Nanocomposite and nanomaterials

Composite birnessite-coated polyacrylonitrile fibers: synthesis and application

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The functional materials based on nanostructured manganese oxides attract considerable scientific interest as inexpensive and non-toxic compounds for practical application in rechargeable battery technology, heterogeneous catalysis, hazardous waste remediation, and other fields.

Birnessite-type manganese oxides (δ-MnO_2) have recently received close attention because of their unique adsorptive and catalytic properties. Birnessite is a layered mineral. It consists of layers of edge-sharing MnO_6 octahedra in which the manganese has a mixed valence (+3 and +4 or even +2), and negatively charged cations (Na^+, K^+, Ca^{2+}) occupying the interlayer region for charge compensation. Birnessite is widely distributed in soils, sediments and ocean manganese nodules in the fine-grained form.

Unfortunately birnessite-type manganese oxides are usually synthesized as fine-grained particles, and this fact leads to limitation of their practical application. The last achievements of nanotechnology allow overcoming these technical drawbacks through synthesis of nanocomposites by embedding of preliminary synthesized inorganic nanoparticels into the porous solid matrixes or by in-situ formation of inorganic nanoparticels on (or inside) of appropriate solid matrixes.

In this study we propose novel nanocomposite material based on birnessite-coated polyacrylonitrile (PAN) fibers, which was prepared by *in situ* formation of birnessite nano-sized grains within and on the fibers' surface. The original PAN fibers have cream color, but composite fibers became black. Microanalysis results of composite fibers showed presence of elements corresponding to the composition of birnessite (Na, K, Mn, O). The SEM images of fibers' surface and cross-cut revealed the formation of the birnessite nanograins (100 nm) within the fibers' pores. XRD and FT-IR analyses also confirmed the formation of composite fibers with the birnessite phase. The chemical analysis of composite fibers after their exposure test at acidic (pH ~ 2) and alkaline (pH ~ 12) solutions showed their good chemical stability both in acidic and alkaline media. Testing of the composite fibers in catalytic oxidation of divalent iron in solution has shown their high efficiency.