The Crystal and Molecular Structure of Disodium DL-Glycerol 3-Phosphate Hexahydrate

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Summary The structure of disodium DL-glycerol 3-phosphate hexahydrate has been determined by *X*-ray diffraction methods; the most interesting feature of this structure is an intramolecular hydrogen bond.

D-GLYCEROL 3-PHOSPHATE is an inhibitor of triose phosphate isomerase (T.I.M.),[1] the substrates of which are dihydroxyacetone phosphate and D-glyceraldehyde 3-phosphate,[2a] whilst L-glycerol 3-phosphate is both a substrate [2b] and an inhibitor[3] for glycerol kinase.

A knowledge of the structure of glycerol 3-phosphate will be of assistance in any structural studies of these enzymes. There is also at the present time considerable interest in general organic phosphate structures as is shown by the recent publication of the structures of adenosine triphosphate[4] and serine phosphate.[5] Glycerol 3-phosphate was crystallized by placing a saturated solution in a small sample tube and restricting the orifice of the tube to *ca.* 3 mm². The tube was then immersed in absolute alcohol which was able to diffuse slowly into the solution. The material crystallised in space group $C2/c$ with cell dimensions $a = 2{\cdot}499$, $b = 0{\cdot}835$, $c = 1{\cdot}380$ nm, $\beta = 105{\cdot}378°$; $M = 324{\cdot}098$ a.m.u., $D_m = 1{\cdot}606 \times 10^3$ kg m^{-3}, $Z = 8$, and $D_c = 1{\cdot}619 \times 10^3$ kg m^{-3}. 1700 non-zero data were recorded photographically and estimated visually. Lorentz and polarisation corrections were made and also a correction for spot extension.[6] The layers of data were then placed on the same scale, and all the data were placed on an approximate absolute scale, by Powell's method[7] which is a development of Wilson's method.[8] A three-dimensional Patterson map was calculated but was insufficiently resolved; the data were therefore sharpened using the Wunderlich function[9] and the map was recalculated. From this map it was possible to determine the position and orientation of the phosphate groups. The remaining atomic positions were found using several Fourier syntheses and the residual (R) value was reduced to 0·11 by least-squares refinement. The $\bar{3}11$ projection of an L-glycerol 3-phosphate molecule in the disodium compound is shown in the Figure.

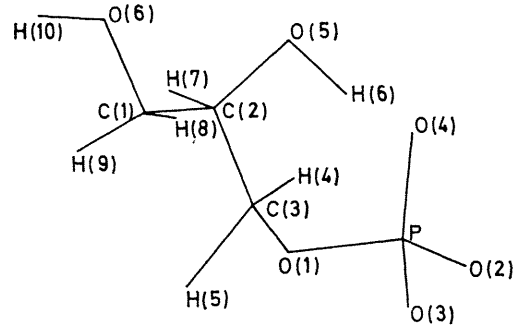

FIGURE. *The* $\bar{3}11$ *projection of an* L-*glycerol* 3-*phosphate molecule in the disodium compound.*

The Table shows the intramolecular bond lengths and angles. The hydrogen bond lengths to the molecules of H(4) and H(5) are as yet unrefined, while those of H(7), H(8), H(9), H(10) are between 0·107 and 0·117 nm with e.s.d.'s of 0·017. In common with other organic phosphates the C(2)–C(1) and C(2)–O(5) bonds of glycerol 3-phosphate are *gauche* with respect to bond O(1)–C(3), but in addition the P–O(1) bond is *gauche* with respect to bond C(3)–C(2). This means that O(5) is positioned 0·266 nm (e.s.d. of 0·001 nm) from O(4). The hydrogen associated with O(5) was found to bridge these two oxygen atoms forming a seven-membered, non-planar ring. This is of particular interest since it has been suggested[10] that the enzymatic action of T.I.M. involves the hydroxy-group on C(2) of the substrate.

Bond lengths (nm) and angles (°) in glycerol 3-phosphate (e.s.d.'s in parentheses)

Bond lengths: P–O(2) 1·518(8), P–O(3) 1·510(8), P–O(4) 1·497(9), P–O(1) 1·630(7), O(1)–C(3) 1·449(13), C(3)–C(2) 1·523(17) C(2)–C(1) 1·523(14), C(1)–O(6) 1·443(15), C(2)–O(5) 1·446(13), O(5)–H(6) 1·220(171), O(5)–O(4) 2·660(10).

Bond angles: O(1)–P–O(2) 107·7(4), O(1)–P–O(3) 101·6(4), O(1)–P–O(4) 106·5(4), O(2)–P–O(3) 114·6(5), O(2)–P–O(4) 112·0 (4), O(3)–P–O(4) 113·4(4), P–O(1)–C(3) 121·8(6), O(1)–C(3)–C(2) 112·6(8), C(3)–C(2)–C(1) 109·9(9), C(2)–C(1)–O(6) 109·2(9), C(3)–C(2)–O(5) 111·5(8), C(1)–C(2)–O(5) 111·2(9), P–O(4)–O(5) 107·3(4), C(2)–O(5)–O(4) 102·6(6), O(5)–H(6)–O(4) 167·6 (15·3).

O(3) and O(4) are involved in hydrogen bonding to water molecules whilst O(2) is hydrogen bonded to O(6) in the glide related molecule with a total bond length O(6)–H(10) · · · O(2) of 0·264 nm. The closest approach of atoms to the sodium atoms are: hydrogen atoms in water molecules 0·192 nm, other hydrogens 0·271 nm, oxygen atoms both in water molecules and on glycerol 3-phosphate 0·236 nm, carbon and phosphorus atoms > 0·31 nm.

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