Chemical Sciences Journal

Muhammed and Hussein, Chem Sci J 2015, 6:3
http://dx.doi.org/10.4172/2150-3494.1000e110

Editorial Open Access

Synthesis of Carbon Nanotubes Using Aliphatic Alcohols as a Carbon Source

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Introduction

Carbon nanotubes (CNTs) are graphite layers have hexagonal carbon rings rolled into cylinders which are discovered first in 1991 [1,2]. According to their unique properties of carbon nanotubes (CNTs) which coming from their atomic structure and size therefore CNTs take wide concerns in technology and science and wide range of application which CNTs entering in it such as electrodes, hydrogen storage and sensors [3,4]. CNTs have different structures and diameters which classified into three types such as: single-walled carbon nanotubes (SWNTs) and multi-walled carbon nanotubes (MWNTs) in addition to few wall carbon nanotubes (FWNTs) [5,6].

Different Methods are used for the synthesis of carbon nanotubes, such as, laser ablation [7], arc discharge [8] and chemical vapor deposition (CVD) [6,9]. Among different method were used for the synthesis CNTs, CVD is the preferred method because it is produce large quantity of CNTs and easy to control the properties of the product [10,11].

Carbon monoxide, hydrocarbons and alcohols such as ethanol, 1-propanol and 2-propanol are sources of carbon can be used in CVD method. Because of alcohols are makes less impurity and safe to treatment in the synthesis CNTs therefore consider the best carbon sources [6,12-14]. Ethanol can participate in the purification of the resulting CNTs when decomposition and produce OH radicals which act as etching agent by removing amorphous carbon during growth [15]. The process of synthesis CNTs can be done in two ways: the first without catalyst and the second by using a catalyst [16]. In this regard CVD method was used to synthesis CNTs by using alcohols such as ethanol, 1-propanol and 2-propanol as a source of carbon at temperature of 750°C.

Briefly, the process of synthesis CNTs includes heating the quartz tube furnace to the required temperature, and Fe/MgO was used as catalyst, then evaporating alcohol at a temperature below its boiling point by using a magnetic heater stirrer with the continuous flow of N_2 gas which is used as a carrier gas at rate equal to 100 cm^3/min. The volume of alcohol which were used was 30 cm^3 and the process of evaporation took 1:30 hr. The heater of tube furnace was turn off when the evaporation process had finished with the continuous flow of N_2 gas until cooling the tube of the precipitation reaction. The purification process of the product which was divided into two types according to the type of synthesis CNTs such as with catalyst and without catalyst. The two products were purified by using the same ways which include: oxidation the remaining product by (30%) H_2O_2 for 4 days at 70°C by using magnetic stirrer [6,17,18], the second type of product (with catalyst) were involved also reflux process of the product with 5 M nitric acid at 80°C for 7 hr.

The Characterization systems used to identify the types of CNTs with their percentage of purification were Raman spectroscopy and thermal gravimetric analysis (TGA). Raman spectroscopy was used to identification of CNTs and provide important information about CNTs such as microscopic structure, electron quantum confinement, phonon and quality of tube [19]. Raman spectra as shown in Figure 1, contains three major peaks: D band at ~1352 cm^{-1} which corresponding to amorphous carbon impurities and defects in the CNTs sample, the second peak G band was shifted at ~1599 cm^{-1} because of high frequency in plan stretching of the C–C bonds, the last peak G′ band at ~2550 cm^{-1} is related to the process of double resonance [20]. The I_D/I_G ratio of the synthesized CNTs from 1-propanol with catalyst, ethanol with catalyst, 2-propanol with catalyst, ethanol without catalyst and 2-propanol without catalyst were 1.35, 1.8, 1.8, 2, 2.1 respectively. The increase the ratio of I_D/I_G which explain the increase number of defects on the sidewall of CNTs.

The TGA was used to evaluation the purities and qualities and to investigation of the presence of CNTs and to identify different types of carbon species [21]. According to the TGA analysis as show in Figure 2, it could be concluded that yield contains MWCNTs with less ratio of FWCNTs when was not used the catalyst, while the yield was mostly FWCNTs when the catalyst was used as shows in Table 1.

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Received July 29, 2015; **Accepted** July 30, 2015; **Published** August 05, 2015

Citation: Muhammed GJ, Hussein F (2015) Synthesis of Carbon Nanotubes Using Aliphatic Alcohols as a Carbon Source. Chem Sci J 6: e110. doi:10.4172/2150-3494.1000e110

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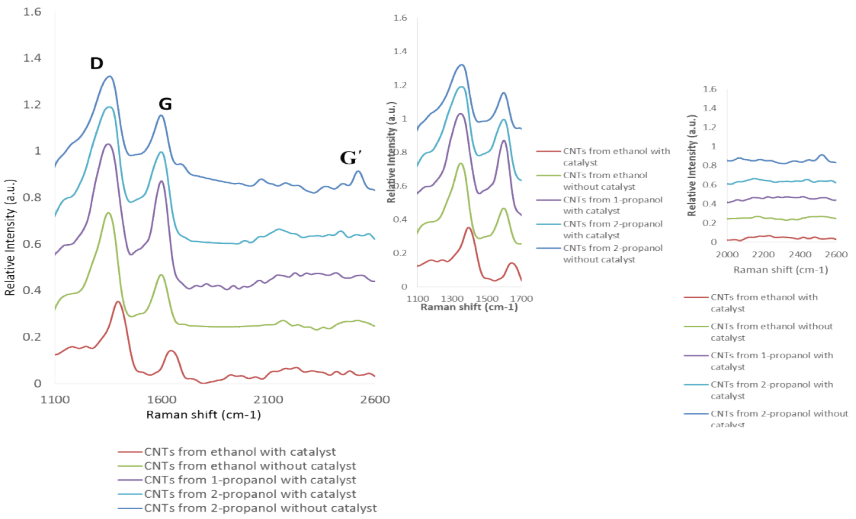

Figure 1: Raman spectra of the synthesized CNTs.

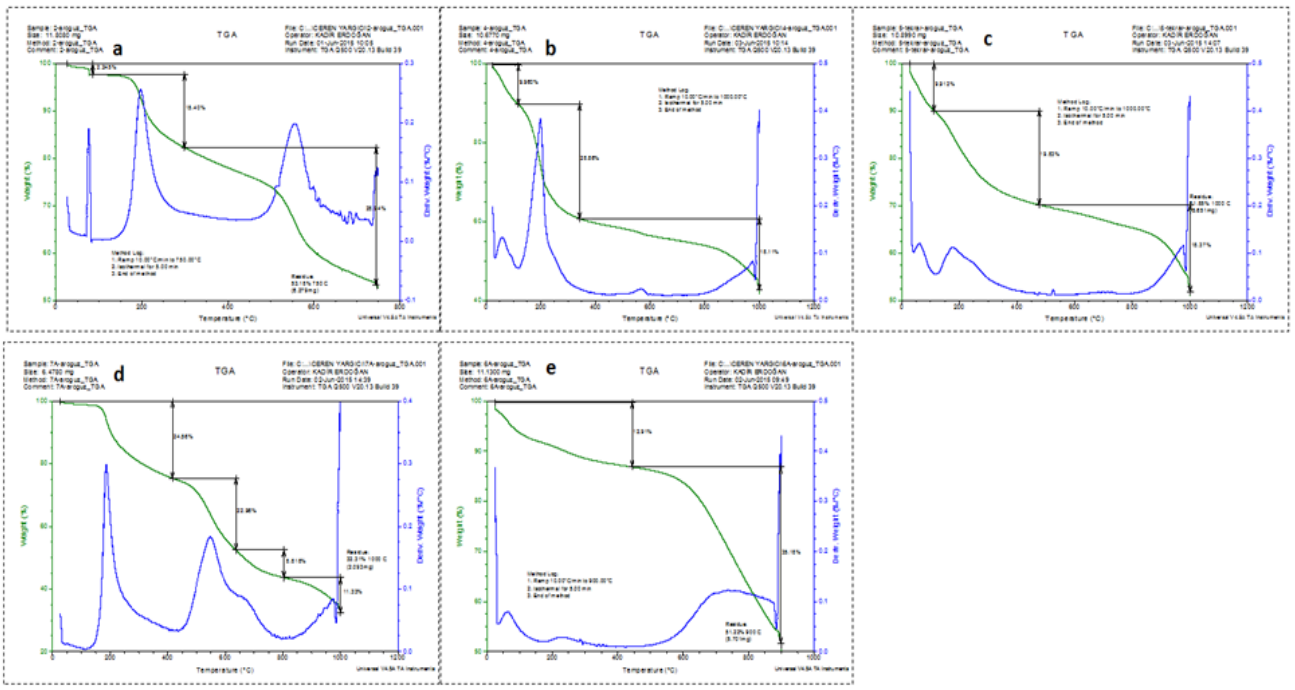

Figure 2: TGA of CNTs grown from a) ethanol without catalyst, b) ethanol with catalyst, c) 1-roppanol with catalyst, d) 2-propanol without catalyst and e) 2-propanol with catalyst.

Type of carbon source	Weight loss%	The range of temperatures °C	Type of CNTs
Ethanol with catalyst	18.11	380-580	FWCNTs
Ethanol without catalyst	28.94	350-580	MWCNTs with less ratio of FWCNTs
1-Propanol with catalyst	12.33	210-500	mostly FWCNTs
1-Propanol without catalyst	-	-	No yield
2-Propanol with catalyst	35.18	400-900	FWCNTs in addition to MWCNTs
2-Propanol without catalyst	22.96	400-600	MWCNTs and FWCNTs

Table 1: The result and conclusions of synthesized CNTs.

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