TENSILE STRENGTH STUDY OF UNSATURATED POLYESTER / POLYVINYL CHLORIDE COMPOSITES REINFORCED WITH GLASS FIBERS

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Abstract

Tensile strength study of UPE/PVC composites reinforced with one and two layers of random glass fibers has been investigated. Hand lay up method was used to prepare sheets of UPE/PVC blends with different weight percentage of PVC(10%,20% and30%) Results show increasing in the values of maximum stresses, yield stresses and modulus of elasticity for UPE/PVC blends with increasing the weight percentage of the polyvinyl chloride (PVC) . UPE/PVC blends reinforced with one layer of glass fiber results show good mechanical properties for the composite which contain 20% PVC. Also the results show that composites reinforced with two layers of glass fiber randomly increasing in values of maximum stresses with increasing PVC percentage .

دراسة متانة الشد لمتراكبات البولي استر غير المشبع/البولي فينيل كلورايد المسلحة بالياف الزجاج

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الخلاصة

لقد تم في هذا البحث دراسة متانة الشد لمتراكبات UPE/PVC المسلحة بطبقة وطبقتين من الياف الزجاج العشوائية الاتجاه. استعملت طريقة التشكيل اليدوي لتحضير قوالب من متراكبات UPE/PVC وبنسب وزنية مختلفة للبولي فينيل كلورايد(١٠%، ٢٠% و٣٠%). اظهرت النتائج زيادة في قيم اقصى اجهاد، اجهاد الخضوع ومعامل المرونة لمتراكبات UPE/PVC مع زيادة النسبة الوزنية للبولي فينيل كلورايد. اظهرت نتائج المتراكبات UPE/PVC المسلحة بطبقة واحدة من الياف الزجاج نتائج ميكانيكية جيدة للمتراكب المحتوي على ٢٠%بولي فينيل كلورايد.كما اظهرت النتائج للمتراكبات المسلحة بطبقتين من الياف الزجاج زيادة عشوائية بقيم اقصى اجهاد مع زيادة نسبة البولي فينيل كلورايد.

Introduction:

A composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications. Modern composite materials are usually optimized to achieve a particular balance of properties for a given range of applications. Given the vast range of materials that may be considered as composites and the broad range of uses for which composite materials may be designed, it is difficult to agree upon a single, simple, and useful definition. However, as a common practical definition, composite materials may be restricted to emphasize those materials that contain a continuous matrix constituent that binds together and provides form to an array of a stronger, stiffer reinforcement constituent. The resulting composite material has a balance of structural properties that is superior to either constituent material alone [1]. The improved structural properties generally result from a load-sharing mechanism. Although composites optimized for other functional properties (besides high structural efficiency) could be produced from completely different constituent combinations than fit this structural definition, it has been found that composites developed for structural applications also provide attractive performance in these other functional areas as well. As a result, this simple definition for structural composites provides a useful definition for most current functional composites.The most common reinforcement is fiber glass, in which glass fibers are embedded within a polymer material. Fiberglass acquires strength from the glass and flexibility from the polymer. However, the mechanical performance of fiber glass reinforced composites depends on not only the properties of constituent components but also the interfacial interactions established between the reinforcing agent and the matrix material[2]. Hand-lay-up and spray-up techniques havebeenusedto produce materials in layers such as resin and fiber and the obtained properties are: high strength and rigidity, light weight, good corrosion resistance and thermal isolation[3,4]. The composite materials are as diverse as porcelain enamel products (glass coated metal), plastic or metal laminated corrugated paper, fiberglass strengthened cement, stainless steel clad carbon steel, fiber reinforced plastics, and steel or glass reinforced rubber (tires)Fiber reinforced plastics (FRP) have been in existence for about fifty years. They have generally been used to replace traditional materials such as wood, aluminum and steel. Significant advantages over these traditional materials include higher strength, lighter weight, greater corrosion resistance, dimensional stability, higher dielectric strength, and improved design flexibility[5]. Thermoplastic are plastics that can be repeatedly melted, such as polyethylene, polypropylene, and polyvinyl chloride(PVC)[6]. Poly(vinyl chloride) (PVC) is one of the most commonly used plastics in our society, and its main applications include pipes, electric wires, window profiles, siding, etc . Pure PVC is a bright white, brittle solid, recently, wood fiber reinforced PVC is getting more popular because of its acceptable mechanical properties ,moisture and fungus resistance, long lifetime, wood-like surface performance, and recyclability . Some weakness of this material including low impact strength and thermal stability imposes restriction on its application, which signals need for additional research on this important product[7]. Thermosetting polymers solidify by a chemical cure. Here, the long macromolecules cross-link during cure, resulting in a network. The original molecules can no longer slide past each other. These networks prevent "flow" even after reheating. The high density of cross-linking between the molecules makes thermosetting materials stiff and brittle. The cross-linking causes the material to become resistant to heat after it has solidified, unsaturated polyester is known for its high strength, stiffness and hardness. It is also known for its dimensional stability, even when hot, making it ideal for under-the-hood applications. In most cases UPE is found reinforced with glass fiber[8,9].

Experimental part:

A hand layout method was used to prepare specimens as sheets with one and two layers of glass fibers

1- Unsaturated Polyester/PVC Blends Preparation

100g of unsaturated polyester resin type Viapad H-265 was mixing with 0.5g accelerator (Cobalt napthenate) a 2g hardener(Methyl Ethyl Keton Peroxide) were added to the mixture and the contents again mixed thoroughly until a homogeneous state of the mixture was obtained ,then we add a sufficient amount of PVC powder (supplied by industrial chemical and resin CO.LTD. DAMAM.KSA) and mixed them again then cast in the prepared sheet, the prepared casting composites sheets were left it to cure and dry for 72hrs at room temperature .Three weight ratio of UPE / PVC (powder) blends were prepared by adding the PVC to UPE resin and mix them using mechanical mixer for 5 minutes asshown in table 1.

Table 1: UPE / PVC composites ratio

Blend no.	UPE/PVC
1	90/10
2	80/20
3	70/30

2- Composites Preparation

Sheets of UPE –PVC blends with weight percentage as shown in table 1, reinforced with one and two layers of chopped strand mat, randomly oriented ,E-glass fiber,450g/m specific surface density supplied from molding LTD Comp. UK. were prepared , sheets were left it to cure and dry for 72hrs at room temperature 25±2.

3- Tensile test

The specimens were cut out of the sheets with dimension according to international specification, ASTM(D638-84),for tensile properties of plastics using instron1195 with load cell 250 kg and the crosshead speed (2mm/min).

4- Optical microscopy

Morphology of samples was determined by using a polarizing microscope mode (OLYMPUS BH-2) with camera (OLYMPUS C-35 AD-4) . The investigation magnification was equal to 50X.

Results and Discussion

1-Stress-Strian Curve for UPE/PVC Blends:

Two important mechanical properties of any resin systems are its tensile strength and stiffness. Results show (figure 1)an improving in tensile properties with the increase of the weight percentage of PVC, which lead to increase in maximum stress, yield stress and modulus of elasticity as shown in table 2, that improvement my be due to the increasing of PVC weight percentage in the matrix , and decrease the clustered of and increasing PVC diffusion in the UPE matrix as shown in the optical microscopy (figure 2).

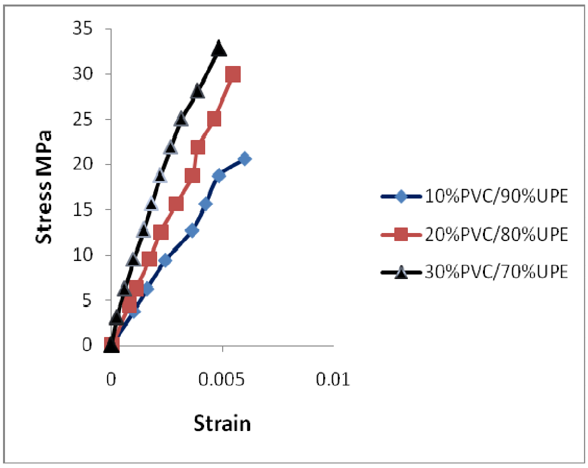
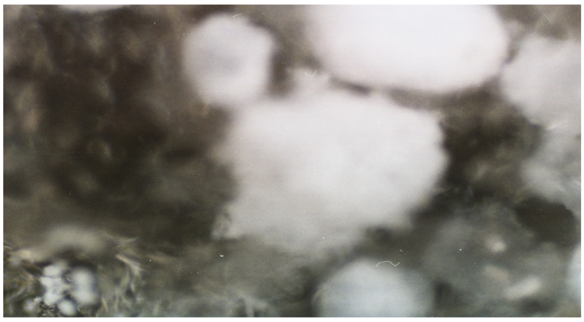


Figure 1: Stress-strain curves for PVC/UPE with deferent blends ratio .

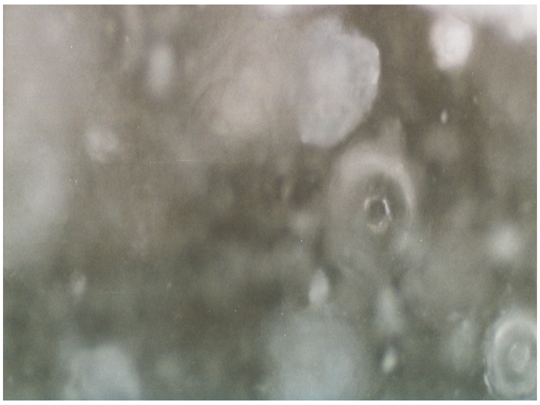
Table 2:Value of ultimate tensile stresses(UTS), yield stresses (σy) and modulus of elasticity(E) for UPE/PVC blends.

(UPE /PVC) %	UTS (MPa)	σy (MPa)	E (GPa)
90/10	20.62	12.3	3.65
80/20	30	15	5.52
70/30	32.81	18.1	8.78



(a)

(b)



(c)

Figure 2: PVC diffusion in the UPE matrix, a)10%PVC , b) 20%PVC, c) 30%PVC.

2-Stress-Strain curve of PVC/UPE Composites reinforced with glass fibers

The stress strain curve for unidirectional materials is usually approximately linear to failure. The tensile strength in the longitudinal direction occurs approximately when the strain in the fiber reaches a value close to the fiber ultimate strain. The transverse strength (and shear strength) are matrix dominated, with the mode of failure being a crack growing parallel to the fibers in the matrix and fiber/matrix interface. The limiting value for the transverse tensile strength is the matrix ultimate strength. For brittle resins and/or poorly bonded fibers, the transverse strength will be lower than the matrix strength [10,11].results of composites reinforced with one layer of glass fibers, (figure 3) showed the composite contain 20%PVC have good mechanical property, and the values of maximum stress, yield stress and modulus of elasticity higher than for other composites as shown in table 3. that can be related to the increasing in the ability of adhesion between the fiber and the matrix(UPE/PVC) lead to decrease the sliding between composite layers when applying stress on the composite, the microscopic picture (figure 4) and the photographic picture (figure 5) for the composite (20%PVC//80%UPE) show clearly the fiber pull-out from the composite.

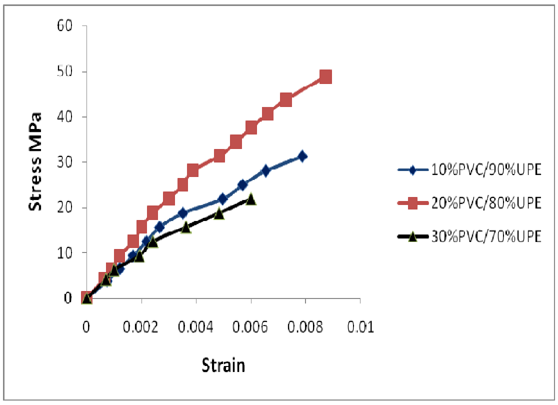


Figure 3:Stress-strain h for PVC/UPE with one layer of glass fiber .

Table 3: Value of ultimate tensile stresses(UTS) , yield stresses(Ơy) and modulus of elasticity(E) for UPE/PVC blends with one layer of glass fiber.

(UPE /PVC) %	UTS (MPa)	Ơy (MPa)	E (GPa)
90/10	31.25	18.5	5.55
80/20	48.75	24.2	7.39
70/30	21.87	15	4.7

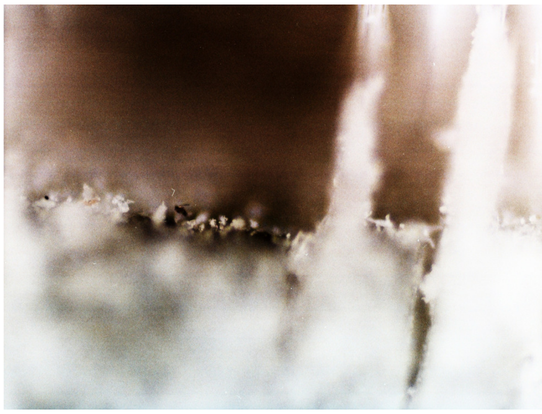


Figure 4:Surface fracture of(20%PVC/80%UPE) with one glass fiber layer.

Figure 5: Photographic picture of(20%PVC/80%UPE) with one glass fiber layer.

The results of PVC/UPE composites reinforced with two layers of glass fibers show that the composites which contain 10% and 30% PVC have batter tensile strength as in(figure 6) high values of maximum stress, yield stress and modulus of elasticity as shown in table 4.Generally, it was found that the tensile strength of the composites increased with increasing fiber contents. The increase in the moduli was expected since the stiffness of the glass fibers was relatively high. It has been widely accepted that orientations and distributions of glass fibers in polymer composites have significant effects on mechanical properties of most glass fiber filled polymer composites[12]. .It was interesting to mention that the effect of fiber loading on the composite strength was less pronounced than that on the composite moduli. This may be caused by the fact that the modulus was obtained in the elastic deformation of the stress–strain curves while the strength was gained at break point in the plastic deformation .(figure 7). Optical microscopy picture show the fracture surface and the fibers pullout covered with layer of the polymers matrix for (30%PVC/70%UPE) composite.

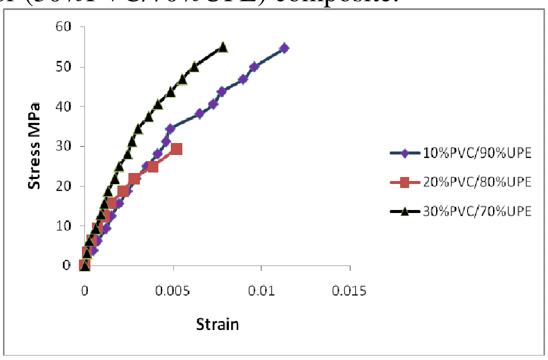


Figure 6:Stress-strain curves for PVC/UPE blends with two layers of glass fiber .

Table 4: Value of ultimate tensile stresses(UTS), yield stresses(Ơy) and modulus of elasticity(E) for UPE/PVC blends with two layers.

(UPE /PVC) %+GF	UTS (MPa)	Ơy (MPa)	E (GPa)
90/10	54.687	29.12	7.17
80/20	29.375	12.15	11.49
70/30	55	21	13.6

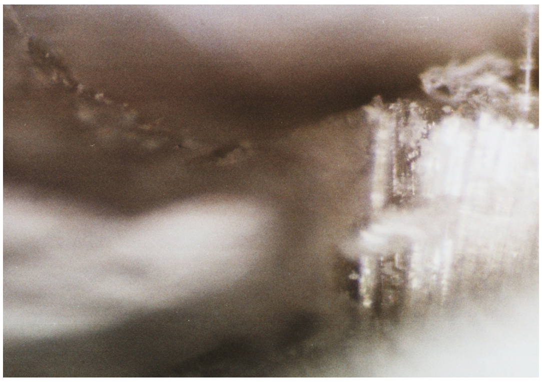


Figure 7: Fracture surface of (30%PVC/70%UPE) with two glass fiber layers.

Conclusion

In this work, UPE mixed with PVC powder with different ratio ,and reinforced with (one and two) glass fiber layers. Tensile values for UPE/PVC blend enhanced with increasing PVC weight percentage. Also tensile values enhanced with addition of glass fiber(one and two) layers to UPE/PVC and are different in the increment with the different of weight percentage ratio of(PVC/UPE), higher values obtain for composite (30%PVC/70%UPE) with two layers glass fiber.

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