Particle size effect of Iridium nanoparticles on hydrogen oxidation and evolution reaction activity in alkaline electrolytes

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Hydroxide exchange membranes fuel cells (HEMFCs) enable the use of non-noble metal or metal-free catalysts for oxygen reduction reaction (ORR) in alkaline electrolytes. However, the activity of hydrogen oxidation/evolution reaction (HOR/HER) in alkaline electrolytes is about two orders of magnitude lower than that in acid on Pt, Pd and Ir[1,2], which makes HEMFCs less cost-effective since a higher loading of precious metal will be required for HOR in HEMFCs or HER in HEM electrolyzers. The reason for the sluggish kinetics of HOR/HER in alkaline electrolytes remains unclear, and therefore, studies of HOR/HER in alkaline electrolytes would be of great importance in order to gain fundamental understandings as well as to develop catalysts with higher activity.

Strmcnik et al. studied the HOR/HER on polycrystalline Ir in 0.1 M KOH, and showed a HOR polarization curve overlapping with the concentration overpotential curve, indicating a facile HOR kinetics on polycrystalline Ir that was attributed by the oxophilic nature of Ir[3]. Their results suggest that Ir is a promising alternative to Pt as HOR/HER catalyst. However, Durst et al. obtained a smaller exchange current density on Ir/C (0.37 ± 0.12 mA/cm^2 at 313 K) than Pt/C in alkaline electrolytes. The discrepancy between these two works might come from the difference of electrode types (polycrystalline Ir with extended surface for Strmcnik et al. and carbon supported Ir nanoparticles for Durst et al.), which is generally known as particle size effect. Particle size effect for HOR/HER has been studied for Pt and Ru[4,5], but it is yet to be investigated for Ir.

In this work, we obtained Ir/C samples with different Ir particle size by heat treating commercial 20 *wt.*% Ir/C at different temperatures. Their HOR/HER kinetics in alkaline electrolyte was evaluated using RDE measurements with correction of solution resistance. The kinetic currents were fitted into the Butler-Volmer equation to get exchange current densities. Our results showed that the specific exchange current density increases as particle size increases. We suspect that the HOR/HER on Ir is facet sensitive, and the different ratios of facets exposed on Ir nanoparticles with different sizes might be responsible for the particle size effect.

References

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