International Journal of Basic and Applied Biology
p-ISSN: 2349-5820, e-ISSN: 2349-5839, Volume 6, Issue 2; April-June, 2019, pp. 106-109

http://www.krishisanskriti.org/Publication.html

Carbon Nanotube – A Unique Management of Fibrosis Lungs Cells

Dr. Ali Ahmad Ansari

Assistant Professor of Physics, Deptt. of Physics, KCET (Kishanganj College of Engineering and Technology) Veriadangj, Kishanganj, Bihar, India—855107
E-mail-aliahmadansari456@gmail.com

Abstract—*Nanotechnology is the new branch of applied science and technology. It is emerging technology stands forefront in the science, research and technology development [1]. Carbon nanotubes (CNTs) are one of the most promising materials in the field of nanotechnology. Carbon nanotubes bend automatically due to their nanoshape. Bending of nanotubes provides buckling and this buckling is usual way for nanotube to reduce its strain. Carbon nanotubes are produced by the many methods such as electric arc discharge, laser ablation and chemical vapour deposition etc. CNTs possess unique electrical, electronics, mechanical, chemical, thermal optical and magnetic properties, due to which these materials are suitable for various applications [2]. The CNTs production is increasing in proportion to their usage. Since materials at the nanoscale behave differently than they do in their massive form, hence these CNTs are subjected to intense toxicological scrutiny. According to the research exposures of CNTs have not any negative effects on human health. The present paper demonstrates the carbon nanotubes play a vital role in unique management of fibrosis liungs cell in the human body [3].*

Keywords*: carbon nanotubes; management; health effects; toxicity; unique.*

1. INTRODUCTION

Nanotechnology-Nanotechnology is the recent emerging field of science and technology, which deals with nanoparticles (1nm=10^{-9} m) and their production[4]. CNTs are nanoparticles with a size range of 1-100 nm, with unique mechanical electrical electronics, thermal, optical, magnetic and vibrational properties, having a wide range of applications in the fields of electronics, computers, aerospace and other industries. Humans get exposed to high concentrations of these particles during the manufacturing process and usage of nano based products [5]. CNTs are a form of carbon with a cylindrical shape and are first observed by Endo (1975), and later by Lijima (1991) in the soot produced by the arc-discharge synthesis of fullerenes. These tubes are made up of thick sheets of carbon called graphene which were rolled up to form a seam less cylinder. On the basis of number of tubes. CNTs are the recent nanomaterials mostly used by nanotechnology in various fields.

In the present time, the CNTs are classified as Single walled (SWCNTs), Double walled (DWCNTs) and Multiwalled (MWCNTs) carbon nanotubes [6].

PRODUCTION

CNTs are multifunctional nanomaterials finding wide range of applications, there by their production is also being increased by the companies. More than 100 companies in the world today are manufacturing CNTs and this number may increase to more than 200 in the next five years. Currently, CNTs account for 28 % market share of overall nanomaterials demand (Table 1). By 2016, the market demand amounts to 333, 043 metric tons with a revenue of $2.4 billions, a five year compound annual growth rate of 19.2 % in unit terms and 20.9[7]

In the coming five years, the CNT production capacities may increase enormously in some manufacturing units(by 2011 Nanotechnology research review, 2012).The Global CNTs, market-industry beckons, 2011 is demonstrated in table-1[7]

Table 1: Annual production capacities of CNTs in manufacturing companies (2010)

S. No	Type of CNTs	Name of manufacturing Company	Annual production capacity (in metric tonnes)	Name of production method
1.	SWCNTs	Mitsubishi Rayon Co. Ltd	1.2	Chemical vapour deposition (CVD)
2.		Kleancarbon Inc.	1.0	CVD
3.		Unidym, Inc	1.5	High-pressure carbon monoxide (HiPCO)
4.		Toray Industries, Inc	1.5	Catalytic chemical vapour deposition (CCVD)

5.		SouthWest Nano Technologies Inc	1.0	Cobalt molybdenum catalyst (CoMoCat)
6.	MWCNTs	Showa Denko K.K	500	CCVD
7.		CNano Technology Limited	500	CCVD
8.		Nanocyl S.A	400	CCVD
9.		Bayer Material science AG	260	CCVD
10.		Arkema Inc	50	CCVD
11.		Hyperion Catalysis International, Inc	50	CVD

Synthesis

CNTs are synthesized by various methods like arc-discharge, laser ablation, chemical vapour deposition (CVD), high pressure carbon monoxide (HiPCO), CoMoCat etc. An energy source is added to carbon source for the synthesis of CNTs, which may vary depending on the synthesis method (Donaldson et al. 2006). Though the CNTs are synthesized by different methods CVD, HiPCO and CoMoCat are the most widely used methods for production of CNTs due to their high yield, purity and low cost of production and the reason for fewer yields of CNTs in arc discharge and laser ablation is due to the evaporation of carbon source at high temperatures. Most important method of synthesis of CNT is chemical vapor deposition method described below[8].

Chemical vapour deposition-

In this method the most commonly used catalysts materials namely nickel cobalt iron or a combination is heated to high temperature in a tube furnace and hydrocarbon gas is passed through the reactor in controlled manner for a definite period of time. The hydrocarbon gas dissociate in the furnace and supplies the necessary carbon atoms for the growth of CNT. At low temperatures 500 to 800 degree centigrade the MWCNT are available where as at high temperature 600 to 1200 degree centigrades SWCNTs are available[9].

Properties

CNTs, due to its nano size exhibits the following properties that is, Mechanical, Elastic, Electrical and Electronic, Thermal, Optical and Magnetic properties etc.

CNTs are made by graphene sheet. It contains c-c bond in its layer which is responsible for the tensile strength and elasticity. By experiment CNTs are good conductors of electricity and conducts electricity thus CNTs contain electrical and electronics properties. CNTs are good conductor of heat due to their nano shapes and geometrical structure. Theoretically it is predicted that thermal conductivity of CNT is larger than graphite. Theoretically it is predicted that CNT is the the best absorber of light and contain many optical properties. CNTs bear magnetic propetrties due to its geometrical and nano structure[10].

Study of health effects by CNTs

Though the CNTs are multidisciplinary nanomaterials have unique properties and are useful for many educational and industrial applications, effects on human health were investigated because materials at the nanoscale behave differently from their original form. CNTs can enter into the human body through various routes like skin, lungs and digestive tract. After gaining entry, they can accumulate in different body parts and can bring out changes. However among them studies were conducted in lungs cell model as it is the most sensitive organ [11].Scientists (Cui et al. 2005; Magrez et al. 2006; Davoren et al. 2007; Zhang et al 2007; Muller et al. 2008; Simon-Deckers et al. 2008; Tabet et al. 2009; Patlolla et al 2010; Thurnherr et al. 2011) have performed MTT assay in order to measure the cytotoxicity of CNTs with varying exposure concentrations. The studies indicated decrease in cell viability with increasing concentrations of CNTs[12].

The extent of damage to the cell can be determined by LDH release assay (cell damage marker) (Muller et al. 2008, Simon-Deckers et al. 2008; Zein et al 2008; Patlolla et al 2010; Cesta et al. 2010; Fenoglio et al. 2012;). The cell damage was dose-dependent in RLE cells and was significant at 100 and 150 Qg/mL of MWCNTs (Muller et al. 2008). Exposure to 100 Qg/mL MWCNTs for two days has resulted in 35-40 % cell damage in A549 cells (Simon-Deckers et al. 2008). Zein et al 2008 observed a slight increase in LDH in human peripheral blood lymphocytes after two days exposure to 5, 10, 25 and 50 Qg/mL SWCNTs. Patlolla et al. (2010) exposed human dermal fibroblasts to MWCNTs and quantified the cell damage by performing LDH release assay. The release of LDH increased in time and in dose-dependent manner [13].

Fragmentation and apoptotic bodies. Chromatin condensation and to phosphotidyl serine present on the extracellular surface of cells reflects apoptosis. Methods like DNA fragmentation and annexin V-FITC (fluoresce in isothiocyanate) staining, Caspase-3 and 3/7 activity were used by Bang et al. (2011); Bottini et al. (2006); Cui et al. (2005) and Zeni et al. (2008) to CNTs.

Proliferation of skin fibroblasts can be measured by incorporating BrdU and the cell proliferation in CNT treated cells was delayed because of G2/M block and S phase delay during cell cycle. Cell proliferation was reduced by ~50 % in MWCNT treated fibroblasts after two days at 0.06 Qg /mL (Ding et al. 2005). Davoren et al. 2007 used Alamar blue assay to test the cell proliferation inhibition of SWCNTs exposed A549 lung cells both in the presence and absence of serum. The effect of low concentrations of SWCNTs on A549 lung cells was considerably less in the presence of serum which might be due to the availability of nutrients, whereas at

higher concentrations of SWCNTs the effect is independent of serum.

Exposure to CNTs may effect the genetic material of the cells, which are called genotoxic effects and can be evaluated by MN assay, comet assay and DNA ladder analysis. Scientists (Ding et al. (2005), Muller et al. (2008), Thurnherr et al. (2011)) performed studies to determine the genotoxic effects of CNTs in various cell lines and animal models[14].

Study of fibrosis of lung cells

Exposure to CNTs developed fibrosis in experimental animal used for the study (Warheit et al. 2004; Shvedova et al. 2005; Magnum et al. 2006 ; Mercer et al. 2008; Ma-Hock et al. 2009; Cesta et al. 2010; Fenoglio et al. 2012).[15].Warheit et al. (2004) instilled rats with SWCNTs ranging from 1000-5000 Qg/kg and observed the effects upto 90 days. Shvedova et al. (2005) observed the pulmonary responses of mice by exposing them to SWCNTs at a concentrations of 10, 20, 40 Qg/mouse for 60 days.. Magnum et al. (2006) counted cells, analyzed total protein and LDH levels in BALF (broncho alveolar lavage fluid) and observed the formation of fibrotic lesions in rat lungs after 21 days of exposure to SWCNTs (CVD, ~300-600 m^2/g surface area, 896 % carbon, 2.6 % cobalt and 1.7 % molybdenum) (200 Qg/kg). Increased PDGF levels suggest their role in the formation of SWCNT induced fibrotic lesions. The dispersion of SWCNTs (HiPCO, diameter 0.69-3.7 Qm with <2 wt % of contaminants) will increase the thickness of alveolar wall and number of alveolar macrophages [16). Cesta et al. (2010) exposed rats to MWCNTs (4000 Qg/kg) (microgram per kilogram) for a period of 21 days and observed significant fibrosis & lesions in the lungs. Prior exposure to 2500 Qg/kg lipo polysaccharide (LPS) of E.coli enhanced the effect of MWCNTs by inducing fibrosis, increasing total protein and platelet derived growth factor (PDGF-AA) by two-fold and three to four folds respectively after one day. The effect of MWCNTs decreased with increase in diameter[17].

In all studies the exposure to CNTs (SWCNTs or MWCNTs) caused fibrosis of lungs cell, which is an immune reaction exhibited by host to the target particle and different in each study and is due to variation in dosage & exposure routes.[18]

Cellular internalization of CNTs

Exposure of lung cells to CNTs has resulted in the internalization of nanotubes. Transmission electron microscopy (TEM) observations of MWCNT exposed A549 cells have revealed the presence of two to three micrometer or smaller MWCNTs in the cytoplasm, in an isolated manner, and altered the morphology of cells (Simon- Deckers et al. 2008). In contrast, agglomerates of MWCNTs with different sizes were found in the cytoplasm of murine alveolar macrophage (MH-S) cells (Fenoglio et al. 2012)[19].

CONCLUSIONS

CNTs are multipurpus nanomaterials used in different fields.. Due to their small size, the nanotubes can get entry easily into the human body through lungs, skin and gut. Compared to other organs as lung is the most sensitive organ, most of the studies were conducted on lung cell model. It is evident from the literature that CNTs are toxic to humans and there exists inconsistency among the reports on cytotoxicity of CNTs. It may be due to variation in the synthesis methods, purification method, mode of CNTs exposure i.e., as suspension in the media (or) immobilisation (or) aerosol etc., route of administration, dimensions, metallic content, dispersion media, membrane permeability of a particular cell line and dosage of CNTs used in that particular study and surface chemistry of the nanotubes and experimental materials used in the study. CNTs are able to cause oxidative stress, inflammation; cell damage, granulomas etc., and these effects have been also observed as dose and time dependent. Even though many studies have been conducted there is no clear evidence for the cytotoxicity of CNTs. Owing to their similarity to asbestos and other pathogenic fibres which have toxicity associated with their needle-like shape, further research is needed in this area in order to release the nanobased products into the market safely. Workers who are exposed to airborne CNTs need to take proper measures in order to protect themselves from the effects of CNTs in the body.

FUTURE DIRECTION

As it stands now the majority of commercial nanoparticles applications in devices fabrication, are geared towards the revolution small nanoscale devices production industries. There are some developments in the direction and remotely controlling the function of nanoprobe and other kind of strange nanoparticles. The major turned in further development of nanomaterials to make them multifunctional and controlled by external signal or by local environment. Thus essentialy turning them into nanodevices. If nanotechnology provides less potential with respect to other technology. The other kind of technology may be Pico technology. We may be work on this new technology for finding more potential and facilities in the new direction[20].

ACKNOWLEDGEMENT

I am indebted and grateful to my supervisor Dr. Amita Sharma Assitant Professor of Physics Deptt. of Physics BRABU Muzafferpur Bihar, for her constant guidance and encouragement for research work. My thanks to Dr, B Roy Dr. Dr, V K Thakur, Dr. Madan Jee and other faculty members for their valuable suggestions for research work.

REFERENCES

[1] A systematic study of electronic properties of Bent Carbon Nanotube(CNT)-a research paper Dr, Ali Ahmad Ansari July-2018.

[2] Electronic Transport through bent carbon nanotubes and Nanotechnology theoretically-research paper Dr Ali Ahmad Ansari.-March 2018.

[3] Bottini, M., Bruckner, S., Nika, K., Bottini, N., Bellucci, S., Magrini, A., Antonio, B., & Mustelin, T. (2006). Multi-walled carbon nanotubes induce T lymphocyte apoptosis. Toxicology Letters, 160, 121-126.

[4] Elements of Nanotechnology Education in Engineering Curriculum World wide Research paper-2001.

[5] Concept of conductivity of carbon nanotube- a research paper, October2018

[6] "Theoretical Study of Electronic Transport Through Bent Carbon Nanotubes-a Ph.D Thesis BRABU Muzafferpur Bihar, India by Dr, Ali Ahmad Ansari..

[7] Carbon Nanotube-Productio Properties and Health Effects A Ziauddin –Research Paper July September-2014

[8] Davoren, M., Herzog, E., Casey, A., Cottineau, B., & Chambers, G. (2007). In vitro toxicity evaluation of single walled carbon nanotubes on human A549 lung cells. Toxicology in Vitro, 21, 438-448.

[9] Ding, L., Stilwell, J., Zhang, T., Elboudwarej, O., Jiang, H., Selegue, J.P., Cooke, P.A., Gray, J.W., & Chen, F.F. (2005). Molecular characterization of the cytotoxic mechanism of multiwall carbon nanotubes and nano onions on human skin fibroblast. Nano Letters, 5, 2448-2464.

[10] Seminar report on Carbon Nanotubes slide share Nov-26 2013.

[11] Dong, L., Joseph, K.L., Witkowski, C.M., & Craig, M.M. (2008). Cytotoxicity of single walled carbon nanotubes suspended in various surfactants. Nanotechnology, 19.

[12] Fenoglio, I., Aldieri, E., Gazzano, E., Cesano, F., Colonna, M., Scarano, D., Mazzucco, G., Attanasio, A., Yakoub, Y., Lison, D., & Fubini, B. (2012). Thickness of multiwalled carbon nanotubes affects their lung toxicity. Chemical Research Toxicology, 25, 74-82.

[13] Hamada, N., Sawada, S., & Oshiyama, A. (1992). New one-dimensional conductors: graphitic microtubules. Physical Review Letters, 68, 1579-1581.

[14] Hone, J. (2004). Carbon Nanotubes: Thermal Properties. Diss., Columbia Univ.

[15] Hong, S., & Myung, S. (2007). Nanotube Electronics: A flexible approach to mobility. Nature Nanotechnology, 2, 207-208.

[16] ISO/TS 27687. 2008. www.horiba.com/in/scientific/ products/particle-characterization/applications/what-is-a Nanoparticle/ [17] Lam, C.W., James, J.T., McCluskey, R., & Hunter, R.L. (2004). Pulmonary toxicity of single wall carbon nanotubes in mice 7 and 90 days after intratracheal instillation. Toxicological Sciences, 77, 126-134.

[17] Liu, A., Sun, K., Yang, J., & Zhao, D. (2008). Toxicological effects of multi-wall carbon nanotubes in rats. Journal of Nanoparticle Research, 10, 1303-1307.

[18] Lourie, O., & Wagner, H.D. (1998). Evaluation of Young's modulus of carbon nanotubes by micro-Raman spectroscopy. Journal of Materials Research, 13, 2418-2422 .

[19] Magrez, A., Kasas, S., Salicio, V., Pasquier, N., Seo, J.W., Celio, M., Catsicas, S., Schwaller, B., & Forro, L. (2006). Cellular toxicity of carbon-based nanomaterials. Nano Letters, 6, 1121-1125.