Degradation of Catalyst for PEMFCs

The durability of polymer electrolyte membrane (PEM) fuel cells is a major barrier to the commercialization of these systems for stationary and transportation power applications. Commercial viability depends on improving the durability of the fuel cell components. Durability is difficult to quantify and improve primarily because of the quantity and duration (i.e., up to several thousand hours or more) of testing required. To improve fuel cell durability the individual components need to be well characterized to determine and quantify degradation mechanisms that occur.

Electrode material durability is an important factor in limiting the commercialization of polymer electrolyte membrane fuel cells (PEMFCs). PEMFCs typically use carbon supported nanometer sized Pt and/or Pt alloy catalysts for both anode and cathode. Earlier studies [1,2] have shown that PEMFCs operating under constant potential for thousands of hours gradually lose catalytic active surface area by nano-particle grain growth. Recent testing indicates that potential cycling accelerates the rate of surface area loss [3,4].

Figs. 1(a) and (b) are TEM micrographs of the original Pt/C catalyst and the degraded catalyst. It is clearly the most of the Pt particles have obvious aggregation and the Pt content in the catalyst has a considerable decrease. The morphology of the carbon support also has a difference and which may be attributed the corrosion and aggregation of the C. Pt black is formerly considered stable than carbon black because the oxidation potential of carbon in acid is lower to 0.207V vs. RHE (saturated hydrogen electrode) and the Pt catalyst can accelerate the corrosion of carbon [5].

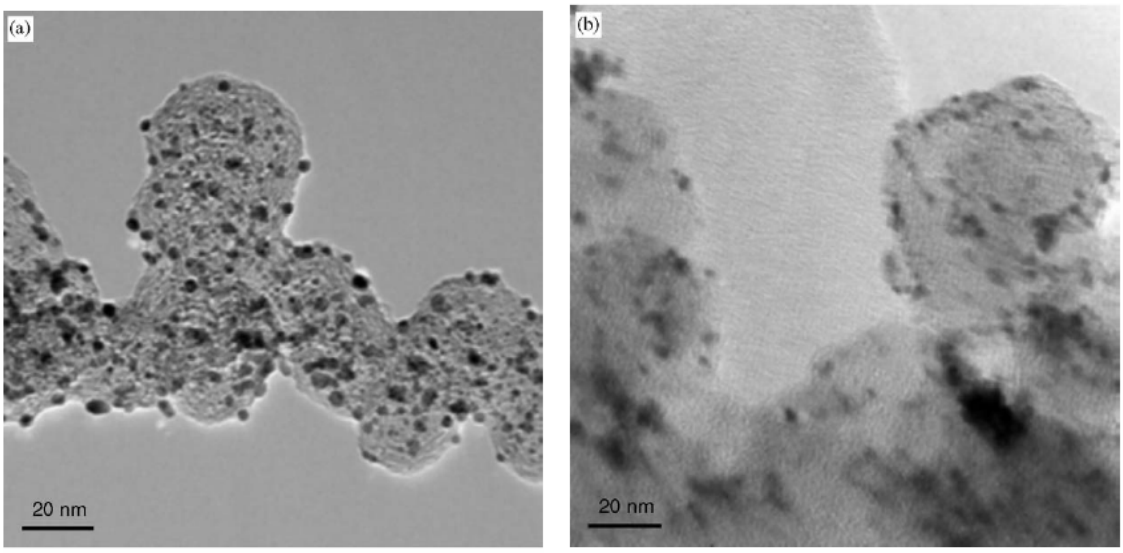

Fig. 1 TEM micrographs of the original Pt/C catalyst (a) and the degraded catalyst (b).

In order to investigate the ambiguous result, XRD are used to analyze the catalyst (Fig. 2). The particle size of the Pt nanoparticles size and the crystalline lattice parameter are calculated. The particles size has an increase from 3.0 to 3.5 nm, not so serious than the change observed in the TEM micrograph (Fig. 1b). The comparison shows the aggregation of the Pt particles is a physical aggregation and the fact that Pt content has a higher decrease can be possibly ascribed to the platinum missing as metal particles when the contact carbon layer has been corroded.

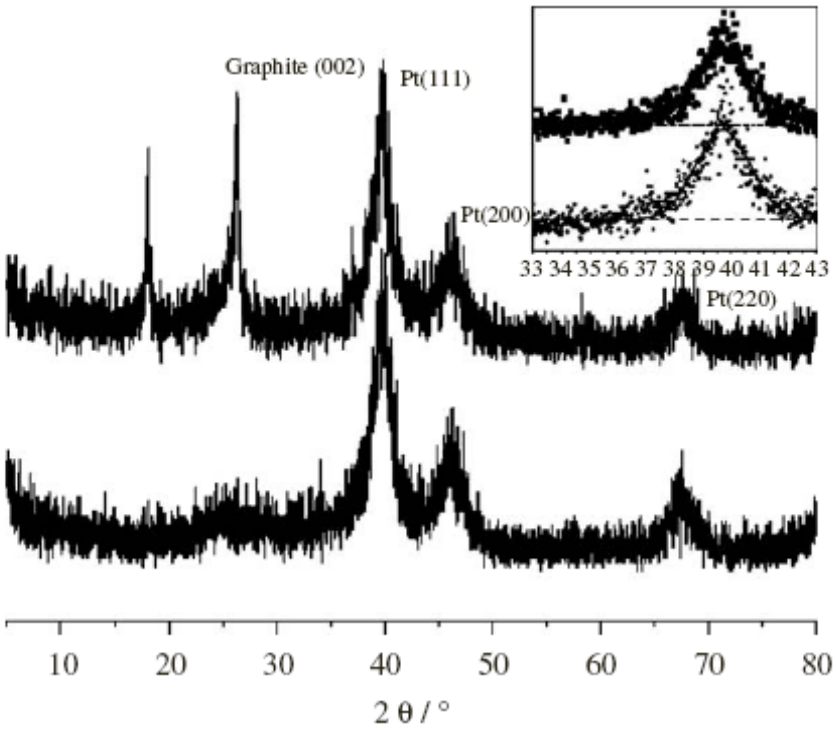

Fig. 2 XRD analysis of the original Pt/C catalyst and the degraded catalyst.

Pt/C catalyst and the degraded catalyst were investigated by cyclic voltammetry using a rotating disk electrode (Fig. 3). In addition to the reduction of hydrogen oxidation current, oxygen reduction potentials have a considerable decrease from ～0.48V vs. SCE to ～0.4V vs. SCE while the hydrogen oxidation potentials maintain constant. The decrease of the reduction potential generally suggests the oxygen reduction activity on the degraded Pt/C catalyst have a considerable decrease comparing with original Pt/C catalyst. The decrease of the oxygen reduction activity is also an important evidence of catalyst degradation.

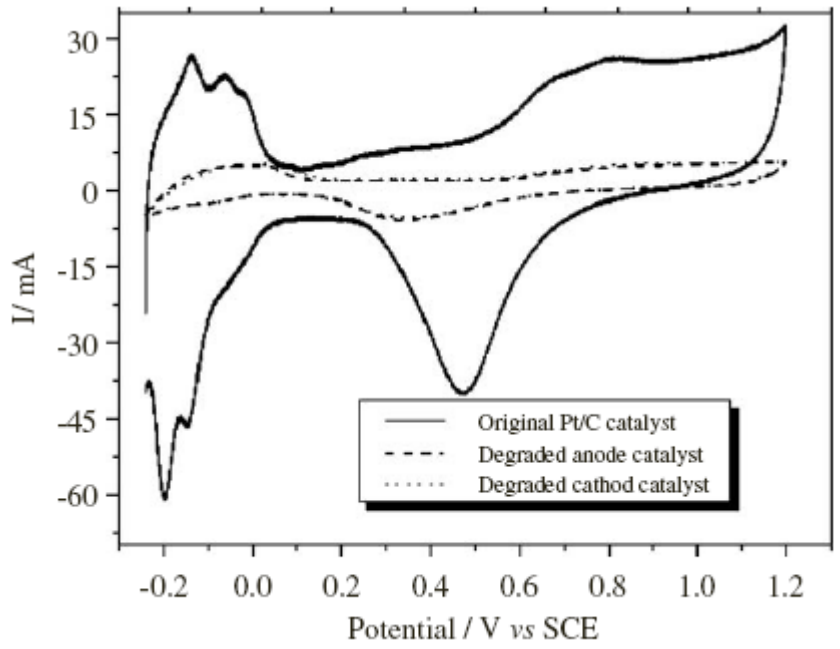

Fig. 3 Cyclic voltammetry of the original Pt/C catalyst and the degraded catalyst.

Electrocatalyst surface area loss is due to the growth of platinum particles. Particle size growth is accelerated by potential cycling whether due to artificial potential cycling or by cycling during fuel cell operation. Catalysts Electrocatalyst surface area loss is due to the growth in platinum particle size.

• Pt particle size growth is accelerated by potential cycling whether due to induced artificial cycling or by cycling such as during testing utilizing an automotive drive cycle.

• Pt particle size growth occurs more rapidly during cycling to high potentials.

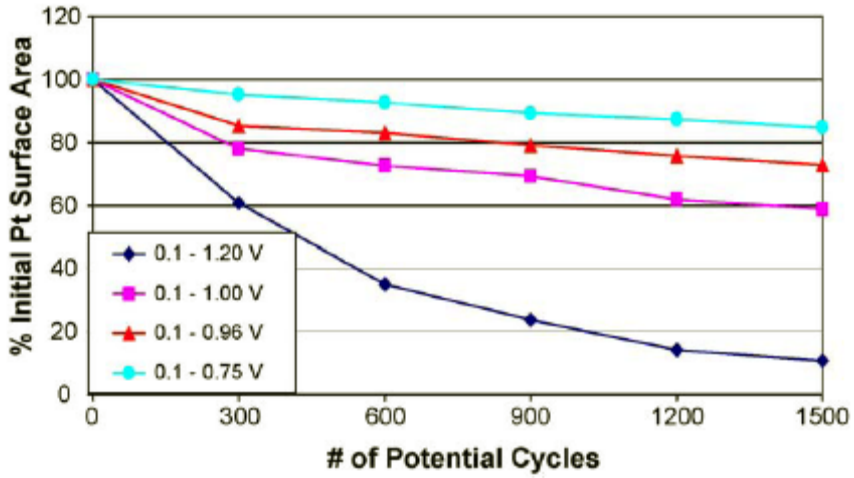

Fig. 4 Potential effects on catalyst surface area loss.

• The Pt particle size rate of growth increases with increasing temperature.

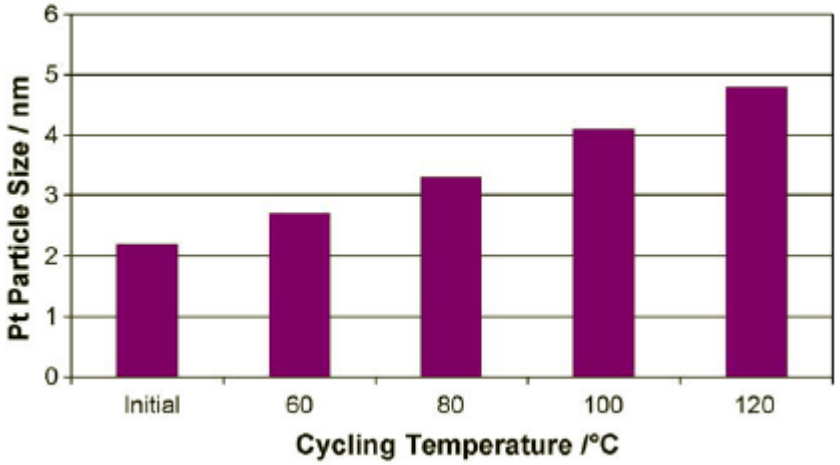

Fig. 5 Temperature effects on catalyst agglomeration.

• The rate of Pt particle growth decreases with decreasing relative humidity.

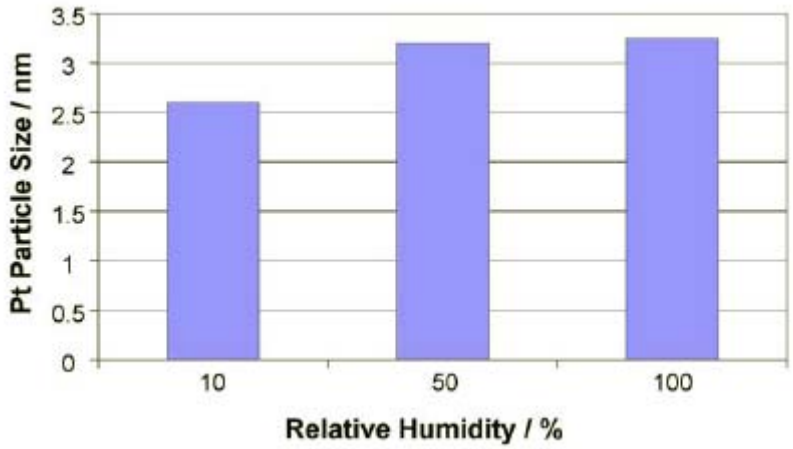

Fig. 6 RH effects on catalyst agglomeration.

• Carbon corrosion was observed to increase with increasing potential and decreasing relative humidity.

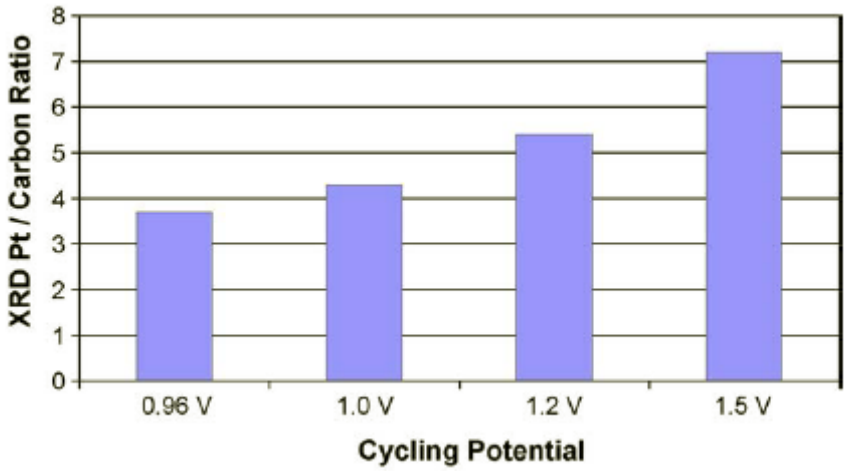

Fig. 7 Potential effects on carbon corrosion.

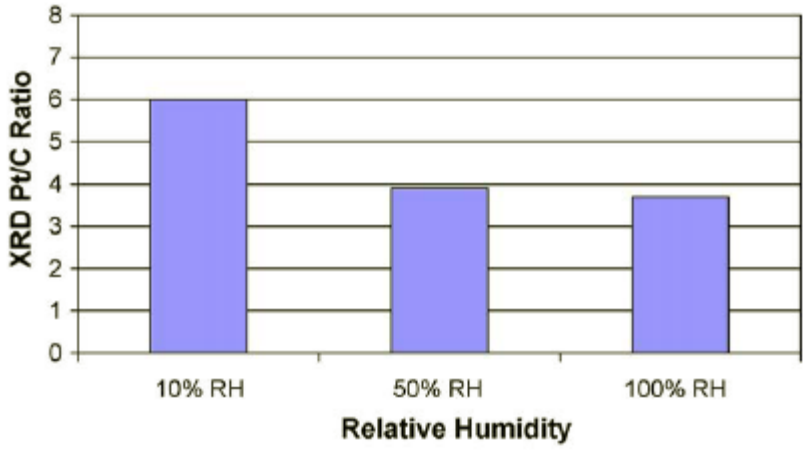

Fig. 8 RH effects on carbon corrosion.

References

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