3-Dimensional Assembly of Nanoparticles into Aerogel Monoliths for Gas-Phase Photocatalysis

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Multiscale nanoparticle assembly is at the heart of efforts to integrate nanoparticles into macroscopic materials and devices [1].The idea of arranging nanoparticles in a modular and defined way to larger entities is extremely appealing, because in such a way a nearly indefinite number of different architectures is accessible from a limited set of building blocks. Among the many geometries, 3-dimensional structures like aerogels are unique in the sense that the size-specific properties of the nanobuilding blocks are fully preserved in the macroscopic material [2]. With their extensive porosity and large surface areas aerogels are particularly attractive for applications in catalysis and photocatalysis [3].
In this talk, we will propose strategies how preformed nanoparticles are assembled into 3-dimensional, porous networks that after supercritical drying result in aerogel monoliths with macroscopic sizes. The controlled gelation of the initial colloidal nanoparticle solutions into volume-filling gels is the decisive and challenging step [4]. Careful selection of the nanoscale building blocks enables subtle tuning of the compositional, morphological, structural, and optoelectronic properties of the aerogels. Gelation inside a 3D-printed polymer scaffold not only improves the mechanical properties, but also offers a versatile tool to tailor the macroscopic aerogel architecture. As a proof-of-concept, we will show the use of metal-metal oxide composite aerogels in the photocatalytic reforming of methanol in the gas phase [5].

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