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Development of Highly Efficient Salinity Gradient Energy Conversion System Using Novel Profiled Ion Exchange Membranes (III)

Mitsuru Higa[1, 2], Eiichi Toorisaka[1, 2], Yuriko Kakihana[1, 2], Minato Higa[1, 2]

[1] Graduate School of Sciences and Technology for Innovation, Yamaguchi University

[2] Blue Energy center for SGE Technology (BEST), Yamaguchi University

Summary

There are few examples of using large RED stacks in research using profiled (PF) membranes, which have a concave-convex structure on the surface of ion exchange membranes. The linear PF membrane reported last year has a concave-convex structure maintained at the edges on both sides of the PF convexity, making it difficult to maintain the concave-convex structure in a large stack. Therefore, in this study, we developed a dotted PF membrane, which is different from the linear PF shape. It is predicted that the concave-convex structure of the dotted PF membrane will be maintained even if the membrane area is increased. In this study, we fabricated a PF membrane with this new concave-convex structure and constructed a cell so that the convex shapes of this PF membrane face each other in the low salt concentration side (LS) flow path, which has a largest resistance in the cell component. We evaluated the power generation characteristics of the RED in stacks using this PF membrane and flat membrane, and compared their performance.

The power generation characteristics were evaluated by supplying model seawater, model river water, and model sewage treated water made with NaCl solution to a RED stack composed of flat membranes and PF membranes. An electronic load device was connected to the electrodes of the RED stack, and the current and voltage were measured by changing the load resistance, and the power generation characteristics of the PF membrane stack and the flat membrane stack were compared from the obtained results.

The open circuit voltages of the two membrane stacks were almost the same under all of the above concentration conditions. This indicates that forming the concave-convex structure of the PF membrane using a flat membrane does not affect the selective permeability of the membrane. In the RED power generation test when model seawater (50 mS/cm NaCl) and model river water (0.3 mS/cm NaCl) were supplied, the internal resistance of the PF membrane stack was less than one-quarter of that of the flat membrane, and the power density was 300% higher than that of the flat membrane. In addition, the pressure drop of the stack using the PF membrane was 13% lower than that of the flat membrane. This will be due to the concave-convex structure of the PF membrane eliminates the need for a spacer net, thereby reducing the electrical resistance and solution feed resistance of the LS side flow path. These results demonstrated the effectiveness of the PF membrane in improving the stack power generation output and reducing the solution feed energy. Next, we evaluated the power generation of a stack consisting of the PF membranes and the flat membranes when using NaCl (0.3 to 3.0 mS/cm), which is equivalent to sewage treated water. As a result, the PF membrane stack had a power density of 1.47 [W/m^2] at the LS side conductivity of 1.0 mS/cm, while the flat membrane had a power density of 0.61 [W/m^2]. The PF membrane showed a power density 2.4 times higher than that of the flat membrane, demonstrating the superiority of the PF membrane even when the LS side solution was equivalent to sewage treated water.