Self-Assembled Mesocrystals: Structural and Morphogenetic Aspects

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Mesocrystals are nanostructured materials characterized by a defined order on the atomic scale (which can be inferred from the existence of an essentially sharp wide angle diffraction pattern) and consist of individual nanosized building units. In the past years, we have structurally characterized a large variety of inorganic-organic nanocomposite materials incl. biological and biomimetic materials as well as nanoparticle self-assemblies. The self-assembly of monodisperse anisotropic nanocrystals (stabilized by organic molecules) allows to generate a special type of mesocrystals which fulfils the criteria of crystalline material on two length scales: ordered superlattice (colloidal crystal) together with specific crystallographic orientation of the crystalline building blocks. One of our recent examples includes the synthesis and detailed structural characterization of 2D and 3D iron oxide based self-assembled mesocrystaline materials. The approach we are using in our study aims to determine the structure of mesocrystals incl. the translational and orientational order of nanocrystals within the superlattice (mainly by means of different electron microscopy techniques) as well as to examine the effect of synthesis conditions on the self-assembly process and especially on the formation of 3D faceted mesocrystals. Furthermore, we are also able to resolve the structural defects generated within the superlattice during the self-assembly process. The performed atomistic modelling not only verifies the proposed mesocrystal structures, but also provides great insight into fundamental structuring principles of mesocrystals.