

Optimized Performance Through Innovative Materials in Oxygenates-to-Hydrocarbons

Publieke samenvatting / Public summary

Aanleiding

European material and energy security needs novel and sustainable methods for producing high-value hydrocarbons. Oxygenates (MeOH, DME) are key intermediates which can be easily transported and stored. OPTIMO will support the economic feasibility of olefins production from renewable oxygenates. Conversion of oxygenates to olefins proceeds over solid acid catalysts via similar mechanistic steps, like dehydration, methylation, and hydrocarbon pool catalysis, for which insights exist in commercially established Methanol-to-Olefins (MTO) technology. However, catalyst deactivation via coke formation remains a key challenge with continuous coke burn-off leading to CO₂ emissions, extra energy use and catalyst lifetime shortening. In-situ water removal has been identified to reduce coking and extend catalyst lifetime. However, the underlying mechanism is not yet understood in detail, limiting understanding on process improvements. OPTIMO will improve understanding of the coking mechanism especially with water removal and use these learnings to further optimise and validate the economically attractive route to renewable olefins.

Doelstelling

OPTIMO, a collaboration between TNO, Hybrid Catalysis and Ketjen, aims to identify the coke formation mechanisms, in particular in sorption-enhanced reaction mode with conditions that differ from conventional MTO (lower temperature regime), and to formulate an innovative integrated reactive sorbent that integrates water sorption and catalytic

Projectinformatie / Project information

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Algemene informatie / General information

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functionalities in a single particle to improve productivity, carbon selectivity and mechanical integrity of the functional material in sorption-enhanced MTO (SE-MTO) for process improvements in oxygenates to hydrocarbon (OTH) processes. TNO's experiments have shown that removing water near the catalyst reduces coke formation and increases catalyst lifetime, in line with literature reports. The project will build on these findings and an existing patent by studying coke formation mechanisms and developing integrated materials that combine catalytic and sorption functionalities. The aim is to enable stable, energy-efficient SE-MTO operation with optimized product selectivity and improved productivity.

Korte omschrijving

To reach the project goal two main activities are being considered:

- Supporting research on coke formation mechanism and its contribution to catalyst lifetime, carbon selectivity and product distribution in SE-MTO. Coke formation mechanisms will be evaluated by systematically varying key process parameters (i.e., reaction and regeneration temperature, sorbent to catalyst ratio, space velocity, pressure) and analyzing catalyst behavior using standardized techniques to assess how water management influences olefin selectivity and catalyst stability. This activity will involve all project partners.
- Hybrid material developments for increased performance in SE-MTO: Building on the insights of the 1st activity, new functional materials will be developed to integrate catalytic activity with water sorption functionality. By optimizing zeolite properties including pore structure, acidity, and framework composition, the project will improve carbon selectivity, minimize coke formation, and enable more efficient, lower-temperature olefin production from renewable methanol.

Resultaat

The anticipated project results include a detailed map of coke formation mechanisms under various SE-MTO operating conditions, the synthesis and validation of a functional catalyst-sorbent material, and a set of process guidelines for achieving high-

yield olefin production at reduced energy input. This will enable further development to TRL 4, opening pathways toward further de-risking, scale-up and eventual commercial implementation. The outcomes will include optimized process conditions, validated multifunctional materials, and improved understanding of reaction pathways supporting the development of cleaner, more sustainable olefin technologies that meet industrial and societal needs. While the MTO reaction serves as the model system, the insights gained are expected to broadly apply to the oxygenates-to-hydrocarbons (OTH) class of transformations. The results support low carbon polymers and sustainable aviation fuel (SAF) value chains by providing a flexible, circular, and renewable route to light olefins.

De data in deze applicatie is afkomstig van de Rijksdienst voor Ondernemend Nederland (RVO) en wordt in samenwerking met de Topsector Energie ontsloten.

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