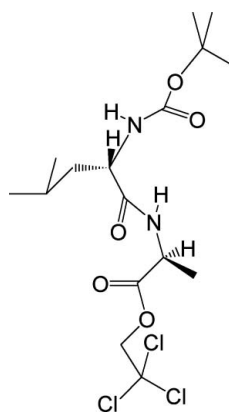


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Key indicators

Single-crystal X-ray study
 $T = 173$ K
Mean $\sigma(\text{C}-\text{C}) = 0.009$ Å
 R factor = 0.043
 wR factor = 0.079
Data-to-parameter ratio = 15.7For details of how these key indicators were
automatically derived from the article, see
<http://journals.iucr.org/e>.***tert*-Butoxycarbonyl-L-leucyl-L-alanine
trichloroethyl ester (Boc-L-Leu-L-Ala-OTce)**The title compound, $\text{C}_{16}\text{H}_{27}\text{Cl}_3\text{N}_2\text{O}_5$, which is an enantiopure dipeptide trichloroethyl ester, adopts an extended conformation. The molecules are linked *via* $-\text{NH}\cdots\text{O}=\text{C}$ hydrogen bonds into a unique β -spiral assembly along the c axis.Received 29 July 2005
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Comment

The 2,2,2-trichloroethyl group (-OTce) is useful for carboxyl protection in peptide synthesis (Marinier *et al.*, 1973; Olsen *et al.*, 1986; Pastuszak *et al.*, 1982; Yamada *et al.*, 2003). By using the -OTce group, the selective removal from other carboxyl protection, such as benzyl (-OBzl), can be carried out by treating the peptide with zinc powder in acetic acid under mild conditions.Boc-L-Leu-L-Ala-OTce
(I)There are two problems for -OTce protection, despite its usefulness. One is the significant racemization that can occur during the -OTce esterification to *N*-benzyloxycarbonyl- (*Z*-) and *N-tert*-butoxycarbonyl- (Boc-) α -amino acids (Dhaon *et al.*, 1982; Neises & Steglich, 1978; Atherton *et al.*, 1981). The other is the oily property and difficult crystallinity of *N*-protected peptide trichloroethyl esters such as *Z*-Ala-OTce (Dhaon *et al.*, 1982), *Z*-Leu-Ala-OTce (Marinier *et al.*, 1973) and Boc-Val-Leu-OTce (Yamada *et al.*, 2003). Therefore, in this paper, to assess the enantiopurity and crystallinity, we have studied the crystal structure of the title compound, (I), as one of our synthetic fragments of cyclosporin O derivatives (Endo *et al.*, 2003).The molecular structure of (I) is shown in Fig. 1. The molecule adopts an extended β -sheet conformation and molecules are tightly linked together by $\text{N}-\text{H}\cdots\text{O}=\text{C}$ hydrogen bonds (Table 2), to form a β -spiral assembly along the c axis (Fig. 2). Packed in the unit cell (Fig. 3), they are tightly linked together by $\text{N}-\text{H}\cdots\text{O}=\text{C}$ hydrogen bonds, forming an infinite spiral along the c axis. The β -helical structure is not common, but it is

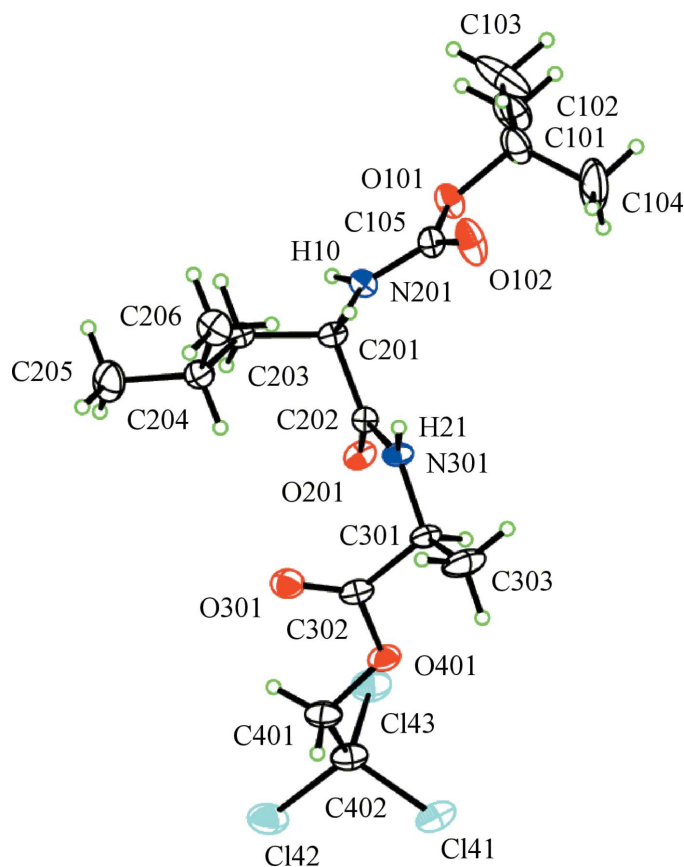


Figure 1
A view of (I), with the atomic numbering scheme. Displacement ellipsoids are drawn at the 20% probability level.

sometimes observed in short peptides (Doi *et al.*, 1994; Görbitz & Gundersen, 1996; Oku *et al.*, 2003).

Experimental

The title peptide, (I), was prepared by the coupling of Boc-Leu-OH (4.88 g, 19.0 mmol) and HCl-Ala-OTce (5.68 g, 22.8 mmol) as solution-phase synthesis. Yield 7.44 g (90%). Crystals of (I) were grown by slow diffusion of hexane vapor into a diethyl ether solution. Analytical data (melting point, ^1H NMR, ESI-MS and $[\alpha]_{\text{D}}^{20}$) are in accordance with the expected structure; $[\alpha]_{\text{D}}^{20} = -46.2^\circ$ (c 0.1, methanol), m.p. = 415–417 K.

Crystal data

$\text{C}_{16}\text{H}_{27}\text{Cl}_3\text{N}_2\text{O}_5$
 $M_r = 433.75$
 Hexagonal, $P6_5$
 $a = 12.1055$ (14) Å
 $c = 26.939$ (5) Å
 $V = 3418.8$ (8) Å³
 $Z = 6$
 $D_x = 1.264$ Mg m⁻³

Cu $K\alpha$ radiation
 Cell parameters from 21563 reflections
 $\theta = 3.3$ – 68.2°
 $\mu = 3.85$ mm⁻¹
 $T = 173.1$ K
 Needle, colorless
 $0.30 \times 0.01 \times 0.01$ mm

Data collection

Rigaku R-AXIS RAPID diffractometer
 ω scans
 Absorption correction: none
 29240 measured reflections
 4134 independent reflections

1326 reflections with $F^2 > 2\sigma(F^2)$
 $R_{\text{int}} = 0.097$
 $\theta_{\text{max}} = 68.2^\circ$
 $h = -14 \rightarrow 14$
 $k = -14 \rightarrow 14$
 $l = -31 \rightarrow 32$

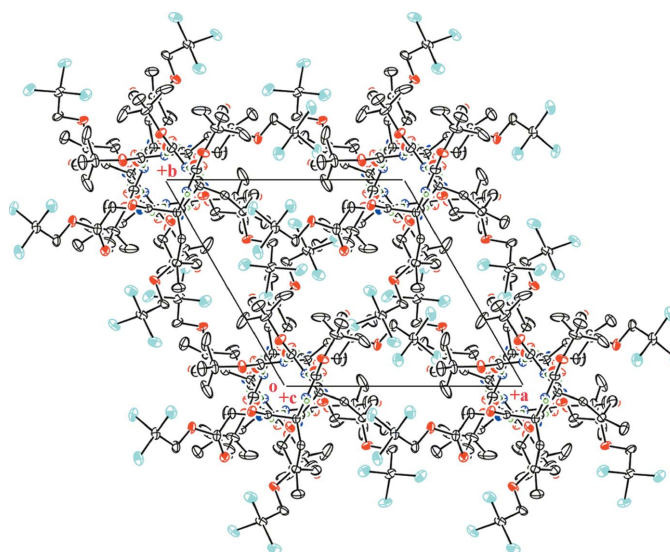


Figure 2
A packing diagram of (I), projected down the c axis.

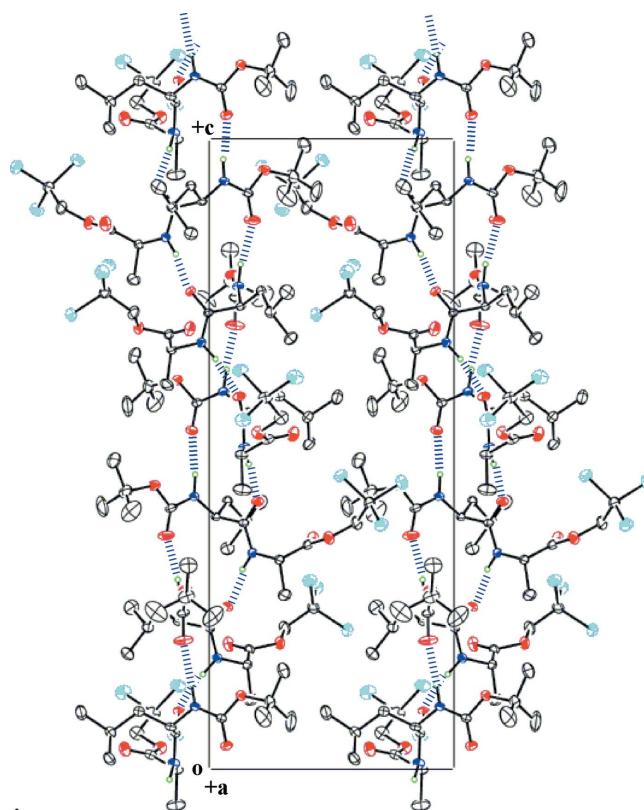


Figure 3
A packing diagram of (I), projected down the a axis. Two β -spiral columns are shown packed in the unit cell along the c axis. Hydrogen bonds are shown as dashed lines.

Refinement

Refinement on F^2
 $R[F^2 > 2\sigma(F^2)] = 0.043$
 $wR(F^2) = 0.079$
 $S = 1.06$
 4134 reflections
 263 parameters
 H-atom parameters constrained

$w = 1/[0.1\sigma(F_o^2) + 2.0]/(4F_o^2)$
 $(\Delta/\sigma)_{\text{max}} < 0.001$
 $\Delta\rho_{\text{max}} = 1.14$ e Å⁻³
 $\Delta\rho_{\text{min}} = -0.65$ e Å⁻³
 Absolute structure: Flack (1983),
 1992 Friedel pairs
 Flack parameter: 0.05 (2)

Table 1

Selected torsion angles (°).

C302—O401—C401—C402	150.4 (5)	C202—N301—C301—C302	−61.6 (6)
C401—O401—C302—C301	−178.1 (4)	C301—N301—C202—C201	178.0 (4)
C105—N201—C201—C202	−91.6 (6)	N201—C201—C202—N301	130.6 (4)
C201—N201—C105—O101	177.2 (6)	N301—C301—C302—O401	151.8 (4)

Table 2

Hydrogen-bond geometry (Å, °).

<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>
N201—H10...O102 ⁱ	0.95	1.97	2.907 (5)	171
N301—H21...O201 ⁱⁱ	0.95	1.89	2.829 (6)	170

Symmetry codes: (i) $+y, -x + y, +z + \frac{1}{6}$; (ii) $+x - y, +x, +z - \frac{1}{6}$.

The ratio of observed/unique reflections was relatively low (32%), although the X-ray measurement was carried out at 173 K with Cu $K\alpha$ radiation. H atoms were positioned geometrically, with $C-H = N-H = 0.95$ Å, and refined using a riding model, with $U_{iso}(H)$ initially assigned to be $1.2U_{eq}$ of the carrier atom. The absolute configuration of (I) agrees with the fact that the 1H NMR spectroscopic data detected no racemization in the preparation.

Data collection: *RAPID-AUTO* (Rigaku, 2003); cell refinement: *RAPID-AUTO*; data reduction: *CrystalStructure* (Rigaku, 2003); program(s) used to solve structure: *SIR2002* (Burla *et al.*, 2003); program(s) used to refine structure: *CRYSTALS* (Betteridge *et al.*, 2003); molecular graphics: *ORTEP* (Johnson, 1965); software used to prepare material for publication: *CrystalStructure*.

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