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Article Review

"Nanotechnology and Carbon Nanotubes: Definition, Properties"

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Abstract:

Nowadays it is difficult to imagine life without nano-technologies, more specific: nanomaterials. Carbon nanotubes are of the most famous important materials used in this field. (CNTs) are allotropes of carbon element, which made of graphite, constructed in a cylindered tube its dimension are nanometers in diameter while reach to a millimetre in length. there unique structural, electronic, mechanical properties are due to high aspect ratio nanoparticles (HARN). many industrial methods are used to produce (CNTs), (CVD) is the most famous method, it is a simple technique with low-cost respect to others. Laser ablation and arc discharge are also used. Foreign nanoparticles (during synthetic technologies) and structural defects are the most major problems associated with (CNTs) manufacturing which lead to a degradation in properties so that purification is needed to enhance reactivity and homogenous structure.

Keywords: Nanotechnology, Carbon nanotubes, Nanoscale dimension, Single-wall carbon nanotube, Multi-wall carbon nanotube.

1- Definition of Nanotechnology

Professor Norio Taniguchi at the University of Tokyo in (1971), was the first one who defined the term "nanotechnology". which translated to English:

"Nanotechnology" is the production technology to get the extra high accuracy and ultra-fine dimensions, i.e. the preciseness and fineness on the order of 1nm (nanometer), 10-9 "meter in length" [1]. While according to "NASA" nanotechnology defined as: "Nanotechnology is the creation of functional materials devices and systems through control of matter on the nanometer length scale (1-100) nanometer, and exploitation of novel phenomena and properties (physical, chemical, biological, mechanical, electrical, ...) at that length scale. Nanotechnology is dramatic changes in our lives, health, resulting in a new material, which had a unique property and represented the most effects in our modern science [2]. Nanotechnology brings evolutionary changes to our lives every day [3].

2-Introduction:

A word nano is a Greek word, which means (small) i.e. scientific treatment at the nanoscale (atomic level) and the help of scientific instruments is known as "nanotechnology" with at the last three decades became the most known field [4]. This word (nanotechnology) is named by "Norio Taniguchi "in 1971 in Japan. He prepared by processing steps including, separation, consolidation, deformation of materials by one molecule or one atom [5]. Nanotechnology has a revolutionized in our lives in general, and precisely in health scenario resulting in new engineering materials, products and devices which have a unique and unusual behaver. nanomaterials, nanocomposite and nanoparticles bring a new scientific field called "nanomedicine", which implies the medical application of nanotechnology leading to the designing, testing and optimizing of the "pharmaceutical" formulations" [6]. The exploration of tubular nanomaterials in all studies and researches are three types listed in the table (1), which are peptide nanotubes, carbon nanotubes. carbon nano hours [2]. On the other hand, nanotechnology has been taken a large area: in industrial process and purifications, e.g.: treatment of wastewater, filtration of water, water desalination while industry including nano-wire of nano-machining, nano-rods, material construction, military production [7].

3- Carbon Nanotubes:

Since (1952) carbon nanotubes has been described by “Radushkevich” while in (1976) "colleagues and Oberlin" descries the microscopic of double and single-walled carbon nanotubes. in (1991) Iijima set the process for the preparation of multi-walled carbon nanotubes (MWCNTs), by a new method (arc evaporation) to fabricate (carbon molecules C_{60}) [8].

Then groups (Bethum and lijim) are set a mechanistic description of the process to build single-walled carbon tubes (SWCNTs), which build as one-atom-thick (a sheet of graphene) this sheet is rolled up to a tubes structure [9],[10].

4- Structure of carbon nanotubes:

Carbon nanotubes are carbon material that its shape as a tube which has a diameter in the range of nanometer-scale (1-100 nm). There are two types of (CNTs), single-walled carbon nanotubes (SWCNTs), and multi-walled carbon nanotubes (MWCNTs) [11].

4-1 single-walled carbon nanotubes:

Its diameter near to (1nm). While its length reaches to millions of times longer. Their different shapes can be, zigzag, archaic and chiral forms on basis of rolling of graphene sheet into a seamless cylinder, electric properties of these types affected by each type, [12] Fig. (1).

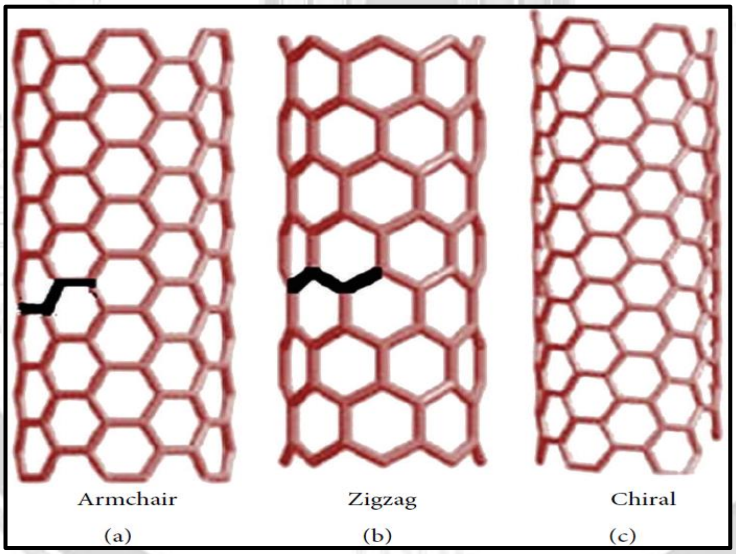

Fig. (1) Carbon nanotube structures of armchair, zigzag and chiral configurations. They differ in chiral angle and diameter: armchair carbon nanotubes share electrical properties similar to metals. The zigzag and chiral carbon nanotubes possess electrical properties similar to semiconductors [6].

4-2 Multi-wall carbon nanotubes: (MWCNTs):

The credit for its manufacture back to the discovering (C_{60}) that encouraged studies and research for other types of carbon compounds having curved graphene (13). (MWCNTs) were made concentric cylinders shape of the rolled-up graphene sheet, A few micrometres reach the length of these tubes, while its diameter is between (10-20) nm., [11], Fig. (2).

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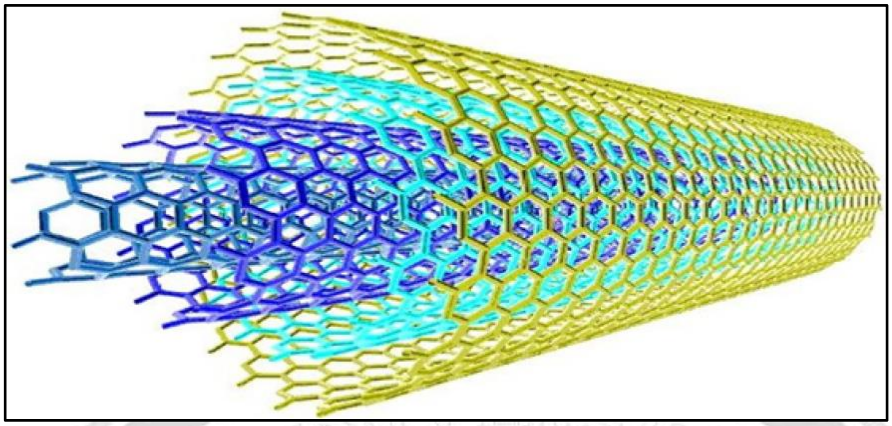

Fig. (2) structure of multi carbon nanotube [11].

Structure of (MWCIVTs) can describe according to two models: first model "Parchment model" a single sheet of graphite around itself by rolling, the interlayer distance is approximately equal to the distance between graphene layers: (3.3A°) comparing to (SWCNTs), it has greater tensile strength. Second model: "Russian model", the sheet of the graphite are arranged in the form of concentric cylinders with a large single-walled nanotube [13],[14].

5- Synthesis of nanotubes:

There are several processes for CNTs synthesis: chemical vapour deposition (CVD), laser ablation, arc discharge (AD), catalyst chemical vapour deposition (CCVD), Ball milling.

5-1 chemical vapour deposition:

In this technique, a substrate covered by a metal catalyst, Fe, Co, Ni or even (a combination) then heated around 700°c to facilitates or accelerates the growth of carbon nanotubes Fig. (3). catalyst particles implemented align holes substrate, growth starts when two gasses pass through the chamber, e.g: (N_2 , H_2 , Ar, CH_4 or C_2H_2). This method is usually used in commercially (industrial process) due to acceptable results for industrial-scale [15],[16].

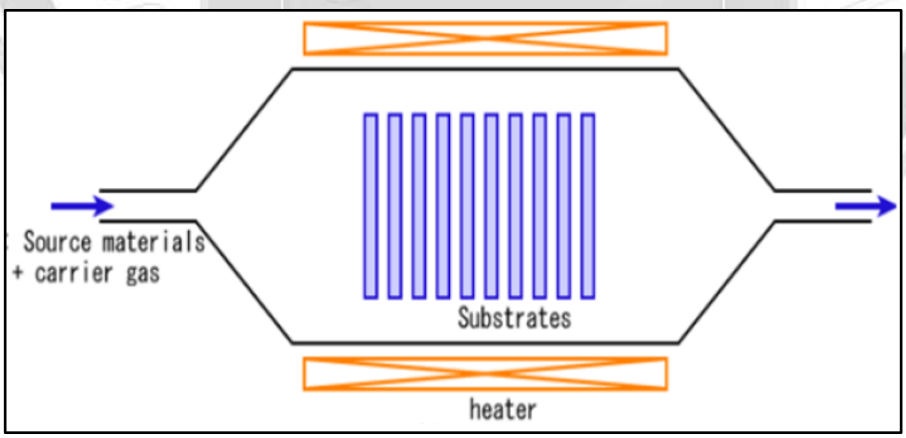

Fig. (3) Chemical vapour deposition [11].

5-2 Laser Ablation:

R.Chard E . and his workers at the first time used laser ablation to get high-quality nanotubes in (1995), carbon target had been placed in a tube – furnace at (1200)°c, intense laser pulses ablated the target, an inert gas (He or Ar) flows carrying the grown nanotubes to a copper collector [15], then cooling the chamber take place, nanotubes and

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structure like fullerenes coating on the sidewalls of nanotubes can be observed. SWNTs formed together due to Van der Waals forces Fig. (4).

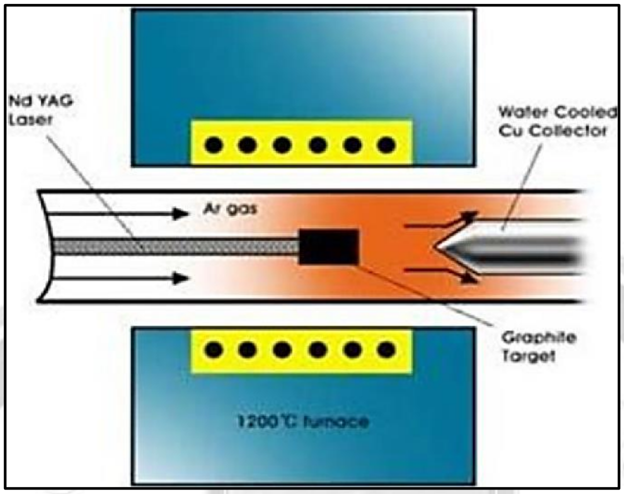

Fig. (4) Laser ablation [11]

5-3 Arc Discharge:

K.and H. in (1990) establish an arc discharge process, to produce a new shape of solid describe as disordered hexagonal packing of soccer-ball-shaped C_{60} molecule, which characterizes as the best quality [17]. In comparison with other methods, this technique causes expansion with fewer defects (in structure) due to high-temperature process (1700) °c. in this method synthesis CNTs can occur by two ways: a synthesis with a catalyst (different) usually with SWNTs, while synthesis (MWNTs) done without catalyst [18],[19]. The process involves passing a current (50 Amp) between two rods of graphite which placed in a container filled with gas (He or Ar) at pressure (50-700) m bar. carbon rods act as electrodes at a different potential, An arc generated due to moving the anode into the direction of the cathode, the distance between them not less (1mm), the process takes (1min), after cooling the chamber nanotubes can be collected. if Ni or Co or some other metals is added to anode a (SWNTs) can produce Fig. (5,6)

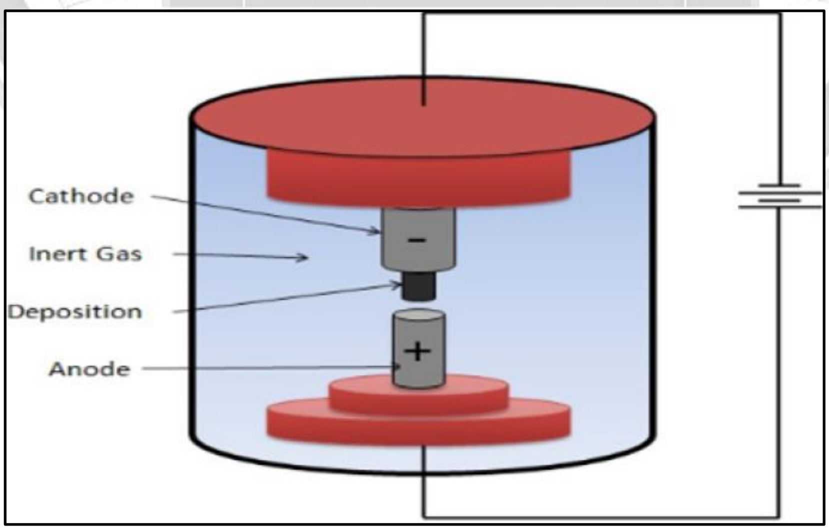

Fig. (5) Arc discharge [11].

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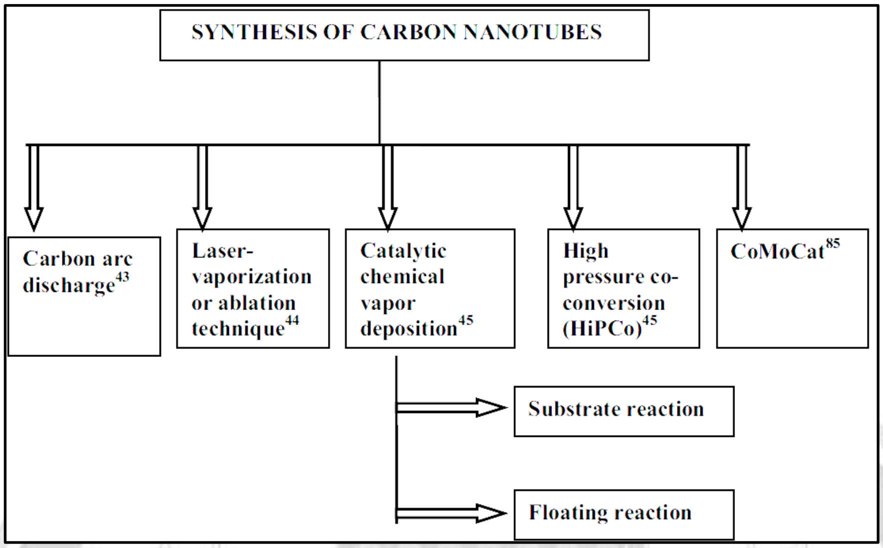

Fig. (6) Synthesis of CNTS [2].

5-4 Catalyst chemical vapour deposition (CCVD):

This technique is characterized by large scale and low-cost production of multi-wall carbon nanotubes [19]. This method describes as the most attractive, flexible, economical among the most methods for (CNTs). At (2002) (MWNTs) growth on Fe catalyst under (atmospheric pressure) [20], this method remains affected by several parameters: Temperature, atmospheric, element catalyst, [21].

This method allows producing (CNTs) to expand on different materials. In this technique, the main process growing CNTs as the same as arc discharge method by exciting carbon atoms which is contact with metallic catalyst particles. The importance of catalyst is to reduce the decomposition temperature of carbon source and allow the nucleation of CNTs which is the most important factor for the preparation of CNTs. In synthesis SWCNTs, usually required catalysts in nano-size particles, on the other hand, synthesis MWCNTs can produce without catalyst [22]. the cost of (SWCWTs) production is still quite high.

some popular metals which describe as (a transition metal) are usually used as catalysts in CVD synthesis of CNTs [23].

(Co, Pd, Fe, In, Na, Pt, Au, W, Co, Ti, ...) these metals and others can be used in the preparation of (MWCNTs) recently because of high carbon solubility in (Ni, Co, Fe) carbides can be formed m so that nucleation and growth of carbon atoms can be carried out [24]. "Chaisitsak, et. al." [25] formed SWCNTs using ferrocene as a catalyst using the floating technique of catalyst and ethanol as a carbon source. in 2002 H "Arutyunyon, et al" [26] prepared CNTs using methane on alumina substrates using two catalysts: Fe/Mo and Fe. Molybdenum had a synergistic effect also it decreased the temperature of growth [26], this is why Mo is used widely as a catalyst in metal-supported catalysts which results in increasing the yield of (CNTs).

5-5 Ball milling :

This process consists of a stainless steel container, graphite powder placed in it along with five hardened steel balls. the milling is carried out at room temperature for (150) hrs. with (Argon) as atmosphere, then this milling powder is heated up to (1400)°c for (6 hrs) under inert gas. Although the mechanism is not known yet. but it is thought that milling leads to nanotube nuclei, while annealing will activate the growth of nanotube. this method produces (MWNTs), but few of (SWNTs) [27].

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6- Properties:

CNTs have an extremely high surface area, high aspect ratio (relationship of width to its length), high mechanical strength its tensile strength is (100) times great than of steel, while its electrical and thermal conductivity approach those of copper [28],[29] these unique properties make CNTs to be good candidates as filler in different polymers and ceramics. also, CNTs describe as good field-effect transistors (FETs) [30].

6-1 Electronic nature of CNTs:

The electric conductivity of CNTs show in (Chiral form). The most parameters that greatly effects on conductivity are defects, chirality (degree of twist), Fig. (7) different diameters and degree of crystallinity of tubular structure [31,32]. CNTs can be either semiconducting or as metallic in their electric behaviour. conductivity is quite complex in MWNTs. it depends on the type of “armchair” [33]. The resistivity and the conductivity of SWNTs have been measured by placing electrodes at different regions of the CNTs, it was (10-4 ohm-cm at 27°c), This result confirmed that SWNT ropes are the most conductive carbon fibre. While the current density was about 107 A/cm2 and theoretical the current should be as high as 1013 A/cm2.

Individual SWNTs contain defects which allow to these tubes to act as a transistor [34], meaning joining CNTs together form a transistor-like device. also, studies reported that SWNTs can route electrical signals at high speed (10 GHz) when used as interconnects on semi-conducting devices [35].

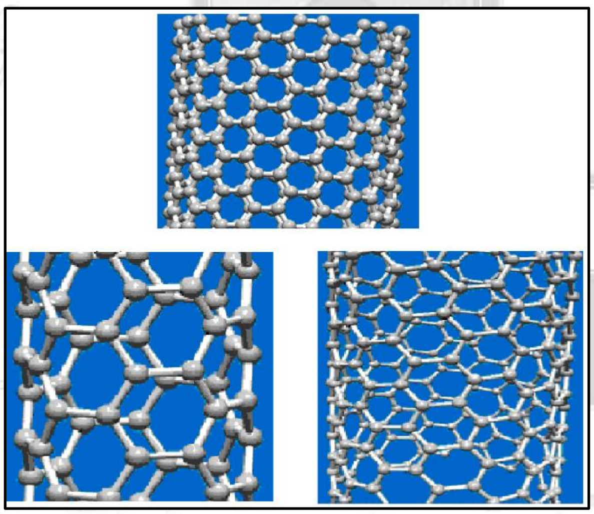

Fig. (7) Chirality or degree of twist [36].

6-2 Thermal conductivity:

Studies from Pennsylvania university has been reported that heat conductivity of the (CNTs) could be the best among other materials, very small (SWCNTs) show superconductivity below (20k) [36]. The translation is basically by “phono conduction mechanism PCM" [37], mechanism “collective vibration of an atom” be still the basic principle in transport (energy). Two parameters which can highly negative effective in transport: firstly: CNTs usually formed with defects (simple vacancies) causes scattering which reduces free path of phonons, secondly, CNTs usually contain some contamination: forms of other carbon, catalyst residual [38]. similarly, it is very important to be attention whether CNTs are only bundled or coupling (CNT-CNT) which decreases conductivity [38],[39]. length free phonons, boundary surface scattering and numbers of phonons active [40],[41].

6-3 Strength and Elasticity:

The graphite processes largest elastic modulus among any known materials [42]. This is due to carbon atoms' of a single sheet of graphite (a honeycomb shape), in other words, each atom is connected to three neighbouring atom

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by very strong bond (covalent) resulting in ultimate high strength fibres. SWNTs are stiffer than steel (100) for comparison and high resistance against damage with high ability to bend. It can returns to its initial state when the load is removed this is why (CNTs) are very useful as probe tips in probe microscopy. on the other hand young modulus of (SWNTs) is (~ 1Tera Pascale), but this value changes depending on different experimental measurement technique [43], it depends on size and chirality of SWNTs, while for MWNTs it depends on the amount of disorder in the nanotube walls, this is expected because outer layers wall break first when (MWNTs) break.

6-4 Electron Emission:

(CNTs) are the best among of any material in electrical emitters due to high sharpness of their tip (very small tips radius curvature) even at low voltage, this is very important for devices work at very low power electrical [44].

The current density that (CNTs) can carry reach to 1013 A/cm2, this current is quiet stable, this was observed by "Deher and his team" s in 1995 at EPF . Other applications use the field emission characteristics of CNs including lighting arrestors, electro microscope sources and low-voltage cold- cathode lighting sources [45].

7- Dispersion of CNTs:

Agglomeration is one of the most problems associated with CNTs due to weak intermolecular forces in various solvents and polymeric mediums [46] to overcome the agglomeration and bundle formation, functionalization or purification of CNTs is so important to enhance its degree of reactivity and homogenous dispersion. The purpose of purification is to remove unwanted particles which stay after synthesis process, on the other hand, “functionalization” produce a special group (specific) on ends of CNTs or its side [47]. There are several processes including covalent, noncovalent dispersion, dispersion by surfactant and dispersion by ultra-sonication.

7.1 covalent functionalization:

In this technique, all the wanted groups (destred) are joined to the tips or on the sidewall of carbon nanotubes (in an irreversible form): fluorine, p-aminobenzoic, carboxylic [48],[49],[50].This technique allows a covalent bond “with polymeric materials with good dispersion in different solvents, but the presences of defects on (CNTs) is a great disadvantage. Fig. (8).

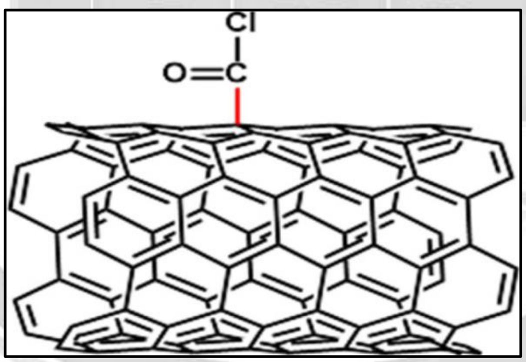

Fig. (8) Functionalization of nanotube by attachment of functional group [11].

7-2 Non-covalent Functionalization:

This technique is described as a very important technology, because it does not cause any damage and could modify the structure of CNTs for the highest level, it depends on secondary bonds (Van der Walls) and also hydrophobic (pi-pi) interaction [51].

James M Hill and Wolfgang Bacsa [52] studies the effect of non-covalent functionalization on the interaction energy of CNTs, they studied the interaction energy between carbon nanotubes and those with non-covalent functionalization polyetheretherketone (PEEK) polymer. they confirmed that non-covalent agglomeration with polymers reduces the interaction energy between tubes so that agglomeration of CNTs. also reduce, Fig. (9).

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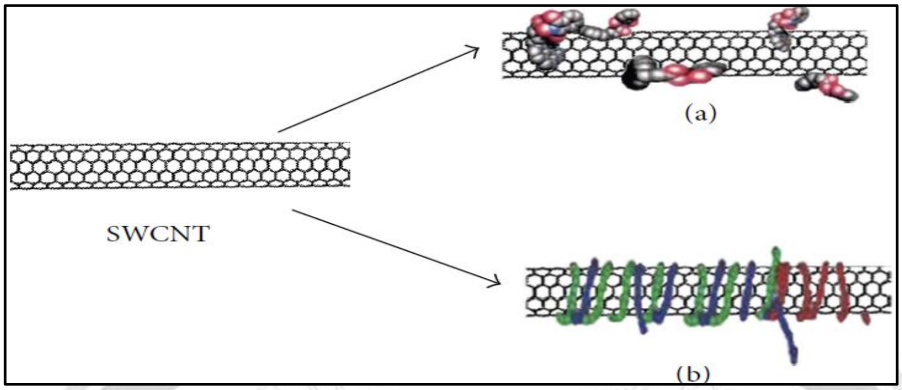

Fig. (9) Noncovalent functionalization of CNTs with [48] :

a: surfactants such as protein adsorbed

b: polymers such as DNA wrapping.

7-3 Dispersion by ultra-sonication:

It is an important technique to elimination agglomeration tendency of carbon nanotubes, waves provide especial vibrational energy to decrease agglomeration and dispersed with a polymeric material or special solvent [53],[54].

7-4 Dispersion by surfactants:

Using especial surfactants for carbon nanotubes dispersion has been reported in polymeric materials [54], dodecyl-benzene sodium sulfonate, polyethyleneglycol, sodium dodecyl sulfate are the most surfactants used to reduce the aggregative tendency of CNTs in solvents and water also. Studys reported that the presence of “benzene mhgs” is important to increase the dispersive of ficiency of CNTs [55]. In addition, the presence of naphthenic “saturated rings” groups give good surfactant –tube affinity. Fig. (10) Show surfactant micelles overcome the Van der Waal’s weaker forces.

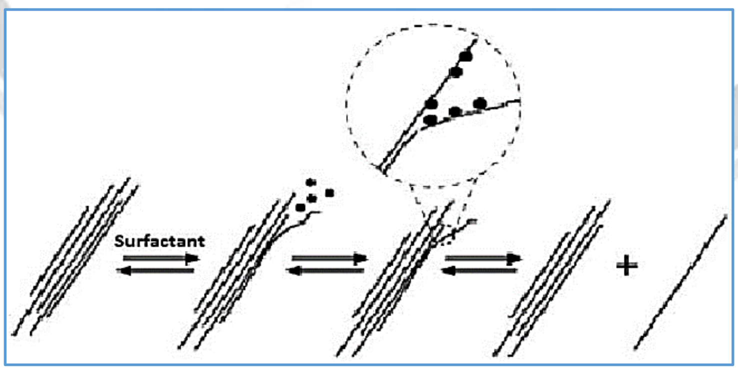

Fig. (10) Mechanism of carbon nanotube dispersion with the help of a surfactant reprinted from Vaisman [50]

8- Conclusion

This material has great potential in different field , engineering , medicine and space. It exceed the rest of the other engineering materials despite its novelty and most researches that has been carried out continuously for nearly two decades. the unique properties that distinguish it from other engineering materials enabled it to gain this important : CNTs are light weight , with high aspect ratio , small size (nm) scale , good tensile strength , thermal and electrical conductivity , these properties and others are eligible to be used in many engineering , medical fields . CNTs are used as a filler in different materials (in metals , polymers , ceramics) , transistors , sensors , capacitors ,and actuators . On the other hand CNTs are also used in different field : of pharmacy and medicine.

Conflicts of Interest

The author declares that they have no conflicts of interest.

References

1- Kim, "Nanotechnology: Introduction", materials science, 510, 2008.

2- Neelesh Kumar, Mehra, et.al. "challenges in the use of CNTs for Biomedical Application". , critical review in Therapeutic Drug carrier system, 25 (2), 196-206 (2008).

3- Wagner FE, et.al . "before striking gold-ruby glass". Nature 407, 69(2000).

4- Franks A, "Nanotechnology". Phys E, 20, 1442 (1987).

5- Taniguchi N. "on the basic concept of nanotechnology". International conf. on production Engineering Tokyo, Japan, Partil (1974).

6- Martin CR, Kohli P. "The emerging field of nanotube biotechnology" Nat. rev. Drug Discover. 2003 : 2: 29-37.

7- Th, Raja M. G, et.al., "Nanotechnology approach using plant rooling hormone synthesized silver nanoparticle as a naorpbuleets for dynamic application". Arabian Journal of chemistry, 11:48-61, 2018.

8- Hosam M, Saleh. et.al.. "Introductory chapter: Carbon nanotubes". Review: Feb. 22nd 2019.

9- Prasek J, Drbohlavora, et.al., "Method For CNTs synthesis". Journal of materials chemistry, 2011, 21: 15 872- 15 884.

10- Ajayan PM , Zhouoz, "Application of CNTs". , in Dress elhaus Ms , Dresselhaus G. editors , Berlin Heidelberg: springer-verlag: 2001-pp, 391-425.

11- Sonia Khana, Nazulislam, "Carbon nanotubes-properties and application". India university, June, 5, 2018, vol. 7, issue 1, original of medicinal chemistry.

12- Torres-Dias, Abraaoc. "From mesoscale to nanoscale mechanics in single-wall carbon nanotubes: carbon, 123, 145 – 150. (2017)

13- Mascian Gioli T, w-x zhang. "Environmental Technologies at the nanoscale". Environ. sci. Techno. (375): 102 A- 108A, 2003.

14- Ali E, Hadis D. et.al. , "carbon nanotubes: properties, purification and medical application". nano review, 2014 9:393 springer.

15- H. Folnabi, "carbon nanotube research, development in terms of published papers and patents" vol. 19, issue 6, Dec. 2012 pps: 2012-2022, scientific Iranica.

16- M. Escobar, L.C , et.al. . "CNTs and nanofibers synthesized by CVDon Ni coatings deposited with vacumeare". PP.rr6-49, (012), Journal of alloys and compounds.

17- Grobert N, "carbon nanotubes becoming clean", mater today 2007, 10 (1) 28-35.

18- Vanderwal RL, "CNTs synthesis in a flame using laser ablation for in situ catalyst generation" . , 2003 , 77(7) 885-889 Ref Type: Generica

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19- M. Kumar, x. Zhao , et.al. “carbon nanotubes from champer by catalytic CVD: molecular crystals and liquid crystals”. , 387(1) (2002), pp. 117-121.

20- A.A Husseini , F. Taleshi. , “Large diameter MWNTs growth on iron-sprayed catalysts by CCVD method under atmospheric pressure”. Indian journal of physics, 84 (7) (2010) , pp. 789-974.

21- Khurshed A. Shah, et.al., “synthesis of CNTs by CCVd : A review on carbon sources, catalysts and substrates”., vol: 41, January 2016, Elsevier.

22- Xia o-Di Wang , et.al. ., “synthesis of CNT by catalytic chemical vapour deposition”. , review chapter , published October 2019.

23- Thess A, Lee R, Nikolaev P, Etalk. , “crystalline ropes of metallic carbon nanotubes”. , science. science may. org. (1996).

24- Zhong G, Hofmann S, et.al.., “Akey growth precursor for SWCNTs. forests Journal of physical chemistry C. 2009; 113(4): 173 21-25.

25- Hans. Liu X, et.al. ., “Template-free directional growth of SWCNTs on a-andr – plane sapphire”. , Journal of the American chemical society. (2005): 127 (15) 5294-5295.

26- Harutyunyan AR, et.al., “CVD synthesis of SWCNTs under soft conditions. nano letters. 2002; (5); 525-530.

27- M. Wilson, Elson, et.al.., “Nanotechnology: Basic Science and Emerging Technology”. 2002.

28- Chang TE, Jensen LR. et.al. , “microscope mechanism of reinforcement in SWCNTs / polypropylene nanocomposite., “polymer, 46, 439 (2005).

29- Jin FL, Park SJ. “Recent advance in CNT. based epoxy composite “. carbon let 14, 1 (2013).

30- Wepasnick KA, et.al.., “chemical and structural characterization of CNTs unfoee. “Anal Bioanal chem, 396, 1003 (2010).

31- Chandra B, Bthattacharjce”., molecular-scale quantum dots from CNT heterojunctions. “ Nanolett. 9(1544) (2009).

32- Dai.H., wong EW, et.al., “probing electrical transport in nanomaterials conductivity of individual CNTs”., science, 272, 523, (1996).

33- S. Reich et.al. ., “carbon nanotubes: basic concepts and physical properties “. , Wiley-VCH (2004) SBN3: 5270-386-8.

34- R, Saito, “physical properties of CNTs”. , word scientific publishing (1998).

35- M, Meyyapaned, “CNTs: science and applications”. , ICRC press (woh).

36- IPOPE, Man D. et.al. , Thermal conductivity of an individual SWCNTs above room temperature. “Nano Letter6: 96-100, 2006.

37- Marcomet Am, Panzer mA et.al., “Thermal conduction phenome in carbon NTs and related nano streubred material “. , Remmodphys 8: 1293 1320 – 2013.

38- Bogumila K, Dawid j. “Thermal conductivity of CNTs new works: A review”. journal of material science 64, 7397-7424, 2019.

39- C, Shil, et.al . , “thermal conductivity and thermos power of an individual SWCNTs. “Nano let, t,1 842 (2005).

40- Maultzsch, J, Reich S, et.al. , “phonon dispersion of CNTs”, solid-state – common, 121,471, (2002).

41- Ishii H, Kobayashi N, et.al “Electron-phonon coupling effect on quantum transport in CNTs using time-department wave – packet approach “physic E , 40 , 249, (2017).

42- R. Saito et.al. “physical properties of CNTs imperial” college press (1998/15B/N 1-8694-093-5).

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43- S. lijlm and Chihashi "SWCNTs if in meter diameter", nature 63603, (1993).

44- R. Saita, "physical properties of CNTs", world scientific publishing (1998) 15 BN 186094-223-7.

45- B.Q. Wei, et.al. , "Appt physical let, 97 11 70 (2001).

46- Khalid Saeed Ibrahim, "CNTs, properties and application", review: vol. 14 , N 0.3 131-144 (2013) Pakistan.

47- Feogakilas V, Korclatask, et.al. , "organic functionalization of CNTs". , J Am chem soc, 124,760 (2002).

48- Kimi H, Min BG. "Functionalization of multi CNTs by treatment with dry zone gas for the enhanced dispersion and adhesion in polymeric composites" carbon let. 11, 298 (2010).

49- Saeed K, "Review on the properties, dispersion and toxicology of CNTs., "chem soc pack, 32, 56, (2010).

50- Wu He, chang X, Liu 3. Zho F., "chemistry of CNTs in biomedical application". Jo. matter chem ., 20, 10 36, 2010.

51- Hirsch A., "functionalization of SWCNTs", An gew chem. in Ed. 41, 1853 (2002).

52- James M, Wolfgang B., "The effect of non-covalent functionalization or the interaction energy of CNTs, P: lop publishing Ltd, 2019 vol. 3, vo. 3.

53- Wa Hc, chang x, et.al, "chemistry of CNTs in biomedical application". , J. matter chem., 20, 1036 (2010).

54- Wang H., "Dispersing CNTs using surfactants" ., Avd colloid reference sci, 14, 364 (2009).

55- Waisman I, Wagner HD, Maram D., "the role of surfactants in dispersion of CNTs"., Adv colloid interface sci: 128-130, 37 (2006).

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مقالة مراجعة:

" التعريف والخواص لتقنية النانو وانابيب الكربون النانوية"

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اخلاصة:

في وقتنا الحالي من الصعوبه تخيل حياتنا بدون النانوتكنولوجي وبشكل ادق المواد النانويه. انابيب الكربون النانويه تعتبر من أشهر المواد المستعمله في هذا المجال والتي تصنع من الكرافيت تركيبها البنائي عباره عن انابيب اصطوانيه الشكل حيث تبلغ ابعاد اقطارها بلنانوميتر في حين اطوالها قد تصل الى بضع مليمترات. ان طبيعة تركيبها المتفرد وكذلك خواصها الالكترونية والميكانيكية تعود الى امتلاكها نسبه قطر/ اطوال عاليه جدا. طرق صناعيه كثيره تستخدم لصناعه انابيب الكربون النانويه، ان طريقة (CVD) من اشهر الطرق المستخدمه والتي توصف بانها طريقه بسيطه مع قله في التكلفه مقارنتا بلطرق الاخرى . ان وجود الرقائق النانويه الغريبه وظهور عيوب في التركيب تعتبر من اهم المشاكل التي تصادف صناعه الانابيب النانويه وهذه بدورها تؤدي الى تدهور في الخواص حيث نحتاج الى عمليات تنقيه دائما في اثناء التصنيع لتحسين فعاليتها والحصول على تراكيب متجانسة.

الكلمات الدالة: تكنولوجيا النانو، الأنابيب النانوية الكربونية، أبعاد المقياس النانوي، الأنابيب النانوية الكربونية أحادية الجدار، الأنابيب النانوية الكربونية متعددة الجدران

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