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EFFECT OF MAGNESIUM OXIDE NANOPARTICLE ON THERMAL STABILITY OF PMMA-MGO COMPOSITE FOR TECHNOLOGICAL APPLICATIONS

[1]Prof. Pranali P.Kharwade, [2]Dr. Nandkishor M. Sawai , [3]Prof. Avinash R. Mankar , [4]Prof. Shweta S. Ingle

[1]Guru Nanak Institute of Engineering & Technology, Nagpur
[2,3,4]Guru Nanak Institute of Technology, Nagpur
[1]pranali61196@gmail.com, [2]nandkishor_sawai@rediffmail.com,
[3]avinashmankar@gmail.com, [4]shwetaingale28081996@gmail.com

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Abstract
Due to their unique chemical stability, high photo catalytic activity, high electric permittivity, and non-toxic nature, metal oxide nanoparticles are used in a wide range of optical, electrical, electronic, biomedical, environmental, and catalytic devices. The current research is focused on developing a nanocomposite of polymethyl methacrylate and magnesium oxide by first synthesising MgO nanoparticles and then treating them with the polymer. Infrared spectrophotometer for determining functional groups, thermogravimetric and differential thermal analyzers for determining thermal stability, scanning electron microscopy for morphology and refractometer, and so on have all been used to characterise the synthesised PMMA-MgO nanoparticle composite. In our research for new uses, we found that adding MgO to PMMA speeds up the reaction and cuts the synthesis time in half, from 40 minutes to 15 minutes. The role of MgO as catalysts has thus been established.
Key words: PMMA (Polymethyl methacrylate), MgO nanoparticle, FTIR Spectrophotometer, Scanning electron microscope, Thermogravimetric analysis, differential thermal analysis and Refractic index.

1. INTRODUCTION

Nanoparticles made of metal oxides are being studied extensively because of their many desirable characteristics. This means they have several uses, including in coatings, catalysts, antibacterial medicine, sensors, semiconductors, capacitors, and batteries. Catalysis, hazardous waste cleanup, paint, superconducting goods, and anti-bacterial actions against food-borne pathogens are just few of the various uses for magnesium oxide (MgO).[2]

The area of materials science has paid a lot of attention to polymer-inorganic oxide nanoparticle composites due to their superior characteristics compared to those

of pure polymers. Nanoparticle fillers made from inorganic oxides may change the thermo-mechanical, optical, electrical, and magnetic characteristics of polymers. [3]Due to the stabilising effects of the polymer matrix on the NPs and the relative ease and flexibility of engineering this class of materials with advanced functionalities, composite materials made of polymers and NPs, such as inorganic, metal, semiconductor, carbon black, and magnetic nonmaterials, have recently attracted considerable attention. Catalysis, hazardous waste cleanup, paint, and superconducting pathogens are just a few of the various uses for magnesium oxide (MgO) [4]. Both magnesium and oxygen have atomic number 12, making them members of the IIA and VIA groups of the periodic table, respectively. The melting and boiling temperatures of MgO are respectively 28520C and 36000C. Different synthesis techniques, such as solution combustion [5,] may be used to create these oxide materials. The terms "co-precipitation," "sol gel," and "green synthesis" (all from [6]) are all quite new to me. Co-precipitation is one of the most effective ways to synthesise nanoparticles without a drop in yield or difficulty in regulating particle size.

Poly(methyl methacrylate) (PMMA) is a widely used thermoplastic that benefits from its excellent optical qualities (clarity, transparency from the near ultraviolet to the near IR), chemical inertness, thermal stability, electrical properties, safety, weather resistance, model ability, and ease of shaping in a wide variety of technological and productive fields.

PMMA has also been widely used to make a variety of optical devices, such as optical lenses, in both its pure and doped states, and is widely considered to be one of the best organic optical materials for a wide range of imaging and non-imaging microelectronic applications.[9] PMMA has been used for more than 40 years in skeletal surgery to secure prosthetic implants, and it has recently gained popularity as a delivery agent for regional high-dose antibiotics to treat soft tissue and osseous infections, including osteomyelitis. PMMA is also often utilised as a support media to facilitate the embedding of uncalcified, whole bones. [10] Calcified tissues may be easily sectioned and examined under the microscope thanks to the material's hardness.

In this study, we looked at how nanoparticles affected polymer throughout the composite manufacturing process.

2. EXPERIMENTAL MATERIALS AND METHODS:-

2.1MATERIALS:-Methyl methacrylate, Magnesium Nitrate, Sodium nitrate, Benzoyl peroxides, Polyvinyl Alcohol, Distilled water.

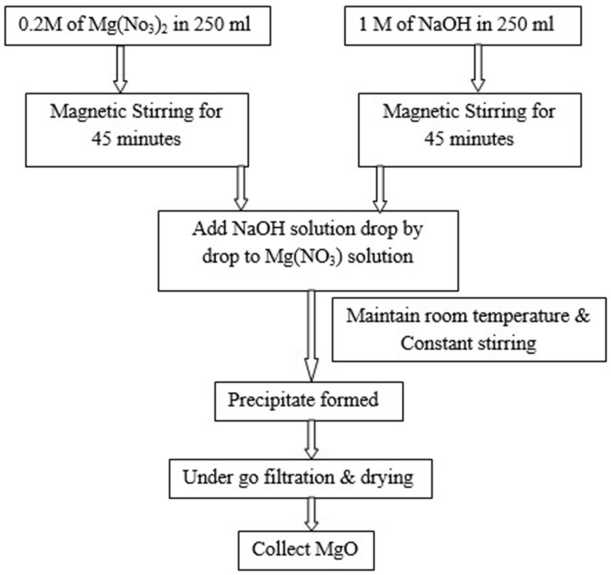
2.2METHOD - I

Synthesis of MgO Oxide by co-precipitation Technique:-

Separately into breakers, Magnesium Nitrate and Sodium Hydroxide were each dissolved in 250 millilitres of distilled water. You should mix each of them individually for thirty minutes using a magnetic stirrer to ensure continuous stirring. At room temperature, add sodium hydroxide solution to magnesium nitrate solution using a burette drop by drop. After thirty minutes, a precipitate with a milky white tint was generated; the collected magnesium oxide nanoparticles were white in colour after being filtered and dried. [11]

$$Mg(NO_3) + 2NaOH \rightarrow Mg(OH) + 2NaNO_2$$

$$2\,Mg(OH)_2 \rightarrow 2MgO + H_2O$$



2.3METHOD- II

Synthesis of Polymethyl Methacrylate by suspension polymerization:-

10 ml of Methyl Methacrylate containing dissolved 0.1 g of benzoyl peroxide in a 250 ml in Rb flask equipped with magnetic stirrer, thermometer and water condenser. Added 20ml of 2% aqueous polyvinyl alcohol solution which acts as a agent. Stir the solution vigorously then heat the content of the flask at about 80^0 C temperature on a heating mental or water bath for 40 minute. The internal temperature begins to rise and will reach a maximum of 85^0C. At this point stop the heating and then add cold water to the flask. The granule of polymer will get separate out, wash with water and dry in an oven at 60 ^{0}C. Take the weight of dried granules. [12]

2.4METHOD- III

Synthesis of Polymethyl Methacrylate-Magnesium oxide nanoparticle composite:-

10ml of Methyl Methacrylate containing dissolved 0.1g of benzoyl peroxide in a 250ml in Rb flask equipped with magnetic stirrer, thermometer and water condenser. Added 20 ml of 2% aqueous polyvinyl alcohol solution which acts as a agent. Stir the solution vigorously then heat the content of the flask at about 80 ^{0}C temperature on a heating mental or water bath after 5 minutes add 1 gm of magnesium oxide nanoparticle for 15 minute. The internal temperature begins to rise and will reach a maximum of 85 ^{0}C. At this point stop the heating and then add cold water to the flask. The polymer composite will get separate out, wash with water and dry in an oven at 60^0C. The product will be obtained.

3. CHARACTERIZATIONS:-

The functional group of PMMA and MgO nanoparticle was studied by using FTIR BRUKER spectrophotometer. The morphology of polymethyl methacrylate, Magnesium oxide nanoparticle and PMMA-MgO nanoparticle composite was studied by using ZEISS Scanning electron microscope and thermal stability of polymethyl methacrylate- magnesium oxide nanoparticle composite and pure polymethyl methacrylate polymer are studied by using Thermogravimetric analyzer and also used differential thermal analyzer and find out the weight loss of pure PMMA and PMMA-MgO nanoparticle composite. Thermal properties measured by TG-DTA.

Refractive index of PMMA-MgO nanoparticle composite determine by using Abbes refractometer.

4. RESULT & DISCUSSION:-

FTIR Spectra:-

FTIR spectroscopy was used to observe the presence of functional group and chemical structure. FTIR spectra of PMMA, MgO and PMMA-MgO nanoparticle composites. The spectra where measured at room temperature in transmittance mode over a wave number range of 3500cm^{-1} - 500cm^{-1}. The characterized of MgO assigned as follows.

Table 1:- The polymethyl methacrylate and PMMA-MgO nanoparticle composites show the following functional group at different frequencies.

Frequencies of PMMA	Frequencies of PMMA-MgO nanoparticle composite	Functional Group
1724.79 cm-^{1}	1727.53 cm-^{1}	C=O (Strong stretching, intensity increased)
1432.66 cm-^{1}	1482.26 cm-^{1}	C-O (Strong stretching, intensity increased)
1238.57 cm-^{1}	1238.05 cm-^{1}	CH_2 (Medium Stretch, Intensity decreased)
1189.94 cm-^{1}	1145.59 cm-^{1}	C-O (Medium stretching, intensity increased)
1000-800 cm-^{1}	924.05 cm-^{1}	C-C (Strong stretch)
720.23 cm-^{1}	836.33 cm-^{1}	CH_2 (Medium stretch, Intensity Increased)

The FTIR spectra of PMMA and PMMA–MgO nanoparticle composite. It is evident that all the two spectra are similar except for a few changes in the spectra of the nanocomposites. The features that are similar identify the presence of PMMA in all of them. The fingerprint characteristic vibration bands of PMMA appear at 1724.79 cm-^{1} n(C=O) and 1439.66cm-^{1} n(C–O). The bands at 3174.08 cm-^{1} and 2900 cm–^{1} Correspond to the C–H stretching of the methyl group(CH3) while the bands at 1300 and 1450 cm–1 are associated with C–H symmetric and asymmetric stretching modes, Respectively. The 1238.57 cm–^{1} band is assigned to torsion of the ethylene group (CH2) and the 1189.94 cm–^{1} band corresponds to vibration of the ester group C–O, while C–C stretching bands are at 1000 and 800 cm^{-1}. Absence of any additional bands other than those of PMMA in the spectrum of PMMA and further they remaining unperturbed in all the three spectra indicate

(1)The purity of the polymer obtained and

(2) Formation of the nanocomposites.

The comparative study of the IR spectra of PMMA and PMMA-MgO nanoparticle composite gives the peaks at 1724.79 cm-^{1} – 1727.53 cm-^{1} strong stretching vibrations and intensity increases the functional group is C=O. The peak of PMMA And PMMA-MgO Nanoparticle composite appear at 1432.66cm^{-1}-1482.26cm^{-1} stretching is strong and intensity is increases the functional group show the CH_3.The peak of C-O functional group appear at 1189.94-1145.59cm^{-1} intensity is decreases the medium

stretching vibration modes. C-C stretching bands are at 1000-942.05cm^{-1} intensity is strong and increased. This data shows the small difference of FTIR spectra of PMMA and PMMA-MgO nanoparticle composites. These few changes show the increase in transmittance of functional groups with an increase of MgO nanoparticle

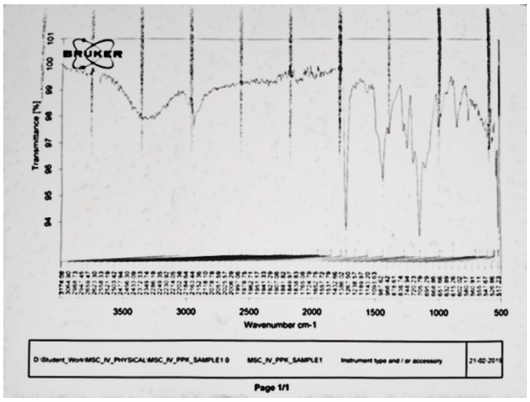


Fig.1 FTIR spectra of PMMA

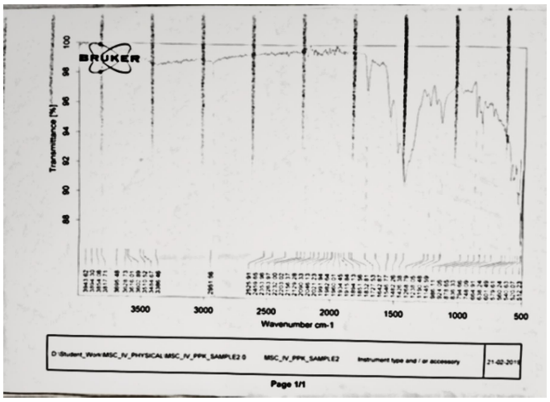


Fig.2 FTIR spectra of PMMA-MgO Nanoparticle Composite

Refractive index:-

Table 2:-

Substances	**Refractive Index**
Distil Water	1.372
Toluene	1.453
Toluene-PMMA	1.456
Toluene-PMMA-MgO Nanoparticle Composite	1.484

At room temperature 23^{0}C determine the refractive index of polymer and polymer composite means PMMA and PMMA-MgO Nanoparticle composite. Firstly taken a pinch of samples in this sample add 2ml of toluene solvent mix them. Then find the Refractive Index with the help of Refractometer. We had found that the Refractive Index of distil water was 1.372 the refractive index of pure toluene 1.453. The sample of PMMA-toluene solvent Refractive Index was found to be 1.456 and main Refractive Index of PMMA-MgO Nanoparticle composite was found to 1.484. It means that the optical properties of PMMA may be changes due to addition of MgO Nanoparticle.

Thermal gravimetric analysis result:-

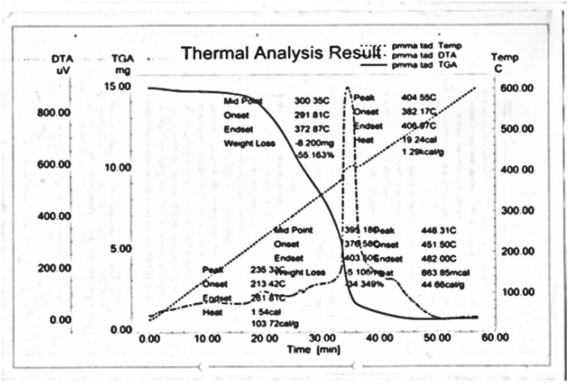


Fig.3 TGA-DTA of PMMA

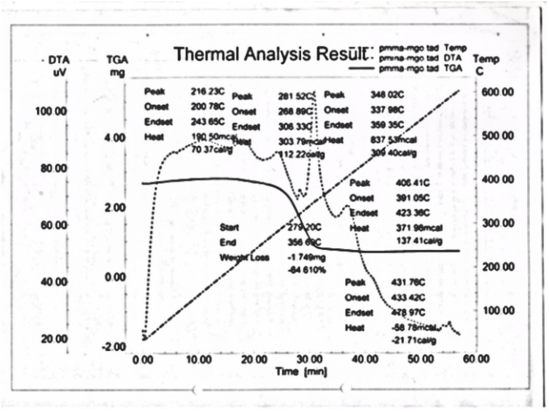


Fig.4 TGA-DTA of PMMA MgO Nanoparticle Composite

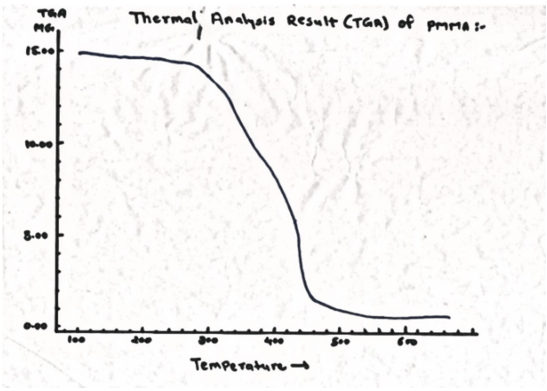


Fig.5 TGA of PMMA

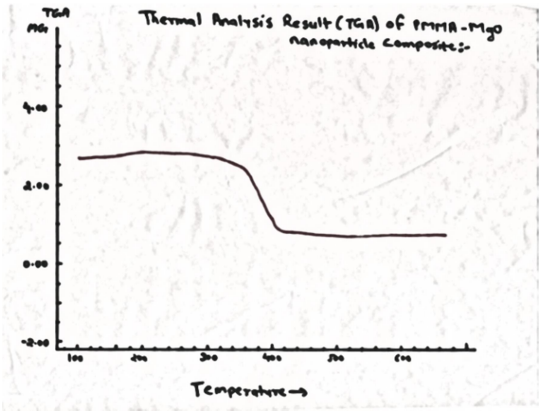


Fig.6 TGA of PMMA MgO Nanoparticle Composite

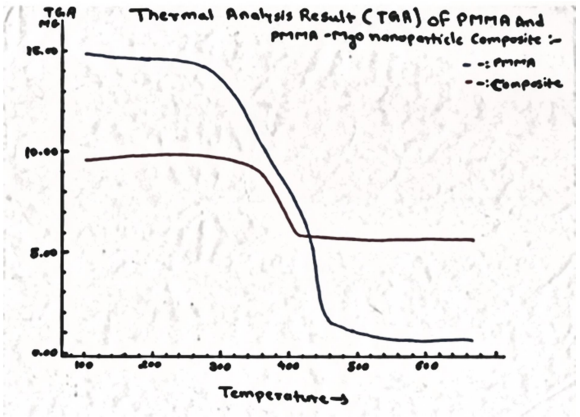


Fig.7 TGA of PMMA & PMMA-MgO Nanoparticle Composite.

Comparison of TGA data of PMMA and PMMA-MgO Nanoparticle Composite:-

Table 3:-

Sr.No.	Start	Onset	Endset	Weight Loss
1 (PMMA)	300-395.18C	291-376.58C	372.87-403.50C	-55.163 to -4.349%
2 (PMMA-MgO Composite)	279.20C	268.65C	356.69C	-64.61%

The thermogravimetric analysis (TGA) was used to look into the thermal stability of these materials, and the associated thermograms are shown below. The effect of nanocomposites on thermal behaviour was investigated by comparing the degrading stability of the nanocomposites with that of the reference PMMA that was synthetically produced.

All of the thermal grammes point to the fact that there is no weight loss up to 2000 degrees Celsius, but that there is consistent weight loss at the same rate up to around 6000 degrees Celsius. The evaporation of water molecules is responsible for the weight loss of the sample from room temperature to 200 degrees Celsius; the evaporation of inorganic elements is responsible for the weight loss from 200 degrees Celsius to 400 degrees Celsius. After 400 degrees Celsius, the sample will experience a weight loss due to the evaporation of any unreacted components that are present in the sample.

Decrease weight loss up-to -55.163 to -34.349% in PMMA and PMMA-MgO Nanoparticle composite weight loss -64.610%. Total weight loss of composite is decreased as compare to pure PMMA.

The weight loss is mainly due to thermal degradation and also higher ^{0}c heating.

Differential thermal analysis:

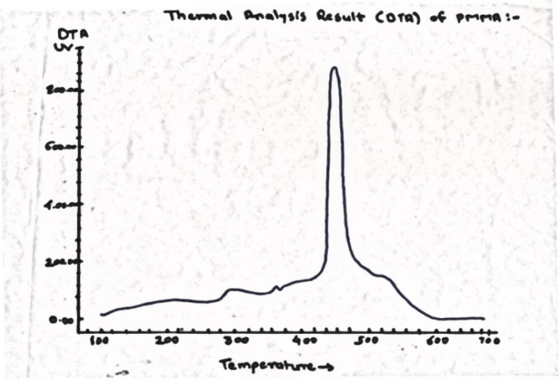


Fig.8 DTA of PMMA

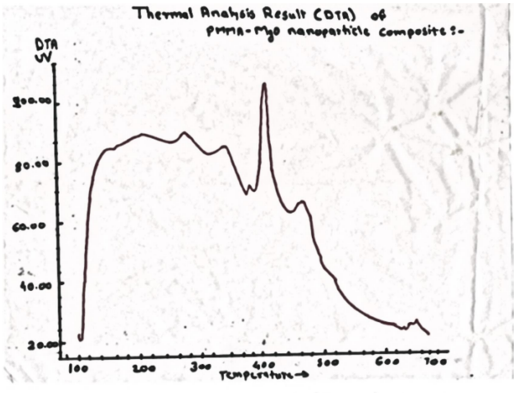


Fig.9 DTA of PMMA MgO Nanoparticle Composite

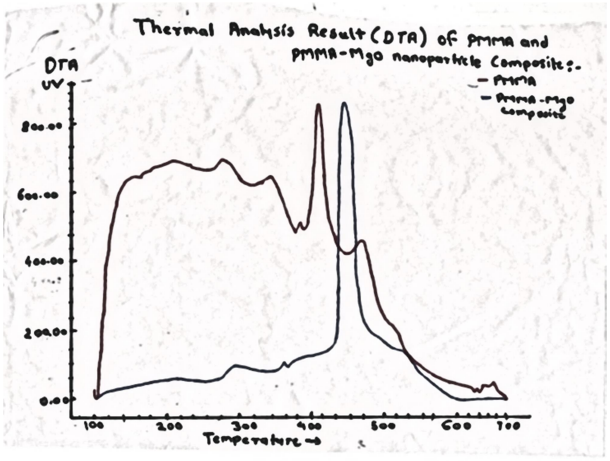


Fig.10 DTA of PMMA& PMMA-MgO Nanoparticle Composite

Table 4-DTA of PMMA:-

Sr.No.	Peak	Onset	Endset	Heat
1	235.33C	213.42C	261.81C	1.54 Cal
				103.72 Cal/g
2	404.55C	382.17C	406.97C	19.24 Cal
				1.29 Kcal/g
3	448.31C	451.50C	482.00C	66.385 mcal
				44.66 Cal/g

Table 5-DTA of PMMA-MgO Nanoparticle composite:-

Sr.No.	Peak	Onset	Endset	Heat
1	216.23C	200.78C	243.65C	190.50 mcal
				70.37 cal/g
2	281.52C	268.89C	306.33C	303.79 mcal
				112.22 cal/g
3	348.02C	337.98C	359.35C	837.53mcal
				309.40cal/g
4	406.41C	391.05C	423.36C	371.96mcal
				137.41cal/g
5	431.76C	433.42C	478.97C	-58.78mcal
				-21.71cal/g

The chemical Decomposition with an increase of temperature was examined through DTA (Differential Thermal Analysis) and is appeared as the endothermic and exothermic peak in DTA curve of PAN nanoparticle and PMMA – MgO nanoparticle composite.

We have compare in between PMMA and PMMA-MgO nanoparticle composites. The Thermal stability of the pure PMMA and PMMA-MgO nanoparticle composite is studied using DTA. The basic idea is to shown that the addition of MgO into PMMA alters the thermal decomposition of such composites, either from a chemical point of view or/ and with respect to the temperature interval of the decomposition. Pure PMMA decompose in broad interval

from ~230^{0}C to 400^{0}C . According to DTA curve in pure PMMA -55.163% weight loss and also small interval in between 448.31^{0}C to 482.00^{0}C with weight loss of -34.349.00%. In PMMA–MgO nanoparticle composite we have seen that first interval in 243.65^{0}Cthen second interval between 281.52^{0}C to 306.33^{0}C then third interval between 348.02^{0}C to 359.35^{0}C and fourth interval between 406.41^{0}C to 423.36^{0}C and five interval between 431.76^{0}C to 478.97^{0}Cwith weight loss -64.610 % .We compare in between PMMA and PMMA-MgO nanocomposite . We see that weight loss decreases in PMMA-MgO nanoparticle composite.

SEM:-

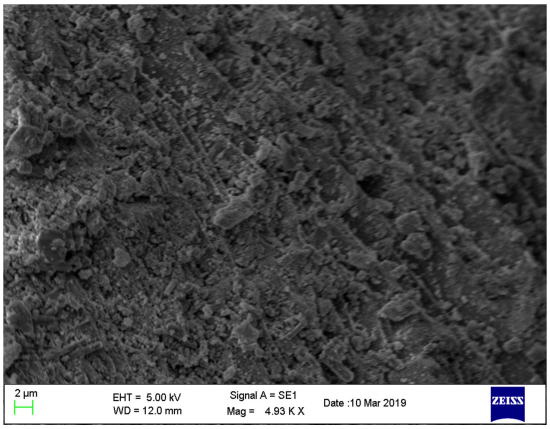


Fig.11SEM image of MgO Nanoparticle

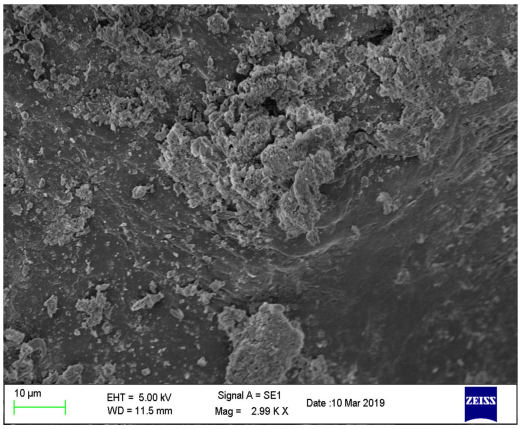


Fig.12(A) SEM image of PMMA-MgO Nanoporticle Composite

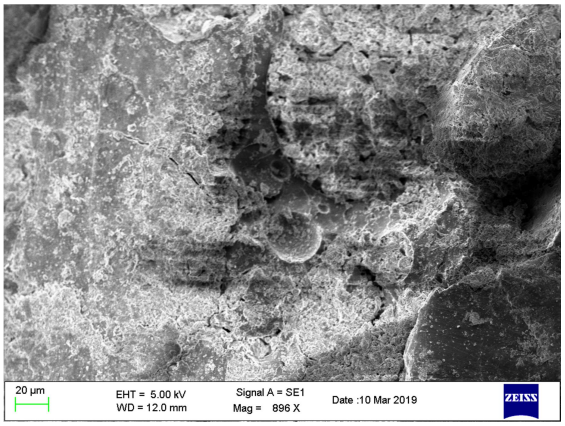


Fig.12(B) SEM image of PMMA-MgO Nanoporticle Composite

The Scanning Electron Microscopy of MgO nanoparticle synthesized under aqueous medium by co-precipitation method.

The SEM image of PMMA-MgO nanoparticle composite under high magnification is shown . Sheet like Shaped morphology is observed in the micrograph of magnesium oxide in fig.11. The SEM pictures show distinguished sheet like morphology with self aligned prismatic nanoparticles. The morphology of MgO nanopowder as revealed by FESEM showed nanoparticle size of the method of synthesized MgO nanoparticle is 2µm.

The SEM image of PMMA-MgO nanoparticle under high magnification with 2.99 KX as shown in fig 12(A) & 12(B) .The SEM graph shows that tha PMMA-MgO nanoparticle are sheetlike and roadlike in shape with 10μm-20 μm in size.

5. CONCLUSION:-

After adding MgO, the reaction is sped up in PMMA, and the amount of time needed to complete the synthesis is cut in half, from 40 minutes to 15 minutes. Therefore, the hypothesis that MgO serves as catalysts has been proven. As a result of the incorporation of MgO nanoparticles, the price of PMMA is decreased. With the incorporation of MgO nanoparticles into PMMA, the production time for PMMA is cut in half when compared to that of pure PMMA. It's possible that the addition of MgO nanoparticles to the PMMA-MgO nanoparticle composite would improve the optical characteristics of the material. The increase in transmittance that occurs with a rise in the amount of MgO present, as well as the increase in transmittance that occurs with an increase in the amount of PMMA present. These findings unequivocally point to the fact that a PMMA-MgO nanoparticle composite has been formed. In order to characterise these PMMA-MgO nanoparticle composites, morphological investigations, thermal analyses, and structural analyses have all been carried out. A lower glass transition temperature as a result of an increased surface-to-volume ratio in the composite material. Insight into the structural changes that may be happening as a consequence of the mixture of MgO nanoparticles and PMMA may be gained from the results that were obtained. The thermal techniques Thermal Gravimetric Analysis (TGA) and Differential Thermal Analysis (DTA) are used in that work to research the change in the thermal stability of PMMA-MgO nanoparticles composites. These approaches are used to analyse the change in the thermal stability of the composites. In terms of the breakdown of PMMA, the shifting of the thermal peaks to higher temperatures than those for pure PMMA may be explained by assuming that the inclusion of MgO nanoparticle in the composites results in greater thermal stability. This can be explained by the fact that the composites. The breakdown of PMMA may be accomplished by the use of magnesium oxide. As a consequence of shifts in activation energy, there may be deterioration there. The effect of nanocomposite on thermal behaviour was investigated by contrasting the degradation stability of the synthetic reference PMMA with that of the original material.

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