Mechanical and Thermal Properties of Heterogonous Epoxy -Cellulose Fiber- Micron Ceramic Particles Composite Systems

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Abstract

The new improved heterogeneous epoxy systems were successfully synthesized at different volume fraction and particle size for (0.1-50 µm) p.s and (10, 20, 30, and 40 %vol..) additives ratios respectively.

The base epoxy firstly cured with the above additive at these ratio by use of mechanical mixing without heat then mold and solidified for 48 hrs. Different thermal and mechanical properties achieved at different volume frication and partial size such as (thermal conductivity, bending resistance , impact resistance and hardness).

The results of final heterogeneous epoxy ceramic systems characteristic properties are:

Lower thermal conductivity at for boron heterogeneous systems than other systems of Al_2O_3 ,SiO_2, ZrO_2 at 0.13 and o.37 for small and large range p.s than others of 0.18,o.21,0.37,and 0.37 for small and large range p.s than others of 0.18,0.21,0.37, and 0.41,0.49,0.55 w/mc°. Hardness of shore is higher for boron heterogeneous system than others one at 38 for large p.s and 87 for small one than others of 79,75,73 and 84,82,81 respectively .

The high value of impact strength for boron system for small and large p.s for than others at 4.1 and 3 than 2.8,2.1,1.8 and 3.8 resistance at small and large p.s for boron heterogonous System than others at 0.25, and 3.8, than 0.28 , 0.35, 0.4 and 0.42, 0.43 and 0. 46 respectively.

Keywords: fine micron particles, heterogeneous, Epoxy system, characteristic mechanical and thermal properties

الخصائص الحرارية والميكانيكية لأنظمة متراكبة مايكروية غير متجانسة للايبوكسي- ألياف السليلوز- حبيبات السيراميك المايكرويه

الخلاصة

في البحث الحالي تم وبنجاح تحضير أنظمة غير متجانسة للايبوكسي عند كسور حجمية وأحجام حبيبية مختلفة للمضافات لكل من بقايا الأوراق المثقبة والحراريات السيراميكية وهي B4C, SiC, AL2O3, ZrO2 عند حجوم حبيبية صغيرة بين 0.1 وكبير يصل إلى 50 مايكرمتر وكسور حجمية بحدود 10 , 20, 30' إلى 40 نسبه حجمية.

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في البداية تم تحضير الايبوكسي الأساس ومن ثم خلط المضافات المذكورة آنفا خلال فترة الإنضاج مع التحريك باستخدام الخلاط الميكانيكي وبدون حرارة ثم تصلبيها داخل قوالب لمدة 48 ساعة ثم انجاز العديد من الخصائص الحرارية والميكانيكية عند كسور وحجوم حبيبية مختلفة مثل التوصيلية الحرارية ، مقاومة الانحناء ، مقاومة الصدمة ، والصلادة.
النتائج النهائية لأنظمة الايبوكسي غير المتجانسة بحبيبات سيرامكيه كانت:
انخفاض خاصية التوصيلية الحرارية لأنظمة الايبوكسي المطعمة بالبور ون وعند حجوم حبيبيه كبيرة وصغيره أكثر من الأنظمة الأخرى المطعمة بالا لومينا والزكونيا والسليكا وذلك على التوالي 0.13 ، 0.37، للبور ون و 0.18، 0.21، 0.37، 0.41، 0.4، 0.55 واط / م.°م . مقاومة الصلادة لشور كانت عاليه لأنظمة الايبوكسي المطعمة بالبور ون سواء الحجم الحبيبي الكبير 83 والحجم الحبيبي الصغير 87 أكثر من البقية المطعمة باللالومينا والزر كونيا والسليكا عند 79 ، 75، 73، 84، 82، 81 على التوالي .
حصلت الأنظمة الايبوكسيه المطعمة بالبور ون وبقايا الورق على أعلى مقاومة للصدمة عند الحجوم الحبيبية الصغيرة والكبيرة عند 4.1، 3 أكثر من بقية الأنظمة المطعمة باللاومينا والزكونيا والسليكا عند 2.8، 2.1، 2.8، 3.8، 3.2، 3 على التوالي .
في النهاية تم الحصول على مقاومة عاليه للانحناء للأنظمة المطعمة بالبور ون وبقايا الورق وحجوم حبيبيه صغيره وكبيره أعلى من البقية عند 0.25 ، 0.38 أكثر من الأخرى عند 0.28 ، 0.35 ، 0.4 ، 0.42 ، 0. 43 ، 0.46 غم / ملم على التوالي .

Introduction

Epoxy has been widely used as protection system of heterogeneous composites in many structures [1-3] , because of its outstanding process ability , excellent thermal resistance , good electrical insulating properties , and strong adhesion / affinity to heterogeneous material with a higher mechanical properties under heavier loading.

Nonetheless the successful application of epoxy- heterogonous composite system is often hampered by their susceptibility to damage by any action agent of abrasion and wear [4-5] , they also show poor resistance to the initiation and propagation of cracks[6].Such processes introduce localized defects in structures and impair their appearance and mechanical strength. The barrier performance of epoxy heterogeneous structures can be enhanced by the incorporation of a second phase that is miscible with the epoxy polymer , by decreasing the porosity and zigzagging the diffusion path deleterious species for instance in organic filler particles at micro- meter scale can be dispersed within the epoxy resin matrix to from an epoxy ceramic composite.

The incorporation of fine particles in to epoxy resins offers environmentally benign solutions to enhance the durability of these structures , since the fine particles Dispersed in composite system and fill cavities [7-9] and cause crack bridging crack defection and crack bowing [10].

Fine micron particles can also prevent epoxy disaggregation during curing , resulting in a more homogenous structures , tend to occupy small hole defects formed from local shrinkage during curing of the epoxy resin and act as a bridge inter connecting more molecules. This results introduced total free volume as well as an increase in the cross-linking density [11-12].

Many authors have been studied application of ceramic –filled particles on the epoxy resin systems[13] to manufacture highly loadable parts and tools where the stiffness as well as the thermal and chemical resistance of these material structures used are higher than those of structure laminate material (SLA) such as special of material automotives structures (SOMOS 7120) applied in fields as direly parts such as lighting housing for proto type purpose as well as tools for the veneering press in small batch production under tests . In order to enable e precise and cast-effective fabrication opt forming has be developed further in the field of secondary processes such as inline – filtration of the material and its feeding as well as the machine software [14].

Aim of present work

This work examine the influence of both fine micron particles (B_4C, SiC,Al_2O_3,ZrO_2) and waste drilling fibers on the characteristic properties thermal and mechanical types of (thermal conductivity , bending strength , impact resistance and hardness shore D) of epoxy matrix heterogeneous composite system that will prepared and optimization of these types and composition on these characteristic properties.

Experiment

Materials:

Material used in this work are:

1. LATA Epoxy 300 quarrytle 8.6 MPa tensile strength 12.4 MPa, compressive strength 51.7 MPa thermal shock resistance 8.3 MPa .
2. Al2O3 alumina of 3.1-3.9 Sp.gr., and 7-50^10-3cal/cm2 thermal conductivity 4.6x104-1.7x105 Pa tensile strength , 4.7x104-3.2x105 compressive strength Pa.
3. ZrO2 of 5.98-6.05 Sp.gr, 10-15^10-3 cal/cm2 thermal conductivity 5.8x104-8.7x104Pa tensile strength , 5.5x105-5.7x106 compressive strength .
4. B4C and SiC as 1.6 and 2.1 sp.gr., 3-4^10-3 cal/cm2 thermal conductivity , 1.1x103-1.8x105 Pa tensile strength, 1.1x104-2.6x105 Pa compressive strength.

Procedures

Preparation of heterogeneous fine micron particles composite system:

Heterogeneous micron particles are prepared by shaking in different fine sieves at two ranges 0.1-25µm and 25-50µm particle size. composite system are usually prepared by dispersing micron fine particles (B_4C, SiC, Al_2O_3, ZrO_2) of particle size (0.1-50µm) at different additive percent (10, 20, 30. and 40% vol.) with a waste drilling papers in to the epoxy matrix by the use of mechanical stirring at optimum rotation velocity of (500 cycle/min), then clean a suitable specified molder and oiled, then applied the homogeneous, heterogeneous fine micron particles composite system in it. Afterward curing them at (30C°) for (48hrs) respectively.

Testing characteristic properties:

1. Thermal conductivity (K):

This test is achieved by the use of (Lee disk) device kocyigit Electron DC 0-30 volt and 6 Am USA in polymer lab under the condition of lab (30C°), at measure the temperatures of sample of two copper disk (T_1, T_2, T_3), calculator the expansion factor and thermal conductivity by the use of two equations below:

$e = P/\pi r\ [r\ (T_1+T_3)\ +2\ (d_1T_1+0.5ds\ (T_1+T_2)\ +d_2T_2+d_3T_3]$ …..(1)

$K=eds\ [T_1+2T_1\ (d_1+0.5ds)\ /r+T_2ds/\ r\ ]\ /\ (T_2 - T_1)$ .. (2)

Where:

e = loss in heat per unit area in ($w/cm^2 . C^\circ$).

P = supplied power in (w).

r = radius of disk in (cm).

d_1, d_2, d_3 = thickness of disks in (cm).

ds = thickness of specimen in (cm).

T_1, T_2, T_3 = measured temperatures of disks no., 1, 2, and 3 in (C°).

K = thermal conductivity in ($w / cm .C^\circ$).

2. Hardness of shore (D):

This type of test is achieved by the use of shore D Amsler Harkeprufer DIN 53505 IS OR 868 device in polymer lab and record the reading of hardness shore of prepared sample.

3. Bending strength

This type of test is achieved by the use of testing device PHYWE three point tester according to ASTM D790 available in polymer lab (three point bending device) and measure the load that distorted the samples from the center point, and evaluated the bending resistance.

4. Impact resistance:

This type of test is achieved by the use of available tester xju-22 pendulum time group 2007 Inc USA in polymer lab under lab conditions (30C°), (1bar), then evaluate the load distorted each one under these conditions.

Results and Discussion

Testing:

1. Thermal Properties:

Figure (1) indicate the effect of different fine size of ceramic particles and waste paper fibers on the insulation and thermal stability of heterogeneous micron composite system. The results show that a thermal properties(thermal conductivity) of heterogeneous micron- composite system reinforced by fine micron particles (B_4C) is higher than other applied one of (SiC, Al_2O_3, and ZrO_2). And the thermal conductivity of particle size (25µm) higher than (50µm) one according to the characterization of small one that contain fine particle small than (1µm) and this particles could be interior the cracks and spaces also it could be stopped or slow the movement of dislocation. But large particles large than (1µm) minimize and slow these space and cracks also according to the strong bonds of boron rather than other oxides additives and the unique properties of carbon atoms than oxygen one [13,14].

2. Mechanical Properties

Hardness, Impact resistance, and Bending resistance figures (3, 4, 5, 6, 7, 8) show that effect of both addition concentration of micron particles (B_4C, SiC, Al_2O_3, ZrO_2) and particles size (0.1-50µm) on the mechanical properties of heterogeneous micron composite system (hardness shore, impact resistance, and bending resistance). The results show that all mechanical properties of micron composite heterogeneous system of (B_4C) additive is higher than other reinforced additive (SiC, Al_2O_3, ZrO_2) filled by (SiC) then (Al_2O_3 the ZrO_2). Also the particle size of (25µm) additive is higher than large one of (50µm) due to the large content of small particle size (1µm) then it stopped the movement of dislocation than other large one of (>1µm) which stop the cracks and space, also due to the strong bonds between boron and carbon atoms than other oxides additives [13, 14].

Conclusions

1- The epoxy heterogeneous micron composite system are modified with (B_4C) and other micron particles both thermal and mechanical properties are modified by (60%) for thermal properties and (20%) for mechanical properties with excellent results for (B_4C) according to its structure and particle size (<1µm).
2- Anew and simple method for reuse of waste drilling papers fibers in order to modify the mechanical and compatibility properties according to its cellulose structure.

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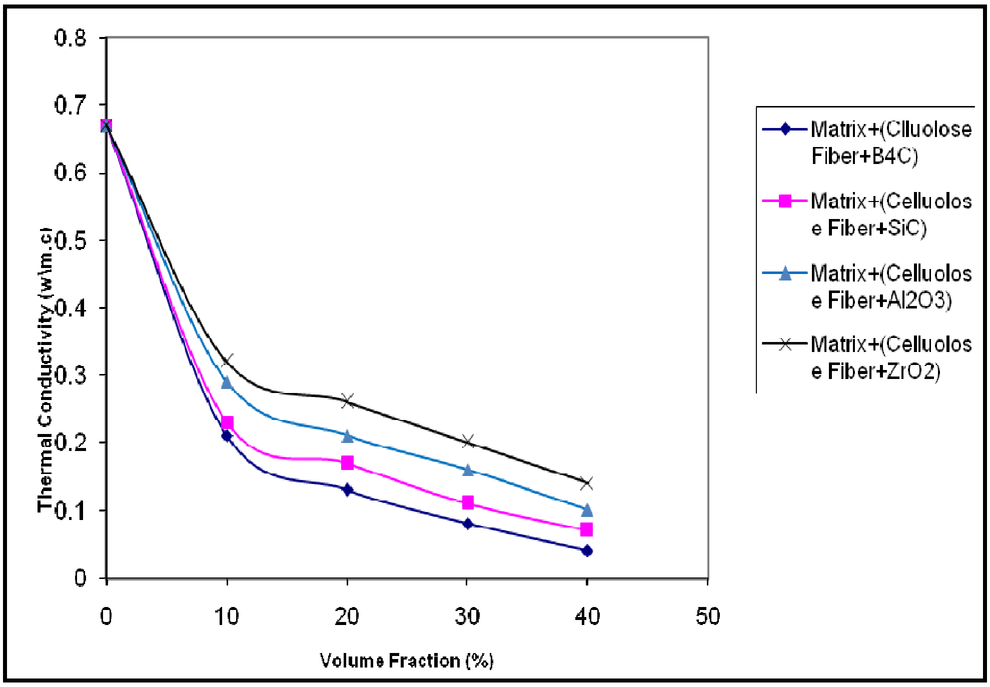

Figure (1): Effect of additive (B_4C, SiC, Al_2O_3, and ZrO_2) of particles size (0.1-25μm) on Thermal Conductivity of epoxy composite system

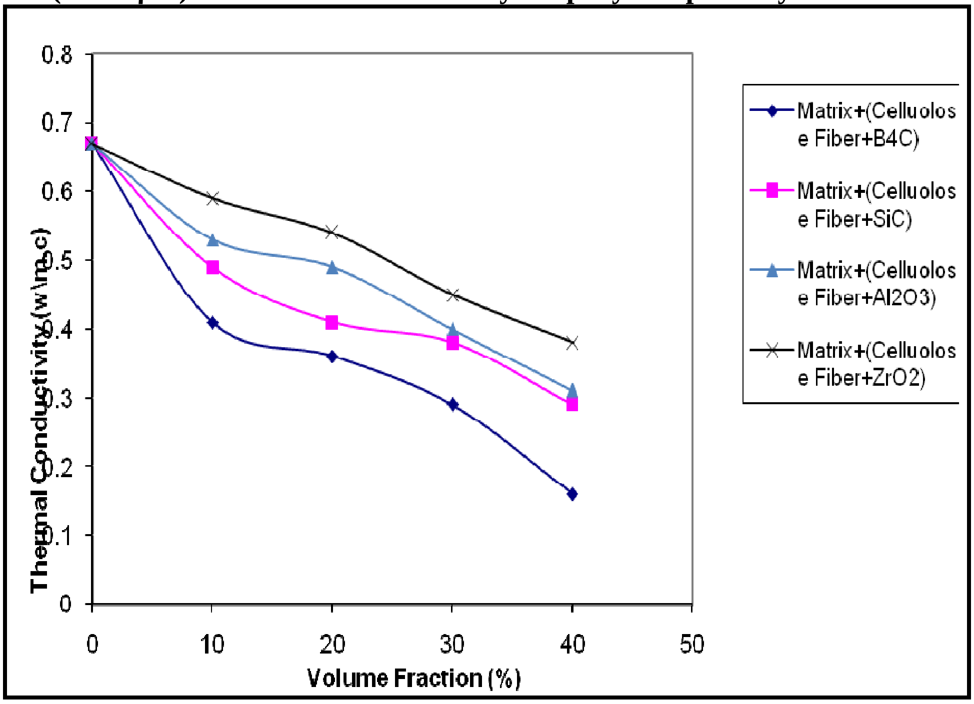

Figure (2): Effect of additive (B_4C, SiC, Al_2O_3, and ZrO_2) of particles size (0.1-50μm) on Thermal Conductivity of epoxy composite system.

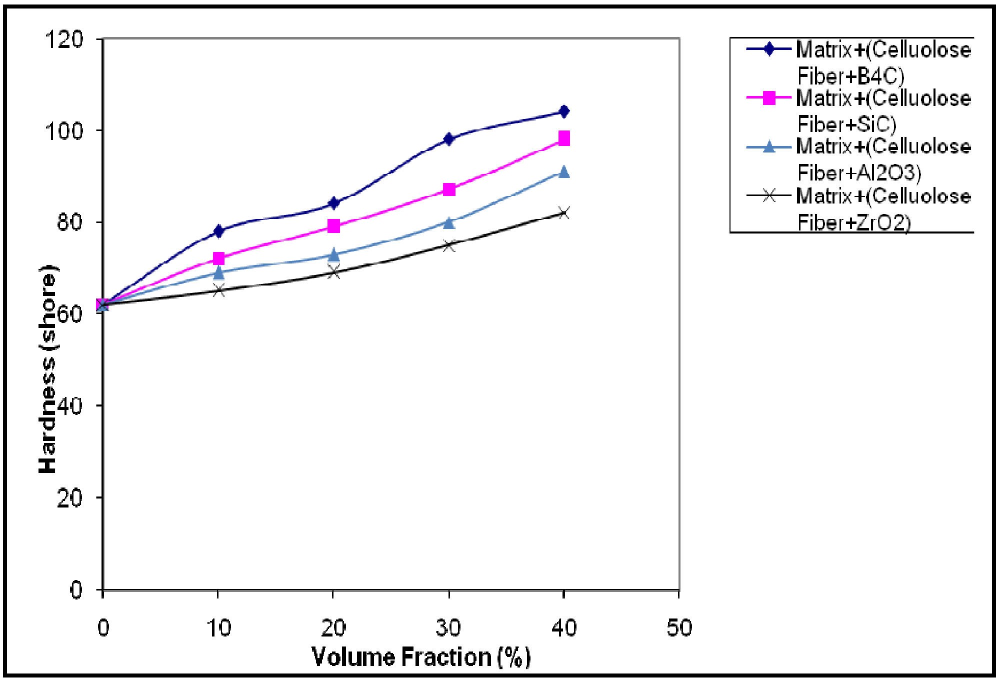

Figure (3): Effect of additive (B_4C, SiC, Al_2O_3, and ZrO_2) of particles size (0.1-50µm) on Hardness Test of epoxy composite system.

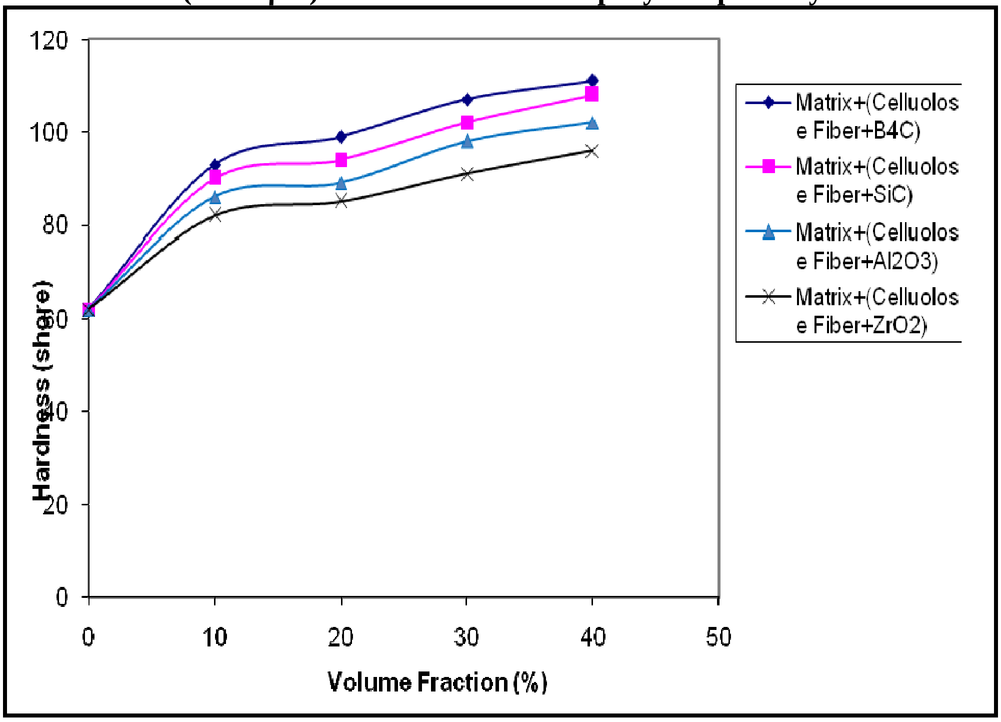

Figure (4): Effect of additive (B_4C, SiC, Al_2O_3, and ZrO_2) of particles size (0.1-25µm) on Hardness Test of epoxy composite system.

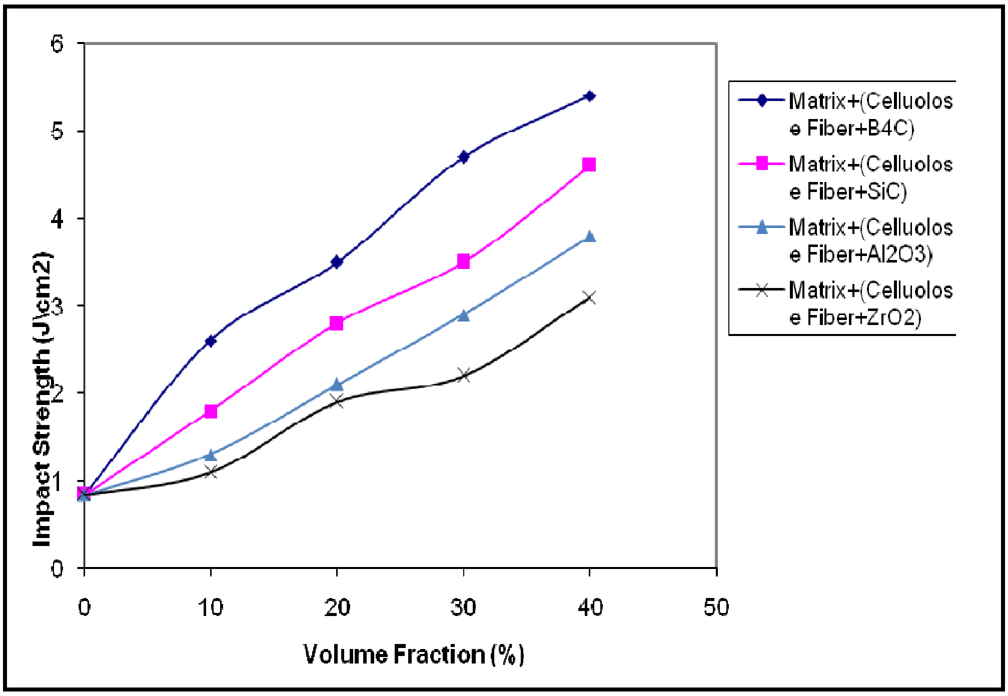

Figure (5): Effect of additive (B_4C, SiC, Al_2O_3, and ZrO_2) of particles size (0.1-50μm) on Impact Strength of epoxy composite system.

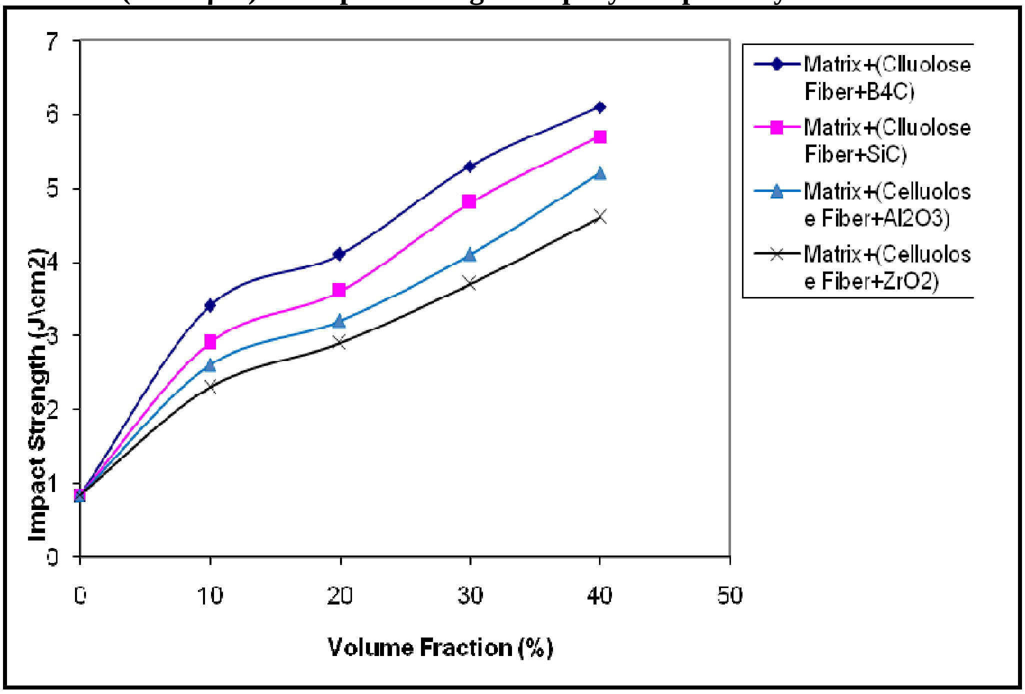

Figure (6): Effect of additive (B_4C, SiC, Al_2O_3, and ZrO_2) of particles size (0.1-25μm) on Impact Strength of epoxy composite system.

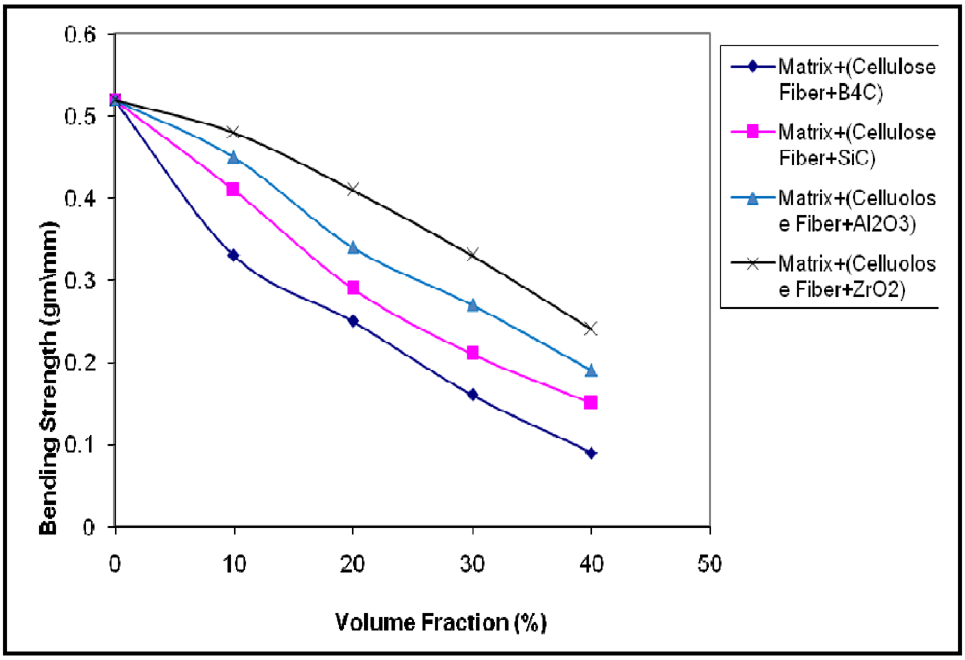

Figure (7): Effect of additive (B_4C, SiC, Al_2O_3, and ZrO_2) of particles size (0.1-25μm) on Bending Strength of epoxy composite system.

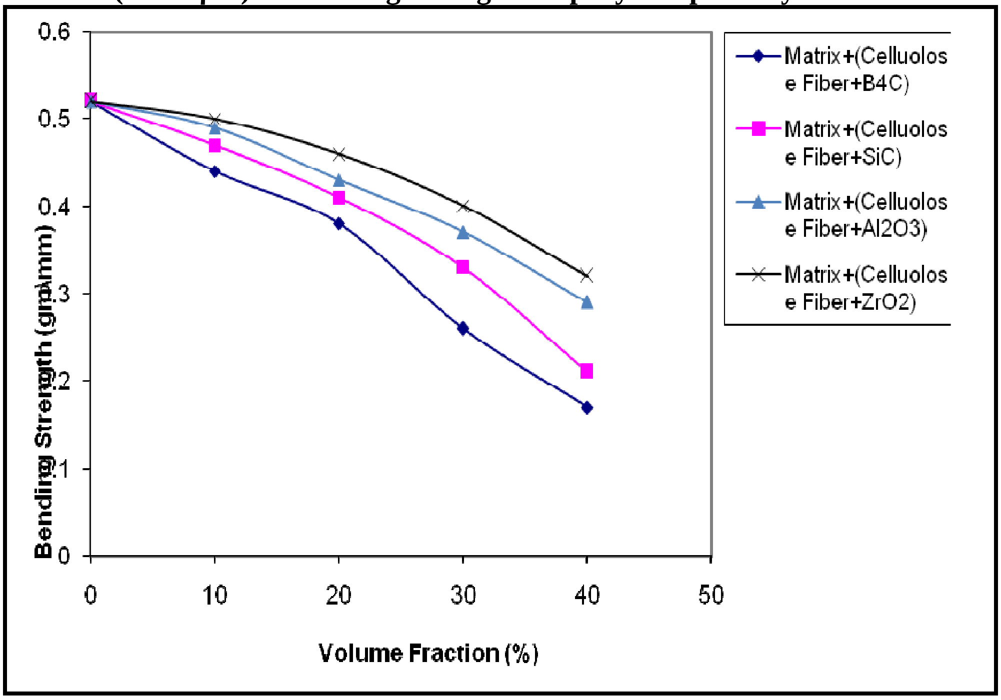

Figure (8): Effect of additive (B_4C, SiC, Al_2O_3, and ZrO_2) of particles size (0.1-50μm) on Bending Strength of epoxy composite system.