

Studying Some Properties of Unsaturated Polyester Composite Reinforced by Carbon Black Particulate

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Abstract

Carbon black plays an important role in improving the properties, especially mechanical and physical properties of unsaturated polyester composite.

In this work the effects of carbon black with different weight percentage (5,7.5,10%wt) was investigated. Sample with and without carbon black exposed for many tests to determine the effect of carbon black contents on some properties of un saturated polyester such as tensile strength, hardness, impact strength, flexural strength, and density.

The results show that the tensile strength values increase at weight 10% carbon black. Also, it was noted that the hardness increased by 7% at the same percentage of carbon black. Impact resistance and flexural strength improved by 22% and 20% respectively as compared with samples without carbon black. The results also show that the density values increase with increasing carbon black percentage for all samples. It is found that, carbon black acts as particulate reinforcement materials results in improvement the mechanical properties of unsaturated polyester.

Keywords: Unsaturated Polyester, Carbon Black, Mechanical Properties, Composite Reinforced Particulate.

الخلاصة:

اسود الكربون يلعب دورا مهما في تحسين الخواص كالخواص الفيزيائية والميكانيكية منها للبولى استر. في هذا العمل تم دراسة تأثير اسود الكربون مع مختلف النسب الوزنية (5,7.5,10%wt). تم تعريض النماذج مع او بدون اسود الكربون الى العديد من الفحوصات مثل مقاومة الشد، الصلادة، مقاومة الصدمة، مقاومة الانثناء، البنية المجهرية والكثافة لحساب تأثير نسب اسود الكربون على خواص البولى استر غير المشبع.

النتائج بينت زيادة في مقاومة الشد عند نسبة اسود كربون 10%wt، كذلك لوحظ زيادة في قيم الصلادة بنسبة 7% لنفس نسبة اسود الكربون، مقاومة الصدمة ومقاومة الانثناء تحسنت بمقدار 22% و 20% على التوالي بالمقارنة مع النماذج بدون اسود الكربون. النتائج بينت كذلك بان قيم الكثافة زادت بزيادة نسب الكربون في جميع النماذج المحضرة، كذلك وجد ان اسود الكربون كمادة دقائقية مقوية محسنة للخواص الميكانيكية للبولى استر غير المشبع.

الكلمات المفتاحية: البولى استر غير المشبع، اسود الكربون، الخواص الميكانيكية، المواد المركبة المقواة بالدقائق.

1 – Introduction

Unsaturated polyester(UP) are one of the most important thermoset material used in composites industry for the preparation of molding compounds, Laminates, coating and adhesives as having low cost and easy to use. [Obayi *et al.*, 2008, Eosman *et al.*, 2012]. However, it is brittle in nature and has poor resistance to crack propagation [Chuntip *et al.*, 2007, Al-Mosawi *et al.*, 2013]. there are several researcher doing for improving properties for these polymers types.

M.Davallo *et al.*, 2010, studied the mechanical properties of unsaturated polyester such as tensile, compressive, flexural properties and fracture energy and found that tensile stress and strain of failure of the near resin was found 63 MPa and 4.7% respectively, also found that fracture energy obtained for the polyester resin lie between the typical values and flexural stress at failure was found 78 MPa.

Asrar *et al.*, 2011, studied the effect of carbon black(CB) on the electrical conductivity of unsaturated polyester, they found that addition of carbon black to polyester caused change of volume resistivity of these materials. Also addition of (15-30wt%) of carbon black to polyester caused limited, almost linear decrease of resistivity.

M.Ibrahim *et al.*, 2012, studied mechanical and thermal properties of composites from (UP), they found that the stiffness of UP/OPA composites relatively increased, which can be seen in the results of tensile and flexural modulus. The thermal stabilities of the composites were increased as the OPA filler content was increased.

Ram *et al.*, 2013, studied the mechanical properties and thermal diffusivity of composites comprising hollow carbon micro tube (CMT) filler and unsaturated polyester. They found that the thermal diffusivity of the CMT-UP composites was increased to 4.056 W/M.K at 50wt% filler loading after reaching a minimum value of about 0.210 W/M.K at 1wt%. The mechanical properties increased up to 80% in the tensile strength and 66% in the impact strength.

2- Experimental Work

2-1 Materials and Methods.

Unsaturated polyester (UP) was used as the matrix material, manufactured from (SIR) company, appearance is yellow, density is 1.3 g/cm³.

The hardener type MEKP (Methyl Ethyl keto peroxide) was added by 2% at room temperature to matrix material, and the cobalt naphthenate also added by 0.5% to speed up the reaction and increase the solidification of the matrix.

Carbon black (CB) with particle size (14 μm) added as reinforcement materials with different percentage weight (5, 7.5, 10%wt) to matrix material. Carbon black was added carefully and gradually to avoid the loss of carbon black. The matrix was stirred and observed to ensure that the carbon black mixed well with the matrix or until a homogenous mixture was obtained.

2-2 Mechanical and Physical Properties.

A. Tensile Test:

The tensile test was performed according to ASTM (D370-05). The test was carried out with a universal testing machine (WDW), China, Time Group Inc. microcomputer controlled electronic. Tests were conducted on at least three samples, rate of loading equal 10 mm/min.

B. Hardness Test:

The hardness of samples were measured by hardness machine shore D hardness. Hardness samples, with dimensions according to ASTM (D2240) were prepared.

C. Impact Test:

The WP400 pendulum impact tester machine. The Charpy test (DINEN 10045/DIN), type (penelenschlawerk gunt Hamburg), according to ASTM D-256-87.

D-Flexural Test:

Flexural tests were performed according to the D 790-86 by using universal testing machine (WDW). Flexural load on 3-point bending was used with recommended testing span to the depth ratio of 16:1.

E- Density Test:

In this test, samples from any previously performed test have been measured their density, this method can be used with sheet, rod, tube, and molded articles. The samples are weighed in air then weighed when immersed in distilled water, and the equation is:

$$\text{Density} = \frac{\text{sample weight in air} - \text{sample weight in water}}{\text{Volume}}, \text{ Density} = \text{g/cm}^3$$

3- Results and Discussion

The mechanical properties of (UP) with different weight percentage of (CB) are presented in **Table 1**.

The tensile strength of pure samples (15.9 MPa) was decreased by additional of (CB) at 5, 7.5%wt, **Fig.1** shows the graph of tensile strength with different percentage of carbon black. Results showed that the tensile strength decreased as the weight percentage of carbon black increased from 5 to 7.5%, but increased as the weight

percentage of carbon black increased beyond 10% . The higher tensile strength might be attributed to better dispersion of carbon black in the polyester matrix ,better wettability and interfacial bond .The lower tensile strength could be due to a number of reasons such as weak interfacial bonding at carbon black and polyester matrix interfaces. Also the decreasing in tensile strength may be due to the large agglomeration size that may be occurs because of the high surface energy of (CB) which decreases the total interfacial surface area of produced composite material between reinforcement and matrix material[**Hu,2001;Abdul Khalil,2007**].

Fig.2 Shows the relationship between percentage of carbon black and the hardness of (UP). The minimum hardness is observed at low wt% of carbon black and increase gradually, this is may be due to that CB particles becomes stress concentration inside matrix leading to decrease in hardness [**Chuntip et al., 2007**].

Impact tests measure the energy expended up to failure under conditions of rapid loading.**Fig.3** shows the relation between the impact strength of Up with different weight percentage of (CB).From this figure is clearly seen ,that increasing of CB percentage lead to increase the impact strength to 7.5%wt.When carbon black percentage increases and internal particle distance reach a suitable range, the impact strength can be improved .But when the carbon black percentage is too high, internal particle distance becomes too small and that may be lead to large size agglomerates,which provide suitable begins for brittle behavior[**Sanchez et al., 2005;Zanib et al., 2012**].

The results of flexural strength of the(UP) with the weight percentage of(CB) are presented in **fig.4**.The adhesion between (UP) matrix and carbon black plays an important role in surface interaction of polymers.

Fig .5 explain the density variation with the increase in percentage of(CB). It is clear that the density increase while the(CB) was increased. The increasing in density may attributed to the molecular weight and viscosity increasing because the density is a function of molecular weight[**Wypych,2000**].

It is was shown that the surface appearance of UP without and with carbon black .At lower percentage of (CB) shows fewer of particles in UP matrix ,less agglomeration and fine dispersion of CB in the matrix and at higher percentage of CB shows the higher number of particles in (UP) matrix, many agglomerate particles [**Francoise, 2001**].

4- Conclusions

In general ,the effect of carbon black on unsaturated polyester was improved the properties of composite.

- 1- The maximum tensile strength which has been achieved by 10% CB.
- 2- The best value of hardness was at 10%wt (CB).
- 3- Impact strength was improved at 7.5%wt ,flexural strength was improved at the same percentage of tensile strength.
- 4- The density increase with increasing CB for all samples prepared.
- 5- The results showed that the higher percentage weight of carbon black shows many agglomerate particle in the surface appearance .

5- References

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Table (1): Mechanical properties of unsaturated polyester with different wt% carbon black.

Carbon Black wt%	Tensile Strength (MPa)	Hardness Shore (D)	Impact Strength (J/m ²)	Flexural Strength (MPa)	Elongation at Break (%)
0	15.9	84.25	47700	6.58	4.3
5	15.43	80.3	49300	5.5	6.42
7.5	14.01	77.0	58000	4.96	8.5
10	21.85	90.55	27000	7.88	5.13

Fig. 1: Effect of CB weight percentage on tensile strength of UP

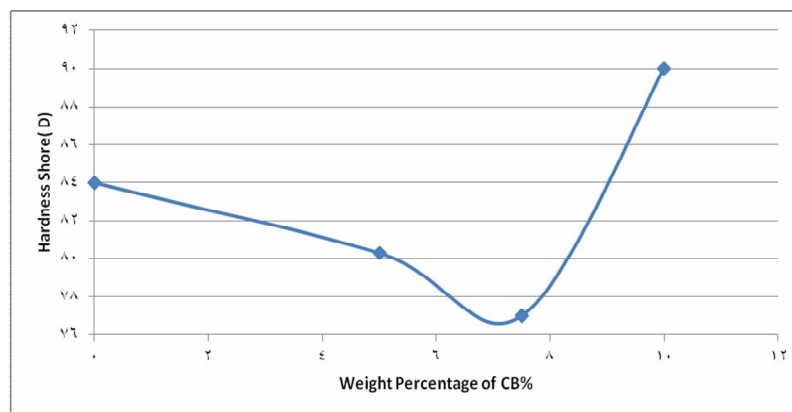


Fig. 2:Effect of CB weight percentage on hardness of UP

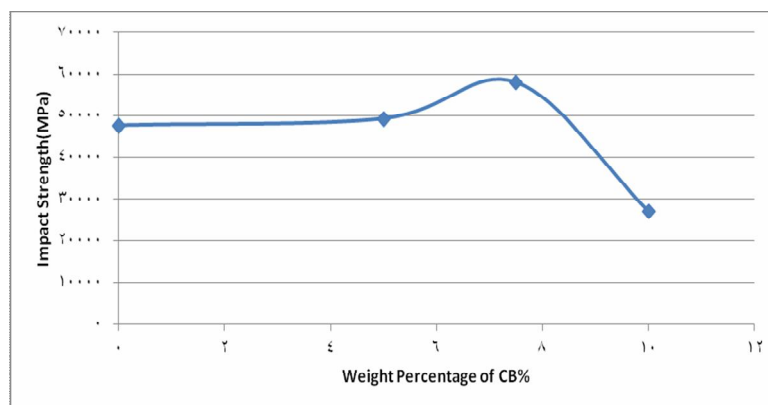


Fig. 3: Effect of CB weight percentage on impact strength of UP

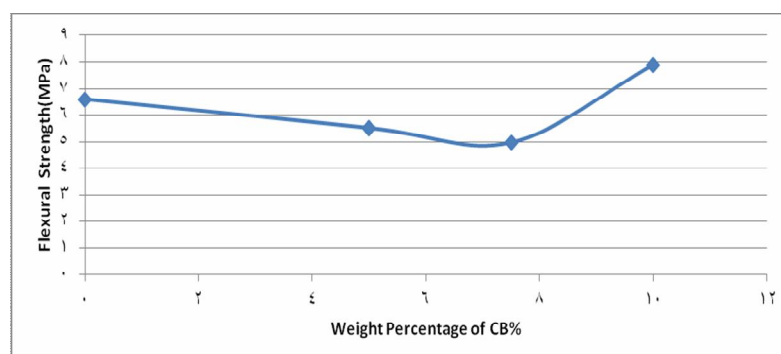


Fig. 4:Effect of CB weight percentage on flexural strength of UP

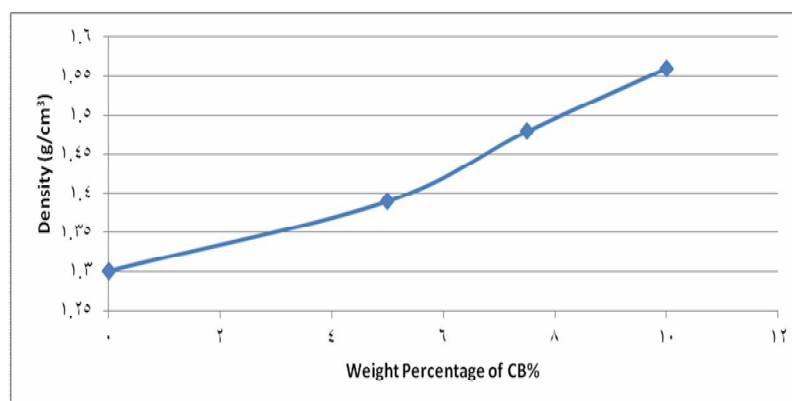


Fig. 5: Effect of CB weight percentage on density of UP