Mechanical Properties of Epoxy Reinforced with different percentage of ceramic particle weights

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Abstract

In this research work, mechanical behavior of reinforced epoxy (quick mast 105) composites filled with varying concentration of aluminum oxide Al_2O_3 and Silicon carbide SiC has been investigated. Composites were prepared by standard method. The objective of this work was to study the mechanical properties such as impact strength, hardness and flexural strength of the prepared composite. the results shows that the composites with 40% of SiC and Al_2O_3 concentration exhibit maximum hardness strength , the impact strength of SiC filled composite increases with increasing concentration, while Al_2O_3 filled composite impact strength decreases with increasing concentration . Modulus of elasticity of SiC filled composite decreases with increasing concentrated while Al_2O_3 filled composite elasticity increases.

Keyword: epoxy**,** aluminum oxide Al_2O_3 and Silicon carbide SiC**,** Mechanical Properties

الخواص الميكانيكية للايبوكسي المدعم بنسب وزنية مختلفة من جسيمات سيراميكية مختلفة

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الخلاصـة

في هذا العمل تم بحث السلوك الميكانيكية لراتنج الايبوكسي المدعم بتراكيز مختلفه من اوكسيد الالمنيوم(Al_2O_3) وكاربيد السليكا(SiC).

تم تحضير المركبات بوساطة الطرق الكلاسيكية، ان الهدف من هذه الدراسة هو دراسة الخواص الميكانيكية مثل قوة الصدمة وقوة المرونة للمركبات المحضرة.

اظهرت النتائج أن المركبات ذات تركيز ٤٠% من اوكسيد الالمنيوم(Al_2O_3) وكاربيد السليكا(SiC) تمتلك اعظم قوة صلابة، وان قوة الصدمة للمركب المدعم بكاربيد السليكا(SiC) تزداد مع زيادة التركيز بينما المركب المدعم باوكسيد الالمنيوم(Al_2O_3) تتناقص قوة الصدمة له مع تزايد التركيز، كما يتناقص معامل المرونة للمركبات المدعمة (SiC) مع زيادة التركيز بينما المركبات المدعمة (Al_2O_3) يزداد معامل المرونة بزيادة التركيز.

الكلمات المفتاحية: الايبوكسي، اوكسيد الالومينا وكاربيد السليكا،الخصائص الميكانيكية.

Introduction

Epoxy is a type of strong adhesive used to stick things together and to cover surfaces .There is an increase demand for advanced materials with better properties to meet new requirements or to replace existing materials.

To improve epoxy resin properties, a common method is introducing in the resin, including liquid rubbers, thermoplastics, copolymers, silica nanoparticles, silicate layer, core shell particles, and combinations of these. The major toughening mechanism involve rubber particle, localized shear banding of matrix as well as rubber bridging. Fracture toughness of rubber toughened epoxy resin is improved, while many other desirable properties, such as elastic modulus and failure strength were decreased significantly [1]. In comparison, rigid nano fillers improved the fracture toughness, stiffness, and even strength of epoxy resin [2-6].

Mechanical properties of fiber-reinforced composites are depending on the properties of the constituent materials (type, quantity, fiber distribution and orientation void content). Beside those properties, the nature of the interfacial bands and the mechanisms of load transfer at the interphase also play an important role [7].

Specific fillers additives are added by researchers now to enhance and modify the quality of composites as these are found to play a major role in determining the physical properties and mechanical behavior of the composites .For many industrial application of glass fiber reinforced epoxy composite, information about their mechanical behavior is of great importance. Therefore, this work presents an experiment study of the mechanical properties of reinforced epoxy composites filled by varying concentration of (SiC) and Al_2O_3.

Experimental Work

Quick mast 105 epoxy resin used in a viscous liquid state at room temperature (18-30 ^{0}C). SiC and Al_2O_3 was used as filler materials. Silicon carbide exhibits favorable mechanical and chemical properties at high temperatures for much application. The benefits of using SiC as reinforcement are to improve stiffness, strength, thermal conductivity, wear resistance, fatigue resistance, reduced thermal expansion and dimensional stability Aluminum oxide particle is a ceramic powder commonly used fillers it is also used as an abrasive due to its hardness.

The epoxy based composites filled with varying concentration of (0, 10 20, 30, 40) % of aluminum oxide Al_2O_3 and Silicon carbide (Sic) were prepared. The required ingredients of resin and fillers are mixed thoroughly in a basin and the mixture is subsequently stirred constantly. Mixture so made is brushed uniformly. Entrapped air is removed manually with squeezes or rollers to couple the laminates structure and the composite is cured at room temperature. The prepared slabs of the composite materials were taken from the mold and then specimens were prepared from composites slabs for different mechanical test.

Impact, hardness and flexural tests were carried out using a pendulum with energy gauge. Chirpy impact test consists of standard test piece that would be broken with the first hammer swing. The test piece is supported at both ends in a way that the hammer strikes it at the middle. The specimen is fixed in its pertaining place, then the energy gauge is initialized (on zero positions), after that the pendulum is freed from its maximum height, where its potential energy converted to kinetic energy. The energy gauge reads the value of fracture energy (V_c) for the sample under test.

Impact strength (I.S) is calculated by[8]:

$$I.S = V_c / A \qquad (1)$$

Where V_c is the fracture energy in joule and A is the cross – Sectional area of the sample (mm^2).

Hardness test was conducted on the sample using shore hardness tester (HT-6510D), its range (0-100 H), resolution (0.1) and measurement deviation: error ($\leq \pm 1$). Sample size used.

$162\times 65\times 28$ (mm^3)

Flexural strength is determined by 3- point bend test. The test sample of dimension were $162\times 65\times 28$ (mm^3) used for test. This test method determines the flexural properties of reinforced composites.

Flexural strength is calculated by:

$$F.S = \sigma_{max} = \frac{3SP}{2B^2 D} \qquad (2)$$

Where

σ_{max} Is the stress at midpoint

P Is the load at a given point on the load – deflection curve (N).

S Is the supported span (mm).

B Is the width of beam tested (mm).

D IS the depth of beam tested (mm).

In addition, Young modulus can be calculated from the following equation:

$$E = \frac{PS^2}{4\delta BD^2} \qquad (3)$$

Where δ is the deflection (mm).

Results and discussion

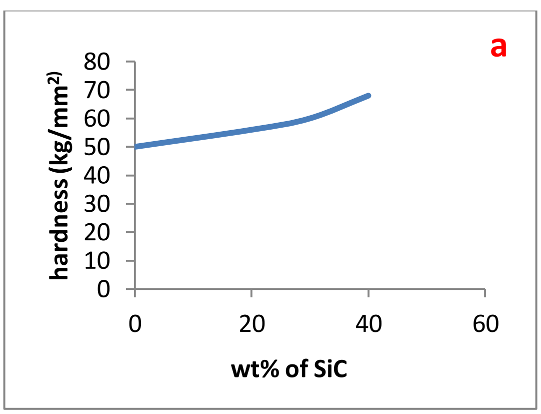
The ultimate hardness strength, impact, and flexural strength for the different composition of composite materials are presented in table (1) and their variation shown in fig.1and fig.2 respectively. Hardness of resin epoxy composite reinforced with different wt % (a) SiC and (b) Al_2O_3 particles are presented in table (1):

Table 1: Experimental Results of Mechanical properties of the specimens

Specimens and Prepared condition (18-20) °C	Reinforcements %	Ductility Hardness kg/mm^2	Impact strength J/m^3	Modulus of Elasticity(GPa)
(Resin epoxy with SiC) composite	0	50	23	3.6
	20	56	33	3.1
	30	60	44	2.5
	40	68	45	1.9
(Resin epoxy with Al_2O_3) composite	0	18.2	12000	2.2
	20	26.8	4000	2.45
	30	33.7	3000	2.78
	40	41.7	1500	3.72

The experimental results indicated that composite filled by (40%) SiC exhibited maximums hardness number (68 kg/mm^2) , this due to uniform dispersion of SiC particles and decrease in inter particle distance with increasing particle loading in the matrix results in increase of resistance to indentation. From the obtained results it is observed that increase in addition Al_2O_3 increases the hardness of the composites.

Impact strength is defined as the ability of a material to resist the fracture under stress applied at high speed. The impact properties of composite material are directly related to overall toughness and composite fracture toughness is affected by inter laminar and interfacial strength parameters.



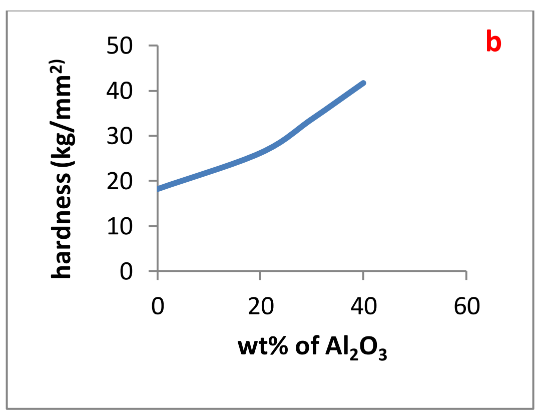


Fig. (1) Hardness of resin epoxy composite reinforced with different wt.% from (a) SiC and (b) Al_2O_3 particles

Experimental result is indicate that Sic filled composites impact strength increases while for Al_2O_3 composites it is decreases with increasing concentration .

The high impact strength is due to good bonding between filler, matrix of the interface molecular chain resulting in absorbs and disperses the more energy, and prevents cracks initiator effectively.

The energy absorbing capability of composites depends on the properties of the constituents ,based on literature review it is found that the benefit of using Sic as reinforcement are improved stiffness strength and chemical stability. Composites filled by Al_2O_3 exhibited good impact strength but increase in concentration of Al_2O_3 leads to decrease in impact strength.

Typically, a polymer matrix with high loading of filler has less ability to absorb impact energy this is because the fillers disturb matrix continuity and each filler is a site of stress concentration, which can act as a micro crack initiator and reduce the adhesion and energy absorption capacity of composite material this is observed in composite filled by 40% Al_2O_3 and SiC [7].

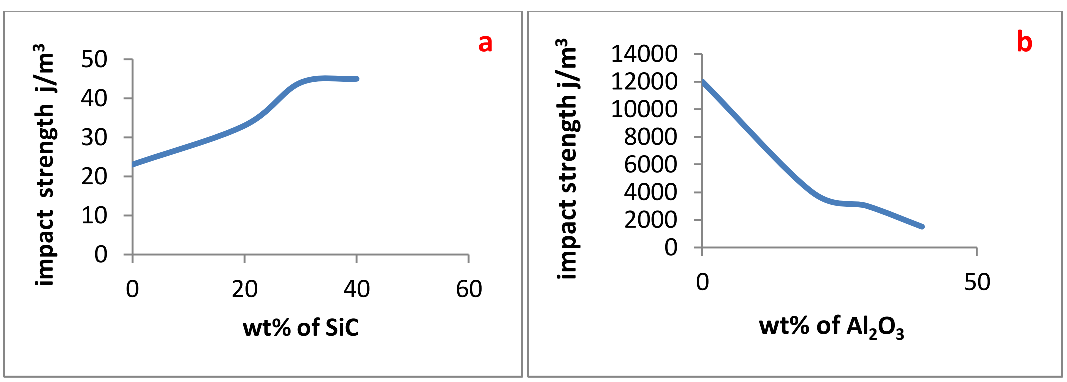


Fig. (2) Impact strength for the epoxy composite reinforced with different wt.% from (a) SiC and (b) Al_2O_3 particles

Comparison of the flexural strength of composite material are shown in table (1) , they indicated that composites filled by 10% Sic exhibited maximum flexural strength 3.1 Map when compared with Al_2O_3 filled composite but lower than the unfilled composites, this due to that good compatibility between filler and matrix . The reduction of flexural strength is observed with increase in addition of Sic this may the fillers disturb matrix continuity and reduction in bonding strength between filler and matrix.

However, test results show that increase in addition of Al_2O_3 enhances the flexural strength, this is due to uniform distribution of filler materials and increased in effective bonding between filler material and matrix and strong polymer filler interface adhesion [9].
Mechanical properties increases with the increase in SiC fine particle filler content up to 10wt % whereas the addition of SiC fine particle content more than10wt % results in the decrease in mechanical properties[10].

Conclusion

In the present research work epoxy based composites filled with varying concentrations of Al_2O_3 and SiC were prepared. Fabrication was conducted at (50^0C) by hand lay –up techniques. Based upon the test results obtained from the different tests, several conclusions can be mentioned:

From the obtained results composite filled SiC by have high impact strength when compared with other filled composites this is due to flat good bonding strength between filler, matrix and flexibility of the interface molecular chain resulting in absorb and disperses the more energy, and prevents that cracks initiator effectively. The flexural strength results indicated that composites filled by 10% SiC exhibited maximum flexural strength (3.1 Mpa) when compared with other filled composites but lower than that unfilled composites this due to that good compatibility between filler and matrix. However, test results show that increase in addition of Al_2O_3 enhances the flexural strength this is due to uniform distribution of filler materials and increase in effective bonding between filler materials and matrix and strong polymer filler interface adhesion composite filled by 40% SiC exhibited maximum hardness (68 kg/mm^2) this due to decrease in inter particle distance with increasing particle loading in the matrix results in increases of resistances to indentation.

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