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TETRAHEDRON: *ASYMMETRY*

Stereoselective synthesis and absolute configuration of (1′*R*,3*R*,4*R*)-4-acetoxy-3-(2′,2′,2′-trifluoro-1′-hydroxyethyl)-azetidin-2-one

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Abstract

The title compound **3**, an intermediate in the synthesis of fluorocarbapenems, is obtained with high stereocontrol by the condensation of (*R*)-(+)-ethyl 4,4,4-trifluoro-3-hydroxybutanoate with *N*-trimethylsilyl cinnamylidenimine. X-Ray diffraction analysis of the condensation product and chemical correlations allowed the unambiguous determination of the absolute configuration. © 1998 Elsevier Science Ltd. All rights reserved.

1. Introduction

The interest in new antibiotics demonstrating stability to β-lactamases and a broad spectrum of activity has long directed synthetic chemists towards finding suitable functionalized azetidinones; owing to the presence of several stereocenters whose correct configuration is crucial for pharmacological activity, there is a need for highly stereoselective syntheses of these molecules. In this regard, the literature reports[1] different stereoselective approaches to 4-acetoxyazetidinone **1**, a key framework for the synthesis of carbapenems, such as thienamycin, 1β-methylcarbapenems and tribactams.[2] Moreover, increasing attention has recently been devoted to fluorine-containing antibiotics,[3,4] where the introduction of this halogen can be an advantageous tool in drug design to alter favourably the pharmacological properties of active classes of drugs. Despite this, only a few examples of fluorinated β-lactams are reported, prepared from fluorinated building blocks[3] or by direct fluorination of azetidinones.[4] To the best of our knowledge, the literature does not report the synthesis of **2**, the trifluoro-analogue of acetoxyazetidinone **1**.

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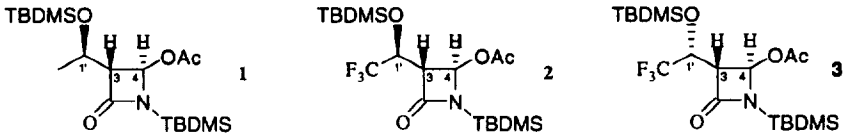
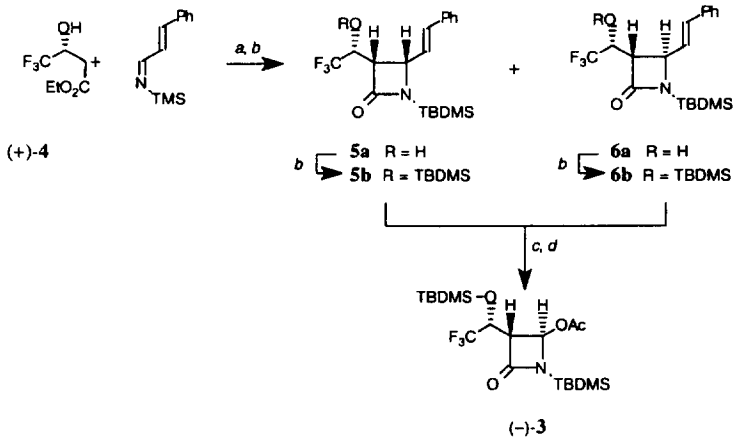


With a view to **2**, in this paper we describe the synthesis and stereochemical characterization of (1′*R*,3*R*,4*R*)-3-(2′,2′,2′-trifluoro-1′-hydroxyethyl)-4-acetoxyazetidin-2-one **3**, bearing the correct configurations at C(3) and C(4) and the undesired configuration at the inducing center C(1′), which might possibly be inverted to the correct one by analogy with literature methods.[5]

2. Results and discussion

Among the several synthetic approaches to 4-acetoxy-azetidinone **1** reported in the literature,[1] the condensation of imines with hydroxybutanoates leads directly to β-lactams with α-hydroxyethyl substitution at C(3): if *N*-trimethylsilyl (*N*-TMS) imines are used, *N*-H azetidinones are recovered.[6] Moreover, it is reported[7] that the condensation of *N*-TMS imine with (*S*)-(−)-ethyl hydroxybutanoate affords the lactam bearing the desired 3*S* configuration. We therefore decided to investigate the condensation of *N*-TMS cinnamylidenimine with racemic and optically active ethyl 4,4,4-trifluoro-3-hydroxybutanoate (**4**), Scheme 1. In this reaction, the correct 3*S* configuration of the product is expected to be induced by (*R*)-**4**, which has the same configuration as the unfluorinated (*S*)-hydroxybutanoate. Racemic **4** was obtained from the commercially available ethyl 4,4,4-trifluoroacetoacetate by treatment with $NaBH_4$ in ethanol, while optically active (*R*)-(+)-**4** (52% ee) was obtained[8] by reduction with baker's yeast. A considerable enhancement of the enantiomeric excess of (+)-**4** was achieved by performing yeast reduction in the presence of allyl bromide (1.5 g l^{-1}), following a procedure previously described for the parent compound[9]: (*R*)-(+)-**4** was recovered in 80% ee and 60% yield.



a: LHMDA; *b*: TBDMS-Cl; *c*: $RuCl_3$, $NaIO_4$; *d*: $Pb(OAc)_4$

Scheme 1.

2.1. Synthesis of (±)-3

The dianion of the racemic hydroxybutanoate was obtained by treating **4** in anhydrous THF at −78°C with two equivalents of lithium bis(trimethylsilyl)amide (LHMDA) in the same solvent, or with two equivalents of lithium diisopropylamide (LDA) in THF/heptane/ethylbenzene; this solution was allowed

to react with *N*-TMS cinnamylidenimine[10] at −78°C. Following the general acid work-up procedure (aq. HCl or NH_4Cl),[6] the expected N–H β-lactams are recovered in very low yields (<10%). If the reaction mixture was treated with *tert*-butyldimethylsilyl-chloride (TBDMS-Cl) at 0°C and then quenched with saturated NH_4Cl,[11] the synthesized β-lactams are recovered in higher yields and chemoselectively protected at nitrogen. ^{1}H-NMR spectroscopy of the crude extract showed the presence of a considerable amount of unreacted **4** and cinnamaldehyde, along with the *N*-TBDMS-β-lactams *cis*-**5a** and *trans*-**6a**.

According to the literature,[12] the ratio of the synthesized stereoisomers is solvent dependent: when carrying out the reaction in THF, ^{1}H-NMR spectroscopy revealed a **5a**:**6a** ratio of 35:65, whilst the reaction carried out in THF/heptane/ethylbenzene afforded the same products in a 65:35 ratio. Purification of the residue by column chromatography afforded unreacted **4** (28% of the starting material) and the expected β-lactam *N*-TBDMS-3-(2′,2′,2′-trifluoro-1′-hydroxyethyl)-4-styrylazetidin-2-one in two diastereoisomeric forms: *cis*-**5a** (16% yield) and *trans*-**6a** (29% yield). No trace of different stereoisomeric forms could be detected among the reaction products. The β-lactams **5a** and **6a** were protected at the hydroxy group as *tert*-butyldimethylsilyl derivative (TBDMS-Cl, DMAP, CH_2Cl_2, 60–65% conversion), affording **5b** and **6b** in 50–55% chemical yield. Higher yields in the protection at the hydroxy group were obtained in the synthesis of the TMS derivative (85–95% yield), but the TMS group proved unstable in the aqueous conditions required in the subsequent transformations. Oxidation of **5b** with sodium metaperiodate and a catalytic amount of ruthenium trichloride in $H_2O/CCl_4/CH_3CN$ solution,[13] followed by treatment with lead tetraacetate in DMF at 70°C, afforded the *trans*-4-acetoxyazetidinone **3** (79%). An identical sample of **3** was obtained starting from **6b**; according to the literature,[7,12] these results indicate that the acetoxy group is introduced under the stereocontrol of C(3), from the opposite face with respect to the hydroxyethyl chain.

2.2. Synthesis of (−)-3

The imine–enolate condensation carried out from (+)-**4** (80% ee) afforded the optically active β-lactams **5a**, $[\alpha]_D$ +37.3 ($CHCl_3$), and **6a**, $[\alpha]_D$ −20.9 ($CHCl_3$), while unreacted **4** was surprisingly recovered in 91% ee. Since any attempt to determine the ee of **5a** and **6a** failed, the ees of the β-lactams were determined after their conversion to **5b** and **6b**, respectively. From the ^{1}H-NMR spectra, recorded in $CDCl_3$ and in the presence of $Eu(hfc)_3$, the two β-lactams showed an ee of 56% and 51%, respectively. Since unreacted **4** was recovered in enhanced ee (91%, starting from 80% ee), the lower enantiomeric purity of the products could be explained by assuming that, during condensation, the dianion partially separates as an enantiomerically pure solid, while the remainder (in lower enantiomeric purity) condensates with the imine. Double bond oxidation with sodium metaperiodate and decarboxylation with $Pb(OAc)_4$ performed separately starting from **5b** and **6b**, afforded (−)-**3** in 56–51% ee, according to a stereoconvergent transformation.

2.3. Stereochemical characterization

All the synthesized β-lactams were readily distinguished by ^{1}H-NMR spectroscopy from the value of $J_{H(3)H(4)}$, the *cis* value always being larger than the *trans* one.[12] In order to define the stereorelationship between C(3) and C(1′), which could not be determined by coupling constant analysis, we resorted to single-crystal X-ray diffraction analysis of enantiomerically pure **6a**, $[\alpha]_D$ −43.8, ee≥95% (determined after conversion to **6b**), obtained by fractional crystallization from chloroform of a sample with $[\alpha]_D$ −20.9.

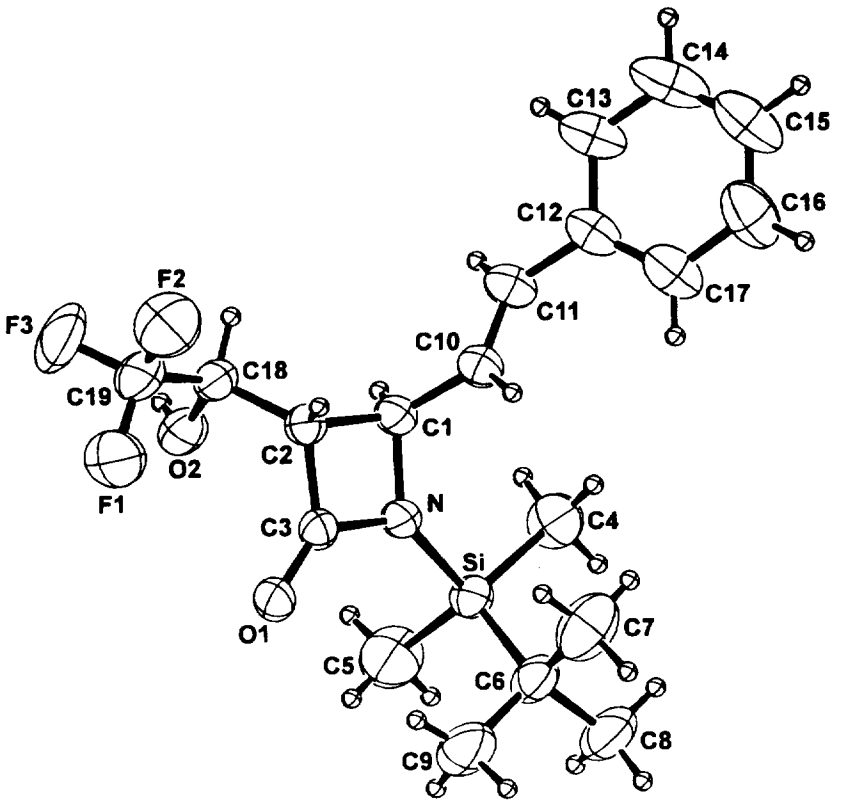


Fig. 1. ORTEP drawing of the molecular structure of **6a**. Thermal ellipsoids enclose 40% probability

Figure 1 shows the molecular structure of **6a**, along with the atom-numbering scheme used throughout. All bond distances and angles are in the expected ranges.[14] The azetidinone ring is slightly puckered, with atomic deviations from least-squares mean plane ranging from −0.026 to 0.030 Å. Its N atom is slightly pyramidal, lying 0.112 Å out of the plane defined by the three atoms to which it is bonded. The mean plane through the four ethylenic C atoms makes a dihedral angle of 78.7° with that of the azetidinone ring, and 29.4° with that of the phenyl group. The major contribution to molecular packing is made by one strong hydrogen-bonding interaction, which involves the –OH function as donor group and the azetidinone O atom as acceptor. This interaction ties the molecules onto the chiral chain, which are separated by normal van der Waal distances.

The X-ray structure confirms the chemoselective silylation at nitrogen and unambiguously shows the relative configurations of C(1′), C(3) and C(4) (C18, C2 and C1, respectively, in Fig. 1) to be 1′*R**,3*S**,4*R**; moreover, since the *R* absolute configuration of starting (+)-**4** is known from the literature, the absolute stereochemistry (1′*R*,3*S*,4*R*) of (−)-**6a** is defined; chemical correlation of (−)-**6a** and (+)-**5a** with (−)-**3**, which does not involve the stereocenters C(1′) and C(3), assigns the following absolute configurations: (1′*R*,3*S*,4*S*) to (+)-**5a** and (1′*R*,3*R*,4*R*) to (−)-**3**.

From these determinations it follows that, by close analogy with the condensation of the unfluorinated ester, the stereogenic center of (*R*)-**4** induces the *S* configuration at the adjacent C(3) stereocenter with high diastereoselectivity, while low stereocontrol is observed towards C(4). Nevertheless, the synthesized β-lactams equilibrate to the more stable 4*R* configuration in a subsequent step of the synthesis, both affording the β-lactam (1′*R*,3*R*,4*R*)-(−)-**3**.

3. Conclusion

The fluorinated acetoxy-azetidinone **3**, an intermediate in the synthesis of fluorocarbapenems, is obtained in optically active form, starting from (*R*)-(+)-ethyl 4,4,4-trifluorohydroxybutanoate, by condensation with *N*-TMS-cinnamylidenimine. The β-lactams **5a** and **6a** are recovered as condensation products, indicating high stereocontrol towards C(3) and low selectivity towards C(4). These stereoisomers equilibrate to the more stable *trans* configuration in a later step of the synthesis affording the title compound (−)-**3** in a single diastereoisomeric form. Chemical correlations and X-ray diffraction analysis of an enantiomerically and diastereoisomerically pure crystal of (−)-**6a** allowed the determination of the absolute configuration of all the synthesized β-lactams.

4. Experimental

^{1}H-NMR spectra were recorded in $CDCl_3$ solution on Bruker AMX 400-WB or DPX-200 spectrometers. Chemical shifts are reported in δ values from TMS as the internal standard (s singlet, d doublet, m multiplet, t triplet, br broad signal). Coupling constants (*J*) are given in Hz. Optical rotations were measured at 20°C on a Perkin–Elmer 241 polarimeter. GLC analyses were performed on a Hewlett Packard 5890 A gas chromatograph on a DB-1 column (30 m×0.53 mm I.D. and 5 μm film phase) from J&W Scientific, with helium as the carrier gas. The enantiomeric purities (ees) of **4** were evaluated on a chiral G-DEX 120 column (30 m×0.25 mm I.D. and 0.25 μm film phase) from Supelchem (accuracy within ±5%). The ee of **5b**, **6b** and **3** were evaluated from the ^{1}H-NMR spectra recorded in $CDCl_3$ solution and in the presence of the chiral shift reagent Eu(hfc)$_3$ (accuracy within ±5%). Mass spectra were determined on a Finnigan Mat SSQA mass spectrometer (EI, 70 eV). Chromatographic purification of the compounds was performed on silica gel (diameter 0.05–0.20 mm). Elemental analyses were performed with a Carlo Erba Elemental Analyzer Mod. 1106. Ethyl 4,4,4-trifluoroacetoacetate, as well as LHMDA and LDA solutions were purchased from Aldrich.

4.1. (±)-Ethyl 4,4,4-trifluoro-3-hydroxybutanoate 4[8]

Ethyl 4,4,4-trifluoroacetoacetate (1 g, 5.4 mmol) in ethanol (10 ml) was slowly added with stirring to a cooled solution of $NaBH_4$ (0.10 g, 2.67 mmol) in absolute ethanol (40 ml). The mixture was allowed to react at room temperature for 1 hour; thereafter it was diluted with water (50 ml), treated with HCl 10%, extracted with diethyl ether (3×50 ml) and dried ($MgSO_4$). After removal *in vacuo* of the solvent, the crude extract was purified by chromatography (light petroleum:diethyl ether=9:1) and distilled (b.p. 83–84°C/20 mmHg) to afford **4** (0.52 g, 52% yield) as a colourless oil. ^{1}H-NMR, δ: 1.33 (3H, t, *J* 7.2), 2.71 (1H, dd, *J* 7.8, 16.8), 2.75 (1H, dd, *J* 4.6, 16.8), 3.56 (1H, d, *J* 5.3), 4.25 (2H, q, *J* 7.2), 4.47 (1H, m); MS *m/z* 187 (M^+).

4.2. (R)-(+)-Ethyl 4,4,4-trifluoro-3-hydroxybutanoate 4

Following the procedure described in the literature,[8] baker's yeast reduction of ethyl 4,4,4-trifluoroacetoacetate afforded **4** (yield 64%) showing $[\alpha]_D$ +9.1 (c 1.2, $CHCl_3$), 52% ee. In order to increase the enantiomeric excess of **4**, the following procedure was adopted:[9] baker's yeast (235 g) was suspended in distilled water (2 l) and magnetically stirred at 37°C for 30 min; allyl bromide (6 g, 50 mmol) was added and stirred for a further 45 min. Subsequently, ethyl 4,4,4-trifluoroacetoacetate (15

g, 81 mmol) was added and allowed to react at the same temperature for 24 hours. The mixture was centrifugated and the mother liquor was saturated with sodium chloride and extracted four times with ethyl acetate. The organic extracts were dried over Na_2SO_4 and filtered and the solvent was distilled. The residue was purified by chromatography (light petroleum:diethyl ether=9:1) and distilled *in vacuo*, affording **4** (60%), $[\alpha]_D$ +14.6 (c 1.2, $CHCl_3$), 80% ee.

4.3. N-tert-*Butyldimethylsilyl-3-(2′,2′,2′-trifluoro-1′-hydroxyethyl)-4-styrylazetidin-2-one* **5a** *and* **6a**

Lithium bis(trimethylsilyl)amide (LHMDA 1.0 M in THF, 24 ml) was slowly dropped into a stirred solution of (*R*)-(+)-**4** (2.0 g, 10.7 mmol, ee 80%) in freshly distilled anhydrous THF (20 ml) at −78°C under nitrogen atmosphere, and allowed to react for 1 hour at the same temperature; freshly prepared *N*-trimethylsilylcinnamylidenimine[10] (10.7 mmol) in THF (20 ml) was then added with a syringe and stirred for 30 min at −78°C; the cold bath was removed and the mixture allowed to warm at room temperature overnight. Thereafter, *tert*-butyldimethylsilylchloride (3.4 g, 22.5 mmol) in THF (4 ml) was slowly added at 0°C; after a further 2 hours the resulting solution was quenched with saturated aqueous NH_4Cl (50 ml) and extracted with ethyl acetate (3×30 ml); the combined organic layers were dried on $MgSO_4$ and concentrated under reduced pressure. ^{1}H-NMR spectroscopy revealed the presence of **5a** and **6a** in a 35:65 ratio; if the reaction was carried out with lithium diisopropylamide (LDA 2.0 M in THF/heptane/ethylbenzene, 12 ml), the ratio was 65:35. The residue was dissolved in ethanol:water (2:1, 30 ml) and potassium acetate (0.8 g, 8.1 mmol) and semicarbazide hydrochloride (0.9 g, 8.1 mmol) were added: the insoluble semicarbazone of cinnamaldehyde was filtered off, the residue diluted with water and extracted with diethyl ether. The organic layers were dried on $MgSO_4$, then concentrated and purified by chromatography (light petroleum:diethyl ether=80:20) to afford unreacted **4** (0.56 g, 28%), ee 91%, **5a** (0.65 g, 16%), $[\alpha]_D$ +37.3 (c 1.0, $CHCl_3$) and **6a** (1.22 g, 29%), $[\alpha]_D$ −20.9 (c 1.0, $CHCl_3$), m.p. 118–122°C. Fractional crystallization from chloroform of the latter afforded a sample of **6a** showing $[\alpha]_D$ −43.8 (c 1.2, $CHCl_3$), m.p. 159–161°C, ee≥95% (evaluated after conversion to derivative **6b**).

(+)-**5a**: ^{1}H-NMR δ: 0.24 (3H, s), 0.26 (3H, s), 1.01 (9H, s), 3.92 (1H, dd, *J* 2.3, 6.2 Hz), 4.33 (1H, ddq, *J* 2.3, 6.3, 8.3), 4.57 (1H, dd, *J* 6.2, 8.7), 5.54 (1H, d, *J* 6.3), 6.67 (1H, dd, *J* 8.7, 16.0), 6.83 (1H, d, *J* 16.0), 7.25–7.54 (5H, m). MS, *m/z*: 385 (M^+).

(−)-**6a**: ^{1}H-NMR δ: 0.22 (3H, s), 0.28 (3H, s), 1.01 (9H, s), 3.44 (1H, dd, *J* 2.9, 5.6 Hz), 4.34 (1H, dd, *J* 2.9, 9.0), 4.56 (1H, ddq, *J* 5.6, 6.3, 7.6), 5.54 (1H, d, *J* 6.3), 6.48 (1H, dd, *J* 9.0, 15.8), 6.77 (1H, d, *J* 15.8), 7.25–7.54 (5H, m). MS, *m/z*: 385 (M^+). Anal. Calcd for $C_{19}H_{26}F_3NO_2Si$: C, 59.20; H, 6.75; N, 3.63. Found: C, 59.02; H, 6.79; N, 3.60.

4.4. N-tert-*Butyldimethylsilyl-3-[2′,2′,2′-trifluoro-1′-(*tert*-butyldimethylsilyloxy)ethyl]-4-styrylazetidin-2-one* **5b** *and* **6b**

TBDMS-Cl (176 mg, 1.17 mmol) was added to a cooled (0°C) solution of **5a** ($[\alpha]_D$ +37.3, 0.30 g, 0.78 mmol) and 4-(*N,N*-dimethylamino)pyridine (DMAP, 143 mg, 1.17 mmol) in anhydrous CH_2Cl_2 (8 ml) and the mixture allowed to react at room temperature for 24 h with stirring. TLC analysis (light petroleum:diethyl ether=80:20) indicated the presence of unreacted **5a**; complete conversion of the substrate could not be achieved either by a longer reaction time or by addition of further reactant (TBDMS-Cl/DMAP). The mixture was washed with 5% HCl, dried and concentrated *in vacuo*. Purification by chromatography (light petroleum:diethyl ether=90:10) afforded **5b** (0.21 g, 55%), $[\alpha]_D$ +60.2 (c 2.2, $CHCl_3$), ee 56% and unreacted **5a** (0.08 g, 26%). The same reaction, starting from **6a**, $[\alpha]_D$ −20.9, afforded **6b** (51%), $[\alpha]_D$ −12.3, ee 52%.

(+)-**5b**: ^{1}H-NMR δ: 0.14 (3H, s), 0.16 (3H, s), 0.20 (3H, s), 0.29 (3H, s), 0.97 (9H, s), 0.99 (9H, s), 3.88 (1H, t, *J* 5.9), 4.29 (1H, dq, *J* 5.8, 6.5), 4.36 (1H, dd, *J* 6.0, 8.8), 6.28 (1H, dd, *J* 8.8, 15.9), 6.68 (1H, d, *J* 15.9), 7.35–7.40 (5H, m). MS, *m/z*: 500 ([M+1]$^+$).

(−)-**6b**: ^{1}H-NMR δ: 0.16 (3H, s), 0.18 (3H, s), 0.22 (6H, s), 0.93 (9H, s), 0.98 (9H, s), 3.34 (1H, dd, *J* 3.0, 5.7), 4.19 (1H, dd, *J* 3.0, 9.0), 4.33 (1H, quintet, *J* 5.7), 6.16 (1H, dd, *J* 9.0, 15.7), 6.61 (1H, d, *J* 15.7), 7.30–7.40 (5H, m). MS, *m/z*: 500 ([M+1]$^+$).

4.5. (*1'*R,*3*R,*4*R)-N-tert-*Butyldimethylsilyl-3-[2',2',2'-trifluoro-1'-(*tert-*butyldimethylsilyloxy)ethyl]-4-acetoxyazetidin-2-one (−)-3*

A catalytic amount of ruthenium trichloride hydrate was added to the following biphasic system: **5b** (88 mg, 0.18 mmol, $[\alpha]_D$ +60.2) in carbon tetrachloride (0.5 ml), acetonitrile (0.5 ml), sodium metaperiodate (154 mg, 0.72 mmol), H_2O (1.0 ml). This mixture was vigorously stirred for 2 hours at room temperature. Then, 5 ml of CH_2Cl_2 were added and the two phases separated and the organic layer was dried on $MgSO_4$ and concentrated. The residue was diluted with 10 ml of diethyl ether, filtered through a carbon pad and concentrated to afford 83 mg of crude acid, which was used without purification. A few milligrams of this extract were dissolved in ether and treated with an ethereal solution of diazomethane: the methyl ester thus obtained gave the desired GC–MS fragmentation (*m/z*: 456, [M+1]$^+$).

The crude acid in DMF (3 ml) and acetic acid (3 ml) was treated at 70°C, in a nitrogen atmosphere, with lead tetraacetate (234 mg, 0.52 mmol). The solution was stirred for 45 min, water (20 ml) was then added, the mixture was extracted with light petroleum (3×10 ml) and the organic layers were dried over $MgSO_4$. After removal of the solvent, 65 mg of (−)-**3** (79% from **5b**) was obtained as a yellowish oil; chromatographic purification (light petroleum:diethyl ether=90:10) afforded an analytically pure sample of *trans*-(−)-**3**, ($[\alpha]_D$ −5.5, ee 55%) along with the corresponding *N*-deprotected lactam (**7**) ($[\alpha]_D$ +2.11, ee 55%).

Following the same procedure described for **5b**, an identical sample of (−)-**3**, ee 50%, was recovered starting from **6b**.

(−)-**3**: ^{1}H-NMR δ: 0.19 (3H, s), 0.21 (6H, s), 0.32 (3H, s), 0.95 (9H, s), 1.01 (9H, s), 2.13 (3H, s), 3.46 (1H, dd, *J* 1.6, 2.6), 4.53 (1H, dq, *J* 2.6, 6.9), 5.86 (1H, d, *J* 1.6). MS, *m/z*: 456 ([M+1]$^+$).

(+)-**7**: ^{1}H-NMR δ: 0.19 (3H, s), 0.21 (3H, s), 0.95 (9H, s), 2.15 (3H, s), 3.54 (1H, dd, *J* 1.4, 4.1), 4.45 (1H, dq, *J* 4.1, 6.9), 5.7 (1H, d, *J* 1.4), 6.41 (1H, br). MS, *m/z*: 342 (M$^+$).

4.6. *X-Ray structure analysis*

Diffraction data were collected at room temperature on an Enraf–Nonius CAD-4 diffractometer using graphite monochromated Mo Kα radiation. The colourless crystal used for data collection measured approximately 0.40×0.30×0.30 mm. Lattice parameters were determined by least-squares refinement on setting angles of 25 automatically centered reflections. Intensities were collected in the ω−2θ scan mode in the 2–27° θ range. In view of the low absorption coefficient (0.147 mm^{-1}) and the almost isotropic crystal dimensions, data were corrected for Lorentz polarisation effects, but not for absorption. The structure was solved by direct methods using the SHELX-86 program,[15] and refined on F^2 with SHELXL-93.[16] All non-hydrogen atoms were refined anisotropically, whereas the H atoms were constrained to ride in calculated positions on atoms to which they are bonded (except the O-bonded one located in a ΔF map).

The absolute structure was established by assigning the known (*R*) configuration to the C18 stereogenic atom. Tables of atomic coordinates and bond distances and angles have been deposited with the Cambridge Crystallographic Data Centre.

Crystal Data: $C_{19}H_{26}F_3NO_2Si$, M_r=385.50, orthorhombic, space group $P2_12_12_1$, a=8.005(2), b=12.460(2), c=21.422(3) Å, V=2136.7(7) Å^3, Z=4, D_{calc}=1.198 Mg/m^{-3}, μ=0.147 mm^{-1}, $F(000)$=816, $2\theta_{max}$=27°; final R=0.0423 and $wR2$=0.122 for 1771 reflections with $I>2\sigma(I)$.

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