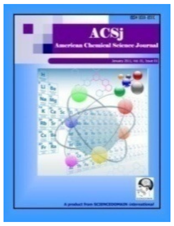

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Effect of Al_2O_3 Filler on Mechanical Behavior Acrylic Films

A. R. Bansod[1*], O. P. Chimankar[1], A. Gandhe[2] and B. Sannaki[2]

[1]Acoustical Research Lab, Department of Physics, RTM Nagpur University, Nagpur, India.
[2]Department of Physics, Gulbarga University, Gulbarga, Karnataka, India.

Authors' contribution

This work was carried out in collaboration between all authors. Author ARB designed the study managed the literature searches, performed the ultrasonic characterization, wrote the protocol, and wrote the first draft of the manuscript. Author AG performed the elemental and morphological analysis. Authors OPC and BS managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

In order to improve the mechanical properties of acrylic films, Poly methyl-methacrylate (PMMA)/Aluminum oxide (Al_2O_3) films are prepared following solution casting technique. The mechanical behavior of prepared films has been analyzed by employing Ultrasonic Pulse Echo method. The morphology of films is examined via XRD and SEM analysis. The synergetic effect is observed in films from obtained ultrasonic data. The elastic modulus is calculated and compared for better utilization.

Keywords: Ultrasonic pulse echo; thin films; XRD; solution casting technique.

1. INTRODUCTION

In order to fulfill the requirements of polymer industry many fabricators usually blend polymers together in order to reach an optimum balance of properties, this approach allows high flexibility in property adjustment and avoids development of new macromolecules which is generally long and

*Corresponding author: Email: ar.bansod@gmail.com;

expensive compared to polymer alloying [1]. Vigorous developments of polymer composite and extensive utilization of polymer materials in technology have led to the polymer composites [2]. Recently polymer matrix-ceramic filler composites receive increased attention due to their interesting electrical and electronic properties, integrated decoupling capacitors, angular acceleration accelerometers and acoustic emission sensors are some potential applications. Ceramic materials are typically brittle, possess low dielectric strength and in many cases are difficult to be processed requiring high temperature. On the other hand, polymers are flexible, can be easily processed at low temperatures and exhibit high dielectric break down fields. The present work deals with the effect of alumina as filler on the mechanical properties of poly-methyl methacrylate films [3-10].

2. EXPERIMENTAL WORK

2.1 Sample Preparation

Poly(methyl methacrylate) (PMMA) (Molecular weight Wm=1,20,000, purity 99%), Al_2O_3, and Acetone were obtained from S.D. Fine Chem. Ltd, Mumbai, India and used as received without further purification. The Citizon electronic balance of accuracy 10^{-4} has been used to measure weight amount of alumina powder and polymer powder. The composite films of 10, 20, 30, 40, 50 and 60 weight percent (Wt %) of Al_2O_3 are obtained by mixing it with the PMMA solution in acetone. It were then dried at 45ºC and kept under oven for 4h before use. In film preparation, filmogenic solution being poured into sterile glass plates of 5x5 cmand allowed to evaporate at ambient temperature and at atmospheric pressure. After evaporation of acetone, the films were further dried in a temperature–controlled oven at 65℃ for 3h to remove any remaining traces of acetone. The thicknesses of the thin films are in 0.2-0.4 mmrange. Density ρ of all thin films was determined by employing the Archimedes Principle using water as immersion liquid and applying the relation equation (1).

$$\rho = \frac{W_1}{W_1 - W_2}\rho_w \tag{1}$$

Where W_1 and W_2 are the weights of the thin films in air and in the water as immersion liquid respectively. ρ_w is the density of water.

3. CHARACETRIZATION

3.1 Structural Characterization

The powder method of X-ray diffractometer [Reguku] is employed to characterize the sample. In X-ray diffractometer, the polymer sample of PMMA has mounted at the centre and diffracted X-rays are recorded by proportional counter after passing through the PMMA sample. When the sample is rotated through an angle θ, the proportional counter is rotated through 2θ. The X-ray diffractometer recorded the spectrum showing the variation of intensity of diffraction lines with diffraction angle 2θ using. X-ray Diffractometer [Regaku].

The XRD spectrum for polymer composite film of PMMA with Al_2O_3 is given in Fig. 1. The appearance of sharp peaks indicates that sample possessed micro crystals also.

In case of composite films of PMMA with Al_2O_3 the micrographs are given in Fig. 2(a-d). The micrographs are given in different magnifications such as (a) 10 k x, (b) 25 k x, (c) 50 k x and (d) 200 k x. The sizes of the particles in this composite film are 55, 325, 350 and 455 nm.

3.2 Ultrasonic Characterization

The ultrasonic velocity and absorption are measured following Ultrasonic pulse echo technique using Pulsar Receiver MHF400 in gated mode with an accuracy of ±1m/s. The operating frequency is 2MHz from longitudinal wave transducer.

It also suggests that size of the particles formed in polymer composites are non-spherical in shape, which could be seen from FESEM images (Figs. 2 (a) and (b)).

The ultrasonic velocity *u* decreases with increase in Al_2O_3 concentration with sharp dip at 10% followed by 30% as shown in Fig. 3. It promotes dissociation of molecules. This dissociation relaxes the Al^+ ions and supports migrations of these ions. Observed absorption α/f^2 is found to be nearly same with increase in filler concentration except less value at 30% and decreases with Temperature as seen in Fig. 4.

Fig. 5 indicates that the acoustical impedance Z increases linearly with increase in Al_2O_3 concentration & decreases with temperature.

This can be explained as heavy metal ions are less susceptible towards displacement, therefore impedance increases. When thermal energy is provided, they now vibrate with higher displacement and therefore impedance decreases with temperature. The Internal pressure (Pi) is found to show same behavior with increase in Al_2O_3concentration in 2MHz frequency.

In Fig 6, it indicates that 20% addition of alumina in matrix enhances the mechanical properties of the polymer and this is confirmed from the Young's modulus.

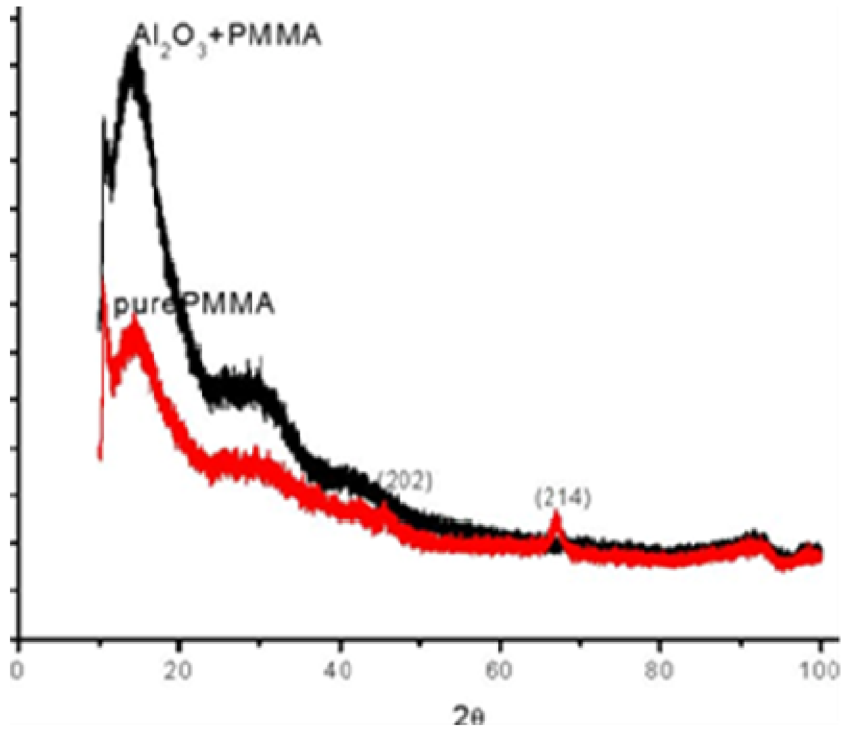
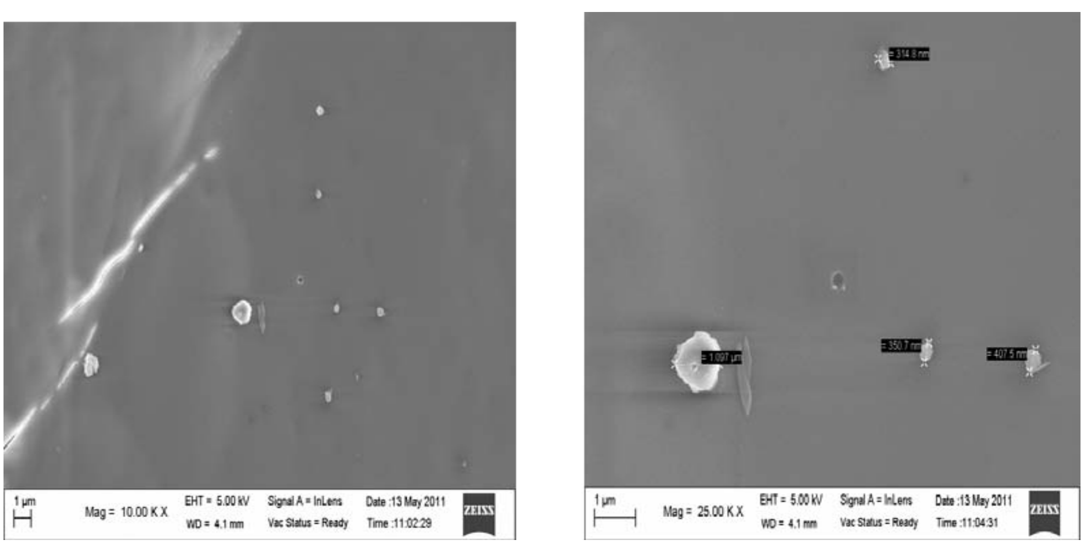


Fig. 1. XRD of PMMA and PMMA/Al_2O_3



Figs. 2. (a) and (b).FESEM of PMMA/Al_2O_3

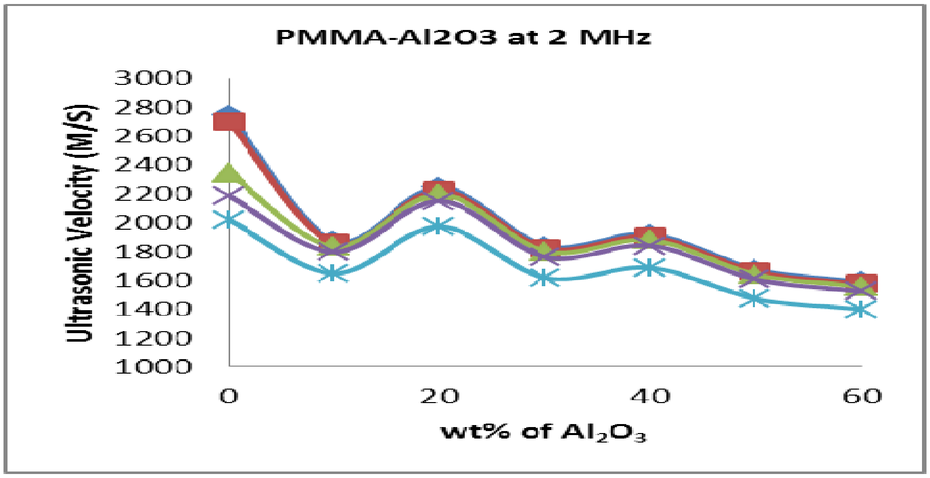


Fig. 3. Variation of ultrasonic velocity at 2MHz

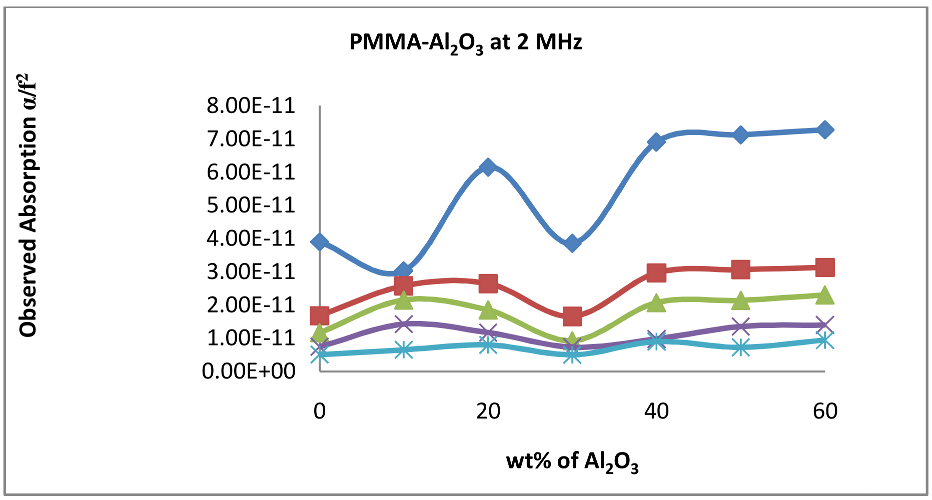


Fig. 4. Variation of observed absorption at 2MHz

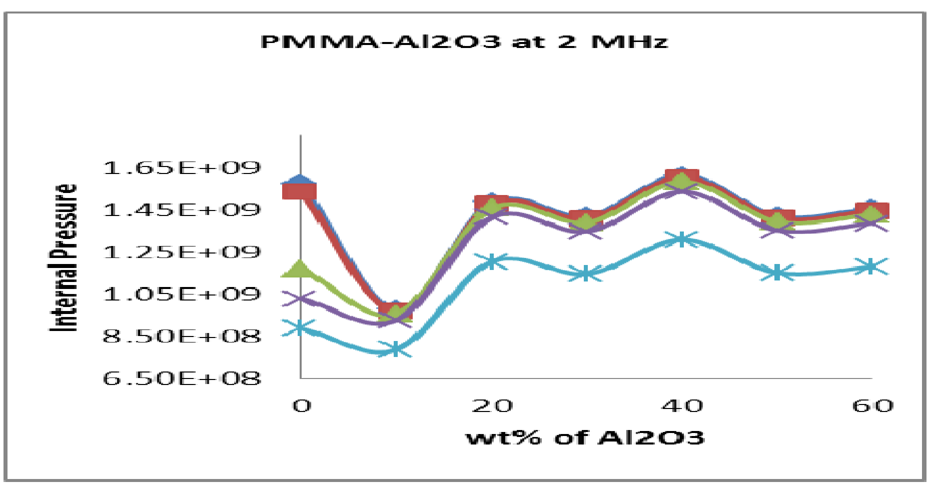


Fig. 5. Variation of internal pressure with Al_2O_3 conc

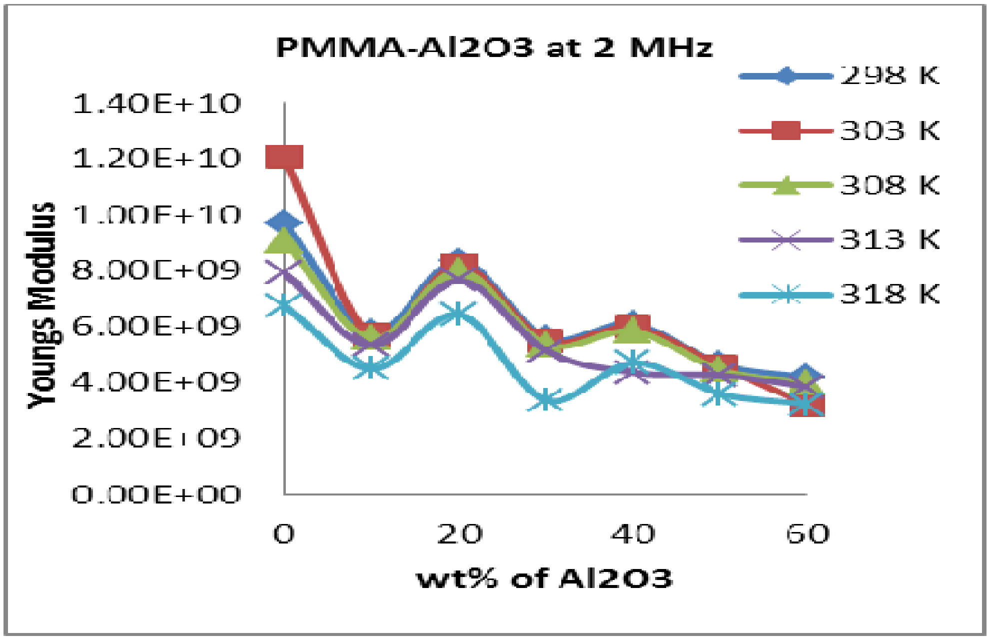


Fig. 6. Variation of young's modulus Al_2O_3 conc

4. CONCLUSION

The composition of PMMA/ Al_2O_3 shows mechanical properties as follows.

The XRD and FESEM of the prepared samples show non-spherical shape. The sizes of the particles in this composite film are 50-450 nm.

Ultrasonic velocity decreases with increase in concentration of Al_2O_3 promote dissociation of molecules except at 20% Al_2O_3.

These facts can be related as follows

As Wt% of Al_2O_3 in PMMA increases, the Dissociation of molecules occurs, this reduces ultrasonic velocity. At 20% Al_2O_3 the acceptance of additive entity is found more and hence young's modulus increased at that concentration. The internal pressure increases with the increase in filler quantity supports the compactness and size dependent absorbing capacity of acrylic materials.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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