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Mechanical Properties of Plants - Synthetic Hybrid Fibers Composites

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Abstract

In this paper, mechanical properties of composites reinforced with hybrid Palms - Kevlar fibers were evaluated. The incorporation of both fibers into a single matrix which is epoxy resin will stabilize mechanical properties. Impact strength, tensile strength, flexural strength and hardness were studied for composite material reinforced with hybrid fibers for Palms and Kevlar as a woven roving. These fibers were mixed with epoxy resin LY 556 in different reinforcement percentage (10%, 20%, 30%, 40%, 50%, 60%, 70%, and 80%) and the effect on the above mechanical properties was studied. It has shown an enhancement in these mechanical properties after reinforcement by fibers the value of mechanical properties will increase with increasing percentage of reinforcement.

Keywords: Plants – synthetic fibers, composites, mechanical properties.

Introduction

The evolutionary history of plants means that the mechanical properties of their load-bearing elements, i.e. the plant fibres, are highly optimized with respect to the mechanical requirements of plants. Moreover, plant fibres themselves can be thought of as composite materials, but with a structure far more complex than any man-made composites[1]. Thus, in addition to the attractive mechanical properties of plant fibres, they might as well provide insight into form and function of a sophisticated composite material[2]. The use of plant fibres as reinforcement in composite materials is finding increasing interest in the automotive and building industry, and the properties of plant fiber composites have been addressed in numerous research studies[3]. Natural fibres have special advantage in comparison to synthetic fiber in that they are abundantly available, form a renewable resource and also biodegradable. Researchers also synthesize nano composites from plant based fibers[4].

A composite is a structural material that consists of two or more constituents that are combined at a macroscopic level and are not soluble in each other[5]. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix[6]. The composite material however, generally possesses characteristic properties, such as stiffness, strength, weight, high-temperature performance, corrosion resistance, hardness, and conductivity that are not possible with the individual components by themselves[7]. The mechanical properties of composite materials have a great important in the field of using these materials, where the values of these properties should be high and acceptable so it can do its duty successfully[8]. Hybrid composites involve two or more types of fibers set in a common matrix[3]. The particular combination of fibers is usually selected to balance strength and stiffness, provide dimensional stability, reduce cost, reduce weight, or improve fatigue and fracture resistance[9]. These materials can be used sufficiently in thermal systems to resist high temperatures comes from hot liquids and gases[10].

Methodology

Materials: There are three types of materials employed in this study: Epoxy resin LY 556 and the hardener HY 951, Palms fibers (as randomly matt) and Kevlar fibers (as woven roving fibers (0° - 45°) with surface density of (285 g/m^2)).

Composite samples Fabrication: Hybrid composite of palms- Kevlar fibers can be fabricated by the hand layup technique using laboratory compression moulding machine. Ultrasonic waves were used to clean palms fibers from husks and dirt. These types of fibers used as consecutive layers in same matrix with 50% Palms fibers and 50% Kevlar fibers. Four types of samples were manufactured as follows: Impact samples: The impact strength was determined using Izod Impact tester for un-notched samples conforming to (ASTM D 256) specification. Tensile strength samples: The standard dumb bell samples are cast according to (ASTM D 638). Flexural strength samples: these samples fabricated according to (ASTM-D790) standard as a rectangular shape (10 mm × 135 mm)[11]. Hardness samples: hardness specimens are a disc shape with (25mm) diameter and (10mm) thickness which fabricated according to (ASTM-D790) standard. Nine samples were manufactured for each tests which different by the resin and reinforcement percentage as shown in table-1.

Table-1
Structure of Samples

Samples number	1	2	3	4	5	6	7	8	9
Resin (Weight %)	100	90	80	70	60	50	40	30	20
Fibers (Weight %)	0	10	20	30	40	50	60	70	80

Determination of Mechanical properties of Composite: Izod impact tester for un-notched samples was used to evaluated impact strength. The universal test instrument manufactured by (ZheJinang TuGong Instrument Co., Ltd) was used to measure tensile strength with a (20KN) load. Flexural strength can be measured by three point test by using universal hydraulic press (Leybold Harris No. 36110) to calculate the maximum load exposed on middle of the sample. Brinell method was used to determined Hardness, this test made with a steel ball (5mm) diameter and (10kg) exposition load, loaded into specimens for (15sec) and universal test instrument manufactured by Uali Test Company (China) used for this test.

Tensile strength can be obtained from the following formula:

$$\sigma = P/A \quad (1)$$

Where: σ = tensile strength in Mpa, P = test load in N., A = cross section area of sample in m^2.

And flexural strength can be obtained from the following formula:

$$\sigma = \frac{3PS}{2bt^2} \quad (2)$$

Where: P= maximum load in N, S = dimension between loaded points in mm, b = sample width in mm, t =sample thickness in mm.

Results and Discussion

Figure-1 represents impact strength values of composite material vs. fibers reinforcing percentage. Generally, the impact resistance considered low to the resins due to brittleness of these materials, but after reinforcing it by fibers the impact resistance will be increased because the fibers will carry the maximum part of the impact energy which exposition on the composite material. All this will raise and improved this resistance. The impact resistance will continue to increase with increased of the fibers reinforcing percentage[12]. But when reinforcement reached to 70% the impact strength will decreased and this gradient in this property increased when reinforcement percentage becomes 80% due to low wettability between fibers and resin.

Figure-2 represents tensile strength of composite material vs. fibers reinforcing percentage. The resin considered as brittle materials where its tensile strength is very low as shown in this Figure, but when reinforcing by fibers this property will be improved greatly, where the fibers will withstand the maximum part of loads and by consequence will raise the strength of composite material[13]. The tensile strength will be increased as the fibers percentage addition increased, where these fibers will be distributed on large area in the resin[14]. even reinforcing by fibers will enhanced tensile strength, but when reinforcement reached to 70% like in impact strength, tensile strength will reduced and this decreasing will be higher when reinforcement percentage becomes 80% due to low wettability between fibers and resin as we mention and the fibers will extract fro resin easily.

Figure-3 shows the flexural strength results before and after reinforcing with fibers. As we seen from this figure the flexural strength of resin will be low before reinforcement because the brittleness of resin. But after added the fibers to this resin the flexural strength will be raised to the producing material because the high modulus of elasticity of these fibers will helps to carry a large amount of loads and raise this strength[15]. And when the reinforcing percentage 70% to 80% flexural strength will strongly decreased as we explain.

Figure-4 represents hardness values of composite material vs. fibers reinforcing percentage. Plastic materials have low hardness, therefore we observed in this figure the lowest hardness value for epoxy resin before reinforcement. But this hardness value will greatly increased when the resin reinforced by hybrid fibers, due to distribution the test load on fibers which decrease the penetration of test ball to the surface of composite material and by consequence raise the hardness of this material[14]. The hardness will be increased with increasing the percentage of fibers reinforcement. But hardness doesn't reduce when reinforcing by fibers increasing to70% and 80% because the samples don't sever from dynamic loads.

Conclusion

The addition of 50% palms fibers and 50% Kevlar fibers improves the tensile strength, flexural strength, impact strength , and hardness of epoxy resin LY 556, but when reinforcement percentage becomes 70% to 80% tensile strength, flexural strength, impact strength will decreased due to low wettability between fibers and resin and the fibers will extract from resin easily, whether, hardness don't reduced when reinforcing by fibers increasing to 70% and 80% because the samples don't sever from dynamic loads. The optimum ratio was 60% fibers with 40% resin.

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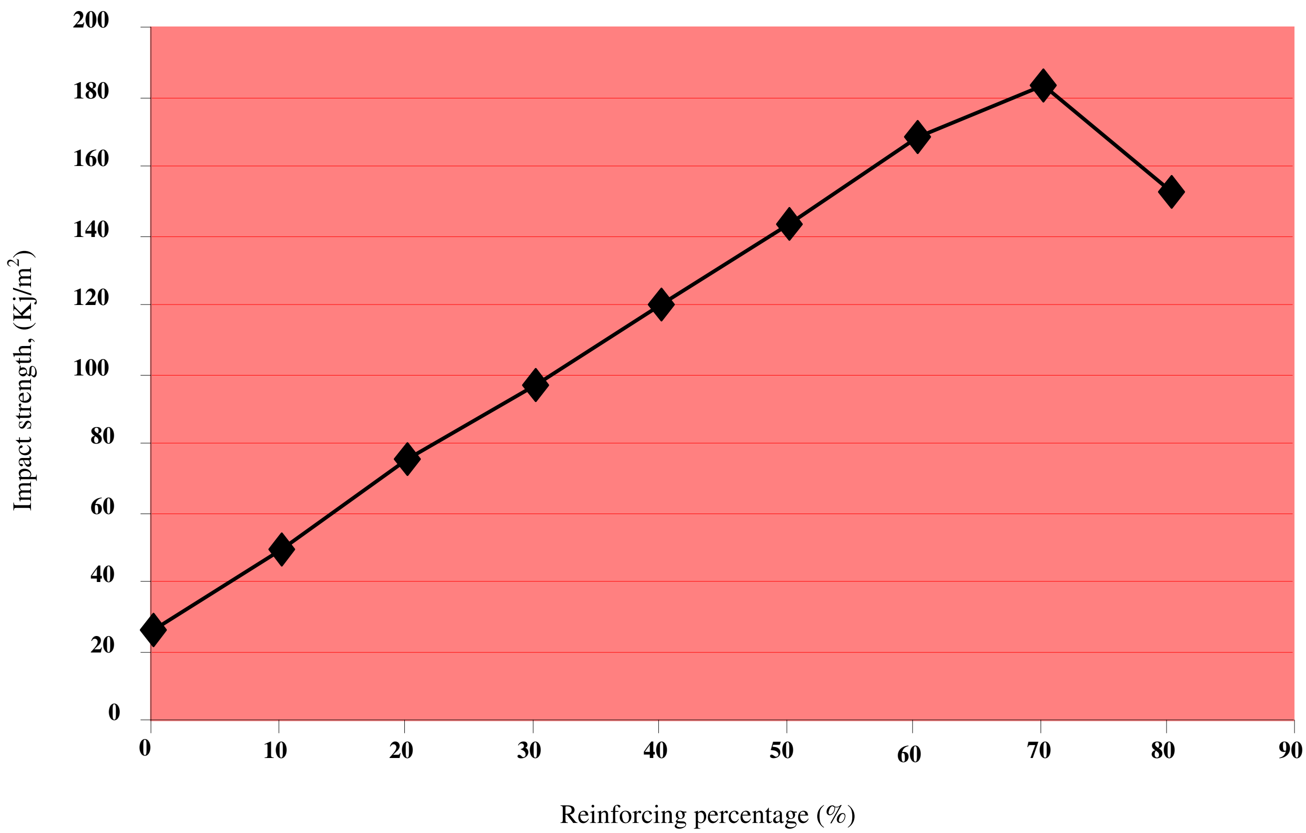

Figure-1
Impact strength values of composite material vs. fibers reinforcing percentage

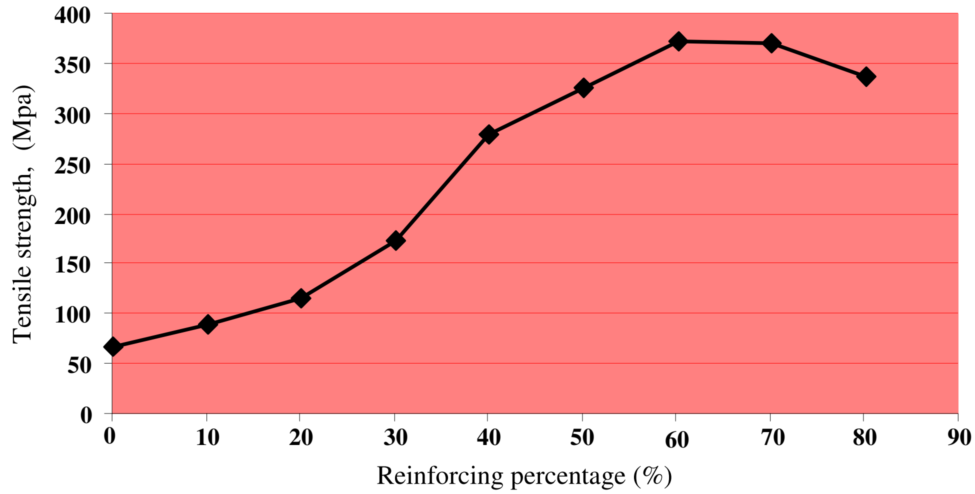

Figure-2
Tensile strength values of composite material vs. fibers reinforcing percentage

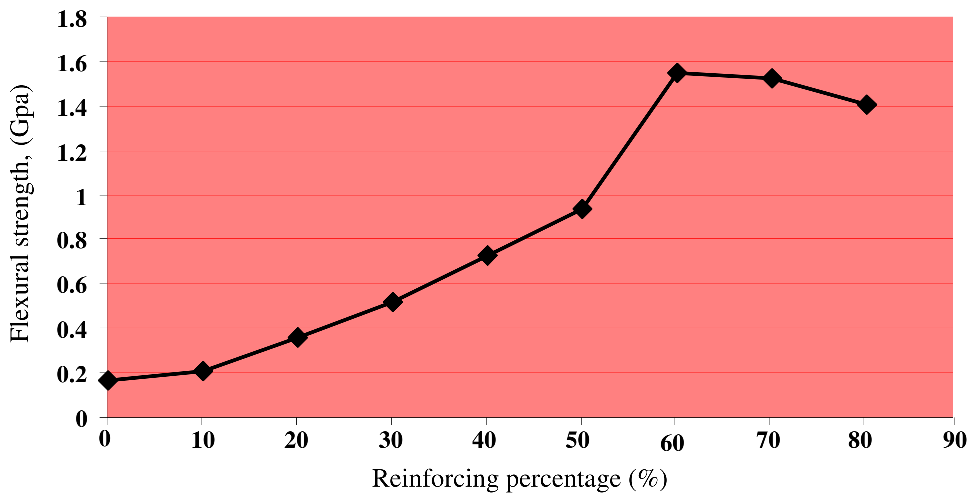

Figure-3
Flexural strength values of composite material vs. fibers reinforcing percentage

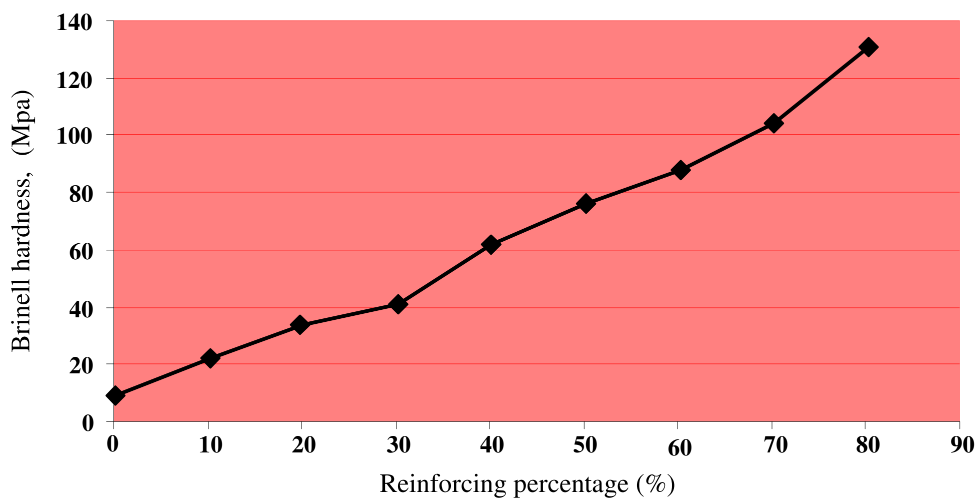

Figure-4
Hardness values of composite material vs fibers reinforcing percentage