Ga-Pt supported catalytically active liquid metal solutions (SCALMS) for propane dehydrogenation – from material stability optimization to kinetic investigation

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Abstract

Selective propane dehydrogenation (PDH) represents a critical and industrially significant process to produce propylene, a key feedstock for the polymer and petrochemical industries. Conventional heterogeneous catalysts used for such processes suffer from deactivation, mainly induced by sintering of active sites and coke deposition (coking).[1] Improving the efficiency and stability of such catalysts is a major challenge.
Supported Catalytically Active Liquid Metal Solution (SCALMS) systems offer unique benefits in addressing these challenges.[2] In SCALMS materials, small amounts of an active metal (e.g. Pt) are placed in a low melting metal matrix (e.g. Ga). The resulting alloy is deposited as droplets onto a porous support. Under reaction conditions, these alloy droplets become liquid resulting in enhanced catalyst activity and selectivity. The unique reactivity and catalytic performance of SCALMS is attributed to the presence of its highly active and dynamic single active sites (Figure 1).[2] SCALMS has been reported as active catalysts for dehydrogenation,[3] and oligomerization,[4] reactions however, a progressive loss in activity has been reported for Ga-Pt SCALMS systems in PDH.[3]

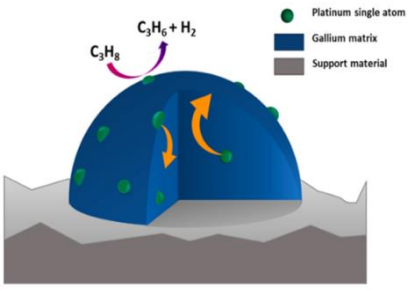

Figure 1. Schematic illustration of the Ga-Pt SCALMS principle[3]

In this contribution, we tackle this challenge by systematically modifying the synthesis approach for the preparation of Ga-Pt SCALMS leading to a more defined material. Furthermore, we demonstrate how critical the reaction start-up procedure is in transforming a deactivating catalyst into highly active, selective, and stable catalyst performance over several hundred hours time-on-stream in PDH. Lastly, detailed kinetic investigations are performed on this stable system to gain more insights into the reaction mechanism at play under the investigated conditions. These data will help in designing and evaluating a SCALMS based PDH process for more benign on purpose propene production.

References

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