

Advanced dual-wetting membrane for enhanced CO₂ capture: Asymmetric hydrophobic and CO₂-philic thin film in membrane gas absorption

Abstract

CO₂ is a major contributor to climate change, making efficient carbon capture essential for emission reduction. Membrane gas absorption (MGA) offers a cost-effective solution, with research often focusing on enhancing membrane hydrophobicity to reduce wettability. However, the potential of CO₂-philic membranes for mixed gas separation remains underexplored. This study addresses the gap by developing asymmetric wetting membranes (PVDF/EDA/GO) with a superhydrophobic side to prevent wetting and a CO₂-philic side to enhance CO₂ capture. The CO₂-philic surface was created by coating PVDF with ethylenediamine (EDA) and graphene oxide (GO). Computational analysis confirmed strong binding energy (-21.07 kcal/mol) between EDA and GO, forming a stable amine complex. The membranes displayed asymmetric wetting, with the CO₂-philic side showing a water static angle (WSA) of $49.6 \pm 2.6^\circ$, and the superhydrophobic side achieved a WSA of $149.7 \pm 3.3^\circ$ and a water gliding angle (WGA) of $9.8 \pm 1.1^\circ$. In MGA, these membranes demonstrated improved performance, with a CO₂ absorption flux of 0.0040 mol/m²s and CO₂/N₂ selectivity of 6. This work highlights the promise of dual-wetting membranes for enhancing CO₂ capture in MGA systems.

Keywords

Asymmetric wetting; CO₂ capture; Graphene oxide; Membrane Gas Absorption; Superhydrophobic