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Dosimetric Aspects of Nylon6 and Its Copolymer

A.Raju[1], B. Sanjeeva Rao[2] and K.Madhukar[3]

1, Research Scholar, Department of Physics, Rayalaseema University, Kurnool. India
2, Govt. Degree College, Rangasaipet Warangal. India
3, Department of Physics, Osmania University, Hyderabad. India
*Corresponding Author E-mail id: amireddyraju123@gmail.com

ABSTRACT - Nylon 6 (PA6) is an industrially important polymer used for different applications. However dosimetric applications of the polymer were not attempted previously, In this context, the authors made n attempt in this regard with ESR as experimental technique. ESR spectra of irradiated PA6 and its copolymers have been recorded at various radiation doses .Linearity of ESR intensity against radiation dose has been verified. The results suggest that nylon 6 and its copolymers are excellent materials for dosimetric applications.

Key words: *ESR spectra, Free radical, Gamma irradiation, PA6 and copolymer.*

I.INTRODUCTION

Measurement of radiation dose is an important aspect in medical physics. For this purpose various types of dosimeters are available. Various types of dosimetric materials are prescribed in literatures using different experimental techniques. Till now alanine is considered to be the best material for dosimetric applications. But all nine dosimeters are expensive and have transportation problem. Therefore need for easily transportable, inexpensive dosimeters are need of hour. Polymer dosimeters are best suited to meet this requirement various types of polymer dosimeters are reported in the literature. They are polycarbonate, poly glycolic acid etc. A good dosimeter posses good radiation dose response and constant temperature/thermal stability. As a part of looking into good radiations, dosimeters, the polymers employed in the present studies are investigated to posses' dosimetric applications.

If any physical property of the system varies linearly with radiation dose, that materials treated as suitable for dosimeter applications. Since exposure to radiation induced chain cleavages and production of free radicals, the concentration of free radicals has to vary linearly with radiation dose. Therefore polymers under present investigation are exposed to different radiation doses and variation free radical concentration against radiation dose is plotted.

With regard to DA, for quantitative ESR measurement, the magnitudes of the microwave power and modulation amplitude are kept as constant in the linear region of the relationship signal intensity value of instrument parameter. Influences of applied microwave power and modulation amplitude on the ESR spectrum shape and intensity have been investigated. Recording of the spectrum at high modulation amplitude gives a two fold increase in signal intensity as compared to the normal material. The doubling of ESR response may make the use of the concerned material for low dosimetric applications.

Alanine is one of the mostly used materials for ESR dosimetry [**T. Kojima et al, 1989**] due to its good dosimetric properties such as sensitivity and stability of ESR signal with time. Besides alanine attempts have been made to explore new dosimetric materials with better radiation sensitivity [**G. M.Hassan et al, 2005** and **S. P. Dias et al, 1999**]. The new material is expected to have a stable radical per radiation energy, sharp line width and thermal stability at room temperature. In this aspect **Mejri et al, 2012** have proposed PGA as dosimetric material. The PGA dosimeter has good sensitivity for low dose, a wide useful dose range and it does not require any special preparation. In order to find useful dose range for PGA, the response curve was plotted with H_{pp} (specific higher peak to peak) versus radiation dose.

Standard dosimetric system should have radiation stability after radiation exposure because in addition to its use in calibration of radiation environment and routine dosimeter for transferring information from an accredited standard to an irradiation facility in order to establish traceability for that calibration facility. Hence radiation induced radicals is an aspect in radiation dose measurement by ESR spectroscopy. Therefore **Mejri et al, 2012** have recorded ESR spectrum of irradiated PGA up to 60 days of post irradiation time.

To study the decay process of free radical species the effect of post irradiation heat treatment on PGA response fading behavior of PGA. The result showed that post irradiation heat treatment led to fast fading due to the recombination of radicals/defects in PGA matrix. The heating at 140°C to 15 minutes was found to be the most suitable procedure to stabilize the response of irradiated PGA dosimeter.

ESR technique is used as a method to measure radiation dose with L-alanine as dosimetric material [**D. Regulla et al, 2000**]. Since L-alanine exhibits linear dose response and radical stability, it is suited for dosimetric applications. As a search for new materials for ESR dosimetry **Lund et al, 2002** have made an attempt on some materials like ammonium tartarate, 2-methyl alanine, salts of formic acid, dithionates and malonic acid. The results suggest that ammonium tartarate and 2-methyl alanine have twice as sensitive as L-alanine. The formate and thionate systems have also shown high sensitivity. High radiation yield, linear increase of ESR signal with radiation dose, narrow line width and stable at room temperature are the important characteristics of an ESR dosimeter according to **Ikeya et al, 2000**Though alanine meets these requirements and search for alternate material is made. In this context, smart phone screen glass, sugars are also tried as dosimetric materials [**K. S. Alzimami et al, 2014**]. In this context **Hasan et al, 2005** have investigated the potential of Gallic acid and its esters for dosimetric aspects. These authors have investigated the radiation sensitivity of Gallic acid anhydrous and monohydrate Ocryl, Lauryl and Ethyl gallate in the dose range of 0.5-20 kGy using ESR spectroscopy. The results indicate that the dose response curve of these materials is found to be complex .These materials find good dosimetric aspects in the intermediate range radiation dose. **Marrale et al, 2014** studied ESR response of phenol compounds for dosimetry of gamma photons beams. The phenols used in this investigation are designated as IRGANOX 1076. The IRGANOX 1076 has shown linear dose response in the dose

range of 12-60 Gy. The advantage of this type of dosimeter is their ability to measure very low radiation dose less than 1 Gy. The ESR signal is found to be stable for thirty days. The mass absorption coefficient of this material has equal value ad that of soft tissue.

Adolfson et al, 2014 have studied the dosimetric aspects of very small dosimeter having dimensions of 4.5mm3mm4.8-3mm with lithium formate as material. This type of small dosimetry is suited for measurement of radiation dose gradients. These authors have prescribed measures for optimization of ESR dosimetry systems for high precession dosimeters. Though alanine is widely used as dosimetric material, choice of parameters for ESR readant is also important while studying dosimetric aspects [**T. Garcia et al, 2009**]. The results showed that alanine dosimetry system is useful to measure doses down to a dose of 2 Gy for radiotherapeutic systems.

II. EXPERIMENTAL

PA6 and its copolymers in powder form are used in the present studies, The polymers are exposed to gamma source (Cobalt 60) with a dose rate of 15 K Gy / hr in air at room temperature,, ESR spectra are recorded on VARIAN X –band spectrometer at 100 K Hz modulation. Dose absorbed by the material is calibrated to the time of radiation.

III. RESULTS AND DISCUSSION

ESR spectra of irradiated PA6 homoplymer at different radiation doses are as shown in Fig 1. Curves 1, 2, 3 are the spectra of PA6 exposed to 1, 3, 4 M. rad dose of irradiation. ESR intentensities are calculated and plot of intensity against radiation dose is plotted as shown in Fig2, The curve is linear indicating that PA6 is suitable for radiation dosimery.

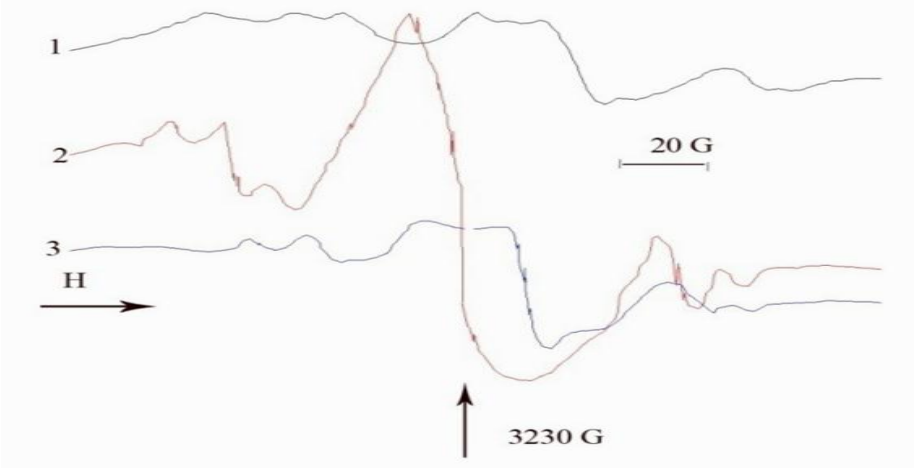

Figure 1: ESR spectra of irradiated PA6 at different doses Curve1 1M.rad, Curve 2 3M.rad, Curve3 4M.rad

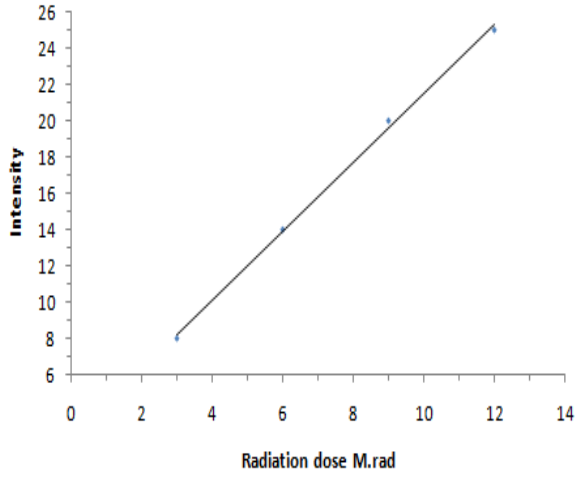

Figure 2 Variation of Radiation dose against Intensity

The ESR intensity is found to vary with radiation dose indicating through the PA6 is suitable for dosimetric application.

IV EFFECT OF TEMPERATURE:

Though the some materials are suitable for dosimetric application a good dosimeter has to be stable up to wide temperature range. In order to investigate temperature dependency of radiation dosimeter.ESR spectra are recorded for PA6 irradiated to different radiation dose at different temperatures. ESR intensities are calculated and intensity radiation dose dependence has been verified at different temperatures. The results are as depicted in figure in figure 3, 4 and 5.

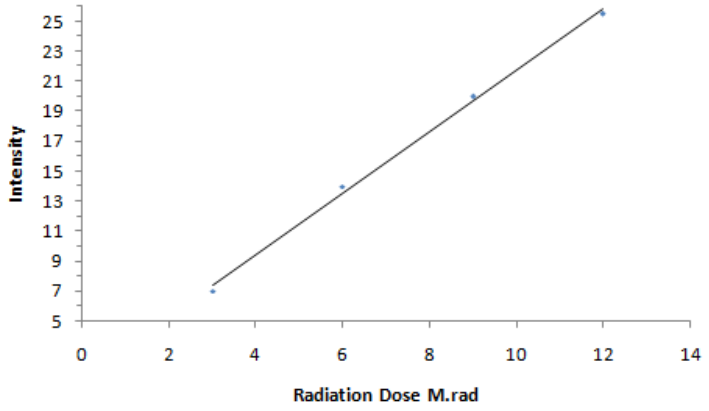

Figure 3 Variation of Intensity against Radiation dose at temperature of 40^0C

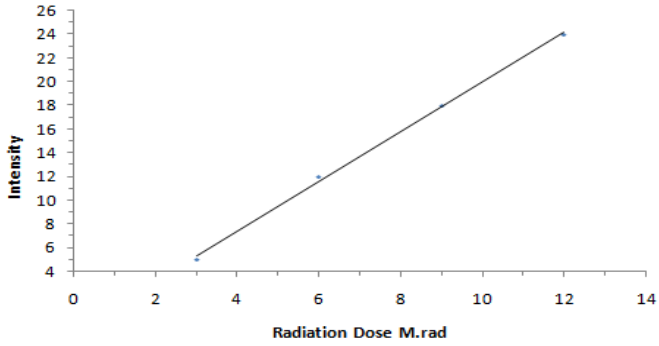

Figure 4 Variation of Intensity against Radiation dose at temperature of 60^0C

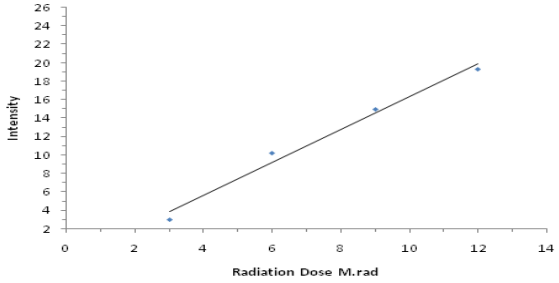

Figure 5 Variation of Intensity against Radiation dose at temperature of 80^0C

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The results suggest that linearly is observed up to 80^0C and beyond this temperature, linearity of ESR signal with radiation dose is not observed. The result suggest that PA6 can be used as radiation dosimeter up to 80^0C within the given radiation dose range.

A radiation dosimetric aspect of PA6 copolymers is also investigated by recording the ESR spectra of copolymer of different compositions at different radiation doses, Figure 6, Figure 7, Figure 8, and Figure 6 represent ESR Spectra of 5/95 composition at different radiation dose while figure 7 and figure 8 represent the ESR spectra of 50/50 composition and 95/5 composition. ESR intensity of 95/5 and 50/50 copolymer linearly varied with temperature but for 5/95 composition linearly or not observed suggesting that this copolymer with this composition is not suitable for dosimetric uses

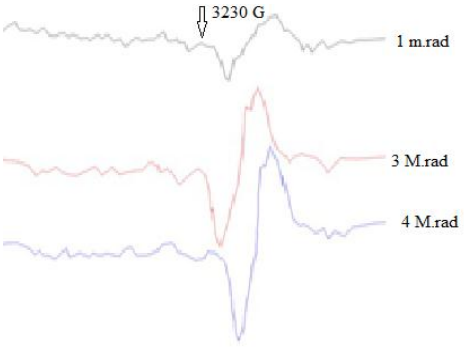

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Figure 6 ESR spectra 5/95 composition at different radiation dose

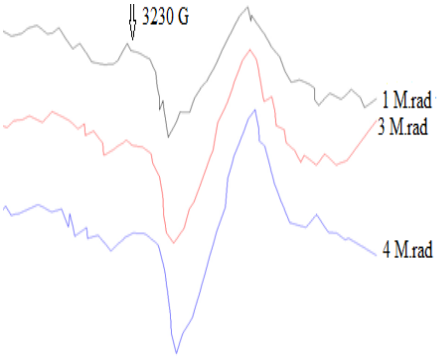

Figure 7 ESR spectra 50/50 composition at different radiation dose

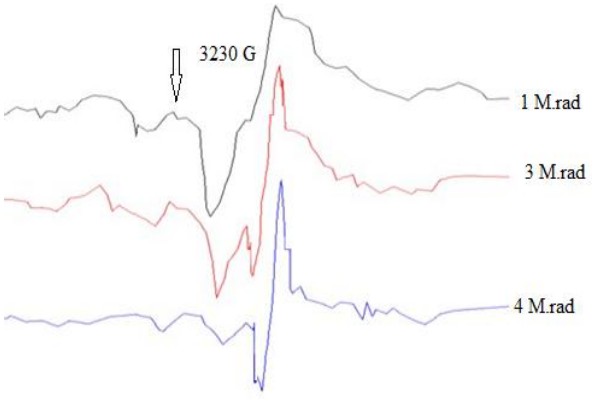

Figure 8 ESR spectra 95/5 composition at different radiation dose

V.CONCLUSION

In conclusion PA 6 and its copolymers have excellent applications as radiation dosimeters. The ESR intensity variation at different temperatures also suggest that the PA6 dosimeters have thermal stability also.

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