ABSTRACT:

CO_2 Hydrogenation to e-MeOH and e-DME: Advances and Challenges

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The catalytic hydrogenation of CO2 to methanol (MeOH) and dimethyl ether (DME) is attracting growing industrial interest within the e-fuels landscape, as these molecules can also serve as liquid organic hydrogen carriers (LOHCs) for efficient hydrogen storage and transport in existing infrastructure [1].
Industrial methanol synthesis is traditionally performed over Cu–Zn–Al2O3 catalysts at high pressure and temperature, though still limited by equilibrium and stability issues. Emerging Cu–Zn–ZrO2 systems offer improved metal–support interactions, thermal resistance and hydrophobicity, resulting in greater catalyst durability in presence of water. Moreover, the hybridization of an optimized methanol synthesis formulation with a dehydration functionality can deliver a novel technological path based on the direct one-pot DME synthesis, which offers a promising route for process intensification, overall enhancing the activity-selectivity pattern and catalyst lifetime [2].
However, significant technological challenges still limit large-scale implementation. This contribution aims to critically analyze the current state of the art in CO2 hydrogenation to e-MeOH and e-DME, highlighting the interdependence between catalyst architecture and reactor engineering. By integrating advances in multifunctional catalyst design with innovative reactor concepts, a rational pathway toward efficient, stable and scalable e-fuel synthesis is outlined, positioning methanol and DME as cornerstone molecules for future Power-to-X technologies based on renewable hydrogen.

[1] G. Bonura, S. Todaro, C. Cannilla and F. Frusteri, in The Carbon Chain in Carbon Dioxide Industrial Utilization Technologies: a Case Study, p.83, D. Wawrzyńczak, I. Majchrzak-Kucęba, C. Pevida. G. Bonura, R. Nogueira, M. De Falco, Eds. (CRC Press, Taylor & Francis Group, Boca Raton, 2022).
[2] E. Catizzone, C. Freda, G. Braccio, F. Frusteri, G. Bonura, J. Energy Chem., 58, 55 (2021).