Synthesis of spiroacetal-triazoles as privileged natural product-like scaffolds using "click chemistry"

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Supplementary Information

General

Experiments requiring anhydrous conditions were performed under a dry nitrogen or argon atmosphere using oven- or flame-dried apparatus and standard techniques in handling air- and/or moisture-sensitive materials unless otherwise stated. Anhydrous dichloromethane (CH_2Cl_2) and triethylamine (NEt_3) were distilled from calcium hydride; anhydrous tetrahydrofuran (THF) was distilled from sodium wire; anhydrous dry toluene was distilled from sodium wire. Solvents used (except for Et_2O) for reactions, work-up extractions and chromatographic purifications were distilled, unless otherwise stated. Commercial reagents were analytical grade or were purified by standard procedures prior to use.[1] Separation of mixtures was performed by flash chromatography using Kieselgel S 63–100 μm (Riedel-de-Hahn) silica gel with the indicated eluent. Mass spectra were recorded on a VG-70SE mass spectrometer at a nominal accelerating voltage of 70 eV for low resolution and at a nominal resolution of 5000 to 10000 as appropriate for high resolution. Ionisation was effected using electron impact (EI^+), fast atom bombardment (FAB^+) using 3-nitrobenzyl alcohol as the matrix or chemical ionisation (CI^+) using ammonia as a carrier gas. Major and significant fragments are quoted in the form x (y), where x is the mass to charge ratio (*m/z*) and y is the percentage abundance relative to the base peak (100%). Infrared spectra were obtained using a Perkin Elmer Spectrum 1000 Fourier Transform Infrared spectrometer as a thin film between sodium chloride plates. Absorption peaks are reported as wavenumbers (ν, cm^{-1}). NMR spectra were recorded on either a Bruker DRX300 spectrophotometer operating at 300 MHz for ^1H nuclei and 75 MHz for ^{13}C nuclei, or on a Bruker DRX400 spectrophotometer operating at 400 MHz for ^1H nuclei and 100 MHz for ^{13}C nuclei, at ambient temperature. ^1H NMR chemical shifts are reported in parts per million (ppm) relative to the tetramethylsilane peak (δ 0.00 ppm). ^1H NMR values are reported as chemical shift δ, relative integral, multiplicity (s, singlet; d, doublet; t, triplet; q, quartet; quintet; m, multiplet), coupling constant (*J*, Hz) and assignment. Coupling constants were taken directly from the spectra. ^{13}C NMR chemical shifts are reported in ppm relative to the chloroform peak (δ 77.0 ppm). ^{13}C NMR values are reported as chemical shifts δ, multiplicity and assignment. Assignments were made with the aid of DEPT, COSY, HSQC, HMBC and NOESY experiments.

Synthesis of triazole 14a–g

General procedures for 1,3-dipolar cycloaddition of azide 5a to alkynes 6

Method A: For terminal alkynes with catalysis by CuI•[P(OEt)$_3$]

To a solution of azide **5a** and alkyne **6** (50.0–100 μL) in anhydrous toluene (250–500 μL) under an atmosphere of argon was added CuI•[P(OEt)$_3$] (0.10–0.12 equiv.). The resulting mixture was heated to reflux for 1 h. After cooling to room temperature, the mixture was purified directly by flash chromatography using hexane–EtOAc as eluent to give the spiroacetal containing a 1,4-disubstituted triazole substituent.

Method B: For symmetrical internal alkynes

A solution of azide **5a** and alkyne **6** (100 μL) in anhydrous toluene (500 μL) was heated to reflux for 1 h. The reaction mixture was purified directly by flash chromatography using hexane–EtOAc as eluent to give the spiroacetal containing a 1,4,5-trisubstituted triazole substituent.

Method C: For trimethylsilylacetylene

A solution of azide **5a** and trimethylsilylacetylene **6** (50.0–100 μL) in anhydrous toluene (500 μL) was heated at 110 °C in a sealed vessel. If the cycloaddition was not complete in 18 h (TLC), a second portion of trimethylsilylacetylene (50.0–100 μL) was added and the mixture was heated at 110 °C overnight. The reaction mixture was purified directly by flash chromatography using hexane–EtOAc as eluent to give the spiroacetal containing a 1,4,5-trisubstituted triazole substituent.

4-[2″-(Benzyloxy)ethyl]-1-{(2′*S,6′*S**,8′*S**)-8′-(*tert*-butyldiphenylsilyloxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-1*H*-1,2,3-triazole (14a)**

Method A: The *title compound* **14a** (39.3 mg, 98%) was prepared as a pale yellow oil from azide **5a** (30.0 mg, 64.4 μmmol), 1-(benzyloxy)but-3-yne (**6a**, 100 μL) and CuI•[P(OEt)$_3$] (2.53 mg, 7.10 μmol) in toluene (500 μL) using the general procedure (method A) described above. Purification was carried out by flash chromatography using hexane–EtOAc (19:1, 7:3 to 1:1) as eluent. HRMS (FAB): found MH$^+$, 626.3413, $C_{37}H_{48}N_3O_4Si$ requires 626.3414. ν_{max} (film)/cm^{-1}: 2931 (C–H), 1455,

1427, 1222 (C–O), 1112 (C–O), 979, 702. δ_H (400 MHz; $CDCl_3$): 1.06 (9 H, s, OSiPh$_2$^{t}*Bu*), 1.25–1.31 (1 H, m, 9′-H$_A$), 1.42–1.51 (1 H, m, 11′-H$_A$), 1.54–1.62 (3 H, m, 5′-H$_A$, 9′-H$_B$ and 10′-H$_B$), 1.70–1.81 (3 H, m, 4′-H$_A$, 5′-H$_B$ and 11′-H$_B$), 1.81–1.96 (2 H, m, 3′-H$_A$ and 10′-H$_B$), 2.05–2.18 (2 H, m, 3′-H$_B$ and 4′-H$_B$), 3.08 (2 H, t, $J_{1'',2''}$ 6.7, 1″-H), 3.63 (1 H, dd, J_{AB} 10.5 and $J_{8'\text{-}CH_2,8'}$ 4.0, 8′-C*H$_A$*H$_B$O), 3.72 (1 H, dd, J_{AB} 10.5 and $J_{8'CH_2,8'}$ 6.3, 8′-CH$_A$*H$_B$*O), 3.79 (2 H, t, $J_{2'',1''}$ 6.7, 2″-H), 3.87–3.94 (1 H, m, 8′-H), 4.55 (2 H, s, OC*H*$_2$Ph), 6.01 (1 H, dd, $J_{2'ax,3'ax}$ 11.1 and $J_{2'ax,3'eq}$ 2.4, 2′-H$_{ax}$), 7.27–7.34 (5 H, m, OCH$_2$*Ph*), 7.34–7.43 (6 H, m, OSi*Ph*$_2$^{t}Bu), 7.54 (1 H, s, 5-H), 7.72–7.75 (4 H, m, OSi*Ph*$_2$^{t}Bu). δ_C (75 MHz; $CDCl_3$): 18.0 (CH$_2$, C-4′), 18.1 (CH$_2$, C-10′), 19.2 (C, OSiPh$_2$^{t}*Bu*), 26.5 (CH$_2$, C-9′), 26.6 (CH$_2$, C-1″), 26.8 (CH$_3$, OSiPh$_2$^{t}*Bu*), 30.8 (CH$_2$, C-3′), 34.5 (CH$_2$, C-5′), 34.6 (CH$_2$, C-11′), 67.2 (CH$_2$, 8′-CH$_2$O), 69.1 (CH$_2$, C-2″), 71.0 (CH, C-8′), 73.0 (CH$_2$, OC*H*$_2$Ph), 81.0 (CH, C-2′), 98.8 (C, C-6′), 119.9 (CH, C-5), 127.6 (CH, OSi*Ph*$_2$^{t}Bu and OCH$_2$*Ph*), 127.6 (CH, OCH$_2$*Ph*), 128.4 (CH, OCH$_2$*Ph*), 129.5 (CH, OSi*Ph*$_2$^{t}Bu), 129.6 (CH, OSi*Ph*$_2$^{t}Bu), 133.6 (C, OSi*Ph*$_2$^{t}Bu), 133.7 (C, OSi*Ph*$_2$^{t}Bu), 135.6 (CH, OSi*Ph*$_2$^{t}Bu), 135.6 (CH, OSi*Ph*$_2$^{t}Bu), 138.2 (C, OCH$_2$*Ph*), 144.8 (C, C-4). *m/z* (FAB): 626 (MH$^+$, 6%), 423 ($C_{26}H_{35}O_3Si$, 55), 405 (31), 386 (M – OSiPh$_2$^{t}Bu, 8), 239 (SiPh$_2$^{t}Bu, 12), 207 (54), 204 (51), 197 (35), 154 (19), 135 (100), 105 (22), 91 (83).

1-{(2′*S**,6′*S**,8′*S**)-8′-(*tert*-Butyldiphenylsilyloxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-4-hydroxymethyl-1*H*-1,2,3-triazole (14b)

Method A: The *title compound* **14b** (13.9 mg, 83%) was prepared as a pale yellow oil from azide **5a** (15.0 mg, 32.2 μmol), prop-2-yn-1-ol (**6b**, 100 μL) and CuI•[P(OEt)$_3$] (1.15 mg, 3.22 μmol) in toluene (500 μL) using the general procedure (method A) described above. Purification was carried out by flash chromatography using hexane–EtOAc (9:1 to 3:2) as eluent. HRMS (FAB): found MH$^+$, 522.2797, $C_{29}H_{40}N_3O_4Si$ requires 522.2788. ν_{max} (film)/cm^{-1}: 3369 (O–H), 2930 (C–H), 2856, 1428, 1222, 1112 (C–O), 1091 (C–O), 980, 703. δ_H (300 MHz; $CDCl_3$): 1.07 (9 H, s, OSiPh$_2$^{t}*Bu*), 1.29–1.36 (1 H, m, 9′-H$_A$), 1.41–1.51 (1 H, m, 11′-H$_A$), 1.51–1.64 (3 H, m, 5′-H$_A$, 9′-H$_B$ and 10′-H$_A$), 1.68–1.87 (5 H, m, 4′-H$_A$, 5′-H$_B$, 10′-H$_B$, 11′-H$_B$ and OH), 1.87–1.99 (1 H, m, 3′-H$_A$), 2.07–2.21 (2 H, m, 3′-H$_B$ and 4′-H$_B$), 3.63 (1 H, dd, J_{AB} 10.5 and $J_{8'\text{-}CH_2,8'}$ 4.2, 8′-C*H$_A$*H$_B$O), 3.83 (1 H, dd, J_{AB} 10.5 and $J_{8'\text{-}CH_2,8'}$ 6.3, 8′-CH$_A$*H$_B$*O), 3.84–3.95 (1 H, m, 8′-H), 4.82 (2 H, s, 4-C*H*$_2$OH), 6.03 (1 H, dd, $J_{2'ax,3'ax}$ 11.0 and $J_{2'ax,3'eq}$ 2.4, 2′-H$_{ax}$), 7.34–7.45 (6 H, m, Ph), 7.68 (1 H, s, 5-H), 7.70–7.76 (4 H, m, Ph). δ_C (75 MHz; $CDCl_3$): 18.0 (CH$_2$, C-4′), 18.2 (CH$_2$, C-10′), 19.2 (C, OSiPh$_2$^{t}*Bu*), 26.5 (CH$_2$, C-9′), 26.8 (CH$_3$, OSiPh$_2$^{t}*Bu*), 30.9 (CH$_2$, C-3′), 34.5 (CH$_2$, C-5′), 34.6 (CH$_2$, C-11′), 56.7 (CH$_2$, 4-CH$_2$OH), 67.1 (CH$_2$, 8′-CH$_2$O), 71.2 (CH, C-8′), 81.2 (CH, C-2′), 98.9 (C, C-6′), 119.9 (CH, C-5), 127.6 (CH, Ph), 129.6 (CH, Ph), 129.6 (CH, Ph), 133.6 (C, Ph), 133.7 (C, Ph), 135.6 (CH, Ph), 135.6 (CH, Ph), 147.2 (C, C-

4). *m/z* (FAB): 522 (MH^+, 3%), 464 (M – ^{t}Bu, 7), 423 ($C_{26}H_{35}O_3Si$, 82), 365 (11), 239 ($SiPh_2{}^t$Bu, 9), 207 (31), 199 (38), 197 (35), 137 (29), 135 (100).

1-{(2′*S**,6′*S**,8′*S**)-8′-(*tert*-Butyldiphenylsilyloxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-4-phenyl-1*H*-1,2,3-triazole (14c)

Method A: The *title compound* **14c** (14.2 mg, 96%) was prepared as a pale yellow oil from azide **5a** (12.0 mg, 25.8 μmol), phenylacetylene (**6c**, 50.0 μL) and CuI•[$P(OEt)_3$] (1.07 mg, 3.00 μmol) in toluene (250 μL) using the general procedure (method A) described above. Purification was carried out by flash chromatography using hexane–EtOAc (99:1 to 19:1) as eluent. HRMS (FAB): found MH^+, 568.3001, $C_{34}H_{42}N_3O_3Si$ requires 568.2996. ν_{max} (film)/cm^{-1}: 2932 (C–H), 2857, 1428, 1390, 1220, 1112 (C–O), 1074 (C–O), 1024, 979, 702. δ_H (300 MHz; $CDCl_3$): 1.08 (9 H, s, $OSiPh_2{}^tBu$), 1.27–1.34 (1 H, m, 9′-H_A), 1.44–1.55 (1 H, m, 11′-H_A), 1.56–1.65 (3 H, m, 5′-H_A, 9′-H_B and 10′-H_A), 1.73–1.89 (4 H, m, 4′-H_A, 5′-H_B, 10′-H_B and 11′-H_B), 1.92–2.04 (1 H, m, 3′-H_A), 2.10–2.26 (2 H, m, 3′-H_B and 4′-H_B), 3.65 (1 H, dd, J_{AB} 10.5 and $J_{8'\text{-}CH_2,8'}$ 4.2, 8′-CH_AH_BO), 3.74 (1 H, dd, J_{AB} 10.5 and $J_{8'\text{-}CH_2,8'}$ 6.3, 8′-CH_AH_BO), 3.89–3.98 (1 H, m, 8′-H), 6.01 (1 H, dd, $J_{2'ax,3'ax}$ 11.1 and $J_{2'ax,3'eq}$ 2.4, 2′-H_{ax}), 7.32–7.47 (9 H, m, OSi$Ph_2{}^t$Bu and Ph), 7.72–7.78 (4 H, m, OSi$Ph_2{}^t$Bu), 7.84–7.89 (2 H, m, Ph), 7.90 (1 H, s, 5-H). δ_C (75 MHz; $CDCl_3$): 18.0 (CH_2, C-4′), 18.2 (CH_2, C-10′), 19.3 (C, $OSiPh_2{}^tBu$), 26.5 (CH_2, C-9′), 26.8 (CH_3, $OSiPh_2{}^tBu$), 31.1 (CH_2, C-3′), 34.5 (CH_2, C-5′), 34.6 (CH_2, C-11′), 67.2 (CH_2, 8′-CH_2O), 71.2 (CH, C-8′), 81.2 (CH, C-2′), 99.0 (C, C-6′), 117.7 (CH, C-5), 125.8 (CH, Ph), 127.7 (CH, OSi$Ph_2{}^t$Bu), 128.1 (CH, Ph), 128.8 (CH, Ph), 129.6 (CH, OSi$Ph_2{}^t$Bu), 129.6 (CH, OSi$Ph_2{}^t$Bu), 130.8 (C, Ph), 133.7 (C, OSi$Ph_2{}^t$Bu), 135.6 (CH, OSi$Ph_2{}^t$Bu), 135.7 (CH, OSi$Ph_2{}^t$Bu), 147.5 (C, C-4). *m/z* (FAB): 568 (MH^+, 3%), 510 (M – ^{t}Bu, 7), 423 ($C_{26}H_{35}O_3Si$, 45), 239 ($SiPh_2{}^t$Bu, 8), 207 (38), 199 (31), 197 (37), 137 (21), 135 (100), 121 (16), 91 (18).

Ethyl 1-{(2′*S**,6′*S**,8′*S**)-8′-(*tert*-butyldiphenylsilyloxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-1*H*-1,2,3-triazole-4-carboxylate (14d)

Method A: The *title compound* **14d** (9.00 mg, 84%) was prepared as a pale yellow oil from azide **5a** (9.00 mg, 19.3 μmol), ethyl propiolate (**6d**, 50.0 μL) and CuI•[$P(OEt)_3$] (0.71 mg, 2.00 μmol) in toluene (250 μL) using the general procedure (method A) described above. Purification was carried out by flash chromatography using hexane–EtOAc (19:1 to 9:1) as eluent. HRMS (FAB): found MH^+, 564.2892, $C_{31}H_{42}N_3O_5Si$ requires 564.2894. ν_{max} (film)/cm^{-1}: 2932 (C–H), 1742 (C=O), 1428, 1221 (C–O), 1113 (C–O), 980, 703. δ_H (300 MHz; $CDCl_3$): 1.06 (9 H, s, $OSiPh_2{}^tBu$), 1.28–1.35 (1 H, m, 9′-H_A), 1.42 (3 H, t, J_{CH_3,CH_2} 7.1, OCH_2CH_3), 1.46–1.55 (1 H, m, 11′-H_A), 1.55–1.65 (3 H, m, 5′-H_A, 9′-H_B and 10′-H_A), 1.69–1.92 (5 H, m, 3′-H_A, 4′-H_A, 5′-H_B, 10′-H_B and 11′-H_B), 2.11–2.23 (2 H, m, 3′-H_B and

4′-H_B), 3.62 (1 H, dd, J_{AB} 10.5 and $J_{8'\text{-}CH_2,8'}$ 4.2, 8′-CH_AH_BO), 3.72 (1 H, dd, J_{AB} 10.5 and $J_{8\text{-}CH_2,8'}$ 6.3, 8′-CH_AH_BO), 3.82–3.89 (1 H, m, 8′-H), 4.45 (2 H, t, J_{CH_2,CH_3} 7.1, OCH_2CH_3), 6.07 (1 H, dd, $J_{2'ax,3'ax}$ 10.9 and $J_{2'ax,3'eq}$ 2.2, 2′-H_{ax}), 7.34–7.44 (6 H, m, Ph), 7.69–7.75 (4 H, m, Ph), 8.25 (1 H, s, 5-H). δ_C (75 MHz; $CDCl_3$): 14.1 (CH_3, OCH_2CH_3), 17.8 (CH_2, C-4′), 18.1 (CH_2, C-10′), 19.2 (C, $OSiPh_2{}^tBu$), 26.4 (CH_2, C-9′), 26.8 (CH_3, $OSiPh_2{}^tBu$), 31.2 (CH_2, C-3′), 34.4 (CH_2, C-5′), 34.5 (CH_2, C-11′), 61.2 (CH_2, OCH_2CH_3), 67.1 (CH_2, 8′-CH_2O), 71.3 (CH, C-8′), 81.6 (CH, C-2′), 99.2 (C, C-6′), 125.7 (CH, C-5), 127.6 (CH, Ph), 129.6 (CH, Ph), 129.6 (CH, Ph), 133.6 (C, Ph), 133.6 (C, Ph), 135.6 (CH, Ph), 135.6 (CH, Ph), 140.0 (C, C-4), 160.9 (C, C=O). *m/z* (FAB): 564 (MH^+, 0.5%), 518 (M – OEt, 2), 506 (M – ^{t}Bu, 5), 486 (M – Ph, 2), 423 ($C_{26}H_{35}O_3Si$, 69), 365 (18), 239 ($SiPh_2{}^t$Bu, 10), 207 (49), 199 (34), 197 (32), 135 (100), 121 (22).

Dimethyl 1-{(2′*S**,6′*S**,8′*S**)-8′-(*tert*-butyldiphenylsilyloxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-1*H*-1,2,3-triazole-4,5-dicarboxylate (14e)

Method B: The *title compound* **14e** (8.30 mg, 78%) was prepared as a pale yellow oil from azide **5a** (8.20 mg, 17.6 μmol) and dimethyl acetylenedicarboxylate (**6e**, 100 μL) in toluene (500 μL) using the general procedure (method B) described above. Purification was carried out by flash chromatography using hexane–EtOAc (19:1 to 9:1) as eluent. HRMS (FAB): found $[M - {}^tBu]^+$, 550.2010, $C_{28}H_{32}N_3O_7Si$ requires 550.2010. ν_{max} (film)/cm^{-1}: 2929 (C–H), 1741 (C=O), 1428, 1098 (C–O), 703. δ_H (400 MHz; $CDCl_3$): 1.07 (9 H, s, $OSiPh_2{}^tBu$), 1.27–1.33 (1 H, m, 9′-H_A), 1.41–1.51 (1 H, m, 11′-H_A), 1.54–1.80 (7 H, m, 4′-H_A, 5′-H_A, 5′-H_B, 9′-H_B, 10′-H_A, 10′-H_B and 11′-H_B), 2.03–2.27 (3 H, m, 3′-H_A, 3′-H_B and 4′-H_B), 3.60 (1 H, dd, J_{AB} 10.3 and $J_{8'\text{-}CH_2,8'}$ 4.8, 8′-CH_AH_BO), 3.71 (1 H, dd, J_{AB} 10.3 and $J_{8'\text{-}CH_2,8'}$ 5.8, 8′-CH_AH_BO), 3.77–3.83 (1 H, m, 8′-H), 3.96 (6 H, s, 2 x OMe), 6.18 (1 H, dd, $J_{2'ax,3'ax}$ 10.6 and $J_{2'ax,3'eq}$ 3.0, 2′-H_{ax}), 7.34–7.44 (6 H, m, Ph), 7.68–7.74 (4 H, m, Ph). δ_C (100 MHz; $CDCl_3$): 17.5 (CH_2, C-4′), 17.8 (CH_2, C-10′), 19.3 (C, $OSiPh_2{}^tBu$), 26.6 (CH_2, C-9′), 26.8 (CH_3, $OSiPh_2{}^tBu$), 30.4 (CH_2, C-3′), 34.4 (CH_2, C-5′), 34.7 (CH_2, C-11′), 52.6 (CH_3, OMe), 53.4 (CH_3, OMe), 66.9 (CH_2, 8′-CH_2O), 71.0 (CH, C-8′), 82.8 (CH, C-2′), 99.4 (C, C-6′), 127.6 (CH, Ph), 129.6 (CH, Ph), 129.6 (CH, Ph), 131.8 (C, C-5), 133.5 (C, Ph), 133.6 (C, Ph), 135.6 (CH, Ph), 135.6 (CH, Ph), 138.0 (C, C-4), 160.1 (C, C=O), 160.3 (C, C=O). *m/z* (FAB): 550 ($[M - {}^tBu]^+$, 2%), 423 ($C_{26}H_{35}O_3Si$, 52), 207 (42), 199 (35), 197 (33), 137 (23), 135 (100).

1-{(2′*S,6′*S**,8′*S**)-8′-(*tert*-Butyldiphenylsilyloxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-4-(trimethylsilyl)-1*H*-1,2,3-triazole (14f)**

Method C: The *title compound* **14f** (7.80 mg, 64%) was prepared as a pale yellow oil from azide **5a** (10.1 mg, 21.6 μmmol) and trimethylsilylacetylene (**6f**, 2 x 100 μL) in toluene (500 μL) using the general procedure (method C) described above. Purification was carried out by flash chromatography using hexane–EtOAc (99:1 to 9:1) as eluent. Unreacted azide **5a** (3.60 mg, 36%) was also recovered. HRMS (FAB): found MH^+, 564.3079, $C_{31}H_{46}N_3O_3Si_2$ requires 564.3078. ν_{max} (film)/cm^{-1}: 2951 (C–H), 1428, 1249 (C–O), 1113 (C–O), 980, 842, 702. δ_H (300 MHz; $CDCl_3$): 0.34 (9 H, s, $OSiMe_3$), 1.07 (9 H, s, $OSiPh_2{}^tBu$), 1.26–1.34 (1 H, m, 9′-H_A), 1.40–1.53 (1 H, m, 11′-H_A), 1.53–1.64 (3 H, m, 5′-H_A, 9′-H_B and 10′-H_A), 1.70–1.80 (3 H, m, 4′-H_A, 5′-H_B and 11′-H_B), 1.80–1.99 (2 H, m, 3′-H_A and 10′-H_B), 2.06–2.25 (2 H, m, 3′-H_B and 4′-H_B), 3.63 (1 H, dd, J_{AB} 10.5 and $J_{8'\text{-}CH_2,8'}$ 4.2, 8′-C$H_A$$H_B$O), 3.72 (1 H, dd, J_{AB} 10.5 and $J_{8'\text{-}CH_2,8'}$ 6.3, 8′-C$H_A$$H_B$O), 3.88–3.96 (1 H, m, 8′-H), 6.11 (1 H, dd, $J_{2'ax,3'ax}$ 11.0 and $J_{2'ax,3'eq}$ 2.5, 2′-H_{ax}), 7.35–7.43 (6 H, m, Ph), 7.66 (1 H, s, 5-H), 7.70–7.76 (4 H, m, Ph). δ_C (75 MHz; $CDCl_3$): -1.1 (CH_3, $SiMe_3$), 18.1 (CH_2, C-4′), 18.2 (CH_2, C-10′), 19.2 (C, $OSiPh_2{}^tBu$), 26.5 (CH_2, C-9′), 26.8 (CH_3, $OSiPh_2{}^tBu$), 31.2 (CH_2, C-3′), 34.6 (CH_2, C-5′), 34.7 (CH_2, C-11′), 67.2 (CH_2, 8′-CH_2O), 71.1 (CH, C-8′), 80.7 (CH, C-2′), 98.9 (C, C-6′), 126.9 (CH, C-5), 127.6 (CH, Ph), 129.6 (CH, Ph), 129.6 (CH, Ph), 133.7 (C, Ph), 135.6 (CH, Ph), 135.7 (CH, Ph), 146.1 (C, C-4). *m/z* (FAB): 564 (MH^+, 4%), 423 ($C_{26}H_{35}O_3Si$, 74), 405 (15), 239 ($SiPh_2{}^tBu$, 10), 207 (37), 197 (36), 142 (23), 135 (100), 73 (52).

Ethyl 1-{(2′*S,6′*S**,8′*S**)-8′-(*tert*-butyldiphenylsilyloxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-4-(trimethylsilyl)-1*H*-1,2,3-triazole-5-carboxylate (14g)**

Method C: The *title compound* **14g** (9.10 mg, 84%) was prepared as a pale yellow oil from azide **5a** (8.00 mg, 17.2 μmol) and ethyl 3-(trimethylsilyl)propiolate (**6g**, 2 x 50.0 μL) in toluene (500 μL) using the general procedure (method C) described above. Purification was carried out by flash chromatography using hexane–EtOAc (97:3, 19:1 to 9:1) as eluent. HRMS (FAB): found MH^+, 636.3293, $C_{34}H_{50}N_3O_5Si_2$ requires 636.3289. ν_{max} (film)/cm^{-1}: 2955 (C–H), 2857, 1728 (C=O), 1428, 1192, 1112 (C–O), 1079 (C–O), 847, 703. δ_H (300 MHz; $CDCl_3$): 0.39 (9 H, s, $SiMe_3$), 1.08 (9 H, s, $OSiPh_2{}^tBu$), 1.30–1.40 (1 H, m, 9′-H_A), 1.36 (3 H, t, J_{CH_3,CH_2} 7.2, OCH_2CH_3), 1.41–1.49 (1 H, m, 11′-H_A), 1.50–1.61(1 H, m, 10′-H_A), 1.62–1.84 (6 H, m, 4′-H_A, 5′-H_A, 5′-H_B, 9′-H_B, 10′-H_B and 11′-H_B), 1.94–2.03 (1 H, m, 3′-H_A), 2.03–2.21 (1 H, m, 4′-H_B), 2.51–2.66 (1 H, m, 3′-H_B), 3.66 (1 H, dd, J_{AB} 10.0 and $J_{8'\text{-}CH_2,8'}$ 5.6, 8′-C$H_A$$H_B$O), 3.83 (1 H, dd, J_{AB} 10.0 and $J_{8'\text{-}CH_2,8'}$ 4.9, 8′-C$H_A$$H_B$O), 4.02–4.11 (1 H, m, 8′-H), 4.28–4.44 (2 H, m, OCH_2CH_3), 6.65 (1 H, dd, $J_{2'ax,3'ax}$ 11.3 and $J_{2'ax,3'eq}$ 2.6, 2′-H_{ax}), 7.35–7.46 (6 H, m, Ph), 7.74–7.80 (4 H, m, Ph). δ_C (75 MHz; $CDCl_3$): -1.1 (CH_3, $SiMe_3$), 14.2 (CH_3,

OCH_2CH_3), 18.1 (CH_2, C-4′ and C-10′), 19.3 (C, $OSiPh_2{}^tBu$), 26.8 (CH_3, $OSiPh_2{}^tBu$), 27.1 (CH_2, C-9′), 29.7 (CH_2, C-3′), 34.8 (CH_2, C-5′), 35.0 (CH_2, C-11′), 61.8 (CH_2, OCH_2CH_3), 67.1 (CH_2, 8′-CH_2O), 70.4 (CH, C-8′), 80.3 (CH, C-2′), 99.0 (C, C-6′), 127.5 (CH, Ph), 129.5 (CH, Ph), 129.5 (CH, Ph), 133.1 (C, C-5), 133.8 (C, Ph), 134.0 (C, Ph), 135.7 (CH, Ph), 135.7 (CH, Ph), 150.1 (C, C-4), 159.8 (C, C=O). *m/z* (FAB): 636 (MH^+, 1%), 578 (M – ^{t}Bu, 3), 558 (M – Ph, 1), 423 ($C_{26}H_{35}O_3Si$, 39), 214 (22), 207 (27), 199 (33), 197 (38), 135 (100), 73 (45).

Synthesis of triazole 7a–g

General procedures for deprotection of silyl protected spiroacetal-triazoles 14

Method A: Desilylation using TBAF

To a solution of TBDPS-protected triazole **14** in anhydrous THF (1.0 mL) under an atmosphere of argon at room temperature was added activated molecular sieves (0.20 g) and TBAF solution (1.0 mol L^{-1} in THF, 2.0–10 equiv.). After 1–3 h, saturated NH_4Cl solution (1 mL) was added. The aqueous phase was extracted with Et_2O (3 x 2 mL) and the combined organic extracts were concentrated *in vacuo*. Purification by flash chromatography using the appropriate eluent yielded hydroxymethyl spiroacetal-triazole **7**.

Method B: Desilylation using HF•pyridine

To a solution of TBDPS-protected triazole **14** in anhydrous THF (1.0–2.0 mL) in a plastic vial under an atmosphere of argon was added HF•pyridine (1.5–3.4 μL per micromole of triazole) and the mixture was stirred at room temperature. If the desilylation was not complete within 18 h (TLC), a second portion of HF•pyridine (1.3–2.0 μL per micromole of triazole) was added and the mixture was stirred at room temperature for another 18 h. Saturated $NaHCO_3$ solution (4 mL) was added dropwise. The aqueous phase was extracted with Et_2O (4 x 4 mL) and the combined organic extracts were concentrated *in vacuo*. Purification by flash chromatography using the appropriate eluent yielded hydroxymethyl spiroacetal-triazole **7**.

Method C: Desilylation using 3HF•NEt_3

A solution of TBDPS-protected triazole **14** and 3HF•NEt_3 (2.0–3.0 μL per micromole of triazole) in anhydrous THF (300 μL–1.0 mL) was stirred at room temperature under an atmosphere of argon. If the desilylation was not complete within 18 h (TLC), a second portion of 3HF•NEt_3 (2.0–2.5 μL per micromole of triazole) was added and the mixture was stirred at room temperature for another 18 h. Saturated $NaHCO_3$ solution (4 mL) was added dropwise. The aqueous phase was extracted with Et_2O (4 x 4 mL) and the combined organic extracts were concentrated *in vacuo*. Purification by flash chromatography using the appropriate eluent yielded hydroxymethyl spiroacetal-triazole **7**.

Method D: Desilylation using 3HF•NEt_3 and buffered with NEt_3

A solution of TBDPS-protected triazole **14**, 3HF•NEt_3 (2.0 μL per micromole of triazole) and NEt_3 (2.5 μL per micromole of triazole) in anhydrous THF (700 μL) was stirred at 40 °C for 48 h under an atmosphere of argon. A second portion of 3HF•NEt_3 (1.0 μL micromole of triazole) and NEt_3 (1.3 μL per micromole of triazole) were added and the mixture was stirred at 40 °C for 18 h. Saturated $NaHCO_3$ solution (2 mL) was added dropwise. The aqueous phase was extracted with EtOAc (3 x 3 mL) and the combined organic extracts were concentrated *in vacuo*. Purification by flash chromatography using hexane–EtOAc as eluent yielded hydroxymethyl spiroacetal-triazole **7**.

4-[2″-(Benzyloxy)ethyl]-1-{(2′*S**,6′*S**,8′*S**)-8′-(hydroxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-1*H*-1,2,3-triazole (7a)

Method C: The *title compound* **7a** (13.7 mg, 99%) was prepared as a pale yellow oil from TBDPS-protected triazole **14a** (22.3 mg, 35.6 μmol) and 3HF•NEt_3 (2 x 72.0 μL) in anhydrous THF (1.0 mL) using the general procedure (method C) described above. Purification was carried out by flash chromatography using hexane–EtOAc (9:1, 1:1 to 0:1) as eluent. HRMS (FAB): found MH^+, 388.2244, $C_{21}H_{30}N_3O_4$ requires 388.2236. ν_{max} (film)/cm^{-1}: 3400 (O–H), 2942 (C–H), 2870, 1455, 1387, 1223 (C–O), 1099 (C–O), 1048, 980, 737. δ_H (400 MHz; $CDCl_3$): 1.33–1.42 (1 H, m, 9′-H_A), 1.42–1.52 (2 H, m, 9′-H_B and 11′-H_A), 1.53–1.62 (2 H, m, 5′-H_A and 10′-H_A), 1.72–1.87 (5 H, m, 4′-H_A, 5′-H_B, 10′-H_B, 11′-H_B and OH), 1.87–2.04 (1 H, m, 3′-H_A), 2.06–2.16 (2 H, m, 3′-H_B and 4′-H_B), 3.06 (2 H, t, $J_{1″,2″}$ 6.6, 1″-H), 3.56 (1 H, dd, J_{AB} 11.6 and $J_{8′\text{-}CH_2,8′}$ 6.2, 8′-CH_AH_BO), 3.69 (1 H, dd, J_{AB} 11.6 and $J_{8′CH_2,8′}$ 3.3, 8′-CH_AH_BO), 3.78 (2 H, t, $J_{2″,1″}$ 6.6, 2″-H), 3.83–3.90 (1 H, m, 8′-H), 4.55 (2 H, s, OCH_2Ph), 5.94 (1 H, dd, $J_{2′ax,3′ax}$ 11.2 and $J_{2′ax,3′eq}$ 2.3, 2′-H_{ax}), 7.27–7.36 (5 H, m, Ph). δ_C (100 MHz; $CDCl_3$): 17.9 (CH_2, C-10′), 18.1 (CH_2, C-4′), 26.0 (CH_2, C-9′), 26.6 (CH_2, C-1″), 30.8 (CH_2, C-3′),

34.4 (CH_2, C-5′), 34.7 (CH_2, C-11′), 66.0 (CH_2, 8′-CH_2O), 69.1 (CH_2, C-2″), 70.7 (CH, C-8′), 73.0 (CH_2, O*C*H_2Ph), 81.0 (CH, C-2′), 98.9 (C, C-6′), 119.9 (CH, C-5), 127.6 (CH, Ph), 127.7 (CH, Ph), 128.4 (CH, Ph), 138.2 (C, Ph), 145.0 (C, C-4). *m/z* (FAB): 388 (MH^+, 8%), 204 (100), 186 (87), 185 ($C_{10}H_{17}O_3$, 45), 121 (18), 99 (23), 91 (51).

1-{(2′*S**,6′*S**,8′*S**)-8′-(Hydroxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2-yl}-4-hydroxymethyl-1*H*-1,2,3-triazole (7b)

Method B: The *title compound* **7b** (4.80 mg, 71%) was prepared as a pale yellow oil from TBDPS-protected triazole **14b** (12.5 mg, 24.0 μmol) and HF•pyridine (60.0 μL) in anhydrous THF (1.5 mL) using the general procedure (method B) described above. Purification was carried out by flash chromatography using hexane–Et_2O–MeOH (4:1:0, 0:1:0 to 0:19:1) as eluent. HRMS (FAB): found MH^+, 284.1618, $C_{13}H_{22}N_3O_4$ requires 284.1610. ν_{max} (film)/cm^{-1}: 3375 (O–H), 2933 (C–H), 2872, 1456, 1440, 1223 (C–O), 1099 (C–O), 1047, 1017, 979. δ_H (300 MHz; $CDCl_3$): 1.33–1.43 (1 H, m, 9′-H_A), 1.46–1.64 (4 H, m, 5′-H_A, 9′-H_B, 10′-H_A and 11′-H_A), 1.70–1.95 (5 H, m, 3′-H_A, 4′-H_A, 5′-H_B, 10′-H_B and 11′-H_B), 2.05–2.21 (3 H, m, 3′-H_B, 4′-H_B and OH), 2.46 (1 H, br s, OH), 3.57 (1 H, dd, J_{AB} 11.6 and $J_{8'\text{-}CH_2,8'}$ 6.3, 8′-C*H*$_A$H$_B$O), 3.69 (1 H, dd, J_{AB} 11.6 and $J_{8'\text{-}CH_2,8'}$ 3.3, 8′-CH$_A$*H*$_B$O), 3.82–3.90 (1 H, m, 8′-H), 4.81 (2 H, s, 4-*CH*$_2$OH), 5.97 (1 H, dd, $J_{2'ax,3'ax}$ 11.0 and $J_{2'ax,3'eq}$ 2.3, 2′-H_{ax}), 7.74 (1 H, s, 5-H). δ_C (100 MHz; $CDCl_3$): 17.9 (CH_2, C-10′), 18.0 (CH_2, C-4′), 26.0 (CH_2, C-9′), 30.8 (CH_2, C-3′), 34.4 (CH_2, C-5′), 34.6 (CH_2, C-11′), 56.6 (CH_2, 4-CH_2OH), 66.0 (CH_2, 8′-CH_2O), 70.8 (CH, C-8′), 81.2 (CH, C-2′), 99.0 (C, C-6′), 119.9 (CH, C-5), 147.4 (C, C-4). *m/z* (FAB): 284 (MH^+, 12%), 185 ($C_{10}H_7O_3$, 45), 155 (40), 149 (37), 138 (52), 137 (100), 120 (20), 91 (26).

1-{(2′*S**,6′*S**,8′*S**)-8′-(Hydroxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-4-phenyl-1*H*-1,2,3-triazole (7c)

Method A: The *title compound* **7c** (7.10 mg, 81%) was prepared as a pale yellow oil from TBDPS-protected triazole **14c** (15.0 mg, 26.4 μmol) and TBAF solution (264 μL, 264 μmol) in anhydrous THF (1.0 mL) using the general procedure (method A) described above. Purification was carried out by flash chromatography using hexane–EtOAc (9:1 to 7:3) as eluent. HRMS (EI): found $M^{+\bullet}$, 329.1735, $C_{18}H_{23}N_3O_3$ requires 329.1739. ν_{max} (film)/cm^{-1}: 3389 (O–H), 2944 (C–H), 2873, 1438, 1391, 1234, 1202 (C–O), 1076 (C–O), 1046, 1019, 978, 766, 695. δ_H (300 MHz; $CDCl_3$): 1.39–1.47 (1 H, m, 9′-H_A), 1.47–1.68 (4 H, m, 5′-H_A, 9′-H_B, 10′-H_A and 11′-H_A), 1.74–1.97 (4 H, m, 4′-H_A, 5′-H_B, 10′-H_B and 11′-H_B), 1.98–2.11 (2 H, m, 3′-H_A and OH), 2.11–2.26 (2 H, m, 3′-H_B and 4′-H_B), 3.57–3.67 (1 H, m, 8′-*CH*$_A$H$_B$O), 3.72 (1 H, d, J_{AB} 11.3, 8′-CH$_A$*H*$_B$O), 3.86–3.95 (1 H, m, 8′-H), 6.03 (1 H,

dd, $J_{2'ax,3'ax}$ 11.0 and $J_{2'ax,3'eq}$ 2.4, 2′-H_{ax}), 7.30–7.36 (1 H, m, Ph), 7.40–7.46 (2 H, m, Ph), 7.84–7.88 (2 H, m, Ph), 7.95 (1 H, s, 5-H). δ_C (100 MHz; $CDCl_3$): 17.9 (CH_2, C-10′), 18.1 (CH_2, C-4′), 26.0 (CH_2, C-9′), 31.0 (CH_2, C-3′), 34.4 (CH_2, C-5′), 34.7 (CH_2, C-11′), 66.0 (CH_2, 8′-CH_2O), 70.8 (CH, C-8′), 81.3 (CH, C-2′), 99.1 (C, C-6′), 117.7 (CH, C-5), 125.8 (CH, Ph), 128.1 (CH, Ph), 128.8 (CH, Ph), 130.6 (C, Ph), 147.6 (C, C-4). *m/z* (EI): 329 ($M^{+\bullet}$, 4%), 298 (M – CH_2OH, 2), 185 ($C_{10}H_{17}O_3$, 55), 145 (100), 128 (15), 121 (22), 117 (18), 99 (36), 71 (25), 57 (15), 55 (29), 43 (15), 41 (26).

Ethyl 1-{(2′*S**,6′*S**,8′*S**)-8′-(hydroxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-1*H*-1,2,3-triazole-4-carboxylate (7d)

Method B: The *title compound* **7d** (3.50 mg, 70%) was prepared as a pale yellow oil from TBDPS-protected triazole **14d** (8.70 mg, 15.4 μmol) and HF•pyridine (2 x 50.0 μL) in anhydrous THF (1.0 mL) using the general procedure (method B) described above. Purification was carried out by flash chromatography using hexane–EtOAc (9:1 to 1:4) as eluent. HRMS (EI): found $M^{+\bullet}$, 325.1638, $C_{15}H_{23}N_3O_5$ requires 325.1638. ν_{max} (film)/cm^{-1}: 3412 (O–H), 2941 (C–H), 1733 (C=O), 1376, 1222 (C–O), 1044 (C–O), 980. δ_H (300 MHz; $CDCl_3$): 1.38–1.45 (1 H, m, 9′-H_A), 1.42 (3 H, t, J_{CH_3,CH_2} 7.1, OCH_2CH_3), 1.48–1.58 (2 H, m, 9′-H_B and 11′-H_A), 1.58–1.66 (2 H, m, 5′-H_A and 10′-H_A), 1.73–1.94 (6 H, m, 3′-H_A, 4′-H_A, 5′-H_B, 10′-H_B, 11′-H_B and OH), 2.05–2.17 (1 H, m, 4′-H_B), 2.17–2.28 (1 H, m, 3′-H_B), 3.52–3.63 (1 H, m, 8′-CH_AH_BO), 3.63–3.76 (1 H, m, 8′-CH_AH_BO), 3.79–3.88 (1 H, m, 8′-H), 4.44 (2 H, t, J_{CH_2,CH_3} 7.1, OCH_2CH_3), 6.02 (1 H, dd, $J_{2'ax,3'ax}$ 10.8 and $J_{2'ax,3'eq}$ 2.5, 2′-H_{ax}), 8.28 (1 H, s, 5-H). δ_C (100 MHz; $CDCl_3$): 14.3 (CH_3, OCH_2CH_3), 17.8 (CH_2, C-10′), 17.9 (CH_2, C-4′), 25.9 (CH_2, C-9′), 31.2 (CH_2, C-3′), 34.4 (CH_2, C-5′), 34.6 (CH_2, C-11′), 61.3 (CH_2, OCH_2CH_3), 65.9 (CH_2, 8′-CH_2O), 70.9 (CH, C-8′), 81.7 (CH, C-2′), 99.3 (C, C-6′), 125.7 (CH, C-5), 140.2 (C, C-4), 160.8 (C, C=O). *m/z* (EI): 325 ($M^{+\bullet}$, 5%), 294 (M – CH_2OH, 2), 280 (M – OEt, 3), 252 (M – CO_2Et, 2), 185 ($C_{10}H_{17}O_3$, 43), 156 (60), 128 (100), 114 (25), 99 (69), 96 (67), 70 (49), 55 (47), 41 (50).

Dimethyl 1-{(2′*S**,6′*S**,8′*S**)-8′-(hydroxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-1*H*-1,2,3-triazole-4,5-dicarboxylate (7e)

Method C: The *title compound* **7e** (3.50 mg, 69%) was prepared as a pale yellow oil from TBDPS-protected triazole **14e** (8.30 mg, 13.7 mmol) and 3HF•NEt_3 (3 x 34 μL) in anhydrous THF (300 μL) using the general procedure (method C) described above. Purification was carried out by flash chromatography using hexane–EtOAc (4:1, 1:1 to 0:1) as eluent followed by PLC using Et_2O as eluent. HRMS (FAB): found MH^+, 370.1615, $C_{16}H_{24}N_3O_7$ requires 370.1614. ν_{max} (film)/cm^{-1}: 3439br (O–H), 2953 (C–H), 1739 (C=O), 1462, 1290, 1258, 1229, 1204 (C–O), 1105 (C–O), 984. δ_H

(400 MHz; $CDCl_3$): 1.31–1.39 (1 H, m, 9′-H_A), 1.45–1.55 (2 H, m, 9′-H_B and 11′-H_A), 1.55–1.65 (2 H, m, 5′-H_A and 10′-H_A), 1.68–1.90 (5 H, m, 4′-H_A, 5′-H_B, 10′-H_B, 11′-H_B and OH), 2.05–2.19 (2 H, m, 3′-H_A and 4′-H_B), 2.28–2.40 (1 H, m, 3′-H_B), 3.56–3.60 (1 H, m, 8′-CH_AH_BO), 3.68 (1 H, d, J_{AB} 11.7, 8′-CH_AH_BO), 3.76–3.82 (1 H, m, 8′-H), 3.97 (3 H, s, OMe), 4.00 (3 H, s, OMe), 6.15 (1 H, dd, $J_{2'ax,3'ax}$ 11.2 and $J_{2'ax,3'eq}$ 2.7, 2′-H_{ax}). δ_C (100 MHz; $CDCl_3$): 17.8 (2 x CH_2, C-4′ and C-10′), 26.0 (CH_2, C-9′), 30.1 (CH_2, C-3′), 34.3 (CH_2, C-5′), 34.6 (CH_2, C-11′), 52.6 (CH_3, OMe), 53.6 (CH_3, OMe), 66.0 (CH_2, 8′-CH_2O), 71.0 (CH, C-8′), 82.2 (CH, C-2′), 99.5 (C, C-6′), 131.5 (C, C-5), 138.5 (C, C-4), 159.9 (C, C=O), 160.3 (C, C=O). *m/z* (FAB): 370 (MH^+, 3%), 354 (M – Me, 2), 185 ($C_{10}H_{17}O_3$, 100), 149 (61), 137 (29), 127 (27), 121 (18), 95 (18), 85 (41), 71 (76).

1-{(2′*S**,6′*S**,8′*S**)-8′-(Hydroxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-1*H*-1,2,3-triazole (7f)

Method C: The *title compound* **7f** (3.00 mg, 86%) was prepared as a pale yellow oil from TBDPS-protected triazole **14f** (7.80 mg, 13.8 μmol) and 3HF•NEt_3 (41.0 μL) in anhydrous THF (300 μL) using the general procedure (method C) described above. Purification was carried out by flash chromatography using hexane–EtOAc (4:1, 1:1 to 0:1) as eluent. HRMS (EI): found $M^{+\bullet}$, 253.1427, $C_{12}H_{19}N_3O_3$ requires 253.1426. ν_{max} (film)/cm^{-1}: 3390 (O–H), 2944 (C–H), 2873, 1456, 1387, 1220, 1201 (C–O), 1066 (C–O), 1047, 979. δ_H (400 MHz; $CDCl_3$): 1.34–1.43 (1 H, m, 9′-H_A), 1.44–1.64 (4 H, m, 5′-H_A, 9′-H_B, 10′-H_A and 11′-H_A), 1.72–1.86 (4 H, m, 4′-H_A, 5′-H_B, 10′-H_B and 11′-H_B), 1.88–2.03 (2 H, m, 3′-H_A and OH), 2.07–2.21 (2 H, m, 3′-H_B and 4′-H_B), 3.58 (1 H, dd, J_{AB} 11.3 and $J_{8'\text{-}CH_2,8'}$ 6.2, 8′-CH_AH_BO), 3.71 (1 H, d, J_{AB} 11.3, 8′-CH_AH_BO), 3.85–3.91 (1 H, m, 8′-H), 6.03 (1 H, dd, $J_{2'ax,3'ax}$ 11.0 and $J_{2'ax,3'eq}$ 2.5, 2′-H_{ax}), 7.74 (1 H, d, $J_{4,5}$ 9.7, 4-H), 7.74 (1 H, d, $J_{5,4}$ 9.7, 5-H). δ_C (100 MHz; $CDCl_3$): 17.9 (CH_2, C-10′), 18.1 (CH_2, C-4′), 26.0 (CH_2, C-9′), 30.9 (CH_2, C-3′), 34.4 (CH_2, C-5′), 34.6 (CH_2, C-11′), 66.0 (CH_2, 8′-CH_2O), 70.8 (CH, C-8′), 81.1 (CH, C-2′), 99.0 (C, C-6′), 121.5 (CH, C-5), 133.7 (CH, C-4). *m/z* (EI): 253 ($M^{+\bullet}$, 9%), 222 (M – CH_2OH, 7), 185 ($C_{10}H_{17}O_3$, 29), 156 (57), 128 (100), 109 (20), 99 (39), 97 (62), 95 (32), 80 (27), 70 (64), 67 (40), 55 (50), 41 (94).

Ethyl 1-{(2′*S**,6′*S**,8′*S**)-8′-(hydroxymethyl)-1′,7′-dioxaspiro[5.5]undecan-2′-yl}-1*H*-1,2,3-triazole-5-carboxylate (7g)

Method D: The *title compound* **7g** (2.40 mg, 93%) was prepared as a pale yellow oil from TBDPS-protected triazole **14g** (5.00 mg, 7.86 μmol), 3HF•NEt_3 (16.0 + 8.00 μL) and NEt_3 (20.0 + 10.0 μL) in anhydrous THF (700 μL) using the general procedure (method D) described above. Purification was carried out by flash chromatography using hexane–EtOAc (4:1, 3:2 to 1:4) as eluent.

HRMS (EI): found $M^{+\bullet}$, 325.1636, $C_{15}H_{23}N_3O_5$ requires 325.1638. ν_{max} (film)/cm^{-1}: 3411br (O–H), 2925 (C–H), 2853, 1732 (C=O), 1309, 1258, 1194 (C–O), 1082 (C–O), 984. δ_H (300 MHz; $CDCl_3$): 1.29–1.36 (1 H, m, 9′-H_A), 1.40 (3 H, t, J_{CH_3,CH_2} 7.1, OCH_2CH_3), 1.44–1.70 (4 H, m, 5′-H_A, 9′-H_B, 10′-H_A and 11′-H_A), 1.71–1.89 (4 H, m, 4′-H_A, 5′-H_B, 10′-H_B and 11′-H_B), 1.93–2.01 (1 H, m, 3′-H_A), 2.09–2.24 (2 H, m, 4′-H_B and OH), 2.53–2.68 (1 H, m, 3′-H_B), 3.59 (1 H, dd, J_{AB} 11.6 and $J_{8'\text{-}CH_2,8'}$ 6.5, 8′-CH_AH_BO), 3.75 (1 H, dd, J_{AB} 11.6 and $J_{8'\text{-}CH_2,8'}$ 3.3, 8′-CH_AH_BO), 3.95–4.14 (1 H, m, 8′-H), 4.4 (2 H, q, J_{CH_2,CH_3} 7.1, OCH_2CH_3), 6.74 (1 H, dd, $J_{2'ax,3'ax}$ 11.4 and $J_{2'ax,3'eq}$ 2.5, 2′-H_{ax}), 8.14 (1 H, s, 4-H). δ_C (100 MHz; $CDCl_3$): 14.1 (CH_3, OCH_2CH_3), 18.2 (CH_2, C-10′), 18.3 (CH_2, C-4′), 26.3 (CH_2, C-9′), 29.6 (CH_2, C-3′), 34.6 (CH_2, C-5′ or C-11′), 34.6 (CH_2, C-5′ or C-11′), 62.1 (CH_2, OCH_2CH_3), 66.4 (CH_2, 8′-CH_2O), 70.8 (CH, C-8′), 79.8 (CH, C-2′), 99.4 (C, C-6′), 127.6 (C, C-5), 137.9 (CH, C-4), 158.6 (C, C=O). *m/z* (EI): 325 ($M^{+\bullet}$, 2%), 252 (M – CO_2Et, 11), 185 ($C_{10}H_{17}O_3$, 3), 184 (34), 156 (35), 153 (30), 142 (56), 128 (100), 99 (93), 97 (64), 95 (57), 71 (52), 70 (48), 67 (40), 55 (71), 41 (66).

Reference

1. W. L. F. Armarego and D. D. Perrin, *Purification of Laboratory Chemicals*, 4th edn., Pergamon, Oxford, UK, 1997.