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PROFILING THE MECHANICAL AND THERMAL PROPERTIES OF EPOXY NANO COMPOSITES UNDER THE IMPACT OF TITANIUM DIOXIDE AND ZINC OXIDE NANO PARTICLES

PAYAL VINOD KHOBRAGADE

ASSISTANT PROFESSOR, GOVT. SENIOR SCIENCE COLLEGE , GADCHIROLI

Abstract

In this paper, the additive effect of (titanium oxide TiO2 and zinc oxide Zn O) nanoparticles to the epoxy resin as a matrix have been studied, In addition to the manufacturing of hybrid compounds from the same nanoparticles which are (TiO2 / Zn O) depending on the epoxy also as a base material. The hand lay- up method is using to manufacturing the composites from the epoxy resin and nanoparticles with different weight ratios (0.2,0.4,0.6,0.8,1) wt%, Impact Strength test and Compression Strength test and the thermal have been done of all prepared composites. FE(SEM) was used to study the composition of the nanoparticles used in this research, which are titanium oxide and zinc oxide

The results of the tests showed that adding the aforementioned ceramic powders improved the mechanical properties of the composite materials the nano composite (EP+ZnO) had highest Impact Strength (0.8 wt%) and highest Compression Strength , the hybrid (EP+TiO_2 /ZnO) compound had the highest Impact Strength on (0.8wt %) and highest Compression Strength on the ratio(1wt%) followed by (EP+TiO_2) composite had highest Impact Strength on the ratio (0.6wt%) and highest Compression Strength on (1wt%). The results showed that the differential scanning calorimetric (DSC) test has showed that the glass transition temperature of all epoxy composites increases at all weight ratios of reinforcement materials compared with pure epoxy and the high test value of glass transition temperature (T_g) is to the composite composite (EP+TiO_2) that equal (67^{o}C) in the ratio (0.6wt%) , as well as, the crystalline melting temperature of all epoxy composite has showed atypical behavior compared with pure epoxy by increasing the weight concentration.And the results of FE(SEM) showed that Morphology of Zinc Oxide and Titanium Oxide Nanoparticles nearly spherical .

Key words: epoxy resin, nanoparticles, hybrid, Mechanical properties, glass transition temperature

Introduction.

Polymeric materials are important in the industry for many reasons, the most important of which are ease of manufacture, cheapness, and light weight [1]. But after the technological development, especially in the field of aerospace industries and the manufacture of car and aircraft structures, the need to manufacture materials with special specifications increased, so the composite materials industry appeared. Among them are polymeric compounds[2], Also, the required mechanical specifications determine the type of reinforcing material added to the polymeric material, most of the polymeric composite materials contain either ceramic or glass materials (fibers) or powder[3], the heterogeneous distribution of nanoparticles within the base material does not result in a significant change in any of the physical properties of nanostructures Similarly, many experiments have shown that the base material is uniformly homogeneous nanoparticle diffusion, [4]. In this research, a polymer of an epoxy type was chosen, and the reinforcing materials are titanium dioxide and zinc oxide nanoparticles due to their high mechanical characteristics..

………………………………………………………

MATERILS AND METHODS

1 Used materials

Base material that was used in the preparation of the composite material is the German epoxy resin (Sikadur-52), originating with a distinction from the Egyptian Sika Company, and it is in the liquid state and can be polymerized and transformed into a solid state by adding a hardener of the same type of resin as the hardener is characterized as a liquid It has a light viscosity, low density, and a transparent yellow color, and the ratio of hardener to resin is (2: 1). The time it takes for the resin to solidify is

temperature and it was left for two weeks to complete the treatment, after which the samples were cut according to the standard specifications of the tests. Used in research

Table(1) : Properties of Epoxy

Test Method	Typical Results
Compressive strength (BS 6319)	53 N/mm^2 @ 20ºC
Density(20 ºC)	1.1 kg/I
Coefficient of Thermal Eepansion	89×10-6 per ºC (from-20 ºC to +60 ºC)
Viscosity (mpa.s)	1000 @10 ºC
Pot life	20minutes @ 20 ºC 10minutes @ 30 ºC
Specific gravity	1.04
Mixed viscosity	500mpa.s @ 20 ºC

Was used Nano zinc oxide (nano Zn O) and nano titanium oxide (nano TiO_2), two materials tested

Table(2): The properties of nanoparticles

Nanoparti c les	Purty	Partic le siz	Origin	Manufacturer
Zn O	99 %	35-45	US A	US Research Nano materials
TiO_2	99.5%	10-30	US A	Sky spring Nano

2 Preparing samples

The hand-lay method was used to prepare three compounds (EP + Zn O) and (EP + TiO_2), with weight ratios (0.2,0.4,0.6,0.8,1) wt% and the hybrid[EP + (Zn O + TiO_2)] with weight ratios (0.2,0.4,0.6,0.8,1) wt% and were performed for the composites (hand-lay method) was The first step: preparing a special mold for the molding process consisting of a glass plate representing the base of the mold with dimensions (40cm × 40cm) coated with transparent thermal paper in order to prevent the adhesion of the resin to the glass plate and ease of removal of the manufactured pieces, and glass rulers of the required thickness coated with thermo-adhesive foil as an insulating material that has been placed Rulers on the sides of the template To create a template for the sample with dimensions (15×15×0.4) cm

The second step: the samples have been prepared, and the method for preparing samples is summarized by the following steps:

1 - A certain amount of epoxy resin was weighed and a hardener was added in a 2: 1 ratio.

2 - Certain percentages of ZnO and TiO_2 have been added to the epoxy resin according to the following weight ratios (0.2,0.4,0.6,0.8,1, wt%)

3 - The stiffener and the base material were mixed at room temperature well by placing the mixture on the magnetic stirrer mixer device for 30 minutes, after which the mixture was placed on the ultrasonic bath for two hours to obtain a homogeneous mixture and after that the hardener was added and the mixture was placed on the magnetic stirrer mixer device For 15 minutes. 4 - The mixture is poured in the middle of the mold so that it flows to all areas of the mold on a regular basis until the mold is filled to the required level, and here the mold must be completely flat.

5 - The model was left in the mold for a period of three days in order for the sample to solidify permanently before it was removed from the mold, and then after it was removed from the mold it was left for a period of 15 days, and this process is important to complete the polymerization.

6- Samples were cut according to the approved specifications

The necessary heat treatment was performed for the composites, and the search models were cut according to the standard specifications (ASTM).

3 – Testing

1 Impact Strength Test

The study used standard impact fracture energy calculation MODEL(XJJ series) , ASTM standard (6110)

It works to test the toughness of the material that absorbs energy during deformation, for example the shock test to measure the energy required to break a standard sample (Stander bar) is by applying the impulse load, for that sample. The fracture that occurs in the forms of a material is either an elastic fracture, meaning that the material has a remarkable plastic deformation and is called the ductile material. Or it is a brittle fraction, meaning that the material does not show a plastic deformation or shows a slight plastic deformation before refraction and it is called a brittle material such as glass[5]. we used (Izod Test) and counted Impact Strength from equation [6]:

$I.S = U/A$..........(1)

I.S : Impact Strength (KJ/m^2)

U: Breaking energy (KJ)

A: Section area(m^2)

2- Compressive Strength Test

The flexural strength (R_f) was measured by the diametrical of solid disk referred to as the Brazilian disk fracture test. The test performed on disk sample height = 0.4 mm and diameter= 2.5 mm using INSTRON instrument . The specimen was fixed between the device platens to start compressing at acrosshead speed= 0.5mm/ min until fracture occurred .the diametrical compression strength was determind by applying equison(2) [7]:

$\sigma_f = 2 F_{fracture} / \pi Dh$ …………..(2)

Where $F_{fractur}$ is the fracture load (N), (D) is the sample diameter and (h) is the thickness in (mm).

3 –Glass transition temperatures (Tg) Test

To analyze the material characteristics of nano composites, their glass transition temperatures (Tg) were measured using a Mettler Differential Scanning Calorimetry (DSC) equipment. At 5 ^{o}C / minute rate of rise of temperature with scanning up to (280^{o}C) . The information reported the error in the measurement is around .

4- FE(SEM) Test

Results and discussion

The scanning electron microscope (Hitachi S-416) was used to obtain information about the topographical information for TiO2 and ZnO nanoparticle

1 Impact Strength test

The working principle is based on the fact that some of the existing primary energy, such as the kinetic energy in the hammer, is absorbed by the sample before the fracture occurs, as the energy absorbed by the sample depends on the nature of the internal components in the manufacture of the compound material and its resistance to the exerted external stress . The mechanism of failure that occurs in the material with rapid stress is one of the mechanical properties that have been given great attention by researchers because there is always a risk that the polymeric materials may be ductile under the influence of static stress and exhibit greater resistance to impact Like rubber, but it looks brittle for example (epoxy) [8], the reason for the decrease in impact strength values when increasing the concentration of nanoparticles is the agglomeration resulting from a large concentration of the particles and their tendency to form a strong bond between them compared to bonding with epoxy resin [9].

From figure (1), (2),(3), the impact strength Are increasing with an increase in the weight ratio of nanoparticles added to the epoxy resin

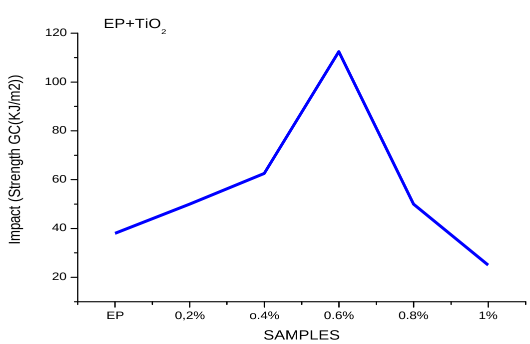

Fig.1: Diagram of the impact strength(Epoxy+TiO_2)

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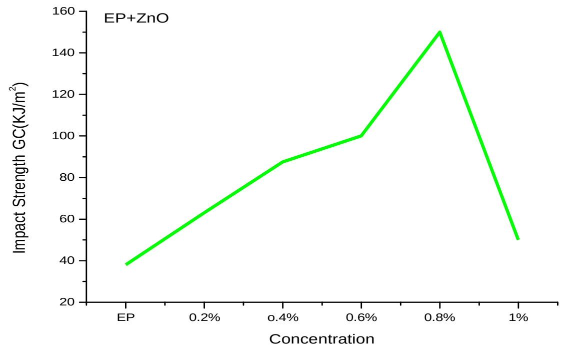


Fig.(2) Diagram the impact strength(Epoxy+ZnO)

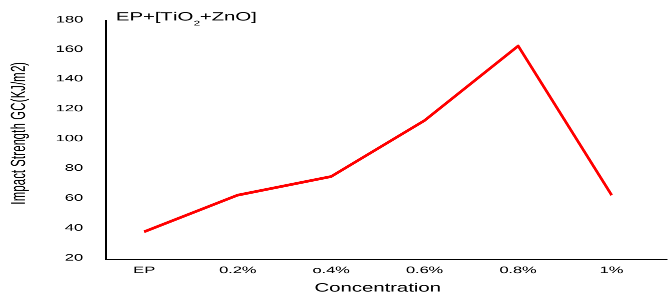
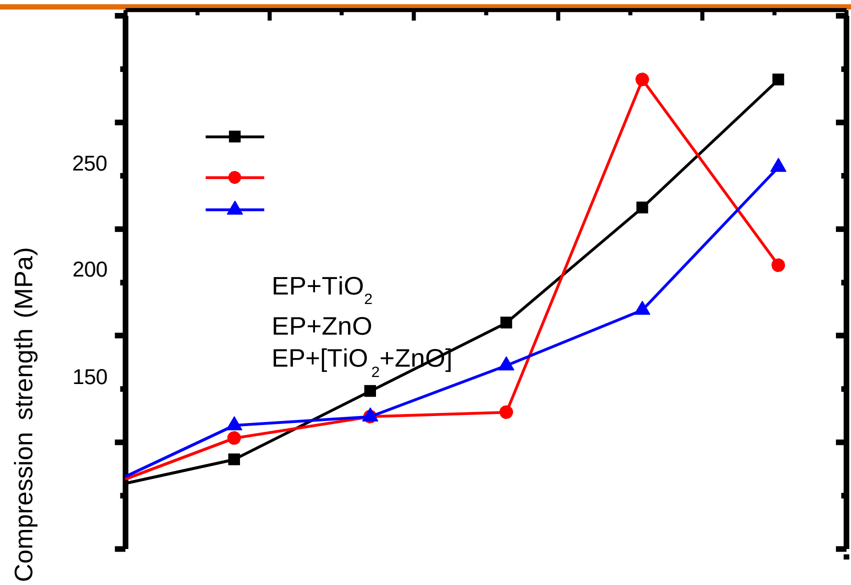


Fig.(3) Diagram of the impact strength[Epoxy+(TIO_2/ZnO)]

2 Compressive Strength Test

The results of the compressibility test showed that the addition of titanium oxide and zinc oxide powder to the epoxy resin improved the compressive strength of the composite material and in the figure(4) showed a model (EP+TiO_2) and hybrid of the highest compressive strength at the ratio (1wt%) flowed (EP+ZnO) at the ratio (0.8wt%). The reason for this is that ceramic powders have high durability and withstand the major part of the applied stress, as well as the process of distributing the residual stress on the base material(Isotropic) in all directions The small size of the particles makes the intervals very small and this hinders the growth of the cracks, The compressive strength of the composite material depends on several factors, including the properties of the substrate, the reinforcing material, the strength of the bond and the cohesion of the interface between the substrate and the reinforcing material. If the interface is strong and durable, the compressive strength will improve significantly and almost reach the tensile strength. This is what we observed in the samples of the composite materials that we obtained compared to pure epoxy material. While in the event that this surface is weak, the reinforced material will separate easily from the substrate and the compressive strength never reaches the level of tensile strength[10].


Compression strength (MPa)
250
200
150
EP+TiO2
EP+ZnO
EP+[TiO2+ZnO]

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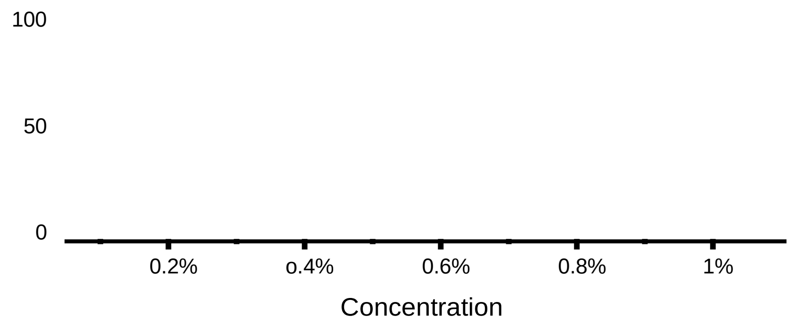


Fig.(4) Diagram of the Compressive Strength(EP-TiO_2),(EP+Zn O) (EP+TiO_2/ZnO)

3- Glass transition temperatures (T g) Test

we showed the glass transition temperature of pure epoxy was recorded before and after the consolidation in the (TiO2,ZnO) nanoparticles different weight ratios (0.2,0.4,0.6,0.8,1) wt%, so using Differential Scanning Calorimetry (DSC) advise , Through the following figure (5,6,7) we note The glass transition temperature (T g) of pure epoxy is (53o C), when the epoxy is cemented with nanoparticles, we notice a change in the glass transition temperature (T g) for all composites (EP+TiO2,EP+ZnO,[EP+(TiO2/Zn O)] it increases with increasing the weight of the reinforcing material down to the ratio (1wt%) then the degree of glass transition decreases with the increase in the weight ratio of the reinforcement while the values of the degree of glass transition remain greater at the Tow composites(EP+TiO2, EP+ZnO) and hybrid (EP+TiO2/ZnO) From pure epoxy, we also notice that the glass transition degree increases with the weight ratio(0.6 wt%) for added The increase in the degree of glass transition by increasing the weight ratios of the reinforcement It indicates the transformation of the material from the more elastic state to the less elastic state and that this pad is evidence of the bond between the base material and the support materials and thus the rate of molecular weight increases, which causes a hindrance in the movement of the polymeric chains. Which requires higher energy to reach the appropriate degree of freedom of movement to transfer to the rubber state and thus increase the degree of glass transition[11],The decrease in the degree of glass transition may be due to agglomeration of the support materials in the substrate, or it may be due to the absorption of moisture.[12].

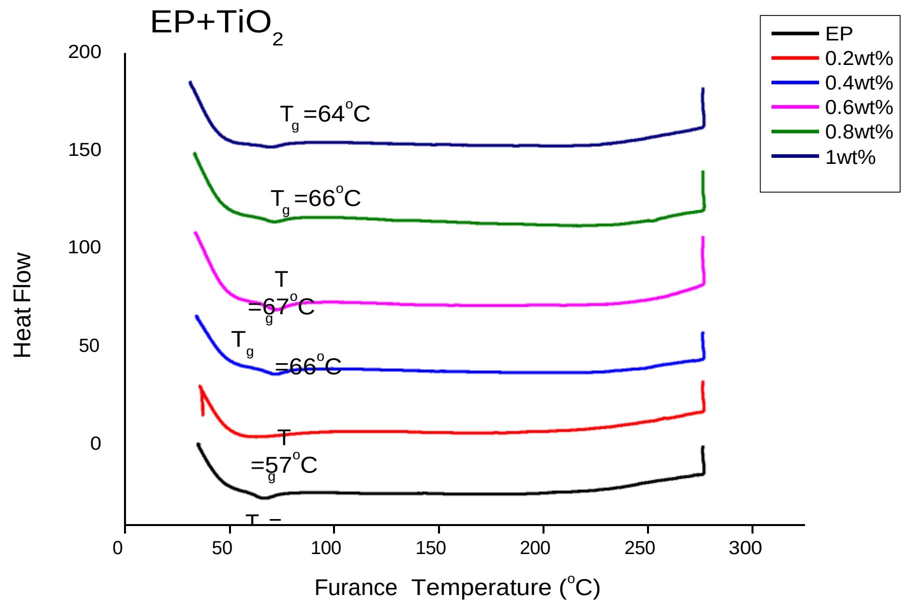


Fig.(5) Diagram of the Glass transition temperatures(Epoxy+TiO_2)

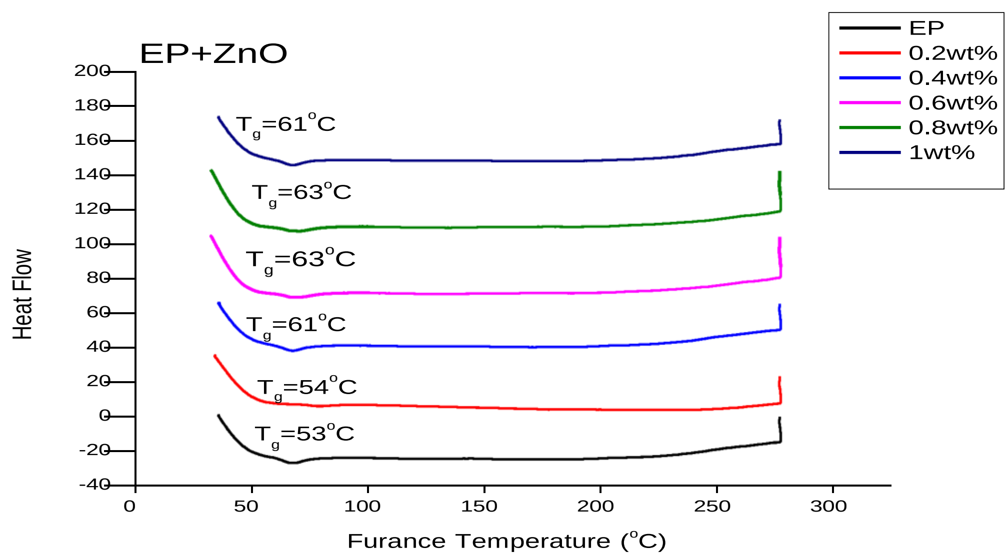


Fig.(6) Diagram of the Glass transition temperatures(Epoxy+ZnO)

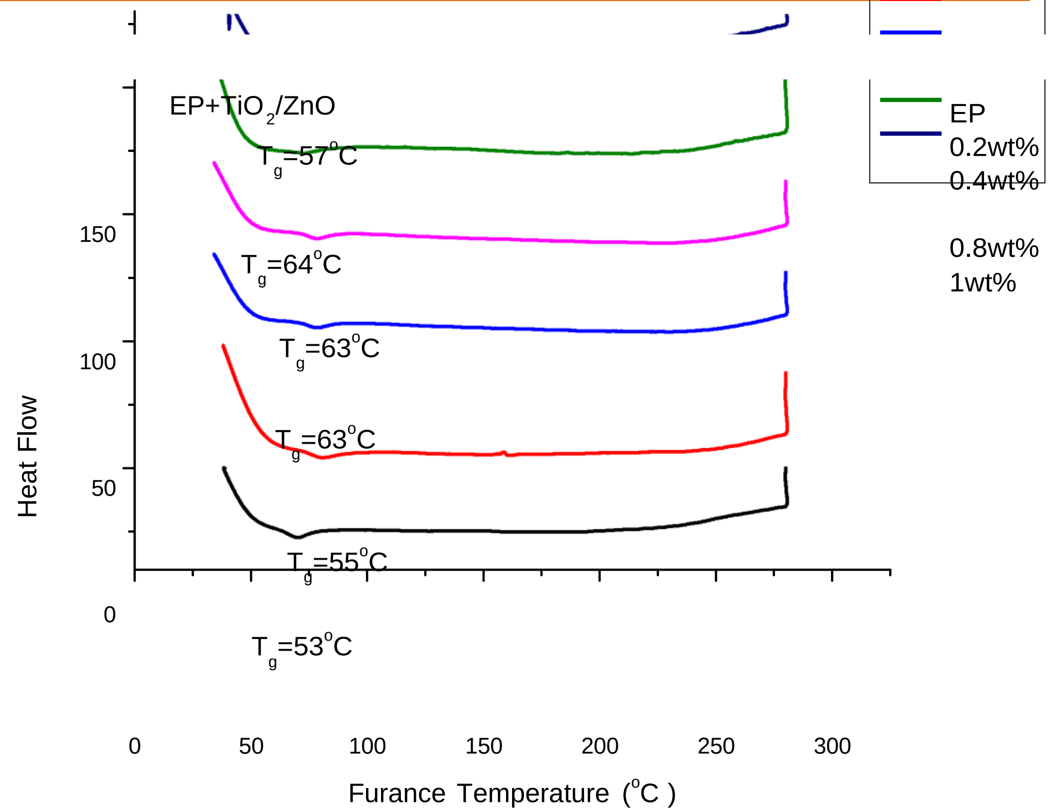
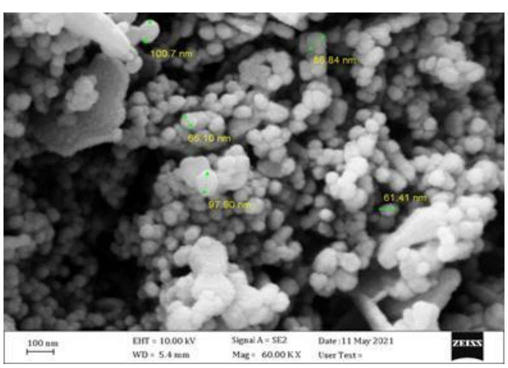
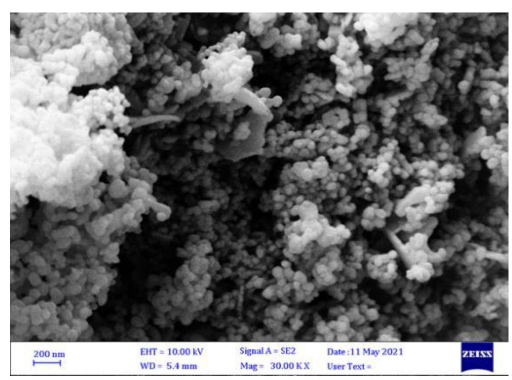


Fig.(6) Diagram of the Glass transition temperatures(Epoxy+TiO_2/ZnO)

4- FE(SEM) Test



(a-6)



(b-6)

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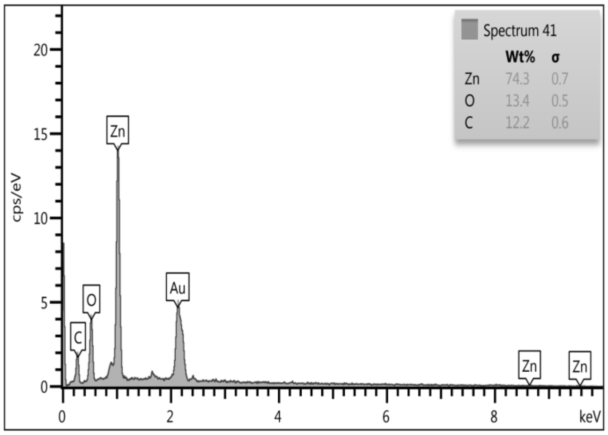
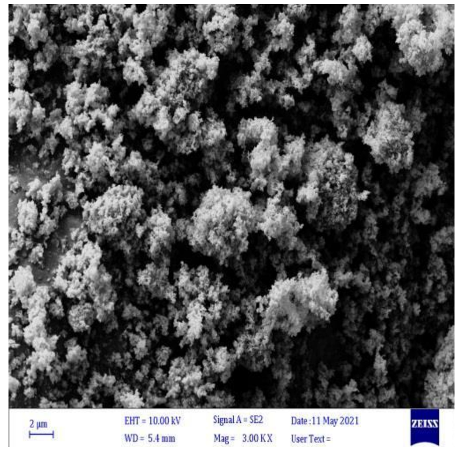
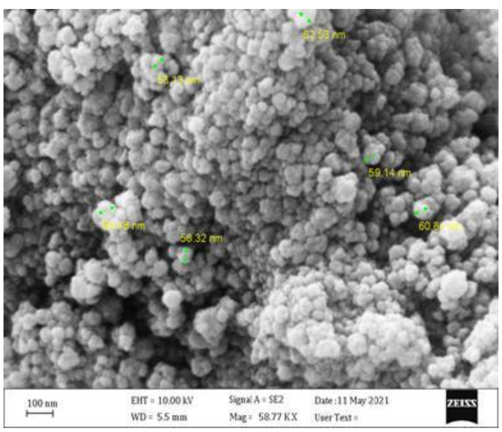




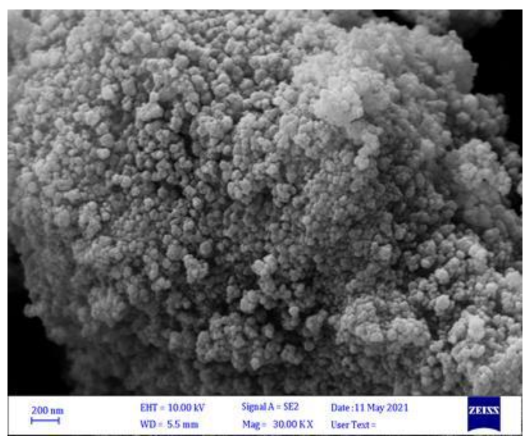
(d-6) (C-6)

Fig.(6) : (a-6),(b-6),(c-6),(d-6) FE(SEM) of ZnO Nanoparticle

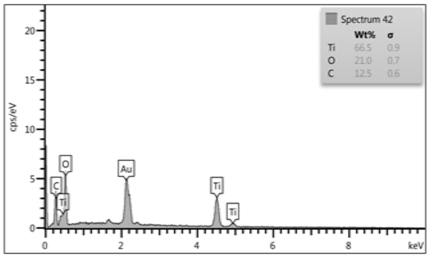
From this Figure(6) we notice that the morphology Zinc Oxide Nano Powder nearly spherical With a powerful magnification of(100nm) ,(200 nm) ,(2µm)

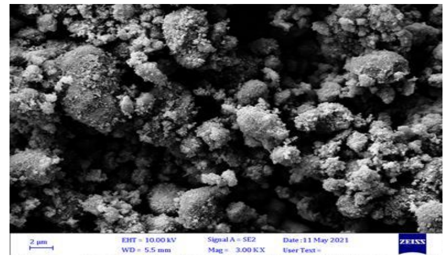


(a-7)



(b-7)





(d-7) (c-7)

Fig.(7):(a-7),(b-7),(c-7),(d-7) FE(SEM) of TiO_2 Nanoparticle

From this figure(7) we Showed that Morphology of the particle is nearly spherical With a powerful magnification of(100nm) ,(200 nm) ,(2µm)

CONCLUSION

1 - The addition of nanoparticles to the epoxy resin improved Mechanical properties

2 - The results of the research showed that fortification with (Zn O) and (TiO_2) powders and with (TiO_2 + Zn O) hybrid produces composite materials that have properties with industrial and technological applications.

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