Multifunctional ZIF-67 Membrane for Environmental Remediation: Organic Pollutant Removal and CO_2 Capture

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Abstract:

Industrialization has significantly increased emissions of volatile organic compounds (VOCs), such as toluene, and carbon dioxide (CO_2), both of which pose environmental and health risks. While toluene exposure can cause respiratory and neural damage, rising CO_2 levels drive climate change, necessitating effective capture and conversion strategies. Metal-organic frameworks (MOFs), particularly ZIF-67, have emerged as promising materials for VOC degradation and CO_2 capture due to their high porosity and adsorption capacity. To enhance structural integrity and efficiency, ZIF-67 membranes were fabricated using an alumina (Al_2O_3) substrate, improving stability and gas-phase interactions for fixed-bed reactor applications. However, MOFs lose efficiency in humid conditions due to competitive water adsorption. To mitigate this, polydimethylsiloxane (PDMS) and 1H,1H,2H,2H-perfluorodecyltriethoxysilane (PFS) coatings were applied, enhancing hydrophobicity and maintaining high adsorption performance. A systematic analysis of ZIF-67, ZIF-67 PDMS, and ZIF-67 PFS membranes demonstrated that hydrophobic modifications significantly improve VOC removal and CO_2 capture. These dual-functional materials offer a sustainable approach to air purification, reducing atmospheric pollution while supporting eco-friendly industrial advancements. This study highlights an innovative pathway toward environmental sustainability and cleaner air.

Keywords:

Air pollution, ZIF-67 membrane, environmental remediation, toluene, CO_2 capture.