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THE EFFECT OF THE ADDITION OF GRAPHENE ON THE MECHANICAL PROPERTIES OF EPOXY

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ABSTRACT. Graphene nanoplatelets were added to epoxy to show the extent of change in mechanical properties of the compound, where three different weight ratios of graphene were used, namely (0.5%, 1%, 1.5%) and all percentages gave an improvement in ultimate stress, the absorbed energy and impact strength, while the best result is at 0.5% at all auditions, where the value of stress and modulus of elasticity were 34.2 Mpa, 1243 Mpa respectively, and the value of the absorbed energy and the impact strength of the formed compound was 1.33 Joules, 22,2 kJ \ m2 respectively, with an improvement rate of 432.4%.

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Introduction

Introduction

Traditional composites are materials made up of at least two components that work together to provide consumers with the desired characteristics. They are usually made up of a matrix and several sorts of reinforcements. Nanocomposites are made up of at least one element with a size of fewer than 100 nanometers [1]. Traditional composites are materials made up of at least two components that work together to provide consumers with the desired characteristics. They are usually made up of a matrix and several sorts of reinforcements. Nanocomposites are made up of at least one element with a size of fewer than 100 nanometers [1]. Graphene, as a newly emerging carbon allotrope, demonstrated a novel property, Graphene, a novel rising carbon allotrope, has demonstrated a new route to circumvent these limits of property investigation [2]. The use of graphene materials, i.e. graphene oxide, reduced graphene oxide, graphene nanoplatelets, and their functionalized forms as fillers of epoxy composites, is reviewed. The purpose of the time- and reagent-consuming functionalization methods of graphene materials is justified by the noticeable improvement of dispersity and adhesion of the graphene sheets to the epoxy matrix, which affects the final properties of graphene-epoxy composites [3].

1. Literature review

Low graphene loading results in a considerable improvement in the mechanical characteristics of composites made of unsaturated polyester resin and graphene oxide , at a 3 weight percent loading of GO, tensile and modulus of Young of the composites both increase by roughly 76 and 41 percent by sequence, when compared to clean PE, the composite's thermal stability was clearly improved, according to thermal analysis [4] , Graphene nano sheets (GNS) with multiple weight percent (0.1, 0.3, 0.5, and 1.0%) percent wt. were used to reinforce the examined tensile strength and young modulus properties of an polymer , when weight percentage was 0.1 percent wt., the improvement in tensile strength was 13 percent when compared to pure epoxy, whereas the improvement in young modulus grew and then dropped at the same weight fraction or weight percentage [5] , Graphene was used in this study to strengthen epoxy as a matrix and improve its mechanical properties , epoxy/nano graphene and epoxy/modified nano graphene composite are the two varieties of epoxy composite that have been produced. For this investigation, three weight percentages—0.5 wt%t, 1.0 wt%, and 1.5wt % were used. enhanced and unenhanced epoxy exhibit the maximum value at 0.5 wt% when contrasted to clean epoxy, where the values were 8000m pa, 6000mpa, and 675 mPa, by sequence, because the properties of the materials change when the filler is added to the matrix, neat epoxy outperformed both nanocomposite materials for maximum stress [6].

2. Methodological approach

The materials used in the sample manufacturing are a matrix consisting of epoxy, in addition to reinforcement that came from adding crumb recycled rubber. Where The polymeric material that was used in this research is transparent epoxy, which had a specific density of 1.1 kg/L as indicated in Fig. 1, epoxy resin (ren floor HT2000) and hardener (HT2000) are combined mechanically for 10 minutes in a 2:1 weight ratio [7], the mixture is then put into a vacuum oven of the type (vacuum Dry Box - DZ2BC), manufactured by Tianjin City Taisite Instrument Co., Ltd.,) under pressure (-80Kpa), and heated to (40 C0) for 30 minutes [8]. Nano graphene powder was used shown in Fig. 2.
The graphene is mixed with the propanone solution mechanically by an electric or hand mixer to facilitate chemically mixing the graphene with the matrix material, mix the mixture using a mechanical mixer, then the mixture is placed again in the ultrasonic device for 60 minutes and a temperature not exceeding 60 degrees Celsius to extract propanone and then leave it for some time until it is noticed that there is no acetone and then add the hardener to the mixture and mix it using a mechanical mixer, the mixture was placed in the vacuum apparatus as mentioned in the previous paragraph and then pour it into the mold.

Fig. 1 Epoxy used


Fig. 2 Graphene

Sample molds were manufactured according to (ASTM) specifications and prepared for manufacturing samples from the previously mentioned material Where 4 types of samples were manufactured (note Table 1).

Table 1 Samples

No	Samples	Abbreviation
1	Epoxy	E
2	Epoxy + 0.5% Graphene	E+0.5%G
3	Epoxy + 1% Graphene	E+1%G
4	Epoxy + 1.5% Graphene	E+1.5%G

tensile test The tensile test samples were manufactured according to the specifications of ASTM (D638-14) as Fig. 3 shows the mold, Using (a Microcomputer Controlled Electronic Universal Testing Machine) model (WDW-100E) with a maximum capacity of (100) KN, installed in the Department of Materials Engineering/Faculty of Engineering/University of Kufa as Fig. 4 [9], For each composition, three samples were tested, and the mean value was determined [10].

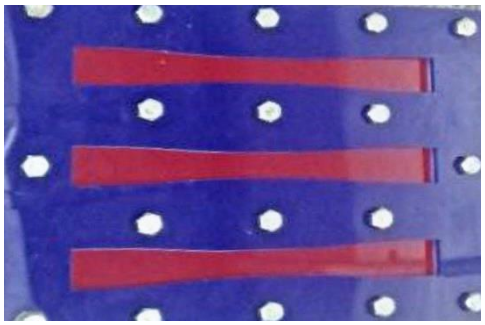

Fig. 3 Tensile Mold

Fig. 4 Electronic Universal Testing

impact test molds are manufactured of impact Resistant Test to standard specifications ASTM (D256-04), Where Fig. 5 shows the shape of the mold. After that, the examination was also conducted in the same college above in the laboratory of the Engineering Materials Department in the device shown in Fig. 6 [7], by electronically using the Charpy method, as the device gives a digital reading, where the dimensions of the sample were entered, and then giving the command to apply force after leaving the raised arm in the device automatically at the moment of giving the command [11].

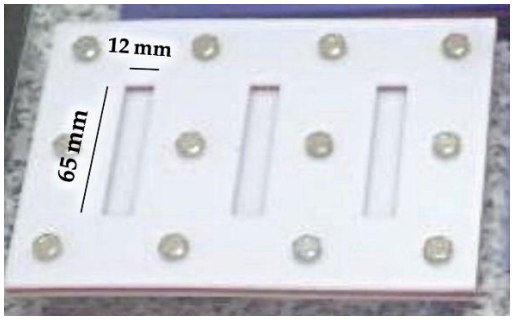

Fig. 5 Impact Mold

Fig. 6 Impact test device

hardness test was checked in the same previous section of Al-Qadisiyah Engineering using the Shore D type hardness tester indicated in Fig 7, where the device works manually with results given by the digital reader located at the top of the device [8].

Fig. 7 Hardness (shore D) test device

3. Conducting research and results

Through this paragraph, the results reached after conducting the tests will be known, where at the beginning of the tests, the values of free epoxy were examined, and then the new compounds consisting of epoxy and graphene were examined, and then the difference in the results was discussed and the extent of improvement obtained from the addition of the nanomaterial.

tensile test after the tensile test was applied, the highest stress value and modulus of elasticity were found for the epoxy sample, and then the results of the additives and fillers added to it were compared so that the results of graphene/epoxy compounds with epoxy alone, the results showed that graphene compounds gave better results in stress and elasticity, this can be seen from the Table ***2.***

Table 2 Tensile properties of Graphene composite

Property	Ep	Ep+0.5%G	Ep+1%G	Ep+1.5%G
Ultimate stress (MPa)	22	34.2	32.5	30.1
Fracture stress (MPa)	21.2	30.4	29.1	28.4
Young modulus (MPa)	957	1243	1204	1198

It can be concluded that 0.5% is the best result, from which we conclude the extent of the homogeneity of the nanomaterial with the epoxy matrix in this ratio, and thus the absence of agglomerations that make the nanomaterial act as cracks and areas of weakness, as this case appeared in the last two percentages 1%, 1.5%, which gave fewer results than the previous percentage, but in the end, the results for the compound are better than the polymeric material alone, Strain stress curves can be seen through the fig. ***8,*** The percentage of improvement can be seen in fig. 9

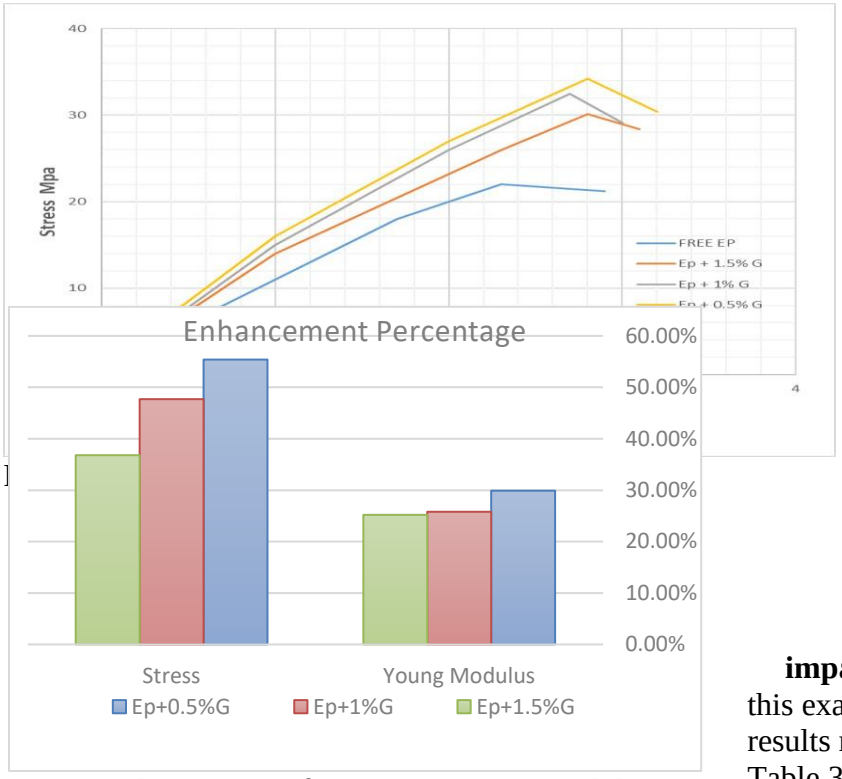

Fig. 9 Enhancement of Stress & Young Modulus

impact test after conducting this examination in advance, the results mentioned in the two tables Table 3, and Table 4 were reached, as they show the readings reached by the test device in terms of the values of absorbed energy and impact resistance.

Table 3 Absorbed Energy (J)

No	Samples	Abs Energy
1	E	0.25
2	E+0.5%G	1.33
3	E+1%G	1.12
4	E+1.5%G	0.887

Table 4 Impact strength (KJ \ m^2)

No	Samples	Impact strength
1	E	4.17
2	E+0.5%G	22.2
3	E+1%G	18.66
4	E+1.5%G	14.78

the best results were in the case of graphene at a rate of 0.5% because of its diffusion and homogeneous distribution and the absence of blocs and therefore have a surface area higher than the rest of the percentages [12], The percentage of improvement can be seen in fig. 10.

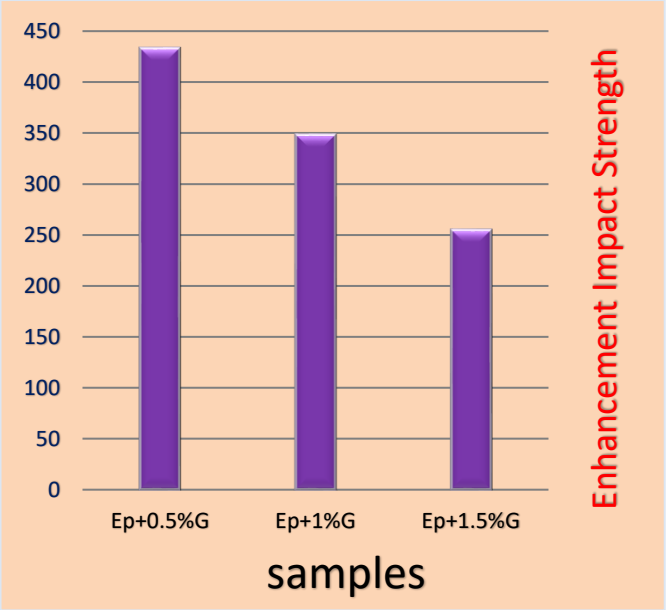

Fig. 10 Enhancement of Impact strength

hardness test Where we tested all sampling models and each model examined 5 different places of the sample and took an average of them, as Table 5 shows the results that were reached, and this is because the shore D test does not enable it to penetrate the sample completely and does not reach the depths of the sample [13].

Table 5 Hardness Test

No	Samples	Hardness (shore D)
1	E	64
2	E+0.5%G	71
3	E+1%G	70
4	E+1.5%G	69

Therefore, a superficial examination works on examining the outer surface without going deep into all the contents of the filler that is present with a substance the matrix may be the area in which the examination is carried out only contains epoxy, or it may be graphene, or it may not exist. For this noticeable the hardness results in which there is no big difference in all of them [14].

Conclusions

Through this research, all percentages gave an improvement in ultimate stress, the absorbed energy, and impact strength, while the best result is at 0.5% at all auditions, where the value of stress and modulus of elasticity were 34.2 Mpa, 1243 Mpa respectively, and the value of the absorbed energy and the impact strength of the formed compound was 1.33 Joules, 22,2 kJ \ m^2 respectively, with an improvement rate of 432.4%.

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