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A Study on Stabilization of Polymers Against Radiation

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Abstract
Polymers undergo degradation process, when interacted with different types of radiations. Due to the degradation process, a depreciation on chemical and physical properties occur, which ultimately effect the mechanical properties. Therefore stabilization is an essential step to prevent degradation of polymer against radiation. In the present studies, the authors attempts stabilization of some polymers against gamma irradiation.

Keywords: *Polymers, radiative degradation, free radicals stabilization*

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INTRODUCTION

Polymers are important class of materials, as they are used for different purposes, in different branches of science and technology [1]. One of the important limitations of these materials is degradation either by chain scission or cross linking processes [2]. To improve their applicability, these materials are to be stabilized against radiation. These materials are either antioxidants or stabilizers. Various types of stabilizers are prescribed in literature, which include HALS (Hindered Amine light stabilizers), phosphates, etc. [3]. In the present studies, the authors have exposed some polymers to radiative degradation. These polymers are mixed with some stabilizers, and how the stabilizers prevent degradation process is investigated. Degradation of polymer is proceeded by free radical reactions [4]. To study free radicals formed on irradiation of polymers, electron spin resonance (ESR) technique is employed. Due to incorporation of stabilizers, formation of free radicals has to be diminished. Therefore by recording the ESR spectra with and without stabilizers are recorded. The area under ESR spectra represents free radical concentration. By comparing the area under ESR spectra, effectiveness of stabilizers is compared.

EXPERIMENTAL WORK

Polymers in powder form are taken, and they are irradiated with cobalt 60, gamma source at a dose rate of 15 kGy/hr in air at room temperature. Stabilizers are incorporated into polymer matrix by several methods. But melt mixing method is used in the present studies. ESR spectra of irradiated polymers are recorded on VARIAN E-line spectrometer operating at X-band frequencies and 100 kHz frequency modulation.

RESULTS AND DISCUSSION

ESR spectra of unirradiated polymer have not shown any signal, indicating that absence any type of free radicals. ESR spectra of irradiated polymers are as shown in Figure 1. The spectrum compose hyperfine pattern as shown in Figure 1. The spectra are assigned to be due to the presence of various types of free radicals. Since irradiation is performed in air, the free radicals formed on irradiation abstract oxygen and convert to peroxy radicals. Formation of peroxy radicals can be identified by the characteristic ESR line shape. Area under the ESR spectrum is calculated by double integration methods [5].

ESR spectra of polymer mixed with stabilizer are as shown in Figure 1. Area under the ESR spectrum is calculated and compared with the polymer without stabilizer. Spectra area with stabilizer is very less than that of without stabilizer. Therefore presence of stabilizer has considerably decreased formation of free radicals. With regard to the interpretation of

ESR spectra of irradiated PP, several types of radicals are proposed in literature. They include macro-radicals of the type (I) formed by the cleavage of methane proton from the backbone of PP [5].

If the chain cleavage occurs with the cleavage of methyl group, formation of macro-radicals of the type (II) and methyl radicals (III) takes place [6]. Radicals I and II abstract oxygen and form mid chain peroxide radicals of the type (III) and (IV) [7]. Considering the ESR spectrum of irradiated PP (Figure 1), the spectrum possesses characteristic asymmetric doublet shape of peroxy radical together with some hidden hyperfine pattern. The hyperfine pattern is attributed to the presence of macro-radical either I or II and peroxy doublet is due to either III or IV.

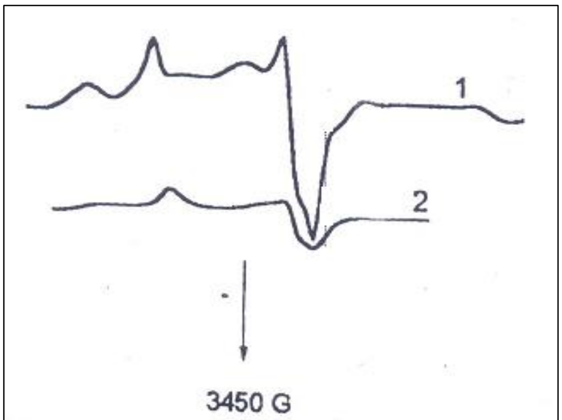

Fig. 1: *Curve 1 and Curve 2 ESR Spectra of Gamma Irradiated PP at Sterilization Dose without and with Stabilizer.*

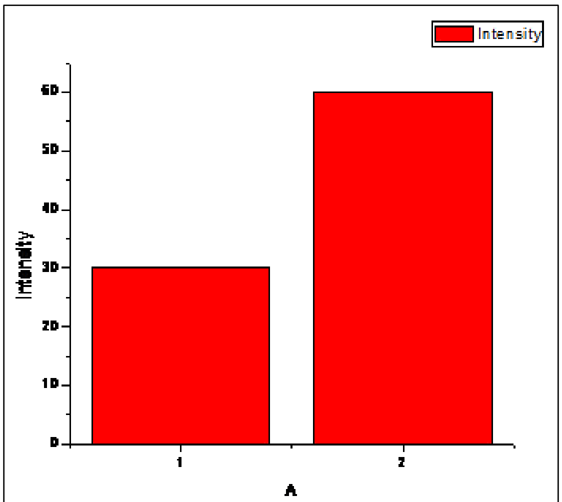

Fig. 2: *Histogram depicting the free radical concentration, (1) irradiated, stabilized PP, (2) irradiated PP*

Super of component spectra resulting from I or II and III or IV results in the experimental observed spectrum of irradiated PP at room temperature. To test the efficiency of stabilizer in mitigating formation of free radicals, ESR spectra are recorded for irradiated PP with and without stabilizer. Resultant ESR spectra are as shown in Figure 1. Considering Figures 1 and 2, spectral areas considerably reduced in case of irradiated PP with stabilizer. To quantify the results, free radical concentration has been measured for both the sample. Since area under ESR spectrum is a measure of free radical concentration, double integration methods are used to measure spectral areas [8] to have a comparison of spectral area histogram is plotted as shown in Figure 2.

It is evident from Figure 2 that spectral areas considerably reduced with addition of stabilizer.

CONCLUSION

In conclusion, radiative degradation of polypropylene can be mitigated with the incorporation of proper stabilizers. ESR technique can be used to assess radiative degradation as well as stabilization of polymers.

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