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A Study on Carbon Nano Tube and Bucky Balls Membrane for Water Purification

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Abstract- Carbon Nanotube are single sheets of graphite (called graphene) rolled into cylinders. The diameter of the tubes is typically of nanometer dimensions, while the lengths are typically micrometers. In this paper we are going Explore the property of Carbon Nanotube which is currently the focus of intense research. The Nanotube may consist of one up to tens and hundreds of concentric shells of carbons with adjacent shells separation of 0.34 nm; we are also going to explore the properties of carbon Nano tube through Raman Spectroscopy, and this paper review the Bucky paper Membrane for water Filtration.

Index Terms— Carbon Nanotube, Optical Properties, Bucky-paper, membrane; filtration method, Raman Spectroscopy.

I. INTRODUCTION

Carbon an element which has the affinity to bond with itself is forming a rich variety of structures and morphologies. Until recently only two types of - carbon crystalline structures were known – diamond and graphite. The first carbon fibers were prepared by Thomas A. Edison to provide a filament for an early model of an electric light bulb. Specially selected bamboo filaments were proposed to produce a coiled carbon resistor, which could be heated comically.

Further research on filamentous carbon proceeded more slowly, since the carbon spiral coil was soon replaced by tungsten filaments. The second stimulus to carbon fiber research came in the 1950's from the space and aircraft industry, which was searching for strong stiff light-weight fibers with superior mechanical properties. This stimulation led to the synthesis of single crystal carbon whiskers, which have become a benchmark for the discussion of mechanical and elastic properties of carbon fibers. Intense efforts were invested in reducing fiber defects and crack propagation as well as in development of highly oriented pyrolytic graphite, which preceded the synthesis of carbon fibers by a catalytic chemical vapour deposition (CVD) process.

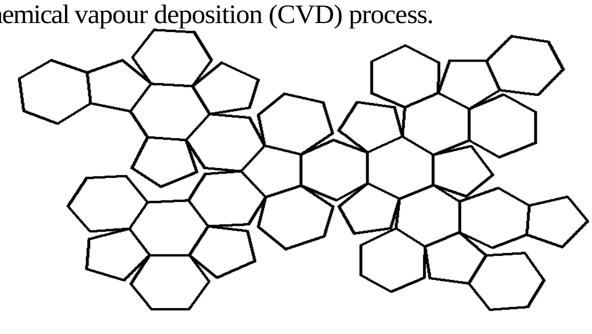

Figure-1 Bucky-Balls

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These molecules are called "Buckminster fullerenes" or short "Bucky balls", in honor of the brilliant philosopher, architect, engineer, mathematician, poet and cosmologist Richard Buckminster Fuller (1895-1983), Now in the structure of carbon is given blew.

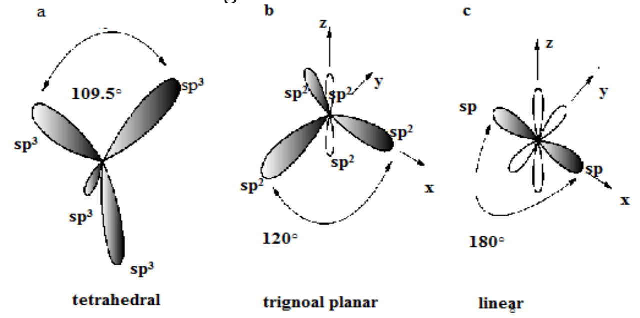

Figure-2: The 3 different hybridization states of carbon (a) sp^3,(b) sp^2, (c) sp^1

Graphite

Graphite is the solid form of carbon stable at room temperature and its structure is made of layers in which each carbon atom is bound to three others. The stacking sequence of this open honeycomb network with an in-plane nearest-neighbor distance a C-C of 1.421 Å, an in-plane lattice constant a_0 of 2.456 Å and a c-axis lattice constant c_0 of 6.708 Å is generally ABAB with a resulting interlayer spacing of 3.34 Å (= hexagonal Bernal graphite [Figure 3]).

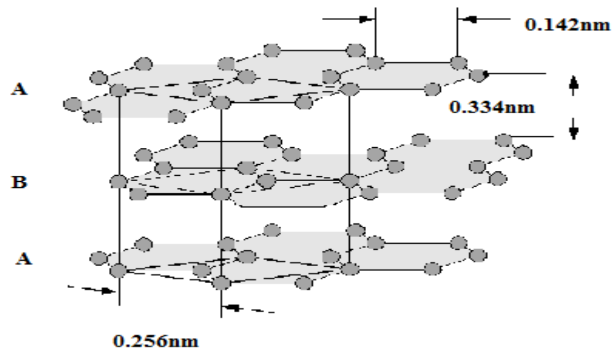

Figure-3 Graphite Structure

Diamond

The high pressure phase of carbon is diamond. Each carbon atom is coordinated tetrahedral by four others and the resulting structure is cubic. This structure is a consequence of the sp^3 hybridization of the bonding orbitals. The c-axis lattice constant a_0 is 3.567 Å and a nearest-neighbor distance a C-C of 1.544 Å (10% larger than that of graphite). The diamond crystal can be viewed as two interpenetrating fcc structures (zinc blend type) displaced by (¼, ¼, ¼) a0 along the body diagonal, with cubic space group Fd3m [Figure 4]

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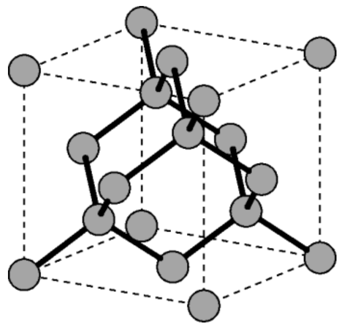

Fig. 4: Diamond in the cubic form

Fullerenes

Fullerene, in honor of the chemist Richard Buckminster Fuller, is a closed cage carbon molecule containing only hexagonal and pentagonal rings. While the number of pentagons has to be exactly 12, the number of hexagons is arbitrary. Such bodies fulfill the Euler's theorem for polyhedral. f + v = e + 2 f: faces, v: vertices, e: edges The most frequent fullerene is the C_{60} molecule with an irregular truncated icosahedra structure that has 90 edges of equal length, 60 equivalent vertices, 20 hexagonal faces and 12 additional pentagonal faces. Each of the carbon atoms in C_{60} is joined to three neighbors through sp^2 bonds, although there must be a small amount of sp3 character due to the curvature.

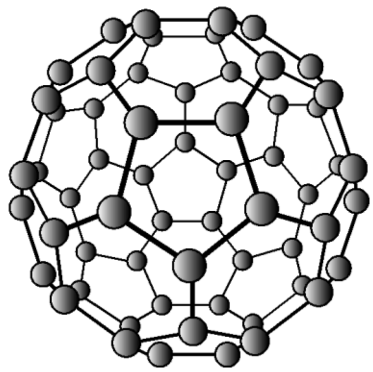

Fig. 5: C60 Buckminsterfullerene with single bonds in pentagons, and double bonds in hexagons

Carbon Nanotube

Carbon Nanotube are the most interesting and enthralling isomer of carbon. The hybridization configuration sp^2 is not only able to form a planar structure as occurring in graphite. The grapheme sheet can also be wrapped up into a closed polyhedral (0-dimensional) e.g. as in fullerenes or rolled up into cylinders (1-dimensional) as in carbon Nanotube.

Raman Spectroscopy

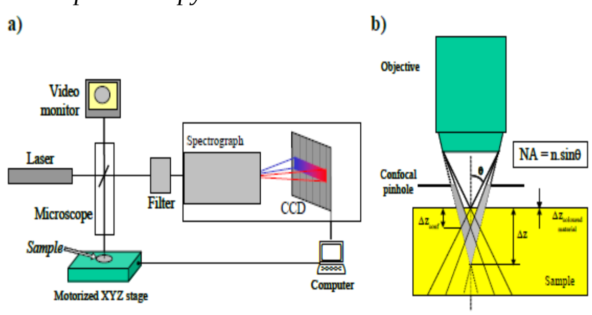

Figure-6 Principle of a conventional micro-Raman spectrometer – b) Observation of a sample through a microscope (NA: Numerical Aperture; n is the refractive index

Bucky-Paper Membranes

Due to the simplicity of their preparation, Bucky-papers were one of the first macroscopic structures fabricated from CNTs and fullerene their mechanical, electrical and thermal properties have been extensively studied. The term "Bucky-paper" is used to describe a mat of randomly entangled CNTs and Bucky bulls prepared by filtration or alternative papermaking processes. CNTs are known to have a strong tendency to aggregate due to Vander Waals interactions, and it is these Vander Waals interactions which also hold the CNTs together into a cohesive Bucky-paper. Consequently Bucky-papers can be highly flexible and mechanically robust as demonstrated by the origami plane. Longer, narrower (fewer walled) and more pure Nanotube typically lead to stronger Bucky-papers with higher tensile strengths. With increasing MWNT diameter, the attractive Vander Waals forces between CNTs become less effective, leading to Bucky-papers with lower tensile strength and poor cohesiveness.

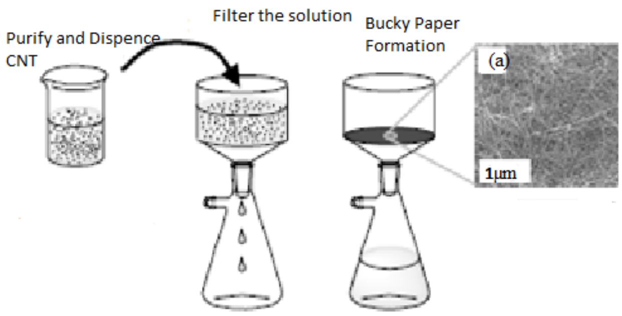

Figure-7 Formation of Bucky Paper

Bucky-Paper Processing

Bucky-papers are typically formed by first purifying the CNTs and then dispersing them in a suitable solvent. Once a well dispersed solution is achieved, it is filtered through a porous up port which captures the CNTs to form an optically opaque CNT Bucky-paper). If the Bucky-paper is thick enough it can be peeled off the support filter intact. As prepared CNTs are highly entangled and typically contaminated with impurities. These impurities include the metal catalyst particles, such as Fe, Co and Ni needed for CNT growth, as well as other carbonaceous by-products including amorphous carbon, fullerenes, and graphitic Nano-particles. The purification and dispersion of CNTs is therefore a critical step in Bucky-paper processing that can affect both the Bucky-paper structure and properties. This point is illustrated the change in Bucky-paper morphology due to differences in the initial CNT and fullerene dispersion quality

Scanning Tunneling Microscopy

Principles behind the operation of the scanning tunneling microscope, the first of many modern "scanning probe microscopes" that have opened up the wonders of surface Nanoscale imaging for scientists. One can see how the basic quantum mechanical principles of tunneling are utilized in the operation of this instrument, how tunneling is used to create a surface "tomogram" which allows the height of the surfaces of conductors to be imaged at the atomic-scale, and how one can use this information to take quantitative measurements on surfaces.

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You will use surface analysis tools to measure the dimensions of the nanogrid (and calibrate your STM) and the bond angles and lengths for graphite.

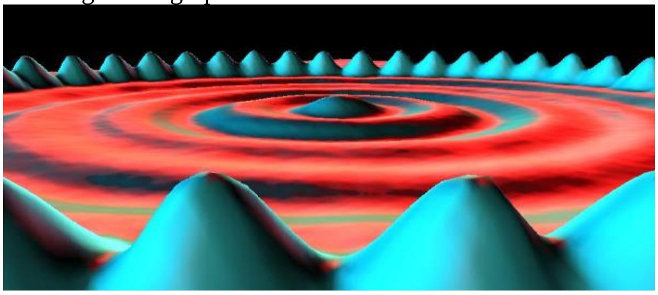


Figure-8 IBM image of a “quantum corral” (ring of atoms binding a surface electron) in which computer 3D reconstructions are used to indicate surface structure

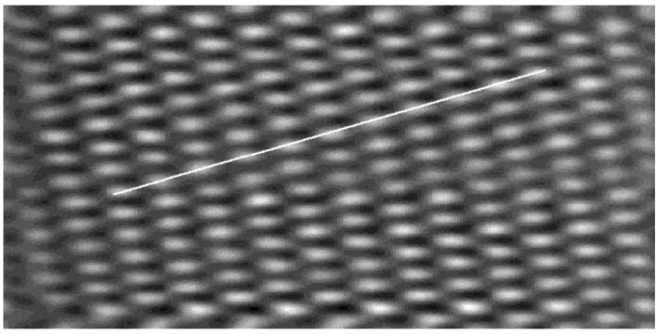


Figure-9 Burleigh instruments image of the surface of graphite, in which gray-scale.

Result and Discussion

In this paper we analyzed some properties of CNT and Bucky paper membrane which are shown in the graphs.

In this figure as we increase the average pore size of CNT the percentage of counts decreases.

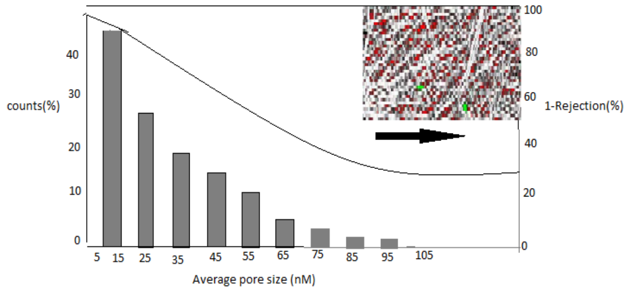


Figure 10. (Histogram - left axis): Average pore size distribution determined by SEM imaging of a Bucky-paper. (Red stars – right axis): Particle rejection tests with polystyrene.

This figure shows that as the fraction of fine CNT increases the average pore size decreases.

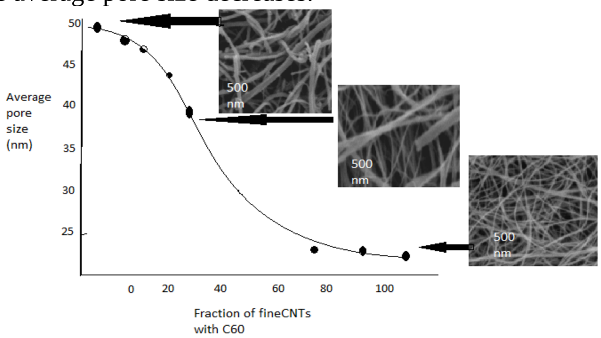


Figure 11. STM images showing (a) the surface and (b) a cross section (52° sample tilt) of a Bucky-paper formed from a mixed dispersion of PS beads and multi-walled carbon nanotubes (5 kV, 5 mm working distance). The PS beads in (a) and (b) had 1 µm and 100 nm diameters, respectively. The cross-section was formed by milling with a Gallium Focused Ion Beam.

In the fig.12 we can see that the CNT with Poly (vinylidene fluoride) indicated by red lines and CNT denoted by Blue line.

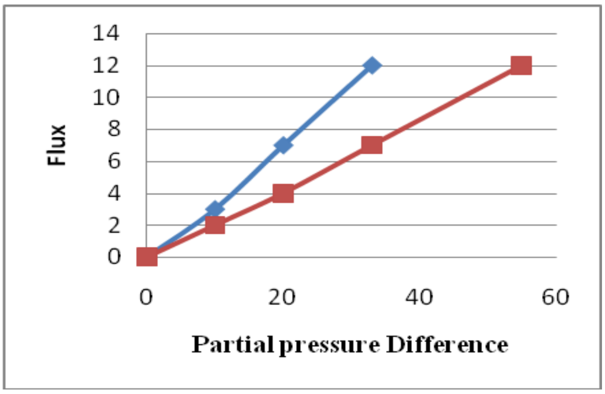
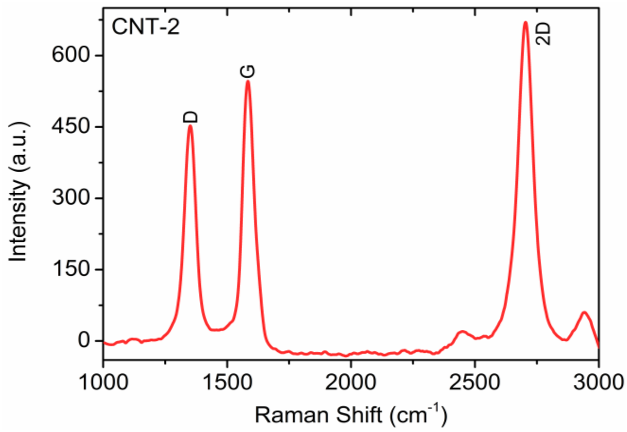
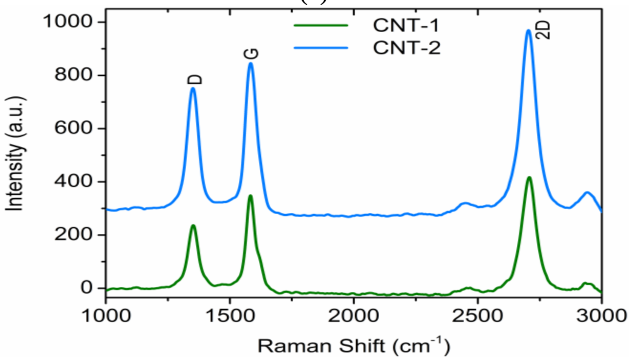


Figure-12 Dependence of water vapor flux on the partial pressure difference across a Bucky-paper membrane in a direct contact membrane distillation setup [stream flux 300 mL/min; salt concentration ~35 g/L; Temp cold ~5 ºC, Temp varied from 25 to 95 ºC].



(a)



(b)

Figure-13 Raman spectra taken from (a) an as grown CNT forest and (b) a forest after infiltrating with epoxy.

Both the D (1,310 cm-1) and G (1,590 cm-1) bands are present. The Raman signal intensity is sensitive to the CNT alignment and is strongest when the incident polarization is parallel to the CNT axis. It can therefore give an indication of the CNT alignment.

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A 783 nm laser with incident power of 2 × 104 W/cm2 was used to avoid luminescence from the epoxy resin (see supplementary material).

Conclusions

Carbon Nanotube with Bucky balls can be used as filter for water purification, and found applications of two types of CNT based membrane the first one is Bucky paper membrane and Isoporous CNT based membrane. These membranes are different in size and structure, and analyzed the Bucky paper properties based on carbon Nanotube for water filtration. The membranes have a size 10nm diameter of pore size. The CNT with Bucky paper membrane does not allow passing the contaminants or Bacteria’s in the water.

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