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**Synthesis and Characterization of Kapok Fibers and its Composites**

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**Abstract:** Most of the developing countries are very rich in agricultural and natural fiber. Natural fibers are lignocellulosic in nature. These composites are gaining importance due to their non-carcinogenic and biodegradable in nature. The natural fiber reinforced composite are dominated over the conventional composites because of the main advantage of low cost. Polymeric materials reinforced with natural fibers provide advantages of high stiffness and strength to weight ratio as compared to conventional construction materials. Natural fiber reinforced composites have gained popularity nowadays because of their processing advantage and good technical properties. The present work includes the processing, characterization of kapok fiber reinforced epoxy composites. Keeping in this view the present study has been undertaken to develop a polymer matrix composite (epoxy matrix) and kapok fiber (Reinforcement) and to study its structural and electrical properties. This study is concerned to investigate the percentage of crystallinity, surface structure, dielectric constant, dielectric loss and resistivity.

**Key words:** Natural fiber, kapok, composites, properties, dielectric loss

**INTRODUCTION**

The United Nations Food and Agriculture Organization (FAO) declared the year 2009 as the International year of Natural Fibers (WHO, 2009). Because with the increase the demands of the renewable resources for consumer product, the biodegradable material is highly preferred. Advantages over the synthetic and the man-made fibers are low cost, low density, specific mechanical strength, sustainability, totally biodegradable, recyclability. Their production does not damage the ecosystem (Rout et al., 2001; Kalia et al., 2009).

In ancient years for any purposes iron was used because of the strong and stiffness and durable properties. At the same time manufacturing difficulties and the high cost leads to develop of new materials at low cost and same properties of iron with light weight. The new developed materials called composites. In all the fields composites are dominated over the steel. Because of their high strength and low weight with low cost. For the last two decades the composites, plastics, ceramics are dominated in the building blocks of materials. Particularly composites are already proved these are the weight saving material (Thomas and Pothan, 2008; Mayilsamy and Rajendran, 2010; Shabudeen et al., 2006).

Fiber reinforcement composite reached the higher stiffness and strength compare than the particle reinforcement composite. Fibers are small cross dimensional so they are directly used in the engineering applications. They are embedded a matrix to form fibrous composite. Composites can differ in the amount of the fiber, fiber type, fiber length, fiber orientation. Fibers are much more mechanically effective than particles. The polymer fiber composite can reach stiffer and strength comparable to the polymer particle reinforced composites is higher. The particle reinforced composites are isotropic and the fiber reinforced composites are anisotropic. Fiber composites strengthening materials have higher ultimate strength and lower density than steel. The lower weight makes handling and installation significantly easier than steel (Pickering, 2008; Mwaikambo and Bisanda, 1999).

The binominal name of this kapok fiber is the *Ceiba pentandra* and it is under the family of Bombacaceae. The kapok fiber is the lightest natural fiber in the world (Mwaikambo and Ansell, 2002; Miwot et al., 2009). This fiber is eight times lighter than the cotton. It is also in the name of silk java cotton, java kapok. The fiber has the very thin wall and a huge hollow region full of air. Compare to the cotton fiber it has the lower content of the cellulose and the higher content of the lignin. This is also

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known as the silk cotton because its natural lustres similarly to the pure silk. The present study includes the processing, characterization of kapok fiber reinforced epoxy composites (Joseph and Thomas, 2008; Cui and Wang, 2009; Paul and Thomas, 1997).

MATERIALS AND METHODS

Collection of fibers: Kapok pods were collected from the NIT Rourkela campus. First broke the kapok pods and separate the fibers, seeds and cover. The investigation is the characterization of the kapok fibers and its composites. So the unwanted things like the kapok seeds and covers were neglected. The fibers were entangled and they were separated by hands.

Processing of fibers: The extractor apparatus consists the round bottom flask, big glass vessel, condenser tube with continuous cooling arrangement, heater, variator. The flask contains the tube is attached to the flask. The flask is placed on the big glass vessel contains of water. The glass vessel was heated by the using of heater and the temperature maintained by the help of variator. The solvent is heated and reflux. The condenser tube has the continuous water circulation; it condensed the vapour into liquid back. After particular time the heating will be stopped and the cooling process was started. The same procedure follows as the many cycles. This process is partially removes the wax and other impurities. This process is called "dewaxing" (Mwaikambo, 2005; Mwaikambo and Ansell, 2002).

In the present study, the extractor solvent is the 1:2 percent of the alcohol and benzene taken in the round bottom flask. The kapok fibers are placed inside the flask and heated using heater, maintained at 65°C for 2 h and then heating was stopped. The cooling process was started for after 2 h. The same procedure follows as the three cycles approximately the full processing time is around 12 h. At last the solvents are decanted. The fibers were washed with distilled water and dried in oven at a temperature of 110°C unless the fiber will be constant.

Composite preparation: In the present study to make two composites one is the raw fiber composites and another one is dewaxed fiber composites. The fibers are taken and cut into small pieces and grind by agate mortar. And the grinded fibers are dried in oven at 50°C for 1 h.

The randomly oriented Kapok Fiber Reinforced Epoxy Resin (KREBC) had been made with the ratio of fiber to resin 10:90. And the 10% weight of the resin added as the hardener. Decided amount of the fiber, epoxy resin, hardener are mixed manually till the homogeneous mixture is formed. Then they poured into the wax coated glass tube. Care had been taken to avoid air bubbles. It was left for curing for 24 h at room temperature around 30°C. Then the composites recovers by breaking the glass tube and the same procedure was followed as the dewaxed fiber to prepare the composites. The structure of fibers and the composites were characterized by using X-ray Diffraction (XRD, PANalytical PW 1830), Scanning Electron Microscope (SEM, JEOL JSM-6480LV). And the electrical properties of composites (HICKI-3532-50 LCR HITESTER) also studied.

RESULTS AND DISCUSSION

Structural studies: The X-ray diffractograms of raw kapok powder and dewaxed kapok powder have been recorded and shown in the Fig. 1. The 2θ values with respect to their consideration for estimation of XRD crystallinity. The diffraction intensities were recorded between 10-60 degrees The degree of crystallinity was determined using the formula:

\[ \text{Crystallinity} = \frac{\text{Area of the crystalline peak}}{\text{Total area}} \times 100\% \]

At peak intensity 2θ angle 22 degree represents the crystalline material and at peak intensity 2θ angle 11 degree represents the amorphous material. The crystallinity percentage of raw fiber is the 54% and the dewaxed fiber is the 63%. The degree of crystallinity percentage was increased for the dewaxed fibers which may be due to regular arrangement in fibers because of the removal of the wax and impurities (Liu and Wang, 2009).

![Fig. 1: XRD pattern of kapok raw and dewaxed powders](image-url)
Morphological studies: As can be seen from the microphotography of the both raw and dewaxed kapok fiber had the appearance of the hollow fibers are broken during grinding. And also the particle shape and size are not uniform because the fibers are properly ground. Roughness of the fiber is increased after dewaxing. Figure 2a-b shows the morphological structure of the raw fiber and the dewaxed fiber, respectively. Figure 2c-d shows morphological structure of the raw fiber composites and dewaxed fiber composites. In the raw fiber composite, the fibers are not properly ground so the hollow fibers are not broken. After dewaxing the grinding was very easy so it get well united to the epoxy resin clearly shown in the Fig. 2. The homogeneity is in the dewaxed fiber composite. The surface is rough for both composites along with some empty spaces. More volume of empty spaces in dewaxed composites compare to the raw fiber composite (Kang et al., 2007; Chung et al., 2009).

Electrical properties: The dielectric constant of raw fiber composite and dewaxed fiber composite as shown in Fig. 3a-b. The dielectric constant was depends upon the polarizability of the material. The polarization occurs due to the present of the material. The dielectric constant of the composite material depends on the interfacial, atomic, electronic and dipole polarizations. The interfacial polarizability arises due to the heterogeneity which is higher for lower frequency. Epoxy is a non-polar molecule. At low frequencies the complete orientation will be possible and the high frequency the orientation is not possible. If the polarizability will be high that dielectric constant will also high. The dielectric constant was decreased with increasing frequency.

The various dielectric parameters are taken out from the LCR meter. The important data are required to calculate the dielectric constant, dielectric loss and resistance. The range selected from the frequency of 100 Hz-1 MHz at room temperature.

The dielectric constant $\varepsilon'$ was calculated from the expression:

$$\varepsilon' = \frac{Cd}{\varepsilon_0A}$$

where, $C$ is the capacitance, $A$ is the area of the sample, $D$ is the thickness of the sample and $\varepsilon_0$ is the electric permittivity in the vacuum ($8.854 \times 10^{-12}$).

At low frequencies the dielectric loss is high and the high frequency the reverse behaviour is observed.
**Resistance**: Resistance of the Raw and Dewaxed fibre has measured using the Hioki LCR meter at the room temperature in the frequency range from 100 Hz-1 MHz for raw fiber composite and dewaxed fiber composite as shown in Fig. 3c-d. The resistance of the material depends on the moisture content, crystalline and amorphous regions, presence of impurities. In the raw fiber composites have the low resistivity compare than the dewaxed fiber composites. The resistance of the dewaxed composite is high it may be due to the removing impurities and wax substances during the process of dewaxing.

In raw fiber composites the resistance is gradually decreasing with increasing the frequency and in dewaxed fibre composites shows high resistance compared with raw fibre composites, these results also correlating with the dielectric constant for various frequencies at room temperature. The saturation of resistance in the high frequency may be due to dipoles being able to no longer follow the field. The saturation resistance in raw fiber composite high frequency compare to that of dewaxed fiber composite.

**CONCLUSION**

Successfully fabricated the raw kapok fiber reinforced epoxy composite and dewaxed kapok fiber reinforced epoxy composite. The crystallinity percentage of the dewaxed fiber powder was increased compare than the raw fiber powder. The crystallinity percentage was increased which may be due to the removing impurities and wax substances during dewaxing. In morphological study the roughness of the surface is increased for dewaxing powder compare than the raw fiber powder. In kapok fiber reinforced composites the kapok
fibers are embedded with epoxy resin along with some empty spaces. The dielectric constant and dielectric loss values decreased with increasing frequency for both composites. The resistance of the raw fiber composite is lower than the resistance of the dewaxed fiber composite.

REFERENCES


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