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5, M.Rahim, AZ-1073, Baku Azerbaijan
Tel.: 99412 538-23-70,
99412 538-40-25 Fax: 99412 538-51-22

E-mail: info@ieeacademy.org
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# Graphene Oxide Nanofibers and Polymers Blends: Electrical Conductivity and Applications

***E.A.Khanmamadova, R.G.Abaszade***
*Azerbaijan State Oil and Industry University, Baku, Azerbaijan,*
khanman.ea@gmail.com, abaszada@gmail.com

**Abstract:** This article investigates the impact of blending graphene oxide (GO) nanofibers with polymers on their electrical conductivity and application domains. Graphene oxide, an oxidized form of graphene, plays a crucial role in nanotechnology due to its unique properties, such as high surface area and reactivity. When graphene oxide nanofibers are blended with polymers, they significantly enhance the electrical conductivity and mechanical properties of the composite materials. These composites find extensive applications in energy storage, sensor technologies, and electromagnetic field management. This article explores the fabrication methods, electrical properties, and modern applications of graphene oxide nanofiber/polymer blends, aligning with current advancements in nanomaterials.

***Keywords:*** Graphene oxide, nanofibers, polymers, electrical conductivity, nanotransistors, nanocomposite materials, applications, flexible electronics.

## 1.INTRODUCTİON

Graphene oxide (GO) is a derivative of graphene characterized by the presence of oxygen-containing functional groups on its surface. These groups can significantly alter its electrical conductivity by introducing defects and electron scattering centers.[1-4] Despite this, GO's high surface area, excellent mechanical properties, and reactivity make it an ideal candidate for various applications in electronics, energy storage, and environmental technologies. Graphene oxide nanofibers (GO-NFs), formed through the reduction of GO, maintain the essential structural properties of graphene while offering enhanced mechanical strength, surface area, and reactivity.[5-12]

Polymers, on the other hand, are highly versatile materials with excellent flexibility, processability, and mechanical properties. When combined with GO-NFs, these polymers create nanocomposites that exhibit superior electrical conductivity and mechanical stability. The synergistic effect between the polymer and the nanofiber results in composites that can be tailored for a wide range of applications, especially in industries that demand lightweight, conductive, and durable materials.

This article delves into the fabrication techniques, electrical conductivity, and potential applications of GO-NF/polymer composites, with a particular emphasis on their relevance to current technological advancements.

## 2. EXPERİMENTAL DETAİL

### Graphene Oxide and Nanofibers

Graphene oxide is produced by oxidizing graphene, introducing oxygen-containing groups such as hydroxyl, epoxy, and carboxyl groups on its surface. These groups significantly alter the electronic properties of graphene, decreasing its conductivity compared to its pristine counterpart. However, GO maintains a high surface area (up to 2630 m²/g), which enhances its capacity for functionalization, making it an excellent candidate for various applications in composites and sensors.

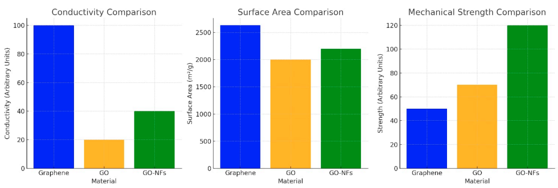



**Fig.1. Electrospinning of Graphene Oxide into Nanofibers for Enhanced Properties**

The conversion of GO into nanofiber form—through techniques like electrospinning—creates GO nanofibers (GO-NFs) that exhibit improved mechanical properties, enhanced surface area, and higher reactivity, compared to bulk GO.(Figure 1) These nanofibers retain a high aspect ratio, which is beneficial for applications requiring superior mechanical strength and high surface-to-volume ratios, such as in energy storage devices and sensors.[13-19] Additionally, the unique properties of GO-NFs make them ideal candidates for enhancing the electrical conductivity of polymer matrices when blended together.

### 3. Impact of Polymer Blending

The combination of GO-NFs with polymers results in nanocomposites that exhibit improved electrical conductivity, mechanical properties, and processability. Polymers such as polystyrene (PS), polyvinyl alcohol (PVA), polyethylene oxide (PEO), and polycarbonate (PC) have been extensively studied in composites with GO-NFs.(Figure 2) The electrical conductivity of these composites is significantly influenced by the type of polymer used, the concentration of GO-NFs, and the method of composite fabrication.[20-28]

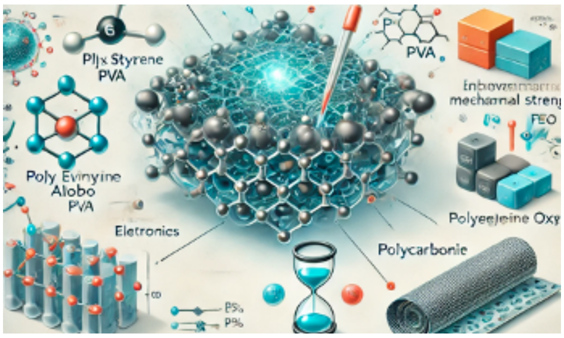



**Fig.2. Integration of Graphene Oxide Nanofibers (GO-NFs) into Polymer Matrices: Enhanced Properties and Applications**

The main advantage of blending GO-NFs with polymers is the enhancement of the mechanical properties of the resulting composite materials.(Figure 2) The polymers act as a matrix that binds the GO-NFs together, improving the structural integrity of the material while maintaining the inherent flexibility of the polymer. Furthermore, the distribution and alignment of GO-NFs within the polymer matrix play a crucial role in enhancing the electrical conductivity of the composite. The optimized dispersion of GO-NFs leads to efficient electron transport, making these composites ideal candidates for applications in flexible electronics, energy storage devices, and electromagnetic shielding.[30,41]
The overall conductivity of GO-NF/polymer composites can be tuned by varying the concentration of GO-NFs, the molecular weight of the polymer, and the preparation method. For instance, increasing the GO-NF content typically leads to a higher conductivity, but beyond a certain threshold, excessive GO-NF content can lead to aggregation, reducing the overall performance of the composite.[31-38]

**4. Nanotransistors and Electrical Conductivity**

Nanotransistors made from GO-NF/polymer composites are gaining attention due to their potential for high-speed electronic applications. These transistors leverage the high conductivity and unique electronic properties of GO-NFs to achieve faster charge transport and more efficient signal processing. By incorporating GO-NFs into the gate or channel material of transistors, the electrical conductivity of the transistor can be significantly improved without compromising the mechanical flexibility of the device.[29]
The role of polymers in these composites is crucial, as they provide mechanical stability and processability, allowing for the fabrication of flexible and stretchable electronic devices. GO-NF/polymer composites can be used in a variety of flexible electronics, including wearable sensors, flexible displays, and flexible solar cells. The incorporation of GO-NFs into these devices enhances their performance by enabling higher current densities and faster switching speeds. These improvements make GO-NF/polymer composites suitable for use in the next generation of electronic devices, such as foldable smartphones, flexible sensors, and wearable electronics.[39]

**5. Applications**

The unique properties of GO-NF/polymer composites make them highly versatile, with applications spanning across several high-tech industries. Below are some of the most promising application areas:

**a. Energy Storage**

GO-NF/polymer composites are extensively used in energy storage devices, such as supercapacitors and batteries. [42-48] The high surface area of GO-NFs increases the charge storage capacity, while the polymer matrix enhances the mechanical properties and processability of the composite. In supercapacitors, these composites provide high electrical conductivity and mechanical stability, making them ideal candidates for flexible and high-performance energy storage devices.

**b. Sensors**

The electrical conductivity of GO-NF/polymer composites can be tuned for use in a wide range of sensor applications, including gas sensors, biosensors, and strain sensors. The high surface area and reactivity of GO-NFs enable excellent sensitivity to environmental changes, making them ideal for detecting gases, biomolecules, or changes in mechanical stress. [40]The flexibility of the polymer matrix allows these sensors to be incorporated into wearable devices or other flexible electronics.

**c. Electromagnetic Shielding**

GO-NF/polymer composites are also used in electromagnetic shielding applications. The high conductivity of the GO-NFs allows for efficient attenuation of electromagnetic interference (EMI), while the polymer matrix provides structural integrity and flexibility. These composites can be used in a wide range of applications, from shielding electronic devices to protecting sensitive equipment from electromagnetic radiation.
**[45]**

**3. CONSOLUSION**

Graphene oxide nanofiber/polymer composites are a promising class of materials that exhibit enhanced electrical conductivity, mechanical properties, and flexibility. The future development of GO-NF/polymer composites lies in the optimization of their properties, including better dispersion of GO-NFs, improved mechanical properties, and high conductivity. Future research should focus on the development of new fabrication methods that can enhance the uniformity of GO-NF dispersion in the polymer matrix, as well as the exploration of novel polymers and graphene derivatives to improve the overall performance of these composites. Additionally, the integration of these materials into real-world applications, such as wearable devices and flexible sensors, will continue to drive innovation in the fields of nanotechnology and electronics.

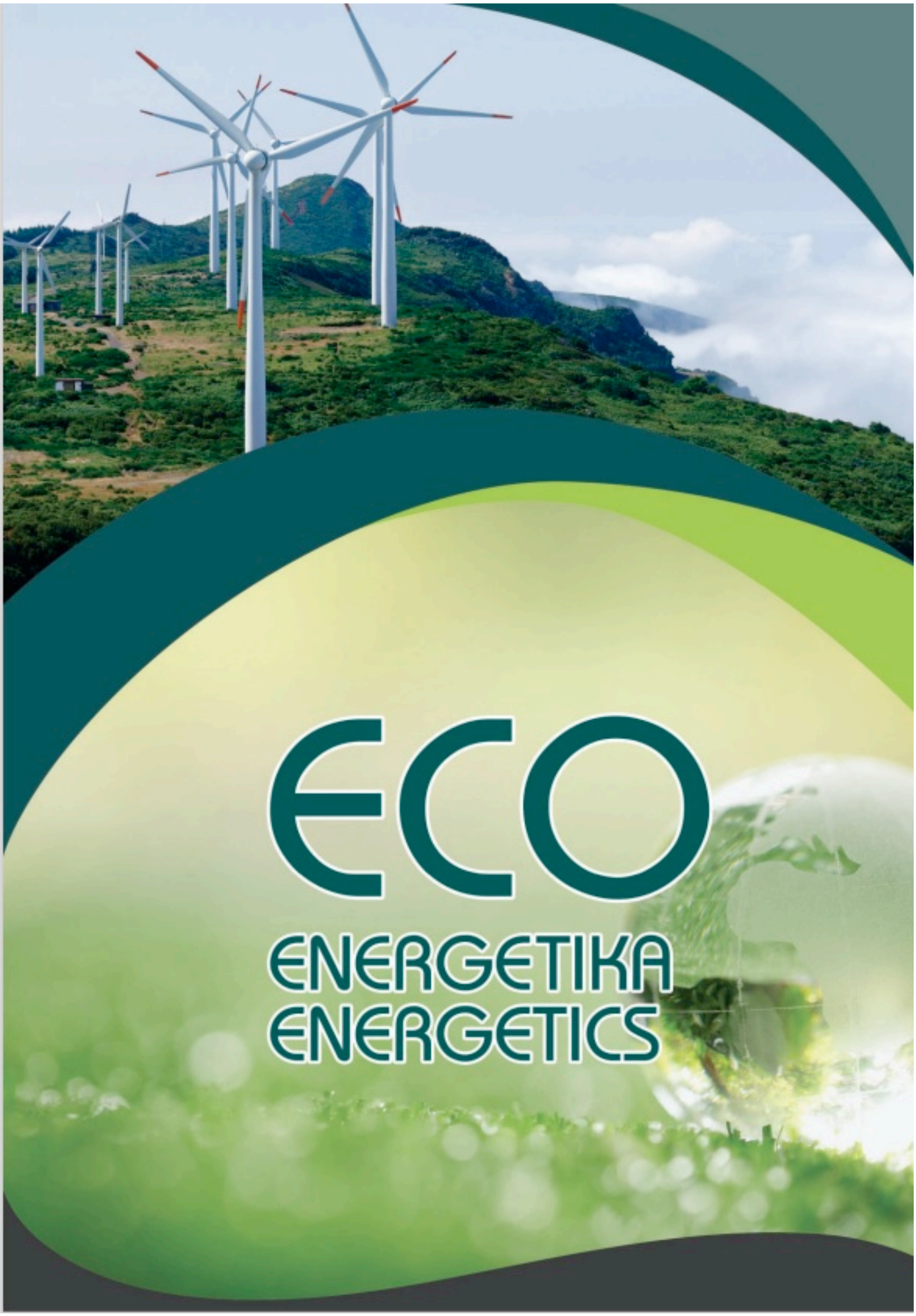
**REFERENCES**

1. Toogood, H.S., Cheallaigh, A.N., Tait, S., Mansell, D.J., Jervis, A., Lygidakis, A. (2015). Enzymatic menthol production: one-pot approach using engineered Escherichia coli. ACS Synth. Biol. 4 (10), 1112–1123.
2. Ahmed, Sh., Sharma, P., Bairagi, S., Rumjitf, N.P., Garg, Sh., Ali, A., Lai, Ch.W., Mousavi, S.M., Hashemi, S.A., Hussain, Ch.M. (2023). Nature-derived polymers and their composites for energy depository applications in batteries and supercapacitors: Advances, prospects and sustainability, Journal of Energy Storage 66, 107391.
10. H.F.Budak, A.E.Kasapoglu, T.O.Margitych, A.Singh, S.Arya, E.Gür, M.O.Stetsenko, Investigation of thermal properties of gadolinium doped carbon nanotubes, Physics and Chemistry of Solid State, 25(1), 142-147 (2024); https://doi.org/10.15330/pcss.25.1.142-147
11. R.G. Abaszade, A.G. Mammadov, E.A. Khanmamedova, F.G. Aliyev, V.O. Kotsyubynsky, Gür E., B.D. Soltabayev, T.O. Margitych, M.O. Stetsenko, A. Singh, S. Arya, Photoconductivity of functionalized carbon nanotubes, Digest Journal of Nanomaterials and Biostructures, 19(2), pp.837-843, 2024
12. Thi Hang, N.N., Frédéric, B., Andreas, B., Véronique, B., Philippe, G., (2019). Synthesis of new biobased linear poly(ester amide)s, European Polymer Journal 121, 109314.
13. B.Sharma, A.Singh, A.Sharma, A.Dubey, V.Gupta, R.G.Abaszade A.K.Sundramoorthy, N.Sharma, S.Arya, Synthesis and characterization of zinc selenide/graphene oxide
3. Du, Z., Su, Y., Qu, Y., Zhao, L., Jia, X., Mo, Y., Yu, F., Du, J., Chen, Y. (2019). A mechanically robust, biodegradable and high-performance cellulose gel membrane as gel polymer electrolyte of lithium-ion battery, Electrochim. Acta.
4. Khanmamedova E.A., The ımpact of radıoactıve radıatıon on the electrıcal transmıssıon propertıes of graphene oxıde (GO), cambridge, uk: v ınternational scientific and practical conference «educatıon and scıence of today: Intersectoral ıssues and development of scıences» August 18, pp.159-163(2023)https://archive.logos science.com/index.php/conference-proceedings/article/view/1073
5. N.G.Guliyev, R.G.Abaszade, E.A.Khanmammadova, E.M.Azizov, Synthesis and analysis of nanostructured graphene oxide, Journal of Optoelectronic and Biomedical Materials, 15(1), 23–30 2023.
6. R.G.Abaszade, O.A.Kapush, A.M.Nabiyev, Properties of carbon nanotubes doped with gadolinium, Journal of Optoelectronic and Biomedical Materials, 12(3), 61–65. 2020.
7. A.G.Mammadov, R.G.Abaszade, V.O.Kotsyubynsky, E.Y.Gur, I.Y.Bayramov, E.A.Khanmamadova, O.A.Kapush, Photoconductivity of carbon nanotubes, Technical and Physical Problems of Engineering, 14(3), 155-160 (2022).
8. Moreira, J.R., Pacca, S.A., Goldemberg, J. (2019). The role of biomass in meeting the Paris agreement, IOP Conf. Series: Earth and Environmental Science 354, 012107.
9. R.G.Abaszade, E.M.Aliyev, A.G.Mammadov, E.A.Khanmamadova, A.A.Guliyev, F.G. Aliyev, R.I.Zapukhlyak,
(ZnSe/GO) nanocomposites for electrochemical detection of cadmium ions, Applied Physics A 130:297, 2024; https://doi.org/10.1007/s00339-024-07472-0
14. V.M.Boychuk, R.I.Zapukhlyak, R.G.Abaszade, V.O.Kotsyubynsky, M.A.Hodlevsky, B.I. Rachiy, L.V.Turovska, A.M.Dmytriv, S.V.Fdorchenko, Solution combustion synthesized NiFe2O4/reduced graphene oxide composite nanomaterials: morphology and electrical conductivity, Physics and Chemistry of Solid State vol.23, № 2 (2022) pp.815-824
15. Rebecca, M., Keith, V., Greg, C., Shan, J., (2021). Biobased foams for thermal insulation: material selection, processing, modelling, and performance, RSC Adv., 11, 4375–4394.
16. R.G.Abaszade, Synthesis and analysis of flakes graphene oxide, Journal of Optoelectronic and Biomedical Materials, 14(3), 107–114 (2022); https://doi.org/10.15251/JOBM.2022.143.107
17. R.G. Abaszade, A.G. Mammadova, E.A. Khanmammadova, İ.Y. Bayramov, R.A.

Namazov Kh.M. Popal, S.Z. Melikova, R.C. Qasımov, M.A. Bayramov, N.İ. Babayeva, Electron paramagnetic resonance study of gadoliniumum doped graphene oxide, Journal of Ovonic Research, Vol.19(2), pp.259-263, 2023.

18. R.G.Abaszade, A.G.Mammadov, I.Y.Bayramov, E.A.Khanmamadova, V.O.Kotsyubynsky, O.A.Kapush, V.M.Boychuk, E.Y.Gur, Structural and electrical properties of sulfur-doped graphene oxide/graphite oxide composite, Physics and Chemistry of Solid State vol.25, № 2 (2022) pp.256-260
19. R.G.Abaszade, A.G.Mammadov, I.Y.Bayramov, E.A.Khanmamadova, V.O.Kotsyubynsky, E.Y.Gur, O.A.Kapush, Modeling of voltage-ampere characteristic structures on the basis of graphene oxide/sulfur compounds, Technical and Physical Problems of Engineering, 14(2), 302-306 (2022);
20. N.Ivanichok, P.Kolkovskyi, O.Ivanichok, V.Kotsyubynsky, V.Boychuk, B.Rachiy, M.Bembenek, Ł.Warguła, R.Abaszade, L.Ropyak, Effect of Thermal Activation on the Structure and Electrochemical Properties of Carbon Material Obtained from Walnut Shells, Materials, 17(2514), 1-21, 2024; https://doi.org/10.3390/ma17112514
21. Khanmamadova EA, Abaszade RG. The Evolution of Green Mobility: A Critical Comparison of Pure Electric and Hybrid Electric Vehicles, Hybrid Electric Vehicles and Distributed Renewable Energy Conversion: Control and Vibration Analysis, 251-288, 2025.
22. Goran, B., (2002). Bioenergy and water—the implications of large-scale bioenergy production for water use and supply, Global Environmental Change 12, 253–271.
23. Abaszade R.G., Moradi N., Pour Kh, Khanmamadova E.A, Functionalized Carbon Nanostructures for Flexible Electronics, Handbook of Functionalized Carbon Nanostructures (Springer, Cham), 2581-2614, 2024.
24. Shichao Zhang, Xiankai Sun, Linghao Wu, Bing Ai, Haoran Sun and Yufeng Chen, Thermal control materials of carbon/SiO2 composites with a honeycomb structure, RSC Adv., 2024, 14, 34081
25. E.A. Khanmamedova, Electrical conductivity properties of graphene oxide, NO. 32(151) (2023): 7TH ISPC «CURRENT ISSUES AND PROSPECTS FOR THE DEVELOPMENT OF SCIENTIFIC RESEARCH» (APRIL 19-20, 2023; ORLÉANS, FRANCE). https://archive.interconf.center/index.php/2709-4685/article/view/3099
26. Khanmamedova E.A., Analysis of electrical conductivity in nanotransistor structures with graphene oxide nanofibers, V International Scientific and Practical Conference «Theoretical and empirical scientific research: concept and trends» p.-152-155, June 23, 2023; Oxford, UK. https://archive.logos-science.com/index.php/conference-proceedings/issue/view/12/12
27. Ju, L., Geng, B., Horng, J., Girit, C., Martin, M., Hao, Z., Bechtel, H. A., Liang, X., Zettl, A., Shen, Y. R., & Wang, F. (2011). Graphene plasmonics for tunable terahertz metamaterials. Nature nanotechnology, 6(10), 630-634. https://pubmed.ncbi.nlm.nih.gov/21892164/
28. Khanmamedova E.A., Abaszade R. G., Safarov R.Y., Namazo R.A.-Graphene-based transistors, Ecoenergetics, №2, pp.52-57, 2023. http://ieeacademy.org/wp-content/uploads/2023/06/Ecoenergetic_-N2-2023-full.pdf
29. Khanmamadova E.A., Dıodes made from carbon nanotubes, International scientific journal «Grail of Science» |No29(July, 2023), p. 225-229. https://archive.journal-grail.science/index.php/2710-3056/article/view/1447
30. Grunwald, A. (2017). Assigning meaning to NEST by technology futures: extended responsibility of technology assessment in RRI. Journal of Responsible Innovation 4 (2).
31. R.G. Abaszade, A.G. Mammadov, V.O. Kotsyubynsky, E.Y. Gur, I.Y. Bayramov, E.A. Khanmamadova,O.A. Kapush, Photoconductivity of carbon nanotubes, International Journal on Technical and Physical Problems of Engineering, Vol.14, №3, pp.155-160, 2022. http://www.iotpe.com/IJTPE/IJTPE-2022/IJTPE-Issue52-Vol14-No3-Sep2022/21-IJTPE-Issue52-Vol14-No3-Sep2022-pp155-160.pdf
32. Kim, F., Cote, L. J., Huang, J. (2012). Graphene Oxide: Surface Activity and Two-Dimensional Assembly. Advanced Materials, 22(17), 1954–1958. https://scholar.google.com/citations?hl=th&user=sbfLJqUAAAAJ&view_op=list_works&sortby=pubdate
33. E.A. Khanmamedova, THERMAL PROCESSING ANALYSIS OF GRAPHENE OXIDE, April 28, 2023; Seoul, South Korea: II International Scientific and Practical Conference «THEORETICAL AND PRACTICAL ASPECTS OF MODERN SCIENTIFIC RESEARCH» https://archive.logos-science.com/index.php/conference-proceedings/article/view/714
34. Anthony, L.S., Vasudevan, M., Perumal, V., Ovinis, M., Raja, P.B., Edison, T.N.J.I. (2021). Bioresource-derived polymer composites for energy storage applications: brief review, J. Environ. Chem. Eng. 9, 105832.

35. Li, L., Hou, L., Cheng, J., Simmons, T., Zhang, F., Zhang, L.T., Linhardt, R.J., Koratkar, N. (2018). A flexible carbon/sulfur-cellulose core-shell structure for advanced lithium–sulfur batteries, Energy Storage Mater.
36. Khanmamedova E.A., Schematic representation of the preparation of graphene oxide, Ecoenergetics, №1, pp.63-67, 2023. http://ieeacademy.org/wp-content/uploads/2023/03/Ecoenergetics-N1-2023-1.pdf
37. Liu, J., Fu, S., Yuan, B., Deng, Z., & Shen, M. (2010). Facile synthesis of graphene oxide and its reduction. Journal of Materials Chemistry, 20(35), 7491-7496. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6628170/
38. E.A. Khanmamedova, Mathematical model analysis of graphene oxide thermal development, no. 26 (2023): i cisp conference «Scientific vector of various sphere' development: reality and future trends» https://archive.journal-grail.science/index.php/2710-3056/article/view/1145
39. Avouris, P. (2010). Graphene: Electronic and Photonic Properties and Devices. Nano Letters, 10(11), 4285–4294. https://pubs.acs.org/doi/abs/10.1021/nl102824h
40. E.A. Khanmamedova, X-ray analysis of graphene based materials, Proceedings of the 7th International Scientific and Practical Conference «Current Issues and Prospects for The Development of Scientific Research» (April 19-20, 2023). Orléans, France https://archive.interconf.center/index.php/2709-4685/article/view/3100
41. Zhang, Y., Tan, Y. W., Stormer, H. L., & Kim, P. (2005). Experimental observation of the quantum Hall effect and Berry's phase in graphene. Nature, 438(7065), 201-204. https://arxiv.org/abs/cond-mat/0509355
42. Katsnelson, M. I., & Geim, A. K. (2008). Electron scattering on microscopic corrugations in graphene. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 366(1863), 195-204. https://www.jstor.org/stable/i25190665
43. Peigney, A., Laurent, C., Flahaut, E., Bacsa, R. R., & Rousset, A. (2001). Specific surface area of carbon nanotubes and bundles of carbon nanotubes. Carbon, 39(4), 507-514. https://www.scirp.org/(S(351jmbntv-nsjt1aadkposzje))/reference/REFERENCESpapers.aspx?referenceid=1135853
44. Xiaohan, W., Jinwon, J., Yanqun, S., Jingang, L., Hongjie, Z., Zhibin, H., Yonghao, N., (2024). Starting materials, processes and characteristics of bio-based foams: A review, Journal of Bioresources and Bioproducts 9, 160–173.
45. Khanmamedova E.A.,X-ray analysis of graphene based materials, 9th International Scientific and Practical Conference «Theory and practıce of scıence: key aspects» February 19-20, 2024 Rome, Italy pp.599-603, https://archive.interconf.center/index.php/2709-4685/article/view/3100
46. Abaszade, R. G.; Mammadov, A. G.; Khanmamedova, E. A.; Aliyev, F. G.; Kotsyubynsky, V. O.; Gür, E.; Soltabayev, B. D.; Margitich, T. O.; Stetsenko, M. O.; Singh, A.; Arya, S. Photoconductivity of functionalized carbon nanotubes, Digest Journal of Nanomaterials & Biostructures (DJNB), 2024, Vol 19, Issue 2, p837, 2024. https://openurl.ebsco.com/EPDB%3Agcd%3A4%3A22925460/detailv2?sid=ebsco%3Aplink%3Ascholar&id=ebsco%3Agcd%3A178220998&crl=c&link_origin=scholar.google.com
47. Guston, D.H., (2014). Understanding 'anticipatory governance. Soc. Stud. Sci. 44 (2), 218–242.
48. Robert, J.S., Miller, C.A., Milleson, V. (2013). Introduction: ethics and anticipatory governance of nano-neurotechnological convergence. In: Hays, S.A., Robert, J.S., Miller, C.A., Bennett, I. (Eds.), Nanotechnology, the Brain, and the Future. Yearbook of Nanotechnology in Society, 3
49. Morales, M.E., Ruiz, M.A. (2016).Microencapsulation of probiotic cells: applications in nutraceutic and food industry, Nutraceuticals.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