

Effect of the Modification of Carbon on the Performance of Fuel Cell Catalysts

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Introduction

Both the anode and cathode in proton exchange membrane (PEM) fuel cells are often made of high surface area carbon. This is because the high surface area carbon is both electronically conductive, and is able to anchor the metallic active species that are used as catalysts. It is known that the addition of functional groups to the surface of this high surface area carbon can greatly influence the ability of metallic active species to anchor themselves to the surface of the carbon. Several methods have been applied to modify the surface of the carbon in order to produce a surface that is rich in oxygenated species. Several papers have been published [1, 2] about the characterization of modified carbon surfaces, with at least one [3] specifically focusing on electrocatalytic performance.

Materials and Methods

Vulcan carbon XC 72R (VC), purchased from Cabot, was used throughout this work. The VC was thermally oxidized in a 5% oxygen/95% helium flow for 5 h at 550 °C in a Quantachrome Instruments Chembet-3000. The products were analyzed with an Omnistar Mass Spectrometer made by Pfeiffer, connected in-line. Diffuse Reflectance Infra Red Fourier Transform Spectroscopy (DRIFTS) spectra were collected with a Thermo Nicolet model Avatar 360FT-IR with a DRIFTS cell. The catalysts were prepared from a Pt sol, which was prepared as previously reported in literature [4]. The metal salt precursor (H_2PtCl_6 , > 37.5 % metal basis, 99.9 % pure, Aldrich) was added to two parts of sodium ethoxide (NaOEt), synthesized 'in-house' by dissolving Na metal (99.95 %, Aldrich) in 10 ml of absolute ethanol. The resulting solutions were refluxed for ~2 hours and then stirred at room temperature for ~20 hours, all under an Ar atmosphere (Praxair).

A 7 mm diameter glassy carbon (GC) rotating disk electrode (RDE) was used for the electrochemical measurements and a three-electrode electrochemical cell was used. The cell solution (typically 0.5 M H_2SO_4) was purged with vigorously bubbling N_2 and then maintained under a N_2 atmosphere at a flow rate of 36 mL/min during the electrochemical measurements. The cyclic voltammograms (CVs) were collected in a N_2 -purged aqueous solution at 25°C with no electrode rotation, with the electrochemistry controlled by an EG&G PARC 175 function generator used in conjunction with a Hokuto Denko HA-301 potentiostat.

Results and Discussion

After the thermal treatment, the DRIFTS spectra show a variation in the intensity of the signals at 1637.4 cm^{-1} and 3423.8 cm^{-1} that correspond to carboxyl and OH groups, respectively. Figure 1 shows the CV plots in N_2 of the catalyst with Pt, (a) using the VC as received, (b) after thermal treatment. It is evident that after thermally modifying the VC, it has a higher

capacity to anchor Pt. This suggests that the thermal modification of carbon gives a higher Pt loading and thus an increased activity towards the Oxygen Reduction Reaction (ORR) is expected. We can infer that the higher loading of Pt in the catalysts using modified VC is due to the modification of the functional groups introduced by the thermal treatment, likely favoring Pt deposition.

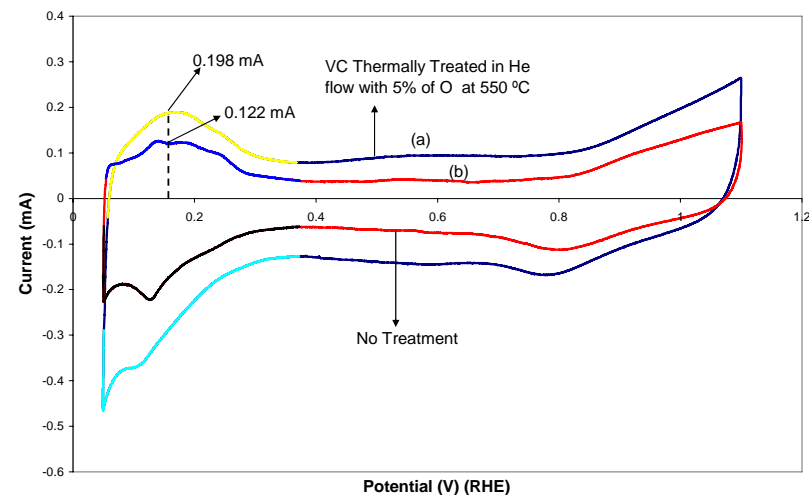


Figure 1. Cyclic voltammograms (10 mV/s, 0.5 M H_2SO_4) of Pt/C catalyst using (a) as-received Vulcan Carbon thermally treated in 5% O_2 95% He flow vs.(b) untreated VC.

From the charge passed in the HUPD region of the CVs, we have determined the amount of Pt deposited on the carbon, indicating that the amount of Pt in the treated VC is roughly 70% higher than in the untreated VC.

Significance

The methodology employed in this work is important because it could be a way of reducing the amount of metal used in the catalyst preparation.

References

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