Design of novel hybrid graphene oxide membranes for water treatment

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Membrane filtration is an attractive technique to secure clean water in an energy efficient manner. In recent years, graphene-derivatives membranes are emerging as attractive candidates for efficient water treatment, attributed to their unique nanochannel networks and robust chemical and mechanical stability [1]. In particular, graphene oxide (GO) is regarded as a versatile platform for separating ions or contaminants, with the possibility of regulating the nanochannels through approaches such as cross-linking, pressure compression and molecular intercalation [2,3], establishing an energy barrier originated from steric hindrance and electrostatic repulsion during permeation. Optimal interlayer spacing combined with appropriate charges could make possible attaining outstanding performance in terms of both parameters.

As part of the collaborative project between KAIST and KU, we have developed novel hybrid GO membranes for water desalination [3,4], following two different strategies: (1) Complexion of crown ethers and cation-intercalated GO composite membranes to tune the GO nanochannel for an effective desalination, and (2) Forming amide-bonded polymer-crosslinked structures with controllable compressed and charged nanochannels. A combined experimental – molecular modeling approach was followed in both cases. Following the first strategy, stable structures were found in which salt rejection rate could be increased up to 60% compared to the neat GO membrane, simultaneously achieving the adequate water permeance. In the second strategy, a simple pressurization process was used to adjust the interlayer distance of the polymer-intercalated GO structure, which varied the relative interaction distance of inserted molecules in nanochannels and the H-bond network inside them. The compressed channels cause a change in the polymer morphology during the insertion, forming different numbers of amide bonds; thus, obtaining narrower interlayer distances and simultaneously obtaining zwitterionic properties in the nanocapillaries. In this case, the salt diffusion rate was slower down up to 5 times compared to the neat GO membrane due to the modified channel, while maintaining a similar water flux.

Overall, it is inferred from these studies that interlayer spacing and appropriate membrane electrostatic properties can be controlled based on molecules intercalation, while making possible attaining outstanding performance of hybrid GO membranes in terms of water permeability and ions rejection. This methodology can also be implemented for the removal of recalcitrant contaminants, including dyes and pharmaceuticals.

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FIGURES

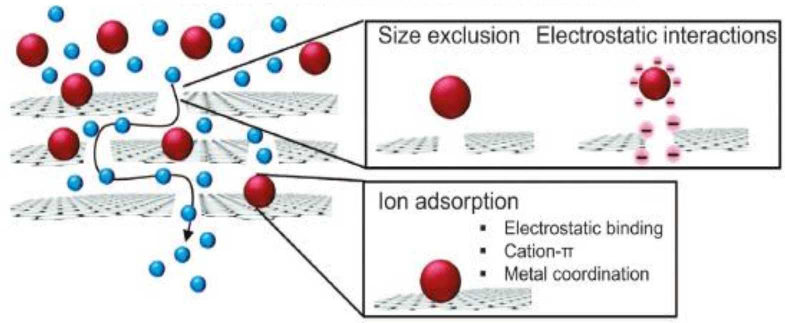

Figure 1: Schematic of the strategies followed for designing effective hybrid GO membranes for water desalination