International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
www.ijset.com, Volume No.1, Issue No.3, pg : 114-116 01 July 2012

Nano and Micro Structural characterization and Effect of electrical stress on microhardness of Laser dye Rh (6G) doped PMMA

Pradeep Kumar Dubey*, Dr. R. Bajpai and Dr. J. M. Keller

Department of PG Studies & Research in Physics & Electronics,
R.D.V.V, Jabalpur – 482 001, M.P
*****E-mail: dubeypk47@rediffmail.com , Cell: 997768561, India

Abstract
Polymeric materials of pure and laser dye Rh (6G) doped PMMA with various compositions were prepared by solution cast method. SEM micrographs, designate comprehensive chain formation with homogeneous texture of laser dye Rh (6G) doped PMMA. The AFM imaging helps us to investigate the nanophase domain morphology of the pure and doped specimens. The phase domain distinction emphasizes the difference in the mechanical interface in doped polymers and surface region of the samples. The effect of electrical stress on microhardness studies have been carried out on pure and doped specimens at various loads using Vicker's microhardness testing. The outcome of SEM and AFM investigations have been correlated with electrically stressed microhardness values.

Key-words: Polymeric materials, Electrical stress, microhardness, SEM and AFM.

INTRODUCTION

Laser dyes are organic compounds that relax radiatively after optical excitation, emitting in the visible or infrared range. These dyes have a range of practical applications when rigidized in a polymer host. One area that may be revolutionized by the use of organic luminophores in plastics is the flat-screen monitor industry. Current thin screens typically use expensive, delicate plasma technology. Organic emitter doped polymer layers offer an inexpensive, malleable, and easy-to-produce alternative. Organic dyes are also of interest for sensors, optical amplifiers, and fiber optics applications **[1]**. Rh (6G) is most widely used laser dye Rhodamines are important fluorescent dyes, chromophores, for spectral calibration in fluorometers, single-molecule detection, as imaging agents for bio molecules.

2. Experimental

2.1 Materials

The Polymethyl methacrylate PMMA (low molecular weight) in granular form as obtained from M/s Research Lab Chem. Industries, Mumbai, India and Rhodamine (Rh6G) and Ammonium Purpurate a crystalline nitrogenous substance having a splendid dichroism, being green by reflected light and garnet-red by transmitted light from Burgoyne, Bridges and Co. Mumbai (India) were used in the present

investigation. Pure and Rhodamine (Rh6G) thin films about 20 to 90 μm in thickness were prepared by the solution cast technique on plane glass substrates inside an oven at 333 K using Benzene as the widespread solvent. Thin films of various compositions of PMMA: Rh (6G):: 2g: 0.005mg, 2g : 0.05mg, 2g : 0.5mg ; and pure PMMA were obtained. The samples so prepared were out gassed in air for 24 hr, followed by room temperature out gassing at a pressure of about 10^{-4} Torr, for a further period of 24 hrs.

2.2. Characterization

The prepared dry samples of Rhodamine (Rh6G) doped Polymethyl methacrylate (PMMA) were characterized by the methods discussed below.

2.2-1 Scanning Electron Microscopy (SEM)

The SEM of the prepared pure and Rhodamine (Rh6g) doped Polymethyl methacrylate (PMMA) films were recorded without sectioning and coating on the scanning electron micrograph (JSM-5600 LV).

2.2-2 Atomic Force Microscopy (AFM)

The AFM consists of a microscale cantilever with a sharp tip (probe) at its end that is used to scan the specimen surface. The cantilever is typically silicon or silicon nitride with a tip radius of curvature of the order of nanometers. AFM topography of pure PMMA and Rhodamine doped PMMA specimens were imaged using (DIAFM-4 instrument) in tapping mode.

2.3 Microhardness measurement

The microhardness of the dry samples were studied with the help of mhp 160 micro hardness tester equipped with a Vicker's diamond pyramidal indenter having a square base and 136º pyramid angle attached to a Carl Zeiss NU2 universal research microscope. The following relation has been used to calculate the Vicker's hardness H_v:

$$H_v = \frac{1.854 \times L}{d^2} \text{ kg/mm}^2 \quad (1)$$

Where L is the load in kg and d is the length of the diagonal of indentation, in mm. Indentations at each load were obtained in replicate number and average hardness number was calculated.

RESULTS AND DISCUSSION

SEM Analysis

The SEM micrographs of 0.5mg Rh (6G) doped PMMA is shown in Figure 1. The micrograph for 0.5 mg Rh (6G) doped PMMA specimen, the phase behavior shows inhomogeneity and phase separated morphology . Homogeneous phase indicates better miscibility of the two materials. However, with increase in the weight percent of Rhodamine (Rh6G) to 0.5 mg in the PMMA matrix shows the inhomogeneity of phase separated behavior.

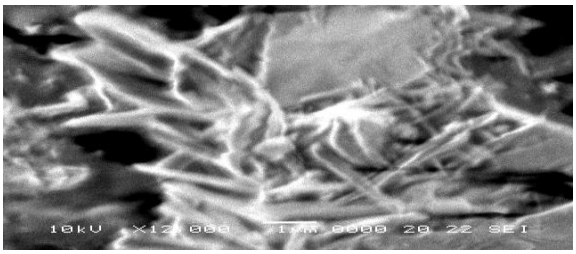

Figure 1. SEM image of 0.5 mg (Rh6g) doped PMMA

AFM Analysis

The surface morphology of 0.5mg Rh (6G) doped PMMA was investigated by three dimensional Atomic Force Microscopy (AFM) as shown in Figure 2.

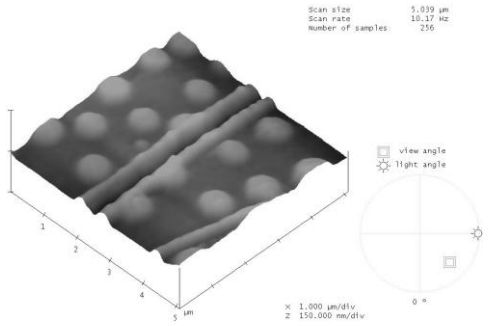

Figure 2.AFM 3D topograph of 0.5mg Rh6G doped PMMA

The AFM images of 0.5mg Rh (6G) doped PMMA reveals the granular particles having spherical or elliptical nature. The spherical or elliptical grains could be attributed to faster growth due to higher concentration of Rh (6G) in PMMA. The spherical nano area phase [2] at the surface of PMMA gives the information on the surface morphological change due to the interaction between the laser dye molecules and PMMA polymer. This reveals the control in nano phase area, which tends to improve the microstructural, morphological and optical properties of polymer.

Effect of Electrical stress on Microhardness

Figure (3) reveals the variation of Hv with load for electrically stressed specimen of pure PMMA, 0.5 mg, 0.05 mg, 0.005mg Rhodamine (Rh6G) doped polymethylmethacrylate at 110^o C and field 25 kV / cm.

It is evident that the value of microhardness $H_{v,}$ is increased in comparison to untreated samples and saturation point of untreated samples are obtained in low load region while for electrically stressed samples the saturation points are obtained in high load region, which shows that the train hardening effect is more in comparison to untreated samples. The value of H_v is gradually increasing from lower load to higher load region for both untreated and electrically stressed samples, which exhibits the crosslinking network also formulated as applied load is increasing. The value of Hv is lowest for pure PMMA and highest for lowest doping of Rhodamine in PMMA, which explains the doped molecules is more hardened than pure samples with better crosslinking between the dye material and the polymer chains of PMMA. It is also clear that the crosslinking of Rhodamine in PMMA is increasing with decreasing the concentration of Rhodamine doped samples. Similarly, the crystallite size has also the optimum value for moderate doping of Rhodamine, which reflects the ordered packed polymer chains are present inside the main chains. These observations successfully explains that the thermal treatment during polarization and simultaneous application of electrical field enhances the network morphology of doped specimen and their crystalline behaviour to such an extent that the microhardness increases to an appreciable extent.

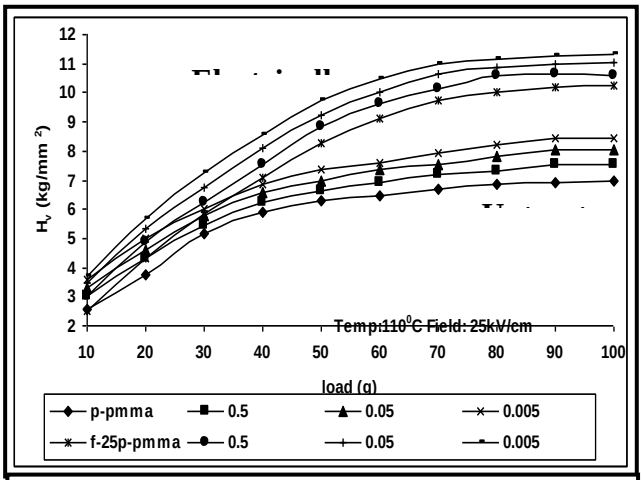

FIGURE (3) Variation of Hv with Load for

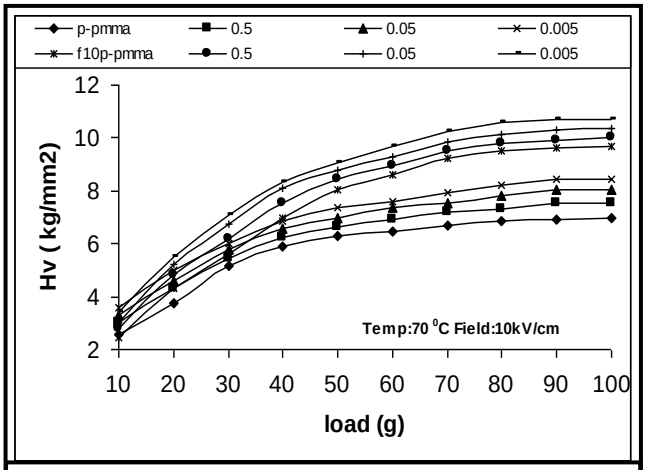

FIGURE (3) Variation of Hv with Load for untreated

CONCLUSION

These results indicated that the Rh (6G) doped PMMA forms compatible polymeric material. Electrical and mechanical stress results in significant changes in the mechanical properties. Cross linking and scissioning phenomena occur depending upon the level of stress developed and chemical structure. The doped polymer shows better elemental, microstructural correlation, morphological features and nano domain structure as investigated by SEM and AFM techniques which can be extensively useful for elegant multitask polymers for leading edge tools.

REFERENCES

1. P. K Dubey, R.Bajpai and J.M.Keller, Microsystem Tech. Springer, **14**(2008) 1165-1171

2. S.Y. Hobbs, *Polymer Morphology Plastic Polymer Science and Technology*, vol. 4, 2nd Editions. John Wiley & Sons (Academic Press, New York, 1982