ISSN: 0974-5823 Vol. 7 No. 1 January, 2022

International Journal of Mechanical Engineering

Some Mechanical Behaviours Of Hybrid Polymers Mixture Composite

Mohanad Salah Hassan* ,Ismail Ibrahim Marhoon ,Yasir Khalil Ibrahim

Dept. of Material Engineering, College of Engineering, Mustansiriyah-University, Baghdad-Iraq

Abstract. the present work reports the effect of hybrid fibers and volume frection on the general mechanical natyre of fiber reinforced blended polymers. Hybrid polymer composite material was prepared from two polymers were epoxy resin (EP) and polysulfide resin (PSR) after that reinforced by two types of fibers, it was used carbon fibers and kevlar fibers, where was weight ratio for epoxy (98 Vf %) and for polysulfide was (2 Vf %) and has been used the fibers as a plain woven and with the volumetric fracture from A2 (5%) and A3(3%). Mechanical characteristics like the impact strength, tensile strength, and hardness have been assessed in the paper. The mechanical tests have been carried out for composite materials prior to and post the reinforcement with those fibers for ascertaining effects of the addition of the fibers upon mechanical characteristics of composite material. The impact of the fiber has been obvious in the improvement of all of the studied characteristics, particularly the impact strength and tensile strength that have been improved due to fiber reinforcement.

Keyword : polymers , blended polymers , hybrid polymers composite, fibers, composite material

1. Introduction

Composite engineers have been focused upon developing new tougher, stronger, light-weight structural materials that support the newest technology and design aspects for complicated-shape structures, such as the aircrafts, large wind turbine blade structures and auto-motive structures [1]. The composite material includes a matrix and a reinforcement form (flakes, particles, fillers or fibers) (polymer, ceramic or metal). Reinforcement is responsible for binding the matrix together for the purpose of achieving the needed shape, whereas reinforcement improves the general mechanical characteristics of the matrix. [2] The hybrid composites combining 2 different fibers or more in one matrix, result in considerably expanding the range of the characteristics which may be accomplished with the advanced composite types.

Hybrid composites are of distinctive characteristics, which may be utilized for suiting many different design requirements at lower costs compared to advanced or traditional composites. Blanched stiffness and strength, blanched bending and membrane mechanical characteristics, decreased cost and/or weight, better fracture toughness, and enhanced impact resistance are examples of the distinctive benefits of the hybrids compared to the standard composites. [3] Glass fiber, carbon fiber and Kevlar fiber are all examples of fibrous materials that have been used as fillers in composites. Because of its numerous amazing mechanical features, including as high specific modulus and strength, light weight, high thermal resistance, and chemical inertness, aramid-fiber is frequently employed in the vehicle industry. Monolithic epoxy's comparatively weak mechanical qualities have been found to hinder its use in components that require great mechanical strength. As a result, a variety of particle/whisker-type fillers have been used in many research studies on reinforcing polymer-based materials to acquire insight into how to overcome the problem [4]. The most extensively utilized synthetic composites are polymer matrix composites (PMCs) [5]. The mechanical properties of the polymers without the reinforcements result in limiting their utilities as structural materials, however, the reinforcement of polymers with the strong fibers provides the ability for constructing composites of polymer matrix. [6] The benefits of the fibre-reinforced PMC compared to the conventional materials include higher degree of the mechanical strength, better dimensional stability, lighter weight, corrosion resistance, higher dielectric strength, and flexibility for improving designs [7]. The present study includes a discussion of impacts of the combination of advantages of the addition of the poly-sulfide rubber and 2 different short fiber types to epoxy matrix for the development of the enhanced matrix material with an objective to attain sufficient adhesive strength with no compromise to other wanted mechanical characteristics of epoxy resin. This paper aims at examining the impact of the poly-sulfide elastomer and fiber concentrations on mechanical characteristics and morphology of the fiber reinforced rubber-modified epoxy systems.

2. Fiber-Reinforced Composites (FRCs)

Fibers represent a major type of the materials of reinforcement, and their primary application in the composite materials is improving physical and mechanical characteristics of matrix resin as a result of their high ratio of strength/weight. High tensile and compression strength, as well as a high elastic modulus, are characteristics of fibre materials. They provide these qualities to the composites to which they are introduced by being the most loaded [8,9]. The kevlar fibres and carbon fibres have been chosen as reinforcements and blend of epoxy and polysulfide as matrix material. De-lamination, interlaminar matrix cracking, longitudinal matrix splitting, fiber pull-out, and fiber fracture are some of the failure processes of fibre-reinforced composite materials [10]. Ceramic fibres, like the carbon fibers and glass fibers, polymeric fibres, like the Kevlar fibres, and metal fiber in form of wires, like the steel and copper wires, are all examples of fibre reinforcement [11]. The carbon fibers of bi- directional woven with density 1.82 g/cm³. The kevlar fiber of bi-directional woven with density 1.44 g/cm³ were utilized. Kevlar fibers and carbon fibers that are utilized in fabricating hybrid FRCs have been illustrated the figures1 (a , b).

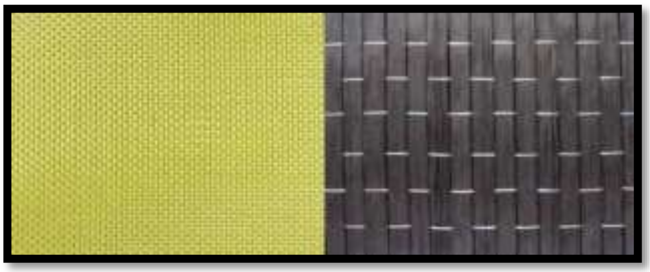


Fig1. a -The kevlar fiber. **Fig. b-** The carbon fiber.

3 . Experimental work

3.1. Materials

This was (Quickmast 105), which is include 2 components: which are hardener and resin. The appropriate epoxy resin to hardener ratio is (3g) epoxy resin to (1g) hardener. Epoxy resin's physical and mechanical properties are shown in Table 1.

Table 1. The epoxy resin characteristics [12].

Test approach	Typical result
Compressive strength	**≥ 70MPa @ 7 days @ 25 °C**
Tensile strength	**≥ 25MPa**
Density	**1.10 ± 0.050**
Flexural strength	**≥ 50MPa @ 7 days**
Viscosity	**3 - 5 poise @ 25ºC** **1 - 2 poise @ 35ºC**
Minimum application on temperature	**5ºC**

 Polysulfide Rubber (PSR):

Sika® Polysulphide (PG), which is made up of 2 parts, which are: hardener and resin, has been employed in this study. (16g) of the poly-sulfide resin to (1g) of the hardener was the recommended ratio. The mechanical as well as the physical characteristics of the poly-sulfide rubber have been listed in Table2.

Table2. The characteristics of polysulfide rubber [13].

Test method	Typical result
Specific Gravity	**1.350**
Compressive Strength	**20Mpa-100Mpa**
Flextural Strength	**550%**
Tensile Strength	**8.30Mpa**
Young Modulus	**3.7Mpa-5Mpa**

- ***Carbon fibres:***

Carbon UD Stockinette carbon fibres from Tenax Company in U.K. were utilized. Carbon fiber has been employed as plain woven bidirectional (0 – 90) material.

Table3. Carbon Fibre Characteristics [14].

Tensile Strength	**3500 Mpa**
Young Modulus	**225 kN/ mm²**
Density	**1.82 g/cm^3**
Elongation	**1.59%**

- ***Kevlar fibers:***

The Kevlar fibre types that have been utilized in the present paper have been the woven kevlar fibers from China Company, China.

Table4. Kevlar fibre types [15].

Tensile Strength	**2860**
Density	**1.44 g/cm^3**
Young Modulus	**131**
Diameter (μm)	**12**

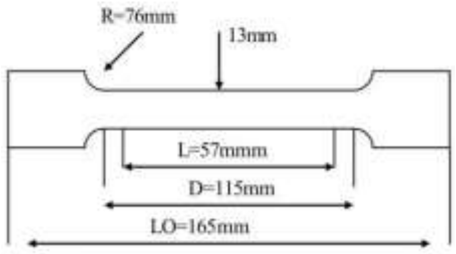
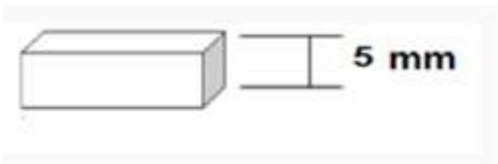
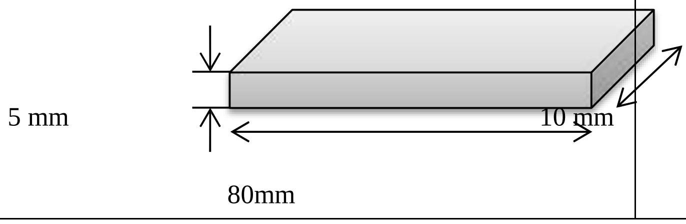
3.2 Blend polymers mixtures and composite preparation

In this experiment, epoxy resin was combined with polysulfide rubber at a ratio of 98 percent epoxy to 2 percent polysulfide rubber. To get a uniform blend with no bubbles, the mixing was continued at room temperature for 2 hours. Cutting and weighting the fibres reinforced the epoxy-polysulfide blend; using a volumetric friction from A2 (5%),A3 (3%) and principles of mixes, weight ratio of fibers may be computed from overall blend weight. This process involves pouring of a blend portion in the mold prior to the addition of 1st fiber layer, followed by the repetition of this operation for the purpose of creating composite material that has been reinforced by 3 fibre layers. Samples that have been created in such manner are shown in Table (5). Composite materials have been left at the temperature of the room for 24h prior to being removed from molds and placed in a drying oven at 60^{o} Celsius for 8h for completing the process of the solidification and reducing any tensions that might've formed throughout reinforcement operation. Finally, for each test, samples have been sliced based on specified conditions.

Table5. Standard dimensions of the samples that have been utilized in this study.

Sample	Properties
A1	Epoxy[PS] (98 Vf%)+polysulfide [PSR] (2 Vf%)
A2	A 1 that has been reinforced by 2 carbon fibre layers and a 1 kevlar fibre layer
A3	A 1 that has been reinforced by 2 kevlar fibre layers and 1 carbon fibre layer

Table6. Testing Sample Dimensions.

Test types	Standard dimensions of specimen	Standarization code
Tensile test		**ASTM-D638M**
Hardness		**ASTM-D2240**
Impact		**ISO-179**

3.3 Mechanical Tests

There have been 3 test types carried out on samples that have been prepared:

a. Tensile Strength

which can be defined as the measurement of a material's capacity to withstand static forces which attempt to break it. Equation [16] was used to calculate tensile strength.

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

Here:

σ represents the value of the Tensile strength (N/m²). F represents the value of the applied load (N).

A represents the sample's cross sectional area (m²).

Tensile testing has been performed based on (ASTM-D 638) with the use of tensile machine (i.e. computer regulated universal machine of testing) of the WDW50 model.

b. Hardness testing

Hardness can be defined as a surface mechanical quality that is the resistance of the material to penetrating or deforming plastically [17]

Hardness testing has been carried out with the use of Shore D hardness instrument TH-210 model that has been developed to measure polymeric material hardness, according to standard specifications (ASTM-D2240). The Shore D is a compass-like instrument that assesses the polymeric materials' hardness on a scale from 0 to 100 by measuring the penetration or indentation depth. A needle that has a 1.4mm diameter and 30º conical point is located in the center of the device.

c. Impact testing

Which is one of the practical methods for determining a material's strength and resistance to breaking when subjected to high-speed stress. Equation (2) [18] was used to compute impact strength:

$$I.S = Uc/(A \quad (2)$$

Here:

IS: stands for impact strength (J/m²).

A: represents sample cross section area (m²).

Uc: The amount of energy required for breaking sample (J).

The impact test has been performed with the use of Charpy impact testing equipment of the model IMI that has been designed for the evaluation of polymeric materials' impact fracture energy, in accordance with standard specifications (ISO- 179).

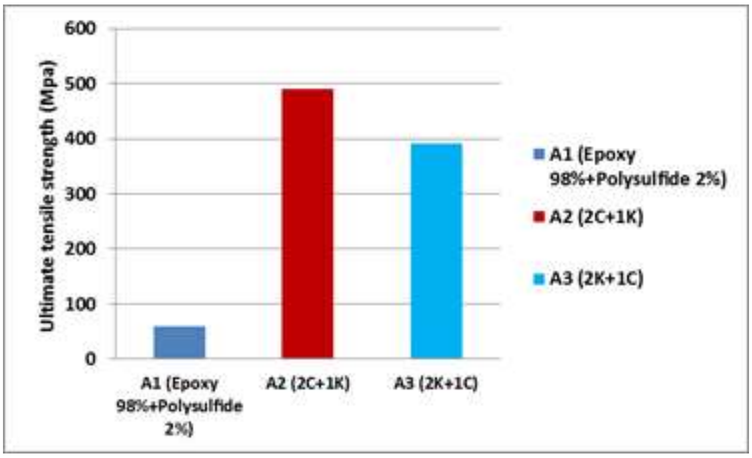
4.1. Result and Discussion

4.1. Tensile Strength

Figure 2 shows experimental findings for the value of the tensile strength, which show that tensile strength has been increased following carbon and kevlar fibre reinforcing. Adding 5% carbon and kevlar fibers to a 98 percent epoxy-2 percent polysulfide rubber blend matrix (A2) and 3% carbon and kevlar fibres to 98 percent epoxy-2 percent poly-sulfide rubber blend matrix (A3) resulted in the increased value of the tensile strength to 490MPa for sample A 2 and 391MPa for sample A 3. As loading progressed, the composite material started elongating linearly as a response to applied stress, with material of matrix deviating to the submission point whereas fibers kept extending and resisting to the point of the collapse of the resistance. The composite materials failed fully with the failure of the matrix material.

Fibers bear a significant load portion, increasing composite material's tensile strength; none-the-less, the composite material types that have been reinforced with 2 carbon fibre layers and a 1 kevlar fibre layer (A 2) are of a higher value of the tensile strength compared to the composite materials that have been reinforced by 2 kevlar fibre layers and 1 carbon fibre layer (A 3).

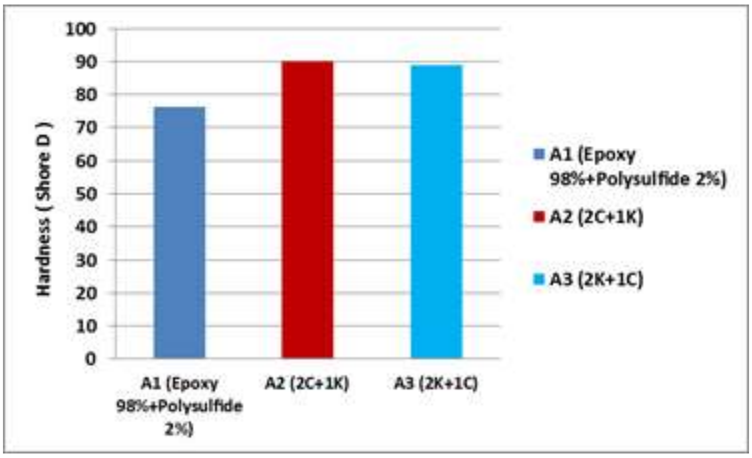
Figure2. Composites ultimate tensile strength.



4.2. Hardness

Figure 3 shows hardness experimental results, which show that value of hardness has been increased following carbon and kevlar fibre reinforcing. Adding 5% carbon and kevlar fibers to a 98 percent epoxy-2 percent poly-sulfide rubber mix matrix (A2) and 3% kevlar and carbon fibers to a 98 percent epoxy-2 percent poly-sulfide rubber blend matrix (A3) resulted in a hardness increase of 90.1 for sample A2 and 89. For the sample A 3. Because load has been dispersed over fibers, the rate of the penetration on the surface of the composite material was reduced while the value of its hardness was increased. The rise of the composite hardness indicates strong bond between the blend and the fibers, which reduces the blend molecules' movement.

Figure 3 . Hardness values of the composites



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4.3. Impact Strength

The impact strength trial findings given in figure (4) show that following carbon and kevlar fibre reinforcing, the impact resistance increased. Adding 5% kevlar and carbon fibers to 98 percent epoxy-2 percent poly-sulfide matrix of rubber blend (A2) and 3% kevlar and carbon fibers to a 98 percent epoxy-2 percent poly-sulfide matrix of rubber blend (A 3) had resulted in increased impact resistance of 205.455KJ/m2 for A2 sample and 285.321KJ/m2 for the A 3 sample. Fibers bear majority of stress and work for distributing it across a greater region, limiting potential of stress concentration in one location and acting as a barrier to breaking, prevention of small fractures' propagation that could emerge due to the impact. The composite materials that have been reinforced by 2 carbon fibre layers and 1 kevlar fibre layer (A 2) were shown to be having lower level of the impact resistance compared to the composite materials that have been reinforced by 2 kevlar fibre layers and 1 carbon fibre layer (A 3).

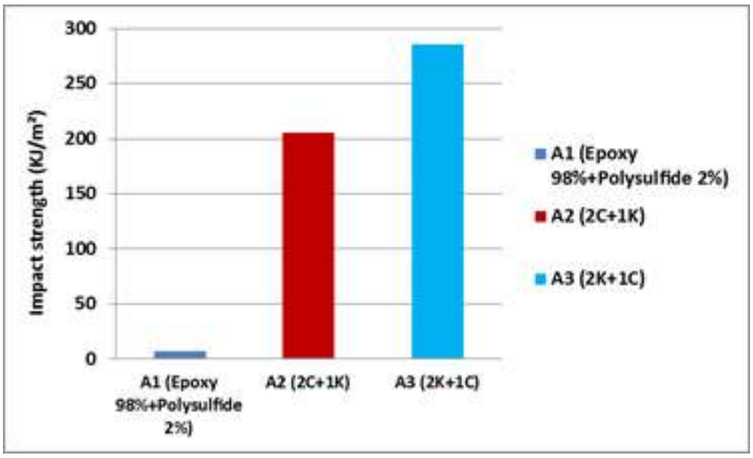

Figure4. Impact strength of composites.

5. Conclusions

A number of conclusion may be drawn as follows :

1. Fiber matrix bonds prove to be a prime important to the strength of hybrid composite .
2. The presence of reinforcing hybrid fibers have enhanced matrix resistance.
3. As a result of high mechanical carbon fiber characteristics, the rise in the value of the tensile strength of sample A2 was quite obvious, as illustrated in figure (2). It has a very high tensile strength, which gives composite material a high value of the tensile strength.
4. As a result of the existence of 2 carbon fibre layers as well as a middle layer of kevlar fibers, Sample A2 had a high hardness value. Because carbon fibres have a higher density than kevlar fibres, the sample's hardness value increased as a result of this property, as shown in table3 and table4.
5. The considerable increase in the value of the mechanical characteristics, particularly the impact and tensile strengths, when utilizing kevlar and carbon fibres with low poly-sulfide percentage (2%) has been shown to provide a considerable opportunity for the utilization of this composite material type in a variety of the mechanical applications, in particular, the ones that require high-specification and light-weight parts. Which would result in allowing it to be utilized as a replacement for metal or iron parts in applications where the value of the weight is a factor, such as autos, aircraft, and pipes.

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