GROWTH OF CARBON NANOTUBES ON ACTIVATED CARBON FIBERS

Woo Sik Kim, Sook Young Moon, Dong Yun Han, Yanfang Chen and Yun-Soo Lim
Dept. of Ceramic Engineering, Myongji University, Kyunggi-do 449-728, Korea

Corresponding author e-mail address:yslim@mju.ac.kr (Yun-Soo Lim)

Introduction

Carbon nanotubes (CNTs) have attracted attention from physicists, chemists and engineers. CNTs have been extensively investigated due to their unique properties, such as high strength, high wear resistance, good electrical and thermal conductivity [1-2]. This work is designed to fabricate composites that have potential application as filler having high strength and good thermal conductivity using homogeneously distributed CNTs on the carbon composite [1, 3]. CNTs can be grown on most substrates such as silicon, silica, alumina or aluminosilicates [1, 3]. There are a few reports discussing CNTs synthesized on carbon materials. Two problems in CNT growth on graphite substrates are that transition metals are easily diffused into the carbon substrates and that the different phases of carbon materials are able to form on the graphite substrates because the growth conditions are similar to the diamond or diamond-like carbon growth [1].

Experimental

CNTs were synthesized on activated carbon fibers by chemical vapor deposition (CVD) method. The activated carbon fibers were placed in the middle of the furnace. One end of the quartz tube in the furnace is used to introduce H_2/N_2 gases and catalyst and the other end is connected to a water vessel. The ferrocene ($C_{10}H_{10}Fe$, M_W=186, Aldrich Co.) that was used as catalyst dissolved with xylene. The dissolved ferrocene/ xylene mixture solution is pumped into the furnace by syringe pump. The end of syringe injector was located around 230°C in the furnace for the pyrolysis of mixture of ferrocene/xylene. The furnace temperature is increased with a ramp rate of 10 °C /min. The CNTs growth temperature was 800°C and kept for 3 h.

Morphology of grown CNTs is analyzed using scanning electron microscopy (SEM, Hitachi S-3500N). Some CNTs on activated carbon fibers are measured by high resolution transmission electron spectroscopy (HR-TEM, Philips CM200). The TEM samples were prepared by ultrasonically dispersing the CNT/fibers in alcohol and then making several droplets on TEM copper grids. The samples were imaged at various TEM power up to 150 keV. FTIR spectrum was measured using the KBr-pellet method. Spectrum was taken using an MB104 of Bomen Co. spectrophotometer in the wave number ranging from 4000 to 400 cm^{-1}.

Results and Discussion

Surface morphology of grown CNTs at the experimental condition is shown in Fig. 1. The winding-type CNTs are laid on the activated fiber surface. These CNTs are very difficult to detach from activated fibers mechanically. The growth of CNTs is expected by the interaction of the molten catalyst particles and hydrocarbon species [1]. The CNT growth process could be that the carbon-contained iron nanoparticles melt at much lower temperatures due to their small size [1].

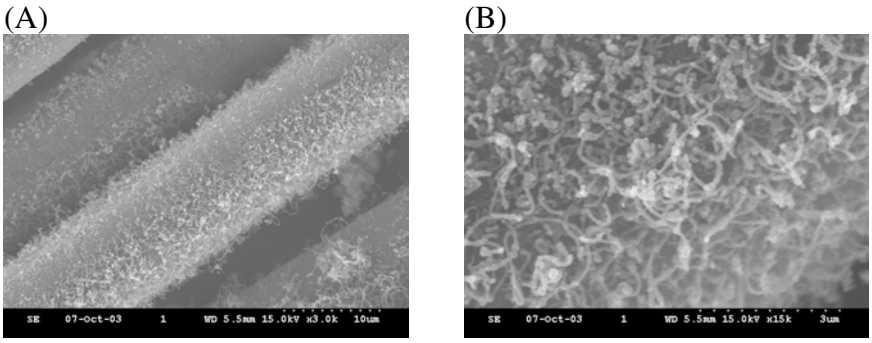

Figure 1. SEM images of (A) CNTs grown on activated carbon fibers at 800°C and (B) their high magnitude

Fig. 2 shows the HRTEM photographs of the grown CNTs on the activated carbon fiber surface. Fig. 2-(A) and (D) show that a straight segment in the grown CNTs consists of graphene sheets. Fig. 2-(B) shows that CNTs have relatively uniform diameters. Average diameter of CNTs was 15 nm. The CNTs clearly show hollow structure along the center. A high magnitude of the CNTs of Fig. 3-(B) is shown in Fig. 3-(C). The shape and the structure of the CNTs did not change appreciably.

Fig. 3 shows the FTIR absorption spectrum of the fabricated CNTs that were washed by nitric acid. The FTIR spectrum showed the absorption at 1630 cm^{-1} in the so-called G-band region, which is typical for sp^2 hybridized carbon [4].

Conclusions

CNTs are synthesized on the surface of the activated carbon fibers by CVD. The multi-walled winding-type CNTs can be grown on the surface of activated carbon fibers at the 800°C. The optimum CNTs growth condition was in ferrocene/xylene mixture of 6.5 mol% with activated carbon fibers that were activated by KOH of 1 mol at 900°C.

Acknowledgement

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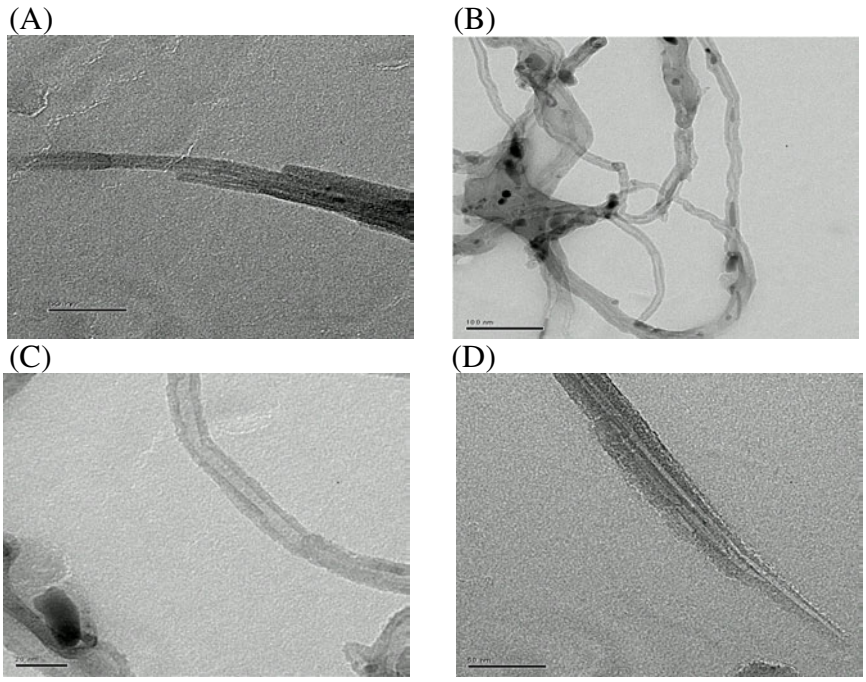

Figure 2. HR-TEM images of the grown CNTs on the activated carbon fiber surface

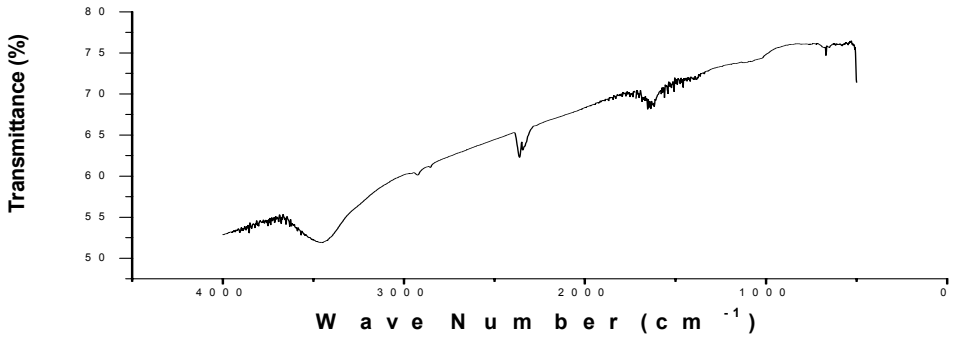

Figure 3. FTIR spectrum of fabricated CNTs that were washed by nitric acid

References

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