Å-scale chemistry & engineering of two-dimensional materials for energy-efficient molecular separation

High-performance molecular-selective membranes are expected to play a crucial role in improving the energy-efficiency of separation processes and reducing the industrial carbon emission. Our laboratory is engaged in chemistry and engineering of two-dimensional materials at the angstrom length scale to address challenges in the scalable fabrication of nanoporous membranes separating molecules based on their relative diffusivities through custom-designed nanopores.

In this talk, I will present our work on the synthesis of nanoporous two-dimensional materials focusing on graphene and zeolite precursors using a number of top-down and bottom-up synthetic strategies. In case of graphene, I will discuss defect nucleation and expansion strategies that allow incorporation of vacancy defects (nanopores) at a high density but with a narrow pore-size-distribution with a resolution of 0.3 Å for molecular differentiation, leading to realization of record-high performance in post-combustion carbon capture [1-9]. I will discuss mechanical reinforcement strategies that allows one to scale-up nanoporous single-layer graphene membranes for gas separation [1,7] which has led to a pilot plant demonstration project on carbon capture. Finally, I will discuss synthesis and tuning of gas transport pathways from nanoporous two-dimensional nanosheets and their films that allow facile fabrication of membranes for pre-combustion carbon capture [11,12].

References

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