Title:

A Nanostructured Lamellar Membranes for Mono-/multivalent Ion-Selective Separation

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Abstract:

Lithium extraction from aqueous streams, particularly saltwater brine, has made an impact in the lithium recovery business due to its economic feasibility. Conventional methods for extracting metals, such as lithium, from seawater or brine include recrystallization, chemical precipitation, and solvent extraction. However, those processes involve high energy consumption and have a low recovery efficiency. More seriously, the high-volume use of organic solvents as extractants causes an environmental challenge. From this viewpoint, the development of sustainable lithium recovery methods from water resources has been highly sought-after. Particularly, membrane-based separation technology has been considered as ecologically benign option for lithium recovery due to its great energy efficiency and simple continuous operation. Herein, we studied lithium-selective sieve channels made of stacked 2D graphene oxide and transition metal carbides and nitrides (MXene), coordinated with surface – SO^{3-} group. The interplanar spacing in the height range of 0.3 to 0.8 nm, created from the stacked 2D sheets, offers higher energy barriers for multivalent ions to enter into the confined channels. More importantly, the intercalation of the sulfonate group offers an active hopping site for fast Li^+ permeation to constructed nano capillaries. The binding energy of Li^+ – SO^{3-} is calculated to be – 0.77 eV, the smallest interaction among monovalent species. Those functionalized membranes exhibit ultrafast transport of Li^+ with high selectivity against other monovalent and divalent species due to the combined effect of size exclusion (steric hindrance) and different binding affinities. The resulting 2D graphene oxide channels in the fabricated membranes led to ultrahigh inter-cation selectivity, Li^+/Mg^{2+} of 10^4 beyond the commercial membranes as well as $MgCl_2$ rejection above 94 % were achieved.