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Development of Highly Efficient Salinity Gradient Energy Conversion System using Novel Profiled Ion Exchange Membranes

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Summary

In recent years, stacks consist of a cation exchange membrane (CEM), a high salinity feed path, an anion exchange membrane (AEM), and low salinity feed path are used for salt concentration and desalination in electrodialysis (ED). Reverse electrodialysis (RED) also used stack with the same structure and converts the salinity gradient energy (SGE) between brines of two salt concentrations into electric power. One of the barriers to obtain the high efficiency of the SGE conversion process is the high electrical resistance of the low salinity feed path caused by a spacer net that is made from non-ionic conductive material and keep distance between the CEM and AEM constant. This study aims to fabricate profile (PF) membranes that reduce the electrical resistance of both the membrane and the feed path, and also reduce the fouling properties by giving novel shapes in the CEM and AEM. PF membranes were fabricated from commercial flat sheet membranes (C-2 and A-2, ASTOM Corp. Tokyo, Japan) and self-made flat sheet membranes as base films. RED stacks were constructed with the flat sheet and PF membranes.

The characteristics of the stacks were evaluated to develop a high-efficiency SGE conversion system. PF membranes were fabricated from the flat sheet membranes by a hot-pressing method. RED stacks with 40 pairs and 400 [μm] membrane distance were constructed using the flat sheet and PF membranes, respectively. A model seawater (50 mS/cm NaCl solution) and model river water (0.3, 2.0, 4.0, 5.0 mS/cm NaCl solution) as high and low salinity solutions, respectively, were used in the RED power generation test. The current-voltage (*I-V*) and current-power (*I-P*) curves were obtained for each concentration condition by connecting an electronic load device to the two electrodes of the RED stack and controlling the resistance between the electrodes. From the *I-P* curve, the maximum power density (PD_{gross}), which represents the maximum RED power output per unit membrane area, was calculated. PD_{gross} of both the two stacks increased with increasing conductivity of the low feed solution and reached a maximum value. In the case of the RED power generation test with PF membrane, the maximum PD_{gross} was obtained as 1.47 W/m^2 at an electrical conductivity of 2.0 mS/cm for the low feed solution. On the other hand, the value for the flat sheet membrane was 0.92 W/m^2, indicating that the stack with PF membrane showed 1.59 times higher value than that with flat sheet membrane. Jiyeon Choi et al. reported a PD_{gross} of 1.39 W/m^2 of RED power generation test using PF membranes they made. This means that the PF membrane stack used in this study shows the highest power density in the world.