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Zirconium Titanate Dispersed Poly(Methylmethacrylate) Nanocomposite Film

Shantkumar Babangol¹, Arunkumar Lagashetty^{2,*}¹Department of Chemistry, S.S.K Basaveshwar College of Arts, Science and Commerce Basavakalyan, Bidar – 585 327, Karnataka, India.²Department of Chemistry, Appa Institute of Engineering & Technology, Gulbarga – 585 106, Karnataka, India.

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ABSTRACT

New properties and applications of polymers will be developed by insertion of metal oxide nanomaterials in the polymers to form composite materials. Nano sized zirconium titanate dispersed poly(methyl methacrylate) nanocomposite (ZrTiO₄-PMMA) was prepared by solvent casting method is reported. The structural of the prepared nanocomposite was carried out by X-ray diffraction (XRD) technique. This study reveals the development of crystallinity in amorphous poly(methylmethacrylate) by the insertion of crystalline oxide material. The scanning electron micrograph (SEM) tool was used to know the morphology of PMMA nanocomposite film. Bonding nature of the composite materials is observed by Fourier transfer infrared (FT-IR) tool.

1. Introduction

New polymer composite materials were prepared by dispersion inorganic materials like nano sized metal oxides into polymers, which shows various properties and applications [1, 2]. These composite materials exhibit markedly improved properties and applications compared to the pure polymers and pure oxide materials. Inorganic materials filled in polymer matrix are responsible for the integrity of these properties and applications [3, 4]. Recent research highlights more towards the conventionally filled polymers due its high thermal stability and heat resistant property. Desired properties for the said composites will be dependence on the method of preparation. Different methods are in the literature to enhance the desired properties of polymers by oxide reinforcing utility at nano scale [5, 6].

Fine dispersion of inorganic nanomaterials of size typically 10-100 nm in to an organic polymer matrix constitute a new class of nanocomposite materials [7]. In addition to this, nanocomposite materials based on nanosized inorganic materials have been of great interest to researchers due to their applications [8, 9]. Fibrous materials like metals/ metal sulphides /metal oxides etc., dispersed polymer nanocomposites have been extensively studied since they exhibit interesting properties with many applications such as quantum electronic devices, magnetic recording materials, sensors, capacitors, smart windows, toners in photocopying, conducting paints and rechargeable batteries [10-14]. These composites are often prepared by dispersing nanomaterials in a non-conducting polymer matrix [15].

The present investigation reports the synthesis of zirconium titanate dispersed poly(methyl methacrylate) nanocomposite film (ZrTiO₂-PMMA) through solvent casting method. Then the prepared composite films were characterized by different characterization techniques.

2. Experimental Methods

2.1 Materials and Methods

Poly (methyl methacrylate) was obtained commercially. Acetone is used as a solvent for preparation of zirconium titanate dispersed PMMA composite film. Solvent casting method is adopted for the synthesis of composite film.

2.2 Synthesis of Poly(Methyl Methacrylate)-Zirconium Titanate (ZrTiO₄-PMMA) Nanocomposite Film

Zirconium titanate dispersed PMMA nanocomposite film was prepared by solvent casting method. 2 g of PMMA was stirred in 50 mL of acetone and is kept for 10 hrs in a closed container and the solution was stirred under magnetic stirrer for 10 minutes. 0.1 g of zirconium titanate nanoparticles are mixed in to the PMMA gel thoroughly in a rotary evaporator which was constantly maintained at 80-90 °C in a water bath. The gel solution containing zirconium titanate oxide was transferred into a petridish containing hot water as an immiscible solvent and it is kept 8 hrs for evaporation of acetone solvent. The fine zirconium titanate dispersed PMMA film was obtained and are characterized by various characterization techniques. The optical image of as prepared PMMA composite film is given in Fig. 1.



Fig. 1 Optical image of ZrTiO₄-PMMA nanocomposite film

2.3 Instrumentation

The powder X-ray diffraction pattern of zirconium titanate dispersed poly(methyl methacrylate) nanocomposite film was obtained from GEOL JDX-8P X-ray diffractometer using CoK α radiation. The morphology of the nanocomposite film was obtained from Leica Cambridge-440 scanning electron microscope. The infrared spectrum of PMMA composite was recorded on a Perkin-Elmer FTIR spectrometer [model 100] in the range 4000-300 cm⁻¹.

*Corresponding Author

Email Address: arun_lagashetty@yahoo.com (Arunkumar Lagashetty)

3. Results and Discussion

3.1 X-Ray Diffraction

XRD pattern of pure PMMA sample is reported in our earlier work [16]. The pattern shows the absence of Bragg's reflections indicates the amorphous nature of PMMA. Fig. 2 shows the indexed XRD pattern of zirconium titanate dispersed PMMA nanocomposite film. The pattern shows the presence of some zirconium titanate reflections and is indexed in the pattern by the reference of JCPDS file 034-0415. The zirconium titanate peaks in the composite pattern confirm the formation of zirconium titanate dispersed PMMA composite and development of crystallinity in the polymer matrix. Development of crystallinity in PMMA matrix is due to the complexation of zirconium titanate nanomaterials with PMMA matrix. A comparison of the x-ray diffraction pattern of pure PMMA with its zirconium titanate dispersed PMMA nanocomposites shows that the diffraction peaks is due to development of crystallinity in the amorphous PMMA. The broad halos in the region 5° to 20° correspond to the organic phase present in the PMMA.

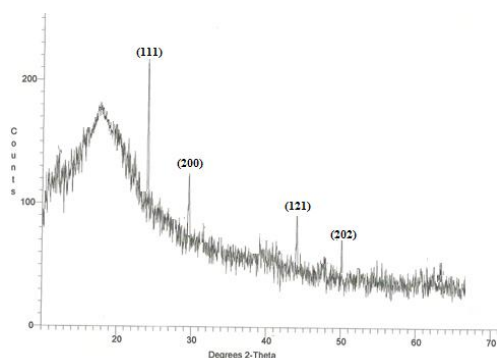


Fig. 2 XRD pattern of ZrTiO₄-PMMA nanocomposite film

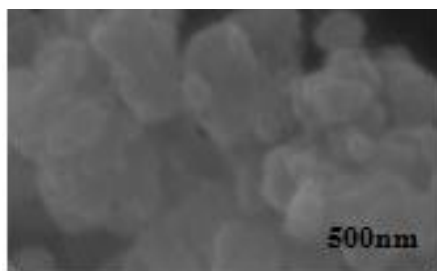


Fig. 3 SEM image of ZrTiO₄-PMMA composite film

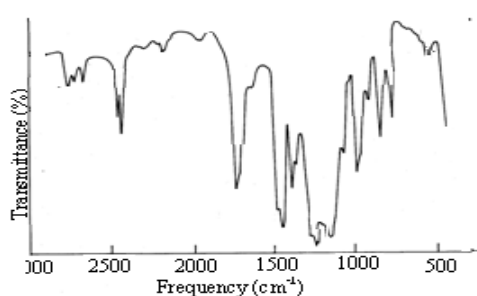


Fig. 4 FTIR of ZrTiO₄-PMMA composite film

3.2 Scanning Electron Micrograph

Morphological observation of the prepared composite sample was studied by using scanning electron micrograph images. Fig. 3 shows SEM image of ZrTiO₄-PMMA nanocomposite film. Zirconium titanate particles on the PMMA matrix can be observed. Irregular shaped zirconium titanate particles with self-doped compact arrangement can also be seen. Close packed compact arrangement of zirconium titanate particles with PMMA confirms the composite formation.

3.3 Infrared Spectroscopy

Bonding nature in the prepared composite was well studied with infrared study. Fig. 4 shows FT-IR spectrum of ZrTiO₄-PMMA composite

film. FTIR of pure PMMA is discussed in our earlier study [16]. Some additional peaks and shift in the frequencies in the PMMA composite spectrum in comparison with that of pure PMMA is observed. Some peaks shifts in the composite spectrum are due to the presence of inserted Zirconium titanate in the PMMA matrix and it may be possible due to H-type interactions between metal oxide and polymer matrix. Some characteristic peak of metal-oxygen [17] below 1000 cm⁻¹ is appeared in the composite spectrum indicates the presence of zirconium titanate particles. Some oxide peaks in the composite spectrum due to masked in the polymer matrix.

4. Conclusion

XRD study concludes the development of crystallinity in amorphous poly(methyl methacrylate) takes place due to incorporation of Zirconium titanate nanomaterials. Morphological changes was observed in the composite material by the addition of nanoscopic inorganic materials to polymers. Shift in the frequency and additional reflections and in the FTIR study is observed in PMMA composite compared to its pure PMMA. This work directs us to prepare new composites of PMMA with different nanomaterials.

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