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(Review Article)

Synthesis and characterization of low dimensional structure of carbon nanotubes

Rajesh Kumar Mahto and Satish Kumar *

Department of Physics, RadhaGovind University, Ramgarh, Jharkhand-829122, India.

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Abstract

This research paper describes in detail the processes of making and analysing carbon nanotubes. The latest information gained from research and growing carbon nanotube arrays will be presented and debated. Insight into carbon nanostructured materials and their applications in a wide variety of developing areas of nanoscale research and nanotechnology will be facilitated by the achievements presented in this area. A number of theoretical and experimental investigations have been conducted to determine the best methods for making carbon-related nanomaterials, which are widely recognized as one of the most interesting areas of both science and nanotechnology. Theoretical and experimental research that led to the transformation of these nanomaterials at a critical juncture. The goal of this article is to present a brief summary of recent developments in our knowledge regarding the production, properties and potential applications of low-dimensional carbon nanomaterials. These events are described as fascinating on the one hand and important on the other. To fabricate carbon nanomaterials in a wide range of structural configurations, a number of diverse processing processes are used. This research delves into the many methods used to make carbon nanoparticles and the materials themselves. Nanomaterials include things like graphene and carbon nano walls, carbon nanofiber and carbon nanotubes, and fullerenes and carbon-encased metal nanoparticles. Chemical vapor deposition is one such method, and is used in the production of a variety of practical items.

Keywords: Carbon nanotubes; Low dimensional Carbon Nanotubes; Conductivity; Characterization

1. Introduction

Carbon, a non-metallic element found in coal, is essential to all known forms of life, hence one may reasonably conclude that carbon is the foundation of life. Diamonds and graphite, both carbon-based materials, have an optimum balance of brittleness and malleability. Because of its unusual qualities, graphite (its softest form) may be used as a skin lubricant and as a diamond for drilling. By filtering them via this benign material, harmful substances may be reduced. It's the element with the greatest melting point and it's found in abundance in nature. Chemically speaking, carbon nanomaterials are the progeny of the carbon 60 molecule, but carbon micro materials are far smaller. Nanomaterials made of carbon have been the subject of intensive study because of their remarkable structural, electrical, mechanical, optical, and chemical properties. Carbon nanomaterial formations may be classified as zero-dimensional (0D), one-dimensional (1D), or two-dimensional (2D) based on its nanoscale range (100 nm) in different spatial orientations (2D). Fullerene, onion-shaped carbon, nanoparticles encased in carbon nanotubes, carbon Nano fibres, graphene, and 1-dimensional carbon nanotubes (2-D) are all examples of the types of structures that make up these carbon nanomaterials.(Mostofizadeh et al., 2011).

Carbon nanotubes, or CNTs, are very small tubes that are only a few micrometres long and formed completely of carbon atoms (compared to the nanometres their diameters typically occupy). Since its discovery, numerous ludicrous claims have been made about carbon nanotube (CNT), including "CNT is 100 times stronger than stainless steel and 6 times

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*Corresponding author: Satish Kumar
Department of Physics, RadhaGovind University, Ramgarh, Jharkhand-829122, India.

lighter." CNT not only has the same degree of hardness as pure diamond and is twice as heat resistant, but it also has a larger heat capacity. According to reports, CNT can carry current up to 1,000 times as much as copper. Carbon nanotubes (CNT) have been demonstrated to resist temperatures as high as 4000K without losing any of their structural integrity. Depending on their size and chirality, carbon nanotubes (CNTs) can have either a metallic or a semi conductive conductivity. Depending on how many graphitic layers they include, CNTs are most frequently referred to as single-walled (SWCNTs), double-walled (DWCNTs), or multi-walled (MWCNTs) (MWCNTs). Quantum chemistry, more especially orbital hybridization, can be used to characterise the atomic bonds that make up a CNT. Similar to graphite, CNTs feature sp2 chemical bonding throughout their structures**.”**(Shanov et al., 2006).

1.1. Structure of carbon nanotubes

The layers of carbon atoms that make up a carbon nanotube are arranged in a hexagonal (honeycomb) mesh. Graphene, A single carbon atomic layer is rolled into a tube and chemically bonded to create a carbon nanotube.

1.2. Carbon nanotubes zero-dimensional

Carbon black, nano diamond, nano fullerene C60, and carbon-coated non-metal particles are only a few examples of the various zero-dimensional carbon nanomaterials.

1.3. Carbon nanotubes One Dimensional

As the ultimate one-dimensional substance, carbon nanotubes really have two minuscule dimensions, which may be misleading.”

1.4. Carbon nanotubes 1D or 2D

In the past few decades, the study of one-dimensional (1D) carbon nanotubes (CNTs) and zero-dimensional (0D) carbon dots (CDs), two of the many versatile carbon-based nanostructures, has advanced to a new level.(Dresselhaus et al., 2004)”

1.5. Properties of Carbon Nanotubes

Layers of bonded carbon atoms form the hexagonal, honeycomb-like structure of carbon nanotubes. A sheet of one atom thick graphene is rolled up and chemically bonded into a cylinder to form carbon nanotubes. To make a nanotube, one may either utilise a single carbon shell or many shells (cylinders within other cylinders of carbon) (cylinders inside other cylinders of carbon).The electric, thermal, and structural characteristics of carbon nanotubes may vary widely depending on their specific physical shape.(Lekawa-Raus et al., 2014)

1.6. Single-walled carbon nanotube structure

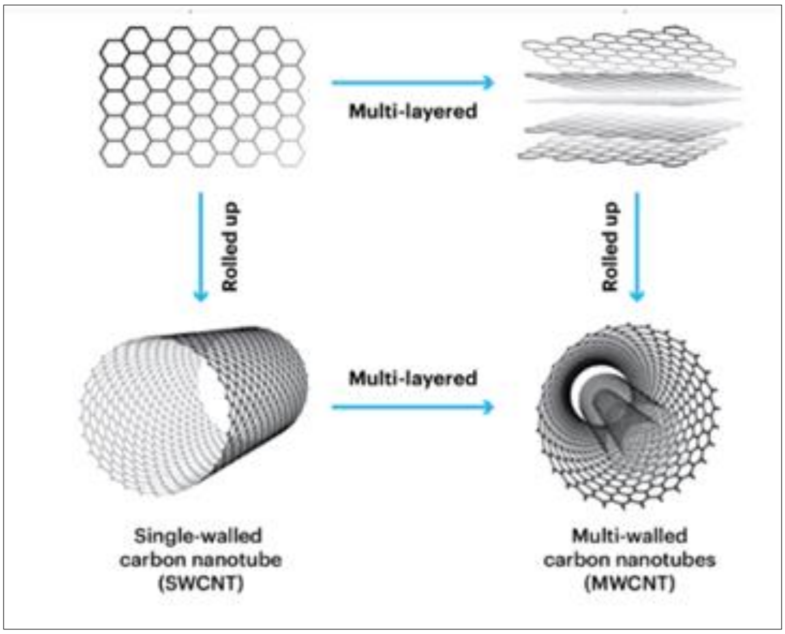

Figure 1 Single-walled carbon nanotube structure

Armchair, Chiral, and Zigzag are examples of single-walled carbon nanotube-based structures. The design uses coiled graphene. Rolling a piece of paper from the corner is one idea, for example. (n,m) chiral vector describes nanotube structure. Here's a chiral vector. Nanotube design impacts electrical properties. "Metallic" nanotubes have n m multiples of 3. (Very conducting). Some armchair nanotubes are semiconductors.(Odom et al., 1998)

1.7. Multi-walled carbon nanotube structure

Two-structured nanotubes. Russian Doll nanotubes include another (with a lesser diameter). Graphene is rolled up in the Parchment model. Multi-walled nanotubes may prevent chemical reactions, much like single-walled nanotubes do. Stronger nanotubes have more walls.(Behler et al., 2006)

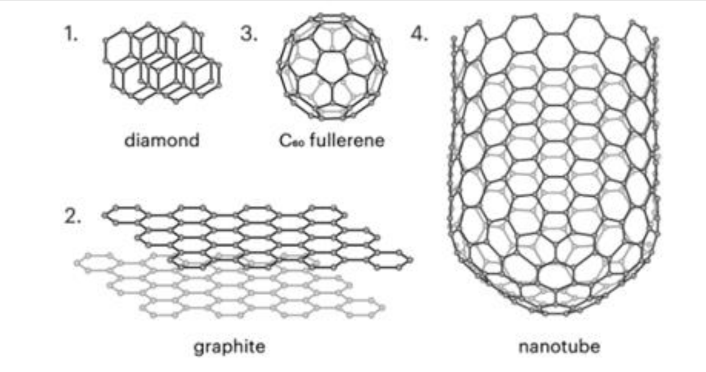

Figure 2 Multi-walled carbon nanotube structure

1.7.1. Benefits of Carbon Nanotubes

- It is a great alternative to metallic wires because of its tiny size and light weight.
- The alternatives for the materials needed to create them are sufficient.
- They perform nearly as well in stifling temperatures as they do in soaring ones.
- Increase the mechanical energy conductivity of composites.(Akbari & Buntat, 2017)

1.7.2. Drawbacks of Carbon Nanotubes

- Scientists are still working to fully understand how carbon nanotubes function.
- They are challenging to handle because of their little size.
- At the moment, producing nanotubes involves a lot of physical labour.
- If at all possible, we must switch to more modern technologies. That would need a great deal of effort.
- Given how rapidly this technology is becoming outdated, investing in it now can be dangerous.(Fiyadh et al., 2019)

1.7.3. Applications of Carbon Nanotubes

Numerous characteristics and uses for carbon nanotubes make the most of their unique aspect ratio, mechanical toughness, electrical conductivity, and thermal conductivity.

Single-wall CNTs are molecularly perfect, possess outstanding stiffness, strength, and toughness, in addition to having extraordinarily high thermal and electrical conductivity, thanks to the remarkable properties of carbon. It is the only element in the periodic table capable of building intricate networks of connections with itself, each as powerful as the carbon-carbon bond. Each atom's delocalized pi-electron, which is permitted to roam freely across the entire structure rather than being linked to its donor atom, enables the first known molecule with metallic-type electrical conductivity. The carbon-carbon bond has a higher intrinsic thermal conductivity than even diamond because of its high-frequency vibrations.(Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, 2022)

1.7.4. Other Carbon Nanotubes Applications

CNTs can be used, among other things, for coatings, nonporous filters, catalytic supports, and solar collection. Unexpected uses for this good content will definitely be found in the future; some of these uses may turn out to be the most important and helpful of all. Many scientists have looked into using CNTs to make waterproof and/or conductive paper. Furthermore, it has been shown that CNTs can absorb infrared light, indicating that they might have uses in the area of I/R optics..(Zhou, 2001)

1.7.5. Carbon Nanotubes Properties

- CNTs have high thermal conductivity
- CNTs have high electrical conductivity
- CNTs aspect ratio
- CNTs are very elastic ~18% elongation to failure
- CNTs have very high tensile strength
- CNTs are highly flexible — can be bent considerably without damage
- CNTs have a low thermal expansion coefficient
- CNTs are good electron field emitters (Saito, 1998)

1.7.6. Carbon Nanotubes Applications

- CNTs field emission
- CNTs thermal conductivity
- CNTs energy storage
- CNTs conductive properties
- CNTs conductive adhesive
- CNTs thermal materials
- Molecular electronics based on CNTs
- CNTs structural applications
- CNTs fibers and fabrics
- CNTs biomedical applications
- CNTs Air & Water Filtration
- CNTs catalyst supports
- Other CNT applications (Nano, 2018)

1.8. Important Barriers That Limit the Application of Carbon Nanotubes

CNTs are used in several applications and have excellent qualities. Despite this, this industry still faces a lot of difficulties and opportunities. One of the biggest challenges to the widespread application of CNTs is their dispersion. It is extremely challenging to separate individual CNTs from bundles as a result of the Van der Waals forces that cause CNTs to congregate. Frequently, the properties of the bundles fall short of those of the individual nanotubes. CNT surface modification has received substantial theoretical and experimental study, and this strategy has proven effective in resolving dispersion-related problems. Because it is outside the purview of this chapter, this subject is not covered here. At this point, it's important to understand how these surface alterations affect the characteristics and applications of CNTs in addition to how they improve CNT dispersion. Numerous studies show that functionalization causes structural flaws that lower the thermal, electrical, and mechanical properties of CNTs. Additionally, as the majority of these surface alterations necessitate the use of potentially dangerous solvents, cytotoxicity considerations must be taken into consideration, particularly in biomedical applications. Therefore, it is crucial to carefully examine this paradoxical outcome.(Ferreira et al., 2018)

1.9. Characterization

1.9.1. Optical spectroscopy and optical characterization

One-dimensional SWCNTs and their electrical and optical characteristics enable extensive optical spectroscopy. Utilising resonance, photoluminescence, and absorption spectroscopies to examine and alter the excitonic characteristics of SWCNTs. Raman spectroscopy SWCNTs that are immobilised, solution-dispersed, or air-suspended are used to study granularity. We investigate the water adsorption layer using temperature-dependent SWCNT photoluminescence. Single-molecule spectroscopy could be used to investigate SWCNTs that have been wrapped in SDS on a surface covered with a polymer. DTT evens out tube photoluminescence. Tracking SWCNTs in solution helps determine nanotube length distribution. We use SWCNT-based PVAc sheets for low-temperature optical and far-infrared spectroscopy. Fermi energy affects doped SWCNT absorption and CD spectra. Because of the phase shift effect and surface plasmon amplification, doped nanotubes have higher CD values.

1.9.2. Advanced characterizations

Individual CNTs have notoriously difficult Young's moduli, tensile strengths, and strain to failure measurements. One frequent experimental setup involves measuring strain-stress by a deflection measurement, with transverse loading serving as the loading type of choice. All the computations are done using a nonlinear generalisation of Kirchhoff's rod theory. “Carbon nanofibers (CNFs) have higher tensile strength and Young's modulus due to their epitaxial growth on top of multiwall carbon nanotubes (MWCNTs).The 13C isotope has been connected to heat conduction in SWCNTs because of its function in the localisation of high-energy optical phonons. Researchers study statistical self-diffusion of highly rarefied specular particle-wall reflections to gain understanding of the quick gas diffusion inside CNTs indicated by MD simulations.”(Muskens et al., 2006)

1.10. Carbon nano tubes synthesis

CNTs degrade hydrocarbons below SDT. Carbon disperses in iron, cobalt, and nickel. High-melting-point, low-vapor-pressure CVD carbon precursors. Iron, Co, and Ni are SWCNT-adhesive. Cobaltocene, ferrocene, and nickelocene decompose hydrocarbons. Flexible tubes. Nanoparticles CDCNTs. Coatings aid CNT deposition. CNTs aren't affected by pyrolysis or hydrocarbons. 730°C acetylene created CNTs on stainless steel. Nanoparticles are poor catalysts, research shows. Metal roughens CNTs. Metals catalyse. In 2008, zeolite-based Fe-Co catalyst quadrupled CNT gigas. Increasing CNT catalytic activity by changing metal ratios and calcining catalysts. CoMo3%CNT on MgO. Gold, silver, platinum, and palladium produce CNTs. CNTcatalyzes CVD, arc-discharge, and laser-vaporization. Grow CNTs. CNTs link catalyst temperature and pressure. CNTs affect hydrocarbon decomposition below SDT. High-temperature iron, cobalt, and nickel scatter carbon. CVD carbon precursors melt and vaporise quickly. Iron, Co, and Ni have strong CNT adhesion, reducing SWCNT prices. In-situ organometallocene (ferrocene, cobaltocene, nickelocene) catalysts increase tube diameter. Metal nanoparticles create CDCNTs. Thin catalysts help deposit CNTs. CNTs don't need pyrolysis or hydrocarbon degradation. Acetylene at 730°C creates CNTs. Research suggests nanoparticles are poor catalysts. Rough metal grows CNTs. Alloys catalyse Fe-Co catalysed CNT gigas doubled in 2008. Metal ratios and catalyst calcination can increase CNT growth catalytic phases. MgO grows 3% Co-Mo and Ni-Mo CNT. Gold, silver, platinum, and palladium boost CNT. CNTcatalyzes CVD, arc-discharge, and laser-vaporization. CNT growth is inherited. Temperature and pressure affect CNTs.**(Prasek et al., 2011)**

2. Limitation of Carbon Nanotubes

Despite CNTs' promising future in the medication delivery industry, their use is restricted for a number of reasons. When CNTs are put to use in the real world, issues such as bundling, insolubility, hydrophobicity, a very high surface area (leading to protein opsonisation), and the presence of contaminants occur CNTs' toxicity is also a major obstacle. Due to the structural similarities between carbon nanotubes (CNTs) and asbestos fibres, toxicological studies of CNTs have recently attracted a lot of attention.

- Almost all biocompatible solvents are unable to properly dissolve certain compounds (aqueous based).
- In this way, CNTs with stable properties might potentially be mass-produced.
- Trying to become as clean as possible and then some.

3. Research Gaps and Challenges

Some research gaps hinder application. Amorphous carbon, metal catalysts, and ash contaminate CNTs. Impurities impact form, catalysis, and electro catalysis.

Destabilizing non-nanotube carbon. CTs slow enzymes. CNT contaminants affect sensor performance. Separating metallic and semiconducting CNTs is hard. CNTs need current technology. CNTs improve small-geometry rate, mass transfer, and current control.

Liquid and gas-phase treatments, oxidation, and chemical purification are decontamination methods. Nanotubes remove impurities. Curl-prone HNO3-purified CNTs. Temperatures can't completely eradicate CNT pollutants. CNTs form by filtration and annealing. CNTs were unclean able. Understand the purifying process. Purifying CNTs modifies form and flaws. Functionalize CNTs.

Non-sensing CNTs absorb. Defective MWCNTs reduce conductivity. Pentagonal nanotube defects are charged. Water-purifying CNTs require topological defects and electroactivity. Water-based dispersion. Dispersants and CNTs don't disperse in hydrophobic graphite. Functionalization boosts adsorption.

4. Literature review

(Ismail et al., 2020)"This research proves that catalyst-free MWCNTs and CNPs can be created by ablation with a pulsed laser from graphite targets that dissolve in water. Scientists have noticed that the optical absorption and structural properties of materials change depending on the wavelength of the laser used. Synthetic CNTs were found to be polycrystalline and have a diamond-like structure using X-ray diffraction analysis. We found that the typical diameter of the CNTs generated by the 532 nm laser was 20 nm and the typical length was a few micrometres. In contrast, 1064 nm laser generated CNTs had a smaller average diameter of 75 nm and more sub-micrometer sized CNTs (SEM). The team showed that CNPs can be kept in CNTs. Here, a transmission electron microscope was used to view MWCNTs and determine their shape (TEM). Raman peaks in the D-band, G-band, and 2D-band are possible for MWCNTs made through chemical vapour deposition." When MWCTs are formed using two distinct laser wavelengths, the IG/ID intensity ratio is diminished. Absorption is higher in colloidal MWCNTs than in MWCNTs made using 1064 nm laser pulses. At room temperature, the sensitivity and current-voltage properties of hybrid In/p-MWCNT/n-Si hetero junction light detectors were investigated as a function of CNT layer thickness. Two wavelengths, 650 and 850 nm, were determined to be the most sensitive for the hybrid MWCNTs/n-Si photo detector. After testing with a 532 nm laser, the photo detector's maximum response was calculated to be 0.53 A/W. Energy band diagram of a MWCNTs/Si hetero junction, drawn optically.

(AhmadAqel et al., 2012) Since the Japanese scientist "SumioIijima" discovered carbon nanotubes in 1991, there has been a significant amount of interest in them." This interest has come from both a purely theoretical and practical perspective. There are a wide variety of methods for creating carbon nanotubes. Large-scale production and purification methods that are cost-effective are still in the research and development stages. This overview of carbon nanotubes covers their background, different varieties, structural makeup, synthesis, and characterization techniques. Numerous researchers throughout the world are interested in carbon nanotubes. These structures are remarkable in many ways, making them a novel material with a wide variety of exciting potential uses.

(Atchudan et al., 2015)On mono dispersion spherical iron oxide nanoparticles, graphenated carbon nanotubes (G-CNTs) were synthesisedutilising acetylene as the carbon precursor and an easy chemical vapour deposition approach (IONPs). High-quality G-CNTs can be produced on a wide scale by controlling reaction variables like temperature and carbon source flow. A transmission electron micrograph reveals the flaky graphene coating the CNTs (TEM). With the help of Raman spectroscopy and X-ray diffraction, the degree of graphitization was determined. The synthesised G-CNTs' low D/G intensity demonstrated the high degree of graphitization present in these materials. High carbon deposition yield in the synthesis of G-CNTs is achieved at an ideal reaction temperature of 900 °C, when metallic clusters are created by IONPs. The CNTs measured in at 50 nm in diameter, while the foiled graphene flakes measured in at 70 nm. In summary, we find that IONPs offer a promising catalytic template for increasing the productivity of nano hybrid G-CNTs on a quantitative and qualitative level. Whether or not the G-CNTs developed are ideal for usage in nano electronic devices like super capacitors is debatable, depending on the degree of graphitization accomplished during manufacture.

(Malikov et al., 2014) Multi walled carbon nanotubes were created using chemical vapour deposition while a Fe-Co/alumina catalyst was present. To create the nanotubes, this was done. The nanotubes were oxidized next, and following that, polyvinyl alcohol was grafted onto them (PVA). Techniques including XRD, FTIR, EDX, SEM, and TEM as well as Raman spectroscopy, as well as thermo gravimetric analysis (TGA), were used to describe the nanostructure that was created. The FTIR analysis revealed unique peaks that are linked to the expected ester group. The fact that there is evidence for this. The identification of polymer nanocomposites containing multi walled carbon nanotubes and polyvinyl alcohol was done using scanning and transmission electron microscopy. Images of nanotubes taken at very high magnification reveal that PVA grafting occurs mostly at defects in the nanotubes' sidewalls. Fischer esterification was used to connect the nanotubes to the PVA matrix, which is a unique approach and a key part of the study's findings. In order to complete the task, this step was taken.

(Yu et al., 2008) We used single-walled carbon nanotubes that had been treated with octadecylamine and methyl-cyclodextrin to make composites using conventional R&D techniques. Single-walled carbon nanotubes were produced using an oxidation process and then put through an acyl halogenation process using thionyl chloride and dimethylformamide. Octadecylamine and methyl-cyclodextrin were combined to produce molecules, which were subsequently dissolved in solvents. Transmission electron microscopy and Fourier transform infrared spectroscopy allowed us to follow the growth of surface functional groups on functionalized single-walled carbon nanotubes. It was found that the modification has changed the structural characteristics of the nanotubes. The dissolution of functionalized single-walled carbon nanotubes has been reported to be significantly aided by both dimethyl sulfoxide and dimethylformamide.

(Xia & Song, 2005) It was possible to create carbon nanotube/polyol dispersions using a mechano chemical method that were uniformly disseminated and long-lastingly stable. Additional in situ polymerization was necessary for the creation of nanocomposites including carbon nanotubes and polyurethane (PU). Individual multi-walled carbon nanotubes (MWNT), commonly known as MWNT, can be dispersed. Carbon nanotube addition to polyurethane improved the material's degree of phase separation, according to spectra acquired using the Fourier transform infrared technique (FTIR). A dynamic mechanical analysis (DMA) showed that a slight decrease in the glass transition temperature was produced by adding more carbon nanotubes to polyurethane (Tg). According to tensile strength tests conducted on polyurethane, MWNT are superior in terms of increasing the material's modulus, SWNT, however, excel in enhancing the material's ability to elongate. It was shown that there is a correlation between the form factor and shear thinning exponent of carbon nanotubes in polyol dispersion, and that MWNT and SWNT specifically reinforce PU. By looking at the Raman shift of SWNTs, it is possible to better understand the interactions of SWNTs with polymers and the status of their dispersion in polyols or PUs. SWNTs or MWNTs can be used to improve the thermal conductivity and thermal stability of polyurethane.

(Shawky et al., 2011) Fabrication of MWCNT-aromatic polyamide nanocomposite membranes was carried out via polymer grafting (PAs). In order to examine the surface form, roughness, and mechanical strength of the nanocomposite membrane, atomic force microscopy, scanning electron microscopy, and micro-strain analysis were used (SEM). Optical and scanning probe micrographs show the MWCNTs are equally dispersed throughout the PA matrix. The composites displayed increasing trends in their Young's modulus, hardness, and tensile strength as the mechanical testing went on. With more MWCNT present in the composite material, the membrane strength will increase proportionally. MWCNT addition raised the salt content and rejected organic debris as compared to 10% PA membrane as a control. The NaCl rejection value was 3.17 and the humic acid rejection factor was 1.67 for the nanocomposite membrane created by synthesising PA with 15 mg/g MWCNTs in 10% PA casting solution. A table with the results can be found below. The membrane's permeability also dropped by a factor of 6.5.

(Balázsi et al., 2003)Ceramics that have been reinforced with multiwall carbon nanotubes (MWNT) have been produced into composites for use in various applications. Sintering by use of a hot isostatic press (HIP) was the procedure that was utilized for the processing of composite materials. Composites constructed using MWNTs and silicon nitride revealed considerable gains in their bending strength and elastic modulus when contrasted with matrices that had extra carbon fiber, carbon black, or graphite. These matrices were used as a comparison. Nevertheless, the samples of silicon nitride that were created without the incorporation of any carbon displayed an even greater value because of the higher densities they possessed. It has been established that the inclusion of carbon fibre causes the material's quality to decline throughout the sintering process. Structures without carbon nanotubes were produced by sintering the material at high pressure and temperature for lengthy periods of time.

(Venkatesan et al., 2011) Natural hydroxyapatite was obtained from Thunnusobesus bone chitosan that was synthesised with functional multi-walled carbon nanotubes in addition to HAP, HAP, and HAP. This is the first demonstration of the F-MWCNT scaffold made of chitosan. The Hap/f-MWCNT composite scaffolds significantly decreased the heat stress resistance, water permeability, retention capacity, and degradation. Hap and F-MWCNTs were shown to be tightly implanted in the chitosan matrix by a number of imaging techniques. The chitosan/HAp composites' porosity varied from 70 to 200 m, whereas that of the f-MWCNTs/HAp and g-chitosan/HAp composites was 46 to 200 m. Cells in composite scaffolds grow twice as quickly as those in pure chitosan, according to an in vitro analysis utilising the MG-63 cell line. These findings show that f-MWCNT-g-chitosan/hap composite scaffolds and chitosan/hap composite scaffolds are appropriate biomaterials for bone tissue engineering.

(Micheli et al., 2014)Carbon nanotubes (CNTs) with multiple walls that have been amino-functionalized and untreated long carbon nano fibers were used to create epoxy nanocomposites (CNFs). Viscosity measurements were used to analyse the uncured mixes. To determine how nano reinforcement affects the curing process, differential scanning calorimetry was employed. Finally, the thermo-mechanical and electrical characteristics of the cured nanocomposites were studied. The viscosity of an epoxy monomer at room temperature is only slightly increased by the addition of CNTs because CNFs have a lower specific area. As a result, the epoxy monomer's oxirane rings interact with the CNT's amino groups. The amount of nano reinforcement slows down the curing reaction's rate and increases the degree of epoxy conversion. The glass transition temperature of the nanocomposites is decreased with the addition of CNTs and CNFs, which may be related to the plasticization of the nano reinforcement. The storage modulus of epoxy resins is markedly raised by the addition of CNTs and CNFs. This increase is bigger with amino-functionalized CNTs due to, among other things, a stronger contact with the epoxy matrix. The electrical conductivity is significantly increased by the addition of CNTs and CNFs. In actuality, the percolation threshold is lower than 0.25 by weight percent because of the high aspect ratio of the nano enforcement employed.

(Balandin, 2011)Scientists and engineers have been more interested in a material's thermal properties in recent years. Due to the very high heat transfer rates achievable in low-dimensional devices, heat removal is a significant obstacle in the advancement of electronics. In terms of thermal conductivity, carbon allotropes and their derivatives are unrivalled. Amorphous carbon, which is even less thermally conductive than graphene and carbon nanotubes, has the lowest thermal conductivity of any carbon-based substance at ambient temperature. Five orders of magnitude's worth of difference separates them. In this study, the thermodynamic properties of nanostructured carbon materials including graphene, carbon nanotubes, and disordered nanostructured carbon are examined. Scientists are curious about how size affects heat conduction in two-dimensional crystals like graphene because of this peculiar correlation. I also go over the possibility of future gadget housing made of graphene and other carbon-based materials. an appropriate temperature.

(Li et al., 2005)"The commercial manufacture of double-walled carbon nanotubes (DWNTs) utilisinggraphene or multi-walled carbon nanotube nanowires (MWNTs/CNFs) as carbon feedstock was carried out using hydrogen arc discharge (DWNTs).By using this method, a sizable number of DWNTs were synthesised. DWNTs may be produced at a rate of 4 grammes per hour. To our surprise, we found that MWNT/CNF-produced DWNT was much purer than DWNT made from graphite powder. The majority (more than 80%) of the carbon nanotubes were DWNTs, and the remaining (20%) were SWNTs, according to high-resolution transmission electron microscopy. DWNT can range in size from 1.75 nm to 4.87 nm inside and 1.06 nm to 3.93 nm outside. Isolated DWNTs were found to have uncapped ends, and cobalt, a key catalytic ingredient, was found to be absent, was essential to the formation of DWNTs. Cryogenic nitrogen adsorption investigations were also conducted to learn more about the pore topologies of the synthesised DWNTs."

(Dai et al., 1995)The properties of encapsulated (CN) have aroused extensive debate, as well as the potential applications of these nanotubes. 1–5.Nanotubes can be filled in two distinct ways: either by the in-situ formation of metal/carbon composites in an arc reactor 2, 5 or by the capillarity-driven filling of open nanotubes with liquid reagents. Both of these processes are described further below. 3, 4. In this piece, we will discuss an alternative way for constructing nanoscale structures using nanotubes, which we will present. Carbide rods are created when the tubes come into contact with the flammable oxide and/or halide species. Too far, we have made substantial strides in producing nanoscale rods of the solid carbides TiC, NbC, Fe3C, SiC, and BCx. These rods had typical measurements of 20 urn in length and 2-30 nm in width. Recently conducted research has shown that these rods, like bulk materials, are magnetic and superconducting. This raises the possibility that they could be used to study how confinement and reduced dimensionality affect the properties of solid states and could be used to investigate this question. The technological applications of these carbide nano rods could possibly include their application in nanostructured composite materials.

(Chow et al., 2013)Protection of human health and safety is significantly hampered by the identification of biological and chemical species. The results of this investigation suggest that hydrothermally generated Cu-doped ZnO rods at 95 °C can improve the sensor performance at room temperature (RT). Maintaining a steady temperature is ideal for these rods' performance. The broad term "characterization" encompasses a variety of methods, including photoluminescence, Raman, X-ray photoelectron spectroscopy, scanning electron microscopy, and X-ray diffract. We created a dual rod device using focused ion beam technology to demonstrate the utility of Cu-doped ZnO rods for gas sensor applications and to contrast them with pure ZnO. In-depth reports are given on the outcomes of tests done on both pure ZnO and ZnO rods doped with Cu. Our analysis indicates that, Cu-ZnO sensors have higher selectivity, a quicker response time, and increased RT sensitivity. Miniature sensors based on Cu-ZnO rods might make effective H2 detectors with minimal power requirements. These sensors may be made smaller.

5. Research Objective

To evaluate the synthesis and characterization of low dimensional structure of carbon nanotubes

5.1. Synthesis methods of carbon nanotubes

Arc discharges were initially utilised accidentally to produce carbon nanotubes (CNTs), but today there are numerous other techniques. The output type enables specification of the precursor (which could be a solid, liquid, or gas), heat source, reaction time, temperature, reaction environment, and generally, what cnt is and how it functions. Carbon nanotube synthesis is possible through arc discharge, laser ablation, and chemical vapour deposition. There are many ways to make carbon nanotubes, including dipping graphite in cold water, mechano-thermal synthesis, break down, torsion of graphene layers using solar energy, pyrolysis, liquid-phase synthesis, and electrochemical synthesis.

5.1.1. Electrolysis

1995's liquid phase is used. Alkali or Alkaline-earth metal electrowinning avoids chloride deposition. Using DC voltage in molten alkali-alkaline earth metals creates multi-walled carbon nanotubes. Forms lithium carbide (1).

$$2Li++2e++2C \text{ (graphite) } =Li2C2 \quad (1)$$

Lithium carbide makes liquid cnt (Li2C2). Use 2–10 nm and 0/5 micrometrecnts. Nanographite, nanofiber, and CNTs. Manufactured single-walled CNTs. LiCl, KCl, LiBr. Parameters include electrolysis, time, and molten salt. Process optimization enhances MWCNT production 20–40%. No-equipment electrolysis. Non-mass-produced, high-quality, low-energy.

5.1.2. CVD

CVDutilises CO2, C2H2, C2H4 and other hydrocarbons at 350-1000 C. Cnt development is affected by time, temperature, catalyst diameter, speed, and reactant gas. Depending on the heat source, cvd is classified as thermal, flame, or infrared.

5.1.3. Mechano Thermal

Amorphous carbon vacuum-annealing. Amorphizes ball-milling. Depending on the atmosphere (Ar or air), cup speed (300 rpm or more), ball-to-powder ratio, number of balls, and powder quality, amorphous carbon synthesis may take up to 180 hours. Milling reduces crystallite size, creating amorphous structure. Cup-ball friction may generate cnt from graphite powder. Amorphous carbon vacuum-furnished. 1400 C transforms amorphous carbon into nanotubes. Nanotube-making. Mechano-thermal is simple, mass-produced, inexpensive, and needs no special equipment.

5.1.4. Laser Ablation

Lasers start graphite nanotubes. Cooling evaporation. Nanotubes formed from carbon atoms and molecules. MWCNTs use graphite rods. Fe-Ni-Co-He-H2-Ar graphite. Pulsed lasers are more energy-intensive. CO2-ablated ND: YAG. 1 micrometer-long 4-30 nm cnt. Amorphous carbon, catalyst particles, fullerene are contaminants. Catalysts form nanotubes. Laser ablation catalysts include Co/Ni, Co/Pt, Co/Cu, Ni/Pt. Production quality depends on substrate-to-target distance, target composition, laser beam strength, catalyst type, ambient gas, and reaction temperature. This pricey method produces high-purity carbon nanotubes.

5.1.5. Flame Synthesis

Carbon oxidation creates cnt. Three-phase flame synthesis. Carbohydrates. When carbon atoms diffuse into a metallic catalyst, nanotubes develop. Acetylene, methane, ethanol, and ethylene are carbon feed stocks. Flame type impacts nanotube and amorphous carbon quality. Optimize temperature, gas, and catalyst. This inexpensive, sluggish process mass-produces single-walled cnt.

5.1.6. Arc discharge

Arc discharge generates nanotubes. Graphite arcs. Soot is split-carbon. (Liquid nitrogen, toluene, not ionised water) plasma rotation (liquid nitrogen, toluene, not ionised water). Plasma arc produces inexpensive nanotubes. Plasma volume, temperature, and anode evaporation increase with rotation. Graphite plus a metal catalyst make single-wall nanotubes. Pressuring, guiding. Arc discharge governs speed, not efficiency and quality. CO2 flames Carbohydrates. Metals produce carbon nanotubes. Acetylene, Methane, Ethanol, and ethylene are carbon feedstock's. Nanotube/amorphous-carbon fire. Catalyser, gas Cnt mass-produced.

6. Characterization methods of carbon nanotubes

In electron microscopy, an electron beam is used to examine a sample in order to generate an image. Electrons' diffraction effects happen at far lower physical dimensions than lights. The microscope was the first tool that allowed scientists to investigate tiny objects in great detail. Its founders' inventiveness and analytical prowess are on full display in the instrument's transformation from its primitive beginnings some 300 years ago to its modern incarnation.

- The scanning tunneling microscopy (STM).
- The atomic force microscopy (AFM).
- The X-ray photoemission spectroscopy (XPS).
- The grazing incidence small angles X-ray scattering.

- The X-ray absorption near-edge structure spectroscopy.
- The Raman spectroscopy.

6.1. Electron Microscopy

In order to characterise any nanomaterial, A crucial instrument, electron microscopy enables the direct examination of size, shape, and structure. TEM, SEM, AFM, and STM can all be used to probe the nanoscale and sub nano meter details of the CNSs' local structure. TEM and SEM are useful for verifying bundle exfoliation and the cleanliness of the material. However, Because the sample is damaged by the electron beam used in TEM and SEM, these techniques are ineffective.

Due to physical limitations on light, light microscopy has a maximum magnification range of 500–1,000 times and a maximum resolution of 0.2 m. In the early 1930s, scientists realised this theoretical limit and began developing methods to peer into living cells to study their complex inner workings. To examine tiny objects, scientists use electron microscopy. To irradiate this tiny sample, a constant-current electron beam is required.

- “The information that TEM or SEM examination can yield are the following.””
- “The topographical information: the surface features of an object or "how it looks", its texture.””
- “The morphological information: the shape and size of the particles making up the object.”””
- “The composition information: the elements and compounds that the object is composed of and the relative amounts of the”

6.2. X-ray absorption near edge structure spectroscopy

The X-ray absorbing near-edge structure, sometimes referred to as the reasonably close X-ray absorbance fine structure (NEXAFS), is situated 50 eve above the optical absorption. Just little above the Fermi level, it contains the band structure's empty zone. Thus, it may be possible to determine the electrical arrangement of some components.

7. Conclusion

Carbon is a versatile element that can take on an abundance of interesting nanostructures in the scalar, vector, and quaternary dimensions. Microporous carbon, carbon scrolls, carbon onions, nanotube, graphite, carbon dots, nano fibers, Nano horns, and fullerene are all examples of carbon nanostructures (CNS) (C60). CNTs and graphene are two of the most notable examples of carbon nanostructures. The exponential growth in the number of publications dedicated to CNS and the breadth of its applications, the field's expanding significance in the scientific community, applications of which include energy conversion, energy storage, and environmental clean-up. Reliable synthesis methods include ball milling, arc discharge, chemical vapour deposition, hydrothermal carbonization/pyrolysis, microwave-based approaches (particularly for functionalized CNS), and others. A wide range of processes, such as arc discharge, laser ablation, and chemical vapour deposition, are used in large-scale synthesis (AD). Recent studies on the production of carbon nanotubes (CNT) and graphene (GNT) have focused on green chemistry and the use of renewable resources like biomass, indicating a shift toward more economical and environmentally friendly processes. Determining the structure-property relationship is crucial since numerous characterization studies have shown conclusively that CNS features depend on morphology. In this work, future prospects are presented and synthesis and characterization are thoroughly analysed.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest.

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