CATALITIC SYNTHESIS OF CARBON NANOTUBES IN THE ORGANIC LIQUID

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We recently have developed a new method for synthesizing a wide variety of carbon nanomaterials in the organic liquid[1)]. The method realized a simple, speedy, and high-purity growth of carbon nanotubes in alcohol liquids[2)]. In this study, how carbon nanotubes start growing at the interface between catalysts and alcohol liquids is reported.

A schematic drawing of our liquid-phase deposition reactor is shown in Fig. 1. The Si substrate coated with a small amount of FeOx particles is resistively heated around at 700-1000 °C in the methanol. A catalytic decomposition of methanol occurs at the FeOx surface, then a solid-phase carbon deposition is observed on the surface. The reaction can occur on the catalyst surface, because the growth condition is realized just on the surface. As the temperature of the methanol is below ca. 50 °C, i.e. its boiling point, an unintentional, side reaction hardly occurs in the liquid phase. This unequilibrium at the interface between the solid and the liquid phase is the most essential character, which gives a high purity, high quality, and a speedy growth of carbon nanotubes.

Fig. 2 shows the (a) SEM and (b) TEM image of the grown materials with 3 nm-thickness of FeOx at a reaction temperature of 700 °C. Merely 10 min. growth gave fibrous nanomaterials having a diameter of around at 20 nm and some micron length. The growth rate of the fibrous nanomaterials was very high compared to that by the gas phase growth such as a chemical vapor deposition method. As shown in Fig. 2 (b), a tubuler structure was observed from the fibrous materials, which could be called as carbon nanotubes. A few iron particles were found at the top ends and the inside of the carbon nanotubes. Fig. 3 shows the (a) SEM and (b) TEM image of the grown materials with 1 nm-thickness of FeOx at a reaction temperature of 700 °C. The SEM image showed a similar morphology as indicated in Fig. 2 (a), however, the fibrous materials did not have a tubular structure as shown in Fig. 3 (b). Such a small difference of the added amount of FiOx gave the carbon fiber which was different from the tubular structure. A chemical and/or physical states of the catalyst is one of the effective parameter for the growth and structure of the grown materials.

Acknowledgement
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References

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2) Y. F. Zhang, M. N.-Gamo, C. Y. Xiao, and T. Ando, Jpn. J. of Appl. Phys., ***41***, L408-L411 (2002).

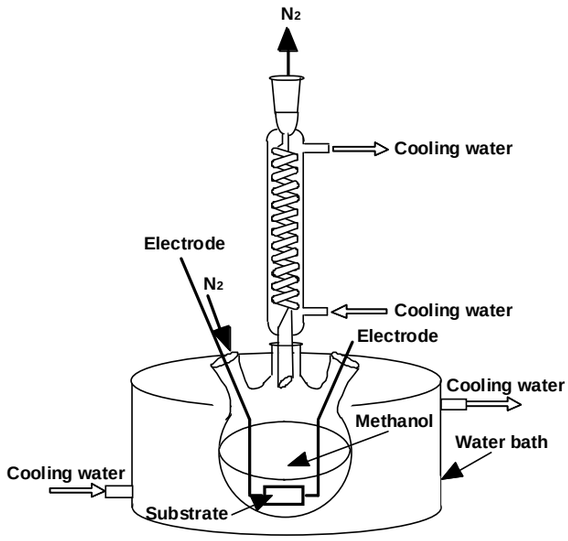

Fig. 1 Liquid-phase deposition system

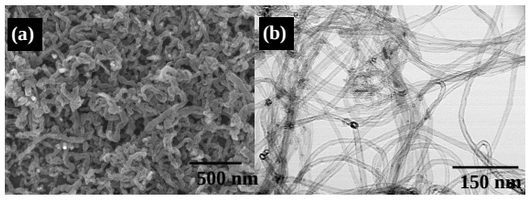

Fig. 2 (a) SEM and (b) TEM image of the grown materials with 3 nm-thickness of FeOx at a reaction temperature of 700 °C for 10 min.

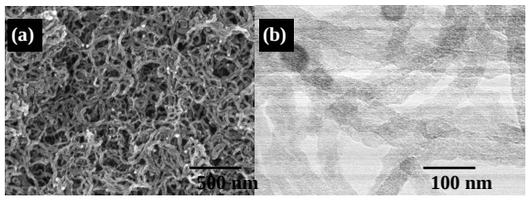

Fig. 3 (a) SEM and (b) TEM image of the grown materials with 1 nm-thickness of FeOx at a reaction temperature of 700 °C for 10 min.