

Effects of metal and nitrogen on the formation of nano-shell containing carbons

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When a mixture of a polymer and a metal compound was heat treated in an inert atmosphere, we found a carbon consisting of shell-like and amorphous carbons. Such carbons showed a catalytic activity for oxygen reduction reaction (ORR). We named the carbon “nano-shell containing carbon” (NSCC) and carried out researches. NSCC can be platinum replacement for ORR catalyst used in polymer electrolyte fuel cells. The ORR activity was enhanced by addition of nitrogen-containing compound to the mixture of carbon precursor. However, roles of metal and nitrogen for the formation of nano-shells and ORR activity have not been clearly elucidated.

We have a hypothesis that nano-shell is formed according to the following manner. Carbon dissolves in metal particles derived from metal compounds, the carbon saturate in the metal particles and form layers of carbon outside of the metal particle as nano-shells.

We used several kinds of iron compounds as metal compounds changing particle sizes and concentrations. Uracil was used as a nitrogen-containing compound and nitrogen contents in the carbon precursors were changed. Particle size of iron, nano-shell's size and thickness of the carbon layers, and ORR activities were measured.

As the result, we found that the iron compounds' species, particle size and concentration did not influence nano-shell structure and ORR activities. However, metal compounds are essential. When nitrogen content increased in precursors, nano-shells became smaller, had thinner carbon layers and showed higher ORR activities. We concluded that the dominant factor to form nano-shell structure and ORR activities is nitrogen content.