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THE ADVANCED CARBON MATERIALS OFFERING UTILIZATION WHICH WOULD BOTH BE SUSTAINABLE AND CURRENTLY ON THE EMERGENCE

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Abstract— Producing and using renewable resources with no net carbon emissions is an ideal goal for a sustainable society. Much academic and commercial interest has been focused on carbon materials due to their potential uses in CO2 usage, renewable energy storage as well as conversion, and biomedicine. Yet, there are problems with energy consumption and pollution in the production of certain novel carbon compounds. Thus, sustainable carbon element preparation processes need to be developed that are cheap, scalable, industrially appealing, and commercially viable. Here, sustainability is shown through the production of carbon compounds from biomass and its by-products. This brief study provides an overview of recent developments in the synthetic approach of sustainable carbon compounds and their potential applications. Sustainable carbon materials are discussed extensively, with a focus on the original aims and numerous sustainable ways for their production. This survey offers fundamental understanding and substantial guidance for developing sustainable carbon compounds for use in new catalytic and medicinal applications. The extraordinary versatility of nanostructured carbon materials makes them ideal for catalytic and biological applications. To overcome present obstacles on the path to a carbon-neutral society, it is essential to sustainably synthesize next-generation nanostructured carbon materials. This article summarizes the latest research on nanostructured carbon materials including their potential uses in catalysis and medicine.

Keywords — Advanced Carbon Nanomaterials; Chemical Component; Sustainable Carbon Materials; Synthesize Next-Generation Nanostructured.

I. INTRODUCTION

Carbon is a ubiquitous chemical component of life on Earth. It can form bonds with a wide variety of elements according to its unique properties. Many allotropic forms of carbon are known to exist. Diamond, Graphite, and Buckminsterfullerene are all allotropes that are often seen. Of them, the thermodynamic stability of graphite is the highest. Due to its high conductivity, it has many potential uses in the electrical industry, including as batteries, electrodes, solar panels, and many more. Graphene is literally simply layers upon layers of graphene. As reported by (Bashir et al., 2021). Graphene, a recently found 2-dimensional carbon allotrope, is comprised of one sheet of atoms organized in a honeycomb pattern. Carbon nanoparticles are popular because of their excellent strength and durability. It is possible to produce decreased graphene oxide (go) as well as graphene quantum dots by oxidation, among other graphene derivatives (GQDs). These byproducts may be used in several further procedures. Carbon nanotubes are really a new and exciting form of the element carbon (CNTs). Physical and chemical characteristics of CNTs, fullerenes, as well as graphene are quite comparable despite substantial variances in production. Developing novel derivatives and composites from fullerenes is especially difficult since they were found initially. Yet, CNTs including graphene hold great promise as feasible alternatives for a variety of applications and offer a vast untapped research potential. In several scientific fields—those concerned involving adsorption, separation, catalytic processes, and so forth—active carbon has been shown to be an effective adsorbent.

II. OBJECTIVE

The research aimed to fulfill the following objectives:

- To study Advanced carbon nanomaterials
- Challenges and future
- Applications of advanced carbon materials

III. METHODOLOGY

Carbon has been a crucial component of the growth of human civilization. In all of its forms, it is adept at forging ties that are unrivaled by any other material. During the last thirty years, scientists have employed several approaches to synthesis to produce an abundance of carbon-based nanomaterials. Its one-of-a-kind makeup and extensive range of potential applications open up several fields of study and practical applications. Wastewater and wastewater treatments, biomedical water treatment, including energy storage, and generation are just a few of the many uses for carbon-based nanomaterials. Here, we'll take a closer look at the top four carbon-based nanomaterials: carbon nan-tubes, buckminsterfullerene, activated carbon, as well as graphene oxide. It has been extensively addressed how synthesis may be used across disciplines. This study provides a methodical basis for considering the potential applications of carbon-based nanomaterials that draws attention to the difficulties encountered so far. The purpose of this investigation is to provide a thorough analysis of these compounds, which will benefit the development of carbon-based nanomaterials as well as pique the curiosity of many academics and businesses.

IV. AN ADVANCED CARBON NANOMATERIALS

Among the elements that could potentially be found in the highest quantities in nature and in people is carbon. It has a special property that allows it to combine with many other kinds of materials. Carbon may have several different allotropic shapes. Among the most recognized allotropes are diamond, graphite, as well as buck-minster fullerene. It is believed that graphite remains the most thermodynamically substance. Because of its high conductivity, it may be used in a wide variety of electrical applications, including but not limited to batteries, electrodes, solar cells, and the like. (Pandit et al., 2018) Graphite is made up of several layers or sheets of graphene that are layered one on top of the other. Graphene is a newly discovered carbon-based allotrope that consists of a single layer of molecules organized in a two-dimensional honeycomb structure. This allotrope of carbon was discovered very recently. Because of its exceptional durability, it is often used in the production of several other carbon nanoparticles in the role of a precursor. When graphene has been oxidized to produce graphene oxide, further graphene derivatives, including reduced graphene oxide (go) and graphene quantum dots (GQDs), may then be created. These derivatives have further applications in a wide variety of processes. Carbon nanotubes are yet another recently discovered member of something like the carbon family (CNTs). CNTs, fullerenes, and graphene are all connected in terms of their chemical as well as physical characteristics, despite the fact that their production processes are noticeably distinct from one another. Due to the fact that fullerenes were discovered first, the production of derivatives and composites including them is the most theoretically complex. (Sharma et al., 2018) Despite this, carbon nanotubes (CNTs) and graphene both provide great scope for study and are viable alternatives for a wide variety of applications. Carbon in its activated state has also been shown to be an excellent adsorbent in a variety of diverse disciplines, including adsorption, separation, catalytic processes, and other similar applications. Because of its extraordinary capabilities, carbon nanomaterials are becoming an increasingly important area of study. As a consequence of this fact, people are finding work in a diverse array of industries. At this time, carbon nanomaterials are used in a variety of separation processes, including those that purify water. The superior electrical and optical capabilities, in addition to the combination of a molecular-sized diameter and a microscopic structure, encourage the creation of innovative electronic devices in the field of electronics. Because of their strong electrical and thermal conductivities in addition to their great mechanical strength, these materials are suited for use as protective components in engineering goods. The biological field is another one in which nanomaterials have shown their exceptional value. Moreover, they have applications in sensing as well as the controlled distribution of medications and medicines. In addition to this, they offer a tremendous amount of promise for high-performance applications in nanoelectronics, hydrogen storage, sensor technology, optoelectronics, and the modification of polymers. (Cao & Wang, 2021)

Challenges and future

Particles with a focus on the future are increasingly being used in areas such as water treatment, separation processes, electrical engineering, and medicine. They encounter several difficulties while being among the most flexible and efficient materials used in such processes. These issues need to be fixed so that their potential applications may be studied more thoroughly. Pure CNTs don't work as well as needed in wastewater treatment since they have surface contaminants. Carbonaceous species and traces of metal catalysts employed in CNT production are the sources of these contaminants. They pose a serious threat to important qualities and must be eliminated immediately. This can only be achieved by subjecting the CNTs to treatment with both acidic and basic solutions. Despite the expensive expense of their manufacture, CNTs may aid in adsorbing the abundant Natural Organic material (NOC) and other hazardous materials that can impair the water's quality for consumption. CNTs may also be used to purify water by removing harmful microorganisms. Nevertheless, due to CNTs' poor solubility in water, effective disinfection operations cannot be achieved. (Abraham et al., 2022)

Hence, further procedures like coating and modification are required. The higher cost of CNTs relative to their alternatives restricts their widespread use. Reduce, reuse, and recycle as much as you can to help alleviate this issue. It has also been shown that CNTs are harmful to ecosystems and living things. SWCNTs, for instance, cause lung inflammation and cell growth in rats because of their bio persistence. Carbon nanotubes (CNTs) will soon be used in premium composites. Compared to carbon fibers, CNTs offer a larger surface area and more flexibility, making them a promising candidate for application in energy conservation and storage devices, conductive fabrics, etc. The only drawback is that it is difficult to scale up these procedures while maintaining a low cost. Display and photovoltaic devices may benefit from CNT films' usage as transport-conducting films. Indium tin oxide (ITO) films are another option, although they aren't the only ones. With a cheap printing process, SWCNT films may potentially find use as flexible thin-film transistors (TFTs). (Elango et al., 2022) The challenge of integrating high-performance SWCNT devices persists. This is because controlling CNTs' diameter, chirality, location, and density is very challenging. To successfully synthesize CNT-based electrical devices, this must be overcome.

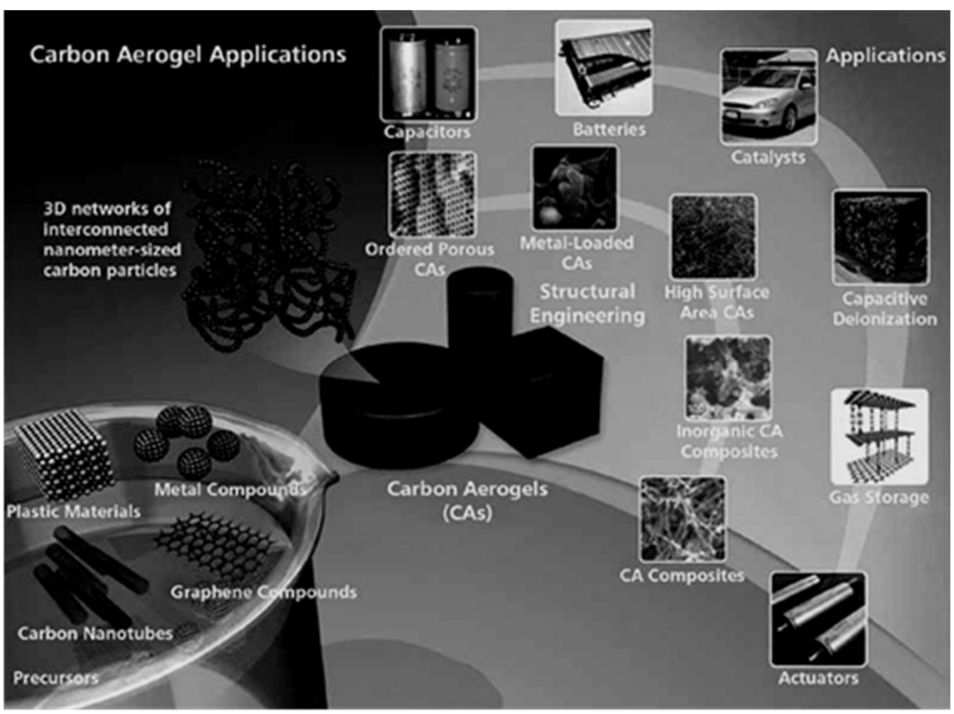

FIGURE 1. ADVANCED CARBON

V. APPLICATIONS OF ADVANCED CARBON MATERIALS

Due to their exceptional mechanical, thermodynamic, chemical, optical, and electrical capabilities, advanced carbon nanomaterials have attracted considerable interest from the scientific community in recent years. The fields of material science and technology are founded on advanced carbon compounds including graphene, fullerene, fibers, activated carbon, and nanotubes. The electrical, photovoltaic, energy-saving, and pharmaceutical industries all benefit from these high-tech carbon compounds. (Bilal et al., 2018)

- **Drug transport**

Improvements in drug delivery systems are interesting because they have the potential to improve the therapeutic efficacy of already available medications. The primary goal of designing a better drug delivery system (DDS) is to deliver therapeutic medicines to the site of illness in a managed fashion, minimizing off-target consequences. As nanotechnology has progressed in recent years, it has helped alleviate some of these issues by incorporating nanoscale drug carriers into the drug delivery system (DDS). Due to their excellent physical and chemical features, improved carbon materials have been widely explored as nano-sized drug carriers for delivering therapeutic compounds.

- **Use Cases for Energy Storage**

There has been a lot of effort put into developing cutting-edge electrode materials in response to the rising need for extremely efficient energy storage devices in recent years. Because of their superior physicochemical and thermo-mechanical qualities, improved carbon materials have been the subject of much research for use in long-term, environmentally friendly energy storage systems. (Ndlwana et al., 2021) Electrocatalysts, electro-conductive preservatives, intercalation hosts, and ideal substrates for active materials can all be made using advanced carbon materials due to their controllable porous structure, large surface area, high conductivity, high-temperature stability, excellent anti-corrosion property, and compatibility in composite materials. These applications are made possible by advanced carbon materials.

- **Fuel cell usage**

Electrochemical fuel cell technology is crucial for providing a dependable as well as long-lasting energy conversion system. Fuel cells have evolved as a solitary device for applications requiring energy storage spanning from mobile phones through power plants due to its superior efficiency, superior efficiency, and decreased pollutant emission. The catalyst support is an essential part of the fuel cell development process. The stability of the catalyst affects how far it spreads and how much more reactive it is. Catalyst supports typically have a high surface area, strong thermal and electrical conductivity, stability in a variety of working medium types, and a high absorption capacity to facilitate the transport of reactants. The efficiency of a fuel cell may be increased with the help of a catalyst. Modern carbon materials have these and other advantages. Fuel cells employ catalysts and catalyst support made from improved carbon materials to improve cell performance.

(Verma et al., 2023) Compared to other materials, advanced carbons have many advantages, such as resistance to alkaline and acidic environments, excellent electrical conductivity, as well as a broad surface area. Fuel cellular membrane electrode assemblies also benefit from the incorporation of these cutting-edge nanomaterials. (MEA).

- **Uses of Organic Photovoltaics**

Organic photovoltaics (OPVs) have recently attracted the attention of several academic institutions due to their potential use as a conformal, flexible, lightweight, and cheap power supply for various commercial applications. On a global scale, OPVs manufactured from earth-abundant, benign elements are the most effective solar technology for transformation. Despite their impressive capacity for large-scale development, their performance for commercial applications may be enhanced. To achieve these performance objectives, OPV devices make considerable use of transparent flexible electrodes made from sophisticated carbon-based materials, hole transporters, and electron acceptors. There has been a lot of interest in developing and using high-tech photovoltaic devices made from carbon. Fullerenes, graphene, activated carbon, and carbon nanotubes are all examples of advanced carbon nanomaterials with promising features for use as active materials in the creation of OPV devices. (Sajad & Karimi, 2021)

- **Uses for Electronics**

Because of their unique features, advanced carbon materials are well known for their use in electronics. Among sophisticated carbon materials, graphene stands out as the top option for cutting-edge electronics due to its exceptional properties. Graphene's extraordinary strength, thermal and electrical conductivity, and electron mobility give it the potential to usher in a technological revolution in electronics. Transistors, interconnections, sensors, and thermal management are among of graphene's most common applications in electronics. (Ndlwana et al., 2021) It is a very effective electrical conductor and ranks among the best in the world.

- **Mechanical Use in the Everyday World**

Graphene's status as both the lightest and strongest known material is one of its most fascinating qualities. It has the flexibility of rubber but is much lighter than metal. Graphene's exceptional inherent mechanical qualities, including as stiffness, strength, and toughness, make it standout as a reinforcing element in composite material. To improve performance, range, and weight, graphene is being considered for usage (perhaps combined with plastic) as a material that would replace steel in aircraft structures. It is used to coat the outside of planes to prevent any electrical harm from occurring, because of its high electrical conductivity. This coating is also used to measure strain rate, which provides pilots with early warning of any changes in wing stress. Graphene's advantageous qualities make it feasible to develop high strength requiring prospective applications like body armor for armed personnel. Due to its lightweight nature and rather excellent frequency response, graphene is a viable material for the construction of speakers and electrostatic audio microphones. Graphene may be integrated into a wide range of composites, making them ideal for use in industries where strength and weight are paramount, such as aerospace. (Ndlwana et al., 2021) It is used to improve the strength and weight of a variety of materials without significantly altering their properties. The aviation sector might benefit greatly from the use of a composite material since it is both cheaper and more durable than steel. This is why graphene is being used in these products.

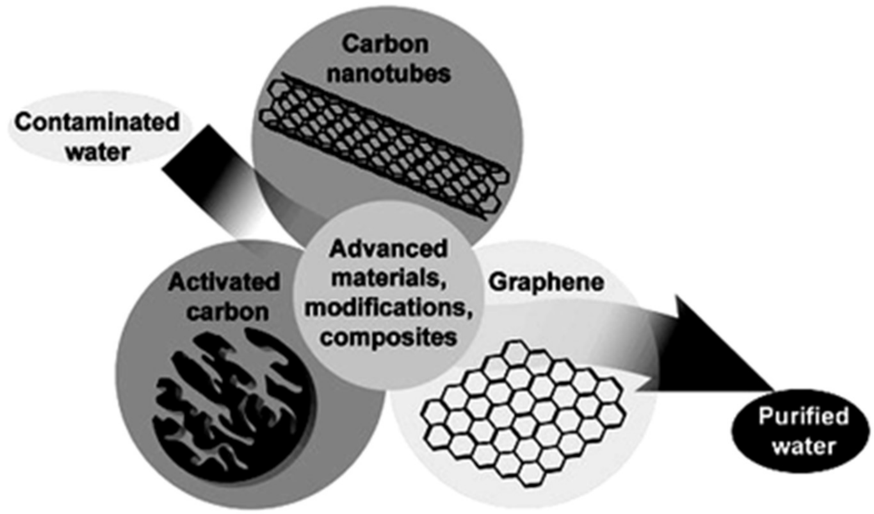

FIGURE 2: - ADVANCED CARBON MATERIAL AND APPLICATIONS

CONCLUSION

The nanotube, fullerene, activated carbon, and graphene oxide are some of the most notable examples of different forms of carbon. The creation of these particles is broken down in great depth in this article, in which both the traditional methods and the modified versions of those methods are discussed. In this article, the many uses of carbon nanomaterial are investigated. It is standard practice to combine carbon nanotubes with a variety of organic and inorganic elements in order to get a homogeneous structure. It has been shown that once carbon nanotubes (CNTs) and graphene are agglomerated with polymers, the modified material's electrical conductivity, as well as mechanical strength, diminish. On the other hand, the modifications result in significant improvements to the attributes such as catalytic activity and capacitance. In addition to efficient synthesis, multidimensional carbon nanomaterials have been generated via the optimization and control of their structural features. These nanomaterials are unquestionably more beneficial. It is essential, in the field of energy business, to enhance the storage capabilities of these materials while keeping prices as low as possible. In conclusion, carbon-based nanomaterials are still confronted with a broad variety of research obstacles, all of which need to be investigated in order to make them scalable. This is an encouraging step in the right direction for the creation of carbon nanomaterials, which should pique interest in a variety of different areas of study.

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