Preparation of High-Performance Ion-Exchange Membranes by Radiation-Induced Graft Polymerization

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Applications of ion-exchange resin include production of pure water, softening of hard water, recovery of metal ions, purification of bioproducts, and catalytic enhancement of hydrolysis. The matrix of conventional ion-exchange resins consists of a copolymer of styrene (St) and divinyl benzene (DVB). This matrix was chemically modified to add the ion-exchange moieties. For example, the sulfonic acid group, as a strongly acidic cation-exchange group, can be introduced into the matrix crosslinked with DVB under considerably drastic reaction conditions, e.g., long-period immersion of the matrix polymer in concentrated sulfuric acid or chloro-sulfuric acid at an elevated temperature. These preparation schemes induced deterioration of physical strength and emission of polymer debris. In addition, a highly cross-linked matrix with chemical and physical endurable strength prevents us from preparing an arbitrary shape of ion ex-changer. We have thus far used ion-exchange beads or ion-exchange membranes based on the St-DVB copolymer matrix.

A novel and simple preparation method for sulfonic-acid-group-containing material was proposed as an alternative to sulfonation of conventional styrene(St)-divinyl-benzene(DVB) matrix. Sodium styrene sulfonate (SSS) was grafted in liquid phase onto electron-beam-irradiated cellulose triace-tate (CTA) and polyethylene (PE) membranes.

(1) Hydrophilic SSS could be easily grafted onto the hydrophilic CTA membrane.

(2) SSS could be grafted onto PE membrane carrying pre-grafted polymer branches with monomer units of acrylic acid (AAc), hydroxyethyl methacrylate (HEMA), hydrolyzed glycidyl methacrylate (GMA) and hydrolyzed vinyl acetate (VAc).

(3) SSS could be readily co-grafted with HEMA and AAc by immersing the irradiated PE membrane in an aqueous solution of AAc/SSS and HEMA/SSS mixtures.

The density of the SO_3H group of the resultant membrane amounted to 2.5 mol per kg of the H-type product, which is equivalent to that of a commercially available cation-ex-change membrane.

These cografting procedures enabled us to introduce a hydrophilic monomer as SSS into PE under relatively mild reaction conditions as compared with those of conventional sulfonation based on a St-DVB matrix.