Effect of Reinforcing by Palms-Carbon Hybrid Fibers on Mechanical Properties of Conbextra Epoxy EP-10 Resin

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Abstract

The objective of this research is to study the effect of reinforcing with different percentage (20%, 40%, and 60%) of hybrid palms-carbon fibers on mechanical properties of conbextra epoxy EP-10 resin. The aim from this incorporation of both fibers into a single matrix will stabilize mechanical properties and lowering manufacturing costs. In this research the impact strength, tensile strength, flexural strength, and hardness were studied for composite material reinforced with hybrid fibers for palms and carbon as a woven roving (0°-90°) with density (1.45g/m^3). These fibers were mixed with conbextra epoxy EP-10 resin in different reinforcement percentage and studied these effects on the mechanical properties of conbextra epoxy EP-10 resin. It has shown an improvement in these mechanical properties after reinforcement by fibers where the value of mechanical properties will increase with increasing percentage of reinforcement. Impact strength increased from (23Kj/m^2) to (170Kj/m^2), and tensile strength from(70MPa) to (365MPa), and flexural strength from(0.162GPa) to (1.55GPa), and hardness from(8.5N/m^2) to (80N/m^2) for reinforcing percentages 0% and 60% respectively.

Keywords: Hybrid Fibers, Composite Material, Mechanical Properties.

الخلاصة

يهدف هذا البحث الى دراسة تاثير التقوية بنسب مختلفة (20%,40%,60%) من الياف النخيل–الكاربون الهجينة على الخواص الميكانيكية لراتنج الإيبوكسي كونبكسترا EP-10 ،حيث الهدف من دكج هذين النوعين من الألياف في ارضية واحدة هو الحفاظ على الخواص الميكانيكية و خفض تكاليف التصنيع . في هذا البحث تم دراسة مقاومة الصدمة ،مقامة الشد ، مقاومة الانثناء ، الصلادة للمادة المركبة الناتجة المقواة بالياف هجينة من ألياف النخيل الطبيعية و الياف الكاربون بشكل حصيرة ثانية (0°-90°) و بكثافة ($m^3$1.45g/). حيث تم مزج هذه الالياف في ارضية من راتنج الايبوكسي كونبكسترا و بنسب تقوية مختلفة و دراسة اثر ذلك على الخواص الميكانيكية ، اظهرت النتائج تحسن هذه الخواص بعد التقوية بالالياف اضافة الى زيادة قيمة هذه الخواص مع زيادة نسبة التقوية بالالياف اضافة الى ويادة قيمة هذه الخواص مع زيادة نسبة التقوية. فبالنسبة الى مقاومة الصدمة ارتفعت من ($23K\,j/m^2$) و مقاومة الشد من (70MPa) الى (365MPa) و مقاومة الانثناء من (1.162GPa) الى (1.55GPa) و الصلادة من(8.5 N/m^2) الى (80N/m^2) و لنسب تقوية 0% و 60% على التوالي.

الكلمات المفتاحية: الألياف الهجينة ، مادة مركبة ، الخواص الميكانيكية.

Introduction

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. One constituent is called the reinforcing phase and the و in which it is embedded is called the matrix **(** Kaw, **2006).** 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 **(DeGarmo *et.al.*, 2008)**. There are many types of composite materials and several methods of classifying them, one such method is bases on geometry and consists of three distinct families:

1- Laminar Composites: laminar composites are those having distinct lagers of materials: bonded together in some manner.

2- Particular Composites: particular composites consist of discrete particles of one material surrounded by a matrix of another material.

3- Fiber-Reinforced Composites: the most popular type of composite material is the fiber-reinforced composite geometry.

(Morom *et.al.*, 1986)studied the effect of hybrid fibers (Palms / Carbon) on the impact strength of epoxy resin. Also,(**Al-Mosawi ,2009)** investigated the effect of changing the reinforcement percentage by fibers on Mechanical properties, for composite material consists of conbextra epoxy (EP-10) resin reinforced by biaxial woven roving carbon fibers.(**Azhdar,1992)** studied the impact fracture toughness of fiber reinforced epoxy resin. (**Al-Jeebory *et.al.*, 2009)** studied effect the change of reinforcement percentage of fibers on the thermal conductivity for polymeric composite material consist of conbextra epoxy (EP-10) resin reinforced by biaxial woven roving S—type glass fibers.

In the present study, investigate the Impact Strength, Tensile Strength, Flexural Strength, and Brinell hardness of the using palm fiber with carbon fiber in composite material.

Hybrid Composites

Hybrid composites involve two or more types of fibers set in a common matrix. 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. Types of hybrid composites include: (1) interplay (alternating layers of fibers); (2) interplay (mixed strands in the same layer) ;(3) interply-intarply ;(4) selected placement (where the more expensive material is used only where needed); and (5) interply knitting (where plys of one fiber are stitched together with fibers of another type) **(DeGarmo *et.al.*, 2008)**

Conbextra epoxy EP-10 Resin blong to epoxy group. Epoxy or polyepoxide is a thermosetting polymer formed from reaction of an epoxide "resin" with polyamine "hardener". Epoxy has a wide range of applications, including fiber-reinforced plastic materials and general purpose adhesives **(Dorey *et.al.*,1978).** High strength, high modulus carbon fibers are about ($7\mu m$-$8\mu m$) in diameter and consist of small crystallites of turbostratic graphite, one of the allotropic forms of carbon. There are three routes for producing fibers with graphite layers oriented preferentially parallel to the fiber axis: (1) Orientation of polymer precursor by stretching; (2) Orientation by spinning; (3)Orientation during graphitization **(Morom *et.al.*,1986).**

Experimental Work

The experimental work includes the following points:

(1) Materials: There are three types of materials employed in this study such as:

a- Matrix material, Conbextra epoxy EP-10 resin which mixed with (Metaphenylene Diamic) as a hardener with [1:3] percentage.

b- Reinforcing fibers: Two types of fibers were used as follows:

1- Palms fibers: which belongs to cellulose fibers.

2- Carbon fibers: a woven roving fiber (0^{o}- 90^{o}) with density of ($1.45g/m^3$) supplied from (K and C Moulding Ltd).

These types of fibers used as consecutive layers in same matrix with 50% palms fibers and 50% Carbon fibers. Palms fibers was fill up in a tank including distiller water and exposed to ultrasonic waves to remove peels and dirt from it to provide high wettability with resin.

(2) Test Specimens: Four types of specimens were manufactured as follows:

a- Impact Specimens: impact specimens fabricated according to the (ASTM-E23) standard suitable to Charpy Impact Instrument. Notch depth is (0.5mm) and notch base radius is (0.25mm).

b- Tensile Strength Specimens: these specimens manufactured according to the (ISO-R-527) standard.

c- Brinell Hardness Specimens: hardness specimens are a disc shape with (25mm) diameter and (10mm) thickness for hardness.

d- Flexural Strength Specimens: these specimens fabricated according to (ASTM-D790) standard as a rectangular shape (10mm×135mm).

Three specimens were manufactured for each test which different by the resin and reinforcement percentage as shown in **Table (1).** Hand molding was used to manufacture the specimens some resin spread in the mold and the fiber layer put on it and this process repeated to obtain the desired thickness.

Table 1:Structure of Specimens

Specimens number	1	2	3
Resin (weight %)	80	60	40
Fibers (weight %)	20	40	60

(3) Mechanical Tests: in this study four types of mechanical tests were used to determine the properties of composite material, and these tests are:

a- Impact Test: Charpy Impact Instrument was used to determine the impact resistance of composite material.

b- Tensile Test: this test was used to calculate the tensile strength of composite material under uniaxial load. The universal test instrument manufactured by (ZheJinang TuGong Instrument Co., Ltd) used to measure this property with a (20kN) load.

c- Hardness Test: In this test the "Brinell method" was used to measure hardness, this test made with a steel ball (5mm) diameter and (10kg) exposition load, loaded into specimens for (15sec), and the hardness number represents the diameter of impression after the load removal, which left on surface by the ball. Universal test instrument manufactured by (Uali Test Company) used for this test.

d- Flexural Strength Test: Flexural strength can be measured by three-point test by using universal hydraulic press (ZheJinang TuGong Instrument Co., Ltd) to calculate the maximum load exposed on middle of the specimen.

Results and Discussion

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 have done its duty successfully. From the mechanical tests done on the conbextra epoxy EP-10 resin reinforced with hybrid palms and carbon fibers. The results represent the values of impact strength, tensile strength, hardness, and flexural strength with the fiber reinforcement percentage.

Figure **(1)** shows the value of impact strength with 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 **(Al-Mosawi , 2009).**

Figure (2) shows the tensile strength of composite material, where the resin considered as brittle materials therefore, its tensile strength is very low. But after 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. The tensile strength will be increased as the fibers percentage addition increased, where these fibers will be distributed on large area in the resin.

Figure (3) represent the flexural strength of resin before and after reinforced with hybrid fibers. As mentioned above, the resin is brittle, therefore its flexural strength will be low before reinforcement 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 increase the strength of composite material.

Figure (4) shows the hardness of composite materials. Generally, the plastic materials have low hardness, when used the lowest value for conbextra epoxy-10 resin before reinforcement. But this hardness value will greatly increase 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. The hardness will be increased with increasing the percentage of fibers reinforcement.

Conclusions

From the obtained results was get:

1-Low mechanical properties (Impact, Tensile, Flexural Strength, and hardness) of the conbextra epoxy EP-10 resin.

2- Improvement of mechanical properties after reinforcement by palms and carbon fibers.
3- When increasing the reinforcement percentage to 60% the impact strength will increase about 700 % while the tensile strength will increase about 400% for the same reinforcing percentage.
4- When increasing the reinforcement percentage to 60% the flexural strength will increase about 900% while the hardness will increase about 1000% for the same reinforcing percentage.

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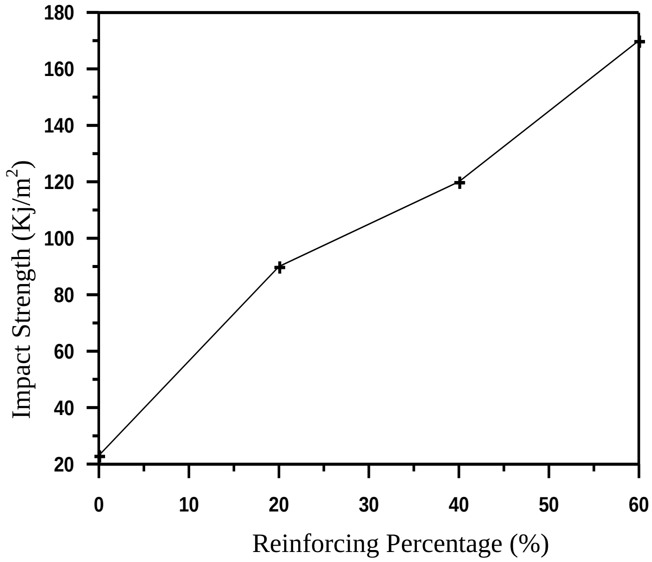

Figure 1: Impact strength-reinforcing percentage curve of composite strength

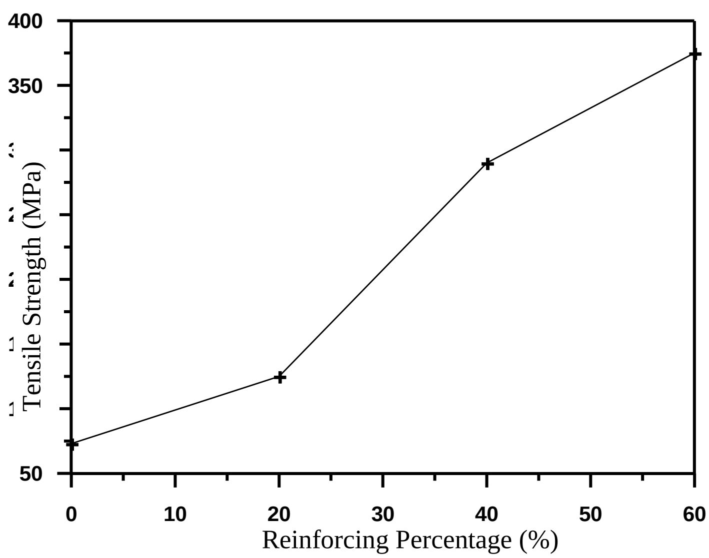

Figure 2: Tensile strength-reinforcing percentage curve of composite strength

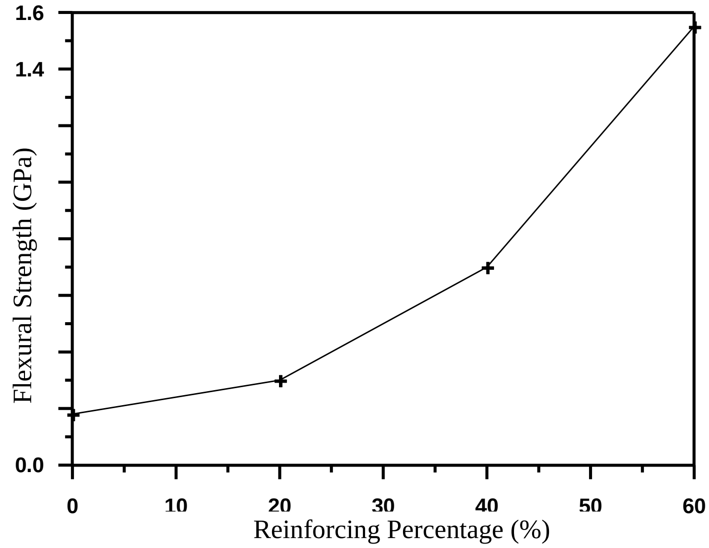

Figure 3: Flexural strength-reinforcing percentage curve of composite strength

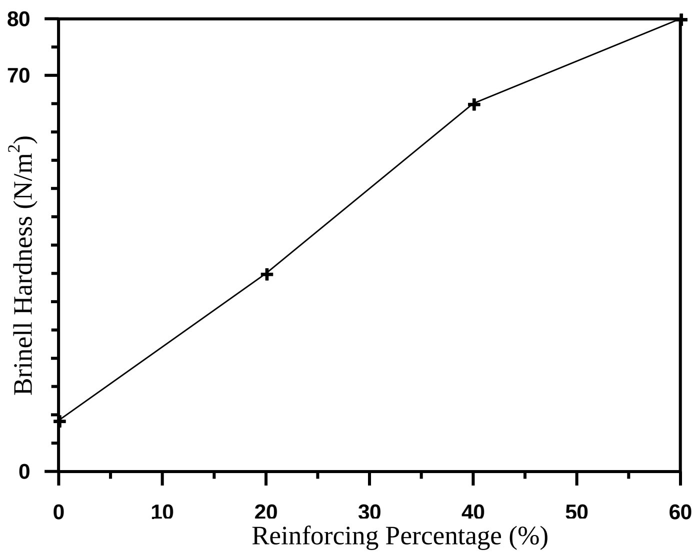

Figure 4: Hardness-reinforcing percentage curve of composite strength