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Effective Dimethyl Ether Production from Methanol Dehydration in Polymeric Catalytic Membrane Reactors.

Bao K. Doan, George Q. Chen, Colin A. Scholes

Department of Chemical Engineering, The University of Melbourne, Melbourne, VIC 3010, Australia

doanb@student.unimelb.edu.au

ABSTRACT

Dimethyl ether (DME) is a valuable chemical that finds its application in various fields, such as a clean fuel, refrigerants, and green solvents [1]. DME has attracted considerable attention as an eco-friendly substitute for conventional liquified petroleum gas (LPG), owing to its high cetane number, low ignition temperature, and minimal pollutant emissions [1]. Furthermore, DME can be prepared indirectly or directly from CO₂, making it an ideal product for the carbon capture and utilization technology.

The DME production via the dehydration of methanol in the gas phase is the conventional approach, with the reaction normally conducted using an acid catalyst (Al₂O₃ or HZSM-5). However, these catalysts suffer from several drawbacks, including the catalyst deactivation caused by water and coke formation at high temperature (> 250 °C). Furthermore, the thermodynamic equilibrium nature of methanol dehydration limits DME yield, and recycling of reagents is significant to maximise DME production. Therefore, developing a new strategy to maximize reaction performance at low temperatures remains a major challenge.

Catalytic membrane reactors (CMRs) have emerged as a promising solution by undertaking both reaction and separation stages within one technology, enabling the in-situ removal of products, thereby improving the reaction efficiency in accordance with Le Chatelier's principle [2]. This leads to process intensification, significantly reduced equipment expenses and energy demand, and enhanced overall process efficiency compared with a conventional fixed-bed reactor (FBR) [3]. Herein, this investigation developed and investigated the improvement in reaction performance and separation capability of CMRs for DME production, utilising high temperature resilient polymeric membranes (Matrimid, CTA, and PEBAX1657), with their surfaces functionalised with HZSM-5. Under identical conditions at 200°C, polymeric-based CMRs enhance methanol conversion by 25% and increase DME productivity by 10 mmol/(g.h) relative to a FBR. Moreover, continuous removal of by-product water within the CMR raises the DME concentration in the product stream by up to ninefold higher than FBR.

Reference

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KEY WORDS

catalytic membrane reactor; ZSM-5; polyimide; dimethyl ether; methanol dehydration

BIOGRAPHY

Bao Doan is a PhD candidate in Chemical Engineering at the University of Melbourne. His research focuses on the development of polymeric membranes for gas and vapour separation, as well as their integration into membrane reactor systems. His work aims to reduce CO₂ emissions by enabling the conversion of CO₂ into low-emission future fuels, with particular emphasis on catalytic membrane reactors for CO₂ conversion to dimethyl ether (DME).

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