Enhancement of mechanical properties of unsaturated polyester resin by mixing with carbon-Kevlar hybrid fibers

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Abstract:

Mechanical properties of unsaturated polyester resin (SIROPOL 8340-PI) incorporated with carbon - Kevlar hybrid fibers were calculated . Impact strength , tensile strength ,flexural strength ,and hardness were studied for composite material reinforced with hybrid carbon - Kevlar fibers as a woven roving (٠°-٤٥°) with density (1.77g/cm^3) and (1.47g/cm^3) respectively . These fibers were mixed with unsaturated polyester 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 and the value of mechanical properties will increase with increasing percentage of reinforcement .

Keywords : Hybrid Fibers , Composite Material , Mechanical Properties .

الخلاصة :

تم حساب الخواص الميكانيكية لراتنج البولي أستر غير المشبع (SIROPOL 8340-PI) المدمج مع ألياف الكاربون - كيفلار الهجينة . تم دراسة مقاومة الصدمة ، مقاومة الشد ، مقاومة الإنثناء ، والصلادة للمادة المركبة المقواة بألياف هجينة بشكل حصيرة ثنائية (٠°-٤٥°) من ألياف الكاربون- كيفلار بكثافة (1.77g/cm^3) و(1.47g/cm^3) على التوالي . تم مزج هذه الألياف في أرضية من راتنج البولي أستر غير المشبع وبنسب تقوية مختلفة (60%,40%,20%) ودراسة أثر ذلك على الخواص الميكانيكية ، حيث تم تحسين هذه الخواص بعد التقوية بالألياف و زيادة قيمة هذه الخواص مع زيادة نسبة التقوية بالألياف .

الكلمات الدالة : الألياف الهجينة ، المادة 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 [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 [Liyong,2002]: Laminar Composites, Particular Composites ,and Fiber-Reinforced 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 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 [Michel,2007].

High strength , high modulus carbon fibers are about (7μm -8μm) 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 [Liyong,2002]. Unsaturated polyester resin belong to thermosetting plastics which have good thermal and physical properties ,and usually used in composite materials for different application ,where it distinct by excellent adhesive capability especially to fibers and moderate viscosity [Mallick,2007] .

[Morom,1986] studied the effect of hybrid fibers (Carbon /Kevlar) on the impact strength of epoxy resin. [Ali,2009] was investigated the effect of changing the reinforcement percentage by fibers on Mechanical properties, for composite material consists of conbextra epoxy resin reinforced by biaxial woven roving kevlar fibers .[Azhdar,1992] was studied the impact fracture toughness of fiber reinforced epoxy resin. [Abbas, Ali,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 .

Experimental Work .

The experimental work includes the following points :

a- Matrix material: Unsaturated polyester resin (SIROPOL 8340-PI) .

b- Reinforcing fibers: Two types of fibers used in the work :

1- Carbon fibers: a woven roving fibers(٠ º - ٤٥ º) with density of (1.77 g/m^3).

2- Kevlar fibers : a woven roving fibers(٠ º - ٤٥ º) with density of (1.47 g/m^3). Figure (1) shows the chemical structure of Kevlar fibers.

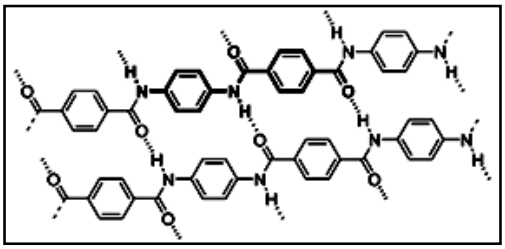


Figure (1): Chemical structure of Kevlar

2- Preparation test samples: four types of samples were manufactured as follows :

a- Impact samples : impact samples fabricated according to the (ASTM-E23) standard suitable to Charpy Impact Instrument .Notch depth is (0.5mm) and notch base radius is (0.25mm). Charpy Impact Instrument was used to determine the impact strength of composite material .

b- Tensile strength samples :these samples manufactured according to the (ISO-R-527) standard . Universal test instrument manufactured by Z.N corporation (China) was used to measured this property with a(20KN) load .

c- Hardness samples : samples are a disc shape with (25mm) diameter and (10mm) thickness . Brinell method was used to measure hardness , this test made with a steel ball (5mm) diameter and (10kg) exposition load, loaded into samples for (15sec) , and

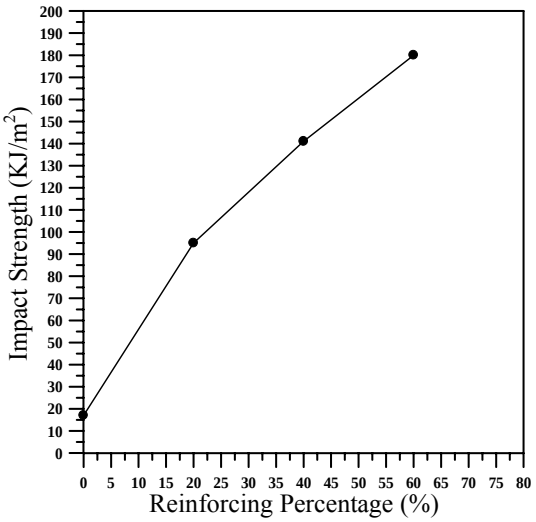
the hardness number represent the diameter of impression after remove the load , which left on surface by the ball. universal test instrument manufactured by Z.N corporation (China) used for this test .

d- Flexural strength samples :these were fabricated according to (ASTM-D790) standard with rectangular shape (10mm×135mm). Universal hydraulic press (Z.N corporation) was used to calculate the maximum load exposed on middle of the sample .

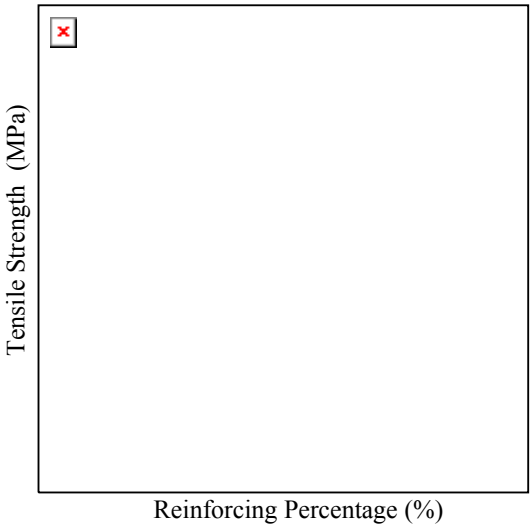
Results & Discussion .

The values of impact strength with fibers reinforcing percentage shown in figure(2).Generally ,the impact strength considered low to the resins contributed 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 strength .The impact strength will continue to increase with increased of the fibers reinforcing percentage [Morom,1986]. The resin considered as brittle materials where its tensile strength is very low as shown in figure(3) ,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 [Abbas, Ali,2009] . As mentioned above ,the resin is brittle ,therefore its flexural strength will be low before reinforcement as shown in figure(4) .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] .

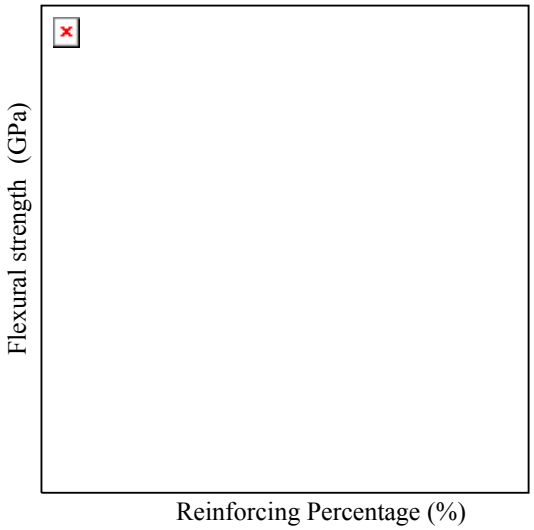
Generally the plastic materials have low hardness ,where we observed in figure(5) the lowest value for unsaturated polyester resin before reinforcement .But this hardness value will greatly increased when the resin reinforced by hybrid fibers .This is to distribution the test load on fibers which decrease 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 [Abbas, Ali,2009] .



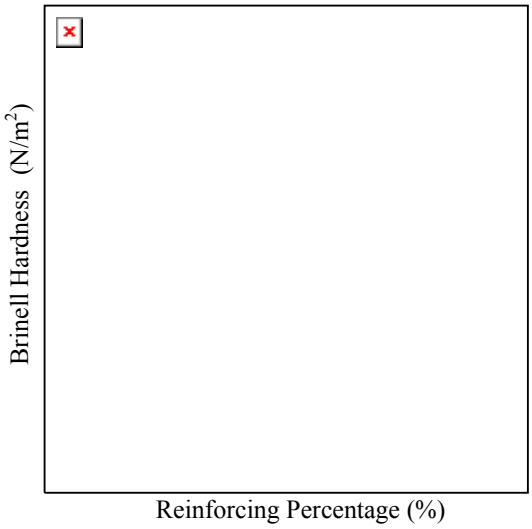
Figure(2): Impact strength versus carbon – Kevlar reinforcing percentage



Figure(3): Tensile strength versus carbon – Kevlar reinforcing percentage



Figure(4): Flexural strength versus carbon – Kevlar reinforcing percentage



Figure(5): Hardness versus carbon – Kevlar reinforcing percentage

Conclusions .

Mechanical properties (impact, tensile, flexural strength, and hardness) were Improved of after reinforcement by carbon-Kevlar fibers. Impact strength increased from(17KJ/m^2) to (180KJ/m^2) ,tensile strength from(52MPa)to (380MPa),and flexural strength from(0.13MPa)to (1.43MPa), and Brinell hardness from(6.9N/m^2) to (77N/m^2) for reinforcing percentages 0% and 60% from carbon - Kevlar respectively.

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