I J R B A T, Issue (XI) Vol (II) May 2023 : 271-277
A Double-Blind Peer Reviewed & Refereed Journal
OPEN ACCESS
e-ISSN 2347 – 517X
Original Article
INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE AND TECHNOLOGY
 www.ijrbat.in

# A STUDY ON MULTIFUCTIONAL APPLICABILITY OF CARBON NANOTUBE, GRAPHENE AND THEIR COMPOSITE

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Communicated : 20.01.2023 | Revision : 22.02.2023 & 07.03.2023 Accepted : 29.03.2023 | Published : 30.05.2023

**ABSTRACT:**
Carbon based materials such as carbon nanotube and Graphene is one of the most promising materials in the field of nanotechnology and which has attracted a tremendous amount of research in the last few years. Because of its high surface to volume ratio, high electrical conductivity, high mechanical strength, high thermal conductivity,high electronic mobility, and high chemical stability. dew to such property CNTs and GNS is extremely attractive materials. In this review paper we are studied about multifunctional applicability about carbon nanotube and graphene and their composite with various semiconducting metal oxides such as ZnO,TiO2,SnO2,CuO,ZnS,etc and conducting polymers such as polyaniline (PANI).etc and studied there applicability in various filed such as gas sensors, bio sensors, supercapacitors, photocatalysis activity and many biological applications.

**Keywords :-** Carbon nanotube, Graphene, nanotechnology, semiconducting metal oxides, conducting polymers.

## INTRODUCTION :

Carbon is an IV group of element. Carbon is known to be associated with its rich and diverse form of chemistry. Carbon atoms participate in the formation of a great number of molecules. carbon nanomaterial's have a unique place in Nano science due to their exceptional electrical ,thermal, chemical, and mechanical properties; which have applications in various areas such as composite materials ,energy storage conversion ,sensors, drug delivery, field of emission devices, and Nano scale electronic devices. development of nanofabrication techniques and nanomaterials that have progressed within the last two decades, graphite is now being actively used as a starting material to engineer various types of carbon-based nanomaterials (CBNs), including single or multi-walled nanotubes, fullerenes, nanodiamonds, and Graphene. In the last few years, study of carbon based nanomaterials have become the most studied for developing of gas sensors, biosensors, supercapacitors , photocatalytic activity , photoluminescence and lithium ion battery etc. carbon nanomaterials are used Specially because of their outstanding and remarkable physical and electrical properties. carbon nanomaterials e.g., carbon black (CB), fullerene, carbon fiber (CF) , carbon nanotubes (CNTs) and graphene(GNS)(fig 1) Graphene and CNTs are allotropes of carbon. Graphite is a multilayers form of carbon. Graphene is a single layer of graphite and it is 2 dimensional and when graphene is in cylindrical form then it is called as carbon nanotube ,this are obtained in single layer and multilayer form and it is 1 dimensional nature which have received a great covenant of attention as materials, With



http://doi.org/10.29369/ijrbat.2023.02.1.0039

their inherent physical and electrical properties, such as high surface-to-volume ratios, high electrical or heat conductivities, chemical inactivity, and high tensile strength. With the deeper gratefulness development of nanofabrication techniques and nanomaterial's that have developed within the last two decades, graphite is now being actively used as a starting material to engineer various types of carbon-based nanomaterial's (CBNs), including single or multi- walled nanotubes, fullerenes, Nano diamonds, and Graphene [1] These carbon based materials possess excellent mechanical strength, electrical ,thermal conductivity, and optical properties much of the research efforts have been focused on developing these advantageous properties for various applications, such as high-strength composite materials and electronics. Each member of the carbon family exhibits unique features and has been broadly exploited in various biological applications including bio sensing, drug delivery, tissue engineering, imaging, diagnosis and cancer therapy [2]

Carbon-based nanomaterials, such as carbon nanotubes (CNTs),and graphene(GNS) can be found in functionalized or non-functionalized forms. graphene or carbon nanotubes can be functionalized with –COOH and –OH groups via chemical oxidation methods to produce GO and functionalized carbon nanotubes, which are highly dispersible in water compared to their pristine counterparts. These nanomaterials can also be functionalized with metal or metal oxides. such as ZnS, $SnO_2$ , $TiO_2$,$WO_2$, .[3]. With increasing interest in nanotechnology, many types of metallic and carbon-based nanomaterials have emerged. Initial interest in these nanomaterials was for application in the electronics industry, due to their exceptional thermal and electrical properties.[3] Nanocomposites are the combinations of two or more nanoparticles synthesized by various techniques which shows unique physical properties and extensive application potential in different areas.

**Applications of carbon based materials**

| **Carbon based materials Such as SWCNT, MWCNT and GNS** | **Biological Applications** | **Electronic** | **Sensing Applications** |
|---|---|---|---|
| | Drug delivery, tissue engenearing, imaging diagnosis, cansor theapy, antibacterial study, dye detection | Solar cell, semiconductor chip, supercapacitor. Batteries, photocatalitic activity | Gas sensors detection of flammable and toxic gasses<br>Bio sensors used as dye removal |

**Types of carbon-based nanomaterials**

There are various types of carbon nanomaterials such as carbon black, fullerence , carbon nanotube and graphene all this nanomaterials their properties and applications discus as follows

**Carbon black**

Carbon black is produced by the incomplete combustion of coal and coal tar, petroleum products or vegetable matter. Carbon black is a form of Para crystalline carbon that has a high surface-area-to-volume ratio, although lower than that of activated carbon Carbon black is used as a colorant and reinforcing filler in tires and other rubber products; pigment and wear protection additive in plastics, paints, and ink pigment. It is used in the as a food colorant when produced from vegetable matter Carbon black is available with surface areas that are higher than 1000 m2/g, particle size lower than 50 nm, and density much lower than the theoretical value for graphite (2.25 g/cm3).[4]

**Fullerenes**

Fullerene is nothing but an allotrope of carbon it consist of carbon atoms that are connected by single and double bond .the structure is quite



http://doi.org/10.29369/ijrbat.2023.02.1.0039

similar to that of graphite and is made up of sheet connected hexagonal cage like structure ,they are referred as buckyballs and buckytubes like structure. Fullerenes are stable, but not totally unreactive. Fullerenes are used in the medical field as light activated antimicrobial agent.it is used as conductor, it is used in making cosmetics product

**Carbon Nanotube**

Carbon nanotubes can be considered as cylindrical formed by rolling or folding of Graphene sheet. There are two types of carbon nanotubes 1) single walled carbon nanotube (SWCNT) and 2) multi walled carbon nanotubes (MWCNT). CNTs were discovered in 1991 by Iijima et al., there has been a rising interest among researchers to discover their unique mechanical stiffness, strength, high thermal conductivity, electrical, chemical, mechanical and physical properties to develop high performance devices in nanotubes for their numerous applications. CNT can be observed as one of the most promising materials among their Nano scale material. Carbon nanotubes are a very sensitive material because they can easily interact with many gases and change their conductivity in the presence of several studies at room temperature, even if these investigates have different chemical behaviour Because of the arrangement of the atoms on the surface of the MWCNTs and their high area/volume ratio, adsorption processes are highly preferred, which increases their sensitivity to the surrounding atmosphere[5]. MWCNTs can vary greatly, which includes variations in outside diameter, number of concentric walls along with growth-induced structure, such as internal caps of nanotube walls, and other defects in the graphitic structure. Furthermore, depending on the growth conditions, nanotubes can be quite straight or highly entangled in their bulk forms. This wide range of variability in nanotube structure and the structure/size dependence of nanotube properties is a key barrier towards applications of carbon nanotubes in structural and functional composites.[6]

The carbon nanotube has been attractive in various applications such as energy storage devices, sensors and actuators. The one-dimensional Nano scale structures of nanotubes, nanowires, and nanoparticles have a large surface area to volume ratio, which is an advantage to maximize the surface response.[7] The fibre like structure of the CNT can have tremendously large aspect ratios (length/diameter) which is particularly necessary for both mechanical strengthening and the creation of electrically conductive ways for electrical property variation[6] CNTs have attracted growing attention as a highly competent vehicle for transporting various drug molecules into the living cells because their natural morphology helps penetration across the biological membranes. Carbon nanotubes are widely used in biomedical applications due to their versatile properties. These are the attractive candidates for the carrying of anticancer drugs, genes and proteins for chemotherapy [2]

Carbon nanotubes (CNTs) attract more attention because of their unique properties and have become the most promising materials for high-sensitive gas sensors. As a kind of promising sensing material, CNTs, have been found to possess electrical properties and are highly sensitive to extremely small quantities of gases, such as alcohol, ammonia (NH3), carbon dioxide (CO2) and nitrogen oxide (NOx) at room temperature,[8] Among the different carbon allotropes, CNTs have attracted escalating attention as a highly competent vehicle

**CNT Based Nano composite materials**

Nano composites are the mixtures of two or more such Nano sized substances or nanoparticles synthesized by some appropriate techniques shows unique physical properties



http://doi.org/10.29369/ijrbat.2023.02.1.0039

.The wide scientific and technical interest in developing of composite materials, wherever can take advantage of the unique properties of carbon nanotubes, has resulted in a tremendous amount of literature on the processing, characterization, and demonstrating of CNT-based composites.

Carbon nanotube /polymer composite are synthesized as a promising materials for industrial devices with advanced applications such as supercapacitors, sensors, electromagnetic absorbers, photovoitaic cells, photodiodes and optical limiting devices (murat ates et al,2017) The elastic behavior and strength of SWCNTs and MWCNTs have been studied extensively. One of the major reasons for the interest in utilizing carbon nanotubes as reinforcements in polymer nanocomposites is their reported exceptionally high stiffness and strength as compared to existing high-performance carbon fibers [6] multiwall carbon nanotube (MWNT) doped polyaniline (PANI) composite thin films for hydrogen gas sensing applications.[9] A pristine CNT exhibits low sensitivity or response signals for many pollutant gases such as NO2, CO or NH3 Therefore, dopants or many metal nanoparticles have been introduced to CNTs to enhance their sensing performance such as response signal, recovery time and operation temperature [10]

**Graphene**

Graphene is a 2D single layer of carbon atom with hexagonal packed structure. Nanomaterial consist of single atom thick layer. Structural arrangement is of sp2-hybridized carbon atoms. This structure offers unique optical, mechanical, and electrical properties, including high strength, thermal conductivity, flexibility, and biocompatibility. Among these properties, Over the last two decades, research on Graphene has greatly increased, and various exceptional properties have been observed by investigators. Graphene is described as the planar graphitic sheet of graphite, consisting of sp2 hybridized carbon network with a carbon-carbon distance of 1.42Å and an interlayer spacing of 3.4Å (Figure no 2) The two dimensional graphene is a promising conductor because of optical and electrical properties. Among the various allotropes of carbon, graphene is the most attractive material due to its unique intrinsic properties. Around 70 years ago, in 1947, Wallace evaluated the electronic structure of graphene and McClure deduced the corresponding wave equation in 1956. The name “graphene” was first introduced in 1987 by Mouras and co-workers as “graphitic intercalation compounds[2] In principle, electrons in individual graphene sheets delocalize over the complete sheet, which provides ballistic charge transport [11]

**Nanocomposite materials**

As compared to the study of single GNS based material, composite of Graphene with many materials such as in metal oxide ZnO, SnO2,TiO2,WO2,MnO2, Fe2O3,NiO,CuO,ZnS ,CdS and so on and conducting polymers such as Polyaniline , polypayrrole which shows better electrical ,mechanical, chemical and magnetic properties , and they shows better applicability as compare to study of individual material Graphene and graphene-based nanocomposites have also been used in bacteria detection and antibacterial applications. It has been reported that GO presents antibacterial effect, although the mechanisms and efficacies are under certain debate.[12] The attachment of commercial TiO2 powders to graphene has also been extensively researched for improved photocatalytic performance. The development of graphene/TiO2in photo catalysis should first be attributed to the improved absorptivity of pollutant molecules, which is a requirement for good photo catalytic activity. It is well known that carbonaceous materials have outstanding absorption properties this is used in various



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environmental applications. [13] G-based composites have emerged and exhibited applicable properties. One of the most commonly used ones is PANI/G or PANI/GO super capacitors. PANI/GO is utilized in super-capacitors with high performance, durability, and environmentally friendly features [14] GO/PANI composites have shown higher specific capacitances than PANI, as well as a higher stability after 1000cycles (i.e., capacitance retention was around 86%)[15] Likewise, PANI/G displayed higher conductivity and electromagnetic interference (EMI) shielding than PANI at room temperature The GO/PANI composite displays an excellent electrochemical performance due to a synergistic effect between PANI and GO. Besides,[15]

**Multifunctional Applicability of carbon based Nano composite**

| **Carbon based composite materials** | **Method for preparation of composite** | **Morphology and particle size** | **Field of applications** | **Referen-ces** |
|---|---|---|---|---|
| GNS/TiO2 | Hydrothermal method | 100 nm and 20nm | Electrochemical biosensor assess the freshness of meat | [16] |
| PANI/ GNS and Ppy/GNS | Chemical oxidation polymerisation | 5% GNS highly porous clearly seen | Electromagnetic interference shielding | [5] |
| PANI/MWCNT (Nanofiber) | Electrospinning | 272nm(at 0.1g/ml) | L.P.G.gas sensing | [5] |
| PANI/TIO2 PANI/GNS | Situ chemical oxidation polymerisation | 2micro-meterfor PANI/Tio2 1 micro-meter for Core shell type structure indicating more surface area | Dye Removal | [5] |
| GO/IONP | Two step process | 100 nm | Antibacterial study | [12] |
| GNS/PANI | Modified hummers and composite by situ polymerization | 3 to 5 micro -meter | Super capacitors | [17] |
| PANI/MWCNT | Situ oxidative polymerisation | 30-40 nm , obtained interwoven fibrous structure | Transport properties | [9] |
| AuNPs/MWCNT PdNp/MWCNT | | 100nm 100NM | For No2 gas sensing(at 45 to 250 $^{0}$ C) | [10] |
| CuO/SWCNT | Hydrothermal method | 1.5 to 6(micro-meter) | Highly sensitive wireless H2S gas sensor | [18] |
| TiO2/GNS | In situ growth and reduction process or a facile, one-pot growth method. | 100 to 400 nm | Photo catalytic performance | [13] |
| PANI/GO | Chemical oxidation polymerisation method | layered and fibrous structures .(100nm) | High performance super capacitors | [15] |



http://doi.org/10.29369/ijrbat.2023.02.1.0039

**CONCLUSIONS :**

Carbon based materials such as carbon nanotubes and Graphene both are extremely very promising materials in the field of material science; due to their unique properties and multifuctionality. As compared to the study of single carbon based materials. Composite with many metal oxide such as ZnO,TiO2, SnO2 etc and conducting polymers such as polyaniline (PANI) which shows potential application in various field of super capacitor, gas sensors ,photo catalytic activity ,and bio sensing applicability

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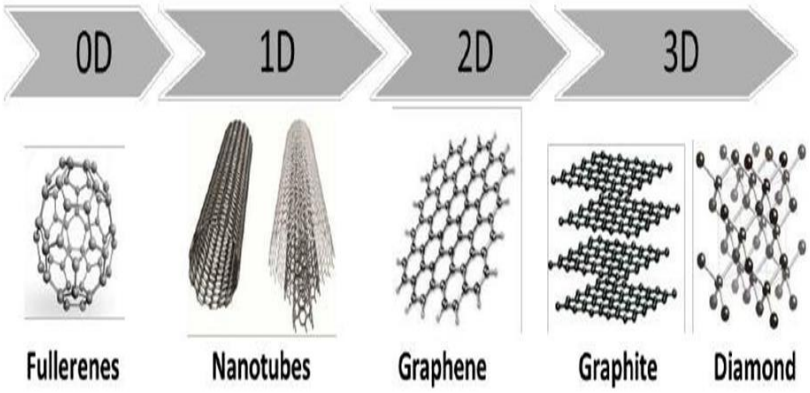


**Figure 1:types of carbon based materials. © Source by, @phdthesis{phdthesis, author = {Srivatsa, Thushar}, year = {2017}, month = {08},title = {Graphene Based surface coatings on ceramic membranes for water desalination}**

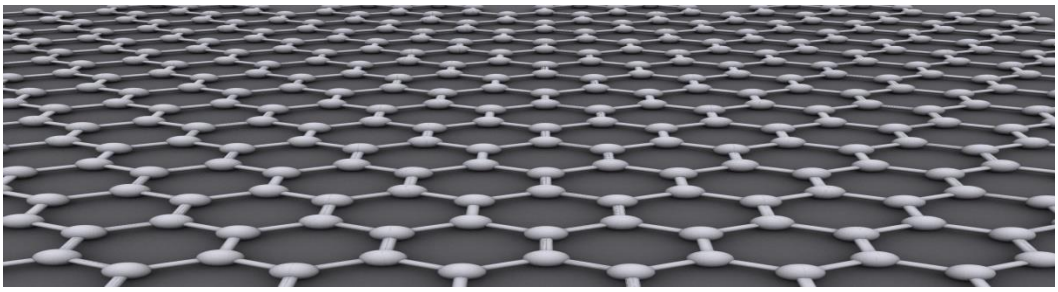

**Figure no-2 structure of Graphene (source by https://en.wikipedia.org/wiki/Graphene)**



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