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THE CRYSTAL STRUCTURE OF A THYMINE PHOTODIMER ("THYMER E")

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There is currently much interest in the biological role played by the dimers of thymine formed in DNA by ultraviolet irradiation. These thymine dimers can also be obtained under a wide variety of conditions from ultraviolet irradiation of thymine and its derivatives. (For details see Reference (1).) Beukers and Berends (2) who first isolated a thymine dimer suggested that the two thymine molecules are linked by a cyclobutane ring formed between their two 5,6 double bonds. Wulff and Fraenkel (3) pointed out that cis-linkage of the thymine to the cyclobutane rings would give rise to four stereoisomeric dimers. In 1966 Weinblum and Johns (1) obtained four different isomers from u.v. irradiation of aqueous solutions of thymidylthymidine and from frozen aqueous thymidine solutions. They tentatively assigned to these the four different stereoisomeric structures of Wulff and Fraenkel. Although there have been a number of crystallographic

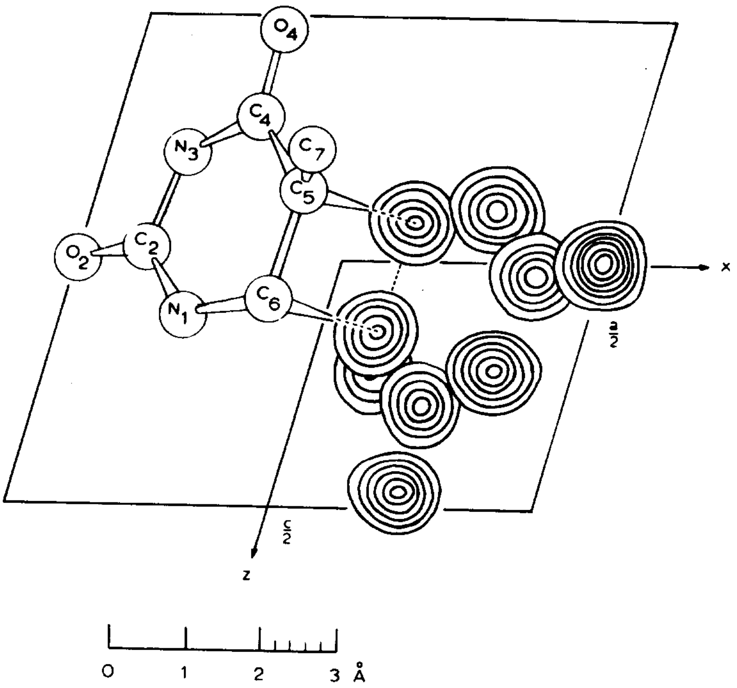

FIG. 1

Superimposed sections of the electron-density distribution, taken through the atomic centers parallel to (010). Contours are at arbitrary intervals. A perspective drawing of half of the dimer is also shown.

speculations (4) and both chemical and spectroscopic assignments (5) concerning these stereoisomers, to date there have been no unequivocal structural determinations by complete crystal structure analysis.

We have found that one of the chromatographic fractions, D, of Weinblum and Johns, assigned structure IV of Wulff and Fraenkel, contains two crystal species. One is triclinic, the other monoclinic; we have designated these D and E respectively. Full three-dimensional diffractometric data have been collected for the monoclinic form which has a = 7.082, b = 11.667, c = 6.847 Å, β = 105.6°; space group $P2_1/c$ with Z = 2 dimers per cell. This thymer must therefore be centrosymmetric in accordance with Weinblum and Johns' assignment.

The crystal structure was solved by the symbolic addition procedure (6) using only the Σ_2 relations. The reliability index, R, is currently 0.10 and the structure is being further refined. The electron density map is shown in Fig. 1 and confirms the cyclobutane structure generally accepted.

The fact that the triclinic form D is $P\bar{1}$ (by N(z) test) and has exactly half the unit cell volume of E suggests that it is a polymorphic variant of E. Its crystal structure analysis is currently in hand as is that of the tetragonal form C, space group $P4_12_12$ with Z = 4 dimers per cell. This latter dimer would be required to have a twofold axis, also in support of Weinblum and Johns' assignment as stereoisomer III. Unfortunately we have not yet been able to prepare good crystalline specimens of thymer fractions A and B.

Results of the fully refined dimer E structure and its hydrogen bonding scheme will be reported elsewhere in due course.

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