Testing of mechanical properties of Polymer nano composites

Novepreet Dhall[1]*, Shivraj Puggal[2]

[1]*School of Mechanical Engineering, Lovely Professional University,Phagwara, ,India*

[2]*School of Mechanical Engineering, Lovely Professional University,Phagwara, ,India*

1. Introduction

Nanotechnology is which involved in control and manipulation of materials at the nanoscale which is (1 to 100 nanometre (nm)), nanoparticles have higher subsurface to volume ratio of phase and higher facet ratio. There are great variety of nanomaterials which have different rage of properties and as many as applications. we can observe this in over surroundings as there are in tiny electron devices, miniature batteries and in some parts of automobiles.

Nanotechnology is divide into various materials such as:

- Nanocomposites
- Nano fibers

1.1 Composite

Composites are formed from two or more than two integral materials with evidential dissimilar chemical or physical features when united produce a material with different characteristics from the separate components. They are formed of separate substances known as constitutive materials.

1.1.1 Matrix phase

The main phase which have an incessant character is termed as matrix. matrix is more often than not is much ductile and to a lesser extent hard phase.

1.1.2 Reinforced (Dispersion)Phase

There is an additional phase which is imbedded in the matrix in an aperiodic form called dispersed phase. All the loads acted over the matrix are transfer to this reinforced through interface. It is powerful compared to the matrix phase so it is all so called reinforced phase. The degree of mechanical behaviour improvement depends on the strong bound between matrix and reinforced interface.

1.1.3 Classification of Composite

- **Natural composites**: there are many natural materials which comes under natural composites e.g. Wood, bones, shells etc.

- **Man Made composite**s: These composites formed via merging two or additional materials in certain properties under controlled circumstances e.g. Fiber reinforced composites, concrete and RCC, Reinforced glass etc.

1.1.4 Applications of composite material

- It is used in Aerospace industry
- Used in production of high cost racing cars and bicycle frames.
- Also used in the industrial and engineering structure

1.2 Fibre reinforced polymers (FRP)

The composite material which is made up of polymer matrix strengthened with fibers. These fibers which are frequently used are fiberglass, carbon whereas epoxy is used as polymer. FRP's are used in many different areas which are aerospace, automobile, marine and structure industries. The extent of the strength and elasticity are improved in fibre reinforced plastic depend on the mechanical properties of both fiber and matrix. Strengthening of the matrix happens when the FRP materials displays increase in strength or resistance relative to the strength and resistance of the matrix alone.

1.2.1 Advantages of Fiber Reinforced Polymers:

1. High strength to weight ratio
2. FRP are of low cost
3. Corrosion resistant.

1.3 Polymer Nanocomposites

PNC consist polymer with nanoparticles or nano fillers spread in the polymer matrix. There are different shapes of these polymers. These systems need precise compounding steadiness of the attained scattering orientation of the dispersed phase.

1.4 Epoxy Nanocomposites

Epoxy nanocomposite is a composite which is in resin form, this is also called as thermoset plastic which is an irreversibly cured from a soft solid or of a resin. The wide range of epoxy resin in applicable in coating, electrical, automotive, marine, aerospace and civil infrastructure. The epoxy resin refers to the both polymer and curing agent (hardener).

1.5 Clay Nano particles

Nanoclays are nanoparticles of layer's mineral silicates. chemical composition of each clay is different. Clay nanoparticles such as montmorillonite clay. This is the most common clay in the family of clay. MMT is different from the vary common types of clay which are available from many years such as talc and mica. It has individual layers of one nanometer thick by about 70nm to 150nm across. This clay can absorb about 20-30 times its volume in water. MMT contains of Nano sized deposits of alumina and silicate slips whereas alumina sheet is squeeze in between two silicate sheets which causes a negative charge.

1.6 Types of Fiber

1.6.1 Carbon Fibre

Carbon fibres are created when the fibers are carbonized at high temperatures. Through further processing by stretching the fibers we can enhance its elasticity. Carbon fibres are in diameter ranging from 9 to 17 µm.

1.6.2 Glass Fibre

Glass reinforced plastic (GRP) are composite materials which are made up of plastic which strengthened with fine glass fiber. As other composite resources each overcoming the deficits of the other, as we can see that the plastic resins are durable in compressive loading.Via combining these two, GRP transforms into a material which resists compression and tensile forces.

1.7 Applications of Glass Fiber Reinforced Polymers

- Used mostly in the automotive vehicles such as sport cars, planes, boats etc.
- Vessels and tanks are made using FRP
- Automobile bodies are made FRP

2. Literature Review

This section provides an overview of how these methods are related to each other by means of the results of these methods.

T.H. Mahdi, et.al (2017) [1]

The mechanical properties of fiber reinforced epoxy modified with MWCNT, MMT Nano clay and Hybrid nanoparticles are used in study. Then Flexure tests are showed is conducted using Zwick-Reoll machine Dynamic. Morphological study conducted with scanning electron microscope. The results are obtained with enhance properties.

Aidah Jumahata, et.al (2012) [2]

Described about the effect of nanoclay on epikote. The materials used in this study are Montmorillonite clay, curing agent and Benzyldimenthylamine (BDMA) accelerator. Electron microscopy is used to study degree of dispersion. Compression tests are conducted to study the outcome of nanoclay. As a result, we found out that nanocomposites propose higher compressive stiffness as compared to straight polymer. We can further improve the study by using three roll mill machine in construction of the nanocomposites.

Farheen Anjuma, et.al (2014) [3]

In this study about the production of ZnO, GFRP composites by material added of catalyst and accelerator. The high speed disperser is used to mix the materials, which is done by high temperature melt press is made of stainless steel. The flexural properties under three-point bending configuration are tested using Universal Testing Machine (UTM). This study proves that mechanical and thermal properties are developed.

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T.D. Ngo, et.al (2015) [4]

Described the investigation of the of nanoclay on the properties of mechanical and fire performance of epoxy glass fiber composite.at first degassing is done then composite materials are mixed using stirring process. Sonication and vacuum infusion process is used. Elemental analysis is carried out by scanning electron microscope. Fire performances test are conducted on samples; heat issue is determined based on feeding of oxygen level. Properties such as creep rupture and durability are tested. Nanoclay filling from 1 to 5wt% were detected to enhance the fire presentation of the epoxy laminates. the results of tensile test are shows the presence of the clay at the levels of settlement percentage contributed to the enhancement in overall properties.

S. Zainuddina, et.al (2008) [5]

In this we are going to study about the properties of epoxy composites under difference environmental conditions. MMT is used as the nanoclay which is filled in the composite. Epoxy and hardener are added and mixed with magnetic stirrer, when we mix with this intense air bubbles are produced in the which are taken out with vacuum desiccator chamber, samples are divided in four different sets then they are cooled in room temperature. weight gain analysis is conducted along with flexural testing for it properties. Scanning electron microscopic analysis is conducted on the specimen after coating of gold done to stop charge build up electron absorption. As result of experiment we found out that as epoxy matrix are delicate to environmental conditions especially under wet conditions. Addition of 1-2wt% nanoclay decrease the weight gain and less discoloration was observed in the sample.2wt% epoxy addition shows that less crack formation and better bonding.

S. Singh, et.al (2014) [6]

In this study we are using MMT nanoclay in E-glass unidirectional fiber to manufacture reinforced composite. Epoxy resin is prepared by using mechanical stirrer. sonication is done to disperses nanoparticles. fiber sheet is prepared and mixture is applied on this sheet and set to drying. Tensile and flexural test are conducted with improvement when there is 3-5wt%. when glass fiber composite shows less degradation at 3wt% along with water resistance of epoxy is improved.

Manjeet Sekhon, et.al (2015) [7]

In this paper we have determine and compare the strength of pin joints made of glass fibers reinforced laminated epoxy. Nanoclay and Nano Tio_2 (titanium dioxide) it is used to improve physical properties. Epoxy L-12, Hardener K-12, Accelerator K-13 are used. Homogenizer is used to stirring, Sonication is used to proper disperse of the nanoparticles. Specimen width and diameter of the hole were evaluated. It is found that strength of bearing at pin joints increases with addition of nanoclay.

Avila A, et.al (2006) [8]

In this we are investigated the influence of MMT, silicate layers on glass fiber epoxy laminate behavior with x-ray diffraction test. The laminate prepared for this process is glass, epoxy nanoclay, the clay which we use in this process is Nanomer I30E. the process starts with the nanoclay dispersion into the epoxy is 1%,2%,5%,10% respectively. the amount of nanoclay dispersed gets increased there increase in stiffness. When the tests are performed then the results shoes as with the specimen with 5% nanoclay shows good performances rate of energy increase the performance of the laminate decrease.as the low velocity impact test is conducted then is shows that energy absorption rate close to 48% at low energies of 20J,15% increase at 60J, and 4% increase at 80J.the amount of nanoclay for the optimal condition is at

Erheng Wang et.al (2008) [9]

In this review low velocity impact bending test are carried out for the deformation and behavior of failure I exposed the failure mode and the mode of failure and crash process of beam under impact loading is that of similar to that of static quisic loading. In the force history displament is very different. qusic stactic loading hence model can also intiale dyamic mode os falure with impact velocity which is lower.

Rohlmann CO et.al (2006) [10]

In this review epoxy clay mixture nanocomposites withat a percentage from 1-10 wt% of particles which are of clay are prepared by mixing. Behavior of nanoparticle is investigated which is manly concentrated on viscoelastic properties and the properties of mechanical. From this review we found that the nanoclay addition in the pure epoxy enhances the properties of the epoxy mixture. Module sof elastic of the nanoparticles was measured at evaluated temperature minimzed as the temperature drope at T_g. the thermal expansion coefficient os both nanocomposites and epoxy is measured using thermos mechanical analyzier and it has found that the incorpartayion of nanoparticles decreased the expansion coefficient of epoxy.

Manjunatha CM et.al (2009) [11]

Tensile test is conducted to know the behavior of the silica nanoparticles modified with glass fiber reinforced epoxy composite, as polymer is modified with addind anout 10 wt% of nanoparticles of silica. the results are that the specimen which is made by adding nanoparticle is enhanced and it is better than that of neat epoxy. The fatigue life of this specimen is also improved compared that of epoxy specimen.

Yoones jafarzadeh et.al (2015) [12]

In this study ZnO nanoparticle is constuctued using thermal induced phase methos of saperation. From DSC analysic it is found that the melting point as well crystiallinity of zno nanoparticles improved by adding it. Adding of nanoparticles increase the modules of storage loss modules tensile strength it alos observed that incorporation of the nanoparticles PWF of the membrains acid rejection is done due to the more pore membranes.

Siddaramaiah et.al (2010) [13]

In this nanocomposites have been prepared with varysing from 0-5 wt% which is modified with MMT nanoclay.it improve the mechanical nad thermal properties of epoxy specimen by adding this nanoclay. Thermal analysi is conducted such as TGA and DMA it is found that all the nanoperticles are stable upto 221^0C. the thermal degradation of kinetic parameters of the composite are calculate during mathematical modules. The TGA thermograms of nanocomposites exhibit higher decomposition temperature as compared that of the pure epoxy.

Van Son Nguyen et.al (2013) [14]

This study is about the preparation and characterization of piezoelectric nanocomposites film based on P(VDF-TrFE) added with ZnO nanoparticles. The dispersion of nanoparticles are observed by using SEM and TEM. the piezoelectric and mechanical properties increase when nanoparticles are added about 10wt% and it is found that strage modules is increased about 25% while it also keeping high piezoeltric activity. the cluster size of the nanoparticles decreases with increase storage modules of nanocomposites.

3. Scope of the study

- The present study focused on improving the Thermomechanical properties of FRP nanocomposites.
- These FRP has wide range of application fields such as: erosive surroundings, engineering of tennis rackets, frames of bicycles etc.
- There is wide scope of future study such to other properties of composites which are moisture absorption it can be improved as we are using glass fiber which is mainly applicable in roofing sheets, sanitary ware, storage tanks, Pipes.
- Recently mechanical and tribological performance of the epoxy matrix is improved by developing the epoxy resin composites modified by nano fillers in the Bearing material of automobiles.

4. Objective of the study

- Main aim of this present study, to evaluate the mechanical properties of the epoxy -hardener system reinforced with nano filler.

- The overall study is observing the effects of MMT clay addition on the mechanical properties of epoxy based PMNC system (polymer Material and Nanocomposite), as it is a nano-filler in this experiment.
- In this study we include the fabrication of nanocomposites with different concentration levels of nano fillers and evaluate their mechanical properties.
- Microstructure of the nanocomposites can be analysed using X Ray Diffraction techniques, Scanning Electron microscope.
- In this study XRD is used to study the level of intercalation of epoxy resin between clay galleries for different clay loading.
- SEM is used to study the deformation and failure mechanism during tensile and impact testing.

5. Equipment, materials and specification

In this chapter we are going to know about the materials which we are using and the steps in while experiment takes place.

5.1 Materials

Unidirectional E-glass fiber and Epoxy Resin T-23, Epoxy Hardener K-59 are purchased from Navabharth chemicals (India) Private limited. Zinc oxide(ZnO), Montmorillonite Nano Clay, Titanium Carbide Nanoparticle which are of 99% purity also purchased from Nano labs (India) Private limited.

5.2 Equipment

The complete setup is basically consisting following items.

- Electronic weighing machine
- Water bath
- Homogenizer
- Ultra-sonication
- Glass beaker
- Metal scrapper
- Unidirectional Glass fiber.

5.3 Fabrication

Weighing of Nanoclay and Base epoxy

At for Epoxy base T-23, hardner K-59 and Nanoclay is measured by using weighing digital machine in required containers as per requirement glass beaker is preferred. As nanoclay is ueed in very small Quantity which is of 1-3% of total quantity of epoxy resin. Which is collected on a paper before mixing it in the beaker.

5.4 Ultrasonication after Mechanical Stirring

Sonication is a process in which sound energy is applied on the particles in a sample. Sonication is highly effective for processing of the nano materials such as carbon nanotubes, nanoclay metal oxides etc., this sonication runs using AC power. It is used to speed dissolution by breaking intermolecular connections, and to evenly dispersing the nanoparticles in liquid. This process is done for 30 min to remove all the babuls formed.

5.5 Mixing Epoxy base Solution in Hardener

As the ultrasonication is done the solution mix is mixed with hardener in the ratio 2:1.

5.6 Coating of Nanoclay mixed Epoxy to Glass Fiber Sheet

As we got the solution ready we must apply the epoxy mixer to glass fiber. Uni directional glass fiber is cut at the shape of wooden mould which is acts as a container, a metal sheet is paced in the mould after Vaseline is applied on it. then glass fiber sheet is placed on the metal sheet before epoxy mix is applied on it. After applying epoxy to sheets these sheets are left to dry in room temperature for two days before processing further.

5.7 Testing methods

5.7.1. Tensile test

The fabrication materials are cut utilizing a saw sharper to get the measurement of the samples for tensile testing according to ASTM: D3039 measures. The test was done utilizing a UTM at an area temperature with 45% relative dampness. The tensile stress is noted as for increment in strain. Two distinct kinds of samples are fabricated based on stands utilized pure epoxy samples and nanofilled epoxy samples. The samples were put in the hold of the machine and

Figure 5.1 Universal Testing machine

the test is performed by applying load until the point when it fractures. The comparing strain and load achieved are plotted on the charts.

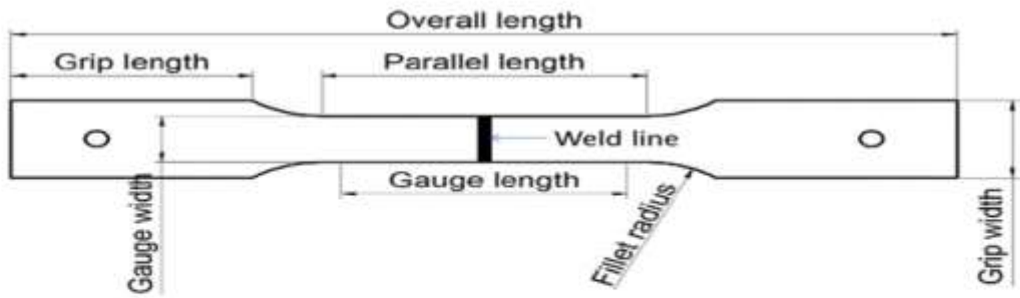


Figure 5.1 Schematic figure of Tensile test specimen.

5.7.2. Flexural test

The flexural test is completed on the similar tractable testing machine according to the ASTM: D790 standards. The flexural test sample is indicated is Fig. the sample to be tried is exposed to a load at its halfway among the supports and until the point when it breaks. This test decides the conduct of the samples when it is subjected to simple beam loading. This test decides the greatest pressure initiated in the external generally fiber.

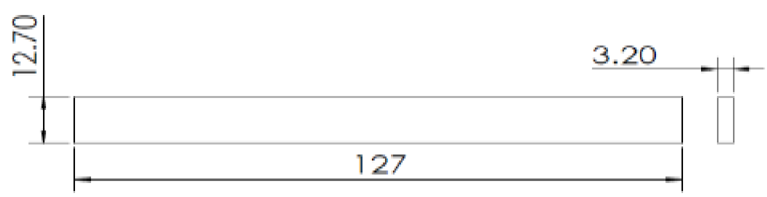


Fig :5.3 Schematic figure of flexural test specimen.

5.7.3 SEM (Scanning Electron Microscope)

SEM is utilized for the observance of specimen's surface. The specimen comes in contact with the electron beam then by colliding with the specimen secondary electrons are released on the top of specimen. The specimen is coated with gold coating before starting the test to prevent charge build up by electron absorption. SEM helps to view the microstructural view of the material the graphs of SEM are used to view the micro structure. This images shows any modification in constitution of material and it also shows and defects such as cracks and voids.

Figure 5.4 SEM (Scanning Electron Microscope

5.7.4. Test Matrices

Table 5.1 Initial Testing Specimens

Specime	No. of specimen		
	Tensile	bending	
0 wt%	1	2	2
1 wt%	4	4	8
2 wt%	3	3	6
3 wt%	3	3	6
0.5wt%	1	1	2
Total specimen			**24**

6. Result and Discussion

6.1 Mechanical Test Results

6.1.1. Tensile Strength

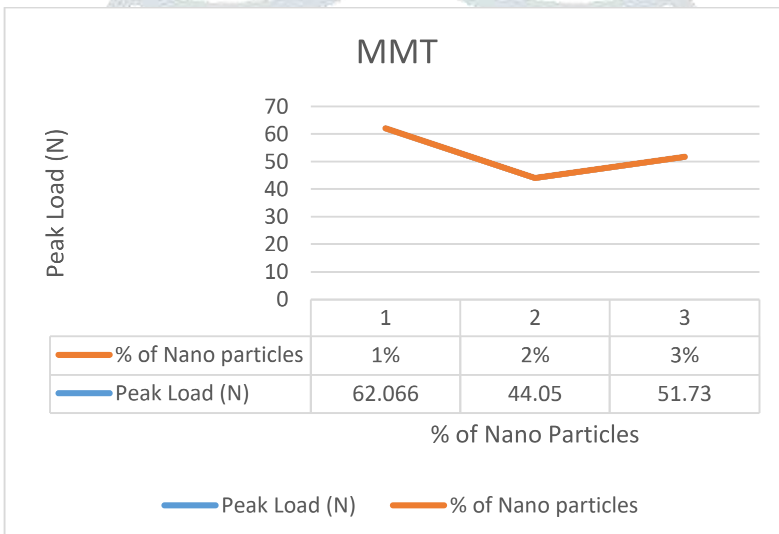
As we obtain the results of this tensile test shows that there is upsurge in tensile strength with increase in the clay percentage. The result of tensile strength is increasing by increasing clay loading up to 3 %. The reason for the increase is the more brittle nature of modified epoxy with use of nanoclay particles.

Table 6.1 Tensile Testing Results of Glass Fiber Specimen.

Sr. No.	Nanoparticle Name	Peak Load (N)	Break (Mpa)	% Elongation	Ultimate Modulus	% of Nano particles
1	MMT	62.066	62.065	4.25	2157.497	1%
	MMT	44.05	31.9	4.49	1552.74	2%
	MMT	90.73	90.73	4.17	2353.634	3%
2	ZnO	36.95	28.31	4.69	1307.578	1%
	ZnO	89.92	89.92	5.92	1961.367	2%
	ZnO	102.871	101.763	6.32	2451.702	3%

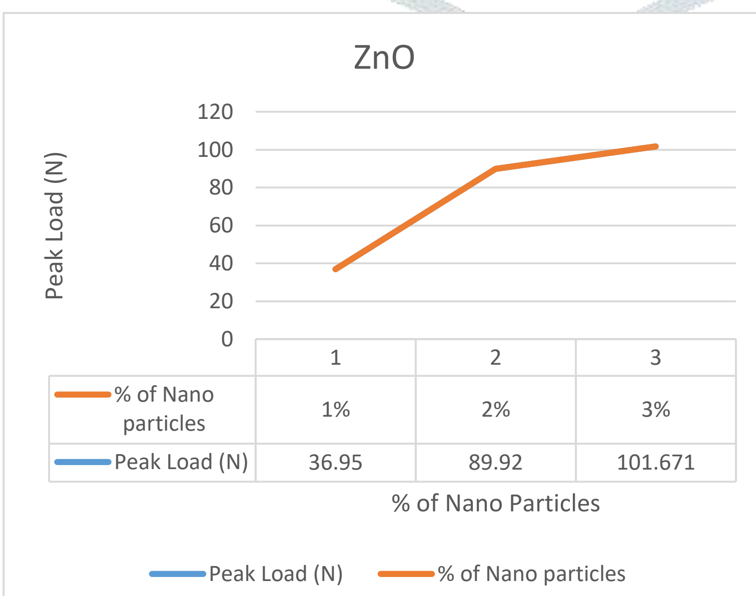
3	TiC	44.014	43.9	4.31	1552.74	1%
	TiC	58.79	58.33	4.24	2059.428	2%
	TiC	44.603	44.603	3.55	1961.361	3%
4	MMT/TiC	49.64	49.64	4.55	1961.431	1%
	MMT/TiC	46.23	46.20	4.28	1932.257	0.5%

From the above table we can see that the increase in nanoparticle percentage lead to increase in the peak load. The variation of the nanoparticles with the percentage with which it is mixed and the improvement it has gone through is represented by graph below.



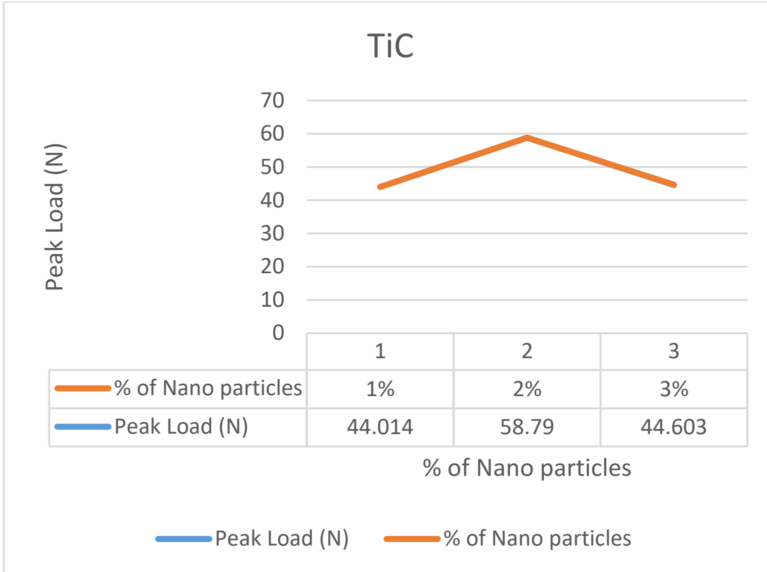
(a)

Fig.6.1 (a) Peak Load (N) of MMT Nanoparticle with fiber



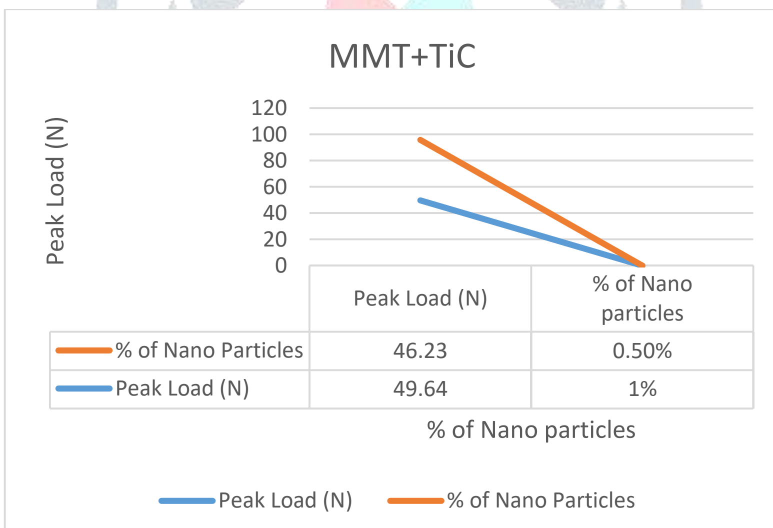
(b)

Fig.6.2 (a) Peak Load (N) of ZnO Nanoparticle with fiber



(c)

Fig.6.3 (a) Peak Load (N) of TiC Nanoparticle with fiber



(d)

Fig.6.4 (a) Peak Load (N) of MMT+TiC Nanoparticle with fiber

Table 6.2. Tensile Strength test of Epoxy Specimen

The above table shows that the value of tensile strength is achieved in 3% loading and the maximum average value is 17.614 as we increase the nanoparticle loading in the epoxy we found that the tensile strength is reduced. As we combine MMT and TiC we found that at 1% it shows an increase in tensile strength compared to the individual strength of the nanoparticles

S.NO	Nanoparticle Name	Peak Load (N)	Tensile strength (MPa)	% elongation	% of Nano particles
1	Pure Epoxy	350	13.086	10.28	0%
2	MMT	425	19.95	9.53	1%
	MMT	360	15.41	15.24	2%
	MMT	495	20.4	10.44	3%
3	ZnO	425	20.71	15.61	1%
	ZnO	455	[illegible]	[illegible]	[illegible]
	ZnO	485	[illegible]	[illegible]	[illegible]
4	TiC	305	[illegible]	[illegible]	[illegible]
	TiC	320	[illegible]	[illegible]	[illegible]
	TiC	345	[illegible]	[illegible]	[illegible]
5	MMT+TiC	445	[illegible]	[illegible]	[illegible]
	MMT+TiC	425	[illegible]	[illegible]	[illegible]

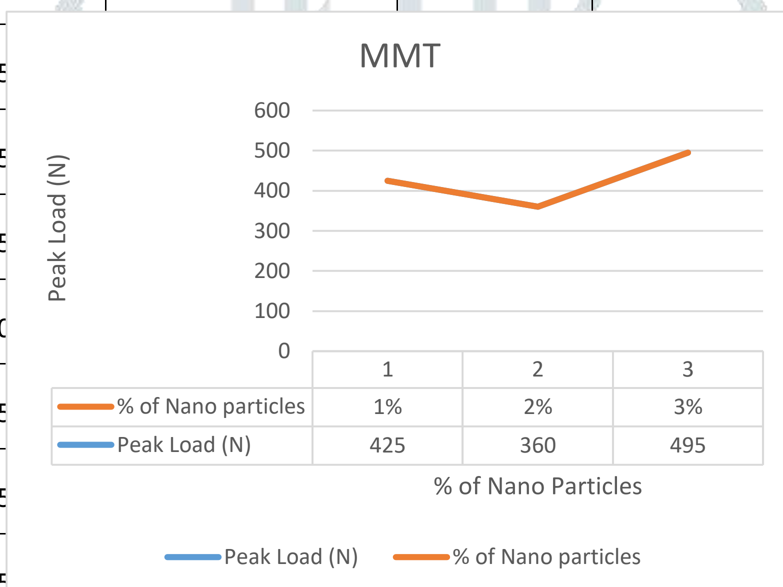


Fig.6.5 Peak Load (N) of MMT Nanoparticle epoxy specimen

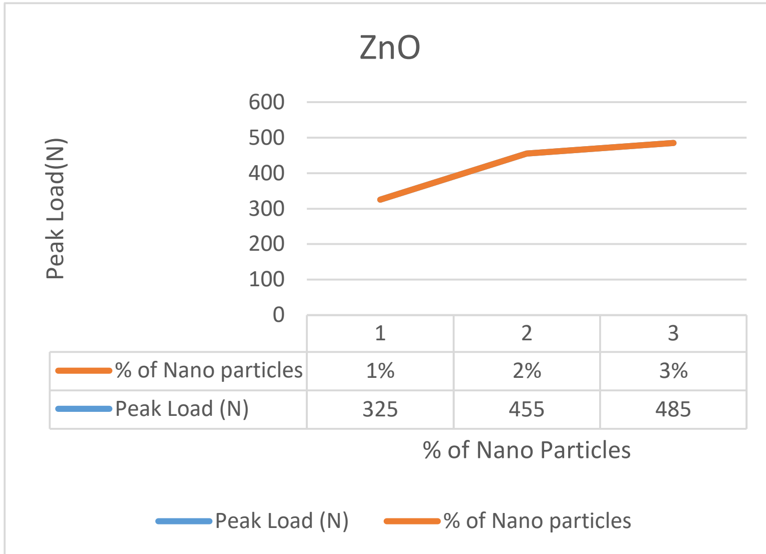
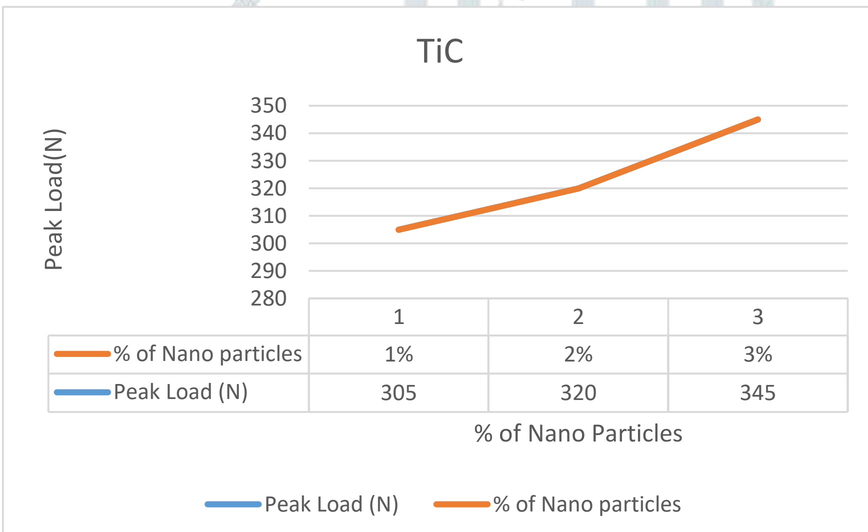


Fig.6.6 Peak Load (N) of ZnO Nanoparticle epoxy specimen.



(c)

Fig.6.7 Peak Load (N) of TiC Nanoparticle epoxy specimen.

6.2 Bending Test Results

The testing samples of numerous nanoparticles filling are tested using the 3-point bending test. This results show that as we increase the nanoparticle loading we increase the bending strength. The value corresponding maximum bending strength 12.535. which is more than double of the pure epoxy specimen without any nanoparticle.

Table 6.3 Bending Test results

S.NO	Nanoparticle Name	Peak Load (N)	Bending Strength(Mpa)	% of Nano particles

1	Pure Epoxy	68.5	4.927	0%
2	MMT	82	8.586	1%
	MMT	97	9.3624	2%
	MMT	112	10.2753	3%
3	ZnO	86	8.214	1%
	ZnO	92	9.367	2%
	ZnO	109	11.684	3%
4	TiC	89	8.6847	1%
	TiC	96	10.486	2%
	TiC	103	11.738	3%
5	MMT+TiC	124	12.635	1%
	+TiC	106	11.248	0.50%

The results of this specimens shows that at 3% in all the specimens the bending values are high than that of other specimens. When compared to the pure epoxy bending strength of specimens with nanoparticles is high and it can with stand more load than compared to pure epoxy.

The specimen which is formed by combing both MMT and TiC has more bending strength than individual nanoparticle specimen.

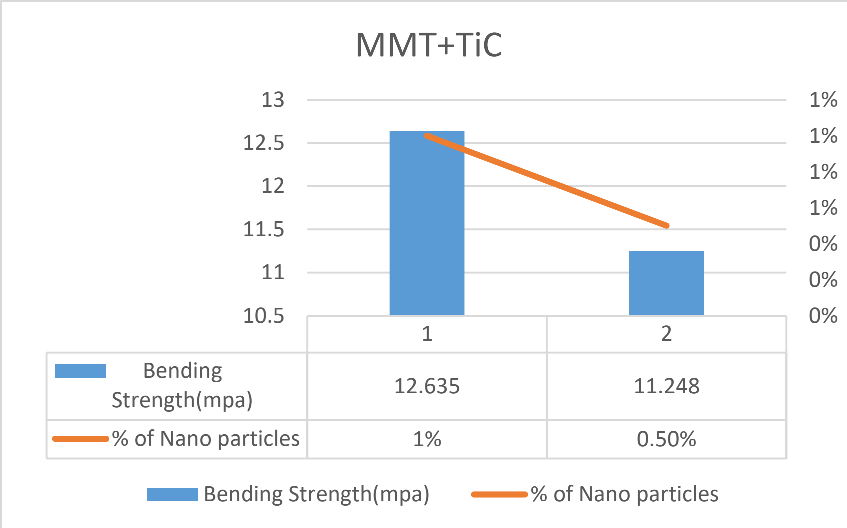


Fig.6.8 Bending strength comparison between MMT and TiC

6.3 Dynamic mechanical analysis (DMA)

Dynamic mechanical analysis is conducted on MMT specimen. tan δ of Epoxy specimen /MMT nanocomposite which is an average value of the storage modules (E) with different percentage of MMT. The results we obtained in this study are compart able to literature data which we shown in the table below and it also listed the average values of T_g for different wt% of MMT.

Name of nanoparticle	% of nanoparticle	E'(Mpa) at 40 ^{0}C	E''_{max} (Mpa)	Tan_{max} δ	temperature (^{0}C)	
					E''_{max}	Tan_{max} δ
pure epoxy	0wt%	2812	403	0.86	77.5	91.3
MMT	1wt%	2569	359	0.89	78	90.2
	2wt%	2135	320	0.85	76	89.5
	3wt%	1893	275	0.83	73	85.5

Table 6.4 Results of DMA analysis of epoxy/MMT nanoparticles

The measured T_g of pure epoxy is 91.3 ^{0}C. as we increase the percentage of nanocomposites the T_g is less less by about 5^0 C that of epoxy resin. Tan δ of the nanocomposites in generally higher than that of the pure epoxy.

6.4 Scanning Electron Microscope (SEM)

The SEM examination which is proceeding on the exterior of nanocomposites in different various amplifications. The surface of pure epoxy is seen at nano level at high magnification. There are micro pores which are visible at lower magnification due to air bubbles entrapped in the epoxy this is occurred when hardener is mixed with epoxy. The surface of this pure epoxy is smooth which shows the brittle failure nature of pure epoxy resin.

(a) (b)

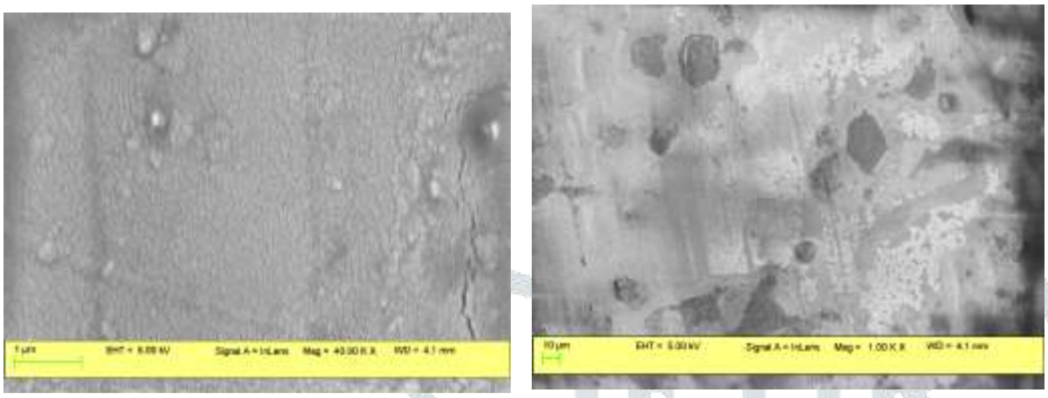


Fig 6.9 The SEM Micrographs of pure epoxy (a) 1μm at 40.00 KX (b) 1μm at 1 KX magnification.

The image of SEM which is shown below is of 1% although the dispersion is occurred uniformly the surface is rough than that of pure epoxy. we can view few differences in the image of different nanoparticles at 1%. Few voids or air bubbles are formed which are visible as dark spots.

(a) (b)

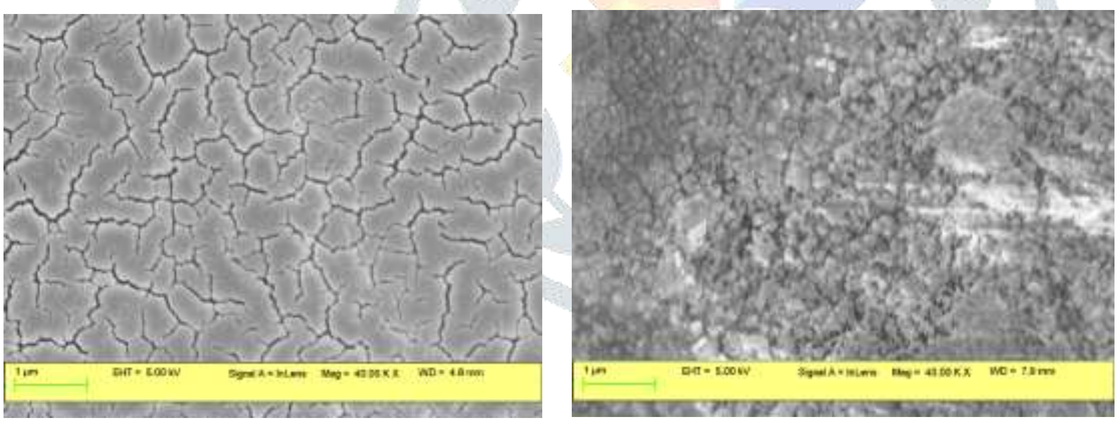
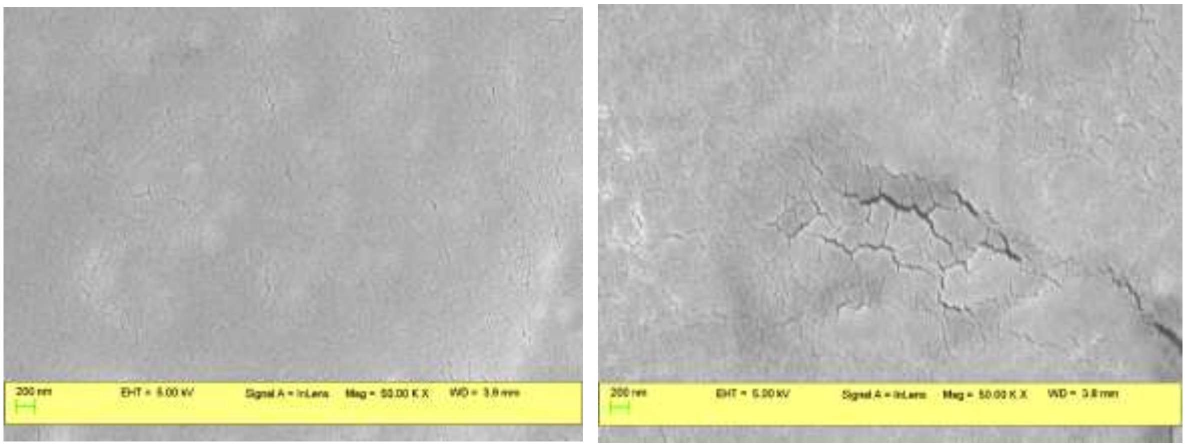


Fig 6.10 The SEM Micrographs of TiC and ZnO (a) 1μm at 40.00 KX (b) 1μm at 40.00 KX

The samples of which at 3% the results are quite good compared to other percentage images. we can see that in 3 % loading the voids and air bubbles which results in failure of the material are less compared to other nanoparticles of different quantity.



(a) **(b)**

(c)

Fig 6.11 The SEM Micrographs of MMT, TiC and ZnO (a)MMT at 200µm at 50.00KX (b) TiC at 200µm at 50.00KX (c) ZnO at 200µm at 50.00KX.

The below SEM image shows that the bonding of MMT and TiC is strong when compared to that of individual nanoparticles of same quantity of 1%. When MMT and TiC are combined together with epoxy at 1% each then combined specimen shows increase in strength and properties than that of individual nanoparticle samples.

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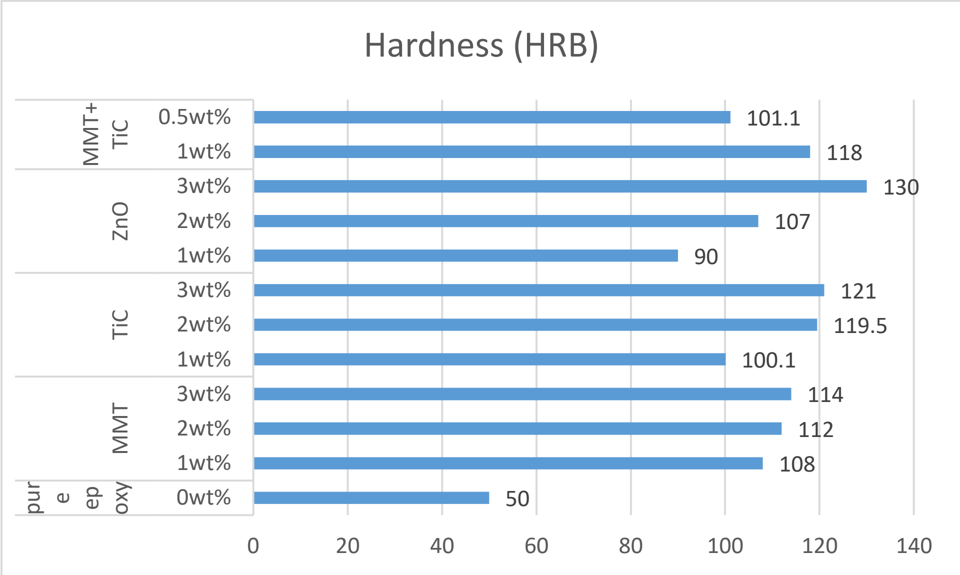
(a)

Fig 6.12 The SEM Micrographs of MMT + TiC (a) 1µm at 30KX.

6.5 Rockwell Hardness Tester

The Rockwell hardness results of specimens filled with nanoparticles are shown in below chart. As a result, it can see that the minimum hardness (HRB) has been noted in ZnO at 1wt% composite *i.e.* 90 and maximum ZnO at 3wt% has hardness value of 130 respectively. The maximum hardness is shown by the ZnO specimen as compared to other nanocomposite filled specimens because embedment of reinforcement of matrix is much more perfect as compared to other specimens.



CONCLUSION

Fiber reinforced nanocomposites are manufactured by using glass fiber which is used as reinforcement and epoxy resin T-23 mixed with hardener K-59 used as matrix. Nanoparticles are added in different weight percentages which are (1wt%,2wt%,3wt% of weight of resin). The Processing is done by using mechanical stirrer in waterbath and then the mixture is placed on ultrasonicator to remove bubbles which formed while stirring. The composites are manufactured by using moulds which are filled manually. Improved intercalation of nanoparticles embedded in epoxy is detected in samples at 1 to 3 wt% nanoparticle loading. Tests to find out the mechanical properties such as bending and tensile test per ASTM standards. After testing is done it has been found that properties of specimen with nanoparticles increase in percentage of nanoparticle in epoxy.

- Tensile strength results show that the addition of nanoparticle to epoxy resin enhance in tensile properties. The maximum tensile strength is recorded as 22.843 which is a value of ZnO at 3wt%.
- Flexural strength results exhibit that the maximum flexural strength of MMT+TiC at 1wt% is 12.365 Mpa.
- Maximum hardness of 130 HRB for zinc oxide at 3wt%.

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