GREEN SYNTHESIS OF GRAPHENE OXIDE FROM TAMARIND SHELL: FLUORIDE REMOVAL EFFICIENCY AND ELECTROCHEMICAL PERFORMANCE

Project Reference No.: *49S_MSC_0130*

College	:	*Bangalore University, Bengaluru*
Branch	:	*Department Of Chemistry*
Guide(S)	:	*Prof. G. Krishnamurthy*
		Dr. Shyamala R
Student(S)	:	*Mr. Nagesh N*
		Ms. Nayana D

Keywords:

Tamarind Shell, Green Graphene Oxide, Fluoride, Photocatalysis, Electrochemical.

Introduction:

1. Water pollution has emerged as a critical global environmental issue, primarily driven by rapid industrialization. Among various industrial sectors, the tannery industry significantly contributes to water contamination due to the discharge of large volumes of untreated or partially treated wastewater [1]. It is projected that industrial wastewater generation may double by 2026, further aggravating the depletion and contamination of freshwater resources. This situation is particularly alarming given the continuously increasing global demand for clean water. Tannery effluents contain a variety of toxic dyes and chemicals that pose serious health and environmental risks. Exposure to these dyes can lead to skin irritation, eye damage, and even carcinogenic effects in humans. Furthermore, these pollutants adversely affect aquatic ecosystems, disrupting the balance of marine flora and fauna [2,3]. Therefore, the development of efficient, cost-effective, and environmentally sustainable methods for the removal of dyes from industrial effluents is of paramount importance.
2. Various conventional techniques, including chemical precipitation, membrane filtration, and biological treatment, have been employed for wastewater treatment. However, adsorption and photocatalysis have emerged as one of the most effective and widely used methods for the removal of dissolved organic contaminants particularly dyes [4].
3. In recent years, graphene oxide (GO) and its composites have attracted considerable attention as advanced adsorbents owing to their large surface area, high functional group density, and excellent adsorption capacity [5]. The incorporation of GO into composite materials often enhances adsorption efficiency due to synergistic interactions between the components.
4. Alongside synthetic materials, natural and renewable resources have gained increasing interest for the development of eco-friendly adsorbents. Tamarind, a widely available natural resource, is particularly promising due to its rich polysaccharide content. Tamarind fruit shell carbon powder (TC), derived from the

tamarind fruit outer shell. TC is biodegradable, biocompatible, non-toxic, and cost-effective. Its stability under both acidic and alkaline conditions, along with its excellent conductive, adsorption, sensing properties, makes it a highly suitable candidate for environmental applications [6].

5. Several studies have explored tamarind-based materials for dye adsorption. Activated tamarind carbon powder (TC) has been successfully utilized for the removal of dyes and organic pollutants [6]. Despite these advancements, there remains a need for novel and more efficient adsorbent materials. In this project, the materials developed in the present namely modified green graphene oxide (GGO). This study represents a promising approach for enhanced fluoride removal from wastewater.

Objectives:

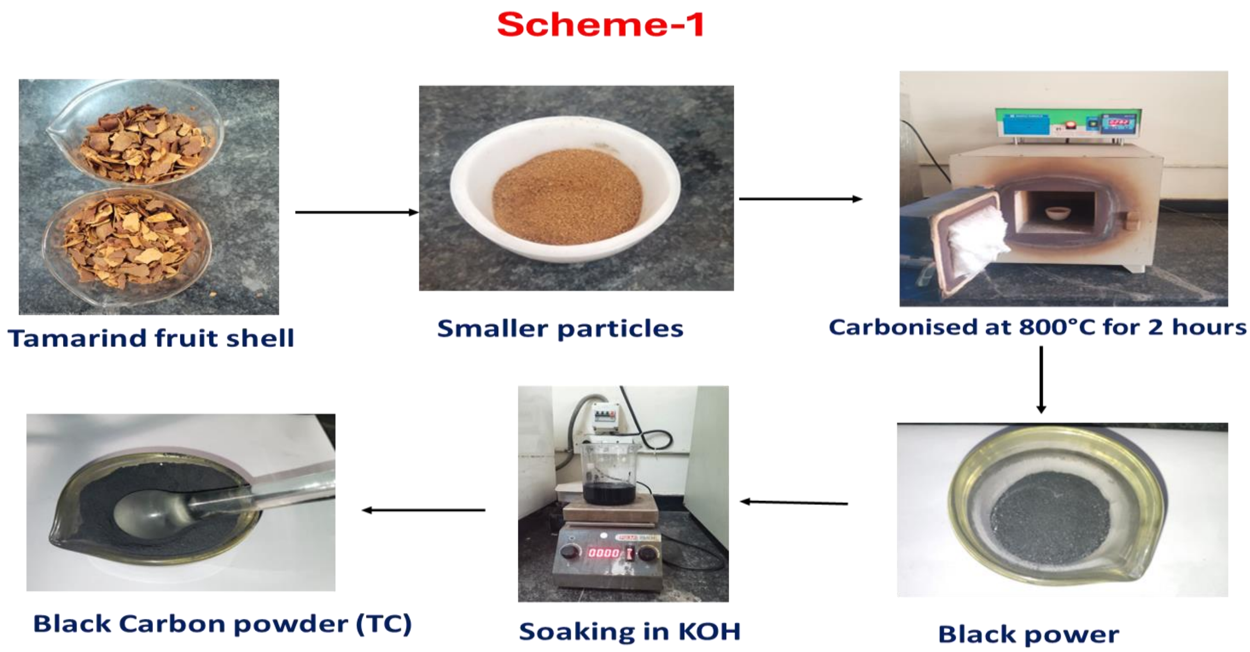
1. To synthesize Graphene Oxide (GO) by Hammers process using Tamarind shell powder and compare with chemical process prepared GO using Graphite powder.
2. To select an appropriate organic pollutant (Fluoride) as a model contaminant for wastewater treatment studies.
3. To comprehensively characterize the synthesized materials using XRD, FT-IR, XPS, BET surface analysis, photoluminescence (PL), and SEM-EDAX techniques.
4. To carry out photocatalysis, and Electrochemical (CV, Battery studies) experiments and perform a comparative evaluation of their efficiencies.
5. To determine the degradation efficiency of the pollutants under both UV and solar irradiation using the synthesized Green synthesized GO.

Methodology:

Step 1: Synthesis of Green Graphene Oxide (GGO)

1. **Preparation Activated Carbon from Tamarind fruit shell**

The tamarind fruit were collected from Bangalore University. The fruit outer shell was collected and initially washed with water to remove dirt and contaminants, later washed thoroughly with deionized water and dried in a hot air oven at 100 °C for 6 h. The dried tamarind fruit shell was grinded using mortar and pestle to make smaller particles. Then, the tamarind fruit shell powder was Carbonised in a furnace at 800°C for 2 hours in an inert atmosphere (such as nitrogen or argon) to produce raw carbon. After cooling the powder grind well and collect the black power, grind it again and by using 100-μm mesh to collect the black power. About 10 g of pre-carbonized black material was activated by soaking in 100 mL of DI water containing 30 g of KOH and stirring for overnight. Further, it was filter and dried at 100 °C for 24 h. The so-obtained carbonized sample was first neutralized with 2 M HCl and washed successively with DI water, ethanol and air-dried overnight at 60 °C under vacuum, leading to the final product which was designated as Tamarind Carbon (TC). As shown in **Scheme 1**.



Scheme 1: Schematic diagram of Tamarind Shell carbon black powder (TC)

2. Synthesis of GGO by Hummer's method:

1.5 g of Tamarind carbon (TC) powder and 1.5 g of $NaNO_3$ were mixed in 70 ml of H_2SO_4 and stirred in an ice bath. Subsequently, 9 g of KMnO4 was added slowly. Then the above reaction mixture was warmed at 40 ºC and stirred for 1 h. After 100 ml water was added. The reaction mixture temperature was increased to 90 ºC for 30 min. Finally, 300 ml of water was added slowly, followed by the slow addition of 10 ml of 30 % H_2O_2. Then reaction mixture was filtered and washed with 0.1 M HCl and water. The GGO precipitate was dispersed in 1:5 water/methanol systems and purified with three repeated centrifugation steps (10,000 rpm for 30 min). The purified sample was dispersed in double distilled water and centrifuged (2500 rpm) to obtain highly exfoliated Green Graphene oxide sheets of TC over solution. This was heated in air at 50 ºC for 48 hours.

Note: Chemical GO synthesised by using Graphite powder in the place of TC powder.

Result and Conclusion:

1. **PXRD**

   The crystallography and phase formation of nanoparticles and nanocomposite samples are presented in Figure 1. In the XRD pattern of GO NPs, the corresponding peak at the angle of 11.09° is related to Miller's index (001), verifying the presence of GO. A similar result was found in reference [7].

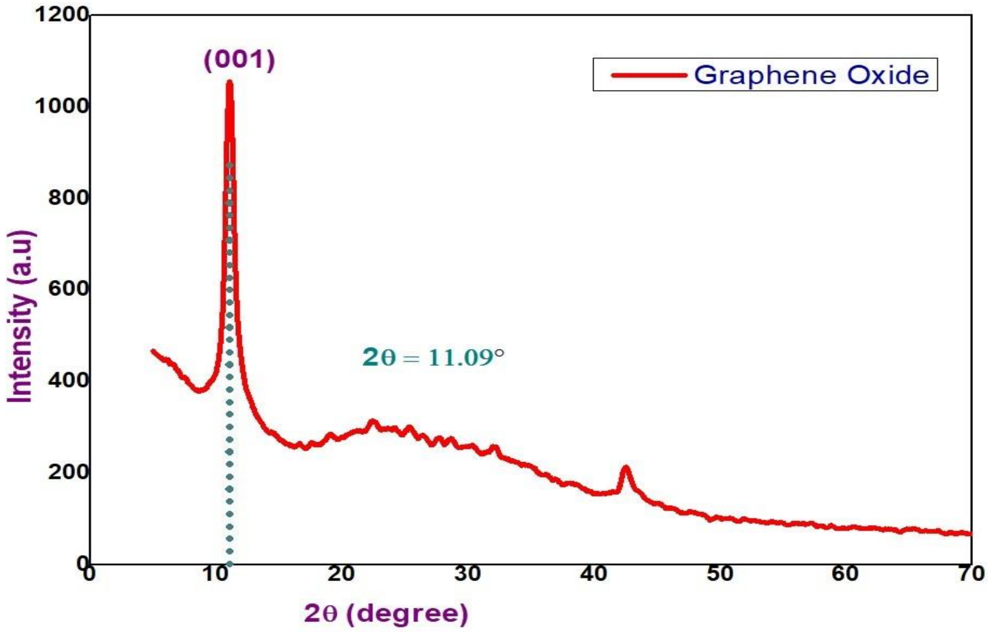


Figure 1. (a) PXRD pattern of GO

Conclusion: In this project, TC, GO and GGO nanocomposite were successfully synthesised for prospective Photochemical and electrochemical applications. The structural analysis and effective interaction of TC, GO and GGO were planned to analyse the properties like XRD, IR and SEM EDAX to confirm the structural properties. Overall, this study highlights the green graphene oxide (GGO) nanocomposites as the next generation of battery biomaterials. Further we planned to degrade the fluoride pollutant in waste water. Beyond water treatment properties, future studies are warranted to investigate the adsorption, sensor, battery and photocatalysis properties.

References:

1. [1] Saxena, Vivek, "Water quality, air pollution, and climate change: investigating the environmental impacts of industrialization and urbanization." *Water Air Soil Pollut*, Jan. 2025, pp 1-73.
2. [2] Anusha Priya Singh, Sayli Dongre, Shaifali Sharma, Kriti Joshi, Harsh Bagdare, Ragini Bobade, Om Prakash and Rohit Sharma, ‘’Decolourizing distillery spent wash using fungal biotechnologies: from pollution to potential’’ *Singh et al. Bioresour. Bioprocess*. 2026 13:42 pp 1-25.
3. [3] Daggupati Sridhar, “Rivers under stress: a comprehensive review on pollutant sources, human and ecological impacts, analytical, statistical, and geospatial methods and restoration strategies, for evaluating river water quality in India” *Environ Geochem Health* 2026 48:160
4. [4] Amitrajeet A. Batabyal, Hamid Beladi, “Tanneries, pollution and water quality in the Ganges in Kanpur, India: a stochastic analysis” *Sustainability Analytics and Modeling 6* 2026 10005.
5. [5] T. Ramesh, N. Rajalakshmi, K.S. Dhathathreyan, “Activated carbons derived from tamarind seeds for hydrogen storage” *J. Energy Storage* 4 (2015) 89-95.

6. [6] Shivani Dhall, Srijan Pushkarna, Jyoti Prakash and Kapil Sood, “Green carbon dots: a review on sustainable synthesis, challenges and emerging applications” *Nano Express* 7 2026 012001.
7. [7] Vaddi Venkata Narasimha Phanikumar, Boyapati Venkata Appa Rao, Kauveri Vengatajalabathy Gobi, Raghavan Gopalan and Raju Prakash, “A Sustainable Tamarind Kernel Powder Based Aqueous Binder for Graphite Anode in Lithium-Ion Batteries” *Chemistry Select* 2020, 5, 1199 –1208.
8. [8] Zhu, J., Fan, C., Ning, C. & Wang, W. “Cathodic electrophoretic deposited HA-rGO-ZnO ternary composite coatings on ZK60 magnesium alloy for enhanced corrosion stability”. *Ceram. Int.* 2023 49, 37604–37622.

Future Scope:

The future scope of this project includes:

1. Removal of fluoride from ground water or water bodies are highly difficult. Using our synthesized compound, we can able to prepare the filter beds or materials.
2. This GGO Synthesis was cost effective, eco-friendly and raw material were from agricultural waste.
3. The agricultural waste material environmentally friendly, and produces materials suitable for sensors, supercapacitors, and pollutant removal and expected to show significant synergistic improvement.
4. The GGO is a green synthesis compound, it is a better raw chemical for battery material in future.