Liquid metals research breaks ground in sustainable chemical manufacturing with metal-enhanced catalysts

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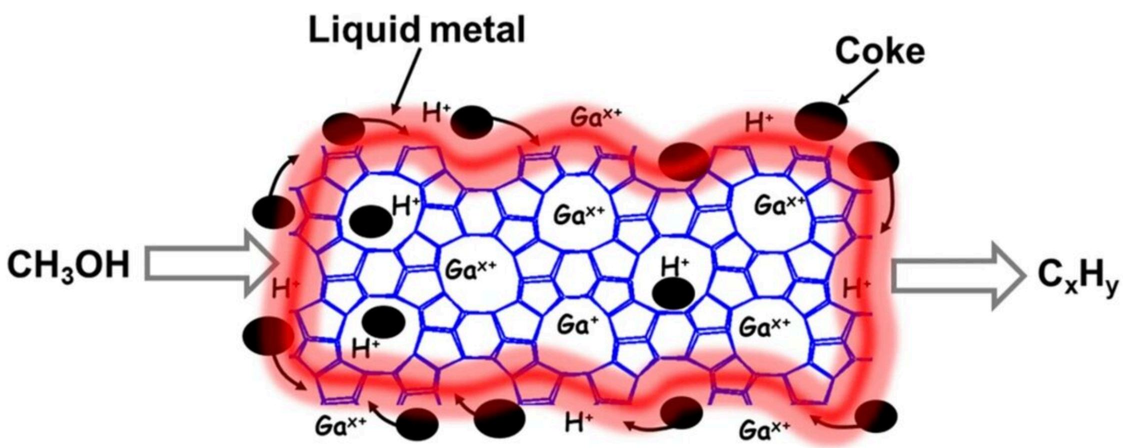

Scheme of the effect of liquid metal on the MTH reaction by desorption of carbon species. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-46232-9

A team of co-authors from five different countries, has uncovered a new design concept for catalysts used in the industrially crucial methanol-to-hydrocarbon (MTH) process, enabling the production of high-demand chemical commodities from source-abundant methanol.

"A remarkable 14-fold increase in the catalyst's lifetime was achieved by employing liquid gallium as a promoter, which molecular-level effects on the working catalyst were uncovered through meticulous in situ spectroscopic studies conducted at Charles University," said one of the authors of the study Mariya Shamzhy from Charles University Center of Advanced Materials, Faculty of Science.

In a significant advancement for the field of chemical engineering, scientists have unveiled a novel approach to enhancing the efficiency and sustainability of the MTH process, a key method for converting methanol into valuable chemicals and fuels. This research demonstrates the use of low-melting-point metals, such as gallium (Ga), to significantly improve the performance and lifespan of the catalysts involved in the MTH process. The research is published in the journal *Nature Communications*.

Traditionally, the MTH process has relied on zeolite catalysts. While effective, these catalysts suffer from rapid deactivation caused by coke deposition, necessitating frequent and costly regeneration treatments. The innovative approach introduced by the research team leverages the unique properties of gallium to slow the deposition of coke and enhance the desorption of carbonaceous species from the zeolite catalysts. This not only extends the catalysts' operational life but also increases the process's overall efficiency and sustainability.

A key finding of the research was that physically mixing ZSM-5 zeolite with liquid gallium resulted in a catalyst that demonstrated an enhanced lifetime in the MTH reaction, increasing by a factor of up to approximately 14 times compared to the traditional ZSM-5 zeolite catalysts. This remarkable improvement opens the door to more cost-effective and environmentally friendly chemical manufacturing processes.

The implications of this research are profound, offering an alternative route to the design and preparation of deactivation-resistant zeolite catalysts. By reducing the need for regular regeneration treatments, this method not only lowers production costs but also decreases the environmental footprint associated with chemical manufacturing.

This breakthrough represents a pivotal step forward in the quest for more sustainable and efficient chemical production methods. It underscores the potential of integrating novel materials and innovative techniques to overcome longstanding challenges in the industry.

The research team's findings offer a promising path forward for the development of next-generation catalysts that will play a crucial role in the sustainable manufacture of valuable chemical products from methanol.

"The new concept of the utilization of liquid metals as promoters of zeolite catalysts introduces exciting possibilities for the development of more efficient and robust catalytic systems for a wide range of industrial processes," concluded one of the corresponding authors, Vitaly V. Ordomsky from Université de Lille, Unité de Catalyse et Chimie du Solide.

More information: Yong Zhou et al, Liquid metals for boosting stability of zeolite catalysts in the conversion of methanol to hydrocarbons, *Nature Communications* (2024). DOI: 10.1038/s41467-024-46232-9

Provided by Charles University

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