Determination of Some Mechanical Properties of Unsaturated Polyester Reinforced with Glass Fiber and Plam Fiber

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Abstract

In this work a composite materials is prepared containing matrix of polymer (unsaturated polyester) reinforced with different reinforcing materials (glass fiber + plate fiber) in different values of volume fraction %.

All samples for to mechanical tests were prepared by hand layup process. The mechanical tests can be classified into: bending, tensile strength, tensile strength at break, elongation at break and hardness. The study of mechanical test shows that the mechanical properties increase with the increase in volume fraction.

Keywords: unsaturated polyester, glass fiber, palm fiber, polyester mechanical properties

دراسة الخصائص الميكانيكية للبولي استر الغير مشبع المدعم بالياف النخيل والياف الزجاج

الخلاصـــــة

في البحث الحالي تم تحضير مواد مركبة جديدة التي هي عبارة عن مخلوط بوليمري ، يتكون من مزج بولي استر غير مشبع مع اضافة نسب حجميه مختلفة من الياف النخيل والياف الزجاج على التوالي . تم استخدام طريقة القولبة اليدوية في تحضير العينات المستخدمة في الاختبارات الميكانيكية. الاختبارات الميكانيكية والتي تضمنت الاختبارات الانحناء , مقاومه الشد , الصلادة , وكانت نتائج الاختبارات الميكانيكية تزداد بزيادة النسب الحجميه المضافه من الياف ازجاج والياف النخيل.

Introduction

Composite materials are quite common today and are used in nearly every segment of civilian and military industres. The idea of reinforcement is not new. Over the centuries natural fibers, such as grass or animal hair, have been used to improve the strength and to lessen shrinking of pottery prior to firing and increase the strength in mud houses. This idea in the present form has been exploited with the development of glass, carbon and later of aramid fibers [1].

World War II led to the birth of glass-fiber-polyester composites for radomes and secondary aircraft structures, such as doors and fairings, which were designed and placed into production. Glass-fiber composites were recognized as valid space materials when they were picked for fabrication and production of Polaris submarine missile casings.

In the late 1950s, research efforts focused on light weight elements in the search for fibers of even greater strength that could compete successfully in the marketplace with aluminum and titanium. Boron fibers

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were the first result of this effort (1963), followed by carbon, beryllium oxide, and graphite. A composite consisting of 80% advanced polymer and 20% aluminum has been developed for automotive applications [2].

The major advantages of composite materials are low density, high specific strength and stiffness, good corrosion resistance and improved fatigue properties. Because of these properties, they have successfully replaced many conventional metals [3]; Polymeric composite materials, for example, can solve some of the problems resulting from the deficiencies of conventional steel-reinforced-concrete materials, and other polymeric materials in load-bearing structures in aircraft, automobiles, ships, pipelines, storage tanks, etc.

Flexibility of manufacturing is also a unique characteristic. Large complex structures can be fabricated in one piece thus minimizing tooling costs and the need for joints and fastenings. The fact that during the manufacture the material itself is being made at the same time as the component, by suitable choice of the constituents, requiring properties which can be attained. The technologies developed allow the manufacturer to optimize and control the composites' structure, i.e. fiber-matrix interactions, matrix crystalline, degree of cure and fiber arrangement.

Despite all these advantages and since all matrix materials are highly flammable compared to metals like aluminum or steel, they can burn vigorously with evolution of smoke. Even if inorganic fibers like E-glass are the reinforcing structures, the composite fire resistance will be determined by that of the organic matrix and the relatively low melting point of these fibers compared to typical flame temperatures [5,6].

Polymer matrix composite (PMC) materials are increasingly being used in all aspects of our society, from transportation (trains, autos and airplanes) and civil engineering (bridges, wall reinforcement,) to electronics and sporting goods. The aerospace military industry has been using these materials for more than 40 years, principally due to their demand for low weight structures [1].

The material properties of physically mixed components depend on the content of the reinforcements, their adhesion to the polymer matrix, the uniformity of fillers dispersion, and other factors [3].

In (2000), Karl [7] indicated a classification of hybrid materials as class I hybrids with weak bonding between the constituents like inorganic ,organic phases (Vander Waals bonding) and class II hybrids with strong covalent or iono-covalent bonding between the two phases. Also it was noticed that nanocomposites usually have a continuous phase/ matrix including a nanosized second phase / filler with particle sizes below (100) nm.

In 2003, Ahamed [8] made an investigation into the properties of unsaturated polyester resin reinforced with rice husk. Results show that composite materials of rice husk gain better mechanical properties compared with composite prepared from unsaturated polyester resin without filler.

In [2004], Al-Hadad [9] studied two types of thermoset resins in proper blends of different mixture ratios from

Epoxy and unsaturated polyester. To make blend under code, SI was reinforced with fine Iraqi petroleum coke which was fired under 1100 ºC .mixture gave good mechanical properties of brightness and stiff structure. The properties were displaced to its resin forced samples, but actually these properties are less than those of S_2 matrix and they reinforced sample properties, except in the tensile result which indicates weak behavior of S_2 matrix .

In 2005, John [10] studied the variations in impact strength and compressive strength of unsaturated polyester based on sisal/glass hybrid composites with fiber loading. The impact strength of these hybrid composites has been found to be higher than that of the matrix, whereas a marginal decrease was observed in the compressive strength of the hybrid composites over that of the matrix. The effects of NaOH treatment and trimethoxy silane (coupling agent) treatment on the impact and compressive properties of these sisal/glass hybrid composites were studied. No significant improvement in impact strength of the sisal/glass hybrid composites was observed in these treatments, whereas a marginal increase in compressive strength of these hybrid composites was observed. In the present work, six hybrids composite are prepared. fiber mixture of (glass and palm) as a reinforcements in (Epoxy) resins with volume fraction (5,10,15) % respectively and study the mechanical properties of a composite consisting of an unsaturated polyester resin as a matrix and (glass fiber+ plam fiber) as a conductive fiber.

Experimental

Materials

The matrix used in this study was an un saturated polyester resin 860 un saturated polyester . manufacturedbya company SIR Saudi Arabia), It is Viscous Liquid, transparent, pink and it is type of thermosetting Polymer.

The liquid convert to solid by adding hardener additives (HMTA), which is transparent liquid with 2% for each 100 gm of unsaturated polystyrene at room temperature.

Fiber Glass

In this research E-Glass Type used in woven Roving form as strengthening for the mean material (Unsaturated polystyrene)these fiber is immersed in an orderly manner in form of regular layers. This type of fiber surpass many characteristics one of these It has high ductility while this gives to the resin material high ductility .

These fiber supplied by (Mowding LTD.UK company. It composite has little aced so it content of high present of (Silica SiO2) and other different present of oxides like (K2O , Na2O , B2O3 , CaO , MgO , Al2O3) also there are other material found in very little percent as a stain like (TiO2 , Fe2O3 , F) . Which show in table below

Preparation Methods for Composites Materials

a- The unsaturated polyester liquid mixed with (HMTA) hardener (11-13) % liqued. The mixture reinforced by glass fiber and palm fiber with different values of volume fraction. The metal mould was cleaned with dimensions (25×25×3) cm used for casting the sheet of hybrids composite material. The

fablon was fixed on the inner mould faces before casting to facilitate the releasing of casting hybrids and having smooth faces.

b- The specimens were cut according to standard dimensions for each test, using fractions of the reinforced resin of plam fiber (2.5, 5, 7.5, 10, 12.5, 15) vol %.

c- The masses of the reinforcement materials (hydroxyapatite before and after calculation process) were calculated according to the required volume fractions).

d- The masses of the resin (unsaturated polyester) were calculated according to the required volume of cast, the accelerator and the hardener, were added as a weight % with an amount of (0.5%) and (2%) respectively

e- The reinforcement filler of HA and the matrix (including the accelerator and the hardener) were mixed at room temperature continuously and slowly to avoid bubbling during mixing .The process was continued for (10) minutes until the mixture became homogeneous. Temperature rose which indicated the beginning of reaction process. Temperature raising was very necessary for the mixture to have a certain viscosity and to avoid particle precipitation

f- The mixture was poured from one corner into the mould (to avoid the bubble formation which causes cast damage) and the uniform pouring was continued until the mould was filled to the required level .

g- The mixture was left in the mould for (24) hrs at room temperature to solidify. Than the cast was placed inside an oven dryer for (1) hr at $(55)^0$C , this step was important to reveal complete polymerization, best coherency, and to relieve residual stresses.

Mechanical Properties

Tensile Tests

Tensile properties were obtained using a ZWICK universal testing machine which is available at the National Company for Chemical and Plastic industries. The standard sample for tensile test, dumbbell-shape die – cut sample was cut according to ASTM (D638) [11]. Test specimens type 1434 with a thickness of 4mm were used in this research .

Hardness Tests

Shore hardness tester was used. Tests were carried out according to ASTM D2240 and ISO/R 868.

Bending Test

The instrument was used to calculate the modulus of elasticity of blend and composite. The resulting deflection of the specimens can be read by measurement of deflection after the mass is applied gradually. In this research a three-point loading system was used to determine the modulus of elasticity. All the specimens of bending test of blend had a depth of 10mm and thickness 3 mm . the ratio of span to depth is (32:1) according to the standard specification of ASTM (D790 m-86) [12].

Results and Discussion.

Tensile Strength

It can be defined as the maximum tensile sustained by the material being tested to its breaking point [13].

Tensile strength = F/A

where: F= force applied in N,

A= cross section area mm^2.

Figure (1) shows the variation in tensile strength of unsaturated polyester at different wt.% of glass fiber and plate fiber. From this figures, it is clearly seen that the tensile strength increases with increasing wt% of plam fiber. The tensile strength of a composite depends on many parameters including 1) Type of additives; 2) additives percentage; and 3) Resin type. The parameters of major influence on tensile strength are Additives percentage and tension properties of both resin and additives. As a support for the present results, John [10].

Suggests the addition of fiber to polymer matrix to increase the elastic movement of polymeric chains, however the most important observation is that all the blends have strongly improved the elongation compared with pure PS and without using compatibilsers.

Tensile Strength at Break

The values of tensile strength at break (σ_B) were determined by using tensile test.

Figure (2) shows the variation in tensile strength at break of unsaturated polyester at different vol. % of glass fiber and plam fiber. From this figure it is clear that the increasing of % fiber content leads to a decrease in the fracture stress because the addition of fiber causes an increase in the elasticity which leads to reduce the strength of the material [10].

Shore Hardness

Hardness is commonly defined as the resistance of a material to static penetration by a harder material; also it can be defined as a resistance of material to local deformation[13].

In the present work shore hardness test was used to measure the hardness. Figure (3) shows the variation in shore hardness of unsaturated polyester at different wt.% of glass fiber and plam fiber.

From this figure it is clear that there is a pronounced effect of the addition of fiber at different volume percents on the hardness of the material. Increase in % fiber content leads to a increase in the hardness, this may be due to the fact that the hardness is generally considered to be a property of the surface therefore this behavior of hardness is expected. The addition of the fiber leads to an increase in the elasticity and a decrease in the matrix surface resistance to the indentation.

Bending Test

The modulus measures the resistance of a material to elastic deformation. Figure (4) shows the variation of modulus of unsaturated polyester at different vol.% of glass fiber and plam fiber.

From this figure it is clear that there is a pronounced effect of the addition of fiber at different volume percents on the modulus of elasticity of the material. Increase in % fiber content leads to a increase in the modulus of elasticity, this may be due to the fact that the addition to that the matrix has begun to transform the material to glassy state and the effect of the voids existing in the matrix which contain gases confined in it expanding with the rise of temperature , thus causing formation of internal stresses that

would reduce the strength in addition to the variation in the values of thermal expansion between the matrix and the reinforced materials which lead to creating stresses that reduce the strength of composites[14].

Conclusions

After reinforcement of PS with glass fiber and using plam fiber as a filler, hardness, tensile strength, tensile strength at break, elongation at break and modulus of elasticity increase in the increase of filler fraction

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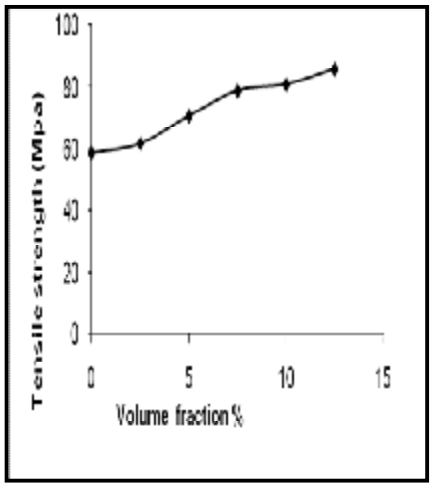
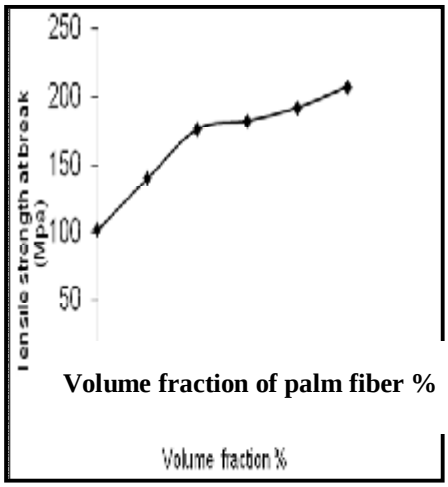


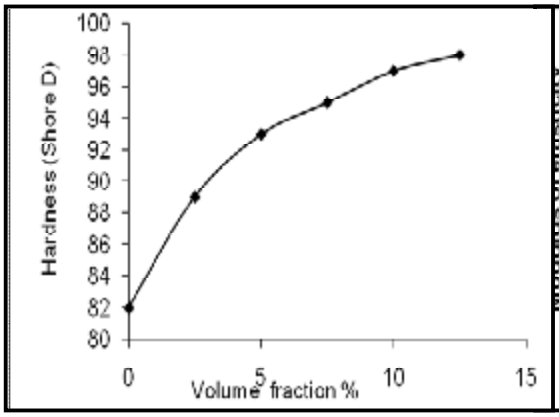
Volume fraction of palm fiber %

Figure (1) Tensile strength of unsaturated PS as a function of different % of volume fraction palm fiber and constant glass fiber content (8% wt).



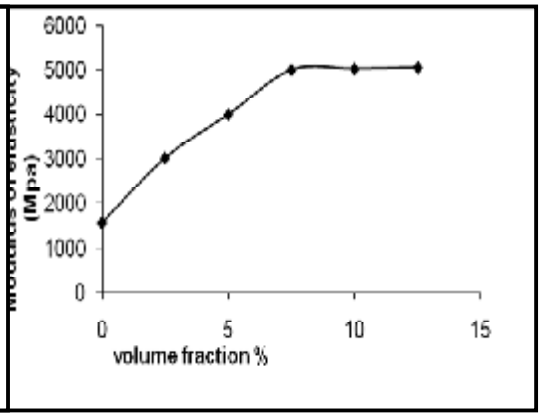
Volume fraction of palm fiber %

Figure (2) Tensile strength at break of unsaturated PS as a function of different % of volume fraction palm fiber and constant glass fiber content (8% wt).



Volume fraction of palm fiber %

Figure (3) Shore hardness of unsaturated PS as a function of different % of volume fraction palm fiber and constant glass fiber content (8% wt).



Volume fraction of palm fiber %

Figure (4) Modulus of elasticity of unsaturated PS as a function of different % of volume fraction palm fiber and constant glass fiber content (8% wt).