

Study of physical and sound absorbing property of epoxy blended coir dust biocomposite

G Nath and S P Mishra

Department of Physics, Veer Surendra Sai University of Technology, Burla, Sambalpur, Odisha, India

Email: ganesh_nath99@yahoo.co.in

Abstract. Reinforcement biocomposite has gained more attention recently due to its low cost, abundantly availability, low density, specific properties, easy method of separation, enhanced energy recovery, CO₂ neutrality, biodegradability and recyclable in nature. As a waste product of coconut fruit, the coconut coir dust (CCD) obtained from the coconut husk. The biocomposite material prepared from the CCD modified with the proper blended solution with the help of ultrasonic technique. The study of adiabatic compressibility of acetone / water (70/30) worth its blending property for bleaching of CCD. The biocomposite material of CCD was prepared with epoxy resin. The different physical properties such as sound absorption coefficient, thermal conductivity and electrical conductivity were measured. The morphological study of biocomposite and measurement of sound absorption coefficient shows good evidence of sound absorbing characteristics of biocomposite of CCD. The sound absorption property of composite material shows a significant result where as the thermal conductivity and electrical conductivity executes a weak result. Thus biocomposite of CCD can acts as a good sound absorber and band conductor of heat and electric current.

Key word: Coconut coir dust (CCD), blended solution, ultrasonic wave, intermolecular interaction, sound absorption coefficient, thermal conductivity, electrical conductivity

1. Introduction

Technological advancement of world has come forward for utilization of different type of agricultural waste product from different agricultural sources like bagasse, paddy, wheat, straw, husk, waste vegetables, food products, oil production, jute fibre, groundnut shell wooden mill waste, coconut husk, cotton stalk etc. The utilization of different kind of waste products from agricultural sector now appears as a new material called biocomposite. The biocomposite have enormous properties like acoustic, electrical, thermal and dielectric which creates more interest in different industries, economical development of country, new technical applications for material engineering and its proper implementation in different fields where it needs. As weight saving material the composite has already proven its importance in the modern day for day to day applications. The lingo cellulosic nature of natural fiber composites gaining its importance due to its non carcinogenic and biodegradable nature. The composites made from natural fiber are very cost effective material especially in building and construction purpose packaging, automobile and railway coach interiors and storage devices. Coir is a



natural fibre extracted from the husk of Coconut fruit [1,2]. The husk consists of Coir fibre and a corky tissue called pith. Due to more lignin content the coir is considered as more durable compared to other natural fibres. With increasing emphasis on fuel efficiency, natural fibres such as coir based composites enjoying wider applications in automobiles and railway coaches and buses for public transport system. The durable nature and light weight of natural fiber like coir based composite has wider application in automobiles and railway coaches and buses for public transport system has requires less emphasis on fuel efficiency. On looking to the scenario of different industry, building construction materials, different components of vehicle industries, the biocomposite was prepared from coconut coir dust which has significant physical properties [3-5] and has wide applications. The different experiments has been performed for preparation of the biocomposite like ultrasonic measurement has been done to study the compatibility of solvent mixture used for bleaching of the dries coconut coir. The results of thermal conductivity, electrical conductivity and sound absorption coefficient have shows a significant results for supporting of coconut coir dust biocomposite can be acts as good thermal and electrical insulator as well as good sound absorber.

2. Material and method

The coconut husk are collected from the ripe and matured coconut fruit which are in the last stage of coconut fruit. These husk were allowed to dried in sunlight for 4-6 days. The dried husk are stored in a polythene. The collected husk is now converted into small pieces in to average length of 9-10 cm cutting by the scissor. The compatible solvent mixture of acetone and water was prepared (70/30) with the help of ultrasonic interferometric technique. The small pieces of coconut husks are bleached with the compatible solvent system of acetone/water (70/30) to remove the impurities present on the surface of the small husk. It was air-dried for 24 hours and in an oven at 60°C to constant weight. The small pieces of coir are now grinded through the grinder. The dried coir dust was separated into different particle size of 150µm with test sieve method and stored in air-tight lid containers. A handmade metallic mould is designed of diameter 29 mm, for the fabrication of bleached fiber-reinforced epoxy composite as shown in Figure 1. For fabrication of the composite, a metallic mould was taken and its bottom was spread by a plastic releasing agent and silicon spray is applied to the plastic sheet so that the composite plate can be removed easily. By weight proportion of 10:1 ratio the coconut powder and epoxy are mixed together and stirrer for 30minutes to form a uniform matrix. The air bubbles and avoided by pressing the matrix poured over the fibers. Lastly, to remove excess matrix load is given to it and left for curing at room temperature for 24 h.

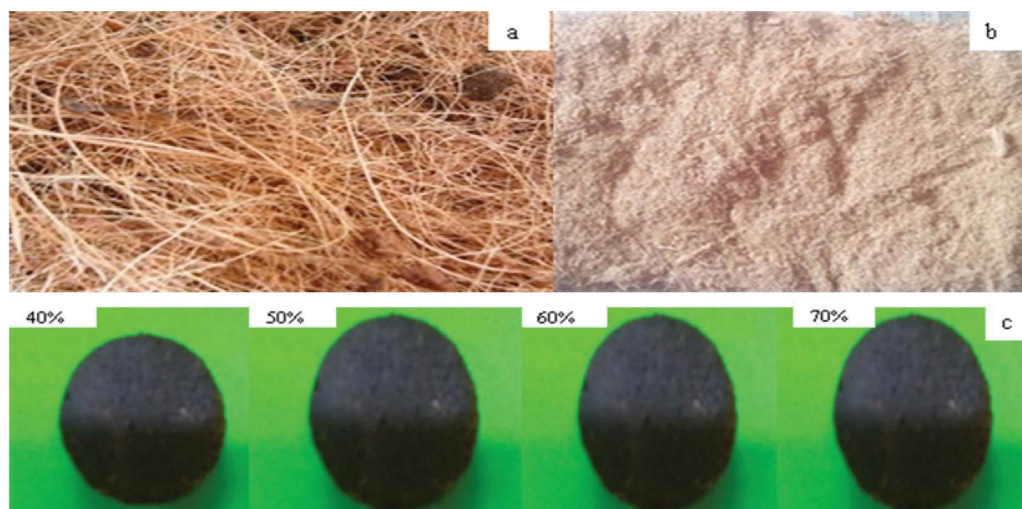


Figure 1. (a) Bleached coir in sunlight, (b) grinded coir fibre, (c) composites of CCD with epoxy

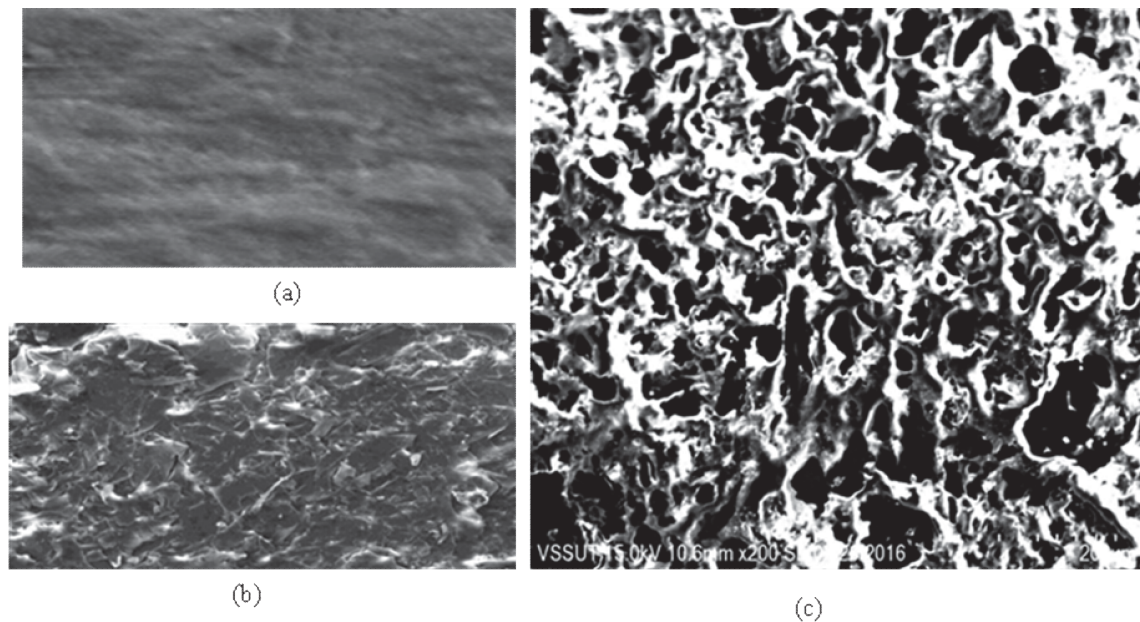


Figure 2. (a) and (b) SEM of surface of biocomposite (c) EDS of biocomposite

3. SEM analysis of biocomposite

The surface morphology of biocomposite was examined with HITACHI SU 3500 Scanning Electron Microscope. Scanning electron micrographs are shown in the Figure 2. Some amount of inter particle void spaces are present and the particles are multifaceted type.

4. Experimental arrangement

A multi-frequency ultrasonic interferometer (2MHz) was used to measure the ultrasonic velocity in the blended solution of acetone and water (Mittal Enterprises, New Delhi, Model-MX-3) within accuracy of $\pm 0.01 \text{ ms}^{-1}$. The velocity of the ultrasonic wave through the blended medium can be determined by accurate measurement of the wavelength of the ultrasonic wave produced at a known frequency of quartz crystal in the measuring cell [6]. A water circulating bath was used to maintain the temperature of the solution at a desired temperature through the jacket of double walled cell within $\pm 0.01 \text{ K}$ using a constant temperature bath and the temperature was monitored with a platinum resistance thermometer with an accuracy of $\pm 0.001 \text{ K}$.

$$\text{Ultrasonic velocity: } C = f\lambda \quad (1)$$

$$\text{Compressibility: } \beta = \frac{1}{\rho C^2} \quad (2)$$

and the excess value can be determined as

$$\beta^E = \beta_{\text{mix}} - (X_A \beta_A + X_B \beta_B) \quad (3)$$

where X_A , X_B , β_A , β_B and β_{mix} are mole fraction, isentropic compressibility of acetone, water and mixture respectively.

For measurement of resistance and conductivity, electric current was measured through the composite in the experimental arrangement as shown in Figure 3. A 12 Volt battery is connected to supply the power in the circuit. The resistivity of the sample was calculated as

$$\rho = R \frac{A}{L} \quad (4)$$

where R, L and A be the resistance, length and area of cross section of the sample of the material
Now the conductivity of the sample is calculated using the relation:

$$\sigma = \frac{1}{\rho} = \frac{L}{RA} \quad (5)$$

The thermal conductivity of the composite materials was calculated for each composition with the help of Lee's method using the relation

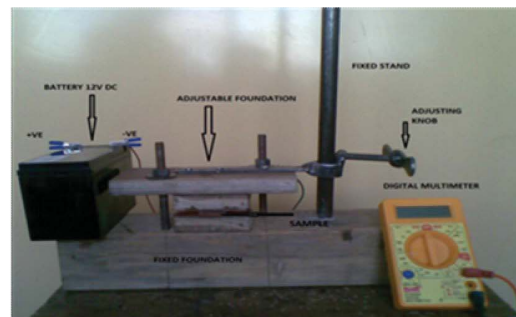
$$K = \frac{msd}{A(\theta_1 - \theta_2)} \frac{d\theta}{dt} \quad (6)$$

where m is the mass, s is the specific heat of the material of the disk, d and A be the thickness area of the sample.

The sound absorption coefficient was performed using impedance tube kit measurement method as shown in figure. The impedance tube device set comprises the low and high frequency tubes with samples holders, loudspeakers case and audio amplifier, two microphones and supply sets. The small tube (high frequency) can be used as stand alone with its own loudspeaker case, or alternatively be mounted on the bigger one (low frequency). The microphones are connected to the PC, which also includes a random noise generator. A user friendly software (SCS8100) interface guides the user through the measurement and the store and print operations of the results.



(a)



(b)



(c)



(d)

Figure 3.(a) For measurement of ultrasonic velocity, (b) electrical conductivity, (c)thermal conductivity and (d) noise absorption coefficient

5. Result and discussions

The computed values of density of the acetone / water mixture and measured values of ultrasonic velocity in the binary mixture are used to calculate the isentropic compressibility and its deviated values. The deviated values are found to be negative for the entire mole fraction of mixture of acetone and water as shown in Figure 4. The negative values of excess isentropic compressibility indicates that the liquid mixture is less compressible than the pure liquids forming the solution and molecules in the mixture are more tightly bound than in pure liquids[7].

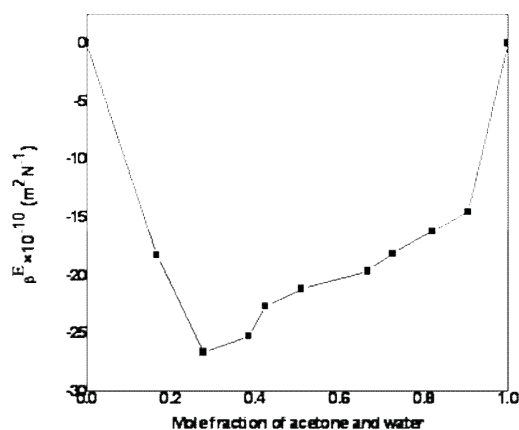


Figure 4. Variation of isentropic compressibility with blended of acetone /water mixture

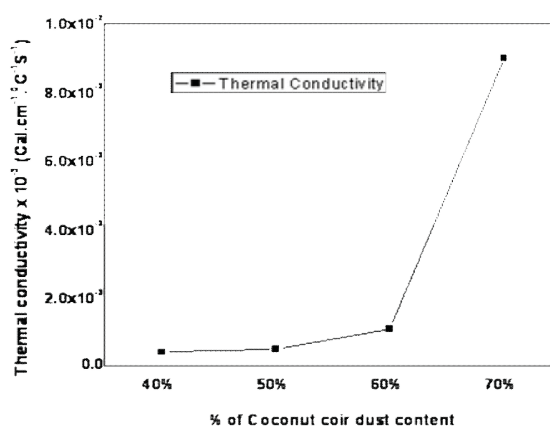


Figure 5. Variation of thermal conductivity with CCD

Thus negative values of excess isentropic compressibility indicate strong specific interactions between component molecules and interstitial accommodation of smaller molecules in the void created by bigger molecules. The negative excess isentropic compressibility results reduction of volume of mixture favouring the fitting of component molecules in to each other. Thus, the solvent mixture of acetone/water (70/30) gives best result for treatment of coconut coir for biocomposite.

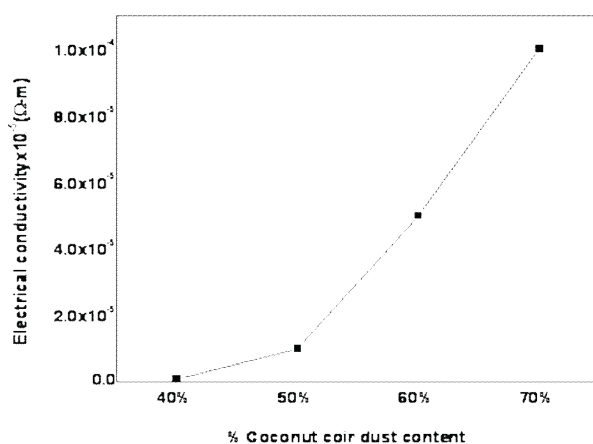


Figure 6. Variation of electrical conductivity with CCD

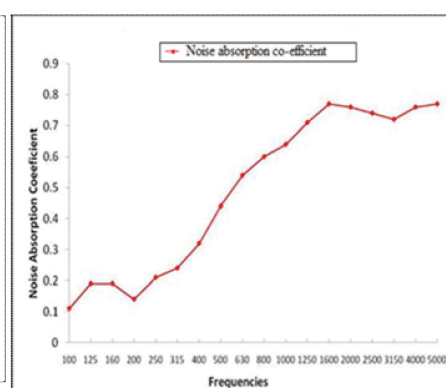


Figure 7. Variation of noise absorption with frequency

Electrical conductivity of a sample gives an insight into the macroscopic properties of the material related to its ability to the extent to which it can conduct electricity or behave as an insulator. The

thermal conductivity as well as electrical conductivity increases with increase of content of CCD as shown in Figure 5 and Figure 6. This may be attributed due to fact that ion exchange characteristics of coconut coir dust with polymer chain of epoxy resin molecule [8,9]. This increasing trend of thermal and electrical conductivity is very small of the order of 10^{-3} and 10^{-5} respectively for which this biocomposite material can be acts as thermal and electrical insulator in various electrical circuits while those having higher value of conductivity can be used at points where there is a requirement of a good conducting material together with having high strength. The noise absorption coefficient of CCD increases with increase of frequency as shown in Figure 7 which is the same result as that obtained in the literature [10]. This may attributed due to fact that the randomly oriented polymer chain of epoxy molecule with CCD molecules absorbs the sound energy. The morphology of the composites clearly indicates that the roughness of the surface is very high so that it can absorb any sound energy incident on it as shown in Figures 2 a and 2 b. The SEM structure of ECD as shown in Figure 2 c shows that if any sound energy travels through the material it loses its energy and the material can act as like a black body. As a result with increase of frequency of sound energy the absorption of sound energy goes on increasing [11-13]. The optimum value is 0.77 for the frequencies of 1600 Hz and 5000 Hz. It gives a good absorption coefficient for the frequencies higher than 1250 Hz with around 0.7. For the lower frequencies (less than 400 Hz) the coefficient are lower.

6. Conclusion

The negative increase of isentropic compressibility confirms that the acetone/water (70/30) is the best solvent mixture for bleaching of the coconut husk. This result confirms the proposed solvent mixture has good impact on formation of biocomposite from natural fibre. The weak results of thermal and electrical conductivity confirm that the biocomposite made from CCD with epoxy resin can be used as insulator in electrical circuit as well as thermal insulation. The CCD biocomposite shows a good sound absorbing property for which it can be used as sound absorbing material for building architecture.

7. Acknowledgement

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