RADIOCHEMISTRY

Radiolysis of Highly Enriched Oxygen-18 Water Solutions containing Hydrogen Peroxide-16,16

THE use of the isotope oxygen-18 opens new possibilities to gain information regarding the primary processes in irradiated aqueous solutions. Using ordinary water in the presence of oxygen-16,18, Hart, Gordon and Hutchison¹ were able to obtain information regarding some of the reactions of molecular oxygen. Backhurst, Johnson, Scholes and Weiss², using water enriched 1.5 mol. per cent in oxygen-18 at pH 1.2, were able to investigate the incorporation of oxygen-18 into the hydrogen peroxide formed. Recently, highly enriched (92-95 atom per cent oxygen-18) water became available prepared in the Isotope Distillation Plant of the Weizmann Institute and contained practically 100 per cent deuterium, which enables one to investigate the fundamental processes involved, and high concentrations of hydrogen peroxide-16,16 itself may be used to protect the hydrogen peroxide formed by various mechanisms, while serving as a scavenger of radicals at the same time.

We investigated the action of 200-kVp. X-rays and 2.9-MeV. protons on solutions of approximately 1 M hydrogen peroxide-16,16 in water, which contained 92-95 atom per cent oxygen-18.

Reactions were carried out in the presence and absence of initially added oxygen-16,16 or oxygen-18,18 (94 per cent) and in the presence or absence of added 1 M bromide. The reaction products investigated were oxygen-16,16, oxygen-16,18 and oxygen-18,18 formed during radiolysis as well as the same species formed from the decomposition of the hydrogen peroxide after irradiation was completed. Hydrogen peroxide was decomposed by platinum-black, which has been shown (Anbar, M., unpublished work) not to produce during decomposition any induced exchange between the various isotopic species of hydrogen peroxide. Hydrogen peroxide also does not appreciably exchange its oxygen with water. The presence of a high concentration of hydrogen peroxide protects the hydrogen peroxide formed during irradiation, the isotopic composition of which remains intact, and enables its total yield and mode of formation to be investigated.

It was found that in the case of X-rays the yield of hydrogen peroxide-18,18 is relatively unaffected by added bromide ions; the yield is proportional to dose up to total doses of 2 Mrads, the *G* value being approximately 0.4. On the other hand, in the case of proton irradiation, the yield of hydrogen peroxide-18,18 is reduced by a factor of nearly 10 when bromide is present during irradiation.

The yield of hydrogen peroxide-16,18 in a solution irradiated with X-rays is reduced to half in the presence of bromide, and to one-tenth when proton irradiation is used. For X-rays, the yield of hydrogen peroxide-16,18 remains approximately constant in the pH range 0.3-11. That of hydrogen peroxide-18,18 decreases very significantly above pH 8. These results point to different mechanisms for the formation of hydrogen peroxide-18,18 and hydrogen peroxide-16,18. Tracer experiments using originally added oxygen-18,18 proved that hydrogen peroxide-18,18 does not originate to any large extent from this source. In

addition to the radical intermediates H and OH formed from the water by the radiations³, it is assumed that molecular products, H₂ and H₂O₂, may be produced directly from water⁴.

Our results show that hydrogen peroxide-18,18 can indeed be formed through a distinct 'molecular' mechanism from water alone, whereas 'scrambled' hydrogen peroxide-16,18 results from reactions of H¹⁸O radicals or their equivalent with hydrogen peroxide-16,16, according to:

Full details of this work are being prepared for publication.

MICHAEL ANBAR
SHMUEL GUTTMANN

Isotope Department,
Weizmann Institute of Science,
Rehovoth.

GABRIEL STEIN

Department of Physical Chemistry,
Hebrew University,
Jerusalem, Israel.

¹ Hart, E., Gordon, S., and Hutchison, D. A., *J. Chim. Phys.*, **52**, 570 (1955).

² Backhurst, J. D., Johnson, G. R. A., Scholes, G., and Weiss, J., *Nature*, **183**, 176 (1959).

³ Weiss, J., *Nature*, **153**, 748 (1944).

⁴ Allen, A. O., and Schwarz, H. A., Proc. Second Int. Conf. Peaceful Uses of Atomic Energy, **29**, 30 (1958).

Non-destructive Analysis of Microgram Quantities of Silver by Radioactivation

A NON-DESTRUCTIVE method of determining $\mu\text{gm.}$ quantities of silver by use of the nuclear reactor JRR-1 and an RCL-256-channel pulse-height analyser has been investigated.

In the present work, a sample (0.1-10 gm.) is placed in the reactor for 30 sec. to be irradiated with neutrons at a flux of 3×10^{11} neutrons per sq.cm./sec., cooled for 10 sec., counted for 20 sec., further cooled for 10 sec., and counted for 20 sec. The scintillator used is a 2-in. thick, well-type sodium iodide crystal. An aluminium vessel (2.5-mm. thick) is inserted in the well as an absorber for β -rays. At the first counting 128 channels in the analyser are used, and in the second counting the rest are used. The resultant γ -spectrum shown on the monitor (Braun tube) is photographed and the height of photopeak due to 0.66 MeV. γ -rays with silver-110 ($T_{1/2} = 24.2$ sec.) is measured. By the comparative method the amount of silver is determined.

An example of the coefficient of variation of single analyses has been obtained by the use of six standard samples which include 1.25 $\mu\text{gm.}$ of silver each. The coefficient estimated from six values is only 2.8 per cent, the average area under photopeak being 3.4×10^3 counts. Results of analysis are shown in Table 1.

In the case of lead, interference is negligible. In the case of bismuth, slight interference due to *Bremsstrahlung* is found. In the case of zinc sulphide, though two

Table 1. RESULTS OF ANALYSIS

Sample	Silver found (p.p.m.)
Lead	1.09
Bismuth I	7.6
Bismuth II	< 0.02
Zinc sulphide (silver added)	22.2