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Mechanical Properties of Hybrid Nano Graphene Oxide and Si Oxide Fiber-Glass Composites Materials

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Many practical applications in the automotive industry, aerospace applications, construction and others have benefited from the development in composite materials and reinforced by glass fibers and nanoparticles, in this work is improving mechanical properties from adding Nano particles and study of the effect of adding a mixture of nanoparticles of Graphene nanoparticles and Sio2 nanoparticles on the mechanical properties of hybrid compounds, Where the models of the hybrid compound were studied for the purpose of tests and by manual paving method. The mixture was mixed with different weight ratios (1%, 2% and 3%) for the purpose and evaluation of mechanical properties. The ultimate stress for unreinforced specimen with fiber glass is (80.77.7MPa) and its values and the best value was 77.69 Mpa for reinforced specimen by 2 % of Graphene ,92.13 Mpa for specimen by Sio2 at 3% and was 97.78 MPa at 2.5% hybrid from (Graphene and Sio2) , Also this addition improvement from hardness strength and impact strength and endurance limits at fatigue test and this happen due to good distribution of nanomaterials in composite materials as shown in SEM figures.
Keywords: Graphene, Sio2, hybrid composite , Nano composites, fiber glass, epoxy resin.

1. Introduction

Recently, this type of polymeric compounds has been used at a great rate, as it has a huge amount of wonderful and different applications. The main characteristics of these compounds that distinguish them from many metals are low density, good fatigue and corrosion resistance, and thermal insulation, and bad expansion (Shams et al., 2013) [1].

A composite polymer matrix has very good properties (mechanical and chemical) , like good modulus and strength, fatigue, and corrosion strength. They have been considered good alternatives to metal materials used in many everyday applications, such as aircraft, land and sea transportation, such as ships, and electrical and electronic installations (Zhuge al, 2012) [2].

These reinforced polymers compounds have distinctive properties that have distinguished them and become useful in mechanical applications such as magnetism, strength, thermal expansion, and high specific hardness, the most important of which is low energy consumption during manufacturing. (A.A. Taher al, 2021) [3,4].

Typical zones of composite applications in the car industry, aircraft forming, wind energy plants, boats, etc. (Varga et al, 2010) [5,6] .Due to the improved properties through the addition of nanomaterials and fillers it has been used in many industrial applications, electronics, aerospace applications and food packaging. Even by adding lower fillers, compared to conventional composites, it gives strengthening in mechanical properties, gas permeability and fire. (Khalil et al, 2013) [7]. Nanocomposites used in polymers are of great industrial importance during the recent period. Many groups of polymeric matrices, as well as the nanofillers used, were studied. It led to a number of improvements in chemical and physical properties (Chiu and Chen, 2015) [8].

One of the most important factors that affect the properties of the compound in the polymer, including the size and shape of the filling, as well as the composition, amount and degree of adhesion of the filling within the matrix. The use of nanomaterials as a filler within the adhesion area may lead to a set of much stronger interactions with matrix, thus improving and strengthening the metal.

In typical compounds, it is possible to obtain enhancement and obtain a good compound through good mixing, but it fails with nanomaterials, because the interactions that occur within the components may determine the bulk properties. (Esteves, et 2005) [9].

The addition of nano SiO2 helped enhance the mechanical properties of all sizes and weight ratios of particles, as well as improving the fracture toughness due to the penetration of the nanomaterial into the deformation of the matrix plastic, and thus helped to create a shield in the area, fill voids, and strengthen the shear resistance of the fiber used. (Jajama and Tippur, 2012) [10]

Ti oxide nanoparticle and graphene are some of the most interesting compounds currently available. Through this development in the industry, it has the ability to be used successfully in many applications and industries, including acoustic stimuli and energy storage etc (Al-Akaishi, A. Salih, 2021) [11,12].

Through research, it was found that 10% by weight nanocomposites showed a good combination of properties. They gave an increase in scratch resistance and modulus, as well as an increase in strain resistance to failure, while remaining durable. While composites containing micronized additives mean gains in scratch resistance and a reduction in stress to failure (Ng et al, 2001) [13,14].

2. Experimental Work

The volume of resin required to fill the mold within is calculated using ASTM (D638-10) type (I) and the impact test standard ASTM (D256-04), and the mold is manufactured using a CNC device in accordance with these dimensions. Figure (1) indicates casting by CNC machine of the ASTM standard dimensions of the tensile test.

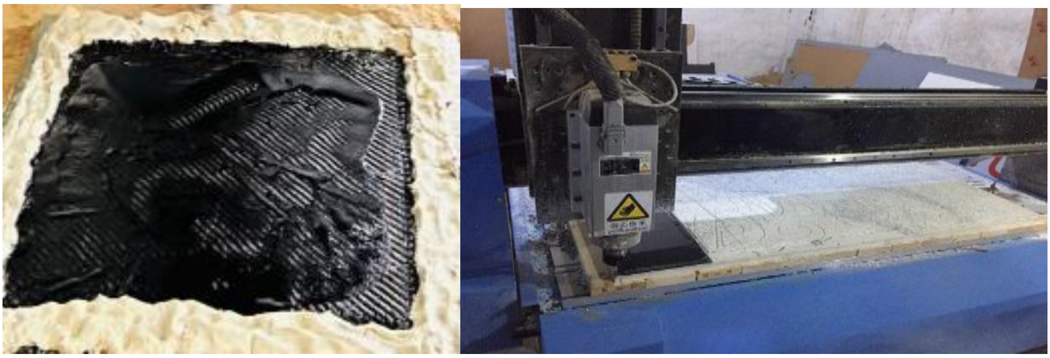

Figure 1 Mold of Specimens from CNC machine

3 Mixing Process of Nano Composite:

The nano composites were prepared by adding the nano particles to resin without hardener. The mixing process consists of two mixing stages. The first stage was carried out by using a magnetic stirrer for 30 min [15]. The second mixing stage was done by using the ultrasound mixer device (MTI Corporation) (see Figure (2)) for 10 min . Resin was poured into the molds and dried for 24 hours, then the molds were opened to extract the samples. The mixing processes were done at the University of Kufa in the Faculty of Engineering in nanotechnology and advanced material research unit.

Figure 2:Ultrasonic Mixer

3. Results and discussion

Figure 3 shows the stress-strain curve of epoxy when adding two layers of fiberglass to pure epoxy and finally the composite material by adding hybrid composite materials from Graphene and Sio2 at weight ratios of 1% and 1.5%) respectively, where the increase and improvement in the amount of stress is noted to reach 97.78Mpa due to the good mechanical properties of added nanomaterials as well as the distribution homogeneity between materials.

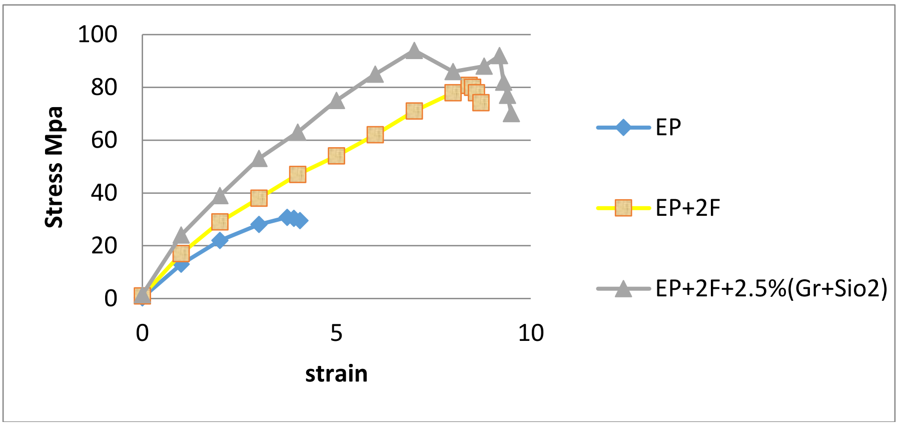

Figure 3 :stress - strain curve of Two fiber glass with hybrid nano composite materials

The good and homogeneous distribution of the nanomaterials with the composite material of epoxy and fiberglass, and the manufacture of samples in a good manner with the least possible gaps and cracks, was reflected in the homogeneous fracture process after the test, as noted in figure 4.

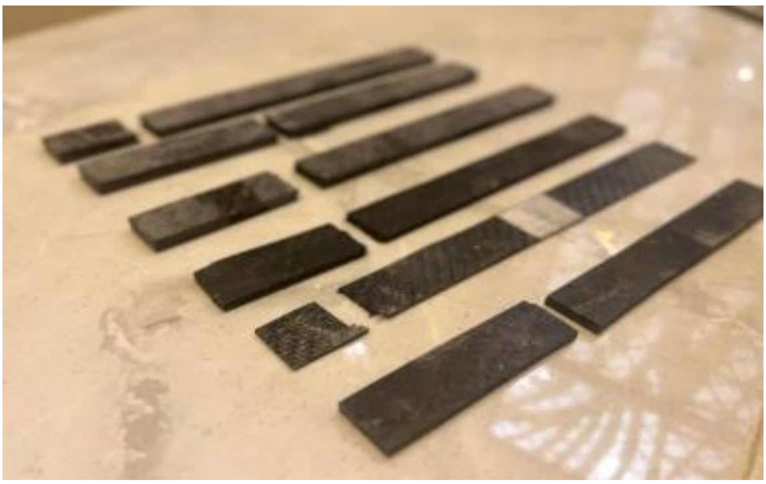

Figure 4 : Specimens After Tensile Test of Epoxy fiber glass with Different weight fraction of Nanoparticles

Through the following figures 5, it shows the amount of hardness increase of the composite material with increasing weight ratios of nanomaterials of Graphene and Sio2, where the best result obtained is at 2% and 3% of Graphene and Sio2 respectively, as well as when forming the hybrid composite The best result was when mixing 3% of the two nanomaterials, the nature, diffusion, and density of the nanomaterials, where the higher density and diffusion on the sample surface is much higher. This leads to an increase in the bonds formed between the atoms in addition to filling the empty space between the atoms, and for all these reasons, the strength of the surface's resistance to plastic deformation increases.

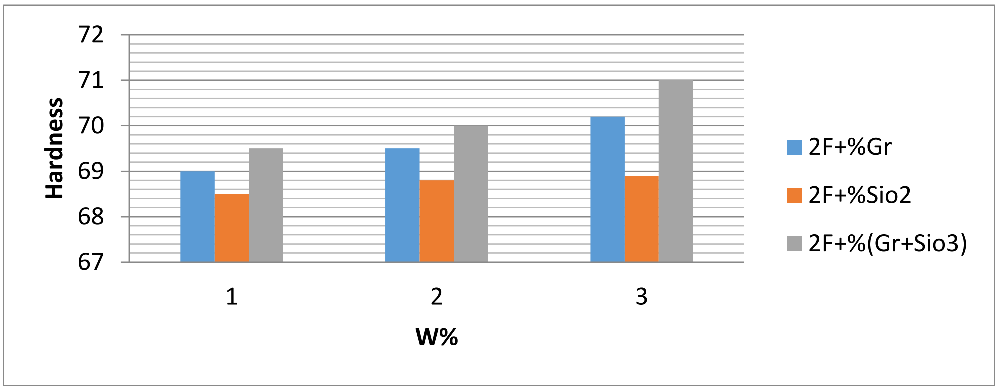

Figure 5: Hardness test of composite with two layer of fiber glass with Nano particles

Figure 6 showed the effect of increasing the impact strength when adding Graphene and Sio2 nanoparticles, and this occurs due to the good mechanical properties of nanoparticles, which improved the properties of the resulting composite material. The best values were at 3% for Graphene and 3% for Sio2, and the resistance was no difference at the mixing value which amounted to 165 KJ/m2.

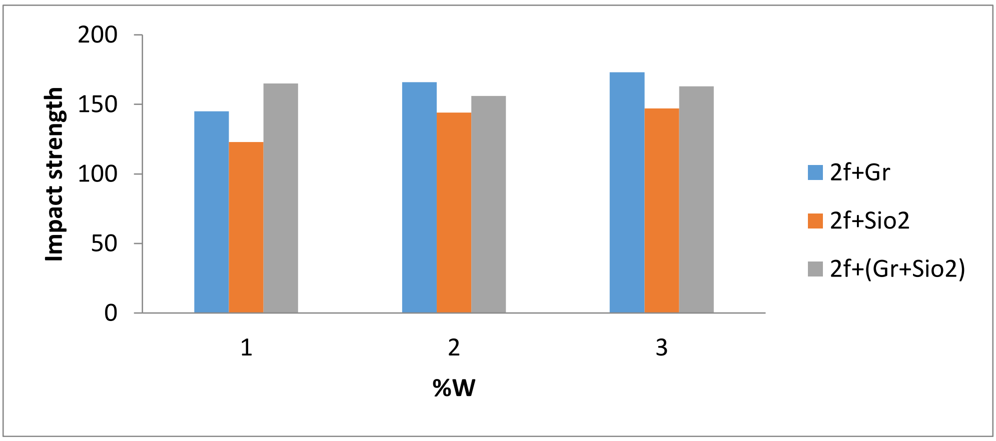

Figure 6: Impact Strength of composite with two layer of fiber glass with Nano particles

The good and homogeneous distribution of the nanomaterials with the composite material of epoxy and fiberglass, and the manufacture of samples in a good manner with the least possible gaps and cracks, was reflected in the homogeneous fracture process after the test, as noted in figure 7.

Figure 7: Specimens After Impact Tested of Epoxy fiber glass with Different weight Fraction of Nanoparticles

SEM images provide a good indication of the morphology of the surface, agglomeration, segregation, and particle distribution. Figure 8 shows the SEM images of the reinforced epoxy with one fiber and the best value of addition nano particles of 2% Graphene, 3% Sio2 and the hybrid between them. It is clear from these images that have As a result of the correct and good mixing process, the distribution and homogeneity were good for all weight ratios used, but agglomeration can be seen and thick cracks in hybrids caused non-homogenized in the composite regions.

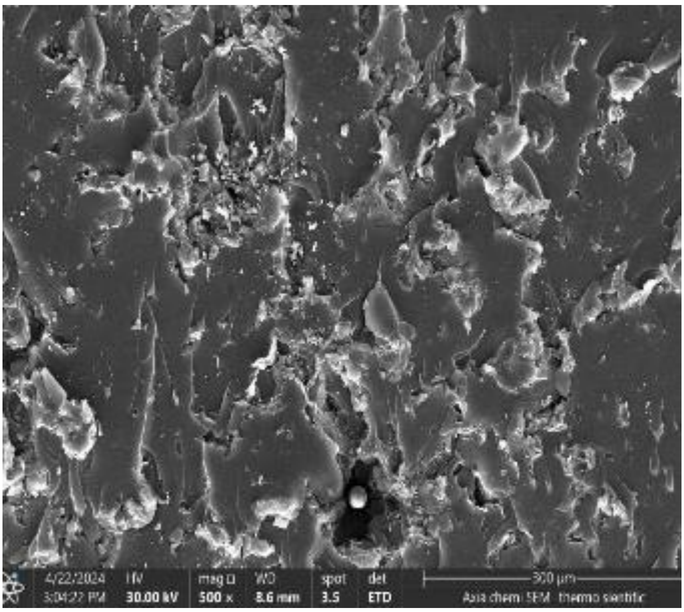

Figure 8: SEM of 2F+2%hyb of nano composite

4. Conclusion

From previous the following conclusions may be written:

Tensile strength of nanocomposite which reinforced by (Graphene) is higher than (Sio2) at the same volume fraction, the addition of nano particles and fiberglass to epoxy were not effected in hardness test, good improvement in impact when added nanoparticles.

The maximum enhancements in ultimate tensile strength, Young modulus and fracture strength are (22%,15% and 7%) respectively by using 2% Graphene, and the maximum enhancements in ultimate tensile strength , Young modulus and while the fracture strength are (16%,13% and 5%) respectively by using 2% Sio2, the maximum enhancements in ultimate tensile strength, Young modulus and fracture strength are (27%, 21% and 9%) by using 2% hybrid nanocomposites, finally the SEM images shows the adding nanoparticles of (Graphene, Sio2, and hybrid) as the filler particles caused homogenize in the composites regions.

References

[1] H. R. Shams, D. Ghanbari, M. Salavati-Niasari, P. Jamshidi, Solvothermal synthesis of carbon nanostructure and its influence on thermal stability of poly styrene, Composites: Part B, 55 (2013) 362–367.

[2] J. Zhuge, J. Gou, R. Chen, A. Gordon, J. Kapat, D. Hart, C. Ibeh, Fire retardant evaluation of carbon nanofiber/graphite nanoplatelets nanopaper-based coating under different heat fluxes, Composites: Part B, 43 (2012) 3293–3305.

[3] A.A. Taher, A. Mohammed, M.H. Al-Hatemmi, and H.J. Jabber, "Study rheometric, physic-mechanical properties of nitrile butadiene rubber blended with hydrogenated nitrile butadiene rubber as a model of sustainable", Journal of Green Engineering, Vol. 11, No. 1, Pp. 29 – 38, 2021.

[4] A.T. Abdalzahra, and A.A. Taher, "A dynamic Analytical Approach to Nonlinear Stall-Spin Aircraft", Journal of Mechanical Engineering Research and Developments, Vol. 44, No. 1, Pp. 422-434, 2021.

[5] Cs. Varga, N. Miskolczi, L. Bartha, G. Lipoczi, Improving the mechanical properties of glass-fiber-reinforced polyester composites by modification of fiber surface, Mater. Des. 31 (2010) 185–193.

[6] A.S. Hammood, M.H.R. Al karaishi, A.A. Taher, and L.J. Habeeb, "Effect of different natural composite material lyres on structural analysis of Aircraft body," Journal of Mechanical Engineering Research and Developments, Vol. 44, No. 5, Pp. 339-344, 2021.

[7] H.P.S.A. Khalil, H.M. Fizree, A.H. Bhat, M. Jawaid, C.K. Abdullah, Development and characterization of epoxy nanocomposites based on nano-structured oil palm ash, Composites: Part B, 53 (2013) 324–333.

[8] F. Chiu, Y. Chen, Evaluation of thermal, mechanical, and electrical properties of PVDF/GNP binary and PVDF/PMMA/GNP ternary nanocomposites, Composites: Part A, 68 (2015) 62–71.

[9] A.C.C. Esteves, A. M. Barros-Timmons, J.A. Martins, W. Zhang, J. Cruz-Pinto, T. Trindade, Crystallization behaviour of new poly(tetramethyleneterephthalamide) nanocomposites containing SiO2 fillers with distinct morphologies, Composites Part B, 36 (2005) 51–59.

[10] K. C. Jajam, H.V. Tippur, Quasi-static and dynamic fracture behavior of particulate polymer composites: A study of nano- vs. micro-size filler and loading-rate effects, Composites: Part B, 43 (2012) 3467–3481.

[11] Y. Zare, New models for yield strength of polymer/clay nanocomposites, Composites: Part B, 73 (2015) 111–117.

[12] Al-Akaishi, A. Salih, M.H. Alturaihi, H.J. Jaber, and A.A. Taher, "Experimental Study of Thermal conductivity of Ag Nanofluid, Vol. 44, No. 4, Pp. 368-372, 2021.

[13] C.B. Ng, B.J. Ash, L.S. Schadler, R.W. Siegel, A study of the mechanical and permeability properties of nano- and micron-TiO2 filled epoxy composites, Adv. Compos. Lett. 10 (2001) 101–111.
[14] Taher, A.A. Oraibi, A.H. Abd Ali, F.A.M. Jaber, H.J. "Mechanical Properties of Graphene Oxide/Polyvinyl Chloride Composite Film", International Journal of Mechanical Engineering, 2022, 7(1), pp. 669-673.
[15] Dhiaa, A.H., Taher, A.A., Diwan, A.A., Thahab, S.M., Azez, R.J., Study the thermal properties of PVP/CuNPs composite prepared by different concentrations IOP Conference Series: Materials Science and Engineering, 2020, 870(1), 012153 .