Nanocomposites and nanomaterials

Carbothermal synthesis of porous silicon carbide using silica mesoporous molecular sieves

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The samples of β-SiC (crystallite size ca. 17-70 nm) with high structural and sorption characteristics (S_{BET} up to 410 m^2/g, V_{pore} up to 1.0 cm^3/g), which exceeds corresponding figures of reported in the literature counterparts, were obtained using carbon-silica composites (aerosil or initial silica matrixes SBA-3, SBA-15, KIT-6, MCF) as precursors. The possibility of forming SiC during the carbothermal reduction as well as its adsorption characteristics are determined by the type and porosity of silica MMS and carbon component, C/SiO_2 ratio, and degree of filling of silica MMS pores by carbon through sorption concentration in the pores and sorption interaction with the walls of the matrix framework. Application of the initial silica MMS KIT-6 with its specific 3D structure and crosscutting mesopore system, high sorption volume, which allows reaching closer to the stoichiometric ratio of C/SiO_2, and a gradual matrix pore filling with organic precursor allows obtaining SiC samples with the highest porosity parameters.

Morphology (a presence of fibers) and consequently textural parameters of SiC are largely determined by the porosity of the carbon component of initial carbon-silica composites, as well as the number of contact zones of silica and carbon phases. In the case of using of silica MMS a contact area of silica and carbon is determined by specific surface of mesopores. As evidenced by SEM and ad(de)sorption of nitrogen a content of silicon carbide fibers depends on mesopore specific surface area of carbon materials derived from carbon-silica composites (inverse relationship). Such correlation between the type of structure of the silicon carbide and mesopore specific surface area of carbon component in the composite indicates a templating role of carbon in the carbothermal reduction reaction.

SiC-KIT-6 with a maximal surface area has a high adsorption capacity of H_2 (1.24 wt.% at 77 K and 1 atm.) under the condition of low level of absorption energy for all samples ($|\Delta\mu_0|_{H2}$ up to 2.3 kJ/mol, and ca. 5.0 kJ/mol for carbon), caused by the low frame density of atoms in the structure of the studied sorbents. Maximal among the existing porous materials specific adsorption of hydrogen by SiC (ϱ up to 15 μmol/m^2) was found, corresponding to almost complete filling of their surface with H_2 in the exanimated conditions (77 K, 1 atm.).