

N89 - 14914

ORIGINAL PAGE IS
OF POOR QUALITY

RADIATION EFFECTS ON POLYMERIC MATERIALS

By

Richard L. Kiefer
Department of Chemistry
College of William and Mary
Williamsburg, VA 23185

Materials placed in the geosynchronous earth orbit will be subjected to a radiation environment consisting of electrons and protons each with a flux of 10^8 particles $\text{cm}^{-2} \text{sec}^{-1}$ and ultraviolet radiation with an energy flux of 0.14 joules $\text{cm}^{-2} \text{sec}^{-1}$. Future satellites will likely be constructed of polymer matrix composites because of their light weight and high strength. In the presence of such radiations, polymeric materials are known to suffer a degradation of properties due to both chain scission and crosslinking. Thus, it is important to study changes in properties of polymers after irradiation with charged particles, with ultraviolet radiation, and with combinations of both. An apparatus for this purpose has been built at the NASA Langley Research Center. It consists of a chamber 9 inches in diameter and 9 inches high with a port for an electron gun, another port for a mass spectrometer, and a quartz window through which an ultraviolet lamp can be focused. The chamber, including the electron gun and the mass spectrometer, can be evacuated to a pressure of 10^{-8} torr. A sample placed in the chamber can be irradiated with electrons and ultraviolet radiation separately, sequentially, or simultaneously, while volatile products can be monitored during all irradiations with the mass spectrometer.

The apparatus described above has been used to study three different polymer films: lexan, a polycarbonate; Pl700, a polysulfone; and mylar, a polyethylene terephthalate. The repeat units of the three polymers are shown in Figure 1. All three polymers had been studied extensively with both electrons and ultraviolet radiation separately, but not simultaneously. Also, volatile products had not been monitored during irradiation for the materials. A high electron dose rate of 530 Mrads/hr was used so that a sufficient concentration of volatile products would be formed to yield a reasonable mass spectrum. The intensity of the ultraviolet source (a 1000 watt xenon lamp) was set to 1.5 solar constants with a calibrated photometer. The temperature of the sample could be monitored with a thermocouple, but it could not be controlled. Thus, in the electron irradiations, the sample temperature was 35 to 40° C, while it went up to 110° C in the ultraviolet irradiations. All irradiations were for 8 hours.

The mass spectrometer results showed that for lexan and mylar the largest concentrations of volatile products had masses of 44, 28, 16, and 12, corresponding to products of CO_2 , CO , O , and C . This indicates that chain scission occurs most readily at the carbonyl group in these polymers. For the polysulfone, masses seen were 64, 48, 32, and 12, corresponding to products of SO_2 , SO , O_2 or SO_2 (doubly charged), and C . This indicates that the sulfone group most readily participates in chain scission.

Comparisons of separate, sequential, and simultaneous irradiations with electrons and ultraviolet radiation were made for each polymer. The radiation damage in each irradiation was monitored by noting changes in the uv/visible spectrum from the baseline spectrum taken on unirradiated films. Absorbance spectra were integrated by the spectrometer and the baseline area was subtracted from the area after irradiation. The results are shown in figures 2, 3, and 4 for lexan, P1700, and mylar respectively. The notation e-/uv means an 8 hour electron irradiation followed by an 8 hour ultraviolet irradiation. The notation, uv/e-, means the reverse. The result for the ultraviolet irradiation of mylar indicates that the film probably contains an ultraviolet inhibitor. The results show that synergistic effects appear in the sequential irradiations for P1700 and mylar and in the simultaneous irradiation for lexan. Further work is anticipated to determine the reasons for these effects.

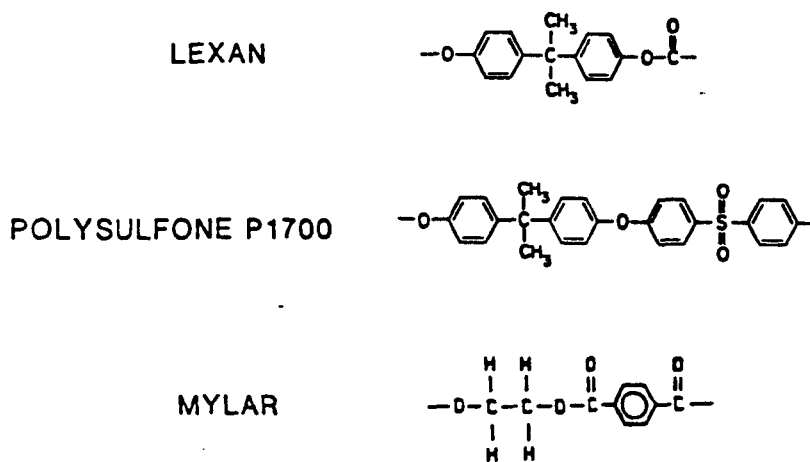


Figure 1.

MATERIALS STUDIED

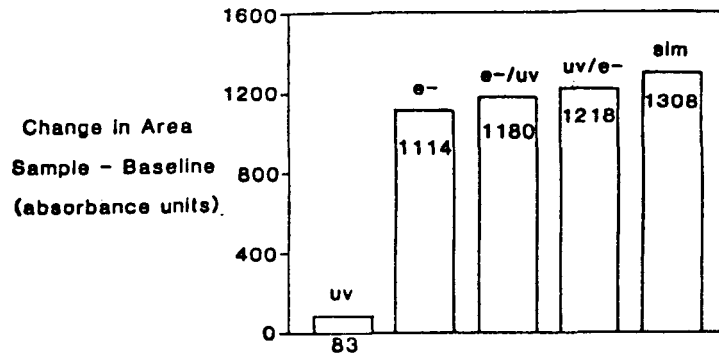


Figure 2. Change in Area in UV/Visible Spectra for Lexan Irradiations

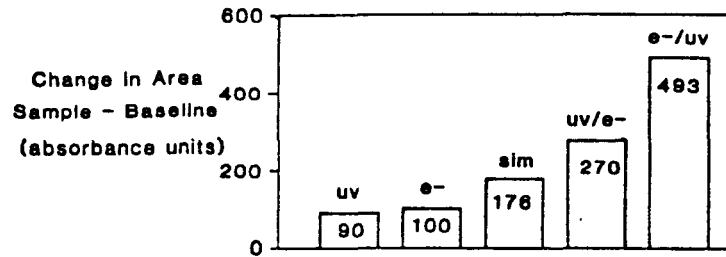


Figure 3. Change in Area in UV/Visible Spectra for Polysulfone P1700 Irradiations

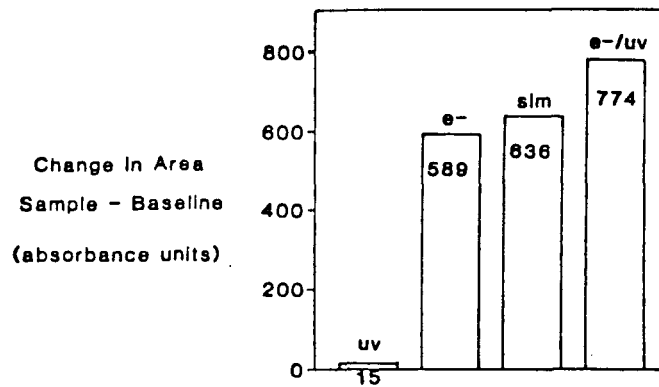


Figure 4. Change in Area in UV/Visible Spectra for Mylar Irradiations