International Journal of Theoretical & Applied Sciences, 8(2): 50-53(2016)

ISSN No. (Print): 0975-1718
ISSN No. (Online): 2249-3247

Suitability of Carbon Nanotubes as Drug Carrier

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(Received 19 August, 2016 accepted 12 October, 2016)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The application of nanotechnology has tremendous potential in healthcare, particularly for the development of better pharmaceuticals. Size of Nano tubes is an important criterion for selecting suitable nano material. Smaller sized nano material with more surface area is preferred. The surface area of Carbon Nano Tubes (CNT) was measured by Methylene blue method. The size of Carbon Nanotubes was reduced using ball milling The presented work is a prelude in the direction of using Carbon Nano material as a vehicle for drug delivery to the desired sites. Analysis of CNT by TEM and SEM shows reduction of CNT in uneven sizes.

Keywords: Carbon Nanotubes, Surface area, Methylene Blue Method. Ball milling

I. INTRODUCTION

Nano enabled drug delivery has already been successful in delivering drugs to specific tissues within the body, and promises capability that will enhance drug penetration into cells, as well as other means to improve drug activity. It is known that the efficacy of a drug can be increased if it is delivered to its target selectively and its release profile is controlled.

In the past decade, two blossoming technology, have been hot research topics of the world. The powerful utility of concerted application of nanotechnology and biotechnology has been recently exemplified by breakthroughs in biodirected nanosynthesis /assembly and Nano-aided biological recognition. While current effort is focused on searching for methods to mimic or exploit the unique capabilities of bioagents in producing nanostructures.

Nano-scale devices attached with antibodies and loaded with drugs can serve as a targeted drug delivery vehicle that can transport chemo-therapeutics or even therapeutic genes into diseased cells while sparing the loading of healthy cells with drugs. Targeting a drug to its site of action would not only improve the therapeutic efficacy but also enable a reduction in total dose of the drug, which must be administered to achieve a therapeutic response, thus minimizing unwanted toxic effects of the drugs. Dendrimers, silica-coated micelles, ceramic Nano-particles and cross-linked liposomes have already shown to have potential for being a drug carrier. Moreover, Carbon Nano materials (CNM) that have been extensively used for various bio-applications also show possibility of being used for drug delivery [1].

One of the primary objectives in the development of drug delivery system is the controlled delivery of drug to its site of action at an optimal rate [2] and in the most efficient way possible. Nano-particles, chiefly due to their small particle size (below 1 μm), offer many advantages for medical applications [3]. The particle size enables intravenous and intra-arterial injection, since particles of this size can easily traverse even the smallest blood capillaries with inner diameter of 3-8 μm [4]. A small size also minimizes the possible irritant reactions at the injection site [5].

The nano scientist are fantasizing that ones CNM along with drug is introduced into living system, it can act as a self driven syringe and deliver the medicine to the site of requirement. Not only that they are planning to make CNM a disposable syringe which can be removed from the system either by degradation or excreting it from the system.

Carbon Nanotubes (CNTs) have emerged as a recent and promising option especially in cancer therapy. This is mainly due to their unique properties, which render them extremely versatile through the incorporation of several functional groups and targeting molecules at the same time, while their natural shape allows them to selectively penetrate across biological barriers in a non-invasive way.

Once chemically-modified with suitable functional groups, can be considered as a valuable system in comparison to the already existing nanodevices. This will include the estimation of the most recent advances in the field of nanotechnology, together with a cautious evaluation of potential risks and hazards associated with the extensive use of this fascinating, but still unknown, nano material.

II. SURFACE AREA MEASUREMENT

Surface area measurement of CNM was done using Methylene blue method. Various concentrations (0.1 x 10^{-5}M to 1 x 10^{-5}M) of methylene blue (LOBA CHEMIE PVT. Ltd.) solution were prepared with distilled water. The magnitude of absorbance (optical density) at its λ_{max} (670 nm) was recorded with the help of a spectrophotometer (Systronic 169).

These optical densities were plotted against concentration of methylene blue (Figure 4.7). This graph was used as the standard graph for determining the amount of dye adsorbed on the surface of the carbon materials.

The concentration of methylene blue adsorbed by the CNM was calculated from the difference between the methylene blue concentration before and after adsorption onto the carbon by using the standard graph (Fig. 1).

From this difference in the concentration of methylene blue, the surface area of carbon was calculated by using equation1

S (Surface area, Km^2 / Kg) = $\boldsymbol{N}_g\, a_{MB}\, \boldsymbol{N}\, \boldsymbol{10^{-20}} / \boldsymbol{M}$ (1)

Where $\boldsymbol{N}_g$, a_{MB}, N *and* M are number of molecule of methylene blue adsorbed at the surface of carbon (i.e., $\boldsymbol{N}_g = N_m * M$), surface area of one molecule of methylene blue (which is $197A^{o\,2}$) Avogadro's number (6.02×10^{23} mole $^{-1}$) and molecular weight of methylene blue (373.9 g mol^{-1}) respectively. N_m is the number of moles of methylene blue per gram of carbon required to form amonolayer. 10^{-20} is the conversion factor to get km^2 / kg. This equation can be modified to get equation 2 by putting the values of Avogadro's number,

$$Surface Area = \frac{1187.736 * C * V}{Wt} \quad (2)$$

C = Conc *difference in Moles/Liter*

V = Volume of *Methylene blue* solution *in ml*

Wt = *Wt of carbon in gms*

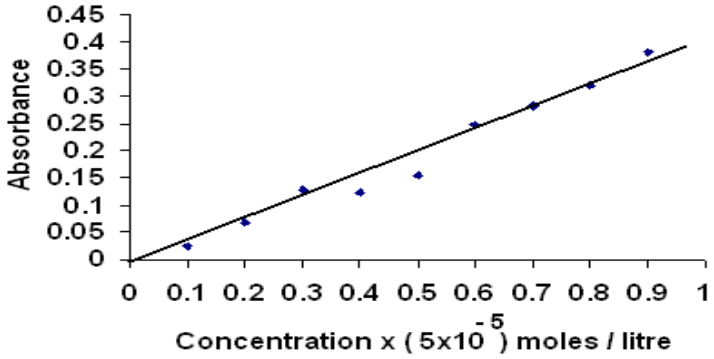
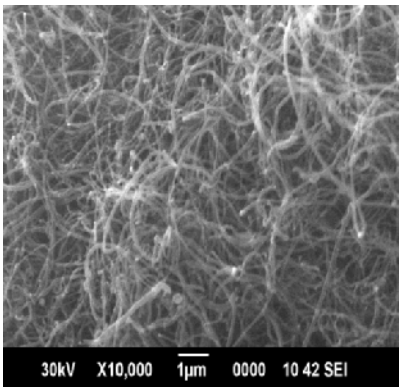
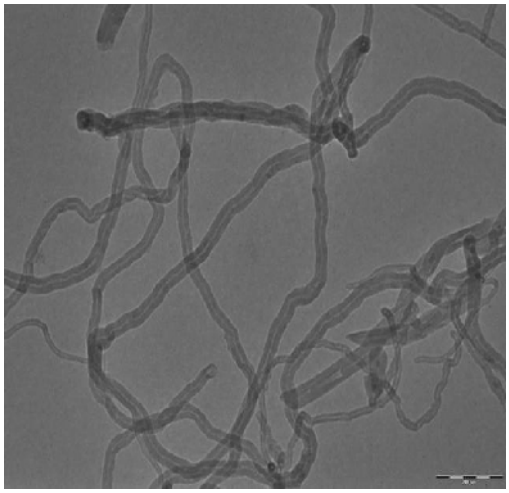


Fig. 1. Calibration Curve of Absorbance Vs Concentration.

Results of the surface area of CNM calculated by this technique is 98.6 m^2/gm for MWCNT



(a)



(b)

Fig. 2(a) SEM and (b) TEM of MWCNT procured from Monad Nanotech Pvt. Ltd.

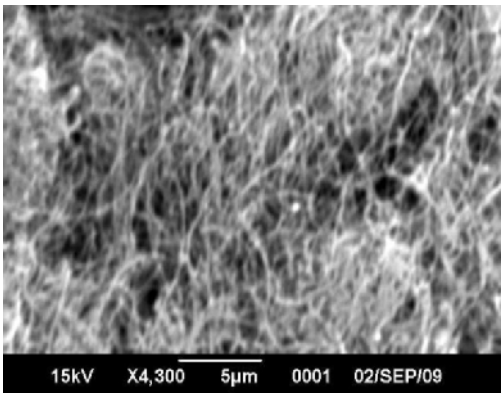
Scanning electron micrographs and transmission electron micrographs reveals that the length of CNT is 5-15 µm and diameter ranged from 10-20 nm. Lumen size of CNT is 1/3rd of diameter i.e. 3.33to 6.67nm.
The very long CNT are not very suitable material to be used as drug carrier; hence it was decided to reduce the length by ball milling.

III. TAILORING OF CNM

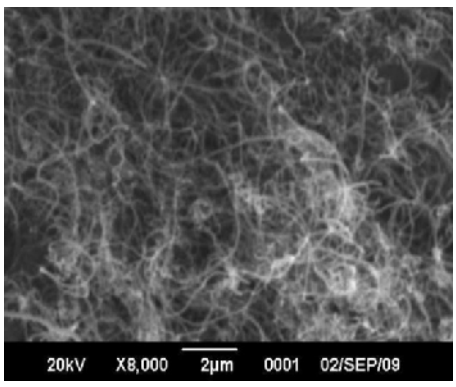
Since SEM showed rather long sizes of CNT it was decided to try to cut them to smaller sizes using centrifugal ball milling. Ball milling of MWCNT was done on high efficiency ball mill (Retsch make, model S1000). It was ball milled at different frequency for different period of time. Scanning electron micrographs of Ball milled CNTs were taken.CNT on ball milling at 50 rpm shows considerable reduction in length, but there was uneven breaking in the length of CNT. Whereas ball milling at higher rpm (90 rpm) damaged the CNT structure (Fig. 3).

Table 1: Ball milling at different frequencies and time.

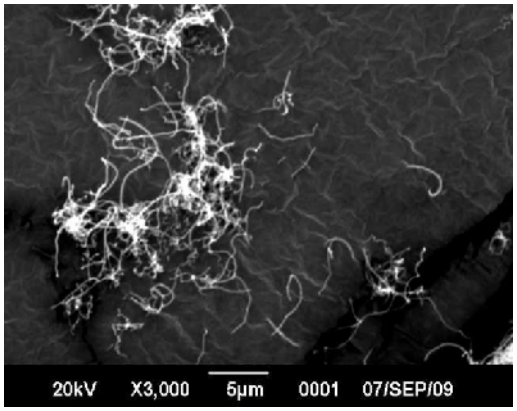
Frequency (rpm)	Time in minutes	
10	15	30
50	15	30
90	15	30



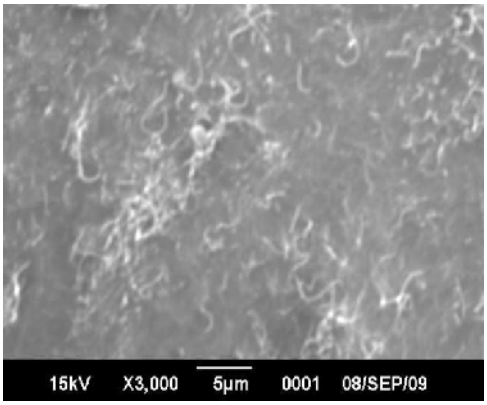
(a) 10rpm 15 Mins



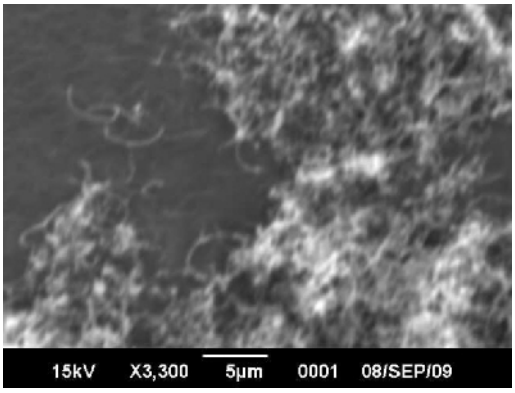
(b) 10 rpm 30 mins



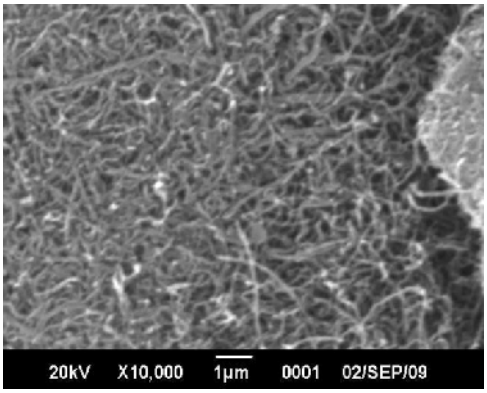
(c) 50 rpm 15 mins



(d) 50 rpm 30 mins



(e) 90 rpm 15 mins



(f) 90 rpm 30 mins

Fig. 3. SEM of Ball milled CNT at different frequencies and for different durations.

IV. CONCLUSION

Since no literature was available regarding the use of ball mill to reduce the size of CNM, it was decided to try ball milling for reducing the size of CNT. No doubt the size gets reduced but the sizes are not similar, moreover, ball milling is damaging impact on CNT. Therefore, it was concluded that this method is not suitable for tailoring the size of Nanotubes.

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