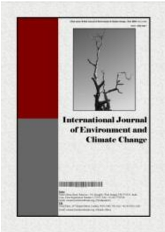


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# Studies on Water Absorption Properties of Fiber-Board Prepared Using Sugarcane Bagasse with Natural Resins

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

A study was conducted to evaluate the effect of fiber content and incorporation of natural resin on the water absorption behavior and swelling in thickness of sugarcane bagasse (SB)-reinforced epoxy-natural resin fiber-boards. Artificial (epoxy) and natural resins (cashew nut shell liquid (CNSL) resins, black dammar and pine resins) were used as a binder. The weight proportions of fiber: epoxy + hardener: natural resin were viz., 1:1:1.50, 1:1:1.75, 1:1:2. The lowest water absorption percent value for the sample immersed for 2 h and 24 h is shown by board prepared by mixing cashew nut shell liquid resin. There was less swelling in the thickness of the fiber board made with the fiber to resin weight ratio of 1:2.75. The cashew nut shell liquid resin was found to be effective in terms of Water absorption (WA) and thickness swelling (TS). Hence, the cashew nut shell liquid resin would be an alternate source for artificial resin source with less environmental hazards.

*Keywords:* *Natural fiber; water absorption; thickness swelling; dammar resin; pine resin; cashewnut shell liquid resin.*

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## 1. INTRODUCTION

In recent years, the demand for wood-based panels has grown rapidly. Fiber-boards are one of the most popular panels. MDF (Medium Density Fiber-board), which is defined as a fiber-board panel with a density of 500 to 1000 $kg.m^{-3}$. A panel made of cellulosic fibers glued with resin under heat and pressure is known as medium density fiber-board [1]. Medium density fiber-boards are widely used in non-structural applications, such as in the home and office furniture industries.

A variety of non-woody fibers have been studied in the production of MDF panels in recent years. Rhododendron [2], canola [3], wheat straw, kenaf, coffee bean residues, banana leaf stem and lamina, okra, sugarcane bagasse, sunflower and corn stalk, and hemp were tested [4].

Sugarcane bagasse is a solid lignocellulosic material left after the extraction of juice from the sugarcane stalk. The main use of bagasse is as a combustible material for energy supply in sugarcane factories [5]. There is a wide variety of products that can be made from bagasse fibers, including filters, absorbents, geotextiles, fiber-board, packaging, and molded products [6].

Resin accounts for at least 29% of the cost of a panel when making MDF. The performance and cost of MDF are significantly impacted by resin efficiency [7]. Natural resins are solid or semi-solid substances that typically include a complex mixture of terpenes, an organic molecule. These are soluble in some organic solvents but insoluble in water. They may be sourced either from insects or plants. Incorporation of natural resin would reduce the cost of product and increase the biodegradability of the board. Use of hybrid resin could impart strength and biodegradability as well. A byproduct of the extraction of cashew (Anacardium occidentale) nuts is cashew nut shell liquid (CNSL) [8]. In India and Southeast Asia, the Dipterocarpaceae family of trees provides dammar resin. A triterpenoid resin known as dammar gum contains several triterpenes and their oxidation products. [9]. Rosin is the the non-volatile exudate of pine resin known as rosin has hydrophobic properties and is frequently utilized and modified as a precursor for numerous industrial uses, including paints, inks, and adhesives [10].

Water absorption (WA) and thickness swelling (TS) are important physical properties, strongly associated with the dimensional stability of wood- based panels [11]. Water absorption of the sugarcane bagasse fiber composites is studied by several researchers. Characterization of the boards in terms of various structural properties like Water absorption (WA) and thickness swelling (TS) helps material scientists to find new applications in diversified fields.

The objective of the present work is to study the effect of fiber content and incorporation of natural resin on the water absorption behavior and swelling in thickness of sugarcane bagasse- reinforced epoxy-natural resin fiber-boards.

## 2. MATERIALS AND METHODS

### 2.1 Materials

For this work, sugarcane bagasse fibers (SBF) were used to manufacture the fiber board. The sugarcane bagasse was procured from the local market. Artificial (epoxy) and natural resins (cashew nut shell liquid resins, black dammar and pine resins), were purchased from the local suppliers, Coimbatore, Tamil Nadu. The synthetic resin used is Epoxy resin LY 556 and hardener HY 951.

### 2.2 Preparation of Fiber Board

The collected sugarcane bagasse was dried in a solar tunnel dryer. The dried material was subjected to shredding using a shredder available in the department of Renewable Energy Engineering, TNAU, Coimbatore. At ambient conditions, the shredded sugarcane fibers were packed in a polyethylene bag. To prepare the adhesive, combinations of natural and artificial resins were mixed in different ratios. Based on the preliminary trials, the combinations of adhesive mixtures were fixed as Fiber: Epoxy + hardener: Natural resin as in three different ratios 1:1:1.50, 1:1:1.75, 1:1:2 with three natural resins dammar resin, Pine resin and CNSL (cashewnut shell liquid) resin designated as F1,F2,F3,F4,F5,F6,F7,F8,F9 respectively.

The adhesives were mixed manually with shredded fibers to get a mixture. A hydraulic press was used to compress the mixture to get a rigid fiber board of the size of 25x25 cm. Once, after the compression of the board, the fiber boards were dried in shade.

**Fig. 1. Water absorption test specimens**

The test pieces were square with a side length of (50±1) mm. In accordance with EN 325, the thickness of each test piece was measured with an accuracy of 0.01 mm at the intersections of the diagonals.

## 2.3 Water Absorption Test (WA)

The IS3087 standard was followed in conducting the water absorption tests. The samples before and after accelerated aging were soaked in water for 2 hours and 24 hours. Water absorption was calculated using Equation 1 [12]

$$WA(\%)=\left[\frac{Wf-Wi}{Wi}\right]*100 \quad (1)$$

Where, WA is the water absorption(%), $W_f$ is the final weight after soaking for 2 hours and 24 hours and $W_i$ is the initial weight.

## 2.4 Thickness Swelling (TS)

The IS3087 standard was followed in conducting the thickness swelling tests. Thickness swelling is calculated from the difference in a specimen's thickness before and after soaking in water for 24 hours. This swelling was measured using a digital caliper with a precision of 0.01 mm. The percentage of thickness swelling was calculated using Equation 2 [12].

$$TS(\%)=\left[\frac{Tf-Ti}{Ti}\right]*100 \quad (2)$$

Where, TS is the thickness swelling (%), $T_f$ is the final thickness after soaking for 2 hours and 24 hours and $T_i$ is the initial thickness.

# 3. RESULTS AND DISCUSSION

## 3.1 Water Absorption

The quality of MDF panel is being assessed by the parameters such as water absorption (WA), thickness swelling (TS), and dimensional stability. The water absorption values of the boards prepared by mixing sugarcane bagasse with cashew nut shell liquid resin are less compared to boards made up of the other two resins mixed with sugarcane bagasse. Figs. 2 and 3 shows the average values of water absorption over 2 and 24 h respectively. The lowest water absorption percent value for the sample immersed for 2 h is shown by F8. This could be because the higher resin percentage created more linkages between fibers, preventing water absorption. Cashew nut shell liquid resin fiber-boards are showing the lowest water absorption percentage.

Fiber-boards made with dammar resin show first an increase in the water absorption percentage and then a decrease with the addition of natural resin. Pine resin fiber-boards have moderate water absorption percentage values. There was not much difference observed in the Water absorption percentage of samples immersed for 2 h and 24 h.

There was an increasing trend in the water absorption percentage of the samples immersed for 24 h, 36 h and 48 h according to Fig. 4. F2 is showing highest values while F8 is showing the lowest values.

### 3.2 Thickness Swelling

When the samples are immersed (Fig. 5) in the water for 2 h, the minimum swelling in thickness is found in F8, which is the board prepared from Cashew Nut Shell Liquid resin. For boards made using dammar resin, there was a decreasing trend observed with further addition of natural resin. Pine resin fiber-boards first showed a decrease and then an increase in the thickness swelling percentage.

Fig. 6 shows the thickness swelling percentage for the samples immersed in the water for 24 h. The same trend was observed in the boards prepared with hybrid resin. Initially, there was a decrease in the value and then an increase in the thickness swelling percentage.

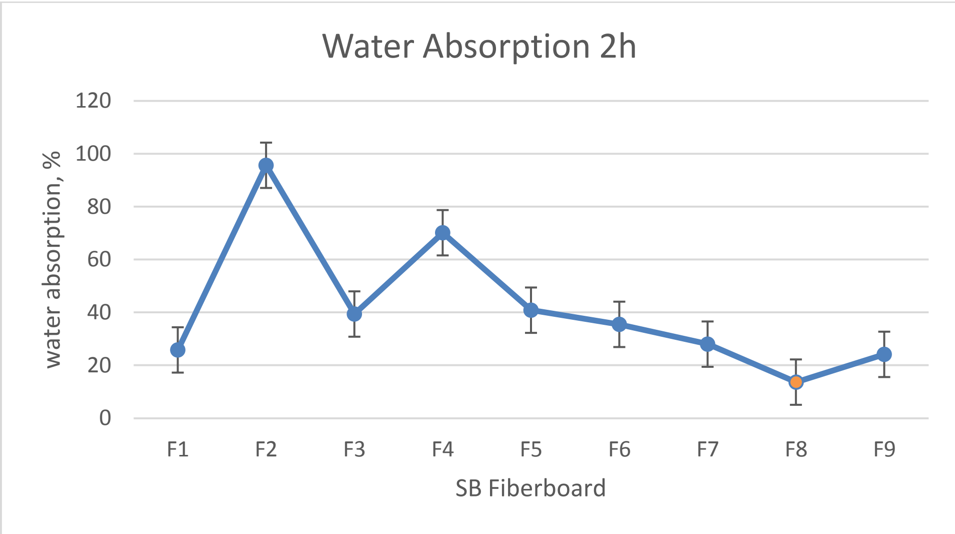


**Fig. 2. Percentage of water absorption by the fiber-boards immersed for 2 h**

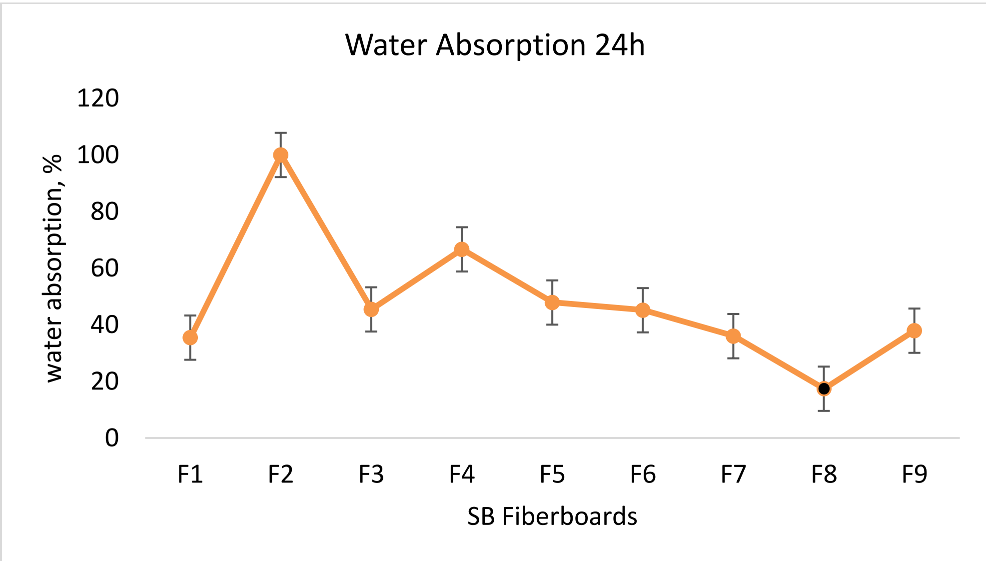


**Fig. 3. Percentage of water absorption by the fiber-boards immersed for 24 h**

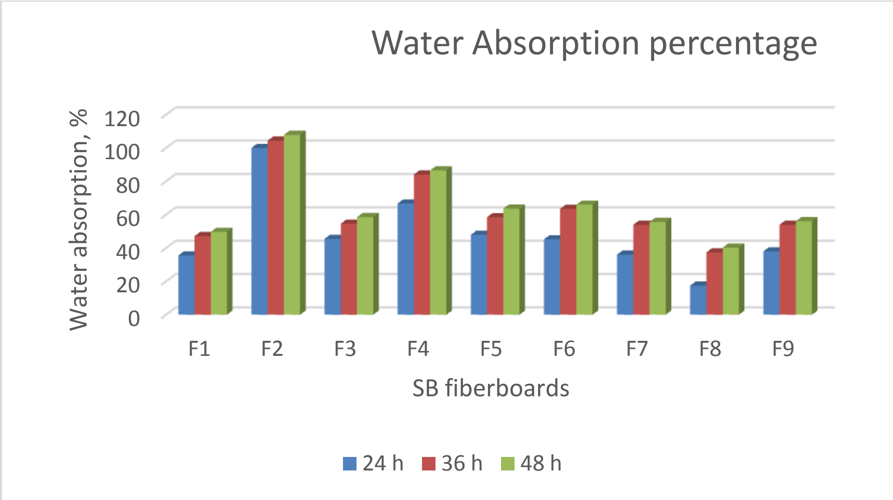


**Fig. 4. Percentage of water absorption by the samples immersed for 24 h, 36 h and 48 h**

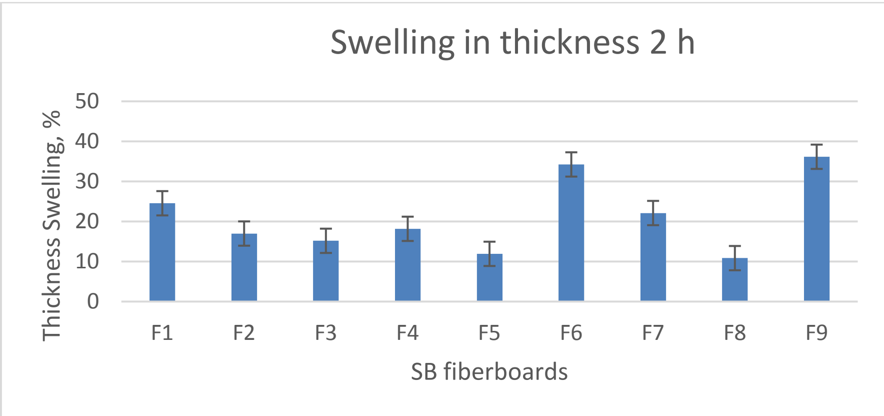


**Fig. 5. Thickness swelling values of fiber-boards immersed for 2 h**

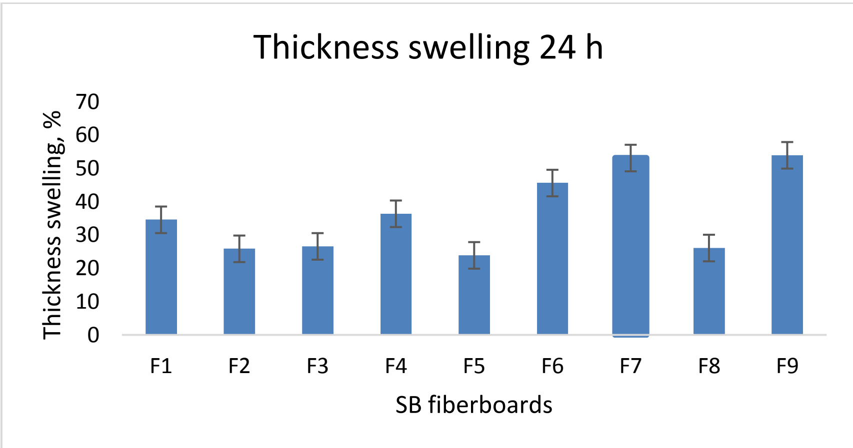


**Fig. 6. Thickness swelling values of fiber-boards immersed for 24 h**

## 4. CONCLUSION

Sugarcane bagasse fiber-boards made with a hybrid resin consisting of synthetic and natural resin had shown lower average values of water absorption and thickness swelling percentage. Cashew Nut Shell Liquid resin gave the best results, with the lowest water absorption percentage values, followed by Pine resin and dammar resin. There was less swelling in the thickness of the fiber-board made with the fiber to resin weight ratio of 1:2.75. Thickness swelling values are higher for the board incorporated with Cashew Nut Shell Liquid resin. Dammar resin fiber-boards showed lower swelling in thickness values but higher water absorption percentage for both the 2 h and 24 h immersion tests.

It can be concluded that fiber boards made by mixing sugarcane bagasse with Cashew Nut Shell Liquid Resin is the best of all other sugarcane bagasse-reinforced epoxy-natural resin fiber-boards. Hence, the cashew nut shell liquid resin would be an alternate source for artificial resin source with less environmental hazards.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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