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PI and PI+ITO+GO Polymeric Composite Thin Films: A Study of Electron Radiation on its Surface Microhardness

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Abstract: ***When polymer film or polymeric polymer composite films were exposed to electron radiation they undergo chain scission or crosslinking according to their different physical parameter. For radiation scission and crosslinking are two opposite consequences. The effect of electron radiation on the surface microhardness of PI and PI+ITO+GO polymeric composite thin films was studied to understand and analyze the radiation-induced crosslinking and radiational scissioning. The Carl Zeiss NU_2 Universal research microscope was used to measure study the surface microhardness of the radiated films. The value of H_v is found to be higher for polymeric composite radiated films. The maximum level of microhardness occurs around the radiation dose of 0.6 Mrad. The variation of H_v with electron radiation doses ranging from 0.2 to 1.6 Mrad, at various loads of 20, 40, 60 and 80g. The dose at 0.6 Mrad found to have maximum value of microhardness within all the PI+ITO+GO films.***
Keywords: Polyimide, Indium Tin Oxide, Graphene Oxide, Electron Radiation, Microhardness.

I. INTRODUCTION

The interest in environmental issues is growing very fast and hence there is increasing demand of environmentally friendly materials, which do not burden the environment significantly. Hence, Polymeric composite thin films are an important class of materials being specifically designed and used for the applications, which take advantage of enhanced properties, offered by properly fabricated materials. The modification of polymeric composite thin films by radiation is an important industrial process throughout the globe. Extensive studies have been undertaken to understand this technology and the effect of radiation on the most significant classes of polymers and polymeric composite films are reasonably well catalogued and understood [1-6].

Electron beam accelerators produce a stream of electrons moving at very high speeds. The electrons are generated when a current is passed through a tungsten wire filament in a vacuum. The wires heat up due to the electrical resistance and emit a cloud of electrons. These electrons are then accelerated by an electric field to over half the speed of light and pass out of the vacuum chamber through a thin titanium window into the atmosphere.

Once outside the vacuum chamber, the electron beam can be used for a number of applications including polymerization, sterilization, air treatment and plasma generation, amongst others. The accelerator has a large lead encased vacuum chamber containing an electron generating filament or filaments powered by a filament power supply. During operation, the vacuum chamber is continuously evacuated by vacuum pumps.

The PI and PI+ITO+GO polymeric composite films of different composition were radiated with different doses of electron on different load to study their surface microhardness. The microhardness properties of PI and PI+ITO+GO polymeric composite can also be studies on factors including the individual structures materials. The radiational environment also affects the macromolecules behavior of PI and polymeric composite thin films. The gross effect of radiation may vary with the variation of radiation dose and the percentage concentration ITO+GO.

The value of H_v was then calculated for PI and polymeric composite thin films from the measured diagonals of the indentation.

II. CHARACTERIZATION

A. Electron Radiation

The electron radiation on the 5 cm square shaped and 15 μm thickness PI and PI+ITO+GO (films designated as PITOGO-1, PITOGO-2, PITOGO-3, PITOGO-4 and PITOGO-5) polymeric composite thin films were carried out at the beam dose form 0.2 to 1.6 Mrad (dose interval 0.2) using electron accelerator (ILU-6-M_3 type) [6] with an electron beam of energy 2MeV with given pulse rate of 10 pulses/s. Before electron radiation characterization the films were cured for 160°C for 2 h as to avoid hydroscopic possibilities.

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B. Microhardness

The microhardness characterization was performed using Carl Zeiss Universal Research microscope (NU_2) universal research microscope attached with a Vickers diamond pyramidal indenter [7]. The H_v (Vickers Hardness number) was calculated using the relation:

$$H_v = \frac{2L\sin\theta/2}{d^2} = \frac{1.8544 \times L}{d^2}\left(kg/mm^2\right)$$

Where, L is load in kg and d is diagonal of Vicker's indentation in mm.

III. RESULT AND DISCUSSION

The electron radiation beam ranging from 0.2 to 1.6 Mrad had been used to study the surface microhardness of PI ad PITOGO polymeric composite thin films. The nature for choosing these does rang is to understand electron radiation stems in more straight forward and comprehensive way, however, dose rang above 1.6 Mrad causes complexities in event distribution which still evade a complete understanding.

PI and PITOGO polymeric composite thin films absorb energy from energetic electron charged particles and injected in their medium gets trapped inside and transforms some form of reactivity and also provide radiation crosslinking.

Figures 1 - 4 illustrate the variation of H_v with electron radiation doses ranging from 0.2 to 1.6 Mrad, at various loads of 20, 40, 60 and 80g. Moreover, after 80g mechanical deformation in the physical properties was observed within the PI and PITOGO polymeric composite thin films and they exhibit the similar trend in the given dose range. The best microhardness result was observed at the load of 60g.

The most fascinating effect of radiation is observed around the dose of 0.6 Mrad. At this dose level, the increase in the value of H_v is approximately 70% for all the PITOGO polymeric composite thin films in compare to PI film.

The figure 1-4 clearly shows that the values of H_v for electron radiated polymeric composite thin films are higher in compared to the corresponding non-radiated ones. The radiated PITOGO-2 found to have higher value of H_v among the other polymeric composite thin films.

The level of microhardness for PI and Polymeric composite thin films found to be maximum amongst all the radiated dose of 0.6 Mrad at all the loads. Thereafter, the value of H_v gradually decreases with increase in dose. However, these values are still higher than the corresponding PI films. Increase in the values of H_v values for PITOGO polymeric composite thin films in compare to PI film indicate the predominance of radiation crosslinking and also reveal the increase in crosslink density between the particles of ITO and GO with the chains of PI matrix.

The crosslinking occurs due to free radicals, which are produced in the polymer matrix. When accelerated electrons interact with the ITO and GO particles along with constituent polymer metrix and they develop a dense crosslink network.

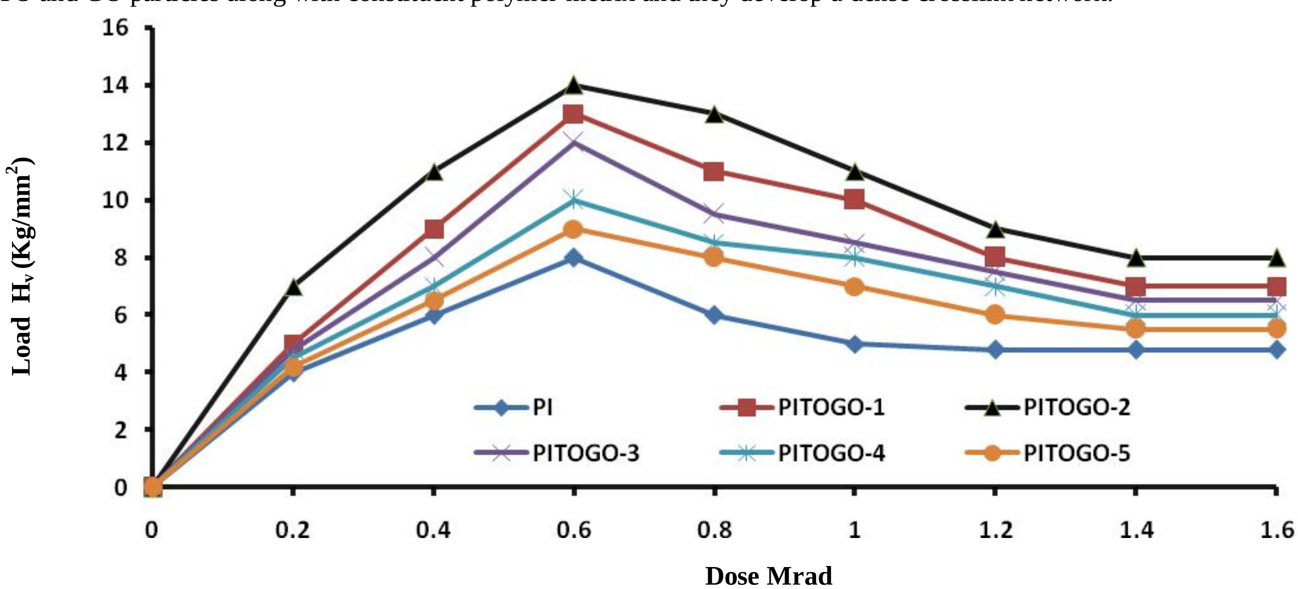

Figure 1: Variation of H_v with dose of electron radiation at the load of 20g.

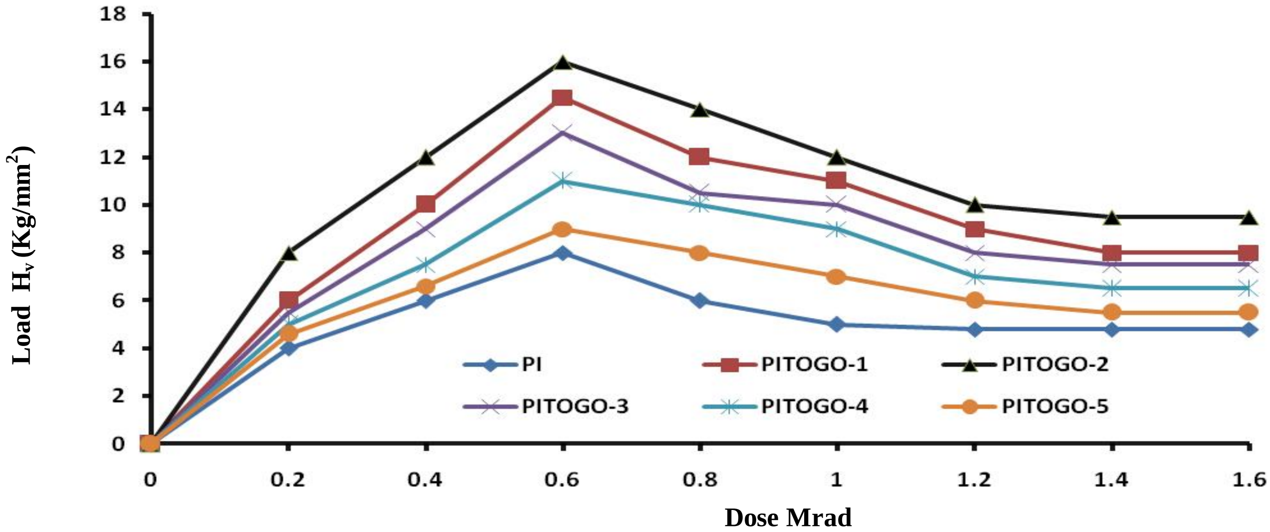

Figure 2: Variation of H_v with dose of electron radiation at the load of 40g.

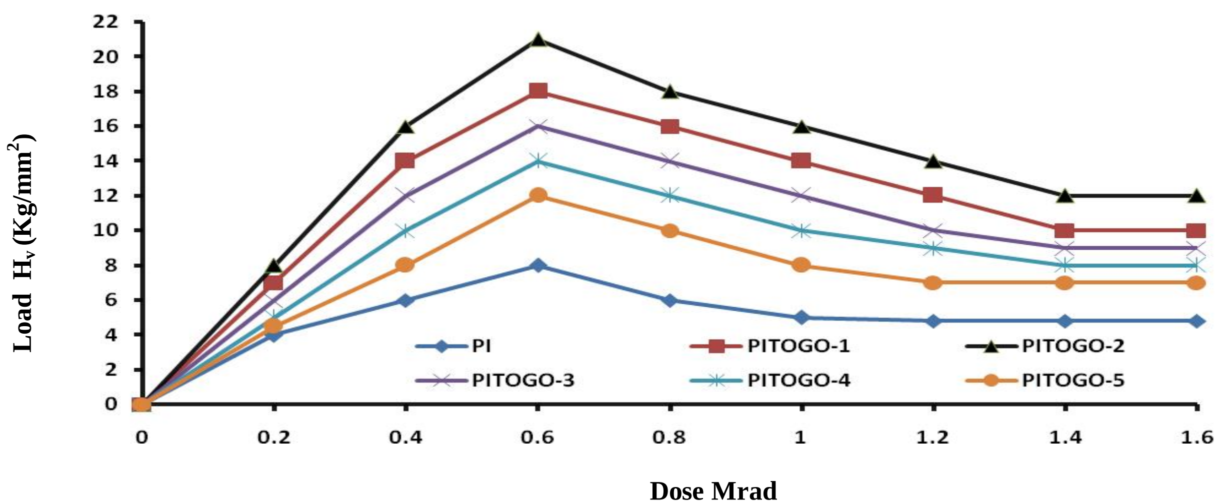

Figure 3: Variation of H_v with dose of electron radiation at the load of 60g.

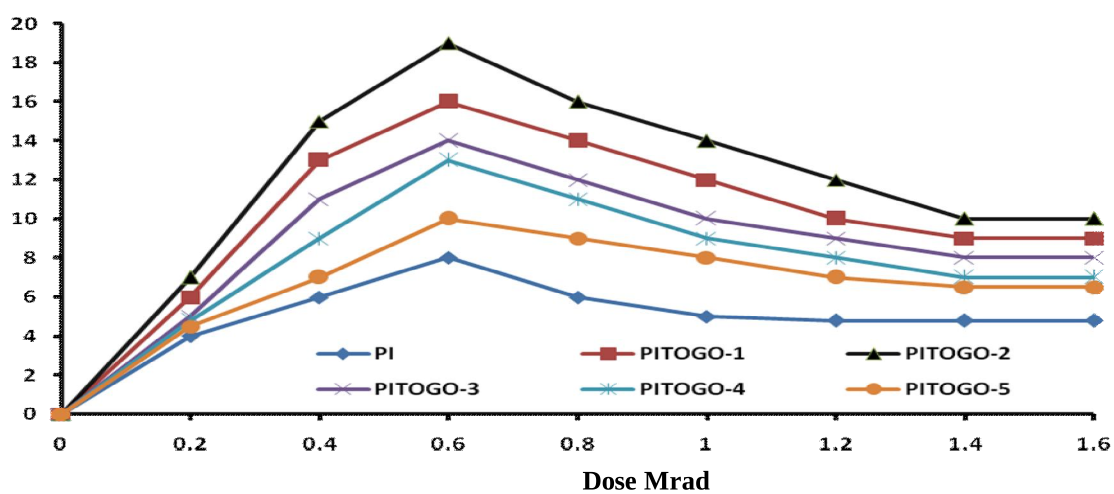

Figure 4: Variation of H_v with dose of electron radiation at the load of 80g.

IV. CONCLUSIONS

This research paper had illustrated the H_v profile curves at versus dose of electron radiation, it can be concluded that the electron radiation produces hardening in the PI+ITO+GO polymeric composite thin films. The value of H_V was found to be maximum at 0.6 Mrad and at the load of 60 g. Moreover, beyond the dose rate of 1.6 and load at 80 g, the PI and PI+ITO+GO composite thin films become brittle and cracks are observed.

The study reveals that electron radiation of PI and PI+ITO+GO polymeric composite thin films, which leads to significant change in the microhardness properties due to simultaneous occurrence of radiation crosslinking dense packaging of ITO+GO particles within PI matrix and radiation scissioning phenomenon. Thus advance and multi-graded polymeric composite thin films can be developed with optimum weight proportion having good mechanical properties (microhardness) with environmental friendly in nature.

V. ACKNOWLEDGMENT

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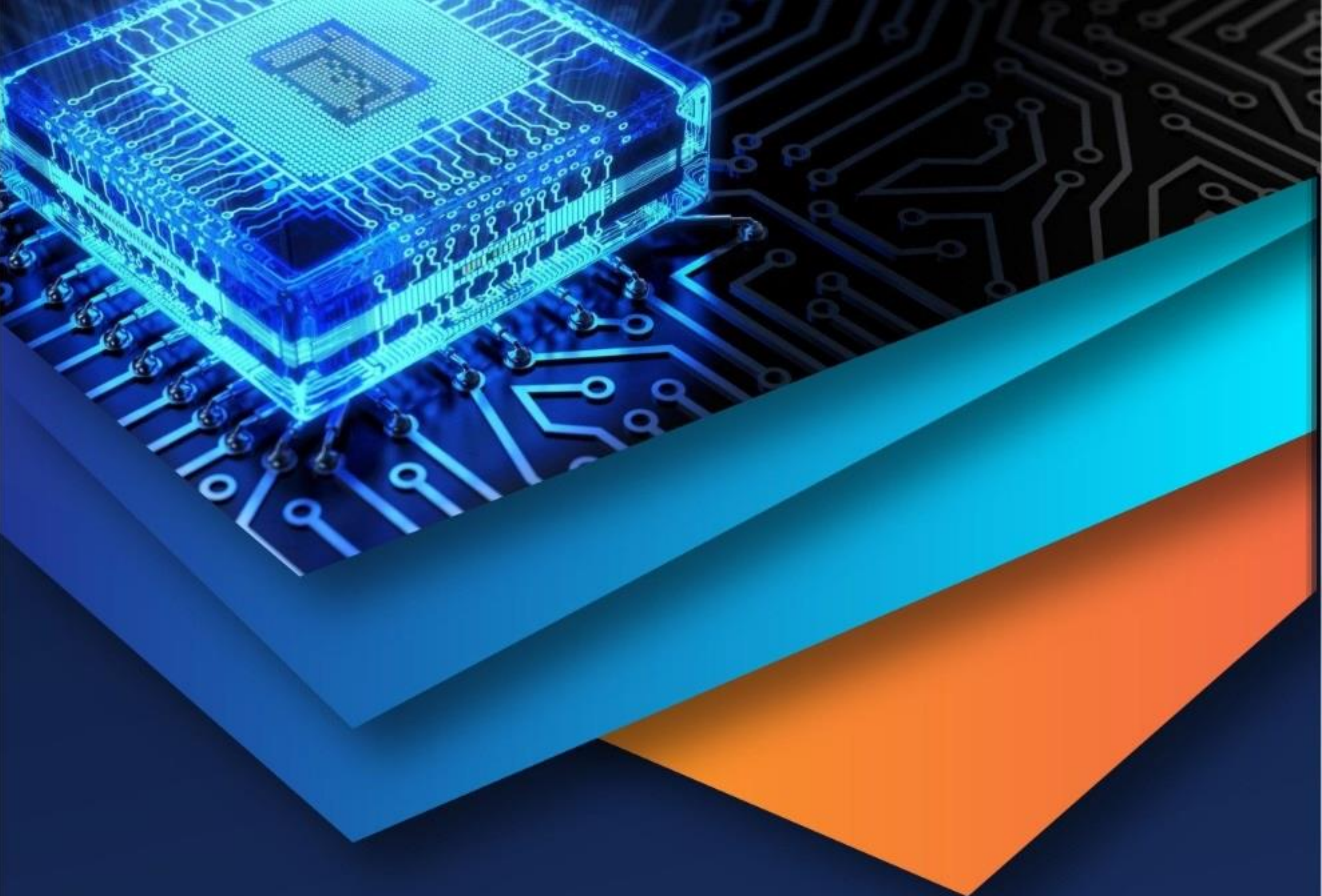

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