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INVESTIGATION OF THE AQUEOUS GLYCINE SOLUTION AS A GAMMA - RAY AND NEUTRON DOSIMETER

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Investigation of the Aqueous Glycine Solution as a Gamma-Ray and Neutron Dosimeter*

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RADIATION effects on dosimeters for use in medicine and biology should be qualitatively similar to those to be observed in the investigated sample. This criterion is satisfied by chemical dosimeters in aqueous solution when the dosimeter is required for water or biological materials. Amino acids have been proposed as radiation dosimeter for the kilorad and megarad range in measurements of gamma-ray and mixed radiation doses. The solid alanin dosimeter[1] due to its similarity to biological systems in absorbing radiation has been used for depth-dose measurements in animals in which the dose is evaluated from the results of electron spin resonance measurements. Glycine solution has been suggested[2] as a gamma-ray and fast-neutron dosimeter and changes in glycine concentration by radiolytic deamination have been found to proceed linearly with radiation dose over the 10^5–10^8 rads range.

Radiolysis of amino acids, particularly glycine, has been studied extensively and nine products have been identified[3] following the irradiation of aqueous glycine solution. The yield of ammonia which is the main product of deamination of glycine is dependent on the concentration and pH[4,5] of the irradiated solution. It has been found that at a constant dose of approximately 10^5 rads the yield of ammonia depending on the pH of the irradiated solution shows two maxima, one at pH $\sim$ 3·5 and one at pH 9, and a minimum at pH $\sim$ 6. The deamination of glycine remains the same whether the experiments are carried out in air or in vacuum and the oxygen concentration has no effect on the yield of ammonia.

Methods

Gamma irradiations were carried out with a 300-Ci cobalt-60 gamma-ray source at a dose rate of 1180 rads/min and calibration was made with a Fricke dosimeter under identical condition. A light water moderated and cooled reactor with a thermal power of 1 MW and a neutron flux of $1 \cdot 18 \times 10^{11}$ n/cm^2/sec was used for the neutron irradiations. The samples were irradiated in water shielded channels inside the core and the neutron flux was measured by self-powered neutron detectors.[6] The gamma dose rate in the reactor was determined by means of a calorimeter[7] and an aqueous oxalic acid system.[8] As container small pyrex bottles with an internal diameter of 30 mm were used for the gamma irradiations of the same dimensions while plastic bottles were used for exposure to neutrons. The dosimeter solution was prepared from analytical grade glycine after recrystallization from hot water at 85°C sulfuric acid and bidistilled water. The evaluation of the response under different conditions showed that 0·1 *M* glycine and 0·002 *N* sulfuric acid gave best results in the dosimeter system. 0·002 *N* sulfuric acid was added to the glycine solution to adjust to a pH = 4·0. (This value of pH was selected as the change in the initial pH of the solution had to became fairly large in order to obtain accurate results.) The pH of the solution was read with a Coleman pH-meter. The relationship between the amount of absorbed dose and Δ pH (which represents the difference in pH between the irradiated and the unirradiated solutions) was plotted on a semilogarithmic graph in Fig. 1. The pH change from 0·05 to 2 in relation to absorbed dose can be expressed by a straight line as shown in Fig. 2. The absorbed dose could be obtained from the

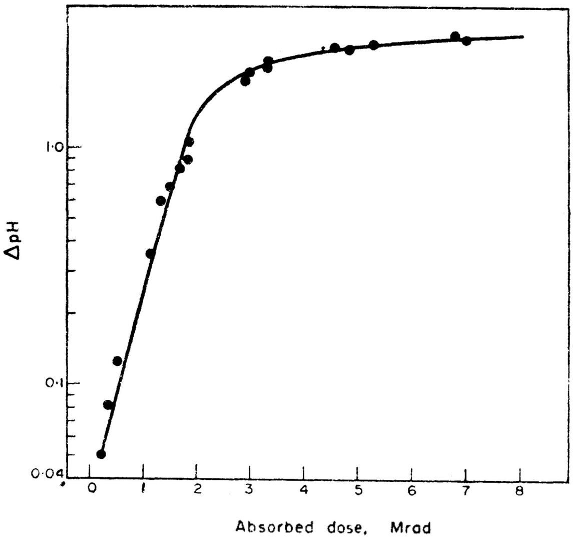

FIG. 1. Dependence of Δ pH on absorbed dose (irradiation with cobalt-60 gamma rays).

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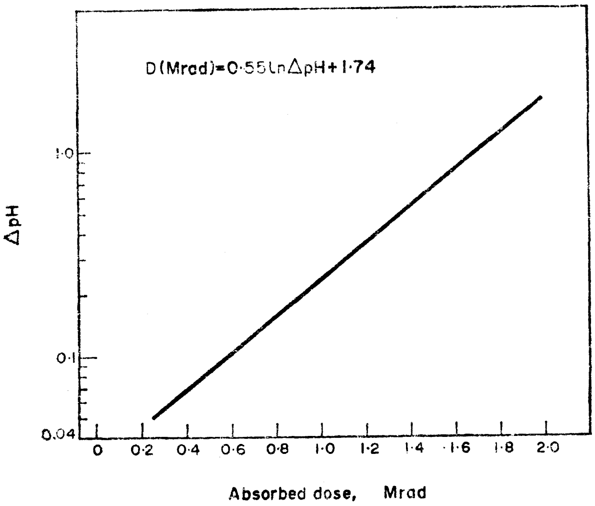

FIG. 2. Absorbed dose as a function of Δ pH.

relation in the following form;

$$D = a \ln \Delta \text{ pH} + b.$$

Figure 3 indicates that the yield of ammonia is linear with absorbed dose and corresponds to a G value of $2{\cdot}33 \pm 0{\cdot}34$ for Co-60 gamma radiation. The values which were obtained from neutron irradiation are indicated in Fig. 4. In this case the relation is linear approximately up to 10^{15} n/cm^2.

Conclusion

The dosimeter can be used not only for the dosimetry of neutron and gamma radiations but also to measure the neutron flux within certain limits. For use as a chemical dosimeter it has several advantages. it can be prepared from readily available chemicals and it is insensitive to many common impurities, it has a long storage life under normal laboratory conditions and the glycine system is independent of such other parameters as the presence or absence of oxygen or vacuum. Changes in the temperature between 10° and 40°C did not effect the deamination

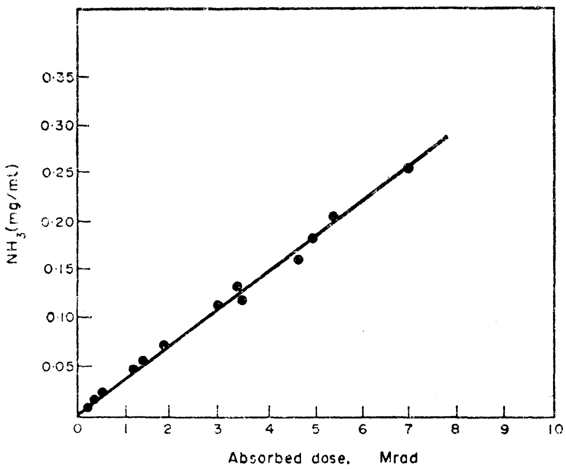

FIG. 3. Yields of ammonia as a function of total dose.

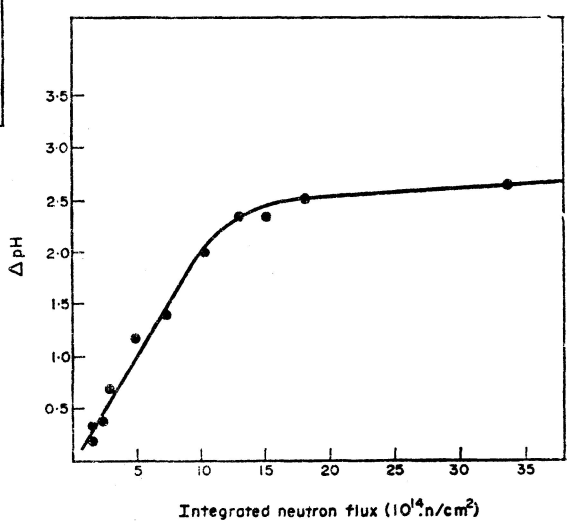

FIG. 4. Δ pH as a function of integral neutron flux (in reactor irradiation).

of glycine. The system is applicable to dose measurements in the range of 1×10^5–2×10^6 rads.

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