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Achievement of distinctively high durability at nanosized Pt catalysts supported on carbon black for fuel cell cathodes

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ABSTRACT

We have established a method for the preparation of Pt nanoparticles (NPs) with a series of target mean-diameters (d_m) and sharp size-distribution, supported on graphitized carbon black (GCB), Pt/GCB, without changing the mean interparticle distances ($d_{Pt\text{-}Pt}$), on GCB surfaces. This is achieved by the deposition of additional Pt-skin layer(s) on the NPs surfaces of the core Pt/GCB from its suspending aqueous solution, which contains precise amounts of Pt-complex equivalent to the projected thickness of Pt skin-layer(s), by simple bubbling of hydrogen, where the core Pt/GCB was prepared by the nanocapsule method that is able to provide NPs with highly uniform dispersion on the support with an extremely narrow size distribution. Contrary to the common view, we were able to demonstrate a lack of dependence of the long-term stability on the particle size of Pt NPs (d_m < 5 nm) using test protocols for monitoring the load-change cycling and start/stop operation of polymer electrolyte fuel cells (PEFCs) at 65°C. This finding is the evidence of that the so-called “particle size effect” on the stability is not intrinsic but avoidable for the NP catalysts in addition to our previous demonstration of the independence of the initial specific activity upon Pt NPs sizes for the oxygen electroreduction. This deviation from “common-sense,” i.e., the improvement of the activity and stability at Pt NPs by means of the sharp size distribution and their uniform dispersion on the GCB support, becomes extremely important as a guiding principle to develop cathode catalysts for practical PEFCs. The present unique achievement of the durability is probably brought about by the mitigation of nonuniform growth of Pt NPs via Ostwald ripening. This is most likely due to the uniform Pt dissolution/re-deposition among the uniformly sized and distributed nanoparticles.

Keyword:
Fuel Cell; Pt Nanoparticle; Durability; Particle Size Effect; Cathode Catalyst

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