Preparation and electrochemical behavior of carbonaceous fiber sheets derived from bamboo

Takuya Matsumura, Taro Kinumoto*,
Miki Matsuoka, Tomoki Tsumura and Masahiro Toyoda

Dept. of Appl. Chem., Faculty of Eng., Oita Univ.,
700 Dannoharu, Oita, 870-1192, JAPAN

*Corresponding to kinumoto@oita-u.ac.jp

Bamboo is sustainable natural resource with high CO_2 immobilization capacity and is expected to use in the next generation. For this purpose, development of the application technique is required.

The microstructure of bamboo is fibrous, and therefore fiber can be obtained easily rather than woods, which is one of the advantages of bamboo.

In this study, we tried to obtain the fiber from bamboo through a series of physical and chemical treatments and then evaluate its electrochemical performance after sheet forming and carbonization processes.

Relatively young bamboo growing in Oita prefecture, Japan, was obtained and cut into a strip specimen. The specimens were pressed repeatedly by a hydrostatic press to form several breaches. The specimens were boiled in 0.1 mol dm^{-3} sodium hydroxide aqueous solution for 3 hours. After boiling, those were washed repeatedly by water and then pressed again to obtain the fiber bundles. The bamboo fiber is obtained from the fiber bundles by using a blender and is dispersed in water to form a sheet. After sheet forming, heat treatment was carried out at several temperatures under argon atmosphere to obtain carbonaceous fiber sheets.

The size and shape of the fibers in the sheets were investigated by an optical microscope (OM) and field emission scanning electron microscope (FE-SEM). The microstructure of fiber was also observed by FE-SEM. X-ray diffraction (XRD) was used to evaluate the carbonization degree. The electrochemical behavior was investigated in 0.1 mol dm^{-3} perchloric acid aqueous solution under nitrogen atmosphere by cyclic voltammetry.

Figure 1 shows SEM image of carbonaceous bamboo fiber after heated at 1000ºC. This result indicates that the carbonaceous fiber sheet can be obtained from bamboo in this study. The diameter of fiber was *ca*. 5 μm, which is similar to carbon fiber that used in the fuel cell.

Figure 2 shows XRD patterns of carbonaceous bamboo fiber after heated at 1000, 1500 and 2000ºC. The peak corresponding to 002 diffraction of graphite was appeared and become sharpened with increasing in the heat treatment temperature.

The electrical conductivity of carbonaceous bamboo fiber sheet, which is measured by the four-probe method, is lower than that of the carbon paper composed by carbon fibers.

Figure 3 shows the cyclic voltammograms of carbonaceous fiber sheets obtained after the heat treatment at various temperatures. The double layer capacity was obtained and was decreased as the temperature increases.

From the results, it was considered that carbonization proceeds with increasing in the temperature; on the other hand, the surface area is decreased. We successfully obtained the carbonaceous fiber sheet from bamboo through a series of physical and chemical treatments and evaluated the electrochemical behavior; unfortunately, its electrical conductivity is not sufficiently to apply for the electrochemical devices such as fuel cells, batteries, electrochemical capacitor and so-on. We now continue to study for increasing in the conductivity with low heat treatment temperature.

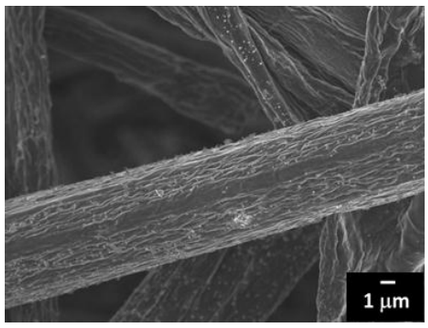

Fig. 1 SEM images of carbonaceous bamboo fiber after heated at 1000ºC.

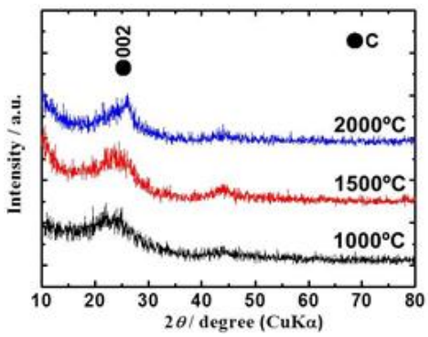

Fig. 2 XRD patterns of bamboo fiber after heated at 1000, 1500 and 2000 ºC.

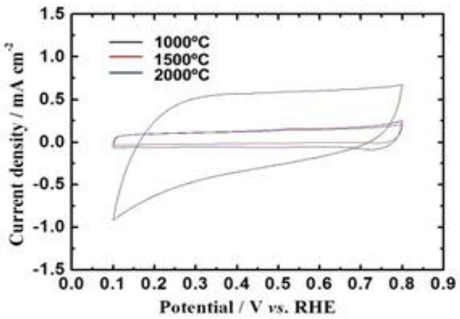

Fig. 3 Cyclic voltammograms of various carbonaceous fiber sheets.

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