Dean&Francis

ISSN 2959-6157

The Potential of Graphene Electronics in Environment

Yilin Yang

Tianjin NO.4 high School, Tianjin, China
*Corresponding author: yangmr@hiyidata.cn

Abstract:

The Earth's environment has been severely damaged, necessitating urgent protection measures. In this context, graphene, a highly popular material, shows promising potential for application in environmental protection. Drawing from previous studies, this article will provide a concise overview of graphene's remarkable characteristics, such as its high conductivity, large surface area, and exceptional strength. It will then explore how graphene and its derivatives can be utilized in the environmental field, focusing on its structure and surface area, which are key to its effectiveness.The difference between activated carbon (AC) and graphene is also discussed to highlight graphene's unique advantages. New technology is able to apply graphene family in cleaning up water and soil by obsorbing ions through its chemical properties. the report also addresses the current limitations and challenges associated with the widespread utilization of graphene, highlighting areas for further research and development. Building upon these insights, this article aims to provide a comprehensive understanding of graphene's potential in environmental remediation.

Keywords: Graphene; Soil remediation; Environment

1. Introduction

The Earth's environment has suffered significant damage, making it essential to take urgent protective measures to prevent further degradation. The rapid growth of population, along with the development of industrialization and agriculture, has led to a considerable increase in pollutants. Graphene is a very special material that scientists discovered not too long ago. It is made of a single layer of carbon atoms arranged in a honeycomb pattern. Even though it is extremely thin, it is one of the strongest materials known to us. Graphene is also an excellent conductor of electricity and heat, making it very useful for many things.Due to its outstanding physical and chemical properties, graphene is primarily used in electronic devices. For example, graphene is used as cathode and anode material in lithium-ion batteries because its large surface area provides more active sites for the adsorption and storage of lithium ions. Developing graphene for widespread use in environmental protection appears to be a promising choice. Its structure can be used to adsorb harmful ions in water or air, just as it adsorbs lithium ions in lithium-ion batteries. If this paper apply graphene to environmental protection, could it potentially slow down the rate of Earth's pollution and help mitigate global warming. In the rest of my report, I will present how can graphene be used in environment conservation and what applications is able to be manufactured based on existent technology.

2. Graphene

Carbon is the sixth element in the periodic table, with a ground state electron configuration of 1s22s22Px-12Py12Pz0,as shown in Figure 1 [1]. In order to make things easier, the 2pz energy level is maintained without an electron, even though it is equal to the 2px and 2py energy levels. A carbon atom has 6 electrons around its core, 4 of which are valence electrons. The electrons in the valency of the carbon can be divided into two kinds: sp, sp2 and sp3. The double bond of C3 and C3 gives rise to a kind of honeycomb net, also known as single layer graphene. The unit cell of graphene is composed of 2 carbon atoms, and the unit cell vectors a1 and a2 are equal to 2.46 Å. Resonance and delocalization contribute to the stabilization of the planar ring. Consequently, these surfaces usually interact with other molecules via physical adsorption ($\pi - \pi$ interactions). Hydroxy, carboxy and so on are easy to adhere to the void defect. Because of the local variation in the density of π-electrons [2-4], the reconstructed defect has the potential to enhance the local reactivity. Experimental results have shown that metallic atoms can be captured in recovered vacancies [5]. Substituted noncarbon atoms (e.g., N and B), which have more or fewer valency electrons than those of carbon atoms, thereby improving their surface reactivity [6]. Furthermore, nitrogen-doped graphene is an effective electrocatalyst for reduction processes [7][8]. Another efficient way for making graphene sheet less inert is by reacting it with halogen atoms such as chlorine and fluorine [9-12]. Apart from the aforementioned processes, an alternative way of altering graphene's performance is via oxidation. Attaching oxygenated groups on the sp2 hybridized surfaces allows the resulting graphene materials to be hydrophilic and more reactive.

3. AC and graphene

Apart from the aforementioned processes, an alternative way of altering graphene's performance is via oxidation. Attaching oxygenated groups on the sp2 hybridized surfaces allows the resulting graphene materials to be hydrophilic and more reactive. Today, the use of graphite based materials provides a number of benefits for the development of novel carbon-based sorbents based on carbon nanotubes and graphene as substitutes for conventional adsorbents. Firstly, single layered graphene materials have two basic surfaces available for adsorption of pollutants [13]. Secondly, GO and rGO can be readily synthesized by chemical stripping of graphite, without the need for complicated equipment or metal catalysts [13]. The resultant graphene material does not contain any residual catalyst and does not require any more purifying steps. In the particular situation of GO, the material as produced has many oxygen containing functional groups and does not need any further acidic treatment to give GO its hydrophilicity and reactivity. This is an important benefit as these function groups probably contribute to the binding of the metal ions to the GO plates [13]. Based on these properties, graphene demonstrates extraordinary potential for environmental management.

4. 3D GBM

Generally speaking, a 3D GBM has essential design characteristics which are perfect for the control of pollution. It has a high surface area that increases the ability to interact with contaminants, and a well defined pore structure is conducive to the diffusion of contaminants. Those characteristics, coupled with their superior functionality and ease of recycling, have enabled 3D GBM to become an excellent environment friendly material. The 3D GBM has high stability in water, from a wide range of harsh, acid, saline, and even organic solvents like N, n-dimethyl formamide (DMF), cyclohexane (CH) etc. Depending on the kind of pollution, 3D GBM can be classified into 3 categories: Heavy Metal, Organic Dyestuffs, Oils and Organic Solvents. Moreover, other micro-contaminants like tetracyclines, fluoride and chlorophenol can also be absorbed by 3D GBM. These advances provide a new platform for applying 3D GBM to purify water. In addition, the 3D GBM can be used to absorb the air pollutants, which are CO2, exhaust gases like NOx and SO, and other poisonous gases like acetone and formaldehyde [14]. At present, the release of untreated wastewater from the dye plants has polluted the river and caused a variety of unnatural colours. Because of its porous structure, graphene is an excellent choice for cleanup. In 2010, GO/DNA hydrogels were prepared by Xu et al. They were tested for their dye-loading capacity of safranin O.The combined hydrogel showed an overall dye-loading capability of 960 mg · g-1 on the GO component of the acquired 3D GBM. Part of the reason why the hydrogels can be highly adsorbed is due to the strongly electrostatically interacting with the negative GO and DNA. Up to now, many kinds of GBMs with excellent absorption capability have been successfully processed by different kinds of 3D GBMs [14].

Ramesha et al. to adsorb cation (MB and MV) and anion (orange G) dyes. The absorption rate of rGO was 95% for cation dye, while that of anion dye was 50%. The cation dye has an electrostatic interaction with the negatively charged rGO, and the anion dye is adsorbed by π-πinteraction with rGO [15].

Hazardous materials are frequently released by industry factories into rivers, which upset the ecology of water system. Hazardous materials are frequently released by industry factories into rivers, which upset the ecology of water system. Three dimensional GBM has been used to deal with a variety of heavy metals, such as Cu2+, Pb2+, Cd2+, Cr (VI), etc. The absorption ability is usually equal to or better than other common materials. For example, the maximal absorption capability of graphene-based hydrogels is 139.2 mg · g-1 for Cr (VI) and 373.8mg · g-1 for Pb2+, which are far superior to those of the mesoporous γ Fe2O3 (15.6 mg · g-1) and AC (66mg · g-1) for Cr (VI), and in the case of Cr (VI), the total amount of carbon dioxide (40mg · g-1), and the commercially available R-FeOOH (1.0mg · g-1) for Pb (I) [14]. CNT (CNT) aerogel exhibits superior ability to remove Pb2+ in water at 230-45mg · g-1, which is equal to or greater than that of CNTs (1.66-49.95mg · g-1) described in the literature [14].

5. Soil Remediation

Beyond water purification, graphene also shows potential in soil remediation. The utility model can be used for adjusting the PH value of the soil and absorbing the poisonous metallic ions. In the treatment of waste water contamination, in-situ fixing of pollutants is carried out by means of the adsorption of liquid pollutants onto a fixed solid sorbent. As with the water-cycle, groundwater is a major route for possible dispersal of nanomaterials in the environment. In fixing, with the exception of the soil itself, the additive is well placed to remove contaminants capable of adsorption, complexation, or precipitation of pollutants. This technique is useful in remediation of non-biodegradable pollutants that could only be moved from one location to another. In situ stabilization of pollutants is based on the reduction of their mobility and availability, either by precipitation or increased adsorption. The diffuse environmental impact such as plants, micro-organisms and people may be limited when changes are applied. Thus, the transport and absorption of pollutants in the soil have far-reaching impacts on the control of pollution and the sustainability of the process [16].

6. Limitations

Despite the fact that graphene has a lot of advantages, there are some limitations in its application. Despite improvements in this technique, it has been prohibitively expensive to produce high-quality, mass-manufactured graphene. Furthermore, standard of graphene is not be regulated. They also cause toxic effects on different biological models. The growing and expected usage of GBNs in biomedical applications raises human and environmental concerns. While GBNs have been studied in cellular as well as in animal models, the effect of GBNs on man remains largely unknown. People can be affected by GBNs via various routes of exposure, ranging from production to environment. Thereby, both the abiotic and biotic compartments of the ecosystem will get disturbed. Among GBNs, GA is considered poisonous [17].

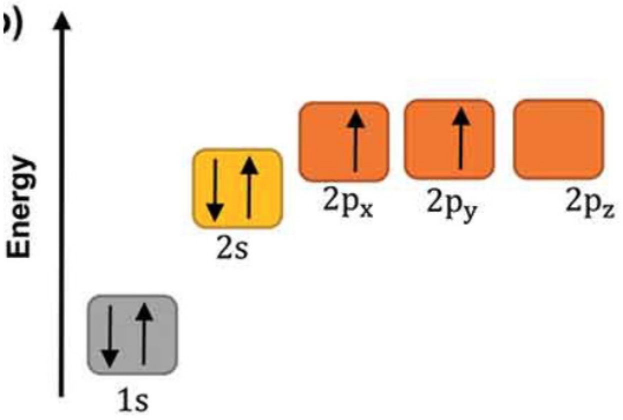

Fig. 1 Energy levels of outer electrons in carbon atoms [1].

7. Conclusion

In conclusion, graphene demonstrates significant potential for environmental conservation, offering numerous benefits across various applications. AC is replaced by graphene and graphene-family, which provide higher efficiency for people to clean up pollutant. It is proved that graphene can be used in water purification like absorbing dyes in rivers, air purification, soil remediation etc. However, risks of graphene towards human beings and animals are not transparent. The future of graphene looks bright. Its unique properties could bring about incredible advancements across various fields, from technology to healthcare, and even in helping our planet.

References

[1] Yang G., Li L., Lee W. B., Ng M. C. Structure of graphene and its disorders: a review. Science and Technology of Advanced Materials, 2018, 19(1): 613-648.

[2] Duplock E. J., Scheffler M., Lindan P. J. D. Hallmark of perfect graphene. Physical Review Letters, 2004, 92: 225502.

[3] Boukhvalov D. W., Katsnelson M. I. Chemical functionalization of graphene with defects. Nano Letters, 2008, 8: 4374-4379.

[4] Peng X., Ahuja R. Symmetry breaking induced band gap in epitaxial graphene layers on SiC. Nano Letters, 2008, 8: 4464-4468.

[5] Cretu O., Krasheninnikov A. V., Rodríguez-Manzo J. A., et al. Migration and localization of metal atoms on strained graphene. Physical Review Letters, 2010, 105: 196102.

[6] Maldonado S., Morin S., Stevenson K. J. Structure, composition, and chemical reactivity of carbon nanotubes by selective nitrogen doping. Carbon, 2006, 44: 1429-1437.

[7] Wang Y., Shao Y., Matson D. W., et al. Nitrogen-doped graphene and its application in electrochemical biosensing. ACS Nano, 2010, 4: 1790-1798.

[8] Qu L., Liu Y., Baek J. B., et al. Nitrogen-doped graphene as efficient metal-free electrocatalyst for oxygen reduction in fuel cells. ACS Nano, 2010, 4: 1321-1326.

[9] Fan L., Zhang H., Zhang P., et al. One-step synthesis of chlorinated graphene by plasma enhanced chemical vapor deposition. Applied Surface Science, 2015, 347: 632-635.

[10] Bousa D., Luxa J., Mazanek V., et al. Toward graphene chloride: chlorination of graphene and graphene oxide. RSC Advances, 2016, 6: 66884-66892.

[11] Robinson J. T., Burgess J. S., Junkermeier C. E., et al. Properties of fluorinated graphene films. Nano Letters, 2010, 10: 3001-3005.

[12] Liu H. Y., Hou Z. F., Hu C. H., et al. Electronic and magnetic properties of fluorinated graphene with different coverage of fluorine. Journal of Physical Chemistry C, 2012, 116: 18193-18201.

[13] Perreault F., Fonseca de Faria A., Elimelech M. Environmental applications of graphene-based nanomaterials. Chemical Society Reviews, 2015.

[14] Shen Y., Fang Q., Chen B. Environmental Applications of Three-Dimensional Graphene-Based Macrostructures:

Adsorption, Transformation, and Detection. Environmental Science & Technology, 2015, 49(1): 67-84.

[15] Kumar V., Kim K.-H., Park J.-W., Hong J., Kumar S. Graphene and its nanocomposites as a platform for environmental applications. Chemical Engineering Journal, 2017, 315(1): 210-232.

[16] Zhao L., Yang S., Yilihamu A., Wu D. Advances in the applications of graphene adsorbents: from water treatment to soil remediation. Reviews in Inorganic Chemistry, 2019, 39(1): 47-76.

[17] Dasari Shareena T. P., McShan D., Dasmahapatra A. K., et al. A Review on Graphene-Based Nanomaterials in Biomedical Applications and Risks in Environment and Health. Nano-Micro Letters, 2018, 10: 53.