Study the Effect of Volume Fraction of Mica with Different Particle Size on the Mechanical and Electrical Properties for Unsaturated Polyester Composites

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Received on: 4/12/2011 & Accepted on:7/6/2012

ABSTRACT

This study was carried out to investigate the effect of adding mica (5, 10, 15, 20, 25 % vf) with variable particle size (35, 57, 70µm) on the mechanical and electrical properties of the unsaturated polyester composites. Some mechanical tests were carried out like (impact strength, flexural strength) and dielectric strength. Flexural strength and dielectric strength were found to increase with filler concentrations whereas impact strength was found to decrease at higher concentrations for all particle size.

Keywords: Composites, Unsaturated Polyester, Mica, Mechanical Properties.

دراسة تأثير الكسر الحجمي للمايكا باحجام حبيبية مختلفة على الخصائص الميكانيكية والكهربائية للمادة المتراكبة للبولي استر غير المشبع

الخلاصة

تم اجراء هذه الدراسة لبحث تاثير الكسر الحجمي للمايكا (5,10,15,20,25 % vf) باحجام حبيبية مختلفة (35, 57, 70 µm) على الخصائص الميكانيكية والكهربائية للمادة المتراكبة للبولي استر غير المشبع . اجريت بعض الاختبارات الميكانيكية مثل (مقاومة الصدمة ومقاومة الانحناء)ومقاومة العزل الكهربائي واوضحت النتائج زيادة قيم مقاومة الانحناء ومقاومة العزل الكهربائي عند زيادة الكسر الحجمي للمايكا بينما لوحظ نقصان مقاومة الصدمة عند زيادة الكسر الحجمي لكل الاحجام الحبيبية.

INTRODUCTION

Particulate filled polymer composites are becoming attractive because of their wide applications and low **c**ost. Nowadays, filler play an important role in the plastic industry .In the course of time, these basic raw materials have been refined and today, it becomes the source from which most so-called inorganic fillers are derived(Farid (2008)). It is important to be able to control the degree of bonding between the matrix and the reinforcement. To do so, it is necessary to understand all the different possible bonding types, one or more of which may be

https://doi.org/10.30684/etj.30.20.8
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acting at any given instant. Here is the classification of the important types of interfacial bonding: -

1. Mechanical bonding which is efficient in load transfer when the applied force is parallel to the interface.
2. Chemical bonding :- there are two types of chemical bonding :-
   a- Dissolution and wettability bonding: - interaction between components occurs at an electronic scale.
   b- properties, reduced flammability, reduced creep, planar reinforcement and excellent resistance to weathering and corrosive attack by acids of alkalis. Mica is invaluable in the electrical industry because of its unique combination of physical, chemical and thermal properties, low power loss factor, dielectric constant and dielectric strength (Usifer and Fajaro (1999)). Reaction bonding :- in this case , transport of atoms occurs from one or both of the components to the reaction site, that is, the interface(Sharma (2000)).

Mica is a reinforcing agent that will impart excellent dimensional stability of molded parts. Some of it's advantages include low warp, excellent electrical The general formula for mica is AB2-3 (Al, Si)Si-3 O-10 (F, OH)-2. In most mica the A is usually potassium, K, but can be calcium, Ca, or sodium, Na, or barium, Ba, or some other elements in the rarer mica. The B in most mica can be aluminum, Al, and/or lithium, Li, and/or iron, Fe, and/or magnesium, Mg (Sreeknathetal. (2009)). The mica group is a large group with nearly 30 members recognized, but only a few are common. Those few however make up a large percentage of the most common rock types found in the Earth's crust. The following are some of the more common mica minerals: Biotite, Fuchsite, Lepidolite, Muscovite, Phlogopite and Zinnwaldite.

Muscovite Mica is a hydrated silicate of potassium and aluminum. Phlogopite Mica is a hydrated silicate of potassium and magnesium (Xanyhos(2005)). In general the mechanical properties of particulate filled polymer composites depend strongly on size, shape, and distribution of filler particles in the matrix polymer and good adhesion at the interface surface (Bose and Mahanwar (2004)).

Polymers typically exhibit tow type of failure: shear yielding and crazing. In contrast to shear yielding, which results in relatively high energy dissipation, crazing is often the precursor to brittle fracture. Under special conditions, such as compressive loading, both thermoplastics and thermosets can be made to shear yield, but under tension many polymers fail in a brittle manner (Tijssenetal. (2000)). Crazing occurs when localized regions yield, forming an interconnected array of microvoids. Fibrillar bridges of oriented molecular chains form between void. At high enough tensile loads, these bridges elongate and break, enabling crack propagation. Crazing absorbs fracture energy and increases fracture toughness. Generally, crazing is thought to proceed in three stages: initiation, widening and breakdown of the fibrils and creation of crack (Giessen etal. (2005)).

Physical and mechanical properties of mineral fillers filled polypropylene composite were analyzed by NurdinaA.Kadiretal. (1999). the strength of mica/pp composite was higher than silica/ pp. Bose and Mahanwar (2004) investigated the effect of particle size of filler on properties of nylon-6. Sreeknath, etal. (2009) reported effect on concentration of mica on properties of polyester elastomer composites. Firoozianetal. (2003) studied the prediction of mechanical properties of mica-filled epoxy composite using various mechanicals models.

The main goal of the current research is to study the effect of particle size of mica on mechanical and electrical properties of unsaturated polyestercomposites for different volume fraction

EXPERIMENTAL WORK

Materials

The polyester used was unsaturated polyester (UP) resin, the curing of (UP) was done at room temperature by the incorporation of 2 volume percent methyl ethyl ketone peroxide (MEKP). A 1% (volume percent) cobaltnaphenate was added as a catalyst.Muscovite mica obtained from Perak, Malaysia with different particle size (35, 57, 70µm) were used as fillers.

Preparation of samples

Hardener and catalyst were added with unsaturated polyester for getting the sample as fast as possible. Contents were mixed very well to avoid bubbles; finally these contents were reinforced with mica with different volume fractions (5, 10, 15, 20, and 25%) for all particle size. Before compounding, the fillers were dried at 100C° for 6 hours. The composites were cured at room temperature until they were dry.

TESTS

Dielectric Strength

The dielectric strength was carried out using (HV-50Hz 300KV) testing machine. The dielectric strength can be obtained from the following equation (Schwartz (1982)):-

$$D = \frac{V}{b} \ldots\ldots. (1)$$

Where

V= breakdown voltage (KV)

b= thickness of the sample (mm)

The measurements dimensions of dielectric strength were: diameter 40mm and thickness: 6.73 mm (according to ASTM-D150).

Impact test

The charpy impact test on unnotched specimens was determined using (5 Jules) pendulum impact testing machine. Test was conducted in accordance with ASTM-D179, taking specimens of dimensions: length 55mm and width: 10 mm.

Flexural test

This test was carried out with the hydraulic piston, its type is ley Bold Harris, No. 36110. The measurement dimensions of Flexural specimen was: length 15 cm and width: 3 cm based on ASTM-D790.

RESULTS AND DISCUSSION

Impact strength

Figure (1) shows the variation of impact strength with mica load. It can be seen that the impact strength increment at low weight percentage of filler. This is because of the filler particles, which may represent points for a localized stress concentration, from which the failure will begin, or this is mainly due to the reduction of elasticity of material due to filler addition and thereby reducing the deformability of matrix and in turn the ductility in the skin area, so that the composite tends to form a weak structure also. An increase in concentration of filler reduces the ability of matrix to absorb energy and thereby reducing the toughness, so impact energy decreases (Thomas etal. (2004)).

Flexural strength

It is observed in Fig (2) that the increase in volume fraction of mica leads to increase in flexural strength for all particle size, these results can be explained as the total area available to deformation stress and played an important role in flexural properties (Singh and Kirandeep (2005)).The effect of filler on flexural strength may be due to the increase in the filler content in a polymer composite there is increase in effective surface fracture energy, size of voids and agglomeration of filler particles. The dispersed particles make the crack propagation path longer, absorb a portion of energy and enhance the plastic deformation. Therefore, the surface fracture energy increase and the strength of composites increase with volume percentage of filler (Parvaisetal. (2010)).

Dielectric Strength

It can be seen from Fig (3) that the dielectric strength increased with increase in mica concentration and attained maximum. At higher filler loading the dielectric strength values remained constant with the increase in filler. This have been due to the leakage of current from un encapsulated interstitial filler particle at higher filler loading with larger particle size where as in case of smaller particle size there was proper dispersion which did not affect the properties (Bose and Mahanwar (2004)).Also, it can be seen that at volume fraction (10%), the smallest t particle size (35µm) had higher value of dielectric strength while the other particle size (57, 70µm) had lower values of dielectric strength. This may be due to aggregation of filler particles, which are thought to introduce defect centers that distort and enhance the local electric field, resulting in reduced breakdown strength. This field distortion is primarily due to the difference in permittivities of the filler and the polymer matrix under AC conditions, and mainly due to differences in conductivities under DC conditions (Akram and Javed (2005)).

CONCLUSIONS

a) There was a significant increment in the flexural strength with an increase in the filler loading.
b) Particle size of mica (57µm) had higher values in flexural strength property, while particle size (35µm) showed slightly increment in values with increase in the filler loading.
c) There was a decrease in the impact strength values with an increase in the filler loading for all particle size.
d) There was a significant increase in the dielectric strength, but at higher filler loading the dielectric strength values remained almost constant all particle size.
e) The dielectric strength values showed better for higher particle size of mica.

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Table (1):Characteristics of muscovite mica (Sancaktar and Walker (2004)).

Characteristic	Muscovite mica
Density (gm/cm^3)	2.6-3.2
Hardness	80-105
Compression strength(kg/cm^2)	1900-2850
Modulus of elasticity ($gm/cm^3 \times 10^{-3}$)	1400-2100

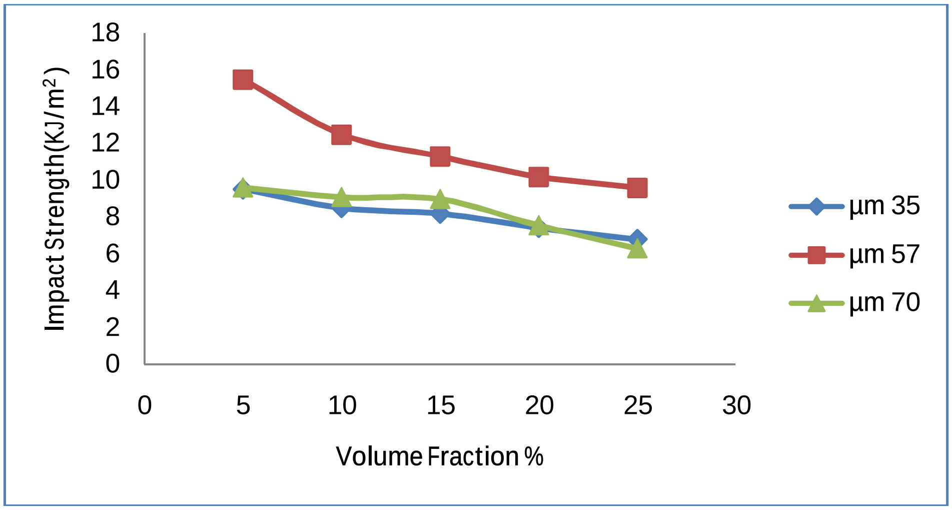


Figure (1): The impact strength for mica filled UP composites with different filler loading.

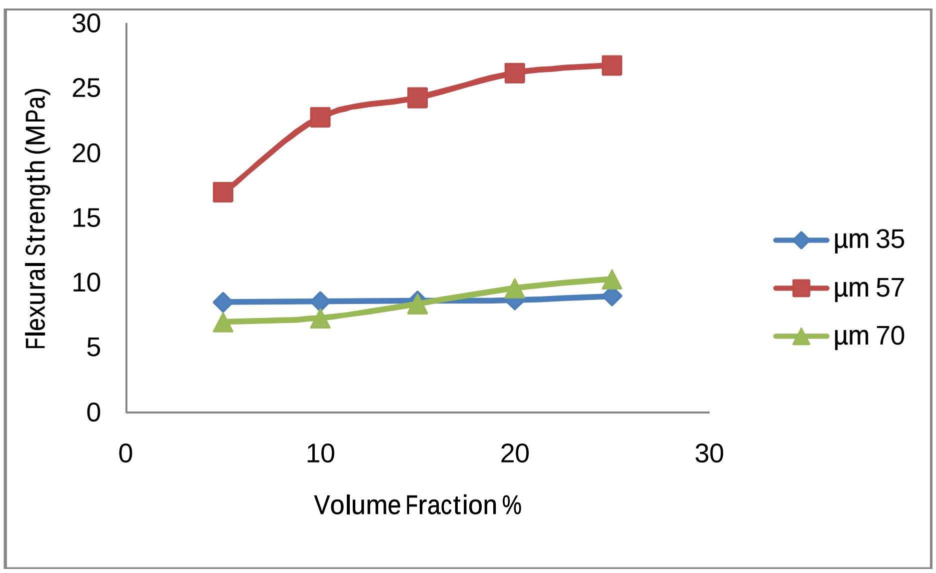
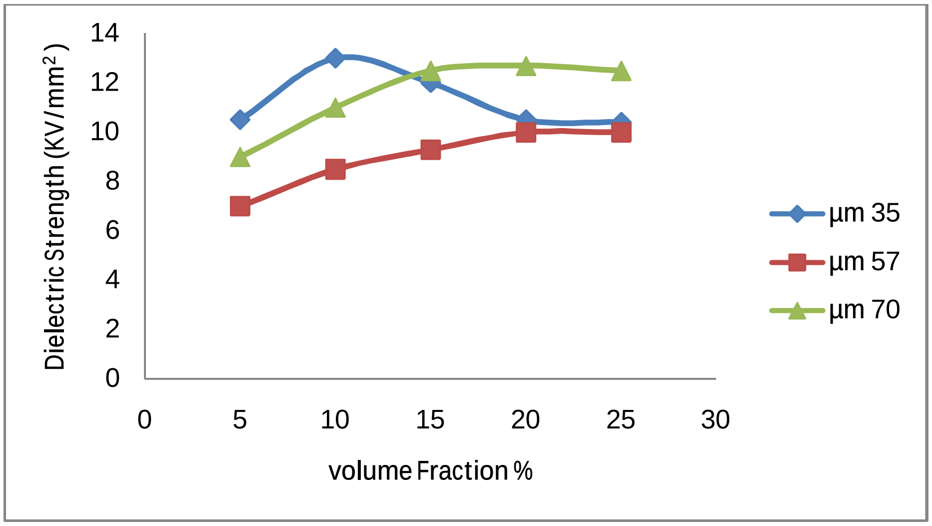


Figure (2): The flexural strength for mica filled UP composites with different filler loading.



Figure(3): The dielectric strength for mica filled UP composites with different filler loading.