Development of an Oil Sorbent Material from Bamboo Fiber and Silica Fume for Water Sources

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Abstract

This study aimed to determine the optimal mixing ratio of silica fume and bamboo fibers for the fabrication of oil-absorbent materials and to evaluate the absorption efficiency of each formulation. The cellulose structure of bamboo pulp was modified by incorporating silica fume, which provides hydrophobic characteristics that enhance oil uptake. The mixing ratios of bamboo fiber to silica fume were prepared at 10:0, 9:1, 8:2, and 7:3 by weight. The samples were tested for oil absorption efficiency, and the results showed that the 9:1 ratio exhibited the highest performance, achieving an efficiency of 97.83% at 30 minutes and maintaining stable absorption throughout the experiment. The 8:2 ratio yielded the second highest efficiency, with an average of 88.04% at 30 minutes, while the 10:0 ratio showed the lowest efficiency with an average of 54.89%. Furthermore, pore structure analysis using Scanning Electron Microscopy (SEM) revealed that the sample with the 9:1 ratio exhibited a porous morphology characterized by a dense, interconnected network with a high degree of surface roughness with an average pore size of 12.89 to 21.16 micrometers, indicating that this specific pore structure significantly increases the surface area and creates effective capillary action for oil entrapment, resulting in the highest absorption efficiency among the tested ratios.

Keywords : Bamboo, Oil, Silica Fume, Absorbent Material

Introduction

The problem of oil stains floating on the surface of the water in schools smells rotten, destroys the scenery and affects water quality. Small ecosystems as well as the health of students and personnel. The current management guidelines, such as the use of machinery or chemicals, have high costs and may leave residues. Not suitable for small water sources in educational institutions. Absorbent materials from natural fibers are therefore an interesting choice because they are safe and environmentally friendly.

This project therefore aims to develop oil-absorbing materials from bamboo fiber, which is an agricultural waste material. Mixed with silica fume in different proportions to create hydrophobic properties (Hydrophobic) but absorb oil well by experimenting to find the right ratio and test the efficiency in terms of absorption amount, duration and ability to reuse after squeezing the oil.

To develop oil-absorbing materials that are low cost, safe, residue-free and can be reused many times to be a sustainable approach to solving wastewater problems and reduce the burden of water management budget in schools or small water sources in general.

Methodology

1. Experimental Procedure

1.1 Preparation of Bamboo Pulp

The bamboo pulp was washed with distilled water until a neutral pH was obtained. It was then bleached with a 4% hydrogen peroxide (H_2O_2) solution for 90 minutes to improve its whiteness and remove impurities. After bleaching, the pulp was washed again with distilled water until a neutral pH was achieved. The cleaned pulp was dried in a hot-air oven at 105 °C for 3 hours or until a constant weight was obtained to remove residual moisture. The dried pulp was then stored in a desiccator to prevent moisture absorption before being ground into a fine powder for subsequent experiments.

1.2 Preparation of the Viscous Mixture

Forty grams of the prepared bamboo pulp powder were weighed and divided into four equal samples of 10 g each. Each sample was immersed in 900 mL of 18% (w/v) sodium hydroxide (NaOH) solution for 35 minutes. The treated pulp was then separated using a Büchner funnel and a vacuum filtration system. The resulting pulp was transferred to a beaker, sealed with Parafilm, and cured at 95 °C for 20 hours until a dark brown slurry was obtained.

Subsequently, starch glue, vinegar, and baking soda with a total volume of 25 mL were added and thoroughly mixed. The mixture was sealed with Parafilm and cured at 30 °C for the designated period. A 4% NaOH solution was then added and stirred until a homogeneous mixture was obtained. Silica fume was incorporated into the mixture at bamboo pulp-to-silica fume weight ratios of 10:0, 9:1, 8:2, and 7:3. Sodium sulfate was then added at the specified ratio, and the mixture was stirred until uniform. Finally, the mixture was refrigerated for 22 hours to obtain a homogeneous viscous mixture suitable for molding.

1.3 Fabrication of the Oil-Absorbent Material

The prepared viscous mixture was poured into a cylindrical mold with a diameter of 100 mm and a height of 15 mm. A 10 wt% sulfuric acid (H_2SO_4) solution was then added to induce coagulation and solidification of the material. After complete solidification, the molded specimen was removed from the mold and thoroughly washed with distilled water to eliminate residual chemicals.

The water contained within the material was subsequently replaced with acetone through a solvent-exchange process. The specimen was then air-dried at room temperature until completely dry before being sealed in zip-lock bags for storage and further characterization of its oil-absorption properties.

Result and Discussion

Study the absorption of oil from the lining material from silica fume and bamboo fibre to test the absorption efficiency. Oil and compare the differences in each ratio. Table 1 shows the oil-absorbing efficiency of absorbent materials from silica fume in various ratios found that in. The ratio of 10:0 at 10 minutes has an average adsorption efficiency of 19.65 percent at 20 minutes. The average absorption efficiency is 52.20 percent at 30 minutes, the average absorption efficiency is 54.89 percent. In a ratio of 9:1 at 10 minutes, the average adsorption efficiency is 82.07 percent at 20 minutes. The average adsorption efficiency is 94.56 percent at 30 minutes, the average adsorption efficiency is 97.83 percent. In a ratio of 8:2 at a time of 10 minutes, there is an average absorption efficiency of 84.24 percent at a time of 20 minutes.

Table 1 bamboo fiber to silica fume ratio's efficiency

Time (minute)	Amount of oil (g)	The amount of apsorbent pad (g)		The apsorption efficiency (%)
		Before	After	
Ratio 10 : 0				
10	$3.6 * 10^{-1}$	4.92	5.25	19.65
20	$9.6 * 10^{-1}$	5.44	6.4	52.21
30	1.01	3.82	4.83	54.89
Ratio 9 : 1				
10	1.51	5.38	7.33	82.07
20	1.74	5.58	7.96	94.56
30	1.8	6.15	8.96	97.83
Ratio 8 : 2				
10	1.55	5.21	6.76	84.24
20	1.62	5.21	8.69	88.04
30	1.57	5.21	7.31	85.32
Ratio 7 : 3				
10	$8.8 * 10^{-1}$	6.16	7.04	47.83
20	1.15	6.16	7.31	62.51
30	1.2	6.17	7.88	65.22

Conclusions

Therefore, it can be concluded that the most suitable ratio for increasing adsorption efficiency is the ratio. 9:1 Because it provides the maximum adsorption value and maintains continuous performance throughout the experimental period, while other ratios are less effective, especially 10:0, which gives the lowest result throughout the experiment.

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