Molecular Transport at 2D Interfaces: Solvent-Responsive Behaviour and Mechanisms

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Outside their traditional biological context, membranes are of great research interest due to their diverse and dynamic properties under varying environmental conditions. Their ability to exhibit responsive behaviour when exposed to external stimuli makes them highly attractive for targeted and adaptive applications. In materials science, significant efforts have been devoted to replicating such behaviour in inorganic membranes by identifying the right structural and chemical combinations to induce responsiveness or even adaptive functionality. Previous studies have explored external triggers such as electric fields, pH, temperature, and ionic strength in both polymeric and 2D-material-based membranes, demonstrating their potential for advancing fundamental understanding of molecular behaviour at the nanoscale as well as for practical applications. More recently, solvent-responsive membranes have attracted increasing attention due to their relevance in separation technologies. In this work, we demonstrate that graphene and other 2D-material-based membranes can be specifically functionalised to achieve solvent-responsive behaviour. Their separation performance, including rejection and flux, can be tuned in a controlled manner depending on the properties of the surrounding solvent. Both experimental studies and molecular simulations confirm the responsive structural behaviour of these membranes. We show that parameters such as solvation dynamics, phase behaviour, and interfacial interactions can significantly influence liquid transport within angstrom-scale channels. In this talk, I will present the key membrane properties, discuss the proposed mechanisms underlying the observed solvent-responsive phenomena, and highlight potential applications in liquid transport and advanced separation technologies.

References

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