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# Development of Hydrophilic Semi-Permeable Membranes Used for Pressure Retarded Osmosis Power Generation by a Radiation Grafting Method

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Summary

Pressure retarded osmosis (PRO) is an ideal zero-emission technique to generate energy from a salinity gradient of two solutions separated by a semipermeable membrane. To obtain high output power, the semipermeable membranes are required to easily permeate water and restrict salt permeation. Thus, the objective of this study is to develop the novel semipermeable membranes with high water permeability and low salt permeability by a radiation-induced grafting method. In this first year, I investigated the water and salt transport properties of the membranes with various hydrophilic graft chains for designing the suitable semipermeable membranes.

A 25-μm-thick poly(vinylidene fluoride) (PVDF) film was irradiated with 10-30 kGy g-rays. The irradiated PVDF films were immersed in grafting solutions of various monomers such as acrylic acid (AA), 2-hydroxyethyl methacrylate (HEMA), 2-hydroxyethyl acrylate (HEA), vinylpyrrolidone (VP), and styrene. The styrene grafted films were sulfonated to convert styrene units to styrene sulfonic acid sodium salt (SSS) units. The water uptake, water permeability, and salt permeability of the prepared hydrophilic grafted membranes were measured.

As the water uptake of the membranes became larger, both the water permeability and salt permeability increased. The water permeability of the hydrophilic grafted membranes reached more than 6,000 $mol/m^2$ h, which was five-times higher than that of FTS-H2O, the commercial benchmark semipermeable membrane. This result made us to expect higher PRO output power. However, no hydrophilic grafted membranes can simultaneously fulfill higher water permeability and lower salt permeability than those of FTS-H2O. Regarding the effect of graft chains, the pSSS grafted membranes showed the lowest salt permeability. This would be because the negatively-charged sulfonic acid groups restrict the invasion of $Cl^-$ due to electrostatic repulsion.

A PRO test cell was designed and fabricated, and the test with FTS-H2O membrane was performed. The water permeability linearly increased with the driving pressure, the difference between the osmosis pressure and applied pressure. In a future work, the radiation-grafted semipermeable membranes will be prepared and used for PRO tests.