Supporting Information

Copper (I) Catalyzed Coupling of Alkynyl Glycosides: Synthesis of Buta-1,3-Diyne Linked Disaccharides and Dinucleosides

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Experimental Section

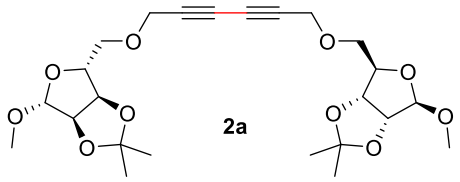
1.0 General information:

All the reactions were performed in a 50 ml round bottom flask at room temperature. ^{1}H and ^{13}C NMR spectra were recorded on 400 MHz spectrometers with TMS as internal standard. Chemical shifts are expressed in parts per million (δ ppm). Signal multiplicities are represented by the following abbreviations: (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, dd = double doublet), coupling constant (*J* values) in Hz and integration. Silica gel coated aluminum plates were used for TLC. The products were purified by column chromatography on silica gel (100-20 mesh) using Hexane-ethyl acetate as the eluent to obtain the pure products. Exact mass of all products was analyzed by using HRMS having QTOF analyzer. Optical rotations were measured on a Rudolph Research Analytical, Autopol I. Reagents used were mostly purchased from Sigma Aldrich and TCI.

1.1 General procedure for the synthesis of buta-1,3-diyne linked disaccharides using alkynyl glycosides: To the stirred solution of alkynyl glycosides in DCE was added appropriate amount of aniline followed by catalytic addition of copper (I) bromide at room temperature. The reaction mixture was stirred under atmospheric air at same temperature for 12 hours. After the formation of the product as judged by the TLC, the reaction mixture was quenched by 1N HCl until the reaction mixture became neutral, which was extracted using ethyl acetate (3 times). The collected organic layers were dried over anhydrous sodium sulphate, concentrated under reduced pressure and purified by flash chromatography (4-30% ethyl acetate in hexane) on silica gel to provide products generally as yellowish/whitish gummy type solid/oil.

2.0 Analytical data for compounds

1,6-bis(((3aR,4R,6R,6aR)-6-methoxy-2,2-dimethyltetrahydrofuro[3,4-d][1,3]dioxol-4-yl)methoxy)hexa-2,4-diyne (2a)



Prepared by dissolving 50 mg alkynyl glycoside (0.20 mmol) in 4 ml of DCE followed by addition of aniline (9 µl, 0.1 mmol) and copper (I) bromide (3 mg, 0.02 mmol) at room temperature for 12 hours and purified by flash chromatography (5-10% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **2a** in 65% (32 mg) as a yellowish gummy type solid.

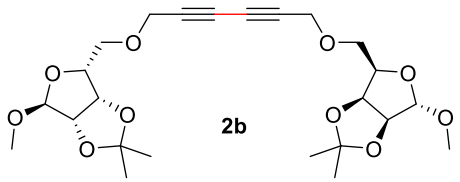
^{1}H NMR (400 MHz, $CDCl_3$): δ 4.90 (d, *J* = 1.0 Hz, 2H), 4.59 (d, *J* = 6.0 Hz, 2H), 4.51 (d, *J* = 5.9 Hz, 2H), 4.25 (t, *J* = 7.2 Hz, 2H), 4.20 (s, 4H), 3.56 – 3.50 (m, 2H), 3.46 – 3.39 (m, 2H), 3.27 (s, 6H), 1.41 (s, 6H), 1.23 (d, *J* = 12.2 Hz, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 112.4, 109.2, 85.0, 84.8, 81.9, 75.1, 70.9, 70.5, 58.8, 54.8, 26.4, 24.9

HRMS (ESI): *m/z* calcd for $C_{24}H_{38}NO_{10}$ [M+NH_4] +500.2496, found 500.2491

$[\alpha]_D^{30}$ = -56.00 (c 0.25, $CHCl_3$)

1,6-bis(((3aS,4R,6S,6aS)-6-methoxy-2,2-dimethyltetrahydrofuro[3,4-d][1,3]dioxol-4-yl)methoxy)hexa-2,4-diyne (2b)



Prepared by dissolving 50 mg alkynyl glycoside (0.20 mmol) in 4 ml of DCE followed by addition of aniline (9 µl, 0.1 mmol) and copper (I) bromide (3 mg, 0.02 mmol) at room temperature for 12 hours and purified by flash chromatography (5-10% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **2b** in 63% (31 mg) as a yellowish gummy type solid.

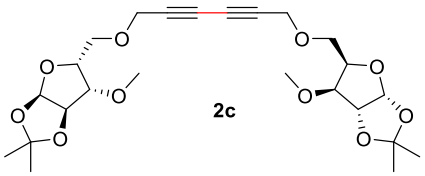
^{1}H NMR (400 MHz, $CDCl_3$): δ 4.85 (s, 2H), 4.67 (dd, *J* = 5.9, 3.8 Hz, 2H), 4.49 (d, *J* = 5.9 Hz, 2H), 4.33 – 4.20 (m, 4H), 4.12 – 4.02 (m, 2H), 3.90 – 3.78 (m, 2H), 3.72 – 3.63 (m, 2H), 3.27 (s, 6H), 1.39 (s, 6H), 1.24 (s, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 112.6, 107.2, 84.8, 79.8, 78.6, 75.2, 70.6, 68.3, 59.1, 54.7, 26.0, 24.8

HRMS (ESI): *m/z* calcd for $C_{24}H_{38}NO_{10}$ [M+NH_4] +500.2496, found 500.2492

$[\alpha]_D^{30}$ = +26.40 (c 0.25, $CHCl_3$)

1,6-bis(((3aR,5R,6S,6aR)-6-methoxy-2,2-dimethyltetrahydrofuro[2,3-d][1,3]dioxol-5-yl)methoxy)hexa-2,4-diyne (2c)



Prepared by dissolving 50 mg alkynyl glycoside (0.20 mmol) in 4 ml of DCE followed by addition of aniline (9 µl, 0.1 mmol) and copper (I) bromide (3 mg, 0.02 mmol) at room temperature for 12 hours and purified by flash chromatography (5-10% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **2c** in 62% (31 mg) as a yellowish gummy type solid.

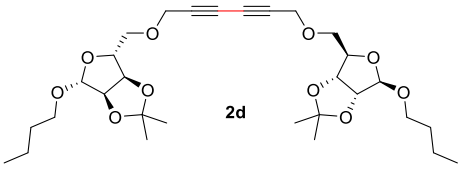
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.84 (d, *J* = 3.8 Hz, 2H), 4.50 (d, *J* = 3.8 Hz, 2H), 4.31 – 4.28 (m, 2H), 4.26 – 4.12 (m, 4H), 3.75 (dd, *J* = 10.1, 5.2 Hz, 2H), 3.68 – 3.59 (m, 4H), 3.35 (s, 6H), 1.42 (s, 6H), 1.25 (s, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 111.7, 105.1, 84.1, 81.5, 78.9, 75.2, 70.5, 67.6, 59.1, 58.0, 26.8, 26.3

HRMS (ESI): *m/z* calcd for $C_{24}H_{38}NO_{10}$ [M+NH_4] +500.2496, found 500.2495

$[\alpha]_D^{30}$ = -55.20 (c 0.25, $CHCl_3$)

1,6-bis(((3aR,4R,6R,6aR)-6-butoxy-2,2-dimethyltetrahydrofuro[3,4-d][1,3]dioxol-4-yl)methoxy)hexa-2,4-diyne (2d)



Prepared by dissolving 50 mg alkynyl glycoside (0.17 mmol) in 4 ml of DCE followed by addition of aniline (8 µl, 0.08 mmol) and copper (I) bromide (2.5 mg, 0.01 mmol) at room temperature for

12 hours and purified by flash chromatography (4-8% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **2d** in 60% (29 mg) as a yellowish gummy type solid.

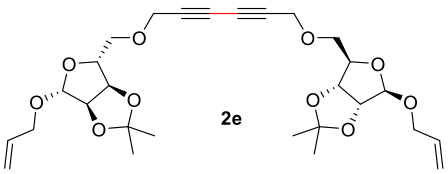
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.00 (s, 2H), 4.60 (dd, *J* = 6.0, 0.8 Hz, 2H), 4.53 (d, *J* = 6.0 Hz, 2H), 4.26 – 4.21 (m, 2H), 4.20 (s, 4H), 3.60 (dt, *J* = 9.6, 6.6 Hz, 2H), 3.48 (ddd, *J* = 17.3, 9.4, 7.3 Hz, 4H), 3.30 (dt, *J* = 9.6, 6.5 Hz, 2H), 1.49 – 1.44 (m, 4H), 1.42 (s, 6H), 1.34 – 1.27 (m, 4H), 1.25 (s, 6H), 0.85 (t, *J* = 7.3 Hz, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 112.4, 108.1, 85.2, 84.7, 82.0, 75.1, 71.0, 70.6, 67.5, 58.8, 31.5, 26.4, 24.9, 19.3, 13.8

HRMS (ESI): *m/z* calcd for $C_{30}H_{50}NO_{10}$ [M+NH_4] +584.3435, found 584.3437

$[\alpha]_D^{30}$ = -36.00 (c 0.25, $CHCl_3$)

1,6-bis(((3aR,4R,6R,6aR)-6-(allyloxy)-2,2-dimethyltetrahydrofuro[3,4-d][1,3]dioxol-4-yl)methoxy)hexa-2,4-diyne (2e)



Prepared by dissolving 50 mg alkynyl glycoside (0.18 mmol) in 4 ml of DCE followed by addition of aniline (8.5 µl, 0.09 mmol) and copper (I) bromide (2.5 mg, 0.01 mmol) at room temperature for 12 hours and purified by flash chromatography (6-12% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **2e** in 61% (31 mg) as a yellowish gummy type solid.

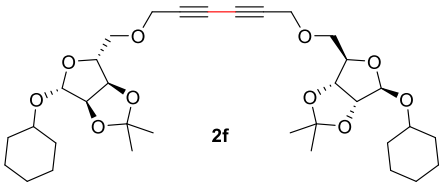
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.87 – 5.75 (m, 2H), 5.25 – 5.18 (m, 2H), 5.16 – 5.10 (m, 2H), 5.06 (s, 2H), 4.59 (dd, *J* = 15.3, 6.0 Hz, 4H), 4.26 (t, *J* = 7.2 Hz, 2H), 4.19 (s, 4H), 4.13 – 4.07 (m, 2H), 3.89 (dd, *J* = 12.9, 6.1 Hz, 2H), 3.56 – 3.43 (m, 4H), 1.42 (s, 6H), 1.25 (s, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 133.7, 117.4, 112.5, 107.1, 85.1, 84.9, 81.9, 75.1, 70.9, 70.6, 68.0, 58.9, 26.4, 24.9

HRMS (ESI): *m/z* calcd for $C_{38}H_{40}NO_5$ [M+H] +552.2809, found 552.2811

$[\alpha]_D^{30}$ = -16.00 (c 0.25, $CHCl_3$)

1,6-bis(((3aR,4R,6R,6aR)-6-(cyclohexyloxy)-2,2-dimethyltetrahydrofuro[3,4-d][1,3]dioxol-4-yl)methoxy)hexa-2,4-diyne (2f)



Prepared by dissolving 50 mg alkynyl glycoside (0.16 mmol) in 4 ml of DCE followed by addition of aniline (7.3 µl, 0.08 mmol) and copper (I) bromide (2.3 mg, 0.01 mmol) at room temperature for 12 hours and purified by flash chromatography (4-8% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **2f** in 62% (31 mg) as a yellowish gummy type solid.

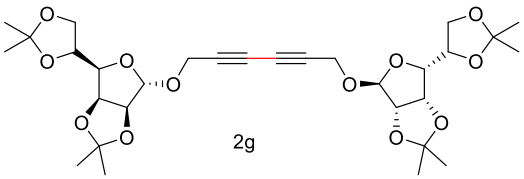
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.17 (s, 2H), 4.61 (d, *J* = 6.0 Hz, 2H), 4.52 (d, *J* = 6.0 Hz, 2H), 4.23 (d, *J* = 6.7 Hz, 2H), 4.20 (s, 2H), 3.61 – 3.43 (m, 8H), 1.87 – 1.59 (m, 12H), 1.42 (s, 6H), 1.25 (s, 6H), 1.18 (t, *J* = 8.8 Hz, 8H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 112.3, 105.6, 85.5, 84.7, 82.2, 75.1, 74.6, 71.1, 70.6, 58.8, 33.3, 31.0, 26.4, 25.6, 24.9, 24.1, 23.8

HRMS (ESI): *m/z* calcd for $C_{34}H_{54}NO_{10}$ [M+NH_4] +636.3748, found 636.3749

$[\alpha]_D^{30}$ = -37.60 (c 0.25, $CHCl_3$)

1,6-bis(((3aS,4S,6R,6aS)-6-((R)-2,2-dimethyl-1,3-dioxolan-4-yl)-2,2-dimethyltetrahydrofuro[3,4-d][1,3]dioxol-4-yl)oxy)hexa-2,4-diyne (2g)



Prepared by dissolving 50 mg alkynyl glycoside (0.16 mmol) in 4 ml of DCE followed by addition of aniline (7.3 µl, 0.08 mmol) and copper (I) bromide (2.3 mg, 0.01 mmol) at room temperature for 12 hours and purified by flash chromatography (5-10% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **2g** in 58% (29 mg) as a yellowish gummy type solid.

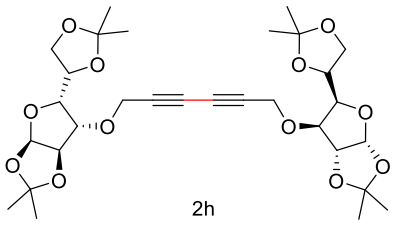
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.09 (d, *J* = 1.8 Hz, 2H), 4.72 (dd, *J* = 3.6, 2.1 Hz, 2H), 4.58 – 4.52 (m, 2H), 4.37 – 4.31 (m, 2H), 4.21 – 4.17 (m, 4H), 4.05 (ddd, *J* = 6.9, 4.1, 2.0 Hz, 2H), 4.00 – 3.94 (m, 2H), 3.90 – 3.84 (m, 2H), 1.40 (s, 6H), 1.39 – 1.38 (m, 6H), 1.31 (s, 6H), 1.26 (s, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 112.7, 109.2, 104.9, 84.9, 80.7, 79.4, 74.6, 73.0, 70.3, 66.8, 54.4, 26.9, 25.9, 25.2, 24.5

HRMS (ESI): *m/z* calcd for $C_{30}H_{46}NO_{12}$ [M+NH_4] +612.3020, found 612.3023

$[\alpha]_D^{30}$ = +36.30 (c 0.25, $CHCl_3$)

1,6-bis(((3aR,5R,6S,6aR)-5-((R)-2,2-dimethyl-1,3-dioxolan-4-yl)-2,2-dimethyltetrahydrofuro[2,3-d][1,3]dioxol-6-yl)oxy)hexa-2,4-diyne (2h)



Prepared by dissolving 50 mg alkynyl glycoside (0.16 mmol) in 4 ml of DCE followed by addition of aniline (7.3 µl, 0.08 mmol) and copper (I) bromide (2.3 mg, 0.01 mmol) at room temperature for 12 hours and purified by flash chromatography (5-10% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **2h** in 60% (30 mg) as a yellowish gummy type solid

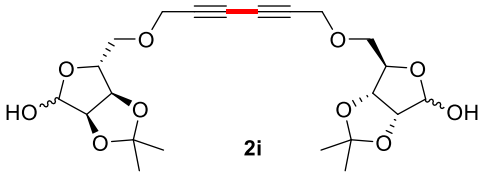
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.88 (d, *J* = 3.7 Hz, 2H), 4.60 (d, *J* = 3.6 Hz, 2H), 4.38 (s, 4H), 4.28 – 4.21 (m, 2H), 4.10 (ddd, *J* = 5.4, 4.7, 4.1 Hz, 4H), 4.10 – 4.07 (m, 2H), 3.99 (dd, *J* = 8.6, 5.3 Hz, 2H), 1.50 (s, 6H), 1.43 (s, 6H), 1.36 (s, 6H), 1.32 (s, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 111.9, 109.1, 105.2, 82.8, 81.7, 81.0, 75.1, 72.4, 70.5, 67.3, 58.6, 26.8, 26.8, 26.2, 25.3

HRMS (ESI): *m/z* calcd for $C_{30}H_{46}NO_{12}$ $[M+NH_4]$ +612.3020, found 612.3023

$[\alpha]_D^{30}$ = -44.20 (c 0.25, $CHCl_3$)

3aR,3a'R,4R,4'R,6R,6aR,6'R,6a'R)-6,6'-((hexa-2,4-diyne-1,6-diylbis(oxy))bis(methylene))bis(2,2-dimethyltetrahydrofuro[3,4-d][1,3]dioxol-4-ol) (2i)



Prepared by dissolving 50 mg of alkynyl riboside (0.21 mmol) in 4 ml of DCE followed by addition of aniline (9.4 µl, 0.10 mmol) and copper (I) bromide (3 mg, 0.02 mmol) at room temperature for 12 hours and purified by flash chromatography (30-45% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **2i** in 56% (28 mg) as a yellow gummy type solid.

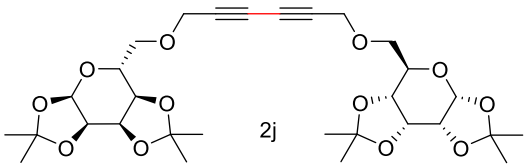
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.23 (d, *J* = 2.3 Hz, 2H), 4.82 (dd, *J* = 10.6, 3.9 Hz, 2H), 4.64 (dd, *J* = 5.3, 2.6 Hz, 2H), 4.41 (d, *J* = 3.0 Hz, 2H), 4.36 (d, *J* = 2.2 Hz, 4H), 3.67 (d, *J* = 14.5 Hz, 4H), 1.49 (s, 6H), 1.33 (s, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 112.3, 107.6, 88.4, 85.6, 81.3, 74.4, 70.6, 63.7, 55.4, 26.3, 24.7

HRMS (ESI): *m/z* calcd for $C_{22}H_{34}NO_{10}$ [M+NH_4] +472.2183, found 472.2187

$[\alpha]_D^{30}$ = -119.20 (c 0.25, $CHCl_3$)

1,6-bis(((3aR,5R,5aR,8aR,8bR)-2,2,7,7-tetramethyltetrahydro-5H-bis([1,3]dioxolo)[4,5-b:4',5'-d]pyran-5-yl)methoxy)hexa-2,4-diyne (2j)



Prepared by dissolving 50 mg alkynyl glycoside (0.16 mmol) in 4 ml of DCE followed by addition of aniline (7.3 µl, 0.08 mmol) and copper (I) bromide (2.3 mg, 0.01 mmol) at room temperature for 12 hours and purified by flash chromatography (4-10% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **2j** in 62% (31 mg) as a yellowish gummy type solid

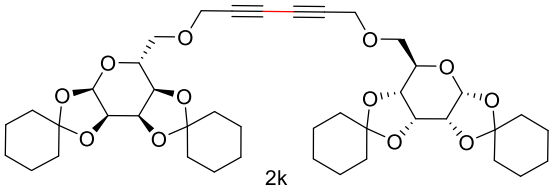
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.47 (d, *J* = 5.0 Hz, 2H), 4.54 (dd, *J* = 7.9, 2.4 Hz, 2H), 4.29 – 4.24 (m, 4H), 4.20 (d, *J* = 1.5 Hz, 2H), 4.17 (dd, *J* = 5.6, 3.6 Hz, 2H), 3.92 (ddd, *J* = 7.0, 5.0, 1.7 Hz, 2H), 3.70 (dd, *J* = 10.1, 5.0 Hz, 2H), 3.61 – 3.55 (m, 2H), 1.48 (s, 6H), 1.39 (s, 6H), 1.28 (s, 6H), 1.26 (s, H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 109.4, 108.6, 96.3, 77.2, 75.3, 71.1, 70.6, 70.4, 69.0, 66.8, 59.0, 26.0, 25.9, 24.9, 24.4

HRMS (ESI): *m/z* calcd for $C_{30}H_{46}NO_{12}$ [M+NH_4] +612.3020, found 612.3025

$[\alpha]_D^{30}$ = -45.50 (c 0.25, $CHCl_3$)

1,6-bis(((3a'R,5'R,5a'R,8a'R,8b'R)-tetrahydro-5'H-dispiro[cyclohexane-1,2'-bis([1,3]dioxolo)[4,5-b:4',5'-d]pyran-7',1''-cyclohexan]-5'-yl)methoxy)hexa-2,4-diyne (2k)



Prepared by dissolving 50 mg alkynyl glycoside (0.13 mmol) in 4 ml of DCE followed by addition of aniline (7.3 µl, 0.08 mmol) and copper (I) bromide (2.3 mg, 0.02 mmol) at room temperature for 12 hours and purified by flash chromatography (5-8% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **2k** in 58% (29 mg) as a yellowish gummy type solid

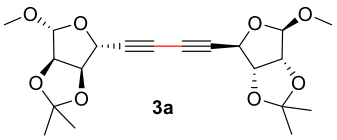
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.47 (d, *J* = 5.0 Hz, 2H), 4.55 (dd, *J* = 7.9, 2.4 Hz, 2H), 4.31 – 4.24 (m, 4H), 4.22 – 4.15 (m, 4H), 3.91 (ddd, *J* = 7.0, 5.1, 1.7 Hz, 2H), 3.76 – 3.69 (m, 2H), 3.58 (dd, *J* = 9.9, 7.0 Hz, 2H), 1.69 (dd, *J* = 8.8, 4.7 Hz, 4H), 1.60 (d, *J* = 6.2 Hz, 4H), 1.56 – 1.51 (m, 8H), 1.51 – 1.41 (m, 16H), 1.33 (s, 8H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 109.9, 109.2, 95.9, 75.3, 70.7, 70.5, 70.3, 70.0, 69.0, 66.8, 58.9, 35.6, 34.2, 34.0, 25.1, 25.0, 23.9, 23.8, 23.7, 23.5

HRMS (ESI): *m/z* calcd for $C_{42}H_{62}NO_{12}$ $[M+NH_4]$ +772.4272, found 772.4276

$[\alpha]_D^{30}$ = -48.70 (c 0.25, $CHCl_3$)

1,4-bis((3aR,4R,6R,6aR)-6-methoxy-2,2-dimethyltetrahydrofuro[3,4-d][1,3]dioxol-4-yl)buta-1,3-diyne (3a)



Prepared by dissolving 50 mg alkynyl glycoside (0.25 mmol) in 4 ml of DCE followed by addition of aniline (12 µl, 0.12 mmol) and copper (I) bromide (3.5 mg, 0.02 mmol) at room temperature for 12 hours and purified by flash chromatography (5-10% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **3a** in 66% (32 mg) as a whitish solid.

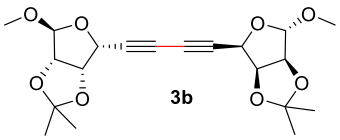
^{1}H NMR (400 MHz, $CDCl_3$): δ 4.97 (s, 2H), 4.81 (d, *J* = 5.8 Hz, 2H), 4.77 (s, 2H), 4.60 (d, *J* = 5.8 Hz, 2H), 3.32 (s, 6H), 1.38 (s, 6H), 1.23 (s, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 112.9, 109.2, 85.1, 85.0, 77.3, 75.1, 69.7, 54.5, 26.2, 24.9

HRMS (ESI): *m/z* calcd for $C_{20}H_{30}NO_8$ $[M+NH_4]$ +412.1971, found 412.1973

$[\alpha]_D^{30}$ = -84.00 (c 0.25, $CHCl_3$)

1,4-bis((3aS,4R,6S,6aS)-6-methoxy-2,2-dimethyltetrahydrofuro[3,4-d][1,3]dioxol-4-yl)buta-1,3-diyne (3b)



Prepared by dissolving 50 mg alkynyl glycoside (0.25 mmol) in 4 ml of DCE followed by addition of aniline (12 µl, 0.12 mmol) and copper (I) bromide (3.5 mg, 0.02 mmol) at room temperature for 12 hours and purified by flash chromatography (5-10% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **3b** in 64% (31 mg) as a pale brown gummy type solid.

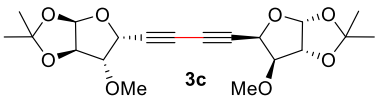
^{1}H NMR (400 MHz, $CDCl_3$): δ 4.86 (s, 2H), 4.68 (d, *J* = 4.0 Hz, 2H), 4.62 (d, *J* = 2.7 Hz, 2H), 4.49 (dd, *J* = 10.4, 6.0 Hz, 2H), 3.27 (s, 6H), 1.45 (s, 6H), 1.27 (s, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 113.5, 107.1, 84.6, 80.7, 73.0, 72.2, 71.3, 54.9, 26.3, 25.3

HRMS (ESI): *m/z* calcd for $C_{20}H_{30}NO_8$ [M+NH_4] +412.1971, found 412.1970

$[\alpha]_D^{30}$ = -44.00 (c 0.25, $CHCl_3$)

1,4-bis((3aR,5R,6S,6aR)-6-methoxy-2,2-dimethyltetrahydrofuro[2,3-d][1,3]dioxol-5-yl)buta-1,3-diyne (3c)



Prepared by dissolving 50 mg alkynyl glycoside (0.25 mmol) in 4 ml of DCE followed by addition of aniline (12 µl, 0.12 mmol) and copper (I) bromide (3.5 mg, 0.02 mmol) at room temperature for 12 hours and purified by flash chromatography (5-10% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **3c** in 62% (31 mg) as a dark brown gummy type solid.

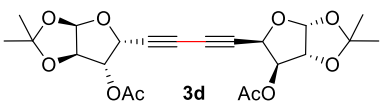
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.85 (d, *J* = 3.7 Hz, 2H), 4.80 (d, *J* = 2.9 Hz, 2H), 4.50 (d, *J* = 3.7 Hz, 2H), 3.73 (d, *J* = 3.0 Hz, 2H), 3.46 (s, 6H), 1.41 (s, 6H), 1.24 (s, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 112.1, 104.7, 85.3, 82.1, 73.1, 71.8, 71.1, 58.9, 26.8, 26.1

HRMS (ESI): *m/z* calcd for $C_{20}H_{30}NO_8$ [M+NH_4] +412.1971 found 412.1967

$[\alpha]_D^{30}$ = -17.60 (c 0.25, $CHCl_3$)

(3aR,3a'R,5R,5'R,6S,6aR,6'S,6a'R)-buta-1,3-diyne-1,4-diylbis(2,2-dimethyltetrahydrofuro[2,3-d][1,3]dioxole-5,6-diyl) diacetate (3d)



Prepared by dissolving 50 mg alkynyl glycoside (0.22 mmol) in 4 ml of DCE followed by addition of aniline (10 µl, 0.11 mmol) and copper (I) bromide (3 mg, 0.02 mmol) at room temperature for 12 hours and purified by flash chromatography (10-12% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **3d** in 55% (27 mg) as a brown gummy type solid.

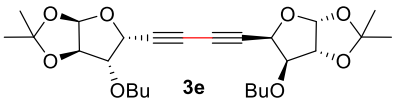
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.89 (d, *J* = 3.7 Hz, 2H), 5.28 (d, *J* = 3.0 Hz, 2H), 4.91 (d, *J* = 3.0 Hz, 2H), 4.49 (d, *J* = 3.7 Hz, 2H), 2.08 (s, 6H), 1.43 (s, 6H), 1.24 (s, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 169.3, 112.6, 104.7, 82.9, 76.7, 72.3, 71.6, 70.6, 26.7, 26.1, 20.6

HRMS (ESI): *m/z* calcd for $C_{22}H_{30}NO_{10}$ [M+NH_4] +468.1870, found 468.1865

$[\alpha]_D^{30}$ = +21.60 (c 0.25, $CHCl_3$)

1,4-bis((3aR,5R,6S,6aR)-6-butoxy-2,2-dimethyltetrahydrofuro[2,3-d][1,3]dioxol-5-yl)buta-1,3-diyne (3e)



Prepared by dissolving 50 mg alkynyl glycoside (0.20 mmol) in 4 ml of DCE followed by addition of aniline (9.4 µl, 0.10 mmol) and copper (I) bromide (3 mg, 0.02 mmol) at room temperature for 12 hours and purified by flash chromatography (8-10% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **3e** in 62% (30 mg) as a yellowish gummy type solid.

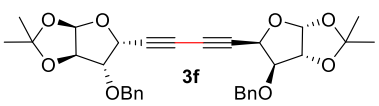
^{1}H NMR (400 MHz, $CDCl_3$): δ 5.93 – 5.79 (d, 2H), 4.79 (dd, *J* = 6.6, 2.9 Hz, 2H), 4.54 – 4.40 (m, 2H), 3.81 (d, *J* = 2.8 Hz, 2H), 3.65 – 3.47 (m, 4H), 1.50 (dd, *J* = 17.3, 7.1 Hz, 8H), 1.40 (s, 6H), 1.23 (s, 6H), 0.89 – 0.83 (m, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 112.0, 104.8, 83.8, 82.9, 73.1, 71.7, 71.3, 71.3, 31.6, 26.8, 26.1, 19.1, 13.8

HRMS (ESI): *m/z* calcd for $C_{26}H_{42}NO_8$ [M+NH_4] +496.2910, found 496.2908

$[\alpha]_D^{30}$ = -10.40 (c 0.25, $CHCl_3$)

1,4-bis((3aR,5R,6S,6aR)-6-(benzyloxy)-2,2-dimethyltetrahydrofuro[2,3-d][1,3]dioxol-5-yl)buta-1,3-diyne (3f)



Prepared by dissolving 50 mg alkynyl glycoside (0.18 mmol) in 4 ml of DCE followed by addition of aniline (8.2 µl, 0.09 mmol) and copper (I) bromide (2.5 mg, 0.01 mmol) at room temperature for 12 hours and purified by flash chromatography (7-10% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **3f** in 66% (32 mg) as a yellowish gummy type solid.

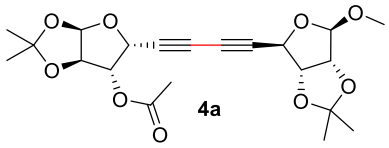
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.31 – 7.20 (m, 10H), 5.90 (d, *J* = 3.7 Hz, 2H), 4.84 (d, *J* = 2.8 Hz, 2H), 4.66 (q, *J* = 12.1 Hz, 4H), 4.50 (d, *J* = 3.7 Hz, 2H), 3.95 (t, *J* = 9.8 Hz, 2H), 1.39 (s, 6H), 1.22 (s, 6H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 137.0, 128.5, 128.0, 127.9, 112.1, 104.8, 82.9, 82.6, 73.5, 72.8, 72.0, 71.3, 26.8, 26.1

HRMS (ESI): *m/z* calcd for $C_{32}H_{38}NO_8$ $[M+NH_4]$ +564.2597, found 564.2598

$[\alpha]_D^{30}$ = -41.60 (c 0.25, $CHCl_3$)

(3aR,5R,6S,6aR)-5-(((3aR,4R,6R,6aR)-6-methoxy-2,2-dimethyltetrahydrofuro[3,4-d][1,3]dioxol-4-yl)buta-1,3-diyn-1-yl)-2,2-dimethyltetrahydrofuro[2,3-d][1,3]dioxol-6-yl acetate (4a)



Prepared by dissolving 50 mg of alkynyl riboside (0.25 mmol) and alkynyl xyloside (0.22 mmol) in 6 ml of DCE followed by addition of aniline (9.4 µl, 0.10 mmol) and copper (I) bromide (3 mg, 0.02 mmol) at room temperature for 12 hours and purified by flash chromatography (8-15% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **4a** in 15% (12 mg) as a darkish solid.

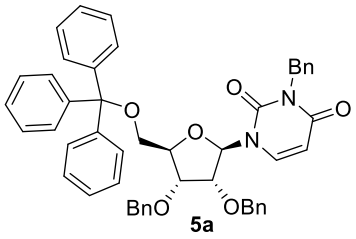
^{1}H NMR (400 MHz, $CDCl_3$) δ 5.89 (d, *J* = 3.7 Hz, 1H), 5.27 (d, *J* = 3.1 Hz, 1H), 4.96 (s, 1H), 4.91 (d, *J* = 3.1 Hz, 1H), 4.81 (d, *J* = 5.8 Hz, 1H), 4.76 (s, 1H), 4.59 (d, *J* = 5.8 Hz, 1H), 4.50 (d, *J* = 3.7 Hz, 1H), 3.30 (s, 3H), 2.08 (s, 3H), 1.43 (s, 3H), 1.38 (s, 3H), 1.24 (s, 3H), 1.23 (s, 3H)

^{13}C NMR (101 MHz, $CDCl_3$) δ 169.4, 112.9, 112.6, 109.2, 104.7, 85.0, 85.0, 82.9, 77.4, 76.7, 75.0, 72.2, 72.0, 70.6, 69.4, 54.5, 26.7, 26.2, 26.1, 24.9, 20.6

HRMS (ESI): *m/z* calcd for $C_{21}H_{30}NO_9$ $[M+NH_4]$ +440.1921, found 440.1919

$[\alpha]_D^{30}$ = -15.20 (c 0.25, $CHCl_3$)

3-benzyl-1-((2R,3R,4R,5R)-3,4-bis(benzyloxy)-5-((trityloxy)methyl)tetrahydrofuran-2-yl)pyrimidine-2,4(1H,3H)-dione (5a)



5a

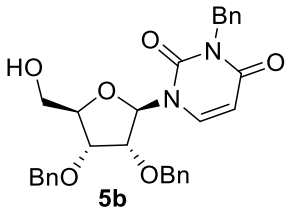
Prepared by dissolving 150 mg uridine (0.61 mmol) in 10 ml of dry pyridine followed by portion wise addition of 257 mg trityl chloride (0.92 mmol) under inert condition at room temperature for 12 hours and purified by flash chromatography (2-5% DCM/Methanol) on silica gel (mesh size 60-100) to obtain C5 tritylated uridine in 90% (272 mg) as a white powder which was dissolved in dry DMF followed by addition of sodium hydride and benzyl bromide at 0^{o}C. The reaction mixture was stirred at room temperature for 2 hours. After completion of reaction as judged by TLC the reaction mixture was extracted with ethyl acetate and water. The combined organic layer was collected, reduced under high vacuum and purified by flash chromatography (7-10% EtOAc/Petroleum ether) using silica gel (mesh size 60-100) to obtain **5a** in 80% (338 mg) as a white crystalline powder.

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.06 (d, *J* = 8.1 Hz, 1H), 7.60 – 7.54 (m, 2H), 7.45 – 7.42 (m, 2H), 7.40 (dd, *J* = 5.3, 3.4 Hz, 2H), 7.36 (dd, *J* = 4.3, 2.7 Hz, 2H), 7.34 – 7.29 (m, 20H), 7.21 – 7.16 (m, 2H), 6.09 (s, 1H), 5.26 – 5.15 (m, 3H), 4.92 (q, *J* = 12.3 Hz, 2H), 4.44 (d, *J* = 11.7 Hz, 1H), 4.35 (d, *J* = 8.9 Hz, 1H), 4.29 – 4.21 (m, 2H), 3.96 (d, *J* = 4.7 Hz, 1H), 3.58 (ddd, *J* = 27.2, 11.3, 1.9 Hz, 2H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 162.6, 150.7, 143.0, 137.8, 137.1, 137.0, 136.8, 129.3, 129.0, 128.7, 128.5, 128.5, 128.1, 128.0,128.0, 127.9, 127.8, 127.7, 127.4, 101.5, 89.0, 87.4, 81.0, 78.1, 73.7, 72.0, 71.1, 60.6, 44.0

HRMS (ESI): *m/z* calcd for $C_{49}H_{45}N_2O_6$ [M+H] +757.3278, found 757.3270

3-benzyl-1-((2R,3R,4R,5R)-3,4-bis(benzyloxy)-5-(hydroxymethyl)tetrahydrofuran-2-yl)pyrimidine-2,4(1H,3H)-dione (5b)



5b

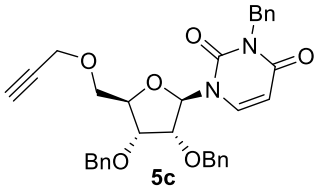
Prepared by dissolving 300 mg (0.39 mmol) of 5a in DCM followed by addition of TFA (121 µl, 1.58 mmol) and H_2O (10 µl, 0.39 mmol) at room temperature for 2 hours and purified by flash chromatography (10-20% EtOAc/Petroleum ether) on silica gel (mesh size 60-100) to obtain **5b** in 95% (194 mg) as white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.45 – 7.42 (m, 2H), 7.40 (d, *J* = 1.4 Hz, 1H), 7.28 – 7.20 (m, 12H), 7.17 (t, *J* = 2.0 Hz, 1H), 5.68 (d, *J* = 3.7 Hz, 1H), 5.63 (d, *J* = 8.1 Hz, 1H), 4.99 (q, *J* = 13.7 Hz, 2H), 4.70 (d, *J* = 12.2 Hz, 1H), 4.59 (d, *J* = 12.2 Hz, 1H), 4.50 (d, *J* = 11.7 Hz, 1H), 4.35 (d, *J* = 11.7 Hz, 1H), 4.21 – 4.15 (m, 2H), 4.03 – 3.96 (m, 1H), 3.90 (dd, *J* = 12.4, 2.1 Hz, 1H), 3.64 (dd, *J* = 12.4, 2.1 Hz, 1H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 162.7, 150.7, 139.3, 137.4, 137.2, 136.5, 129.2, 128.5, 128.5, 128.4, 128.1, 128.0, 127.8, 127.7, 101.6, 91.4, 83.0, 78.2, 74.5, 72.3, 71.9, 60.9, 44.1

HRMS (ESI): *m/z* calcd for $C_{30}H_{31}N_2O_6$ [M+H] +515.2182, found 515.2178

3-benzyl-1-((2R,3R,4R,5R)-3,4-bis(benzyloxy)-5-((prop-2-yn-1-yloxy)methyl)tetrahydrofuran-2-yl)pyrimidine-2,4(1H,3H)-dione (5c)



5c

Prepared by dissolving 180 mg (0.35 mmol) of 5b in DMF followed by addition of sodium hydride 168 mg (0.70 mmol) and propargyl bromide 121 µl (0.525 mmol) at 0°C for 2 hours. After completion of reaction as judged by TLC the reaction mixture was extracted with ethyl acetate and water. The combined organic layer was collected, reduced under high vacuum and purified by flash chromatography (7-15% EtOAc/Petroleum ether) using silica gel (mesh size 60-100) to obtain **5c** in 80% (155 mg) as a yellowish gummy type solid.

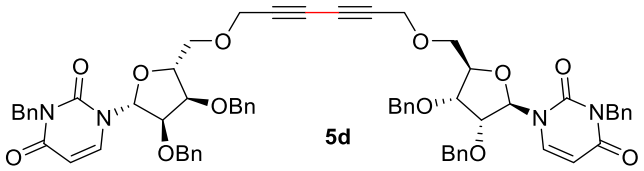
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 8.2 Hz, 1H), 7.46 – 7.42 (m, 2H), 7.30 – 7.20 (m, 12H), 7.16 (s, 1H), 5.98 (d, *J* = 1.8 Hz, 1H), 5.61 (d, *J* = 8.2 Hz, 1H), 5.06 (s, 2H), 4.74 (d, *J* = 2.0

Hz, 2H), 4.41 – 4.37 (m, 1H), 4.28 – 4.23 (m, 2H), 4.06 (d, *J* = 2.3 Hz, 2H), 3.90 (dd, *J* = 7.7, 4.8 Hz, 1H), 3.86 – 3.79 (m, 2H), 3.62 (dd, *J* = 11.0, 2.0 Hz, 1H), 2.38 (t, *J* = 2.3 Hz, 1H)

^{13}C NMR (101 MHz, $CDCl_3$): δ 162.7, 150.8, 137.8, 137.3, 137.2, 136.8, 129.1, 128.7, 128.4, 128.0, 127.9, 127.7, 127.6, 101.4, 89.0, 81.0, 78.8, 78.6, 77.2, 75.1, 74.2, 72.2, 71.4, 67.4, 58.5, 44.0

HRMS (ESI): *m/z* calcd for $C_{33}H_{33}N_2O_6$ [M+H] +553.2339, found 553.2334

1,1'-((2R,2'R,3R,3'R,4R,4'R,5R,5'R)-((hexa-2,4-diyne-1,6-diylbis(oxy))bis(methylene))bis(3,4-bis(benzyloxy)tetrahydrofuran-5,2-diyl))bis(3-benzylpyrimidine-2,4(1H,3H)-dione) (5d)



5d

Prepared by dissolving 100 mg 5c (0.19 mmol) in 6 ml of DCE followed by addition of aniline (9 µl, 0.09 mmol) and copper (I) bromide (2.7 mg, 0.01 mmol) at room temperature for 12 hours and purified by flash chromatography (15-30% EtOAc/Petroleum ether) on silica gel (mesh size 100-200) to obtain **5d** in 65% (130 mg) as a yellowish gummy type solid.

^{1}H NMR (400 MHz, $CDCl_3$): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J* = 8.2 Hz, 2H), 7.43 – 7.38 (m, 4H), 7.31 – 7.27 (m, 4H), 7.25 – 7.18 (m, 20H), 7.15 (s, 2H), 5.95 (d, *J* = 1.4 Hz, 2H), 5.59 (d, *J* = 8.1 Hz, 2H), 5.01 (d, *J* = 2.4 Hz, 4H), 4.75 (d, *J* = 6.7 Hz, 4H), 4.36 (t, *J* = 8.4 Hz, 2H), 4.23 (dd, *J* = 6.9, 4.9 Hz, 4H), 4.08 (d, *J* = 5.4 Hz, 4H), 3.93 – 3.85 (m, 4H), 3.80 (dd, *J* = 10.9, 1.9 Hz, 2H), 3.57 (dd, *J* = 10.9, 2.0 Hz, 2H)

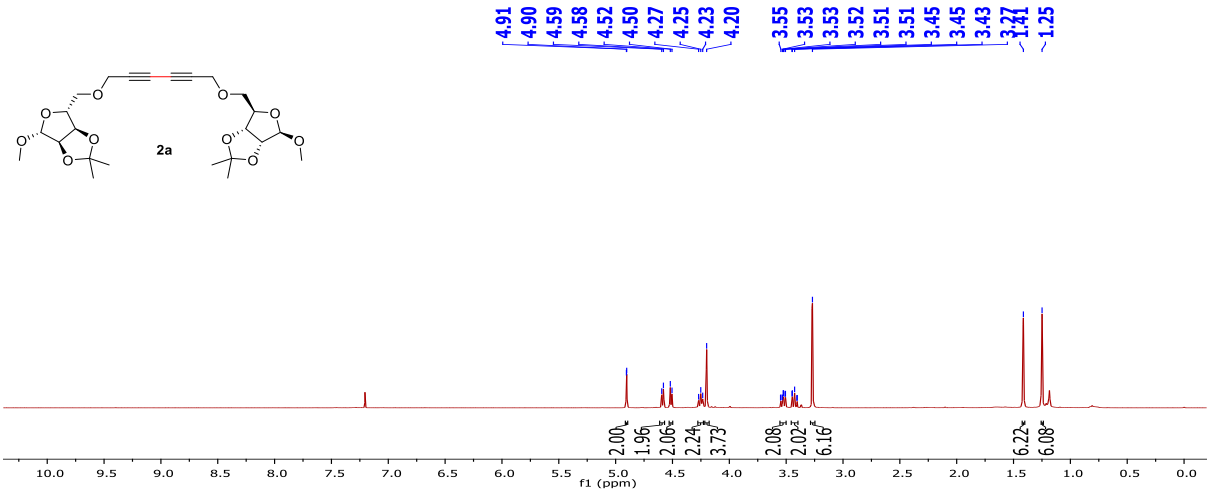
^{13}C NMR (101 MHz, $CDCl_3$): δ 162.6, 150.7, 137.7, 137.4, 137.2, 136.8, 129.1, 128.6, 128.4, 128.4, 128.4, 128.0, 127.9, 127.8, 127.6, 101.4, 89.2, 80.8, 78.5, 75.0, 74.1, 72.2, 71.4, 70.5, 67.7, 59.0, 43.9

HRMS (ESI): *m/z* calcd for $C_{66}H_{63}N_4O_{12}$ [M+H] +1103.4442, found 1103.4438

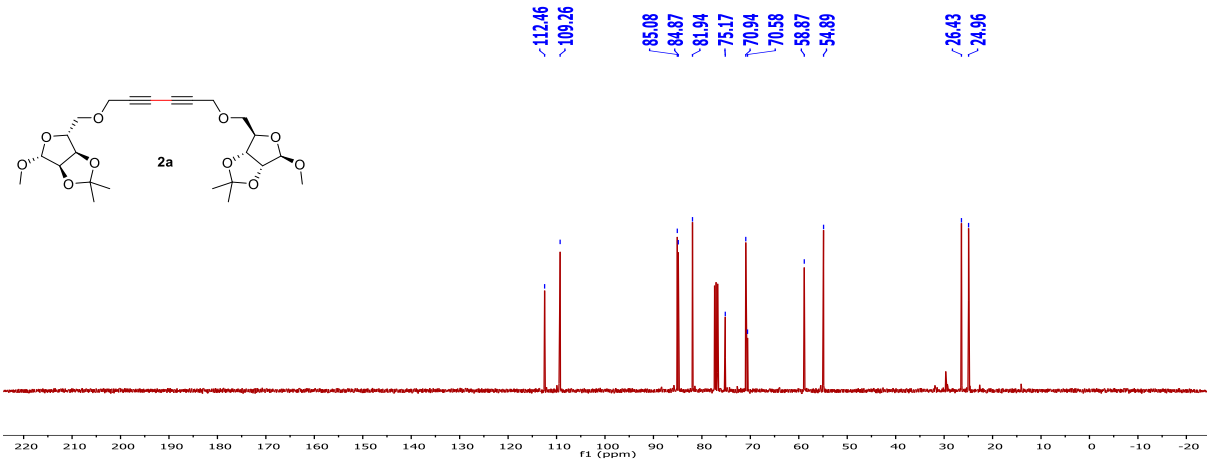
$[\alpha]_D^{30}$ = +86.40 (c 0.25, $CHCl_3$)

3.0 NMR spectra for compounds

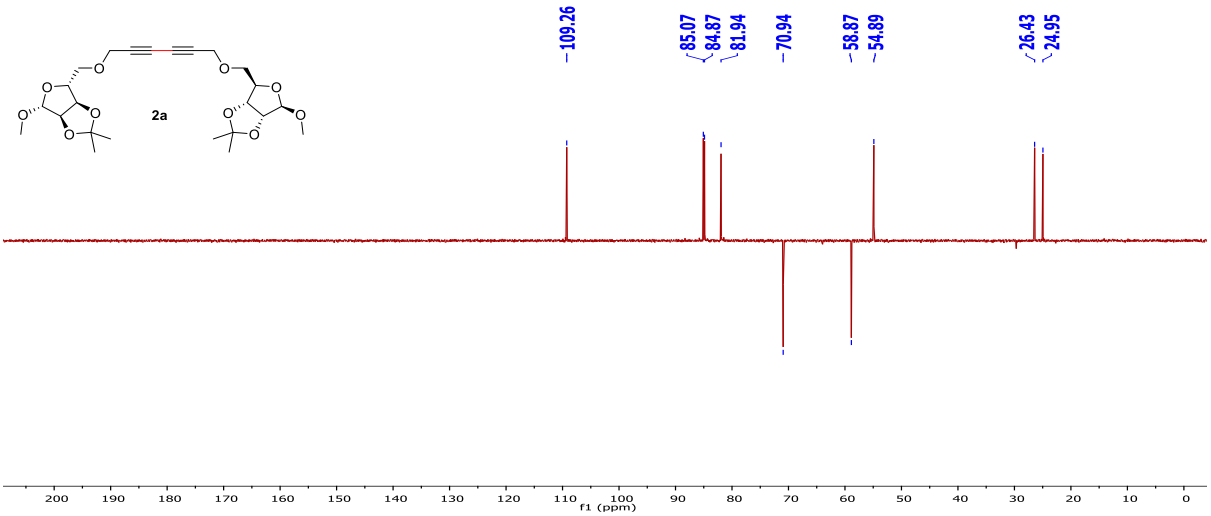
^{1}H NMR (400 MHz, $CDCl_3$) of 2a



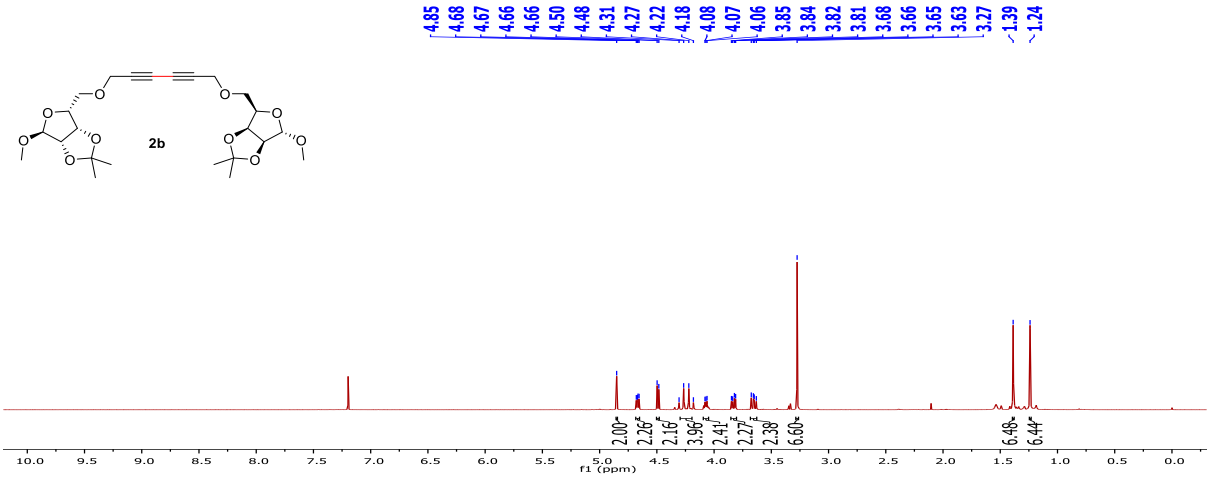
^{13}C NMR (400 MHz, $CDCl_3$) of 2a



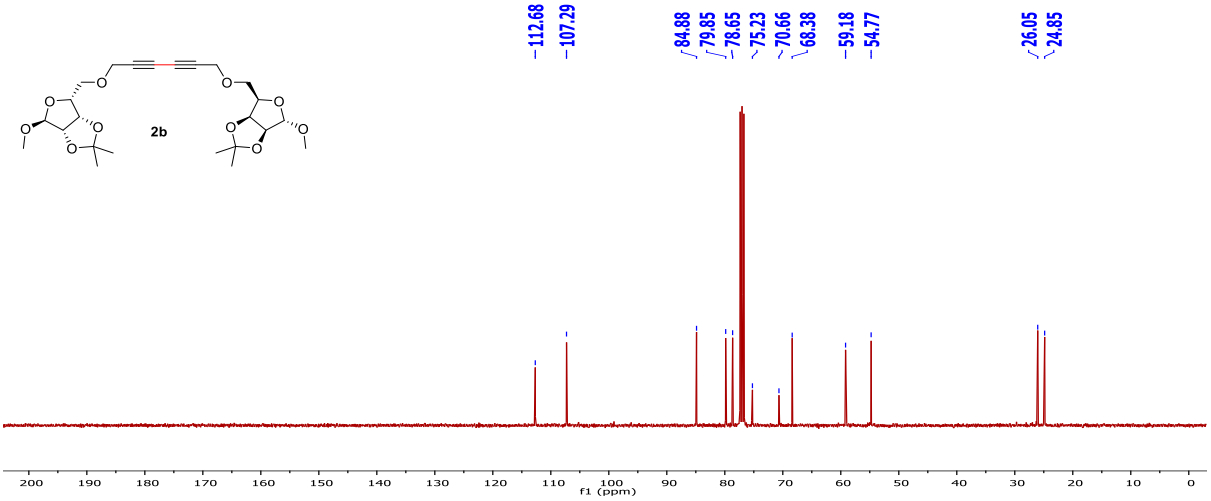
DEPT 135 (101 MHz, $CDCl_3$) of 2a



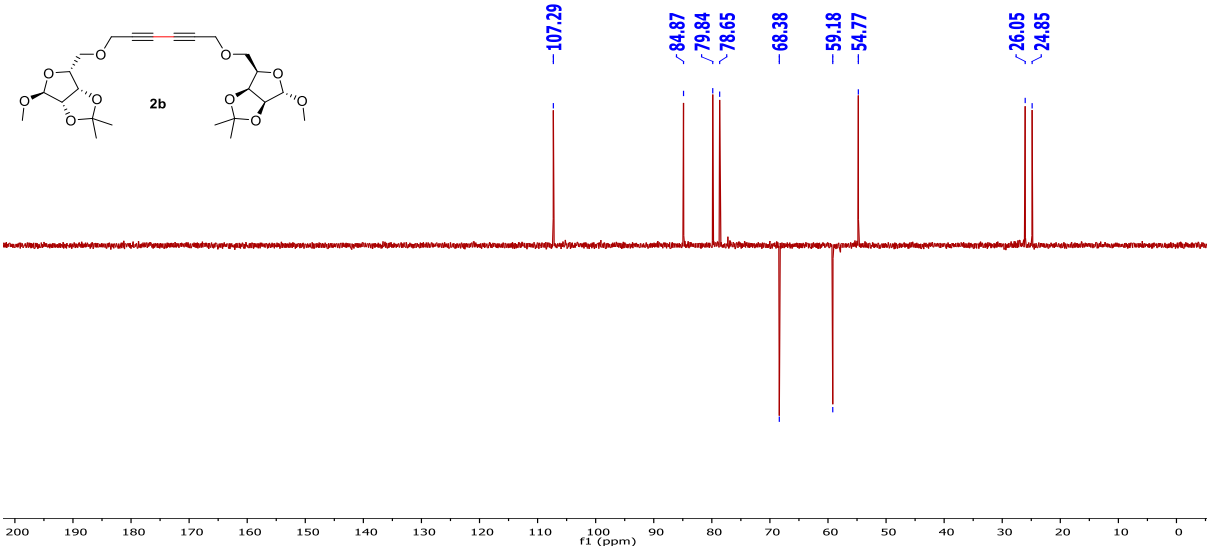
^{1}H NMR (400 MHz, $CDCl_3$) of 2b



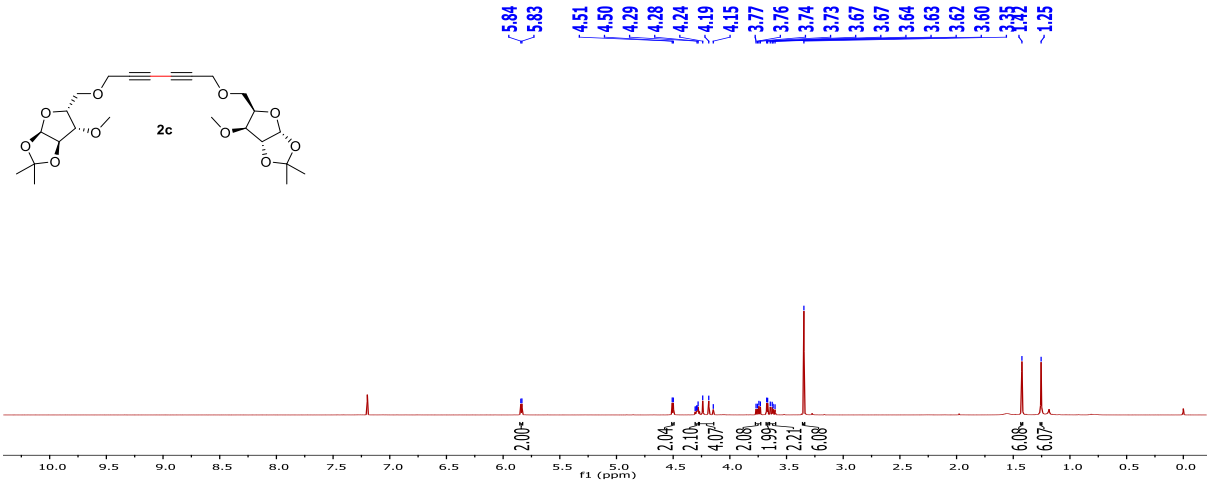
^{13}C NMR (400 MHz, $CDCl_3$) of 2b



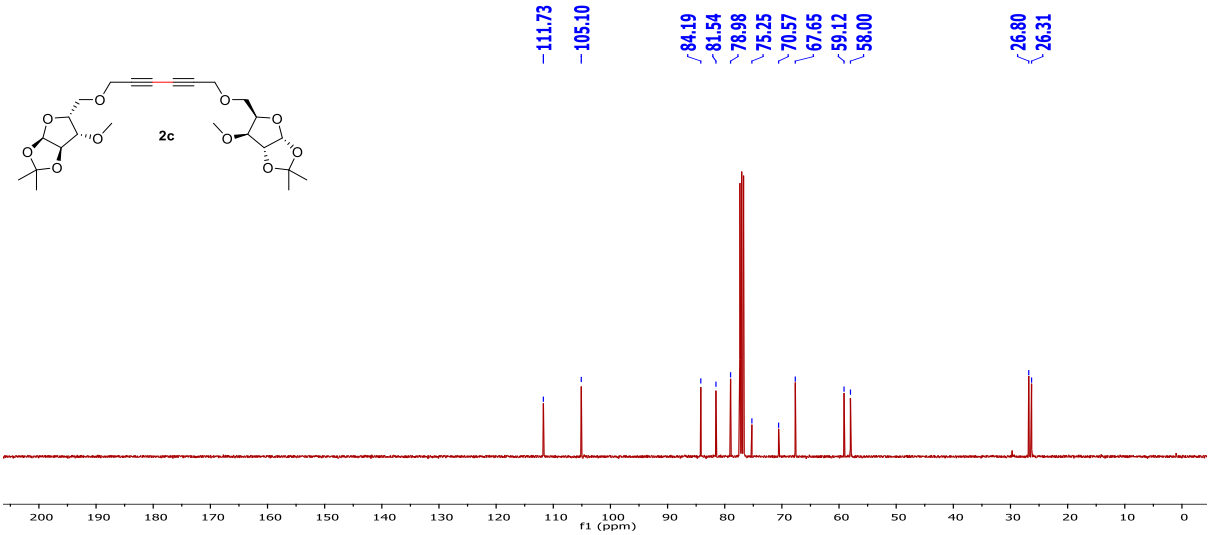
DEPT 135 (101 MHz, $CDCl_3$) of 2b



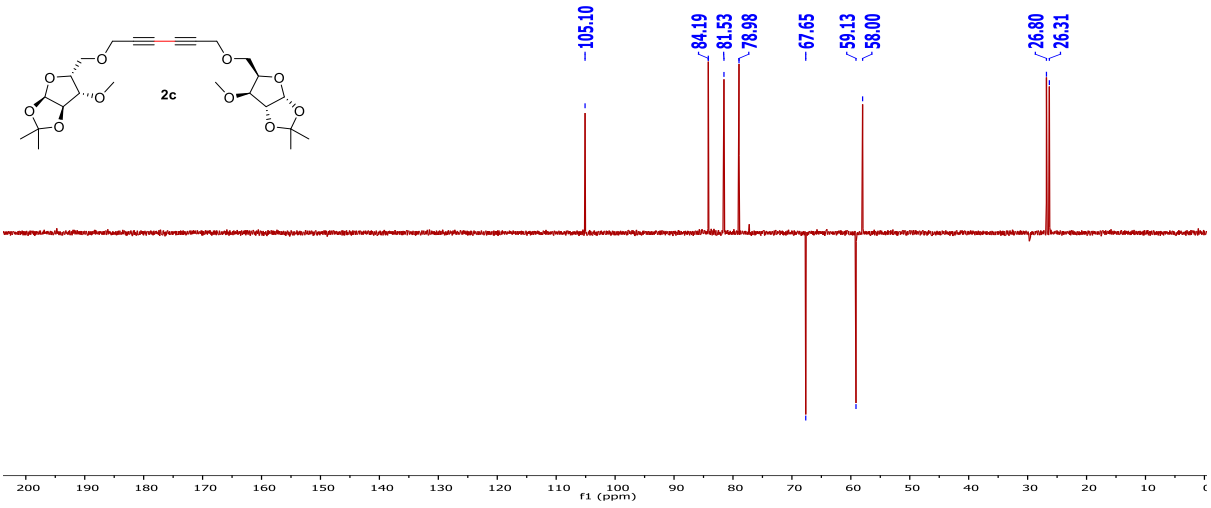
^{1}H NMR (400 MHz, $CDCl_3$) of 2c



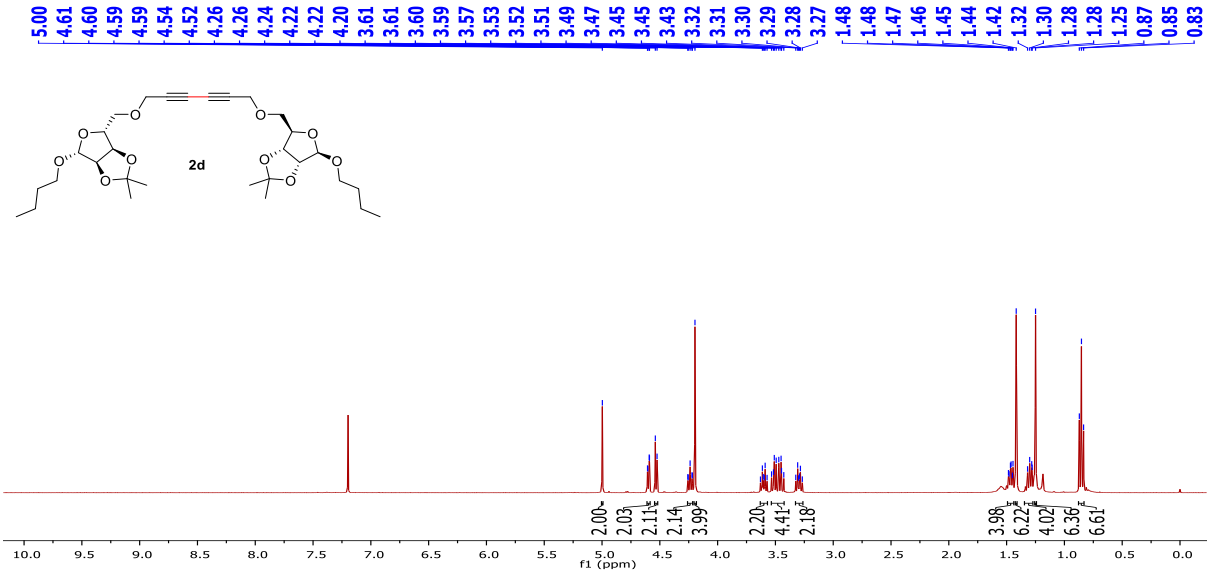
^{13}C NMR (400 MHz, $CDCl_3$) of 2c



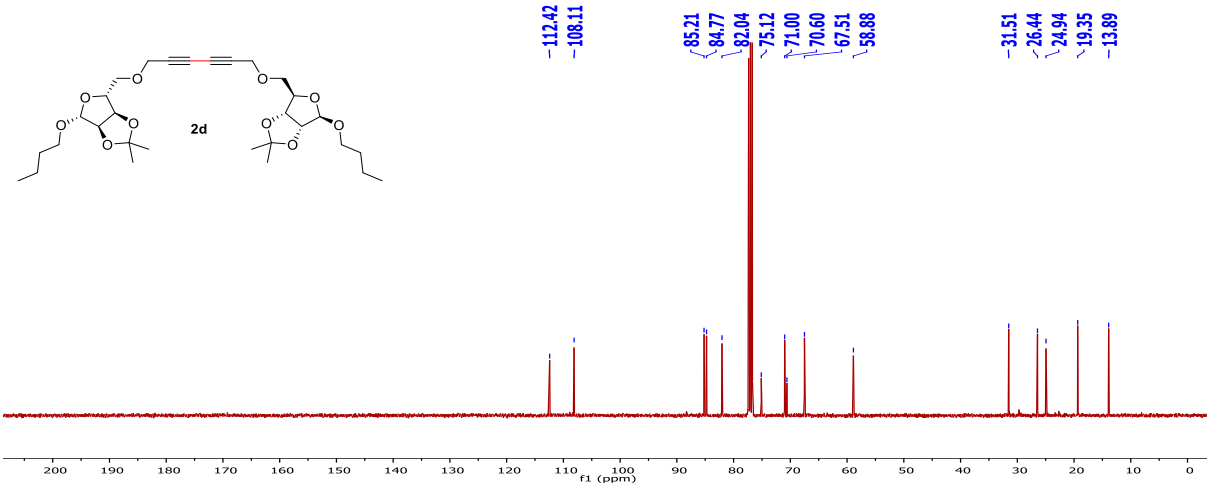
DEPT 135 (101 MHz, $CDCl_3$) of 2c



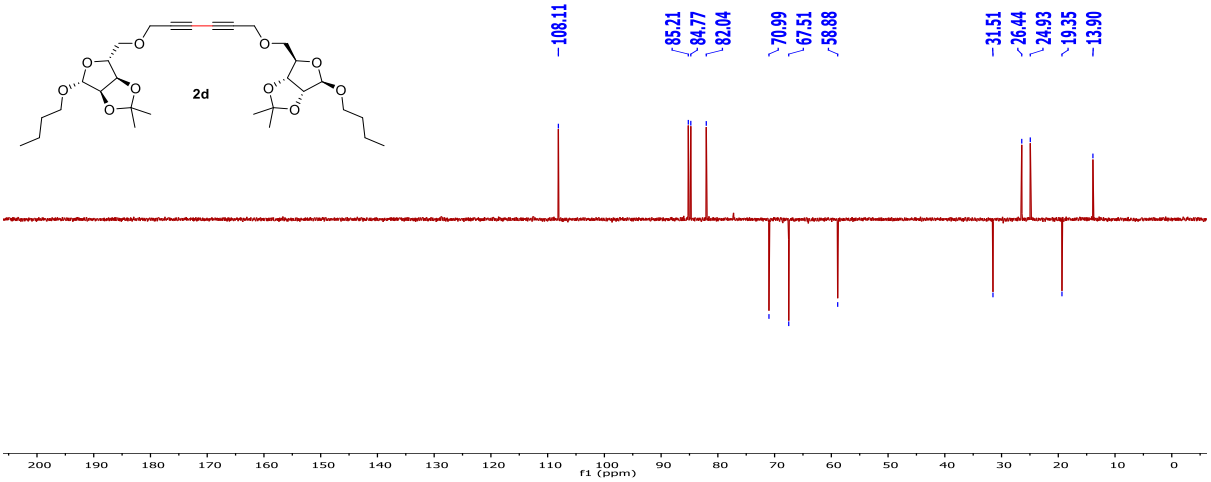
^{1}H NMR (400 MHz, $CDCl_3$) of 2d



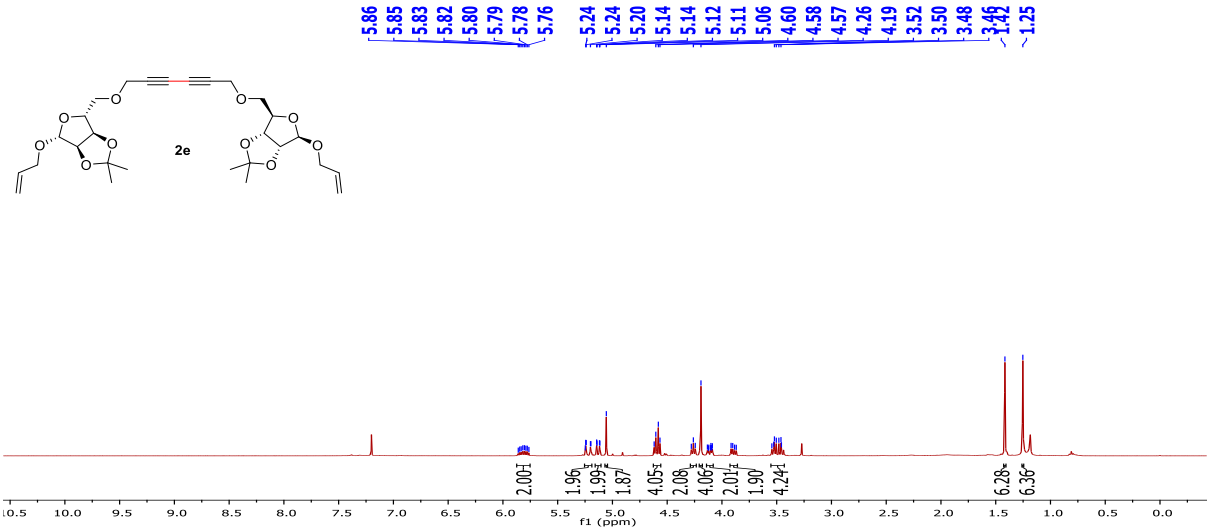
^{13}C NMR (400 MHz, $CDCl_3$) of 2d



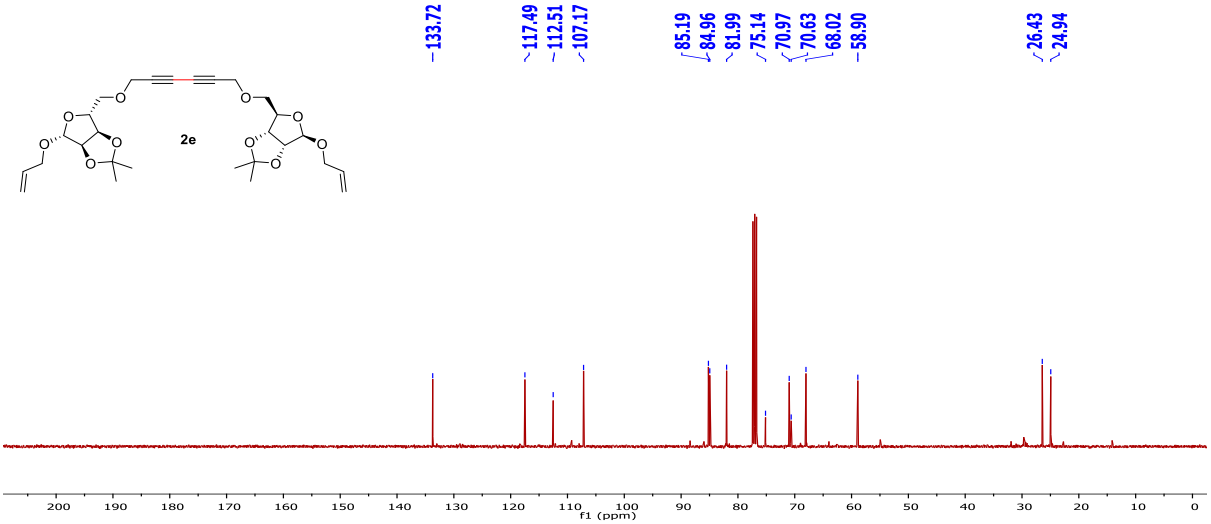
DEPT 135 (101 MHz, $CDCl_3$) of 2d



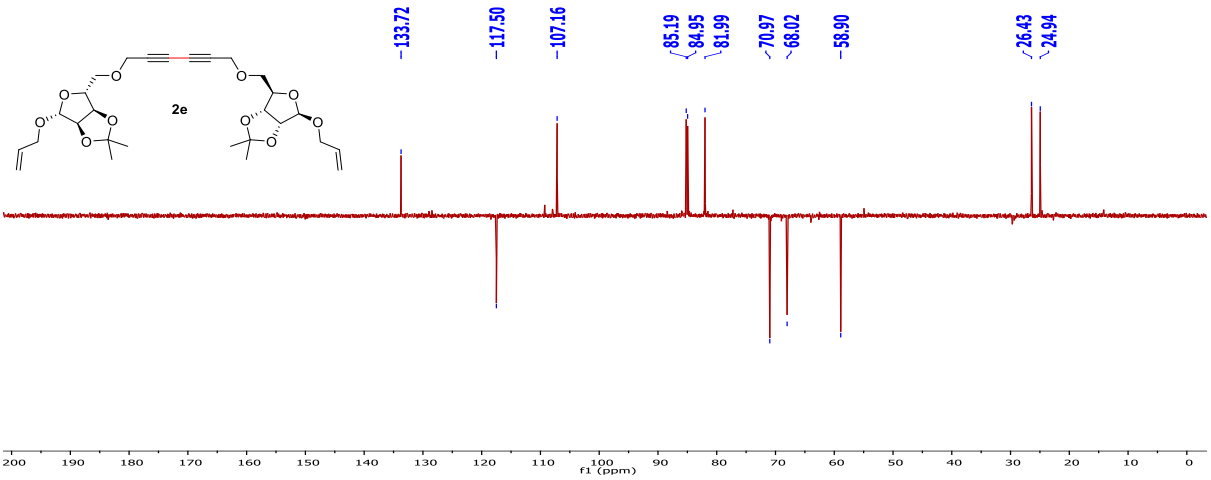
^{1}H NMR (400 MHz, $CDCl_3$) of 2e



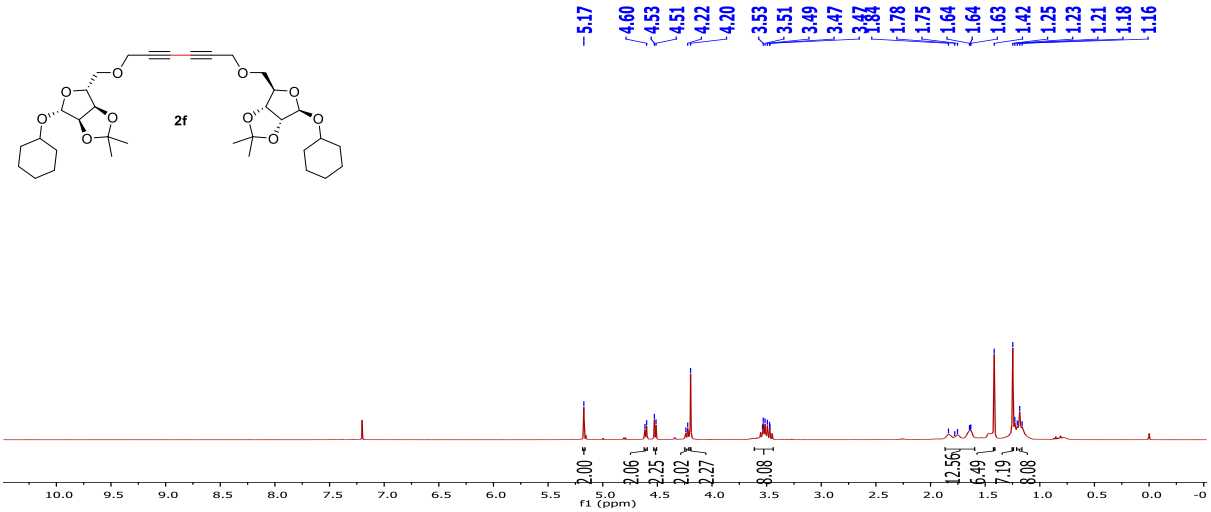
^{13}C NMR (400 MHz, $CDCl_3$) of 2e



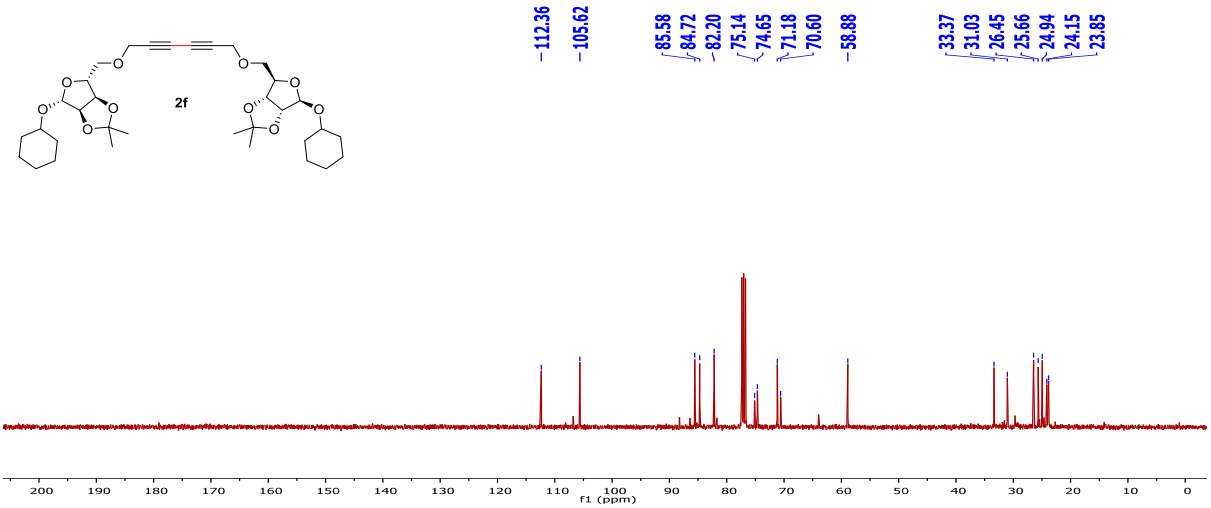
DEPT 135 (101 MHz, $CDCl_3$) of 2e



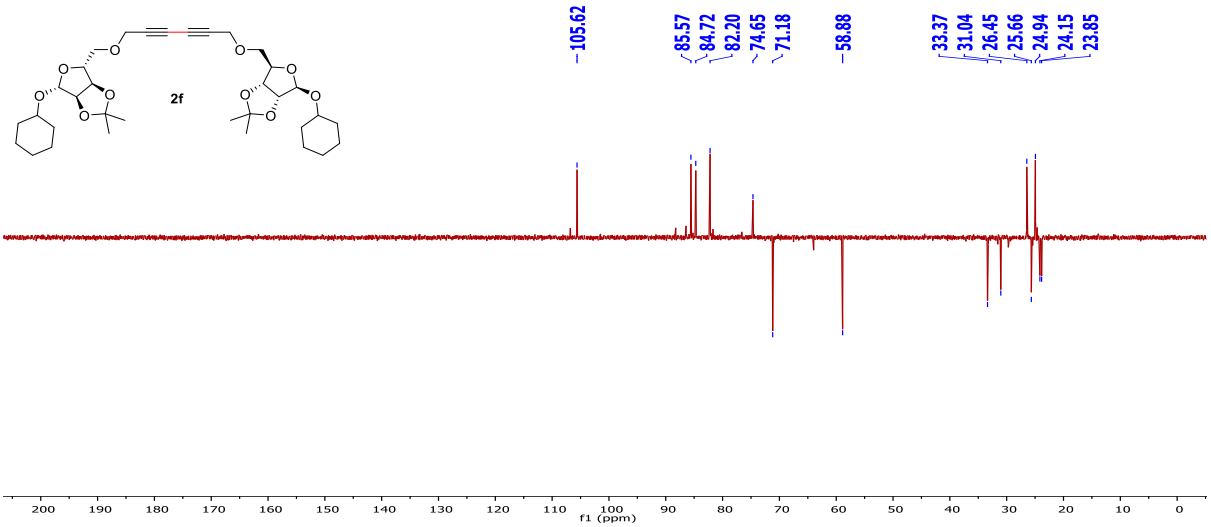
^{1}H NMR (400 MHz, $CDCl_3$) of 2f



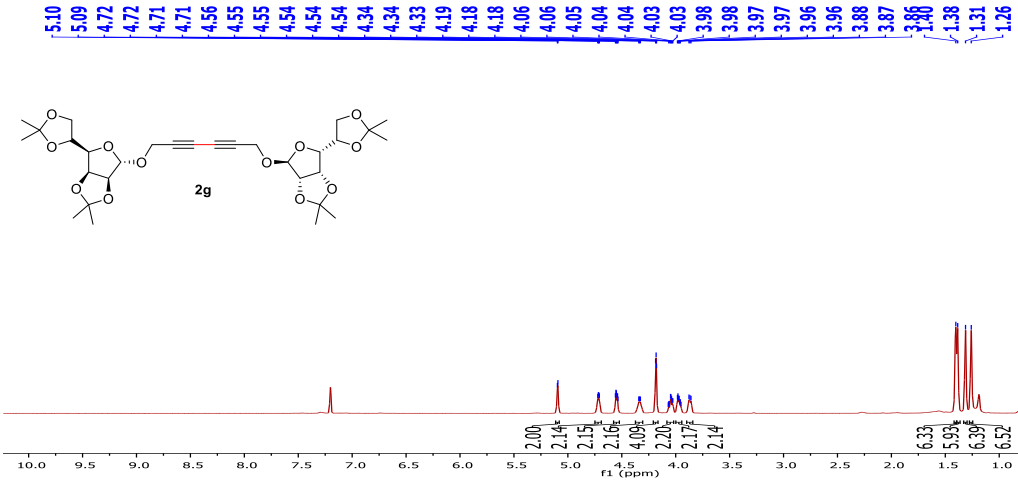
^{13}C NMR (400 MHz, $CDCl_3$) of 2f



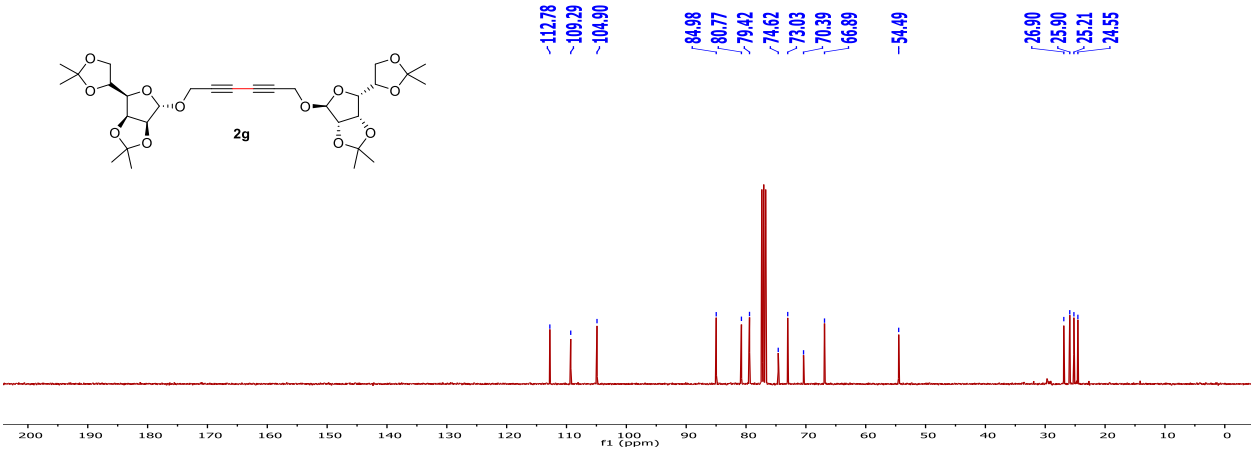
DEPT 135 (101 MHz, $CDCl_3$) of 2f



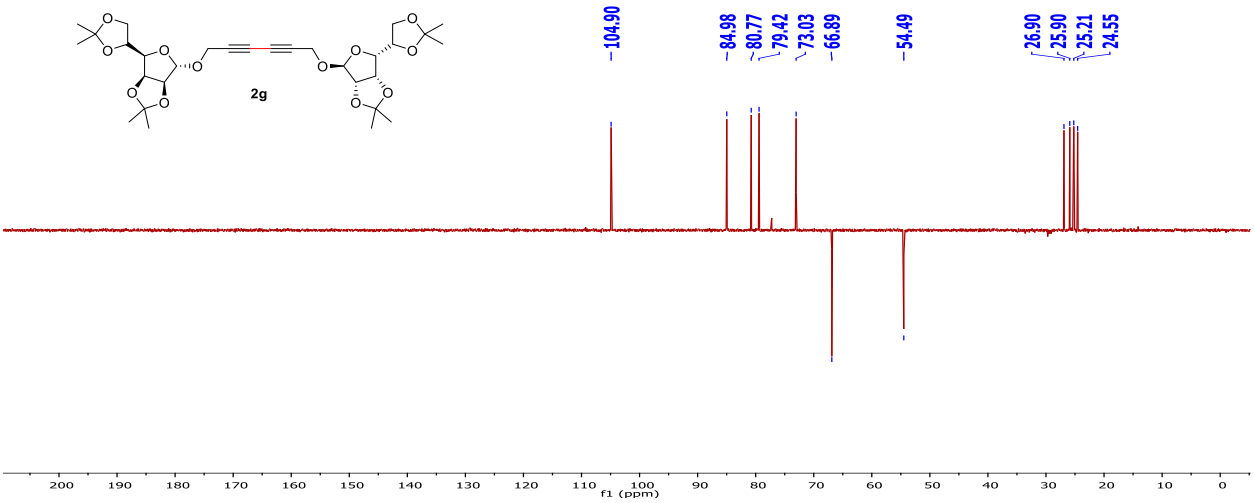
^{1}H NMR (400 MHz, $CDCl_3$) of 2g



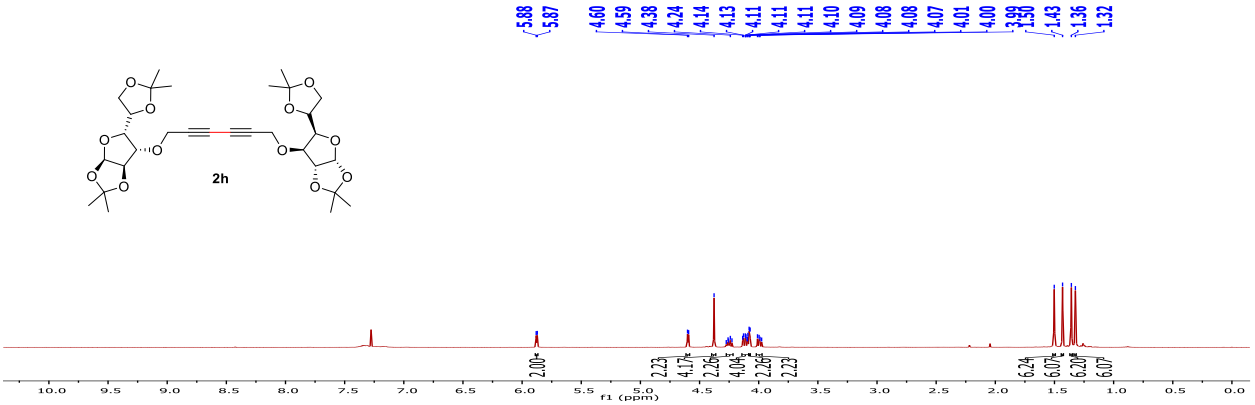
^{13}C NMR (400 MHz, $CDCl_3$) of 2g



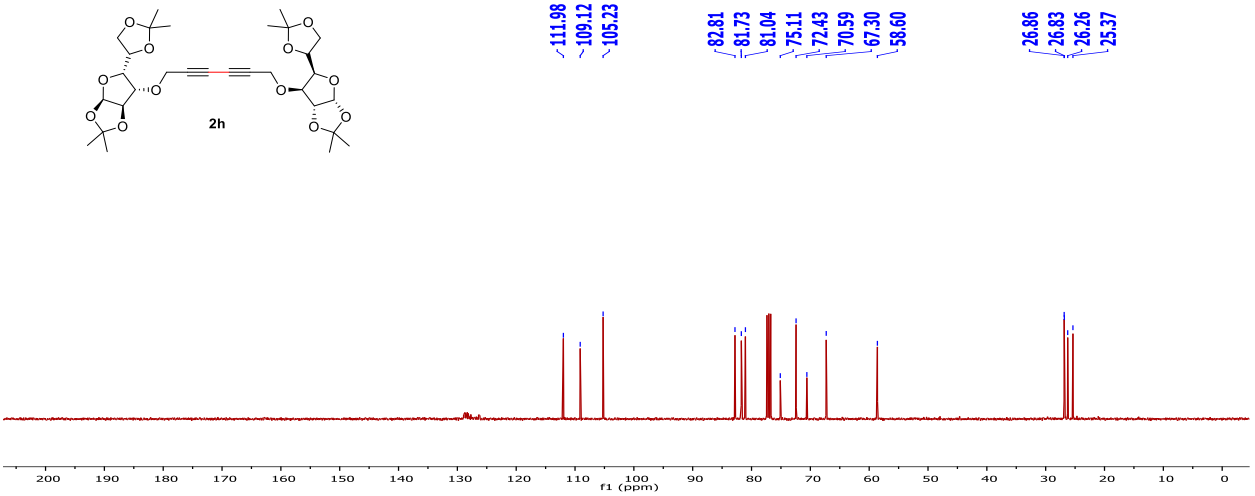
DEPT 135 (101 MHz, $CDCl_3$) of 2g



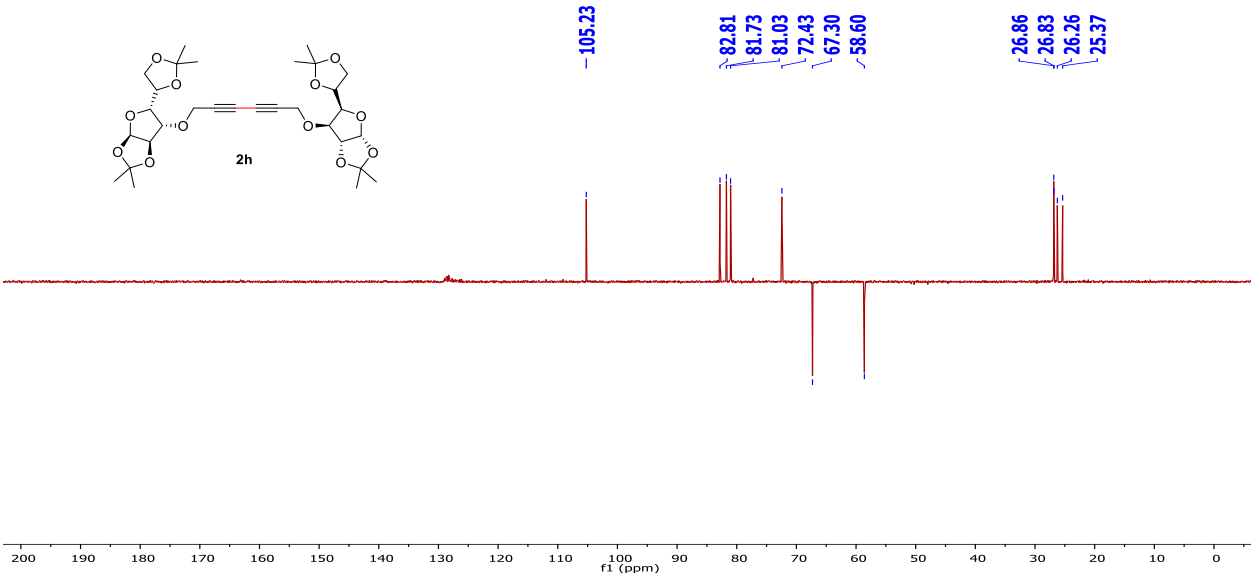
^{1}H NMR (400 MHz, $CDCl_3$) of 2h



^{13}C NMR (400 MHz, $CDCl_3$) of 2h



DEPT 135 (101 MHz, $CDCl_3$) of 2h



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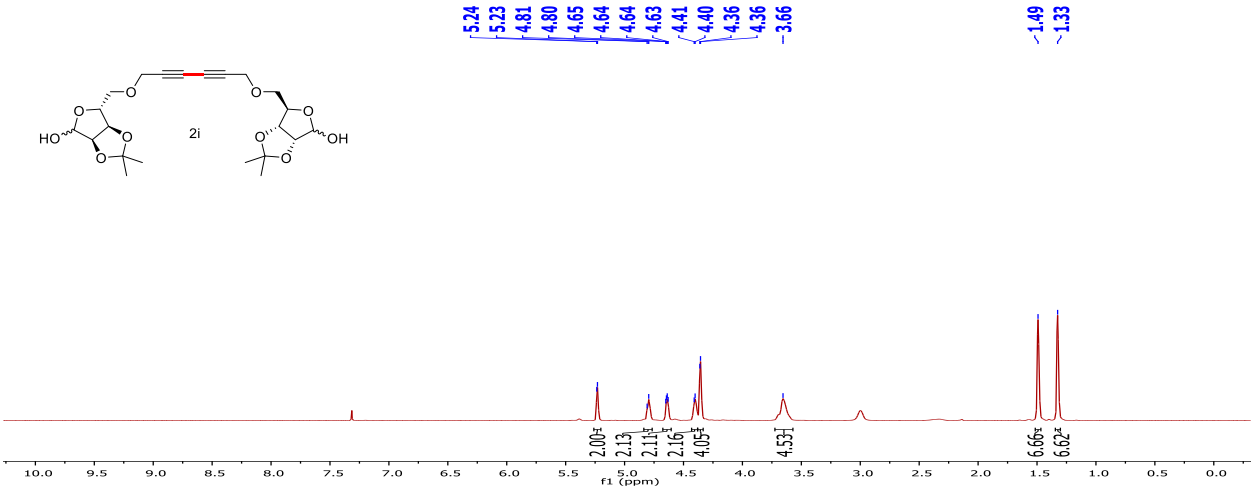
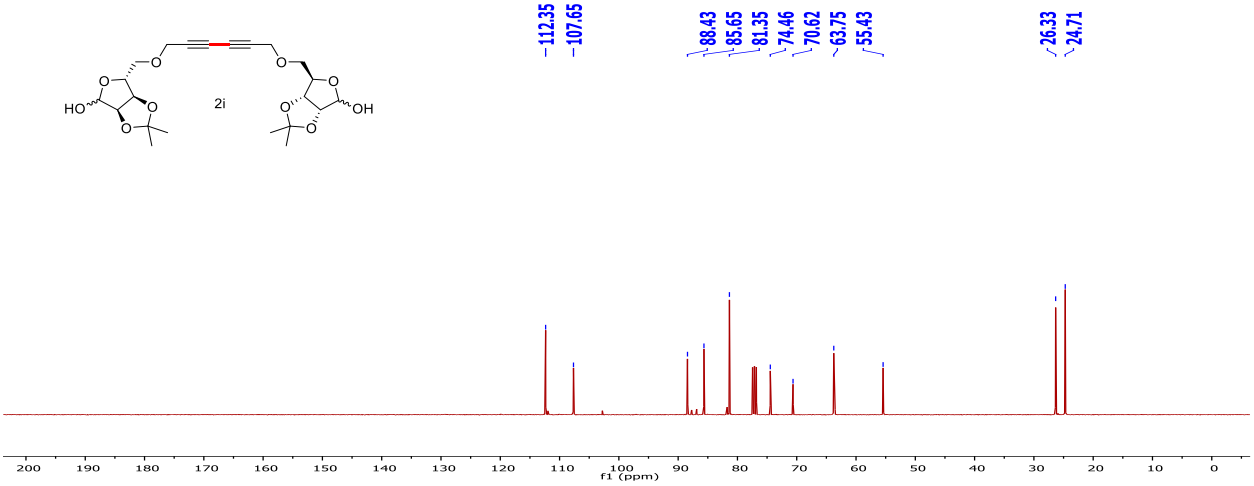


^{13}C NMR (400 MHz, $CDCl_3$) of 2i



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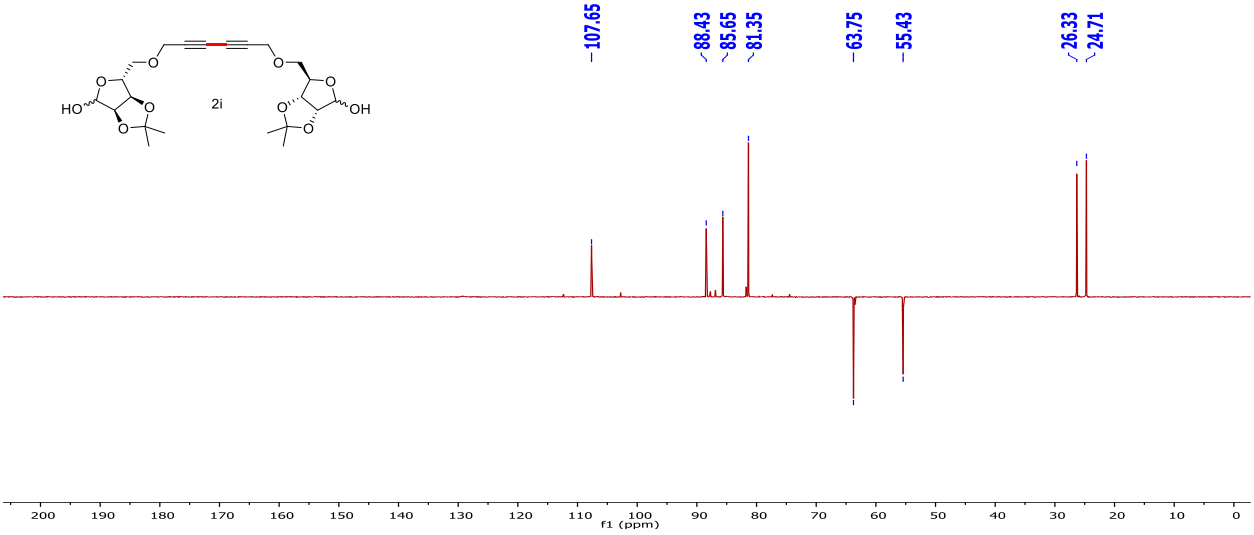

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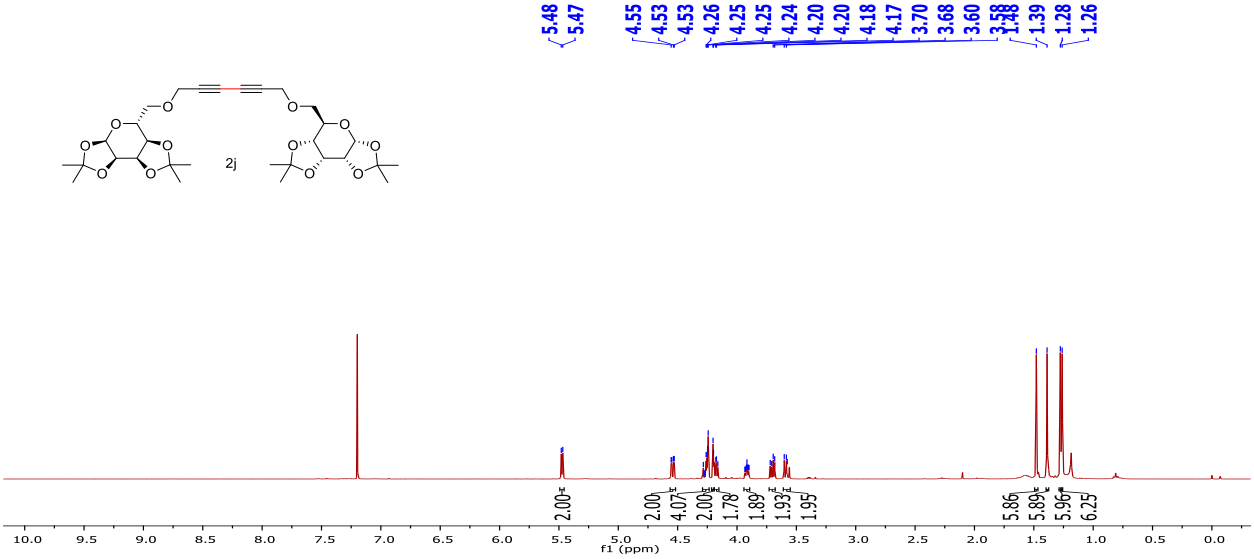
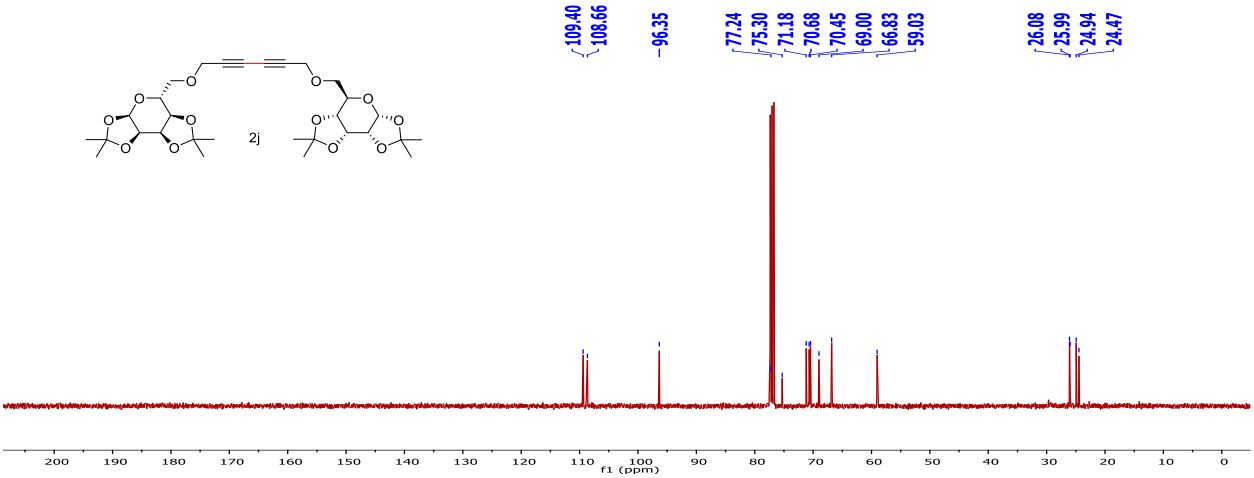


^{13}C NMR (400 MHz, $CDCl_3$) of 2j



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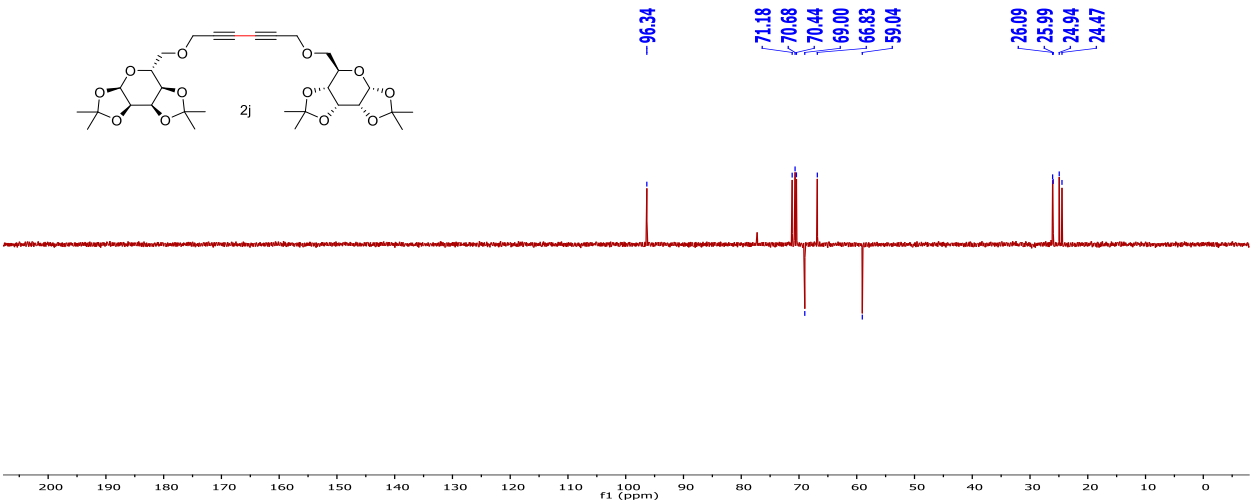
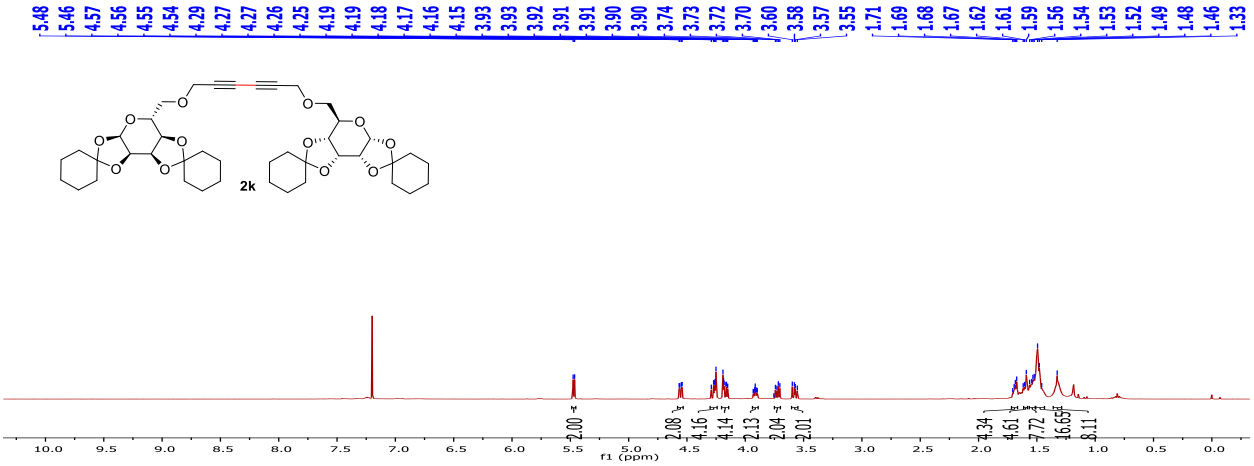
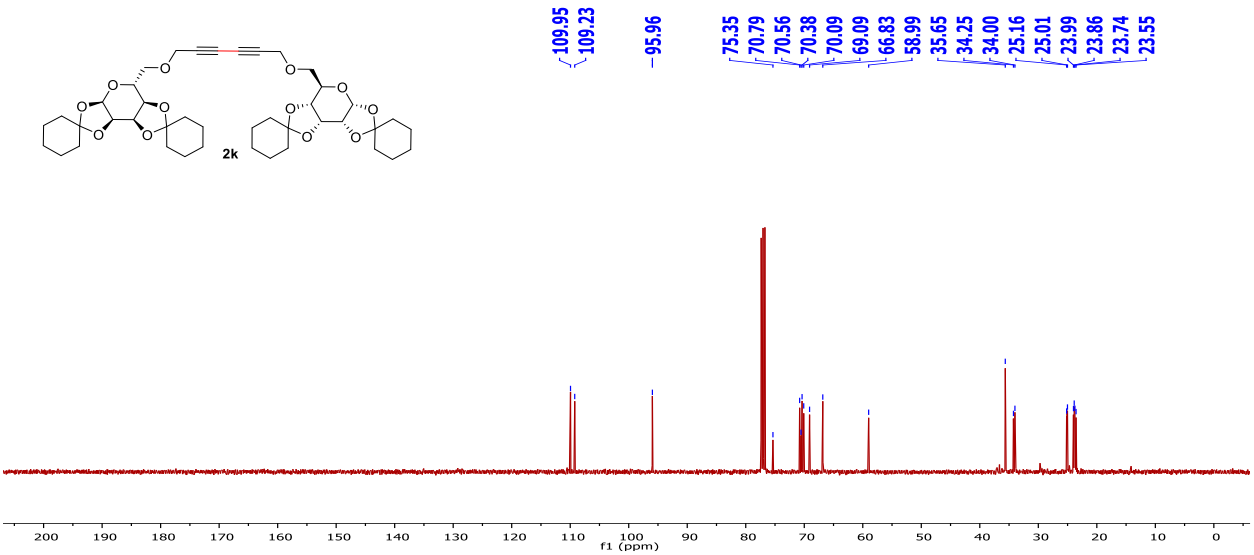


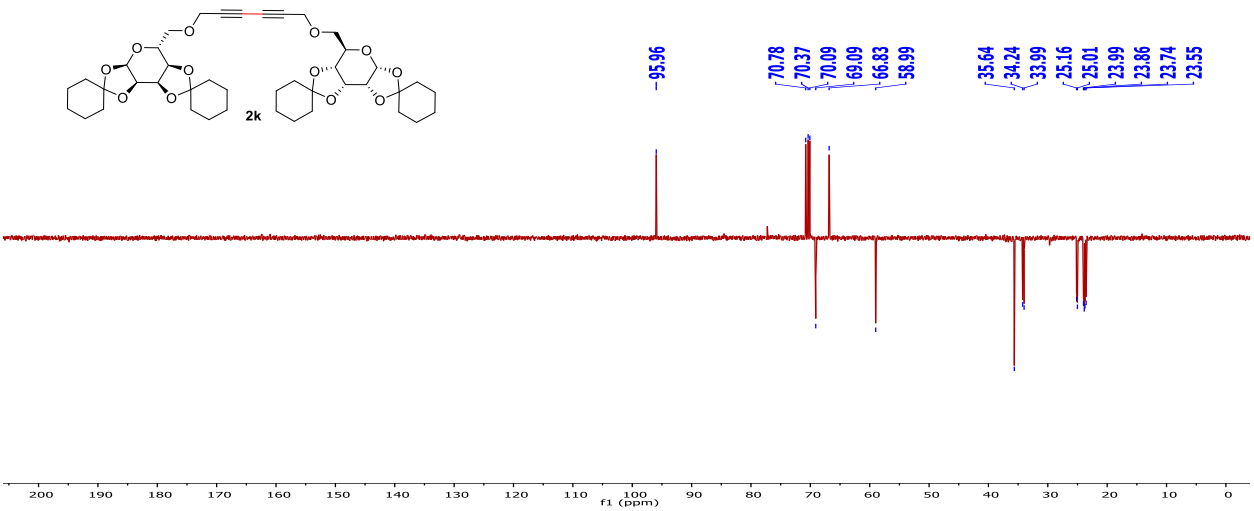
^{1}H NMR (400 MHz, $CDCl_3$) of 2k



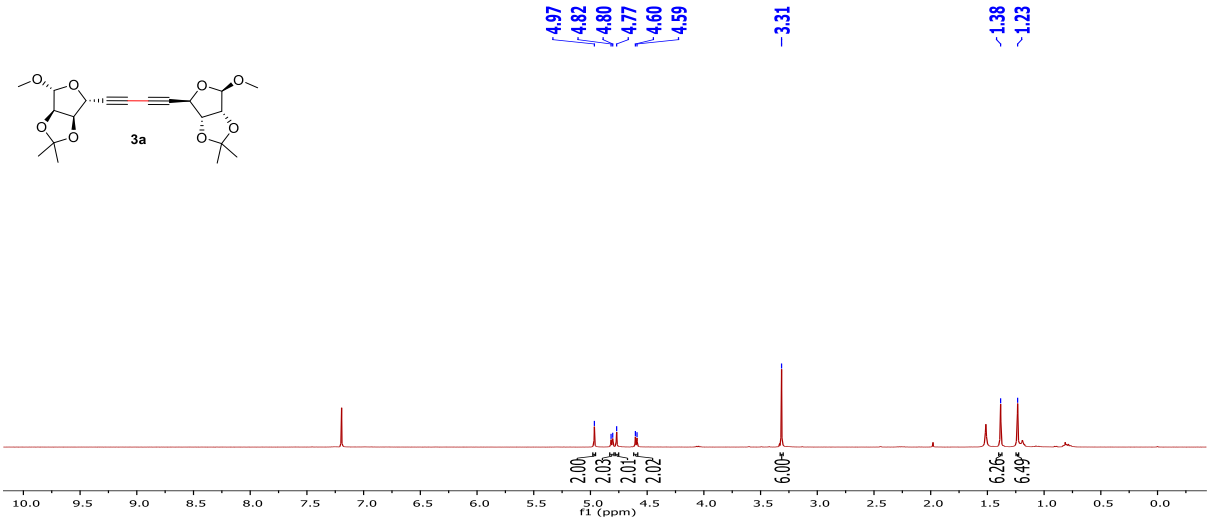
^{13}C NMR (400 MHz, $CDCl_3$) of 2k



DEPT 135 (101 MHz, $CDCl_3$) of 2k



^{1}H NMR (400 MHz, $CDCl_3$) of 3a



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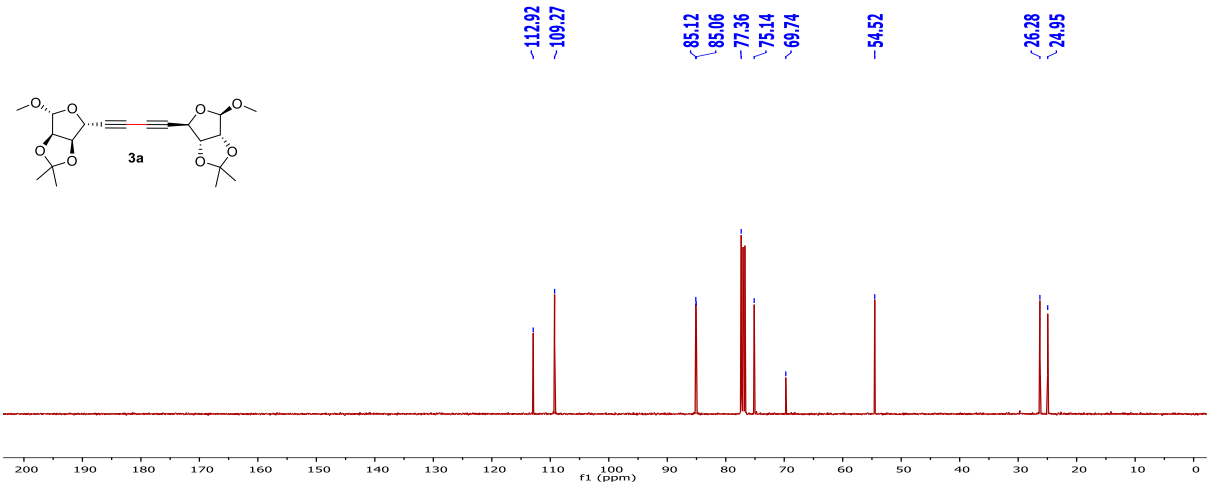
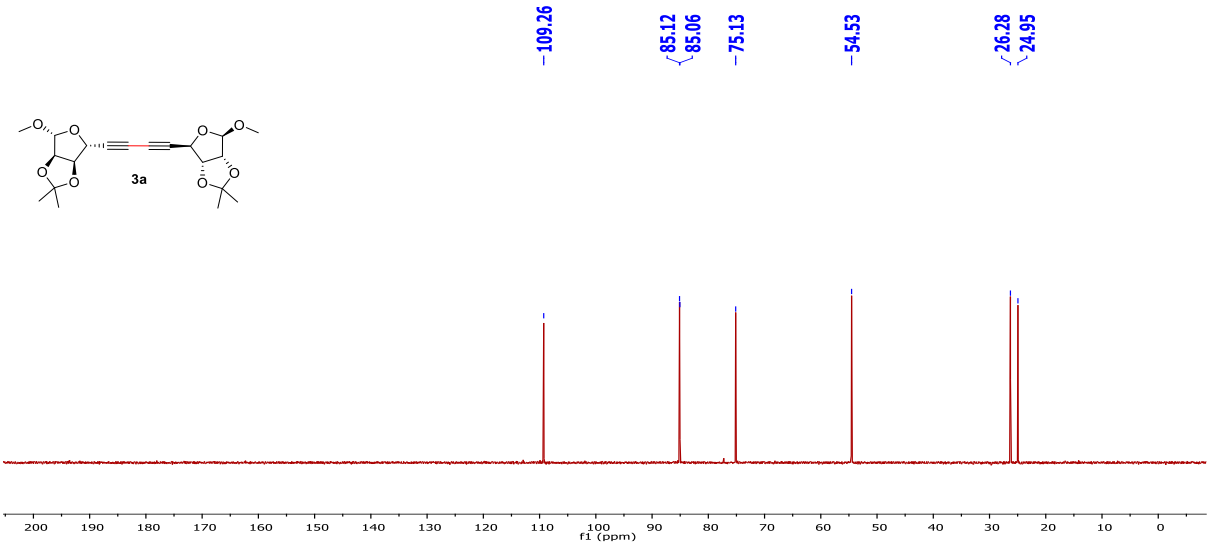
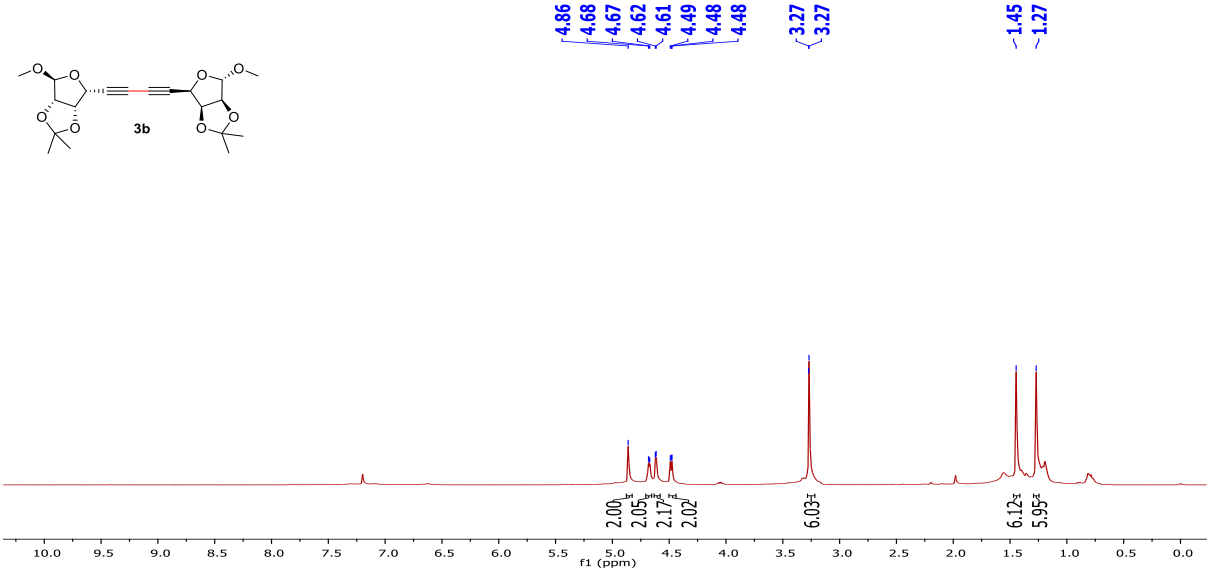


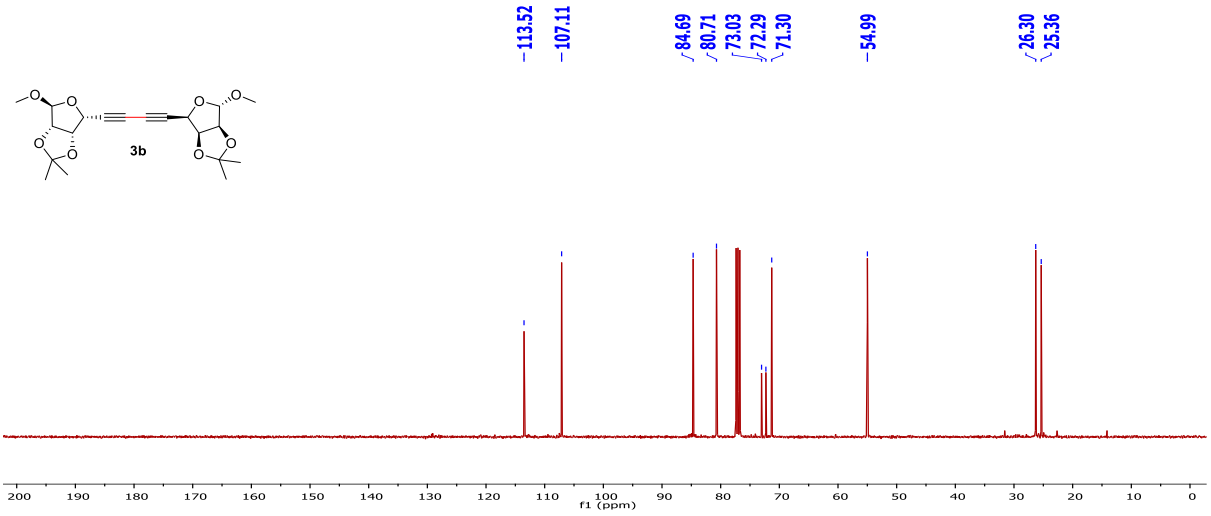
DEPT 135 (101 MHz, $CDCl_3$) of 3a



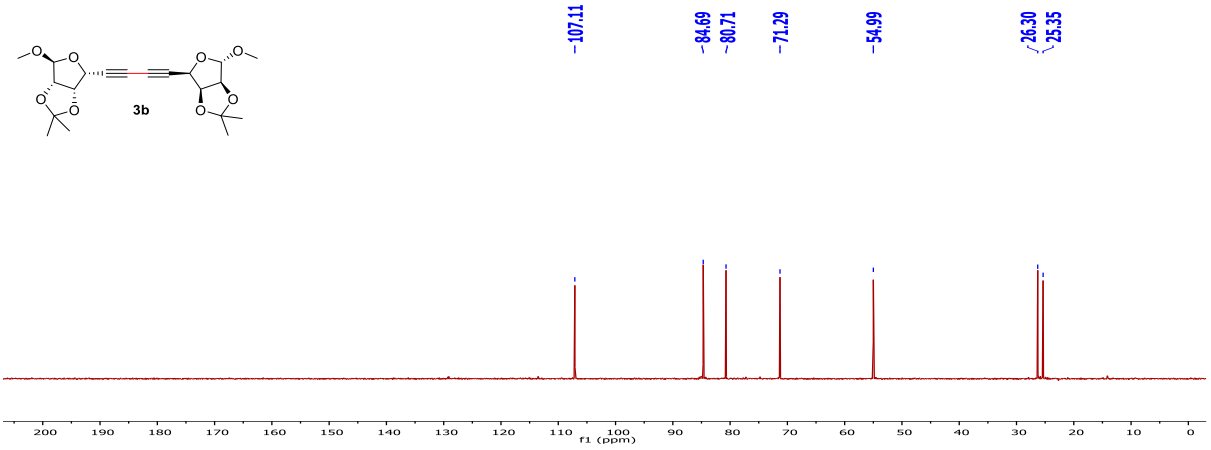
^{1}H NMR (400 MHz, $CDCl_3$) of 3b



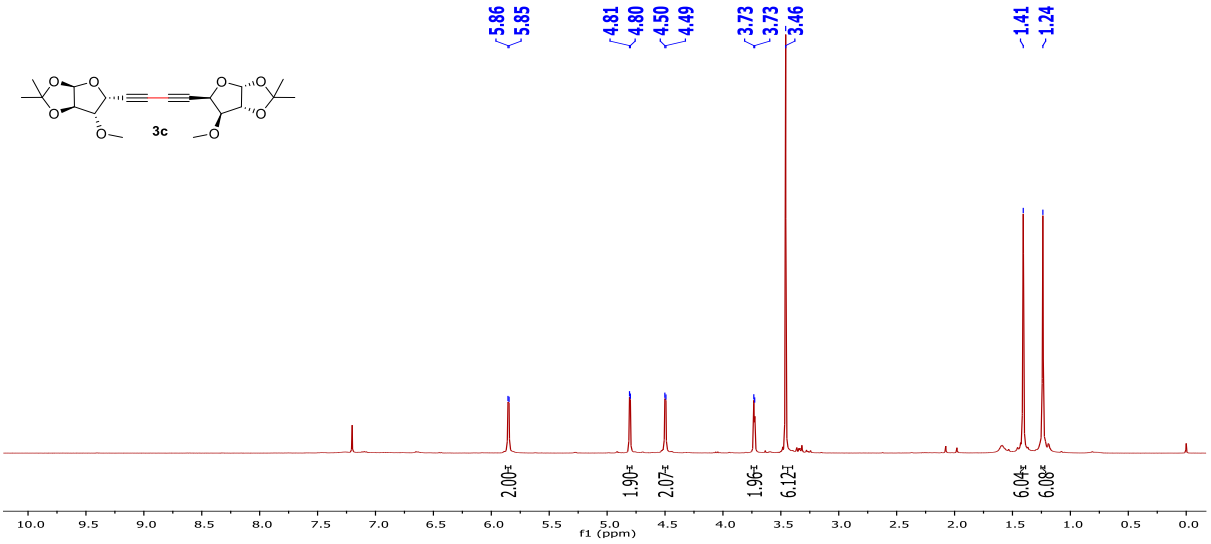
^{13}C NMR (400 MHz, $CDCl_3$) of 3b



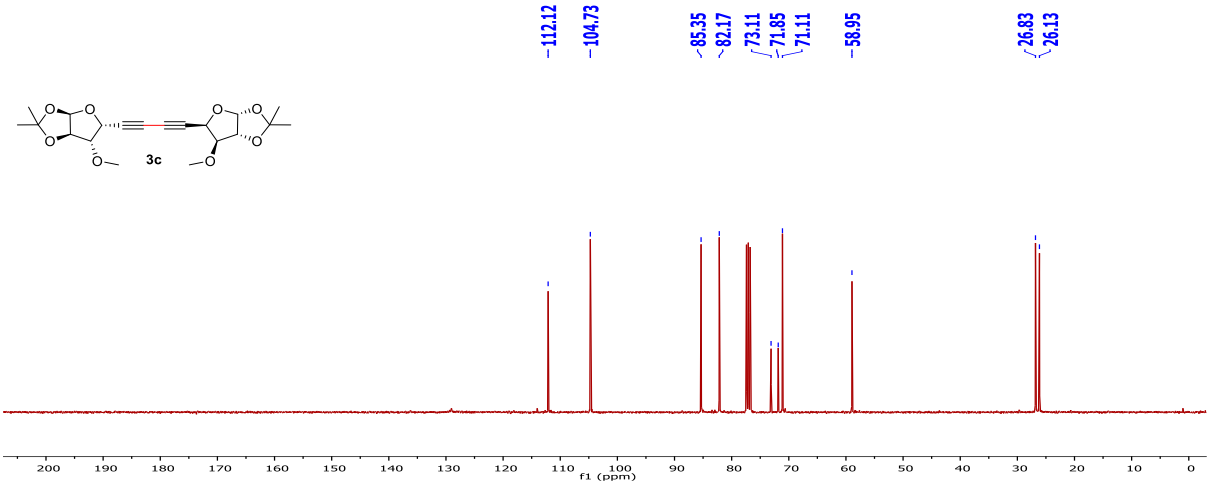
DEPT 135 (101 MHz, $CDCl_3$) of 3b



^{1}H NMR (400 MHz, $CDCl_3$) of 3c



^{13}C NMR (400 MHz, $CDCl_3$) of 3c



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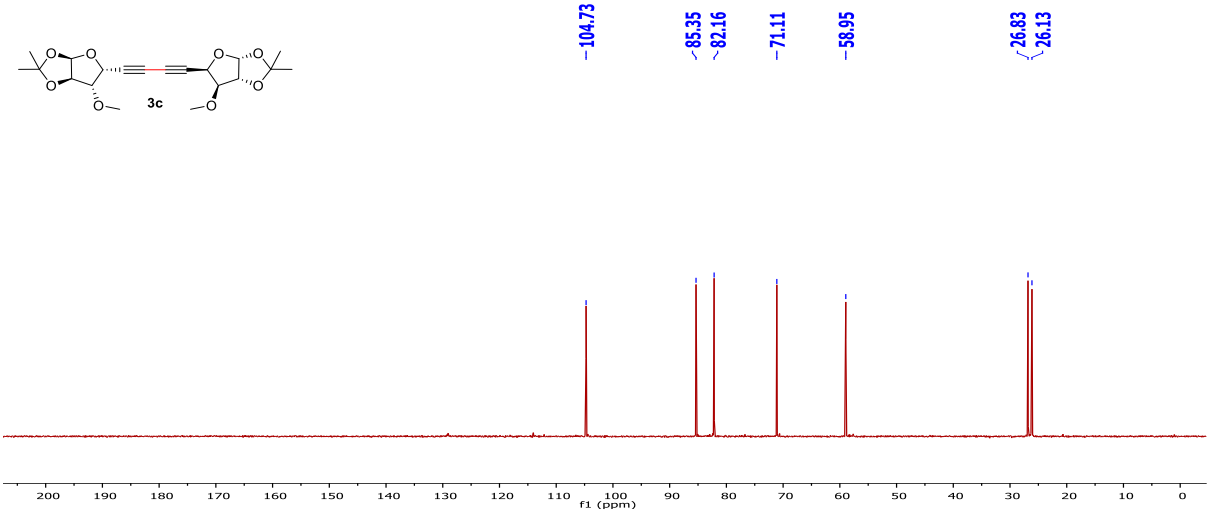
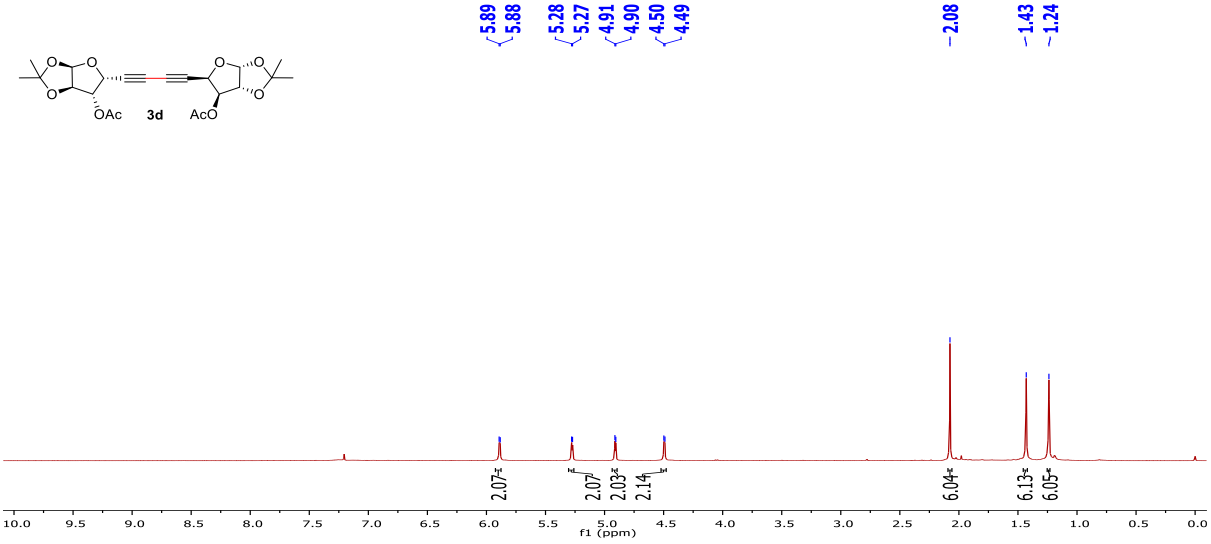
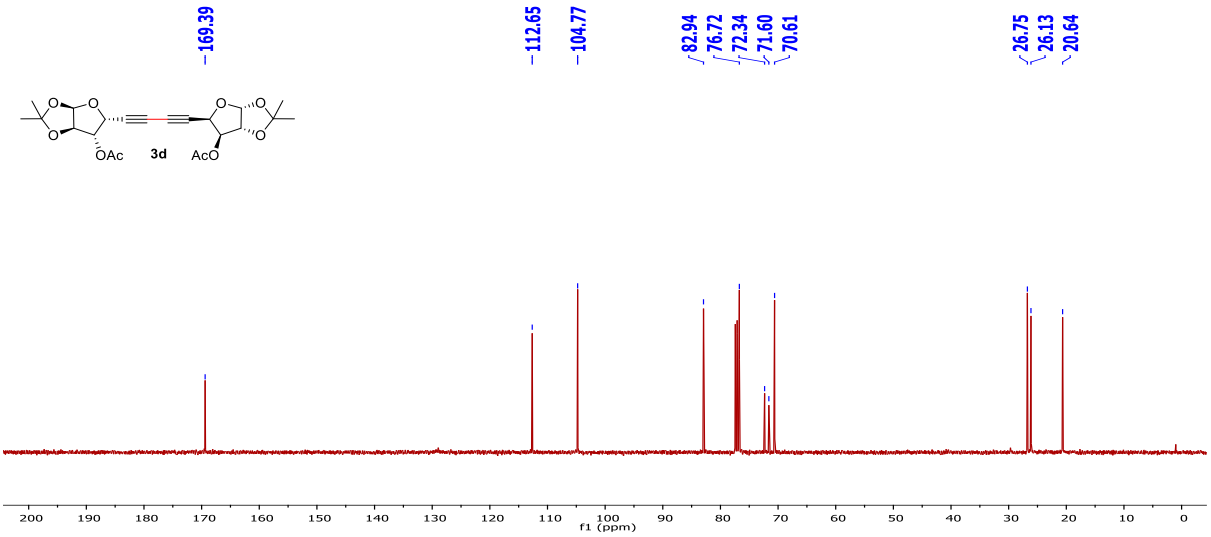


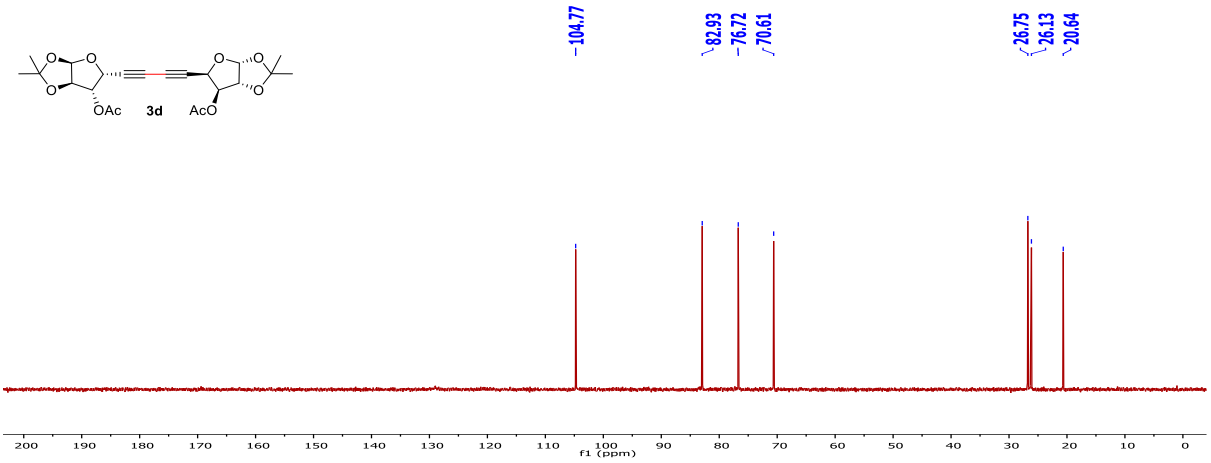
^{1}H NMR (400 MHz, $CDCl_3$) of 3d



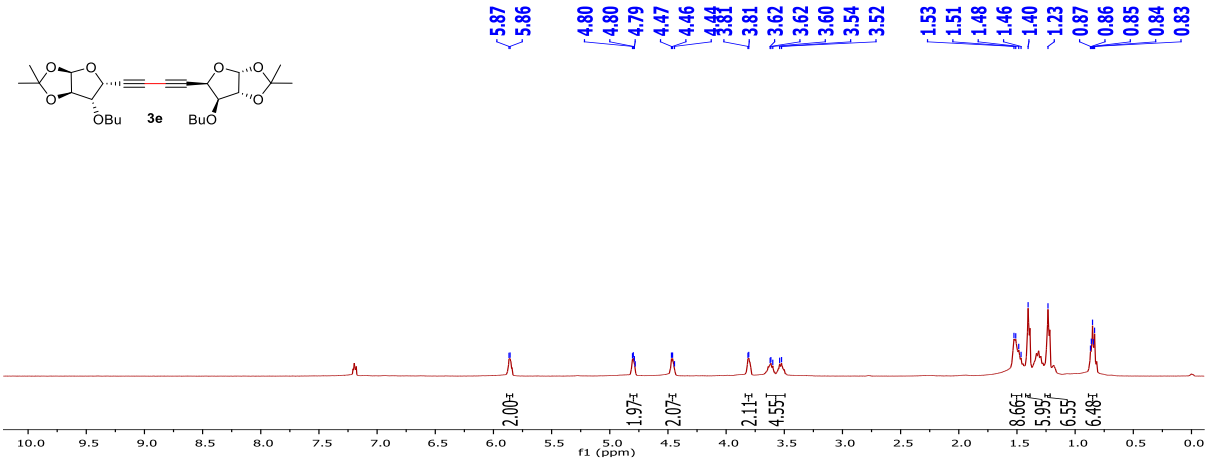
^{13}C NMR (400 MHz, $CDCl_3$) of 3d



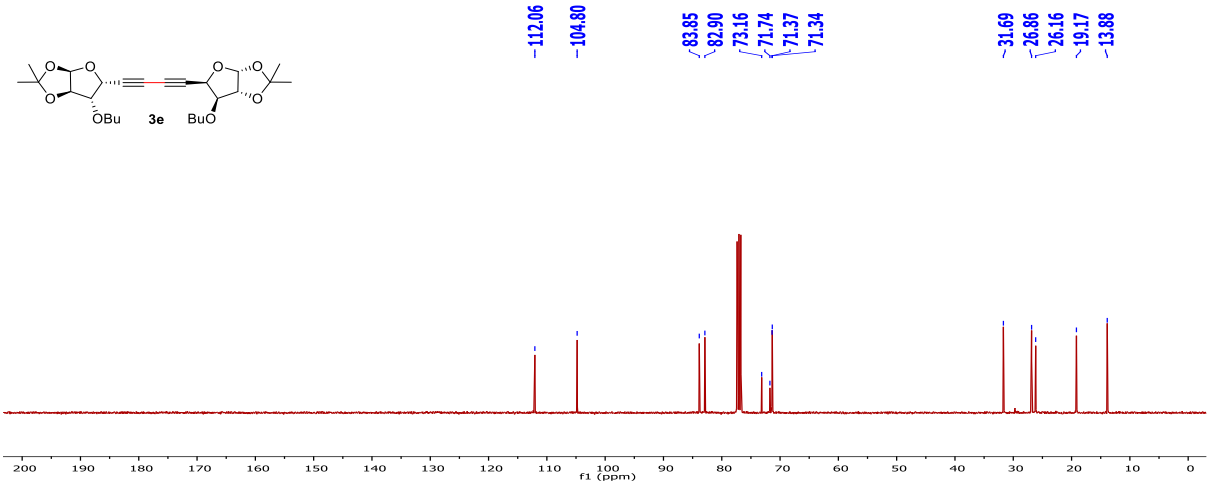
DEPT 135 (101 MHz, $CDCl_3$) of 3d



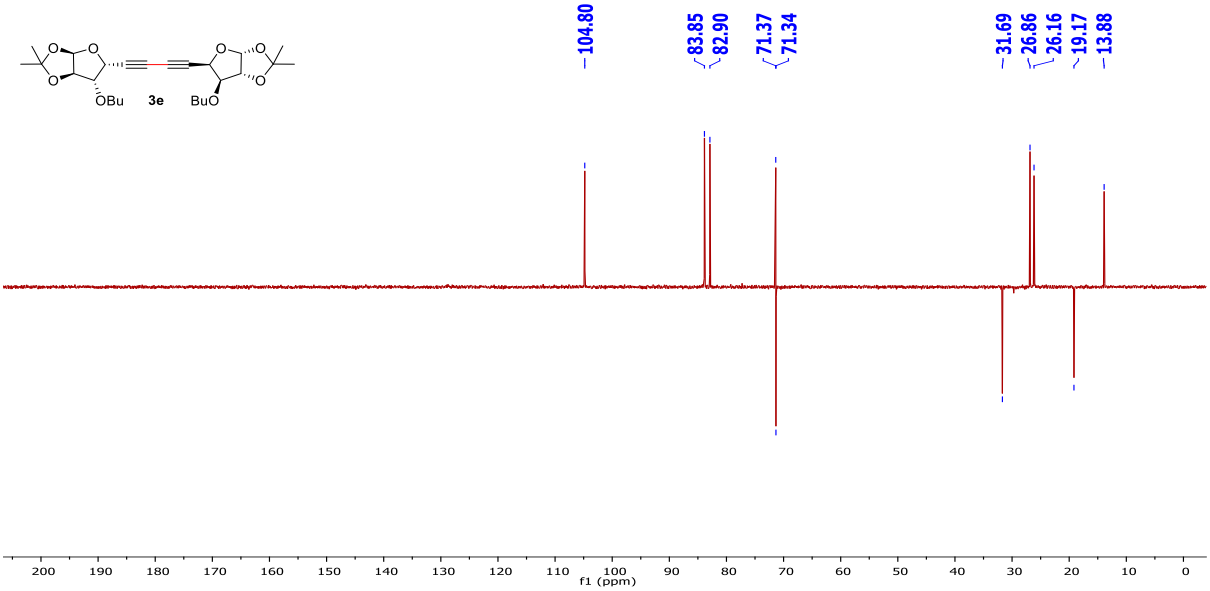
^{1}H NMR (400 MHz, $CDCl_3$) of 3e



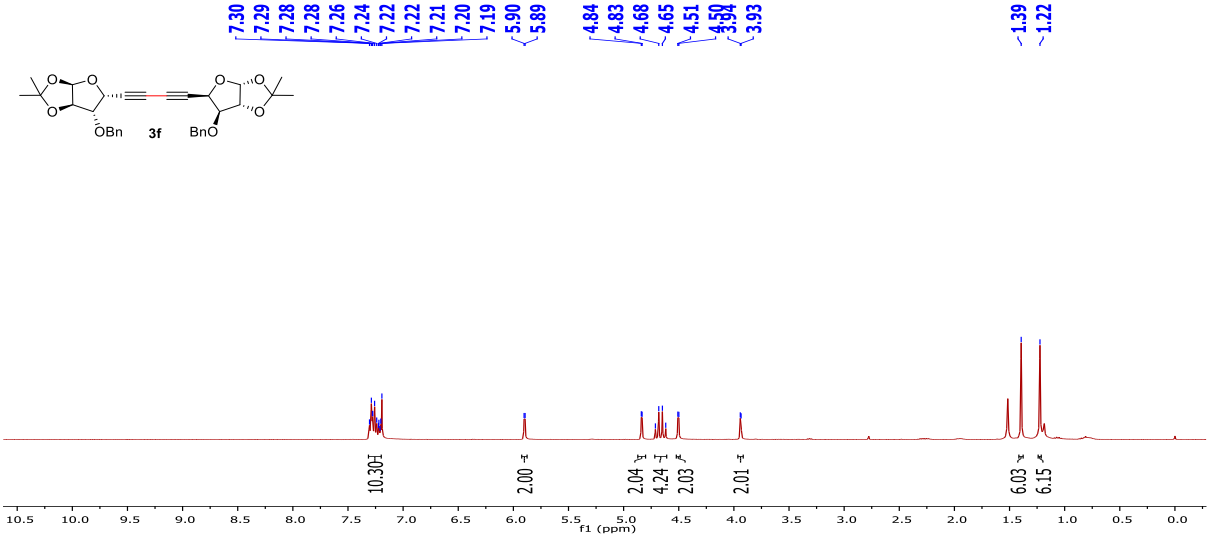
^{13}C NMR (400 MHz, $CDCl_3$) of 3e



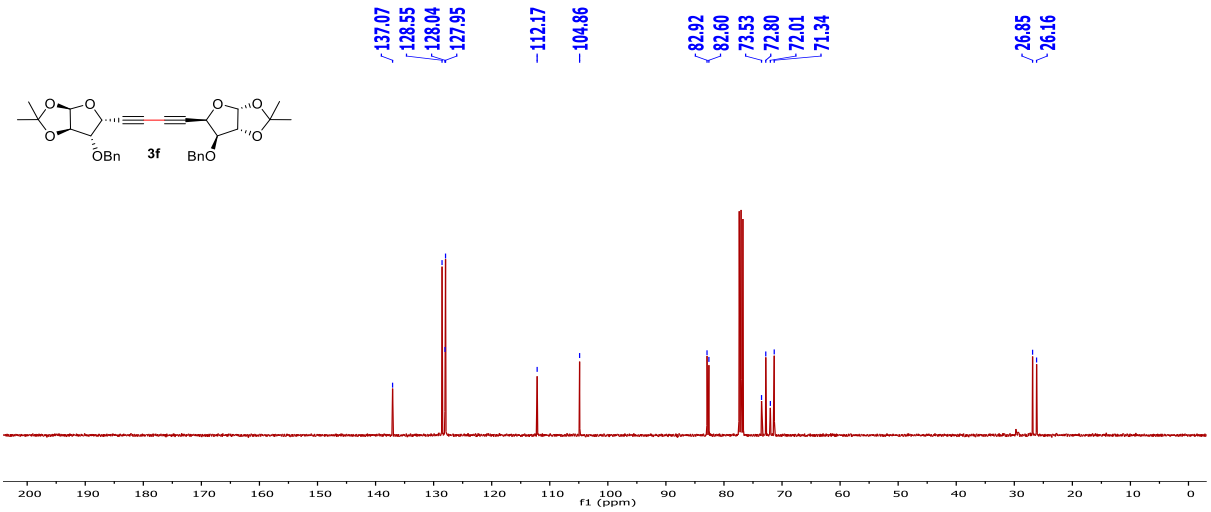
DEPT 135 (101 MHz, $CDCl_3$) of 3e



^{1}H NMR (400 MHz, $CDCl_3$) of 3f



^{13}C NMR (400 MHz, $CDCl_3$) of 3f



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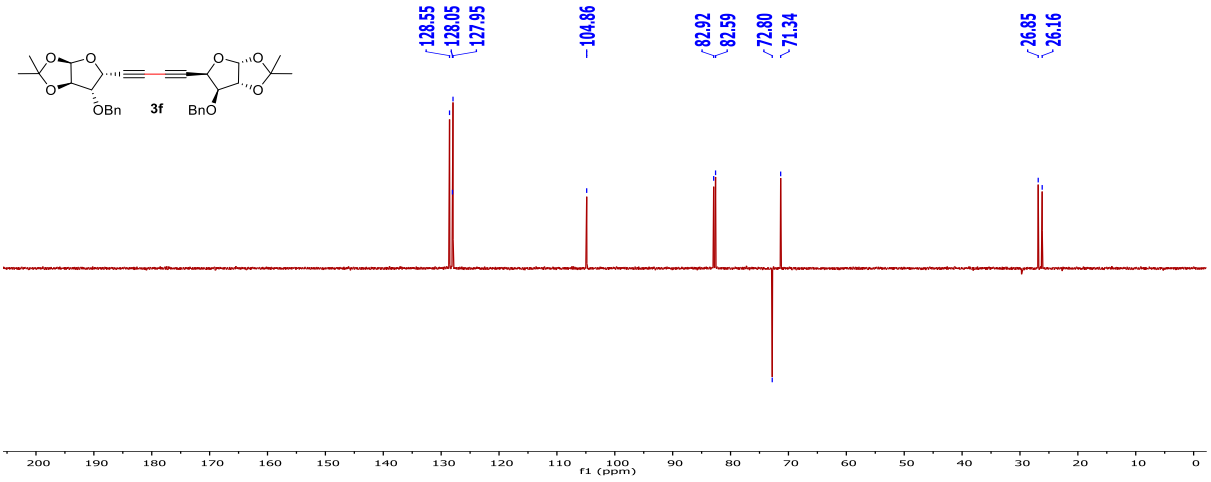
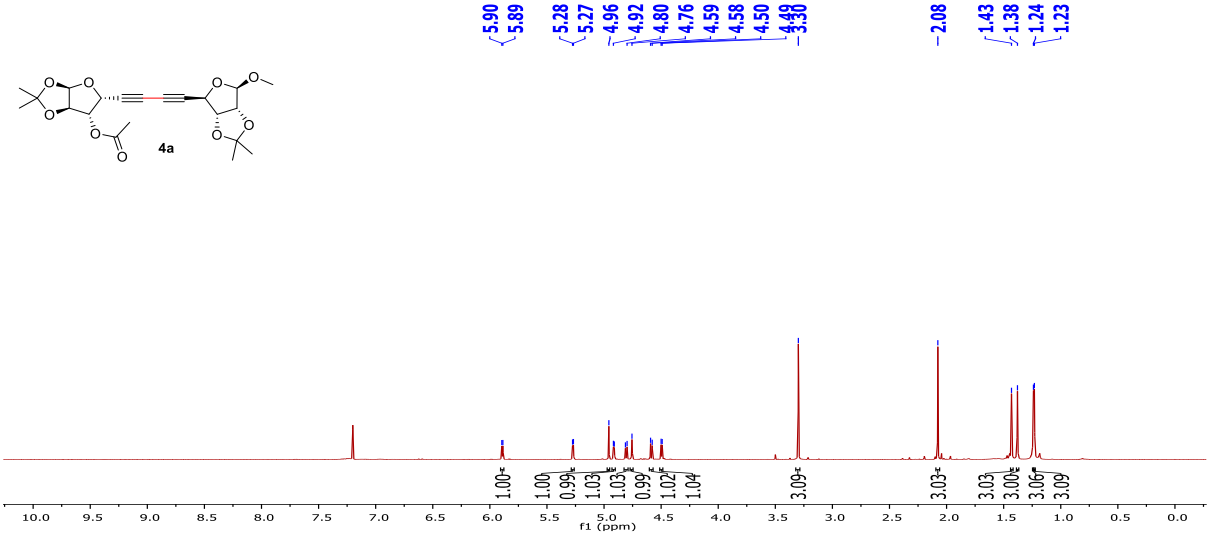
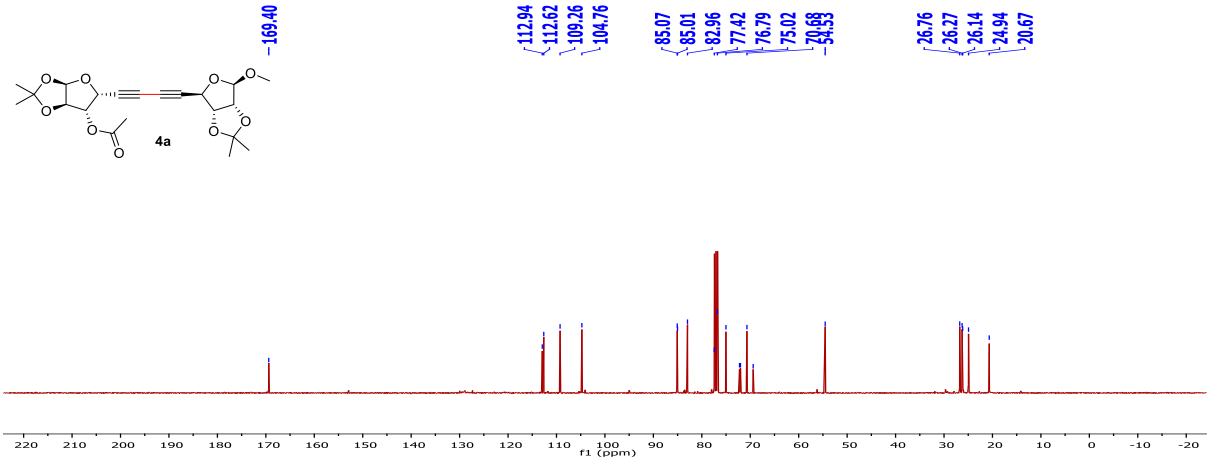


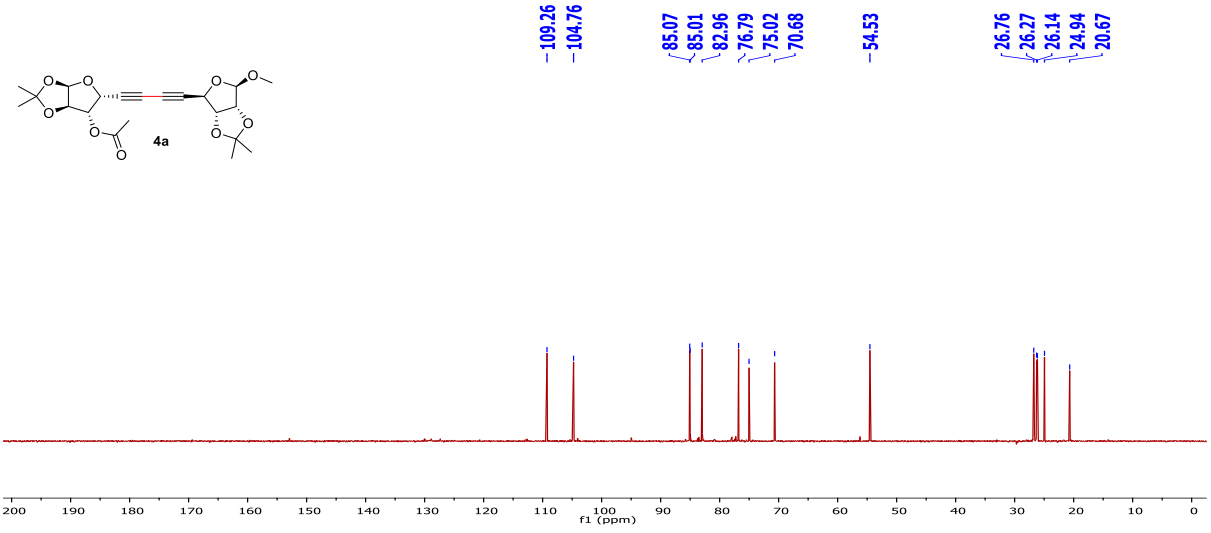
^{1}H NMR (400 MHz, $CDCl_3$) of 4a



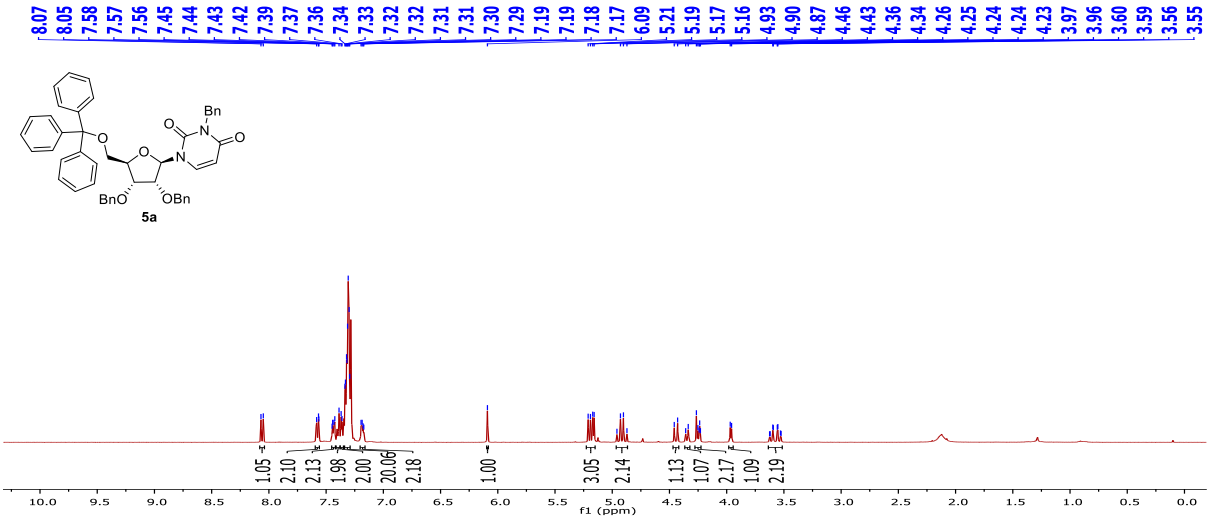
^{13}C NMR (400 MHz, $CDCl_3$) of 4a



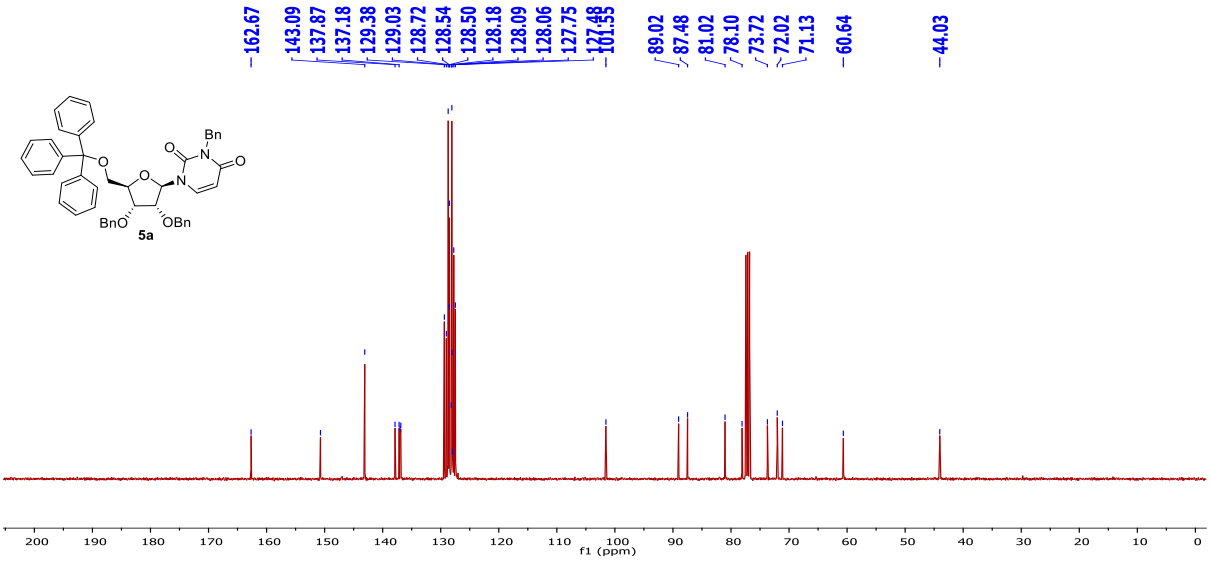
DEPT 135 (101 MHz, $CDCl_3$) of 4a



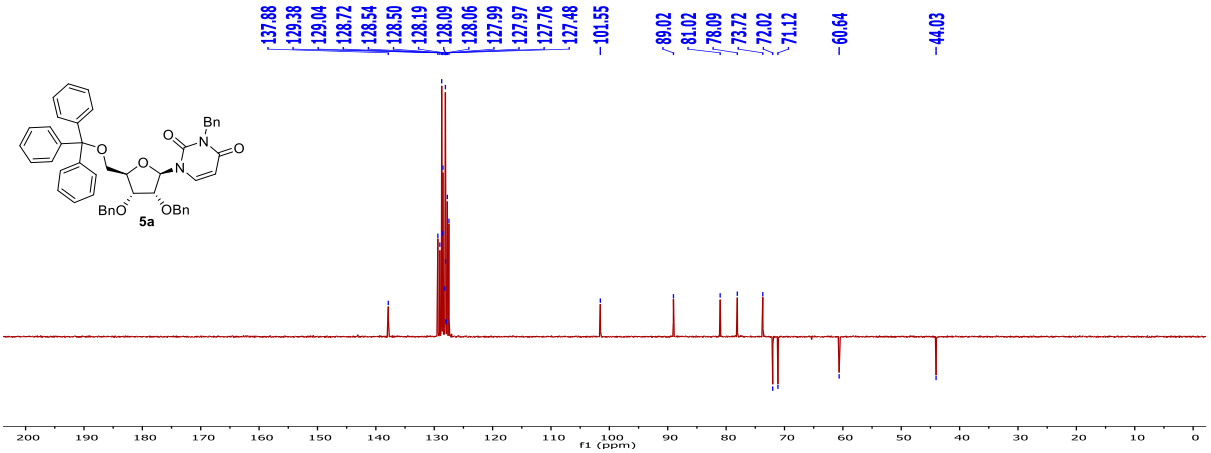
^{1}H NMR (400 MHz, $CDCl_3$) of 5a



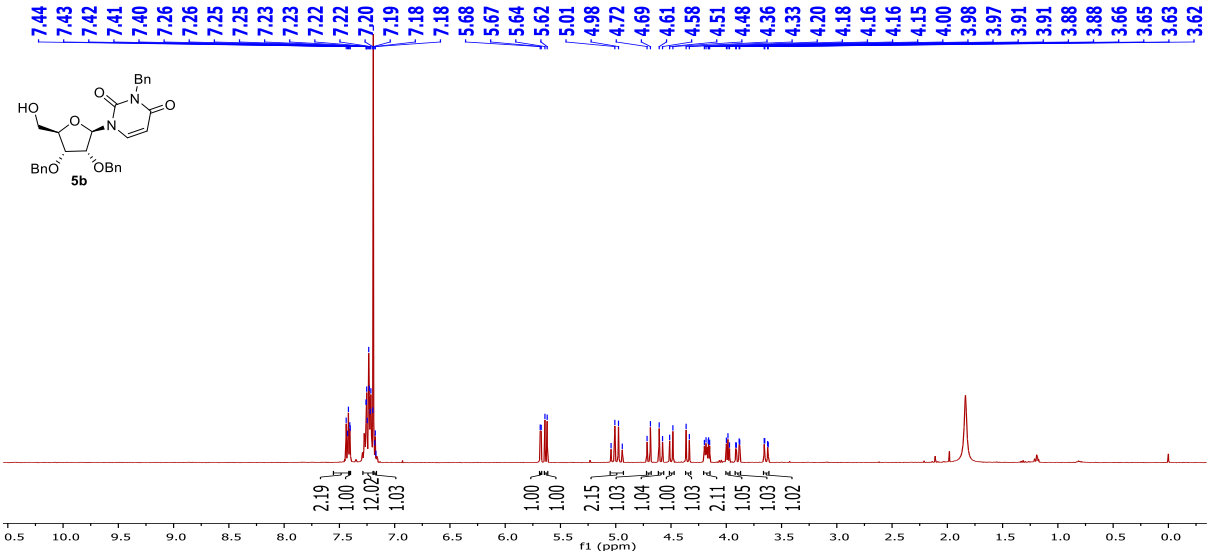
^{13}C NMR (400 MHz, $CDCl_3$) of 5a



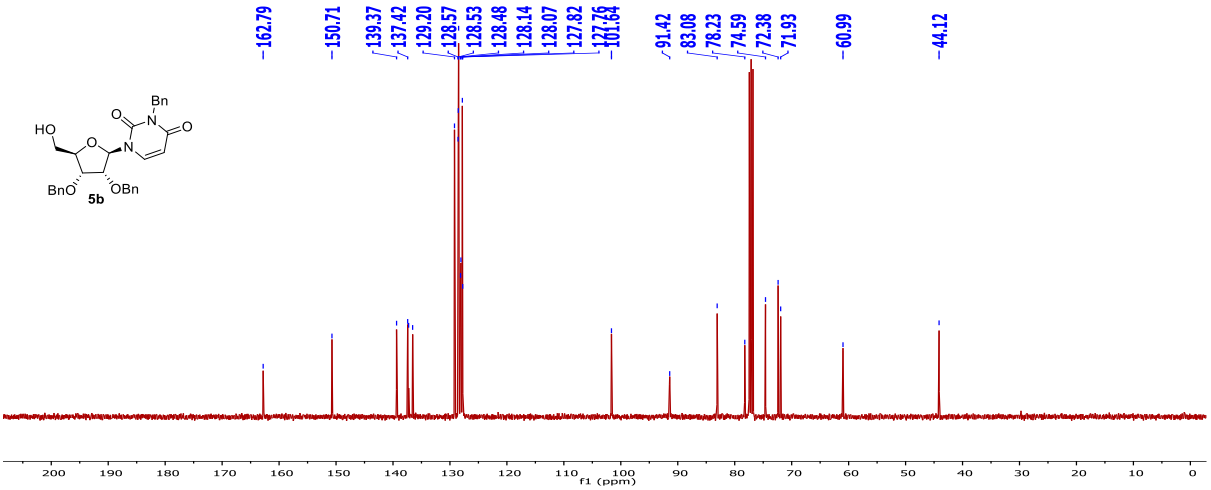
DEPT 135 (101 MHz, $CDCl_3$) of 5a



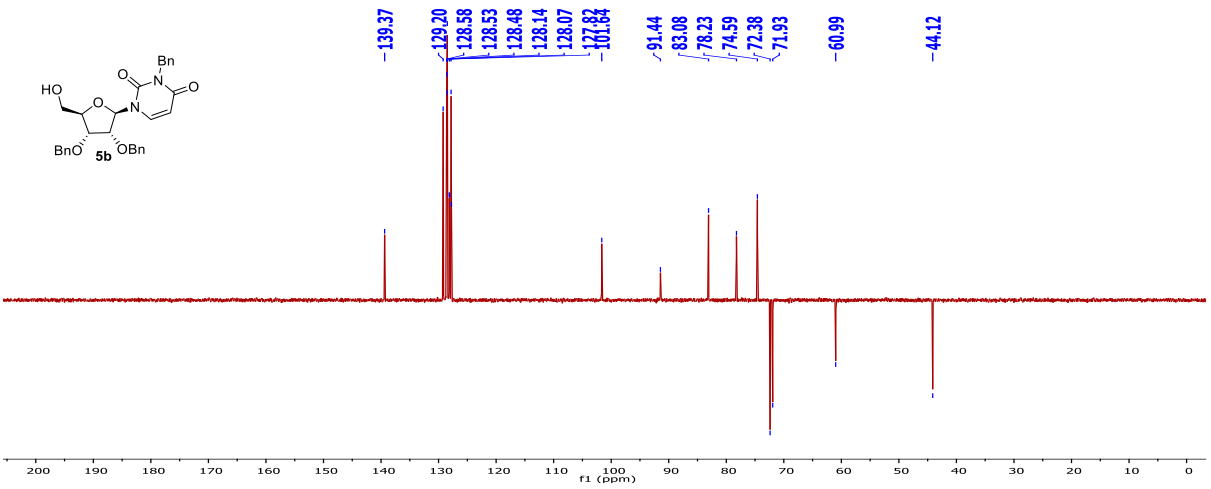
^{1}H NMR (400 MHz, $CDCl_3$) of 5b



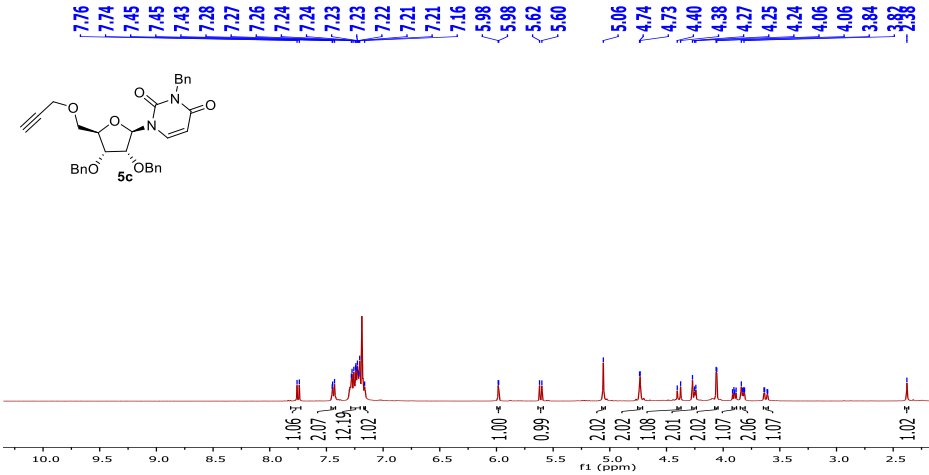
^{13}C NMR (400 MHz, $CDCl_3$) of 5b



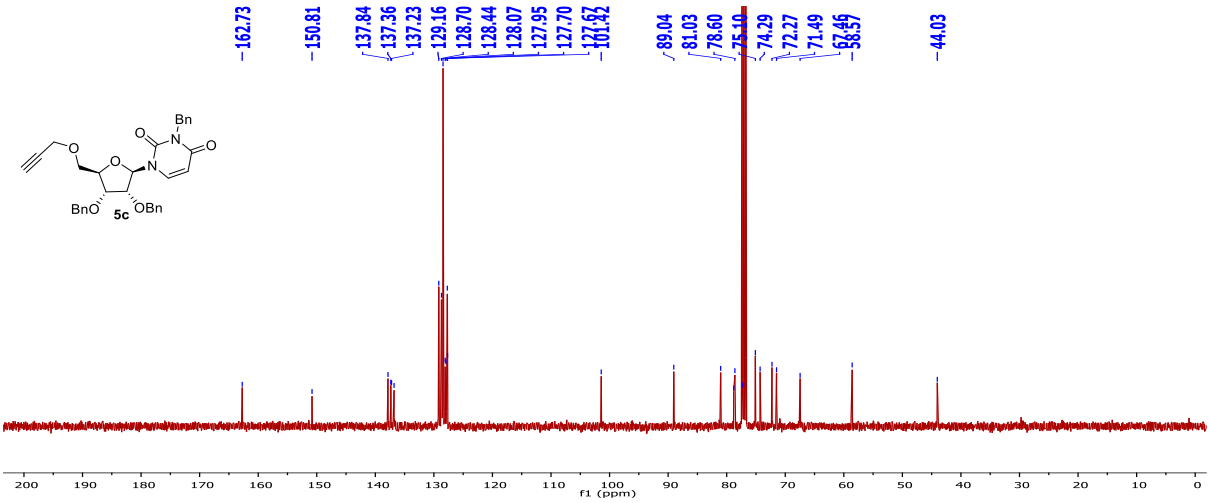
DEPT 135 (101 MHz, $CDCl_3$) of 5b



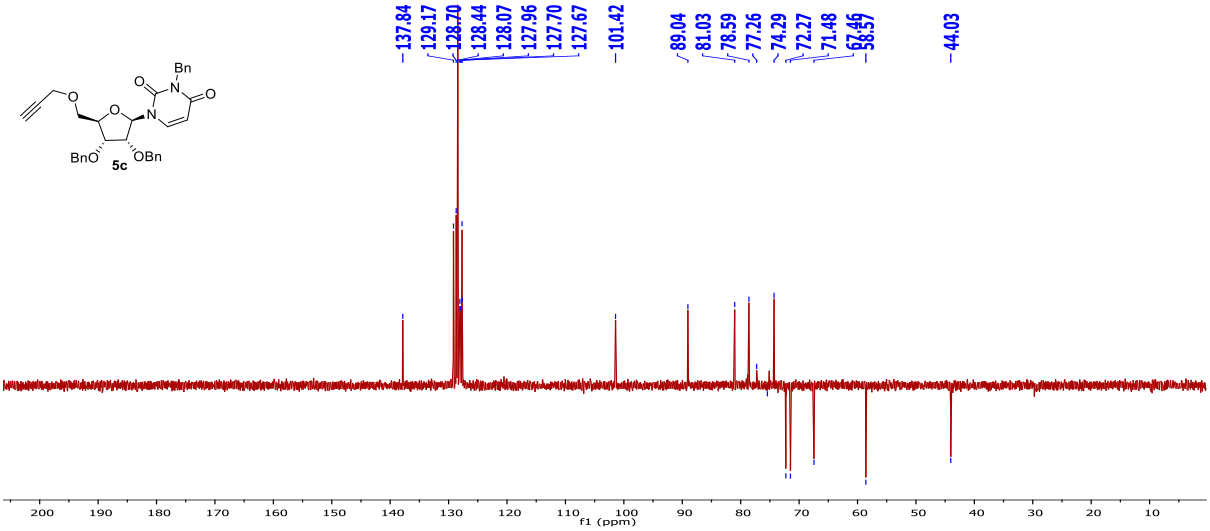
^{1}H NMR (400 MHz, $CDCl_3$) of 5c



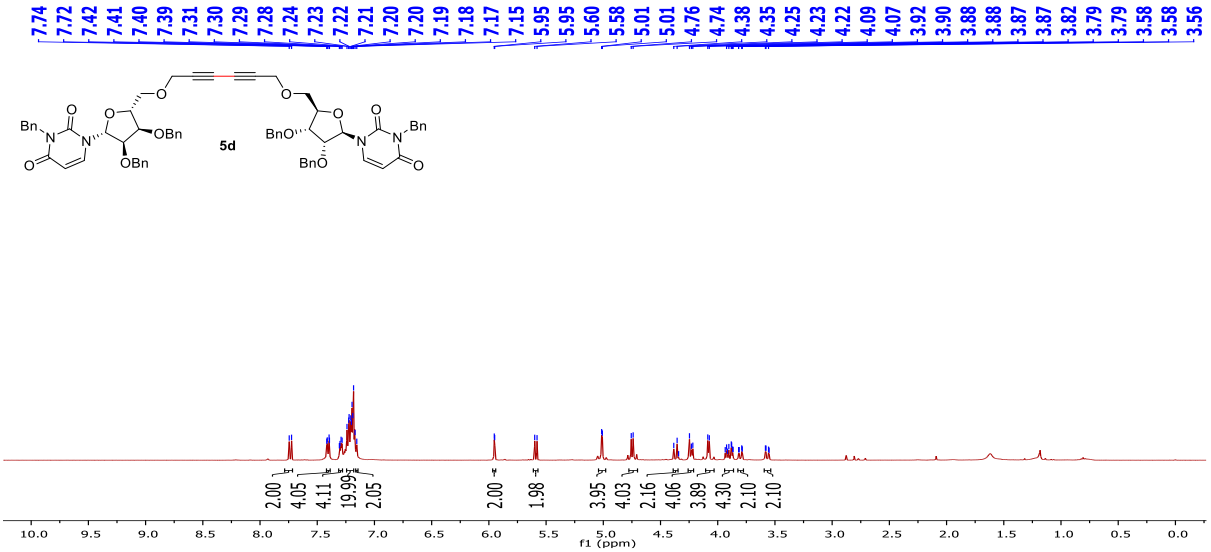
^{13}C NMR (400 MHz, $CDCl_3$) of 5c



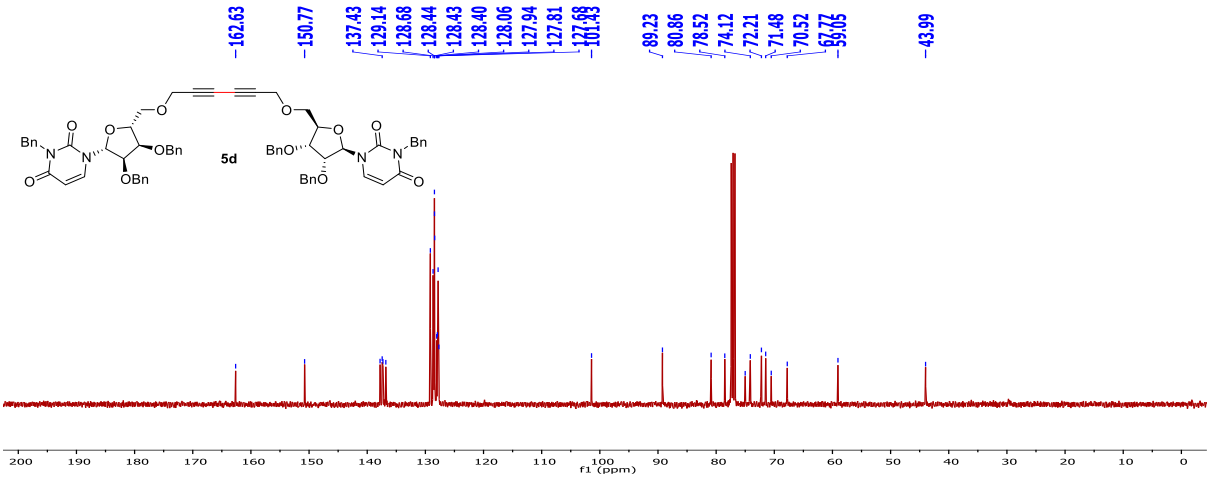
DEPT 135 (101 MHz, $CDCl_3$) of 5c



^{1}H NMR (400 MHz, $CDCl_3$) of 5d



^{13}C NMR (400 MHz, $CDCl_3$) of 5d



DEPT 135 (101 MHz, $CDCl_3$) of 5d