Abnormal ionic selective properties of chemically modified graphene oxide membranes and its application for energy devices

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Over the past decade, carbon-based materials such as carbon nanotube, graphene and graphene oxide (GO) has received great attention in the fields of water purification and energy application. Especially, GO have been considered as a prospective material for ion exchange membranes due to their unique ion transport properties. The numerous numbers of angstrom-scaled channels with negative charges can be easily formed by stacking the GO sheets, so the GO membranes can be utilized as effective ion-permeable membranes where ions are sieved out by steric exclusion and the electrostatic repulsion. Moreover, GO membranes is composed of a hydrophobic backbone and hydrophilic oxygen functional groups, which has a similar structure to polymer membrane such as Nafion, and exhibits excellent cation transport performance (H^+, Na^+, K^+). For these reason, previous studies have been demonstrated the ion selective properties of GO membranes for energy application such as proton exchange membranes and reverse electrodialysis, however, more dedicated approaches are needed to modify GO membranes for efficient membranes.

Herein, first we present abnormal proton-selective transport through thermally reduced GO membranes (rGO) encapsulated in an epoxy resin. After reduction, the interlayer spacings was decreased to 4.4 Å (the effective spacing is almost 1 Å) and the electrical conductivity was recovered. Through the rGO membranes, the proton can permeate 58.8 times faster than K^+, superior to the performance of Nafion membranes [1]. Next, the epoxy-encapsulated rGO membrane was applied in the reverse electrodialysis system that converts the concentration difference between sea water and fresh water into electrical energy. In addition to negatively charged GO membranes, positively charged GO membranes functionalized by quaternary ammonium was fabricated. The series connected oppositely charged GO membranes exhibited the outperformed power density exceeding commercial standards. These strategies for chemical modification of GO membranes can offer the chance to efficiently engineer the energy applications and further ionic devices.

Reference

[1] S. E. Lee, K. Y. Chun, J. Kim, S. Jo, *C.-S.Han, "Abnormally selective proton transport through angstrom channels of highly reduced graphene oxide", Journal of membrane science, 659, 5 Oct 2022, 120801.