

However, from this and other work mentioned, it is clear that the magnitude of the first rapid oxidation, even allowing for a considerably greater real surface, is much larger than would be expected from a sorption-diffusion oxidation theory<sup>6</sup>; and it seems that a controlling mechanism must be sought leading to differential equations of a similar form but involving other physical magnitudes. Detailed results and a discussion of them will be published in due course.

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<sup>1</sup> Tronstad, L., *Trans. Faraday Soc.*, **29**, 502 (1933). Winterbottom, A. B., *J. Sci. Instr.*, **14**, 203 (1937).

<sup>2</sup> Evans, U. R., and Miley, H. A., *NATURE*, **139**, 283 (1937). Dobinsky, S., *NATURE*, **138**, 31 (1936).

<sup>3</sup> Drude, P., *Wied. Ann.*, **36**, 884 (1889); Tronstad, *loc. cit.* (1).

<sup>4</sup> Evans, U. R., and Miley, H. A., *loc. cit.*, (2).

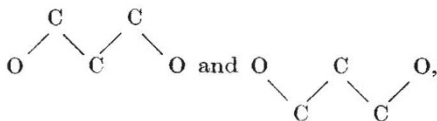
<sup>5</sup> Bowden, F. P., and Bidler, K. E. W., *Proc. Roy. Soc., A*, **154**, 640 (1936).

<sup>6</sup> Wilkins, F. J., *Phil. Mag.*, **11**, 422 (1931).

### Hydrogen Bridges in Solid Pentaerythritol

USING the method of Fourier series, a quantitative crystal analysis of pentaerythritol,  $C(CH_2OH)_4$ , has now been carried out, and some of the interesting features of the determined structure will be given below.

Of the alternative space groups  $C_2^2-14$  and  $S_6^2-14$  chosen first by one of us<sup>1</sup>, the latter should now be regarded as the correct one for this compound. The central carbon atom of a molecule is placed at 000 and surrounded tetrahedrally by the four methylenic carbon atoms at  $xyz$ ,  $xyz$ ,  $y\bar{x}\bar{z}$  and  $\bar{y}x\bar{z}$  with  $x = 0.165$ ,  $y = 0.140$  and  $z = 0.10$ , the interatomic distance for the C—C bond being hence 1.57 Å. The four hydroxyl oxygen atoms are also arranged in such general positions with the values of the parameters  $x = 0.313$ ,  $y = 0.265$  and  $z = 0.00$ . From these and above values the C—O bond distance is computed to be 1.46 Å. The oxygen atoms thus lie in the same plane  $z = 0$  as the central carbon and besides not far from the base diagonals. If the hydrogen atoms of the OH groups are not taken into consideration, the molecule possesses approximately the symmetry of  $D_{2d}-42m$ , precisely  $S_6-4$ , with one pair of primary alcohol radicals puckered upwards and the other downwards, namely,



all the bond angles of these atoms being approximately tetrahedral. Such a structure is found in the case of pentaerythritol tetrabromide vapour, in which, according to an electron diffraction study carried out by de Laszlo<sup>2</sup>, the bromine atoms in the molecule form a square.

The most interesting aspect of the structure is the close approach of the hydroxyl groups on adjoining molecules. In the plane  $z = 0$ , four oxygen atoms, one out of each molecule, constitute a square of length of side 2.55 Å. This is shown by an idealized figure (Fig. 1), though strictly in the actual case the

line joining the central carbon and a hydroxyl oxygen in the molecule makes a small angle with one of the base diagonals.

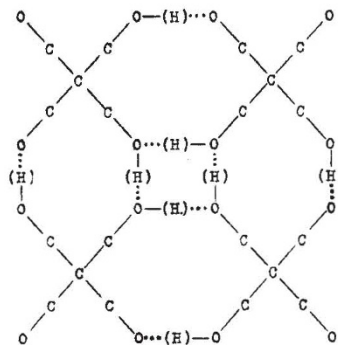


Fig. 1.

The value 2.55 Å. for the above O—O distance, which must be bridged by a hydrogen atom, is considerably less than that assigned by Bernal and Megaw<sup>3</sup> to their 'hydroxyl bond', while it is precisely the same as those found in the cases of  $KH_2PO_4$ <sup>4</sup> and  $NaHCO_3$ <sup>5</sup>, in which, however, the O—O distance is not between two OH groups but between OH and O. At any rate it is evident that the molecules in a layer parallel to the (001) plane are linked more or less firmly to each other by hydrogen bridges in closed rings, where, according to Huggins<sup>6</sup>, the 'synchronized oscillations' may cause an increased stability of the intermolecular linkage. Such layer-like structure explains in a natural way the perfect cleavage along (001).

A detailed account of the present work will be published shortly.

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<sup>1</sup> Nitta, I., *Bull. Chem. Soc. Japan*, **1**, 62 (1926). For a further bibliography of this subject, see P. P. Ewald and C. Hermann, "Strukturbericht".

<sup>2</sup> de Laszlo, H., *C.R.*, **198**, 2235 (1934).

<sup>3</sup> Bernal, J. D., and Megaw, H. D., *Proc. Roy. Soc., A*, **151**, 384 (1935).

<sup>4</sup> West, J., *Z. Krist.*, **74**, 306 (1930).

<sup>5</sup> Zachariasen, W. H., *J. Chem. Phys.*, **1**, 634 (1933).

<sup>6</sup> Huggins, M. L., *NATURE*, **139**, 550 (1937).

### Band Spectrum of Thallium Hydride

THALLIUM metal was heated in vacuum resistance furnace, which was filled with hydrogen at 500 mm. pressure. At a temperature of about 1,500° C., some bands in the yellow and red part of the spectrum were emitted. The same bands were also obtained in the emission from a thallium-copper arc burning in hydrogen at high pressure. At low pressure (less than 500 mm. mercury) in the arc no bands were present. With increasing pressure the bands get gradually stronger, and at a pressure of about four atmospheres the yellow and red bands are intense. Under the same conditions in the arc a fainter band system also appears in the blue and violet part of the spectrum.

The spectrum has now been photographed from 8000 Å. to 4000 Å. One of the strongest bands at