CARBON NANOTUBES: A REVIEW ON
DIFFERENT WAY OF PRODUCTION

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ABSTRACT
Carbon Nanotubes are one the most important materials of future. Carbon Nanotube Composites plays a vital role in or day to day life. Its explicit strength and outstanding mechanical properties makes it even more important to human society welfare. Research has been going on a large scale to know more about the compound and enhance its properties as required by us. This paper throws light on the techniques have been developed to produce Nanotubes in sizeable quantities, including arc discharge, laser ablation, chemical vapor deposition methods.

Keywords- CNT, Composites, arc discharge, laser ablation, chemical vapor deposition methods.

1. INTRODUCTION
Carbon is unique among the elements in its ability to assume a wide variety of different structures and forms. It is now a little more than twenty years since nanotubes were discovered. Carbon nanotubes have unique physical and chemical properties that chemists are trying to better understand through laboratory research. One of the physical properties of carbon nanotubes is that it's possible to make them only a single atomic layer thick. This means that they can be about 1/50,000th the thickness of a human hair. One of the interesting physical properties about carbon nanotubes is that when you have two of them which have slightly different physical structures and they are joined together, the junction between them can function as an electronic device. This electronic behavior depends upon the structure of the two tubes. Currently scientists are trying to make carbon nanotubes in large amounts with a high degree of purity, so that the physical structures are all the same. If they have similar physical and chemical properties then it becomes easier to predict their behavior which would ultimately make them more useful for possible nanosensors. These nanosensors could behave like semiconducting materials in microelectronic circuits, or detect small changes in electric current, or register chemical reactivity, or changes in air pressure or temperature. Since carbon nanotube science is relatively new, scientists from the fields of chemistry, physics and the material sciences are just beginning to unlock its mysteries and hypothesize about its potential applications.

2. METHODS OF PRODUCTIONSOF CNTs

A. Arc Discharge Method
Arc Discharge method has been reported for producing carbon nanotubes. In this method, as shown in Fig1 nanotubes are produced through arc vaporization of two carbon rods placed end to end with a distance of 1mm in an environment of inert gas such as helium, argon at pressure between 50 to 700 mbar. Carbon rods are evaporated by a direct current of 50 to 100 amps driven by 20V which will create high temperature discharge between two electrodes. Due to this, anode will get evaporated and rod shaped tubes will be deposited on cathode.

Bulk production of CNTs depends on uniformity of plasma arc and temperature of deposition.

Fig.1 arc discharge method
B. Laser Ablation Method

First large-scale (gram quantities) production of SWNTs was achieved in 1996 by the Smalley’s group at Rice University. A pulsed or continuous laser is used to vaporize a 1.2 at. % of cobalt/nickel with 98.8 at.% of graphite composite target that is placed in a 1200°C quartz tube furnace with an inert atmosphere of ~500 Torr of Ar or He. Nanometer-size metal catalyst particles are formed in the plume of vaporized graphite. The metal particles catalyze the growth of SWNTs in the plasma plume, but many by-products are formed at the same time. As the vaporized species cool, small carbon molecules and atoms quickly condense to form larger clusters, possibly including fullerenes. The catalysts also begin to condense, but more slowly at first, and attach to carbon clusters and prevent their closing into cage structures. Catalysts may even open cage structures when they attach to them. From these initial clusters, tubular molecules grow into single-wall carbon nanotubes until the catalyst particles become too large, or until conditions have cooled sufficiently that carbon no longer can diffuse through or over the surface of the catalyst particles. It is also possible that the particles become that much coated with a carbon layer that they cannot absorb more and the nanotube stops growing.

The SWNTs formed in this case are bundled together by Vander waals forces. The nanotubes and by-products are collected via condensation on a cold finger downstream from the target. In principle, arc discharge and laser ablation are similar methods, as both use a metal-impregnated graphite target (anode) to produce SWNTs, and both produce MWNT and fullerenes when pure graphite is used instead. However, the length of MWNT produced through laser ablation is much shorter than that produced by arc discharge method. Therefore, this method does not seem adequate for the synthesis of MWNT. The diameter distribution of SWNTs made by this method is roughly between 1.0 and 1.6 nm. Because of the good quality of nanotubes produced by this method, scientists are trying to scale up laser ablation. However, the results are not yet as good as for the arc-discharge method, but they are still promising. Two new developments in this field are ultra fast Pulses from a free electron laser method and the continuous wave laser-powder method.

![Fig.2 laser ablation method](image)

C. Chemical vapor deposition (CVD)

While the arc discharge method is capable of producing large quantities of unpurified nanotubes, significant effort is being directed towards production processes that offer more controllable routes to the nanotube synthesis. A class of processes that seems to offer the best chance to obtain a controllable process for the selective production of nanotubes with predefined properties is chemical vapour deposition (CVD) [19]. In principle, chemical vapour deposition is the catalytic decomposition of hydrocarbon or carbon monoxide feedstock with the aid of supported transition metal catalysts.

It is carried out in two step process:-

1. Catalyst is deposited on substrate and then nucleation of catalyst is carried via chemical etching or thermal annealing. Ammonia is used as an etchant. Metal catalysts used are Ni, Fe or Co.

2. Carbon source is then placed in gas phase in reaction chamber. Then carbon molecule is converted to atomic level by using energy source like plasma or heated coil. This carbon will get diffused towards substrate, which is coated with catalyst and Nanotubes grow over this metal catalyst. Carbon source used is methane, carbon monoxide or acetylene. Temperature used for synthesis of nanotube is 650 – 9000 C range. The typical yield is 30%.
D. Plasma Enhanced CVD (PECVD)

Plasma-enhanced chemical vapor deposition (PECVD) systems have been used to produce both SWNTs and MWNTs. PECVD is a general term, encompassing several differing synthesis methods. In general PECVD can be direct or remote. Direct PECVD systems can be used for the production of MWNT field emitter towers and some SWNTs. A remote PECVD can also be used to produce both MWNTs and SWNTs (Figure 3). For SWNT synthesis in the direct PECVD system, the researchers heated the substrate up to 550 to 850°C, utilized a CH4/H2 gas mixture at 500 mT, and applied 900 W of plasma power as well as an externally applied magnetic field.

Fig3. Plasma Enhanced CVD

CONCLUSION

This paper describes the review on the different way of production of carbon nanotubes. CNTs are an important aspect of human society and hence are the most researched compound in the present era. The following conclusion can be drawn from above discussion:

A. Both arc-discharge and laser ablation methods suffer from disadvantages of being expensive and uneconomical methods of production of carbon nanotubes on large scale, despite they yield high quality carbon nanotubes with reasonable high yield.

B. Chemical Vapor Deposition is best-suited, economic method of production of high purity Single Walled Carbon Nanotubes (SWNT) on large scale.

REFERENCE


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