MODIFICATION OF C/C COMPOSITE BIPOLAR PLATE BY ADDITION OF ELECTRO-CONDUCTIVE CARBON BLACK

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Introduction

Fuel cells constitute at present one of the most promising sources of energy for the future[1]. In the existing polymer fuel batteries one of the structural elements requiring improvement is the so-called bipolar plate, which is the connecting device between the single cell units, conventionally made of graphite[2]. The bipolar plate is a multi-functional component within a solid polymer fuel cell (SPFC) prismatic stack. Its primary function is to supply reactant gases to the gas diffusion electrodes (GDE) via a flow field in the surface. It must also provide series of electrical connection between the individual cells, and effectively remove product water. An ideal bipolar plate would incorporate the merits of these materials, such that it would be high in electrical conductivity and corrosion protection, of low density but with high mechanical strength, impermeable to reactant gases, chemically inert, and allow for ease of manufacture. Carbon fiber reinforced carbon(C/C) composites are receiving interest and are considered as the most important candidate for bipolar plate, because of the high ratio of strength-to-density and the excellent corrosion resistance as well as the high electric conductivity. Its electric conductivity, however, is inherently insufficient to apply it to a bipolar plate. In this study, thus, to enhance the electric conductivity of C/C composite bipolar plate, modification of the plate was carried out via addition of electro-conductive carbon black(CB) which also can play a role to prevent the crack-growth of the composite.[3]

Experimental

PAN-based 2/2 twill-weave carbon fabric (from Toray Co. Ltd.) and phenol-formaldehyde resin were used for preparation of C/C composite. Electro-conductive carbon black(CB), HIBLACK, supplied from Korea Carbon Black Co. Ltd., was used for enhancing the electric conductivity of C/C composite bipolar plate. Phenol resin was utilized with solvent (methanol) and coated onto the carbon fabric to form a prepreg. Green body of C/C plate (50×50×5mm) was molded by hot pressing at 160°C for 2hrs and at 180°C for 2hrs. Carbonization of the green body was conducted as following step; heated up to 600 °C by 20°C/hr and held at that temperature for 2 hrs, and then heated up to 1200°C in the furnace.

The electrical conductivity of carbon plate was determined using a four point probe technique. Surface morphology was investigated by SEM. Flexural strength and modulus were determined by three point bending test (ASTM D 790M), while interlaminar shear strength (ILSS) was tested by short beam shear method (ASTM D 2344).

Results and Discussion

Electric conductivities of green body before carbonization and C/C plate with different CB content were shown in Fig.1. Electric conductivity of C/C plate without CB was not more than 13.5/Ωcm, while that of C/C plate containing CB increased with increasing CB content and up to 35.7/Ωcm at the highest (15wt%) CB content. Enhancement of electric conductivity stems from the increasing percolation path of conduction in the C/C plate by CB inclusion.

Fig.2 shows the surface of C/C plate without CB(a) and with CB(b). We can find a lot of crack-growth in C/C plate without CB(a) which plays as the defects of the composite. While, as shown in Fig. 2(b), it is obvious that the filling effect of CB was effectively appeared in C/C plate with almost crack-free feature.

Flexural strength and modulus of C/C plate with different CB content were shown in Fig.3. Flexural strength and modulus of C/C composite without CB were 180Mpa and 80Gpa, respectively. Both properties of CB-containing C/C composite increased with increasing CB content and showed the maximum value at 10 wt% of CB content. It is considered that CB has an adverse influence on the crack formation of the composite by filling effect and thus, reduces the microcracks or pores produced by carbonization. At above 10wt% of CB content, however, flexural strength and modulus decreased by the delaminating role of excess CB in C/C composite.

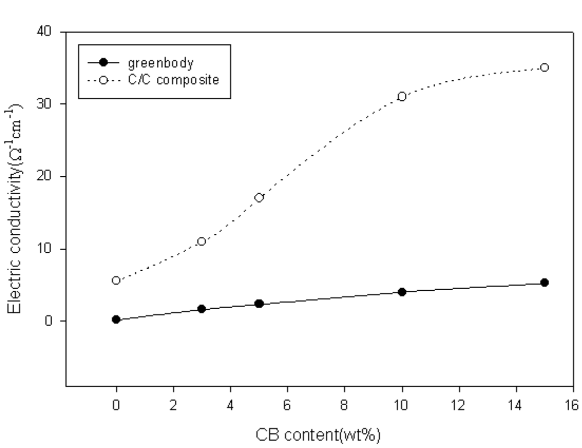
Conclusions

Modification of C/C bipolar plate for improving the electric conductivity was carried out by addition of electro-conductive CB. Inclusion of CB enhanced the electric conductivity of the C/C composite largely by increasing conduction path. In CB containing C/C composite, crack formation was reduced by the filling effect of CB. At 10wt% of CB content, C/C composite showed the maximum flexural properties as well as the high electric conductivity (32/Ωcm). But at CB content more than 10wt%, flexural properties were reduced by the delaminating role of excess CB in C/C composite.

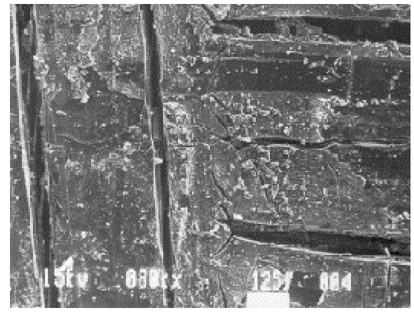
References

1. T.F. Fuller., *J. Electrochem Soc. Interface*, 6(3), pp.26-32, 1997
2. C. del Rio, M. C. Ojeda and J. L. Acosta, *European Polymer Journal*, 36(8), pp.1687-1695, 2000
3. E. Yasuda, Y. Tanabe and S. Kimura, *Proceeding of 4th International Carbon Conference*, pp.665-667, 1986

Fig.1 Electric conductivity of C/C plate with CB content.



(a)



(b)

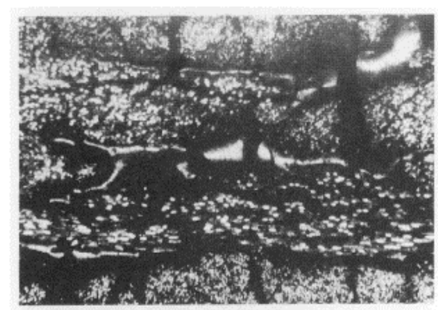


Fig.2 SEM micrographs of the C/C plate without CB(a) and with CB(b) (10wt%)

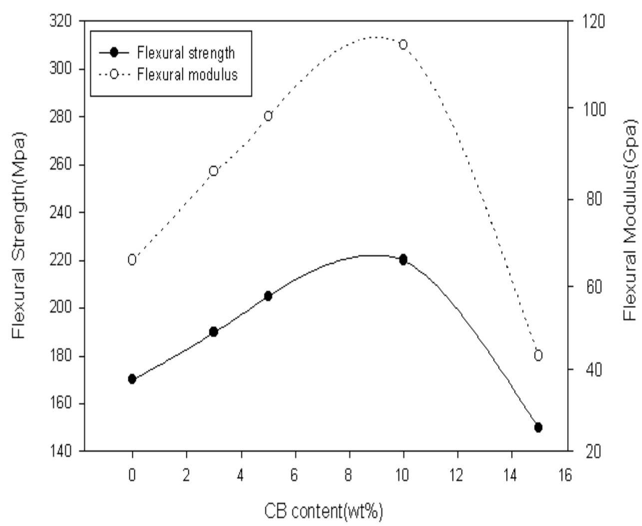


Fig.3. Flexural strength and modulus of C/C plate with different CB content