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# EXPERIMENTAL ANALYSIS ON ACOUSTIC, VIBRATION AND MOISTURE ABSORPTION PROPERTIES OF NATURAL BIO-POLYMER COMPOSITE

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## ABSTRACT

Composites Materials- Aircraft, Ship, Automobile. Their most attractive properties are the high strength-to-weight ratio. Polymer composites are used because overall properties of the composites are superior to those of the individual polymers. The natural bio-resin are prepared from neem and Thennamarakudi oil with the concept of polyester resin. The reinforcement is screw pine fibre and fish scale fibre. The aim of this experimental study has targeted to investigate the vibration damping, sound absorption and moisture absorption of reinforced polyester resin polymer composites. The specimen fabricated are naturally bio-degradable and eco-friendly to environment because the resin and fibre are natural ingredients. Mainly to avoid all types of pollution. The laminated specimens were fabricate using hand lay-up technique and the specimens are subjected to the investigated as per the ASTM standards. The Moisture absorption test, Vibration test, Acoustics test were carried out on the laminated specimen to determine their properties.

***Keywords:*** *Thennamarakudi, Hand lay-up, Polyester, Vibration, Acoustics and Moisture.*

## 1. Introduction

Generally, Natural fibres are potential replacement for synthetic fibres in automotive and aerospace engineering applications due to the low carbon footprint associated with them. Reducing resonant amplitude of the vibration is an important issue in a machine component design process. Generally, damping associated with the fibre reinforced composite structure is higher than conventional metal structures due to the visco-elastic behaviour, fibre -matrix interaction and the damping due to damage.

In recent years, Bio Fiber Reinforced Composites (BFRC) are used in many sectors due to various attractive properties that they offer such as light weight, biodegradability, renewability, low cost and corrosion resistance. BFRC are used in many industries such as automotive, aerospace, sporting equipment, marine, electrical, construction and household appliances. Kenaf, sisal, screw pine, coir.

Kenaf fibers provide high stiffness and strength values [1 & 2]. They also have higher aspect ratios making them suitable to be used as reinforcement in polymer matrix composites. Pineapple Leaf Fiber served as reinforcement in most of the polymer matrix has shown its significant role as it is cheap, exhibiting better properties when compared to other natural fiber [3]. PALF is a lignocellulosic fiber extracted from the leaves of plant Ananas comosus belonging to the Bromeliaceae family by retting (separation of fabric bundles from the cortex).

PALF has a ribbon-like structure and is cemented together by lignin material, which contributes the strength to the composites. In recent years, there is a growing interest in the use of bio fibers as reinforcing components for thermoplastics and thermoset. Sisal fiber, a member of the Agavaceae family is a natural and biodegradable crop. Moreover, sisal fiber is a stable, strong and versatile material and it has been recognized as important resources for polymer composites [4]. One of the best-known natural fibers is kenaf fiber, which is used for a variety of applications. Kenaf (Hibiscus Cannabinus Leaves) is a high-yielding cordage crop traditionally grown for the production of twine and rope. Newer application for kenaf fibers includes paper products and building materials.

The main drawbacks of Bio Fiber Reinforced Composites are their water absorption, poor dimensional stability, poor /adhesion with matrix, and poor processability at high fiber contents [5]. Chemical treatment of the natural fiber can help to overcome such drawbacks to improve the interfacial between fiber and the matrices, resulting in improved properties of fiber reinforced composites. Various chemical treatment methods such as alkaline treatment, silane treatment,

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benzoylation treatment, permanganate treatment and peroxide treatment have been applied on the various natural fibers to improve their properties and the fiber matrix interface by converting them from hydrophilic nature into hydrophobic nature. Alkaline treatment is used to improve interfacial strength between fiber and matrix and dynamic flexural modulus of the composites.

The scope of this present project work is to investigate the effect of fibers on acoustics, vibration and moisture absorption properties of natural based bio-polyester composites.

## 2. Experimental Details

### 2.1 Preparation of Resin

Neem or Thennamarakudi oil, Formic acid, Hydrogen peroxide were used in the first step modification. Maleic acid and Morpholine were used for further modification of hydroxylated oil fatty acid in different synthesis schemes. Benzoyl peroxide was used as a radical initiator and N, N-Dimethylaniline was used as accelerator in the curing process. Styrene was used as a monomer. Fibres were soaked in 2%NaOH solution in a water bath where the temperature was maintained throughout at 22ºC for 24 h, then washed with distilled water and allow to dry and then the fibres were chopped into2-3 mm size.

Hydroxylation of oil was carried out by using 100 ml of oil, 100 ml of 97% formic acid and 55 ml of 30% hydrogen peroxide. Ice water bath was used externally to keep the temperature below 40 º C. The reaction was vigorously stirred overnight. The resulting emulsion was poured into a separating funnel and extracted with ether. The aqueous layer was removed. The resulting ether layer was dried over anhydrous sodium sulphate and the ether was removed by a rotator evaporator. The resulting product was hydroxylated oil. The above obtained hydroxylated oil was then reacted with maleic anhydride to get the resin. Morpholine was used as a catalyst.

The curing process was carried out in two steps by first mixing the obtained resins with 2 wt% benzoyl peroxide as the catalyst and 0.5 wt% N, N Dimethylaniline as the accelerator. And the second step was the addition of 10 ml of styrene and let them cure in room temperature.

The mold was spread out with silicon oil, to the above cured resin, add different weight ratio of the fibres and mix well and then it was poured in to the glass mould, after a few hours we can get a fibre reinforced polymeric sheet.

### 2.2 Preparation of Composite Laminate

Hand layup technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to surface.

Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product. Reinforcement in the form of woven mats or chopped strand mats are cut as per the mold size and placed at the surface of mold after Perspex sheet. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener and poured on to the fibre already placed in the mold. The polymer is uniformly spread with the help of brush.

Second layer of fibre is then placed on the polymer surface and a roller is moved with mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present. The process is repeated for each layer of polymer and mat, till the required layers are stacked. After placed in the plastic sheet, release gel is sprayed on the inner for better removal of polymeric sheet.

### 2.3 Sound Absorption Coefficient Measurement

The sound absorption coefficient can be measured with the help of an impedance tube tester as per ASTM standard E1050 and is shown in figure 1. The impedance tube testing method is implemented by generation of plane wave in a tube by a sound source and then the sound pressure is measured in a microphone position in close proximity of the sample.

An impedance tube was used with a sound source connected to one end and the test sample was mounted to another end. The loudspeaker generates the broadband random waves and the sound wave propagating as plane wave in the tube hit the sample, get partially absorbed and subsequently reflected. The acoustical properties of the test sample were tested in the frequency range 100-2000Hz. This system tests a sound absorptive material, processes the results, and reports the results in a graph of the absorption coefficient in various frequencies. Thus, the absorption coefficient of each sample is tested.

### 2.4 Vibration Damping Factor Measurement

The damping factor was determined by using the free vibration method as per the ASTM standard D 790 and is shown in figure 2. Specimens were cut into the specified dimension from the laminate. The specimens are placed in the form of cantilever beam structure by using clamp fixture. An accelerometer sensor with sensitivity 98.4mV\g was placed at the tip of specimen at the free end. The output signals are received by means of connecting the accelerometer sensor with the data acquisition card which is connected to PC and interfaced with DEWE software.

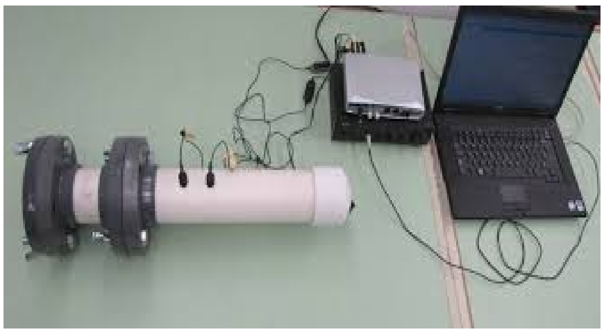

**Fig. 1 Sound absorption measurement setup**

**Fig. 2 Vibration setup**

The free vibration response of composite laminates obtained from the DEWE software while the specimen was made to oscillate. Numbers of trails were taken to obtain accurate readings for the calculation of damping factor (ζ). The damping factor was calculated by taking the values of the successive peaks from the free vibration response graph (wave form graph) obtained from the DEWE software and is shown in Figure 3. The equation (1) is used to determine the damping factor.

$$\ln (x_1/x_2) = 2\pi\zeta / \sqrt{1-\zeta^2} \quad (1)$$

where, $x_1$, $x_2$ - successive peaks from the free vibration response graph.

### 2.5 Moisture Absorption Measurement

The ASTM standard for moisture absorption test is D 570 (ASTM D 570). For the moisture absorption test, the specimens are dipped in sea water, distilled water, drinking water. The material initial weight are noted, often room temperature for 12 hours or until equilibrium. Specimens are removed, patted dry with a lint free cloth, and weighed. Water absorption is expressed as increase in weight percent (Equation 2).

Water Absorption = [(Wet weight - Dry weight)/ Dry weight] * 100 (2)

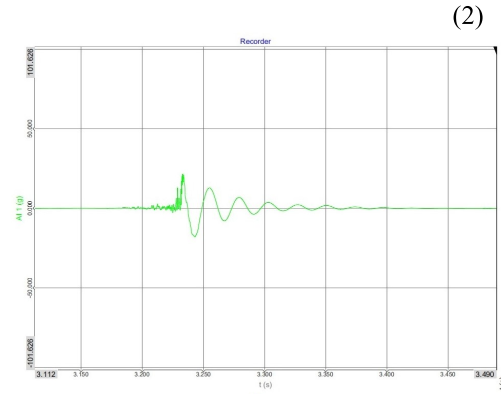


**Fig. 3 Vibration response graph**

## 3. Results and Discussion

The calculated results are analyzed in this section.

### 3.1 Analysis of Sound Absorption Coefficient

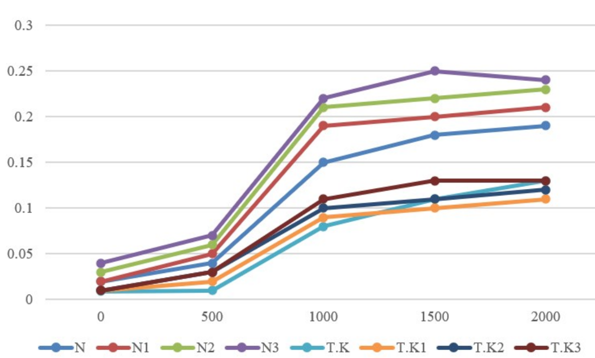


**Fig. 4 Sound Absorption Coefficient vs Frequency (Fish Fibre)**

The sound absorption coefficient of neem resin has good absorptivity rate than Thennamarakudi resin. Neem 30% have good sound absorption from the lower frequency to higher frequency variation as shown in Figure 4. The reinforcement in both resins are fish scales.

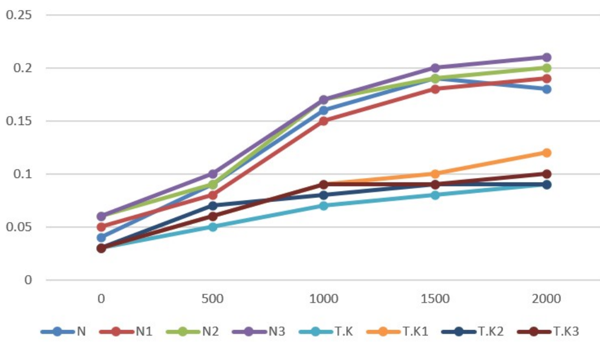


**Fig. 5 Sound Absorption Coefficient vs Frequency (Screw Pine Fibre)**

The sound absorption rate of neem resin has maximum value at high frequency neem 30% show better property than other specimens as shown in Figure 5.

### 3.2 Analysis of Vibration Damping Factor Measurement

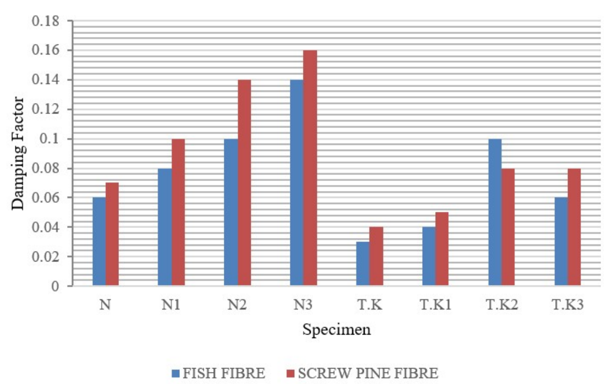


**Fig. 6 Damping Factor for various specimen**

From the Figure 6, it is understood that the neem resin shows the good damping factor value than Thennamarakudi resin. The screw pine fibre and neem resin show higher damping factor. The Thennamarakudi resin have poor damping factor on two type of fibre.

### 3.3 Analysis of Moisture Absorption Measurement

In drinking water, the moisture absorption rate for both resin with reinforcement have absorptivity rate in neem 20% and Thennamarakudi 30% have low absorb than another specimen as shown in Figure 7.

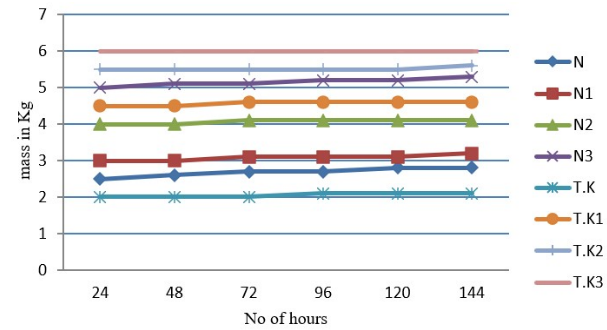


**Fig. 7 Moisture Absorption in Drinking Water**

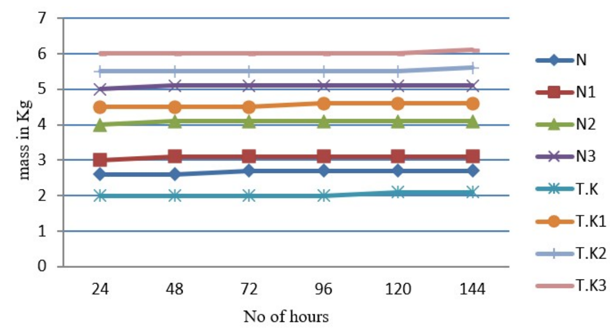


**Fig. 8 Moisture Absorption in Distilled Water**

In distilled water the moisture absorption rate for all specimen is lower when compared to drinking water and sea water. Thennamarakudi 30% and neem 30% have lower moisture content as shown in figure 8.

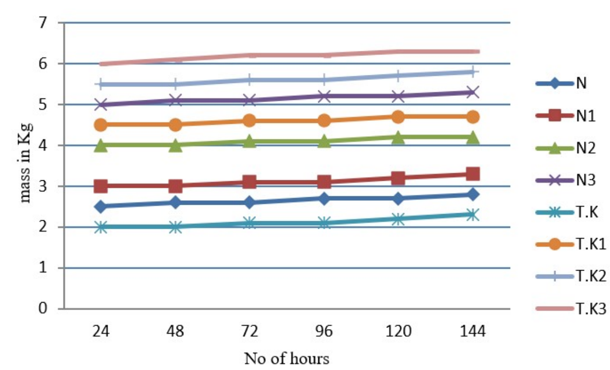


**Fig. 9 Moisture Absorption in Sea Water**

In sea water the absorption rate is higher than other distilled water and the drinking water as shown in Figure 9. All specimen has high moisture content in it.

 

## 4. Conclusion

By using natural fibre based composite materials, it is possible to create a composite laminate with superior acoustics and vibration damping performance without compromising the stiffness-to-weight ratio. The sound absorption coefficient of neem resin and screw pine composite 30% show more absorption rate over than fish fibre composite on both resins. The vibration damping factor of neem resin and screw pine fibre show good damper value than another composition. The moisture absorption of neem resin will have high absorptivity rate and Thennamarakudi resin have low absorptivity rate. These results suggest that the screw pine fibre reinforced composites have good sound and vibration properties in neem resin but not in Thennamarakudi resin.

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