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Preparation of SWCNT and MWCNT from Biological Molecule

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ABSTRACT

Yoshinori Ando synthesized carbon nanotubes first time and Sumio lijima characterized carbon nanotubes in the roll of discovery. In 20th century, it was exciting and innovative scientific development for scientists and researcher in the field of nanotechnology. Now-a-days new areas of application of carbon nanotubes being identified. It has been observed that in Carbon Nanotubes, $C_{10}H_{16}O$ (also known as Camphor) a biological molecule exist. In the present study, Single wall and Multi wall Carbon nanotubes (hereafter referred as SWCNT and MWCNT respectively) have been grown in the temperature range of 750-1000^{0}C through pyrolysis of camphor in presence of ferrocene, a catalyst. The dimensions of SWCNT are 1.2 - 1.3 nm (diameter) and 1.2 - 1.3 mm (length) while that of MWCNT are 20 - 40 nm (diameter) and 22 - 42 mm (length). The characterizations have been done mainly by laser Raman spectra. These CNTs have potential features like absence of amorphous carbon, good purity level and metallic behavior too.

Keywords: ***carbon nanotubes; solar cells; carbon nanotube (CNT)/ Si heterojunction solar cells; single-walled carbon nanotube (SWCNT); double-walled carbon nanotube (DWCNT); multi- walled carbon nanotubes (MWCNT)***

INTRODUCTION:

Yoshinori Ando synthesized carbon nanotubes first time and Sumio lijima characterized carbon nanotubes in the roll of discovery of nanotubes. In late 20th century, it was exciting and innovative scientific development for scientists and research scholars in the field of nanotechnology. Now days new areas of application of carbon nanotubes being identified [1,2].

By using Chemical Vapour Despostion process carbon nanotubes were produced from hydrocarbons. For synthesizing CNTs, purified petroleum products are used i.e. methane, acetylene, benzene, etc. In future, fossil fuels are also alternative source for many kinds of useful applications. A biological hydrocarbon ($C_{10}H_{16}O$) Camphor is used as a synthesis carbon nanotubes. The molecular structure of Camphor is given in Figure 1.

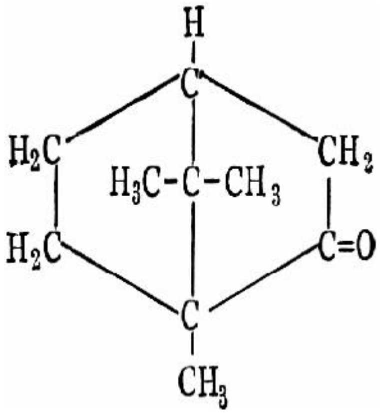

Fig 1: Molecular structure of camphor

Camphor is obtained from Camphor tree. It is a white crystalline solid that sublimates at room temperature can be melt at 180^o. In eastern region, it is used for medicine but other country like America and Europe are less known about it. It is sweet to keep them disinfected from germs and used as insect repellent. During prayers, Indian people burn it in temples. Camphor fumes are non irritant to eyes and its paste is also

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used in the eye make up. It is also used as a plasticizer. It is also eco friendly source due to its green products. Due to its volatile and non toxic nature it is friendly used. Camphor is very cheap.

Camphor has shown the potential of producing fluerences, diamond like carbon, carbon beeds that found in laboratory scale and its applications are in photovoltaic cell, secondary lithium battery. This is first report of carbon nanotubes (CNTs) for both SWCNTs and MWCNTs (See figure 2).

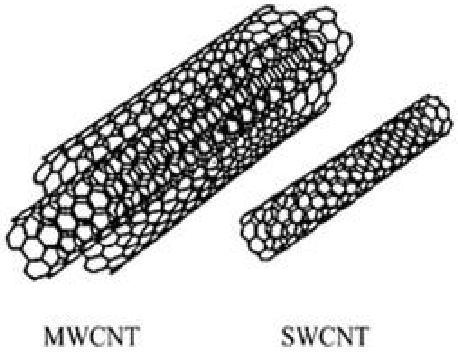

Fig 2 SWCNT and MWCNT

2. EXPERIMENTAL DETAILS :

A quartz tube of one meter long having diameter 30 mm works as a chemical vapour deposition (CVD) reactor which was kept horizontally inside two Electric furnaces. Input of the quartz tube is connected to an argon gas supply output of the quartz tube is connected to water bubbler.

Some quantity of Camphor i.e. 0.1 gm to 0.5 gm and ferrocene (1 wt% approximately) is taken in aluminium tub/boat and then it is kept inside the quartz tube in the centre of the first furnace [3-5]. Initially flow of the argon is very fast i.e. 500 ml/min then after sometime flow of argon is reduced to an experimental value i.e. 55-100 ml/min. Second furnace is switched on to obtain temperature (800-1000^{0}C) for paralysis when the second furnace attain set temperature, then the first furnace to get set vaporization temperature (100 – 203^{0}C). After 4 and 5 minutes ferrocene and camphor first furnace than pyrolyze in the second furnance. At room temperature both the furnace cool down then a thick layer of carbon deposited which is observed in the inner wall of the quartz in the middle region of the second furnace zone [5-6]. The obtaining of this carbon powder was discovered by scanning electron microscopy (SEM), transmissions electron microscopy (TEM) high resolution transmission electron microscopy (HRTEM). Through Raman Spectrometer, Raman spectra has taken.

$$\textbf{Comphor} \xrightarrow[\textbf{Ar : H}_2]{\textbf{1000 °C}} \textbf{Graphene}$$

$$\textbf{Comphor + Ferrocene} \xrightarrow[\textbf{Ar : H}_2]{\textbf{750 °C}} \textbf{Carbon Nano Tube}$$

The dimensions of SWCNT are 1.2 - 1.3 nm (diameter) and 1.2 - 1.3 mm (length) while that of MWCNT are 20 - 40 nm (diameter) and 22 - 42 mm (length) as given in the following Table 1.

Table 1

Dimension	**SWCNT**	**SWCNT**
Diameter	1.2 - 1.3 nm	20 - 40 nm
Length	1.2 - 1.3 mm	22 - 42 mm

3. RESULTS AND DISCUSSION :

3.1 EFFECT OF CONTROL PARAMETER :

In pyralytic chemical vapour deposition process ferrocene is a good iron catalyst particles for growing carbon nanotubes. In this process, vaporisation was took place through mixture of ferrocene and Camphor at different temperature from 100^0C to 230^0C in the first furnance while it was pyrolized at different temperature ranging from 800^0C to 1050^0C in the second furnance through different flow rates of argon and for different pyrolysis periods [6-8]. Quality and quantity of CNT's which was observed depend on some parameters. At low vaporisation temperature less than 105^0C at low pyrolysis temperature. Less than 850^0C. The CNTs was low which was seen through TEM. Good quality of uniform CNTs was obtained at vaporisation temperature 200^0C and pyrolysis temperature 900^0C.

The melting point of the ferrocene is 176^0C while that of camphor is 179^0C. So when they melt simultaneously at a temperature of more than 180^0C in the first furnace than homogeneous mixture was obtained which give uniform CNTs. When the flow rates of argon was 50ml/min less vapor of CNTs is seen passes through the tubes while when the flow of argon rate was 100ml/min good quality of CNTs was passes through the tubes. It was seen that 0.2 gm camphor give good results means obtained 40 mg of CNTs. When the ferrocene concentration was high than 1% more metal particles were observed while for low concentration more amorphous carbon was obtained hence the weight of camphor and ferrocene has a important role for the production of CNTs and pyrolysis time was verified from 10-60 mins. When the prolysis period increases good length of CNTs were obtained.

3.2 GROWTH MECHANISM OF SWCNT AND MWCNT :

Molecular structure of camphor and carbon nanotubes has a difference. There are 10 molecules of carbon in camphor in which 7 carbon molecules form 3 dimensional structure which consist hexagonal and pentagonal rings and remaining 3 carbon are methyl-ones. Mass spectra of camphor vapour having high abundance of hexagonal and pentagonal carbon rings [9-11]. Top carbon atoms has sufficient energy to detach it at 900^0C and obtained reactive carbon atom of hexagonal. When such reactive hexagonal carbon atom added up simul-taneously they form either single layer graphene or multi layer graphene. When thermodynamic conditions are favourable than nano size catalyst particles are found hence curved graphene sheets formed. So we can say that curved grapheme sheets are camphoric hexagonal unit of carbon. When the two sided carbon atom detached then reactive pentagonal carbon obtained which help for nanotubes. Due to pentagonal unit CNTs are hollow and not straight when they are seen through HRTEM.

In each molecule of camphor there is one atom of oxygen. During the pyrolysis process oxygen atom helps in oxidising amorphous carbon into CO_2 gas which is exhausted out but camphoric nanotubes is that which has best optimized conditions they are free from metallic particles without any additional separations, through conventional hydrocarbon like ethylene, acetylene and methane etc nanotubes growth due to adding of individual carbon atom which catalyzed by metal particles. So we can say that addition of carbon atom we need of catalyst particles so these particles are trapped into nanotubes formation. Pentagonal and hexagonal rings are the building blocks in the camphor for the formation of nanotubes.

3.3 RAMAN SPECTROSCOPY:

Through Raman spectroscopy we can study overall materials property using laser beam. When we use argon laser of wavelength 5145 Å at 20mw we see Raman Spectra of CNTs and show 1μm size in 90sec.

The range of Raman shift was 1200 cm^{-1} to 1800 cm^{-1} [12]. D band of graphite has Raman shift 1354 cm^{-1} while G band has Raman shift 1584 cm^{-1} at E_2g. G band say formulization of CNTs through crystalline graphite carbons. Higher intensity of G band indicates higher degree of graphitization, while D band at 1554 cm^{-1} say distortions in the graphenes sheets. Intensity ratio of D band and G band is 0.5

which show disordered in crystallinity. Similarly for thermal decompositions I_d/I_g = 0.85 - 1.3. To observed radial breathing mode (RBM) range of Raman shift should be low i.e. 500 cm^{-1} for single wall nanotubes. A_{1g} breathing mode observed at Raman shift 186 cm^{-1} represents CNTs having diameter 1.2nm.

4. CONCLUSIONS:

When the camphor which is a biological hydrocarbon, is decompose through catalyst then single walled carbon nanotubes and multiwall carbon nanotubes (SWCNT and MWCNT) will be prepared. Amorphous carbon is extremely low and presence of catalyst particle is almost negligible. If controlling factor are chosen carefully then large quantity of SWCNTs prepared otherwise not. Camphor is green, regenerative and cheap material which is interested for researchers for making nanotubes.

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