

increment of water. They also indicate that swelling depends on changes in lattice energy that accompany lattice adjustment. Swelling stops when no further adjustment takes place. This does not happen until the adsorbed water is several hundred Å thick and has achieved a preferred configuration compatible with a b dimension of ~ 9.0 Å.

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Received March 22, 1971.

¹ Low, P. F., Ravina, I., and White, J. L., *Nature*, **226**, 445 (1970).

² Graham, J., and Rolfe, P., *Nature Physical Science*, **229**, 59 (1971).

³ Ravina, I., and Low, P. F., *Clays and Clay Minerals* (in the press).

Light Emission from the Dissolution of Gamma Irradiated Alkali Halides in Water

We have been studying the primary processes in the radiation chemistry of aqueous and organic systems¹⁻⁴. Evidence has been accumulating for the presence of correlated ion pairs in the irradiated liquid and frozen aqueous solutions. Reactions of the mobile electrons and holes with the appropriate scavengers have been found to be interdependent. In order to explain the data^{6,7}, it was suggested that the primarily formed electrons and holes are not randomly distributed in the system, but instead move about as correlated electron-hole pairs which may be imagined as solid state excitons. I wish to report here some of our recent experimental evidence pointing towards the possible involvement of triplet excitons of Frenkel type. When gamma irradiated alkali halides are dissolved in water, stored energy is transferred to the solvent. Earlier studies^{9,10} of light emission from this process have been verified and extended.

The emitted light has been identified as due to a $T_1 \rightarrow S_0$ transition of the water molecule. This was indicated by the identification of the emission (phosphorescence) from various added acceptors. As the light emitted from the acceptors is phosphorescence, a triplet state is invoked. We believe that the emission from the triplet of the acceptors is obtained because of their population *via* a triplet-triplet transfer from the solvent triplets. We also verified that when irradiated alkali halides are dissolved in pure water, the emission obtained is quenched by known triplet quenchers such as oxygen¹¹ and certain other paramagnetic ions such as Co^{2+} .

Initial results from some known triplet induced reactions such as cis-trans isomerization of proper solutes also indicate the presence of the triplet state of water.

At this stage we are not able to decide whether the triplet excited state of water is populated *via* the exchange interaction of low energy electrons liberated on dissolution, or *via* an energy transfer process from triplet excitons of irradiated sodium chloride. There is evidence that energy equivalent to about 5 eV is liberated from X-ray induced luminescence⁸.

Our observations and the postulate of a triplet state of water seem to be consistent with the recent observations of a triplet state of water (at about 4.2 eV) by Hamill¹³, Compton *et al.*¹⁴ and Kuppermann¹⁵. A stable triplet excited state of water will be of great interest in radiation chemistry and photobiology. A short version of our ideas was given at the International Meeting on Primary Radiation Effects in Chemistry and Biology, March 9-14, 1970, at Buenos Aires, and also at the

Fourth International Congress of Radiation Research, June 29-July 4, 1970, at Evian.

Our attention has just been drawn to an article claiming the discovery of the phenomenon of light emission from this process. We would like to point out that the phenomenon of light emission from the process has been known for some time^{9,10} and the explanation in ref. 16 has been given before¹². Our ideas on the possible involvement of a triplet excited state were presented, and the phenomenon of light emission experimentally demonstrated⁴, at a Symposium on Radiation Chemistry held at Trombay on February 7, 1970.

I thank Dr J. Shankar, of Bhabha Atomic Research Centre, for encouragement, and Dr P. N. Moorthy, Dr C. Gopinathan, and Professor W. H. Hamill for helpful suggestions.

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Received December 9, 1970.

¹ Moorthy, P. N., *Proc. Chemistry Symp., Chandigarh, India*, **2**, 186 (1969).

² Gopinathan, C., *Proc. Chemistry Symp., Chandigarh, India*, **2**, 196 (1969).

³ Rama Rao, K. V. S., Shastri, L. V., and Shankar, J., *Radiation Effects*, **2**, 193 (1970).

⁴ Mittal, J. P., *Proc. Symp. Radiation Chemistry, Trombay, India, BARC-489*, 40 (1970).

⁵ Mittal, J. P., and Libby, W. F., *Nature*, **220**, 1027 (1968).

⁶ Moorthy, P. N., *Proc. Symp. Radiation Chemistry, Trombay, India, BARC-489*, 37 (1970).

⁷ Gopinathan, C., *Proc. Symp. Radiation Chemistry, Trombay, India, BARC-489*, 28 (1970).

⁸ Spicer, W. E., *Phys. Rev.*, **106**, 726 (1957).

⁹ Westermarck, T., and Grapengiesser, B., *Nature*, **188**, 395 (1960).

¹⁰ Westermarck, T., and Grapengiesser, B., *Arkiv för Kemi*, **17**, 142 (1961).

¹¹ Erikson, L. E. G., *Acta Chem. Scand.*, **16**, 2113 (1962).

¹² Ahnstrom, G., *Acta Chem. Scand.*, **19**, 305 (1965).

¹³ Lewis, D., and Hamill, W. H., *J. Chem. Phys.*, **51**, 456 (1969).

¹⁴ Compton, R. N., *et al.*, *J. Chem. Phys.*, **48**, 901 (1968).

¹⁵ Kuppermann, A., *Proc. Intern. Symp. on Radiation Chemistry and Biology*, 161 (AEC, 1970).

¹⁶ Arnikaar, H. J., Damle, P. S., Chauré, B. D., and Madhar Rao, B. S., *Nature*, **228**, 357 (1970).

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