

***N*-[Tris(hydroxymethyl)methyl]glycine
(tricine)**

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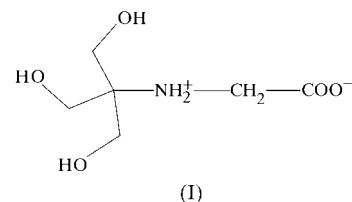
The title compound, $C_6H_{13}NO_5$, adopts a zwitterionic form where the carboxylic acid H atom is transferred to the amino group. The methyl-glycine backbone is planar. The tris-(hydroxymethyl)methyl group is rotated as a rigid group around the amino-methyl bond by $22(1)^\circ$ and the carboxylic acid plane is rotated by $19.76(12)^\circ$ from the plane of the main skeleton. Apart from their H atoms, the three hydroxymethyl groups adopt a propeller-like conformation around the amino-methyl bond, close to C_3 symmetry.

Comment

Tricine {*N*-[tris(hydroxymethyl)methyl]glycine} was first prepared by Good (1962) to serve as a buffer for chloroplast reactions. It is an amphoteric compound widely used in gel electrophoresis (SDS-PAGE systems) to separate proteins in the range 1–100 kDa (Schager & von Jagow, 1987). Buffer solutions of tricine have a useful pH range of 7.4–8.8. A common use of these buffers is in ATP assays using the luciferase/luciferin light-emitting reaction, for which it was found to be the best of ten common buffers tested by Webster & Leach (1980). Tricine buffers were also found to be efficient scavengers of hydroxyl radicals in a study of radiation-induced membrane damage (Hicks & Gebicki, 1986), and tricine/dimethyl sulfoxide solutions may be used for cryopreservation of tissues and organs (Roy *et al.*, 1985). Tricine is a good complexation agent for divalent alkaline-earth and transition metal cations (Good *et al.*, 1966). Stable complexation of Th^{4+} , Ce^{3+} , La^{3+} and UO_2^{2+} has also been reported (El-Roudy *et al.*, 1997). Although the formation of these complexes in solution has been studied by potentiometric methods and polarimetry, only two crystal structures, *i.e.* of a Zn^{2+} and an Ni^{2+} complex, have been reported (Menabue & Saladini, 1992). The crystal structure of pure tricine has not been reported to date. Our interest in the coordination chemistry of *N*-alkylated amino acid derivatives led us to perform an X-ray diffraction study of the title compound, (I).

The molecule of (I) crystallizes in a zwitterionic form, the carboxylic acid H atom being transferred to the amino N

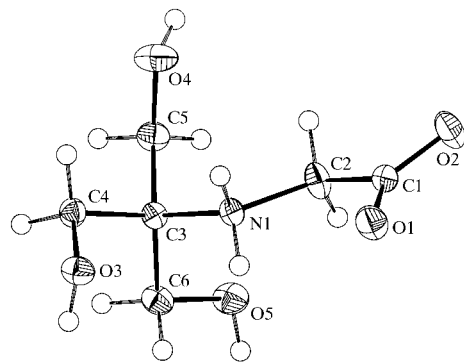
atom. Bond distances and angles within the molecule compare well with those of the anionic species (Menabue & Saladini, 1992), with the exception of those involving the amino group. The N1–C2 bond length and the C2–N1–C3 valence angle are larger in the neutral zwitterionic form with a tetravalent N atom than in the anionic form with a trivalent N atom [average reported values $1.478(3) \text{ \AA}$ and $116.9(2)^\circ$, respectively]. However, the N1–C3 bond distance is essentially unaffected by protonation of the amino N atom.



The main skeleton of the molecule, C1–C2–N1–C3, is practically planar. The tris(hydroxymethyl)methyl group is rotated around the N1–C3 bond by $22(1)^\circ$, as shown by the torsion angles C2–N1–C3–C4, C2–N1–C3–C5 and C2–N1–C3–C6 (see Table 1). A projection of the molecule along the N1–C3 bond shows that the three hydroxymethyl groups, apart from their H atoms, adopt a propeller-like conformation with an idealized C_3 symmetry, as shown by the similar values of the torsion angles N1–C3–C5–O4, N1–C3–C4–O3 and N1–C3–C6–O5 (see Table 1). This is equivalent to the conformation adopted by the tris cation [tris(hydroxymethyl)methylammonium] in the monohydrogen phosphite (Averbuch-Pouchot, 1994), the 2-[(2,6-dichlorophenyl)-amino]phenylacetate (Castellari & Ottani, 1997) and the *N,N*-dimethyldithiocarbamylacetate (Ng, 1995) salts.

The carboxylate group is not coplanar with the main skeleton but rotated by $19.76(12)^\circ$ around the C1–C2 bond. Despite the fact that the carboxylic acid group is ionized, there is considerable asymmetry between the carboxy C–O bond lengths, which probably reflects the different involvement of these two O atoms in hydrogen bonding (see below).

Molecules of (I) are linked together in the crystal by an extended three-dimensional hydrogen-bond network (Table 2 and Fig. 2). Full saturation of every donor involved in the hydrogen bonding is observed. The carboxylate O1 and O2

**Figure 1**

An ORTEP (Johnson, 1976) plot of (I). Displacement ellipsoids are drawn at the 50% probability level and H atoms are shown as small spheres of arbitrary radii.

atoms are acceptors of one and two hydrogen bonds, respectively. Each of the hydroxy groups establishes a hydrogen bond with a neighbouring O atom of a carboxylate or another hydroxy group. Atoms O3 and O5 are both donors and acceptors, whereas atom O4 acts only as a donor. A number of weaker intramolecular C—H...O bonds towards the hydroxyl groups may be relevant in stabilizing the propeller-like conformation of the hydroxymethyl groups around the amino-methyl bond.

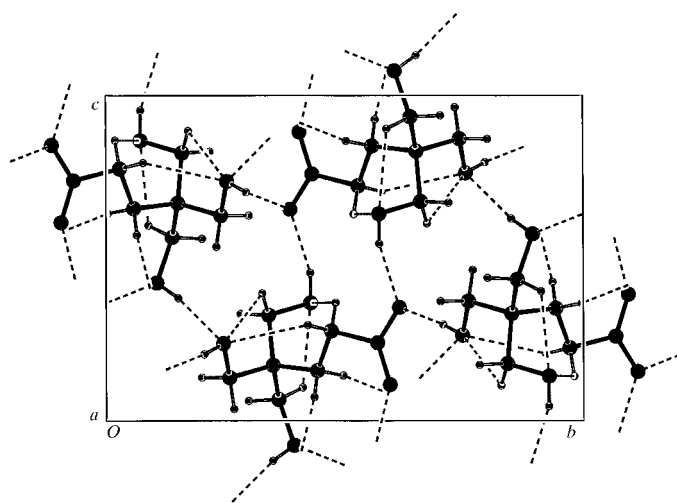


Figure 2
Projection of the crystal structure of (I) along the *a* axis, with the hydrogen-bond network shown as dashed lines.

Experimental

Tricine (Sigma–Aldrich, 98%) was used as purchased and was recrystallized from ethanol. Within a few days, large transparent block-shaped crystals of (I) grew from the solution.

Crystal data

$C_6H_{13}NO_5$	$D_x = 1.523 \text{ Mg m}^{-3}$
$M_r = 179.18$	Mo $K\alpha$ radiation
Monoclinic, $P2_1/n$	Cell parameters from 25 reflections
$a = 6.2806 (16) \text{ \AA}$	$\theta = 9.69\text{--}14.07^\circ$
$b = 13.5616 (13) \text{ \AA}$	$\mu = 0.133 \text{ mm}^{-1}$
$c = 9.6165 (10) \text{ \AA}$	$T = 293 (2) \text{ K}$
$\beta = 107.488 (11)^\circ$	Prism, colourless
$V = 781.2 (2) \text{ \AA}^3$	$0.49 \times 0.20 \times 0.12 \text{ mm}$
$Z = 4$	

Data collection

Enraf–Nonius CAD-4 diffractometer	$\theta_{\text{max}} = 29.96^\circ$
Profile data from ω – 2θ scans	$h = 0 \rightarrow 8$
2434 measured reflections	$k = 0 \rightarrow 19$
2255 independent reflections	$l = -13 \rightarrow 12$
1920 reflections with $I > 2\sigma(I)$	3 standard reflections
$R_{\text{int}} = 0.020$	frequency: 180 min
	intensity decay: 1.1%

Refinement

Refinement on F^2	$w = 1/[\sigma^2(F_o^2) + (0.0479P)^2 + 0.1832P]$
$R[F^2 > 2\sigma(F^2)] = 0.030$	where $P = (F_o^2 + 2F_c^2)/3$
$wR(F^2) = 0.089$	$(\Delta/\sigma)_{\text{max}} < 0.001$
$S = 1.063$	$\Delta\rho_{\text{max}} = 0.39 \text{ e \AA}^{-3}$
2255 reflections	$\Delta\rho_{\text{min}} = -0.19 \text{ e \AA}^{-3}$
149 parameters	Extinction correction: <i>SHELXL97</i>
Only coordinates of H atoms refined	Extinction coefficient: 0.069 (6)

Table 1
Selected geometric parameters (\AA , $^\circ$).

O1—C1	1.2379 (11)	N1—C2	1.4906 (11)
O2—C1	1.2623 (11)	N1—C3	1.5175 (11)
C2—N1—C3	118.62 (7)		
C3—N1—C2—C1	177.57 (7)	C2—N1—C3—C4	−157.24 (8)
O1—C1—C2—N1	19.76 (12)	N1—C3—C4—O3	−46.39 (9)
O2—C1—C2—N1	−159.87 (9)	N1—C3—C5—O4	−53.88 (10)
C2—N1—C3—C5	−39.57 (11)	N1—C3—C6—O5	−66.90 (9)
C2—N1—C3—C6	82.69 (10)		

Table 2
Hydrogen-bonding geometry (\AA , $^\circ$).

<i>D</i> —H... <i>A</i>	<i>D</i> —H	H... <i>A</i>	<i>D</i> ... <i>A</i>	<i>D</i> —H... <i>A</i>
N1—H1A...O1 ⁱ	0.896 (13)	1.991 (13)	2.8830 (11)	173.0 (12)
N1—H1B...O3 ⁱⁱⁱ	0.923 (13)	1.876 (13)	2.7894 (11)	170.3 (11)
O3—H3...O5 ⁱⁱⁱ	0.816 (16)	1.928 (16)	2.7347 (11)	170.2 (15)
O4—H4...O2 ^{iv}	0.851 (19)	1.904 (19)	2.7220 (11)	160.9 (17)
O5—H5...O2 ^v	0.862 (17)	1.764 (17)	2.6224 (11)	174.0 (16)
C2—H2A...O5	0.944 (15)	2.494 (14)	3.0781 (13)	120.2 (10)
C2—H2B...O4	0.985 (14)	2.523 (14)	3.1380 (15)	120.4 (10)
C4—H4B...O4	0.966 (13)	2.462 (13)	2.8775 (12)	105.7 (9)
C5—H5B...O5	0.960 (14)	2.473 (13)	2.8460 (13)	103.0 (9)

Symmetry codes: (i) $1 - x, -y, 1 - z$; (ii) $-x, -y, 1 - z$; (iii) $x - \frac{1}{2}, \frac{1}{2} - y, z - \frac{1}{2}$; (iv) $1 - x, -y, 2 - z$; (v) $\frac{3}{2} - x, \frac{1}{2} + y, \frac{3}{2} - z$.

All H atoms were located on a difference Fourier map and their coordinates were refined isotropically [$C-H = 0.94 (2)$ – $1.01 (1) \text{ \AA}$], with displacement parameters constrained to those of the parent atom; $U_{\text{eq}}(\text{H}) = 1.2U_{\text{eq}}(\text{C/N})$ or $1.5U_{\text{eq}}(\text{O})$.

Data collection and cell refinement: *CAD-4 Software* (Enraf–Nonius, 1989); data reduction: *HELENA* (Spek, 1997); structure solution: *SHELXS97* (Sheldrick, 1990); structure refinement: *SHELXL97*; molecular graphics: *ORTEPII* (Johnson, 1976).

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Supplementary data for this paper are available from the IUCr electronic archives (Reference: BJ1011). Services for accessing these data are described at the back of the journal.

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