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Radiation-Chemical Synthesis of Nanocomposite Adsorbents Based on Polypropylene Fibers for Selective Removal of Heavy Metals and Radionuclides

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Polypropylene (PP) fibers are widely used in sorption processes. The range of their possible applications can be extended by modification with the use of radiation-induced graft polymerization method. This method allows grafting of nano- microchains of a vinyl monomer with a desired functional group onto the inert surface of PP base, ensuring control over the length and density of the grafted chains. The resulted material consists of two parts: the polymeric base and the chemically bound chains with functional groups (ion-exchange or chelating), and so it can be used as polymer adsorbent.

In the past decades, fibrous polymer adsorbents have been considered as potential alternative to granular ion exchange resins because of their high adsorption parameters. Numerous adsorbents on the base of PP fibers have been synthesized, but only a few of them could be adjusted for selective removal of pollutants from water effluents because of limited variety of available functional groups.

In recent years, hybrid adsorbents (polymer/inorganic nanoparticles) have been developed as a new class of adsorption materials. They were fabricated mostly by the in-situ formation of inorganic nanoparticles or by incorporation of preliminary formed inorganic nanoparticles into voids of macroporous ion exchange resins. Although polymer fibers are very attractive support in preparing hybrid adsorbents, there are only a few publications on this theme.

The considered research was focused on the fabrication of novel hybrid adsorbents based on the polypropylene fibers coated with inorganic nanoparticles for selective removal of heavy metals and radionuclides.

The hybrid adsorbents were synthesized through a two-stage experiment: radiation-induced graft polymerization of a vinyl monomer with functional group (ion-exchange or chelating) onto the PP fibers' surface, followed by the in situ formation of inorganic nanoparticels within the grafted chains.

For selective removal of radionuclides from contaminated waters (natural or industrial origin) 4 types of hybrid adsorbents based on grafted polypropylene fibers have been synthesized: PP fibers coated with ferrihydrite (iron hydroxide) nanoparticles; PP fibers coated with manganese hydroxide; PP fibers coated with K-Ni and K-Cu hexacyanoferrate; PP fibers coated with hydroxyapatite nanoparticles.

FT-IR-ATR, and X-ray diffraction techniques confirmed the formation of inorganic nanoparticles on the PP fibers surface. SEM study revealed that nanoparticles form a homogeneous layer of nanosized aggregates which are rather regular in shape and closely fit one to another forming a compact texture the fibers' surface. The synthesized composite fibers were found to be stable in aggressive solutions for long time. The targeted radionuclide'adsorption on the composite fibers was studied as a function of contact time, pH, initial ion concentration and the presence of competitive ions. The synthesized adsorbents demonstrated fast adsorption kinetics, high adsorption capacity and rather high selectivity.

The proposed strategy of the nanocomposite fibers synthesis opens ample opportunities for the fabrication of adsorbents, catalysts, biochemical and chemical sensors on the base of commercially available polymer fibers, fabrics, resins and membranes.

Country/Organization invited to participate

Ukraine

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