

Nanostructuring of PEFC Electrode Catalysts using Carbon Nanofibers

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Polymer electrolyte fuel cells (PEFCs) are promising energy conversion systems, while further improvement of electrochemical performance as well as a considerable decrease in noble metal loading are essential for their commercialization. Applications of carbon nanofibers, instead of state-of-the-art carbon black, may realize such improvements by nanostructuring PEFC electrode catalysts. In general, carbon black with a satisfactory electronic conductivity possesses a large specific surface area, suitable for catalyst dispersion, while carbon nanofibers possess an excellent electronic conductivity along with the fibers. In this study, carbon nanofibers are applied as electrode fillers and catalyst supports.

(1) Carbon nanofibers as electrode fillers

As model carbon nanofibers, vapor grown carbon fibers (VGCF®, Showa Denko) were used. Agglomeration of fibers was prevented, by applying a homogenizer to mechanically destroy the agglomerates. Fig. 1 shows the current-voltage (I-V) characteristics of a cell with cathode, to which carbon fibers were added (mixed) as electrode fillers. With increasing the amount of carbon fibers added, Pt loading decreases. However, we have found an improvement of electrochemical performance by adding carbon fibers. Consequently, I-V characteristics could be improved especially at higher current densities, whereas Pt loading was decreased 15 %. Lower electrical conductance, a homogeneous microscopic current collection, and thus a more effective use of Pt catalysts may be reasons for these improvements.

(2) Carbon nanofibers as catalyst supports

Since it has been known that the surface of carbon fibers, especially carbon nanotubes, is chemically stable in general, high dispersion of noble metal catalysts on carbon fibers could be difficult. First, the mixtures of carbon nanofibers (VGCFs) with carbon black were applied as catalyst supports. Vulcan (XC72, Cabot Co.) was used as a model carbon black. Pt catalysts were prepared via the conventional impregnation technique. I-V characteristics of cells using such (mixed) supports were measured. Cell voltage at 200 mA/cm² was shown in Fig. 2, indicating that cell voltage exhibited an optimum around 10-25 % (VGCF). The dependencies of ohmic and nonohmic overvoltages on the fraction of these carbon nanofibers have also been revealed.

As Pt crystallite size of these electrode catalysts was ca. 20-30 nm, an in-situ colloidal process using H₂PtCl₆, NaHSO₃, and H₂O₂ was also applied. As an example, FESEM micrograph of electrode catalysts using carbon black was shown in Fig. 3. This process enables to prepare highly-dispersed Pt particles in a diameter of a few nanometers. We therefore applied this preparation procedure to carbon nanofibers used as catalyst supports. FESEM micrograph of Pt electrode catalysts using carbon nanofibers (VGCF) was shown in Fig. 4. Pt catalyst particles were homogeneously dispersed on this highly-

conductive carbon nanofibers. Electrochemical evaluations of such nanofiber-supported electrode catalysts are in progress.

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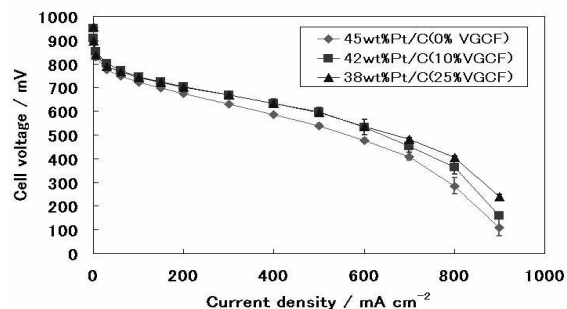


Fig. 1: I-V characteristics of cells with cathode containing different amounts of carbon nanofibers (VGCFs). 45wt%Pt/C (0% VGCF, Pt loading: 0.52mg/cm²) 42wt%Pt/C (10% VGCF, Pt loading: 0.49mg/cm²) 38wt%Pt/C (25% VGCF, Pt loading: 0.44mg/cm²)

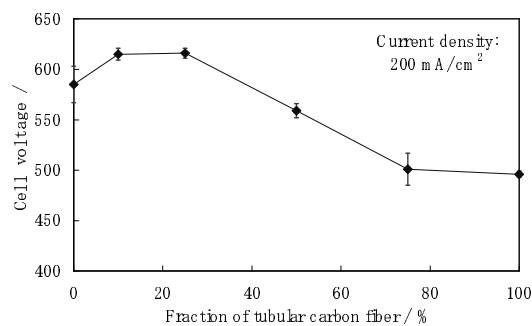


Fig. 2: Cell voltage at 200mA cm⁻² with various contents of carbon fibers (VGCFs) in electrode catalysts.

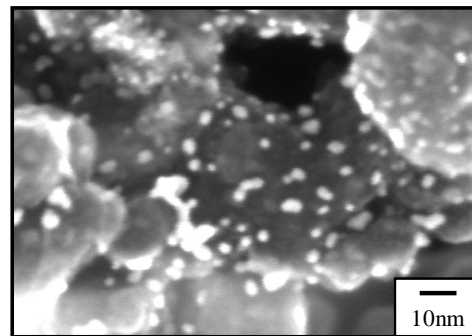


Fig.3: FESEM micrograph of Pt/C(carbon black) electrode catalysts prepared via in-situ colloidal impregnation.

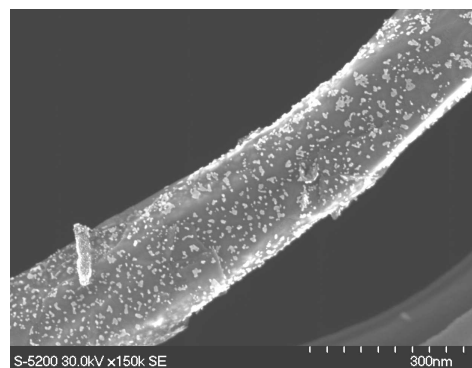


Fig.4: FESEM micrograph of Pt/C(VGCF) electrode catalysts prepared via in-situ colloidal impregnation.