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

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Though the crosslinked ion-exchange membrane based on the styrene (St)-divinyl benzene (DVB) copolymer matrix is widely used, its crosslinked polymer structure has limited the diffusion of molecule and ion. Therefore, in order to satisfy new needs for ion-exchange, research and development on the design of a graft-type, different from the conventional crosslinked-type ion exchanger is necessary.

Radiation-induced graft polymerization (RIGP) has been one of the methods for preparing new materials containing functional moieties on the polymer chains grafted on a variety of physically and chemically trunk polymers. By applying the pre-irradiation grafting method, a quaternary ammonium salt group and a sulfonic acid group were introduced onto a nonporous polythylene film and a porous polyethylene hollow fiber, respectively. Since the reaction rate of direct grafting of the hydrophilic ion-exchange groups-containing monomers onto the hydrophobic base polymers is low, a cografting method is proposed.

Generally, there are two methods, direct or indirect, for investigating the characteristics of the grafted polymer chain containing ion-exchange groups. Unfortunately, it is difficult to isolate the polymer chain of the ion-exchange membrane prepared for practical use. As a result, the indirect method for examining the ion-exchange characteristic of the grafted polymer chain is useful for designing ion-exchange membrane by RIGP as well as in evaluating the grafted polymer chain.

First, we had developed a nonporous anion-exchange membrane for the regeneration system of dialysate used in peritoneal dialysis. The permeability of urea was investigated by alternating the density of grafted polymer chain that contained quaternary ammonium salt groups. Second, a porous ion-exchange membrane for high-speed protein recovery was developed. The adsorption amount of protein was examined by changing the density of sulfonic-acid-group-containing grafted polymer chain.

By optimizing the graft polymerization reaction and the subsequent introduction reaction of ion-exchange group, the grafted polymer chains containing ion-exchange groups were able to provide spaces for the permeation of urea or holding of protein. Because of its mild reaction condition and reasonable production cost, RIGP is a promising method for preparation of novel graft-type functional materials.