

(which are freely available for local contacts in the deranged regions of cellulose) and the slight distortion from an orthogonal lattice of the crystalline regions (which may occur in either sense to suit the environment) provide a mechanism for the adaptation of the ordered molecular structure to the histology of tissues, and for the production of a strong, but adaptable, continuous lattice work of chains. In such a structure, one can scarcely define strict crystal boundaries; but some statistical description of the distribution in size and locality of the crystallized regions or 'fascicles' is essential for progress in the quantitative theory of fibre behaviour. In particular, the reaction kinetics of polymeric bonds in groups is determined by the size of the group as well as by the energy of the individual bond. This effect of polymeric co-operation explains the striking difference in the physical chemistry of polymers from that of the monomeric congeners.

The molecular structures assigned to cellulose are given in Figs. 1 and 2. Both are projections of the mats of chains on the plane in which the pyranose ring lies, to the scale shown, with normal displacements from the reference plane shown by figures in units  $10^{-10}$  cm., plain above, barred below. In Fig. 1 the plane of reference is the (*a b*) plane of the lattice described by Meyer and Misch; in the top half through the set of chains with chelate bonds; in the bottom half through the set below the first, at a distance  $\frac{1}{2} c \cdot \sin \beta = 3.93$  A. In Fig. 2 the plane of reference lies in the plane of the rings in the central chain, normal to the (101) plane of the lattice adopted by Andress (the small monogram in each ring indicates the symmetry operations, and the sign H represents a hydroxyl bond).

The models were constructed by geometrical calculation, assuming the lengths of C-C bond 1.52 A., C-O bond 1.43 A.; the O-O hydroxyl bonds suggested are about 2.6 A. Material models might be cut rather smaller to allow fitting in space.

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<sup>1</sup> *Helv. Chem. Acta*, **20**, 232 (1937).

<sup>2</sup> Particularly in *J. Chem. Soc.*, 1495 (1935).

<sup>3</sup> *Z. phys. Chem.*, **B43**, 79 (1939).

<sup>4</sup> *Z. phys. Chem.*, **B4**, 190 (1929).

## Molecular Shape and Size of Hyaluronic Acid and Chondroitinsulphuric Acid

THE hyaluronic acid, which was first isolated from vitreous humor<sup>1</sup>, and later has been found in, for example, synovial fluid<sup>2</sup> and navel cord tissue<sup>3</sup> gives highly viscous solutions and is often precipitated as fibres. Its molecules have therefore been assumed to have a chain structure. The chondroitinsulphuric acid gives less viscous solutions and is precipitated at most in small fibres of little coherence. Levene and La Forge<sup>4</sup> tentatively expressed its structural formula as a tetrasaccharide, a view which seemed to receive support from von Fürth and Bruno<sup>5</sup>, who by the aid of Northrop's diffusion method obtained a molecular weight of about 975.

Both these polysaccharides are rapidly degraded by alkali even at room temperature<sup>6</sup> and are also very easily broken down by oxidative agents<sup>7</sup>. In order to obtain the substances in a state as native as

possible, they must therefore be prepared without the use of alkali and excluding air. We have found that solutions of hyaluronic acid and chondroitinsulphuric acid so prepared show a marked double-refraction of flow. The hyaluronic acid preparations were all rather polydisperse. For those isolated from vitreous humor, the particle-length was estimated to about 4800 A. The hyaluronic acid from synovial fluid showed a higher degree of polymerization with a particle-length of about 700 A.; that from the navel cord was still more polymerized, the particle-length lying outside the range that could be estimated with the apparatus used<sup>8</sup>. An extrapolation attempted from viscosity measurements gave a value of the order of about 10,000–12,000 A. These results leave no doubt of the long-chain structure of the hyaluronic acid and, assuming a length of about 10 A. of the disaccharide unit, suggest molecular weights of the order of 200,000–400,000.

The chondroitinsulphuric acid appeared somewhat less polydisperse. The best preparations showed particle-lengths of about 4700 A. This acid, too, has thus without doubt a linear structure, the molecular weight probably being of the order of 200,000.

A detailed report of this work will be published elsewhere.

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<sup>1</sup> Meyer, K., and Palmer, J. W., *J. Biol. Chem.*, **107**, 629 (1934).

<sup>2</sup> Meyer, K., Smyth, E. M., and Dawson, M. E., *J. Biol. Chem.*, **128**, 319 (1939).

<sup>3</sup> Meyer, K., and Palmer, J. W., *J. Biol. Chem.*, **114**, 689 (1936).

<sup>4</sup> Levene, P. A., and La Forge, F. B., *J. Biol. Chem.*, **15**, 155 (1913).

<sup>5</sup> von Fürth, O., and Bruno, T., *Biochem. Z.*, **294**, 153 (1937).

<sup>6</sup> Blix, G., and Snellman, O., unpublished data.

<sup>7</sup> Skanse, B., and Sundblad, L., *Acta Scand. Physiol.*, **6**, 37 (1943).

<sup>8</sup> Snellman, O., and Björnsthål, Y., *Koll.-Beih.*, **52**, 403 (1941).

## Lattice Constant of Diamond and the C-C Single Bond

RECENTLY, Lonsdale<sup>1</sup> has published a brief account of her measurements on single crystals of diamond using the divergent beam method<sup>2</sup>. At the same time, measurements were made by me on a specimen of diamond dust employing the X-ray powder method developed to a high degree of precision by Bradley and Jay<sup>3</sup> and others. The two sets of measurements are of interest to the physicist because they provide a comparison of the accuracy obtainable by the powder method with that obtainable by Lonsdale's method; they are of interest to the chemist because they lead to the most accurate value yet of the C-C single bond in diamond.

The specimen was obtained from commercial diamond dust by sieving through a very fine bolting-silk sieve (*c.* 175 mesh). The sizes of the small diamond crystals were therefore in the range 0.01–0.001 cm. approximately. The method used was that described by Lipson and Wilson<sup>4</sup>. The lattice constant of diamond is such that the K-radiations of cobalt, iron and manganese are most suitable for precision measurements as they give the  $19\beta$ ,  $16\beta$  and  $11\alpha_1 + 11\alpha_2$  lines respectively at high angles (*c.*  $80^\circ$ ). A 19-cm. diameter camera was used; in addition, one photograph was taken in a 9-cm. diameter camera of the van Arkel type. The apparent