Understanding of catalytic performance of direct methanol fuel cell electrodes using gas-phase-synthesized carbon nanofibers

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Introduction

The anode performances of carbon nanofibers (CNFs) as support materials were examined to improve the activity of Pt-Ru/CNFs catalysts for the performance of the Direct methanol fuel cell (DMFC). The structural effect of CNFs such as platelet, herringbone and tubular fibers on the anodic performance was evaluated using a Cyclic Voltammetry (CV) method, SEM, TEM, and so on. Several kinds of CNFs were prepared from thermal CVD method using metal catalysts in our laboratory. Carbon nanofiber and their adequate modifications can afford various defined structures, surfaces, and nano-spaces for Pt-Ru metal particles. The present authors examined the Pt-Ru catalytic performances at defined parts of carbons, such as edge and basal planes, inclined edge and perpendicular edge, or graphitization degree of basal planes. Measurements of catalytic performance were carried out using 60 wt% Pt-Ru (1:1 mol/mol) supported on the various gas phase-grown carbon using 3-electrode half cell connected CV system. The anodic performance of catalyst supported on the CNFs was compared to that of the commercial E-TEK catalyst.

Experimental

The carbon paper (Toray co., SHF-806B) was used in this experiment as the electrode diffusion layer and catalyst supporting material which was treated for giving the hydrophobicity as Teflon dispersion solution (Mitsui・ Dupont

Fluorochemical Inc., FEP120-J). The PtRu/CNFs catalyst was prepared after mixing the CNFs with distilled water, and added $RuCl_3 \cdot nH_2O$ (Wako Co.) and $H_2PtCl_6 \cdot 6\,H_20$ (Wako Co.) with stirring. The slurry was reducted using 0.5M $NaBH_4$. and the filtering, washing and drying were subsequently done. The catalyst slurry was prepared through the mixing with 20 wt% of Nafion solution (Wako Co, 5% Nafion dispersion solution) compared to Pt weight and catalyst. The slurry was brushed on the carbon paper. The weight of Pt-Ru/C catalyst was controlled to 2±0.5mg and subsequently dried at room temperature for 12hr. The Cyclic Voltammogram was measured at the room temperature for the scan speed of 20mV/sec using an equipment of Hokudo Denko Inc., HZ-3000.

Results and Discussion

Table 1 shows the schematic picture of various CNFs used as supported materials in the experiment.

Table 1. Schematic picture of various CNFs used as supported materials in the experiment.

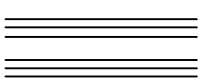
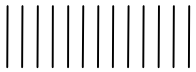
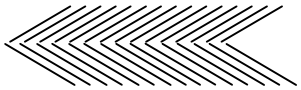
	Tubular	Platelet	Herringbone	
Struc-ture				
dia.	20nm	150nm	150nm	10nm
code	Tubular	Platelet	Herringbone-150	Herringbone-10

Fig. 1 show SEM photographs of various CNFs with 10-200 nm diameter. The tubular CNF (carbon nanotube) shows high uniformity in diameter of 20 nm and high aspect ratio. The platelet and herring 150-CNFs show good linearity, otherwise low aspect ratio was observed in the platelet-CNF. Herringbone-10 shows good uniformity in diameter and low linearity.

Fig. 2 show Cyclic Voltammograms of various catalysts supported on the CNFs and compared with the commercial E-TEK catalyst supported on the Vulcan XC72-R. The highest value of current was observed in the herringbone 150-CNF to be 118 mA. However, the peak potentials of the catalysts supported on the CNFs were higher than that of the E-TEK catalyst about 0.2 V. The herringbone 10-CNF shows the lowest value of current as 20 mA. The authors were evaluated the reason of the result from the view of the size of Pt catalyst and surface property of CNF using a FE-TEM.

ACKNOWLEDGEMENT

This work was carried out within the framework of the CREST program. The present authors acknowledge the financial support of Japan Science and Technology Corporation (JST).

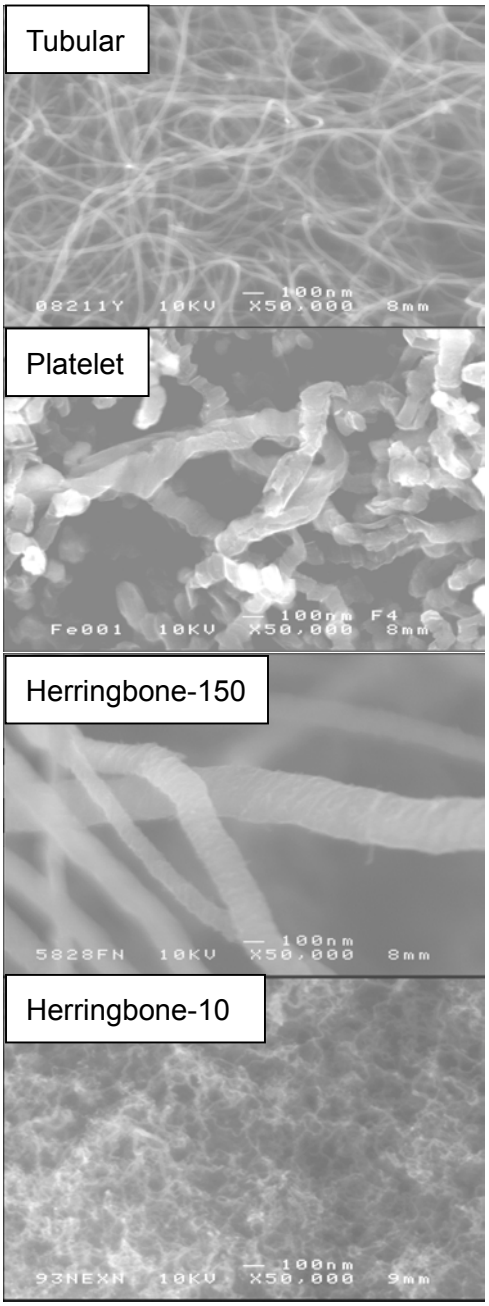


Fig. 1. SEM Photographs of various CNFs.

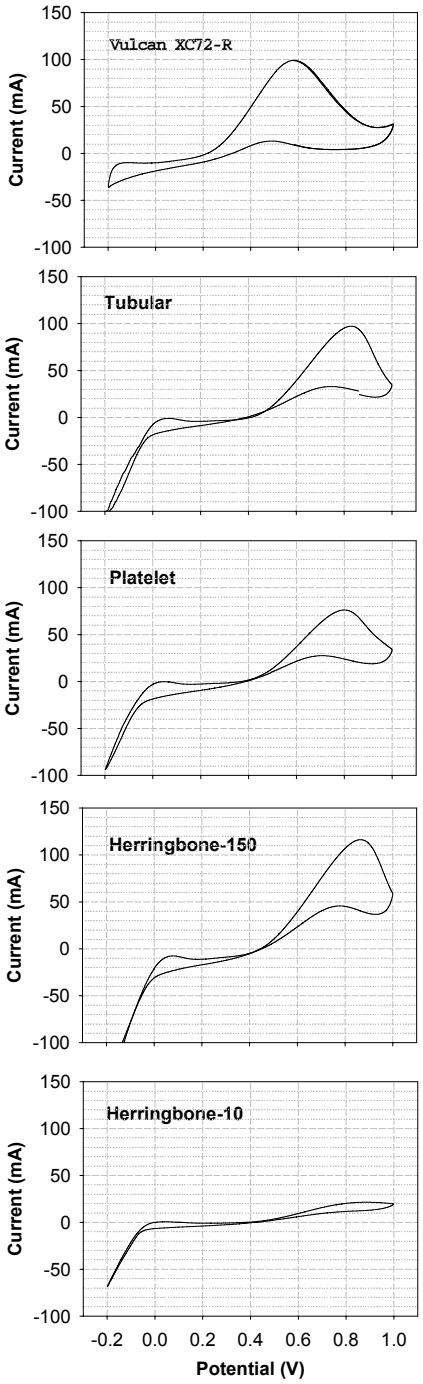


Fig. 2. Cyclic Voltammograms of catalysts supported on the various carbons