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THE DEVELOPMENT OF COMPOSITE MATERIALS BY CURING THE FIBERGLAS

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ABSTRACT

The current research aims to develop the mechanical properties by treating the fiberglass with nano materials. The methodology that was adopted can be summarized as prepare the (tensile, impact, and vibration) molds with proper ASTM dimensions by CNC machine, after that preparation of nanoparticle suspension that consists of H2O and (1wt%, 3wt%, and 5wt% SiO2) respectively. Firstly, magnetic stirring was used for mixing H2O and Silica powder for 10 minutes. Secondly, the ultrasonic was used to disperse nanoparticles in water for 15 minutes. The mechanism that was adopted in treating fiberglass was immersion the pieces of fiberglass in nanoparticle suspension for one minute at room temperature and after that heated the fiber at 50C in thermal furnace for 10 minutes to accelerate the drying process, after that drying the fibers for two hours to remove the moisture of fibers. The hand lay up process was used for preparation the samples that fabricated of epoxy and 2layers of E-glassfiber at RT and normal humidity. The control case was the results of samples fabricated of epoxy with fiberglass without treatment with nano silica. The comparison between the results that occurred from the samples fabricated of epoxy and two layers fiberglass that immersed in nanoparticle suspension and the control case to know the development in mechanical properties.The key findings showed that highest value of impact was 36kJ/m^2 in samples fabricated of epoxy and fiberglass that immersed in nanoparticles suspension with 1wt% SiO2 and 99wt% H2O with increasing percentage 43% as compared to control case. The highest value of tensile was 45MPa in control case. The highest value of natural frequency was in samples manufactured from epoxy and 2layers fiberglass treated by 1wt% SiO2 with increasing percentage13% as compared to control case.

KEYWORDS

NANO particles suspensions, immersing the fiberglass, Impact strength, tensile strength, vibration, natural frequency.

1. INTRODUCTION

In resent, the demand for composite materials has increased due to their wide applications in industrial and military fields, including the automotive , aircraft, aerospace and other sectors of industries. Tserpers and Sioutis (2025), highlighted in their research that composites are increasingly used in space structures and there is urgent requirement for new materials withstands the harsh conditions of space. Daksh et al. (2022) investigated in statistical study that 50% of the structure of Boing 787 was fiber reinforced polymers and 75% of exterior areas in the Eurofighter were carbon fiber reinforced composite material, this is due to high resistance to corrosion, high specific strength, thermal stability, thermal insulation, electrical insulation and other properties. The more important property is high specific strength and stiffness relative to their light weight that reflect in reduce the fuel consumption. The content of nano silica that used in the current research was very small amount to enhance the performance of composite material as will be explained in discussion the results, and this led to reduce the weight of composite and aligned with trends of these industries.

Hamzat et al.(2025) indicated that composite materials consist of material that form the matrix like polyester, epoxy, vinyl ester, and polyurethane are used to protect the fiber from harm and employed as glue to hold the fibers together and transfer the stresses to fibers.

Many researchers have been studied the factors that improve the mechanical properties such as adding nano materials as a filler material, reinforced polymers by fibers, treated the fibers with chemical treatment, governing in orientation of fibers and by synthesis the resin matrix, etc. in addition to investigate the influence of mechanical properties when the composites expose to high temperature and moisture for long time or subjecting to external crack to avoid the damages in composite materials.

Burhan et al.(2019), investigated the active in wear by adding SiO2 as a filler with different weight ratios (2%, 6% and 10%) to unsaturated polyester. The study was conducted that there was improvement in wear resistance at 10% SiO2. Singh et al.(2017), studied the effect of adding SiO2 with different percentages (0, 2%, 4%, 6% and 8%) to epoxy in tensile and flexural properties. The results showed that the increasing percentage in tensile and flexural strength were 30.5% and 17% respectively as compared to neat epoxy at 4wt% SiO2. More than 4wt% SiO2, tensile and flexural strength decreased due to agglomeration. Amaro et al. (2013) highlighted in effect of treatment HCl and NaOH to fiberglass in composite fabricated of epoxy reinforced by glass fiber and indicated that there was decrease in flexural modulus and flexural strength with increase in exposure time. Hiremath et al (2024), explored the active of immersing Basalt fiber in nitric acid with weight ratio 6.9% for 30 minutes, the results showed that the

increasing percentage in tensile strength for samples fabricated of BF/Epoxy was 87% as compared to samples fabricated of epoxy anbasalt without treating by nitric acid, this is due to increase the adhesive force between fiber and matrix. Some researchers investigated the active of of mixing two polymers to improve the mechanical properties, Raheem et al. (2024) studied the effect of adding polyurethane (PU) and liquid silicone rubber (LSR) with weight ratios (3%, 6%, 9% and 12%) to epoxy resin. Results showed that increasing percentage in tensile strength was 11.76% when adding 6wt% (LSR) and increasing percentage in elongation was 38% at 12wt% (PU) as compared to neat epoxy. Dookhi and Tahir (2023) studied the effect of external crack in tensile, impact and hardness. They found that the external crack in samples fabricted of epoxy and one layer fiberglass reduce the tensile, impact and hardness with percentages 8.8%,24.73% and 2.8% respectively as compared to samples without crack. Belaid et al.(2015), examined the active of aging time for different periods (30, 60, 90 and 120 days) at aging temperature 80C on mechanical properties and found as the aging time increase to 120 days, the elastic modulus and stress at break decreases 50% and 22% respectively.

Before delving into the aim of research and research topic, some concepts that related to nano material that contributed in composite materials and some concepts concerned the technical characterization of them will be exposed as explaine bellow.

Fiber glass: is of brittle nature, being eminently covalently bonded material. The stress-strain diagram of fiberglass is elastic complete and transfer directly to rupture. The more percentages of components that incorporating in the composition of fiberglass are (52-56)% SiO2, (16-25)% CaO, (8-13)% B2O3 and (12-16)% Al2O3. E-glass type is the most widely used in (GFRP) due to low cost and high properties. The ultimate stress of E-glass is 130KP/mm^2 and the modulus of elasticity is 45000KP/mm^2.

Polymers: one of the most important materials that used in manufacturing of mechanical parts because light weight, high specific strength as compared to metals and poor conductivity, polymers can be classified to three categories according to technical specifications, thermoplastic, thermosetting, and elastomers. Thermoplastic is distinguished with its recyclability and solubility in organic solvent while, the thermosetting is not recyclable and soluble in organic solvent. Elastomers are characterized by the ability to restore its natural shape after being stretched to high elongation when the force removed from it and have high yield strength.

Nano Materials: are defined as materials that at least one of their dimension is in the nano scale. The more important feature of nano materials is the large surface area to volume ratio which increase the reactivity of nano materials in composite and enhance the mechanical properties.

Joudeh and Link(2022), highlighted to small size of nanoparticles that offers the ability to fill cracks and voids that occurred in composite material that lead to improve mechanical properties. In this paper, the development in mechanical properties (tensile, impact and vibration) will be studied when using epoxy reinforced by 2layers fiberglass treated with mixture contains (1wt%, 3w% and 5wt%) SiO2 individually with DI H2O.

2. EXPERIMENTAL WORK

2.1. Material used

2.1.1. Epoxy Sika

Dur 52 was used as a matrix manufactured from Sika company in U.A.E This type of epoxy is characterized with high mechanical and adhesive strength, suitable in both dry and damp conditions. The viscosity of Sika dur 52 is 500 mpa.s at 20 °C. The density of epoxy and hardener is 1.1 kg/liter. The mixing ratio of epoxy and hardener is 2:1. The tensile strength for epoxy with hardener at 20 °C is 25 N/mm^2. See Fig.1.

2.1.2. E-glass fiber

randomly type produced by Tayshan fiberglass Co., Ltd. With thickness 0.5 mm with density 2.5 g/cm^3 as shown in Fig.2.

2.1.3. Nano Silica

Nano scale is artificial type was manufactured in Changsha san tech company in china. The diameter in nano scale is (30±5)nm with purity 99% as shown in Fig.3.

2.2. Sample preparation

The first step is preparation the molds according to dimensions of ASTM utilizing plastic sheets and shaping by (CNC) machine. The tensile molds was produced by using three plastic sheets with dimensions (180*230)mm and a thickness 2.5mm and form the tensile mold with dimensions according to ASTM (D638-14) as shown in Fig. 4 and Fig. 5. Impact mold was prepared by using three plastic sheets with dimensions (120*150)mm with a thickness 5mm and shaped the impact mold with dimensions (55*10*10)mm according to ASTM dimensions (D256-04) as shown in Fig. 6. The vibration mold was prepared by using three plastic sheets with dimensions (380*115)mm with a thickness 2.5mm and shaped the mold vibration according to the dimensions that available in the device of vibration test (300*37*5)mm as shown in Fig. 7.

The second step is shaping the E-glass fiber according to dimemensions of molds.

Preparation of nano particles suspensions: the preparation was performed by mixing SiO2 at weight ratios (1%, 3% and 5%) with distilled water for ten minutes by magnetic stirring shown in Fig. 8 followed by ultrasonic as shown in Fig. 9 for 15 minutes at room temperature. The

magnetic stirring duration was verified by repeating the process four times for 10 minutes and there is a break for 5 minutes between each process and other and there is not any precipitation of nano fluid at the bottom of the beaker that used for mixing, therefore, there is not requirement of more time. There is need for more time if the mixing process between materials having high viscosity such as epoxy with nano material.

After that immersing the fiberglass in (N.P.S) for 1 minute at room temperature 25 °C followed by heating at 50°C in electronic furnace as shown in Fig. 10 for ten minutes after that, fibers was extracted and left for two hours for drying and remove the moisture. Before specification the time for immersion fiberglass in (N.P.S), the process of immersion was repeated for 3 times, at the first was for 0.5 minute and the second was for 1 minute and the third was for 1.5 minute, and by weighting the fiber after immersion, there is not difference in weight between immersion for 1 minute and 1.5 minute, therefore the duration of immersion was fixed in one minute. Stefania et al.(2009) investigated the active of heating temperature and the duration of heating in properties of glass fiber. The study was conducted that there is slightly increase in strength loss at 150 °C and the large strength loss was at 350 °C, after that the increase in strength loss with increase heating temperature, the study was concluded that in duration time for two hours and heating temperatures (350 °C, 450 °C, 550 °C), the reduction in strength were 20%, 50% and 65% respectively. Therefore, the selection of heating temperature (50°C) in the current research was in the safety side.

After that mixing the epoxy with hardener in mixing ratio 2:1 by mechanical mixing for ten minutes to achieve the homogeneity between epoxy and hardener, then pouring the mixture of epoxy and hardener in the molds that was prepared previously and putting the first layer of fiberglass above the mixture, after that pouring the mixture of epoxy and hardener above the piece of fiber, then putting the second layer of fiber above the mixture and finally pour the mixture of epoxy and hardener above the second fiberglass. The process was performed at RT. The samples were left for 48 hours for drying after that extracted from molds.

Fig. 1.Epoxy

Fig. 2. E-glass fiber

Fig. 3. Nano silica

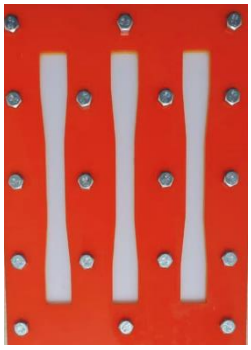


Fig. 4. Tensile mold

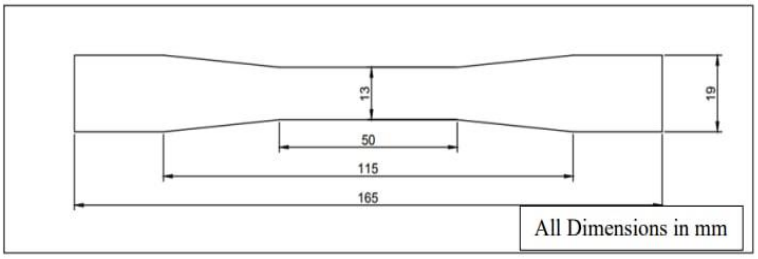


Fig. 5. Dimension of tensile mold

Fig. 6. Impact mold

Fig. 7. vibration mold

Fig. 8. magnetic stirring

Fig. 9. Ultrasonic

Fig. 10. Furnace

2.3. Working procedure

After preparing the tensile, impact and vibration samples for control case and samples that treated with (N.P.S) that contains different percentages of SiO2 and H2O, the specimens became ready to perform testing for knowledge the development in mechanical properties by comparing the results that were achieved from the treated samples with control case. Below some samples that represent composites with different content of nano fluid shown in Fig.11, Fig.12, Fig.13, Fig.14 and Table1, Table 2, Table 3, Table 4 that explane the composition of each sample.

Fig. 11. specimen 1

Fig. 12. specimen 2

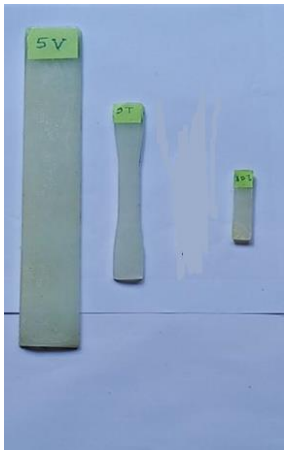


Fig. 13. specimen 3

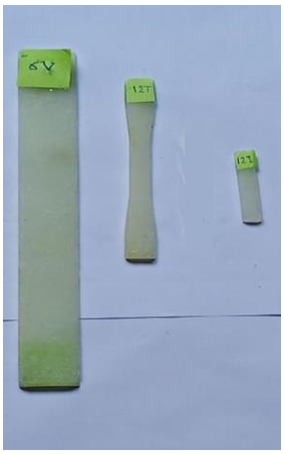


Fig. 14. specimen 4

Table 1. represent the composition of specimens with the content of (N.P.S)

Specimen	Component
1	Epoxy+2Layers of fiberglass (without immersion in nanoparticle suspension)
2	Epoxy+2Layers of fiberglass immersed in nanoparticle suspension consists of 1% silica and 99%water
3	Epoxy +2Layers of fiberglass immersed in nanoparticle suspension consists of 3% silica and 97%water
4	Epoxy +2Layers of fiberglass immersed in nanoparticle suspension consists of 5% silica and 95% water

Table 2. represent the composition of vibration samples, EP denote epoxy & FG denote fiber glass

No	Symbol	Composition
1	1v	Ep + 2FG without treatment in N.P.S
2	4v	Ep+2FG treated with N.P.S contains 1% SiO2 and 99% H2O
3	5v	Ep + 2FG treated with N.P.S contains 3% SiO2 and 97% H2O
4	6v	Ep+2FG treated with N.P.S contains 5% SiO2 and 95% H2O

Table 3. represent the composition of tensile samples

No	Symbol	Composition
1	2T	EP+2FG without treatment in N.P.S
2	7T	EP+2FG treated with N.P.S contains 1% SiO2 and 99% H2O
3	9T	EP+2FG treated with N.P.S contains 3% SiO2 and 97% H2O
4	12T	EP+2FG treated with N.P.S contains 5% SiO2 and 95% H2O

Table 4. represent the composition of impact samples

No	Symbol	Composition
1	2I	EP+2FG without treatment in N.P.S
2	8I	EP+2FG treated with N.P.S contains 1% SiO2 and 99% H2O
3	10I	EP+2FG treated with N.P.S contains 3% SiO2 and 97% H2O
4	12I	Ep+2FG treated with N.P.S contains 5% SiO2 and 95% H2O

2.4. Tests

2.4.1.Tensile Test

The composite material resistance to fracture when the material is subjected to tensile stress. The test was performed in the college of materials Engineering at Babylon University. The test is done by (Micro Computer Control Electronic Universal Testing Machine), made by People Republic of China, Time group INC, Max capacity 5 kN see Fig. 15. The specification of this device are approved by the operating company. The device was calibrated by the college in same testing period. According to ASTM, the test was done at RT with 3mm/min cross head speed, three samples were tested for each structure as shown in Fig. 16. The mean value was evaluated for each case.

2.4.2. Impact Test

he test is made for examining the durability of material that subjected to sudden force, this test was carried out using a device (Impact Tester)-Charpy notched- bar impact test) made by gunt wp 400 in germany as shown in Fig. 17. The test has been implemented in college of material

Engineering in Babylon university. Three samples were tested using the standard impact specimen ASTM (D256-04) and the average was calculated for each composite . The test is done at room temperature. and samples that were failed after the test shown in Fig. 18 The impact bending test is 25 N.M. The dimensions of impact sample shown in Fig. 19.

Fig. 15.Machine of tensile test

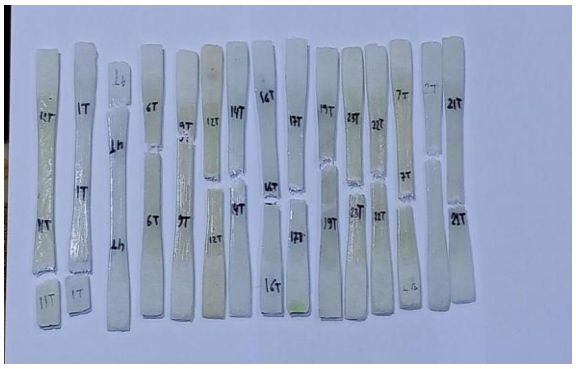


Fig. 16. samples after testing

Fig. 17. Charpy Device

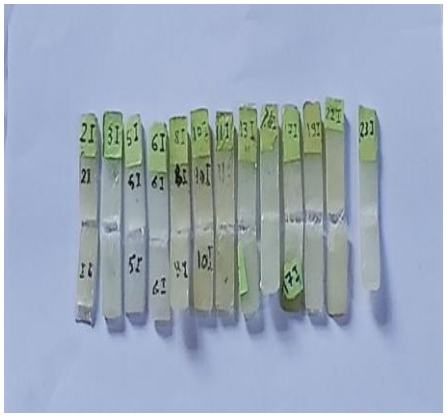


Fig. 18. Impact sample after test

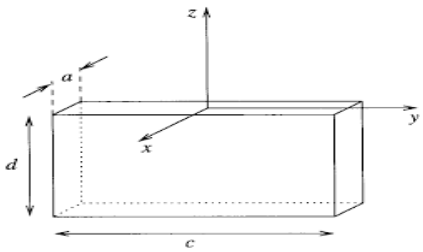


Fig. 19.Dimensions of impact samples

c= 55mm

d=10mm

a=10mm

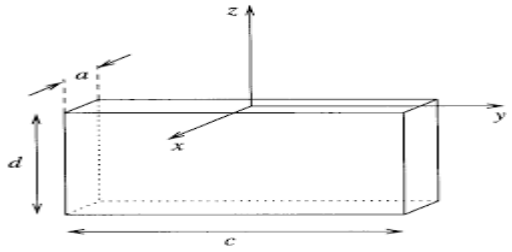
Impact Strrength can be calculated using the following relation

$$Gc=Uc/A \quad (1)$$

where Gc= impact strength (J/m^2), Uc=impact energy (J), A=cross sectional area of sample (m^2).

2.4.3.Vibration Test

The vibration test was done by hitting the vibration sample that its dimensions shown in Fig. 20 and fixed in the support fixing sample shown in Fig. 21 by hammer that shown in Fig. 22, there is an accelerometer below the sample as shown in Fig. 23, the accelerometer converts the linear movement of sample to voltage in the amplifier as shown in Fig. 24, that converts the voltage generated to wave in the oscilloscope as shown in Fig. 25 and Fig. 26. The test was done at room temperature.



C=300mm

d=37mm

a=5mm

Fig. 20. dimensions of vibration sample

Fig. 21. support fixing sample

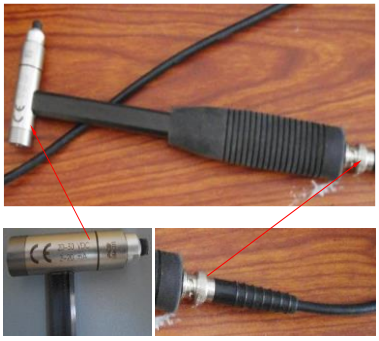


Fig. 22. hammer

Fig. 23. Accelerometer

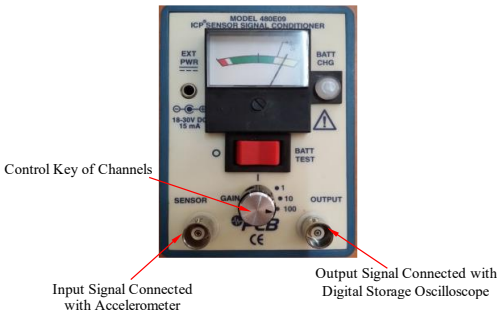


Fig. 24. Amplifier

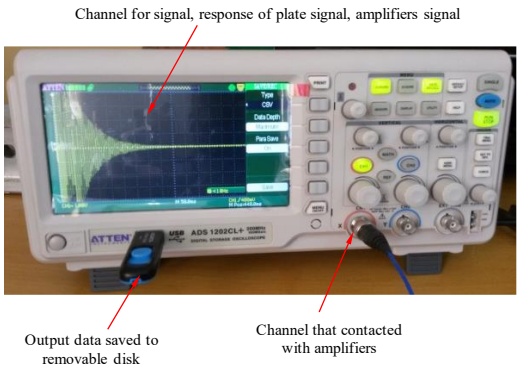


Fig. 25. oscilloscope

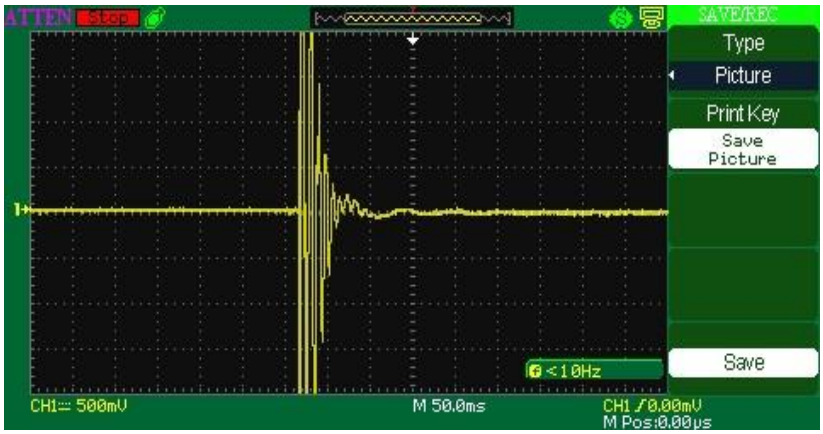


Fig. 26. sample of wave of vibration

3. RESULTS AND DISCUSSION

3.1. Tensile Test

The resultants of tensile samples indicated that maximum value of tensile was 45 MPa in samples fabricated of epoxy and two layers fiberglass without treatment in N.P.S (control case) and the treatment of N.P.S to fibers led to reduction in values of tensile strength as shown in Table 5 and Fig. 27.

Table 5. values of tensile according to content of SiO2 in N.P.S

The weight ratio of SiO2 in nanoparticle suspension %	Tensile strength MPa
0%	45
1%	28.666
3%	34.87
5%	34.5

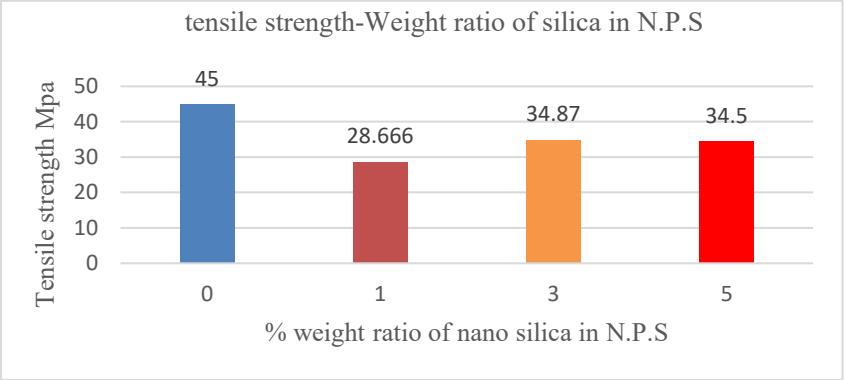


Fig. 27. Tensile strength-content of SiO2 in N.P.S

The Percentages of decreasing in values of tensile strength in samples fabricated of glass fiber reinforced epoxy (GFRE) treated with (N.P.S) contains SiO2 with weight ratios (1%, 3% and 5%) and H2O were 35.5%, 22 % and 24% respectively as compared to control case. The maximum value of tensile strength in control case reflects the range of bonding force between fibers and matrix and the adhesion in the interfacial among them and this indicated obviously in images of FESEM as shown in Fig. 28 and Fig. 29 And aligned with the research of Yang et al. (2024) which highlighted to the fiberglass/matrix interfacial and conducted that interfacial adhesion properties are a key factor affecting the mechanical properties of composite.

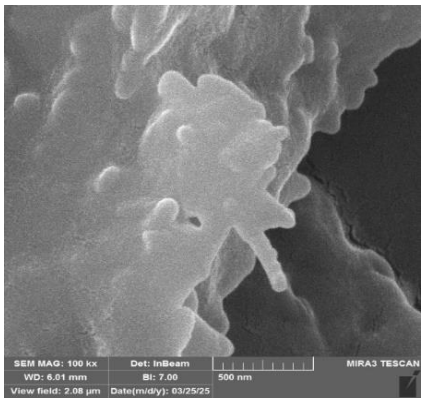


Fig. 28. control case

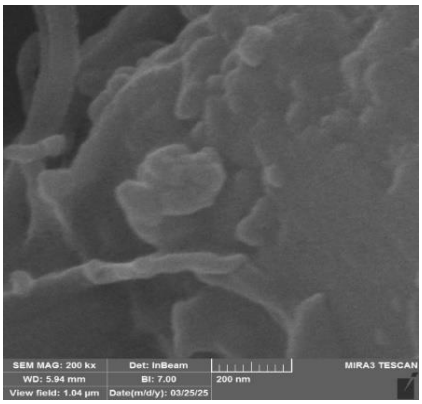


Fig. 29. control case

Damanic et al. (2025) investigated the role of using glass fiber in composites and were widely used due to their exceptional mechanical properties, durability and light weight nature. Epoxy has large ability for wetting the fiber glass and penetrate the surface of fibers due to low viscosity and this fact showed clearly in the images of FESEM (28), (29) That indicate the connecting between fibers and epoxy. After treating the fiberglass with N.P.S consist of 1wt% SiO2 and 99wt% distilled H2O ,the distribution of nanoparticles was homgeneous and there is n't aggregation of nano particles of silica as shown in Fig. 29 and Fig. 30, therefore the silica gel that was formed by mixing SiO2 with distilled water filled the gaps between the glass fibers and make stronger mechanical strength in the fiber but reduce the bond between matrix and fiber and this indicated clearly in the results of strain in the Fig. 31. The maximum value of strain was 9.55% with increase percentage 27% as compared to control case. This was compatible to what was reached, Shafi et al. (2019), in research that investigated the mechanical properties and insulation thermal for glass fiber impregnated with silica gel. The study was proved that the impregnated silica gel filled in gap between the glassfiber and tighten the silica aerogel to glassfiber by the bon-si-o-si-net work and via OH groups of the silica gel surface. Therefore the silica gel and fiberglass form stronger mechanical strength with excellent mechanical strain and thermal insulation.This fact that mentioned in the previous research explained the maximum value of elongation and the highest value of impact that will be explained in impact results in case of epoxy reinforced by two layers fiberglass treated with N.P.S contains 1% SiO2 and 99% DI H2O.

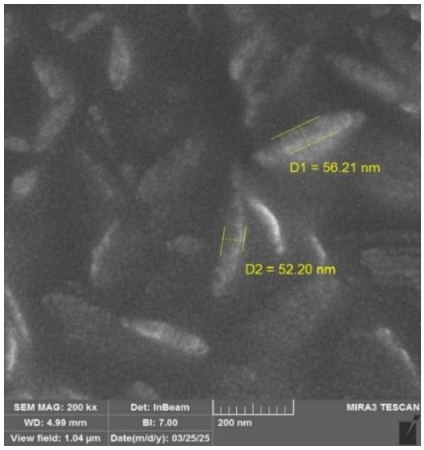


Fig. 30. Image FESEM for sample Treated with N.P.S with 1% SiO2

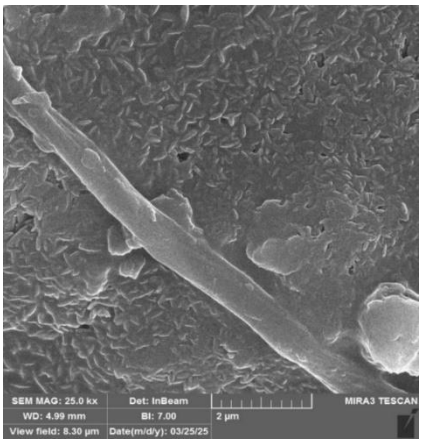


Fig. 31. Image FESEM for sample Treated with N.P.S with 1% SiO2

The results of tensile decreased after treating fibers with N.P.S and this aligned to what was conducted by Villasmil et al.(2019) mentioned that the silica aerogels are characterized by their vulnerability to moisture, extreme fragility and low tensile strength, therefore the interfacial between fiberglass and epoxy very weak and the silica gel work in seperating between the fibers

and epoxy. The images of FESEM in Fig. 33 and Fig. 34 showed that there is a beginning of aggregation of nano particles of SiO2 in samples fabricated of fiberglass treated with N.P.S contains 3wt% SiO2 and 97wt% DI H2O and this cause reduction in values of tensile and impact.

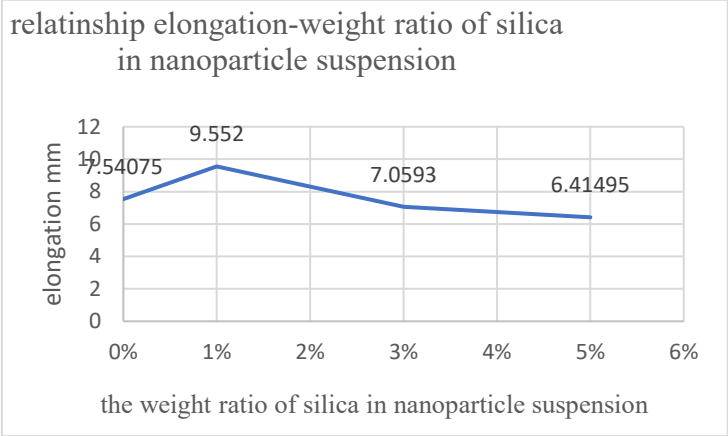


Fig. 32. elongation –weight ratio of silica in N.P.S diagram

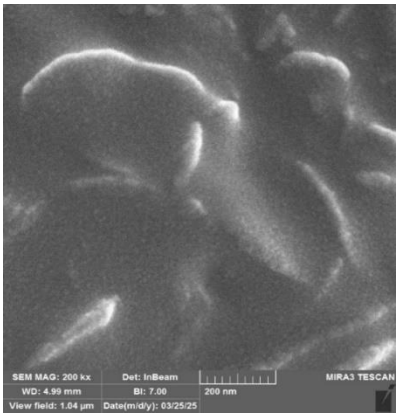


Fig. 33. image FESEM for sample Treated with N.P.S with 3% SiO2

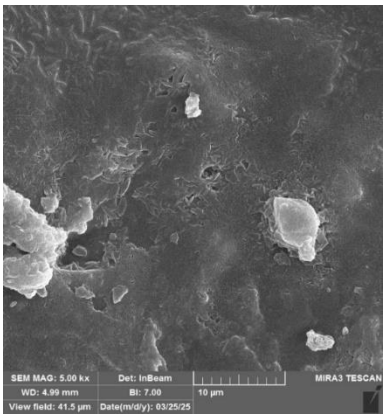


Fig. 34. image FESEM for sample treated with N.P.S with 3% SiO2

The images of FESEM in Fig. 35 and Fig. 36 showed the formation of cluster because of agglomeration of nano particles of silica in silica gel and formation weak areas and concentrated stresses that lead to decrease the tensile stresses.

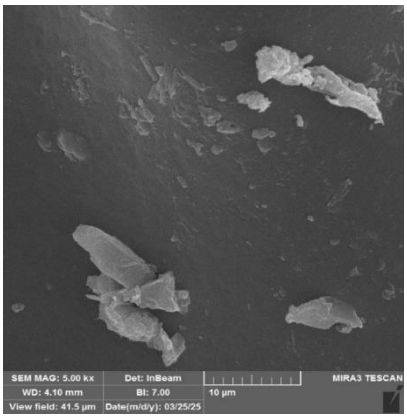


Fig. 35. Image FESEM for samples Treated with N.P.S with 5% SiO2

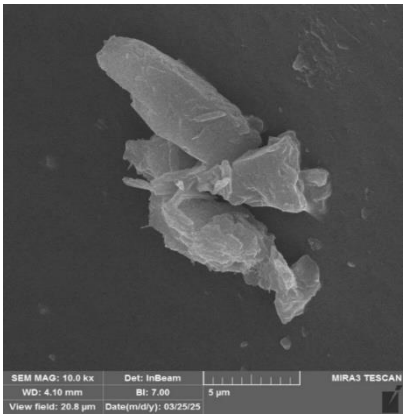


Fig. 36. image FESEM for samples treated with N.P.S with 5% SiO2

The agglomeration or Van Der Waal Phenomena have large impact in degradation of mechanical properties as mentioned Israelachvil,(2006) who investigated the Van Der Waals forces and explained that these forces are always present and play role in different phenomena (for example surface tension, adhesion, the strength of solids, the stability of membranes and colloidal suspensions. The forces of van der waals is may be attractive or repulsive. When the nanoparticles was in attractive case, this lead to formation weak area in composite and cause degradation in mechanical properties. The Van Der Walls is depend on the Zeta Potential of nanoparticles and value of PH and ultrasonication duration. When the value of zeta potential approach from izoelectric point, there is a chance to agglomeration. Junior and Baldo (2014) highlighted on the relation between zeta potential and the value of pH indicating that for PH values below the isoelectric point (IEP) at (PH=2), the positive value of zeta potential of water suspensions of α-quartz and α-cristabalite experiences a sudden increase with the increase in specific surface area of the powders. For PH values above the (IEP), the zeta potential values of crystalline forms of silica (α-quartz and α-cristobalite) get gradually more negative with the increase in pH conversly in the case of vitreous silica for PH values above 6. There occures a sudden change toward more negative values of zeta potential than those presented by quartz and cristobalite. It is known and commonly for getting nanofluid with better dispersion, there is a need for longer time of ultrasonicating, but Mahbubul et al .(2017), indicated that the idea of the need for longer ultrasonication of nano fluid for better nanoparticles dispersion may not be always right, there is is an optimum duration for better dispersion stability achieved by repeating the process of ultrasonic for different duration to get the best.

3.2. Impact Test

The maximum value of impact strength was 36 KJ/m^2 with percentage increase 43% as compared to control case in the sample manufactured from epoxy and 2 layers fiberglass treated with (N.P.S) consists of 1wt% SiO2 and 99wt% distilled water . This result reflects the impact of silica gel that filled the glassfiber and create stronger layer as was mentioned in tensile test and increase the strain of composite and reduce the the brittle nature of composite. The test was performed by subjecting perpendicular force to longitudinal direction of fibers, therefore the fiberglass seem resistance to this force. The results of impact strength in the cases of samples treated with (N.P.S) contains (3wt% and 5wt%) SiO2 was decreased to 27.21 KJ/m^2 and 25.83 KJ/m^2 respectively with slightly increasing 7.9% and 2.5% as shown in Table 6 and Fig. 37. The results of impact strength indicate the impact of agglomeration in two cases of SiO2 content in N.P.S that led to reduce the impact of silica gel in strengthen the fibers. The minimum value of impact strength was in control case while maximum tensile strength in it, stiffness and

toughness are often opposing properties, composites provide a pathway to achieve a balance or even a combination of both through intelegent material selection and structural design. Song et al. (2021), investigated the difficulty of obtaining natural structure that collect stronger, stiffer and lighter materials, they usually consist of hard and soft phases arranged in a complex hierarchy.

Table 6. explane the results of impact strength according to content of SiO2 in N.P.S

weight ratio of silica in nanoparticle suspension %	Impact strength (kJ/m^2)
0	25.2083
1	36
3	27.216
5	25.833

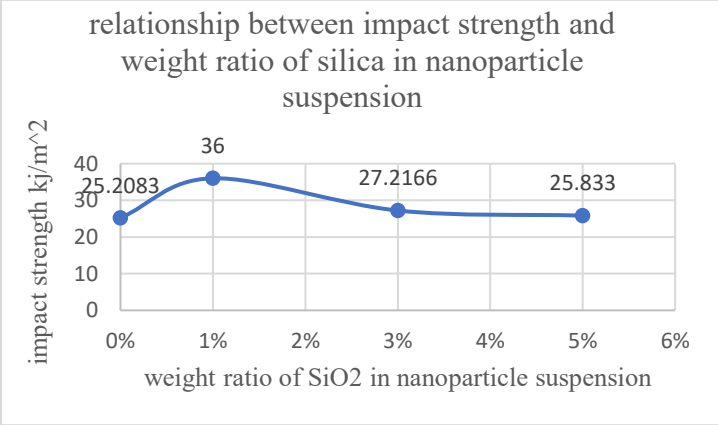


Fig. 37. impact strength-wight ratio of SiO2 in N.P.S

3.3. Vibration test

The maximum value of natural frequency was 114.28 HZ with increasing percentage 14.28% as compared to control case in composite fabricated of fiberglass treated with N.P.S contains 1wt% SiO2 and 99wt% DI H2O, in the rest contents of SiO2, the values of natural frequency decreased as shown in Table 7 and Fig. 38. The agglomeration that was happened in rest cases cause to unhomogeneity distribution of nano particles that led to lower natural frequency due to variation in material properties within the composite, while uniform distribution of nano particles led to consistent material properties and high natural frequency. Maleky et al. (2022) showed that existence of agglomeration phenomenon can dramatically affect the dynamic responses behaviors of nanocomposites structure. Mobark et al. (2023) conducted that nanoparticles dispersed within the specimen can increase energy dissipation during vibration leading to improved damping characteristics.

Table 7. represent values of natural frequency according to content of SiO2 in N.P.S

No	Weight ratio of SiO2 in nanoparticle suspension%	Natural frequency Hz
1	0(control case)	100.498
2	1	114.28
3	3	106.175
4	5	113

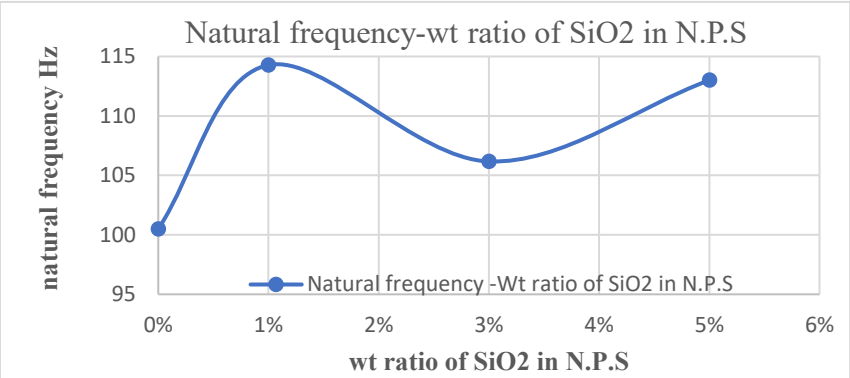


Fig. 38. Natural frequency- content of SiO2 in N.P.S diagram

Bulut et al. (2019) investigated the active of adding small amounts of nano materials in damping and natural frequency and explored that small amount of nano clay (NC) particle incorporations into BFRP composites was found the most effective for damping and natural frequency of the produced NC modified basalt/ epoxy nanocomposites.

Now, economic side of treatment fibers process will be spotlighted by calculating the amount of silica that was used in this process and comparing with conventional methods by mixing polymer with nano materials for achieving the same result in mechanical properties. The amount of SiO2 that used in current research in N.P.S was 1 gram and amount of distilled water was 99 gram in N.P.S contains 1wt% SiO2 and 99wt% DI H2O and this amount of silica is enough for treating 50 pieces of fiberglass with dimensions (55*10)mm that can be used in producing 25 impact samples, in other speech, the amount of SiO2 that required for one sample of impact equals 0.04 gram of SiO2. The amount of nano silica that used in conventional method was calculated on depending on the amount of polymer and the reinforcement material that incorporate in fabrication of the sample, therefore the difference between two is very large as example, Venkatesh et al. (2023) investigated the active of using of SiO2 in weight ratios (0, 2%, 4%, 6% and 8%) with epoxy reinforced by 4 layers of Jute fiber. The research conducted that maximum impact was 2.9J at 8wt% SiO2. The result of impact is approximately close with the current research.

The amount of epoxy in Venkatesh research as follow:

Volume of impact sample= (55*10*10)mm

The volume of epoxy in sample =the total volume-volume of jute fiber, the thickness of jute=0.5mm

The volume of jute fibers= 4 layers*(0.5*55*10)mm=1100mm^3

The total volume=(55*10*10)mm = 5500mm^3

The volume of epoxy = 5500-1100=4400mm^3, the density of epoxy =1100kg/m^3

The mass of epoxy = 1100*4400*10^-9=4.84 grams, the density of jute fiber=1.5

g/cm^3=0.0015g/mm^3, the volume of jute fiber=1100mm^3

The mass of jute=density*volume=0.0015*1100=1.66gram, the total mass=fiber mass+epoxy mass=1.66+4.84=6.49 grams, the weight ratio of silica was 8%, the amount of nano silica that utilized in venkatesh research for producing one sample is equal to 0.08*6.49=0.5192 gram

The amount of SiO2 in current research was 0.04gram that represent 7.7% of the amount used in venkatesh research. The comparison was performed between research and current research if there is similar result in mechanical property, there is permission for checking the economic side but if there is dissimilar in results, there is not acceptability to check the economic side as example, singh et al.(2018), investigated the active of mixing SiO2 with epoxy and conducted that mixing of SiO2 enhance the tensile and flexural strength, while in the current research there is a degradation in results of tensile after treating glass fiber with SiO2, therefore it is not possible make comparison.

4. CONCLUSION

1-The maximum value of tensile strength was 45MPa in control case (without treating fibers with N.P.S) after treating fibers with N.P.S consists of 1wt% SiO2 and 99wt% DI H2O the results of tensile decreased due to separation that was done by silica gel between fibers and matrix. In the rest cases the values of tensile reduce due to agglomeration.

2- the maximum value of of impact was 36 kj/m^2 in samples fabricated of epoxy and fibers treated with N.P.S consists of 1wt% SiO2 and 99wt% DI H2O due to silica gel that filling voids in fiberglass and strengthen the fibers. In the rest cases the values of impact decreased due to agglomeration.

3- Maximum value of natural frequency was 114 HZ in samples fabricated of epoxy and fibers was treated with N.P.S contains 1wt% SiO2 and 99wt% DI H2O due to homogeneous distribution of nano particles in samples. In the rest cases the values of natural frequency was decreased due to agglomeration that cause to variation in properties of materials that led to decrease the natural frequency.

4- There is possibility of improving the mechanical properties by using another nano material such as TiO2 that is characterized with its moderately soluble in common solutions and thermally stable and chemical inert and stable againt oxidation and PH change.

5- There is possibility of enhancing the mechanical properties by using another content of SiO2 in N.P.S such as 1.5%, 2% and 2.5% for knowledge the changes in mechanical properties or by using another type of glass with more modulus of elasticity than E-glass for improving the mechanical properties.

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