

5-8 How Does a Cocatalyst Enhance the Activity of the Oxygen Reduction Reaction? — Improvement of Fuel Cell Performance —

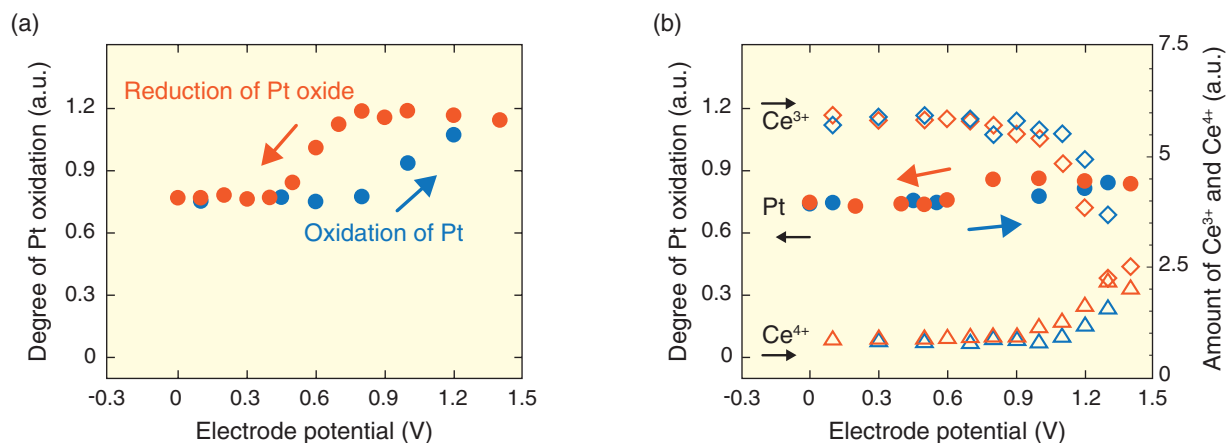


Fig.5-17 Oxidation status of Pt and Ce

Oxidation status of (a) Pt in the conventional Pt catalyst and (b) Pt and Ce in Pt–CeO_x nanocomposite catalyst. In the Pt–CeO_x nanocomposite catalyst, oxidation of the Pt surface is greatly suppressed. Blue and red data points correspond to positive- and negative-going scans, respectively.

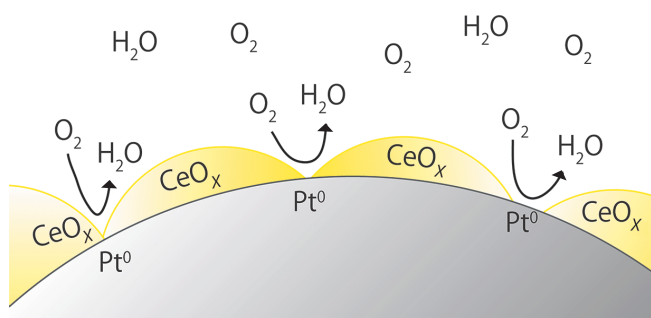


Fig.5-18 Schematic illustration of oxygen reduction reaction at the surface of the Pt–CeO_x nanocomposite

It was confirmed that oxidation of the Pt surface is suppressed by the CeO_x/Pt interface, and the intrinsic high catalytic activity remains enhanced.

The polymer electrolyte fuel cell (PEFC) is a clean and compact power generation system that can perform below 100 °C, can be miniaturized easily, and emits only water as exhaust. These features enable integration of the PEFC into automobiles and mobile electronic devices. On the other hand, the PEFC demands a large amount of an expensive precious metal (platinum, Pt), which limits its wide adoption. In the last decades, many studies for reducing the amount of Pt in PEFCs have been carried out. For example, high-performance electrode materials with efficiencies close to the theoretical value have been explored.

The Global Research Center for Environment and Energy based on Nanomaterials Science (GREEN) at the National Institute for Materials Science (NIMS) investigated the nanocomposite catalyst Pt–CeO_x, which exhibits higher oxygen reduction reaction (ORR) activity than the conventional Pt catalyst, and established its synthetic method. A joint research group comprising researchers from GREEN

and JAEA investigated the role of cerium oxide in the Pt–CeO_x catalyst and elucidated the mechanism by which the ORR activity on the catalyst is enhanced.

To elucidate the valence of platinum and/or cerium atoms in the Pt–CeO_x catalyst and the conventional Pt catalyst under ORR, in situ X-ray absorption fine structure measurements were carried out at SPring-8. The results revealed that on the conventional Pt catalyst, a surface oxide began to form at the potential at which ORR starts to occur. However, on the Pt–CeO_x catalyst, Pt oxide formation was suppressed, but Ce³⁺ was oxidized to Ce⁴⁺ at the potential at which Pt is oxidized (Fig.5-17). These results suggest that on the Pt–CeO_x catalyst, charge transfer at the Pt/Ce interface occurs, and Ce³⁺ in the Ce oxide is oxidized instead of Pt (Fig.5-18). Previous studies reported that the Pt surface oxide reduces the ORR activity. Finally, it is concluded that the Pt–CeO_x catalyst exhibits intrinsic high ORR activity due to the suppression of Pt oxide formation.

Reference

Masuda, T., Tamura, K. et al., Role of Cerium Oxide in the Enhancement of Activity for the Oxygen Reduction Reaction at Pt–CeO_x Nanocomposite Electrocatalyst - An In Situ Electrochemical X-ray Absorption Fine Structure Study, *The Journal of Physical Chemistry C*, vol.116, issue 18, 2012, p.10098-10102.