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Study of the effect of the addition of nano oxides (CuO,NiO,CrO) on the physical properties of epoxy

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Abstract :

In this research, the impact of adding nanoparticles to epoxy that are represented by (copper oxide (CuO), nickel oxide (NiO), and chromium oxide (CrO)) was examined. The manual method of forming was employed to create epoxy and nanofiber composites with different weight ratios, mechanical tests and thermal checks were conducted for all of the prepared composites. The outcomes of the impact test demonstrated that the extra weight of the reinforcements increased the strength of epoxy, the highest value of durability was achieved with the composite Ep-15% CuO, which was equal to (J/m 0.34). The results of the hardness test demonstrated that the harderness of epoxy increases as the weight ratio of the reinforcements increases, the highest hardness was achieved for the composite (EP-%CuO), which has a thermal conductivity coefficient of (76.4) HB. The effect of the weight ratio of the reinforcements on the thermal properties of all polymeric composites was also studied, and the results showed that the thermal conductivity of all polymeric composites increases as the weight ratio of the reinforcements increases. The highest value of this property was achieved for the composite (Epoxy-CuO), which has a surface that is both uniform and spread out, the effect of the weight ratio on the microstructure of the composite is also studied, and the results showed that the surface is smooth and lacks cracks.

Keywords: epoxy – nanoparticles – Impact factor – hardness – thermal conductivity.

دراسة تأثير إضافة أكاسيد نانوية (CuO,NiO,CrO) على الخواص الفيزيائية للإيبوكسي

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مستخلص:

في هذا البحث تم فحص تأثير إضافة جسيمات نانوية للايبوكسي ممثلة بـ (أكسيد النحاس (CuO) وأكسيد النيكل (NiO) وأكسيد الكروم (CrO)). تم استخدام طريقة التشكيل اليدوية لإنشاء مركبات الايبوكسي والألياف النانوية بنسب وزن مختلفة ، وتم إجراء الاختبارات الميكانيكية والفحوصات الحرارية لجميع المركبات المعدة. أظهرت نتائج اختبار التأثير أن الوزن الزائد للتعزيزات زاد من قوة الايبوكسي ، وتم تحقيق أعلى قيمة للمتانة مع مركب (Ep-15% CuO) ، والذي كان يساوي (J/m 0.34) واظهرت نتائج اختبار الصلابة ان صلابة الايبوكسي تزداد مع زيادة نسبة وزن التعزيزات وقد تحققت اعلى صلابة للمركب (EP-%15CuO) الذي له معامل توصيل حراري (76.4) HB. كما تم دراسة تأثير نسبة وزن التعزيزات على الخواص الحرارية لجميع المركبات البوليمرية، وأظهرت النتائج أن الموصلية الحرارية لجميع المركبات البوليمرية تزداد مع زيادة نسبة وزن التعزيزات. تم تحقيق أعلى قيمة لهذه الخاصية للمركب (Epoxy-CuO) الذي له سطح موحد ومنتشر ، كما تم دراسة تأثير نسبة الوزن على البنية المجهرية للمركب ، وأظهرت النتائج أن السطح أملس ويفتقر إلى الشقوق.

الكلمات المفتاحية: الايبوكسي – الجسيمات النانوية – معامل الصدمة – الصلادة – الموصلية الحرارية.

1- Introduction

Engineers and designers have a passion for the effective way materials are engineered and used in multiple different industries. Because they are produced through multiple different processes that are based on structural and design principles that are compatible with functional performance. Alongside the analysis of their failures regarding this performance, researchers in mechanical engineering and structural materials seek to create structures that have both aesthetics and corrosion resistance in terms of strength and durability[1]. Experts in the field of materials science (such as metals, ceramics, and polymers) have recognized that there is a difference in the properties of available materials and the behavior that results from environmental and practical conditions on the functionality of materials[2].

Metals have multiple beneficial thermal and electrical properties, they are highly resistant to corrosion and have a long lifespan, in addition to being magnetic. Other metals have the capacity to act and form, but their chemical susceptibility to corrosion is low. Regarding ceramic materials, they are inorganic and non-metallic substances like carbides, nitrides and oxides. Ceramic materials have low thermal and electrical conductivity, and are considered to be insulating. They have a reputation that is derived from their brittle nature and thus their low resistance to pressure. However, these materials have a high hardness and a large capacity for compressive stress, they are also very chemically inert (chemically Inert). As such, ceramic items are not utilized on a daily basis. Because of its higher pressure than other metals, it is capable of withstanding high temperatures[3] .

Lightweight organic polymers (Wight Light) have a high degree of malleability similar to plastics.[4] Plastics are composed of different types of adhesive molecules, which are produced via a polymerization process in order to create large molecular structures of organic compounds with a high degree of polymerization. They're referred to as elastic materials, and their structure can expand and return to original state after being removed. Polymers have a low conductivity for electricity and heat, so they are an insulating material for electricity, and compared to metals, they have a higher density, greater elongation, more corrosion resistance, and have a lower hardness. It's not considered to be solid. However, when the pressure is applied to it, it will stretch and then the elongation will evolve over time. As a result, its effectiveness is primarily derived from temperature[5,6].

2- Practical part

2-1 Materials used

a- Matrix Materals

Epoxy resin was employed as the base material for polymeric composites, the resin type (Nitofill, EPLV) is manufactured in (Fosroc Jordan), and the components are composed of A and B, where A is the resin itself, and B is the hardener of the resin (Metapheny Diamic), and is considered to be a transparent liquid with a medium degree of polymerization and a high degree of adhesion. When it is added with a hardener, it becomes solid.

b- Reinforcement Materals

The used nanooxides were prepared, which are chromium oxide(CrO), nickel oxide(NiO) and copper oxide(CuO).

The oxides have been prepared to follow the following steps:-

1. Initially, chromium, nickel and copper nitrate are obtained as raw materials. Usually these chromium nitrate and nickel nitrate come in the form of green crystals and copper nitrate is blue.

2. Chromium-nickel and copper nitrate is heated in the presence of air (oxygen) inside a suitable crucible or vessel. It must be ensured that the temperature rises slowly to avoid the formation of undesirable intermediate products..

3. After heating is complete, the product (oxide) is allowed to cool. It produces green powder for chromium and nickel and black powder for copper.

2-2 Impact Test Instument

For the purpose of estimating the energy required to break the material's fracture, the impact resistance of the material can be determined. Employ the impact measuring device - Garbi (Charpt and Test) as depicted in Figure (1) and created by Test Mechines Inc. AMITYVLIE,New Yourk)(TMI Mechine in the U.S.A) and located at the University of Technology / Department of Applied Sciences.

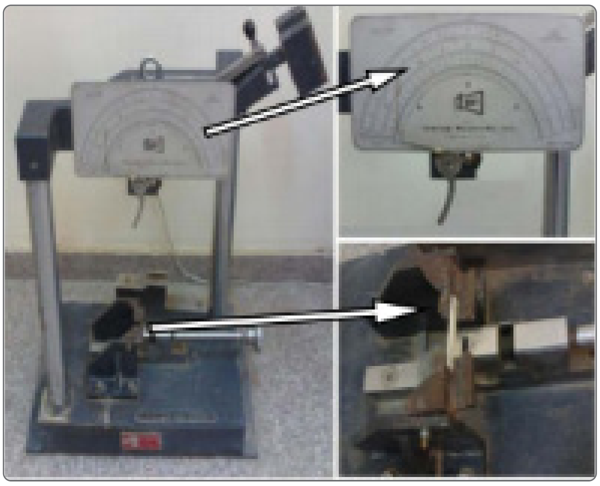


Figure (1) Shock Tester Images

2-3 Hardness Test Instrument

The toughness of the samples was determined by the Shore (D) method, and the device used in this test is (Shore D Hardness Tester TH210) and is located at the University of Technology/ Department of Applied Sciences, it is a manual device that contains a spring that is loaded with stitches that resemble needles that penetrate the surface of the sample and then recorded the number that appears on the device's screen (recoil method, the energy that is absorbed is displayed on the screen).

Figure (2) Shore D hardness tester pictures

2-4 Thermal Conductivy Test Instrument

Use a tablet device designed by the company (Griffen & George) located at the University of Baghdad's/ College of Science's/ Department of Physics, the design of which is shown in Figure 4. It consists of three disks (A, B, C) and an electric heater (Heater) that is connected to the electrical circuit in order to place the sample between the two disks (A, B) and the electric heater is placed between the disk (B, C) and when the power is turned on, the electric heater is used to heat the last disk and the temperature of the second highest is recorded (Ta, Tb, Tc).

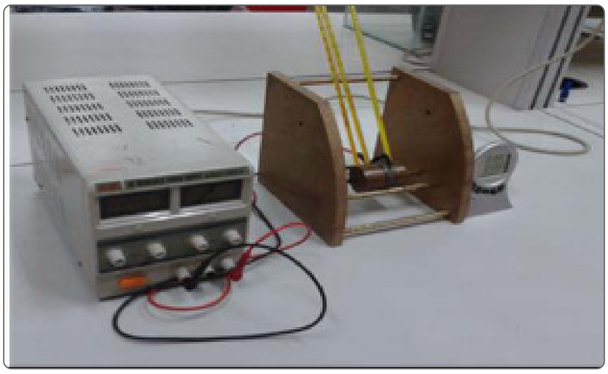


Figure (3) Thermal conductivity tester (Li tablet).

2-5 Scanning Electron Microscopy (SEM)

is a powerful analytical tool that is used to investigate the internal composition and surface characteristics of pre-prepared samples. Before the exam, the sample must be prepared in a proper way to yield the greatest possible results, such as attaching the sample to a conductivity layer and covering it with this. SEM provides specific information about the topography of the sample's surface, including the size, shape and distribution of granules or microstructures in the cadastral system.

3-Results and discussion

3-1 Impact test results

The impact test is one of the most important dynamic mechanical tests that assess the durability of materials for impact, the purpose of this test is to determine the actual energy required to break the sample, and the method for doing so was based on the idea that some of the existing primary energy, such as the kinetic energy of thehammer, was transferred to the sample before the fracture occurred and the energy was then absorbed[7]. The sample is based on the composition of the concrete's components and their resistance to external pressure applied to them, this information is relevant when determining the sample's composition[8]. Also, we observed that the impact strength of the EP-CuO composite was greater than the other composites' due to the strong chemical bond between the base material and the reinforcing material, this chemical bond is responsible for the enhanced mechanical properties observed in the composite, as well as the lowest values were obtained at Ep-CrO, and through Figure (4) we also observed that the EP-CuO composite possessed a lower durability than the other composites.

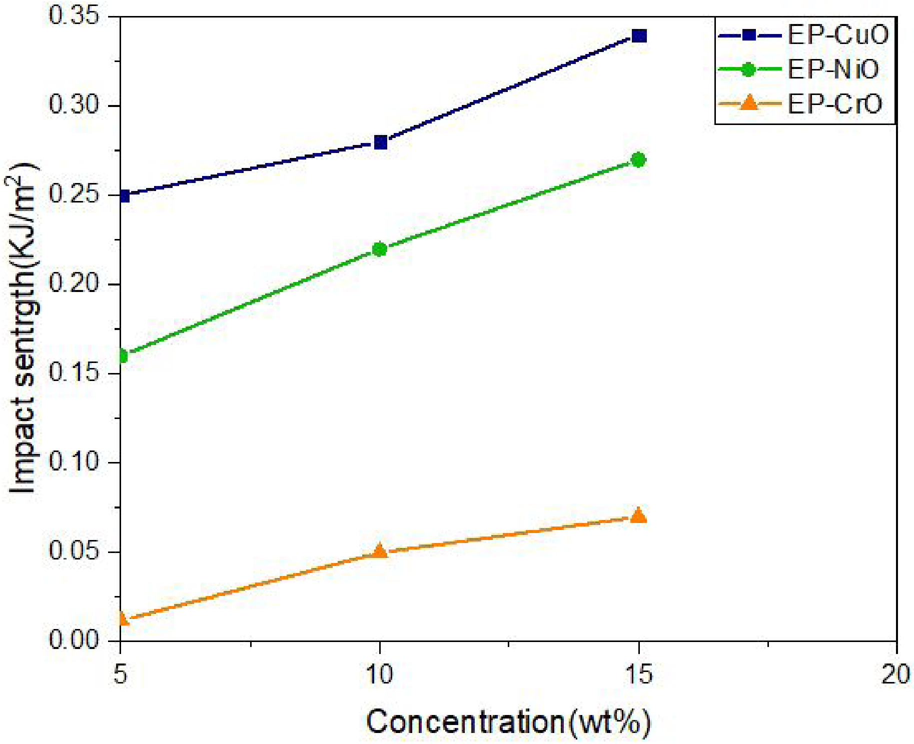


Figure (4) Impact test results for epoxy fortified with nanoxide particles

3-2 Hardness test results

The hardness test of the type (Shore) was selected for the purpose of adding nanoparticles of oxide (CuO, NiO, CrO) to the epoxy at a ratio of (5, 10, 15)% Solvents' figure (7). The amount of copper oxide added to the epoxy was greater than the amount of secondary particles, and this was because of the shape of the particles, their size, and the ease of attachment to the epoxy. This led to an increase in the hardness of the material, which in turn restricted the movement of the chains of polymer and increased the hardness of the prepared material. We also observed that the EP-CrO composite's hardness values are lower than the other composites' hardness values, this may be the cause of this. It's the consistency of the polymeric composite's fuse or the lack of uniformity between the base material and the type of augmented particles, both of which will impede the flow of the liquid base material into the environmental spaces and thus reduce the hardness of the prepared material [9,10].

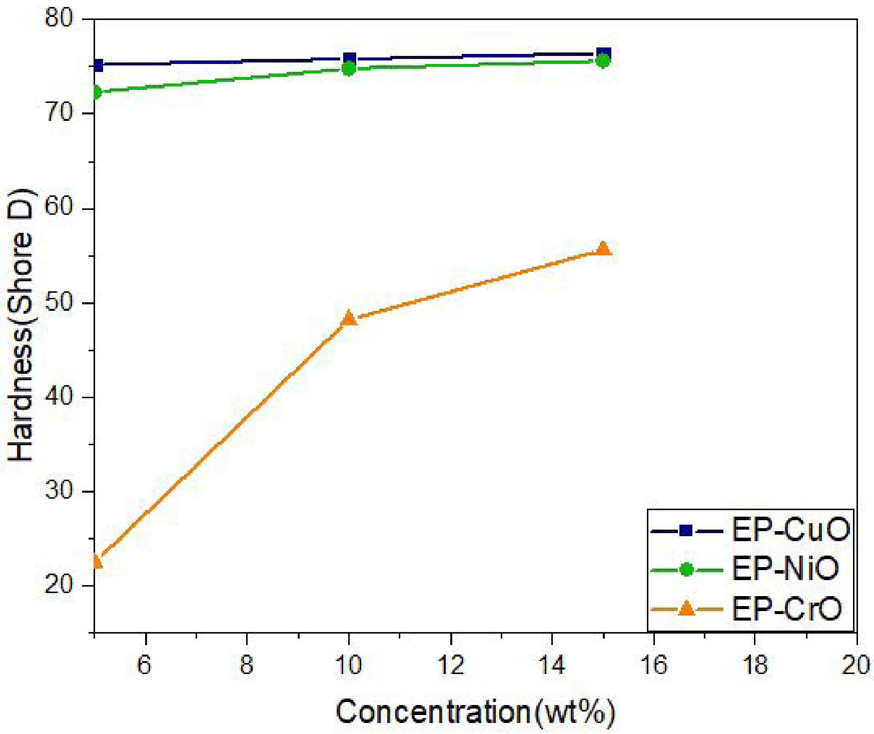


Figure (5) Hardness test results for epoxy reinforced with nanoxide particles

3-3 Thermal Conductivitiy Coefficient

The thermal conductivity (k) of epoxy resins reinforced with oxide nanoparticles (CuO, NiO, CrO) was calculated using the Lee's Disc method in percentages (5, 10, 15), where Figure (6) shows the highest values When epoxy resins are reinforced with copper oxide, since the nanoparticles essentially do not contain voids, their thermal conductivity becomes larger, and the lowest values in the compounds of different reinforcement ratios EP-CrO, they have the following values The values of thermal conductivity are lower than those of epoxy resins containing copper oxide or nickel oxide, because the presence of these nanoparticles in the matrix reduces the degree of entanglement between the molecular chains, which gives them greater freedom of movement, thereby increasing their ability to vibrate, which leads to an increase in the thermal conductivity values of the composites. In addition, these nanoparticles can density the components of the composites, reducing the number of voids formed during the manufacturing process of the composites, thereby increasing the thermal conductivity values[11,12]

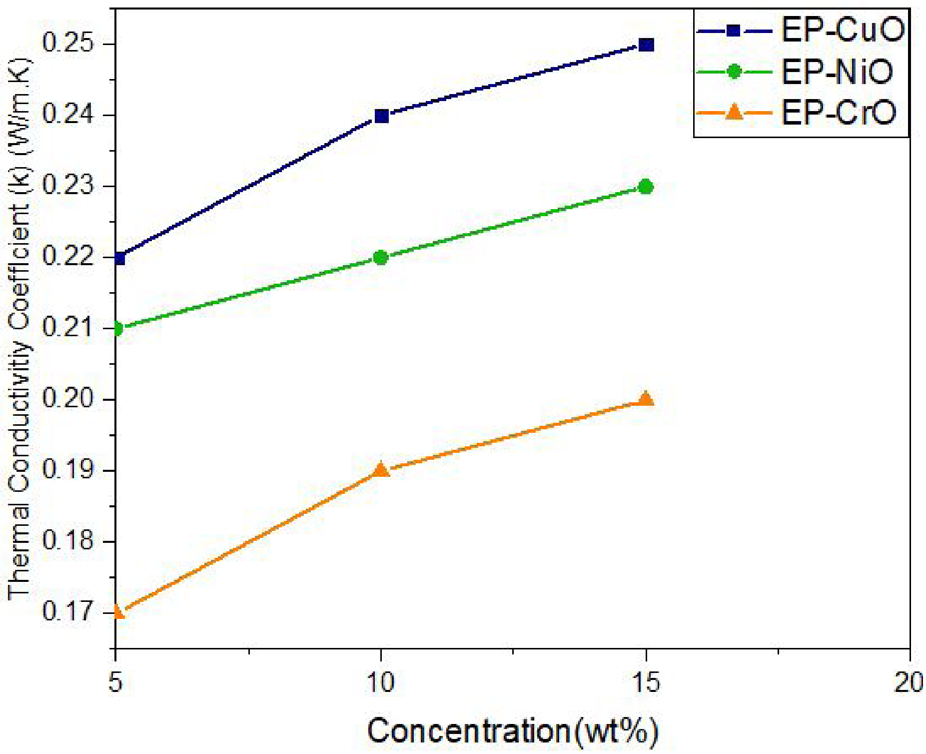
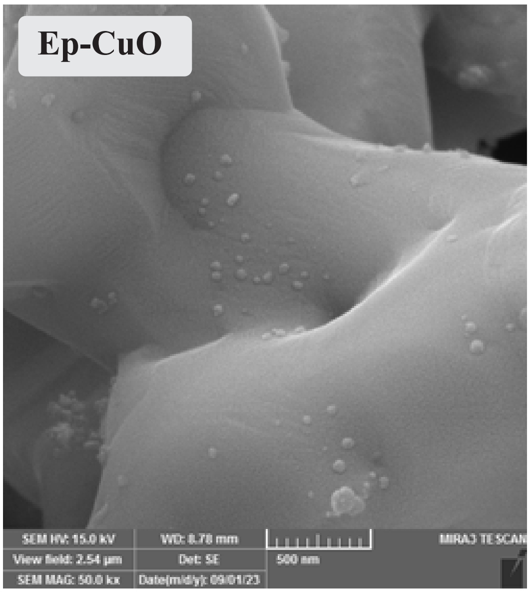
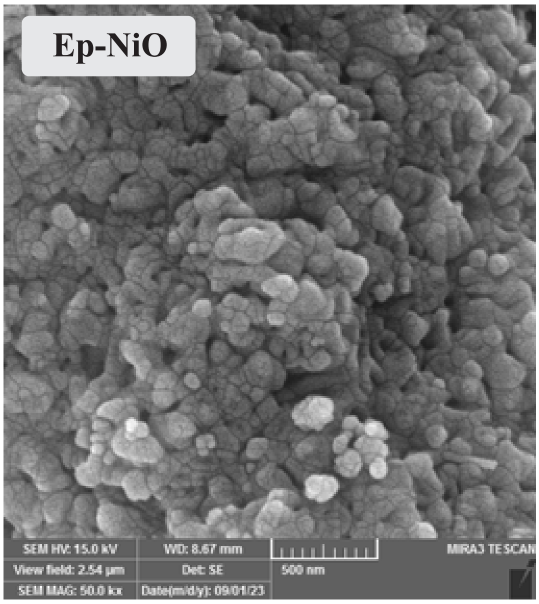


Figure (6)Thermal Conductivity Test for Epoxy Fortified with Nanoxide Particles

3-4 The results of the scanning electron microscope test

when mixing epoxy with oxides (CuO, NiO, CrO) have been microscopic images of copper oxide more homogeneous to the surface and there is a clear diffusion of copper oxide molecules with epoxy, the reason is that a chemical reaction occurs between the materials. Epoxy is an organic polymer while copper oxide is an inorganic mineral compound. When mixed, chemical bonds form between the epoxy and the copper ions in the oxide. These chemical bonds help to disperse copper oxide molecules homogeneously within the epoxy material. This uniform distribution of metal particles improves the mechanical properties of the resulting composite material, such as hardness and tensile and compressive resistance.[13,14) In addition, copper oxide molecules play a role in improving the thermal properties of the composite material. They act as “coordination” sites for thermal vibrations within the material, increasing the degree of glass transition and improving thermal conductivity as in Figure (7).





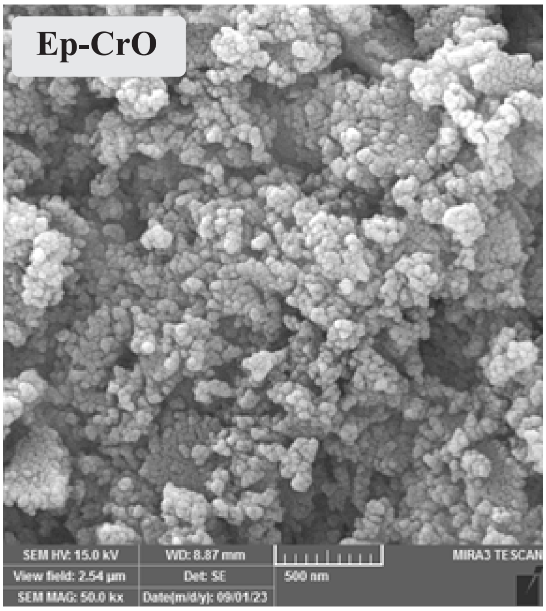


Figure (7) \ Microscopic images of prepared samples (epoxy-oxide).

4-Conclusions

In this study, the effect of adding nanoparticles (copper oxide, nickel oxide, and chromium oxide) to epoxy was investigated. Mechanical tests and thermal analyzes were performed on epoxy-nanocomposites with different weight ratios. The results showed that increasing the proportion of nanoparticles improved the mechanical and thermal properties of the epoxy, with the Ep-15% CuO composite achieving the best performance in terms of impact resistance and hardness. The thermal conductivity of the polymeric composites also increased with the increase in the reinforcement ratio, and the Epoxy-CuO composite was the highest in this property. Microscopic analyzes showed a clean, crack-free surface of the composites.

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