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Development of Valence-Selective Separation Process Using Charged Mosaic Membrane

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Summary

Piezodialysis process using a reverse osmosis (RO) membranes has been widely used as a seawater desalination. On the other hand, there is a charged mosaic (CM) membrane that has potential application to desalination. A CM membrane has a structure in which a negatively-charged layers (N layer) and positively-charged layers (P layer) are arranged in parallel with respect to the membrane thickness direction, and each layer penetrates both the surfaces of the membrane. As other transport properties of CM membranes, they are able to easily control the valence selectivity of ions by arbitrarily changing the ratio of N layers to P layers.

Many methods for preparing CM membranes have been proposed such as polymer blending method, laminating method, microsphere gel method, and microphase separation method. However, these CM membranes have low bonding strength between the P layers and N layers, and when pressure is applied to the membrane, water leaks from the bonding portion. Hence, there have been no reports of CM membranes that can use for piezodialysis processes. Therefore, in this study, a CM membrane having sufficient mechanical strength to withstand the use of piezodialysis was prepared by heavy ion bean track graft polymerization, and desalination of low salinity solutions by piezodialysis using the membrane was investigated. In addition to this, three types of CM membranes with different ion exchange capacity ratio of N and P layers, λ: CM-1 (λ = 0.69), CM-2 (λ = 1.3), CM-3 (λ = 1.9) were prepared to examine the relationship between the membrane charged structure and the electrolyte permselectivity. Permeation experiments of a diffusion dialysis with the CM membranes were performed using various solutions of electrolytes that consists of monovalent cations and monovalent anions (1-1 type electrolyte), divalent cations and monovalent anions (2-1 type electrolyte), and monovalent cations and divalent anions (1-2 type electrolyte).

The CM membranes prepared by heavy ion beam track graft polymerization had high mechanical strength. In a piezodialysis system consisting of the CM membrane and 500 [ppm] NaCl solutions as the initial concentration, the salt concentration at the high pressure side decreased and that on the low pressure side increased by applied pressure of 0.4 [Mpa]. This indicates that the CM membrane can desalinate the salt solutions by a different mechanism as a RO membrane.

In a diffusion dialysis system using various electrolytes (NaCl, KCl, $CaCl_2$, Na2SO4), CM-1 has ca. twice higher 1-2 type electrolyte flux compared to CM-3, on the other hand, CM-3 had higher 2-1 electrolyte selectivity than CM-1, indicating that CM membranes can control the valence selectivity of ions with changing their charged structure.

From these results, the CM membrane prepared by the heavy ion track graft method can be applied to desalination processes in piezodialysis and highly selective separation of electrolytes; hence, it can be applied to desalination of low salinity solutions and purification of pharmaceutical raw materials.