ABSTRACT:

H_2 Chemical Storage in E-Fuels: Novel Materials for Power-to-X

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The urgent need to mitigate anthropogenic CO2 emissions while ensuring energy security has positioned Carbon Capture Utilisation and Storage (CCUS) technologies as a benchmark for the global energy transition [1]. In the CCU framework, this work reports recent results on CO2 catalytic hydrogenation into high-value energy carriers via Powerto-Methane (PtM) and Power-to-Liquid (PtL) pathways. Integrating advanced catalyst synthesis, multi-scale characterisation, and process simulation, it addresses coupling catalyst architecture and process design to overcome kinetic/thermodynamic barriers in circular carbon systems. For PtM, CO2 methanation under steady-state and ICCU strategies is reported. Ni on USY zeolites showed interesting performance with coke resistance; hierarchical porosity and particle size/dispersion drove the catalytic behavior [2]. Rhenium dual-functional materials decoupled capture/conversion, achieving 100% methane selectivity via site-adsorbent synergy [3]. Conversely, PtL (CO2 to methanol) faced distinct constraints: Cu catalysts are selective only at 150-220°C, beyond which RWGS/methanation dominate [4]. Metal-support interfaces can be tuned via proper selection of precursors. Cu-Fe-Ce/Cu-Fe screening at high pressure favored CO/CH4 over methanol, warranting further study. Selectivity depends on metal composition, redox, and conditions. Overall, effective CO2 utilisation needs integrated catalyst-process design: PtM flexibility suits dynamic regimes; PtL demands precise catalysts + advanced reactors.

[1] International Energy Agency, World Energy Outlook 2025, 2025. www.iea.org/terms.
[2] G. Sorbino, O. Tammaro, A. Padua, A. Basco, S. Scognamiglio, M. Sisti, R. Arletti, A. Marocco, M. Pansini, G. Landi, S. Esposito, Int. J. Hydrogen Energ 103(2025)887–900.
[3] S. Scognamiglio, R. Checa, J. Ivañez, L. Liatard-Juvenelle, E. Cecen, B. Lunardelli, Y. Aizac, M. Aouine, Y. Lefkir, E. Berrier, G. Landi, F. Morfin, L. Piccolo, ChemCatChem 18 (2026) e01522.
[4] L. Chianese, R. Viscardi, C. Bassano, A. Muscatello, M. Fontana, M. Castellino, G. Landi, S. Scognamiglio, S. Esposito, V. Palma, G. Iervolino, V. Vaiano, Chem Eng J 525 (2025) 169870.