

## CRYSTAL STRUCTURE OF L(+) CYSTEINE HYDROCHLORIDE MONOHYDRATE\*

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### 1. INTRODUCTION

THE determination of the crystal structure of L(+) cysteine hydrochloride monohydrate was undertaken as a part of a series of structure determinations of amino-acids and related compounds in this laboratory. The structure of cysteine is of interest in view of the fact that cysteine readily oxidises into cystine in which the disulfide bridge is significant in the folded configuration of proteins.

While much work has been done on cystine and its derivatives,<sup>1-4</sup> little work has been done on cysteine.<sup>5</sup>

This is a preliminary note on the structure which has been established in all its essential details. Detailed report after complete refinement of the structure will be published in due course.

### 2. EXPERIMENTAL

Good crystals of L(+) cysteine hydrochloride monohydrate were grown by slow evaporation of an aqueous solution and were obtained as needles along [001].

Oscillation and Weisenberg photographs taken with  $\text{CuK}\alpha$  radiation gave the following cell dimensions:

$$a = 19.48 \text{ \AA}, b = 7.12 \text{ \AA}, c = 5.52 \text{ \AA}$$

The zero, first, and second layer Weisenberg photographs taken about the needle axis (*c*) and Buerger precession photographs of the  $a^*c^*$  and  $b^*c^*$  reciprocal lattice planes showed that the general systematic absences were only in  $h00$ ,  $0k0$ , and  $00l$  reflections for *h*, *k*, and *l* odd respectively thus fixing the space group uniquely to be  $P 2_12_12_1$ .

The density of the crystals determined by the method of floatation using a mixture of benzene and bromoform was 1.51 g./c.c. This leads to the total weight of the unit cell to be 696 while the calculated value assuming four formula units of  $\text{C}_3\text{H}_8\text{NO}_2\text{SCl}$ ,  $\text{H}_2\text{O}$ , in the unit cell comes to be 700 thus clearly establishing that the compound is a monohydrate.

Intensities were recorded on multiple films using the equi-inclination Weisenberg technique for  $hk0$ ,  $hk1$ ,  $hk2$ , and  $hk3$  reflections and were measured by visual estimation against a standard intensity strip recorded for the same crystal. They were then reduced to the absolute scale by Wilson plots.

### 3. DETERMINATION OF THE STRUCTURE

The positions of the heavy atoms, chlorine and sulphur were determined by interpreting peaks from a sharpened Patterson map of the *c* and *b* projections. It was noticed that while the single peak due to Cl-Cl interaction could be identified in the unsharpened Patterson of the *c* projection, that due to the S-S interaction could not be so identified though the strength of this peak also was expected to be nearly the same as that for the Cl-Cl one. This was presumably due to the effect of overlap of peaks. However, a sharpened Patterson using the function  $[(\sum Z_j / \sum f_j)^2 - 1]$  for sharpening brought out the S-S interaction single peak convincingly. The merits of this sharpening function are being studied and will be reported later.

The rest of the structure was worked out in both the *c* and *b* projections by the beta general synthesis<sup>6</sup> whose superiority over the heavy atom phased synthesis has been demonstrated recently.<sup>7</sup> In the present case, chlorine and sulphur were used as the known (P) atoms. All the remaining atoms could be fixed from these syntheses. A structure factor calculation with the co-ordinates of all the atoms as determined from these maps gave an R value of 28% for both the *c* and *b* projections.

The structure was then refined by three-dimensional least squares refinement with individual isotropic temperature factors for the atoms. After six cycles of refinement, the R value reduced to 15.6% for a total of about 600 reflections. When unobserved reflections were omitted, the R value was 12.4%.

### 4. MAIN FEATURES OF THE STRUCTURE

The co-ordinates of the atoms at the stage of the last refinement are given in Table I. A map

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of the structure projected along the c-axis is shown in Fig. 1. The bond lengths and the bond angles are shown in Table II.

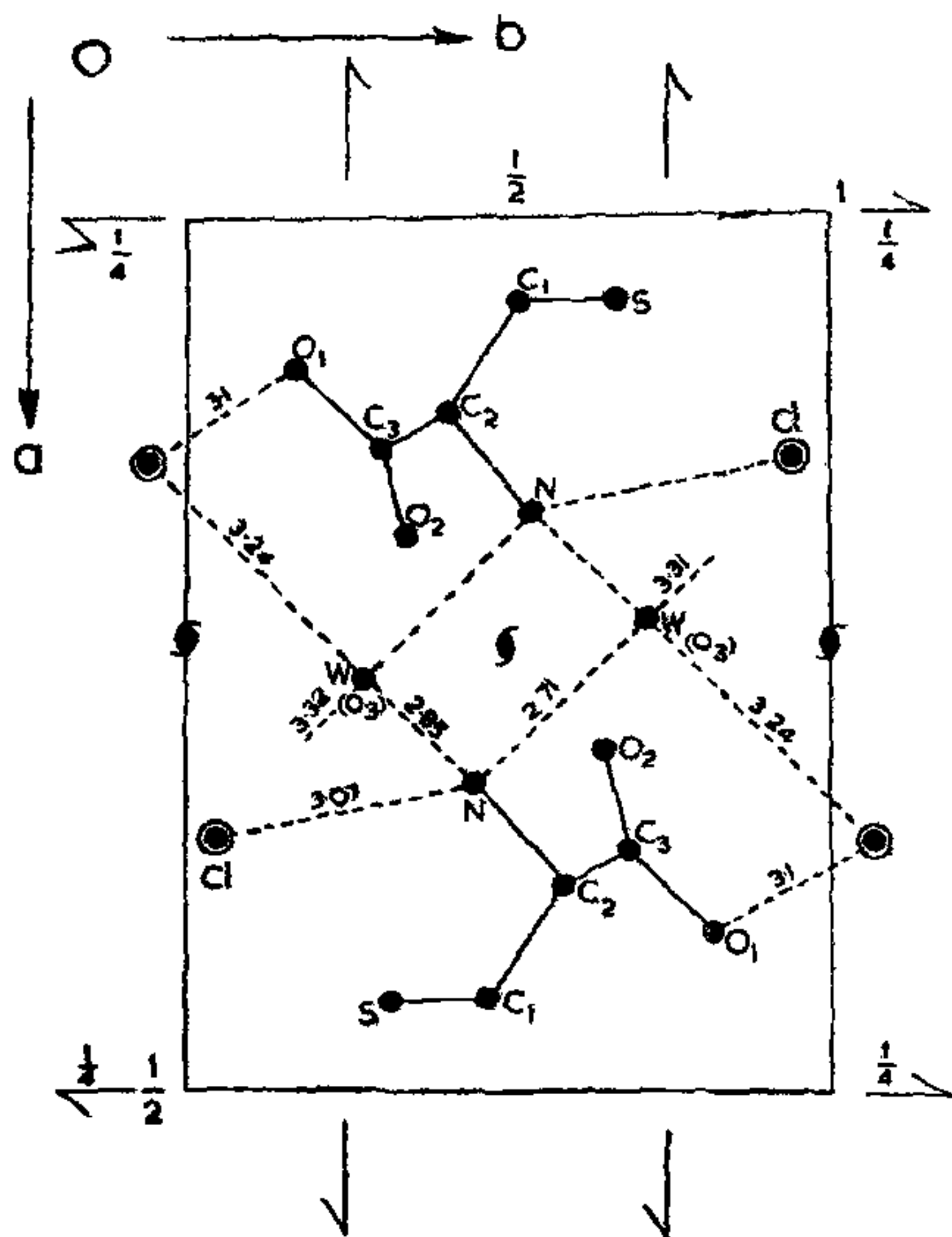


FIG. 1. Structure of L(+) Cysteine hydrochloride monohydrate projected down the c-axis. Hydrogen bonds are marked by dashed lines.

TABLE I

Atomic co-ordinates of L(+) cysteine hydrochloride monohydrate  
(Origin as in *International Tables*, Vol. I)

Atom	Atomic Co-ordinates			Temp. factor B (Å <sup>2</sup> )
	x	y	z	
Cl	0.3596	0.0520	0.0145	2.09
S	0.4513	0.3214	0.4344	2.63
O <sub>1</sub>	0.4097	0.8195	0.4487	2.55
O <sub>2</sub>	0.3122	0.6584	0.3891	3.08
O <sub>3</sub>	0.2641	0.2362	0.4282	2.33
N	0.3269	0.4595	0.8024	1.19
C <sub>1</sub>	0.4533	0.4786	0.6879	0.95
C <sub>2</sub>	0.3869	0.5903	0.7363	1.01
C <sub>3</sub>	0.3649	0.6916	0.5140	1.90

Table II shows that all the bond lengths and bond angles are normal within the accuracy of

TABLE II

Bond lengths and bond angles

S—C <sub>1</sub>	1.795 Å	S—C <sub>1</sub> —C <sub>2</sub>	115° 34'
C <sub>1</sub> —C <sub>2</sub>	1.532 Å	C <sub>1</sub> —C <sub>2</sub> —C <sub>3</sub>	111° 58'
C <sub>2</sub> —C <sub>3</sub>	1.494 Å	C <sub>1</sub> —C <sub>2</sub> —N	111° 48'
C <sub>2</sub> —N	1.540 Å	C <sub>2</sub> —C <sub>3</sub> —O <sub>1</sub>	111° 24'
C <sub>3</sub> —O <sub>1</sub>	1.319 Å	C <sub>2</sub> —C <sub>3</sub> —O <sub>2</sub>	125° 59'
C <sub>3</sub> —O <sub>2</sub>	1.261 Å	O <sub>1</sub> —C <sub>3</sub> —O <sub>2</sub>	122° 30'
		C <sub>3</sub> —C <sub>2</sub> —N	105° 20'

refinement reached so far. The system of hydrogen bonds may be seen in the figure. The hydrogen bonds are of the type O—H...Cl, N—H...Cl and N—H...O. The value of the bond lengths for C—O (1.26 and 1.32 Å) in the carboxyl group indicates that most probably the structure is of the non-zwitterion form and that one of the carboxyl oxygens exists in the O—H form. The hydrogen bonding around nitrogen is also normal and has tetrahedral arrangement. The structure is stabilised by a chain of hydrogen bonds formed by the water molecule with the neighbouring chlorine atoms and the amino-nitrogen. The surroundings of the water are nearly tetrahedral.

These features are under closer examination and a complete three-dimensional least square refinement is under progress.

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