

Development of thin anion-exchange membranes for reverse electro dialysis

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Salinity gradient energy or Blue Energy is a promising renewable energy source for the future. Gibb's free energy of mixing in a process where rivers with a low salinity flow into the saline sea. This energy potential is fairly huge. When a river runs into a sea, spontaneous mixing of fresh and salt water occurs. This natural process is irreversible (no work is attained from it). However, if the mixing is done reversibly, work can be obtained from the mixing process [1].

Reverse electro dialysis (RED) uses energy derived from the difference between the chemical potentials of concentrated and diluted salt solutions [2]. A concentrated salt solution (e.g. sea water) and a diluted salt solution (e.g. river water) are brought into contact through an alternating series of anion exchange membranes (AEM) and cation exchange membranes (CEM) [3]. According to Donnan effect, the difference of chemical energy of two solutions separated by ion exchange membranes generates potential. The ionic current is converted to electronic current by redox reactions at the cathode and the anode. The following effects reduce the cell potential and power in RED. i) activation overpotential, ii) concentration overpotential, iii) resistance towards electron transport in the electronic conductors and resistance towards ion transport in the electrolyte [3]. In addition, this overpotentials increased by materials used in RED such as ion-exchange membranes, electrodes, etc. Ion exchange membranes and electrodes play an important role in determining the resistance of RED stacks and the voltage drops at low current density due to activation overpotential, respectively.

Recently, pore-filling membranes are intensively being studied for several applications such as fuel cells since they are able to have extremely low resistance due to thin thickness (20~50 μm) and good mechanical stability due to porous substrate. Monomers with the large amount of vinyl sulfonic acid or polymers with high ion exchange capacity are filled in polyolefin porous substrates (i.e., lithium battery separators) with a crosslinker, and then pore-filling membranes are crosslinked by heat or UV. The porous substrate is completely inert to chemicals and mechanically prevents the excess swelling of the filling polymers. In addition, the substrate matrix restricts the change in membrane area from the dry to the swollen state.

In this study we focus on the energy dissipation represented by the various ion exchange membranes, resulting in an increase in overpotential. The anion pore-filling membranes were prepared using a polyethylene porous substrate. Monomers were filled in the substrate and crosslinked under heating. Afterward, quaternization was carried out to attach ion-exchangeable functional groups to polymer backbones. We successfully prepared two different types of ion exchange membranes with no defects. A lab-made RED stack with different cell pairs (up to 4 cell pairs) was used to the iron (II)/iron (III) redox couple for the electrochemical conversion. Commercially available AMX from ASTOM, Japan and thin anionic conducting pore filling membranes prepared in this study as anion-exchange membrane and platinum-

coated titanium and iridium-coated titanium as metal electrode were investigated and compared by current-voltage polarization curves. Voltage in the RED stack was measured in two and four electrode systems. As a result, open circuit potentials of reverse electro dialysis were highly dependent upon permselectivity of the membranes. The ionic resistance of the thin anion-exchange membranes was much lower than that of commercially available AMX, and current-voltage relationship for the thin anion-exchange membranes was shown to be better than that for the AMX membrane.

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