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Editorial

Thermo and pH-Responsive Polymers and Adsorbents for Separation Purposes

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Problem description

Environmental pollution remains one of the major problems both on the national and international level. One of the most severe problems with respect is the presence of toxic substances such as heavy metal ions, anions in the industrial wastewaters. Heavy metals such as lead, cadmium and copper [1], and different types of dyes in wastewater [2] are known to pose risks to environment and human. Various conventional techniques [3] and advanced oxidation processes have been used for the removal of dyes from wastewater [4]. There is a huge need for developing new, effective and cost-efficient technologies for removal of pollutants from wastewaters. Among many sorptive materials, various forms of synthetic polymers containing complexing molecule, which are abundantly at low cost, have emerged as one of the most important materials for the synthesis of new sorbents [5].The use of high-energy radiations in the grafting and copolymerization processing is known to improve the physicochemical qualities of many polymer products to expand their utilizations. This trend is envisaged to be continuously growing to form a big application field of polymeric products. The grafting of hydrophilic monomers into polymeric substrates generates perm-selective membranes with interesting properties for the use in different separation processes such as in reverse osmosis desalination of saline water [6] and wastewater treatments [7]. The possible use of such functionalized graft copolymers in the field of wastewater and low level nuclear waste treatments has been one of the research fields of our group that current continues in developing new polymers with additives [8]. This mini-review focuses mainly on our results from the studies on the synthesis and use of thermo and pH-responsive polymers for separation use in wastewater treatment and separation purposes.

Fundamentals of grafting and copolymerization

Removal of heavy and toxic metals from wastewater using functionalized polymers as adsorbent is under research and development in many laboratories. Functional groups can be introduced in the polymeric materials by radiation grafting technique. The membrane selectivity towards some heavy and toxic metals which may exist in the wastewater and low level nuclear waste is very important factor to be investigated. Temperature-sensitive as well as pH-sensitive membranes and gels have been suggested for use in a variety of novel applications including controlled drug delivery, immobilized enzyme reactors, chemo-mechanical devices, artificial muscles, and separation processes [9-11]. Radiation based technologies (gamma rays or electron beam) are considered to be among the most convenient ways to produce and sterilize polymer gels and membranes. There are many advantages of the radiation-based technologies of polymer-based stimuli-responsive materials over the conventional techniques. Since the chemical reactions in the processed materials are initiated by radiation, there is no need to use (usually toxic) initiators, crosslinking agents or other auxiliary substances. This helps to reduce costs, makes the technology simple, does not lead to by-products and waste, and the resulting product is of high purity. Radiation-based technologies can easily be handled also by small companies and the costs of production, being an important component of the final shelf-price of the product, are considerably lower than for the corresponding conventional procedures, as proven by the already implemented radiation-based technologies, e.g. hydrogel wound dressings.

Our works on polymer production and application works

Recently, we have studied radiation-induced synthesis of poly(N-isopropylacrylamide/maleic acid) P(NIPAAm/MA) and poly(N-isopropylacrylamide/itaconic acid)P(NIPAAm/IA) copolymeric hydrogels [12,13].''Stimuli-responsive intelligent or smart hydrogels'' refer to a special class of hydrogels which exhibit dramatic changes in their physical or chemical behavior in response to slight variations in external conditions such as temperature, ionic strength or pH of the medium. Poly(N-isopropylacrylamide) (PNIPAAm) hydrogel is the best known temperature-sensitive polymeric network, which exhibits a lower critical solution (LCST) at about 32–24°C [14] If NIPAAm is copolymerized while crosslinked with some anionic monomer, such as itaconic acid (IA), the gel acquires pH-sensitive behavior and its temperature sensitivity is modulated [15].In our research laboratories, those thermo and pH responsive hydrogels were prepared and characterized with respect to their swelling properties and network structures. We have found that these hydrogels have high adsorption capacities for cesium or uranium cations [16,17] Adsorption results at different temperatures show that P(NIPAAm/IA) hydrogels adsorb Cs^+ ions at temperatures lower than the lower critical solution temperature (LCST). We described the removal of radioactive cesium in the aquatic system with the use of these hydrogels for the first time. According to our experimental results, the observed cesium or uranium uptake suggests the potential use of these hydrogels in removal of harmful radioisotopes from water. We have also recently studied adsorption of methylene blue (MB) as a cationic dye from aqueous solution was carried out by using P(NIPAAm/MA) copolymeric hydrogels as adsorbent that were noted as effective potential sorbents to use for the removal of cationic dyes that cause important problem in textile industry wastewater [16].

Concluding remarks

The use of high-energy radiations in the grafting and copolymerization processing is known to improve the physicochemical properties of many products to expand their utilizations. Our studies confirmed that "Stimuli-responsive intelligent or smart hydrogels" are effective for removal of metals and cationic dyes. Our running research activities are to go through to increase the application fields of those hydrogels by improving their structures.

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