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Smart Carbon Nanotube: Classification, Properties , Synthesis, Characterization,Pharmaceutical Application.

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ABSTRACT:
With advances in nanotechnology, the applications of nanomaterial are creating broadly and greatly. The characteristic residences of carbon nanotubes (CNTs) make them the most selective candidate for quite a number multifunctional applications. The higher floor area of the CNTs in addition to the functionality to manipulate the surfaces and dimensions has furnished larger conceivable for this nanomaterial. Carbon nanotubes (CNTs) have been significantly investigated in the ultimate decade due to the fact their choicest residences may want to advantage many application. Carbon nanotubes (CNTs) are the nanotechnology's utmost specific inventions. Over the previous two decades, many scientists round the globe have investigated CNTs cautiously because of their superb prospective in distinct areas. The CNTs possess larger conceivable for applications in biomedicine due to their crucial electrical, chemical, thermal, and mechanical properties.The special properties of CNT are exploited for numerous applications in the biomedical field. They are beneficial in both therapeutic and diagnostic applications. They form novel service structures which are also capable of site-specific shipping of therapeutic agents. In this study thevaluate is focuses on carbon nanotubes properties, synthesis, characterization, boom mechanism, advanced biomedical software.

I. INTRODUCTION :

Carbon is that the 15th most abundent element in the crust and fourth most abundent element in universe by mass after helium and oxygen.consistent with the arrangement ofcarbon atoms, different properties are developed for carbon nanotubes. (CNTs)and these CNTs research has explode within the last decade with hope to commercial exploit their truely remarkable properties. Carbon nanotubes having nanoscale dimensions (1-D)have been documented over the past 15 yrs. These molecule were first discovered byijma in 1991 when he was studyingthe synthesis of fullerences by using discharge discharge technique. The high resolution transmission microscopy was employed for observation of that phenomenon. Nanotube prepared bygraphene sheet roll up to make cylindrical structure Sp^2 hybridization atom advantage of nanotube beingthat, they need prospective nanofluidic device for control delivery ofmedicine , poor solubilityconditions ofmedicine , faster deactivation and limited bioavailability are often fulfill by using CNTs which preferred used as drugcarrier.main disadvantage of CNTs which is chance for dissociation in biological fluid. These review specialise in the utilization of smart nanotube .

1.Properties:

1.1.Strength:

Carbon nanotubes have a greater tensile power than steel and Kevlar. This electricity originates from sp2 bonds between the character carbon atoms. Carbon nanotubes are now not only strong, they are additionally elastic. Upon application of force, nanotube can bend and returns to its unique structure when the pressure is removed. A nanotube’s elasticity does have a limit, and below very robust forces, it is feasible to completely deform to structure of a nanotube. A nanotube’s energy can be weakened by using defects in the structure of the nanotube. Formation of defects is take place due to atomic vacancies or carbon bonds rearrangement . because of Defects in the shape of nanotube can cause a small segment of the nanotube to become weaker, which in flip causes the tensile power of the entire nanotube to weaken. The tensile electricity of a nanotube relies upon on the power of the weakest section in the tube similar to the way the power of a chain.

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1.2 Electric properties:

The sp2 bonds between carbon atoms outcomes in conducting nature of carbon nanotubes. They can also stand up to sturdy electric currents due to the fact of the strong nature of bonds. Single walled nanotubes can route electrical indicators at speeds up to 10 GHz when used as interconnects on semi-conducting devices. Their electrical properties can be manipulated by means of utility of external magnetic field, mechanical force etc.

1.3Thermal properties:

Carbon nanotubes are capable to face up to high temperatures, for this reason acting as very right thermal conductors. The temperature steadiness of carbon nanotubes is estimated to be upto 28000oC and about 750oC in air. The carbon nanotubes are shown to transmit over 15 times the quantity of watt per minute as compared to copper wires .

II. SYNTHESIS OF CARBON NANOTUBE

There are different methods for CNT synthesis can be shown in Fig.The firstly CNT was synthesized unintentionally by Iijima through arc discharge. But current scenario was different because varies methods are available for CNT synthesis. These different methods are mentioned through CNT's properties, such as temperature, time, heat source, precursor, mechanism, atmosphere of reactions, etc. The most popular methods for CNT preparation was laser ablation, arc discharge, and chemical vapor deposition . The primary observation was done by Iijima over multiwalled nanotubes. These research was continued by assume single-walled nanotubes in synthesis within a years. As mentioned earlier, MWCNT and SWCNT were synthesized via chemical vapor deposition, laser ablation, gas-phase catalytic growth, arc-discharge, etc . The manufacturing of compound using carbon nanotubes involves an outsized quantity of CNTs. But a typical quantity of CNTs wasn't possible to be produced economically through laser ablation or arc discharge methods.

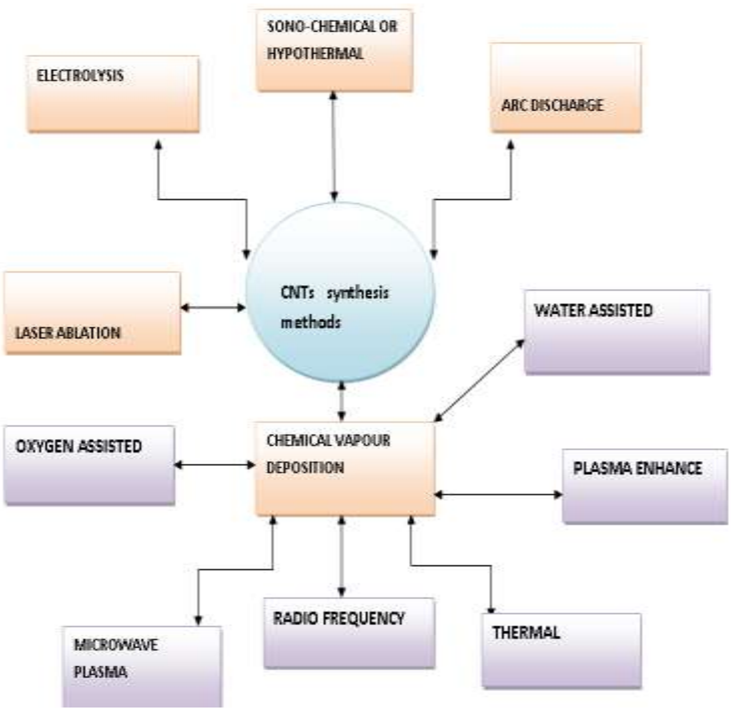

Figure 1 :Preparation methods of nanotubes

2.1 LASERABLATION METHOD :-

This method, firstly demonstrated by Smalley's group, the principles and mechanisms of laser ablation are similar to the arc discharge but, the difference is that the energy is provided by a laser hitting a graphite pellet containing catalyst materials (such as nickel or cobalt). The laserwas operated in pulsed mode or in continuous mode, vaporizes the carbon and catalyst metal. These vaporized species are directed to a water-cooled copper collector by flow of neutral gas where they condensed . Among the laser beam ablation parameters that can be optimized by the output, wavelength (for fast and complete ablation, the chosen wavelength should having minimum absorption depth to ensuring the all the energy is delivered in a small volume)duration of plus was short (for maximize peak power and to minimize conduction loss in surrounding environment)pulse repetition rate (should be fast)beam quality (bright,having focusability and homogeneity)With help of this method, we will collect MWCNTs within the soot length of 1.5 nm to 3.5 nm in diameter and with length around 300 nm. Nanotube crystallinity was obtained by function of the furnace temperature (1200 _C is optimal for best quality CNTs). By using small quantities of metal catalyst within the pellet, SWCNTs with good crystallinity are often obtained.

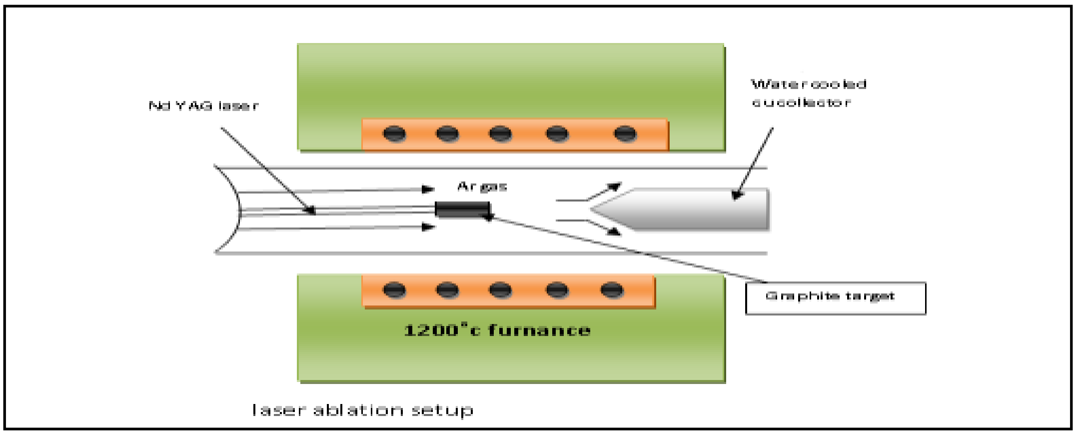

Figure 2: Laser ablation setup

2.2.ARC DISCHARGE METHOD:-

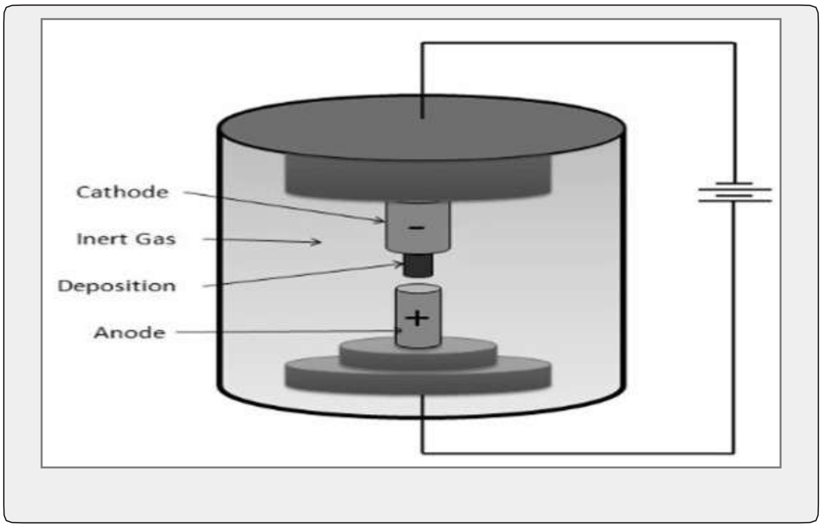

Figure 3: Arc discharge setup

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Carbon arc discharge method was firstly used to creating C 60 fullerens these is most common& easiest method for carbon nanotube preparation . by using this method nanotubes can be synthesized, carbon electrodes was heated in high temperature with total absence of oxygen by electric current. If a catalyst is added to at least one of the electrodes,nanotubesare often obtained. These mechanism is based on energy transfer between the target (graphite), which is kept attemperatures on the brink of its freezing point , and an external radiation source . same mechanism which is applies in laser ablation. The major advantage of this system is that it's possible, by appropriately tuning the method parameters, to supply nanotubes with a really good degree of crystallinity, which leads to superior electrical and mechanical properties. This is thanks to the heat at which the method operates (above 2000 K),which is far higher compared to CVD. The major drawback of these method is nanotubes have to be separated from other carbon products and catalyst residue.in these Various metals can be used as catalysts: iron, nickel, cobalt,boron,etc. An inert gassuchas helium or argon fills in chamber,which is kept at low pressure. After the arc is activated, a plasma consisting of carbon, rare gases, and catalyst vapors is stable between the electrodes, where a potential difference is applied. The anode is eroded during the process.Among the variables that can be controlled to optimize the yield and the quality of this process, we can used:sort of doped anode (which are often homogeneously or heterogeneously doped)nature and concentration of catalystsgases composing the plasmainert gas pressurearc current intensity-distance between the electrode.

2.3.FLAME SYNTHESIS METHOD:-

SWCNTs are formed by hydrocarbon fuels and tiny aerosol metal catalysts in a controlled flame atmosphere . Flames are less expensive than existing methods for the fabrication of nanotubes in large quantities. Three common components for the development of CNTs are necessary, these are a carbon source, metal catalyst particles & a heat source. The catalytic precursors was incorporated in the flame system in this method addition are nucleated & are finally condensed into solid metal spherical nanoparticles.The composition of even the final synthesized product might also used by both the catalytic properties & alteration of the flame parameters . the repercussion of various flame patterns for inclusion of inverse diffusion, partially mixed & premixed flames was used in manufacturing of nanotubes as well as nanofibers. By utilizing the pentacarbonyl & iron vapours as a source of a metal catalyst, nanotubes with having single-walls could be identified in the post-flame area of the premixed argon/oxygen/acetylene flame,was about 50 Torr (6.7 kPa) used. Nanotubes which are detected to form & amalgamate into bunches of 40 & 70 nm height directly above of the burner (within ~30 ms).

2.4.SILANE SOLUTION METHOD:-

Nanotubes were produced by the silane solution technique by immersing the substrate into a silane solution along side a metallic catalyst, frequently Co: Ni in or around a proportion of 1:1; along with a carbon source such like ethylene containing feedstock gas has been used over the substrate & deposition of the catalyst there in as heating is provided to the substrate by utilizing an electric current. The substrate used in these is a stainless steel mesh or carbon paper. As per result reaction is developed amongst the gas as well as catalyst, to produce CNTs mounted onto the substrate which is conductive.

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2.5CHEMICAL VAPOUR DICOMPOSITION:-

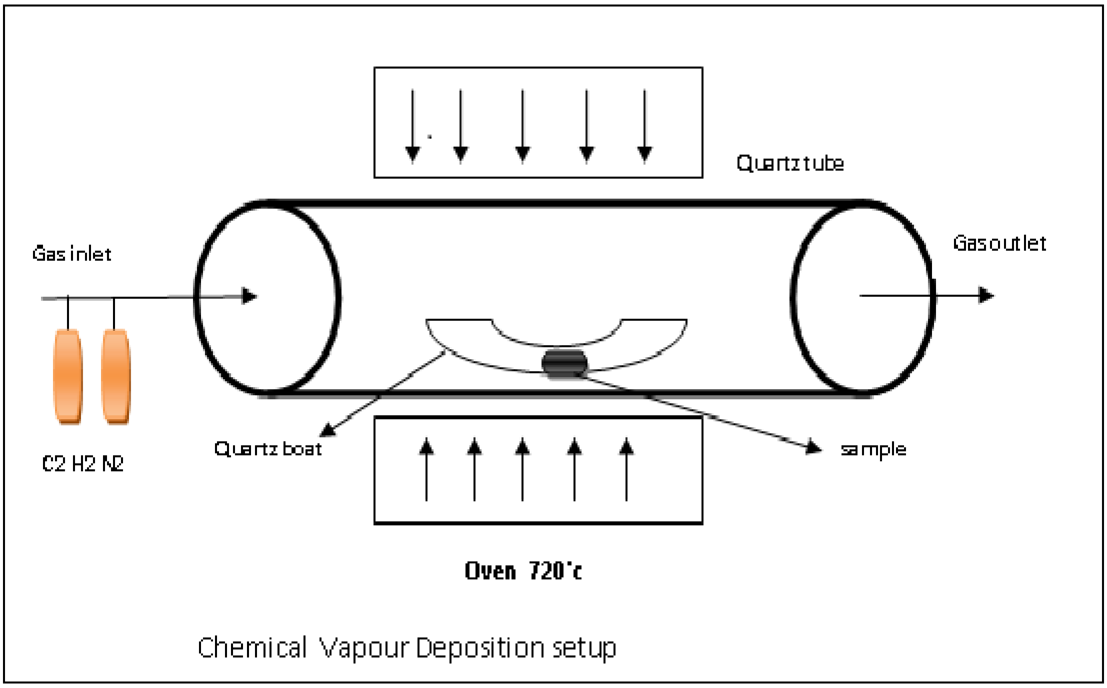

Figure 4 : Chemical Vapour Dicomposition

chemical vapor deposition (CCVD) has become the quality technique for CNT synthesis. used for the first time in 1993.for synthesis of MWCNTs using acetylene vapor deposition at 1000K or benzene deposition at 1400K on iron particles, this method, based on carbon atom excitation with metallic particles, has been extensively apply to produce CNTs using other catalyst particles such as nickel or cobalt . It was found that the dimensions of the metal particles was directly connected to the dimensions of the obtained CNTs.IN CVD Synthesis carbon nanotube synthesis depends on hydrocarbon pyrolysis over the particle or without catalyst, when deposition of carbon take place at specific site. Catalyst material used in CVD mostly solid,liquid,gas can be placed in furnace or continuously fed from outside. the carbon source used in CVD typically hydrocarbonmaterial, or possibly gaseous such as acetylene orethelyne or liquid like different type of alcohol which usually supply as reactor by evaporation by using suitable method.carreir gases used as carbon input clouds to the reactor,mixture of carrier gas and hydrogen used as reducing agent reactant concentration in the mixture used as accurate flow meter,the operating temperature inside the quartz was 500˚c to 1200˚c.support material are used in tube from inside which are covered catalyst to that behave active site for growth of carbon nanotube.Four main parameter decide type of nanotube,which depends on nature of reactor,hydrocarbon source,catalyst and growth temperature,low temperature range of 600-900˚c yields MWCNT. And where as more than 900˚gives the SWCNT.from many advantages CVD having many disadvantages which is discussed as follows:

1.Its typicall process which required volatile precursor at room temperatureand used of metal precursor is very limited.

2.Most important disadvantage is health and safety aspect of these technique which is represented by used of highly toxic precursor such as NI(CO)4 or explosive (B2H6).

3.Byproducts of CVD reactor are also hazardous.

Many parameters are important in CVD synthesis like hydrocarbon,temperature and catalyst some main parameter are discussed in briefly as following:

A .precursor

Most commonly precursor used in CNT are methane, ethylene, acetylene, benzene,xylene, and carbon monoxide. growth of CNT from

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pyrolysis of benzene at 1100˚ C, wherase , helical MWCNTs was obtained at 700˚ C from acetylene. In those situation iron nanoparticles used as the catalyst. Later, MWCNTs were also grownfrom many other precursors including cyclohexane and fullerene. in other methods, SWCNTs were prepared by disproportionation of carbon monoxide at 1200 C, in the presence of molybdenum nanoparticles. then, SWCNTs were developed from benzene,acetylene,ethylene, methane, cyclohexane,fullerene etc. by using various catalysts. in low-temperature synthesis of high-purity SWCNTs from alcohol on Fe–Co saturated with zeolite platform and these is reason, ethanol became the most popular CNT predecessor in the CVD method globally. important character of ethanol is that ethanol- grown CNTs are mostly free from amorphous carbon, receivable to the engraving result of OH radicalbehind time, perpendicular SWCNTs also increase on Mo-Co-coverd quartz and silicon substrates. Recently, Maruyama's group has shown that inregular supply of acetylene in ethanol CVD remarkable aid of ethanol maintain the catalyst's activity and thus increase the CNT growth rate.

B .Catalyst :

For manufacturing CNTs, generally, nanometer-size metal particles need to permitted hydrocarbon decay at a slower temperature than the unforced decay temperature of the hydrocarbon. most frequently employed metals are Fe, Co, Ni, because of two main motivation:

(i)Towering solubility of carbon in these metals required excessive temperatures; and

(ii)Excess carbon diffusion rate in these metals are, high melting point and low equilibrium-vapor pressure of these metals provide extensive temperature wall of CVD for a extends scope of carbon precursors. other role of CNT catalysts, especially value specify that transition metals are shows well organized catalysts not only in CVD but also in arc- discharge and laser-vaporization methods. Therefore, it is likely that these evidently dissimilar methods assume that ordinary broadening techniques of CNT, which is not even clear. Hence this is an open area of research to correspond various CNT methods in word of the catalyst's character is complete dissimilar temperature and pressure range catalystsupport

C. catalystsupport:

ThesimilarcatalystworkingdistinctivelyondifferentholdupthematerialsfrequentlyusedmembraneinCVDaregraphite,quartz,silicon,siliconcarbide,silica,alumina,alumino-silicate(zeolite),CaCO3,magnesiumoxide,etc.ForanorganizedCNTgrowth,thecatalyst–substratereactionshouldbeexplorewithmaximumrecognition.Metal–substratereactionmightstopthecatalyticeffortsofthe metal.The substrate materials surface morphology and finishing properties much affected yield and quality of the obtaining CNTs. Zeolite supports in catalysts in their nanopores have give remarkable high yields of CNTs with a limited diameter scattering. Alumina materials are describe for superiorior catalyst support than silica unsettled to the strong metal–support interlinked with eachother, which gives high metal dispersion and also high solidity at catalytic sites.Such interactions blocks metal grade from collecting and established unfortunate huge mass that guid to graphite particles or faulty MWCNTs. in XPS analysis of CNT growth from different precursors on iron catalyst placed on alumina and silica substrates have affirm that theoretical predictions. Thin Alumina flakes (0.04–4 m thick) loaded with iron nanoparticles have shown high yields of aligned CNTs of high solidity aspect ratio. in reasearch confirmed that oxide substrate, basically used as a physical support for metal catalyst, could be playing some chemistry within the CNT growth, the chemical state and structure of the substrate are more important than metal.

III. CLASSIFICATION:

Classification of CNTs Nanotubes might also indeed be alienated into more than a few classifications based totally upon the wide variety of sheets of graphene existent in the CNTs. The following are therefore sub-divided into:

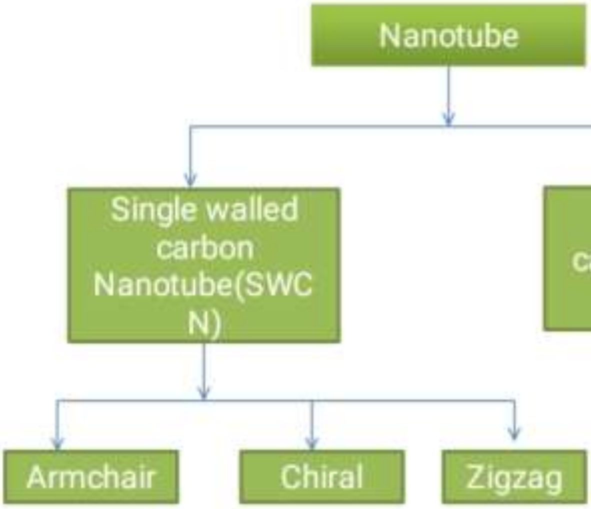

Figure 5 : Types of Nanotube

3.1 Single walled CNTs (SWCNTs) :

The single-walled CNTs consists of of the orientation of layer of graphene sheet. For its synthesis, a catalyst is required. SWCNTs are now not pure and have no complicated structure. It can be twisted conveniently . They show up as granular or black fluffy powder &a bright steel look on occasion . SWCNTs are on hand in a variety of structures that can be trundled up in some sort of a seamless tube in a multitude of ways. This arrangement may also allow SWCNTs to act according to chirality and diameter as more of a definitely demarcated semiconducting, metal or semi-metallic shape . There has been an innovation concerning methods of making ready an array or a tightly packed bundle of single-walled CNT inside commercially manageable requirements of reaction and having diameter of ideally less than 0.2µ in U.S. patent for synthesis of SWCNTs .

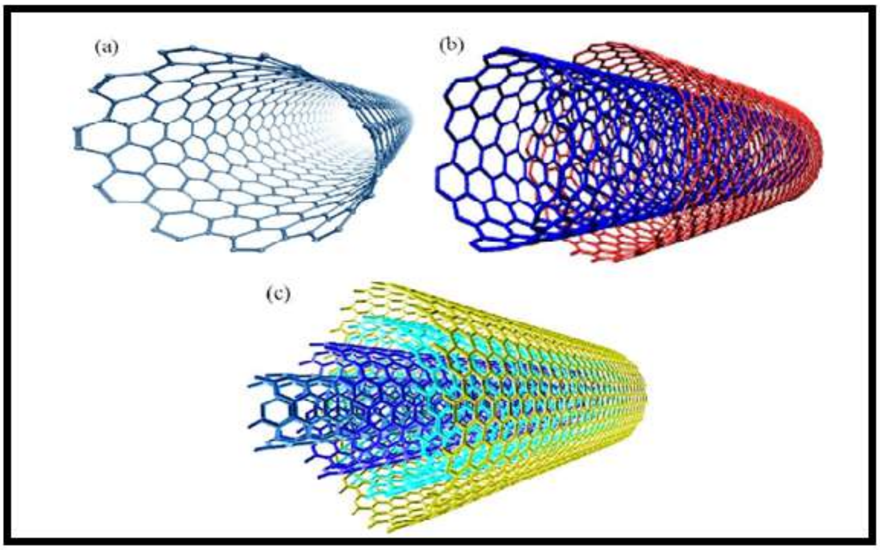

Figure 6 : Types of nanotube

3.2.Multi-walled CNTs (MWCNTs):

CNTs which comprised of multi-layered graphene rolled over themselves be contingent on the wide variety of tubes of the rolled sheets with diameters varying as of 2–50 nm . No catalyst is required for its synthesis. MWCTs are tremendously pure and structurally complex. It cannot be twisted without problems . These tubes have a distance of approximately 0.34 nm in between layers . They more often than not show up as fluffy black and granular powder. MWCNTs of two various classes hinge on the graphitic sheet association sample are existent. One is a structural association of the Russian-doll mannequin wherein the graphitic sheets are equipped as concentrically aligned sheets, for instance a sheet of (0, 14) SWCNT enclosing a smaller diameter (0, 12) SWCNT. In the 2nd mannequin one, it is referred to as a parchment paper model wherein a single layer of graphitic rolls spherical itself, approximating a scroll of parchment or like a newspaper rolled round .

3.3.Double-walled CNTs (DWCNTs):

Apart from these, there is any other kind of CNTs that resembles SWCNTs i.e. they are structurally similar. These nanotubes constituted of two concentric layers encasing its internal cylindrical tube inside its outer tube . They are of giant concern in the pharmaceutical.

IV. CHARACTERIZATION:

It is well recognized that the first character to study elements not seen to the bare eye was a microscope made by using man. Tremendous advancement has been performed ever seeing that the aforementioned discovery in unsophisticated crude shape 300 years in the past and has become a microscope by way of potential of electrons instead than light as a source of illumination. Numerous sorts of electron microscopy, has already being employed to explicate nanostructures, together with CNTs. Nonetheless, each of them has sure constraints. CNTs are the most quintessential among carbon nanostructures because they have the most imperative attributes for progressive applications. In particular, electron microscopes are used for properties exhibited by the CNT.

4.1. Raman Spectroscopy :

It is suitable for quick and reliable screening of SWCNT presence. The Raman scan is a fast, easy, non-invasive and non-destructive approach for characterization. The instrumentation is frequently on hand to a extensive array of communities and can be carried out at room temperature and stress . The synthesis and purification tactics of the SWNTs were evaluated the use of this spectroscopy . This is a very touchy method for examining modifications in the traits of nanotubes synthesized the usage of distinct procedures and conditions.

4.2Transmission electron microscopy (TEM):

This microscopy is employed in lieu of the evaluation of skinny tinny specimens via the formation of a projected photograph via the electrons passageway. TEM in many respects resembles the conventional (compound) light microscope . It permits for the detailed assessment of the nanostructures. TEM gives solely qualitative information on that of the shape, its size, and the shape of carbonaceous materials and nonCNT impurities in the sample as well. TEM has certainly been used in imaging the cellular uptake of composites of CNT pills and therefore to regulate the consequence after cellular uptake of the element of CNT .

4.3.Scanning electron microscopy (SEM):

It offers a summary of pattern elements although not as a lot of prone to guidance of sample and its homogeneity than TEM. This is often being used in the prior evaluation of the morphology of CNT. SEM is most likely the solely approach successful of imparting statistics on both CNT metal impurity content material and morphology .

4.4.Proton NMR :

This is being inured to investigate the development of CNT functionalization. The existence of purposeful businesses would also be anticipated with the aid of dint of one of a kind peaks resulting after the alteration of the magnetic surroundings. H NMR is being used to analyze synthesis as well as and attaching the practical group to CNTs .

4.5Thermogravimetric analysis:

This analysis is being applied to quantitatively ascertain the awareness of carbonaceous and non-carbonaceous materials present in bulk samples of CNT and the homogeneity and thermal steadiness of CNT. It also offers facts on the comparative abundance of nanotubes, catalytic constituent part, and extra carbonaceous structures .

4.6Atomic force microscopy (AFM)

Among the current microscopy methods, AFM is the utmost extensively employed technique of characterization. The comprehensive use of this AFM is attributed inside a short time to 3-dimensional pattern topography via potential of atomic resolution, for a enormously low fee . This technique also affords us with information on the nanotube's length and an estimated evaluation on the diameter of bundles

V. APPLICATION OF CNT

There are many potential applications of carbon nanotubes owing to its remarkable properties. They have potential to be used in electronics, textile industry as water proof and tear proof fabric, sensor based on the property of thermal conductivity and many more. They possess extraordinary heat and electrical conductivity behaviour, making it a suitable candidate for numerous applications. . Some of the important applications of carbon nanotubes are discussed below.

5.1. PHARMACEUTICAL APPLICATIONS

The flexible structure of CNTs permitted to used for a different functions in and around the body. In the nanotube containing drug dosage form allows to decreased its specific distribution, as well as remarkable costs to pharmaceutical industries and their patient. The nanotube commonly contain the one of two active pharmaceutical ingredient and drug can be placed in nanotube by its side or drag behind or inside the nanotube. Both are effective methods for the drug delivery and distribution of inside the body . Important properties , such as they have capacity to easily cross-cellular membranes,significantly increase the prospective of therapeutic use nanotubes. In recent study its found that water soluble SWCNTs shift easily into the cytoplasm or nucleus of a cell between its membrane, without producing any harmful effect. In Research its confirmed that carbon nanotubes was effectively used to deliver drugs into neoplasm cells, increasing therapeutic effect which allows for selective drug delivery to the site of action. New approaches are also being discovered, for example, by using microchips and CNTs controlled release drug reservoirs was prepared .

5.1.1.Drug Delivery

To deliver the drug has become a major area or researchers motive to enhance the capability of therapeutic molecules. Some times researchers having difficulty to overcome from poor distribution of between cells, undesirable damage to healthy tissue, toxicity and lack of the ability to select the particular cell type for treatment. Many times molecules are binded to the walls and spike of these soluble nanotubes, for achieving better results targeted delivery of peptides, nucleic acids and various drug molecules .

nanotube have several advantages for drug delivery:

i) Nanotubes size in the range of 10–40 nm,
ii)They have ability to provide a rod-like frame,
iii)Increased dimension to carry drugs,
iv)Potential to deliver drugs to the nucleus and,
v) Inert and nontoxic in nature.

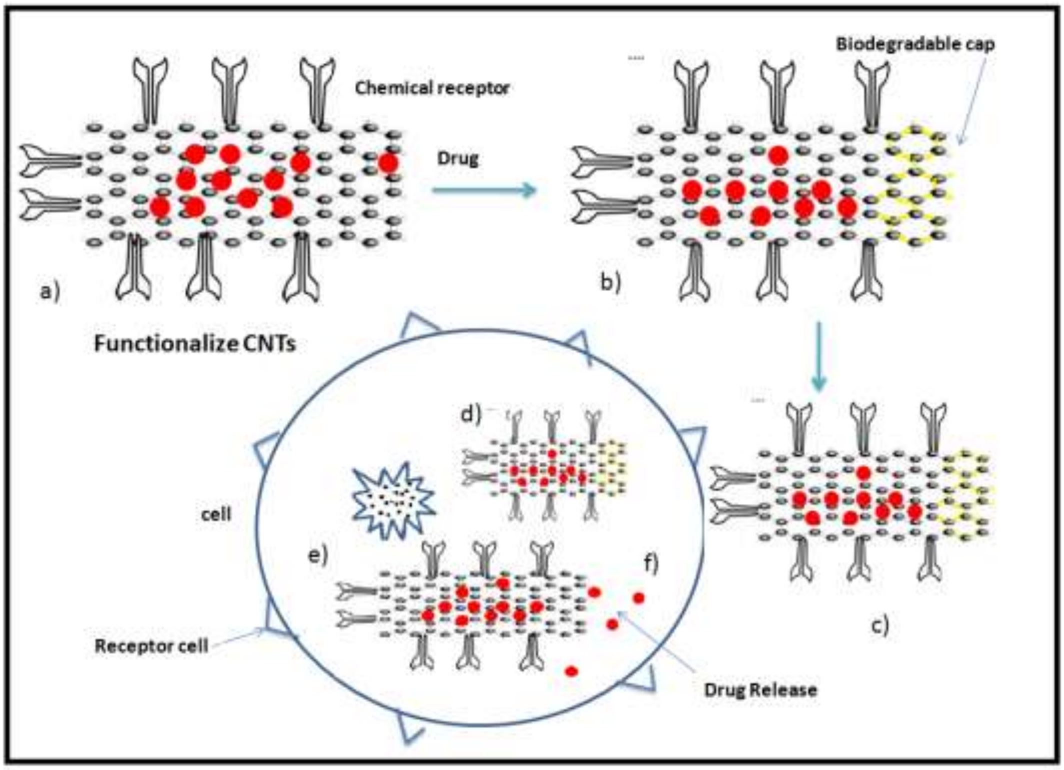

Figure 7: Drug delivery of Nanotube

For delivery of drug ,by using general process in which drug is placed on the surface or functionalized CNTs. then obtained combination then introduced into host body by classic ways by injectably and orally or directly to the target organ by using magnetic combination,for example manget was guided by externally to the target organ ,like lymphatic nodes.then cell consume nanotube containing drug capsule and then nanotube breakes there contents into cells and delivered the drug to targeted siteCarbon nanotubes having ability to carry drug molecules across the cytoplasmic membrane and nuclear membrane without developing toxic effect ,its prove that CNTs conjugation of drug provid safer and more effective treatment then the traditional drug preparation.after reaching in targeted site nanotubes having two possibilities of deliver the drug

1.Entry of drug into cells by without incoration of carbon nanotube carrier or both drug &CNTs carrier enters the cells then incorporation method which is more effective than first method,because when drug enter in the cells,the atmosphere of inside the cells was degraded because drug conjugate deliver drug molecule in inside the cells.

2.In non-incorporationmethod,the extracellular atmosphere helps for degrade drug carrier conjugates and then drug cross across the lipid membrane to enter in the cells,there is also probability penetrate the drug itself during degradation.

The cell incorporation take place either endocytosis pathway or diffusion pathway,that is the endocytosis independent pathway.cell membrane cross ability of CNTs for drug delivery because of simple hydrophobic interaction,electroststic adsorption and covalent bonds in there structurebut also by absorbing into hollow cylinder,nanotube having ability not only to penetrate into cells to promote the cellular uptake of therapeutic molecules but also kept intact during transportation and cellular penetration & last property of CNTs to decresed dosage of drug and consequently their toxicity mostly for anticancer drug.

5.1.2.Gene Delivery

The use CNTs are not only to deliver the medicinal molecules but also to deliver genes directly into the cell and across the nuclear membrane. The lipophilic nature of biological

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membranes acts major barrier for direct intracellular delivery of therapeutic drugs and molecular probes and makes intracellular transport one of the key problems in gene therapy. Because of their ability to cross cell membranes, SWCNTsacts as major carriers for biologically active molecules including genes, DNA, RNA and many more. CNTs might be fictionalized at their terminal ends with single stranded DNA or peptide macromolecule , and hybridized with the complementary DNA sequences to make supramolecular nanotubes based structure . Gene therapy is a method of correcting faulty genes by introducing DNA molecules into the nucleus, which are the cause of certain chronic or inherited diseases. Some transport systems for DNA deliver include liposomes, cationic lipids, and nanoparticles, like the recently discovered CNTs.When combined with SWCNT, DNA probes can be protected from enzymatic cleavage and interference from acid- binding proteins. nucleic. The DNA-SWCNT complex exhibits excellent biological stability characteristics and increases the self-transmission capacity of DNA compared to DNA used alone. In fact, compared to naked DNA, the stable complex between plasmid DNA and cationic CNT has been shown to enhance gene therapy capabilities. CNTs bound to DNA were found to release DNA before being destroyed by the cellular defence system, thus significantly promoting transfection. Uses CNTs as gene therapy vectors to demonstrate that these modified structures can efficiently transport genes in mammalian cells and remain intact, because CNT-gene complexes retain the ability to express proteins. Pantarotto et al. developed a new type of functional SWCNT-DNA complex and reported high DNA expression compared to naked DNA.

5.1.3.Peptide Delivery

Carbon nanotubes are researched greately in administered and targeted delivery of peptides. Furthermore moderation of nanotubes by attaching definite functional groups qualify delivery of small peptides into the nuclei of fibroblast cells. Desfite the fact of that mechanism of how tubes computing and left cells is uncertain, they arrive to be nontoxic .

Researchers are constantly explore novel routes to administered macromolecules that will possibly develop the new biological products such as bioblood proteins and biovaccines. correspondingly, the favourable of DNA and RNA therapies will depend on innovative drug delivery systems.CNTs are getting highly vulnerable molecules for applications in medicinal chemistry. Biologically active peptides can easily be bind with a stable covalent bond of CNTs. the conjugation of peptide from the foot-and-mouth disease virus to CNTs. The peptide-CNT combination computing considerably lead for demonstrative motive and could find future applications in vaccine delivery

5.1.4.Carbon nanotubes in cancer therapy.

5.1.4.1. By Drug Delivery

CNT can be used as a drug carrier for treating tumors. The efficacy of cancer drugs used alone is not only limited by their systemic toxicity and narrow therapeutic range, but also by drug resistance and limited cell penetration. Since carbon nanotubes can easily pass through the plasma membrane and nuclear membrane of the cell, the anticancer drugs carried by the carrier will be released in situ in full concentration. Therefore, its function in tumor cells will be greater than in the effect of therapies. Therefore, there is a need to develop effective delivery systems that can improvethe cellular uptake capacity of existing potent drugs. The high aspect ratio of carbon nanotubes has great advantages over existing delivery carriers, because the high surface area can provide multiple binding sites for drugs.Many anticancer drugs have been combined with functionalized carbon nanotubes and tested successfully in vitro and in vivo, such as epirubicin, Adriamycin, cisplatin, methotrexate, quercetin, and paclitaxel.To avoid the harmful effects of anticancer drugs on healthy organs and cells, our team connected epirubicin to a magnetic CNT compound obtained by fixing a layer of magnetite nanoparticles (Fe_3O_4) on the surface of the nanotubes. Write like a necklace and on the tip of a short carbon nanotube. Other authors have used epirubicin magnetic carbon nanotube complexes to attack lymphoid tumours. These systems can be guided by externally placed magnets to target regional lymph nodes.For the same reason as before, the chemotherapeutic agent can bind to the complex formed by the CNT and the antibody against the overexpressed antigen on the surface of the cancer cell. By attracting antigen and antibody, tumor cells can take up the CNT only before the anticancer drug separates from the CNT. Therefore, the target delivery was achieved. The main obstacle to effective cancer treatment is that overexpression of p-glycoprotein improves the output of anticancer drugs, leading to multidrug resistance, leading to poor anticancer effects. Li et

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al. have shown that SWCNT conceivable rational by p-glycoprotein antibodies and loaded with the anticancer drug doxorubicin. Compared to free Adriamycin, the preparation has 2.4-fold higher cytotoxicity to K562R leukaemia cells.observed in the mouse breast cancer model that in vivo administration of the paclitaxel SWCNT conjugate has a higher efficacy in inhibiting tumor growth and is less toxic to normal organs. . Longer blood circulation, increased tumor absorption and slower drug release from SWCNTs can be attributed to higher therapeutic efficacy and fewer side effects.

I) Through antitumor immunotherapy.

, some studies have shown that carbon nanotubes used as carriers can be used effectively in antitumor immunotherapy. This treatment involves stimulating the patient's system to attack malignant neoplasm cells. This stimulation can be achieved by administering cancer vaccines or therapeutic antibodies as drugs. Some authors have verified the use of carbon nanotubes as a vaccine delivery tool. Yang's research team observed that the combination of MWCNT and tumor lysate protein (tumor cell vaccine) can significantly and specifically improve the efficacy of antitumor immunotherapy in mouse models with H22 liver tumors . In vitro, the combination of CNTs and tumor immunogens can act as natural antigen presenting cells (such as mature dendritic cells) by carrying tumor antigens to immune effector T cells. This effect is due to the high affinity and negative charge of the antigen on the surface.

Activation of the complement system and the ancillary effects of CNTs may play a role in stimulating antitumor immunotherapy. However, the mechanism is still unknown.

5.1.4.2.Local antitumor hyperthermia therapy

has recently proposed that carbon nanotube hyperthermia therapy is an effective cancer treatment strategy. SWCNT shows strong absorption in the near infrared region (NIR; 700-1100 700nm). These nanomaterials are considered effective candidates for hyperthermia because they generate a lot of heat when excited by near-infraredlight . The photothermal effect can induce local thermal ablation of tumor cells by overheating SWCNTs bound by tumor cells such as pancreatic cancer. In recent years, this technology has advanced and proven its viability in clinical applications.

5.1.4.3. Carbon nanotubes are used to treat infections

Because infectious agents are resistant to a variety of antiviral and antibacterial drugs, or because some vaccines in the body are ineffective, NTCs have been tested to solve these problems. Functionalized CNT has been shown to act as a carrier for antibacterial agents (such because the antifungal amphotericin B). CNTs can be covalently bound to amphotericin B and transported to mammalian cells. Compared to the free drug, the conjugate has reduced antifungal toxicity by approximately 40%. Our research team successfully combined pazufloxacin mesylate with highly adsorbed amino MWCNT and used it in the experimental analysis of infection treatment. Functionalized CNT can also be used as a vaccine delivery program. The binding of bacterial or viral antigens to NTCs allows a complete antigenic conformation to be maintained, thus inducing an antibody response with the correct specificity. Binding of functionalized CNTs with B and T cell peptide epitopes can generate a multivalent system that can induce a strong immune response and thus become a good candidate for vaccine administration. Therefore, the functionalized CNT can serve as a good carrier system for the administration of candidate vaccine antigens.Furthermore, since bacteria can be adsorbed on the surface of the CNT (such as E. coli), the CNT itself can have antibacterial activity. The antibacterial effect is attributed to the oxidation of glutathione, an antioxidant in cells induced by carbon nanotubes, which leads to increased oxidative stress in bacterial cells and ultimately cell death.

5.1.4.4. Carbon nanotubes for neurodegenerative diseases and Alzheimer's syndrome.

As a promising biomedical material, NTC has been used in the field of neuroscience. Due to its small size and accessible external modifications, CNTs can cross the blood-brain barrier through various targeting mechanisms, thereby acting as an effective delivery vehicle for the target brain. It has been observed that SWCNTs have been successfully used to deliver acetylcholine to the brains of mice affected by Alzheimer's disease, with a high safety margin. Many other functionalized SWCNT or MWSCNT are successfully used as a delivery system suitable for the treatment of neurodegenerative diseases or brain tumors. Generally, the results of these studies indicate that NTCand therapeutic molecule conjugates have a better effect on neuron growth than drugs used alone. Carbon nanotubes are used as antioxidants.People have known the theory of oxygen free radicals about fifty years ago. However, only in the last two decades have they explosively discovered their role in disease development and the protective effect of antioxidants on health.However, the potential role of carbon nanotubes as free radical scavengers is still an emerging field of research. Some scientists recently reported that carbon nanotubes, especially carboxylated carbon nanotubes, are antioxidants in nature and may have useful biomedical applications in preventing chronic diseases, aging, and food preservation . Francisco-Marquez et al. The presence of -COOH groups has been shown to increase the free radical scavenging activity of SWCNTs, whereas carboxylated SWCNTs are at least as good or even better than their non-functionalized partners and free radical scavengers. Its antioxidant properties have been used in anti-aging cosmetics and sunscreens to protect the skin from free radicals formed by the human body or ultraviolet radiation. Since free radicals are known to be very harmful species, further research on various forms of CNT will be needed in the future to develop their valuable role as free radical scavengers for biomedical and environmental applications.

5.1.5.Carbon nanotubes for drug delivery across the barrier .

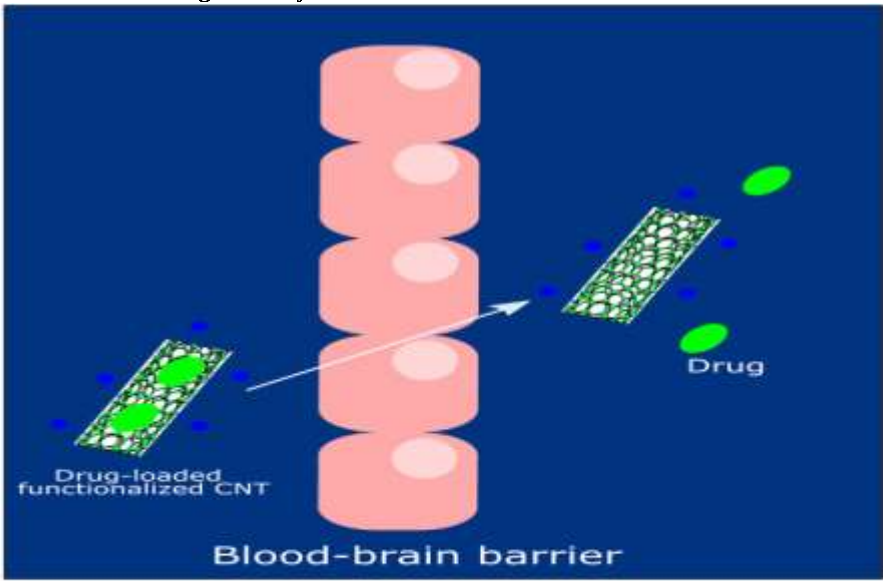

Figure 8 :Carbon nanotube containing drug transport across the BBB.

The drug delivery to the brain is challenging because its difficult to cross the blood-brain barrier (BBB). Some latest studies have shown the probability of targeting the brain with functionalized carbon nanotubes. In comparison with other nanocarriers, they shows intrinsic optical and thermal properties. In addition, the ability of organized carbon nanotubes to pass the biological barriers by transcytosis and passive process produced them excellent nanocarriers in brain targeting . A diagrammatic presentation of functionalized CNT-intervened drug delivery cross the BBB is shown in Fig.The first confirmation for the potential of the functionalized carbon nanotubes to pass the blood-brain barrier when deliver effectively was supplied using a coexisted BBB model of porcine brain endothelial cells.the functionalized MWCNTs passes the BBB through a transcellular route and there is no role of tight junction. the ability of carbon nanotubes to cross BBB and distinct on the targeting of amyloid β plaques in Alzheimer's disease and the early detection of the disease, functionalized carbon nanotubes are selected as the nanocarriers for the Pittsburgh compound B with a suitable ligand. This study acknowledged the potential of functionalized carbon nanotubes to deliver the drugs and compounds that sometimes don't cross BBB .

5.1.6.Carbon nanotubes in vaccine delivery

The carbon nanotubes bind with antigenic peptides possibly overcome the major obstacle lonked with vaccine delivery.The alternative characteristic of carbon nanotube compose them magnificant vaccine delivery systems possess massive capability to restoring the innate immune response. The carbon nanotubes too demonstrate the best non-viral gene delivery vector which may possibly restricted the other non-viral vectors which is having poor pharmacokinetic profile.The ability of a vaccine to unconstrained immune enhanced the efficiency of that specific one. The vaccine responded with cytotoxic T cells which intent at the infected cells through pathogen clearance. The CNTs are ability restoring various genes throughout immune response production adore nuclear factor kappalight-chain-enhancer of B cells, interleukins, and tumor necrosis factor-α. The antigen introducing cell plays aimportant part in the immune reaction of the cells. They uptake antigen and then destroy it and then delivers it to the surface complexes through major histocompatibility complex.

5.1.7.Tissue engineering and regenerative medicine

Tissue engineering and regenerative medicine by carbon nanotubes have been developed recently. In this method, cells are enfold into acceptable biological materials so that the advancement of the unusual tissues occurs. The carbon nanotubes seemed to useful for invent the mechanoelectrical platform characteristic , for the impact of the micro atmosphere of the cell, and they permited the chemical reactions inside the cells.

5.1.8.Bone and muscle regeneration.

The used of carbon nanotubes as plateform for stimulation of the neural system is a achieving progress in the field of neurosurgery, osteology, and cardiology. The bone progression is carried by the functionalization of the carbon nanotubes which support definite groups that binded to the carbon cations. Usually, MWCNTs are used for these methods which help in the bone development. The conducting property and the ability of CNT to electrically provoke the cells support in osteogenic differentiation and cell proliferation.The microtubules/extracellular matrix protein imitating morphology of CNTs and the capability to encourage cell attache make them able to engage with synthetic bone medium. The MWCNTs can be used for the evolution of muscle. The electrically directed hydrogels has been prepared with the participation of MWCNTs making an electrical restoring that enhance the muscle development by improving the myotube expansion .The extension phase of myotube has enlarge because appropriate of the electrical responses create by MWCNTs. The development of biohybrid tissue chosen to conduct the introducing of a present technique for solve the remaining strugling in the biorobotics and drug development. The stem cell therapy has been developing due to the recent development in tissue engineering and regeneration due to the initiate of various methods which based on the implementation of CNTs. Thus, the established mesenchymal stem cells having ability of disimilarity into different cells and tissues. The SWCNTs having capabilty of living in the same cellular structure without changes in the consequential possibility for 24 h. This important parameter of CNTs permit their continuous use in stem cell therapy and in the tissue regenerative techniques.

5.1.9.CNTs in Neuroprosthetic implants

The SWCNTs are tested by larger power and increase conductivity properties. Implant is prototypes are prepared by glued fill up of SWCNTs for the stop of nanotube distribution. An aqueous suspension of SWCNT with a particular amphiphilic polymer increase cellular desired and increses the implementation in biomedicine. The existance of a positive charge on the top of the polymer is a acceptable rational for the enhanced cellular adhesion. The incubation of the prepared nanotube films with neuronal cells within the medium is a particular estimation of the biocompatibility. The polymer inserted nanotube-contain layer-to-layer structure is helpful in the development of the neural cells . The spraying technique of the SWCNTs and MWCNTs solutions into the already prepared heated substrate is prevalent.The capability of the formed material is bigger within the culture and is compatible for the implanting procedure. These develop neuroprosthetic implants are suitable for neuronal maintenance and regulation. The formed neuritis suitably resemble the external characterizations of the nanotube involved structures. developeneuroprosthetic implants are acceptable for neuronal maintenance and regulation. These neuritis worthy to match the external properties of the nanotube involved structures. Thus, the layer-to-layer SWCNTs are often suitably utilized for neuronal development and implantations. The structural characterizations and therefore the morphology of the merchandise are liable for these effects. The capability of the layer-to-layer membrane for associating various drug substances allows neural growth following synaptic relationships without varying the versatile characteristics of SWCNT which is that the loophole in the production of implantable materials. Studies prove the immense potential for CNTs because the electrode material in retinal implants with greater biocompatibility and electrical properties . Several surface modifications are done to fabricate the electrodes with the intention of directly stimulating the spiral ganglion neurons employing a neuroprosthetic cochlear implant which consists of an array of electrodes. MWCNTs used along side conducting polymers could intensify electroactivity of neural electrodes. The surface properties of carbon nanotubes including polarity, charge and its chemistry could produce efficient neuron electrode coupling .In order to spot the effectiveness of the implant after surgery, the cross-section of the implanted electrode is completed by scanning microscopy . The condition of the implanted electrode are often done by two imaging techniques, ex vivo photoacoustic microscopy and resonance imaging.

5.2.Diagnostic application

5.2.1 CNTs as biosensor

Biosensors, which may accept the biological signals and output the chemical or physical information after transference, are principally wont to realize the specific detection of the bio¬molecular. Therefore, the activity of biosensors is of essential significance,particularly in drug discovery. The superior electrochemical properties, high specific surface area and exposure sensitivity of the CNTs render them a perfect detector , which may realize the accurate and rapid detection during a relatively low concentration. collate with other material¬dependent biosensors, the CNTs¬based biosensors show multiple profit such as high reactivity, low response time, less redox reaction and a long life span. The most usual biosensors depends on CNTs are enzyme biosensors and DNA biosensor.

5.2.2. CNTs as biomedical imaging

This resembles a superb idea for perfect imaging of the cells,tissues, and organs. Carbon nanotubes are often used for improvisation of the functionalities just in case of imaging . The two specialized methods which will be utilized are photoacoustic imaging and resonance imaging. Moreover, carbon nanotubes are often provoked by additionally applying an external magnetic flux . The absolute identification of the CNT extend when novel elements are inserted.The capacity of imaging are often developed by the use of varied techniques like by the addition of gold nanoparticles, quantum dots etc. It has to be properly evaluate the toxicity strength of the added component. This is a encouraging methods for the therapy of a tumor.

5.2.3.Carbon nanotubes for biomolecular detection

Protein functionalized carbon nanotubes are utilized for the productionof a lab-on-a-chip (LOC) that is capable of detecting low-density lipoprotein. The various physicomechanical properties of CNTs are significant in biomedicine such they might act as biomarkers and implantable devices. The greater electrical and mechanical properties of the CNT enable it as an proper material for the gathering of supersensitive LOC which might be helpful for biomolecular detection. Another fasinating truth is the evolution of a suspension of CNT with the nickel oxide support which acts as a biomarker for cholesterol diagnosis . The existence of nickel oxide establishes larger surface expansion, greater electromechanical properties and has greater degradation potential towards protein, enzyme, RNA, antibodies then on The nickel oxide creates a greater electrostatic potential which may be a key factor behind the transmission of the antibody through electrostatic connections with carbon nanotubes. Carbon nanotubes gives electronic plateform and they act as a carrier on the electrode surface. Carbon nanotubes also are selective thanks to their characteristic nature which causes decreased utilization of samples and lesser energy consumption.Lipoproteins are characterized by the function of transportation of cholesterol in the bloodstream and are metabolized within the liver, kidneys, and within the tangential tissues. Moreover, the cholesterol immobilization results in the contact of apolipoproteins with sulfated glycosaminoglycans which cause cholesterol deposition within the arterial surfaces. This eventually results in the formation of plaques which causes the reduced flexibility of arteries and causes major heart diseases like atherosclerosis. The general method for the assessment of the number of LDL molecule is by nuclear resonance spectroscopy, electrophoretic methods, and ultracentrifugation methods.All these methods are having high cost, time- consuming and tedious. Thus, the use of an impedimetric LOC is preferential to in particular . The metal oxide used in the impedimetric LOC is indium‐ tinoxide along with anti-apolipoprotein and bovine serum albumin characterized CNT‐ nickel oxide nanocomposite.

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