Electron Spin Resonance Studies of Deuterated Borate Glasses Irradiated with Gamma Rays at Liquid Nitrogen Temperature

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The present investigation was undertaken with the expectation that paramagnetic absorption measurements would yield information regarding the hydrogen atoms produced in the radiolysis of B–O–H–O–B or H_2O in borate glass.

For the purpose of examining the effect of water or B–O–H–O–B in glass, borate glass, B_2O_3, was deuterated. The deuterated B_2O_3 glass used was made from the melting of D_3BO_3 prepared by the hydrolysis of trimethyl borate with D_2O.

The infrared spectrum of the deuterated B_2O_3 glass is shown in Fig. 1. The components of the hydrogen and deuterium atoms in the glass seem to be H : D = 1 : 1.

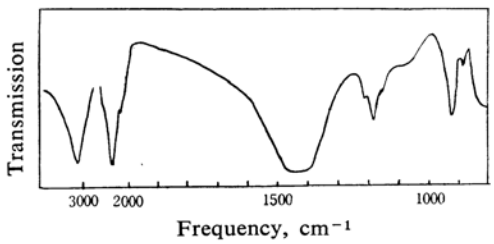

Fig. 1. The IR spectrum of deuterated borate glass.

The sample was irradiated at liquid nitrogen temperature with Co^{60} gamma rays (1×10^6 r). Derivative curves were obtained with a Varian 4501 ESR spectrometer at liquid nitrogen temperature employing a modulation frequency of 100 kc./sec.

The first derivative curve of the spectrum is shown in Fig. 2. The derivative peaks denoted by P_2, P_3, P_4 and P_5, and P_b (Bray's symbol) were found to be the same as have been reported previously.[1] The observed spectrum at 77°K appears to display other new derivative peaks. The additional peaks will be denoted by H_1 and H_2 for the outer pair, and D_1, D_2 and D_3 for the inner lines.

The paramagnetic resonance spectra of a free atomic hydrogen (S = 1/2, I = 1/2) would be expected to consist of a doublet with a

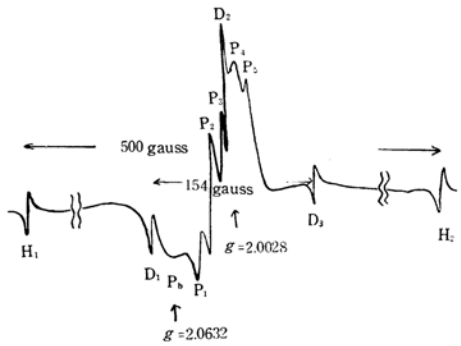

Fig. 2. The ESR spectrum obtained from γ-ray irradiated (1×10^6 r) deuterated borate glass.

separation of 506 gauss, while those of a free atomic deuterium (S = 1/2, I = 1) would consist of a triplet with a separation of 156 gauss between outer components.[2]

Therefore, H and D resonances seem to arise from the hydrogen atom center, H^0 of interstitial vacancy produced by the radiolysis of B–O–H–O–B or H_2O in glass. The derivative peaks denoted by D_1, D_2 and D_3 cannot be observed in nondeutrated samples.

At room temperature, hydrogen atoms may diffuse to form hydrogen molecules or BOH. Thus, no paramagnetic resonance absorption due to H^0 and D^0 centers can be observed.

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2) P. Kusch, *Phys. Rev.*, **100**, 1188 (1955).