Creating membranes with ordered subnanometer channels for molecular separation

Gongping Liu

College of Chemical Engineering, Nanjing Tech University
State Key Laboratory of Materials-Oriented Chemical Engineering
E-mail: gpliu@njtech.edu.cn

Molecular separations are widely used in water desalination and chemical industries, but are energy intensive. Compared with conventional separation processes, membrane technology used for molecular separation can reduce energy consumption by an order of magnitude. Polymeric membranes generally do not possess regular and continuous subnanometer channels, leading to an inherent trade-off between permeability and selectivity. In the past decade, novel membrane materials, represented by metal-organic frameworks (MOFs) and two-dimensional materials, can address this challenge by providing excellent permeability and selectivity through their assembled subnanometer channels.

This presentation will present our recent progresses on MOF and 2D materials-based membranes for gas and liquid molecular separation. We eliminated lattice defects in MOF membranes based on a high-probability theoretical coordination strategy providing sufficient chemical potential to overcome the steric hindrance that occurs when completely connecting ligands to metal clusters. We proposed a solid-solvent processing strategy to fabricate an ultrathin MOF mixed-matrix membrane (thickness less than 100 nm) with filler loading up to 80 vol.%. These MOF-based membranes showed high and stable separation performance for gases, water desalination and an organic solvent azeotrope. For 2D materials-based membranes, we focused on tuning the hydrophilicity/hydrophobicity of the transport channels for water desalination. In the hydrophilic graphene-based membranes, sub-nanometer sized channels with controlled surface charge properties could realize selective transport water molecules over ions based on size sieving and electrostatic effect. In the hydrophobic graphene-based membranes, water molecules can evaporate through the membrane channels while the ions are fully rejected because liquid water could not enter into the hydrophobic channels.