Hongjuan Tong* and Wenqiang Tang

Crystal structure of 4-methyl-4-nitropentanoic acid, $C_6H_{11}NO_4$

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Abstract

$C_6H_{11}NO_4$, monoclinic, $P2_1/c$ (no. 14), $a = 19.1903(7)$ Å, $b = 18.4525(6)$ Å, $c = 9.2197(3)$ Å, $\beta = 95.879(1)^\circ$, $V = 3247.61(19)$ Å³, $Z = 16$, $R_{gt}(F) = 0.0495$, $wR_{ref}(F^2) = 0.1194$, $T = 173$ K.

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The asymmetric unit (four molecules) of the title crystal structure is shown in the figure. Table 1 contains crystallographic data and Table 2 contains the list of the

Table 1: Data collection and handling.

Crystal:	Colourless block
Size:	0.19 × 0.12 × 0.08 mm
Wavelength:	MoK α radiation (0.71073 Å)
μ :	0.11 mm ⁻¹
Diffractometer, scan mode:	D8 VENTURE, φ and ω
θ_{max} , completeness:	25.7°, >99%
$N(hkl)_{measured}$, $N(hkl)_{unique}$, R_{int} :	34982, 6176, 0.065
Criterion for I_{obs} , $N(hkl)_{gt}$:	$I_{obs} > 2 \sigma(I_{obs})$, 4192
$N(param)_{refined}$:	409
Programs:	Bruker [1], Olex2 [2], SHELX [3, 4]

atoms including atomic coordinates and displacement parameters.

***Corresponding author: Hongjuan Tong**, Collaborative Innovation Center of Green Manufacturing Technology for Traditional Chinese Medicine in Shaanxi Province, School of Pharmacy, Shaanxi Institute of International Trade & Commerce, Xi'an, China, E-mail: hongjuantong@163.com. <https://orcid.org/0000-0001-7219-8018>

Wenqiang Tang, Collaborative Innovation Center of Green Manufacturing Technology for Traditional Chinese Medicine in Shaanxi Province, School of Pharmacy, Shaanxi Institute of International Trade & Commerce, Xi'an, China. <https://orcid.org/0000-0001-5150-4549>

Source of material

A mixture of methyl 4-methyl-4-nitropentanoate (13.6 g, 77.7 mmol), H₂O (20 mL), and sodium hydroxide (6.2 g, 155.0 mmol) was stirred in methanol (200 mL) at 25 °C for 4 h. The reaction was monitored by thin-layer chromatography. The solution was concentrated and diluted with water, and the pH was adjusted to two by adding hydrochloric acid solution (4 mol/L). Then the mixture was

Table 2: Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å²).

Atom	x	y	z	U_{iso}^*/U_{eq}
C1	0.75608 (11)	0.64871 (12)	−0.0723 (2)	0.0367 (5)
C2	0.73326 (14)	0.72754 (13)	−0.0825 (3)	0.0585 (7)
H2A	0.706299	0.739142	−0.000821	0.088*
H2B	0.704067	0.735546	−0.174664	0.088*
H2C	0.774710	0.758787	−0.078538	0.088*
C3	0.80611 (13)	0.63013 (15)	−0.1853 (3)	0.0565 (7)
H3A	0.847565	0.661336	−0.170800	0.085*
H3B	0.782473	0.637847	−0.283447	0.085*
H3C	0.820428	0.579287	−0.174277	0.085*
C4	0.69429 (11)	0.59658 (12)	−0.0813 (2)	0.0359 (5)
H4A	0.665347	0.604531	−0.175119	0.043*
H4B	0.712503	0.546397	−0.081792	0.043*
C5	0.64757 (11)	0.60351 (11)	0.0415 (2)	0.0350 (5)
H5A	0.675130	0.590960	0.134848	0.042*
H5B	0.632397	0.654583	0.047987	0.042*
C6	0.58415 (11)	0.55602 (11)	0.0218 (2)	0.0337 (5)
C7	0.92257 (10)	0.44876 (11)	0.0671 (2)	0.0296 (5)
C8	0.86350 (10)	0.40871 (11)	0.1245 (2)	0.0293 (5)
H8A	0.846285	0.437086	0.204732	0.035*
H8B	0.881073	0.361752	0.165345	0.035*
C9	0.80290 (10)	0.39479 (11)	0.0083 (2)	0.0306 (5)
H9A	0.821137	0.368898	−0.073968	0.037*
H9B	0.784470	0.442072	−0.029089	0.037*
C10	0.74218 (10)	0.35086 (11)	0.0585 (2)	0.0293 (5)
C11	0.67860 (11)	0.35406 (13)	−0.0543 (3)	0.0433 (6)
H11A	0.638989	0.329650	−0.015980	0.065*
H11B	0.689465	0.329817	−0.143807	0.065*
H11C	0.666394	0.404785	−0.075686	0.065*
C12	0.76261 (12)	0.27347 (11)	0.0974 (3)	0.0439 (6)
H12A	0.802466	0.273427	0.172937	0.066*
H12B	0.775717	0.248413	0.010533	0.066*
H12C	0.722874	0.248497	0.134020	0.066*
C13	0.56382 (12)	0.35839 (13)	0.3456 (3)	0.0472 (6)
H13A	0.600837	0.321590	0.353621	0.071*
H13B	0.584818	0.406546	0.361079	0.071*
H13C	0.538046	0.356125	0.248310	0.071*
C14	0.55212 (12)	0.34131 (13)	0.6122 (3)	0.0478 (6)
H14A	0.519089	0.328427	0.682318	0.072*
H14B	0.572771	0.388805	0.637438	0.072*
H14C	0.589296	0.304768	0.615088	0.072*
C15	0.51379 (10)	0.34429 (11)	0.4602 (2)	0.0329 (5)
C16	0.45390 (10)	0.39909 (11)	0.4473 (2)	0.0325 (5)
H16A	0.473254	0.447322	0.476092	0.039*
H16B	0.434680	0.402127	0.343691	0.039*
C17	0.39417 (11)	0.38264 (11)	0.5381 (2)	0.0354 (5)
H17A	0.375231	0.333948	0.511865	0.043*
H17B	0.412538	0.381622	0.642437	0.043*
C18	0.33636 (11)	0.43665 (11)	0.5171 (2)	0.0323 (5)
C19	0.82245 (11)	0.43839 (11)	0.5703 (2)	0.0315 (5)
C20	0.88257 (10)	0.38917 (11)	0.6127 (2)	0.0331 (5)
H20A	0.866486	0.338432	0.598889	0.040*
H20B	0.897645	0.396017	0.717734	0.040*
C21	0.94537 (10)	0.40079 (11)	0.5274 (2)	0.0333 (5)
H21A	0.966544	0.448418	0.554780	0.040*
H21B	0.928839	0.402546	0.422200	0.040*

Table 2: (continued)

Atom	x	y	z	U_{iso}^*/U_{eq}
C22	1.00167 (11)	0.34277 (11)	0.5520 (2)	0.0331 (5)
C23	1.05905 (12)	0.35373 (13)	0.4508 (3)	0.0503 (6)
H23A	1.092088	0.313142	0.461992	0.075*
H23B	1.083956	0.399105	0.475913	0.075*
H23C	1.037897	0.355992	0.349520	0.075*
C24	1.03104 (13)	0.33656 (13)	0.7097 (3)	0.0503 (6)
H24A	0.993059	0.325579	0.769665	0.075*
H24B	1.053214	0.382466	0.741832	0.075*
H24C	1.065913	0.297617	0.720061	0.075*
N1	0.79737 (9)	0.63679 (11)	0.0767 (2)	0.0426 (5)
N2	0.72169 (9)	0.38875 (10)	0.1960 (2)	0.0354 (4)
N3	0.96799 (10)	0.26962 (10)	0.5037 (2)	0.0436 (5)
N4	0.48169 (10)	0.26949 (10)	0.4223 (2)	0.0402 (5)
O1	0.80612 (10)	0.68733 (11)	0.1613 (2)	0.0805 (7)
O2	0.81854 (9)	0.57622 (10)	0.1064 (2)	0.0614 (5)
O3	0.55162 (8)	0.54987 (9)	0.13922 (16)	0.0439 (4)
H3	0.515449	0.524521	0.120596	0.066*
O4	0.56416 (8)	0.52655 (9)	−0.09352 (16)	0.0455 (4)
O5	0.97344 (7)	0.46448 (9)	0.16907 (15)	0.0397 (4)
H5	1.005219	0.486990	0.131798	0.059*
O6	0.92375 (7)	0.46551 (8)	−0.06038 (15)	0.0372 (4)
O7	0.69537 (9)	0.44870 (9)	0.18189 (19)	0.0539 (5)
O8	0.73406 (9)	0.35905 (9)	0.31411 (17)	0.0511 (4)
O9	0.50447 (10)	0.21668 (9)	0.4906 (2)	0.0674 (5)
O10	0.43602 (9)	0.26558 (9)	0.3203 (2)	0.0580 (5)
O11	0.34033 (8)	0.49239 (8)	0.44751 (17)	0.0440 (4)
O12	0.28062 (8)	0.41778 (8)	0.57958 (17)	0.0411 (4)
H12	0.249494	0.449598	0.563435	0.062*
O13	0.76674 (7)	0.42231 (8)	0.63628 (16)	0.0407 (4)
H13	0.733639	0.450048	0.606388	0.061*
O14	0.82438 (7)	0.48858 (8)	0.48409 (17)	0.0411 (4)
O15	0.99058 (12)	0.21474 (9)	0.5639 (2)	0.0753 (6)
O16	0.92169 (9)	0.26922 (10)	0.4027 (2)	0.0699 (6)

extracted with ethyl acetate and washed with brine. The organic layer was concentrated under reduced pressure, and the residue was purified by column chromatography using petroleum ether and ethyl acetate (5:1, v/v) as eluent. Crystals were obtained by slow evaporation of the aforementioned mixed solution at room temperature after a week.

Experimental details

All hydrogen atoms were placed in theoretical positions and refined in riding models with the U_{iso} values set to 1.2 or 1.5 times of those of the attached atoms. The distances of C–H bonds were constrained from 0.98 to 0.99 Å. Oxygen-bound H atoms were also included in the refinement in the riding model with O–H = 0.84 Å and their $U_{iso} = 1.5 U_{eq}(O)$.

Comment

The γ -aminobutyric acid (GABA) is a kind of non-protein amino acid widely distributed in nature, such as in plants, animals, and microorganisms. It can be produced by plant extraction, isolation, microbial fermentation, and chemical synthesis [5, 6]. Some γ -aminobutyric acids are the primary inhibitory transmitters of the mammalian central nervous system. They have significant physiological functions such as lowering blood pressure, sedation, anti-anxiety, anti-epilepsy, enhancing memory, preventing diabetes, and regulating insomnia [7–11]. Therefore, γ -aminobutyric acid and its derivatives have broad application prospects in pharmaceutical research [12, 13]. The 4-methyl-4-nitro-pentanoic acid is an essential intermediate for the synthesis of γ -aminobutyric acid derivatives. In addition, it has been widely used in the preparation of lactam, nitro acid, and nitro amide. As a precursor of γ -amino acid, the crystal structure of the title compound would provide a crucial pharmacodynamic fragment for drug molecular design and synthesis.

The asymmetric unit contains four crystallographically independent molecules, as shown in the figure. The bond lengths of C6–O4, C7–O6, C18–O11, and C19–O14 in the title molecule are 1.221(3), 1.218(3), 1.219(3), and 1.223(3) Å, respectively. It illustrated characteristic C=O double bonds. In addition, the bond length of N1–O1, N1–O2, N2–O7, N2–O8, N3–O15, N3–O16, N4–O9, N4–O10 in the title molecule are in the range of 1.211(3)–1.220(3) Å. The bond lengths of C–C, C–N are in the range of 1.489–1.529 Å and 1.531–1.542 Å, respectively. These bond distances are all in their normal ranges. The molecules are connected to each other through hydrogen bonds between carboxyl groups and carboxyl groups, including O3...H3...O4, O13...H13...O11, O12...H12...O14, and O5...H5...O6. The lengths of hydrogen bonds are 1.7906 (16), 1.8015 (15), 1.8374 (14), and 1.8010 (15) Å. It can be seen that the hydrogen bonds are stable and strong.

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