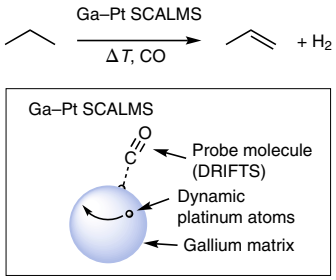
LIQUID-METAL CATALYSIS

Probing dissolved platinum

ACS Catal. https://go.nature.com/2IlgxrX (2019).



Supported catalytically active liquid metal solutions (SCALMS) are a very recent class of catalysts based on metal alloys that are liquid under reaction conditions. Palladium–gallium phases rich in gallium are the prototypical SCALMS, and have shown superior alkene dehydrogenation activity and stability compared to conventional supported metals. However, the determination of the structure–activity properties for such systems is not trivial, due to their unconventional physicochemical properties and the related scarcity of established characterization techniques. Now, Jörg Libuda and colleagues report an operando diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS) approach for the study of propane dehydrogenation using gallium–platinum SCALMS, which represents an important step forward in the understanding of this class of catalysts.

The authors compared the activity of Ga/Al_2O_3, Pt/Al_2O_3, and $Ga_{37}Pt/Al_2O_3$ during propane dehydrogenation, monitoring the reaction with gas chromatography, while simultaneously following the interaction of the active phase with CO — used as the probe molecule — by DRIFTS. Ab initio molecular dynamics simulations based upon DFT methods were employed to model the catalyst's active site as well as its interaction with CO, in order to guide the interpretation of the infrared spectra. Interestingly, the simulations confirm the dynamic behaviour of Pt atoms in the gallium matrix, which occasionally reach the surface of the liquid, becoming amenable to activate the reactant (pictured). Recording DRIFTS spectra under either Ar/propane or CO/propane atmospheres, the group identified conditions under which CO can serve as a spectroscopic probe. Interestingly, the Ga–Pt SCALMS showed the highest activity and selectivity compared to the control catalysts. Moreover, while CO partially inhibited propane dehydrogenation on Pt/Al_2O_3, the reaction on $Ga_{37}Pt/Al_2O_3$ was unaffected.

The spectral features of absorbed CO reveal important differences in the active sites of simple supported platinum and liquid-metal solutions. In particular, the electronic properties of Pt species are significantly altered within SCALMS due to the influence of the gallium matrix, as well as the possible presence of hydrocarbon co-adsorbates.

Davide Esposito

Published online: 13 March 2019
https://doi.org/10.1038/s41929-019-0258-y