MASTER'S THESIS

Synthesis and characterization of carbon nanotubes by liquid-phase deposition at low temperature

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Synthesis and Characterization of Carbon Nanotubes by Liquid-phase Deposition at Low Temperature

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ABSTRACT

In this study, a low-temperature synthesis of carbon nanotubes by liquid-phase deposition was performed. The samples were characterized with FESEM, EDX, TEM, Raman and FTIR. FESEM micrographs showed that tube-like structures with average diameter of 60 nm were grown at 18 ^{o}C by applying 50 V and adding 0.56 mM Ni catalyst into the methanol. HR-TEM images and electron diffraction patterns showed that the tube-like structures were multi-wall nanotubes where each fringe of the layers was separated by about 0.337 nm. Furthermore, Raman spectrum showed two strong characteristic vibrational modes at 1352 cm^{-1} and 1585 cm^{-1}, which is commonly found for carbon nanotubes. In the IR spectrum, absorption peak of 1575 cm^{-1} was observed which is belonged to CNTs vibrational mode. These findings confirmed that carbon nanotubes were grown by the liquid-phase deposition.

The effect of deposition temperature, catalyst concentration, applied voltage, separation of electrodes and deposition duration on the nanotube growth had also been studied. Through the FESEM images, it was found that nanotubes were grown form 18 ^{o}C to 55 ^{o}C. Besides, it is noted that nanotubes can only grow within a narrow range of Ni concentrations from 0.056 mM to 0.84 mM. No nanotube was grown outside this range. It was also revealed that nanotubes could only grow when the applied voltage was less than 800 V. Besides, with decreasing the separation between the electrodes, more nanotubes were grown. As the deposition duration increased, more nantoubes were grown and the growth rate was the highest between 3 hrs to 6 hrs deposition. Finally, through the charge density calculation, it was suggested that the free charges were accumulated near the surface of electrode. The accumulated

positive charges would react on the surface of silicon substrate and initiate the CNTs growth.

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