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Crystallization of Mesostructured Materials with Atomic Disorder

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The synthesis route to organic-inorganic periodic assemblies using surfactant micelles has led to the discovery of a new structural type of materials that are called mesoporous materials (uniform pore diameter in the range of 2 ~ 30 nm) such as MCM-41 (with hexagonal structure), MCM-48 (cubic Ia3d), SBA-1 (cubic Pm3n) and so on [1,2]. The X-ray powder diffraction pattern of these mesostructured silica materials indicates that the mesopores are ordered, while atoms in the silica frameworks are disordered similar to the structure of amorphous silica. The mesoporous silica with the amorphous frameworks can be obtained in the form of particles exhibiting facets [1,3,4]. The faceted nature of the mesoporous particles is a considerable debate as regard to the possibility for the formation of 'crystals' by self-organization of the surfactant micelles with the amorphous silica frameworks.

In recent years, we performed studies on the silica synthesis in order to clarify the debate concerning the faceted nature of the mesoporous silica particles. The result of these studies has revealed that it is indeed possible to obtain the mesoporous silica particles exhibiting completely single crystal-like morphology [5]. The X-ray powder diffraction and field emission scanning electron microscopy showed that the MCM-48 silica was obtained in the form of single crystal-like truncated cubes with the size up to 3 microns in diameter, despite the amorphous nature of the silicate framework. The single crystal-like morphology of the MCM-48 was obtained by the synergistic self-assembly between surfactant and silicate. In the case of the SBA-1 silica, the crystal size increased to 15 microns. We investigated the morphological development against the crystallization time, in order to understand the crystallization mechanism. These results indicate that the mesoporous silica can form *truly* single crystals or at least single crystal-like geometries by self-organization between the surfactant micelles and the silica frameworks despite the amorphous nature. We discuss this interesting result in respect of current concept on single crystal structures.

In addition, we report on our recent results on syntheses of the structurally ordered mesoporous carbon and platinum, using the mesoporous silica crystals as the template. This template synthesis strategy uses the infiltration of carbon or platinum precursors, followed by the conversion to carbon or platinum inside the silica mesopores, and subsequent dissolution of the silica template. The resultant materials retain the ordered porosity of the silica template [6].

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