SYNTHESIS AND ANALYSIS OF SUPERHYDROPHOBIC RICE-STRAW FELT FOR OIL ABSORPTION

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Keywords:

Superhydrophobic materials, Oil absorption, Oil spill remediation, Agricultural waste utilization, oil-water separation.

Introduction:

Economic and industrial growth has intensified water pollution through oil spills and wastewater. Oil spills severely affect marine ecosystems and pose ecological and economic threats. Conventional cleanup methods often rely on costly and non-biodegradable materials. A sustainable alternative uses waste rice straw to develop oil-absorbing materials. Rice straw, a byproduct of large-scale agriculture, is abundantly available and eco-friendly. This project explores transforming rice straw into superhydrophobic felt for oil absorption.

Oil absorption involves capturing oil molecules on or within absorbent materials. Superhydrophobic materials repel water while attracting oil, ideal for spill cleanup. Rice straw fibres are woven or compressed into a dense felt structure. The felt is chemically treated with hydrophobic agents like dichloromethane. These treatments reduce surface energy, enhancing water repellence and oil affinity. Optimizing felt density, structure, and treatment improves oil absorption efficiency. Performance is evaluated by testing oil absorption capacity, and durability. The use of natural fibres reduces environmental impact compared to synthetic materials. This method supports sustainability and utilizes agricultural waste effectively. It offers a cost-effective, biodegradable solution for oil spill and wastewater treatment. Combining innovation with conservation, this approach aligns with global eco-goals. The study aims to replace conventional absorbents with natural, sustainable alternatives.

Objectives:

I. Characterization of rice straw felts for oil absorption.

II. To study the effectiveness of different size straw-felt on oil absorption.

Methodology:

Collection and Pre-processing of Rice Straw:

- Collect rice straw from agricultural residues or local sources. Clean the rice straw thoroughly with distilled water to remove dust, dirt, and impurities.
- Dry the rice straw under sunlight or in an oven at 60–80°C for several hours to ensure complete removal of moisture.
- Cut the rice straw into small pieces to enhance uniformity.

Fig1: Rice Straw

Alkali Treatment using sodium hydroxide:

- The fibres were then immersed and stirred in aqueous sodium hydroxide at room temperature for 1hr to construct microstructures.
- Eliminates lignin, hemicelluloses and other non-cellulosic components from rice straw, exposing the cellulose structure.
- Increases surface area and roughness, which improves the material's adhesion to coatings or chemical treatments.

Fig2: Alkali Treatment

Neutralization using citric acid

- The solution was then neutralized by citric acid.
- It helps in modifying the surface properties of materials, making them more suitable for specific applications such as coatings or composites.

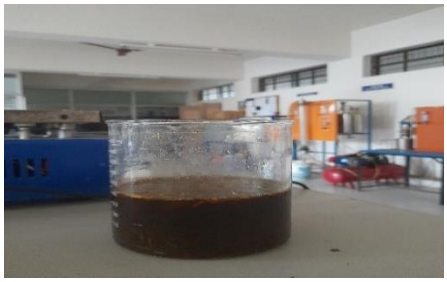

Fig3: Neutralization

Cleaning with deionized water

- The treated fibres were then taken out and cleaned by deionized water.
- Transfer the rice straw into a clean container filled with deionized water.
- Soak the straw for 1–2 hours to loosen any adhered impurities and dissolve water-soluble contaminants.

Fig 4: Cleaning with deionised water

Molding the rice straw into felts

- The fibres were pressed into molds and dried at 60℃ to form fibre felts with desired shapes.
- Place the prepared fibres in a mold. Align the fibres manually or mechanically to ensure a uniform orientation.

Fig5: Moulded Felt Fibres

Immersion in di-chloromethane

- The fibre felts were then immersed in the di-chloromethane solution for 10-15 min at room temperature.

- The immersion process can improve adhesion during further treatment, such as hydrophobic coating application, and the immersion step optimizes its ability to repel water and absorb oil.

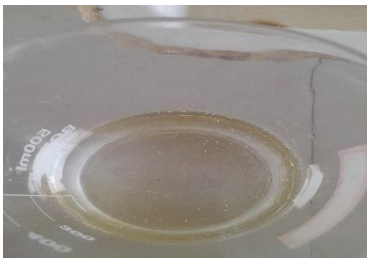
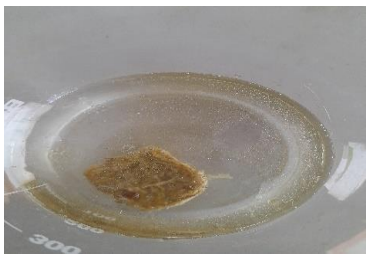


Fig6: Felt fibres after immersion in di-chloromethane

After taking out from the solution of di-chloromethane the rice straw felts are ready for oil/water separation.

Results and Conclusion:

Results:

Sample 1: Cooking oil and water

Initial State During Absorption Final State

Fig:7



Initial State: The oil-water mixture shows significant emulsification, with oil dispersed throughout the water.

During Absorption: The super hydrophobic straw felt quickly absorbs the oil, leaving clear water behind.

Final State: A noticeable reduction in oil content is observed, with the felt retaining the absorbed oil effectively.

Sample 2: Diesel and water

Initial State During Absorption Final State

Fig:8

Initial State: The diesel-water mixture shows significant emulsification, with oil dispersed throughout the water.

During Absorption: The super hydrophobic straw felt quickly absorbs the diesel, leaving clear water.

Final State: A noticeable reduction in diesel content is observed, with the felt retaining the absorbed oil effectively.

Table1: Weight and thickness analysis of samples Before and After Drying and Absorption

Samples (weight)	Before drying (gm)	After drying (gm)	After absorption (gm)	Thickness (mm)
Sample 1	5.37	2.54	5.45	0.46
Sample 2	6.29	3.61	6.71	0.57

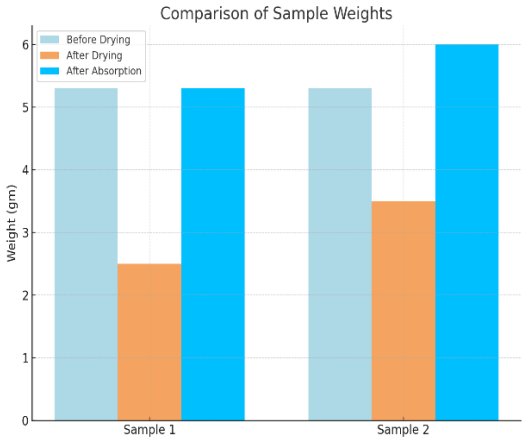

Fig 9: Comparison of sample weights

Conclusion:

- This study validates the potential of super hydrophobic rice straw felt as a sustainable, effective, and eco-friendly solution for oil spill remediation.

- It is prepared using a quick, low-cost chemical treatment method.
- The felts show excellent oil-water separation and super hydrophobicity.
- The material is biodegradable and cost-effective, making it a good alternative to synthetic sorbents.

Project Outcomes and Industry relevance:

This project focuses on creating a material from rice straw that repels water and absorbs oil. This development can be applied in industries such as oil spill remediation, wastewater treatment, and industrial cleaning.

The project offers a cost-effective, eco-friendly solution for cleaning up oil spills and separating oil from water in various settings. By utilizing rice straw, an agricultural byproduct, it promotes sustainable practices and waste reduction.

The material's superhydrophobic properties enhance its performance in water-based environments, making it ideal for marine cleanup operations. Additionally, it can be used in wastewater treatment facilities to separate oils from contaminated water.

The project contributes to the fields of materials science, environmental engineering, and waste management, offering practical solutions to global environmental challenges while utilizing renewable resources.

Project outcomes and learnings:

The project focuses on creating an eco-friendly, sustainable material for oil spill cleanup by modifying rice straw into a superhydrophobic felt. The key outcomes include the successful development of a material with high oil absorption capacity, which is also water-repellent, making it ideal for selective oil absorption in spill situations.

It demonstrates the use of agricultural waste, reducing environmental impact while promoting sustainability. The project highlights the potential for scalable, cost-effective production and the material's biodegradability.

Learnings from the project include understanding how surface modifications can alter material properties, overcoming challenges in synthesizing uniform treatments, and applying analytical techniques like SEM and contact angle measurements.

The project also emphasizes the importance of environmental impact, material optimization, and scaling laboratory results for industrial use, offering a holistic view of how waste can be turned into valuable, functional products for real-world applications.

Future Scope:

- Scaling Up: Develop processes for industrial-scale application.

- Field Trials: Conduct tests in real-world conditions to assess performance.

- Material Innovation: Integrate advanced coatings to improve durability and reusability.
- Reusability of straw felts.
- Oil recovery from the absorbed straw felts.
- Other chemical treatment process for a better oil absorption rate.