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Intensified catalytic reactors based on solid-state ion-conducting membranes

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Abstract

The gas exchange, diffusive, and catalytic pathways on the surface of intensified membrane reactors usually determine the evolution rate, the selectivity towards target reaction products, and the system's stability. Solid-state ionic materials are essential components of modern energy technologies like fuel cell batteries and electrolyzers. In recent years, their use has grown beyond these applications and gained significance in the process industry. Solid-state ionic materials play a vital role in reducing CO_2 emissions and electrifying industrial processes, leading to sustainable development.

Solid-state ionic materials are used in electrochemical solid-electrolyte systems to shift chemical equilibria within the catalytic reactor in a favorable direction. These systems also facilitate the in-situ separation of valuable products. Novel reactor concepts involve using microwaves and ceramic ion-conducting cells to electrochemically drive catalytic reactors. This requires selective electrocatalysts with adjusted diffusive and catalytic properties to produce specific gas products and thin electrolyte membranes. Protonic membrane reactors employing ceramic proton conductors like doped $BaZrO_3$ are one such innovation. These materials show high chemical stability in carbon-rich environments and excellent proton conductivity, making them an ideal choice for integrating catalytic reactions and separation simultaneously[1–3]. This results in the production of pressurized H_2. These innovations improve per-pass yield, energy efficiency, and catalyst stability, advancing process intensification and sustainability[4,5]. Thus, solid-state ionic materials are a crucial ingredient in modern energy technologies, and their use in the process industry is rapidly growing to achieve sustainable development goals.

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