学 位 論 文 概 要

題 目　High-performance organosilica membranes for separation of organic solvent mixtures in reverse osmosis and pervaporation
(逆浸透および浸透気化による有機溶媒分離のための高性能オルガノシリカ膜)

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Currently, organic liquid separations rely heavily on energy-intensive routes such as distillation, crystallization and, adsorption. As an emerging technology, membrane-based separation of organic liquids without the involvement of phase-change is expected to be the game-changer in chemical and petrochemical industries. Herein, this work developed a procedure that saves significant amounts of energy during the membrane-based separation of organic liquids via organic solvent reverse osmosis (OSRO). The proof-of-concept was confirmed using a theoretical calculation to demonstrate energy-consumption at less than 1/100th and 1/10th that of conventional distillation and pervaporation (PV), respectively. Besides, exceptionally stable and mechanically robust organosilica-derived membranes, including Bis(triethoxysiyl)acetylene (BTESA), fluorine-doped bis(triethoxysiyl) methane (F-BTESM), and Cetyltrimethylammonium chloride-etched bis(trimethoxysiyl)hexane (CTAC-BTMSH), were prepared and utilized for the separation of diverse organic azeotropes such as methanol/toluene, methanol/dimethyl carbonate (DMC). Importantly, a generalized solution-diffusion model was successful in predicting the permeation behaviors through organosilica membranes when used in an OSRO modality, and proved to be capable of accurate predictions on pressure-dependent experimental permeation flux and rejection for a wide range of feed concentrations (0-55 wt%) and pressures (2-14 MPa). On the other hand, the pervaporation performance of the BTESA membrane for organic liquids was also performed and compared with the OSRO separation processes. Also, it was found that the generalized solution-diffusion model enabled the description of the pervaporation performance of the BTESA membrane for organic liquids. This study lends important insight into the development of organosilica membranes for energy-efficient separation of organic liquids.