No. 2314

Development of Porous Thin-Film Substrates with Robust Structure and High Air Permeability for High-Performance Ion-Exchange Membranes

Hidetoshi Matsumoto

Tokyo Institute of Technology

Summary

Ion exchange membranes (IEMs) are widely used in various fields, such as salt production, chlor-alkali production, water treatment, chemical/pharmaceutical/food-processing, and battery/fuel-cell technologies. One promising approach to improve the performance of IEMs is to reduce the electrical resistance by making IMEs thinner. In the commonly-used IEMs for salt production, thick polymer woven fabrics have been used as a reinforcement. Recently, IEMs based on porous polymer thin films as a reinforcement have attracted much attention, particularly for battery applications. Our previous work reported that highly porous silica nanofiber (SiO_2-NF) sheets was a promising substrate of IEMs for increasing the ion-exchange-component ratio in the membranes, subsequently reducing the electrical conductivity. However, inorganic materials such as SiO_2 are inherently brittle, leading to poor mechanical properties of the NF sheets.

In this work, a representative super engineering plastic, polybenzimidazole (PBI), was used as the NF material. PBI-NFs with diameters ranging from 200 to 800 nm were prepared by electrospinning. Thereafter, the as-spun PBI NF sheets were hot-pressed to improve to increase the NF connectivity and then used them as a stable NF reinforcement. Anion-exchange membranes (AEMs), composed of poly(4-vinylpyridine-co-divinylbenzene) (poly(4VP-co-DVB)) containing quaternary pyridinium groups, were prepared by radical copolymerization and successive quaternization. The hot-pressed PBI-NF sheets were used as a porous substrate, and immersed in the monomer solution composed of 4VP, DVB, and initiator for radical copolymerization. Their structures and physicochemical properties were characterized by scanning electron microscopy, Fourier transform infrared spectroscopy, potentiometric titration, electrochemical impedance measurements, dynamic state transport number measurements, and tensile tests. AEMs containing hot-pressed PBI-NFs showed low electrical resistance and good transport number. The prepared membranes showed approximately five times higher tensile strength compared to the ones containing SiO_2-NFs, indicating that the hot-pressed PBI-NFs are a promising reinforcement.