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Preparation and Characterization of Reduced Graphene Oxide Decorated With Iron Oxide Nanoparticles

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Annotation: After being synthesized, graphene oxide was treated with potent reducing agents to decrease it. Nano iron oxide was then used to adorn the reduced graphene oxide sheets. The produced compounds were subjected to spectral and nanoscopic analyses using FT-IR, FESEM, AFM, and XRD.

Keywords: graphene, reduced graphene oxide, iron oxide.

Introduction

Graphene is a two-dimensional, atomically thin carbon structure that resembles a honeycomb. It has garnered a lot of interest due to its exceptional optical and electrical qualities. Due to these unique qualities, graphene and its derivatives are highly desirable for a variety of applications. However, the challenge of synthesizing graphene in large quantities while maintaining high purity remains a major obstacle. In simple terms, graphite is composed of many layers of graphene (1-4).

Then, reduced graphene oxide (RGO) is created by chemical reduction. Reduced graphene oxide has been made using a variety of reducing agents, such as formaldehyde, sodium hydroxide, sodium borohydride, sodium hydrate, sodium dithionite, L-ascorbic acid, and hydrazine hydrate. The types and quantities of oxygen-containing groups, including as hydroxyl, carboxyl, and epoxy groups, determine the range of materials with different physical and chemical properties that are produced by this reduction process.. (5-6).

The intriguing mechanical, chemical, and electrical characteristics of concentrated graphene oxide are presently being investigated for potential uses in energy storage, improved electronics, and optoelectronics. The photoresponse characteristics of solution-processable concentrated graphene oxide devices for the detection of UV and infrared light have already been investigated

by researchers. Additionally, concentrated graphene oxide's enormous surface area makes it a perfect template for adsorbents that remove organic contaminants and dyes from aquatic environments.(7-8).

The medium's pH, the adsorbent's porosity and surface area, the type of dyes, temperature, and the capacity to interact with the dye molecules all have a significant impact on how well foamed graphene (RGO) composites remove organic water contaminants. Foamed graphene is suited for the adsorption of cationic dyes because to its many adsorption sites, particularly negatively charged oxygen-containing defects, wrinkled surface morphology, and π-electron-rich domains.. (9).

The chemical composition iron(II,III) oxide, or magnetite, has the formula Fe3O4. It can be found in nature as the mineral magnetite. Iron(II) oxide (FeO), which is extremely rare, and iron(III) oxide (Fe2O3), which is found naturally as the mineral hematite, are two other iron oxides besides this one. Fe2+ and Fe3+ ions make up iron(II,III) oxide, which is sometimes denoted by the symbol FeO • Fe2O3. In a lab setting Iron (II, III) oxide is made up of both Fe^{2+} and Fe^{3+} ions, and its formula is $FeO \bullet Fe_2O_3$. It looks like a black powder in a scientific setting.. Because of its permanent magnetism, this molecule is ferrimagnetic even though it is frequently mislabeled as ferromagnetic. Its principal application is as a black pigment, commonly known as "Mars black." Instead of being mined from the native mineral, it is usually manufactured for this purpose, which allows for better control over particle size. (10-11).

Experimental part

Preparation of reduced graphene oxide K1

Weigh out an equal amount of reduced graphene oxide and place it in a beaker. Add 1 ml of hydrochloric acid to the beaker and stir the mixture until it becomes homogeneous. Next, introduce 1 ml of 80% aqueous hydrazine and heat the mixture to 100°C while continuing to stir for 120 minutes. After the reaction, collect the precipitate through centrifugation and wash it with deionized water to remove any remaining hydrazine. Finally, dry the precipitate at 50°C until its weight remains constant(12).

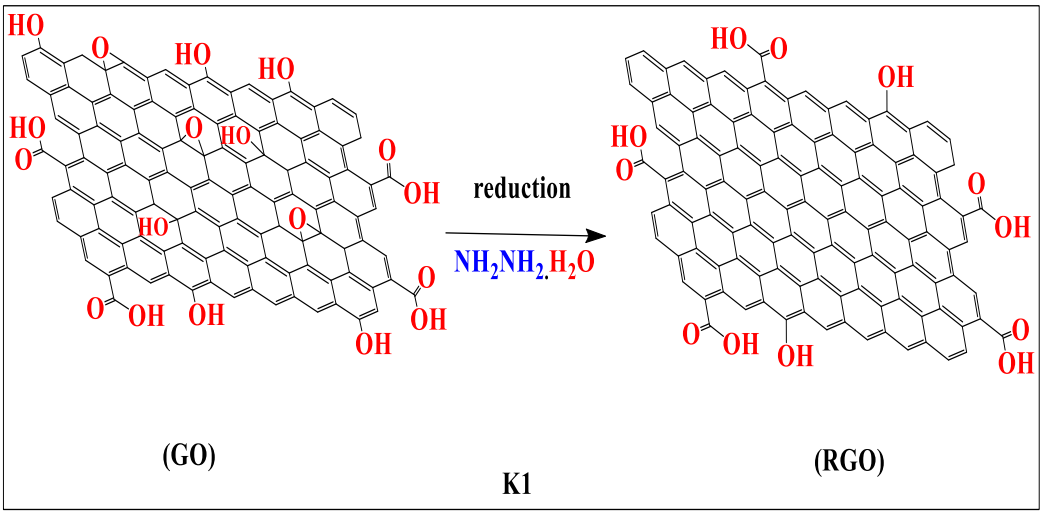


Figure 1. Steps for preparing reduced graphene oxide

Preparation of a decorated Ortho-amino phenol-reduced graphene oxide- Fe3O4 K2

An equal weight of reduced ortho-aminophenol-graphene oxide was combined with iron oxide (Fe3O4) and then dissolved in 25 mL of distilled water. The mixture was centrifuged for 60 minutes, after which the precipitate was collected. The product was washed with deionized water and dried at 50°C until a constant weight was achieved(13).

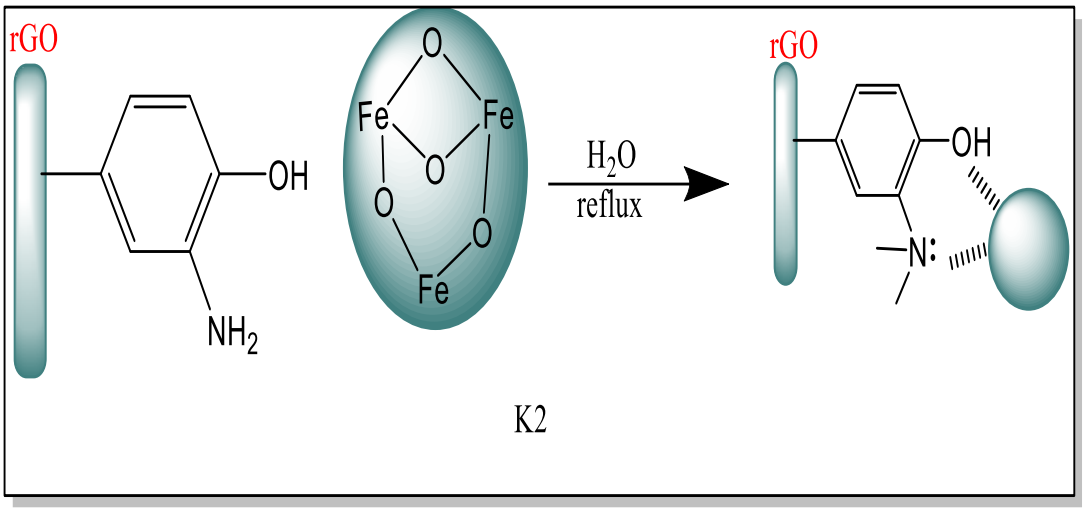


Figure 2. Steps for preparing reduced ortho-aminophenol-graphene oxide (OANO) Fe3O4

Results and Discussion

Discussion of the complex decorated ortho-aminophenol-reduced graphene oxide [K2]Fe3O4

The prepared compound was characterized spectroscopically using FT-IR spectroscopy. A band was observed at 3419 cm^{-1}, indicative of the phenolic (OH) bond. Additionally, bands appeared at 3245 cm^{-1} and 3359 cm^{-1}, corresponding to the symmetric and asymmetric stretching of the primary amine group (NH_2). A band was also detected at 3049 cm^{-1}, representing the aromatic (C-H) bond, while another band appeared at 1625 cm^{-1}, associated with the aromatic (C=C) bond. Finally, bands at 451 cm^{-1}, 586 cm^{-1}, and 676 cm^{-1} were attributed to the stretching of the (Fe-O) bond.

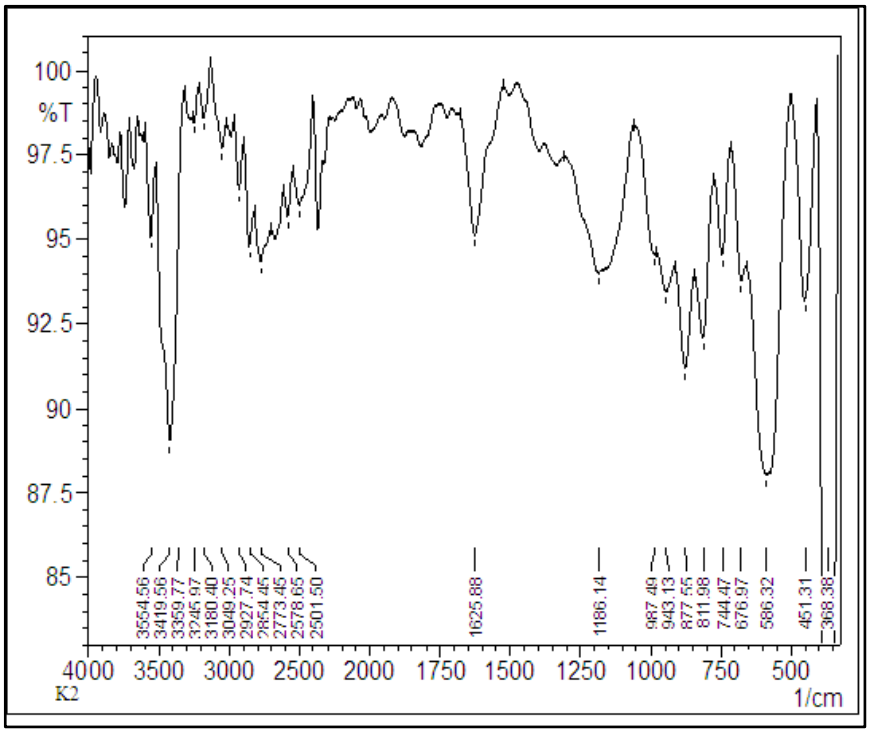


Figure 3. Infrared spectrum of compound K2

The X-ray spectrum of the compound K2 revealed a 2θ angle value of 87.29°. The interlayer distance was measured at d = 1.11 nm, while the grain size was determined to be D = 27.84 nm, and the number of layers was n = 27.84, as illustrated in Figure 4.

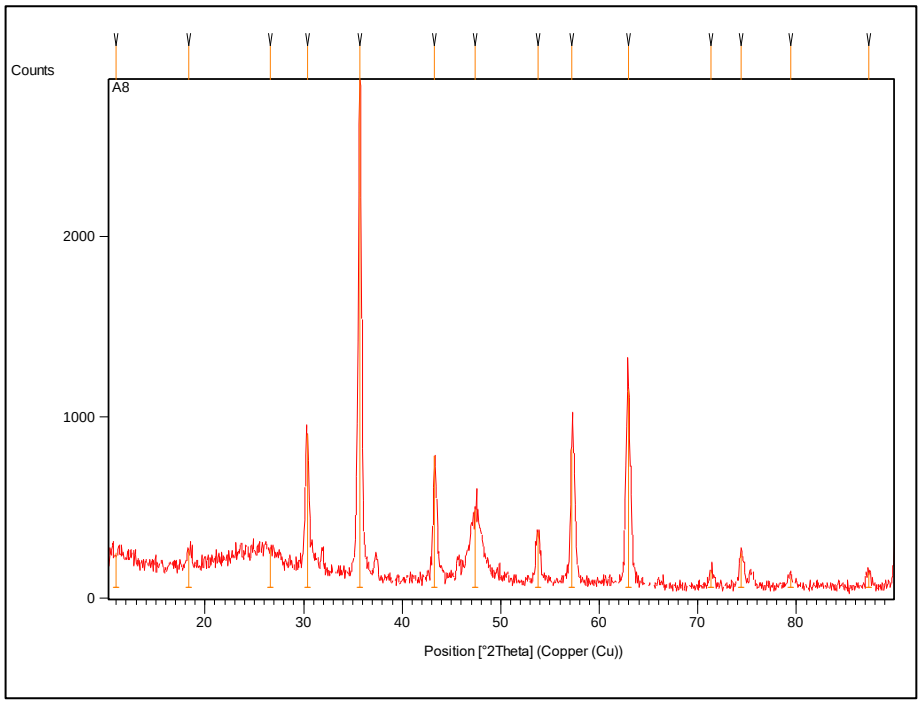
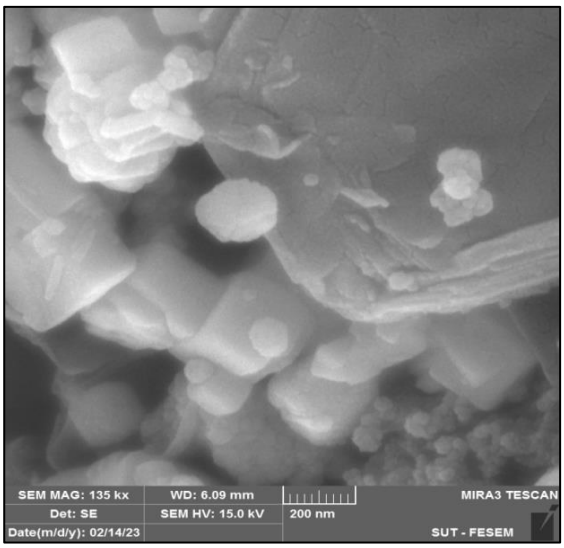


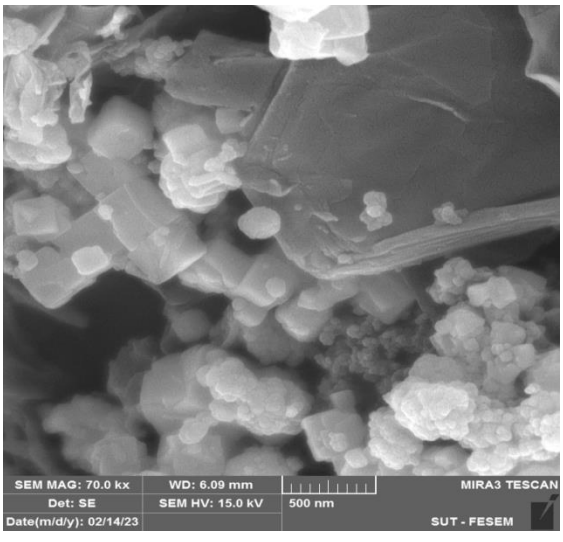
Figure 4. X-ray spectrum of compound K2

The following findings are shown by the compound (K2)'s morphological pictures, which are displayed in Figure 5:

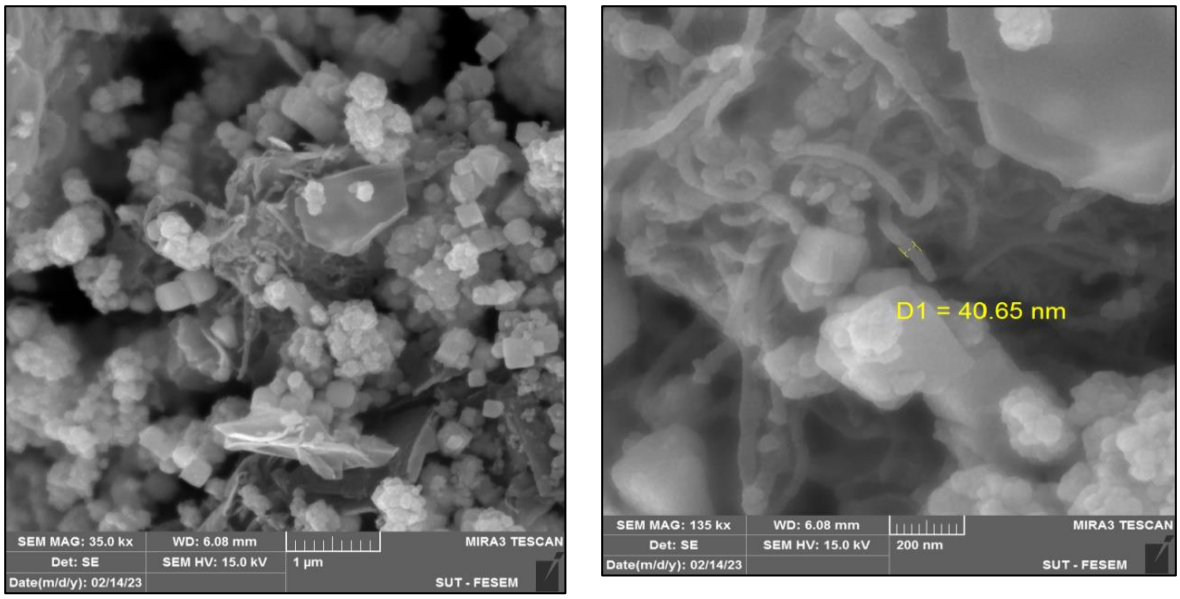
1. Grain size decreases to 27.84 nm along with a drop in scaling (a). A decrease in the d value to 11.16 nm in comparison to sample A6 further supports the expected rise in material density .
2. The pictures show translucent plates with different-sized cubic iron oxide (b) decorations.
3. Moreover, there are threadlike thickenings along the borders, threadlike structures, and cubic thickenings (b, c).



A



B

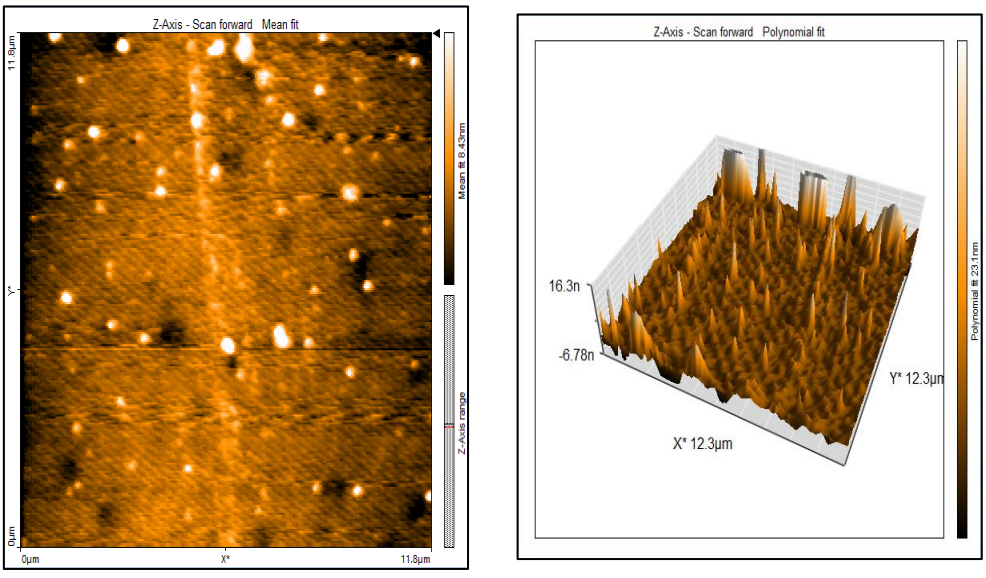


C D

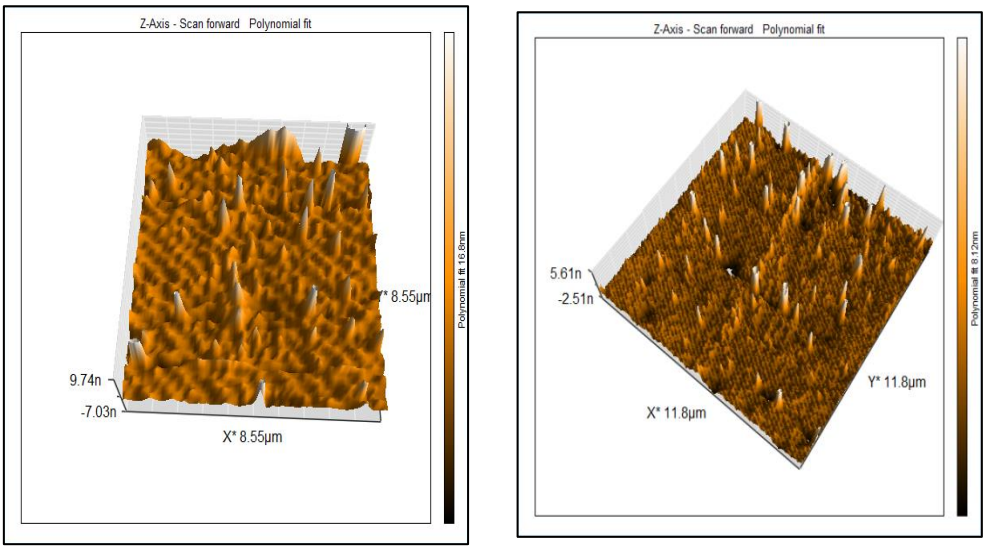
Figure 5. FESEM images of K2 complex

The following morphological details are shown by the compound K2 atomic force microscope (AFM) pictures shown in Figure 6:

1. The plate's surface has round holes that are dispersed randomly (a).
2. Iron oxide is distributed semi-regularly on the plate surface, showing up as non-overlapping forms (c) and needle-like shapes (b). This distribution shows the presence of different crystalline structures and an uneven distribution, which contrasts with the cubic shapes shown in the scanning electron microscope (SEM) images. The preparation procedure can require a longer homogenization time.
3. The plates had heights of up to 16.3 nm and somewhat thicker edges (c, d).



A B



C D

Figure 6. AFM images of the K2 complex.

References

1. Novoselov, K. S. *et al.* Electric field effect in atomically thin carbon films. *Science* 306, 666–669. https://doi.org/10.1126/science.1102896 (2004)
2. Kienitz, P. *et al.* Graphene-based optoelectronic mixer device for time-of-flight distance measurements for enhanced 3D imaging applications. *Nano Lett.* 23, 5535–5540. https://doi.org/10.1021/acs.nanolett.3c00909 (2023).
3. Montanaro, A. *et al.* Optoelectronic mixing with high-frequency graphene transistors. *Nat Commun.* 12, 2728. https://doi.org/10.1038/s41467-021-22943-1 (2021).
4. Behura, S. K., Wang, C., Wen, Y. & Berry, V. Graphene–semiconductor heterojunction sheds light on emerging photovoltaics. *Nat. Photon.* 13, 312–318. https://doi.org/10.1038/s41566-019-0391-9 (2019).
5. Lesiak, B. *et al.* Chemical and structural properties of reduced graphene oxide—dependence on the reducing agent. *J. Mater. Sci.* 56, 3738–3754. https://doi.org/10.1007/s10853-020-05461-1 (2021).
6. Chudziak, T. *et al.* A comparative investigation of chemical reduction of graphene oxide for electrical engineering applications. *Nanoscale* 15, 17765–17775. https://doi.org/10.1039/D3NR04521H (2023).
7. Ghosh, S., Sarker, B. K., Chunder, A., Zhai, L. & Khondaker, S. I. Position dependent photodetector from large area reduced graphene oxide thin films. *Appl. Phys. Lett.* 96, 163109. https://doi.org/10.1063/1.3415499 (2010).
8. Chitara, B., Krupanidhi, S. B. & Rao, C. N. R. Solution processed reduced graphene oxide ultraviolet detector. *Appl. Phys. Lett.* 99, 113114. https://doi.org/10.1063/1.3640222 (2011).
9. Zhao, J., Ren, W. & Cheng, H.-M. Graphene sponge for efficient and repeatable adsorption and desorption of water contaminations. *J. Mater. Chem.* 22, 20197–20202. https://doi.org/10.1039/C2JM34128J (2012).
10. Kumar, S., Kumar, M., & Singh, A. (2021). Synthesis and characterization of iron oxide nanoparticles (Fe2O3, Fe3O4): a brief review. *Contemporary Physics*, *62*(3), 144-164.

11. Ganapathe, L. S., Mohamed, M. A., Mohamad Yunus, R., & Berhanuddin, D. D. (2020). Magnetite (Fe3O4) nanoparticles in biomedical application: From synthesis to surface functionalisation. *Magnetochemistry*, *6*(4), 68.

12. Mohammed, Y. A., Al-Somaidaie, Gh. H., Samir, A. H. Synthesis Of Carboxylic Acid Functionalized Reduced Graphene Oxide (RGO) With Enhanced Heavy Metals Adsorption Capability. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 10(3). 414. (2019).

13. Liu, S., Yu, B., Wang, S., Shen, Y., & Cong, H. Preparation, surface functionalization and application of Fe3O4 magnetic nanoparticles. Advances in colloid and Interface Science, 281, 102165. (2020).