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Studying the effect of reinforcing by fibers and particles on mechanical properties for polymer Matrix composite materials

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Abstract: The using of polymer matrix composite materials has found a wide range of applications in our modern day world. This is as a result of the combination of characteristics which are achieved by these materials. This work aimed on the preparation of polymeric-matrix composite material in order to improve its mechanical properties by using more than one type of reinforcement with different volume fraction values. This composite materials prepared from unsaturated polyester resin as a matrix, reinforced by E-glass fiber with (5%) volume fraction and graphite particles of (1%, 3%, 5%,7% and 10%) volume fractions, and study the effect of these fillers on the properties of polyester. The reinforcing by different types of materials with different values of volume fraction led to improve the mechanical properties (i.e. tensile strength, modules of elasticity and hardness) significantly, because of the contribution of both graphite particles and glass fibers to bear the applied load, also due to the high hardness graphite particles

Keywords: graphite particle, glass fiber, mechanical properties

Introduction:

Composite based upon polymer materials are being used in a wide range of industries due to some of their properties, such as: high modulus, specific strength, good fracture, fatigue properties, and corrosion resistance [1,2]. Several of materials are being used which are ranged from low performance glass fiber/polyester, used in small boats and domestic productions, to high performance carbon fiber epoxy, used in military aerospace [1]. Generally, certain polymers featured good mechanical characteristics, which could be enhanced by mixing them with different types of materials [3]. Composite can be produced when two or more materials are joined together for showing a combination of properties that can't be achieved. Otherwise, according to the principle of combined action, higher property combinations are achieved by the combination of two or more individual materials [4, 5]. Unsaturated polyester reinforcing by particulates plays a vital role in the enhancement of the mechanical properties [6]. Fibers are very important example of reinforcing materials due to the desired conditions and transfer strength to matrix constituent by influencing and enhancing their required properties. Fiber may be classified into synthetic fibers (manmade fibers) or natural fibers. Some of synthetic fibers examples are: E- glass fibers which have electrical applications, C-glass which shows high corrosive resistant and S-glass which can be used in structural application, and at high temperatures. Glass fibers can be found in the continuous form,

chopped, and woven fibers, etc. [7]. Filler are inert materials which can be used in glass fiber reinforcing polymer (GFRP) composites in order to modify the chemical and physical properties of the polymers matrix to reduce materials cost, improve processability, improve performance. The commonly used fillers are carbon black, calcium carbonate, clay, alumina tri-hydrate, magnesium hydroxide, bone powder, coconut powder, hematite powder, TiO_2, SiO_2, ZnS, graphite, etc. The effect of these fillers on mechanical properties like tensile and flexural strength, inter laminar shear strength, tensile modulus, hardness, impact strength were tested experimentally by different methods [7].

Bhanu praksh , T. Madhusudhan [8] this work described the impact strength developing for various kinds of polymeric matrix composites materials reinforced by glass fiber, epoxy resins and various types of fillers (i.e. fibers, particulates and flakes). The results present that epoxy resin reinforced by glass fiber shows better results as compared with epoxy resin reinforced by any other kinds of reinforcement. In the present work, there is concentration on the impact strength of the composite materials. This study is limited to the glass-epoxy composites with different fillers.

Ugochukwu Chuka Okonkwo, Christian Ebele Chukwunyelu, Bright Uchenna Oweziem, Austine Ekuase [9] in this study, controlled factors such as: fibers aspect ratio, fibers volume fractions, and orientation of fibers, used for determining the optimum tensile strengths of polyester resin reinforced by coir fibers. After using Archimedes principle for determining the volume fraction of fibers, tensile test was carried out on the samples which consist of treated and untreated coir fibers reinforced polyester resin composites, respectively.

V. Vijaya Bhaskar , Kolla Srinivas [10] this paper aims at the mechanical properties of polyester reinforced by glass fiber. This reinforcing was in two forms: Woven Rovings (WRG) and Chopped Strand Mat (CSMG) E-glass fibers. The samples are fabricated by hand lay-up method. The composites are cut according to ASTM Standard for corresponding tests, like, flexural, compression and impact tests. So, that flexural strength, compression strength, impact strength and inter laminar shear stress (ILSS) of polymer matrix composites are determined. From these tests and further calculation, the polyester composites reinforced in the form of (CSMG) shows better characteristics than that of (WRG).

Prof T. Madhusudhan , Keerthi Swaroop G [11] Developing composites with natural fibers and fillers as a prospective alternate materials for some engineering implementation, especially, in aerospace and automobile applications. Natural fiber composites are very attractive, since they have high specific strength, light weight, bio-degradability and low cost. In this study, hybrid composites which in the form of jute/glass fiber, sisal glass fiber, natural rubber glass fiber, natural rubber jute fiber. The characteristic of these materials have been studied. For hybrid composites, epoxy resin has been used as a binder which results in strong bond in the hybrid composites. When fillers are added to the composite, further improvement in composites performance of can be achieved.

Gul Hameed Awan Liaqat Ali khalid Mahmood Ghauri Engr.Ramzan and Engr. Ehsan [12] A detailed study of production and properties evaluation of glass fiber reinforced polyester composites has been accomplished by using different fibers cross sections : (1ply), (2ply) and (3ply) sheets. The hand lay-up process has been chosen as the processing method for this purpose. PMC were evaluated in terms of their mechanical and metallurgical applications and characterizing.

Basappa Hulugappa, Mysuru V. Achutha, Bheemappa Suresha [13] woven glass-fiber reinforced epoxy composite which was filled with two kinds of fillers :graphite, silicon carbide (each 5 , 10% wt) was produced by hand layup process then compressed by using hot-press. This composite were inspected for mechanical properties such as tensile, flexural strength and impact strength in addition to fracture toughness. The results indicate that these mechanical properties were enhanced with the increasing of filler percentage. The unfilled glass-fiber reinforced epoxy composite has tensile strength of (305 MPa) and increased up to (404.2) MPa at 10 wt% silicon carbide.

Tayfun Uygunoglu, Ibrahim Gunes, Witold Brostow [14] In this study, physical and mechanical characteristics of polymeric composite reinforced by wastes that combine boron have been studied. The polymeric composite was produced with epoxy-based resins and wastes additives. The wastes were added into the mixture with various ratios by substituting the resins from (0 to 66%wt). Slump-flow and viscosity tests were done on fresh sample after mixing. The fabricated composites were cured in air and they were demoded after 24 hrs. They earned maximum strength after 7 days. Thus, tests were carried out on 7 aged samples. These tests include flexural strength, compressive strength, water absorption, wear resistance and density tests. As a result, the wastes addition was lead to increase the compressive strength and made the composites more brittle with low flexural strength.

Zakaria bin Dris, Azril Dahari Johari, M.N.M.Ansari [15] this study aimed to survey the various types of fibers reinforcement and test methods in order to measure the mechanical properties of polyester matrix composite with various type of fiber reinforcing. Various types of fiber reinforcement have been used to enhance the mechanical properties of polyester matrix composite. This paper also survey the effect on mechanical properties by varying filler amount, varying amounts of carbon nanotube additives, varying immersion durations in water and varying architectures for hybrid composite. By reviewing the different factors that affecting the properties of composite with different type of fiber; a new high performance polyester matrix composite can be developed.

Experimental Procedure

1-Materials

A- Unsaturated polyester: is form of a diaphanous sticky liquid at room temperature which is one of Thermosets polymers that switched into solid state by adding Hardener. The hardener used in this work is Methyl Ethyl Keton Peroxide (MEKP), which is added by (2g) to (100g) of unsaturated polyester resin at

room temp. (Percentage of styrene 32, viscosity at 25 ºC is 1000 cups, Appearance Transparent, pH solid basis 22, specific gravity 1.15) [6]. after Hardener was added, mixing process immediately begin for(8 to10 minutes) , then the mixture becomes very viscous and the temperature rises, this lead to accelerate the process of hardening.

B-Reinforcing materials: Two types of particles were used in this research. These types were E-glass fiber with volume fraction of (5%) and graphite particulars of volume fractions (1%, 3%, 5%, 7% and 10%)

2- Mechanical Tests

A- Tensile Test: This test was used to determine the behavior of composite materials under the effect of tensile load (axial load) as shown in figure (1). The tensile test was performed on flat specimens. The tensile test specimen preparation and testing procedures were conducted according to (ASTM D412).

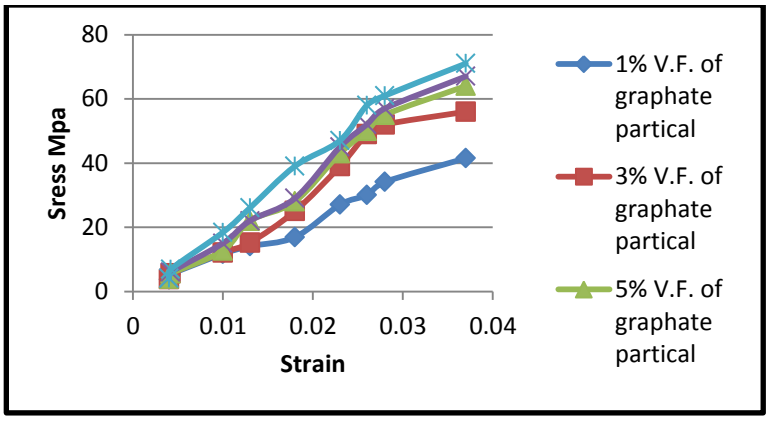

Figure (1): the effect of graphite particles and glass fibers on the tensile features of the composite materials

B-Modulus of Elasticity: Modulus of elasticity can be calculated from the result of tensile test, which is the slope of Load-elongation curves. The following figure (figure (2)) show the effect of different volume fraction values of graphite particles on modulas of elasticity of polymeric-matrix composite material which prepared in this research.

While figure (3) show the effect of different volume fraction values of graphite particles on Tensile stress at fracture point of this polymeric-matrix composite material.

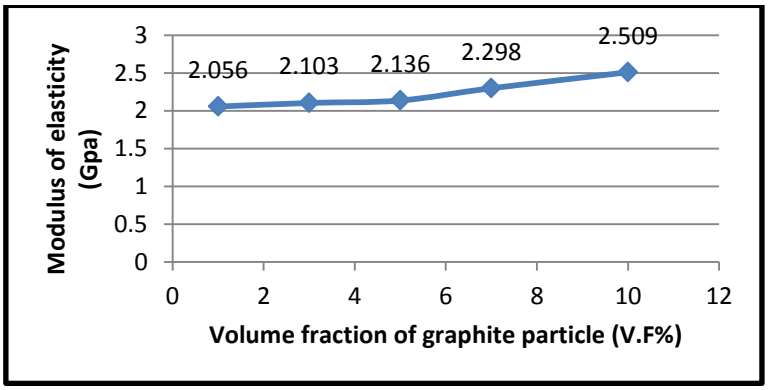

Figure (2): the effect of graphite particles and glass fibers on the modules of elasticity of the composite materials

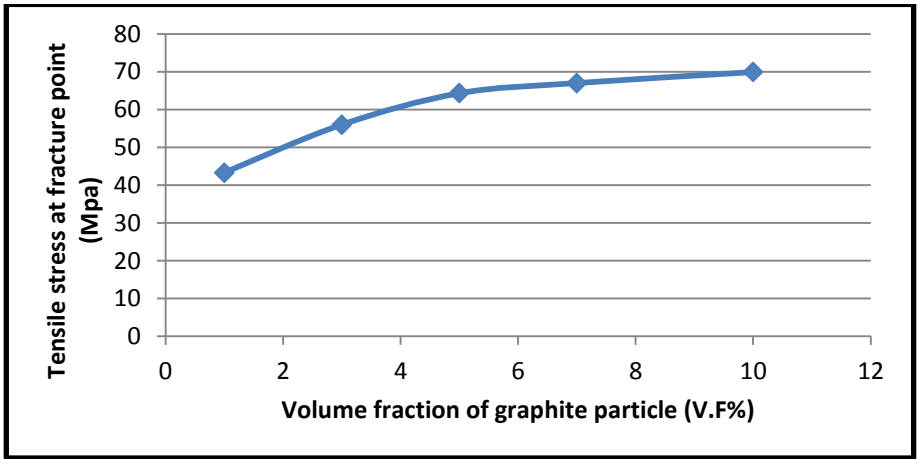

Figure (3): the effect of graphite particles and glass fibers on the modules of elasticity of the composite materials

C-Hardness test: Hardness can measure the plastic deformation for the materials that suffered under external applied stress. By using Shore-D hardness test device in which, the sample surface must be very flat, diameter of the samples are more than (30 mm) with a thickness greater than (3 mm). The results of this test are shown in figure (4).

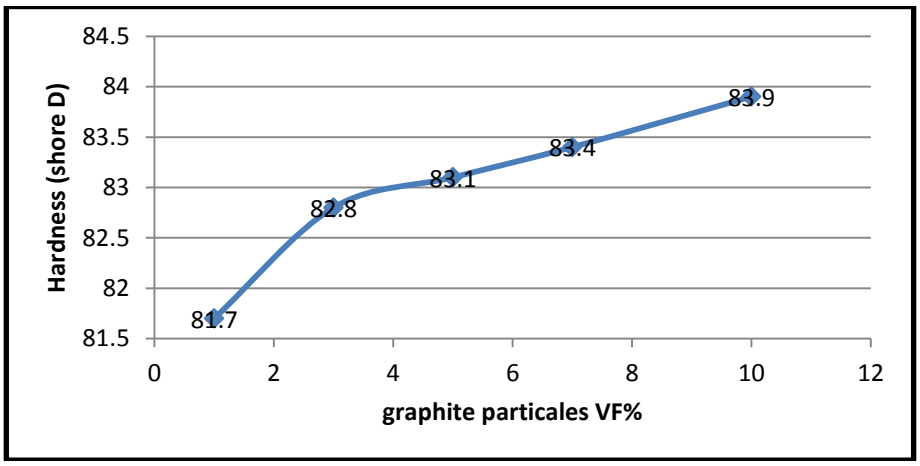

Figure (4): the effect of graphite particles and glass fibers on the Shore-D hardness of the composite materials

Result and discussion

The study results reveals that graphite particles have great effect on improving mechanical properties of polymeric-matrix composite materials based on unsaturated polyester which have good harmonize with results obtained by (6).

These results can be summered and discussed as following:

1- The values of tensile strength and modules of elasticity improved with the increasing of volume fraction of graphite particles as shown in figure (1,2,3).

This is due to the following reasons:

a- The Interconnection improvement between the base polymeric- material with the reinforcement fillers.

b- the contribution of both graphite particles and E-glass fibers for bearing the applied load, due to the random distribution and the ease of penetration of the reinforcing materials within the polymeric matrix, which creates full interfaces between the polyester and the reinforcing materials, and voids diminishing in the prepared composite material

c- The improvement in tensile strength and modules of elasticity was also resulted from the high modules of elasticity of graphite particles as compared with the unsaturated polyester and E-glass fiber.

2- As shown in figure (4), the hardness values of polymeric-matrix composite materials prepared in this research continuously increased when the volume fraction of graphite particles increased, this is due to the improvement in interfacial bonding and the high hardness of graphite particles which contribute in resisting to plastic deformation.

Conclusion:

The increase of the volume fraction of the graphite particles in the composite material which was prepared from the unsaturated polyester as a base material which also reinforced by E-type glass fiber led to significantly increase in the values of mechanical properties performed in this research, namely tensile strength, modules of elasticity and hardness.

Recommendation:

1- Study other mechanical properties for this type of composite materials such as (fatigue test, creep test and impact test).

2- Study the mechanical and physical properties of polymeric-matrix composite material made of polyester resin as a matrix, reinforced by different graphite particles volume fractions.

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الملخص: إن استخدام المواد المركبه ذات الاساس البوليميري قد وجد مجال واسع من التطبيقات في الوقت الراهن وذلك يرجع الى الجمع بين الخصائص التي توفرها هذه المواد . ان هذا العمل يركز على تحضير مواد مركبه ذات اساس بوليميري (البولستر الغير مشبع) الذي تمت تقويته بالياف زجاجيه من النوع E بنسبة 5% حجماً اضافة الى دقائق الكرافايت بنسبة 1% ، 3% ،5% ، 7% ونسبة 10% حجماً ، كما تم دراسة تاثير هذه الاضافات على بعض الخواص الميكانيكية للبوليستر. ان هذه التقوية بأكثر من مادة تقوية واحدة ادى الى تحسين الخواص الميكانيكية بشكل واضح (مثل مقاومة الشد ومعامل المرونة اضافة الى الصلادة)ز يرجع هذا بسبب مشاركة كل من الياف الزجاج ودقائق الكرافيت في تحمل الاحمال المسلطة اضافة الى الصلادة العالية لدقائق الكرافيت.

الكلمات المفتاحية: دقائق الكرافايت ، الياف الزجاج ، الخواص الميكانيكية.