ISSN 2321-743X

International Journal of Research in

Engineering and Bioscience

Volume 7 Issue 3 (Pages 32-39)

IJREB

Journal home page: www.ijreb.org

TENSILE PROPERTIES OF PALM FIBER REINFORCED POLYESTER COMPOSITES: EFFECT OF FIBER LENGTH, FIBER TREATMENT AND WATER ABSORPTION

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ABSTRACT

Water immersion tests were performed on palm fiber reinforced unsaturated polyester composites to investigate the impact of water absorption on the mechanical properties. In this work, a palm composite specimen with a 27% fiber volume fraction and fiber lengths of 5 mm and 10 mm was taken into consideration. The procedure for conducting a water absorption test involves submerging a specimen in room temperature in sea water, distilled water, and well water for varying different time (24, 48, 72, 96, 120, 144, 168, 192, 216, 240 hours). According to the ASTM standard, the tensile properties of the water absorption specimen were evaluated and contrasted with the dry composite specimen. The palm specimen's tensile characteristics were observed to diminish as the proportion of moisture uptake increased. After three hours of alkali treatment with 3% NaoH, percentage of moisture uptake in composite specimen is decreased.

Key words: *Palmfiber, Alkali treatment, Tensile properties, Water absorption*

INTRODUCTION

Since environmental consciousness is rising, eco-friendly materials in engineering have gained popularity. The demand for natural fibers to reinforce composite materials has increased dramatically in recent years due to their low density, low cost, bio degradability, renewable, acceptable specific properties, less processing wear, and enhanced energy recovery. Compared to natural fiber reinforced composites, synthetic fibers like glass or carbon fiber have negative properties like recyclability, biodegradability, co_2 sequestration, and cutaneous and reciprocating irritation[1]. Natural fiber reinforced polymeric composites have drawbacks like hydrophilic natural fibers not being compatible with hydrophobic thermoset and thermoplastic matrices, requiring physical and chemical modification to improve adhesion [2].

Biomechanical qualities of natural plant fibers rely on cellulose content, crystallinity, and micro fibril angle relative to the primary fiber axis. Cellulose-rich and crystallinity-rich fibers exhibit excellent mechanical properties [3]. Since cellulose determines fiber strength and stiffness, natural fiber qualities are determined by chemical makeup. Hemi celluloses and lignin, limit moisture absorption, thermal degradation, and biodegradation [5,6,7]. The fiber surface is altered by alkali content in the solution [8]. Composites absorb water depending on fiber type, voids, and fiber-matrix adhesion. Lignin content present in the fibers is responsible for thermal stability[9,10,11]. Water absorption or moisture diffusion in polymer composites is governed by three mechanisms: diffusion of water molecules into the micro gaps between polymer chains, diffusion of water molecules within the structure of fibers and hydrogen bonding with the hydroxyl group of cellulose molecules, and migration of water molecules into. To work with hydrophobic thermosets and thermoplastics, natural plant fibers must be treated [12,13,14]. [15] studied pultruded jute fiber reinforced unsaturated polyester composite water absorption. Marine water has higher flexural and compression strengths than purified water and acidic solution, according to the study. Distilled water has the highest permeability coefficient (Pc), followed by acidic solution and sea water. Lowest seawater permeability coefficient. After prolonged exposure, saltwater ionic salts inhibit diffusion [14].

A very few works only illustrate the impact of water absorption on the mechanical characteristics of palm fiber. In order to better understand how moisture absorption affects the mechanical properties of composites, this research focuses on the behaviour of palm fiber reinforced polyester composites. Surface-modified palm fibers are also used in this investigation.

EXPERIMENTAL PROCEDURE

Materials

Palm fiber, was gathered in Vetturnimadam, Nagercoil, Tamilnadu, India. Thus, fibers are taken from the leaves. The study's matrix material, unsaturated polyester resin, is commercially available and was procured from M.N. polyester (India) private limited located in Coimbatore, India. It has a density of 1.23 and a specific gravity of 1.12 when gathered. Methyl ethyl ketone peroxide, or MEKP, was combined with the matrix. In addition to using cobalt peroxide as the accelerator, this served as the catalyst. Table 1 displays the typical chemical makeup of palm fiber. Table 2 lists the mechanical and physical characteristics of the fiber that was employed in the investigation.

Table 1:Typical Chemical Composition of Palmfiber (%).

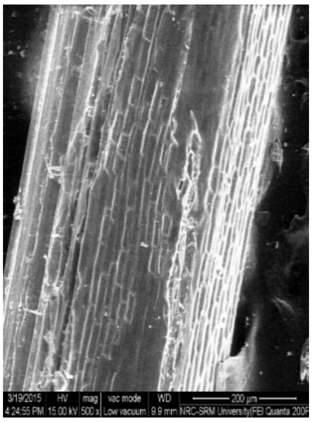
Chemical Composition	Percentage (%)
Cellulose Content	74.01
Hemi Cellulose Content	14.34
Lignin Content	6.40
Wax Content	0.72
Moisture Content	9.30

The 500X SEM images of untreated and alkali-treated palm fiber are shown in Figure 1(a) and (b). Untreated fiber has a pectin, lignin, and other impurity layer [16]. Alkali-treated fibers had better surface roughness than untreated fibers in Figure 1(b). Because non-cellulosic components, inorganic compounds, and waxes are removed, treated fibers have clean, rough surfaces and a smaller diameter [17]. Defibrillation and rough surface promote fiber-matrix interfacial bonding in composites [18].

Table 2 : Physical and Mechanical properties of palmfiber.

Diameter(mm)	0.15-0.32
Density at room temp, g/cc	1.43
Mean Breaking strength (kgf)	9.71
Tensile stress (Kgf / cm^2)	141.4
Tensile strain (%)	5.34
Elongation at Break (%)	4.40
CV % of strength	39.06
CV % of Elongation	21.85

(a)



(b)

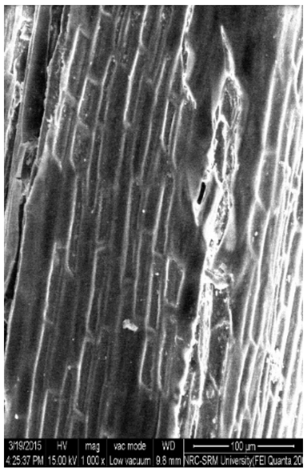


Figure 1: (a) SEM micrograph of Untreated palmfiber, (b) SEM micrograph of NaOH treated palm fiber.

Chemical treatment

Composites require better fiber-polymer matrix bonding. Due to hydroxyl and other polar groups in the fiber, moisture absorption is lofty, resulting in poor interfacial bonding with the polymer matrix and reduced composite mechanical characteristics. Chemical treatment is essential to solve this issue. Fibers become less hydrophilic and absorb less moisture. To improve composite mechanical properties, fiber surface modification is important.

Composite preparation

This study's composite specimens were made using 27% treated and untreated palm fibers and individually reinforced in polyester resin utilising a 200 X 200 X 3.2 mm moulding box by Hand Layup Technique. Then wax polish was applied to the mould to release the sample quickly. MEKP was added to the polyester resin as a catalyst, while cobalt peroxide was utilised as an accelerator. Shortest fiber weight was calculated and placed on the moulding board. The resin mixture was put to the fiber to make the composite. Impregnating fiber with brush and roller prevented air bubble voids. The composites cured for 4–5 hours at room temperature. After curing, ASTM-standard test specimens were cut from the composite material.

Water Absorption Test

We examined how water absorption affects palm fiber reinforced unsaturated polyester composite. Samples for tensile, tests were machined to 165*19*3.2mm³. Dry specimen weight was measured first. Water absorption tests were performed by immersing the palm composite test specimen in sea, distilled, and well water in a beaker at room temperature for various times. We took the specimens from the sea water after 24 hours and removed all surface water with tissue paper. The specimens were weighed on a digital balance at 24, 48, 72, 96, 120, 144, 168, 192, 216 and 240 hours. The same process was performed on test specimens in distilled and well water. Weight difference estimated moisture absorption. Moisture content vs square root of time is plotted after measuring the test specimen's percentage weight growth. The proportion of water absorption in palm composites was estimated by comparing the weight of samples immersed in different types of water and as dry samples using the following equation

$$\Delta M(t) = \frac{M_t - M_0}{M_0} \times 100 \qquad \text{-----------(1)}$$

Mechanical Testing

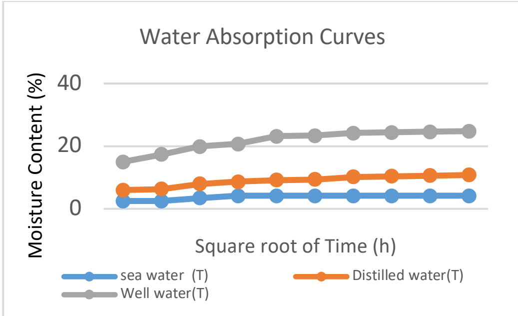
Tensile Testing

The tensile strength of the palm composite specimen was analysed before and after water immersion as per the American Standard for

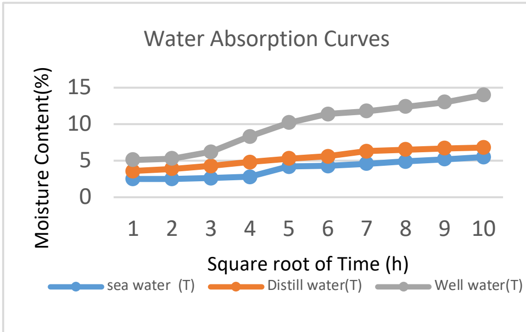
Testing of Material (ASTM D638) using a computerized universal testing machine at a cross head speed of 50 mm/min.

RESULTS AND DISCUSSION

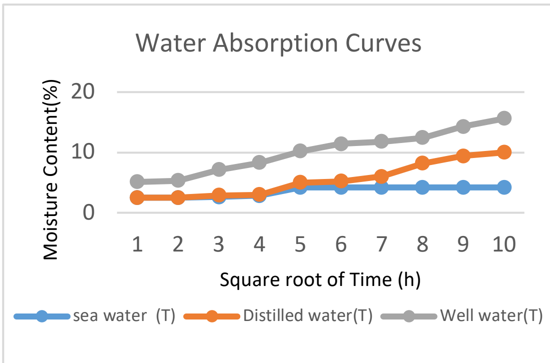
Results from experiments are reported in two parts. First, we examine diffusion into palm fiber reinforced polyester composites, and then we examine how water absorption in sea water, Distilled water, and well water at ambient temperature affects mechanical properties. Natural fiber reinforced composite materials absorb water based on fiber volume percentage, orientation, type, exposed surface area, interfacial bonding, diffusivity, matrix-water response, surface protection, and voids [19]. Absorption curves for treated and untreated palm composite in sea, distilled, and well water are shown in Figure. 1. The moisture absorption curve shows that specimen water absorption increases with immersion time. After that, it reaches saturation without further growth, and fiber treated with NaoH solution absorbs less water than untreated fiber because it breaks the hydrogen bond and activates the hydroxyl group of cellulose. After treatment, fiber surface structure changes, making it hydrophobic and improving fiber /matrix interaction.



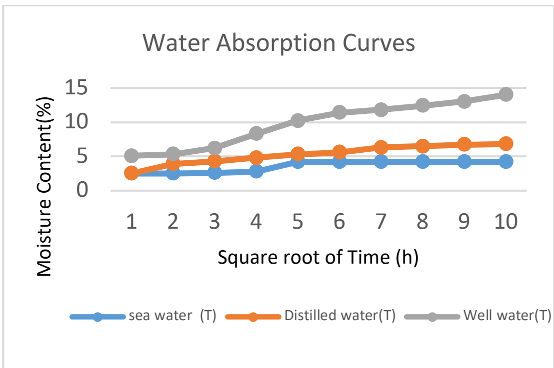
5mm Treated



5mm Treated



10 mm treated



10mm Treated

Figure.2: Water absorption curves for specimen exposure to different environment

From the experimental data, the palm composite showed higher absorption in well water compared to distilled and sea water. In most of the cases, Specimen immersed in Distilled and well water, water uptake reached the saturation level in about 15 root hours and it was also concluded that Moisture absorption of 10 mm fiber was higher than 5 mm fiber. But the composite immersed in sea water absorbed less amount of water and reached the saturation level earlier than other type of water and saturation limit which was almost 13 root hours. Diffusion into the composite material matrix was slowed down because of the density and big salt molecules (sodium chloride, in particular) found in sea water. [14].

Effect of water absorption on Tensile strength

Tensile strength of composite in different aqueous environments for different time intervals is shown in Figure.2. The palm specimen without moisture absorption has 30.21 MPa tensile strength. After moisture absorption in sea, distilled, and well water for different time periods, palm tensile strength was analysed. Sea water-immersed specimens demonstrated a significant drop in tensile strength after two days, but distilled and well water specimens had a higher decrease. The composite's discontinuous fiber and polyester matrix swelling in sea water considerably alter its tensile strength compared to other types of water. The tensile strength of 4 days immersion NaoH- treated palm is 24.21%, 6.25%, and 16.56% higher than two days wet sample for sea, distilled, and well water, but it is 12.35%, 8.21%, and 14.27% higher for untreated palm. The composites' mechanical characteristics may have increased due to the strong water aggregate swelling the fibers and polymer matrix [15].

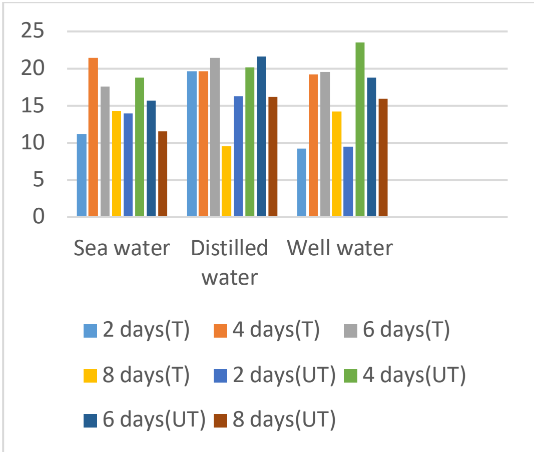


Figure 3: (a). Tensile strength of 5mm palm composite.

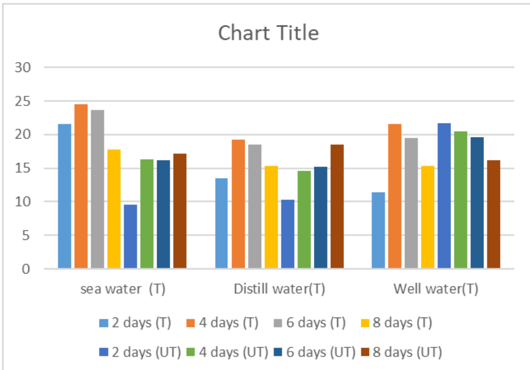


Figure 3: (b). Tensile strength of 10 mm palm composite.

Composite tensile strength dropped after 4 days. Due to discontinuous fiber in palm composites. Figure.3(b) illustrates the composite's tensile strength for 10 mm fiber. Sea water delivers better results than distilled and well water. This is because fiber length increases. After 4 days, NaoH-treated wet sample tensile strength increases 6.52%, 10.12%, and 7.68% from 2 days. Untreated palm increases 6.91%, 6.18%, and 8.31%. Composite tensile strength gradually decreases after that. In contrast to 5mm fiber, 10 mm fiber's tensile strength is considerably affected by water uptake. When fiber length increases, it absorbs more water than matrix, reducing interfacial bonding and strength. In tensile tests, NaoH surface modified palm Composite is less affected by immersion than untreated composites. All samples with NaoH surface treatment of palm composite demonstrated lower strength than dry samples because to water uptake.

CONCLUSIONS

The influence of water absorption on palm fiber reinforced polyester composite mechanical and water absorption qualities was compared in sea water, distilled water, and well water. palm specimens exposed to water had lower tensile, than dried specimens due of reduced fiber-matrix interface bonding. In water absorption studies, fiber treatment reduced composite moisture absorption, supporting fiber/matrix interaction. Composites with treated fiber have the best mechanical properties.

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