Characterization of catalytically-active Pt-alloy surfaces and core-shell nanoparticles using atom probe tomography

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Bimetallic heterogeneous catalysts have proven remarkably successful in catalysing a wide range of important processes, in fuel-cells, exhaust emission control and in hydrocarbon processing. However, the effects of the operating environment on the surface composition, structure and stability of the noble metal catalysts are poorly understood at the atomic-scale. This knowledge will be required to produce the improved catalysts needed for future energy- and materials-efficient technologies.

Atom probe tomography offers a unique method for studying these materials, offering atomic-scale chemical identities of the catalyst surfaces and chemisorbed species. We have used APT to show a rich variety of behaviour in Pt-based alloys, investigating the effects of high temperature/pressure oxidation. These reveal pronounced surface segregation behaviour, strongly dependent on the treatment conditions, crystallographic plane and alloy composition. Furthermore, while subsequent reduction treatments remove oxides, the marked changes to the metallic surface compositions remain. Such results suggest using sequential oxidation and reduction treatments as an alternative synthesis method for designing and preparing nano catalysts with controlled surface compositions.

In parallel work, we are also investigating the use of finely tailored core-shell nanoparticles, using APT amongst other techniques to examine the chemical composition of a range of such materials and how they may change as a function of thermal/gas exposures. Alongside a description of the sample preparation methods, I will present a range of recent results, highlighting the correlation between catalytic efficiency and the atomic-scale chemical/structural information uniquely provided by APT.