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Key indicators

Single-crystal X-ray study

T = 120 K

Mean $\sigma(\text{C}-\text{C}) = 0.002 \text{ \AA}$

R factor = 0.055

wR factor = 0.108

Data-to-parameter ratio = 19.3

For details of how these key indicators were automatically derived from the article, see <http://journals.iucr.org/e>.Methyl 2-benzyl-1-benzyloxy-6a-methyl-1,2,3,3a,4,6a-hexahydrocyclopenta[*b*]pyrrole-3a-carboxylate: hydrogen-bonded $R_4^4(24)$ sheetsIn the title crystal structure, $\text{C}_{24}\text{H}_{27}\text{NO}_3$, molecules are linked by two $\text{C}-\text{H}\cdots\text{O}$ hydrogen bonds into $R_4^4(24)$ sheets.

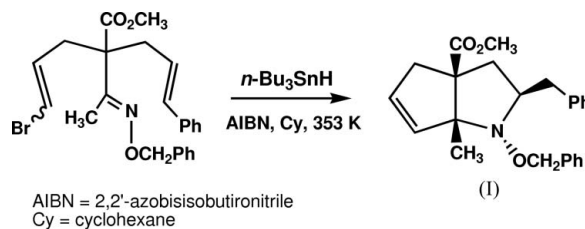
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Comment

Pyrrolidine-containing derivatives are present in a large number of biologically active natural products and numerous therapeutic agents. Radical cyclizations have emerged as a useful synthetic tool and have been reported in the synthesis of alkaloids and related pyrrolidinic compounds *via* the generation and trapping of nitrogen-centred radicals *e.g.* aminyl, iminyl, amidyl radicals *etc.* (Esker & Newcomb, 1993; Fallis & Brinza, 1997; Bowman *et al.* 1996; Guindon *et al.*, 2001) However, no reports about the capture of neutral alkyl-oxyaminyl radicals by a multiple function have been published up to date for the preparation of fused pyrrolidine derivatives. We describe here a fused pyrrolidine derivative, (I), prepared for the first time *via* an alkyl-oxyaminyl radical, which has been generated through the reductive intermolecular or intramolecular addition of carbon radicals to the carbon atom of oxime ethers (Friestad, 2001; Naito *et al.*, 2000; Tauh & Fallis, 1999; Marco-Contelles *et al.*, 1996; Enholm *et al.*, 1990). We carried out this reaction from methyl 2-[(*E*)-1-(benzyl-oxyimino)ethyl]-5-bromo-2-cinnamylpent-4-enoate by a double bond in a cascade process yielding the title compound, (I). This reaction involves two sequential 5-*exo* ring closures involving vinyl and neutral alkyl-oxyaminyl radicals, in a chain radical reaction, in which the attack of the radical is stereocontrolled by the carboxymethyl group, and hence determining the stereochemistry of the new bonds on the opposite face to that group.



The title molecule, (I), is shown in Fig. 1. There are no unusual bonds lengths or angles in the structure. The puckering of the two five-membered rings N1/C2/C3/C3A/C6A and C3A/C4/C5/C6/C6A as defined by the pseudorotation parameters P and $\tau(M)$ (Rao *et al.*, 1981), are, for the former, $P = 182.4 (1)^\circ$, $\tau(M) = 48.6 (1)^\circ$, reference bond N1—C2, corresponding to a twist on N1—C2 and, for the latter, $P = 340.4 (6)^\circ$, $\tau(M) = 12.2 (1)^\circ$, reference bond C3A—C4, corresponding to an envelope on C3A.

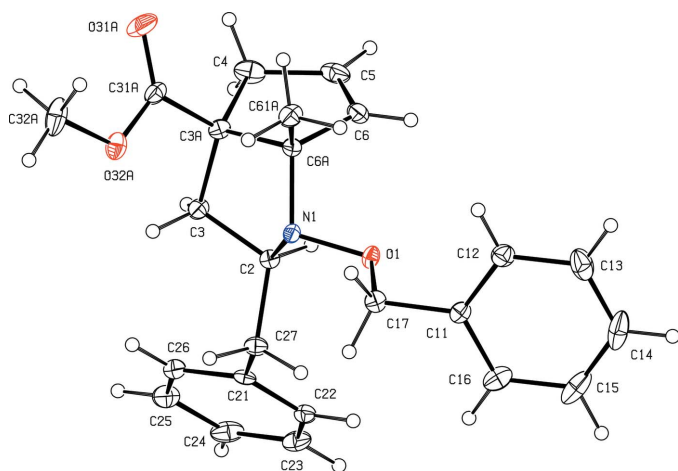


Figure 1
A view of (I), showing displacement ellipsoids drawn at the 30% probability level.

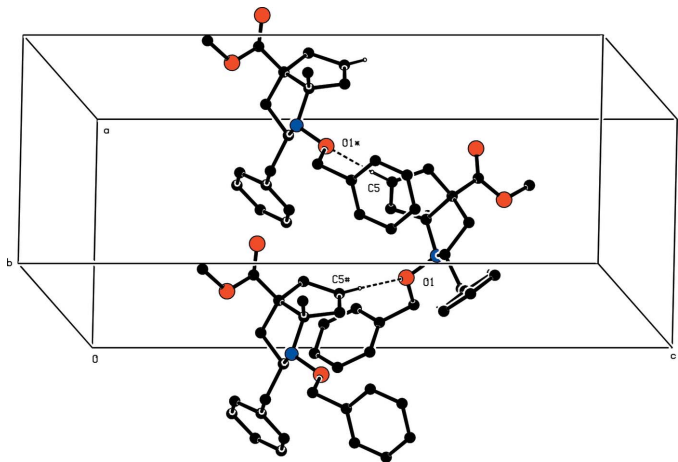


Figure 2
A view of the C6 chain formed by the C—H...O hydrogen bonds (dashed lines). The atoms labelled with an asterisk (*) and hash (#) are related by the symmetry operators $(\frac{1}{2} + x, \frac{1}{2} - y, 1 - z)$ and $(-\frac{1}{2} + x, \frac{1}{2} - y, 1 - z)$, respectively.

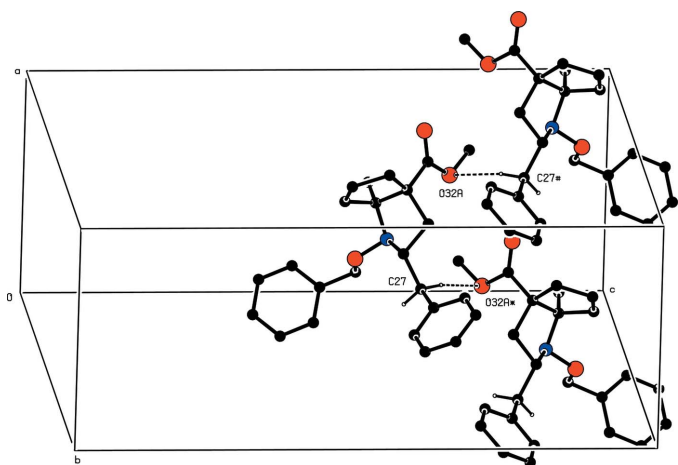


Figure 3
A view of the C(7) chain formed by the C—H...O hydrogen bonds (dashed lines). The atoms labelled asterisk (*) and hash (#) are related by the symmetry operators $(-\frac{1}{2} + x, y, \frac{3}{2} - z)$ and $(\frac{1}{2} + x, y, \frac{3}{2} - z)$, respectively.

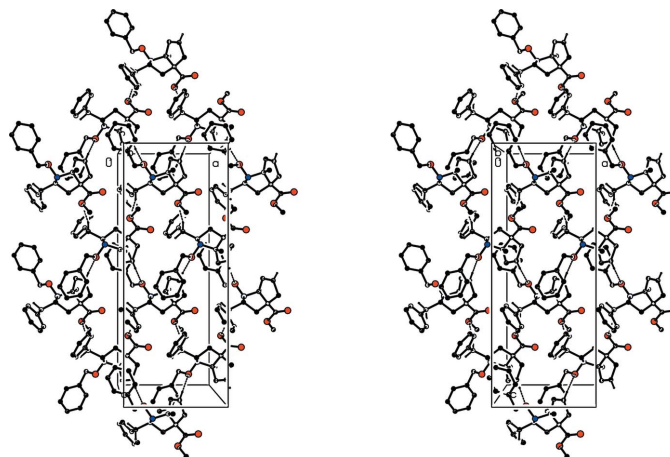


Figure 4
A stereoview of the (010) sheet showing the C6 and C8 chains and the $R_4^1(24)$ rings. Hydrogen bonds are shown as dashed lines

Two C—H...O hydrogen bonds are involved in the supramolecular structure (Table 1). C5—H5...O1($\frac{1}{2} + x, \frac{1}{2} - y, 1 - z$) forms a C(6) chain (Fig. 2) (Bernstein *et al.*, 1995) and C27—H27B...O32A forms a C(7) chain (Fig. 3), both of which run parallel to the *a* axis. The latter hydrogen bond links anti-parallel C6 chains of the former type into a sheet consisting of a network of $R_4^1(24)$ rings which lies parallel to (010) (Fig. 4). Atom C5 is a hydrogen donor to O1 in the molecule at $(\frac{1}{2} + x, \frac{1}{2} - y, 1 - z)$, atom C2a in this molecule is a hydrogen donor to O1 in the molecule at $(x, \frac{1}{2} - y, -\frac{1}{2} - z)$, C27 in this molecule is a hydrogen donor to O32A in the molecule at $(-\frac{1}{2} + x, \frac{1}{2} - y, 1 - z)$, while C5 is a hydrogen donor to O32A in the molecule at (x, y, z) . Two such sheets occur in the unit cell; one in the range $0.0 > y > 0.5$ and $0.5 > y > 1.0$. There are no interactions between adjacent sheets, C—H... π or π — π interactions being absent.

Experimental

A solution of methyl 2-[(*E*)-1-(benzyloxyimino)ethyl]-5-bromo-2-cinnamylpent-4-enoate (350 mg, 0.77 mmol), 2,2'-azobisisobutyronitrile (39 mg, 0.23 mmol) and tributyltin hydride (0.26 ml, 0.92 mmol) in cyclohexane (39 ml) was degassed for 1 h by bubbling dry argon, and subsequently stirred at 353 K for 6–8 h. After cooling to room temperature the solution was evaporated under low pressure to dryness. Purification of the crude mixture by flash column chromatography with 5% (*v/v*) AcOEt/hexanes yielded a white solid (63 mg, 22% yield) mp 355 K. HRMS (EI) calcd for $C_{24}H_{27}NO_3$ 377.19909, found 377.19907. The solid was recrystallized from ethanol producing white crystals suitable for X-ray analysis.

Crystal data

$C_{24}H_{27}NO_3$
 $M_r = 377.47$
 Orthorhombic, *Pbca*
 $a = 8.8410$ (17) Å
 $b = 20.584$ (4) Å
 $c = 22.344$ (2) Å
 $V = 4066.2$ (12) Å³
 $Z = 8$
 $D_x = 1.233$ Mg m⁻³

Mo $K\alpha$ radiation
 Cell parameters from 4921 reflections
 $\theta = 6.4$ – 28.5°
 $\mu = 0.08$ mm⁻¹
 $T = 120$ (2) K
 Plate, colourless
 $0.38 \times 0.33 \times 0.12$ mm

Data collection

Bruker–Nonius KappaCCD diffractometer	48795 measured reflections 4921 independent reflections
φ - ω scans	3477 reflections with $I > 2\sigma(I)$
Absorption correction: multi-scan [SADABS (Sheldrick, 2003) and EVALCCD (Duisenberg <i>et al.</i> , 2003)]	$R_{\text{int}} = 0.041$ $\theta_{\text{max}} = 28.5^\circ$ $h = -11 \rightarrow 11$ $k = -26 \rightarrow 26$ $l = -29 \rightarrow 27$
$T_{\text{min}} = 0.970$, $T_{\text{max}} = 0.990$	

Refinement

Refinement on F^2	$w = 1/[\sigma^2(F_o^2) + (0.0174P)^2 + 3.2146P]$
$R[F^2 > 2\sigma(F^2)] = 0.055$	where $P = (F_o^2 + 2F_c^2)/3$
$wR(F^2) = 0.109$	$(\Delta/\sigma)_{\text{max}} = 0.001$
$S = 1.11$	$\Delta\rho_{\text{max}} = 0.36 \text{ e } \text{\AA}^{-3}$
4921 reflections	$\Delta\rho_{\text{min}} = -0.23 \text{ e } \text{\AA}^{-3}$
255 parameters	
H-atom parameters constrained	

Table 1

Hydrogen-bond geometry (\AA , $^\circ$).

$D-H \cdots A$	$D-H$	$H \cdots A$	$D \cdots A$	$D-H \cdots A$
$C5-H5 \cdots O1^i$	0.95	2.51	3.444 (2)	169
$C27-H27B \cdots O32A^{ii}$	0.99	2.59	3.548 (2)	163

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

H atoms were treated as riding atoms, with aromatic C–H = 0.95 \AA , CH₂ C–H = 0.99 \AA , both with $U_{\text{iso}}(\text{H}) = 1.2U_{\text{eq}}(\text{C})$, and methyl C–H = 0.98 \AA , with $U_{\text{iso}}(\text{H}) = 1.5U_{\text{eq}}(\text{C})$.

Data collection: COLLECT (Hooft, 2004); cell refinement: DIRAX/LSQ (Duisenberg *et al.*, 2000); data reduction: EVALCCD (Duisenberg *et al.*, 2003); program(s) used to solve structure: SHELXS97 (Sheldrick, 1997); program(s) used to refine structure: OSCAIL (McArdle, 2003 and SHELXL97 (Sheldrick, 1997); molecular graphics: PLATON (Spek, 2003); software used to prepare

material for publication: SHELXL97 and WORDPERFECT macro PRPKAPPA (Ferguson, 1999).

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