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Study of Thermal Conductivity and Hardness of Coir Fiber Reinforced Epoxy Composite

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Abstract

Researchers are drawn to polymer reinforced natural fibers composite for the development of new materials. The research aims to use waste fibers, specifically coir, to create polymer composite materials. Thermal conductivity and hardness of the composite results are determined under various conditions. Coir fiber is used as the reinforcement material and Coir powder is used as the filler material in the study. In the case of the matrix, the epoxy resin used in the study is taken. For the desired properties, variations in fiber concentration and in the matrix filler were observed. The hand layup technique is employed to produce the composite material. Fibers are cut to the necessary dimensions and combined with epoxy to create the composite. The size of the fiber also varies to understand the impact of fiber size on properties, it was found that the increase in thermal conductivity and the hardness of the matrix for the same length coir fiber and the increase in percentage of filler under the given conditions. The hardness and thermal conductivity of the composite are found to be barely affected by changes in the length of the coir fiber in the matrix. The thermal conductivity values for 5% coir fiber, 5% coir powder, and a fiber length of 20 mm are 0.218, 0.219, and 0.224 W/mK, respectively. The hardness values for 5% coir fiber, 5% coir powder, and a fiber length of 20 mm are 45.2, 59.2, and 80 W/mK, respectively.

Keywords: Natural fiber, coir fiber, epoxy, property, composite material

INTRODUCTION

Natural fibers offer a range of benefits that make them attractive for various engineering applications. Their low cost, eco-friendliness, and abundance contribute to their popularity. Additionally, the ability to adjust filler concentration allows for customization to suit specific requirements, offering versatility in engineering designs. Moreover, repurposing waste materials, such as plant and agricultural fibers, not only reduces environmental impact but also maximizes resource utilization, aligning with sustainable practices. That sounds like a comprehensive research project aimed at exploring the thermal properties and feasibility of natural fiber polymer composites for various applications. Studying thermal conductivity and hardness at different concentrations of coir or coir powder for a fixed fiber length allows for understanding how varying the filler content affects these properties. Additionally, investigating the effect of varying fiber lengths provides insights into the role of reinforcement in the composite structure. Overall, this research could contribute valuable information on optimizing natural fiber polymer composites for thermal applications, potentially leading to the development of cost-effective, environmentally friendly materials with tailored properties to meet specific engineering needs.

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LITERATURE REVIEW

Numerous scholars recommended using natural fiber reinforced polymer composite materials in the literature. Coir fiber and powder have been investigated in recent years for a variety of uses. It offers two advantages: it is easily accessible in nearby locations and it maximizes trash utilization. Because epoxy can form a strong bind with natural fibers, it has been the material of choice for matrix for the past few decades. Both thermoplastic and thermosetting natural fiber polymer composite materials' mechanical and thermal characteristics are given after chemical treatment. After treatment, the properties are improved because of improved bonding. [1]. Bio-fillers play a major role in environmental preservation as well as the production of inexpensive composites. Tensile strength and modulus are enhanced when leftover peanut shell powder is used to reinforce epoxy resin. The reason for this is the stronger bond between the resin and filler. [2]. The tribological behavior of natural fiber reinforced polymer composites is reviewed and discussed in the literature, where it is claimed that treated and normally oriented fibers have superior wear and friction properties. The underlying theory is that treating a fiber's surface enhances the adherence of the fiber to the matrix [3]. In the literature, two processing methods other than the manual layup procedure were covered [4]. In the literature, important factors that impact a composite's mechanical properties—such as fiber orientation and/or matrix choice are covered [5]. Thermal conductivity, hardness, and stiffness of epoxy resin are all enhanced by the inclusion of groundnut shell filler. These filled composites have a wide range of non-structural applications [6]. The experiment was conducted to determine the hardness of a composite made of coir epoxy at various fiber fractions in the matrix. It has been discovered that adding coir fibers to the epoxy matrix boosts the hardness value [7]. The literature discusses thermal conductivity models and suggests using them to approximate the prediction of polymer composites [8]. Applications of natural fiber-based polymer composites are investigated in the literature for a range of uses with appropriate fiber treatment techniques [9]. The main elements such as coupling agents and fiber geometry that influence the mechanical properties of composites made of natural fibers are covered. [10]. In-depth research and applications of natural fibers as insulating materials are covered in the literature [11, 13]. Natural versus synthetic fibers are discussed in the industrial development of thermal acoustic zones, and reports [14, 15]. The main elements influencing the thermal characteristics of natural fibers are examined. [16]. The literature contains considerable information about fiber changes, particularly for coir fiber [12]. The samples are manufactured and evaluated for hardness and thermal conductivity based on the review that was previously mentioned. The literature indicates that there has been limited research conducted to investigate the potential of using waste fibers, such as coir, to create appropriate materials for various applications.

MATERIALS AND METHODS

In this work, samples with varied ratios of fibers and fillers in the matrix are prepared using coir fiber and coir filler combined with epoxy matrix. The composites are made via hand layup techniques. In this technique, cylindrical molds are utilized for the preparation of samples. Epoxy and hardener are mixed in the appropriate proportions according to the material data sheet provided by the supplier. After being gathered from nearby resources, fibers are chopped to the desired 10, 15, and 20 mm size. Coir powder, which is used as filler, is created by grinding fibers to a 100 µ size. Coir fibers and coir powder are incorporated into the resin and hand-stirred for two minutes to ensure proper mixing, after which they are set aside for curing. The curing duration for the samples is 24 hours at room temperature. Once adequately cured, the samples are cut into the desired shapes and thicknesses for testing and measurement as per ASTM standard. The samples that were prepared are illustrated in Figure 1. Figure 2 displays the setup used for measuring thermal conductivity. Figure 3 features the raw material, which is coir fiber in desired shape.

RESULTS AND DISCUSSION

The following conditions are used to the testing of the manufactured fiber-reinforced polymer composite samples, and the results are plotted:

Figure 1. Sample prepared for testing.

Figure 2. Set up for thermal conductivity measurement. **Figure 3.** Coir fiber after cutting in desired length

Case 1: Variation of Thermal Conductivity In Samples Under Different Conditions

Figure 4 shows the fluctuation in thermal conductivity with the proportion of fiber in epoxy for a fixed fiber length of 10 mm. The fiber distribution in the matrix is arbitrary. In comparison to pure epoxy, the composite's thermal conductivity increases slightly with the addition of fiber to the matrix. Thermal properties are very little affected by the change, and they stay the same between 1% and 5%. Since coir fiber has a lower thermal conductivity, there are no significant changes observed. Figure 5 illustrates the fluctuation in heat conductivity for epoxy filler with 100 micronparticle size made of coir powder. It has been discovered that adding coir powder filler enhances the qualities. Figure 6 displays how the length of the fiber in the epoxy varies in terms of thermal conductivity for fiber sizes of 10 mm, 15 mm, and 20 mm. The graph indicates that there is a little decrease in sample thermal conductivity over 10 mm fiber size.

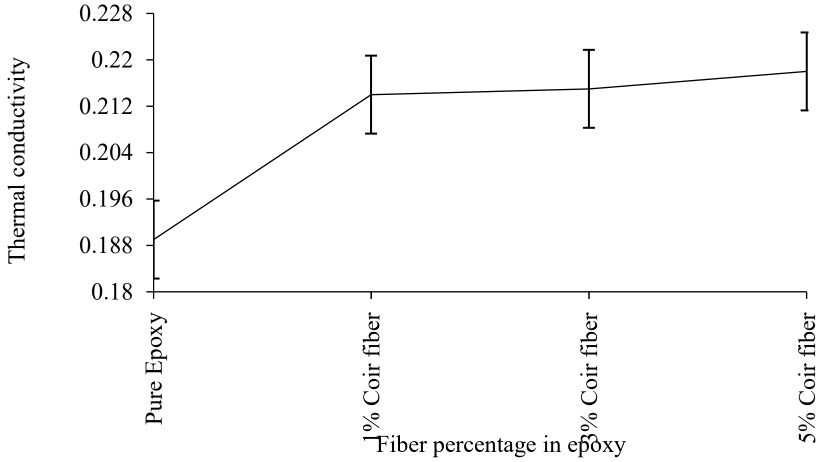

Figure 4. Variation of thermal conductivity (W/mk) with percentage of fiber in epoxy. (10 mm fiber length).

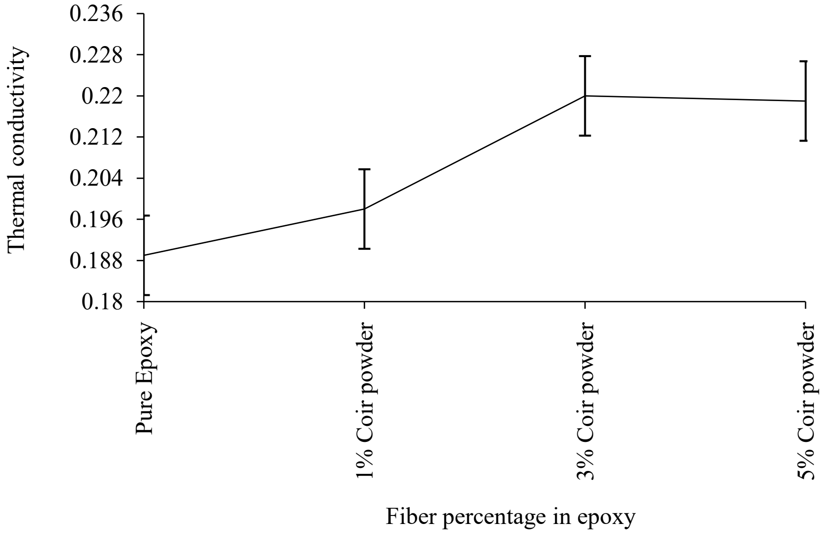

Figure 5. Variation of thermal conductivity (W/mk) with percentage of coir powder in epoxy (100 micron).

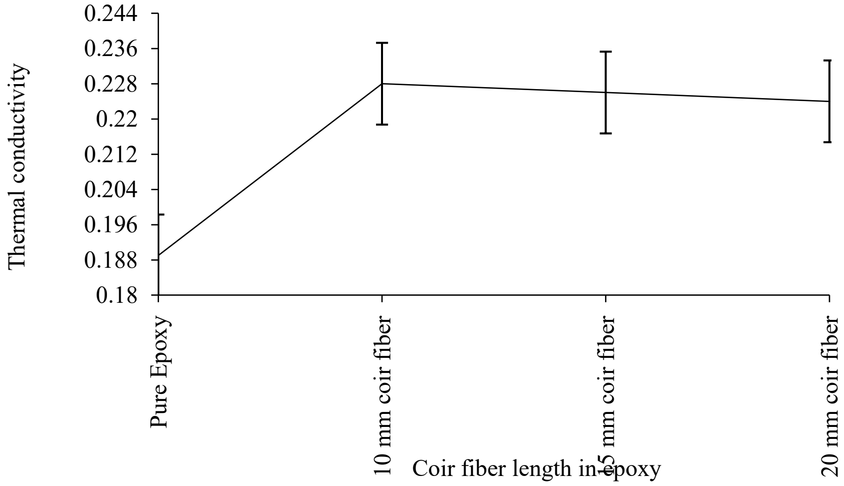

Figure 6. Variation of thermal conductivity (W/mk) with length of fiber in epoxy (10mm, 15mm & 20 mm).

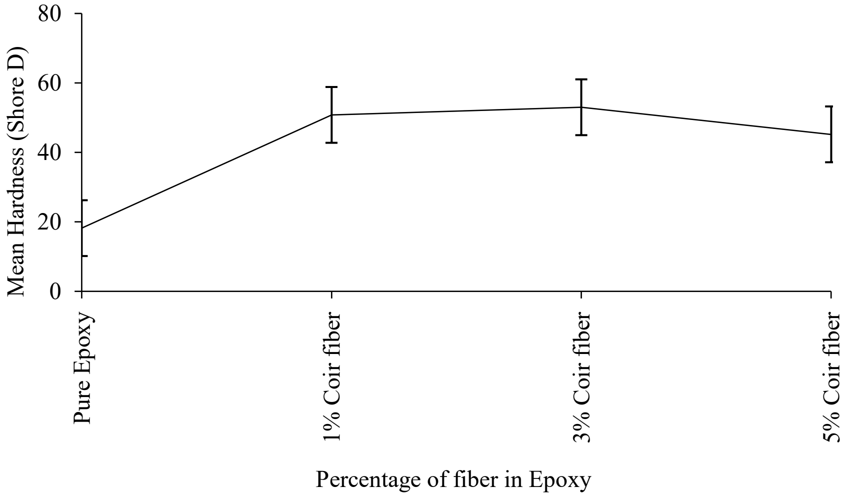

Figure 7. Variation of Hardness with percentage of fiber in Epoxy (10mm fiber length).

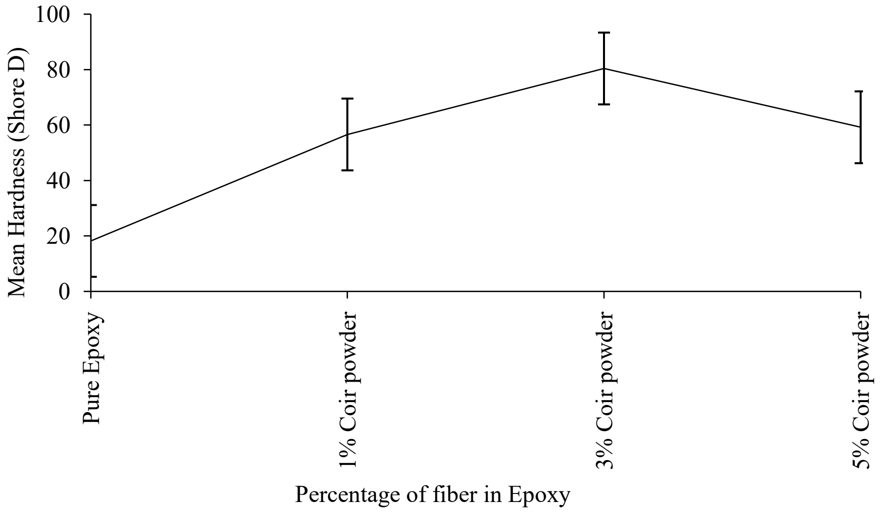

Figure 8. Variation of Hardness with percentage of coir powder in Epoxy (100 micron).

Case 2: Variation of Hardness in Samples Under Different Conditions

For a 10 mm fiber length, Figure 7 illustrates how hardness varies with the proportion of fiber in epoxy. In comparison to pure epoxy, the hardness trend increases, with a little decrement observed after 3% of coir fiber was added to the composite. Adding fiber improves structural bonding between matrix and fiber, and thus the surface properties are improved as a result. The fluctuation in hardness with the proportion of coir powder in epoxy is shown in Figure 8. According to the pattern, properties should increase by 3% before declining. Figure 9 shows how the hardness varies for coir fiber lengths of 10 mm, 15 mm, and 20 mm in epoxy. When compared to pure epoxy, the hardness value increases and then has little to no effect on hardness as fiber length size increases.

CONCLUSION AND FUTURE SCOPE

The thermal characteristics and hardness of the epoxy composite reinforced with coir fiber and coir filler were noted. This study explores the possibility of reusing coir fiber and filler waste to produce polymer composites for suitable applications, such as packaging in the electronic industry, to produce affordable, eco-friendly materials with customized qualities to satisfy certain technical requirements. Additionally, the experiment verifies that coir fiber and coir powder are compatible with epoxy for sample preparation.

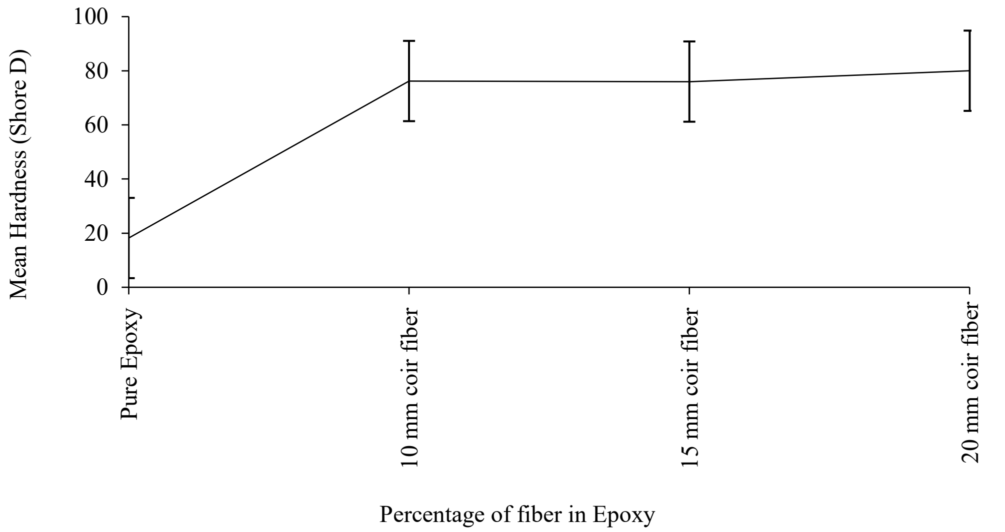

Figure 9. Variation of Hardness with length of coir fiber in Epoxy (10mm, 15mm & 20mm).

The main area of investigation was the concentration of coir fiber and filler in the matrix and how it affected hardness and thermal conductivity. This paper assesses how the length of the fiber affects the qualities. Samples are prepared and tested in conventional procedures. The following observations are noted:

1. Successfully developing polymer composites reinforced with coir fiber and filler at different fiber and filler concentrations.
2. For the same fiber lengths (10mm)for both coir fiber and coir filler composites, resultsshows thatslightly increase in thermal conductivity and hardness as the fiber concentration rises from 1 to 5%.
3. The thermal conductivity and hardness of the composite are little affected by the length of the coir fiber in the matrix.

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