No. 1817

Preparation of Nano-Structure Controlled Ion-Exchange Membranes by Ion Beams and Their Application to Seawater Concentration III

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Summary

Cation and anion exchange membranes (CEMs and AEMs) with low resistance for ion transport and low water flux have been required for applications to a saline water electrodialysis process. The present study deals with the preparation of nano-structure-controlled CEMs and AEMs by a so-called ion-track grafting technique. This new technique involves irradiation of a polymer substrate with an MeV-GeV heavy-ion beam and the graft polymerization into the resulting nano-sized cylindrical latent tracks to introduce cation and anion exchange groups. These one-dimensional ion channels are expected to rapidly transport ions (Na^+ and Cl^-), while the surrounding substrate matrix without any modification should mechanically prevent excess water swelling to restrict water flux.

A 25-μm-thick poly(ethylene-*co*-tetrafluoroethylene) (ETFE) film was irradiated with 310 MeV ^{84}Kr ion beam at a fluence of 4.0×10^8 ions/cm^2. The irradiated ETFE films were immersed in grafting solutions of styrene and chloromethyl styrene (CMS), and then afforded to sulfonation of the grafted styrene units and quaternization of the grafted CMS units for the preparation of CEMs and AEMs, respectively. The water uptakes of these nano-structured CEMs and AEMs were 4-11% and 1-9%, respectively.

As the water uptake of the nano-structured CEMs and AEMs became larger, the membrane resistance decreased and the water flux increased. We adjusted the water uptake at 6-8% and achieved lower membrane resistance and lower water flux compared to those of Selemion® CSO and ASA (standard commercial CEM and AEM used for saline water electrodialysis). In the electrodialysis test using the nano-structured CEM/AEM with such preferable transport properties, the concentration of obtained brine was 30% higher than that of the test using CSO/ASA. It was demonstrated that our novel CEMs and AEMs prepared by an ion-track grafting technique would led to significantly-efficient saline water electrodialysis.