Analysis of carbon substrates used in non-precious metal catalysts for fuel cell applications

N. Subramanian, H. Kim and
B. N. Popov
Department of Chemical Engineering
University of South Carolina, Columbia, SC 29208

Introduction

Slow oxygen reduction reaction is one of the limiting factors for the performance of fuel cells. Pt supported on carbon is the state of art cathode catalysts used in PEMFC. Pt has been alloyed with other transition metals and these have shown an improved catalytic activity [1]. The goal now is to develop non-precious metal catalysts. The mission of developing next generation fuel cells will be aided by synthesizing non-precious metal clusters with activity similar to the Pt catalysts currently in use and cost at least 50% less compared to a target of 0.2g (Pt loading)/peak kW.

It has been shown that non-precious metal catalysts like Co, Fe and Cr supported on carbon have shown activity towards oxygen reduction when treated with a nitrogen containing precursor [2].

The objective of the present work is to study the effect of carbon substrates on oxygen reduction reaction. An attempt was made to generate a metal free catalytic site for oxygen reduction reaction. The surface of Ketjenblack and Vulcan XC-72 supports were modified using chemical and thermal pretreatments. The treated carbons were evaluated in an acidic medium using rotating ring disc electrode (RRDE) method. The half wave potential, $E_{1/2,}$ for oxygen reduction peak was used as a measure for the electrocatalytic activity of the catalyst.

Studies of carbon are also important for another reason. It has been reported that high activity for oxygen reduction reaction results from the presence of both the transition metal and the nitrogen groups created by heat treatment (M-N_4 structure). Thus, to create active sites, it is necessary for the transition metals to be impregnated onto a carbon support. Next, a thermal post heat treatment is used to introduce the nitrogen groups into the catalyst. During the post heat treatment, due to a sintering effect, the impregnated metal particles aggregate, leading to an increase in the particle size of the catalyst. Since a smaller particle size leads to a higher activity for oxygen reduction, it is important to study whether carbon pretreatments reduce the sintering effect of transition metal particles. This effect was studied by evaluating the performance of a transition metal catalyst prepared with treated and untreated carbon supports.

Results and Discussion

Fig. 1 shows the performance of untreated and treated Ketjenblack samples. A comparison of the best performing Ketjenblack and Vulcan XC-72 is shown in Fig. 2. Vulcan shows the best electrocatalytic performance when a combination of chemical and thermal treatment (treatment 7) is used to create the catalytic active sites on carbon. The results indicate that a nitrogen precursor and high temperature are necessary to generate a metal-free catalytic site. Our future work will include optimization of carbon modification processes. Modified carbon would be used for impregnation of optimized transition metal alloys. XPS studies will be conducted on carbon surfaces in order to identify the surface groups present on both treated and untreated carbons.

References

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2. [2] R. Cote, G. Lalande, G. Faubert, D. Guay, J. P. Dodelet and G. Denes, *J. New Mater. Electrochem. Syst.*, **1**, 7 (1998).

Acknowledgment

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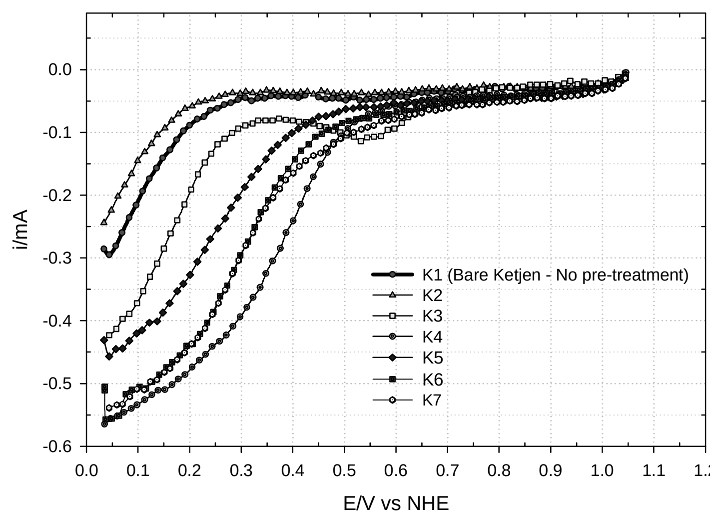

Fig. 1 Disk Currents of Ketjenblack with different treatments at 900 rpm with a scan rate of 5 mV/s.

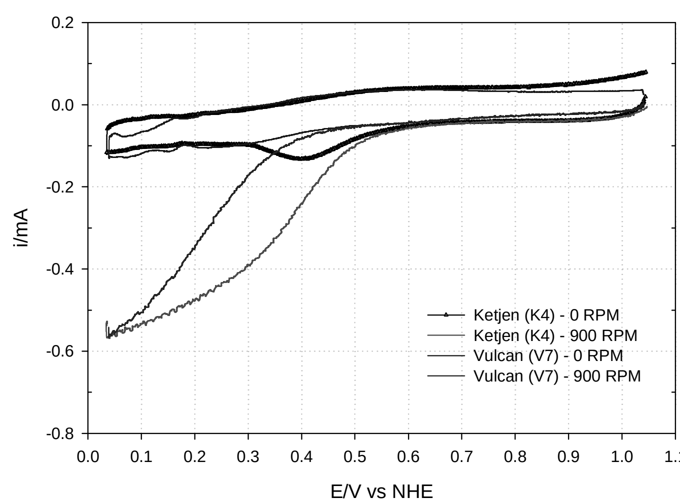

Fig. 2 Comparison of performance of treated Ketjenblack (K4-treatment 4) and Vulcan XC-72 (V7-treatment 7).