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A Review on Natural Fiber Based Oil Absorbents

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Abstract: One of the primary environmental issues that poses a significant threat to human health and ecosystems is oil and organic solvent contamination, which is caused by oil spills and leaks of organic solvents. Numerous oil sorbents have been identified that have good hydrophobicity and oil-absorption capabilities. However, the challenging preparation method, high application cost, and non-biodegradability significantly hinder their practical use. Using widely accessible natural fibres, particularly agricultural waste, for biosorption is an emerging way of treating water. In oil spill cleanup, natural sorbents are favoured as they can be surface modified into hydrophobic and oleophilic. Due to aging, morphological changes, structural fragility, and biodegradation, biological superwetting materials uneven wettability restricts their applicability in demanding applications, including dye adsorption and oil-water separation.

Keywords: *Oil sorbents, Hydrophobic, Oleophilic.*

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I. INTRODUCTION

Due to increased oil processing and transportation due to the expanding global economy, there is a greater chance of oil spills brought on by equipment failures, weather variations, and human errors[1]. Oil spills into rivers, the ocean, or the land pose a serious threat to the environment. During the past few decades, there have been numerous oil spill accidents during the production extraction, transportation, and storage of oil. Since the majority of oil transportation takes place in the water as most the oil transportation is done through the sea[2]. Three major sets of techniques have been developed for cleaning up oil spills. The first category consists of chemical techniques like dispersion, in situ burning, and the use of solidifiers, physical techniques like adsorbents, booms, and skimmers, and third one consists of biological techniques, or bioremediation[3]. Superhydrophobic/super oleophilic membranes or super oleophobic/super hydrophilic materials are designed as part of the standard process for creating oil-water separation membranes[4,5]. Commercially utilized synthetic fibers, such as polypropylene, are not biodegradable and present disposal challenges, in contrast, using sorbents derived from plant fibers does not create more issues when it comes to cleaning up the oil leak[6]. Such contamination is harmful to the ecosystem and causes financial loss.

Oil and water can be separated using a variety of techniques, such as physical skimming, chemical treatment, and bioremediation[7]. Natural superwetting materials are the sole source of scientific inspiration for imitating their unique properties on target substrates for a variety of uses, including corrosion resistance, water harvesting, self-cleaning, anti-bacterial, anti-fogging, de-icing, and oil-water separation[8].

II. NEED FOR OIL ABSORBENTS

Water contamination can be controlled with a variety of technologies, each with varied degrees of efficacy. Nevertheless, the majority of these approaches have the drawbacks of being expensive to operate and maintain, producing hazardous sludge, and requiring a complex treatment process[9]. Physical diffusion, in situ burning, bioremediation, and mechanical recovery are the main techniques utilized to remove oil spills from the water's surface[10]. Numerous technologies, each with varying degrees of effectiveness, can be used to reduce water contamination. The physical method of using sorbents is considered to be the most efficient technique among the available methods[11]. Adsorbents are a cost-effective, efficient, and ecologically friendly way to treat oil spills since they can be collected, the oil can be reused, and post-treatment of oil-loaded sorbents is convenient. Natural adsorbents made from agricultural waste that have a high

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capacity for oil sorption are highly appropriate and useful[12].

III. NATURAL FIBRES WITH OIL ABSORPTION PROPERTIES

The various categories of natural fibers include animal, vegetable, and mineral fibers. They are further divided into seed, bast, stalk, grass/reeds, wood [hard and soft], and leaf fibers[13]. Coconut is one of those numerous agricultural wastes that have been analysed as biosorbents for water treatment. This is because several elements of the tree, such as the shell and coir, have been thoroughly investigated as biosorbents for the removal of a variety of contaminants from water[9].Natural sorbents derived from lignocellulosic waste fibers, such as bananas and jute, have a high oil absorption efficiency and, as they can be reused, and are also very economical and environmentally friendly[6]. To remove oil spills, palm fibers were utilized as a natural sorbent material[14]. Numerous sorbent materials from agricultural by-products have been examined, including water hyacinth, rice straw, coconut fibre, shrimp shells, soybean residue, and corn cobs[12]. Natural fibres have hydrophilic properties because of the cellulose and hemicellulose in their structures, and oleophilic characteristics because of the lignin[15]. Due to their abundance in nature, biodegradability, and non-toxicity when compared to the majority of synthetic sorbents, a variety of natural organic materials, such as kapok fibre, cotton fibre, wood, straw, milkweed, and wool, have drawn more attention recently as an affordable, sustainable, and efficient absorbent for the removal of oil pollutants from industrial sewage[16].

IV. BENEFITS OF ORGANIC OIL ABSORBENTS THAN SYNTHETIC ABSORBENTS

In order to create environmentally friendly functional application materials, researchers worldwide are looking for new sources of biofibres rather than synthetic fibers derived from petroleum[17]. Numerous oil sorbents have been identified that have good hydrophobicity and oil-absorption capabilities. However, the difficult preparation method, high application cost, and non-biodegradability significantly limit their practical use[11]. In addition to water, natural fibre exhibits unique behaviour towards oil, which has drawn a lot of interest for further research. It may be beneficial in oil related applications. Natural fibers have the potential to be used in the near future as interior components, insulation, wrapping papers, furniture, textiles, or packing items because they can either absorb or resist water and oil. Lignocellulosic fibers are effective oil sorbents.[18]. In oil spill cleanup, natural sorbents are favoured since they are less expensive and biodegradable[14]. A growing amount of focus has been placed on the creation of oil-absorbing materials composed of natural fibers. These materials have the same oil-absorbing capacity as synthetic polymers and also benefit from being affordable, sustainable, and eco-friendly[19]. Lignocellulose biomass, which is primarily made up of agricultural, forestry, and agro-industrial waste, is a plentiful, inexpensive, and sustainable energy source. Lignocelluloses are complex biomass made up of lignin molecules that are firmly bonded to carbohydrates like cellulose and hemicelluloses. In recent years, lignocelluloses have gained popularity as a sorbent for oil spills[20].

V. SURFACE MODIFICATION

In order to improve the biomass material's ability to absorb oil, some research has addressed the chemical modification of cellulose fibre or lignocellulose[12]. A practical method for enhancing its oil-absorbing efficiency and creating a green oil removal absorbent is using the one-immersion approach in an ethanolic solution of 1H,1H,2H,2H-perfluorooctyltriethoxysilane [PFOTES]. PFOTES is a hydrophobic fluoroalkylsilane that has been applied to a variety of substrates, including cotton wool, mild steel, and glass, to create a stable fluorosilanated layer that lowers surface energy[21]. In order to achieve the hydrophobicity on the cotton fabric surface, cellulose fibers were surface modified using low-pressure water vapor plasma. This was followed by the application of a pad dry-cure sol–gel coating containing the organic–inorganic hybrid precursor fluoroalkyl-functional siloxane [FAS], which repels water[22]

- *Hydrophobic Properties*

Whether utilized alone or in composites, natural fibers have some drawbacks since they are hydrophilic and interfere with the fibre’s ability to adhere to the matrix. Due to their high cellulose content, they have a hydrophilic character [23,24] . At the molecular level, natural fibers have a large number of free hydroxyl groups that readily form bonds with water. Natural fibre’s ability to absorb water is dependent on a number of fibre-related factors, including size, shape, structure, and arrangement, as well as the circumstances surrounding the fibre’s exposure to water[23]. By combining amphiphilic copolymer additives with polymers including polyvinylidene fluoride [PVDF], polysulfone, and polyether sulfone [PES], materials with switchable hydrophilicity/hydrophobicity can be produced[5,25].

According to reports, kapok fibre has a high absorption capacity for different oils with a value of 30–40 g/g and a naturally occurring hydrophobic wax coating [0.8–1.2 wt%][19]. The hydroxyl [OH] group in natural fibers makes them hydrophilic. They are therefore vulnerable to moisture intrusion[26]. Significant attention has been drawn to superhydrophobic surfaces with water contact angles greater than 150^0[27]. Cellulosic materials are typically modified using chemical reagents such as organic acid derivatives, ester, and anhydrides to enhance their hydrophobic properties[16].

- *Oleophilic Properties*

By grafting poly [2-vinyl pyridine] and hydrophobic polydimethylsiloxane blocks, smart textiles with switchable superoleophobicity, superoleophobicity, and controlled oil/water separation capacity were created[28]. For the development of a superior oil sorbent, sorption selectivity is just as crucial as increased oil-absorbing capacity and quick

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sorption kinetics. Using coloured n-hexane or methylene chloride mixed with water to create an oil layer above the water or oil droplets beneath the water, the sorption selectivity was assessed in this case by extracting the oils from the water[29]. The chemical component of lignocellulosic materials, lignin is made up of aromatic rings in a lengthy chain of polymers connected primarily by b-O-4 ether linkages and a small number of CeO and CeC bonds, which gives it its oleophilic properties[15]. Due to its exceptional performance, graphene has garnered a lot of interest in both academic and commercial settings. It can be added to polymer matrices to increase their oleophilicity and hydrophobicity and utilized for oil sorption[30].

VI. EFFECT OF NANOPARTICLES

With several benefits, such as strong mechanical characteristics, quick sorption rates, large sorbent capacity, and surface chemistry, carbon nanotubes have shown potential in the domains of gas adsorption and oil-water separation. The inherent hydrophobic-oleophilic qualities and high porosity of carbon-based materials, such as carbon fibers, carbon beads, carbon sponges, and carbon aerogels, have made them more appealing as potential solutions for cleaning up oil spills[31]. Reusability is a crucial metric for assessing an oil sorbent's qualities since it can lower the expense of controlling oil pollution and conserve resources for sustainable progress[32]. Over the years, a variety of materials with varying wettability and porosity have been used to address the problem of treating wastewater contaminated by oil and dyes. These materials include metal oxide-based sorbents, carbon nanomaterials [such as carbon black, graphene, carbon nanotube, and carbon fibre], chemically modified foams, synthetic fibers, nanocellulose, and other nanomaterials. These materials, which come in powder, 3D porous structures, and containment boom forms, are frequently altered with costly, poisonous, combustible, and alkyl and fluorinated compounds based organosilane[8]. Graphene aerogels, which can be created using a variety of techniques, such as solvent exchange followed by freeze-drying, hydrothermal cross-linking and polymerization, freezing-drying, oil bath followed by a chemical reaction vessel, and so on, have shown significant promise in the cleanup of oil spills because of their extreme light weight, high compressibility, enormous porosity, and high specific surface area[33].

VII. CONCLUSION

This review provides a general overview on oil spill treatments carried out in marine and aquatic regions. The availability and benefits of natural fibres with hydrophobic and oleophilic properties has been investigated and discussed. Surface modification carried out to enhance the hydrophobic, oleophilic properties and the additional methods and technologies that enhance the properties of natural fibres as oil absorbents are discussed. Hence due to the abundance availability of natural fibres and due to their properties and benefits, natural oil sorbents are recommended effectively than synthetic absorbents as natural absorbents are environment friendly and sustainable.

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