

EXFOLIATED GRAPHITE IN OIL SORPTION

Abstract

The novel use of exfoliated graphite as an adaptable material for oil sorption applications is examined in this book chapter. Due to its hydrophobic properties and porous shape. Exfoliated graphite, which is distinguished by its distinctive structure and high surface area, has outstanding oil sorption capabilities. The fabrication processes for exfoliated graphite-based sorbents, as well as their physicochemical characteristics and the mechanisms governing their oil sorption behavior, are all covered in this chapter. Exfoliated graphite sorbents possible industrial applications and environmental effects are also examined. This chapter highlights the material's promising role in tackling current issues in oil spill management and pollution control by providing a thorough analysis of exfoliated graphite's contributions to environmental cleanup and oil spill mitigation.

Keywords: Sorbent materials; Exfoliated Graphite; Oil Spill Cleanup; Environmental Remediation; Adsorption Mechanisms.

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I. INTRODUCTION

The search for efficient and long-lasting techniques of oil spill management and cleaning has intensified in recent decades due to the rising frequency of oil spills and the resulting environmental damage. Exfoliated graphite has become a standout contender among the various materials investigated for oil sorption as a result of its exceptional qualities and wide range of uses. A technique changes the layered structure of exfoliated graphite, a derivative of natural graphite, into a highly porous, hydrophobic substance with an increased surface area. Exfoliated graphite now has remarkable oil sorption capabilities thanks to this special metamorphosis, placing it at the forefront of cutting-edge approaches to solving oil-related environmental problems [1].

Exfoliated graphite is used in oil sorption to effectively adsorb and remove oil and hydrophobic pollutants from a variety of media by taking use of its hydrophobic properties, porous structure, and high surface area. This chapter examines the complexities of exfoliated graphite-based sorbents, providing a thorough examination of their synthesis processes, physicochemical characteristics, and the underlying mechanisms dictating their oil sorption behavior. Researchers and professionals can modify exfoliated graphite's properties to suit various oil spill scenarios, from minor events to major catastrophes, by knowing the rules that control the material's interaction with oil [2].

Furthermore, it is important to consider the environmental effects of utilizing exfoliated graphite for oil sorption. The environmental sustainability of exfoliated graphite-based sorbents will be covered in this chapter along with potential effects on ecosystems, reusability, and compatibility with current waste management techniques [3].

The incorporation of cutting-edge materials like exfoliated graphite into current cleanup tactics holds the potential of minimizing ecological harm and promoting a more effective recovery process as industry and governments work to improve their preparedness for oil spill catastrophes. This chapter aims to contribute to a thorough knowledge of the role of exfoliated graphite in the future of oil spill remediation and environmental protection by illuminating the science behind its oil sorption capabilities and its prospective applications [4].

A schematic diagram is a way of showing the graphite synthesis and applications (figure 1), we discuss exfoliated graphite mainly oil sorption studies now a day soil pollution has been a serious concern in recent years as a result of oil leak disasters that have spilled hundreds of tons of crude oil into the ocean, such as the oil spill accident involving the oil ship in 2002.

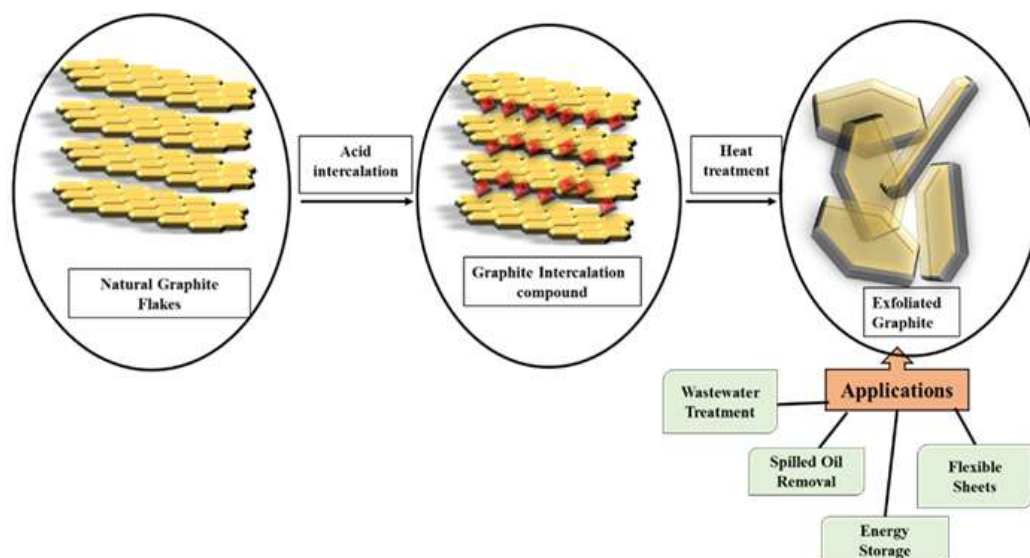
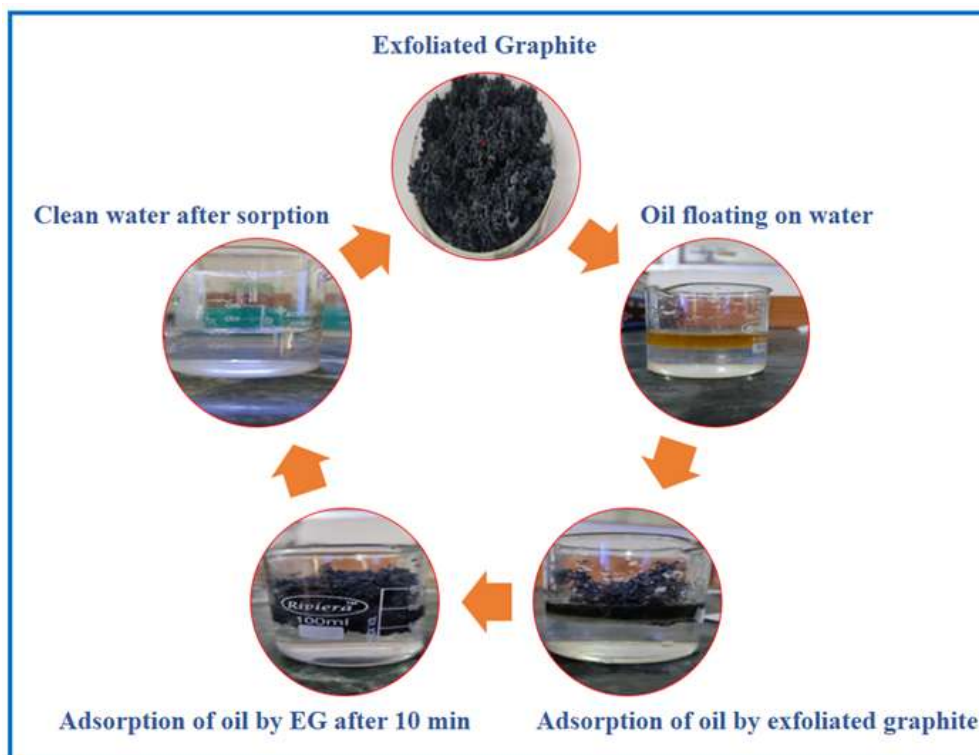


Figure 1: Schematic Diagram of Synthesis and Applications of Exfoliated Graphite.

II. EXFOLIATED GRAPHITE-BASED SORBENTS FOR OIL SPILL CLEANUP

- 1. Exfoliated Graphite:** Exfoliated graphite is made up of layers of graphite that have been removed from one another, creating a structure that is very porous and absorbent. Chemical or thermal exfoliation is two techniques that can be used to create this material [5]. The high surface area, porosity, and hydrophobicity of exfoliated graphite make it suited for oil sorption. Exfoliated graphite may absorb and hold oil when it comes into touch with it thanks to its porous structure [6]. Because of its hydrophobic properties, it repels water while selectively absorbing oil. Exfoliated graphite has been investigated for use in oil spill cleaning and industrial oil separation operations. It can be utilized in a variety of forms, such as powder, flakes, or mats.
- 2. Oil Sorption Mechanism:** Oil molecules can cling to exfoliated graphite's large surface area and porous structure through Vander Waal's forces and hydrophobic interactions. Because it is hydrophobic, graphite may selectively absorb hydrophobic oils and repel water at the same time.
- 3. Adsorption Capacity and Efficiency:** Exfoliated graphite has been demonstrated in experiments to have a high ability to absorb oil, frequently outperforming other common sorbents such as clay minerals and activated carbon. Particle size, level of exfoliation, and surface modification are only a few variables that affect how effective exfoliated graphite is at absorbing oil.
- 4. Reusability and Recovery:** After oil absorption, exfoliated graphite can be retrieved using straightforward physical techniques such as mechanical shaking or squeezing. For material reuse, thermal treatment can also remove absorbed oils.

III. EXPLORING SYNTHESIS TECHNIQUES FOR EXFOLIATED GRAPHITE



The two-dimensional material graphene, or exfoliated graphite, is composed of only one layer of carbon atoms arranged in a hexagonal pattern. The material is highly electrically and thermally conductive, mechanically strong, and optically transparent. The synthesis of exfoliated graphite involves separating individual graphene sheets from a bulk graphite source [7]. Several techniques are available to accomplish this, each having its advantages and limitations. Exfoliated graphite is typically synthesized by the following methods [8].

- 1. Chemical Exfoliation (Graphene Oxide):** To create graphene oxide (GO), which may then be exfoliated to create individual graphene sheets, graphite is chemically oxidized in this process. On its surface, graphene oxide has oxygen functional groups, which makes it hydrophilic and facilitates solvent dispersion. Graphene oxide may be reduced to create reduced graphene oxide (rGO), which has fewer oxygen groups and better electrical conductivity.
- 2. Mechanical Exfoliation (Scotch Tape Method):** This technique, made well-known by the recent discovery of graphene, requires constantly peeling graphite layers with sticky tape. High-quality single-layer graphene can be produced using this method, but it takes a long time and is not appropriate for mass manufacturing.
- 3. Liquid Phase Exfoliation:** Graphite and a solvent are combined in this process, and the layers are subsequently broken apart using mechanical or ultrasonic agitation. Graphite is exfoliated into sheets of graphene suspended in the solvent as a result of the shear forces produced by the agitation. Several uses for the resultant dispersion are possible.

4. **Electrochemical Exfoliation:** This technique includes causing the exfoliation of graphite particles by the use of an electric field. One of the electrodes of an electrolytic cell is typically made of graphite, and the application of voltage causes the layers to exfoliate. By altering factors including voltage, electrolyte composition, and processing time, this technique enables control over the level of exfoliation.
5. **Microwave Exfoliation:** The layers of graphite can expand and exfoliate as a result of the pressure and heat that microwaves can create inside the structures. Comparatively speaking to other strategies, this approach may be rather rapid and effective.
6. **Hummers Method:** EG was produced using a modification of the classical Hummers route, using a reduced chemical consumption of intercalation agents and fewer chemical steps.
7. **Electro Exfoliation:** By using two electrodes immersed in a graphite suspension, an electric field is applied between them. Graphite can exfoliate into thin layers due to electrostatic forces.

IV. MATERIALS AND METHODS

1. **Preparation of Exfoliated Graphite:** Expandable graphite was created by combining natural flake graphite (6 g) with sulfuric acid (10 mL) and hydrogen peroxide (1.0 mL), placing the mixture at 50°C for 90 minutes, washing it to a pH of 5-7, and drying it at 70 °C for 24 hours. Expandable graphite might be quickly heated at 700 °C for 40 seconds to produce EG [9].

In the presence of nitric acid (65%), chemical intercalation of concentrated sulfuric acid (96%) was performed. For the manufacture of EG, natural graphite flakes with an average flake size of 300 m and 94% purity were employed. For 24 hours at room temperature, graphite flakes were submerged in a 4:1 combination of sulfuric and nitric acids (the optimum ratio in our trials). The produced GIC was then washed with distilled water to achieve a pH between 3 and 4 before being baked at 100 °C for 1 hour. At this point, the product is known as residual GIC, and it was transformed to EG using thermal shock at 1000 °C for 5 seconds [10].

The parent components were natural graphite flakes (G) with an average diameter of 300-400m, 98% nitric acid, reagent-grade $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$, and distilled water. The following procedures were used to prepare expandable graphite (EG) samples. EG-1 was produced by treating graphite with 98% HNO_3 for 30 minutes with continual stirring and hydrolysis. EG-2 was created by anodizing graphite in 60% HNO_3 and then hydrolyzing it. EG-3 was produced by intercalating graphite with 98% HNO_3 , followed by anodic oxidation in 60% HNO_3 and hydrolysis. EG-4 was synthesized via graphite anodic polarization in saturated nickel nitrate solutions [11]. Initially, several weight ratios of NGF, perchloric acid, and cupric nitrate were combined at room temperature for 20 seconds. Perchloric acid will be injected into each layer of graphite throughout the mixing process, forming graphite intercalation compounds (GICs). GICs (1 g/500 mL beaker) were equally placed in a quartz glass beaker and then microwave irradiated at 800 W for 40 seconds. Fast microwave heating promotes fast evaporation of intercalation

materials that have been introduced between the layers of graphite, resulting in the formation of EG, a highly porous worm-like structural material [12].

- 2. Oil Sorption Experiments:** In a sealed container, a known mass of exfoliated graphite was brought in contact with a predetermined volume of the oil under examination. To achieve complete oil-graphite interaction, the combination was given a set amount of time to equilibrate (please specify the amount of time). The mixture was separated after equilibration using [filter, centrifugation, or another separation method], and the amount of residual oil in the exfoliated graphite was calculated.

This was done by measuring how much oil the exfoliated graphite took in using an analytical technique. Calculations were made to determine the exfoliated graphite's oil sorption capability. The morphology, structure, and interlayer spacing of the exfoliated graphite before and after oil sorption were analyzed using methods like [SEM, TEM, and XRD] [13-15].

Table 1: Comparison of Previously Reported Heavy Oil Sorption Studies

Material	Experimental method	Heavy oil	Quantity of adsorption mg/g	Ref
EG	-	Engine Oil	13.2	16
EG	-	Engine Oil kerosene	56 32	17
EG	-	Engine oil Crude oil Diesel oil Gasoline	14.40 10.20 9.37 7.30	18
EG	-	Engine oil	15	19
EG	-	Crude oil	70	20
EG	-	Diesel Kerosene Engine oil	47 49 63	21
EG	-	Crude oil	35.72	22
EG	-	Engine oil Crude oil Diesel oil Gasoline oil	7.44 6.12 5.34 4.10	23

*EG: Exfoliated graphite.

V. CONCLUSION

Exfoliated graphite's potential for oil sorption has been thoroughly reviewed in this chapter, laying the groundwork for further developments in the field of environmental remediation. As we go, it is our hope that the knowledge provided here will motivate

academics and professionals to keep probing the limits of exfoliated graphite's potential and contribute to a more sustainable and clean environment.

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