An Investigation of Kaolin influences on Mechanical Properties of Unsaturated Polyester Composites

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Abstract:

The aim of this work is addition of kaolin powder into unsaturated polyester matrix to prepare particulate composites. Samples with and without kaolin exposed for many tests to determine the effect of kaolin contents on the mechanical properties of unsaturated polyester. The results show that, kaolin improved the compression strength by 194% at 7% kaolin, and improved the flexural modulus of unsaturated polyester by 33% at 3% kaolin, and increase the flexural strength by 7% at 5% kaolin, while the impact strength improved by 14% at 9% kaolin and the hardness increased by 4.66% at 3% kaolin. It is concluded that, kaolin acts as binder materials and as particulate reinforcement materials results in improvement in the mechanical properties of unsaturated polyester at relatively low kaolin contents.

الخلاصة:

الهدف من البحث الحالي هو إضافة مسحوق الكاؤولين إلى أساس من البولي استر الغير مشبع لتحضير مادة مركبة دقائقية . عرضت عينات محتوية وأخرى غير محتوية على الكاؤولين إلى عدة اختبارات لإيجاد تأثير الكاؤولين على الخواص الميكانيكية للبولي استر الغير مشبع. النتائج أظهرت الأتي، حسن الكاؤولين مقاومة الانضغاط بنسبة ١٩٤% عند نسبة ٧% من الكاؤولين وحسن معامل الانثناء للبولي استر الغير مشبع بنسبة ٣٣% عند ٣% كاؤولين و كذلك زيادة مقاومة الانثناء بنسبة ٧% عند ٥% ، بينما حسنت مقاومة الصدم بنسبة ١٤% عند ٩% كاؤولين والصلادة ازدادت بنسبة ٤.٦٦% عند ٣% كاؤولين. نستنتج من ذلك، عمل الكاؤولين كمادة رابطة وكمادة دقائقية مقوية حسنة في الخواص الميكانيكية للبولي استر الغير مشبع عند نسب منخفضة نسبيا من الكاؤولين.

1-1 Introduction:

Thermosets polymers such as epoxy and unsaturated polymer are widely used in application such as coating and as a matrix material for making many composites. However, it is brittle in nature and has poor resistance to crack propagation[1].There are several researcher doing for improving toughness for these polymers types. Dongand Lee[2] reported the characterization of epoxy – clay hybrid composites prepared by emulsion polymerization.The effects of promoting and curing process on exfoliation behavior of epoxy / clay nanocomposites were studied by Y.Ke.Jiankun and etal [3].Kornmann and others[4] synthesized epoxy clay nanocomposites and analysed the nature of the curing agent on structure.Peter and Stephanie[5] studied the nanomechanical properties of UV degraded TiO_2/Epoxy nanocomposites. The structural integrity of combinations of graphite and glass fibers with a toughened epoxy matrix under dynamic impact loading were studied by Christors and Levon[6]. Al-asadee[7] was improved the thermosets toughness by used natural pigments.

1-2 Experimental:

1-2-1 Materials Used:

Unsaturated polyester was used as the matrix available locally without detail specifications. The mixing ratio used was 100g of UPE resin with 0.5g accelerator (Cobalt napthenate) and 2g hardener (Methyl Ethyl Ketone peroxide). Add the kaolin as reinforcement materials with chemical composition show in Table (1).

Table (1) chemical composition of kaolin[7].

Oxides	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	L.O.I
%	46.66	0.83	34.41	1.2	0.96	0.34	0.3	0.34	12.92

1-2-1 Mechanical Test:

In this present work unsaturated polyester/ kaolin composite was prepared and investigation by different testing technique, Compression test was performs according to the D17581-88 with samples dimension (10Øx10) mm by using universal testing machine (PHYWE). Flexural tests were performed according to the D790-86 with samples dimension (120x16x6) mm by using universal testing machine (PHYWE). Pendulum charpy test was done according to the ASTM 256-87 using unnotched samples (55x10x10) mm dimension. Brinell hardness was performed according to the ASTM D1415 with samples dimension (30Øx6) mm.

Flexural tests:

The term flexural strength or modulus of rupture is used for the surface stress in the beam when breaking occurs. For a rectangular cross-section beam the flexural strength can be determined from this formula:

Flexural strength=$3FL/2bd^2$ b= breadth of the section
d= the depth

The flexural modulus can be calculated from:

$$\text{Flexural modulus} = \frac{\frac{M}{S}.g.L^3}{48I}$$

M/s= steep initial gradient of the stress-strain graph
I=second moment of area

1-3 Results and Discussion:

Figure (1) shows the effect of addition kaolin on the unsaturated polyester color with increasing kaolin percent.

Figure (1) Effect of kaolin content on unsaturated polyester color.

Figure (2) shows the relation between compression strength and kaolin content, from this curve can be observed that with low percent of kaolin the compression strength increasing this due to high degree of adhesion between the polymer molecules and kaolin particles, because the kaolin act as binding materials[9] , while in high percent of kaolin the compression strength decreases this due to the kaolin particles extended the distances between the polymer molecules, i.e. breaking the intermolecular forces between these molecules[10].

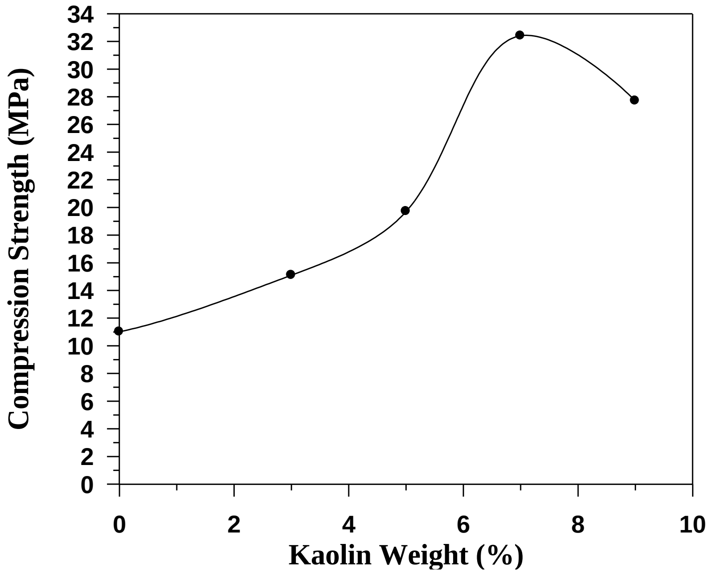


Figure (2) Effect of kaolin contents on compression strength.

Figure (3) shows the effect of kaolin content on the flexural modulus and figure (4) shows the relation between flexural strength and kaolin content, as can be seen from above figures the flexural modulus and strength increasing with increase kaolin percent this due to high degree of adhesion between the polymer and the kaolin while in high percent of kaolin the properties decreases this due to the cross-link density was lowered at high kaolin contents because the distance between the polymers chain increase and kaolin particles prevent the contact between them, besides that in high percent of kaolin the particles act as stress concentrators [10].

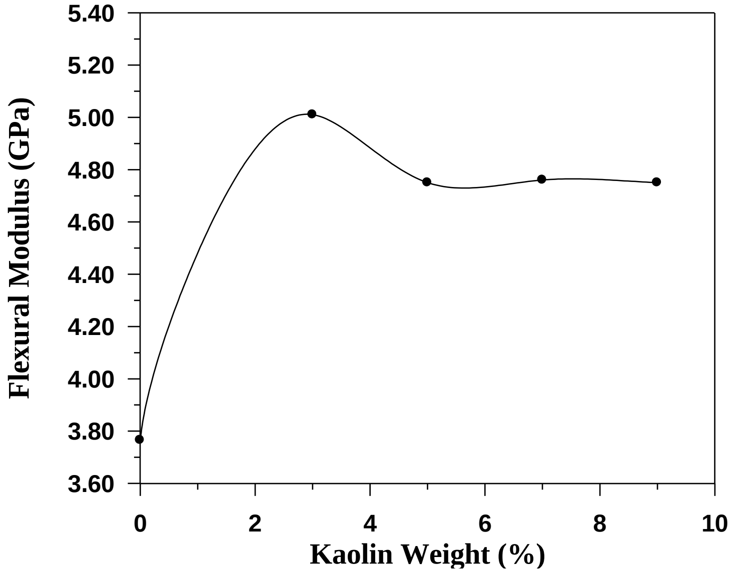


Figure (3) Effect of kaolin contents on flexural modulus.

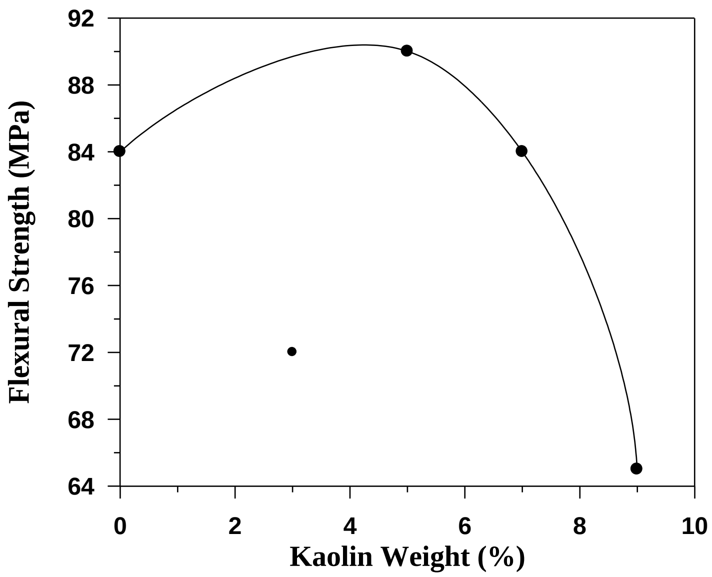


Figure (4) Effect of kaolin contents on flexural strength.

The impact behavior is shown in Figure (5), The impact strength decreases with increasing kaolin content this due to kaolin particles act as a crack initiator, but at high kaolin contents the particles act as crack stoppers so the impact strength increase with high percent of kaolin, as can be seen from figures (6) the agglomerates found in the samples containing kaolin and not seen that in pure samples.

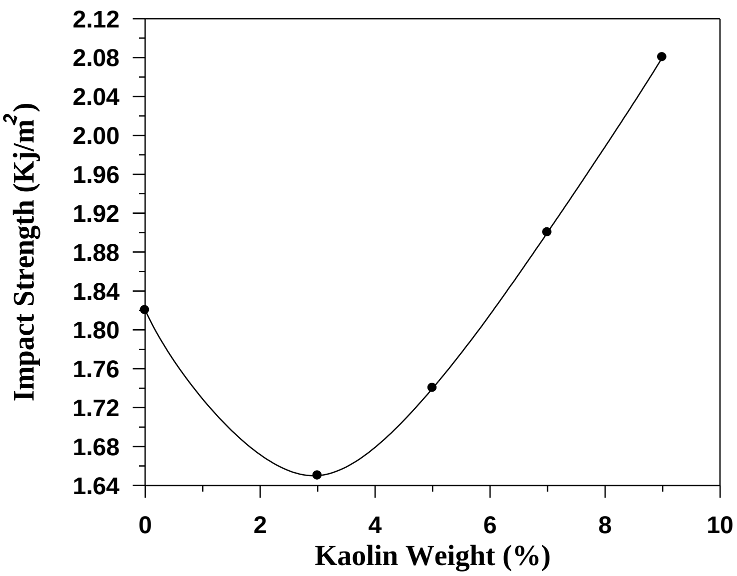
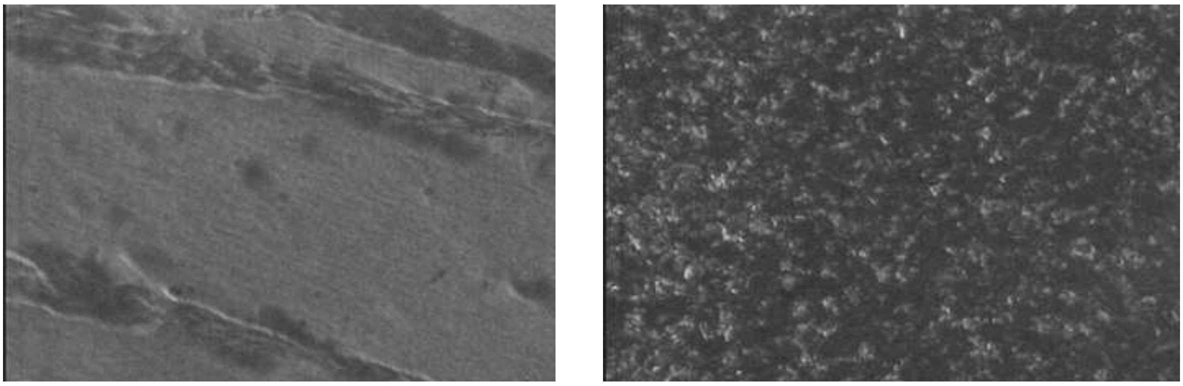


Figure (5) Effect of kaolin contents on impact strength.



(a) (b)

Figure (6) Impact surface (a) blank sample (b) with kaolin.

Figure (7) shows the effect of kaolin content on the brinell hardness, the hardness decrease with low percent of kaolin then is an inversion in the behavior at high percent of kaolin, in low percent the kaolin act as binder materials while in high percent caused reducing the density of cross-linking.

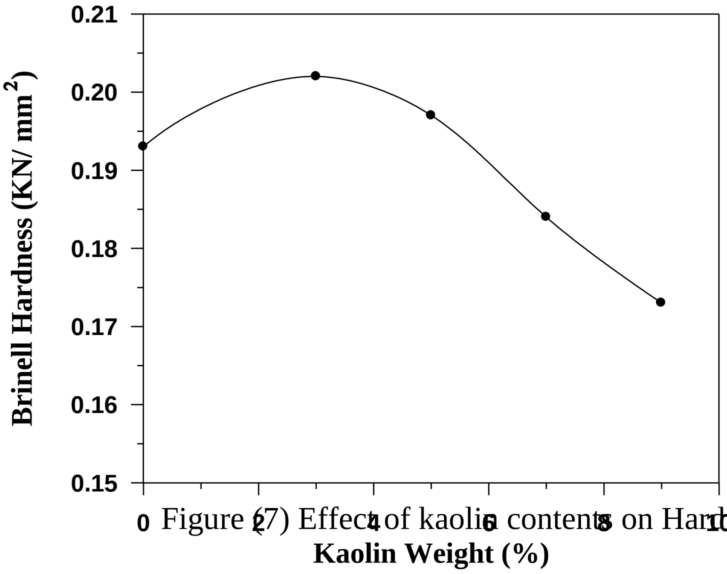


Figure (7) Effect of kaolin contents on Hardness.

1-4 Conclusions:

Addition of kaolin to an unsaturated polyester resin in the 3-9% (this considered relatively low percent) shows that kaolin act as binder and as particulate reinforcement results in improvement in the mechanical properties of the unsaturated polyester via the resulting composite (table 2), this is agree with the available literature that consider kaolin as binding material[2-4].

Table (2) The variation of mechanical properties with addition of Kaolin on unsaturated polyester.

Properties	Kaolin (%)	Improvement Percent
flexural strength	5	7
flexural modulus	3	33
compression strength	7	194
impact strength	9	14
Hardness	3	4.66

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