

presence and mobility of defects in the form of regions of water deficiency³. An extended region of water deficiency may be regarded as a prismatic dislocation loop which is confined to the 010 plane, that is, to its own particular water layer in which it moves in a non-conservative manner.

The considerable reduction in the ability of the crystal to deform plastically when the shear stresses are not developed in the 010 plane may also be explained by the sandwich structure of the lattice. Under such conditions the generation of a slip involves the movement of dislocations, and the breaking of bonds, in the salt layers. That is, the strong ionic bonds must be broken, and this is a more difficult process than the breaking of the weak bonds of the water layer holding any two salt layers together. Indeed, the strong ionic bonds of the salt layer makes the generation and movement of dislocations in the layers difficult.

Although it has been shown that the creep behaviour of polycrystalline bars is greatly influenced by the ambient humidity it has not been possible to demonstrate a similar influence when single crystals are deformed plastically or left to creep under the influence of static loads. Thus, it is not immediately possible to link directly the behaviour of single crystals with that of polycrystalline bars.

The peculiar nature of the polycrystalline material, where 'contacts' between crystals (that is, the grain boundaries) have shrunk to dimensions comparable with the transverse dimensions of the crystal, could give rise to the strong dependence of the polycrystalline bars on humidity. These 'contacts' are regions where a high degree of lattice disorder will prevail, and could therefore act as source for the type of dislocation which we have discussed as being responsible for the plastic behaviour of single crystals. If the activity of these sources were a function of humidity then the strong effect of humidity would be explicable. Work aimed at elucidating this is now in progress.

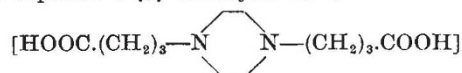
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- ¹ Blakey, *C.S.I.R.O. (Austral.) D.B.R. Rep. Z.7* (1959).
² Russell *et al.*, *C.S.I.R.O. (Austral.) D.B.R. Tech. Paper No. 9* (1960).
³ Eipeltauer, *Zement Kalk Gips*, **13** (6), 259 (1960).
⁴ Perederij, *Chem. Tech.*, **8**, 659 (1956).
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Crystal Structure of 1,4-Piperazine- γ,γ' -Dibutyric Acid

1,4-Piperazine- γ,γ' -dibutyric acid,



was prepared during investigations in polymer chemistry, and gave an infra-red spectrum which was inconsistent with both the normal COOH—COOH dimerization and zwitterion form of amino-acids. It appeared, therefore, that the hydrogen bonding might be of an unusual type, and, in view of this possibility, the crystal structure has been determined by X-ray methods.

The substance crystallizes in space group $P2_1/a$ with $a = 15.55$, $b = 6.50$, $c = 6.70$ Å.; $\beta = 91.54^\circ$; $D_x = 1.24$ gm. cm.⁻³; $D_m = 1.27$ gm. cm.⁻³; $Z = 2$. The space group indicates that the molecule must be

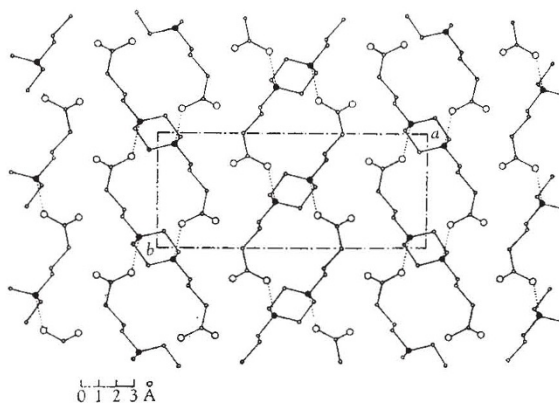


Fig. 1. View of the crystal structure down the c -axis, with hydrogen bonding indicated by broken lines. Small open circles, carbon; black circles, nitrogen; large open circles, oxygen

centrosymmetric, thus locating the centre of the ring at a crystallographic centre of symmetry.

A trial structure was obtained by the sign-fixing method developed by Grant, Hine and Richards¹, and this has been refined by electron-density and least-squares syntheses. The final R value (for 995 of the 1,033 observed reflexions) is 0.147.

A view of the crystal structure down the c -axis is shown in Fig. 1.

The unusual type of structure is confirmed, the hydrogen bonds being between hydroxyl oxygens and the ring nitrogens in adjacent molecules (Fig. 1). The O—H...N distance, 2.60 ± 0.01 Å., is unusually short; compare nicotinic acid² (2.66 ± 0.02 Å.).

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- ¹ Grant, Hine and Richards, *Acta Cryst.*, **13**, 996 (1960).
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RADIATION CHEMISTRY

Metal Ion Redox Systems as Radiation Protective Agents

IN investigations of the sensitivity of enzymes to ionizing radiations both in the solid state and in solution a marked variability has been observed between different batches of one enzyme¹. This has been ascribed to the presence of protective agents which are impurities even in samples of high enzymatic activity, and which are often difficult to remove. Little has been done to identify such natural agents although various substances, particularly sulphhydryl compounds, have long been recognized as being especially effective as protective agents. It was suggested by Howard-Flanders² that these compounds act by donating hydrogen atoms to the radicals formed under the action of radiation, thus repairing the initial damage.

There are, however, other possible mechanisms. The primary action of the ionizing radiation is to