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Effect of Electron Beam Irradiation on Electrochemical Properties of CNT

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1. Introduction

Carbon nanotubes(CNTs) have been studied actively in nanotechnology because they have excellent mechanical properties, thermal stability and electrical properties. However, amorphous carbon and residual metal impurities generated during the synthesis of CNTs may degrade the excellent properties of CNTs including electrical conductivity [1]. In order to improve the physical properties of CNTs by removing the amorphous carbon and metal impurities by increasing the purity of CNTs, a liquid phase purification method [2] and a vapor phase purification method [3] after heat treatment have been studied. However, it takes a long time, resulting in a decrease in electrical conductivity [4]. To solve this complicated process, other researches are proceeding on the change of properties of CNTs through various light sources such as ultrasonic treatment [5] and microwave [6].

In this study, amorphous carbon in CNTs was removed by electron beam irradiation and the improvement of electrochemical properties of CNTs were proceeded.

2. Methods and Results

2.1 Materials

CNTs used TUBALL™(OCSiAl, Luxembourg) CNT powder of SWNT type without purification.

2.2 Electron beam irradiation

CNTs were irradiated with electron beam using electron beam accelerator in Daejeon. The beam were irradiated with 50, 100, 200, 500 kGy at 2.5 MeV(beam current 17.7 mA, dose rate 25kGy/pass) respectively. At a dose of 1,000, 2,000, 5,000 and 10,000 kGy, they were irradiated by the integral method with 2.5 MeV(beam current 4 mA).

2.3 Analysis instrument

The electrical conductivity was analyzed by 4-point probe system (KIST), the analysis of microstructure was analyzed through Transmission Electron Microscopy (TEM, Technai G2 F20, FEI KIST). The degree of defect of CNTs was used as Raman (NRS-3200, JASCO).

2.4 Effect of electron beam on electrical conductivity

Figure 1 is a graph showing the resistivity values in order to confirm the electrical conductivity of CNTs. As the dose increased, the electrical conductivity of the CNTs decreased. At a dose of 1000 kGy, the R value was the minimum point and slightly increased beyond that point. In order to analyze the results, It was performed to examine Raman analysis for the amorphous chemical structure and to examine morphology of CNTs by TEM starting from 0, 1,000 kGy and 10,000 kGy points.

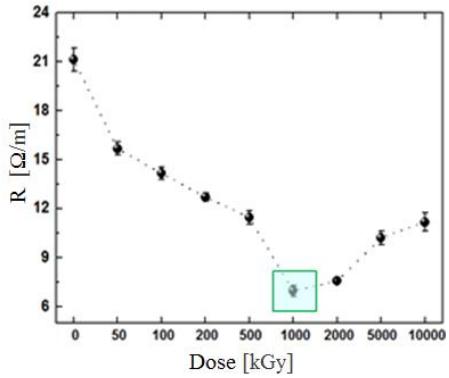

Fig. 1. Resistivity of the CNTs

2.5 Change of chemical structure in CNTs

Raman analysis was performed to see the change of chemical structure through electron beam. The shape of the Raman peaks of the irradiated and unexposed samples were the same as in Figure 2. The D-band and G-band, respectively, at 1,340 cm-^{1} and 1,570 cm^{-1}, are known to exhibit characteristic peak of CNTs. D band, and the graphite character of CNTs, through the G-band, the intensity of the amorphous carbon and the intensity of the intrinsic carbon in the whole CNTs can be known.

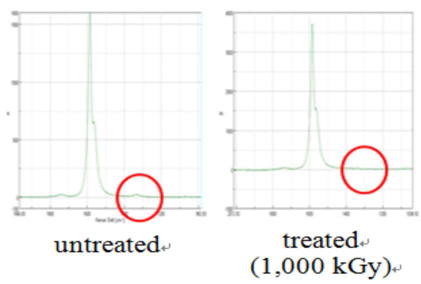

Fig. 2. Raman spectra of CNTs

In the Raman image, the D intensity versus the G intensity is called R.

$$R = I_D/I_G \quad (1)$$

R (Ratio) : Intensity of disorder to intensity of graphite.
I_D: Intensity of disorder (defect in CNTs)
I_G: Intensity of graphite (crystal figure in CNTs)

Based on (1), it was confirmed by the numerical value that the intensity of the D-band decreases as the irradiation dose increases.

Table I: Property of the I_D/I_G in the Raman spectra

Type	I_D/I_G
Untreat	10.41
1,000 kGy	3.94
10,000 kGy	6.92

At a dose of 1,000 kGy, the R value showed the minimum point and slightly increased beyond that point.

2.5 Microstructure analysis of the CNTs.

In Figure 2, which is the TEM analysis of the microstructure of the CNTs according to electron beam irradiation, impurities are randomly distributed inside the CNTs at the 0 kGy irradiated with no electron beam. However, when irradiated with electron beam, impurities were reduced by dose.

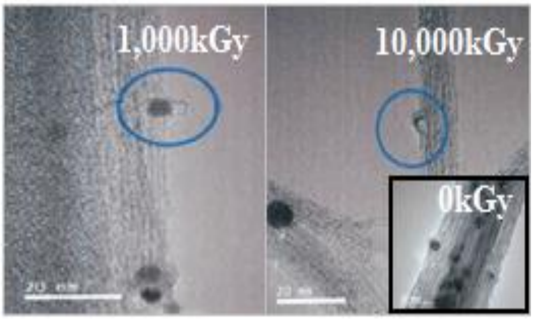

Fig. 3. TEM image of CNTs

3. Conclusions

This paper researched the change of electrochemical properties of CNTs through electron beam irradiation for purifying impurities. After a Raman analysis, to study the impact of the electron beam irradiation by the electrical conductivity of the CNTs was to determine the aimed air chemical structure change that the inflection point appearing in 1,000 kGy. It can be seen that by reducing the proportion of the amorphous carbon electrical conductivity is improved. In addition, TEM analysis shows that the impurities randomly distributed in the CNTs are extracted to the outside of the CNTs, thereby suggesting the possibility of purifying the impurities through post-treatment such as the subsequent vapor phase purification.

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