The Application and Production of Carbon-based Materials

Zihan Zhang*

Beijing Lu He International Academy, Beijing, China

*Corresponding author: zhangzihanlh@126.com

Abstract. With the advancement of technology, the field of materials science also flourishing and developing. This article explores the characteristics and properties of carbon-based materials, elaborates on relevant experiments, and provides prospects. Nowadays, many technological powers in the world have taken action, with some cutting-edge carbon-based materials being invented and used in various fields, especially in aerospace. Whenever a new type of carbon-based material is invented, it is a small step in scientific research, but a big step for humanity. The generation of chemical products is based on their own conditions and resource abundance. The excellent characteristics of carbon-based materials and carbon's high reserves on Earth make them popular chemical materials. Unfortunately, the types of carbon-based materials that humans can currently produce and manufacture are limited. Carbon-based materials, a special chemical material, are closely related to the future of humanity. They comply with the United Nations' initiatives on sustainable development and can also bring huge benefits to users. Additionally, they are one of the indispensable contributors to the human development process.

Keywords: Carbon-based materials; Environment; Graphene.

1. Introduction

Humans, a kind of carbon-based life, are ourselves. Proteins are important units that make up life, and they are also composed of amino acids, where the amino and carboxyl groups are composed of carbon elements. Here is a question what is carbon? For most people, the debut of carbon is in the chemistry class at middle school as the 12th element on the periodic table. Also, the isotope of carbon-12 acts as the standard of the unified atomic mass unit. Actually, carbon is a non-metal, being a stable substance, and it is low toxic in the standard condition. Since carbon has relatively high electronegativity which is the ability to attract paired electrons, it always has eight electrons on the outer shell. At the same time, carbon becomes the basic element of organic chemistry, such as alcohol, ester and aldehyde, they all contain carbon. Alcohol is an important part of human production and life, among which industrial alcohol plays a disinfection role in the medical field, while edible fermented alcohol satisfies people's material needs. Compared with metals, carbon-based material, polyacetylene, has more advantages during conducting electricity. The reason why is that this polymer conducts electricity by its overlapped pi bonding system and it has a non-polar structure because of a few differences between carbon and hydrogen in the electronegativity values, which make the polyacetylene more stable than the delocalized electrons in metals. Carbon-based materials provide lower density than metal, relying on Newton's second law, the metal experiences a larger weight, which troubles the flying plane. Depending on the position of carbon, there are a lot of kinds of isomerism of organic compounds. For instance, every optical isomerism holds at least one chiral center which is the carbon attached with four different groups. However, the geometrical isomerism is separated into cis and trans structures. As the carbon-carbon double bond cannot rotate and every caron binds with different parts. Generally, the way to gain carbon is pretty easy, such as air, ocean and stone, these places have very high carbon reserves. Carbon dioxide, as everyone knows, exists in the air at approximately 0.03%. In prehistoric times, people had already burned carbon for heating during the winter season or processing food. It is obvious that carbon acts as a human's friend for a long time. Many experts tried to find more functions of carbon, and then new carbon-based materials appeared. Carbon-based materials are a kind of compound in which carbon exists as a significant proportion it. Nowadays, people have created several carbon-based materials including new resources, clothing, construction, aerospace and other fields. The main types of carbon-based materials include

carbon fiber, graphene, carbon nanotubes, fullerenes, diamond, porous carbon, fluorescent carbon, and their composite materials. Thanks to carbon-based materials, the world's technological level and environmental protection have been greatly improved and guaranteed, respectively. All the countries in this world contribute to making progress on carbon-based materials, the United States of America acts as one of the leaders, which is the birthplace of many top new materials companies. For example, Exxon Mobil Corporation, 3M, and DuPont. Britain, also a strong country in material engineering, has the capable universes to nature's top materials scientists, such as Cambridge University and the University of Manchester which is the earliest to separate graphene from graphite. To produce a new carbon-based material needs time, energy and various background information. Every creation of material is the great progress of human history.

2. Case Study

Reviewing the Olympic Games which are held once every four years, carbon-based materials undertake an important responsibility in the various major competition venues. In terms of badminton sport, the quality of the racket is closely related to carbon-based materials. There are some kinds of badminton bate, 24T (a ton of carbon cloth),30-40T and 40-60T. The larger the ton of carbon cloth, the lighter the racket, the crisper the racket. For the production of badminton rackets, high carbon fiber bundles will be soaked in a specific concentration of epoxy resin, and after air drying, the fiber sheets will be cut into carbon sheets to wrap around nylon air ducts, and finally assembled into badminton rackets through testing. Usually, athletes in major competitions use carbon fiber badminton rackets, which can effectively showcase their strength and provide a comfortable feeling. Furthermore, making ice with carbon dioxide was large-scale used for the first time at the 2022 Beijing Winter Olympics. This environmentally friendly carbon-based ice-making technology will have a huge impact on future Winter Olympics worldwide. Also, the carbon dioxide transcritical direct cooling ice-making system can ensure uniform ice temperature, which is crucial for maintaining the practicality of the ice surface. Making ice with carbon dioxide is achieved through a reversible compression refrigeration cycle. Through three steps of liquefaction expansion and heat transfer, carbon-based ice-making agents have completed a renewable cycle. Moreover, at the same year's Winter Olympics, Beijing pioneered the first use of carbon-based composite materials to make the Olympic torch. Chinese scientists have also overcome the barriers to the application of carbon-based materials under extreme conditions, making the torch shell a reality at temperatures as high as 800 Celsius degrees, and avoiding the problem of foaming and cracking of carbon-based materials. The carbon-based shoes should not be ignored. The carbon plate is usually bent in a whole piece and placed under the carbon-based running shoes. Due to its good traceability, when the runner applies downward force, the carbon plate can provide greater elasticity, thereby saving the runner's consumption and improving speed. Compared to other materials of running shoes, carbon-based running shoes have higher stability, which can better protect runners from injury, extend their service time, and save the cost of national athlete training. In international competition, carbon-based materials contribute to both players and citizens. The host country of the Olympic Games can greatly reduce investment, athletes can achieve their dreams through carbon-based materials, and participating volunteers and spectators can have a good viewing experience.

3. The Properties and Future Development of New Carbon-based Materials

3.1. Internal Structure of Carbon-based Materials

Carbon-based materials are materials primarily composed of carbon. This material is divided into four types based on dimensions. Zero-dimensional materials are Carbon Quantum Dots and Fullerene. Fullerenes have a hollow spherical configuration with thirty-two sides, looking like a soccer ball. Carbon fiber and carbon nanotubes are included in one-dimensional materials, which have stronger bonds between elements than steel. The main two-dimensional material is Graphene. Graphene is the

one layer of graphite; every carbon connects with three carbons by a covalent bond. Between the graphene layers, there are delocalized electrons that move freely. Three-dimensional materials are made by the three formers, existing in three directions (x, y, z). Diamond shows robustness perfectly, because of its giant molecular structure. Not only diamond can decorate the jewelry, but also it can act as a supporting framework. Each dimension will contribute to the material engineering industry.

3.2. The Environment for Production

Resource, location and cost should be considered by the carbon-based material industries. Usually, the production of chemical substances always relates to carbon-based materials engineering that may result from noise and pollution. Even though transportation in the city center is more convenient, building industries beside the city is not realistic, because of the high rent and purification costs. Also, the equipment used for the preparation of carbon-based materials mainly includes high-pressure concentration carbonization test vessels, nano carbon-based composite material preparation systems, vacuum freeze dryers, etc. These materials can effectively complete the separation and composite technologies required in the manufacturing process of carbon-based composites, and can also record key data required for experiments, providing convenience for researchers. Additionally, the abundant carbon resources are the key to building factories. The United Arab Emirates is a good example. They choose to develop the oil industry rather than food due to their poor soil. Although they do not have such many water and corps resources, they still become one of the richest countries in the world by promoting petroleum trade with other countries. 'Acting According to Local Conditions' is what we should follow.

3.3. The Usefulness of Carbon-based Materials

Firstly, nanocarbon is regarded as one of the advanced carbon-based materials. Its size is between one and one hundred nanometers. The nanocarbon wall is featured by stability, chemical inertness, electrical conductivity, and a huge surface-to-mass ratio, which peculiarities distinguish these carbon-based materials from numerous chemical substances [1]. The nanocarbon is widely used in pure air and water since it can effectively absorb and separate harmful substances. The CNWs are produced by operating the plasma-enhanced chemical vapor deposition (PECVD) method. A part of the gas that contains carbon is atomized and ionized on the substrate surface. Then they grow to the CNWs. Secondly, graphene already become a specific solar cell material. When the chemical doping happens on graphene, one absorbed photon is changed and an increase in the power conversion efficiency of solar cells appears [2]. The charge carriers in graphene reach extremely high values of mobility, up to ~200,000 cm2V−1s−1[3]. Unfortunately, to avoid the leakage currents detaches the experiment from reality, because of the absence of a finite bandgap [4]. However, as for metal nanoclusters, the word 'perfect container' can be used for graphene flake since graphene can easily cover the cluster. The graphene layer can be bent or crumpled, as a result, other materials will make use of the one-atom thin structure for fabricating platform [5]. Thirdly, due to the thermosensitive properties of graphite, it is used to make graphite platelets. The graphite platelet (GP) unities separate averagely in the surface of the substrate by using spray technique uniformly which have a tendency to align parallel to the interfacial plane. Between forty and forty centigrade, low-density polyethylene (LDPE) did not show any phase transition such as crystallization, melting, or glass transition, and the stress-strain response induced by temperature variations was quite reversible [6]. Indeed, transition metal elements have been widely introduced into carbon materials to achieve high electrochemical performances. By using the reaction between salts (like iron (III) nitrate nonahydrate, nickel (II) nitrate hexahydrate, manganese (II) acetate tetrahydrate, and cobalt (II) nitrate hexahydrate) and graphite oxide, graphite oxide-metal-based precursors can be generated [7]. A pure carbon graphite, activated carbon, acts as an ideal filter for polluted water. There are three main factors that optimize activated carbon in the adsorption process, which are its high surface area, porosity and surface reactivity [8]. Due to its strong adsorption performance, activated carbon is also used to make toothpaste. During the cleaning process, the toothbrush rubs off the stains on the teeth, and activated carbon can effectively absorb

these corrosive substances, ensuring human health. In addition, Carbon nanotubes (CNTs) have record high tensile strength and Young's modulus, which makes them ideal for making super-strong yarns, ropes, fillers for composites, solid lubricants, etc. In all these applications, superior mechanical properties of CNTs such as tensile strength in the range from 11 to 63 G Pa, tensile Young's modulus of the order of 1.0 to 1.3 T Pa, and high deformability up to ultimate fracture strain of about 10% are used [9]. At the same time, diamonds attract attention for their excellent characteristic. Currently, High-Pressure High Temperature (HPHT) and Microwave Plasma Chemical Vapor Deposition (MPCVD) technologies are widely used to manufacture large, single-crystal diamonds with good quality and clarity. High-quality single-crystal diamond (SCD) is available in superhard cutting tools, optical components, semiconductor and high-power electronics, and even in quantum applications [10]. Less high-quality coal and high-cost trouble researchers. In order to promote this condition, there is the most studied method which is harnessing non-coking coal to replace part of coking coals, but the caking property of coal blends cannot be fully utilized in such a situation, or producing metallurgical coke pass through adding a small amount of biomass material into coal blends to has also been suggested [11].

3.4. Future Development Areas

Due to the rapid development of technology, carbon-based materials may be more widely used in aeronautics and astronautics and new energy in the future. Depending on the harsh environmental problems, people already expanded their image to the space. Finding a new substance or new 'earth' from the sky is possible. Relying on the properties of carbon-based compounds, it becomes one of the most suitable materials for making spacecraft shells. Since the equipment will experience significantly high temperatures and may suffer a collision with the space junk. National security also requires fighter jets to ensure. Plenty of components of the plane benefit from carbon-based materials. For example, carbon fiber reinforced polymer (CFRP) composite materials are used to manufacture engine blades, intake ducts, and other components, significantly improving engine performance. Similarly, civilian aircraft have become lighter and faster due to the use of carbon-based materials. There is no denying that exploring space gives humans hope to deal with global warming, but people cannot expect the result to be positive or negative. Changing the eye site back to the real earth may solve the trouble quicker. Recently, new energy vehicles are becoming increasingly popular, and brands like Tesla and Xiaomi are gaining popularity among the public. The good conductivity of carbon-based materials can be greatly utilized in new energy vehicles. Once this carbon-based material is promoted, it will surpass oil at a lower price, and the preserved oil can also be well applied to more important fields. As is well known, a large amount of heat is released during carbon combustion, which can be used to catalyze other chemical reactions. At the same time, the substances produced are in the form of gases, which are easily separated from solid products and can be collected for use in other fields. People have no chance to reject carbon-based materials.

4. Suggestions for the Application

Global warming, rising sea levels, and excessive carbon dioxide emissions are some of the main culprits leading to increasingly severe environmental problems. It is really difficult for humans to stop development and close the industry which pollutes the environment. So, finding another method to recycle the pollutants and translate them into another environmentally friendly substance becomes the priority. In addition, the carbon is the main element of carbon dioxide. The acceleration of global warming has greatly destroyed the homes of glacier creatures, making it difficult for polar bears to find a place to survive, and some species are also on the brink of extinction. Humans cannot escape the risk of rising sea levels, and the existence of every species in the world is closely related to human civilization. It is foolish to sit idly by and wait for death. By developing carbon-based materials, these greenhouse gases can be beneficial to society but not destroyed. The cost to obtain carbon is not such high as Helium, Neon and Argon. In addition, as carbon-based life forms, studying carbon-based

materials is also studying humanity itself. In this era of soaring obesity rates, cardiovascular disease is the main culprit in increasing human mortality rates. Changing established dietary habits is not easy, and the development of carbon-based materials may find another new way for humans, such as vascular stents or artificial hearts. Carbon-based materials may cause lower levels of rejection reaction in the human body. And here is a question on how to improve country development with new carbon-based materials. For the high-tech countries, they can sell their carbon-based produce to the other countries and improve life standards. At the same time, even if some backward countries cannot create carbon-based materials, they can still obtain them from other channels. In addition, some countries also prepare new carbon-based materials through technology exchange and cooperation, which is largely beneficial for globalization and sustainable development.

5. Conclusion

Although carbon-based materials have provided many conveniences for human production and life, they still have some drawbacks. The bonding methods of carbon-based materials are diverse, which can be both an advantage and a disadvantage. More carbon-based materials with different properties can be found, but finding materials with similar properties has become a major obstacle to the development of human materials science. It cannot be ignored that new carbon-based materials have appeared just in recent years, and experts still fail to develop extremely mature technology now. So many experimental results are unstable, and more testing and model building are necessary for researchers. Due to the progressiveness preparation of carbon-based materials, many agriculturally based countries cannot develop this technology, which also makes them vulnerable to the threat of technological blockade. In spite of the susceptibility, undeveloped countries should try their best to produce carbon-based materials. For example, to let their people study abroad from those technologically advanced countries or setting effective policies to attract outstanding talents. In recent years, the development of globalization has promoted global cooperation, which has also placed the creation of new carbon-based materials in a favorable environment. Technology sharing plays a particularly important chain in the whole circle. The intention of this article to elaborate on the excellent achievements of carbon-based materials is to stimulate the production of more new types of carbon-based materials, while also looking forward to the emergence of new materials in the future to fill the gaps in related fields. More importantly, carbon-based materials provide superior solutions for achieving carbon neutrality goals, as the next generation of humanity creates better environmental conditions.

References

[1] Vesel, A. , Zaplotnik, R. , Primc, G. , & Mozeti, M. . (2019). Synthesis of vertically oriented graphene sheets or carbon nanowalls-review and challenges. Materials (Basel, Switzerland), 12(18).

[2] Khan, S. , & Lorenzelli, L. . (2017). Recent advances of conductive nanocomposites in printed and flexible electronics. Smart Material Structures.

[3] Bolotin, K. I. , Sikes, K. J. , Jiang, Z. , Klima, M. , Fudenberg, G. , & Hone, J. , et al. (2008). Ultrahigh electron mobility in suspended graphene. Pergamon(9).

[4] Katin, K. P. , Maslov, M. M. , Krylov, K. S. , & Mur, V. D. . (2020). On the impact of substrate uniform mechanical tension on the graphene electronic structure. Materials, 13(20), 4683.

[5] Safina, L. R. , Krylova, K. A. , Murzaev, R. T. , Baimova, J. A. , & Mulyukov, R. R. . Crumpled graphene-storage media for hydrogen and metal nanoclusters. Materials (Basel, Switzerland), 14(9), 2098.

[6] Palomba, M. , Carotenuto, G. , Longo, A. , Sorrentino, A. , & Coscia, U. . (2019). Thermoresistive properties of graphite platelet films supported by different substrates. Materials, 12(21), 3638-.

[7] Wu, Y. , Li, Y. , Yuan, C. , & Dai, L. . (2020). A facile method for the generation of fe3c nanoparticle and fe-nx active site in carbon matrix to achieve good oxygen reduction reaction electrochemical performances. Materials, 13(21), 1-13.

[8] K. Nazal, M. (2020). An Overview of Carbon-Based Materials for the Removal of Pharmaceutical Active Compounds. IntechOpen. doi: 10.5772/intechopen.91934

[9] Korznikova, E. A. , Rysaeva, L. K. , Savin, A. V. , Soboleva, E. G. , Ekomasov, E. G. , & Ilgamov, M. A. , et al. (2019). Chain model for carbon nanotube bundle under plane strain conditions. Materials, 12(23).

[10] Wang, X. , Duan, P. , Cao, Z. , Liu, C. , Wang, D. , & Peng, Y. , et al. (2019). Homoepitaxy growth of single crystal diamond under 300 torr pressure in the mpcvd system. Materials, 12(23).

[11] Wu, Q. , Sun, C. , Zhu, Z. Z. , Wang, Y. D. , & Zhang, C. Y. . (2021). Effects of boron carbide on coking behavior and chemical structure of high volatile coking coal during carbonization. Materials, 14(2), 302.