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Adsorption of polyelectrolyte multilayers imparts high monovalent/divalent cation selectivity to aliphatic polyamide cation-exchange membranes

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Abstract

Nafion membranes coated with polyelectrolyte multilayers (PEMs) exhibit outstanding monovalent/divalent cation electrodialysis selectivity in a single-membrane cell. Nevertheless, the high cost of Nafion and the extensive pretreatments required for polyelectrolyte adsorption on this surface may preclude the use of these membranes in many applications. This work reports that native aliphatic polyamide Fujifilm type 1 cation-exchange membranes modified with protonated poly(allylamine) (PAH)/poly (4-styrenesulfonate) (PSS) films also show extremely high K^+/Mg^{2+} cation selectivities in ED with a single-membrane cell. Even with 0.1 M salt in the source phase, the K^+/Mg^{2+} selectivity is >1000. The very low transfer of divalent cations implies that the PEM forms a complete, continuous coating on the smooth Fujifilm surface. Moreover, for a membrane coated on both sides, the PEM on the anode side is responsible for most of the selectivity. However, the current efficiency is only ~0.6 for PAH/PSS-modified Fujifilm or Nafion membranes. Adsorption of highly water-swollen $(PDADMAC/PSS)_n$ films on Nafion membranes leads to high K^+/Mg^{2+} and Li^+/Co^{2+} selectivities in ED, and the monovalent cation current efficiency reaches 0.8.

Graphical abstract