STEM Characterisation of Pd-Ru Core-Shell Nanoparticle Geometries for Oxygen Evolution

Gloag, L.[1], Webster, R.[2], Benedetti, T.M.[1], Cheong, S.[2] and Tilley, R.D.[1,2]

[1] School of Chemistry, UNSW, Sydney, Australia, [2] Electron Microscope Unit, Mark Wainwright Analytical Centre, UNSW, Sydney, Australia

Nanoparticles offer promising for oxygen evolution (OER) by enhanced surface exposure. The most active metal for OER is ruthenium. [1] However, the poor stability of Ru causes this high activity to be lost within 20 OER cycles.[2] One method to overcome the poor stability is to synthesise bimetallic nanoparticles with a core-shell structure. This geometry allows a balance between the activity and stability to be achieved by optimising the interaction of Ru in the shell with the seed metal in the core. This work focusses on this optimisation for activity vs. stability by tuning the Ru shell thickness on palladium seeds. The Pd-Ru core-shell nanoparticles were synthesized by the slow reduction of ruthenium acetylacetonate in the presence of Pd nanoparticles. Four Ru:Pd ratios (in the range 0.25:1 to 2:1) were used in the synthesis to assess the effect on Ru shell thickness and OER activity.

In this presentation, the relationship between shell thickness and OER activity nanoparticles will be explored through characterisation using high resolution transmission electron microscopy (HRTEM), scanning transmission electron microscopy (STEM), using high-angle annular dark-field (HAADF) imaging performed in a JEOL F200 operated at 200kV. Energy dispersive x-ray spectroscopy (EDX) elemental mapping was used to characterise the core-shell thickness and morphology of the shells. By relating the differences in nanoparticle structure to the OER performance, we find that the activity and stability of the core-shell nanoparticles can be tuned by changing the shell thickness. HRTEM and STEM EDX mapping revealed that the Ru shell thickness can indeed be finely controlled synthetically by varying the Ru:Pd ratio. Overall, the high quality TEM characterisation of Pd-Ru core-shell nanoparticles presented here shows that core-shell nanoparticles can be readily tuned during synthesis to achieve the desired electrocatalytic properties.

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