

Durability of carbon-supported electrocatalysts in alkaline electrolytes for fuel cell applications

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Alkaline fuel cells (AFC) may compete with proton-exchange membrane fuel cells (PEMFC) for stationary or portable applications.^[1] The intrinsic stability of many metals and metal oxides at high pH^[2] led the scientific community to admit that AFC electrocatalysts should be more stable than PEMFC ones, but it is not the case for carbon-supported Pt and Pd nanoparticles (NPs) aged in liquid alkaline environment: severe electrochemical surface area losses are observed upon mild accelerated stress tests in 0.1 M NaOH^[3,4] (Figure). Pronounced detachment of the Pt (and Pd) NPs from the carbon support occurs, but minor degradation of the metal NPs and of the carbon support are observed by identical-location transmission electron microscopy (ILTEM). Additional experiments performed in various alkaline electrolytes (LiOH, NaOH, KOH, CsOH) coupled with *in situ* Fourier-transform infrared spectroscopy linked this detachment to the formation of solid carbonates at the interface between the Pt (Pd) NPs via carbon support corrosion: in essence, the Pt (Pd) NPs do locally catalyze the carbon support corrosion (firstly carbon surface oxides groups are formed, then evolve into CO₂, which leads to the formation of carbonate anions in alkaline environment and finally to metal carbonate precipitation, M₂CO₃, M = Li, Na, K or Cs).^[5]

The loss of Pt NPs is mitigated for solid alkaline electrolytes (anion-exchange membrane), because the counter-cation of the OH⁻ species are immobilized on the polymer backbone and cannot lead to precipitation into M₂CO₃, which happens in MOH aqueous electrolytes. This minored degradation of the Pt/C NPs in AEM electrolytes does not mean that no degradation processes are at stake, though: Ostwald ripening and Pt redeposition are observed. This means that the nature of the predominant mechanisms of degradation differ in solid *versus* liquid alkaline environment, which had also been demonstrated for solid *versus* liquid acidic electrolytes.^[6,7] Finally, it will be shown that these degradations are not unavoidable; non-noble electrocatalysts (e.g. Ni-based) prove much more resistant to corrosion in alkaline environments,^[8] and should therefore be more durable in AFC applications.

References

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