Recent Advances in Developing Platinum Monolayer Electrocatalysts for the O_2 Reduction Reaction

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For Pt, the best single-element catalyst for many reactions, the question of content and loading is exceedingly important because of its price and availability. Using platinum as a fuel-cell catalyst in automotive applications will cause an unquantifiable increase in the demand for this metal. This big obstacle for using fuel cells in electric cars must be solved by decreasing the content of Pt, which is a great challenge of electrocatalysis.

Over the last several years we inaugurated a new class of electrocatalysts for the oxygen reduction reaction (ORR) based on a monolayer of Pt deposited on metal or alloy carbon-supported nanoparticles. The Pt-mass activity of several of these electrocatalysts was ca. 20 times higher than that of commercial Pt/C samples. Long-term fuel cell tests demonstrated their good stability. The origin of their high activity was identified by electrochemical and surface-science techniques, x-ray absorption spectroscopy (XANES), and density functional theory calculations. In situ XANES data indicated that this activity probably reflects the decreased formation of PtOH. These catalysts also showed good durability demonstrated by long-term fuel cell tests. The stability against dissolution under potential cycling regimes induced by a submonolayer of Au clusters on Pt nanoparticles on carbon, was also found for Pt monolayers.

Recent studies focused on further reduction of costs associated with these catalysts. Pt monolayers were deposited on non- noble-metal– noble metal core shell nanoparticles, metal alloy nanoparticles and oxide nanoparticles. The results obtained so far are very encouraging. They may significantly impact science of electrocatalysis and fuel-cell technology, as they have demonstrated an exceptionally effective way of using Pt that can resolve problems of other approaches, including electrocatalysts' inadequate activity and high Pt content.

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