



Mechanical and Thermal Properties of PMMA with Al_2O_3 Composite Films

KEYWORDS

Young's modulus, stress, strain, electron irradiation, weight loss.

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ABSTRACT The composite films of Polymethylmethacrylate (PMMA) with Al_2O_3 at different weight percentage such as 10, 30, 40 and 60 have been used for measurement of Mechanical properties such as stress, strain, and Young's modulus using the Universal Testing Machine at room temperature. The value of stress is increased linearly with strain up to the stress at break and afterwards shown discontinuity. The properties of stress and strain increased as weight percentage of Al_2O_3 increased with PMMA and at 30 weight percent the stress is increased linearly up to 29.08 MPa with strain. The young's modulus of the composite film of PMMA with Al_2O_3 is increased as weight percentage increased. Further, the weight loss and melting temperature of the composite films for pristine and for irradiation by electron beam at dose rate of 100 kGy were measured using Thermo Gravimetric Analysis and Differential Scanning Calorimeter. The weight loss of the composite film after electron irradiation is higher than that of its pristine. It is observed from DSC that melting peak is occurred at temperature 394.27°C for pristine and at 393.31°C after electron irradiation. Hence change in melting temperature is found to be 0.96°C.

INTRODUCTION

Polymer nanocomposites are a novel and fast-growing class of materials with nanosized filler domains finely dispersed in a polymer matrix. Polymer nanocomposites have improved physical properties such as thermal, mechanical, and dielectric properties as compared to conventional polymer composite due to the stronger interactions between polymer and filler phases [1,2]. The important use of nanomaterials is in reinforcing polymer matrices taking advantages of the ultra-high stiffness and hardness exhibited by them. Further, polymers and their composites after electron irradiation exhibit degradation and modifications in physico-chemical effects such as mechanical strength, color and electrical conductivity [3,4]. In current research, it has shown that small additions of certain nanomaterials modify the mechanical properties. The precise mechanism responsible for this enhancement in physical properties is not entirely understood. It is generally believed that molecular level interactions between the nanomaterials and available for such interactions clearly hold the key for the modifications in mechanical properties [5].

EXPERIMENTAL MEASUREMENT

Polymer substance of PMMA and Al_2O_3 are obtained from S. d. Fine Chem. Ltd, Mumbai, India. The different weight percent of Al_2O_3 substance have been used with PMMA for preparing the composite films. The composite films of PMMA polymer with Al_2O_3 are prepared by solution casting method [6] for different weight percentages such as 10, 30, 40 and 60. The mechanical properties are studied by using Universal testing Machine (UTM). These prepared samples are irradiated by electron beam at a dose rate of 100 kGy using Microtron facility at Mangalore University, Mangalore. The Thermal properties for these samples before and after electron irradiation have been measured using TGA (SDT Q600 V20.9 Build 20) and DSC by taking samples of weighing at 6.0 mg were scanned in the temperature range of 0-600 °C under nitrogen atmosphere at a heating rate of 20 °C/min.

RESULTS AND DISCUSSION

Thermal properties:

The weight loss of composites films of PMMA with Al_2O_3 at 10 weight percent have been measured before and after irradiation by electron beam at a dose rate of 100 kGy are given in Figure 1. Here it is observed that the composite film before

irradiation lost its weight 78.30% (4.921 mg) at 358.79 °C and after electron irradiation it lost its weight 100.4% (6.090 mg) at 359.64 °C. This reveals that the weight loss of the composite film is increased after electron beam irradiation.

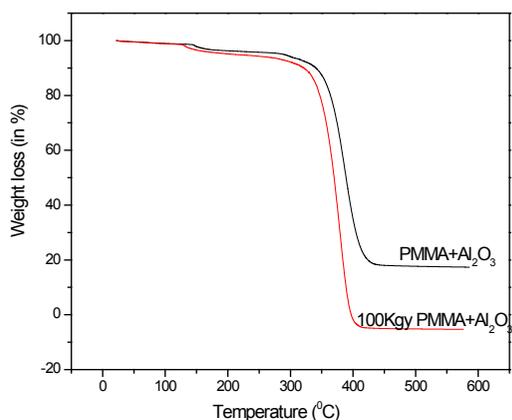


Figure 1. Plots of TGA for Pristine and after electron irradiation of the composite films.

The DSC is also measured for the same 10 weight percent of the composite films of PMMA with Al_2O_3 and is given in Figure 2. It is observed from Fig. 2 that the melting is occurred at temperature 394.27°C for pristine and after electron irradiation it is occurred at 393.31°C. From these results it has been observed that the melting temperature of the composite films of PMMA with Al_2O_3 is decreased after electrons irradiation. Hence it is observed that after electron beam irradiation at a dose rate of 100 kGy the melting temperature of the composite film decreased by 0.96 °C.

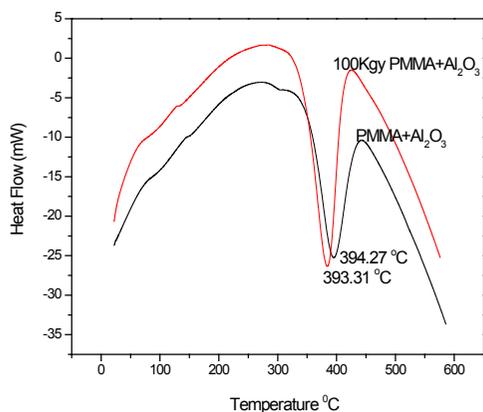


Figure 2. Plots of DSC for Pristine and after electron irradiation of the composite films.

Mechanical Properties

The tensile strength, Young's modulus and stress at break for the composite films of PMMA with Al_2O_3 for different weight percentages such as 10, 30, 40 and 60 are given in Table-1. Here it is observed that the tensile strength and stress at break except at 10 wt% goes on decreased as weight percentage of Al_2O_3 increased in the composite films PMMA. But in case of Young's modulus as weight percentage of Al_2O_3 increased the Young's modulus is also increased. Hence it is observed that the mechanical properties of the polymer of PMMA have been modified by making its composites with Al_2O_3 at different weight percent. The stress versus strain results of the composite films of PMMA with Al_2O_3 for different weight percentages such as 10, 30, 40 and 60 are given in Fig 3. It is noticed from Fig 3 that the discontinuity in stress i.e. the stretching stress for 10 wt% is 16.05, for 30 wt% is 28.88, for 40 wt% is 20.14 and for 60 wt% is 17.09 MPa. Hence it is observed that as weight percentage of Al_2O_3 increased the region of stretching in stress is also increased. The rupture strain for 10 wt% is 0.025, for 30 wt% is 0.038, for 40 wt% is 0.021 and for 60 wt% is 0.015. But except for 30 wt% it is observed that the rupture strain decreases as weight percentage of Al_2O_3 goes on increases. Hence it is observed that the mechanical properties of the polymer PMMA have been modified by its composites with Al_2O_3 at different weight percent.

Table 1.
The mechanical properties of composite films.

Composite film	Wt % of Al_2O_3	Tensile Strength (MPa)	Young's Modulus (MPa)	Stress at Break (MPa)
PMMA with Al_2O_3	10 wt%	15.86	894.23	15.86
	30 wt%	29.42	956.45	29.42
	40 wt%	19.88	1007.00	19.88
	60 wt%	16.93	13592.21	16.93

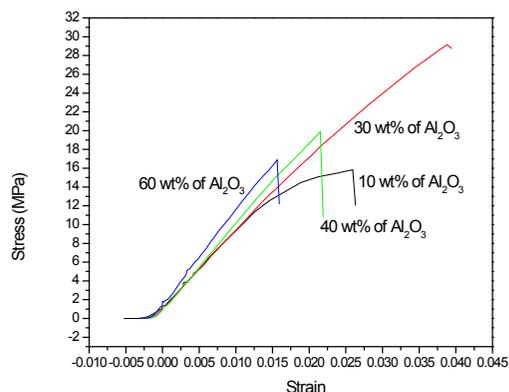


Figure 3. The plots of stress versus strain of the composite films at different wt% of Al_2O_3 .

4. Conclusions

The weight loss of the composite films of PMMA with Al_2O_3 is increases after electron beam irradiation at a dose rate of 100 kGy. It is also observed that after electron beam irradiation at same dose rate the melting temperature of the composite film decreases by 0.96 °C. Further, the mechanical properties of the polymer of PMMA have been modified by its composites with Al_2O_3 at different weight percentages. The stretching in stress is increases but the rupture strain decreases as weight percentage of Al_2O_3 increases.

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