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1:1 Cocrystal of (*S*)-3-(ammoniomethyl)-5-methylhexanoate and (*S*)-mandelic acid

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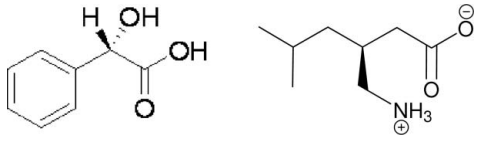
Key indicators: single-crystal X-ray study; T = 296 K; mean σ(C–C) = 0.007 Å; R factor = 0.058; wR factor = 0.148; data-to-parameter ratio = 10.2.

The title compound, $C_8H_{17}NO_2\cdot C_8H_8O_3$, exists as a complex with the base (pregabalin) in the predicted zwitterion form, based on the pK_a differences between the acid and base. The asymmetric unit consists of two molecules of each component. The –NH_3 group adopts the standard propeller conformation. The structure forms pairs of hydrophobic and hydrophilic interactions along both the *a* and *c* axes.

Related literature

For related literature, see: Hoekstra *et al.* (1997); Mulhern (1996); Pope & Peachey (1899).



Experimental

Crystal data

$C_8H_{17}NO_2\cdot C_8H_8O_3$
M_r = 311.37
Monoclinic, $P2_1$
a = 6.2922 (13) Å
b = 27.423 (6) Å
c = 10.009 (2) Å
β = 90.84 (3)°
V = 1726.9 (6) Å^3
Z = 4
Mo $K\alpha$ radiation
μ = 0.09 mm^{-1}
T = 296 (2) K
0.22 × 0.11 × 0.05 mm

Data collection

Bruker APEXII CCD diffractometer
Absorption correction: multi-scan (*SADABS*; Sheldrick, 2002)
T_{min} = 0.956, T_{max} = 0.996
38738 measured reflections
4159 independent reflections
2488 reflections with $I > 2\sigma(I)$
R_{int} = 0.096

Refinement

$R[F^2 > 2\sigma(F^2)]$ = 0.059
$wR(F^2)$ = 0.148
S = 0.92
4159 reflections
407 parameters
1 restraint
H-atom parameters constrained
$\Delta\rho_{max}$ = 0.57 e Å^{-3}
$\Delta\rho_{min}$ = −0.21 e Å^{-3}

Table 1
Hydrogen-bond geometry (Å, °).

D—H···A	D—H	H···A	D···A	D—H···A
O4—H4···O10	0.82	1.69	2.501 (4)	173
O1—H1A···O7^{i}	0.82	1.68	2.493 (4)	171
N1—H1B···O8	0.89	1.92	2.808 (5)	172
N1—H1C···O7^{ii}	0.89	2.23	3.052 (5)	154
N1—H1D···O5^{iii}	0.89	1.93	2.812 (5)	172
N2—H2A···O9^{iv}	0.89	1.90	2.771 (5)	167
N2—H2B···O10	0.89	2.19	3.048 (5)	163
N2—H2C···O2	0.89	1.94	2.804 (4)	163
O3—H3···O10	0.82	1.92	2.708 (4)	160
O6—H6···O7^{v}	0.82	1.88	2.689 (4)	167

Symmetry codes: (i) $x, y, z-1$; (ii) $x-1, y, z$; (iii) $x, y, z+1$; (iv) $x+1, y, z$; (v) $x-1, y, z-1$.

Data collection: *APEX2* (Bruker, 2005); cell refinement: *APEX2*; data reduction: *SAINT-Plus* (Bruker, 2003); program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *XP* (Sheldrick, 1996); software used to prepare material for publication: *SHELXL97*.

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: CS2049).

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  doi:10.1107/S1600536807041803

supplementary materials

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1:1 Cocrystal of (*S*)-3-(ammoniomethyl)-5-methylhexanoate and (*S*)-mandelic acid

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Comment

The title complex, (I), is an important intermediate in the overall synthesis of pregabalin. Pregabalin, marketed as Lyrica by Pfizer (see http://www.lyrica.com), is an approved drug for the treatment of diabetic nerve and shingle pain amongst others.

Taking advantage of the complex's unusual physio-chemical properties, mandelic acid is used to resolve racemic pregabalin on industrial scale. A crystallization of 1:1 mandelic acid to pregabalin results in the free form. Complex (I) forms only with an excess of mandelic acid.

The complex is resolved by either 1) adding two molar equivalents of the acid or 2) adding a slight excess of mandelic acid combined with an inorganic acid, the method of Pope and Peachy (Pope & Peachey, 1899). The resolved pregabalin–mandelic acid complex is isolated and recrystallized to remove the complexed mandelic acid and recover the free form (Hoekstra *et al.*, 1997; Mulhern, 1996). At ratios of 1:1 pregabalin with mandelic acid, the free form was isolated from both slurries and crystallizations. However, with 1:2 pregabalin:mandelic acid, (I) was isolated under both conditions.

All strong hydrogen bond acceptors and donors are utilized. The ratio of donors to acceptors is 5 to 3. Two extra donating protons donate to the same acceptor; resulting in one hydrogen bond acceptor (delocalized carbonyl) accepting three protons. This is an unusual finding. While there are many examples of carbonyl with three hydrogen bonds, it is unusual for a carboxylate to accept three hydrogen bonds.

Some close contacts between the carboxylate group and protons (D—H···A) on the NH_3 group were not hydrogen bonds (*e.g.* N2—H2B—O8). In these cases, the hydrogen bond angles were very bent and the geometry of the accepting OH group did not appear to favor accepting a hydrogen bond. The closeness of these accepting and donating groups could be a function of the forced propeller NH_3 conformation or the opposite charges of carboxylate and NH_3 groups.

Experimental

Attempts to crystallize a suitable diffraction quality crystal took some time. Many of the crystals grown were non-merohedrally twinned at a ratio of 10:1. With careful technique, sheets of crystal could be removed from the twinned crystals. The sheets were high quality single crystals, yet were not of acceptable volume to diffract well. The twinned structures did not refine as well as this untwinned structure. We choose a untwinned crystal and collected for long exposures. The chirality of pregabalin was determined by relative configuration from the fixed chiral center of the mandelic acid.

Refinement

Friedel pairs were merged in the absence of signifcant anomalous scattering effects. H atoms bound to carbon were positioned geometrically, with C—H distances of 0.95 Å, and refined using a riding model.

Figures

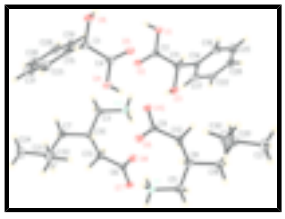

Fig. 1. *ORTEP* diagram. Atomic displacement ellipsoids are at 30% probability, hydrogen atoms are given as arbritary radii.

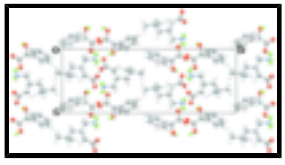

Fig. 2. Hydrophilic/hydrophobic interactions visible by looking down the *a* axis. Protons involved in hydrogen bonding are shown in green.

(*S*)-3-(ammoniomethyl)-5-methylhexanoate–(S)-mandelic acid (1/1)

Crystal data

$C_8H_{17}NO_2 \cdot C_8H_8O_3$	$F_{000} = 672$
$M_r = 311.37$	$D_x = 1.198$ Mg m^{-3}
Monoclinic, $P2_1$	Mo $K\alpha$ radiation $\lambda = 0.71073$ Å
Hall symbol: P 2yb	Cell parameters from 815 reflections
$a = 6.2922$ (13) Å	$\theta = 3.0$–18.4º
$b = 27.423$ (6) Å	$\mu = 0.09$ mm^{-1}
$c = 10.009$ (2) Å	$T = 296$ (2) K
$\beta = 90.84$ (3)º	Plate, colourless
$V = 1726.9$ (6) Å^3	0.22 × 0.11 × 0.05 mm
$Z = 4$	

Data collection

Bruker SMART APEX2 CCD diffractometer	4159 independent reflections
Radiation source: fine-focus sealed tube	2488 reflections with $I > 2\sigma(I)$
Monochromator: graphite	$R_{int} = 0.096$
$T = 296(2)$ K	$\theta_{max} = 28.2$º
φ and ω scans	$\theta_{min} = 1.5$º
Absorption correction: multi-scan (SADABS; Sheldrick, 2003)	$h = -8 \rightarrow 8$
$T_{min} = 0.956$, $T_{max} = 0.996$	$k = -36 \rightarrow 36$
38738 measured reflections	$l = -13 \rightarrow 13$

Refinement

Refinement on F^2	Hydrogen site location: inferred from neighbouring sites
Least-squares matrix: full	H-atom parameters constrained

$R[F^2 > 2\sigma(F^2)] = 0.059$

$wR(F^2) = 0.148$

$S = 0.92$

4159 reflections

407 parameters

1 restraint

Primary atom site location: structure-invariant direct methods

Secondary atom site location: difference Fourier map

$w = 1/[\sigma^2(F_o^2) + (0.0842P)^2]$
where $P = (F_o^2 + 2F_c^2)/3$

$(\Delta/\sigma)_{max} < 0.001$

$\Delta\rho_{max} = 0.58$ e Å^{-3}

$\Delta\rho_{min} = -0.21$ e Å^{-3}

Extinction correction: none

Absolute structure: Flack (1983), with 3849 Friedel pairs

Flack parameter: ?

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å^2)

	x	*y*	*z*	U_{iso}*/U_{eq}
C1	0.1574 (8)	0.34998 (17)	0.3221 (4)	0.0322 (10)
H1	0.0160	0.3398	0.3511	0.039*
O7	0.8185 (5)	0.41070 (11)	1.0833 (3)	0.0319 (7)
O4	0.2132 (5)	0.38722 (12)	0.5318 (3)	0.0329 (7)
H4	0.2384	0.4126	0.5723	0.049*
O10	0.3202 (5)	0.46157 (11)	0.6609 (3)	0.0312 (7)
O1	0.7161 (5)	0.48461 (11)	0.2123 (3)	0.0314 (7)
H1A	0.7378	0.4591	0.1721	0.047*
O9	0.0740 (5)	0.44728 (11)	0.8170 (3)	0.0309 (7)
C2	0.7324 (7)	0.47677 (17)	0.3419 (4)	0.0260 (10)
O8	0.5720 (5)	0.42446 (11)	0.9265 (3)	0.0306 (7)
O2	0.7914 (5)	0.43870 (12)	0.3910 (3)	0.0316 (7)
N1	0.2478 (6)	0.46247 (13)	1.0859 (3)	0.0280 (8)
H1B	0.3520	0.4532	1.0323	0.042*
H1C	0.1254	0.4498	1.0568	0.042*
H1D	0.2754	0.4520	1.1685	0.042*
O5	0.2925 (5)	0.43222 (12)	0.3533 (3)	0.0337 (7)
N2	0.7488 (6)	0.40986 (13)	0.6580 (3)	0.0300 (9)
H2A	0.8432	0.4193	0.7198	0.045*
H2B	0.6220	0.4223	0.6767	0.045*
H2C	0.7891	0.4203	0.5781	0.045*
C3	0.7354 (7)	0.35569 (17)	0.6570 (4)	0.0305 (10)
H3A	0.8756	0.3423	0.6417	0.037*
H3B	0.6429	0.3454	0.5840	0.037*
O3	0.6535 (6)	0.51155 (13)	0.5613 (3)	0.0378 (8)
H3	0.5372	0.4993	0.5760	0.057*
C4	0.2282 (7)	0.39496 (17)	0.4026 (4)	0.0276 (10)
O6	0.1506 (6)	0.35999 (13)	0.1826 (3)	0.0449 (9)
H6	0.0403	0.3745	0.1636	0.067*
C5	0.2322 (7)	0.51655 (17)	1.0857 (4)	0.0309 (10)
H5A	0.3717	0.5303	1.1038	0.037*
H5B	0.1390	0.5267	1.1568	0.037*
C6	0.7182 (7)	0.39958 (15)	0.9754 (4)	0.0245 (9)

C7	0.6390 (7)	0.27979 (16)	0.7801 (4)	0.0289 (10)
H7A	0.7830	0.2671	0.7808	0.035*
H7B	0.5741	0.2711	0.6949	0.035*
C8	0.1473 (7)	0.53650 (16)	0.9530 (4)	0.0278 (10)
H8	0.0023	0.5243	0.9390	0.033*
C9	0.2197 (7)	0.47262 (16)	0.7684 (4)	0.0248 (9)
C10	0.6498 (7)	0.33543 (16)	0.7893 (4)	0.0263 (9)
H10	0.5047	0.3477	0.7999	0.032*
C11	0.6697 (7)	0.52180 (16)	0.4222 (4)	0.0280 (9)
H11	0.5329	0.5341	0.3884	0.034*
C12	0.2836 (7)	0.52008 (16)	0.8331 (4)	0.0274 (9)
H12A	0.2779	0.5455	0.7656	0.033*
H12B	0.4302	0.5173	0.8634	0.033*
C13	0.7829 (7)	0.35234 (16)	0.9105 (4)	0.0271 (9)
H13A	0.7787	0.3269	0.9777	0.032*
H13B	0.9293	0.3555	0.8829	0.032*
C14	0.8380 (7)	0.56137 (16)	0.4073 (4)	0.0273 (9)
C15	0.3129 (7)	0.30842 (18)	0.3442 (4)	0.0317 (10)
C16	0.1376 (8)	0.59252 (15)	0.9640 (4)	0.0299 (10)
H16A	0.2819	0.6050	0.9670	0.036*
H16B	0.0721	0.6009	1.0481	0.036*
C17	1.0324 (7)	0.55679 (19)	0.4744 (4)	0.0365 (11)
H17	1.0617	0.5289	0.5245	0.044*
C18	0.7999 (8)	0.60233 (18)	0.3304 (5)	0.0367 (11)
H18	0.6715	0.6060	0.2842	0.044*
C19	0.5152 (8)	0.31030 (19)	0.2856 (5)	0.0384 (11)
H19	0.5557	0.3379	0.2385	0.046*
C20	0.0145 (8)	0.61907 (18)	0.8497 (5)	0.0399 (12)
H20	0.0888	0.6128	0.7660	0.048*
C21	0.5157 (9)	0.25445 (18)	0.8912 (5)	0.0428 (12)
H21	0.5905	0.2610	0.9759	0.051*
C22	1.1817 (8)	0.59351 (18)	0.4668 (4)	0.0376 (12)
H22	1.3100	0.5902	0.5132	0.045*
C23	0.2604 (9)	0.26761 (19)	0.4164 (5)	0.0402 (12)
H23	0.1288	0.2663	0.4574	0.048*
C24	0.5162 (10)	0.19979 (18)	0.8693 (6)	0.0511 (15)
H24A	0.6601	0.1882	0.8684	0.077*
H24B	0.4476	0.1924	0.7854	0.077*
H24C	0.4411	0.1841	0.9403	0.077*
C25	0.9565 (9)	0.6381 (2)	0.3230 (5)	0.0482 (14)
H25	0.9322	0.6652	0.2692	0.058*
C26	0.5924 (11)	0.2306 (2)	0.3709 (5)	0.0581 (16)
H26	0.6859	0.2045	0.3796	0.070*
C27	0.0182 (11)	0.6735 (2)	0.8746 (6)	0.0572 (15)
H27A	−0.0547	0.6807	0.9559	0.086*
H27B	−0.0511	0.6900	0.8014	0.086*
H27C	0.1628	0.6845	0.8822	0.086*
C28	1.1461 (9)	0.63459 (19)	0.3927 (5)	0.0438 (13)
H28	1.2466	0.6594	0.3895	0.053*

C29	0.6519 (9)	0.2718 (2)	0.2975 (5)	0.0416 (12)
H29	0.7840	0.2729	0.2571	0.050*
C30	−0.2121 (10)	0.6011 (2)	0.8329 (7)	0.0638 (18)
H30A	−0.2891	0.6226	0.7741	0.096*
H30B	−0.2793	0.6004	0.9184	0.096*
H30C	−0.2115	0.5688	0.7957	0.096*
C31	0.3978 (11)	0.2285 (2)	0.4298 (5)	0.0567 (16)
H31	0.3583	0.2011	0.4783	0.068*
C32	0.2890 (11)	0.2730 (2)	0.9043 (9)	0.079 (3)
H32A	0.2092	0.2651	0.8248	0.118*
H32B	0.2907	0.3077	0.9165	0.118*
H32C	0.2241	0.2578	0.9800	0.118*

Atomic displacement parameters (Å^2)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
C1	0.033 (3)	0.036 (3)	0.027 (2)	0.006 (2)	−0.0049 (18)	−0.0074 (18)
O7	0.0370 (18)	0.0379 (19)	0.0205 (15)	0.0059 (14)	−0.0067 (12)	−0.0043 (12)
O4	0.0414 (19)	0.0353 (18)	0.0218 (15)	−0.0024 (15)	−0.0011 (13)	−0.0026 (12)
O10	0.0360 (18)	0.0360 (19)	0.0217 (15)	−0.0011 (14)	0.0076 (12)	−0.0036 (12)
O1	0.041 (2)	0.0336 (18)	0.0199 (15)	0.0036 (15)	−0.0018 (13)	−0.0023 (12)
O9	0.0288 (17)	0.0393 (19)	0.0248 (15)	−0.0096 (14)	0.0014 (12)	−0.0033 (13)
C2	0.021 (2)	0.034 (3)	0.023 (2)	−0.0046 (19)	−0.0009 (16)	−0.0015 (17)
O8	0.0279 (16)	0.0377 (19)	0.0260 (15)	0.0076 (14)	−0.0030 (12)	−0.0009 (13)
O2	0.0337 (18)	0.0352 (19)	0.0258 (15)	0.0051 (14)	−0.0005 (12)	0.0009 (13)
N1	0.0240 (19)	0.037 (2)	0.0232 (18)	0.0005 (17)	0.0012 (14)	−0.0012 (15)
O5	0.0374 (19)	0.039 (2)	0.0242 (16)	−0.0067 (15)	−0.0007 (12)	0.0009 (13)
N2	0.029 (2)	0.035 (2)	0.0262 (19)	−0.0013 (17)	−0.0017 (15)	0.0020 (15)
C3	0.029 (3)	0.038 (3)	0.024 (2)	−0.001 (2)	0.0017 (17)	−0.0009 (18)
O3	0.044 (2)	0.046 (2)	0.0234 (15)	−0.0087 (17)	0.0108 (13)	−0.0042 (13)
C4	0.021 (2)	0.039 (3)	0.023 (2)	0.005 (2)	−0.0016 (16)	−0.0005 (18)
O6	0.055 (2)	0.052 (2)	0.0273 (17)	0.0177 (18)	−0.0158 (15)	−0.0076 (15)
C5	0.028 (2)	0.036 (3)	0.028 (2)	0.001 (2)	−0.0014 (17)	−0.0052 (18)
C6	0.026 (2)	0.029 (2)	0.0177 (19)	−0.0035 (18)	0.0016 (15)	0.0002 (15)
C7	0.024 (2)	0.032 (3)	0.030 (2)	−0.0041 (19)	0.0001 (18)	−0.0045 (17)
C8	0.025 (2)	0.032 (3)	0.026 (2)	−0.0004 (19)	0.0006 (17)	−0.0038 (17)
C9	0.025 (2)	0.029 (2)	0.020 (2)	−0.0009 (19)	−0.0022 (15)	0.0003 (16)
C10	0.026 (2)	0.030 (2)	0.023 (2)	0.0022 (18)	−0.0001 (16)	−0.0024 (16)
C11	0.026 (2)	0.033 (3)	0.025 (2)	0.0010 (19)	0.0031 (16)	−0.0037 (17)
C12	0.027 (2)	0.030 (3)	0.025 (2)	−0.0011 (19)	0.0061 (16)	−0.0040 (17)
C13	0.026 (2)	0.031 (3)	0.024 (2)	0.0010 (19)	−0.0047 (16)	−0.0030 (17)
C14	0.032 (2)	0.029 (2)	0.021 (2)	0.000 (2)	0.0030 (17)	−0.0027 (17)
C15	0.037 (3)	0.033 (3)	0.024 (2)	0.002 (2)	−0.0084 (18)	−0.0072 (18)
C16	0.034 (3)	0.027 (3)	0.029 (2)	0.004 (2)	0.0043 (18)	−0.0050 (17)
C17	0.035 (3)	0.047 (3)	0.027 (2)	0.000 (2)	−0.0001 (19)	0.000 (2)
C18	0.039 (3)	0.033 (3)	0.037 (3)	−0.001 (2)	−0.006 (2)	0.008 (2)
C19	0.039 (3)	0.034 (3)	0.042 (3)	0.005 (2)	−0.003 (2)	−0.001 (2)
C20	0.043 (3)	0.036 (3)	0.040 (3)	0.006 (2)	0.004 (2)	0.000 (2)

C21	0.050 (3)	0.032 (3)	0.046 (3)	−0.012 (2)	0.012 (2)	0.001 (2)
C22	0.037 (3)	0.048 (3)	0.028 (2)	−0.008 (2)	0.0046 (19)	−0.010 (2)
C23	0.041 (3)	0.041 (3)	0.039 (3)	−0.001 (2)	0.000 (2)	0.002 (2)
C24	0.051 (4)	0.031 (3)	0.072 (4)	−0.005 (3)	0.008 (3)	0.006 (3)
C25	0.059 (4)	0.037 (3)	0.049 (3)	−0.011 (3)	0.012 (3)	0.004 (2)
C26	0.072 (5)	0.057 (4)	0.044 (3)	0.021 (3)	−0.015 (3)	−0.001 (3)
C27	0.070 (4)	0.038 (3)	0.064 (4)	0.007 (3)	0.004 (3)	0.001 (3)
C28	0.052 (3)	0.038 (3)	0.041 (3)	−0.013 (3)	0.011 (2)	−0.007 (2)
C29	0.040 (3)	0.049 (3)	0.035 (3)	0.009 (2)	−0.003 (2)	−0.010 (2)
C30	0.054 (4)	0.039 (4)	0.097 (5)	0.003 (3)	−0.031 (3)	0.006 (3)
C31	0.080 (5)	0.045 (4)	0.044 (3)	0.006 (3)	−0.008 (3)	0.010 (3)
C32	0.051 (4)	0.043 (4)	0.145 (7)	0.005 (3)	0.050 (4)	0.010 (4)

Geometric parameters (Å, °)

C1—O6	1.424 (5)	C12—H12B	0.9700
C1—C15	1.516 (7)	C13—H13A	0.9700
C1—C4	1.535 (6)	C13—H13B	0.9700
C1—H1	0.9800	C14—C18	1.381 (6)
O7—C6	1.279 (5)	C14—C17	1.392 (6)
O4—C4	1.315 (5)	C15—C23	1.375 (7)
O4—H4	0.8200	C15—C19	1.410 (7)
O10—C9	1.292 (5)	C16—C20	1.554 (7)
O1—C2	1.317 (5)	C16—H16A	0.9700
O1—H1A	0.8200	C16—H16B	0.9700
O9—C9	1.255 (5)	C17—C22	1.380 (7)
C2—O2	1.210 (5)	C17—H17	0.9300
C2—C11	1.528 (6)	C18—C25	1.393 (7)
O8—C6	1.240 (5)	C18—H18	0.9300
N1—C5	1.486 (6)	C19—C29	1.366 (7)
N1—H1B	0.8900	C19—H19	0.9300
N1—H1C	0.8900	C20—C27	1.515 (8)
N1—H1D	0.8900	C20—C30	1.516 (8)
O5—C4	1.207 (5)	C20—H20	0.9800
N2—C3	1.488 (6)	C21—C24	1.515 (7)
N2—H2A	0.8900	C21—C32	1.522 (8)
N2—H2B	0.8900	C21—H21	0.9800
N2—H2C	0.8900	C22—C28	1.365 (7)
C3—C10	1.540 (6)	C22—H22	0.9300
C3—H3A	0.9700	C23—C31	1.384 (8)
C3—H3B	0.9700	C23—H23	0.9300
O3—C11	1.426 (5)	C24—H24A	0.9600
O3—H3	0.8200	C24—H24B	0.9600
O6—H6	0.8200	C24—H24C	0.9600
C5—C8	1.526 (6)	C25—C28	1.377 (8)
C5—H5A	0.9700	C25—H25	0.9300
C5—H5B	0.9700	C26—C31	1.368 (9)
C6—C13	1.508 (6)	C26—C29	1.402 (8)
C7—C10	1.530 (6)	C26—H26	0.9300

C7—C21	1.532 (6)	C27—H27A	0.9600
C7—H7A	0.9700	C27—H27B	0.9600
C7—H7B	0.9700	C27—H27C	0.9600
C8—C16	1.541 (6)	C28—H28	0.9300
C8—C12	1.552 (6)	C29—H29	0.9300
C8—H8	0.9800	C30—H30A	0.9600
C9—C12	1.506 (6)	C30—H30B	0.9600
C10—C13	1.536 (6)	C30—H30C	0.9600
C10—H10	0.9800	C31—H31	0.9300
C11—C14	1.525 (6)	C32—H32A	0.9600
C11—H11	0.9800	C32—H32B	0.9600
C12—H12A	0.9700	C32—H32C	0.9600
O6—C1—C15	107.3 (3)	C10—C13—H13B	108.1
O6—C1—C4	111.3 (4)	H13A—C13—H13B	107.3
C15—C1—C4	110.2 (4)	C18—C14—C17	119.1 (4)
O6—C1—H1	109.3	C18—C14—C11	121.2 (4)
C15—C1—H1	109.3	C17—C14—C11	119.7 (4)
C4—C1—H1	109.3	C23—C15—C19	118.3 (5)
C4—O4—H4	109.5	C23—C15—C1	121.9 (4)
C2—O1—H1A	109.5	C19—C15—C1	119.8 (4)
O2—C2—O1	124.0 (4)	C8—C16—C20	115.7 (4)
O2—C2—C11	124.4 (4)	C8—C16—H16A	108.3
O1—C2—C11	111.6 (4)	C20—C16—H16A	108.3
C5—N1—H1B	109.5	C8—C16—H16B	108.3
C5—N1—H1C	109.5	C20—C16—H16B	108.3
H1B—N1—H1C	109.5	H16A—C16—H16B	107.4
C5—N1—H1D	109.5	C22—C17—C14	120.1 (5)
H1B—N1—H1D	109.5	C22—C17—H17	119.9
H1C—N1—H1D	109.5	C14—C17—H17	119.9
C3—N2—H2A	109.5	C14—C18—C25	119.0 (5)
C3—N2—H2B	109.5	C14—C18—H18	120.5
H2A—N2—H2B	109.5	C25—C18—H18	120.5
C3—N2—H2C	109.5	C29—C19—C15	120.4 (5)
H2A—N2—H2C	109.5	C29—C19—H19	119.8
H2B—N2—H2C	109.5	C15—C19—H19	119.8
N2—C3—C10	112.0 (3)	C27—C20—C30	110.6 (5)
N2—C3—H3A	109.2	C27—C20—C16	109.6 (4)
C10—C3—H3A	109.2	C30—C20—C16	112.8 (4)
N2—C3—H3B	109.2	C27—C20—H20	107.9
C10—C3—H3B	109.2	C30—C20—H20	107.9
H3A—C3—H3B	107.9	C16—C20—H20	107.9
C11—O3—H3	109.5	C24—C21—C32	110.3 (5)
O5—C4—O4	124.6 (4)	C24—C21—C7	110.0 (4)
O5—C4—C1	124.2 (4)	C32—C21—C7	113.4 (5)
O4—C4—C1	111.2 (4)	C24—C21—H21	107.7
C1—O6—H6	109.5	C32—C21—H21	107.7
N1—C5—C8	112.4 (3)	C7—C21—H21	107.7
N1—C5—H5A	109.1	C28—C22—C17	121.7 (5)
C8—C5—H5A	109.1	C28—C22—H22	119.1

N1—C5—H5B	109.1	C17—C22—H22	119.1
C8—C5—H5B	109.1	C15—C23—C31	121.8 (5)
H5A—C5—H5B	107.9	C15—C23—H23	119.1
O8—C6—O7	123.8 (4)	C31—C23—H23	119.1
O8—C6—C13	120.4 (4)	C21—C24—H24A	109.5
O7—C6—C13	115.8 (4)	C21—C24—H24B	109.5
C10—C7—C21	115.5 (4)	H24A—C24—H24B	109.5
C10—C7—H7A	108.4	C21—C24—H24C	109.5
C21—C7—H7A	108.4	H24A—C24—H24C	109.5
C10—C7—H7B	108.4	H24B—C24—H24C	109.5
C21—C7—H7B	108.4	C28—C25—C18	122.1 (5)
H7A—C7—H7B	107.5	C28—C25—H25	118.9
C5—C8—C16	108.0 (3)	C18—C25—H25	118.9
C5—C8—C12	112.2 (4)	C31—C26—C29	120.5 (6)
C16—C8—C12	111.5 (4)	C31—C26—H26	119.7
C5—C8—H8	108.3	C29—C26—H26	119.7
C16—C8—H8	108.3	C20—C27—H27A	109.5
C12—C8—H8	108.3	C20—C27—H27B	109.5
O9—C9—O10	124.2 (4)	H27A—C27—H27B	109.5
O9—C9—C12	120.3 (4)	C20—C27—H27C	109.5
O10—C9—C12	115.5 (4)	H27A—C27—H27C	109.5
C7—C10—C13	111.8 (4)	H27B—C27—H27C	109.5
C7—C10—C3	108.9 (3)	C22—C28—C25	117.9 (5)
C13—C10—C3	112.1 (4)	C22—C28—H28	121.1
C7—C10—H10	108.0	C25—C28—H28	121.1
C13—C10—H10	108.0	C19—C29—C26	119.7 (5)
C3—C10—H10	108.0	C19—C29—H29	120.1
O3—C11—C14	107.2 (3)	C26—C29—H29	120.1
O3—C11—C2	112.1 (4)	C20—C30—H30A	109.5
C14—C11—C2	109.8 (3)	C20—C30—H30B	109.5
O3—C11—H11	109.2	H30A—C30—H30B	109.5
C14—C11—H11	109.2	C20—C30—H30C	109.5
C2—C11—H11	109.2	H30A—C30—H30C	109.5
C9—C12—C8	115.9 (4)	H30B—C30—H30C	109.5
C9—C12—H12A	108.3	C26—C31—C23	119.1 (5)
C8—C12—H12A	108.3	C26—C31—H31	120.4
C9—C12—H12B	108.3	C23—C31—H31	120.4
C8—C12—H12B	108.3	C21—C32—H32A	109.5
H12A—C12—H12B	107.4	C21—C32—H32B	109.5
C6—C13—C10	116.9 (4)	H32A—C32—H32B	109.5
C6—C13—H13A	108.1	C21—C32—H32C	109.5
C10—C13—H13A	108.1	H32A—C32—H32C	109.5
C6—C13—H13B	108.1	H32B—C32—H32C	109.5
O6—C1—C4—O5	−7.7 (6)	O6—C1—C15—C23	−129.1 (5)
C15—C1—C4—O5	111.3 (5)	C4—C1—C15—C23	109.5 (5)
O6—C1—C4—O4	173.5 (4)	O6—C1—C15—C19	48.5 (5)
C15—C1—C4—O4	−67.5 (5)	C4—C1—C15—C19	−72.9 (5)
N1—C5—C8—C16	180.0 (4)	C5—C8—C16—C20	−168.5 (4)
N1—C5—C8—C12	−56.7 (5)	C12—C8—C16—C20	67.7 (5)

C21—C7—C10—C13	67.5 (5)	C18—C14—C17—C22	1.9 (6)
C21—C7—C10—C3	−168.1 (4)	C11—C14—C17—C22	−176.9 (4)
N2—C3—C10—C7	179.5 (4)	C17—C14—C18—C25	−0.5 (7)
N2—C3—C10—C13	−56.2 (5)	C11—C14—C18—C25	178.2 (4)
O2—C2—C11—O3	−10.0 (6)	C23—C15—C19—C29	1.9 (7)
O1—C2—C11—O3	170.5 (4)	C1—C15—C19—C29	−175.9 (4)
O2—C2—C11—C14	109.0 (5)	C8—C16—C20—C27	179.8 (4)
O1—C2—C11—C14	−70.4 (4)	C8—C16—C20—C30	56.2 (6)
O9—C9—C12—C8	−4.7 (6)	C10—C7—C21—C24	179.5 (5)
O10—C9—C12—C8	173.5 (4)	C10—C7—C21—C32	55.6 (6)
C5—C8—C12—C9	89.1 (5)	C14—C17—C22—C28	−1.0 (7)
C16—C8—C12—C9	−149.6 (4)	C19—C15—C23—C31	−1.6 (7)
O8—C6—C13—C10	−4.2 (6)	C1—C15—C23—C31	176.1 (5)
O7—C6—C13—C10	173.8 (4)	C14—C18—C25—C28	−1.8 (8)
C7—C10—C13—C6	−148.1 (4)	C17—C22—C28—C25	−1.2 (7)
C3—C10—C13—C6	89.3 (5)	C18—C25—C28—C22	2.6 (8)
O3—C11—C14—C18	−131.2 (4)	C15—C19—C29—C26	−1.3 (7)
C2—C11—C14—C18	106.8 (5)	C31—C26—C29—C19	0.5 (8)
O3—C11—C14—C17	47.6 (5)	C29—C26—C31—C23	−0.2 (9)
C2—C11—C14—C17	−74.5 (5)	C15—C23—C31—C26	0.8 (8)

Hydrogen-bond geometry (Å, °)

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
O4—H4···O10	0.82	1.69	2.501 (4)	173
O1—H1A···O7^{i}	0.82	1.68	2.493 (4)	171
N1—H1B···O8	0.89	1.92	2.808 (5)	172
N1—H1C···O7^{ii}	0.89	2.23	3.052 (5)	154
N1—H1D···O5^{iii}	0.89	1.93	2.812 (5)	172
N2—H2A···O9^{iv}	0.89	1.90	2.771 (5)	167
N2—H2B···O10	0.89	2.19	3.048 (5)	163
N2—H2C···O2	0.89	1.94	2.804 (4)	163
O3—H3···O10	0.82	1.92	2.708 (4)	160
O6—H6···O7^{v}	0.82	1.88	2.689 (4)	167

Symmetry codes: (i) *x*, *y*, *z*−1; (ii) *x*−1, *y*, *z*; (iii) *x*, *y*, *z*+1; (iv) *x*+1, *y*, *z*; (v) *x*−1, *y*, *z*−1.

Fig. 1

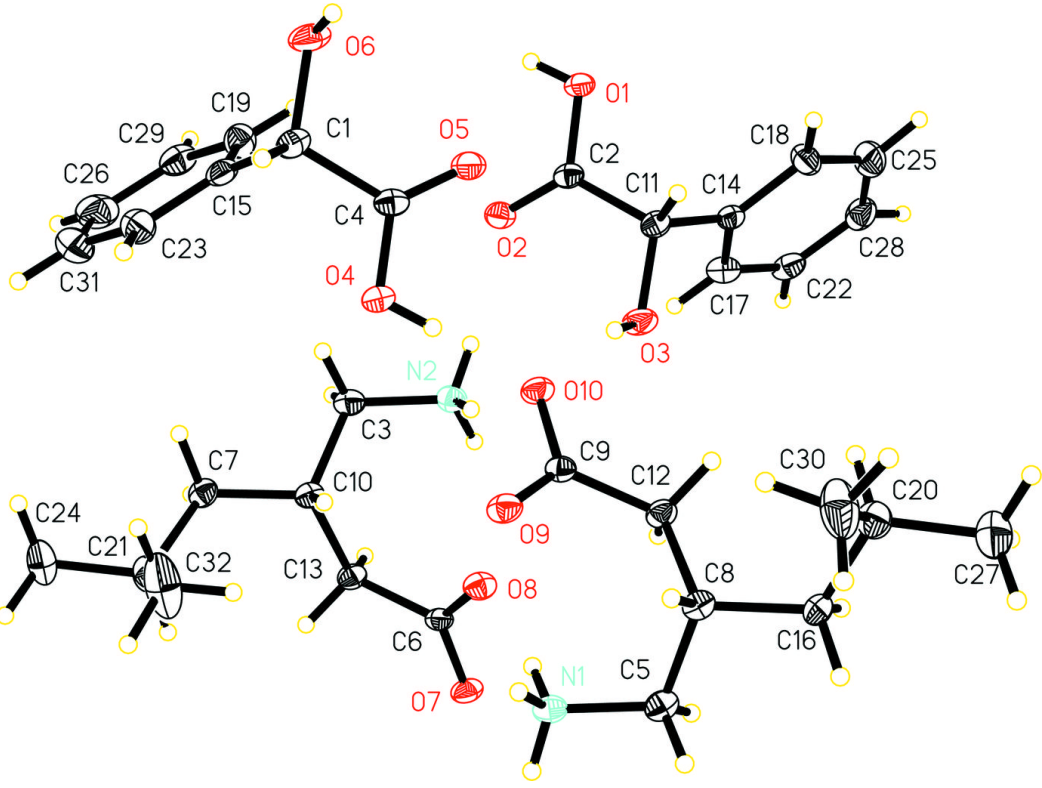
O6
C19
C29
C1
O5
C26
C15
C4
C23
C31
O4
O1
C2
C18
C25
C11
C14
O2
C28
C22
C17
O3
N2
O10
C3
C9
C7
C10
C12
C30
C20
C24
C21
C32
C13
O8
C8
C27
O9
C6
C16
N1
C5
O7

Fig. 2