DTU Chemistry
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ROMEO

Centre for Catalysis and Sustainable Chemistry

Hydroformylation with Integrated SILP Catalyst-Membrane Separation Reaction System

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Hydroformylation as large volume process

Hydroformylation is one of the largest homogeneously catalyzed processes in the chemical industry. Catalysis with supported ionic liquid phase (SILP) catalyst systems (Fig. 1) has successfully been established over the last decades as an industrially attractive approach conducting liquid- and gas-phase reactions.[1] Hydroformylation of olefins by syngas (Fig. 2) to produce aldehydes is a highly important and frequently studied catalytic reaction. Several SILP catalyst systems have demonstrated industrial potential.[2]

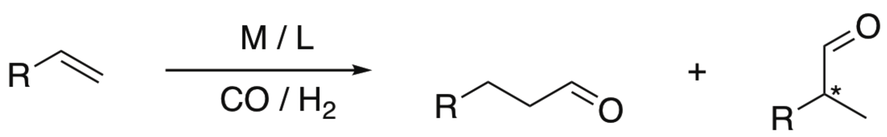

Fig. 2: Metal catalyzed hydroformylation of olefins by syngas

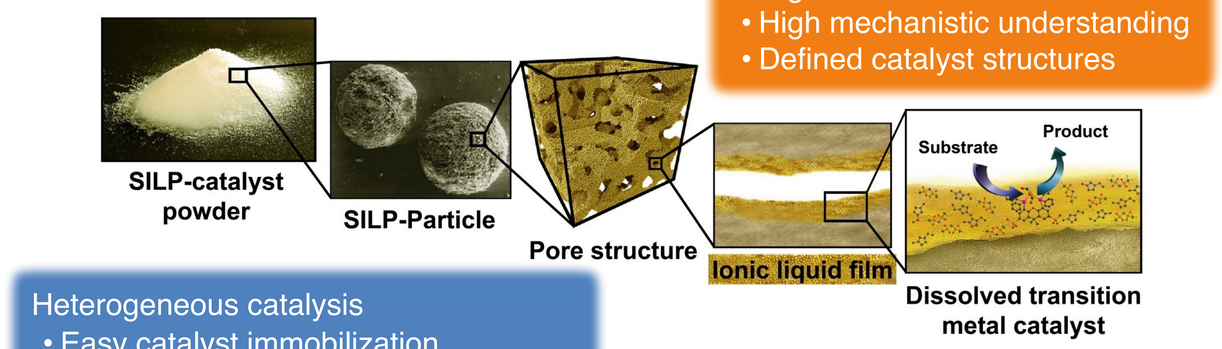

Fig. 1: Supported Ionic Liquid Phase (SILP) materials build the bridge between homogeneous and heterogeneous catalysis

Drawback in SILP hydroformylation

Long-term catalytic performance test (Fig. 3) of SILP catalyst on hydroformylation of olefins exhibits decreasing activity due to the formation of "heavies" by undesired condensation reactions (Fig. 4). This hampers both, activity and selectivity and prevents the implementation of SILP in industry.

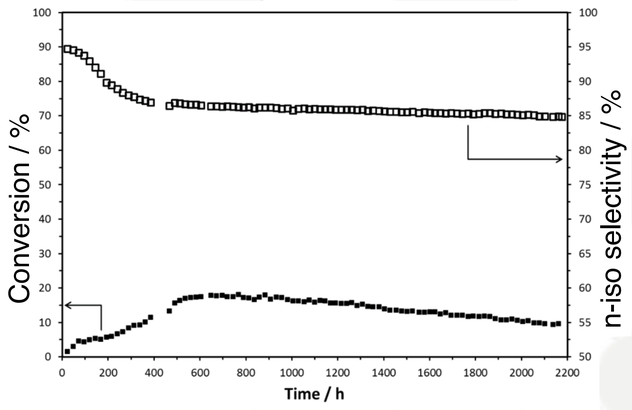

Fig. 3: Long-term performance test of SILP materials

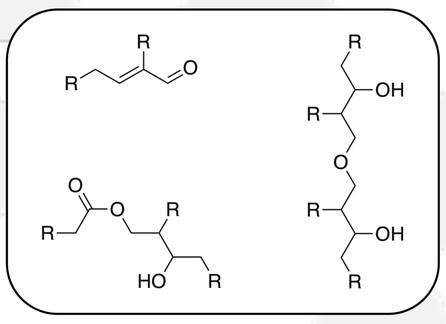

Fig. 4: Possible formation of "heavies" during hydroformylation

ROMEO: Reactor Optimization by Membrane Enhanced Operation

ROMEO's two-in-one reactor design (Fig. 5) improves long-term stability by avoiding aldol condensation. This is achieved by a membrane coating enabling continuous and selective (by-) product separation from the reaction.

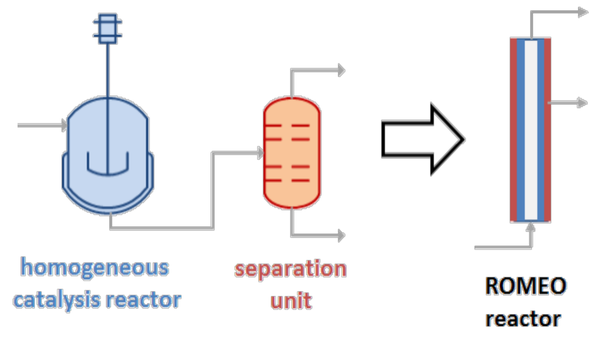

Fig. 5: ROMEO's reactor combines two essential process steps

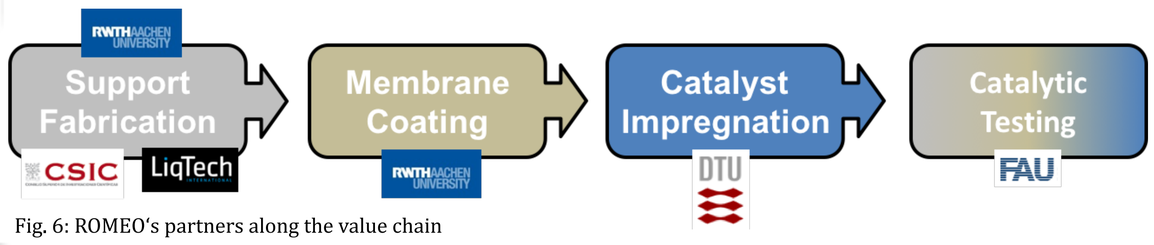

Fig. 6: ROMEO's partners along the value chain

Results

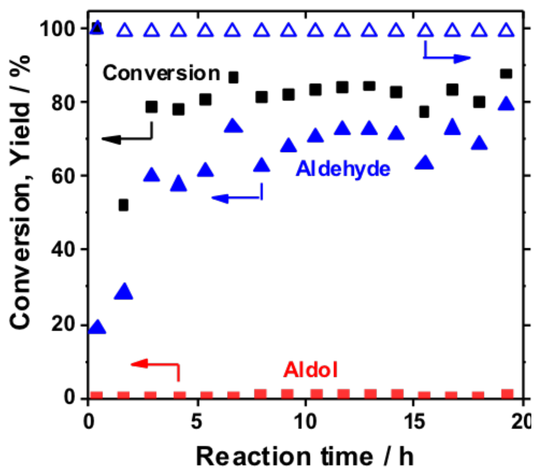

Fig. 7: Gas-phase hydroformylation with ROMEO reactor (without membrane)

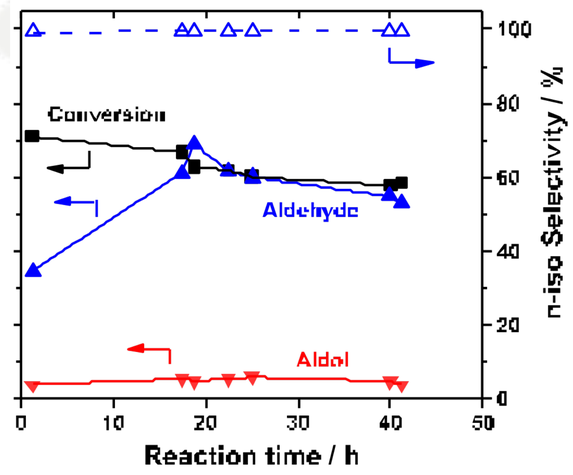

Fig. 8: Gas-phase hydroformylation with ROMEO reactor (with membrane – harmed during operation)

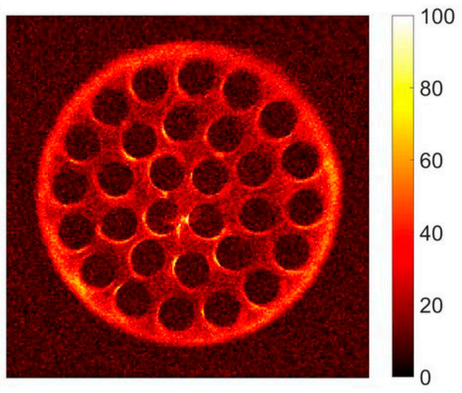

Fig. 9: Magnetic resonance image (MRI) of SILP impregnated ceramic support

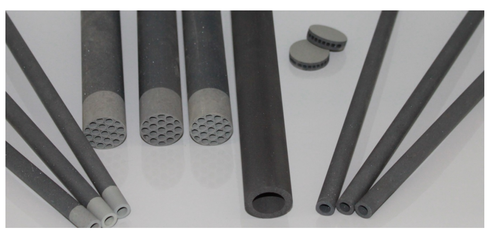

Fig. 10: Various ceramic supports

Fig. 11: A first-class consortium of nine partners from five European countries make up ROMEO's team

Conclusions

In summary, preliminary results indicate that ROMEO's "two-in-one" reactor concept has a great potential to be applied in the chemical industry. At this point, the mechanical stability of the membrane needs to be improved. If this is achieved, a reduction in emissions, energy consumption, space needs and costs in the chemical industry are expected with this new reactor type.

References

[1] S. Bhaduri, D. Mukesh. Homogeneous Catalysis: Mechanisms and Industrial Applications, 2nd Edition. John Wiley & Sons, 2014.

[2] R. Franke, D. Selent, Armin Börner. Applied Hydroformylation. Chemical Reviews, 2012, 112 (11), pp 5675–5732.

Acknowledgements

SPIRE Sustainable Process Industry through Resource and Energy Efficiency
European Commission

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 680395

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