

Preparation of PN-doped carbons from phosphoric acid modified folic acid and their catalytic activity for oxygen reduction reaction

Jun-ichi Ozaki¹, Rieko Kobayashi^{1,2}, Takafumi Ishii¹ and Yasuo Imashiro^{1,2}

¹International Research and Education Center for Element Science, Faculty of Science and Technology, Gunma University

²Nisshinbo Holdings, Inc.

Catalytic ORR activity of carbon-based materials is one of the most interesting and exciting subject of carbon material science, because it gives us an expectation of large cost-down of the polymer electrolyte fuel cell (PEFC) by replacing the current expensive platinum-based catalyst. Doping of non-metallic hetero-atoms to carbon materials is fascinating to realize the catalysts. Nitrogen is the oldest element recognized as an effective dopant. Doping of multiple elements, co-doping, enhances the possibility of catalyst designing. In this paper, we report the ORR activity and its origin of the PN-doped carbons. The PN-doped carbons used were prepared from precursors obtained by modifying folic acid by phosphoric acid at a temperature ranging from 400°C to 1000°C after removing the unreacted phosphoric acid. Carbonization at 1000°C in an inert atmosphere converted the precursors to PN-doped carbons. The ORR activity of the PN-doped carbons showed enhancements in the ORR activity in both acidic and basic electrolytes compared to the N-doped carbons prepared by carbonizing folic acid. A combined study of XPS and molecular orbital calculation revealed the ORR activity originating from a structure with pyridinic-nitrogen and >PO₂ species located at adjacent positions of the zigzag edge of graphitic layer. The PN-doping also resulted in lowering the work function, indicating the ORR activity enhancement originated from the changes in the electronic states of carbons.