synthesizing over 100 new core-shell composites from 19 amorphous MOF shells and over 30 different core-NPs. Besides, various multifunctional nanostructures, such as conformal yolk-amorphous MOF shell, core@metal oxides, and core@carbon, can be obtained through one-step transformation of the core@amorphous MOFs. This work significantly enriches the Stöber method and introduces a platform, enabling the systematic design of colloids exhibiting different level of functionality and complexity.

Nicola Pinna received his Ph.D. in physical chemistry from the Université Pierre et Marie Curie (Paris) in 2001. He has since worked at the Fritz Haber Institute of the Max Planck Society (Berlin), the Max Planck Institute of Colloids and Interfaces (Potsdam), the Martin Luther University of Halle-Wittenberg, the University of Aveiro (Portugal), and the Seoul National University (Korea). In July 2012 he joined the Department of Chemistry of the Humboldt University of Berlin as professor of inorganic chemistry. From July 2016 to April 2021, he was also head of the Department. His research activity focuses on the development of novel materials chemistry routes to nanostructured materials for energy and environmental applications.