Two-dimensional smart material with programmable ionic channels for water purification

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Many materials with varied characteristics have been investigated for water purification and separation applications. Traditional membrane technology is a separation process that allows species to pass through the membrane depending on the pore size. This study offers a new design principle: controlling cations' transport with graphene oxide-polyethyleneimine (GO-PEI) membrane. The regulation mechanism relies on specific interactions between internal components of membrane and ions[1,2].

The fundamental mechanism that opens the ionic channels for the transport of hydrated ions is replacing a fraction of protons in the interlayer PEI with K^+ ions. The K^+/H^+ exchange can be treated as a stochastic process of competition between protons and potassium ions for the available sites on GO–PEI. In the regular state GO–PEI membranes are closed for the transport of hydrated ions due to strong repulsion between the cations and the positively charged PEI. However, the chains of carbonyl groups at the GO and PEI interface act as selective ionic channels, allowing dehydrated K^+ to permeate through.

It should be possible to design membranes with regulated selective K^+ /Na^+ pumping for the extraction of Li^+ or separation of Cs^+. Such membranes will allow building relatively simple artificial structures that reproduce such properties of living matter as switchable ionic permeability and selectivity and will lead to further advances for water purification[3].

References

1. Novoselov K.S. et al. // Science (80-.). 2016. V. 353. № 6298. P.aac943911 - aac9439-11
2. Fares H.M., Schlenoff J.B. // J. Am. Chem. Soc. 2017. V. 139. № 41. P. 14656–14667.
3. Andreeva D. V. et al. // Nat. Nanotechnol. Springer US. 2020. V. 16, № FebruarY. P. 174-180.