MECHANICAL PROPERTIES OF ARALDITE MATRIX COMPOSITES REINFORCED WITH HYBRID CARBON - KEVLAR FIBERS

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Abstract

The mechanical properties of araldite matrix composites incorporated with hybrid carbon - kevlar fibers were evaluated . There are indications that the incorporation of both fibers into a single matrix which is araldite resin 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 as a woven roving(0°-90°) with density (225g/cm^3) and (285g/cm^3) for carbon and kevlar fibers respectively . These fibers were mixed with araldite resin in different reinforcement percentage (20%,40%,60%) and the effect on the above mechanical properties were studied , where we see Improves in these mechanical properties after reinforcement by fibers The value of mechanical properties will increase with increasing percentage of reinforcement .

Keywords : Hybrid Fibers , Composite Material , Mechanical Properties .

الخواص الميكانيكية لمادة مركبة ذات أساس من الإرلدايت مقواة بألياف الكاربون وألياف كيفلار الهجينة

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الخلاصة .

تم في هذه الدراسة حساب قيم الخواص الميكانيكية للمادة المركبة ذات أساس من الإرلدايت المدمج مع ألياف الكاربون وألياف كيفلار الهجينة . حيث هنالك مؤشرات على إن دمج هذين النوعين من الألياف في أرضية واحدة يحافظ على الخواص الميكانيكية ويخفض تكاليف التصنيع . في هذا البحث تم دراسة مقاومة الصدمة ، مقاومة الشد ، مقاومة الإنثناء ، والصلادة للمادة المركبة المقواة بألياف هجينة بشكل حصيرة ثنائية (0°-90°) من ألياف الكاربون وألياف كيفلار بكثافة (225g/cm^3) و(285g/cm^3) على التوالي . حيث تم مزج هذه الألياف في أرضية من راتنج الإرلدايت وبنسب تقوية مختلفة (20%,40%,60%) ودراسة أثر ذلك على الخواص الميكانيكية ، حيث تم تحسين هذه الخواص بعد التقوية بالألياف إضافة إلى زيادة قيمة هذه الخواص مع زيادة نسبة التقوية بالألياف .

الكلمات الدالة : الألياف الهجينة ، مادة المركبة ، الخواص الميكانيكية .

Introduction .

A composite is a structural material that consist 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 one in which it is embedded is called the matrix [Auter,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 . Analysis of these properties shows that they depend on (1) the properties of the individual components; (2) the relative amount of components; (3) the size ,shape ,and distribution of the discontinuous components; (4) the degree of bonding between components; and (5) the orientation of the various components [DeGarmo,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 [Liyong,2002] .
2- Particular Composites : particular composites consist of discrete particles of one material surrounded by a matrix of another material [DeGarmo,2008] .
3- Fiber-Reinforced Composites :the most popular type of composite material is the fiber-reinforced composite geometry ,where continuous or discontinuous thin fibers of one material are embedded in a matrix of another [DeGarmo,2008] .

G.Morom ,E.Drukkler ,A. Weinberg ,and J.Banbaji studied the effect of hybrid fibers (Carbon / Kevlar) on the impact strength of epoxy resin [Morom,1986] . also Ali 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 kevlar fibers [Ali,2009] . Azhdar studied the impact fracture toughness of fiber reinforced epoxy resin[Azhdar,1992] Dr. Abbas , Ali , and Sajed 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 [Dr. Abbas, Ali,2009] .

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)interply(alternating layers of fibers); (2) intarply(mixed strands in the same layer) ;(3) interply-intarply ;(4) selected placement(where the more costly material is used only where needed) ;and (5) interply knitting(where plys of one fiber are stitched together with fibers of another type) [DeGarmo,2008] .

Kevlar Fibers .

Kevlar fibers is an organic aramid fiber with (3100*MPa*) tensile strength, and (131,000 *MPa*) elastic modulus. A density approximately one-half of aluminum, good toughness, and negative thermal expansion coefficient .In addition , it is flame retardant and transparent to radio signals

,making it attractive for a number of military and aerospace application where the service temperature is not excessive [4]. **Table(1)** shows some characteristic of Kevlar fibers .

Carbon Fibers .

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,1986].

Araldite Resin (epoxy resin group) .

Araldite resin belong to epoxy group which have excellent thermal and physical properties ,and usually used in composite materials for different application ,where it distinct by excellent adhesive capability especially to fibers ,also it retain constant dimension after dryness [Dorey,1978] .

Experimental Work .

The experimental work includes the following points :

1- Materials: There are three types of materials employed in this study:

a- Matrix material, Araldite resin (CY223) with density of (1.15-1.2 g/cm^3) which belong to epoxies group was used in this study. **Figure (1)** shows the chemical structure of Araldite resin.

b- Reinforcing fibers: Two types of fibers used here :

1- Carbon fibers: a woven roving fibers(0 º - 90 º) with density of (225 g/m^3).

2- Kevlar fibers : a woven roving fibers(0 º - 90 º) with density of (285 g/m^3).

These types of fibers used as consecutive layers in same matrix .**Figure (2)** shows the chemical structure of kevlar fibers.

2- Preparation Test Specimens: Four types of specimens were manufactured as follows :

a- Impact Specimens : impact specimens fabricated according to the (ASTM-E23) standard suitable to Charby 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- Hardness Specimens : hardness specimens are a disc shape with (25mm) diameter and (10mm) thickness .

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(2)** . Hand molding was used to manufactured the specimens . some resin spread in the mould and the fiber layer put on it and this process repeated to obtain the desired thickness .

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

a- Impact Test : Charby 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 ,where we used the universal test instrument manufactured by Z.N corporation (china) to measured this property with a(20*KN*) load .

c- Hardness Test : In this test we used "Brinell method" was used to measure hardness , this test made with a steel ball (5*mm*) diameter and (10*kg*) exposition load, loaded into specimens for (15*sec*) , and the hardness number represent the diameter of impression after remove the load , which left on surface by the ball. universal test instrument manufactured by Z.N corporation (china) used for this test .

d- Flexural Strength Test : Flexural strength can be measured by three point test by using universal hydraulic press (Z.N corporation) 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 done its duty successfully .From the mechanical tests done on the araldite resin reinforced with hybrid carbon and kevlar fibers we get the results shown in the diagrams which represent the values of impact strength , tensile strength , hardness, and flexural strength with the fiber reinforcement percentage :

1- Impact Strength : **Figure(3)** 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[Ali,2009].

2- Tensile Strength :the resin considered as brittle materials where its tensile strength is very low as shown in **Figure(4)** ,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 [Dr. Abbas, Ali,2009].

3- Flexural Strength :as mentioned above ,the resin is brittle ,therefore its flexural strength will be low before reinforcement as shown in **Figure(5)** .But after added the fibers to this resin the flexural strength will be raise 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 [Ali,2009].

4- Hardness :generally the plastic materials have low hardness ,where we observed in **Figure(6)** the lowest value for araldite 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 .The hardness will be increased with increasing the percentage of fibers reinforcement [Azhdar,1992].

Conclusions .

From the obtained results we get :

1- Low mechanical properties (Impact, Tensile, Flexural Strength, and hardness) of the araldite resin .
2- Improvement of mechanical properties after reinforcement by carbon and kevlar fibers .

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Table(1) : some characteristic of Kevlar fibers[Mallick,2007]

Property	Specific strength ($10^6 m$)	Specific stiffness ($10^6 m$)	Density(Kg/m^3)
Value	0.254	8.8138	0.1439×10^4

Table(2) :Structure of specimens

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

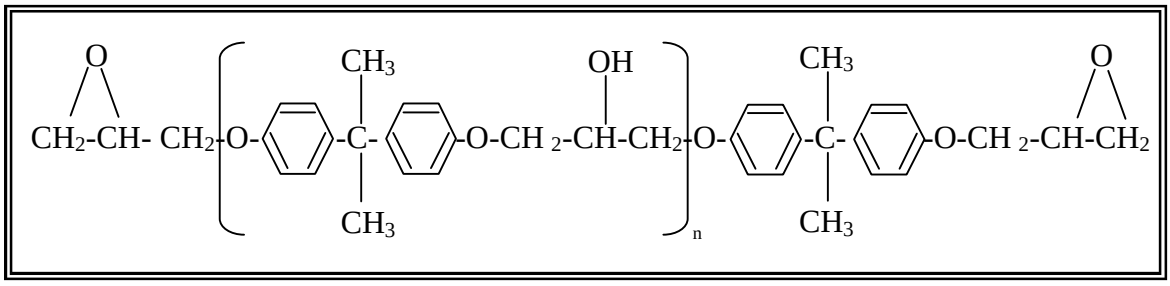

Figure (1): Chemical structure of Araldite resin [Mallick,2007]

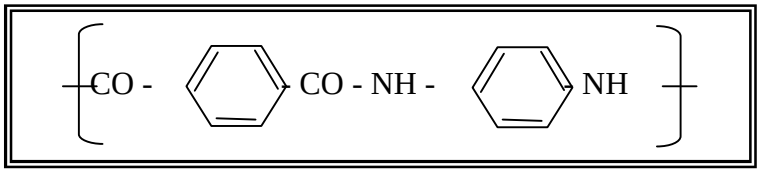

Figure (2): Chemical structure of kevlar fibers[Mallick,2007]

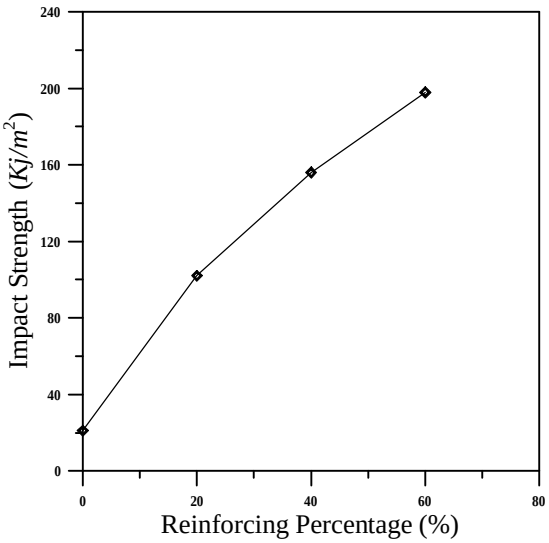

Figure (3): Impact Strength

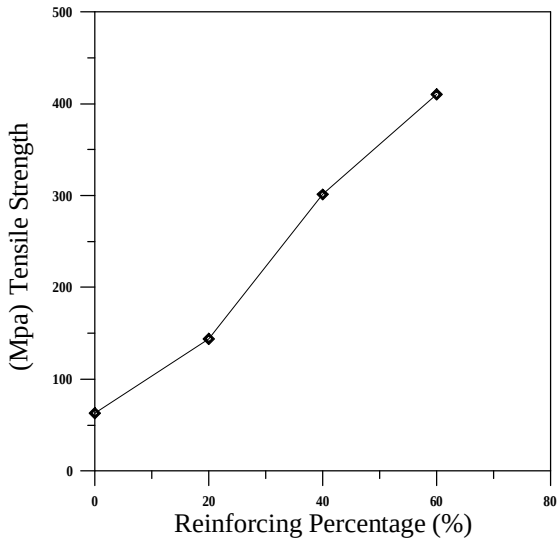

Figure (4): Tensile Strength

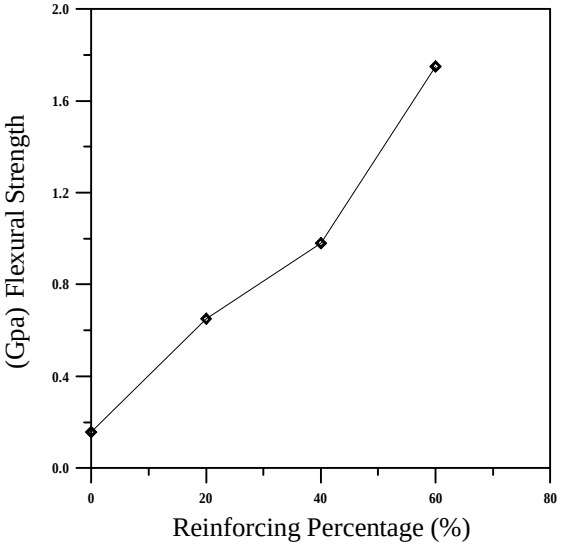

Figure (5): Flexural Strength

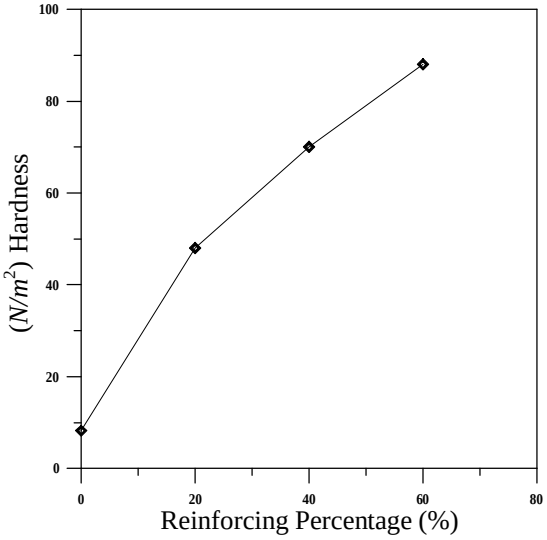

Figure (6): Hardness