

The Effect of Carbonization Temperature of PAN Fiber on the Properties of Activated Carbon Fiber Composites

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Introduction

Activated carbon fibers(ACF) have been widely used in various areas such as water treatment, the removal of SO_x and NO_x and the adsorption of toxic gases. ACF was also used as precursor materials for the fabrication of SiC fiber by reaction with Si containing gaseous sources[1]. Recently, development of a rigid monolithic activated carbon fiber composite(ACFC) material based on pitch fiber was reported[2].

This study examined the effects of carbonization temperature of stabilized PAN fiber precursor on the mechanical and structural properties of the ACFC prepared

from mixtures of the carbonized PAN fibers and phenolic resin particles. Specifically, at two different temperatures, 1073K and 1273K, the stabilized PAN fibers were carbonized in a nitrogen atmosphere to develop two groups of carbon fibers. Then carbon fiber composites were activated at 1123K in carbon dioxide. It is the purpose of this paper to discuss what process condition provides high surface area and strength for ACFC prepared from mixtures of carbonized fibers and phenolic resin binder.

Experimental

Stabilized polyacrylonitrile fiber tows(Tae Kwang, Korea) were used as precursor fibers to produce activated carbon fiber composites in this work. Carbon fiber monoliths were prepared using a vacuum molding process. Two groups of carbon fiber composites(CFC) were developed from the precursor fibers carbonized at 1073K and 1273K, respectively. They were activated in CO₂ at a flow rate of 140cc/min at 1123K for 10 to 90 minutes to yield two groups of activated carbon fiber composites(ACFC), namely, 800F-ACFC and 1000F-ACFC, which were made of the precursor fibers carbonized at 1073K and 1273K, respectively.

Samples of ACFC were characterized by

measuring specific BET surface area and pore size distribution. Density measurements were made using the Archimedes principle. The strength of the ACFC samples was compared by the three-point bending test.

Results and Discussion

The specific surface areas for the two types of ACFC have been plotted as a function of burn-off value in Fig. 1. For activated carbon fiber composites made of the fiber carbonized at 1073K(800F-ACFC) maximum surface area of 1100m²/g was found at about 75% burn-off; more burn-off decreased the surface area. Above 35% burn-off, the specific surface areas of ACFC made of the fiber carbonized at 1073K(800F-ACFC) was much higher than those of ACFC made of the fiber carbonized at 1273K.

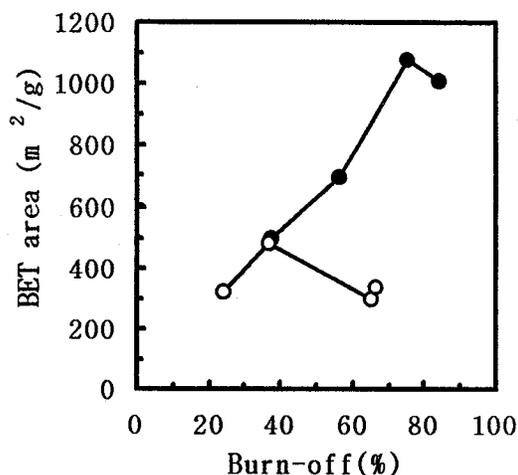


Figure 1. Specific surface area versus burn-off of carbon fiber composites. Carbon fibers were developed at: (●) 1073K; (○) 1273K.

The dominant pore sizes of the 800F-ACFC were around 1.8~2.0 nm. These values are similar to those of PAN based activated carbon fibers[3].

and higher than the dominant pore sizes of 0.8~1.0 nm found in the activated phenolic resin fibers by Kasaoka et al.[4]. The 1000F-ACFC had the dominant pore sizes slightly smaller than the 800F-ACFC. Therefore, it implies that the pore structure of ACFC is associated with that of PAN based activated carbon fiber which is the major constituent of ACFC prepared in this study

Fig. 2 shows the variation in bending strength of the two groups of ACFCs, 800F-ACFC and 1000F-ACFC as a function of burn-off of carbon fiber composites. The mechanical property of ACFCs decreased with increase of the burn-off as expected. The 800F-ACFC had always better bending strength than the 1000F-ACFC at the same burn-off value. Observation of the micrographs revealed detailed differences in structures of the two types of ACFC; the delamination at the interface of carbonized fiber surface and phenolic resin binder is clearly visible in the 1000F-ACFC, while the 800F-ACFC shows good adhesion at the interface.

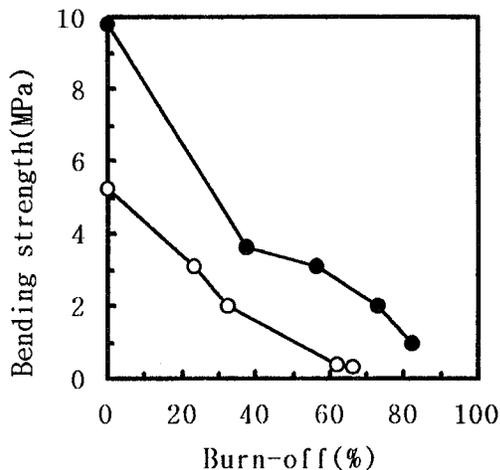


Figure 2. Bending strength of carbon fiber composites at different levels of burn-off. Carbon fibers were developed at: (●) 1073K; (○) 1273K.

Fig. 3 shows the variation in bulk density of the 800F-ACFC and 1000F-ACFC as a function of burn-off of carbon fiber composites. Activation decreased the bulk density of the carbon fiber composites. At the same time volume of the activated carbon fiber composites reduced due to the shrinkage of fiber diameter and length. Therefore, the rate of volume reduction of carbon fiber composites with activation time was greater than the rate of weight loss. And the results shown in Fig. 3 indicate that at the same burn-off value volume of the precursor fiber carbonized at 1073K reduces more than that of the precursor fiber carbonized at 1273K.

The fact that density values of 800F-ACFC were

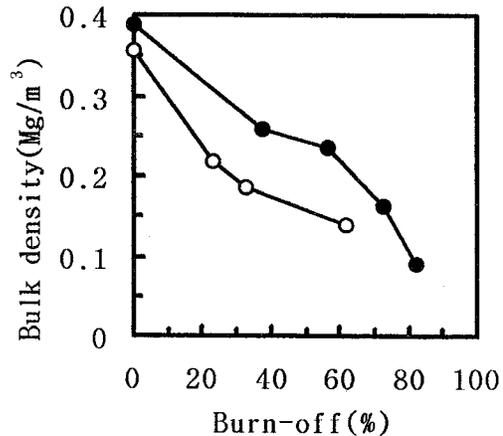


Figure 3. Bulk density of carbon fiber composites at different levels of burn-off. Carbon fibers were developed at: (●) 1073K; (○) 1273K.

always larger than those of 1000F-ACFC at the same burn-off value (Fig. 3) might explain the higher bending strength of 800F-ACFC than that of 1000F-ACFC, as shown in Fig. 2.

Conclusions

At the same burn-off value, the ACFC made of the fiber carbonized at 1073K always has higher specific surface area, bending strength and bulk density than that of the fiber carbonized at 1273K. The bending strength of ACFC increases with bulk density and the density decreases with burn-off. The ACFC made of fiber carbonized at 1073K shows better adhesion between carbonized surface and phenolic resin binder than that of the fiber carbonized at 1273K. Therefore, the higher bending strength of the activated carbon fiber composites made of the fiber carbonized at 1073K is due to the the lower density, and the better bonding strength between carbonized fiber surface and phenolic resin binder.

References

1. Okada, K., Kato, H. and Nakajima, K., J. Am. Ceram. Soc. 1994, 77, 1691.
2. Jagtoyen, M., Derbyshire, F., Brubaker, N., Fei, Y., Kimber, G., Matheny, M. and Burhell, T., Mat. Res. Soc. Symp. Proc., 1994, 344, 77.
3. Ko, T. H., Chiranairadul, P., Lu, C. K. and Lin, C. H., Carbon, 1992, 30, 647.
4. Kasaoka, S., Sakata, Y., Yanaka, E. and Naitoh, R., Int. Chem. Eng, 1989, 29, 101