e-DME from CO_2: Driving the Future with Carbon-Neutral Fuels

Serena TODARO - *CNR-ITAE*

Dimethyl ether (DME), the simplest ether, is emerging as a promising carbon-neutral fuel due to its high cetane number, clean combustion properties, compatibility with existing LPG infrastructure, and ease of storage as a liquid under mild pressure. When produced from captured CO_2 and green hydrogen, DME offers a sustainable alternative to fossil fuels, with low pollutant emissions and broad applicability in transportation, marine, aviation, and power generation sectors.

The presentation focuses on the direct hydrogenation of CO_2 to e-DME using hybrid catalysts that integrate a metal oxide phase for CO_2 activation and a solid acid phase for methanol dehydration. Compared to the traditional two-step route via methanol synthesis, the direct process increases CO_2 conversion efficiency, overcomes thermodynamic limitations, reduces equipment needs, and lowers operational costs. Nonetheless, water formation during the reaction leads to catalyst deactivation, posing a significant challenge.

To overcome this, 3D-printed structured catalysts are investigated, allowing precise control over geometry, porosity, and mechanical strength. A novel “zebra” architecture featuring alternating layers of catalytic material and water-adsorbing components such as LTA zeolite is designed to manage water in situ and improve long-term catalyst performance.

Developed within the framework of the ECCSELLENT project, these findings underscore the value of combining multifunctional catalyst systems, additive manufacturing, and targeted water management strategies to advance CO_2-to-DME technologies and support the transition toward a low-carbon, sustainable energy future.