Redetermination of the crystal structure of *N*-acetyl glycine (2-acetamidoacetic acid), $C_4H_7NO_3$

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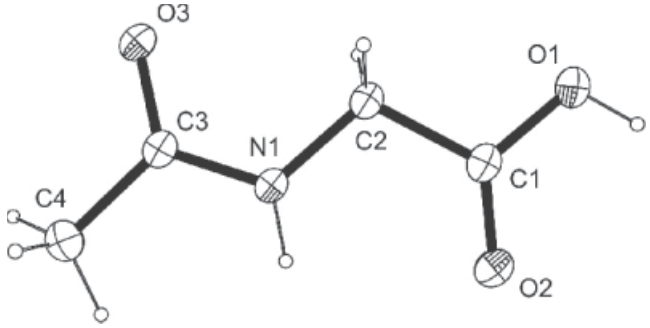

Abstract

$C_4H_7NO_3$, monoclinic, $P2_1/c$ (no. 14), a = 4.8110(2) Å, b = 11.5030(5) Å, c = 9.7660(4) Å, β = 97.864(2)°, V = 535.4 Å^3, Z = 4, $R_{gt}(F)$ = 0.0356, $wR_{ref}(F^2)$ = 0.1099, T = 200 K.

Table 1. Data collection and handling.

Crystal:	colourless trigonals, size 0.129×0.410×0.529 mm
Wavelength:	Mo K_α radiation (0.71069 Å)
μ:	1.25 cm^{-1}
Diffractometer, scan mode:	Bruker APEX-II CCD, φ and ω
$2\theta_{max}$:	56.38°
$N(hkl)_{measured}$, $N(hkl)_{unique}$:	4735, 1310
Criterion for I_{obs}, $N(hkl)_{gt}$:	$I_{obs} > 2\ \sigma(I_{obs})$, 1179
$N(param)_{refined}$:	79
Programs:	SHELX [11], ORTEP-3 [12], MERCURY [13], PLATON [14]

Source of material

In an Erlenmeyer flask, glycine (7.5 g, 0.1 mol) was suspended in water (30 mL) and stirred vigorously until complete dissolution had occurred. Acetic anhydride (21.5 g, 0.2 mol) was added in one portion and stirring was continued for 15–20 min. The solution was kept in a refrigerator overnight to effect complete crystallization. The crystals were collected by filteration and dried at 100–110 °C. The residue was recrystallized from boiling water, yield: 89%.

Experimental details

Carbon-bound H atoms were placed in calculated positions (C–H 0.99 Å) and were included in the refinement in the riding model approximation, with U_{iso}(H) set to 1.2U_{eq}(C). The H atoms of the methyl group were allowed to rotate with a fixed angle around the C–C bond to best fit the experimental electron density (HFIX 137 in the SHELX program suite [11]), with U_{iso}(H) set to 1.5U_{eq}(C). The H atom of the hydroxyl group was allowed to rotate with a fixed angle around the C–O bond to best fit the experimental electron density (HFIX 147 in the SHELX program suite [11]), with U_{iso}(H) set to 1.5U_{eq}(O). The nitrogen-bound H atom was located on a difference Fourier map and refined freely.

Discussion

N-acetyl glycine is the acetyl derivative of the essential amino acid glycine. It is used as the starting material for the synthesis of oxazalones and aryl methyl triazinones [1, 2]. The biological activities of *N*-acyl glycine derivatives include antinociceptive, anti-inflammatory and antiproliferative effects as well as the ability of activating G-protein-coupled receptors [3]. The crystal structure of *N*-acetyl glycine was originally determined by Carpenter and Donhue by means of neutron radiation in 1950 but no atomic coordinates were determined [4]. Their findings were, in principle, confirmed by Peterson *et al.* seven years later [5]. A first refinement providing coordinates and individual anisotropic temperature parameters of carbon, nitrogen and oxygen atoms as well as the coordinates of four hydrogen atoms was achieved by Donhue and Marsh in 1962 [6]. But in this case – as well as in a following study by Mackay [7] – only room temperature data was available. It was found earlier [8] that the infrared absorption spectrum of single crystals of *N*-acetyl glycine (when recorded at room temperature and at -185 °C, respectively, using polarized radiation) showed some remarkable changes with temperature. The cooling produced a pronounced narrowing of the broad bands due to the vibration of hydrogen atoms involved in strong hydrogen bonds and thus furnished examples of NH absorption in the two extremes of weak and very strong hydrogen bonding [8]. The molecule is essentially planar (r.m.s. of all fitted non-hydrogen atoms = 0.0423 Å) with the keto-type oxygen atom of the carboxyl group deviating most from this common plane by 0.066(1) Å. This finding is corroborated by the small value of the O=C–C–N dihedral angle that was measured at only 3.1(2)°. C–N bond lengths were found at 1.332(1) Å and 1.446(1) Å, respectively, with the smaller value formed with the sp^2-hybridized carbon atom. The latter finding is in good agreement with the values reported for the room temperature determination by Donhue and Marsh [6], however, the values are found invariably slightly longer than in the study conducted by Mackay [7]. Hydrogen bonds of the N–H···O and O–H···O type are present. The carboxy group serves as acceptor for the N–H···O type hydrogen bond, giving rise to the formation of centrosymmetric dimers. The O–H···O

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type hydrogen bonds are supported by the oxygen atom of the acetyl moiety as acceptor. In total, the molecules are connected to sheets parallel [1 0 ½]. In terms of graph-set analysis [9, 10], the hydrogen bonds necessitate the two first level graph set descriptors $C^1_1(7)$ and $R^2_2(10)$. The presence of strong N–H···O type hydrogen bonds as indicated by low temperature infrared absorption spectroscopy [8] can, therefore, be confirmed.

Table 2. Atomic coordinates and displacement parameters (in Å^2).

Atom	Site	*x*	*y*	*z*	U_{iso}
H(81)	4*e*	–0.2182	0.3107	0.6134	0.040
H(71)	4*e*	0.191(3)	0.053(1)	0.398(1)	0.026(3)
H(2A)	4*e*	0.0913	0.2765	0.3333	0.027
H(2B)	4*e*	0.3513	0.2714	0.4547	0.027
H(4A)	4*e*	0.3911	–0.0237	0.1321	0.050
H(4B)	4*e*	0.4454	–0.0692	0.2883	0.050
H(4C)	4*e*	0.6996	–0.0178	0.2172	0.050

Table 3. Atomic coordinates and displacement parameters (in Å^2).

Atom	Site	*x*	*y*	*z*	U_{11}	U_{22}	U_{33}	U_{12}	U_{13}	U_{23}
O(1)	4*e*	–0.1010(2)	0.31992(7)	0.55795(8)	0.0317(4)	0.0220(4)	0.0297(4)	0.0013(3)	0.0175(3)	–0.0012(3)
O(2)	4*e*	–0.0936(2)	0.12542(7)	0.55887(9)	0.0448(5)	0.0219(4)	0.0403(5)	–0.0013(3)	0.0281(4)	0.0034(3)
O(3)	4*e*	0.5480(2)	0.19665(7)	0.23176(9)	0.0318(4)	0.0208(4)	0.0316(4)	–0.0035(3)	0.0193(3)	0.0005(3)
N(1)	4*e*	0.2563(2)	0.11694(8)	0.36460(9)	0.0270(5)	0.0173(4)	0.0251(5)	–0.0020(3)	0.0147(4)	–0.0002(3)
C(1)	4*e*	–0.0201(2)	0.21796(9)	0.5177(1)	0.0225(5)	0.0215(5)	0.0207(5)	–0.0005(4)	0.0086(4)	0.0001(4)
C(2)	4*e*	0.1802(2)	0.22996(9)	0.4127(1)	0.0264(5)	0.0196(5)	0.0246(5)	–0.0033(4)	0.0136(4)	–0.0019(4)
C(3)	4*e*	0.4379(2)	0.10785(9)	0.2737(1)	0.0233(5)	0.0199(5)	0.0214(5)	–0.0006(4)	0.0095(4)	0.0004(4)
C(4)	4*e*	0.4987(3)	–0.0109(1)	0.2235(1)	0.0427(6)	0.0202(5)	0.0419(7)	0.0006(5)	0.0249(5)	–0.0031(5)

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