HYDROTHERMAL METHOD FOR TREATMENT OF NANODIAMOND CHARGE IN SUPERCRITICAL WATER AND WATER SOLUTIONS

V.I. Anikeev, I.V. Kozhevnikov, A. Yermakova

Boreskov Institute of Catalysis, Novosibirsk, Russia
E-mail: anik@catalysis.nsk.su

Abstract

One of the methods for production of artificial diamond nanoparticles is explosion of carbon-rich substances. The resulting charge is a highly dispersed black powder containing 89 wt % total carbon, which includes 41% of the diamond phase and 48% of non-diamond carbon and ash impurities (oxides, metals, encapsulated metal carbides and salts adsorbed by the surface). The size of nanoparticles of crystalline or bulbous diamond in the initial charge ranges from 4 to 80 nm.

Treatment and modification of nanodiamond charge (removal of high-carbon non-diamond compounds, metals and oxides from the surface of nanoparticles) are the necessary procedures allowing practical application of the crystals.

As an alternative to conventional methods of charge purification with concentrated strong acids, which have some drawbacks, charge treatment in supercritical fluids, in particular water, was proposed. Morphological and structural changes of the particles during such treatment, selection of appropriate fluids and process condition were investigated.

The charge was treated in an autoclave in the temperature range of 380–460°C at 260 atm pressure. Water and water mixtures with acetic acid or hydrogen peroxide were used as the initial solvent. Residence time of the reaction mixture was varied from 2 to 6 hours.

Solid phase obtained after the treatment was studied using the scanning electron microscopy (SEM), high resolution transmission electron microscopy (HRTEM) and small angle x-ray scattering (SAXS) methods. The composition and volume of the resulting gaseous products were determined.

The study showed that, first, both the gas and liquid reaction products are free of hydrogen peroxide and acetic acid due to their decomposition during the preparation of a mixture. Second, the interaction of carbon with a supercritical solvent yields a large amount of gaseous products, mainly CO and CO_2. The transformation of non-diamond carbon phase and ash impurities is most pronounced when the charge is treated in a solvent initially containing hydrogen peroxide. It was revealed that the parent bulbous diamonds transform into the crystalline structures of 6–10 nm size.