ABSTRACT:

Advances and Challenges in High-Temperature CO_2 Separation Using Membrane Technologies

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The efficient separation of CO_2 from high-temperature flue gases remains a critical challenge in advancing sustainable energy and industrial processes. This review examines the fundamental mass transfer mechanisms governing CO_2 transport in inorganic membranes, with a particular emphasis on diffusion, sorption, and permeation phenomena under elevated thermal and reactive conditions. The analysis highlights how diffusivity, competitive adsorption, and coupled heat–mass transfer interactions shape separation performance in inorganic and hybrid membranes. Special attention is given to membrane reactor configurations, where selective CO_2 transport is integrated with catalytic conversion, enabling process intensification in applications such as dry reforming and carbon dioxide hydrogenation. A comparative evaluation of driving forces, including partial pressure gradients, chemical potential differences, and facilitated transport pathways, provides insight into optimising design and operation. By synthesizing recent advances and identifying persistent bottlenecks, this review outlines pathways for enhancing CO_2 capture and utilisation through high-temperature membrane technologies. Also, our mass transfer model using CFD modelling for CO_2 capture in a hollow fibre membrane will be presented.