Nanocomposites and nanomaterials

Organic-inorganic nanomaterials: from ion-exchangers to membranes

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The methods of synthesis of nanocomposite organic-inorganic ion-exchangers have been developed. The materials are based on semi-rigid and flexible strongly-acidic gel-like ion-exchange resins, they contain (i) only non-aggregated nanoparticles of zirconium hydrophosphate (4-20 nm), (ii) only aggregates of the nanoparticles (50 nm - several microns), (iii) both nanoparticles and their aggregates. The materials were investigated using methods of small angle X-ray scattering, TEM and SEM (air-dry forms), standard contact porosimetry and impedance spectroscopy (swollen forms). The aggregates were shown to be located in structure defects of the polymer and in voids between gel fields. They squeeze pores of the polymer, where functional groups are located (nanosized clusters and channels), exclude them from ion transport. This deteriorates kinetics of ion exchange and electrical conductivity of the composites. The nanoparticles are placed in clusters and channels. Functional groups of the inorganic constituent support ion transport, small amounts of the particles provide high rate of ion exchange. Depending on a type of the polymer matrix and state of particles of zirconium hydrophosphate, the materials can be applied both to traditional and electromembrane processes, particularly they can be used for removal of toxic ions both from aqueous and non-aqueous solutions. Ion-exchange membranes, which contain only non-aggregated nanoparticles have been also obtained, they were applied to whey demineralization. The nanoparticles reduce concentration polarization of the membranes and prevent their fouling.