Effect of Different Concentration of cobalt Oxide (CoO) and Titanium Dioxide (TiO_2) on Diameter of Carbon nanotubes

[1]Mona Ali. A
[2]Rawia Abd Elgani Elobaid
[3]Abdalsakhi S M.H
[4]Ali Soliman
[5]Nafisa Badar Eldeen
[6]Mubarak Dirar

[1 2,5]Sudan University of Science and Technology, Khartoum, Sudan
[3]Al-Neenlen University, Khartoum, Sudan
[4]Omdurman Islamic University, Omdurman, Sudan
[6]International University of Africa & Sudan University of Science and Technology, Khartoum, Sudan

Abstract. The aim of this paper study the effect of concentration of cobalt oxide and titanium dioxide on average diameter of carbon nanotubes ,chemical vapor deposition technique was used to synthase carbon nanotubes doping with cobalt oxide CoO and titanium dioxide TiO_2 at different concentrations (0.5, 1.00 and 1.5). CNTs+TiO_2 have same functional groups for CNTs+CoO expect at wavenumber 560 cm^{-1}which refer to titanium dioxide. The average diameter was calculated from SEM images by used image and origin software. The average diameter of CNTs+CoO (0.5, 1.00 and 1.5) decreased from 29.736 nm for CNTs+CoO (0.5 molar) to 13.486 for CNTs+CoO (1.5 molar). In addition, for CNTs+TiO_2 (0.5, 1.00 and 1.5) decreased from 45.032nm for CNTs+TiO_2 (0.5molar) to 21.951 nm for CNTs+TiO_2 (1.5molar). Cobalt oxide effected on average diameter of carbon nanotubes more than titanium dioxide.

Key words: Carbon nanotubes, SEM, FTIR, average diameter, Surface roughness.

Introduction

Carbon nanotubes are layers of graphite wrapped into cylinders of few nanometers in diameters, and several micrometers in length (Goyal, 2018: 167-168; Aboelazm et al., 2018: 67-74). Depending on the number of shells making tubular structure, the nanotubes can be categorized as single-walled (SWCNT), double-walled (DWCNT) or multiwalled carbon nanotubes (MWCNT). While SWCNT can be considered as a rolled single graphite sheet, MWCNT comprise of several nested cylinders with an inter-shell spacing of approximately 0.34 to 0.36 nm (Bhushan, 2017: 77-79). SWCNT's are usually closed at both ends with fullerene-like semispherical structures containing both hexagons and pentagons.

Carbon nanotubes are representing a promising material due to their unique physicochemical properties (Mahmood et al., 2014: 121-127; Khanna and Islam, 2018: 43-49). Their nanoscale needle shape, high chemical stability, thermal conductivity, and mechanical strength, which confer an advantage in the fabrication of field emitters (Bhushan, 2017: 77-79).

CNTs have amazing properties, which make them potential candidates for a wide range of applications (Rafiei, 2015: 21-25; Muc, 2011: 531-540; Muc, 2010: 1671; Muc et al., 2013: 157-166). Such as electrocatalytic electrodes, molecular channels for water and protons transparent conductive films (Shi and He, 2012: 646-650; León et al., 2017: 49), electrostatically dissipative materials, in photocatalysis, in electronics (diodes, transistors, FETs, logic gates), thermoelectrics, chemical and biological sensors, thermal interface materials (TIMs), magnetic storage devices, reinforcement in polymer nanocomposites ,smart materials, biocompatible devices, in battery storage, and elsewhere (Rahman et al., 2017: 38-40; Ferreire and Asiri, 2018: 89-95).

Material and Methods

Six samples of carbon nanotubes were Prepared by adding 5 g of graphite powder to a mixture of (50 ml) sulfuric acid and (25 ml) of nitric acid. Because the reaction produces an amount of heat, it was cooled to 5 ° C with an ice bath. 25 g of sodium chlorate was added to the solution in addition to cobalt oxide and Titanium dioxide (0.5, 1and 1.5) molar. The solution was heated to 70 ° C in a water bath for 24 hours and then placed in air for 3 days. Most of the graphite was bottom predicted but some carbon was floating. The floating carbon material was transferred to 1 liter of Deionized water (DI). After stirring for an hour, the solution is filtered and dried.

Fourier Transform Infrared spectroscopy analysis (FTIR) was used to characterize functional groups, bonding types, nature of compounds, the surface morphology for each sample of the carbon nanotubes were studied by scanning electron microscope (SEM), Origin Lab and Imagej Programs were used to obtain surface roughness and size distribution from SEM images.

Results and Discussion

FTIR was used to determine the vibration and bending modes of the structure of CNTs+CoO (0.5, 1.00 and 1.5) molar and CNTs+TiO_2 (0.5, 1.00 and 1.5). The spectra are shown in Fig. 1 and Fig. 2.

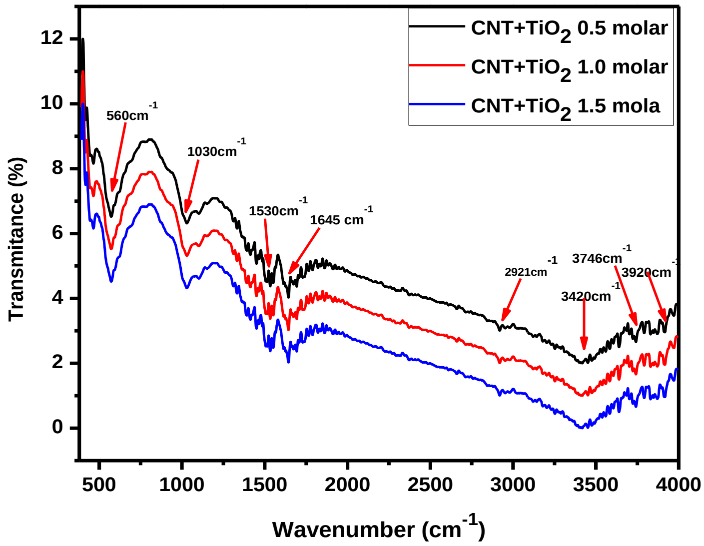

Fig. 1. FTIR analysis for CNTs+CoO (0.5, 1.00 and 1.5) molar

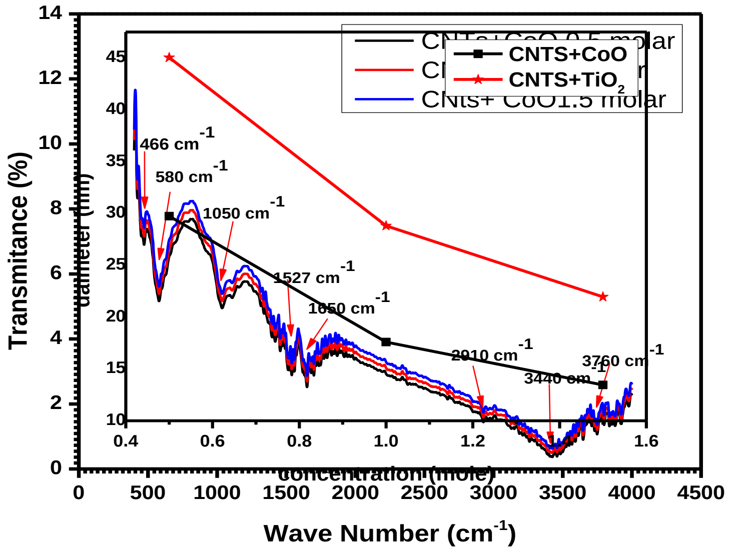

Fig. 2. FTIR analysis for CNTs+TiO_2 (0.5, 1.00 and 1.5) molar

For CNTs+CoO (0.5, 1.00 and 1.5) molar the broad absorption band at 3762, 1050 and580 cm^{-1} can be attributed to the alcohol of H_2O, alkoxy and cobalt oxide stretching vibration. Other sharp peaks observed at 2910 ,1650 and 466 cm-^{1} can be attributed, alkane alkene and alkyle halide. CNTs+TiO_2 (0.5, 1.00 and 1.5) have same functional groups for CNTs+CoO (0.5, 1.00 and 1.5) molar expect at wavenumber 560 cm^{-1}, which refer to titanium dioxide.

Scanning electron microscope (SEM) was used to study size distribution and surface morphology of CNTs+CoO and CNTs+ TiO_2 at different molar (0.5, 1.00 and 1.5) molar as shown in Fig. 3 and Fig. 4.

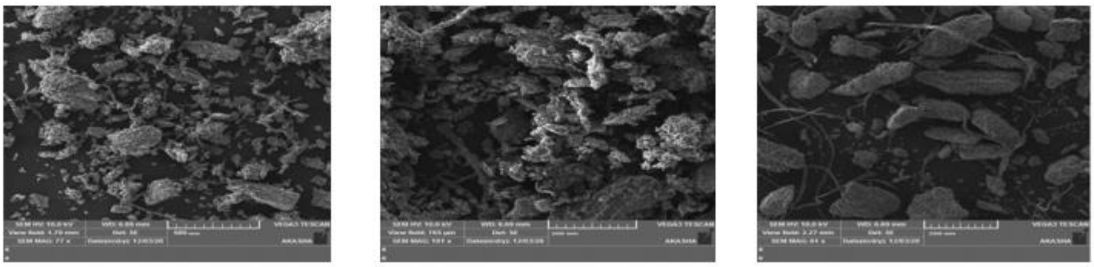

Fig. 3. SEM images of CNTs+CoO (0.5, 1.00 and 1.5) molar

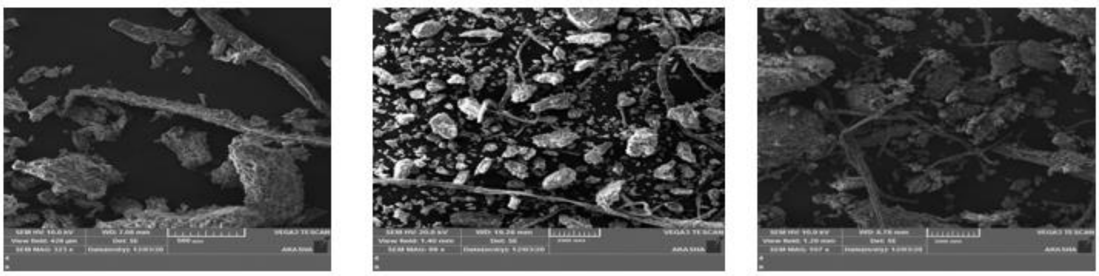

Fig. 4. SEM images of CNTs+TiO_2 (0.5, 1.00 and 1.5) molar

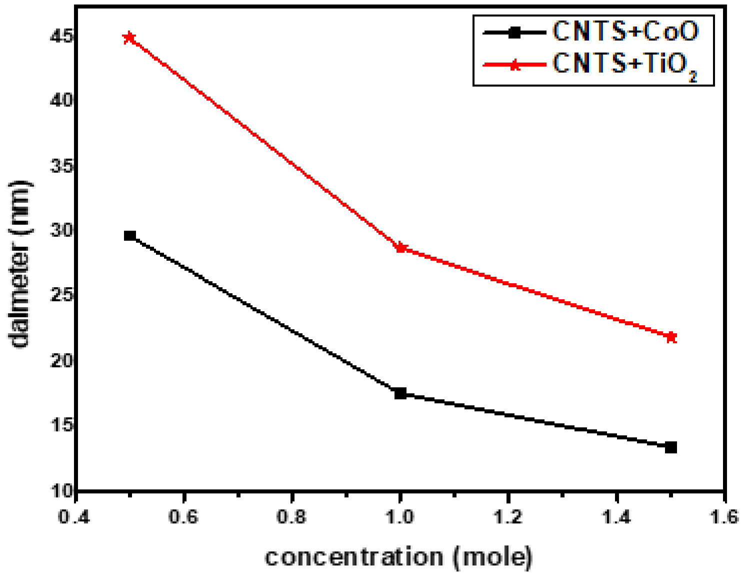

Fig. 5. The decreasing of average diameter of CNTs with increasing of concentration of CoO and TiO_2

Figs. 3 and 4 show the general morphology of CNTs+CoO (0.5, 1.00 and 1.5) molar and CNTs+TiO_2 (0.5, 1.00 and 1.5). Fig. 5 show the average diameter of CNTs, which was calculated using imagej and origin softwares. The diameter of CNTs decreases with concentration of CoO and TiO_2 increase. The diameter for CNTs+CoO 0.5 molar is 29.736nm, for CNTs+CoO 1.00 molar 17.588nm and for CNTs+CoO 1.5 molar 13.485nm. The diameter for CNTs+TiO_2 0.5 molar 45.032 nm, for CNTs+TiO2 1.00 molar 28.813nm and for CNTs+TiO_2 1.5 molar equal 21.951nm.

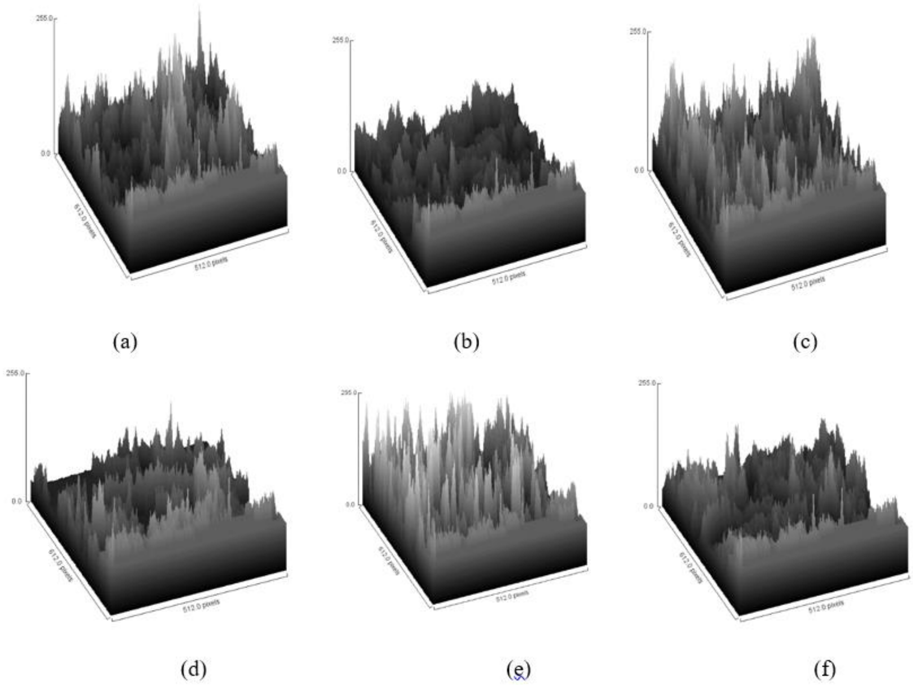

Fig. 6. Surface roughness of carbon nanotubes at different molarity of CoO and TiO_2: a) CNTs+CoO 0.5 molar; b) CNTs+CoO 1.00 molar; c) CNTs+CoO 1.5 molar; d) CNTs+TiO_2 0.5 molar; e) CNTs+TiO_2 1.00 molar; f) CNTs+TiO_2 1.5 molar

Image software was used to obtain surface roughness from SEM images for CNTs+CoO and CNTs+ TiO_2 at different molar (0.5, 1.00 and 1.5) molar as shown in Fig. 6. It is determine the variation of cobalt oxide and titanium dioxide molarity at prepared carbon nanotubes, white color refer to treated by cobalt oxide or titanium dioxide while black color refer to untreated area.

Conclusion

CNTs + CoO and TiO_2 (0.5, 1.00 and 1.5) molar were prepared using chemical vapor deposition technique (CVD), Fourier Transform Infrared spectroscopy analysis (FTIR) was used to characterize functional groups, and bonding types, CNTs+TiO_2 have same functional groups for CNTs+CoO expect at wavenumber 560 cm^{-1}, which refer to titanium dioxide. The average diameter of CNTs+CoO and CNTs+TiO_2 was decreased when concentration increased.

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