Synthesis of Well Dispersed Supported Metal Catalysts by Strong Electrostatic Adsorption and Electroless Deposition

Dissertation Defense by
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Enhancing the catalytic performance of heterogeneous catalysts can be done by increasing active site count as well as modification of the physico-chemical characteristics of the catalyst material. For supported metal nanoparticles this can be achieved by decreasing particle size, thus increasing dispersion or metal utilization on the surface of the particles, while modification of metal properties can be attained by addition of a secondary metal that has a strong interaction to the primary metal, beneficial for a given reaction. In addition, the accessibility of the metal surface is necessary for reliable performance of catalysts. For carbon supported catalysts, Temperature Programmed Oxidation has been used to show the presence of decorating carbon on the metal surface, which can be cleaned by oxidative removal of the carbon overlayer.

In the preparation of supported metal catalysts, the methods of Strong Electrostatic Adsorption (SEA), and its incipient wetness analog, Charge Enhanced Dry Impregnation (CEDI), can yield supported metal nanoparticles with high dispersion and narrow size distribution. Catalysts prepared by SEA and CEDI therefore are desirable as seeds for addition of secondary metal using Electroless Deposition (ED), as the prepared bimetallic catalysts should be of similar dispersion as the base catalyst. These methods were used to demonstrate the preparation of two series of carbon supported bimetallic catalysts containing Pt which were then characterized and evaluated for oxygen reduction reactions. The first system used Pt as the base metal, prepared by SEA on XC72R carbon, with Ru as the secondary metal added by ED. The second system used Co as base metal, prepared by a modified CEDI method on carbon black, with Pt added by ED.

With comprehensive characterization, the resulting Pt-Co/C catalysts had particles with irregular morphology that were larger than the seed Co particles. These were determined to have thin alloyed Pt-Co phases and domains of pure Pt. On the other hand the Ru-Pt/C catalysts did not have alloying of the component metals but do have real bimetallic surface composition. Electrochemical evaluation of these catalysts showed higher mass activities, with respect to platinum content, compared to commercially available monometallic and bimetallic catalysts. This enhancement in performance is associated with the electronic interaction between Pt and Ru on the catalyst surface and the lattice contraction for Pt-Co alloys.

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