Polymer Gamma Dosimeter

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Synopsis

A chemical dosimeter has been developed based on the gas evolution of polymers by γ radiation. The polymers used in this dosimetry were polyacrylamide, poly(vinyl alcohol), and polystyrene. The irradiating γ source was a ^{60}Co annular cell calibrated with the Fricke dosimeter, an average dose rate being 630 rad/min. The irradiated samples were aqueous solution, i.e., polyacrylamide oxygen saturated in water, poly(vinyl alcohol) aerated in water, and polystyrene oxygen saturated in carbon tetrachloride. A manometer system was used as the gas-measuring device. It was found that the dosimeter showed good linearity above 1 Mrad.

INTRODUCTION

Polymer dosimetric systems[1,2] have been reported based on the measurement of change in viscosity of a polymer solution by irradiation. Feng[1] used a flow-type viscosimeter to measure the change in viscosity of aerated solutions of polystyrene in carbon tetrachloride. Boni[2] also developed a polymer degradation dosimeter based on the change in viscosity of polyacrylamide solution. Poly-(vinyl alcohol) and several other polymers were also studied by Alexander and Charlesby[3] based on viscosity change and gel formation by irradiation against solution concentrations.

Hart and Gordon[4] have developed a water dosimeter based on gas evolution resulting from the decomposition of water, with potassium iodide added to catalyze the recombination of the free radical species, exposed to Mrad doses.

In the present dosimeter, measurements were made of the gas evolution from three polymers: polyacrylamide, poly(vinyl alcohol), and polystyrene, which were exposed to ^{60}Co γ radiation. The gas-evolution-versus-dose curve shows good linearity above 1 Mrad.

EXPERIMENTAL

Measurements were made of the gas evolution from three polymers: polyacrylamide, poly(vinyl alcohol), and polystyrene, which were exposed to ^{60}Co γ radiation in the chemistry laboratory at the University of Saskatchewan. The annular gamma cell (Gamma Cell-220, AECL) was calibrated with a Fricke dosimeter whose solution consisted of $FeSO_4$ $7H_2O$ ($2 \times 10^{-3}M$), NaCl ($10^{-3}M$), and H_2SO_4($0.8N$) in triply distilled water, the dose rate being 630 rad/min. The irradiated samples were extremely dilute (0.08%) solutions of polyacrylamide, poly(vinyl alcohol), and polystyrene contained in a glass bottle (125 ml).

Polyacrylamide [average molecular weight $(5–6) \times 10^6$] was dissolved in or-

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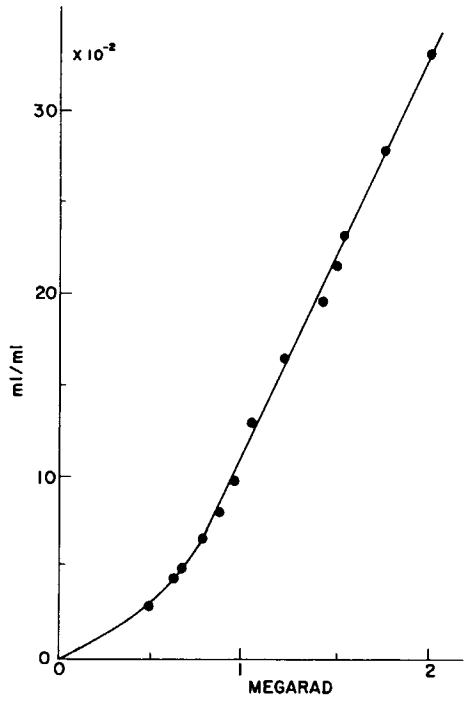

Fig. 1. Gas evolution of polyacrylamide.

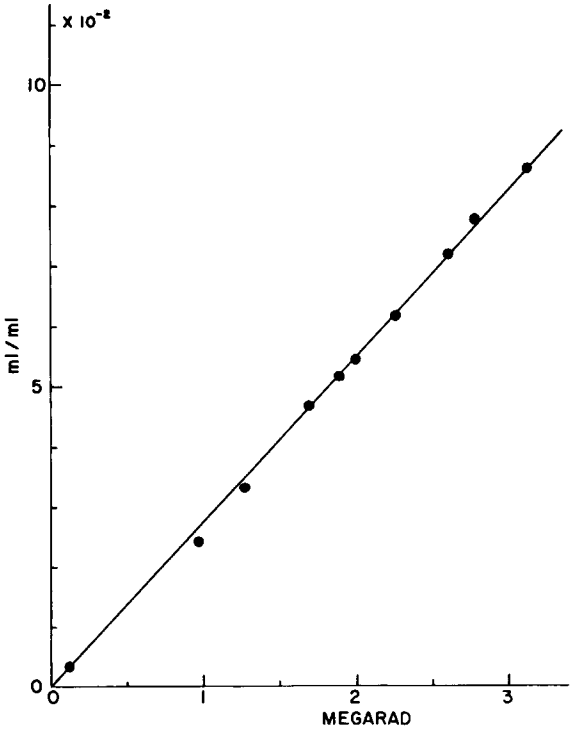

Fig. 2. Gas evolution of poly(vinyl alcohol).

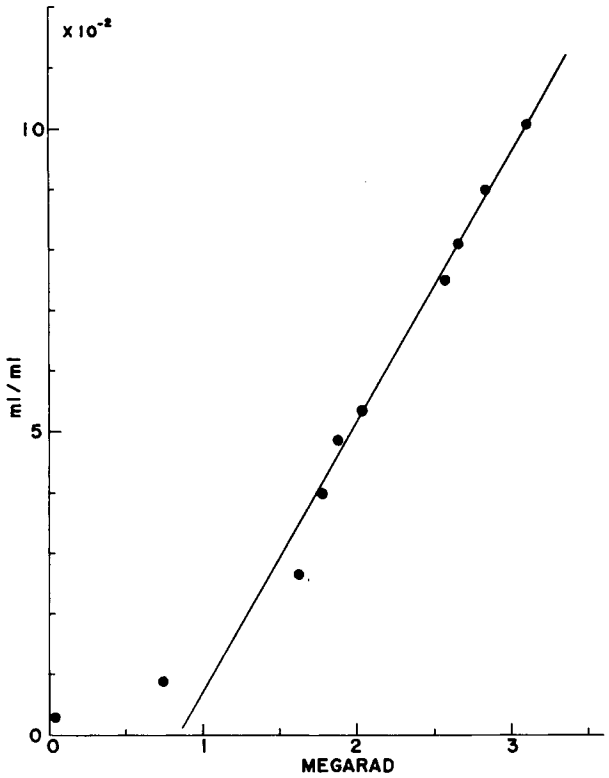

Fig. 3. Gas evolution of polystyrene.

dinary distilled water which was heated and oxygen saturated by O_2 bubbling. Poly(vinyl alcohol) (average molecular weight 115,000) was dissolved in ordinary distilled water which was heated and aerated. Polystyrene (expanded, commercial packing material) was dissolved in carbon tetrachloride and oxygen saturated by O_2 bubbling.

The gas-measuring device was a manometer system[4] filled with dibutyl phthalate kept at room temperature.

RESULTS AND DISCUSSION

Experimental results are shown in Figures 1–3 for the three samples under investigation. As shown in the figures, in general, linearity is fairly good above 1 Mrad.

The shape of the gas evolution curve for polyacrylamide (Fig. 1) is very similar to the viscosity–dose curve measured by Boni,[2] indicating that the gas evolution is also ascribed to degradation by irradiation of the polymer. Since polymer degradation in dilute solution can be interpreted as indirect action in which the free radicals produced in water react with polymer molecules, concentrations of less than 0.1% of polymers were used in this work so it can be assumed that all effects are indirect.[3] The gas–evolution curve of poly(vinyl alcohol) is relatively straight, as shown in Figure 2, at the beginning; but that of polystyrene is approximately linear until low levels are reached, as shown in Figure 3.

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