National Research Council of Italy ITAE vito Hybrid Catalysis Custom Synthesis & Screening

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INTENSIFICATION EFFECT ON CATALYTIC CO_2 HYDROGENATION TO DME PROMPTED BY WATER-ADSORBENT SYSTEMS

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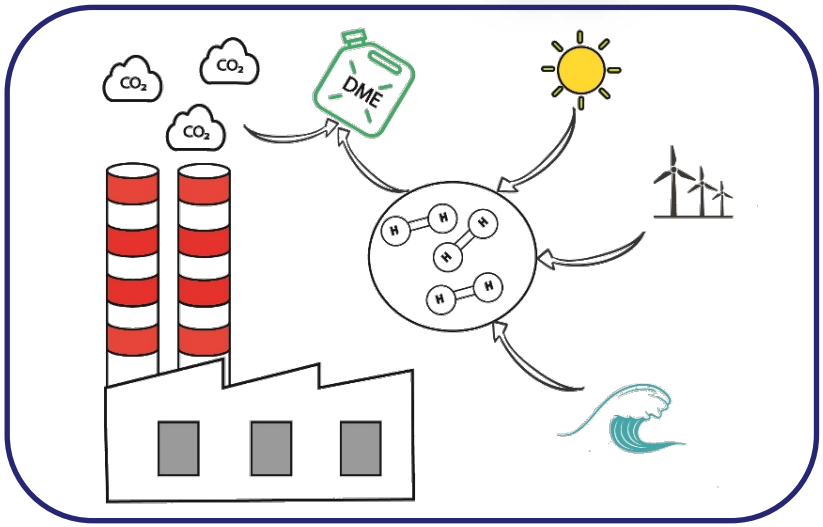


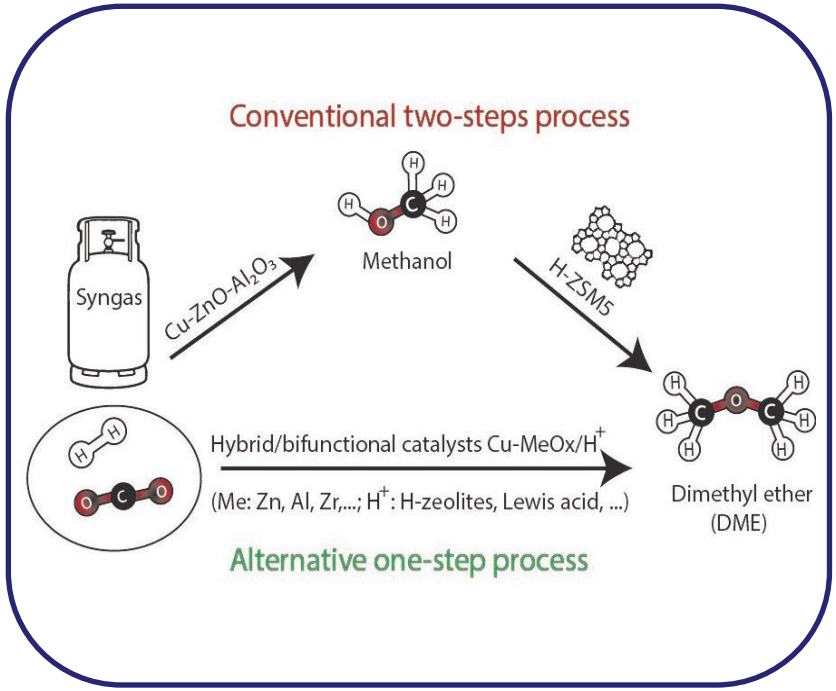
DME

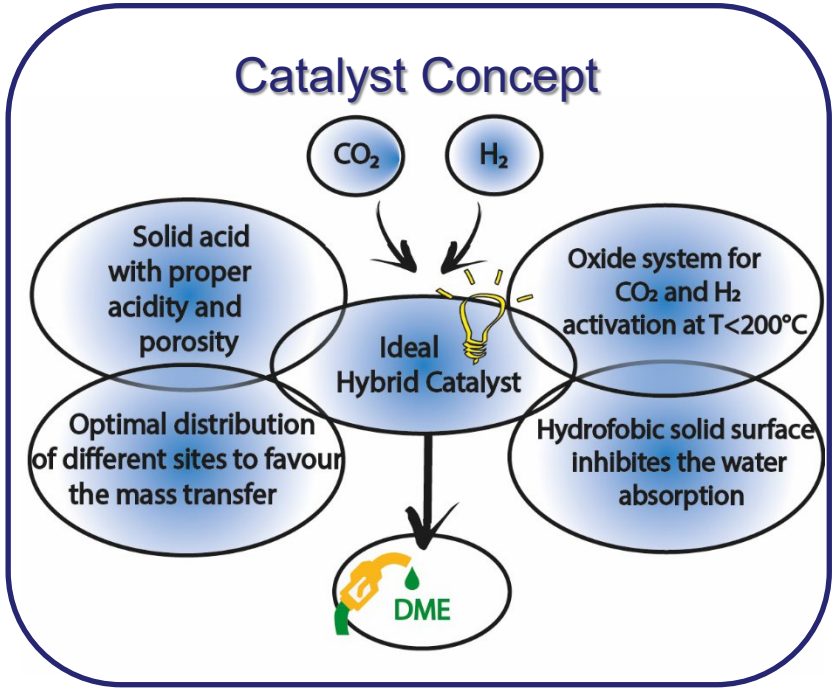
Properties

- High cetane number
- High efficiency of combustion
- Low-emission of NO_x, SO_x and CO

Applications

- LPG alternative
- Transportation fuel
- Power generation

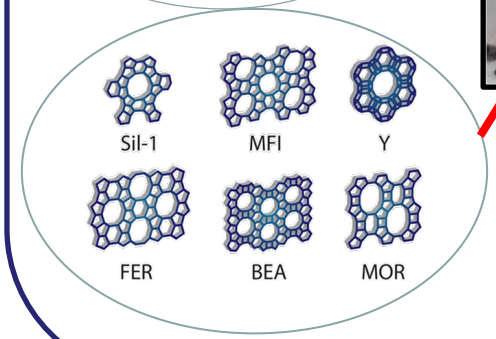




Catalyst Preparation

- Hybrid catalyst: $CuZnOZrO_2$@zeolite (metal-oxides):zeolite (1:1 wt/wt)

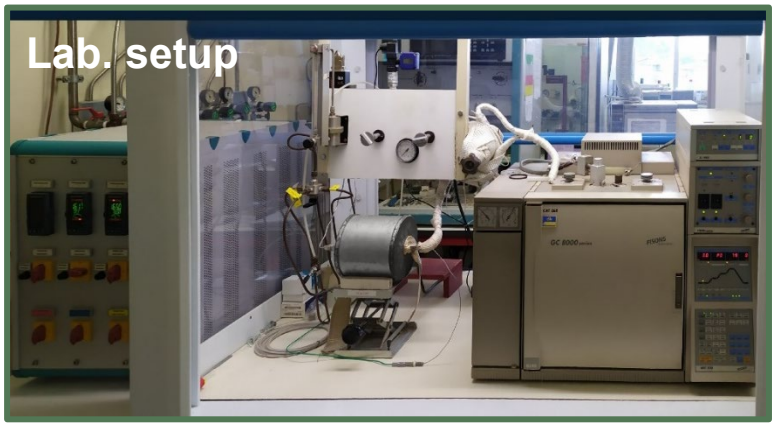
Cu, Zn and Zr nitrate precursors



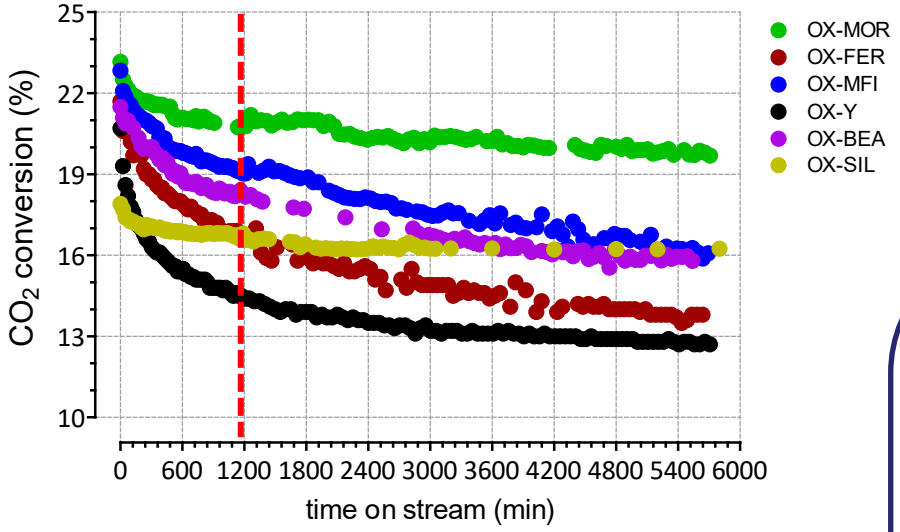
Gel-oxalate coprecipitation method

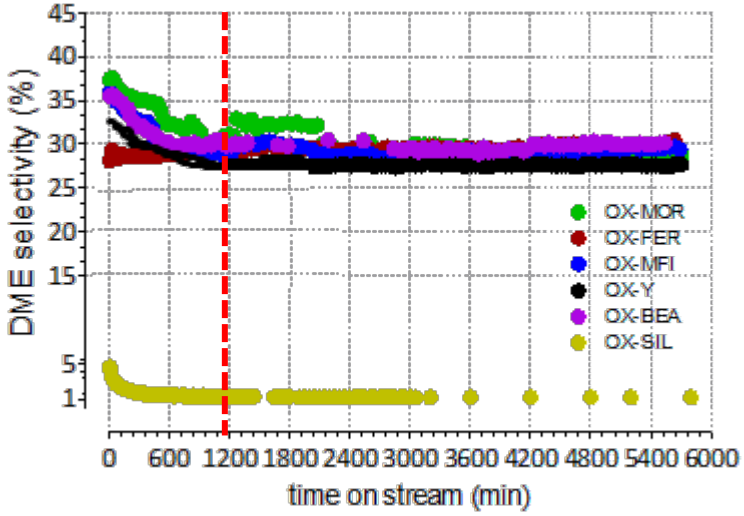
Catalyst Testing

- Reduction *in situ* at 300°C (1 h)
- Testing : (T_R=200-300°C; P_R= 30 bar) GHSV= 8,800-18,000 NL/g_{cat}/h. $CO_2/H_2/N_2$, 23/69/8 v/v



Catalytic behaviour of hybrid systems





Experimental conditions:

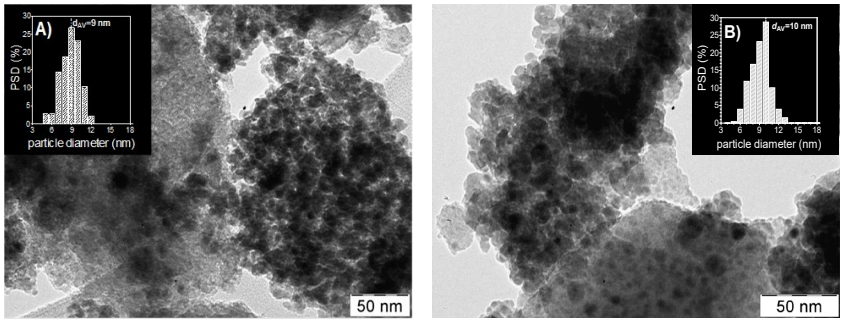
T_R: 260 °C; P_R: 30 bar;

GHSV: 8,800 NL·(kg_{cat}·h)$^{-1}$

H_2:CO_2 3:1 (vol)

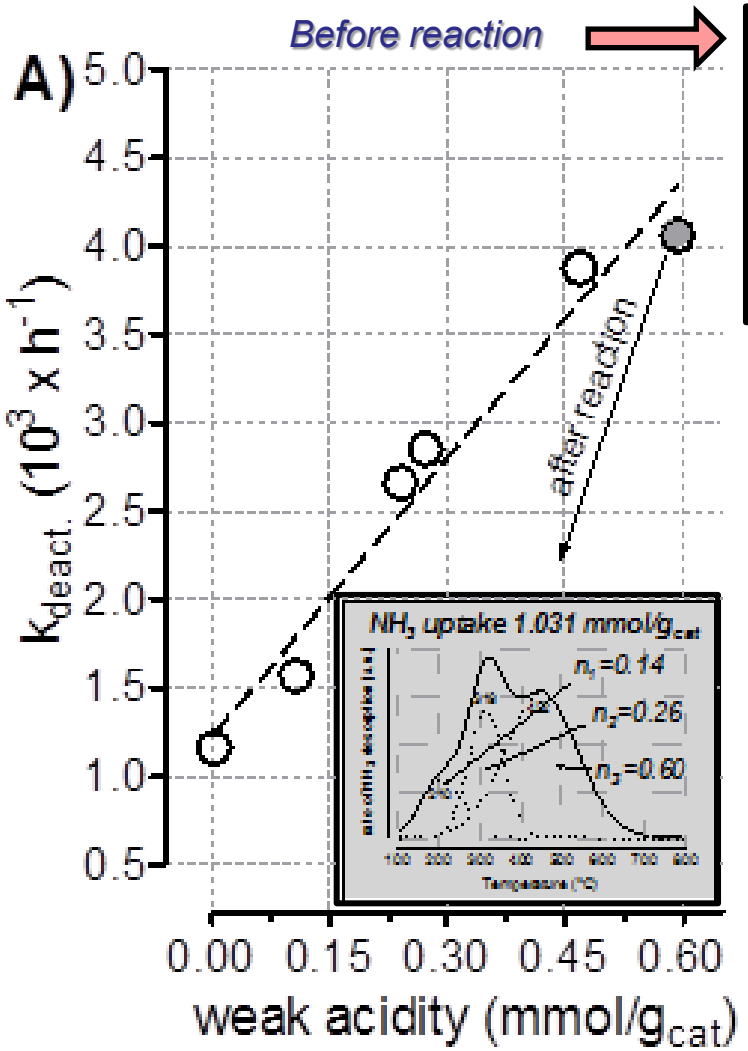
Investigation on coke formation & metal sintering

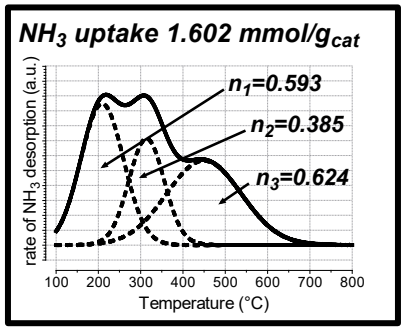
fresh **used**



Neither coke or metal sintering can be invoked as responsible for the decay of activity

The influence of water on the catalytic stability





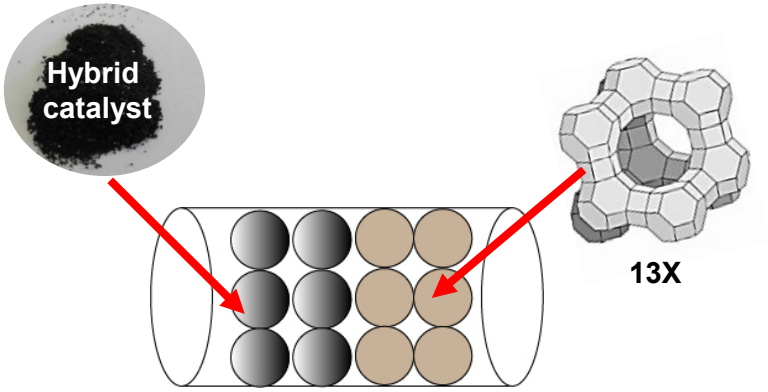
Loss of acid capacity mainly attributable to a decrease in weak acidity.

Deactivation constant (k_{deact}), determined for the various systems as independent on the coke accumulation, increases with weak acidity

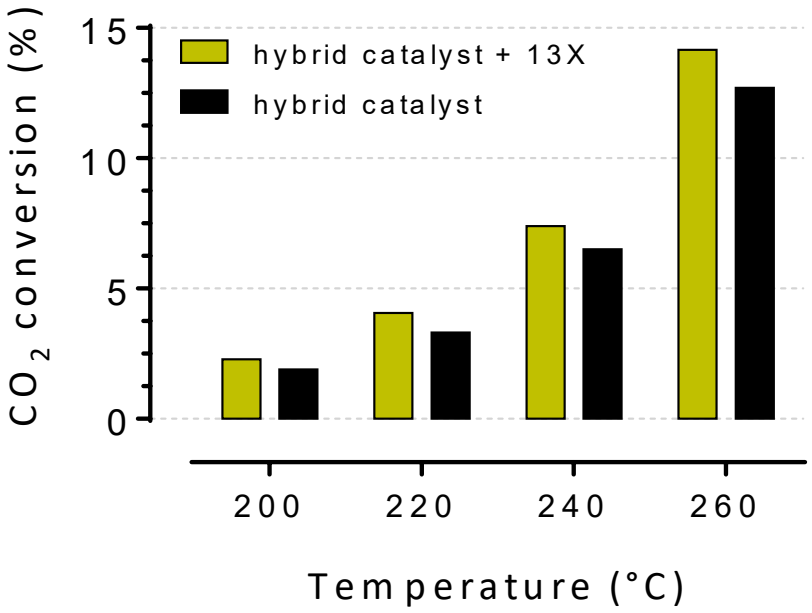
The weak acid sites generated on the hybrid catalysts during co-precipitation exhibit a significant mobility, being more prone to migrate in presence of water.

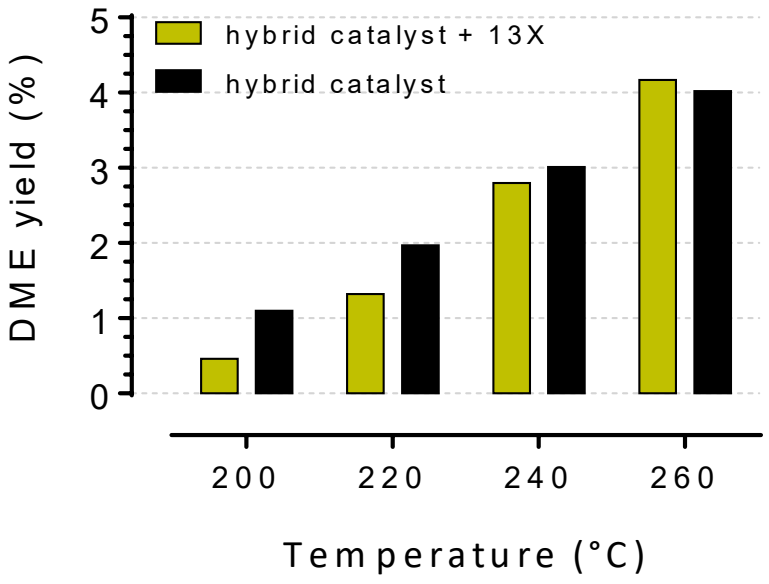
The effect of adding 13X zeolite

Experimental conditions:
T_R: 200-260 °C; P_R: 30 bar;
GHSV: 18,800 NL·(kg_{cat}·h)$^{-1}$
H_2:CO_2 3:1 (vol)



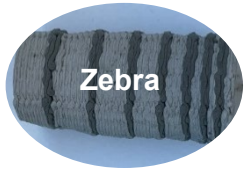
configuration of the bed reactor





Conclusions

- In line with the current policies on CCU, the development of a catalytic process for the direct hydrogenation of CO_2 to DME over hybrid systems is feasible.
- The hybridization of active sites of different nature is fundamental to deliver a process with no limitation in terms of mass transfer.
- The intensification of the synthesis process of dimethyl ether (DME) represents a promising approach to overcome the thermodynamic limitations of the conventional DME process.
- The use of hydrophilic zeolitic matrix systems combined with the hybrid catalyst effectively allows water to be absorbed even at high pressure and temperature.



Future challenges

- 3D printed catalyst obtainerd alternating layers of hybrid system and water adsorbers (e.g. LTA zeolite).

Acknowledgements

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CO2FOKUS ADVANCING CO_2 CONVERSION