

A study of the effect of nano materials on the physical properties of epoxy composites

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Abstract

This research studies the effect of addition of some nanoparticles (MgO, CuO) and grain size (30,40nm) on some physical properties (impact strength, hardness and thermal conductivity) for a matrix blend of epoxy resin with SBR rubber. Hand –Lay up method was used to prepare the samples. All samples were immersed in water for 9 weeks.

The Results showed decreased in the values of impact strength and hardness but increased the coefficient of thermal conductivity.

Key words

Polymer material,
Composite material,
Impact test.

Article info.

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دراسة تأثير المواد النانوية على الخصائص الفيزيائية لمتراكبات الايبوكسي

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الخلاصة

تم في هذا البحث دراسة تأثير اضافة المواد النانوية (MgO, CuO) و بحجم حبيبي (30,40nm) على الخصائص الفيزيائية (مقاومة الصدمة، الصلادة والتوصيلية الحرارية) لخليط من راتنج الايبوكسي مع مطاط ستايريين بيوتاديين (SBR) قبل وبعد الغمر لمدة (10) اسابيع. حيث تم تحضير خليط بوليمري مكون من (EP+SBR) كمادة اساس. استخدمت طريقة القلوبة اليدوية في تحضير النماذج كما تم غمر النماذج في الماء لمدة 9 اسابيع ولوحظ نقصان في قيم مقاومة الصدمة والصلادة وزيادة في قيم معامل التوصيل الحراري.

Introduction

Now a days the large use of polymer materials is attributed to their integration of characteristics, low weight and ease of manufacturing. However for refinement of some characteristics such as mechanical and thermal conductivity, some additives were added to polymeric matrix and formed polymer matrix composite.

A composite is defined as an integration of two or more materials with characteristics different from of their components properties and distinguishable interface.

To improve the properties of composite materials investigate composites with lower fillers size. Nano composite refer to composites in which one phase has nanoscale morphology such as nanoparticles, nanotube or nano structure [1].

Rahman M et al studied the effect of nanosilica on the mechanical and thermal properties of composite material composed of epoxy with polysulfied rubber reinforced by different percentage of nanosilica (1, 3, 5) % wt. The result showed that the young's modulus and tensile strength

decreased at 3% wt. The tensile strength and elongation increased at 5% wt compared with epoxy and polysulfide. The thermal conductivity was increased with the addition of nanosilica in the polymer matrix [2].

Motallebi M et al. prepared nanocomposite material consist of PP/nano CaCO₃ with particle size 70 nm at content (5, 10 and 15) % wt. The result of tensile test refer to the inclusion of CaCO₃ increased the modulus and the elongation at break and decreased the tensile strength. The addition of nano CaCO₃ increased the impact strength and have high value of impact strength at 15% wt [3].

Impact resistance: It is the energy absorbed by the body a certain block on the cross-sectional area [4].

Impact strength is calculated from the relation: [5]

$$I.S = U/A \quad (J/m^2) \quad (1)$$

where

I.S. = impact strength

U = Energy of fracture in (joule)

A = Cross section area in (m²)

Hardness can be defined a measure of materials resistance to plastic deformation [6].

Thermal conductivity: is the ability of a material to conduct heat. and heat transported from high to low temperature regions of a substance [6].

Materials and methods

1- Matrix materials

1.1 Epoxy resin (EP)

Epoxy resin used in this work was Sikadur - 105 which is a two

component, low viscosity epoxy resin system in the form of transparent liquid (which transforms into solid state after adding the hardener to it in a percentage of (2:1).

1.2 Styrene butadiene rubber (SBR)

SBR is derived from two monomers, styrene and butadiene. It is a liquid with white color.

2- Reinforcing materials

2.1 Magnesium oxide (MgO)

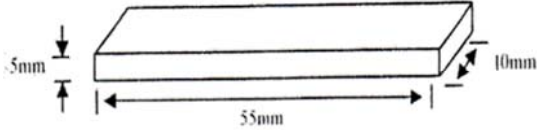
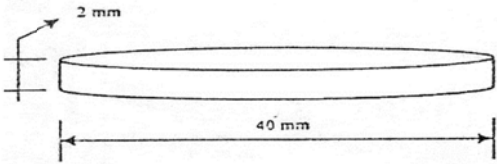
Magnesium oxide (MgO) which is manufactured by Z.D.N (china). It is a white powder with pure 99.9 % and grain size 30 nm. It is soluble in water and in acid and ammonia and insoluble in alcohol.

2.2 Copper oxide (CuO)

Copper oxide (CuO) which is manufactured by Z.D.N (china). It is a black powder with pure 99% and grain size 40nm, the chemical composition of copper oxide nanopowder is 79.87% content copper and 20.10 % content oxygen, and it is insoluble in water and soluble in dilute acids (NH₄Cl), (NH₄)₂CO₃.

Sample preparation

Hand Lay-Up method was used to prepare the samples. Polymer blends were prepared from epoxy and SBR with different ratios (95-5, 90-10, 85-15, 80-20, 75-25) %, and selected the optimum ratio (75-25) % and reinforced with MgO and CuO with weight ratio (3) %.

Test	Samples	Standard specifications
Impact		ISO-179
Thermal Conductivity		Lee's Disc

Results and discussion

1- Impact test

Table 1 show the effect of nano fillers on the impact resistance and Fig.1 and Table 2 show the values of impact resistance before and after immersion, the result refer to increase in this values after immersion because of the

water contribute to an increased the bond force and composition crosslink between the polymeric chains [7]. The reduction in the impact resistance values because of diffusion of water through the material leads to reduce interfacial adhesion between matrix and filler.

Table 1: Effect on nano fillers on the impact resistance.

Polymer mixture (EP+SBR)	Composite material (EP+SBR+MgO)	Composite material (EP+SBR+CuO)
3.3	2.5	2.9

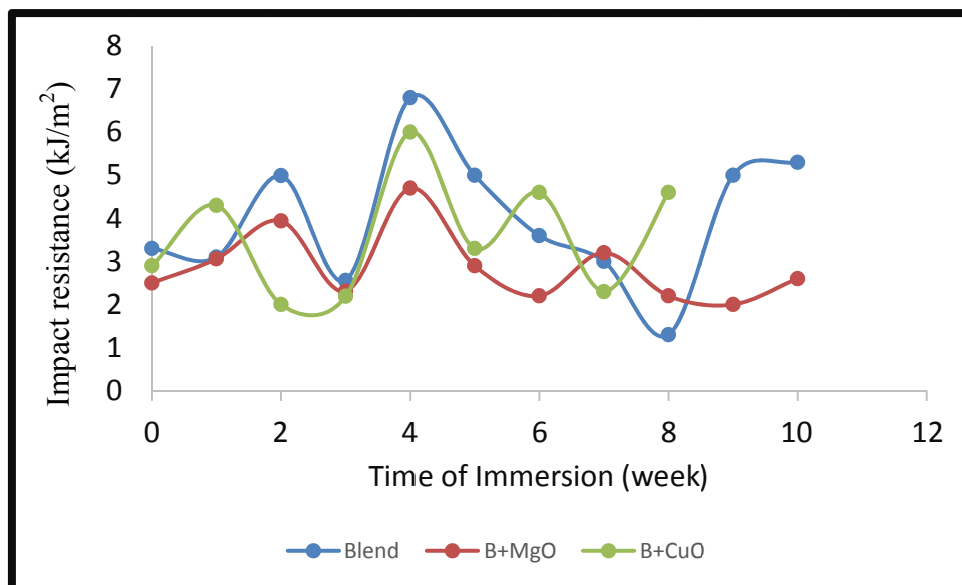


Fig.1: Variation of impact resistance with time of immersion for samples.

Table 2: The values of impact resistance.

Time Week	Polymer mixture (EP+SBR)	Composite material (EP+SBR+MgO)	Composite material (EP+SBR+CuO)
0	3.3	2.5	2.9
1	3.1	3.06	4.3
2	4.99	3.94	2
3	2.56	2.31	2.9
4	6.8	4.7	6
5	5	2.9	3.3
6	3.6	2.2	4.6
7	3	3.2	2.3
8	1.3	2.2	4.6
9	5	2	2.6

2- Hardness test

Table 3 show the effect of nano fillers on the hardness values, Fig. 2 and Table 4 show the values of hardness before and after immersion, the results showed increased after the addition of nano materials, The increase in the hardness values return to increasing the overlap and stack which leads to reduction in the movement of polymer molecules and leads to increase in the resistance of materials to scratch and become more resistance to plastic deformation [8].

After immersion in water, a decrease in the values of hardness were for all

samples because of the effect of water on the samples, which leads to the degradation of material and this leads to reduce the resistance of surface to indentation and scratch, and this showed the negative effects of period [9].

The reduction in the hardness values because of reduce interfacial adhesion between the fillers and matrix materials. Blend hardness decreased after immersion because of the degradation at the ends of polymer chains [6].

Table 3: Effect of nano fillers on the hardness values.

Polymer mixture (EP+SBR)	Composite material (EP+SBR+MgO)	Composite material (EP+SBR+CuO)
69.2	68.3	70

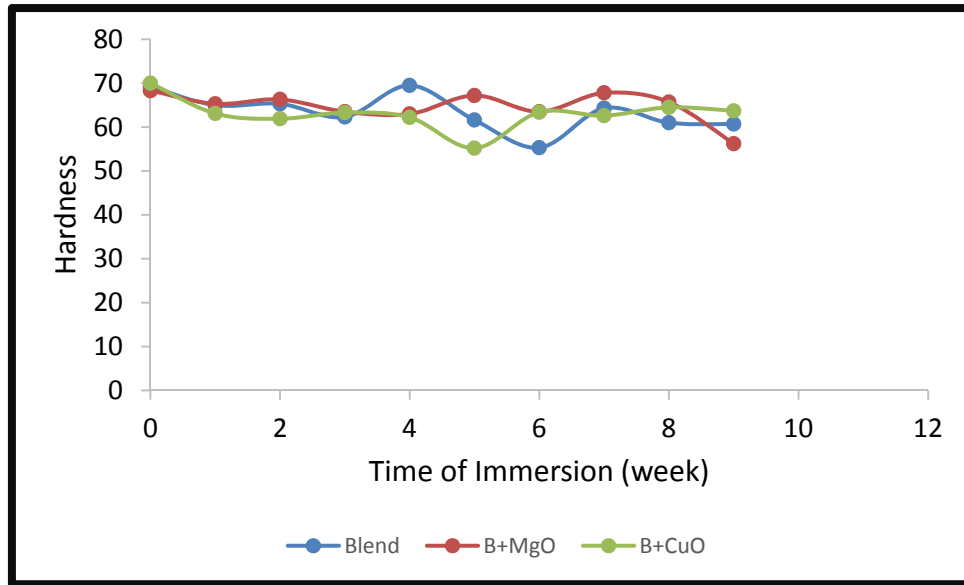


Fig. 2: Variation of hardness with time of immersion for samples.

Table 4: The value of hardness shore D.

Time Week	Polymer mixture (EP+SBR)	Composite material (EP+SBR+MgO)	Composite material (EP+SBR+CuO)
0	69.2	68.3	70
1	65	65.3	63.1
2	65.3	66.3	61.9
3	62.3	63.5	63.3
4	69.5	63	62.2
5	61.6	67.2	55.2
6	55.3	63.5	63.4
7	64.3	62.8	62.6
8	61	65.7	64.5
9	60.7	56.2	63.7

3- Thermal conductivity

Table 5 show the effect of nano filler on the thermal conductivity and Fig. 3 and Table 6 show the values of thermal conductivity before and after immersion. From the results it found the reinforced with nano ceramic oxides leads to increase the thermal conductivity, the addition of ceramic oxides to polymer blend works to reduce the degree of crosslinking between the molecular chains that give

them larger freedom of movement and increase the ability to Vibratory movement, which leads to increase the thermal conductivity [10].

After immersion in water, the increase in thermal conductivity was evident, where that water plays a role in the degradation of composite material, especially in the interface area between the matrix material and the reinforcing materials [11].

Table 5: Effect of nano filler on the thermal conductivity values.

Polymer mixture (EP+SBR)	Composite material (EP+SBR+MgO)	Composite material (EP+SBR+CuO)
0.186	0.303	0.256

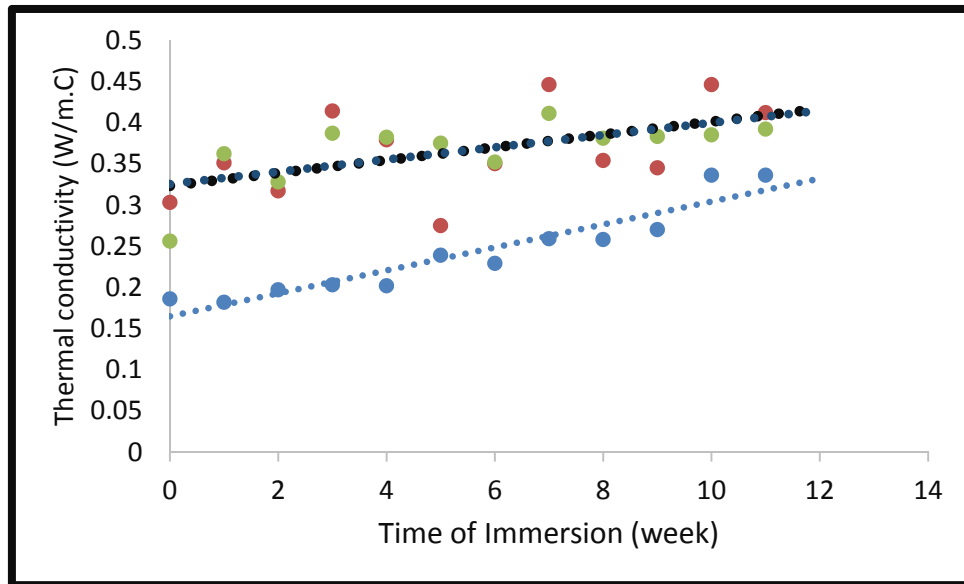


Fig.3: Variation of thermal conductivity with time of immersion for samples.

Table 6: The values of thermal conductivity.

Time Week	Polymer mixture (EP+SBR)	Composite material (EP+SBR+MgO)	Composite material (EP+SBR+CuO)
0	0.186	0.303	0.256
1	0.182	0.351	0.303
2	0.197	0.317	0.362
3	0.203	0.414	0.328
4	0.202	0.379	0.387
5	0.239	0.275	0.382
6	0.229	0.350	0.375
7	0.259	0.446	0.352
8	0.258	0.354	0.411
9	0.270	0.345	0.381
10	0.335	0.446	0.383
11	0.336	0.412	0.385

DSC test

The DSC test in this work was carried out mainly to investigate the effect of blending process for (75 EP+25 SBR)%, blend, on the value of glass

transition temperature. The results for the sample is shown in Fig. 4.

The glass transition temperature is found to be (94.84) °C.

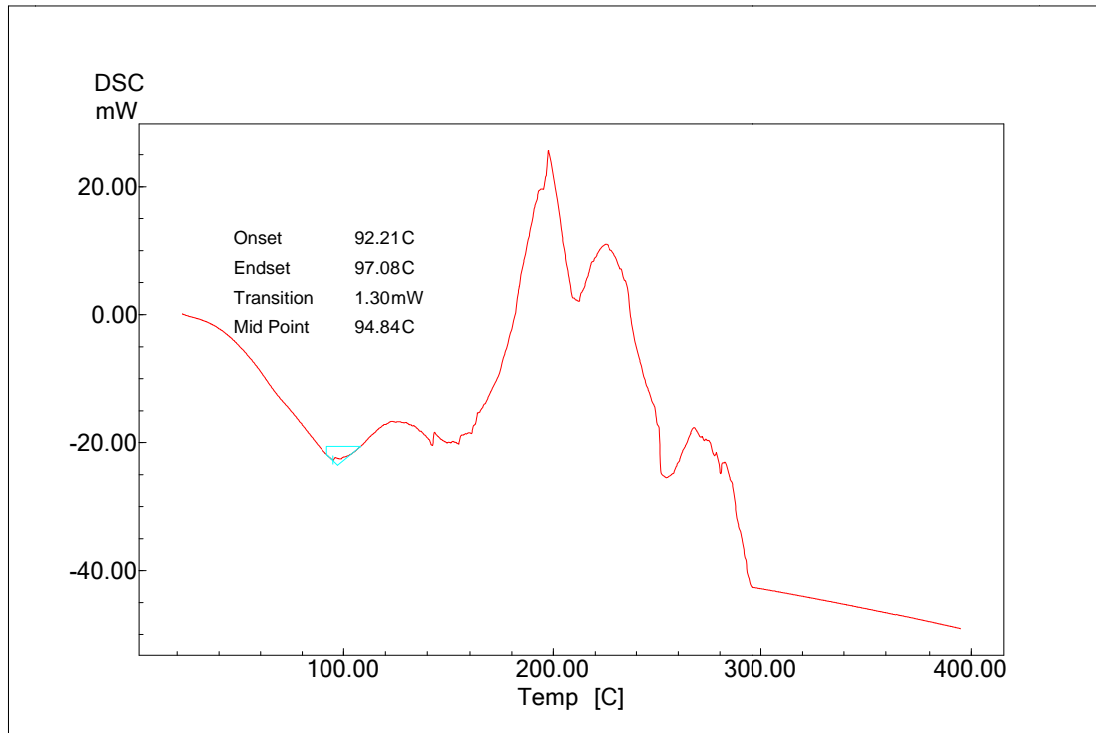


Fig.4: Glass transition temperature for (75 EP+25 SBR)%.

Optical microscope

For the purpose of study of the topography of the material has been used microscopy technique, samples were imaged before and after immersion in water, where the microscope images showed that the surface of the material before immersion seems coherent and this is evidence that the process of mixing a homogeneous. The microscope images of samples after immersion emergence of some of the voids on the surface of the samples and varying degrees.

The images of samples before immersion in water

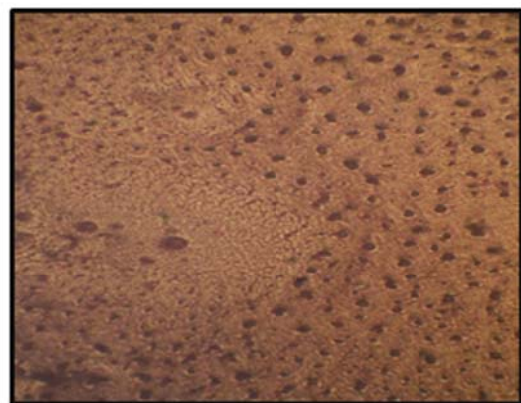


Image (a) blend (EP+SBR).

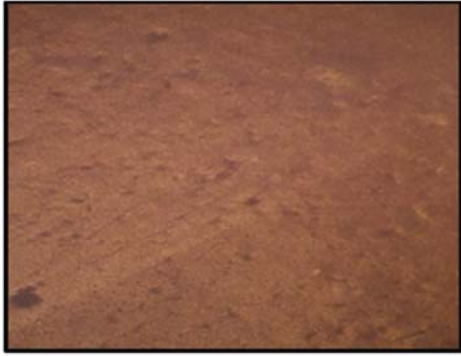


Image (b) (EP+SBR+MgO).



Image (c) (EP+SBR+CuO).



Image (c) (EP+SBR+CuO).

The images of samples after immersion in water

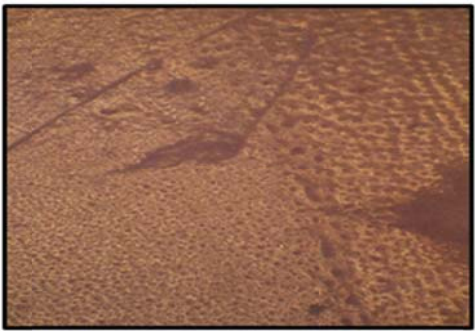


Image (a) blend (EP+SBR).



Image (b) (EP+SBR+MgO).

Conclusions

The values of impact strength and hardness (shore D) of the polymer blend decreased when reinforced with ceramic oxides and after immersion in water, but thermal conductivity values increased with reinforced reinforced and time of immersion.

References

- [1] S.N Masoud, G.Davood, "Polymeric Nanocomposite Material, Advances in diverse industrial application", Hand book, Intechopen, (2011).
- [2] M. Rahman, S. Bhandari, P.K Guchhait, Int J. Plast Technol, 12, 6, (2011) 581-590.
- [3] M. Motalbi, O. Hamed, Sh. Karim, International Journal of Polymer Science, 5, 7 (2012) 358-368.
- [4] Sh. Hanaa, Eng & Tech Journal, 34, 1 (2016) 93-99.
- [5] M. H. Ameen, "Employment of synthetic fibers with polymer blends for impact application", M.Sc, Thesis, Department of Applied Science, University of Technology, (2015).
- [6] I. A. Hamood, "Impact Behaviour for Epoxy Blends and Composites", M.Sc, Thesis, Department of Applied Science, University of Technology, (2009).
- [7] H. Alamri, I.M. Low, material and design, 42, 3 (2012) 214-222.
- [8] H. Bushra, Journal of Al-Nahrain University, 17, 2 (2014) 108-115.
- [9] M. Sadeer, Eng & Tech Journal, 33, 3 (2015) 67-75.

[10] N.A. Hussein, "Study Mechanical and Physical Properties of Epoxy/Polyester Composite Reinforced by Glass fiber and Nano or Micro Al_2O_3 ", M.Sc. Thesis, Collage of Education for Pure Science, University of Mousal (2014).

[11] E. Z. Khalf, "Effect of Chemical Solution on Some of the Physical and Mechanical Properties for Polymer/Ceramic Composite", M.Sc. Thesis, Collage of Education for Pure Science, Al-Anbar University, 2011.