Single Wall Carbon Nanotube - a catalyst support for PEMFC

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Abstract

Carbon nanotubes, prepared by the catalytic decomposition of acetylene at 700^{0}C over a Mm based AB_5 hydrogen storage alloy hydride catalysts, have been used as a support for platinum electrocatalysts. The performance of this electrocatalyst in proton exchange membrane fuel cells has been studied and discussed.

Introduction

Nanostructured carbon materials are potentially of great technological interest for the development of electronic, catalytic and hydrogen-storage systems. The current state-of-the-art catalyst for both the oxygen and hydrogen electrodes in a polymer electrolyte membrane (PEM) fuel cell is based on Pt on a carbon support. When using pure hydrogen and oxygen as the fuel and oxidant, essentially the same Pt catalyst is used at both electrodes of PEMFC in different amounts. The fuel cell's characteristics are claimed to offer a significant improvement over conventional activated carbon

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electrodes because of their higher surface area and also easy permeation of gas and liquid inside the

nanotubes. Their identifying characteristic is that, when many of them bundle together, an aggregate of 100 nm is created. It was observed that the size of the catalyst particles is one of the most important factors that determine the performance of the fuel cell, with smaller particles leading to higher performance [1]. It has also been shown that surface-modified single wall nanotube electrodes could be chemically coated with catalyst at nanoscale levels to provide fuel cell output comparable to conventional cells but with about one-tenth less platinum catalyst[2]. In the present paper, we have investigated the preparation and characterization of carbon nanotube based Pt electrocatalyst, and report the preliminary studies on the performance of the catalyst for proton exchange membrane fuel cells.

Experimental

Carbon nanotubes were prepared by the catalytic decomposition of acetylene at 700^0C over a Mm based AB_5 hydrogen storage alloy hydride catalysts prepared by the hydrogen decripitation route. The as-synthesized carbon nanotubes were purified followed by air-oxidation to remove the amorphous carbon and the alloy-hydrides [3]. Carbon nanotube supported platinum electrocatalysts were prepared by dispersing the purified CNT's in dimineralised water for about 30 mts and slowly 1% chloroplatinic solution was added to the suspension. After 24 hrs magnetic stirring, 1% sodium borohydride solution was added to reduce the platinum. The solution was then filtered and the catalyst powder was dried at 80^0C for about 12 hrs. The pure CNT and platinum loaded CNT samples were characterised by SEM. X-ray Energy Dispersive Spectrum was taken to determine the quantity of platinum loaded in the CNT. Electrodes for the fuel cell were prepared by taking a commercially available electrode backing material carbon paper. The catalyst layer was prepared by brushing the slurry prepared using the Pt loaded CNT with 5 % Nafion solution and water. Two catalyst coated electrodes of 5 sq cm were placed on both sides of a pretreated Nafion 1035 membrane and hot pressed at 130^0C for about 2 mts at a pressure of 1000 psig for about 2 mts. Fuel cell experiments were carried out by placing the pressed membrane electrode assembly in the single cell test fixture from Electrochem Inc, USA. The fuel cell was connected to the

NARA cell test station, from where the humidified fuel and the oxidant was supplied to the fuel cell. The current voltage characteristics of the cell was evaluated at various temperatures using a WON-A-TECH (HPCS 1) system.

Results and discussion

Fig. 1 shows the SEM photograph of the platinum loaded carbon nanotube, which reveals that some platinum particles are being decorated at the edges and some well within the tubes. From the X ray energy dispersive spectrum analysis, the platinum loading was estimated around 2.3 wt% with respect to carbon, which is qualitative. Fig 2 shows the polarization curve of the single cell along with the performance of the commercial catalyst. Fig. 2 shows the difference in performance between the commercial catalyst and the CNT supported catalyst and the difference in the voltage between the commercial catalyst and the CNT supported catalyst increases with increase in current density, which could be attributed to the low loading of 2.3 wt % platinum in the CNT in comparison with the commercial catalyst, which is 20% Pt. The platinum dispersion of clusters is very important for promising electrocatalytic activity for oxygen reduction, which is required for fuel-cell technologies. Further studies are in progress to get a higher loading Pt on the carbon nanotubes.

Conclusion

Test runs on a single cell polymer electrolyte membrane fuel cell with carbon nanotube based Pt electrocatalyst showed that these electrocatalysts are very promising for fuel cell applications. There still exists scope for further improvement in the fuel cell performance, if the platinum loading in the carbon nanotube could be increased to a reasonable level.

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References:

1.Joo, Sang Hown; Choi, Seong Jae; Oh, Ilwhan; Kwak, Juhyoun; Liu, Zheng; Terasaki, Osamu; Ryoo, Ryong.

Nature 412 (6843),2001, 169-172.

2. Bessel, Carol A.; Laubernds, K; Rodriguez, Nelly M.; Baker, R. Terry K. Journal of Physical Chemistry B (2001), 105 (6), 1115-1118

3. M.M. Shaijumon, S.Ramaprabhu

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Fig.1 SEM photograph of the Pt electrocatalyst supported on carbon Nanotube

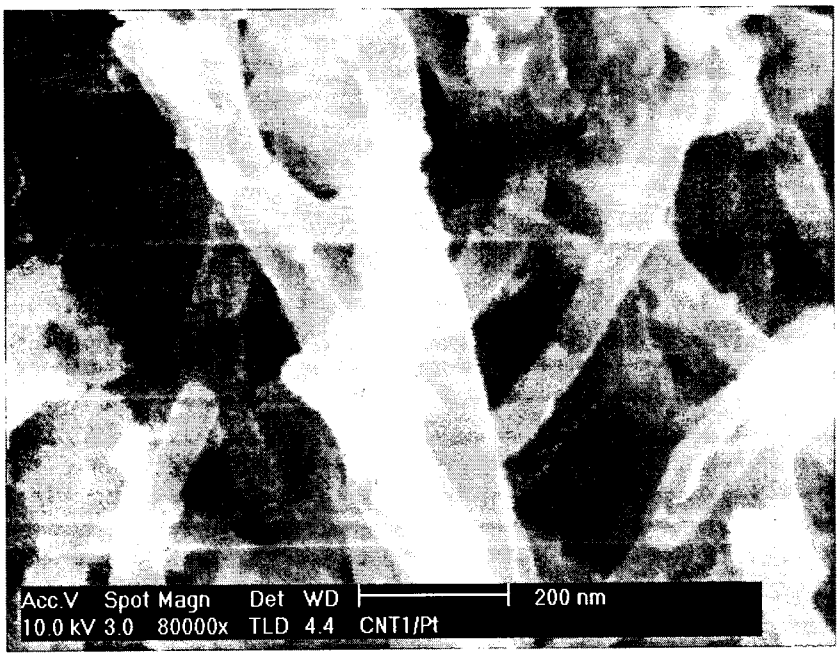

Fig.2 Fuel cell performance of CNT based Pt electrocatalyst