Supporting Information

Novel syntheses of aryl quinoxaline *C*-nucleoside analogs by mild and efficient three-component sequential reactions

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Contents

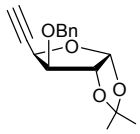
General

Infrared spectra were recorded on a Shimadzu IR-435 instrument in the 400–4000 cm^{-1} region. NMR spectra were recorded with a Bruker DPX-400 spectrometer. Chemical shifts are given as δ values and are referenced to Me_4Si or to the residual solvent signal 7.26 for $CDCl_3$. Data were given as follows: chemical shift in ppm, multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet, br = broad), coupling constant (J/Hz). ^{13}C NMR spectra were recorded at 100 MHz. Internal references of carbon 77.16 was used for $CDCl_3$. HRMS-ESI spectra were recorded on Waters Micromass Q-Tof Micro™ spectrometer with samples dissolved in CH_3OH. Optical rotations were measured at the sodium D line (589 nm) in a microcell (10 cm, 1 mL) at 20 ℃and are in units of degree·mL/(g·dm). Thin-layer chromatography (TLC) was carried out on glass plates coated with Silica GelF_{254}. The zones were detected with UV light when possible, or by charring with 1:9 concd H_2SO_4–EtOH followed by heating. Flash chromatography was performed with silica gel 60.

General procedure for the preparation of terminal sugar alkynes 1a-1e[1]

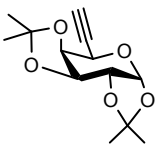
To a mixture of zinc (3 eq), PPh_3 (3 eq) and dry CH_2Cl_2 at 0℃, a solution of CBr_4 (2 eq) in dry CH_2Cl_2 was added dropwise for 15 min with stirring and then a solution of sugar aldehyde[2] (1.0 eq) in dry CH_2Cl_2 was added dropwise for 10min. The mixture was stirred at rt for 6 to 8 h until TLC indicated the complete conversion of sugar aldehyde. The mixture was evaporated. Flash chromatography on silica gel (6:1 - 3:1 petroleum ether-EtOAc) gave a syrup. A dry THF solution of the syrup (1.0 eq) was treated with *n*-butyllithium (2.5 eq) at -45 ℃ until TLC indicated the completion of the reaction. The solution was quenched by water and then evaporated. The residue was dissolved in EtOAc, then washed with water and brine, dried over Na_2SO_4 and evaporated. Flash chromatography on silica gel (5:1 - 3:1 petroleum ether-EtOAc) gave **1a-1e**.

3-*O*-Benzyl-5,6-dideoxy-1,2-*O*-isopropylidene-*α*-D-*xylo*-hex-5-ynofuranose (1a)[3]



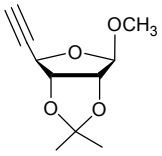
Colourless oil, 72% yield; ^1H NMR (400 MHz, $CDCl_3$) δ 7.40-7.27 (m, 5H, Ar*H*), 5.96 (d, 1H, $J_{1,2}$ = 3.6 Hz, H-1), 4.83 (t, 1H, $J_{4,6}$ = 2.4 Hz, $J_{4,3}$ = 2.8 Hz, H-4), 4.81 (d, B of AB, 1H, J = 12.4 Hz, PhCH_B), 4.74 (d, A of AB, 1H, J = 12.4 Hz, PhCH_A), 4.58 (d, 1H, $J_{2,1}$ = 3.6 Hz, H-2), 4.02 (d, 1H, $J_{3,4}$ = 2.8 Hz, H-3), 2.64 (d, 1H, $J_{6,4}$ = 2.4 Hz, H-6), 1.49, 1.31 (2 s, each 3H, 2CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 137.37 (aromatic C), 128.47, 127.95, 127.80 (5 aromatic *C*H), 111.97 (isopropylidene C), 104.74 (C-1), 82.83 (C-2), 82.43 (C-3), 77.62 (C-5), 76.58 (C-6), 72.60 (Ph*C*H_2O), 70.70 (C-4), 26.82, 26.17 (2 *C*H_3).

6,7-Dideoxy-1,2:3,4-di-*O*-isopropylidene-*α*-D-*galacto*-hept-6-ynopyranose (1b)[3]



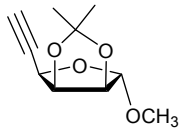
Colourless oil, 76%; ^1H NMR (400 MHz, $CDCl_3$) δ 5.51 (d, 1H, $J_{1,2}$ = 4.8 Hz, H-1), 4.60-4.58 (m, 2H, H-3, H-5), 4.29-4.25 (m, 2H, H-2, H-4), 2.51 (d, 1H, J = 2.0 Hz, H-7), 1.48, 1.47, 1.32, 1.27 (4 s, each 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 109.88, 108.87, 96.35, 78.78, 74.49, 72.56, 70.59, 70.11, 59.97, 26.06, 25.92, 24.74, 24.33.

1-*O*-Methyl-5,6-dideoxy-2,3-*O*-isopropylidene-*β*-D-*ribo*-hex-5-ynofuranoside (1c)[3]



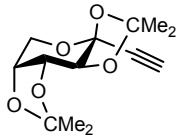
White solid, 63%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.97 (s, 1H, H-1), 4.78 (d, 1H, $J_{3,2}$ = 6.0 Hz, H-3), 4.68 (d, 1H, $J_{4,6}$ = 2.8 Hz, H-4), 4.58 (d, 1H, $J_{2,3}$ = 6.0 Hz, H-2), 3.27 (s, 3H, OCH_3), 1.34, 1.20 (2 s, each 3H, 2CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 112.48 (isopropylidene C), 109.22 (C-1), 85.28 (C-3), 85.09 (C-2), 81.46 (C-5), 74.59 (C-4), 74.07 (C-6), 54.14 (O*C*H$_3$), 26.15, 24.81 (2*C*H$_3$).

1-*O*-Methyl-5,6-dideoxy-2,3-*O*-isopropylidene-*α*-D-*lyxo*-hex-5-ynofuranoside (1d)[3]



Yellow solid, 74%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.90 (s, 1H, H-1), 4.72 (d, $J_{4,3}$ = 4 Hz, 1H, H-4), 4.60 (dd, 1H, $J_{3,2}$ = 5.6 Hz, $J_{3,4}$ = 4 Hz, H-3), 4.53 (d, 1H, $J_{2,3}$ = 5.6 Hz, H-2), 3.32 (s, 3H, OCH_3), 1.50, 1.32 (2 s, each 3H, 2 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 113.43 (isopropylidene C), 107.17 (C-1), 84.82 (C-2), 80.57 (C-4), 77.36 (C-5), 76.60 (C-6), 70.63 (C-3), 54.98 (O*C*H$_3$), 26.29, 25.30 (2 *C*H$_3$).

1,2-Dideoxy-3,4:5,6-di-*O*-isopropylidene-*β*-D-*arabino*-hept-1-yn-3-ulo-3,7-pyranose (1e)

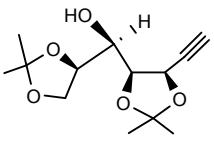


Colourless oil, 80%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.53 (dd, 1H, $J_{5,4}$ = 2.0 Hz, $J_{5,6}$ = 8.0 Hz, H-5), 4.43 (d, 1H, $J_{4,5}$ = 2.0 Hz, H-4), 4.18-4.15 (m, 1H, H-6), 3.73-3.67 (m, 2H, H-7), 2.58 (s, 1H, H-1), 1.46, 1.45, 1.40, 1.29 (4 s, each 3H, 4 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 109.59, 109.54 (2 isopropylidene C), 95.79 (C-3), 81.82 (C-2), 75.72 (C-4), 72.40 (C-1), 70.44 (C-5), 70.16 (C-6), 61.16 (C-7), 26.12, 25.99, 24.63, 24.23 (4 *C*H$_3$); HRMS (ESI) *m/z* Calcd for $C_{13}H_{18}O_5Na$ $[M+Na]^+$: 277.1052. Found: 277.1058.

General procedure for the preparation of terminal sugar alkynes 1f-1g[4]

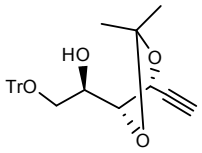
A mixture of sugar hemiacetal (10.0 mmol), anhydrous K_2CO_3 (3.0 eq) and MeOH (20 ml) was refluxed, to which Ohira's reagent (3.5 eq) is added dropwise for 6-8 h. TLC indicated the completion of the reaction. The mixture was evaporated to dryness and water (25 ml) was added. The solution was extracted with EtOAc, dried over Na_2SO_4 and evaporated. Flash chromatography on silica gel (6:1 - 4:1 petroleum ether-EtOAc) gave **1f-1g**.

3,4:6,7-Di-*O*-isopropylidene-1,2-dideoxy-D-*manno*-hex-1-ynitol (1f)[5,6]



Colourless oil,, 86%; ^{1}H NMR (400 Hz,$CDCl_3$) δ 4.68 (dd, 1H, $J_{3,1}$ = 1.4 Hz, $J_{3,4}$ = 7.6 Hz, H-3); 4.30 (dd, 1H, $J_{4,3}$ = 7.6 Hz, $J_{4,5}$ = 1.6Hz, H-4), 4.02-4.14 (m, 3H, H-6, H-7), 3.58 (brs, 1H, H-5), 2.56 (d, 1H, $J_{1,3}$ = 1.4 Hz,H-1), 2.23 (d, 1H, $J_{OH,5}$ = 7.6 Hz, OH), 1.53, 1.45, 1.44, 1.38 (4 s, each 3H, 4 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 11.01, 109.53 (2 isopropylidene C), 80.81 (C-4), 80.56 (C-2), 76.16 (C-6), 74.88 (C-1), 69.84 (C-5), 66.81 (C-7), 66.64 (C-3), 26.82, 26.65, 26.15, 25.27 (4 *C*H$_3$).

3,4-Isopropylidene-6-*O*-triphenylmethyl-1,2-dideoxy-D-*ribo*-hex-1-ynitol (1g)[6,7]



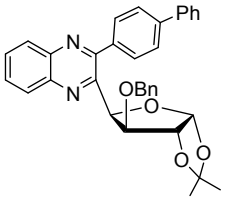
Colourless oil, 85%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50-7.28 (m, 15H, Ar*H*), 4.72 (dd, 1H, $J_{3,1}$ = 2.0 Hz, $J_{3,4}$ = 6.2Hz, H-3), 4.25-4.22 (m, 1H, H-4), 3.92-3.90 (m, 1H, H-5), 3.35-3.34 (m, 2H, H-6), 2.52 (d, 1H, $J_{OH,5}$ = 3.6 Hz, OH), 2.49 (d, 1H, $J_{1,3}$ = 2.0 Hz, H-1), 1.52, 1.40 (2 s, each 3H, C*H*$_3$).

General procedure for the syntheses of aryl quinoxaline *C*-nucleoside analogs (2aa-2gg)

A solution of aryl Iodide (0.81 mmol), $Pd(PPh_3)_2Cl_2$ (5 mol %), CuI (5 mol %) and Et_3N (3 ml) was degassed for 5 min, to which **1a-1g** (0.80 mmol) in Et_3N (4 ml) was added dropwise. The solution was stirred at rt until TLC indicated the completion of the sugar alkyne. The solution was evaporated and CH_2Cl_2 (10 ml) was added, washed with water. $RuCl_3 \cdot H_2O$ (1.3 mol %), $NaIO_4$ (2.4 mmol) and MeCN (5 ml) was added, and 1, 2- phenylenediamine (0.81 mol) was added later. The solution was stirred at rt until TLC indicated the completion of the reaction. The solution was washed with brine, dried over Na_2SO_4 and evaporated. Flash chromatography on silica gel (4:1-2:1 petroleum ether-EtOAc) gave the products **2aa-2gg**.

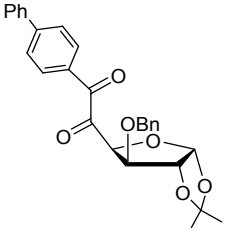
During the synthesis of **2aa**, the intermediate **5** was isolated according the similar procedure except that 1, 2- phenylenediamine was not added.

2-(3-*O*-Benzyl-1,2-*O*-isopropylidene-α-D-*xylo*-tetrofuranos-4-yl)-3-biphenylylquinoxaline (2aa)



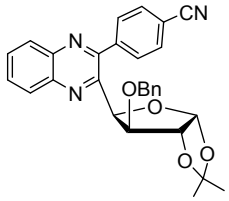
Pale yellow oil, 88%; R_f 0.35 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -70.9 (*c* 1.6, $CHCl_3$); FTIR (thin film): 3061, 3029, 2986, 2931, 1617, 1601, 1580, 1564, 1483, 1454, 766, 700 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.35-8.31 (m, 1H, Ar*H*), 8.19-8.15 (m, 1H, Ar*H*), 7.82-7.78 (m, 2H, Ar*H*), 7.65-7.62 (m, 4H, Ar*H*), 7.48 (t, 2H, *J* = 7.6 Hz, Ar*H*), 7.41-7.31 (m, 3H, Ar*H*), 7.19 (t, 1H, *J* = 7.4 Hz, Ar*H*), 7.09 (t, 2H, *J* = 7.6 Hz, Ar*H*), 6.75 (d, 2H, *J* = 7.4 Hz, Ar*H*), 6.30 (d, 1H, $J_{1',2'}$ = 4.0 Hz, H-1'), 5.87 (d, 1H, $J_{4',3'}$ = 4.0 Hz, H-4'), 4.71 (d, 1H, $J_{2',1'}$ = 4.0 Hz, H-2'), 4.46 (d, B of AB, 1H, *J* = 12.4 Hz, PhCH_B), 4.13 (d, A of AB, 1H, *J* = 12.4 Hz, PhCH_A), 3.86 (d, 1H, $J_{3',4'}$ = 4.0 Hz, H-3'), 1.43, 1.33 (2 s, each 3H, 2 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.44 (C-3), 149.43 (C-2), 141.99, 141.44, 140.35, 137.03 (6 aromatic C), 130.23, 130.00, 129.61, 129.13, 129.07, 128.93, 128.30, 127.94, 127.78, 127.59, 127.27, 127.22 (18 aromatic *C*H), 112.08 (isopropylidene C), 105.29 (C-1'), 83.05 (C-3'), 83.01 (C-2'), 80.03 (C-4'), 71.50 (Ph*C*H$_2$O), 26.96, 26.66 (2 *C*H$_3$); HRMS (ESI) *m/z* Calcd for $C_{34}H_{31}N_2O_4$ $[M+H]^+$: 531.2284. Found: 531.2296.

1-(3-*O*-Benzyl-1,2-*O*-isopropylidene-α-D-*xylo*-tetrofuranos-4-yl)-2-biphenylyl-1,2-diketone (5)



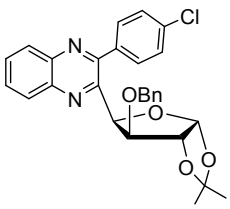
Pale yellow oil, 90%; R_f 0.30 (4:1 petroleum ether-EtOAc); FTIR (thin film): 3134, 2991, 2928, 2861, 1791, 1730 (CO), 1667, 1604, 1453, 1399, 746, 699 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.01 (d, 2H, *J* = 8.0 Hz, Ar*H*), 7.61 (d, 2H, *J* = 7.6 Hz, Ar*H*), 7.55 (d, 2H, *J* = 8.4 Hz, Ar*H*), 7.49 (t, 2H, *J* = 7.2 Hz, Ar*H*), 7.43 (d, 1H, *J* = 6.8 Hz, Ar*H*), 7.19-7.09 (m, 3H, Ar*H*), 6.95 (d, 2H, *J* = 7.2 Hz, Ar*H*), 6.14 (d, 1H, $J_{1',2'}$ = 3.2 Hz, H-1'), 5.70 (d, 1H, $J_{4',3'}$ = 4.2 Hz, H-4'), 4.68 (d, 1H, $J_{2',1'}$ = 3.2 Hz, H-2'), 4.62 (d, 1H, $J_{3',4'}$ = 4.2 Hz, H-3'), 4.53 (d, B of AB, 1H, *J* = 11.2 Hz, PhCH_B), 4.25 (d, A of AB, 1H, *J* = 11.2 Hz, PhCH_A), 1.55, 1.36 (2 s, each 3H, 2 CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.64 (C-1), 189.88 (C-2), 147.21, 139.70, 135.97 (4 aromatic C), 131.33, 129.14, 128.67, 128.38, 128.29, 128.14, 127.41, 127.26 (14 aromatic *C*H), 112.89 (isopropylidene C), 105.87 (C-1'), 83.87 (C-4'), 83.75 (C-3'), 82.14 (C-2'), 72.67 (Ph*C*H_2O), 27.33, 26.65 (2 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{28}H_{27}O_6$ $[M+H]^+$: 459.1808. Found: 459.1813.

2-(3-*O*-Benzyl-1,2-*O*-isopropylidene-α-D-*xylo*-tetrofuranos-4-yl)-3-(4-cyanophenyl)quinoxaline (2ab)



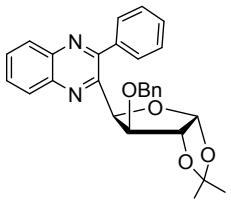
Pale yellow oil, 73%; R_f 0.28 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -59.5 (*c* 1.4, $CHCl_3$); FTIR (thin film): 2986, 2956, 2933, 2227 (CN), 1606, 1483, 1455, 848, 749cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.24-8.21 (m, 1H, Ar*H*), 8.13-8.10 (m, 1H, Ar*H*), 7.84-7.79 (m, 2H, Ar*H*), 7.63 (d, 2H, *J* = 8.0 Hz, Ar*H*), 7.32 (d, 2H, *J* = 8.0 Hz, Ar*H*), 7.18 (t, 1H, *J* = 7.6 Hz, Ar*H*), 7.06 (t, 2H, *J* = 7.6 Hz, Ar*H*), 6.70 (d, 2H, *J* = 7.6 Hz, Ar*H*), 6.03 (d, 1H, $J_{1',2'}$ = 4.0 Hz, H-1'), 5.64 (d, 1H, $J_{4',3'}$ = 4.0 Hz, H-4'), 4.68 (d, 1H, $J_{2',1'}$ = 4.0 Hz, H-2'), 4.48 (d, B of AB, 1H, *J* = 12.4 Hz, PhCH_B), 4.12 (d, A of AB, 1H, *J* = 12.4 Hz, PhCH_A), 3.93 (d, 1H, $J_{3',4'}$ = 4.0 Hz, H-3'), 1.42, 1.32 (2 s, each 3H, 2 CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.11 (C-3), 149.29 (C-2), 143.32, 141.08, 140.75, 136.69 (4 aromatic C), 131.76, 130.64, 129.75, 129.37, 129.15, 128.89, 128.35, 128.14, 127.84 (13 aromatic *C*H), 118.51 (*C*N), 112.49 (aromatic C), 112.34 (isopropylidene C), 105.38 (C-1'), 83.18 (C-3'), 82.75 (C-2'), 81.14 (C-4'), 71.63 (Ph*C*H_2O), 27.02, 26.51 (2 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{29}H_{26}N_3O_4$ $[M+H]^+$: 480.1923. Found: 480.1920.

2-(3-*O*-Benzyl-1,2-*O*-isopropylidene-α-D-*xylo*-tetrofuranos-4-yl)-3-(4-chlorophenyl)quinoxaline (2ac)



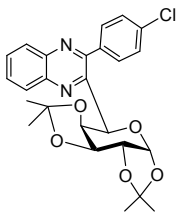
Pale yellow foam, 75%; R_f 0.30 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -66.6 (*c* 1.4, $CHCl_3$); FTIR (thin film): 3108, 2990, 2953, 2932, 1623, 1610, 1578, 1485, 1447, 757cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.29-8.27 (m, 1H, Ar*H*), 8.12-8.10 (m, 1H, Ar*H*), 7.81-7.76 (m, 2H, Ar*H*), 7.34 (d, 2H, *J* = 8.4 Hz, Ar*H*), 7.19-7.04 (m, 5H, Ar*H*), 6.69 (d, 2H, *J* = 7.2 Hz, Ar*H*), 6.22 (d, 1H, $J_{1',2'}$ = 4.0 Hz, H-1'), 5.71 (d, 1H, $J_{4',3'}$ = 4.0 Hz, H-4'), 4.69 (d, 1H, $J_{2',1'}$ = 4.0 Hz, H-2'), 4.45 (d, B of AB, 1H, *J* = 12.4 Hz, PhCH_B), 4.09 (d, A of AB, 1H, *J* = 12.4 Hz, PhCH_A), 3.81 (d, 1H, $J_{3',4'}$ = 4.0 Hz, H-3'), 1.42, 1.32 (2 s, each 3H, 2 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.28 (C-3), 149.31 (C-2), 141.10, 140.96, 136.89, 136.75, 135.22 (5 aromatic C), 130.32, 130.17, 130.08, 129.55, 129.06, 128.62, 128.30, 127.99, 127.66 (13 aromatic *C*H), 112.16 (isopropylidene C), 105.31 (C-1'), 82.93 (C-3'), 82.89 (C-2'), 80.24 (C-4'), 71.43 (Ph*C*H$_2$O), 26.98, 26.59 (2 *C*H$_3$); HRMS (ESI) *m/z* Calcd for $C_{28}H_{26}ClN_2O_4$ $[M+H]^+$: 489.1581. Found: 489.1585.

2-(3-*O*-Benzyl-1,2-*O*-isopropylidene-α-D-*xylo*-tetrofuranos-4-yl)-3-phenylquinoxaline (2ad)



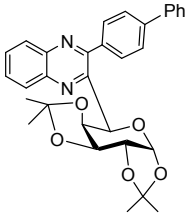
Brown oil, 86%; R_f 0.35 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -60.6 (*c* 1.4, $CHCl_3$); FTIR (thin film): 3082, 3001, 2976, 2934, 1647, 1572, 1453, 1395, 745, 700 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.37-8.33 (m, 1H, Ar*H*), 8.18-8.14 (m, 1H, Ar*H*), 7.83-7.79 (m, 2H, Ar*H*), 7.46-7.40 (m, 3H, Ar*H*), 7.24-7.17 (m, 3H, Ar*H*), 7.09 (t, 2H, *J* = 7.6 Hz, Ar*H*), 6.74 (d, 2H, *J* = 7.3 Hz, Ar*H*), 6.29 (d, 1H, $J_{1',2'}$ = 4.0 Hz, H-1'), 5.78 (d, 1H, $J_{4',3'}$ = 3.6 Hz, H-4'), 4.69 (d, 1H, $J_{2',1'}$ = 4.0 Hz, H-2'), 4.44 (d, B of AB, 1H, *J* = 12.4 Hz, PhCH_B), 4.11 (d, A of AB, 1H, *J* = 12.4 Hz, PhCH_A), 3.74 (d, 1H, $J_{3',4'}$ = 3.6 Hz, H-3'), 1.41, 1.33 (2 s, each 3H, 2 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.67 (C-3), 149.32 (C-2), 141.15, 141.06, 138.08, 137.02 (4 aromatic C), 130.17, 129.94, 129.63, 129.16, 129.09, 128.58, 128.49, 128.26, 127.89, 127.52 (14 aromatic *C*H), 111.97 (isopropylidene C), 105.20 (C-1'), 82.98 (C-3'), 82.88 (C-2'), 79.90 (C-4'), 71.44 (Ph*C*H$_2$O), 26.88, 26.61 (2 CH$_3$); HRMS (ESI) *m/z* Calcd for $C_{28}H_{27}N_2O_4$ $[M+H]^+$: 455.1971. Found: 455.1980.

2-(1,2:3,4-di-*O*-isopropylidene-α-D-*galaacto*-pentopyranos-5-yl)-3-(4-chlorophenyl)quinoxaline (2ba)



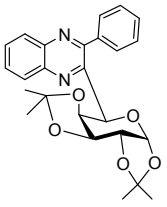
Brown oil, 76%; R_f 0.40 (2:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -153.2 (*c* 1.4, $CHCl_3$); FTIR (thin film): 3064, 2985, 2935, 1737, 1609, 1533, 1494, 1383, 892, 762 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.29-8.26 (m, 1H, Ar*H*), 8.09-8.06 (m, 1H, Ar*H*), 8.77-8.72 (m, 2H, Ar*H*), 7.55 (d, 2H, *J* = 8.4 Hz, Ar*H*), 7.48 (d, 2H, *J* = 8.4 Hz, Ar*H*), 5.83 (d, 1H, $J_{1',2'}$ = 5.2 Hz, H-1'), 5.46 (d, 1H, $J_{5',4'}$ = 2.4 Hz, H-5'), 4.53 (dd, 1H, $J_{3',2'}$ = 2.6 Hz, $J_{3',4'}$ = 7.4 Hz, H-3'), 4.39 (dd, 1H, $J_{2',3'}$ = 2.6 Hz, $J_{2',1'}$ = 5.2 Hz, H-2'), 4.12 (dd, 1H, $J_{4',3'}$ = 7.4 Hz, $J_{4',5'}$ = 2.4 Hz, H-4'), 1.43 (s, 6H, 2 C*H*$_3$), 1.32, 1.17 (2 s, each 3H, 2 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.06 (C-3), 149.92 (C-2), 141.33, 140.86, 137.36, 135.32 (4 aromatic C), 130.21, 130.14, 130.05, 129.57, 129.08, 128.88 (8 aromatic *C*H), 110.10, 108.72 (2 isopropylidene C), 97.10 (C-1'), 72.22 (C-4'), 71.17 (C-3'), 70.13 (C-2'), 68.64 (C-5'), 25.93, 25.80, 24.85, 24.71 (4 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{25}H_{26}ClN_2O_5$ $[M+H]^+$: 469.1530. Found: 469.1526.

2-(1,2:3,4-di-*O*-isopropylidene-α-D-*galaacto*-pentopyranos-5-yl)-3-biphenylylquinoxaline (2bb)



White foam, 89%; R_f = 0.30 (2:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -123.4 (*c* 1.7, $CHCl_3$); FTIR (thin film): 3077, 2999, 2934, 1727, 1606, 1550, 1486, 760, 701 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.34-8.31 (m, 1H, Ar*H*), 8.14-8.10 (m, 1H, Ar*H*), 7.79-7.75 (m, 4H, Ar*H*), 7.70-7.64 (m, 4H, Ar*H*), 7.50-7.47 (m, 2H, Ar*H*), 7.40-7.38 (m, 1H, Ar*H*), 5.90 (d, 1H, $J_{1',2'}$ = 5.2 Hz, H-1'), 5.60 (d, 1H, $J_{5',4'}$ = 2.4 Hz, H-5'), 4.54 (dd, 1H, $J_{3',2'}$ = 2.6 Hz, $J_{3',4'}$ = 7.6 Hz, H-3'), 4.41 (dd, 1H, $J_{2',3'}$ = 2.6 Hz, $J_{2',1'}$ = 5.2 Hz, H-2'), 4.19 (dd, 1H, $J_{4',3'}$ = 7.6 Hz, $J_{4',5'}$ = 2.4 Hz, H-4'), 1.49, 1.44, 1.32, 1.20 (4 s, each 3H, 4 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.97 (C-3), 150.05 (C-2), 142.06, 141.40, 141.03, 140.36, 137.66 (5 aromatic C), 130.02, 129.83, 129.67, 129.17, 129.15, 128.95, 127.81, 127.53, 127.21 (13 aromatic *C*H), 110.13, 108.75 (2 isopropylidene C), 97.27 (C-1'), 72.25 (C-4'), 71.24 (C-3'), 70.17 (C-2'), 68.41 (C-5'), 25.88, 24.92, 24.83 (4 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{31}H_{31}N_2O_5$ $[M+H]^+$: 511.2233. Found: 511.2239.

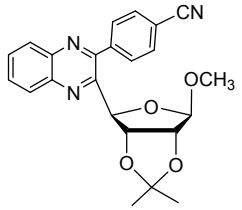
2-(1,2:3,4-di-*O*-isopropylidene-α-D-*galaacto*-pentopyranos-5-yl)-3-phenylquinoxaline (2bc)



Pale yellow oil, 88%; R_f = 0.40 (4:1 petroleum ether-EtOAc)； $[\alpha]_D^{20}$ -154.2 (*c* 1.3, $CHCl_3$); FTIR (KBr): 3069, 3003, 2956, 1738, 1619, 1528, 1480, 748, 703 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.31-8.28 (m, 1H, Ar*H*), 8.10-8.08 (m, 1H, Ar*H*), 7.76-7.69 (m, 2H, Ar*H*), 7.59-7.56 (m, 2H, Ar*H*), 7.52-

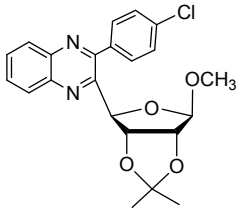
7.26 (m, 3H, Ar*H*), 5.86 (d, 1H, $J_{1',2'}$ = 5.2 Hz, H-1'), 5.50 (d, 1H, $J_{5',4'}$ = 2.4 Hz, H-5'), 4.47 (dd, 1H, $J_{3',2'}$ = 2.6 Hz, $J_{3',4'}$ = 7.4 Hz, H-3'), 4.38 (dd, 1H, $J_{2',3'}$ = 2.6 Hz, $J_{2',1'}$ = 5.2 Hz, H-2'), 4.06 (dd, 1H, $J_{4',3'}$ = 7.4 Hz, $J_{4',5'}$ = 2.4 Hz, H-4'), 1.45, 1.39, 1.29, 1.16 (4 s, each 3H, 4 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.18 (C-3), 150.00 (C-2), 141.38, 140.94, 138.70 (aromatic C), 129.96, 129.78, 129.64, 129.20, 129.10, 128.81, 128.61 (9 aromatic *C*H), 110.08, 108.71 (2 isopropylidene C), 97.22 (C-1'), 72.13 (C-4'), 71.19 (C-3'), 70.11 (C-2'), 68.35 (C-5'), 25.84, 24.89, 24.80 (4 *C*H$_3$); HRMS (ESI) *m/z* Calcd for $C_{25}H_{26}N_2O_5Na$ $[M+Na]^+$: 457.1739. Found: 457.1742.

2-(2,3-*O*-isopropylidene-1-*O*-methyl-β-D-*ribo*-tetrofuranos-4-yl)-3-(4-cyanophenyl)quinoxaline (2ca)



Brown oil, 72%; R_f 0.50 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +1.8 (*c* 1.0, $CHCl_3$); FTIR (thin film): 3064, 2986, 2926, 2853, 2229 (CN), 1607, 1457, 1377, 865, 762 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13-8.10 (m, 2H, Ar*H*), 7.98 (d, 2H, *J* = 8.4 Hz, Ar*H*), 7.83-7.79 (m, 4H, Ar*H*), 5.85 (d, 1H, $J_{3',2'}$ = 6.0 Hz, H-3'), 5.52 (s, 1H, H-4'), 5.00 (s, 1H, H-1'), 4.92 (d, 1H, $J_{2',3'}$ = 6.0 Hz, H-2'), 2.91 (s, 3H, OC*H*$_3$), 1.50, 1.39 (2 s, each 3H, 2 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 152.56 (C-3), 151.32 (C-2), 142.82, 141.24, 140.55 (3 aromatic C), 132.30, 130.85, 130.58, 130.32, 129.49, 129.18, (8 aromatic *C*H), 118.56 (*C*N), 112.93 (aromatic C), 112.32 (isopropylidene C), 110.91 (C-1'), 86.37 (C-2'), 84.96 (C-4'), 82.22 (C-3'), 54.79 (O*C*H$_3$), 26.59, 25.05 (2 *C*H$_3$); HRMS (ESI) *m/z* Calcd for $C_{23}H_{22}N_3O_4$ $[M+H]^+$: 404.1610. Found: 404.1616.

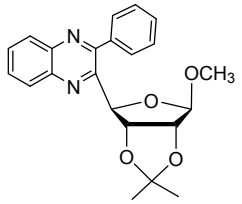
2-(2,3-*O*-isopropylidene-1-*O*-methyl-β-D-*ribo*-tetrofuranos-4-yl)-3-(4-chlorophenyl)quinoxaline (2cb)



Pale yellow oil, 76%; R_f 0.30 (6:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -7.7 (*c* 1.6, $CHCl_3$); FTIR (thin film): 3065, 2992, 2935, 2854, 1613, 1450, 1379, 857, 758 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12-8.10 (m, 2H, Ar*H*), 7.82-7.75 (m, 4H, Ar*H*), 7.51 (d, 2H, *J* = 8.8 Hz, Ar*H*), 5.84 (d, 1H, $J_{3',2'}$ = 5.6 Hz, H-3'), 5.58 (s, 1H, H-4'), 5.02 (s, 1H, H-1'), 4.95 (d, 1H, $J_{2',3'}$ = 5.6 Hz, H-2'), 2.93 (s, 3H, OCH_3), 1.52, 1.40 (2 s, each 3H, 2 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.47 (C-3), 151.52 (C-2), 141.33, 140.39,

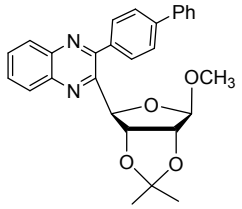
136.79, 135.53 (4 aromatic C), 130.95, 130.56, 130.03, 129.45, 129.11, 128.83 (8 aromatic *C*H), 112.24 (isopropylidene C), 110.89 (C-1'), 86.51 (C-2'), 85.01 (C-4'), 82.42 (C-3'), 54.70 (O*C*H_3), 26.64, 25.10 (2 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{22}H_{21}ClN_2O_4Na$ $[M+Na]^+$: 435.1088. Found: 435.1091

2-(2,3-*O*-isopropylidene-1-*O*-methyl-β-D-*ribo*-tetrofuranos-4-yl)-3-phenylquinoxaline (2cc)



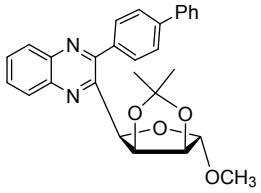
Yellow oil, 86%; R_f 0.40 (5:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -4.5 (*c* 1.5, $CHCl_3$); FTIR (thin film): 3071, 3000, 2933, 2864, 1615, 1458, 1361, 860, 758, 698 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.18-8.13 (m, 2H, Ar*H*), 7.88-7.86 (m, 2H, Ar*H*), 7.82-7.75 (m, 2H, Ar*H*), 7.60-7.51 (m, 3H, Ar*H*), 5.86 (d, 1H, $J_{3',2'}$ = 6.0 Hz, H-3'), 5.68 (s, 1H, H-4'), 5.06 (s, 1H, H-1'), 5.00 (d, 1H, $J_{2',3'}$ = 6.0 Hz, H-2'), 2.98 (s, 3H, O*C*H_3), 1.54, 1.43 (2 s, each 3H, 2 *C*H_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.75 (C-3), 151.77 (C-2), 141.40 , 140.37, 138.37 (3 aromatic C), 130.39, 129.79, 129.48, 129.45, 129.18, 129.17, 128.61 (9 aromatic *C*H), 112.16 (isopropylidene C), 110.86 (C-1'), 86.59 (C-2'), 85.00 (C-4'), 82.56 (C-3'), 54.67 (O*C*H_3), 26.64, 25.12 (2 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{22}H_2N_2O_4Na$ $[M+Na]^+$: 401.1477. Found: 401.1481.

2-(2,3-*O*-isopropylidene-1-*O*-methyl-β-D-*ribo*-tetrofuranos-4-yl)-3-biphenylylquinoxaline (2cd)



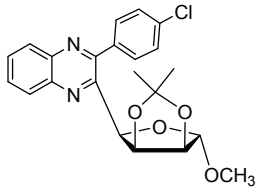
Pale yellow oil, 88%; R_f 0.38 (5:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -2.8 (*c* 2.0, $CHCl_3$); FTIR (thin film): 3048, 2995, 2937, 2861, 1601, 1450, 1382, 750, 701 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.18-8.13 (m, 2H, Ar*H*), 7.97 (d, 2H, *J* = 8.4 Hz, Ar*H*), 7.80-7.75 (m, 4H, Ar*H*), 7.69 (d, 2H, *J* = 7.4 Hz, Ar*H*), 7.49 (t, 2H, *J* = 7.4 Hz, Ar*H*), 7.40 (t, 1H, *J* = 7.4 Hz, Ar*H*), 5.87 (d, 1H, $J_{3',2'}$ = 6.0 Hz, H-3'), 5.74 (s, 1H, H-4'), 5.09 (s, 1H, H-1'), 5.02 (d, 1H, $J_{2',3'}$ = 6.0 Hz, H-2'), 2.99 (s, 3H, O*C*H_3), 1.55, 1.43 (2 s, each 3H, 2 *C*H_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.42 (C-3), 151.77 (C-2), 141.99, 141.48, 140.59, 140.38, 137.28 (5 aromatic C), 130.45, 130.02, 129.82, 129.47, 129.19, 128.90, 127.68, 127.39, 127.27 (13 aromatic *C*H), 112.20 (isopropylidene C), 110.94 (C-1'), 86.63 (C-2'), 85.08 (C-4'), 82.63 (C-3'), 54.71 (O*C*H_3), 26.69, 25.14 (2 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{28}H_{27}N_2O_4$ $[M+H]^+$: 455.1971, found: 455.1973.

2-(2,3-*O*-isopropylidene-1-*O*-methyl-α-D-*lyxo*-tetrofuranos-4-yl)-3-biphenylylquinoxaline (2da)



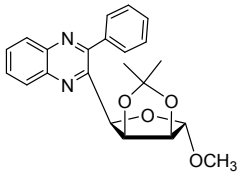
Pale yellow solid, 88%; R_f 0.30 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -46.4 (*c* 1.9, $CHCl_3$); FTIR (KBr): 3031, 2985, 2855, 1642, 1588, 1484, 1381, 832, 769, 695 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.36-8.34 (m, 1H, Ar*H*), 8.15-8.13 (m, 1H, Ar*H*), 7.79-7.74 (m, 4H, Ar*H*), 7.69-7.65 (m, 4H, Ar*H*), 7.48 (t, 2H, *J* = 7.4 Hz, Ar*H*), 7.39 (t, 1H, *J* = 7.4 Hz, Ar*H*), 5.51 (d, 1H, $J_{4',3'}$ = 4.2 Hz, H-4'), 5.32 (s, 1H, H-1'), 4.59 (dd, 1H, $J_{3',2'}$ = 6.0 Hz, $J_{3',4'}$ = 4.2 Hz, H-3'), 4.55 (d, 1H, $J_{2',3'}$ = 6.0 Hz, H-2'), 3.42 (s, 3H, OCH_3), 1.28, 1.16 (2 s, each 3H, 2 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.48 (C-3), 149.54 (C-2), 142.08, 141.21, 141.04, 140.36, 137.40 (5 aromatic C), 129.96, 129.82, 129.54, 129.16, 129.01, 128.96, 127.80, 127.51, 127.22 (13 aromatic *C*H), 113.39 (isopropylidene C), 106.83 (C-1'), 84.69 (C-2'), 81.23 (C-3'), 80.60 (C-4'), 55.34 (OCH_3), 25.78, 25.25 (2 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{28}H_{26}N_2O_4$ M^+: 454.1893. Found: 454.1897.

2-(2,3-*O*-isopropylidene-1-*O*-methyl-α-D-*lyxo*-tetrofuranos-4-yl)-3-(4-chlorophenyl)quinoxaline (2db)



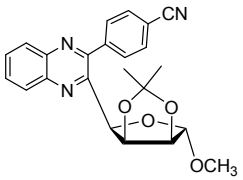
Brown oil, 75%; R_f = 0.50 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -44.3 (*c* 1.7, $CHCl_3$); FTIR (thin film): 2932, 2854, 1651, 1599, 1487, 1382, 827, 774 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.32-8.29 (m, 1H, Ar*H*), 8.10-8.07 (m, 1H, Ar*H*), 7.77-7.72 (m, 2H, Ar*H*), 7.50 (br s, 4H, Ar*H*), 5.36 (d, 1H, $J_{4',3'}$ = 4.4 Hz, H-4'), 5.27 (s, 1H, H-1'), 4.53 (d, 1H, $J_{2',3'}$ = 6.0 Hz, H-2'), 4.47 (dd, 1H, $J_{3',2'}$ = 6.0 Hz, $J_{3',4'}$ = 4.4 Hz, H-3'), 3.38 (s, 3H, OCH_3), 1.21, 1.13 (2 s, each 3H, 2 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.51 (C-3), 149.35 (C-2), 141.22, 140.89, 136.96, 135.46 (4 aromatic C), 130.07, 130.01, 129.51, 129.08, 129.00 (8 aromatic *C*H), 113.41 (isopropylidene C), 106.74 (C-1'), 84.59 (C-2'), 81.07 (C-3'), 80.49 (C-4'), 55.30 (O*C*H_3), 25.70, 25.18 (2 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{22}H_{21}ClN_2O_4Na$ $[M+Na]^+$: 435.1088. Found: 435.1093.

2-(2,3-*O*-isopropylidene-1-*O*-methyl-α-D-*lyxo*-tetrofuranos-4-yl)-3-phenylquinoxaline (2dc)



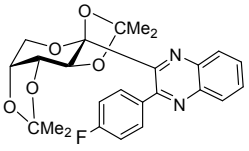
Pale yellow oil, 86%; R_f 0.40 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -35.8 (*c* 1.5, $CHCl_3$); FTIR (thin film): 3052, 2961, 2867, 1629, 1593, 1485, 1386, 844, 760, 699 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.33-8.30(m, 1H, Ar*H*), 8.12-8.10 (m, 1H, Ar*H*), 7.76-7.71 (m, 2H, Ar*H*), 7.57-7.50 (m, 5H, Ar*H*), 5.41 (d, 1H, $J_{4',3'}$ = 4.4 Hz, H-4'), 5.48 (s, 1H, H-1'), 4.50 (d, 1H, $J_{2',3'}$ = 6.0 Hz, H-2'), 4.45 (dd, 1H, $J_{3',2'}$ = 6.0 Hz $J_{3',4'}$ = 4.4 Hz, H-3'), 3.38 (s, 3H, OCH_3), 1.24, 1.13 (2 s, each 3H, 2 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.69 (C-3), 149.52 (C-2), 141.18, 140.95, 138.50 (3 aromatic C), 129.90, 129.76, 129.52, 129.19, 129.12, 128.75, 128.49 (9 aromatic *C*H), 113.31 (isopropylidene C), 106.78 (C-1'), 84.64 (C-2'), 81.13 (C-3'), 80.56 (C-4'), 55.28 (O*C*H_3), 25.75, 25.18 (2 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{22}H_{23}N_2O_4$ $[M+H]^+$: 379.1658. Found: 379.1664.

2-(2,3-*O*-isopropylidene-1-*O*-methyl-α-D-lyxo-tetrofuranos-4-yl)-3-(4-cyanophenyl)quinoxaline (2dd)



White solid, 73%; R_f 0.50 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -26.1 (*c* 2.0, $CHCl_3$); FTIR (KBr): 3063, 2987, 2931, 2854, 2229 (CN), 1607, 1482, 1383, 844, 762 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.32-8.29 (m, 1H, Ar*H*), 8.10-8.07 (m, 1H, Ar*H*), 7.83-769 (m, 6H, Ar*H*), 5.33 (d, 1H, $J_{4',3'}$ = 4.4 Hz, H-4'), 5.25 (s, 1H, H-1'), 4.53 (d, 1H, $J_{2',3'}$ = 5.6 Hz, H-2'), 4.44 (dd, 1H, $J_{3',2'}$ = 5.6 Hz, $J_{3',4'}$ = 4.4 Hz, H-3'), 3.37 (s, 3H, OCH_3), 1.20, 1.13 (2 s, each 3H, 2 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 151.66 (C-3), 148.92 (C-2), 143.11, 141.35, 140.76 (3 aromatic C), 132.45, 130.50, 130.40, 129.59, 129.52, 129.11 (8 aromatic *C*H), 118.30 (CN), 113.52 (isopropylidene C), 113.18 (aromatic C), 106.75 (C-1'), 84.55 (C-2'), 81.05 (C-3'), 80.47 (C-4'), 55.35 (O*C*H_3), 25.65, 25.11 (2 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{23}H_{21}N_3O_4Na$ $[M+Na]^+$: 426.1430. Found: 426.1436

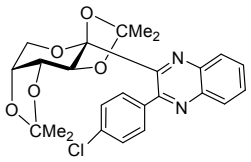
2-(1,2:3,4-di-*O*-isopropylidene-β-D-*arabino*-pent-1,5-pyranos-1-yl)-3-(4-fluorophenyl)quinoxaline (2ea)



Brown oil, 71%; R_f 0.55 (4:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +22.8 (*c* 0.6, $CHCl_3$); FTIR (thin film): 3063, 2995, 2946, 1608, 1550, 1457, 1375, 862, 748 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.18-8.14 (m, 2H, Ar*H*), 7.83-7.76 (m, 2H, Ar*H*), 7.74-7.71 (m, 2H, Ar*H*), 7.14-7.09 (m, 2H, Ar*H*), 5.88 (d, 1H, $J_{2',3'}$ = 2.2 Hz, H-2'), 4.73 (dd, 1H, $J_{3',2'}$ = 2.2 Hz, $J_{3',4'}$ = 7.4 Hz, H-3'), 4.26 (dd, 1H, $J_{4',3'}$ = 7.4 Hz, $J_{4',5'a}$ = 1.6 Hz, H-4'), 3.89 (dd, 1H, $J_{5'a,4'}$ = 1.6 Hz, $J_{5'a,5'b}$ = 13.0 Hz, H-5'a), 3.53 (d, 1H, $J_{5'b,5'a}$= 13.0 Hz, H-5'b),

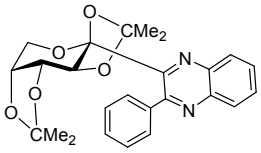
1.50 (s, 3H, CH_3), 1.31 (d, 6H, 2 CH_3), 1.16 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.80 (*C*-F, d, $^1J_{C\text{-}F}$ = 245.0 Hz), 153.90 (C-3), 151.29 (C-2), 140.71 (C-8a), 139.12 (C-4a), 137.07 (aromatic C, d, $^4J_{C\text{-}F}$ = 4.0 Hz), 131.28 (2 aromatic *C*H, d, $^3J_{C\text{-}F}$ = 8.0 Hz), 130.46, 129.74, 129.34, 128.93 (4 aromatic *C*H), 114.04 (2 aromatic *C*H, d, $^2J_{C\text{-}F}$ = 21.0 Hz), 109.05, 108.68 (2 isopropylidene C), 103.97 (C-1'), 72.11 (C-2'), 71.30 (C-3'), 70.43 (C-4'), 60.83 (C-5'), 26.15, 25.92, 25.31, 24.64 (4 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{25}H_{25}N_2O_5Na$ $[M+Na]^+$: 475.1645. Found: 475.1648.

2-(1,2:3,4-di-*O*-isopropylidene-β-D-*arabino*-pent-1,5-pyranos-1-yl)-3-(4-chlorophenyl)quinoxaline (2eb)



Yellow oil, 71%; R_f 0.33 (5:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +21 (*c* 0.5, $CHCl_3$); FTIR (thin film): 3055, 3037, 2986, 2930, 1608, 1552, 1465, 1387, 851, 767 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16-8.11 (m, 2H, Ar*H*), 7.81-7.75 (m, 2H, Ar*H*), 7.66 (d, 2H, *J* = 8.6 Hz, Ar*H*), 7.38 (d, 2H, *J* = 8.6 Hz, Ar*H*), 5.86 (d, 1H, $J_{2',3'}$ = 2.3 Hz, H-2'), 4.71 (dd, 1H, $J_{3',2'}$ = 2.3 Hz, $J_{3',4'}$ = 7.6 Hz, H-3'), 4.24 (br d, 1H, *J* = 7.6 Hz, H-4'), 3.85 (dd, 1H, $J_{5'a,4'}$ = 1.8 Hz, $J_{5'a,5'b}$ = 13.0 Hz, H-5'a), 3.51 (dd, 1H, $J_{5'b,4'}$ = 2.4 Hz, $J_{5'b,5'a}$ = 13.0 Hz, H-5'b), 1.48, 1.30, 1.29, 1.18 (4 s, each 3H, 4 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.69 (C-3), 150.18 (C-2), 139.69, 138.52, 138.13, 132.95 (4 aromatic C), 129.80, 129.44, 128.79, 128.31, 127.94, 126.30 (8 aromatic *C*H), 108.01, 107.73 (2 isopropylidene C), 102.87 (C-1'), 71.05 (C-2'), 70.25 (C-3'), 69.43 (C-4'), 59.84 (C-5'), 25.13, 24.88, 24.29, 23.59 (4 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{25}H_{25}ClN_2O_5Na$ $[M+Na]^+$: 491.1350. Found: 491.1356.

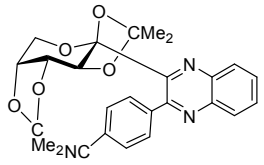
2-(1,2:3,4-di-*O*-isopropylidene-β-D-*arabino*-pent-1,5-pyranos-1-yl)-3-phenylquinoxaline (2ec)



Yellow oil, 83%; R_f 0.52 (4:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +19.8 (*c* 0.5, $CHCl_3$); FTIR (thin film): 3051, 2985, 2938, 2867, 1611, 1554, 1459, 1382, 872, 761, 697 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18-8.16 (m, 2H, Ar*H*), 7.82-7.76 (m, 2H, Ar*H*), 7.72-7.70 (m, 2H, Ar*H*), 7.45-7.41 (m, 3H, Ar*H*), 5.88 (d, 1H, $J_{2',3'}$ = 2.1 Hz, H-2'), 4.73 (dd, 1H, $J_{3',2'}$ = 2.1 Hz, $J_{3',4'}$ = 7.6 Hz, H-3'), 4.25 (br d, 1H, $J_{4',3'}$ = 7.6 Hz, H-4'), 3.86 (dd, 1H, $J_{5'a,4'}$ = 2.0 Hz, $J_{5'a,5'b}$ = 13.0 Hz, H-5'a), 3.51 (d, 1H, $J_{5'b,5'a}$ = 13.0 Hz, H-5'b), 1.48 (s, 3H, CH_3), 1.32 (s, 6H, 2 CH_3), 1.18 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.99 (C-3), 151.40 (C-2), 141.08 (C-8a), 140.77 (C-4a), 139.13 (aromatic C), 130.33, 129.60, 129.32, 127.78, 127.09 (9 aromatic *C*H), 109.05, 108.60 (2 isopropylidene C), 104.00 (C-1'), 72.17 (C-2'),

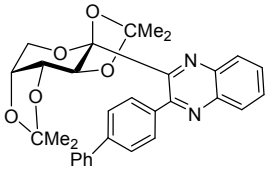
71.39 (C-3'), 70.47 (C-4'), 60.81 (C-5'), 26.15, 25.96, 25.32, 24.70 (4 *C*H_3). HRMS (ESI) *m/z* Calcd for $C_{25}H_{26}N_2O_5Na$ $[M+Na]^+$: 457.1739. Found: 457.1741.

2-(1,2:3,4-di-*O*-isopropylidene-β-D-*arabino*-pent-1,5-pyranos-1-yl)-3-(4-cyanophenyl)quinoxaline (2ed)



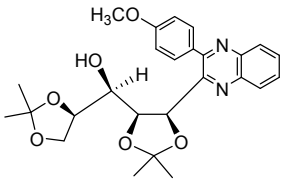
Yellow oil, 70%; R_f 0.42 (5:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +15.7 (*c* 0.5, $CHCl_3$); FTIR (thin film): 3064, 3000, 2986, 2939, 2229 (CN), 1605, 1549, 1458, 1385, 860, 772cm^{-1}; ^{1}H-NMR (400MHz, $CDCl_3$) δ 8.19-8.12 (m, 2H, Ar*H*), 7.83-7.81 (m, 4H, Ar*H*), 7.72 (d, 2H, *J* = 8.4 Hz, Ar*H*), 5.86 (d, 1H, $J_{2',3'}$ = 2.2 Hz, H-2'), 4.71 (dd, 1H, $J_{3',2'}$ = 2.2 Hz, $J_{3',4'}$ = 8.0 Hz, H-3'), 4.23 (dd, 1H, $J_{4',5'b}$ = 1.5 Hz, $J_{4',3'}$ = 8.0 Hz, H-4'), 3.83 (dd, 1H, $J_{5'a,4'}$ = 1.5 Hz, $J_{5'a,5'b}$ = 13.2 Hz, H-5'a), 3.45 (d, 1H, $J_{5'b,5'a}$ = 13.2 Hz, H-5'b), 1.49, 1.32, 1.28, 1.10 (4 s, each 3H, 4 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.84 (C-3), 151.06 (C-2), 145.66, 140.57, 139.37 (3 aromatic C), 131.04, 130.85, 130.40, 130.12, 129.42, 128.99 (8 aromatic *C*H), 119.18 (*C*N), 111.44 (aromatic C), 109.03, 108.98 (2 isopropylidene C), 103.65 (C-1'), 71.99 (C-2'), 71.07 (C-3'), 70.35 (C-4'), 60.91 (C-5'), 26.16, 25.89, 25.34, 24.53 (4 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{26}H_{25}N_3O_5Na$ $[M+Na]^+$: 482.1692. Found: 482.1696.

2-(1,2:3,4-di-*O*-isopropylidene-β-D-*arabino*-pent-1,5-pyranos-1-yl)-3-biphenylylquinoxaline (2ee)



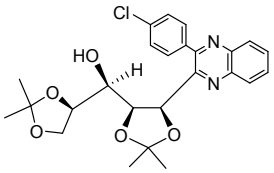
Brown oil, 81%; R_f 0.36 (4:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +8.0 (*c* 1.0, $CHCl_3$); FTIR (thin film): 3065, 2988, 2935, 1601, 1546, 1456, 1383, 844, 766, 697 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.17-8.15 (m, 2H, Ar*H*), 7.82-7.76 (m, 4H, Ar*H*), 7.47 (t, 2H, *J* = 7.6 Hz, Ar*H*), 7.36 (t, 1H, *J* = 7.6 Hz, Ar*H*), 5.89 (d, 1H, $J_{2',3'}$ = 2.4 Hz, H-2'), 4.72 (dd, 1H, $J_{3',2'}$ = 2.4 Hz, $J_{3',4'}$ = 8.2 Hz, H-3'), 4.25 (br d, 1H, *J* = 6.8 Hz, H-4'), 3.88 (dd, 1H, $J_{5'a,4'}$ = 1.8 Hz, $J_{5'a,5'b}$ = 13.2 Hz, H-5'a), 3.53 (d, 1H, $J_{5'b,5'a}$ = 13.2 Hz, H-5'b), 1.50, 1.33, 1.30, 1.17 (4 s, each 3H, 4 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.63 (C-3), 151.38 (C-2), 141.16, 140.83, 140.47, 140.18, 139.11 (5 aromatic C), 130.38, 129.85, 129.64, 129.34, 129.03, 128.77, 127.25, 127.17, 125.92 (13 aromatic *C*H), 109.07, 108.72 (2 isopropylidene C), 104.04 (C-1'), 72.21 (C-2'), 71.38 (C-3'), 70.50 (C-4'), 60.87 (C-5'), 26.22, 25.98, 25.38, 24.70 (4 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{31}H_{31}N_2O_5$ $[M+H]^+$: 511.2233. Found: 511.2236.

2-(1,2:4,5-di-*O*-isopropylidene-D-*manno*-1,2,3,4,5-pentahydroxypentyl)-3-(4-methoxyphenyl)quinoxaline (2fa)



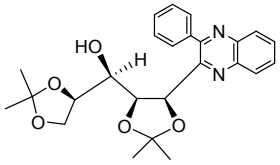
Pale yellow foam, 90%; R_f 0.55 (2:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +57.5 (*c* 0.5, $CHCl_3$); FTIR (thin film): 3431 (OH), 2997, 2926, 2858, 1628, 1457, 1395, 849, 768 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.16-8.11 (m, 2H, H-5, H-8), 7.92 (d, 2H, *J* = 8.8 Hz, Ar*H*), 7.81-7.74 (m, 2H, H-6, H-7), 7.06 (d, 2H, *J* = 8.8 Hz, Ar*H*), 5.36-5.27 (m, 2H, H-1', H-2'), 3.96-3.81 (m, 6H, H-4', H-5', OCH_3), 3.46-3.42 (m, 1H, H-3'), 2.47 (d, 1H, $J_{OH,3'}$ = 6.0 Hz, OH), 1.64, 1.55, 1.15, 1.02 (4 s, each 3H, 4 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.76 (aromatic C), 155.38 (C-3), 149.39 (C-2), 141.76 (C-8a), 140.78 (C-4a), 131.37 (2 aromatic *C*H), 130.56 (aromatic *C*H), 130.33 (aromatic C), 129.57, 129.35, 129.16 (3 aromatic *C*H), 114.00 (2 aromatic *C*H), 110.48, 109.26 (2 isopropylidene C), 79.79 (C-2'), 76.06 (C-1', C-4'), 71.50 (C-3'), 66.98 (C-5'), 55.51 (O*C*H_3), 27.42, 27.18, 26.64, 25.21 (4 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{26}H_{30}N_2O_6Na$ $[M+Na]^+$: 489.2002. Found: 489.2008.

2-(1,2:4,5-di-*O*-isopropylidene-D-*manno*-1,2,3,4,5-pentahydroxypentyl)-3-(4-chlorophenyl)quinoxaline (2fb)



Yellow solid, 77%; R_f 0.65 (2:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +37.1 (*c* 0.5, $CHCl_3$); FTIR (KBr): 3418 (OH), 2989, 2938, 2847, 1609, 1455, 1388, 852, 761 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.16-8.14 (m, 2H, H-5, H-8), 7.91 (d, 2H, *J* = 8.4Hz, Ar*H*), 7.85-7.77 (m, 2H, H-6, H-7), 7.53 (d, 2H, *J* = 8.8Hz, Ar*H*), 5.37 (dd, 1H, $J_{2',3'}$ = 4.4 Hz, $J_{2',1'}$ = 8.0 Hz, H-2'), 5.20 (d, 1H, $J_{1',2'}$ = 8.0 Hz, H-1'), 3.98-3.84 (m, 3H, H-4', H-5'), 3.46 (br s, 1H, H-3'), 2.40 (br s, 1H, OH), 1.62, 1.53, 1.16, 1.02 (4 s, each 3H, 4 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.51 (C-3), 149.18 (C-2), 141.54 (C-8a), 140.93 (C-4a), 136.28，135.70 (2 aromatic C), 131.14, 130.73，130.05, 129.30， 129.15， 128.64 (8 aromatic *C*H), 110.50, 109.17 (2 isopropylidene C), 79.49 (C-2'), 76.25 (C-4'), 75.95 (C-1'), 71.39 (C-3'), 66.94 (C-5'), 27.26, 27.06, 26.59, 25.12 (4 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{25}H_{28}ClN_2O_5$ $[M+H]^+$: 471.1687. Found: 471.1689.

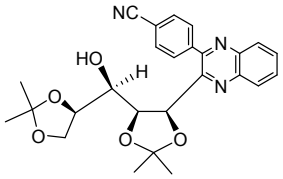
2-(1,2:4,5-di-*O*-isopropylidene-D-*manno*-1,2,3,4,5-pentahydroxypentyl)-3-phenylquinoxaline (2fc)



Pale yellow oil, 85%; R_f 0.35 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +32.6 (c 0.6, $CHCl_3$); FTIR (thin

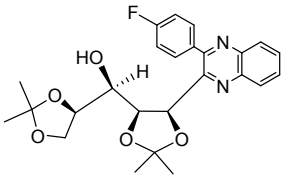
film): 3425 (OH), 3018, 2984, 2950, 2853, 1610, 1458, 1382, 846, 750, 699 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.16-8.13 (m, 2H, H-5, H-8), 7.92-7.89 (m, 2H, Ar*H*), 7.79-7.76 (m, 2H, H-6, H-7), 7.92-7.89 (m, 2H, Ar*H*), 7.53-7.51 (m, 3H, Ar*H*), 5.32-5.25 (m, 2H, H-1', H-2'), 3.94-3.81 (m, 3H, H-4', H-5'), 3.45-3.42 (m, 1H, H-3'), 2.38 (br d, 1H, $J_{OH,3'}$ = 6.4 Hz, OH), 1.61, 1.50, 1.13, 1.02 (4 s, each 3H, 4 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.72 (C-3), 149.58 (C- 2), 141.73 (C-4a), 141.05 (C-8a), 137.93 (aromatic C), 130.68, 129.92, 129.83, 129.41, 129.32, 128.53 (9 aromatic *C*H), 110.55, 109.30 (2 isopropylidene C), 79.83 (C-2'), 76.10 (C-4'), 75.98 (C-1'), 71.45 (C-3'), 66.97 (C-5'), 27.40, 27.16, 26.64, 25.25 (4 *C*H$_3$); HRMS (ESI) *m/z* Calcd for $C_{25}H_{28}N_2O_5Na$ $[M+Na]^+$: 459.1896. Found: 459.1898.

2-(1,2:4,5-di-*O*-isopropylidene-D-*manno*-1,2,3,4,5-pentahydroxypentyl)-3-(4-cyanophenyl)quinox-aline (2fd)



Pale yellow foam, 72%; R_f = 0.32 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +27.3 (*c* 0.7, $CHCl_3$); FTIR (thin film): 3440 (OH), 2986, 2926, 2854, 2230 (CN), 1607, 1546, 1457, 1383, 855, 763cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.19-8.14 (m, 2H, H-5, H-8), 8.08 (d, 2H, *J* = 8.4 Hz, Ar*H*), 7.86-7.83 (m, 4H, H-6, H-7, Ar*H*), 5.38 (dd, 1H, $J_{2',3'}$ = 4.4 Hz, $J_{2',1'}$ = 8.0 Hz, H-2'), 5.15 (d, 1H, $J_{1',2'}$ = 8.0 Hz, H-1'), 4.01-3.85 (m, 3H, H-4', H-5'), 3.48 (br s, 1H, H-3'), 2.42 (d, 1H, $J_{OH,3'}$ = 6.0 Hz, OH), 1.59, 1.51, 1.17, 1.03 (4 s, each 3H, 4 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.50 (C-3), 149.16 (C-2), 142.35 (aromatic C), 141.44 (C-8a), 141.10 (C-4a), 132.10, 131.04, 130.66, 130.47, 129.34, 129.25 (8 aromatic *C*H), 118.59 (*C*N), 113.01 (aromatic C), 110.61, 109.18 (2 isopropylidene C), 79.33 (C-2'), 75.94 (C-4'), 75.66 (C-1'), 71.32 (C-3'), 66.98 (C-5'), 27.18, 27.05, 26.66, 25.13 (4 *C*H$_3$); HRMS (ESI) *m/z* Calcd for $C_{26}H_{28}N_3O_5$ $[M+H]^+$: 462.2029. Found: 462.2036.

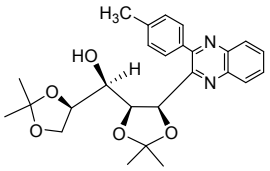
2-(1,2:4,5-di-*O*-isopropylidene-D-*manno*-1,2,3,4,5-pentahydroxypentyl)-3-(4-fluorophenyl)quino-xaline (2fe)



Yellow foam, 74%; R_f 0.43 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +55.3 (*c* 0.5, $CHCl_3$): FTIR (thin film): 3416 (OH), 2988, 2928, 1606, 1514, 1379, 845, 769 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.17-8.14 (m, 2H, H-5, H-8), 7.98-7.93 (m, 2H, Ar*H*), 7.84-7.77 (m, 2H, H-6, H-7), 7.26-7.21 (m, 2H, Ar*H*), 5.37 (dd, 1H, $J_{2',3'}$ = 4.4 Hz, $J_{2',1'}$ = 8.0 Hz, H-2'), 5.22 (d, 1H, $J_{1',2'}$ = 8.0 Hz, H-1'), 3.99-3.83 (m, 3H, H-4', H-5'), 3.46 (br d, 1H, H-3'), 2.42 (d, 1H, $J_{OH,3'}$ = 5.6 Hz, OH), 1.62, 1.53, 1.16, 1.03 (4 s, each 3H, 4 C*H*$_3$); ^{13}C

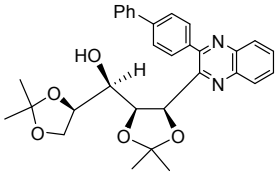
NMR (100 MHz, $CDCl_3$) δ 163.64 (*C*-F, d, $^1J_{C\text{-}F}$ = 249.5 Hz), 154.57 (C-3), 149.22 (C-2), 141.53 (C-4a), 140.88 (C-8a), 133.92 (aromatic C, d, $^4J_{C\text{-}F}$ = 3.0 Hz), 131.76 (2 aromatic *C*H, d, $^3J_{C\text{-}F}$ = 8.0 Hz), 130.69, 129.93, 129.30, 129.12 (4 aromatic *C*H), 115.46 (2 aromatic *C*H, d, $^2J_{C\text{-}F}$ = 22.1 Hz), 110.46, 109.17 (2 isopropylidene C), 79.48 (C-2'), 75.97 (C-1'), 75.81 (C-4'), 71.36 (C-3'), 66.91 (C-5'), 27.27, 27.04, 26.92, 26.58 (4 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{25}H_{27}N_2O_5Na$ $[M+Na]^+$: 477.1802. Found: 477.1809.

2-(1,2:4,5-di-*O*-isopropylidene-D-*manno*-1,2,3,4,5-pentahydroxypentyl)-3-(4-methylphenyl)quinoxaline (2ff)



Yellow oil, 89%; R_f 0.60 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +30 (*c* 0.5, $CHCl_3$); FTIR (KBr): 3426 (OH), 3035, 2989, 2945, 2853, 1606, 1545, 1456, 1387, 852, 761 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.17-8.13 (m, 2H, H-5, H-8), 7.83 (d, 2H, *J* = 8.0 Hz, Ar*H*), 7.80-7.75 (m, 2H, H-6, H-7), 7.35 (d, 2H, *J* = 8.0 Hz, Ar*H*), 5.34-5.28 (m, 2H, H-1', H-2'), 3.96-3.87 (m, 3H, H-4', H-5'), 3.44 (br s, 1H, H-3'), 2.47 (s, 3H, PhCH_3), 2.41 (br s, 1H, OH), 1.64, 1.54, 1.15, 1.03 (4 s, each 3H, 4 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.67 (C-3), 149.41 (C-2), 141.66 (C-4a), 140.84 (C-8a), 139.33, 134.94 (2 aromatic C), 130.46, 129.66, 129.60, 129.27, 129.14 (8 aromatic *C*H), 110.42, 109.17 (2 isopropylidene C), 79.73 (C-2'), 76.00 (C-4'), 75.92 (C-1'), 71.33 (C-3'), 66.84 (C-5'), 27.31, 27.07, 26.51, 25.11 (4 *C*H_3), 21.38 (Ph*C*H_3); HRMS (ESI) *m/z* Calcd for $C_{26}H_{30}N_2O_5Na$ $[M+Na]^+$: 473.2052. Found: 473.2060.

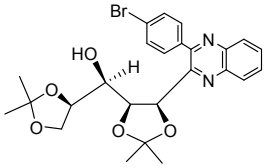
2-(1,2:4,5-di-*O*-isopropylidene-D-*manno*-1,2,3,4,5-pentahydroxypentyl)-3-biphenylylquinoxaline (2fg)



Pale yellow foam, 84%; R_f 0.62 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +29.5 (*c* 0.7, $CHCl_3$); FTIR (thin film): 3431 (OH), 3025, 2988, 2935, 2862, 1608, 1545, 1456, 1382, 847, 758, 699 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.20-8.15 (m, 2H, H-5, H-8), 8.04 (d, 2H, *J* = 8.4 Hz, Ar*H*), 7.85-7.77 (m, 4H, H-6, H-7, Ar*H*), 7.72-7.68 (m, 3H, Ar*H*), 7.53-7.49 (m, 2H, Ar*H*), 5.40-5.34 (m, 2H, H-1', H-2'), 3.98-3.84 (m, 3H, H-4', H-5'), 3.49 (br s, 1H, H-3'), 2.43 (d, 1H, *J* = 5.6 Hz, OH), 1.66, 1.56, 1.17, 1.05 (4 s, each 3H, 4 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.30 (C-3), 149.43 (C-2), 142.13 (C-4a), 141.69 (C-8a), 140.62, 140.54, 136.74 (aromatic C), 130.59, 130.24, 129.81, 129.62, 129.31, 129.21, 128.89, 127.82, 127.70, 127.24, 127.17 (13 aromatic *C*H), 110.50, 109.20 (2 isopropylidene C), 79.72 (C-2'), 76.01 (C-

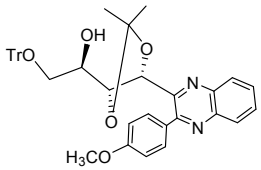
1'), 75.95 (C-4'), 71.43 (C-3'), 66.90 (C-5'), 27.32, 27.12, 26.55, 25.14 (4 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{31}H_{33}N_2O_5$ $[M+H]^+$: 513.2389. Found: 513.2381

2-(1,2:4,5-di-*O*-isopropylidene-D-*manno*-1,2,3,4,5-pentahydroxypentyl)-3-(4-bromophenyl)quinoxaline (2fh)



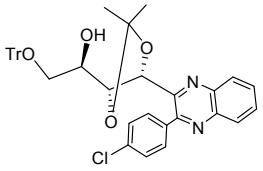
Pale yellow foam, 75%; R_f = 0.53 (2:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ +60.1 (*c* 0.6, $CHCl_3$); FTIR (thin film): 3419 (OH), 2992, 2935, 2847, 1608, 1450, 1384, 855, 758 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.14-8.11 (m, 2H, Ar*H*), 7.83-7.78 (m, 4H, Ar*H*), 7.66 (d, 2H, *J* = 8.4 Hz, Ar*H*), 5.34 (dd, 1H, $J_{2',3'}$ = 4.4 Hz, $J_{2',1'}$ = 8.2 Hz, H-2'), 5.18 (d, 1H, $J_{1',2'}$ = 8.2 Hz, H-1'), 3.97 - 3.81 (m, 3H, H-4', H-5'), 3.44 (m, 1H, H-3'), 2.40 (br d, 1H, OH), 1.60, 1.51, 1.42, 1.00 (4 s, each 3H, 4 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.56 (C-3), 149.25 (C-2), 141.66 (C-4a), 141.05 (C-8a), 136.84 (aromatic C), 131.70, 131.51, 130.87, 130.20, 129.43, 129.26 (8 aromatic *C*H), 124.19 (aromatic C), 110.62, 109.29 (2 isopropylidene C), 79.60 (C -2'), 76.04(C-4'), 75.88 (C-1'), 71.49 (C-3'), 67.06 (C-5'), 27.38, 27.19, 26.72, 25.23 (4 *C*H_3); HRMS (ESI) *m/z* Calcd for $C_{25}H_{27}BrN_2O_5Na$ $[M+Na]^+$: 537.1001. Found: 537.1008.

2-(1,2-*O*-isopropylidene-4-*O*-triphenylmethyl-D-*ribo*-1,2,3,4-butahydroxybutyl)-3-(4-methoxyphenyl)quinoxaline (2ga)



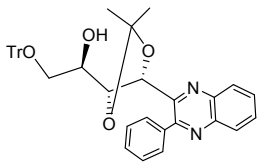
Yellow oil, 84%; R_f = 0.43 (4:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -19.6 (*c* 0.5, $CHCl_3$); FTIR (thin film): 3428 (OH), 3061, 2982, 2925, 2860, 1608, 1515, 1450, 1382, 763, 699 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.16 (d, 1H, *J* = 8.0 Hz, Ar*H*), 8.10 (d, 1H, *J* = 8.0 Hz, Ar*H*), 7.82-7.74 (m, 2H, Ar*H*), 7.70 (d, 2H, *J* = 8.8 Hz, Ar*H*), 7.28-7.18 (m, 15H, Ar*H*), 7.03 (d, 2H, *J* = 8.8 Hz, Ar*H*), 5.33-5.28 (m, 2H, H-1', H-2'), 4.04 (br d, 1H, *J* = 4.8 Hz, H-3'), 3.91 (s, 3H, OC*H*$_3$), 3.06 (dd, 1H, $J_{4'a,3'}$ = 6.0 Hz, $J_{4'a,4'b}$ = 9.6 Hz, H-4'a), 2.85 (dd, 1H, $J_{4'b,3'}$ = 4.2 Hz, $J_{4'b,4'a}$ = 9.6 Hz, H-4'b), 2.35 (br s, 1H, OH), 1.66, 1.50 (2 s, each 3H, 2 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.41 (aromatic C), 155.10 (C-3), 150.07 (C-2), 143.54 (3 aromatic C), 141.62 (C-8a), 140.98 (C-4a), 130.40 (aromatic C), 131.07, 129.48, 129.36, 129.08, 128.45, 127.83, 127.75, 126.97 (21 aromatic *C*H), 113.92 (2 aromatic *C*H), 110.59 (isopropylidene C), 86.65 (ph$_3$*C*O), 79.71 (C-2'), 76.28 (C-1'), 70.94 (C-3'), 64.65 (C-4'), 55.38 (OCH_3), 27.19, 27.12 (2 CH_3); HRMS (ESI) *m/z* Calcd for $C_{41}H_{39}N_2O_5$ $[M+H]^+$: 639.2859. Found: 639.2852.

2-(1,2-*O*-isopropylidene-4-*O*-triphenylmethyl-D-*ribo*-1,2,3,4-butahydroxybutyl)-3-(4-chlorophen-yl)quinoxaline 2gb)



Yellow oil, 74%; R_f 0.0.48 (4:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -20.6 (*c* 0.5, $CHCl_3$); FTIR (thin film): 3437 (OH), 3050, 2989, 2926, 2856, 1615, 1458, 1384, 851, 762 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.18-8.11 (m, 2H, H-5, H-8), 7.86-7.77 (m, 2H, H-6, H-7), 7.66 (d, 2H, *J* = 8.4 Hz, Ar*H*), 7.48 (d, 2H, *J* = 8.4 Hz, Ar*H*), 7.28-7.18 (m, 15H, Ar*H*), 5.31 (dd, 1H, $J_{2',3'}$ = 6.0 Hz, $J_{2',1'}$ = 8.0 Hz, H-2'), 5.20 (d, 1H, $J_{1',2'}$ = 8.0 Hz, H-1'), 4.05-4.01 (m, 1H, H-3'), 3.08 (dd, 1H, $J_{4'a,3'}$ = 6.0 Hz, $J_{4'a,4'b}$ = 9.6 Hz, H-4'a), 2.85 (dd, 1H, $J_{4'b,3'}$ = 6.0 Hz, $J_{4'b,4'a}$ = 9.6 Hz, H-4'b), 2.36 (br s, 1H, OH), 1.64, 1.48 (2 s, each 3H, 2 C*H*$_3$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.20 (C-3), 149.97 (C-2), 143.49 (3 aromatic C), 141.49 (C-8a), 141.25 (C-4a), 136.36, 135.41 (2 aromatic C), 130.98, 130.70, 129.91, 129.54, 129.14, 128.65, 128.43, 127.77, 127.70 (23 aromatic *C*H), 110.78 (isopropylidene C), 86.66 (ph$_3$*C*O), 79.62 (C-2'), 76.22 (C-1'), 70.94 (C-3'), 64.59 (C-4'), 27.12 (2 *C*H$_3$); HRMS (ESI) *m/z* Calcd for $C_{40}H_{35}ClN_2O_4Na$ $[M+Na]^+$: 665.2183. Found: 665.2186.

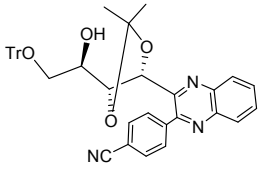
2-(1,2-*O*-isopropylidene-4-*O*-triphenylmethyl-D-*ribo*-1,2,3,4-butahydroxybutyl)-3-phenylquinoxa-line(2gc)



Pale yellow oil, 80%; R_f = 0.52 (4:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -24.8 *(c* 0.5, $CHCl_3$); FTIR (thin film): 3430 (OH), 3039, 2986, 2935, 2852, 1609, 1450, 1382, 851, 760, 699 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.17 (d, 1H, *J* = 8.0 Hz, H-8), 8.09 (d, 1H, *J* = 8.0 Hz, H-5), 7.81-7.73 (m, 2H, H-6, H-7), 7.68-7.66 (m, 2H, Ar*H*), 7.48-7.46 (m, 3H, Ar*H*), 7.24-7.15 (m, 15H, Ar*H*), 5.28-5.22 (m, 2H, H-1', H-2'), 4.01-3.97 (m, 1H, H-3'), 3.05 (dd, 1H, $J_{4'a,3'}$ = 5.6 Hz, $J_{4'a,4'b}$ = 9.6 Hz, H-4'a), 2.83 (dd, 1H, $J_{4'b,3'}$ = 4.0 Hz, $J_{4'b,4'a}$ = 9.6 Hz, H-4'b), 2.26 (br s, 1H, OH), 1.62, 1.43 (2 s, each 3H, 2 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.52 (C-3), 150.29 (C-2), 143.64 (3 aromatic C), 141.60 (C-8a), 141.34 (C-4a), 137.99 (aromatic C), 130.64, 129.79, 129.63, 129.27, 129.14, 128.85, 128.55, 128.51, 127.10 (24 aromatic *C*H), 110.74 (isopropylidene C), 86.75 (Ph$_3$*C*O), 79.84 (C-2'), 76.41 (C-1'), 71.08 (C-3'), 64.76 (C-4'), 27.26, 27.20 (2 *C*H$_3$); HRMS (ESI) *m/z* Calcd for $C_{40}H_{36}N_2O_4Na$ $[M+Na]^+$: 631.2573, found: 631.2578.

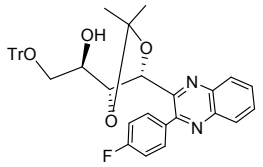
2-(1,2-*O*-isopropylidene-4-*O*-triphenylmethyl-D-*ribo*-1,2,3,4-butahydroxybutyl)-3-(4-cyanopheny-

l)quinoxaline (2gd)



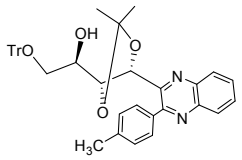
Brown oil, 70%; R_f 0.4 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -4.2 (*c* 1.0, $CHCl_3$); FTIR (thin film): 3441 (OH), 3038, 2995, 2929, 2858, 2227 (CN), 1622, 1454, 1387, 862, 762 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.16-8.11 (m, 2H, H-5, H-8), 7.83-7.75 (m, 4H, H-6, H-7, Ar*H*), 7.66 (d, 2H, *J* = 8.0 Hz, Ar*H*), 7.29-7.17 (m, 15H, Ar*H*), 5.34-5.30 (m, 1H, H-2'), 5.13 (d, 1H, $J_{1',2'}$ = 7.6 Hz, H-1'), 4.02 (d, 1H, *J* = 4.4 Hz, H-3'), 3.11-3.06 (m, 1H, H-4'a), 2.87-2.82 (m, 1H, H-4'b), 2.36 (br s, 1H, OH), 1.60, 1.45 (2 s, each 3H, 2 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.30 (C-3), 149.93 (C-2), 143.45 (3 aromatic C), 142.27 (C-8a), 141.43(C-4a), 141.40 (aromatic C), 132.31，132.15，130.37，129.65, 128.64，128.43，127.83, 127.79，127.04 (23 aromatic *C*H), 118.65 (*C*N), 112.80 (aromatic C), 110.97 (isopropylidene C), 86.67 (Ph_3CO), 79.57 (C-2'), 76.23 (C-1'), 70.96 (C-3'), 64.56 (C-4'), 27.13, 27.07 (2 CH_3); HRMS (ESI) *m/z* Calcd for $C_{41}H_{36}N_3O_4$ $[M+H]^+$: 634.2706. Found: 634.2712.

2-(1,2-*O*-isopropylidene-4-*O*-triphenylmethyl-D-*ribo*-1,2,3,4-butahydroxybutyl)-3-(4-fluorophenyl)quinoxaline (2ge)



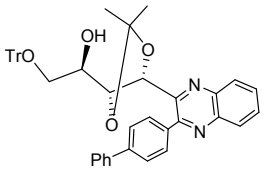
Brown oil, 73%; R_f = 0.45 (4:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -22.3 (*c* 0.6, $CHCl_3$); FTIR (thin film): 3447 (OH), 3061, 2979, 2925, 2857, 1602, 1450, 1378, 847, 764 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.19-8.11 (m, 2H, H-5, H-8), 7.85-7.76 (m, 2H, Ar*H*), 7.73-7.69 (m, 2H, H-6, H-7), 7.38-7.32 (m, 2H, Ar*H*), 7.28-7.17 (m, 15H, Ar*H*), 5.32 (dd, 1H, $J_{2',3'}$ = 6.4 Hz, $J_{2',1'}$ = 8.0 Hz, H-2'), 5.21 (d, 1H, $J_{1',2'}$ = 8.0 Hz, H-1'), 4.06-4.02 (m, 1H, H-3'), 3.09 (dd, 1H, $J_{4'a,3'}$ = 6.0 Hz, $J_{4'a,4'b}$ = 9.6 Hz, H-4'a), 2.85 (dd, 1H, $J_{4'b,3'}$ = 6.0 Hz, $J_{4'b,4'a}$ = 9.6 Hz, H-4'b), 2.38 (br s, 1H, OH), 1.65, 1.45 (2 s, each 3H, 2 CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.44 (*C*-F, d, $^1J_{C\text{-}F}$ = 248.5 Hz), 154.38 (C-3), 150.02 (C-2), 143.50 (3 aromatic C), 141.18 (C-8a), 141.20 (C-4a), 133.97 (aromatic C, d, $^4J_{C\text{-}F}$ = 3.4 Hz), 131.52 (2 aromatic *C*H, d, $^3J_{C\text{-}F}$ = 8.0 Hz), 130.67, 129.64, 129.54, 129.11, 128.44, 127.77, 127.01 (19 aromatic *C*H), 115.47 (aromatic *C*H, d, $^2J_{F\text{-}C}$ = 21.10 Hz), 110.73 (isopropylidene C), 86.66 (ph_3CO), 79.61 (C-2'), 76.21 (C-1'), 70.94 (C-3'), 64.61 (C-4'), 27.15, 27.11 (2 CH_3); HRMS (ESI) *m/z* Calcd for $C_{40}H_{35}FN_2O_4Na$ $[M+Na]^+$: 649.2479. Found: 649.2486.

2-(1,2-*O*-isopropylidene-4-*O*-triphenylmethyl-D-*ribo*-1,2,3,4-butahydroxybutyl)-3-(4-methylphenyl)quinoxaline (2gf)



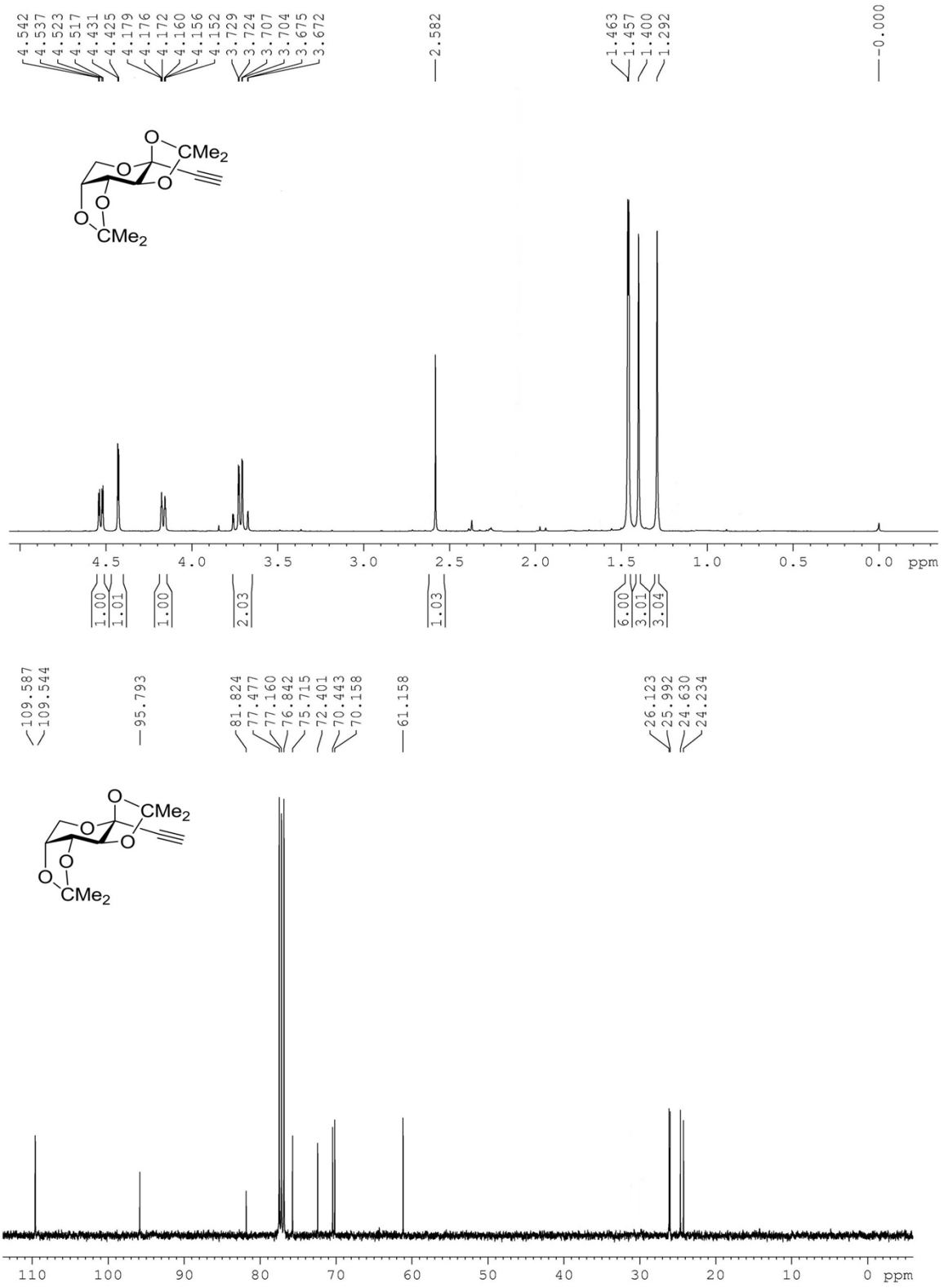
Brown oil, 83%; R_f 0.55 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -14.2 (*c* 0.5, $CHCl_3$); FTIR (thin film): 3438 (OH), 3057, 2990, 2927, 2855, 1626, 1456, 1381, 862, 761cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18-8.09 (m, 2H, H-5, H-8), 7.83-7.74 (m, 2H, H-6, H-7, Ar*H*), 7.60 (d, 2H, *J* = 8.0 Hz, Ar*H*), 7.36 (d, 2H, *J* = 8.0 Hz, Ar*H*), 7.26-7.17 (m, 15H, Ar*H*), 5.29-5.26 (m, 2H, H-1', H-2'), 4.02 (br s, 1H, H-3'), 3.06 (dd, 1H, $J_{4'a,3'}$= 6.0 Hz, $J_{4'a,4'b}$ = 9.6 Hz, H-4'a), 2.83 (dd, 1H, $J_{4'b,3'}$ = 4.0 Hz, $J_{4'b,4'a}$ = 9.6 Hz, H-4'b), 2.46 (s, 3H, PhC*H*$_3$), 2.33 (br s, 1H, OH), 1.65, 1.48 (2 s, each 3H, 2 C*H*$_3$); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.48 (C-3), 150.13 (C-2), 143.53 (3 aromatic C), 141.60 (C-8a), 141.10 (C-4a), 138.96, 135.03 (2 aromatic C), 130.42, 129.64, 129.47, 129.13, 128.65, 128.44, 127.82, 127.74, 126.97 (23 aromatic CH), 110.59 (isopropylidene C), 86.63 (ph$_3$*C*O), 79.76 (C-2'), 76.26 (C-1'), 70.94 (C-3'), 64.63 (C-4'), 27.17, 27.11 (2 CH_3), 21.54 (Ph*C*H$_3$); .HRMS (ESI) *m/z* Calcd for $C_{41}H_{39}N_2O_4$ $[M+H]^+$: 623.2910, found: 623.2918.

2-(1,2-O-isopropylidene-4-O-triphenylmethyl-D-*ribo*-1,2,3,4-butahydroxybutyl)-3-(4-biphenylyl)-quinoxaline (2gg)

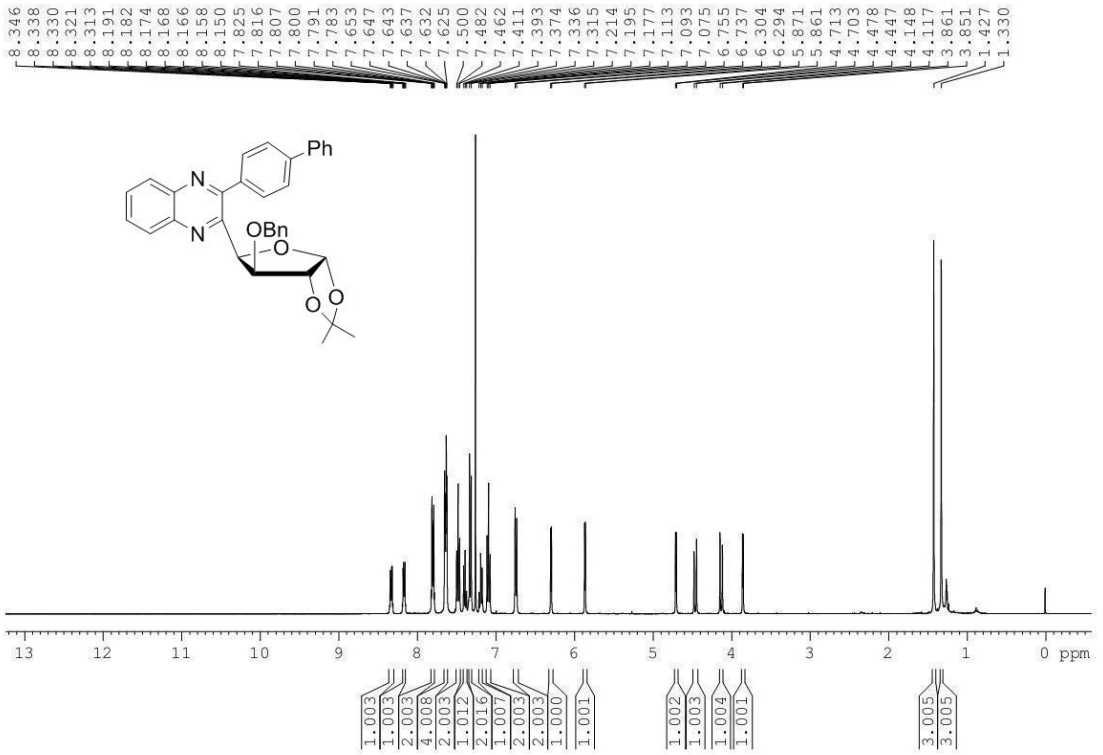


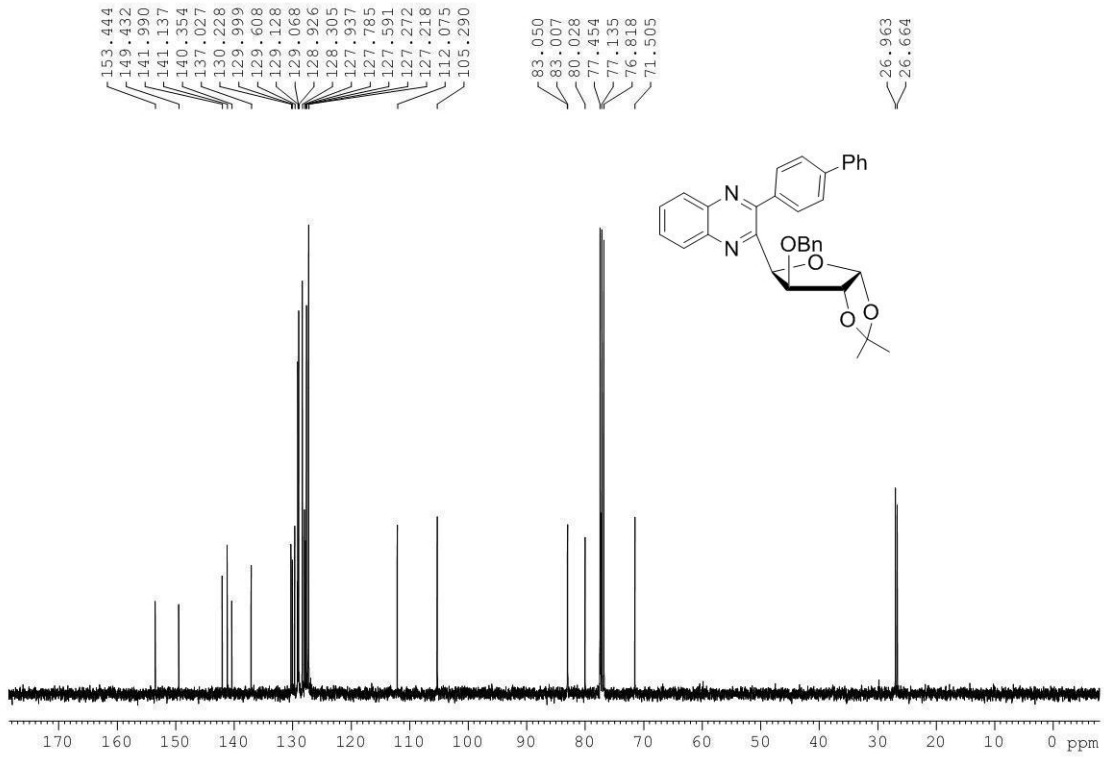
Pale yellow oil, 83%; R_f 0.52 (3:1 petroleum ether-EtOAc); $[\alpha]_D^{20}$ -7.3 (*c* 0.5, $CHCl_3$); FTIR (thin film): 3438 (OH), 3204, 3062, 2986, 2925, 2855, 1634, 1485, 1449, 1393, 849, 765, 700 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$) δ 8.20-8.15 (m, 2H, H-5, H-8), 7.84-7.78 (m, 4H, H-6, H-7, Ar*H*), 7.75-7.70 (m, 4H, Ar*H*), 7.54-7.47 (m, 3H, Ar*H*), 7.28-7.19 (m, 15H, Ar*H*), 5.36-5.31 (m, 2H, H-1', H-2'), 4.06 (br d, 1H, H-3'), 3.10 (dd, 1H, $J_{4'a,3'}$ = 6.0 Hz, $J_{4'a,4'b}$ = 9.6 Hz, H-4'a), 2.88 (dd, 1H, $J_{4'b,3'}$ = 4.4 Hz, $J_{4'b,4'a}$ = 9.6 Hz, H-4'b), 2.36 (br s, 1H, OH), 1.67, 1.50 (2 s, each 3H, 2 C*H*$_3$). ^{1}H NMR (100 MHz, $CDCl_3$) δ 155.12 (C-3), 150.14 (C-2), 143.54 (3 aromatic C), 141.83 (C-8a), 141.63 (C-4a), 141.20, 140.64, 136.85 (3 aromatic C), 130.55，130.05，129.68，129.54，129.21， 128.89，128.68，128.46，127.77，127.25，127.20，127.00 (28 aromatic *C*H), 110.71，110.53 (2 isopropylidene C), 86.67 (ph$_3$*C*O), 79.74 (C-2'), 76.36 (C-1'), 70.99 (C-3'), 64.66 (C-4'), 27.18, 27.15 (2 *C*H$_3$); HRMS (ESI) *m/z* Calcd for $C_{46}H_{41}N_2O_4$ $[M+H]^+$: 685.3066. Found: 685.3074.

^{1}H NMR and ^{13}C NMR of **1e**

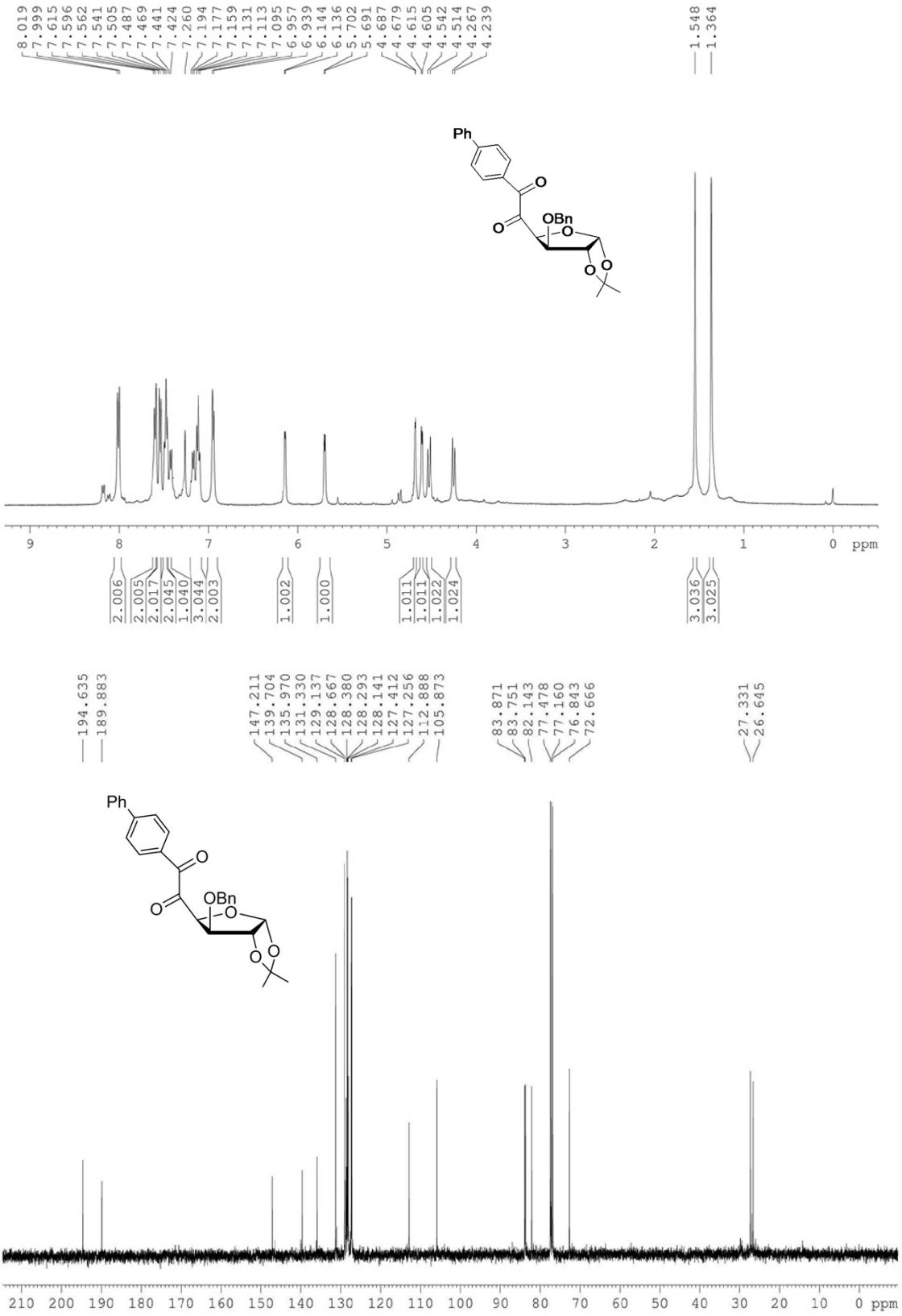


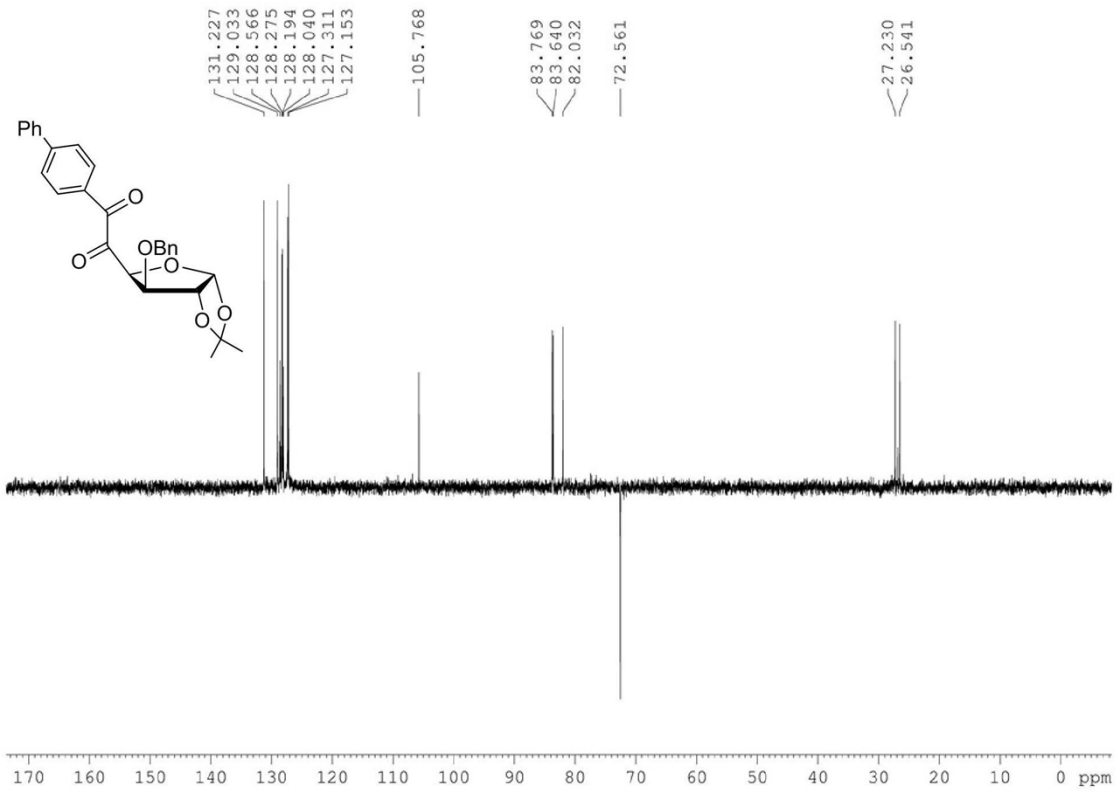
^{1}H NMR and ^{13}C NMR of **2aa**





^{1}H NMR, ^{13}C NMR, DEPT-135, ^{1}H-^{1}H COSY, HSQC and HMBC of intermediate **5**

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128.275
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127.311
127.153
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83.769
83.640
82.032
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26.541
Ph
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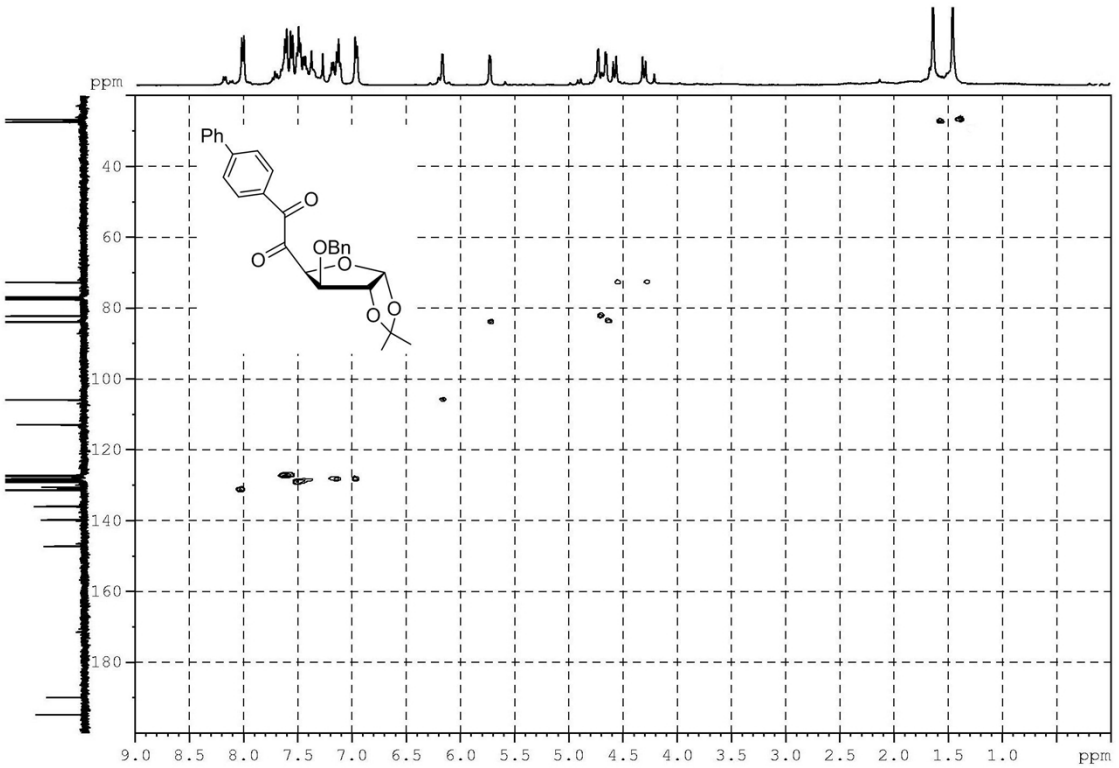
O
OBn
O
O
O
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm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Ph
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O
OBn
O
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60
80
100
120
140
160
180
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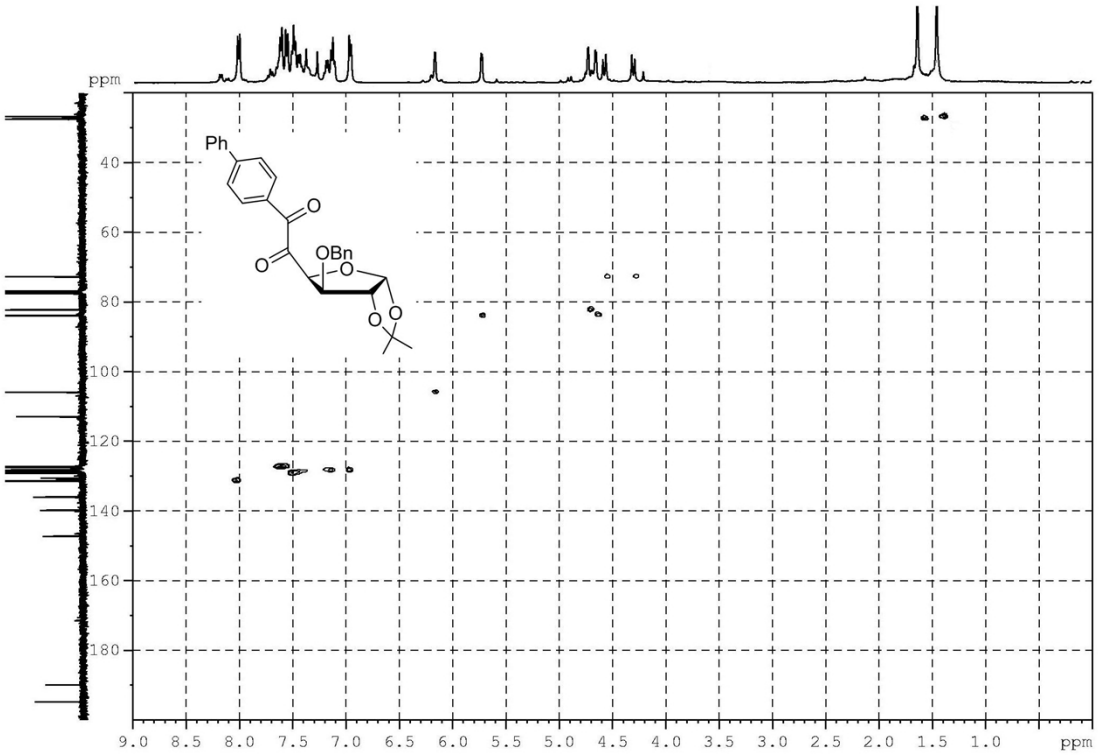
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Ph
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O
OBn
O
O
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60
80
100
120
140
160
180
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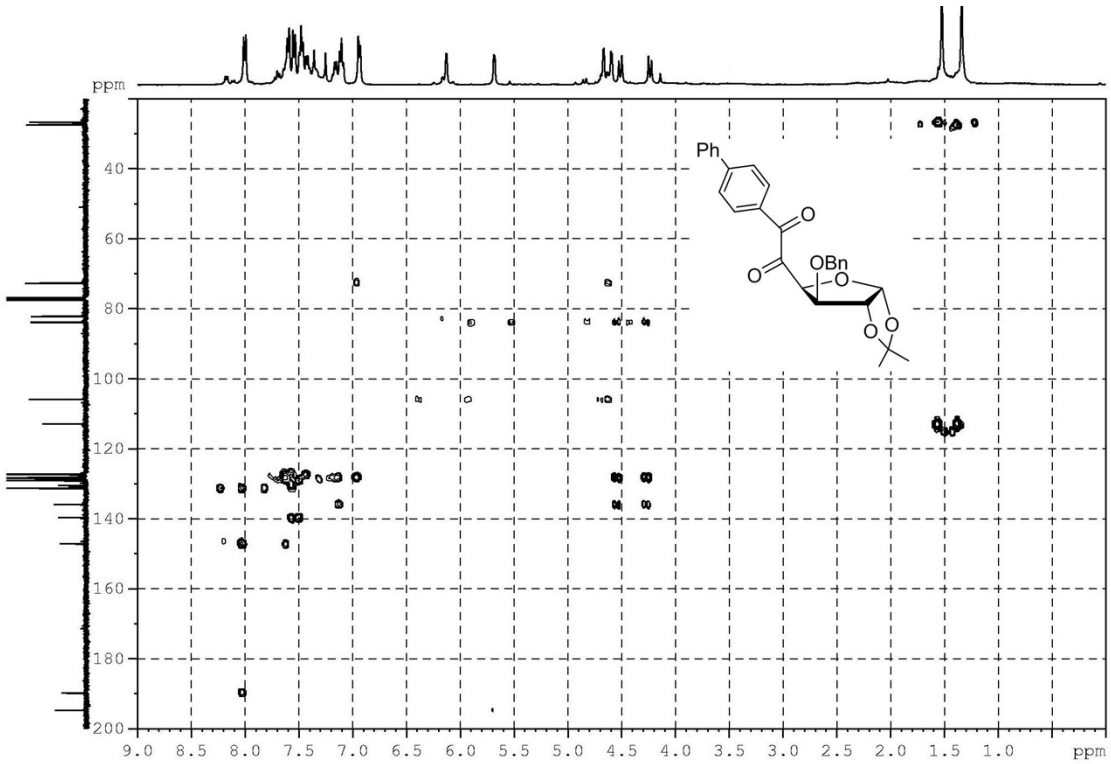
ppm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Ph
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120
140
160
180
200
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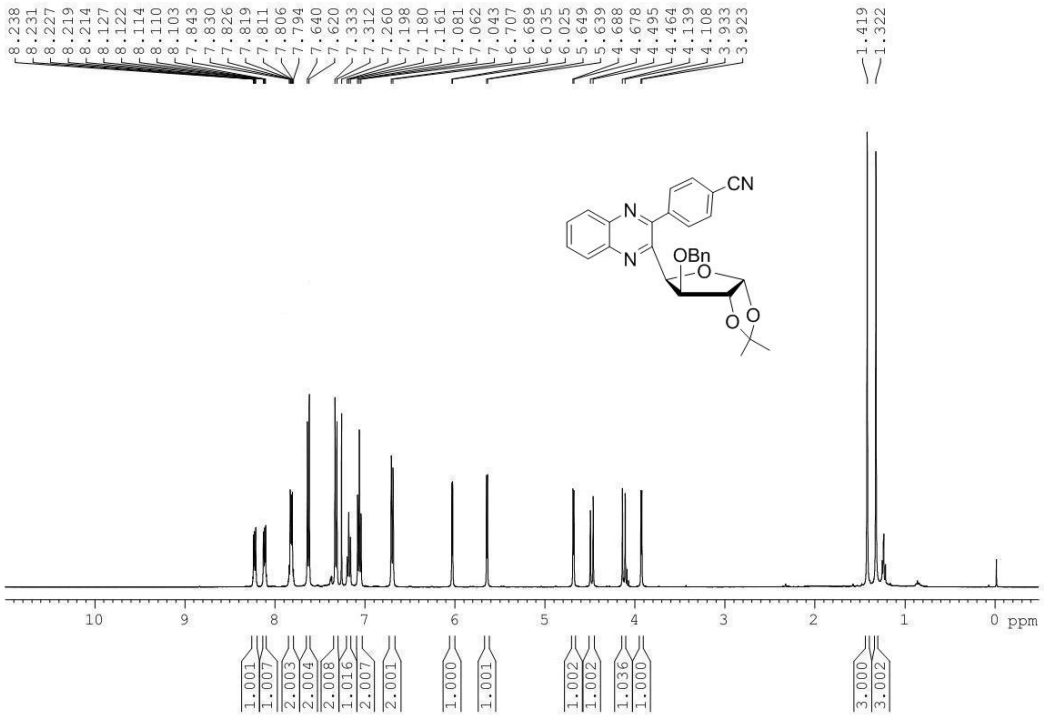
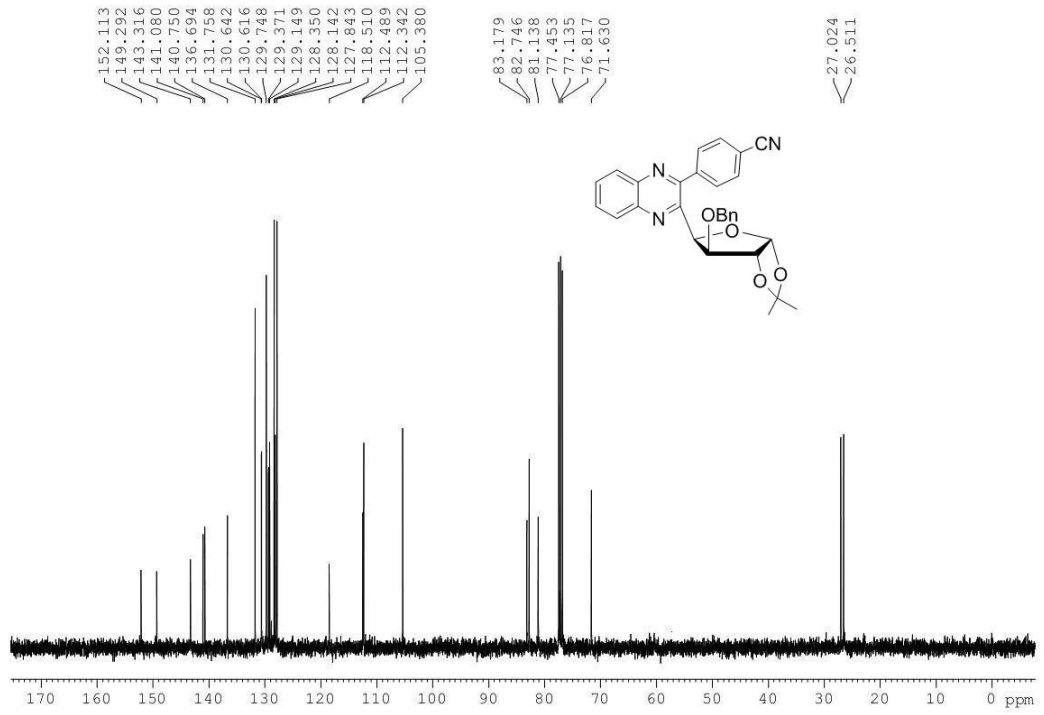
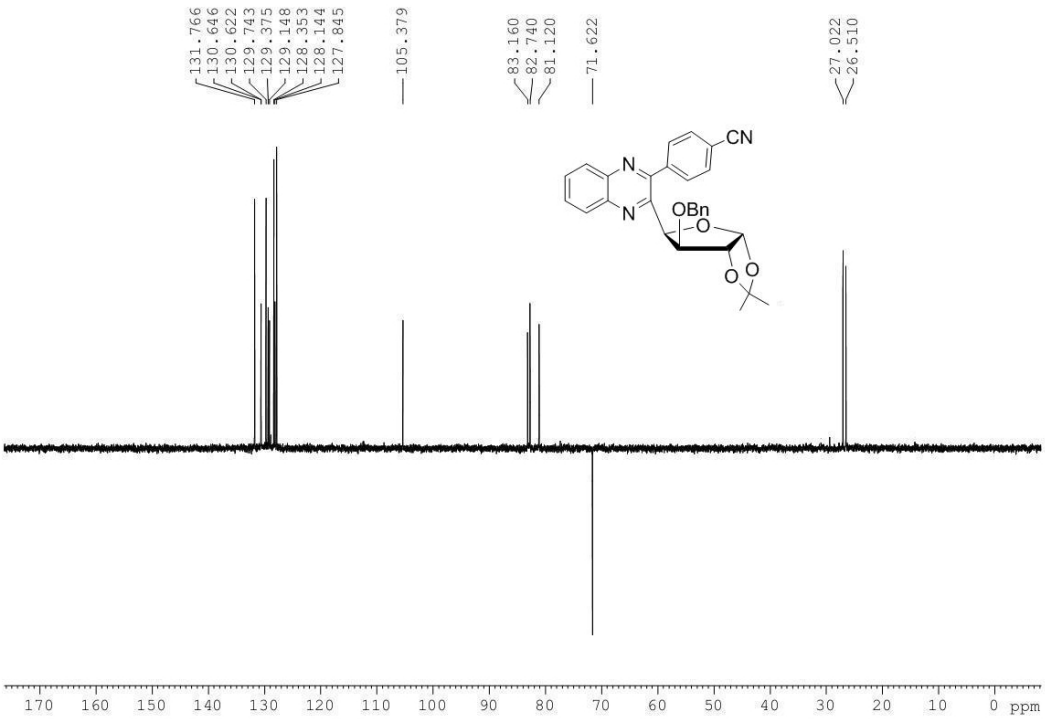
ppm

^{1}H NMR, ^{13}C NMR, DEPT-135, ^{1}H-^{1}H COSY, HSQC and HMBC of **2ab**



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127.845
105.379
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82.740
81.120
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26.510
CN
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N
OBn
O
O
O
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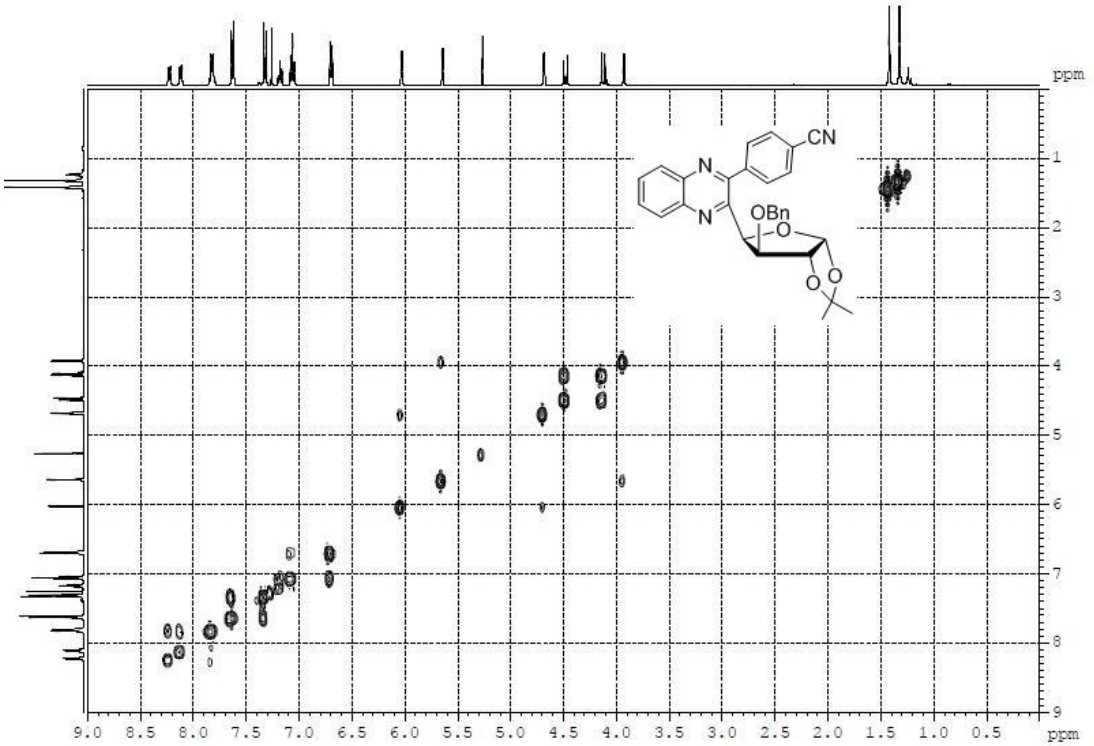
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N
OBn
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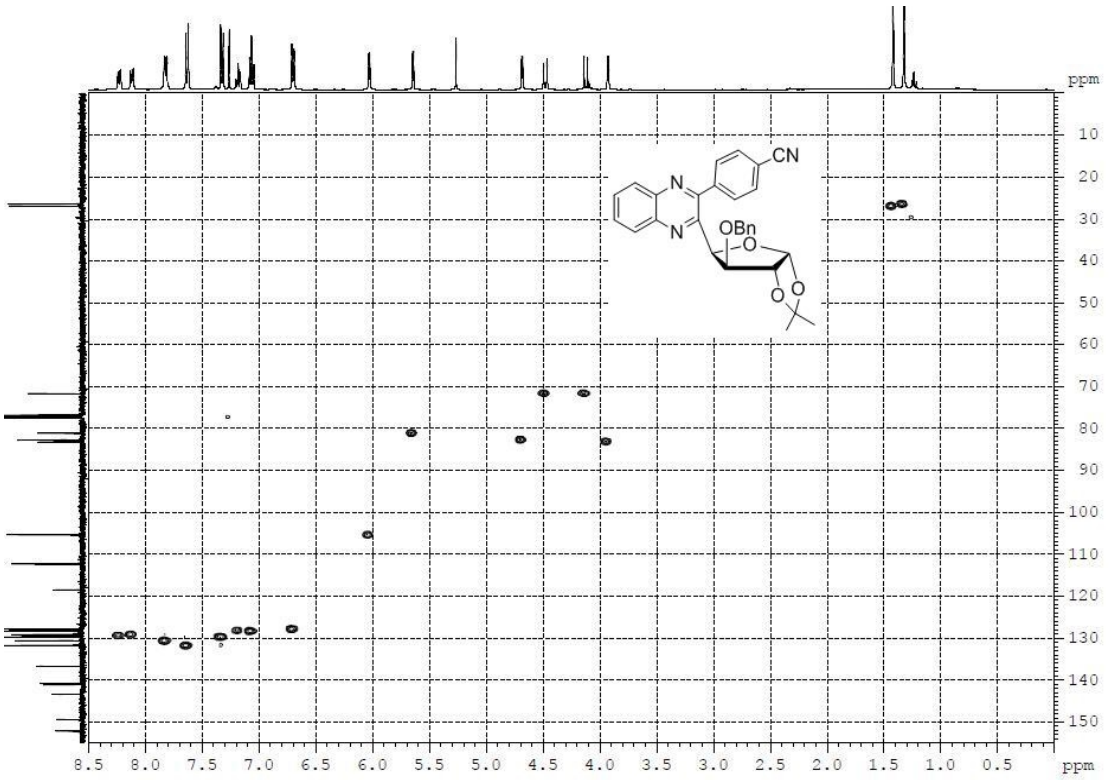
ppm
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N
N
OBn
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O
O
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ppm
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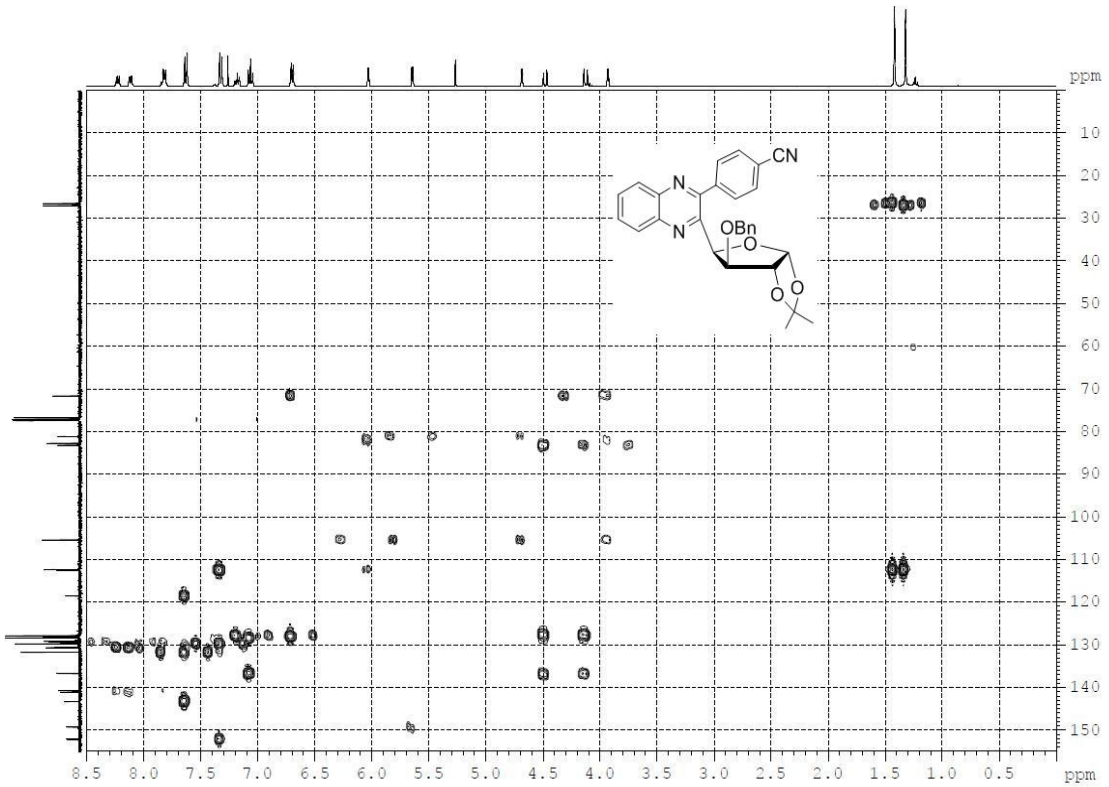
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N
N
OBn
O
O
O
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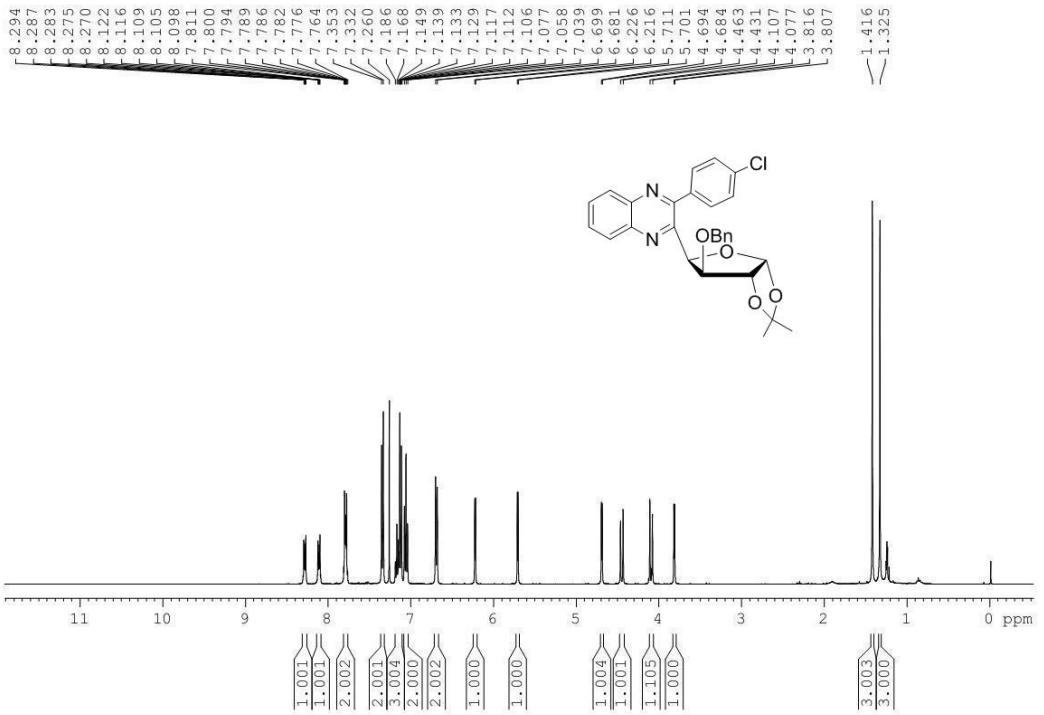
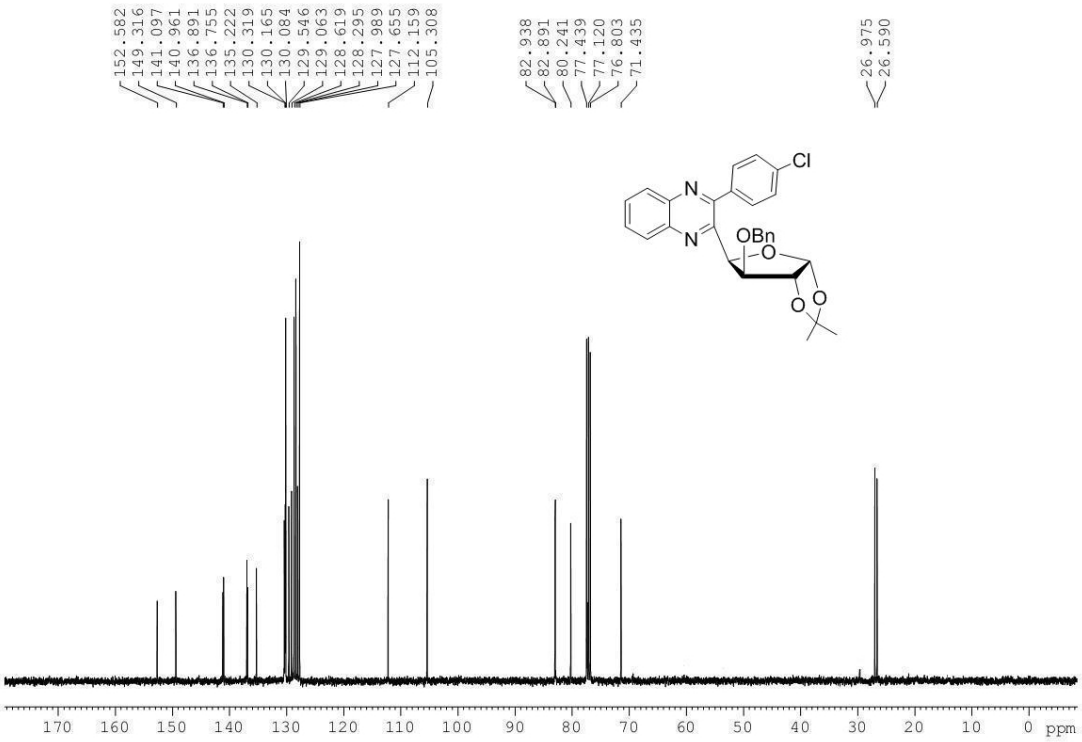
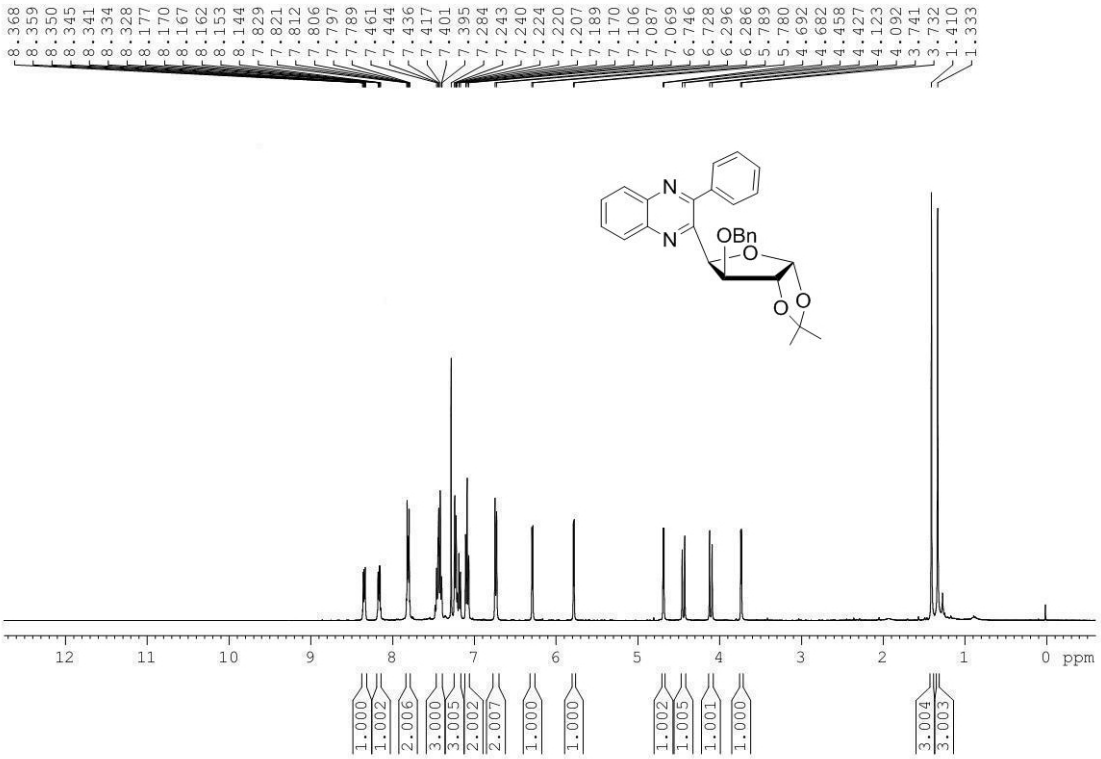
ppm
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

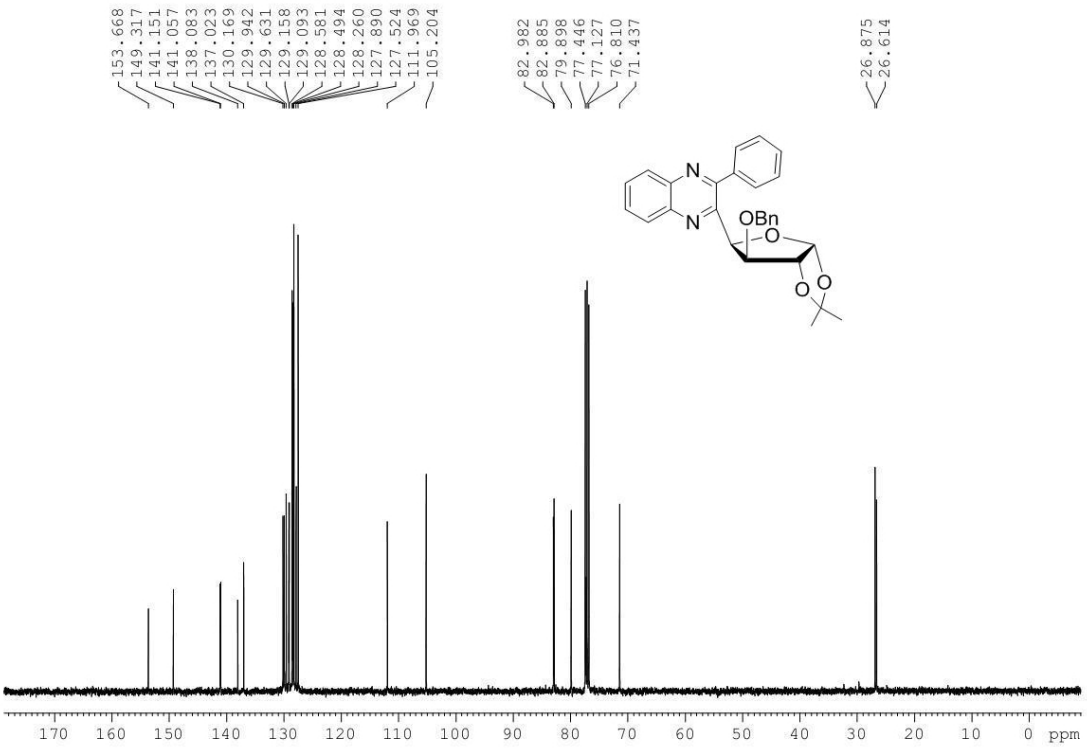
^{1}H NMR and ^{13}C NMR of **2ac**



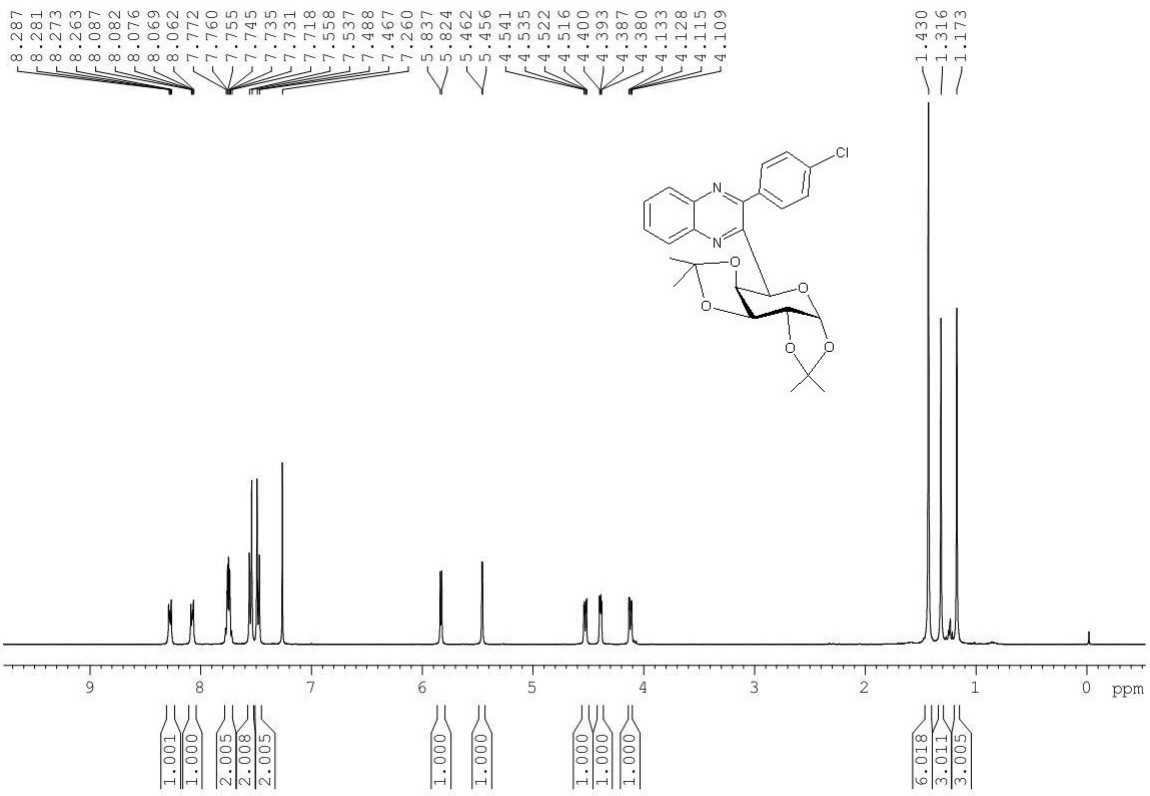


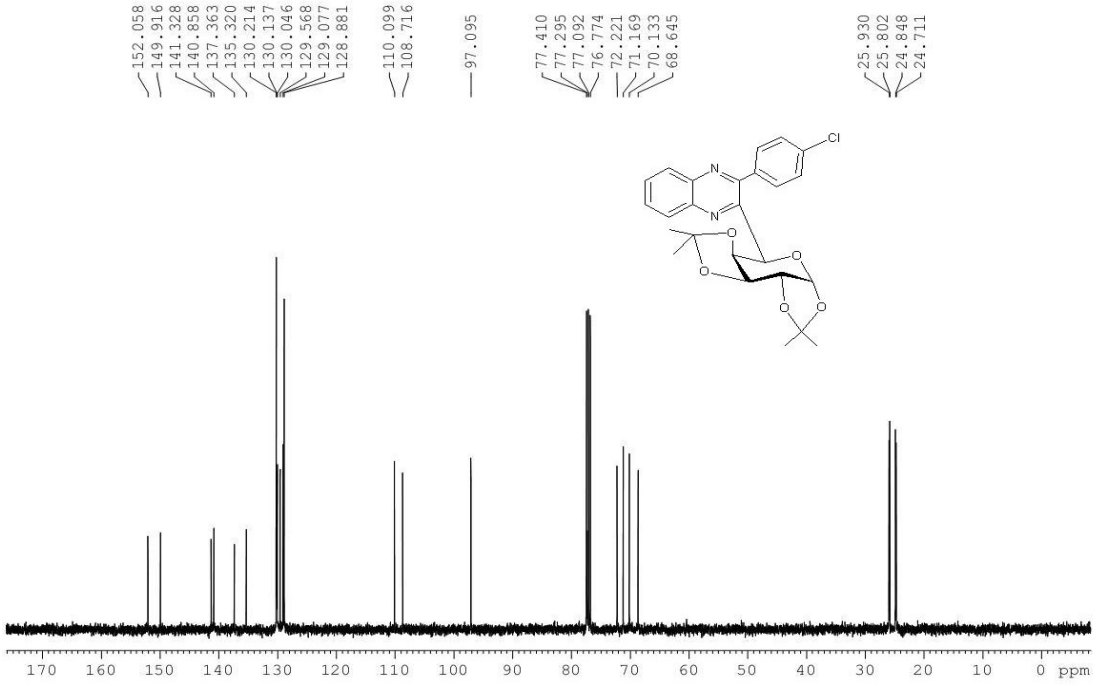
^{1}H NMR and ^{13}C NMR of **2ad**





^{1}H NMR, ^{13}C NMR, DEPT-135, ^{1}H-^{1}H COSY, HSQC and HMBC of **2ba**

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141.328
140.858
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135.320
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130.137
130.046
129.568
129.077
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110.099
108.716
97.095
77.410
77.295
77.092
76.774
72.221
71.169
70.133
68.645
25.930
25.802
24.848
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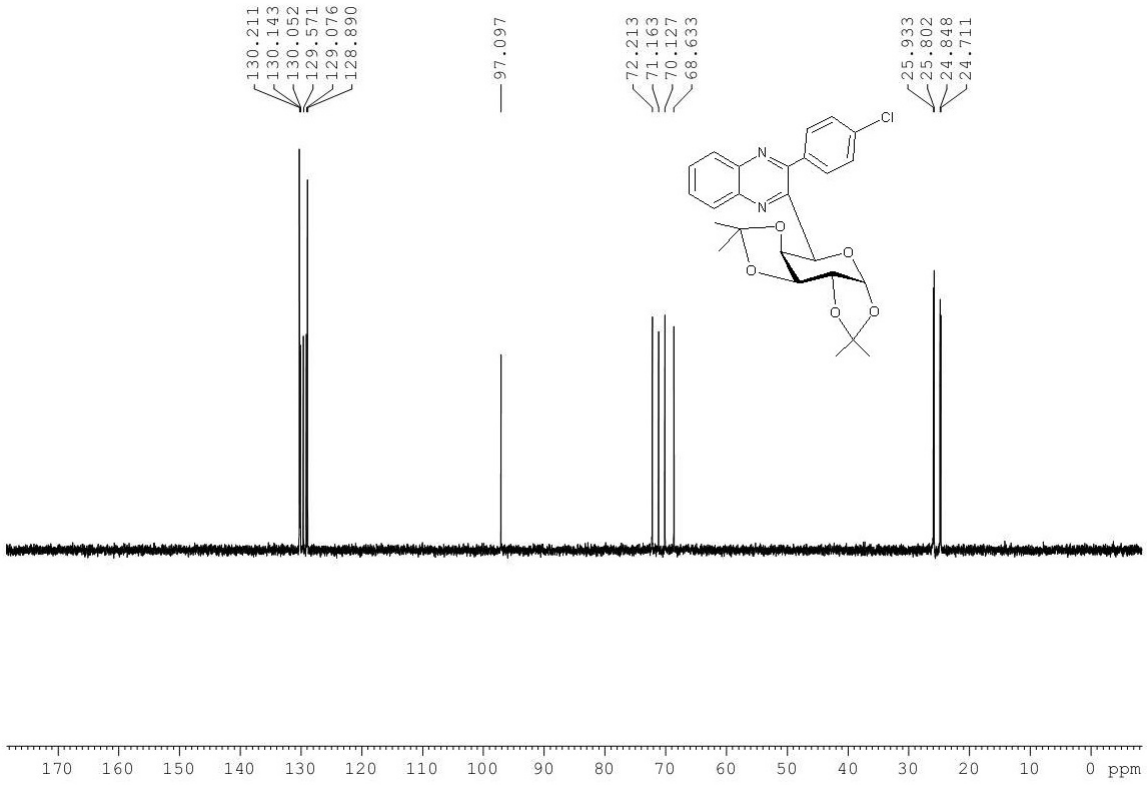
Cl
N
N
O
O
O
O
O
O
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm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130.052
129.571
129.076
128.890
97.097
72.213
71.163
70.127
68.633
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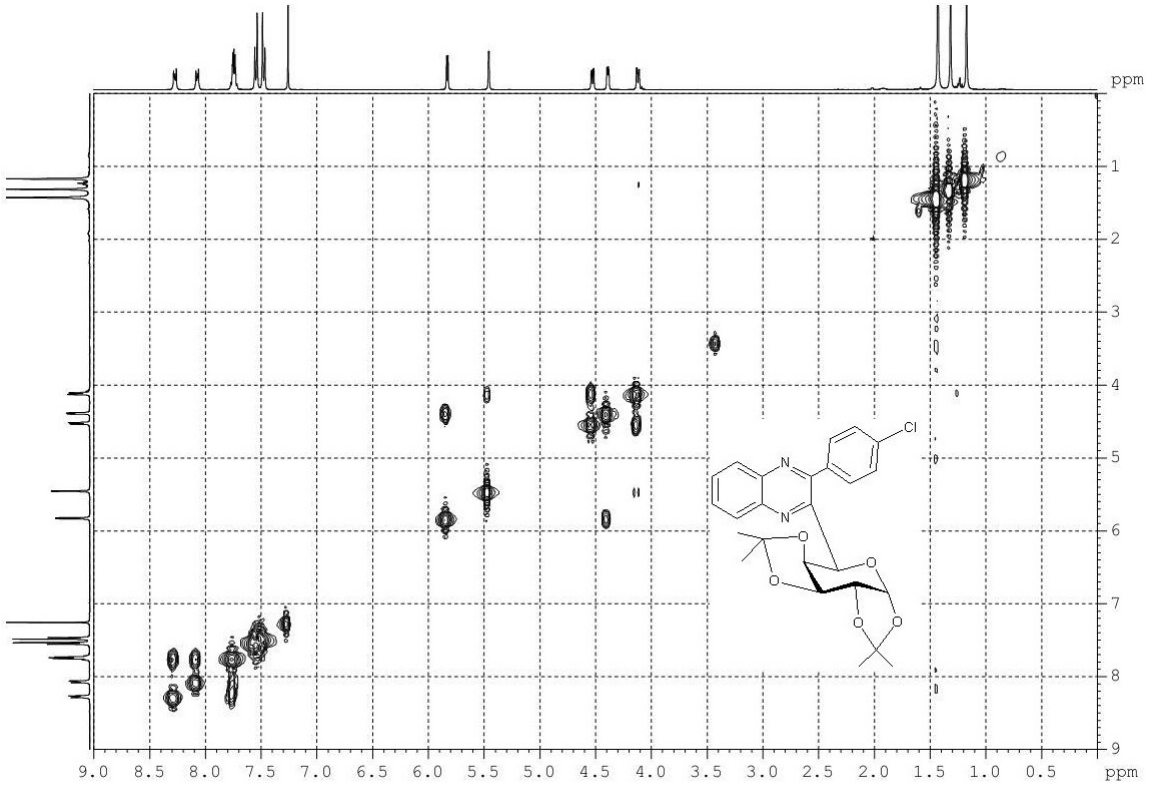
O
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm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Cl
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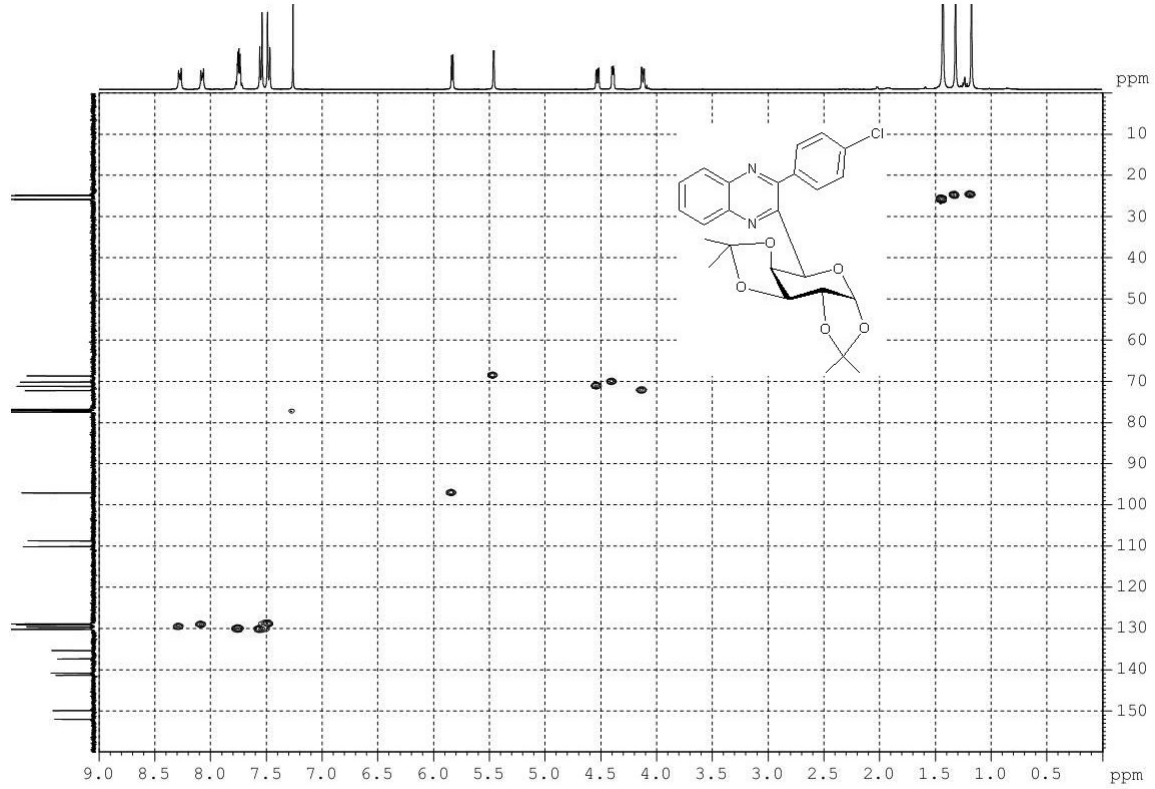
O
O
O
O
O


ppm
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30
40
50
60
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90
100
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120
130
140
150
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
ppm
Cl
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N
O
O
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O
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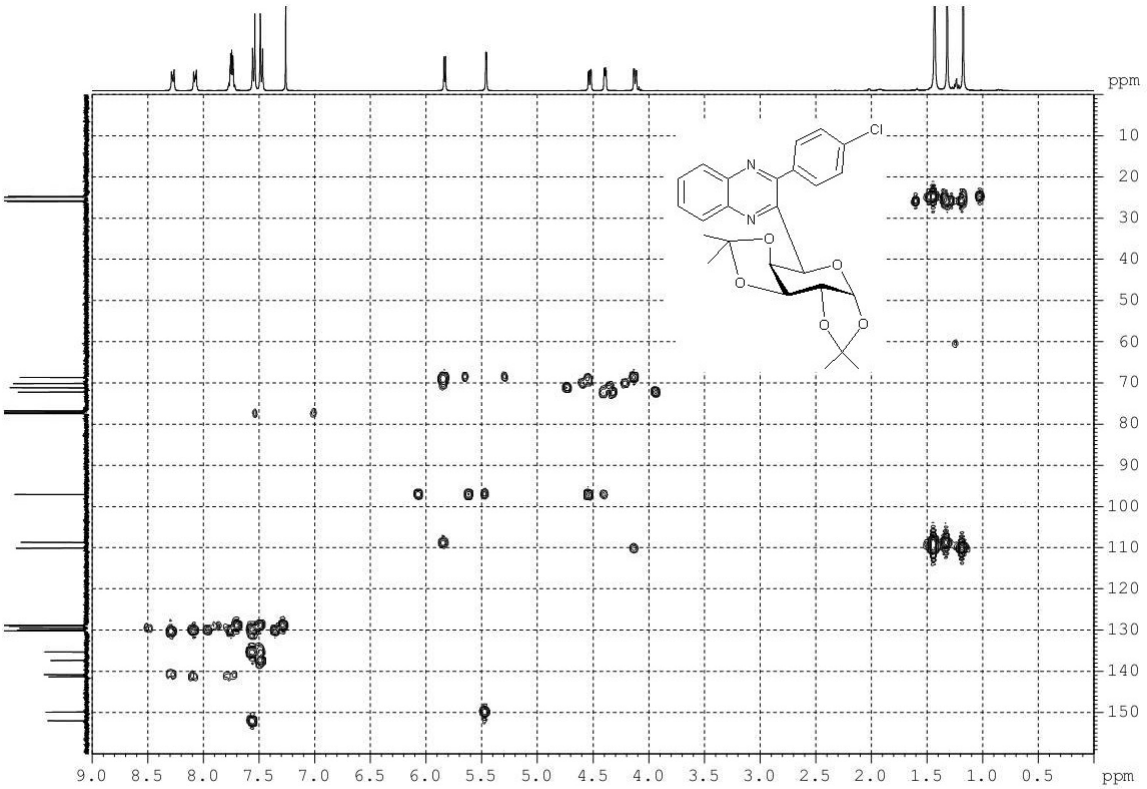
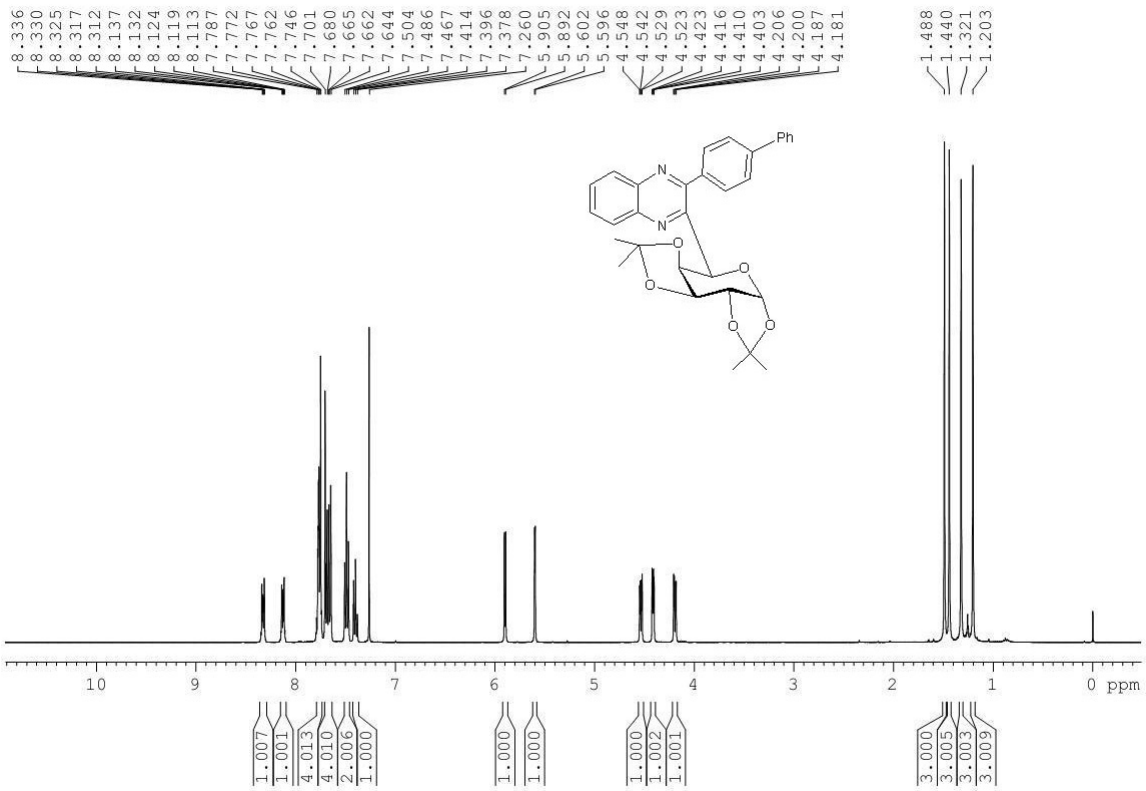


^{1}H NMR and ^{13}C NMR of **2bb**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8.137
8.132
8.124
8.119
8.113
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7.762
7.746
7.701
7.680
7.665
7.662
7.644
7.504
7.486
7.467
7.414
7.396
7.378
7.260
5.905
5.892
5.602
5.596
4.548
4.542
4.529
4.523
4.423
4.416
4.410
4.403
4.206
4.200
4.187
4.181
1.488
1.440
1.321
1.203
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3
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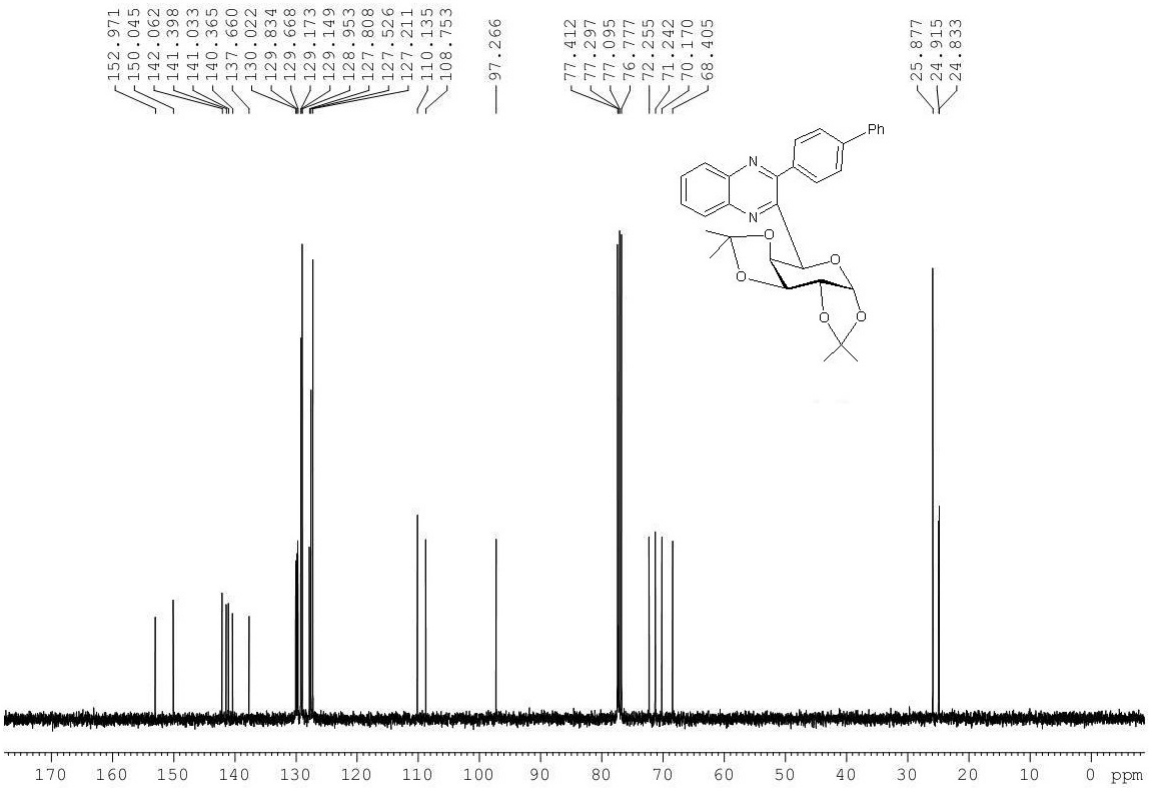
1.002
1.001
3.000
3.005
3.003
3.009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128.953
127.808
127.526
127.211
110.135
108.753
97.266
77.412
77.297
77.095
76.777
72.255
71.242
70.170
68.405
25.877
24.915
24.833
Ph
N
N
O
O
O
O
O
O
170
160
150
140
130
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110
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90
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50
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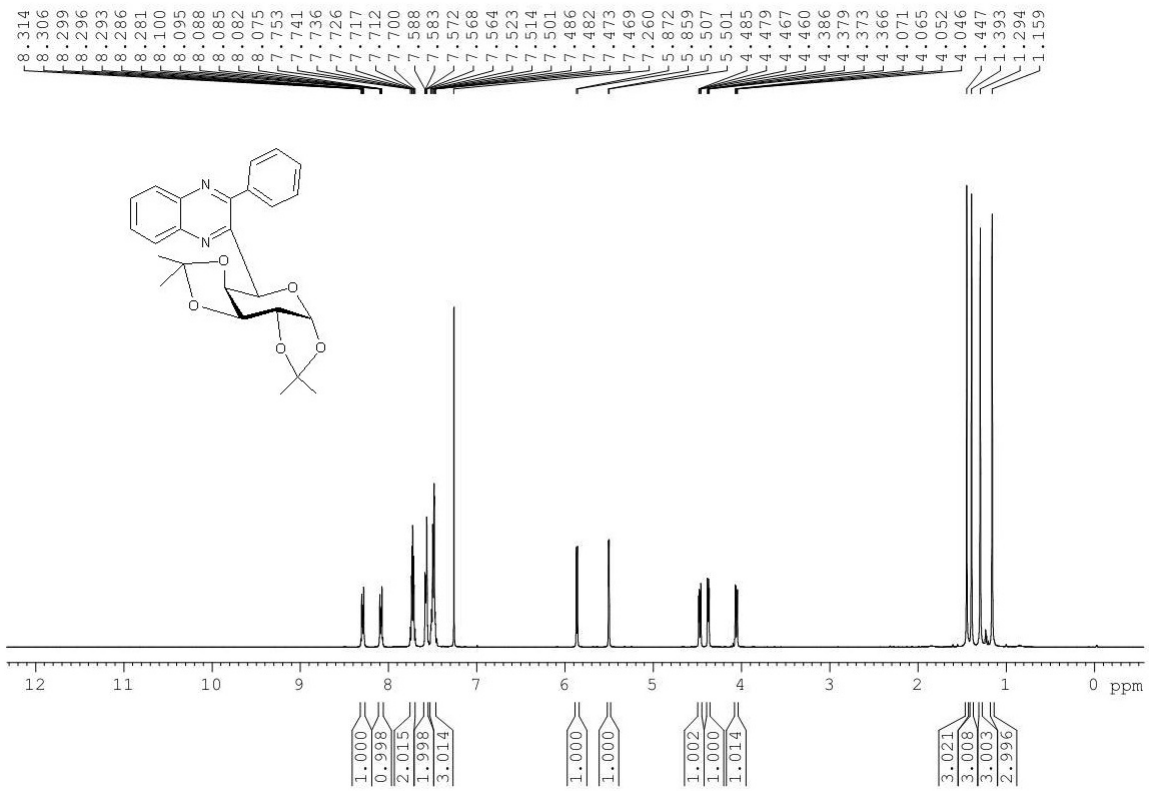
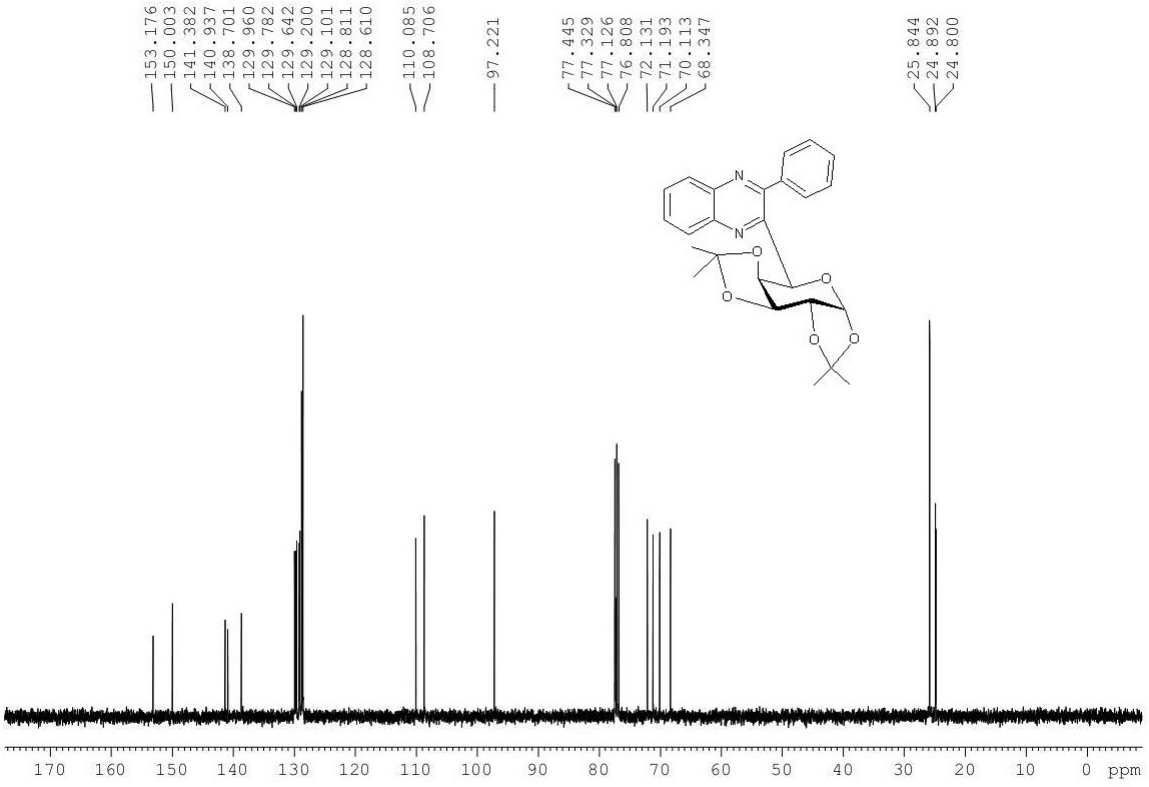
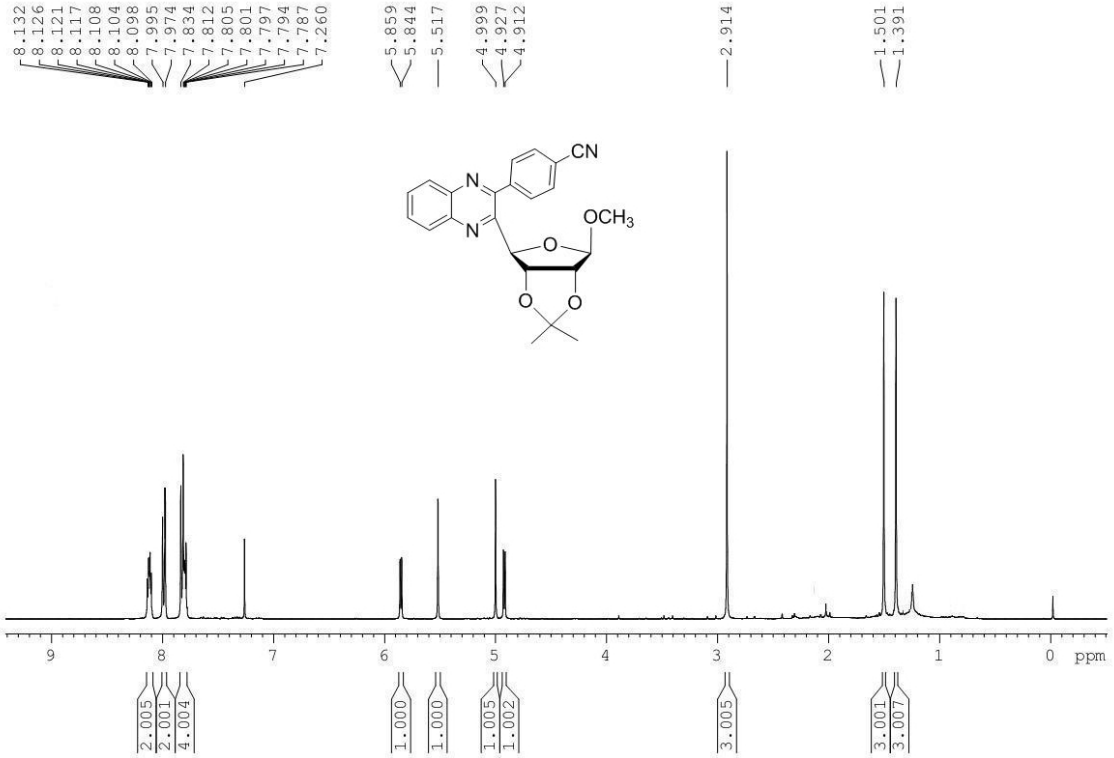
30
20
10
0 ppm

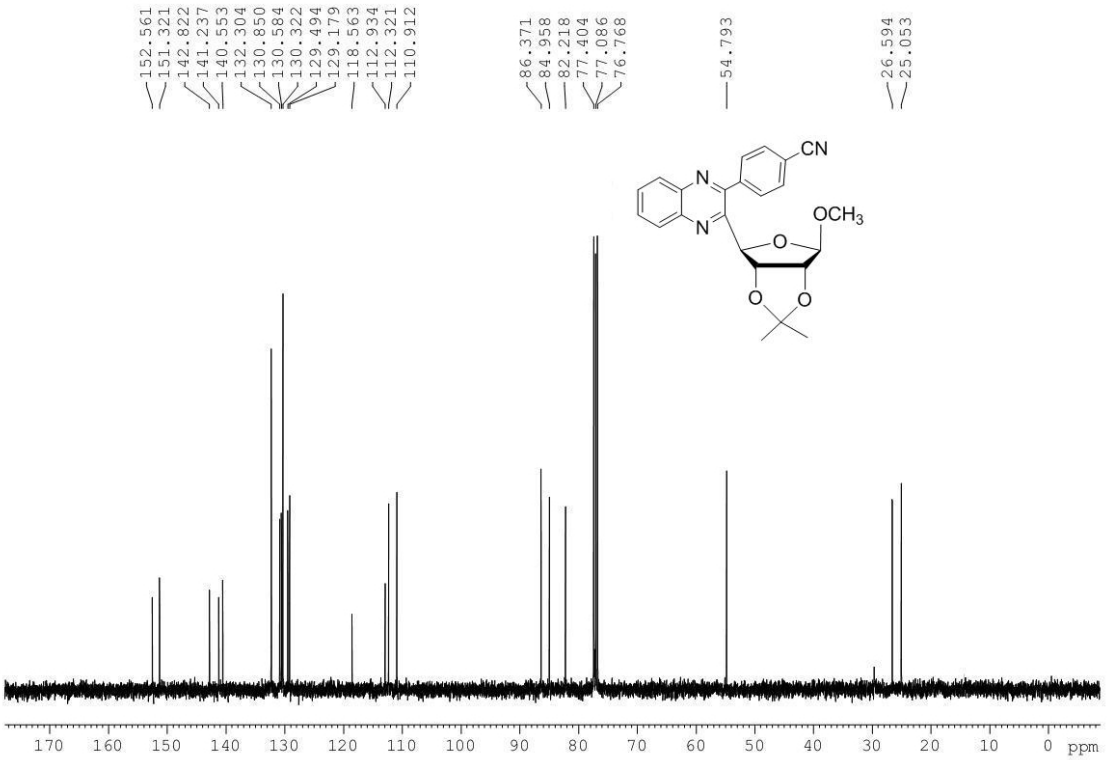
^{1}H NMR and ^{13}C NMR of **2bc**

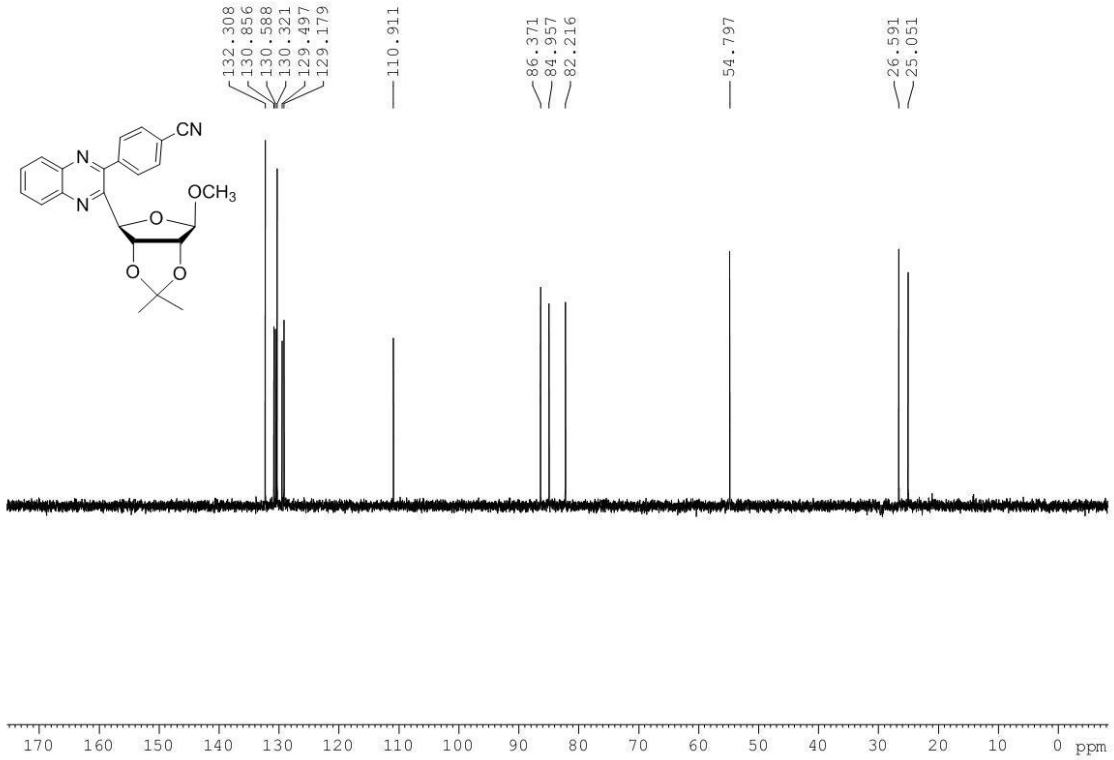




^{1}H NMR, ^{13}C NMR, DEPT-135, ^{1}H-^{1}H COSY, HSQC and HMBC of **2ca**




152.561
151.321
142.822
141.237
140.553
132.304
130.850
130.584
130.322
129.494
129.179
118.563
112.934
112.321
110.912
86.371
84.958
82.218
77.404
77.086
76.768
54.793
26.594
25.053
CN
N
N
OCH3
O
O
O
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


132.308
130.856
130.588
130.321
129.497
129.179
110.911
86.371
84.957
82.216
54.797
26.591
25.051
CN
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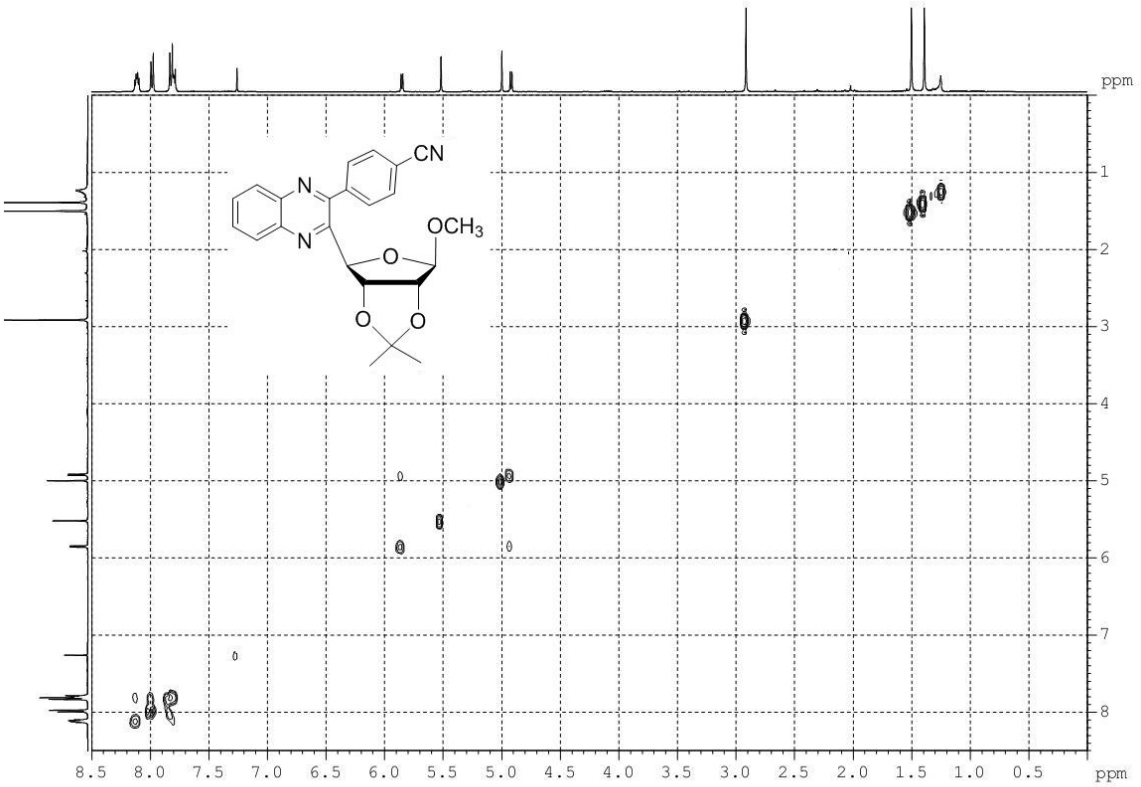
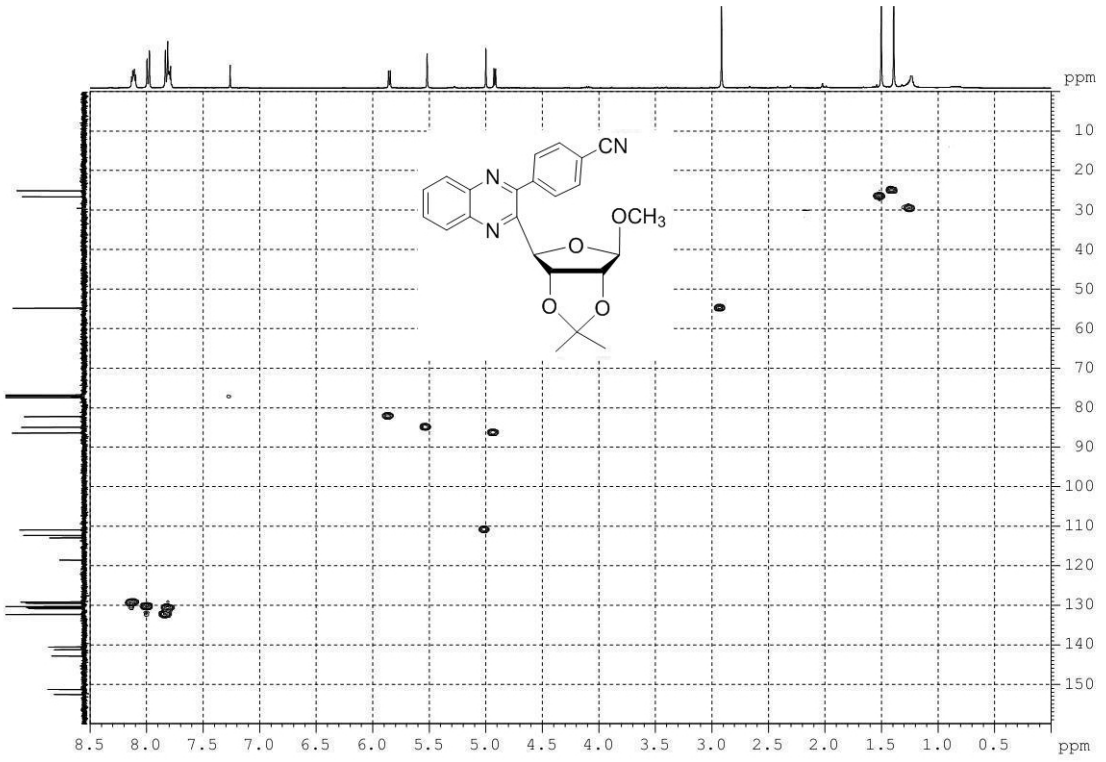
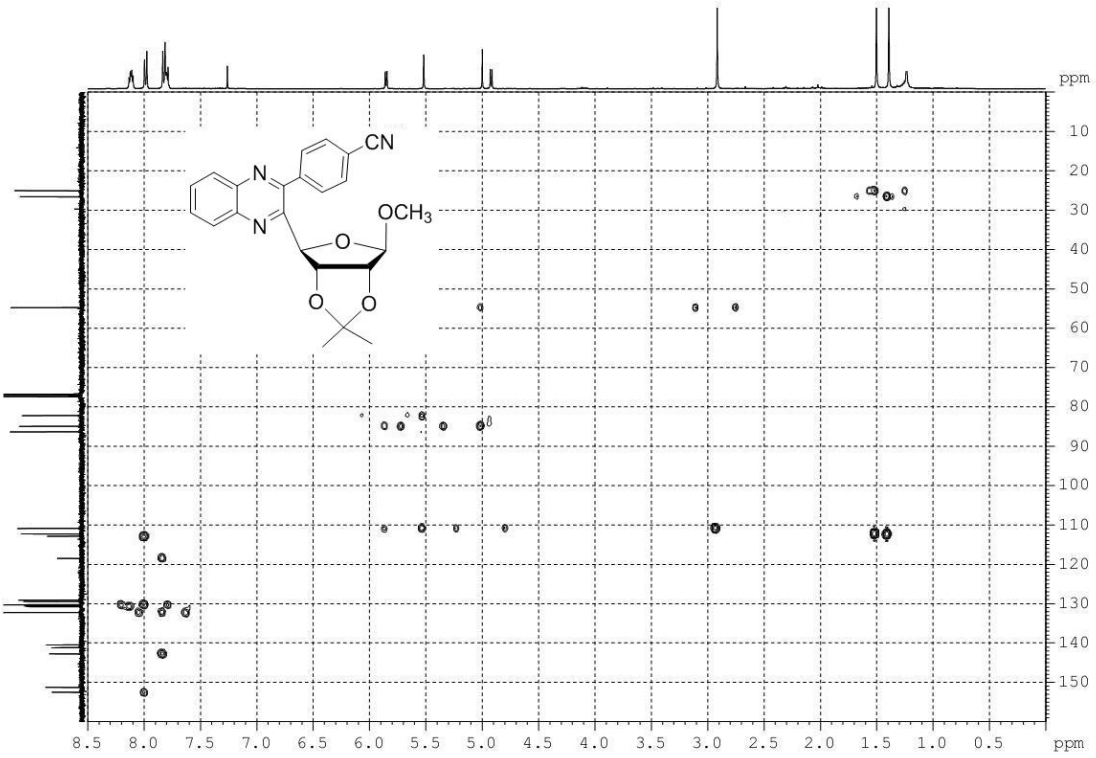
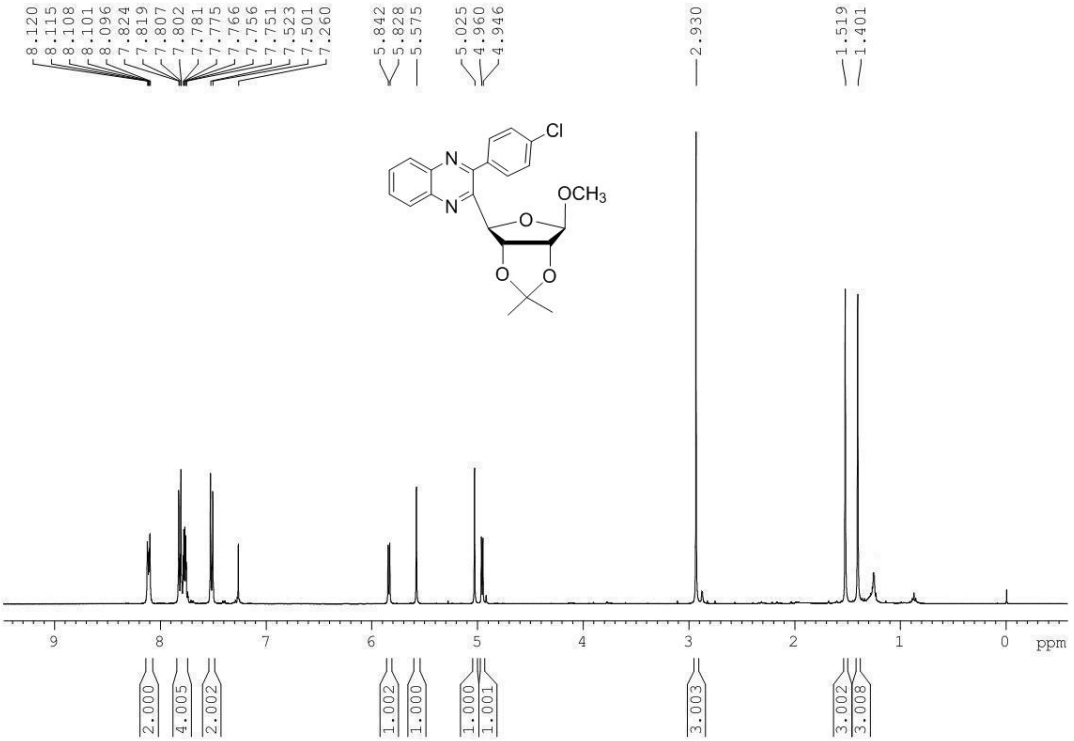
N
OCH3
O
O
O
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

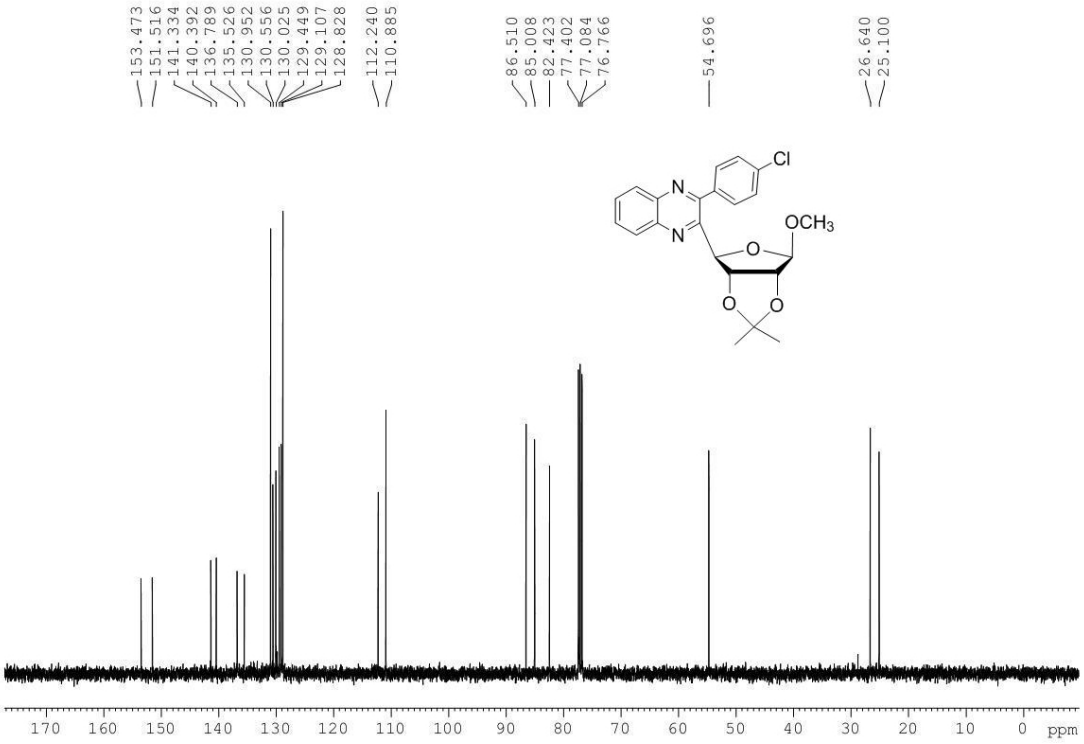

CN
N
N
OCH3
O
O
O
ppm
1
2
3
4
5
6
7
8
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
ppm


CN
N
N
OCH3
O
O
O
ppm
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
ppm

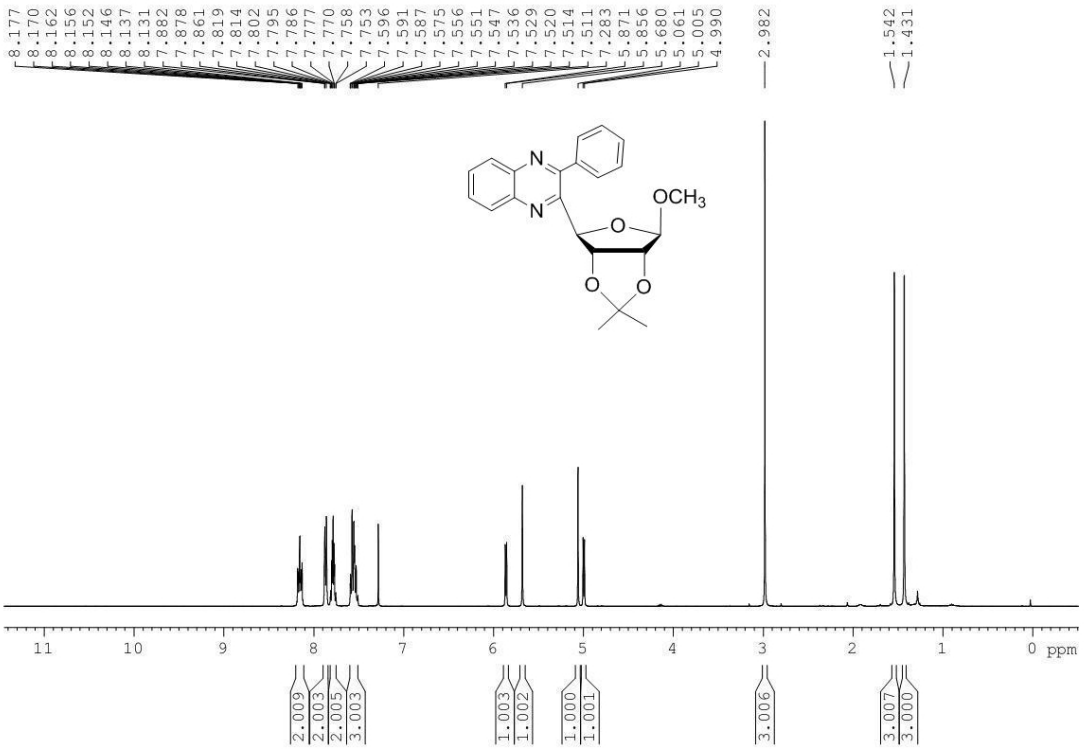


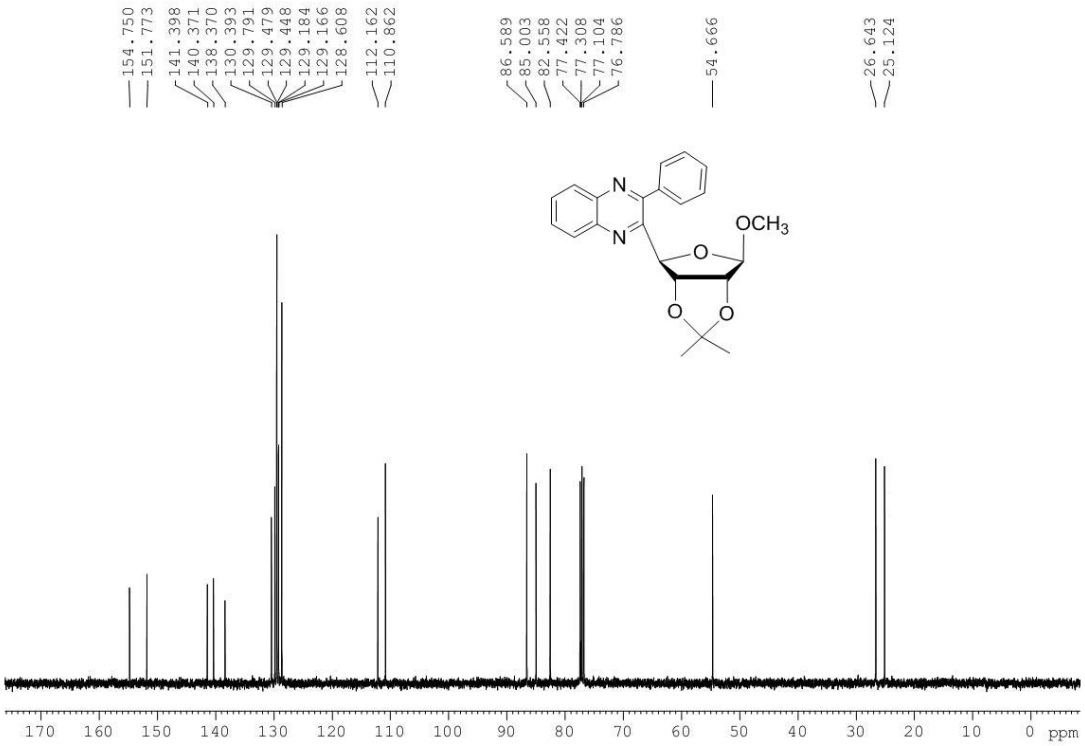
^{1}H NMR and ^{13}C NMR of **2cb**



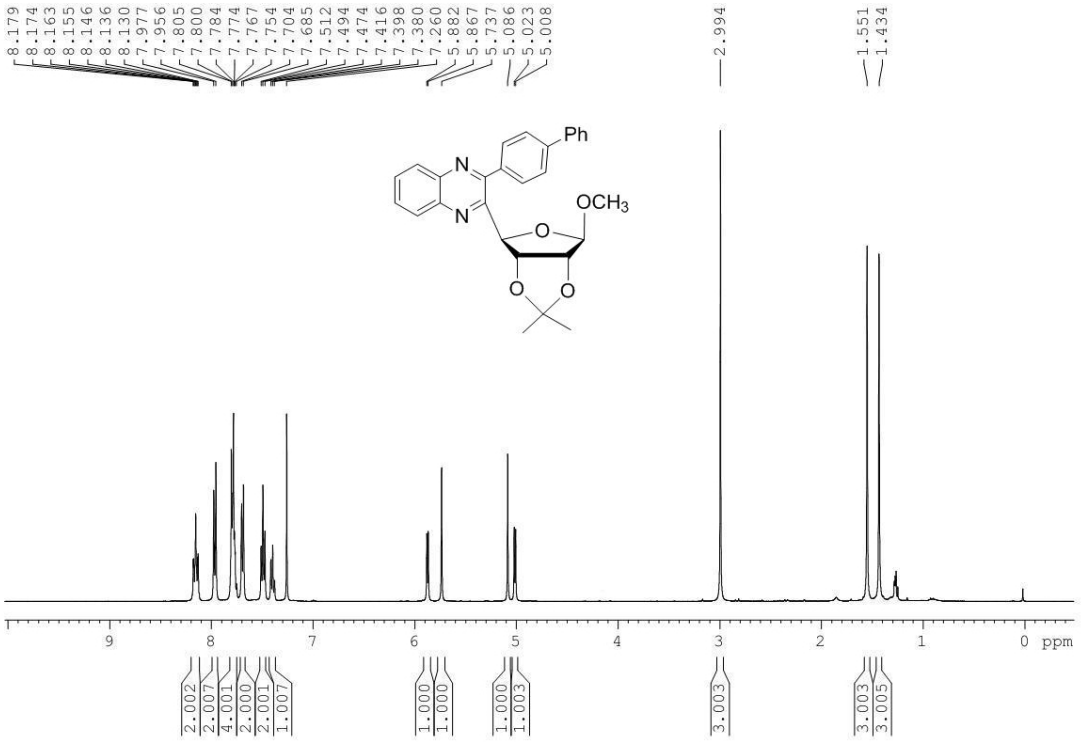


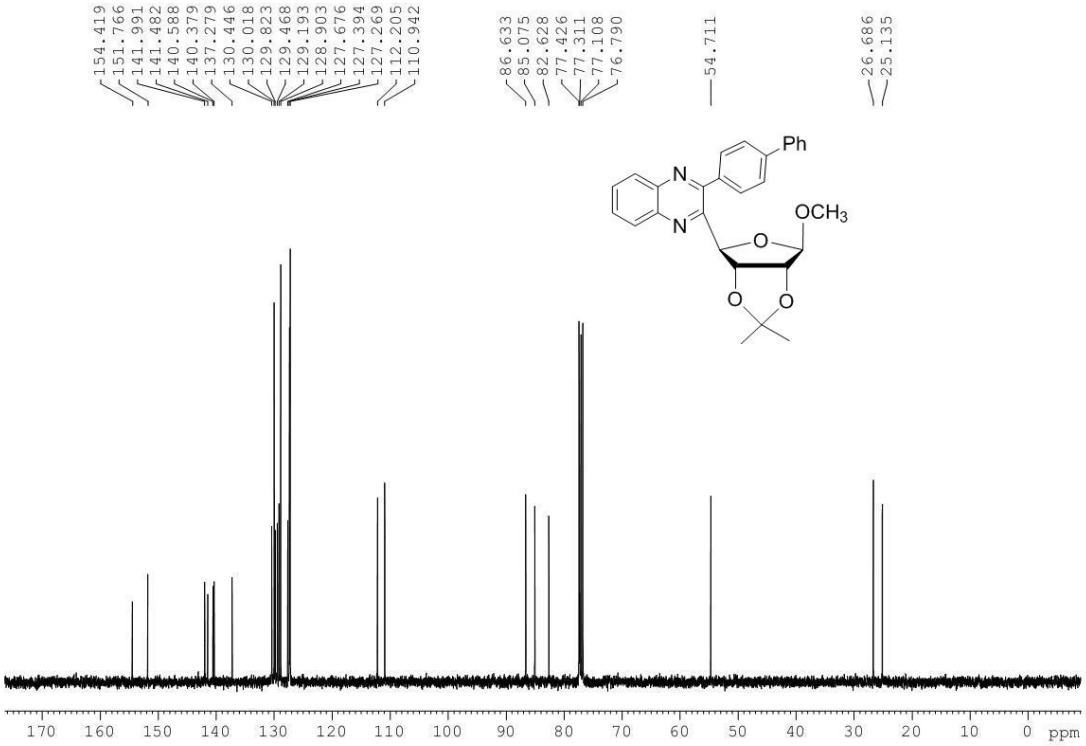
^{1}H NMR and ^{13}C NMR of **2cc**



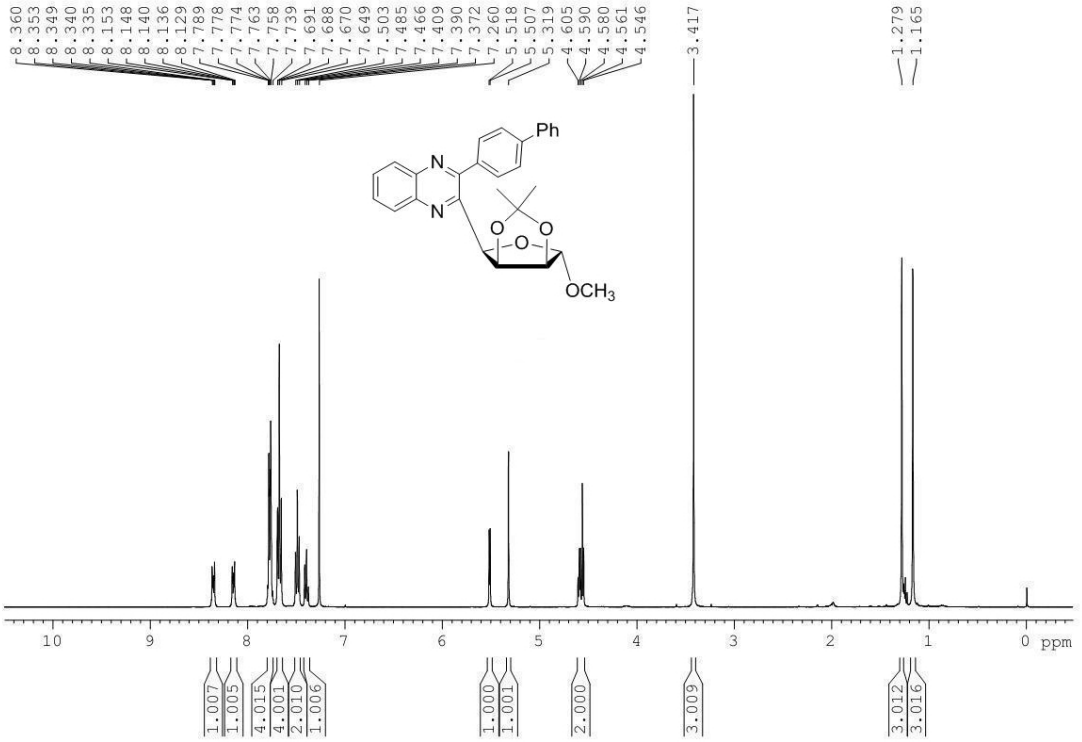


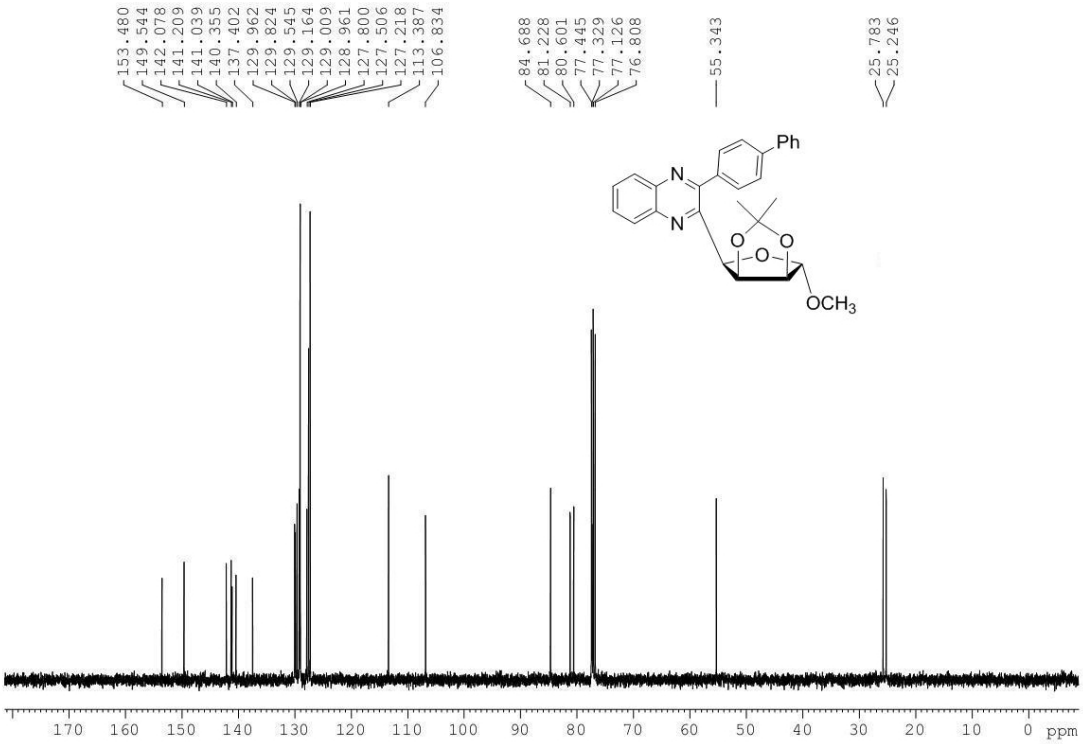
^{1}H NMR and ^{13}C NMR of **2cd**

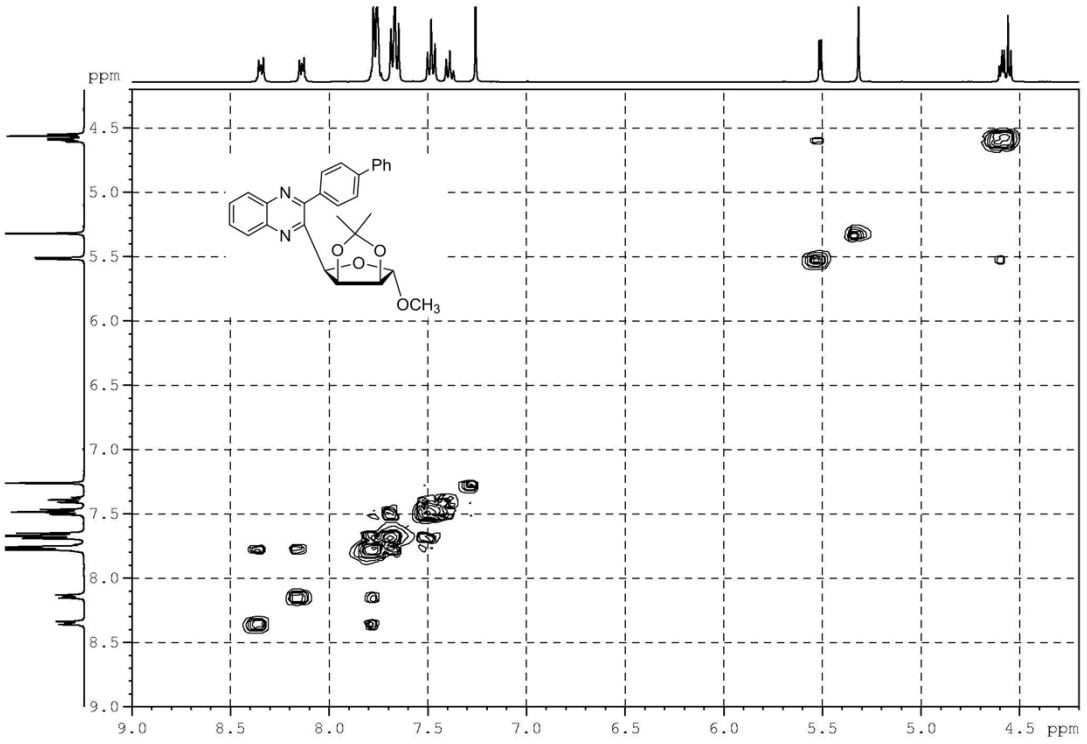

8.179
8.174
8.163
8.155
8.146
8.136
8.130
7.977
7.956
7.805
7.800
7.784
7.774
7.767
7.754
7.704
7.685
7.512
7.494
7.474
7.416
7.398
7.380
7.260
5.882
5.867
5.737
5.086
5.023
5.008
2.994
1.551
1.434
Ph
N
N
OCH3
O
O
O
9
8
7
6
5
4
3
2
1
0 ppm
2.002
2.007
4.001
2.000
2.001
1.007
1.000
1.000
1.000
1.003
3.003
3.003
3.005

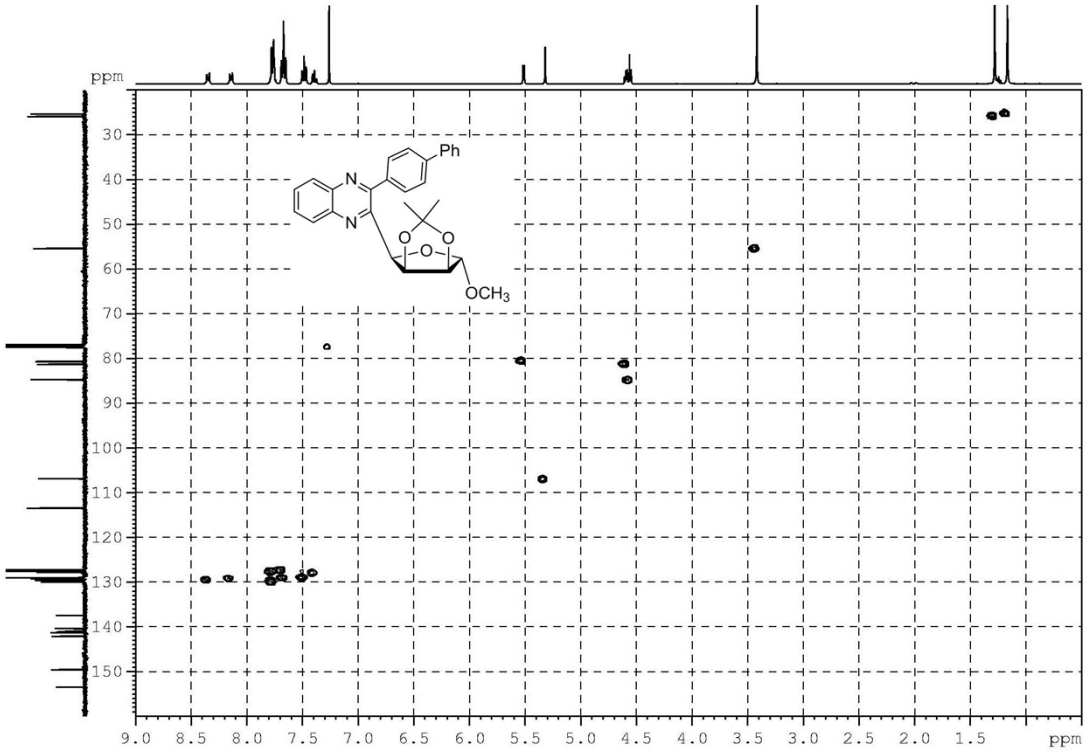

154.419
151.766
141.991
141.482
140.588
140.379
137.279
130.446
130.018
129.823
129.468
129.193
128.903
127.676
127.394
127.269
112.205
110.942
86.633
85.075
82.628
77.426
77.311
77.108
76.790
54.711
26.686
25.135
Ph
N
N
OCH3
O
O
O
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0 ppm

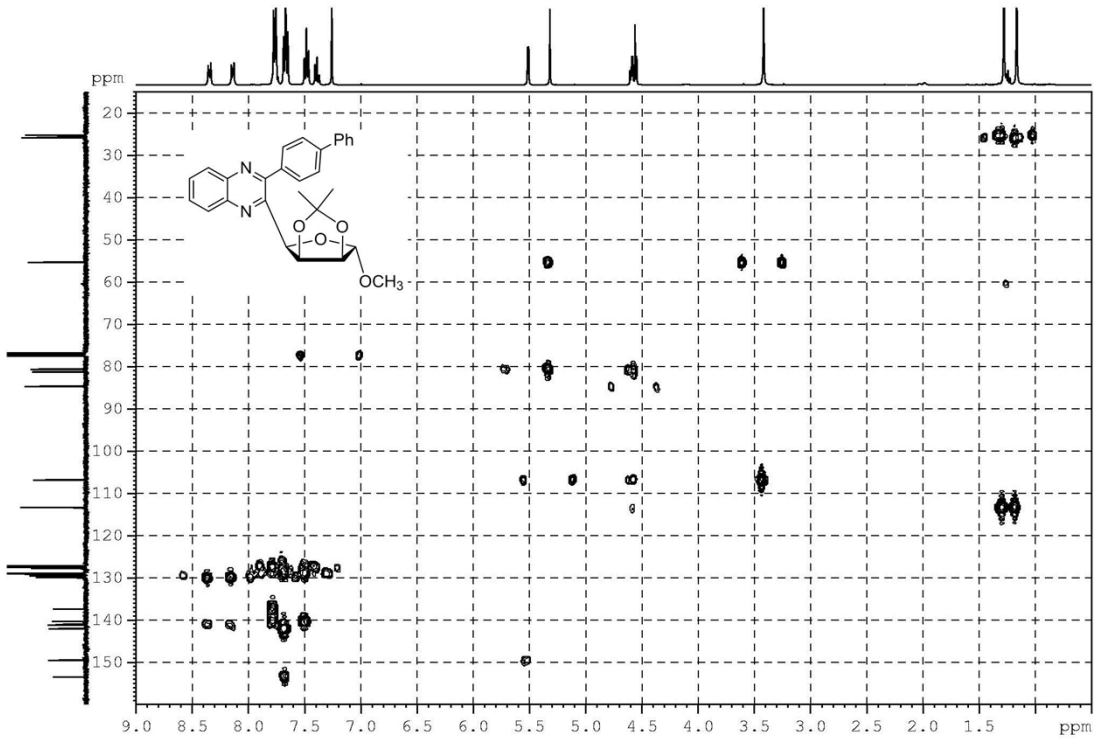
^{1}H NMR, ^{13}C NMR, ^{1}H-^{1}H COSY, HSQC and HMBC of **2da**



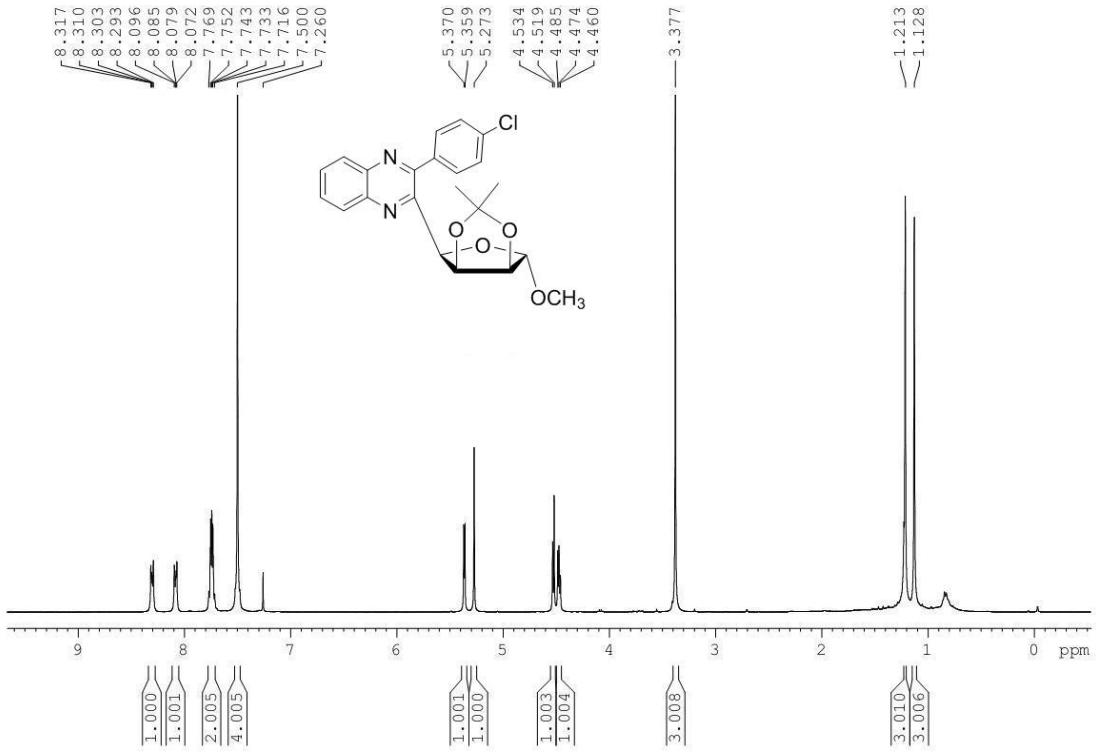


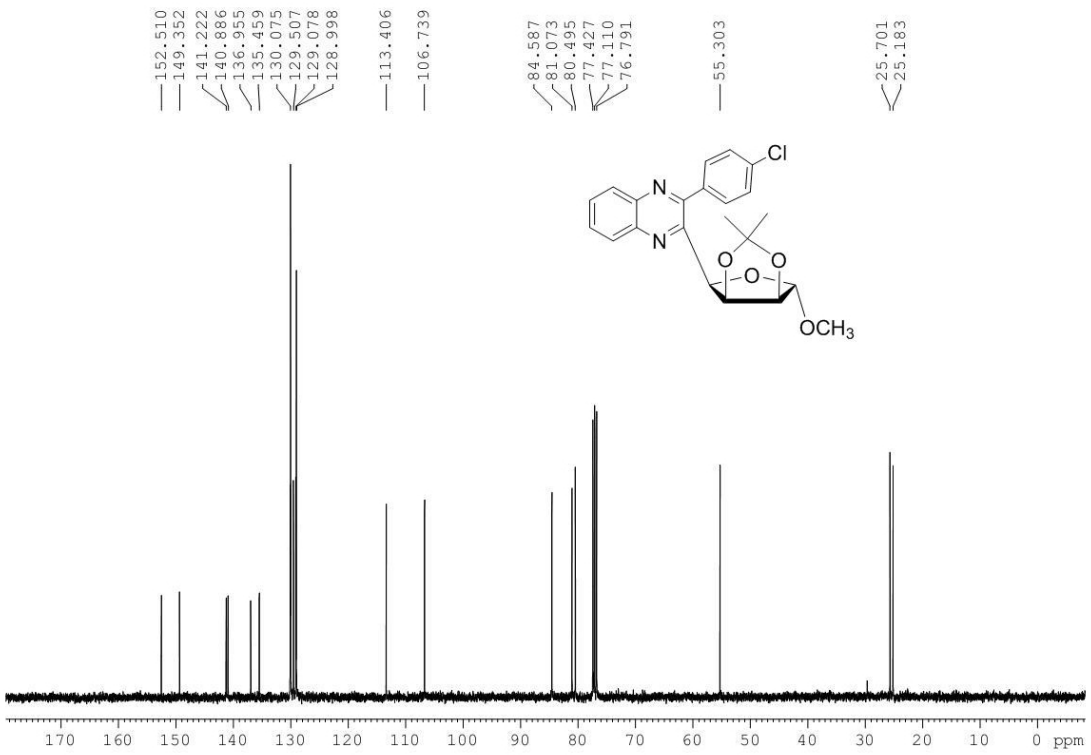

ppm
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 ppm
Ph
N
N
O
O
O
OCH3


ppm
30
40
50
60
70
80
90
100
110
120
130
140
150
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 ppm
Ph
N
N
O
O
O
OCH3

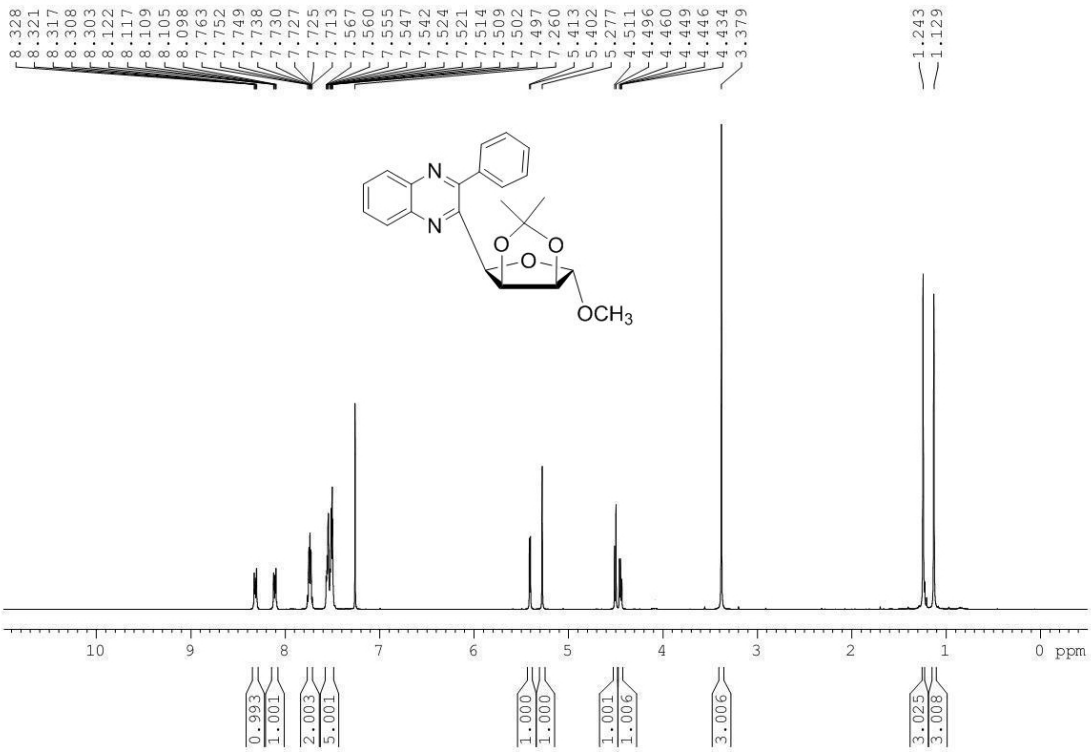


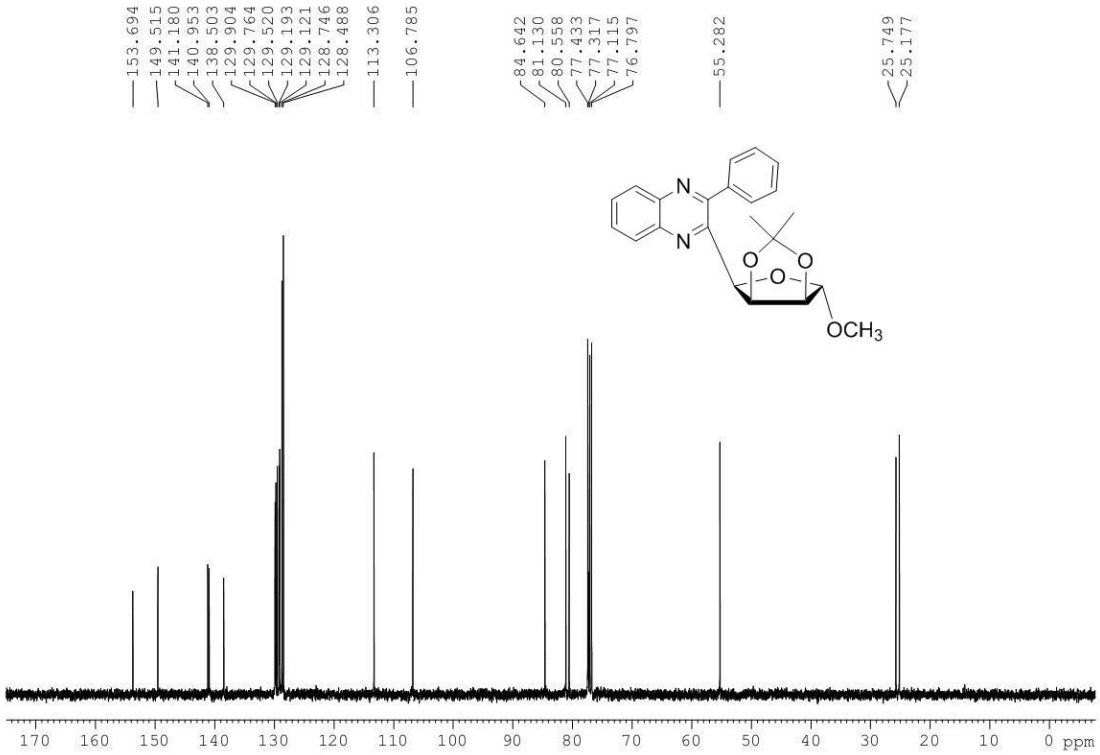
^{1}H NMR and ^{13}C NMR of **2db**



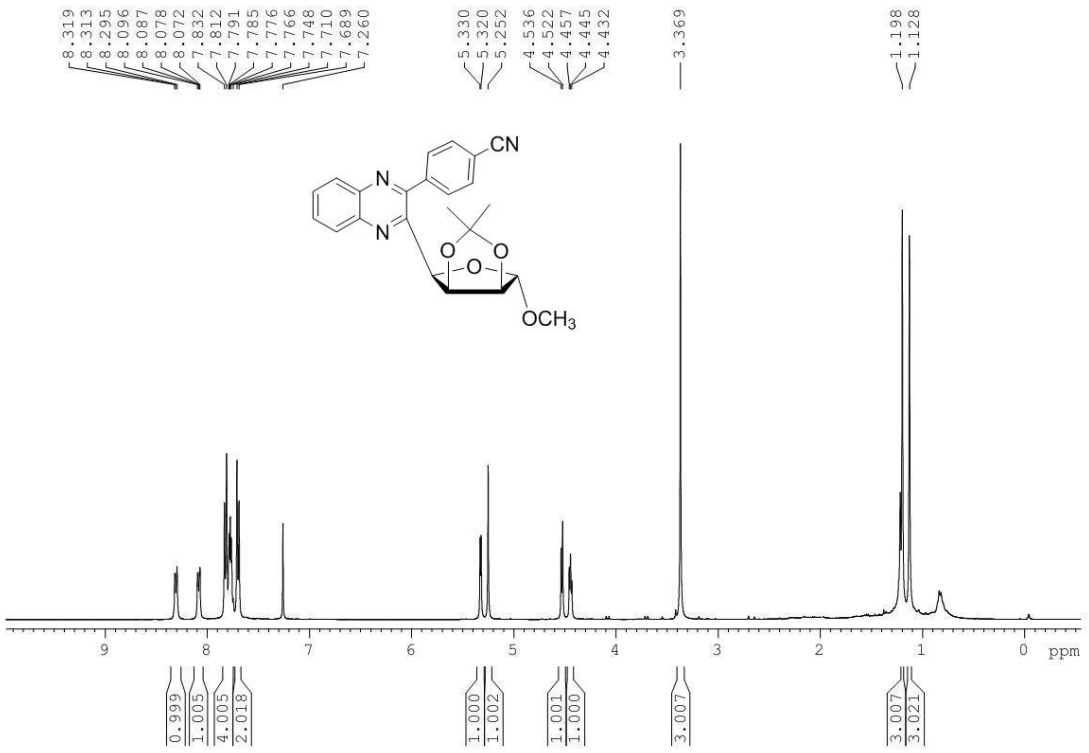


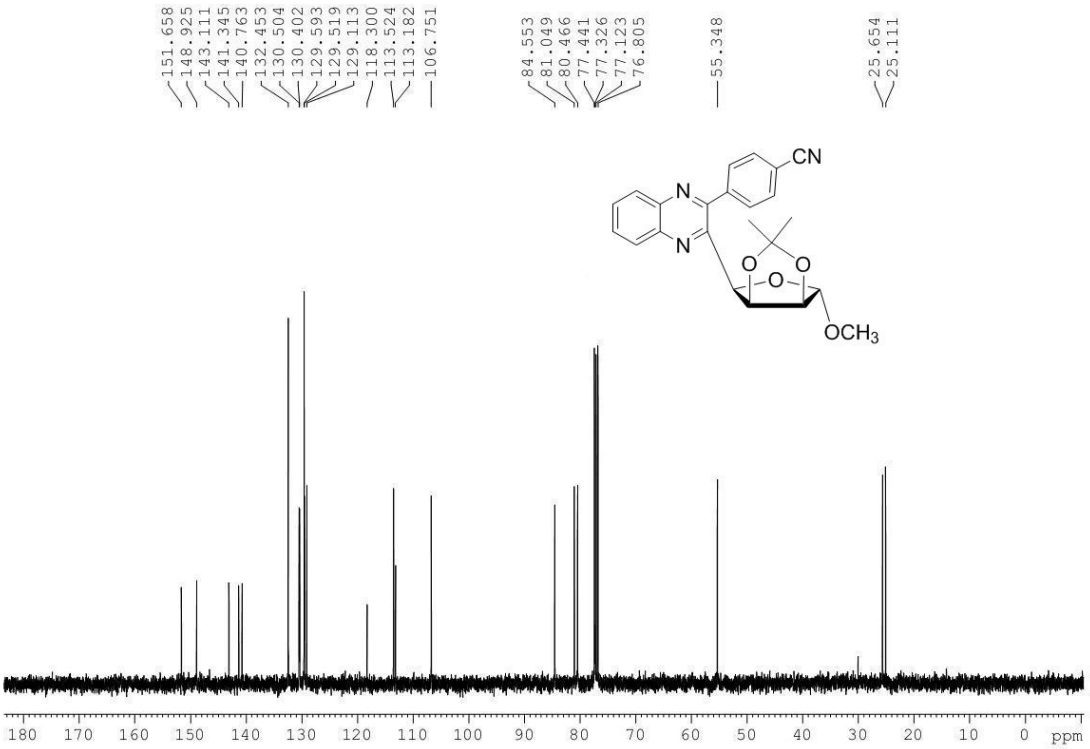
^{1}H NMR and ^{13}C NMR of **2dc**



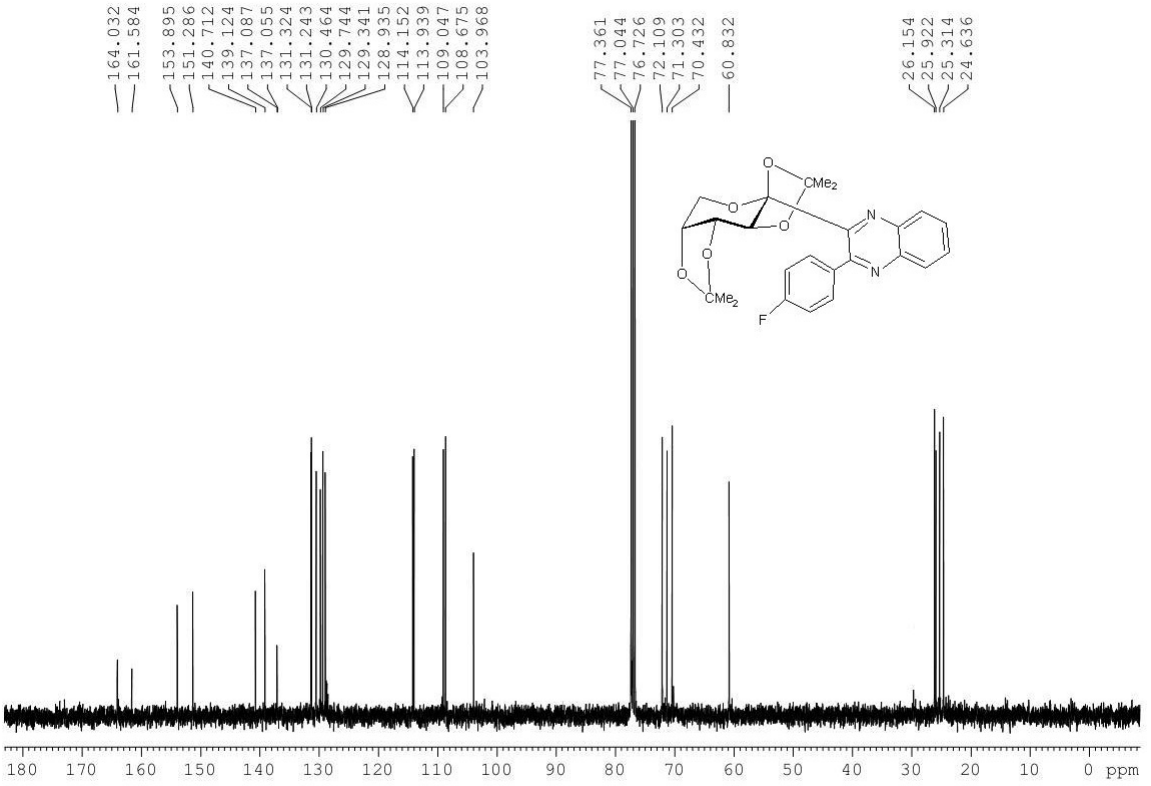


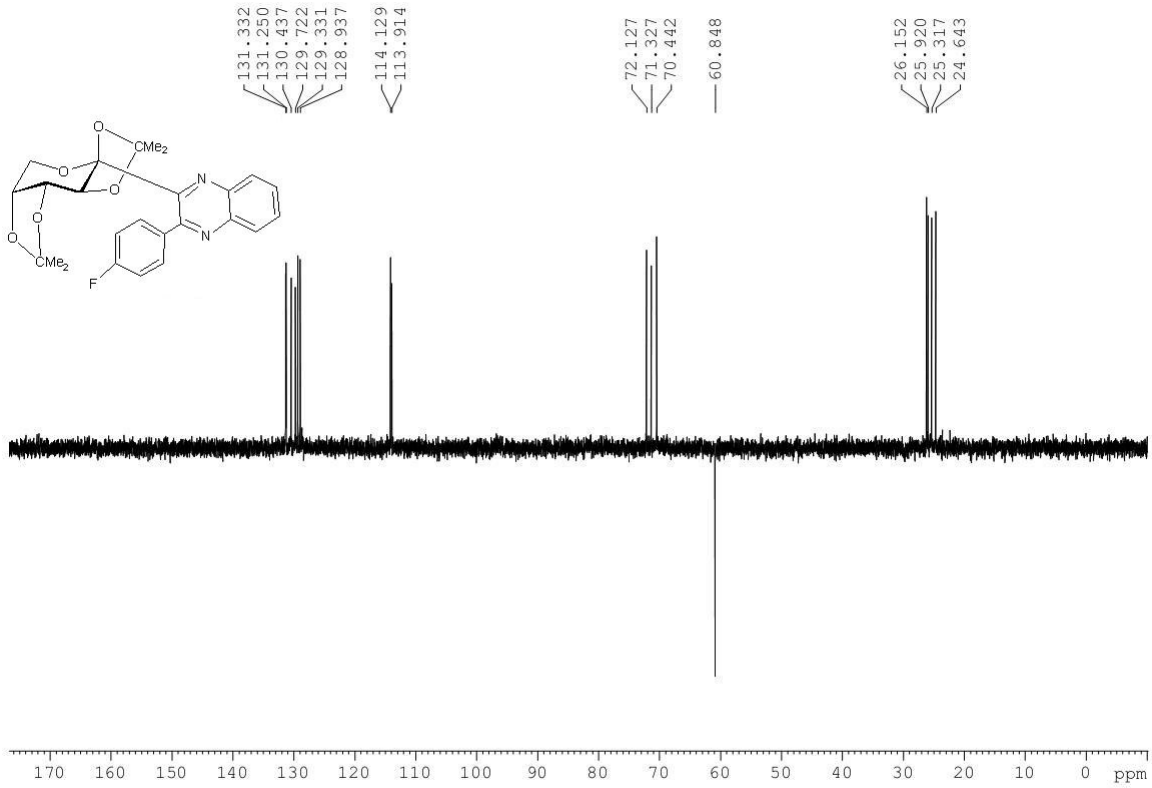
^{1}H NMR and ^{13}C NMR of **2dd**

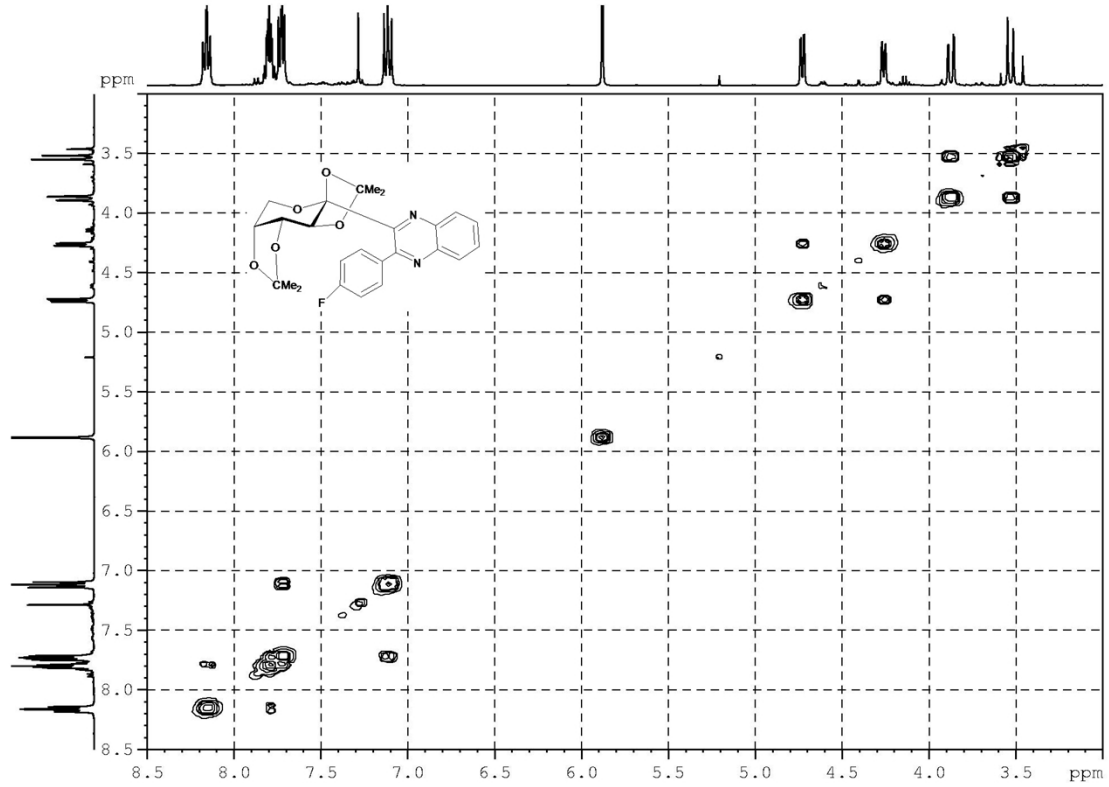


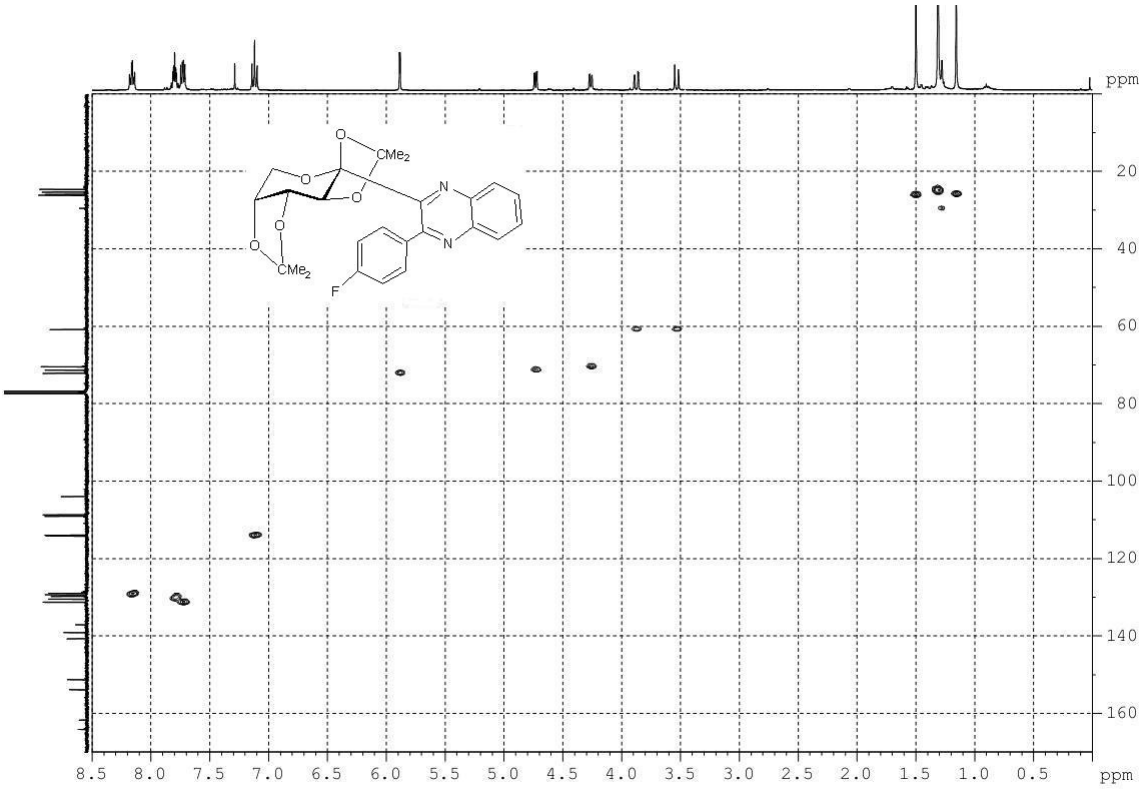


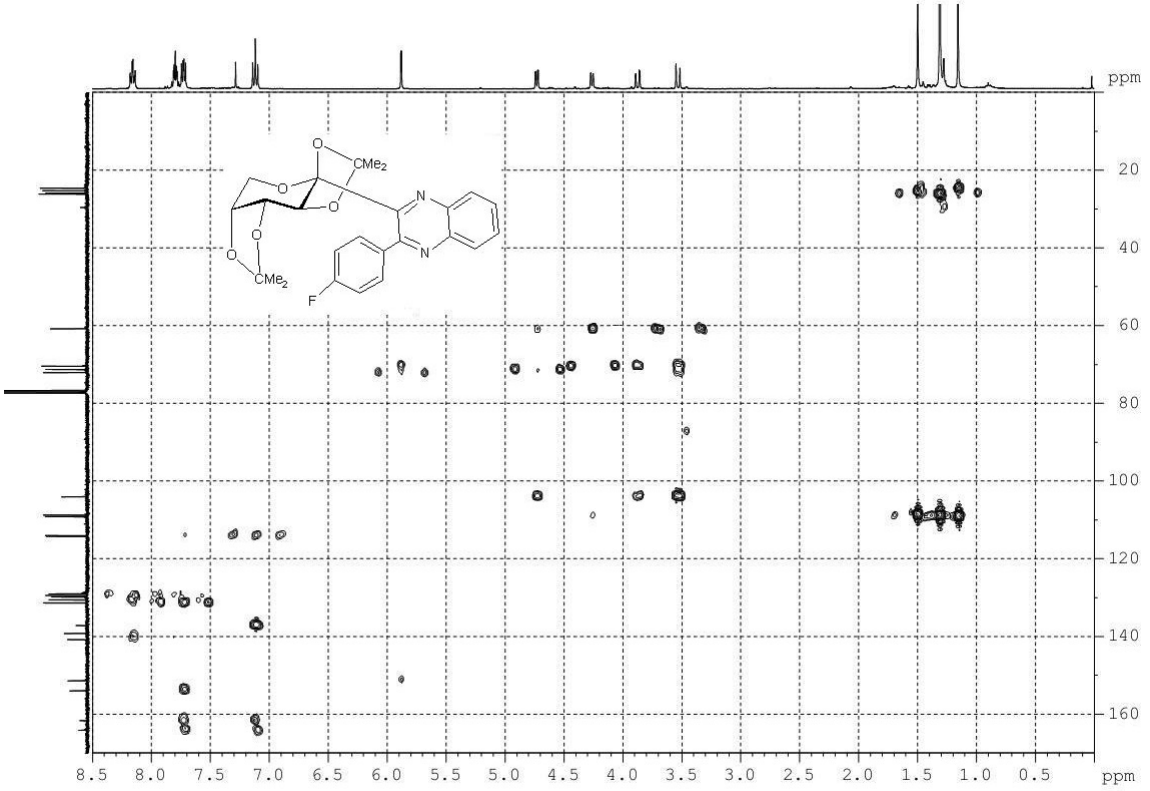
^{1}H NMR, ^{13}C NMR, DEPT-135, ^{1}H-^{1}H COSY, HSQC and HMBC of **2ea**


164.032
161.584
153.895
151.286
140.712
139.124
137.087
137.055
131.324
131.243
130.464
129.744
129.341
128.935
114.152
113.939
109.047
108.675
103.968
77.361
77.044
76.726
72.109
71.303
70.432
60.832
26.154
25.922
25.314
24.636
CMe2
CMe2
F
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

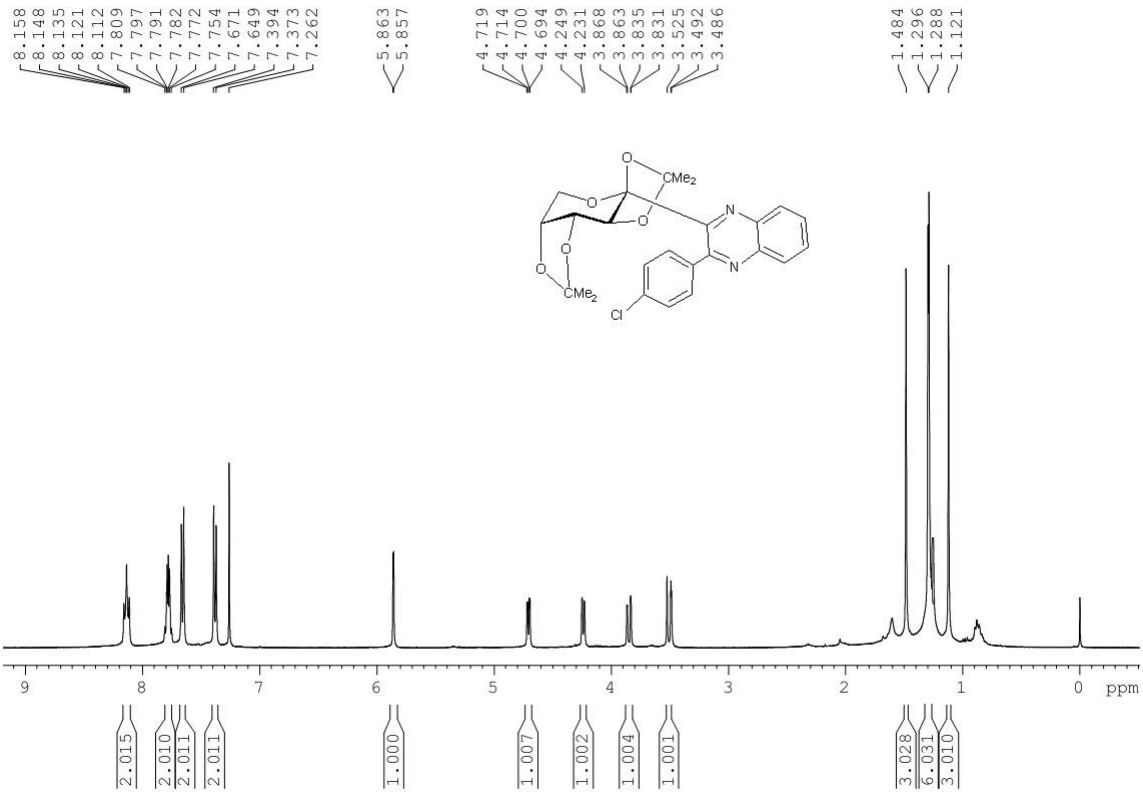

131.332
131.250
130.437
129.722
129.331
128.937
114.129
113.914
72.127
71.327
70.442
60.848
26.152
25.920
25.317
24.643
CMe2
CMe2
F
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

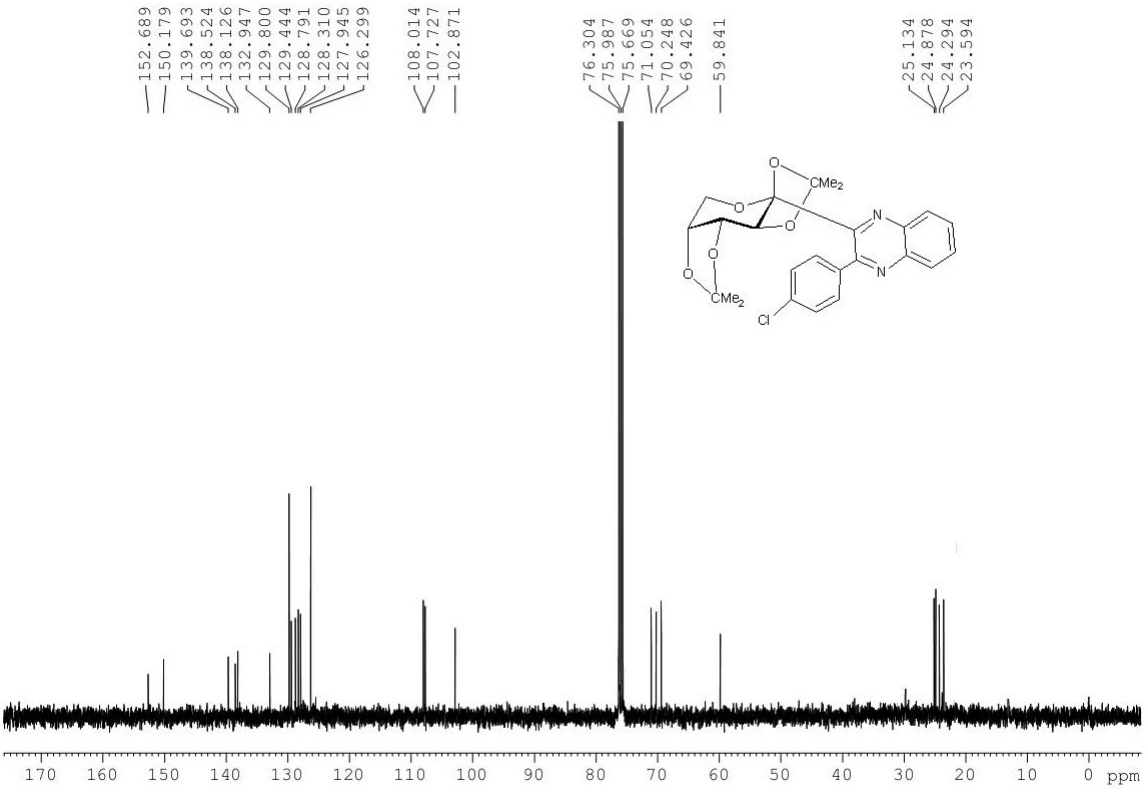

ppm
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 ppm
O
CMe2
O
O
O
O
CMe2
N
N
F


ppm
20
40
60
80
100
120
140
160
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
O
CMe2
O
O
O
O
CMe2
N
N
F

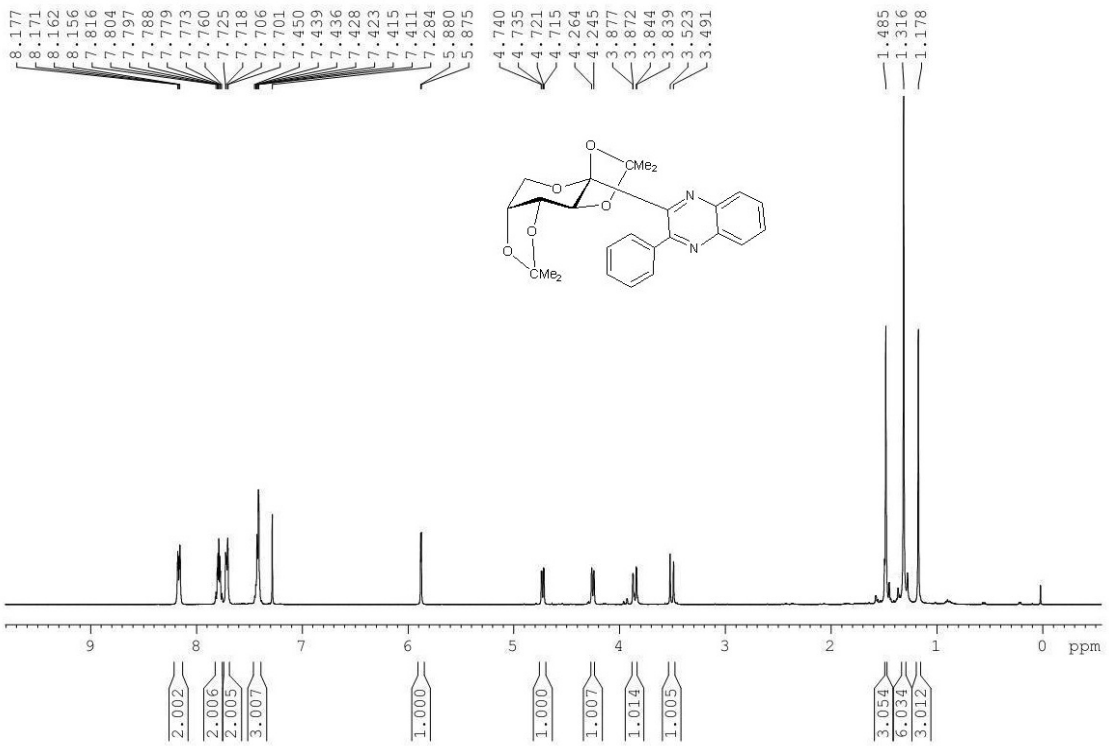


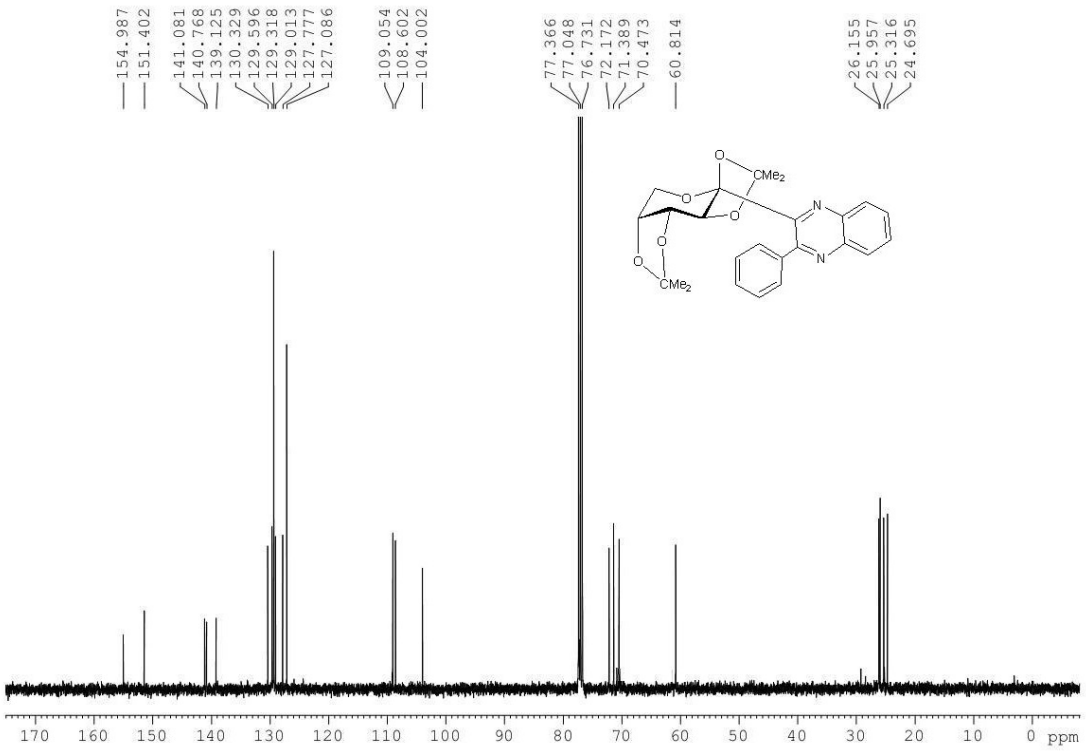
^{1}H NMR and ^{13}C NMR of **2eb**



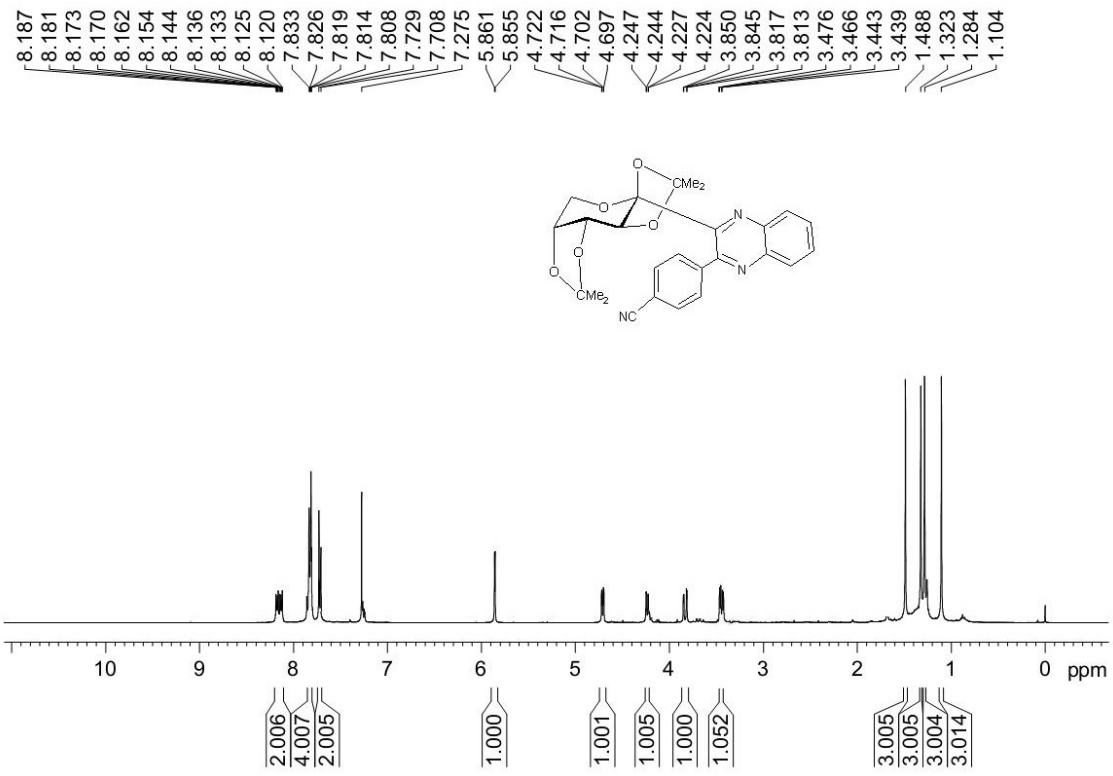


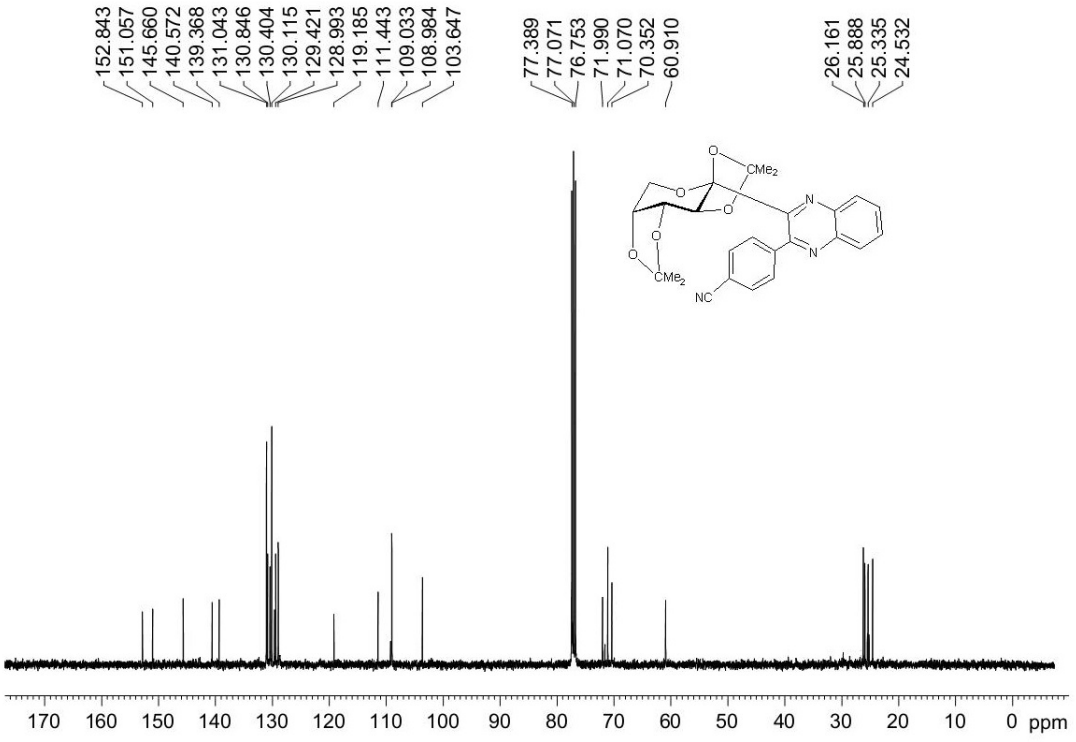
^{1}H NMR and ^{13}C NMR of **2ec**



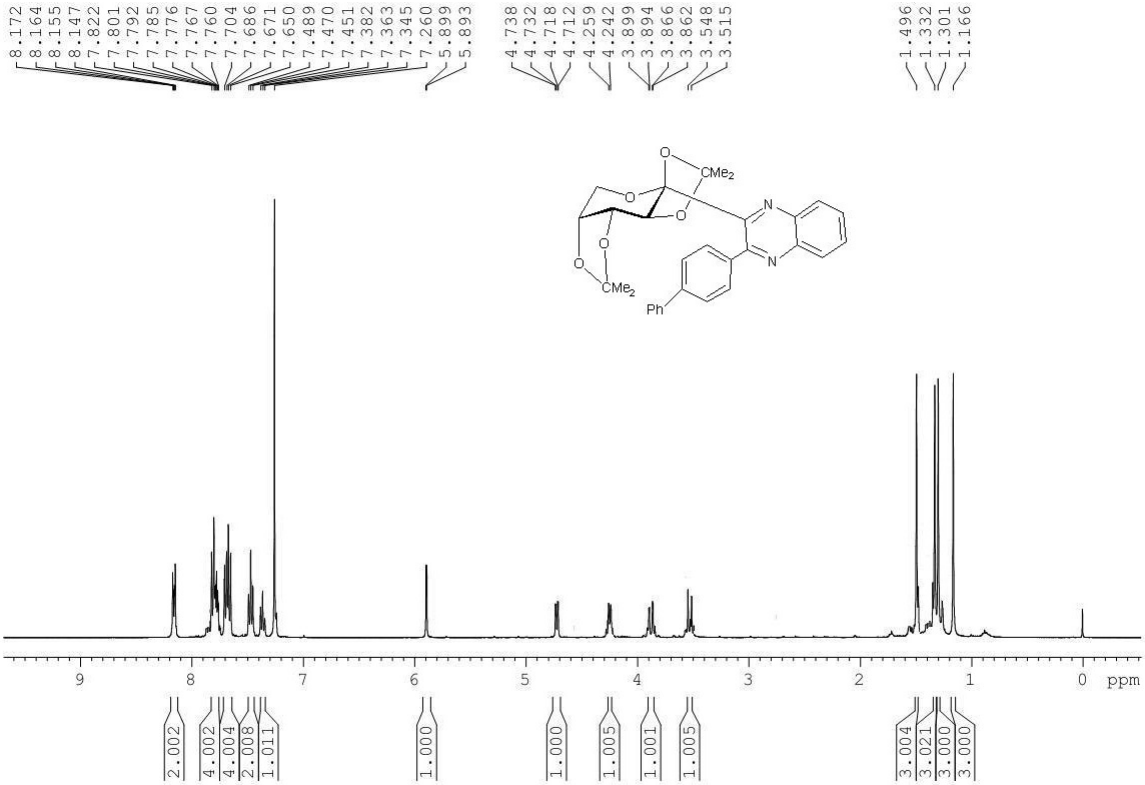


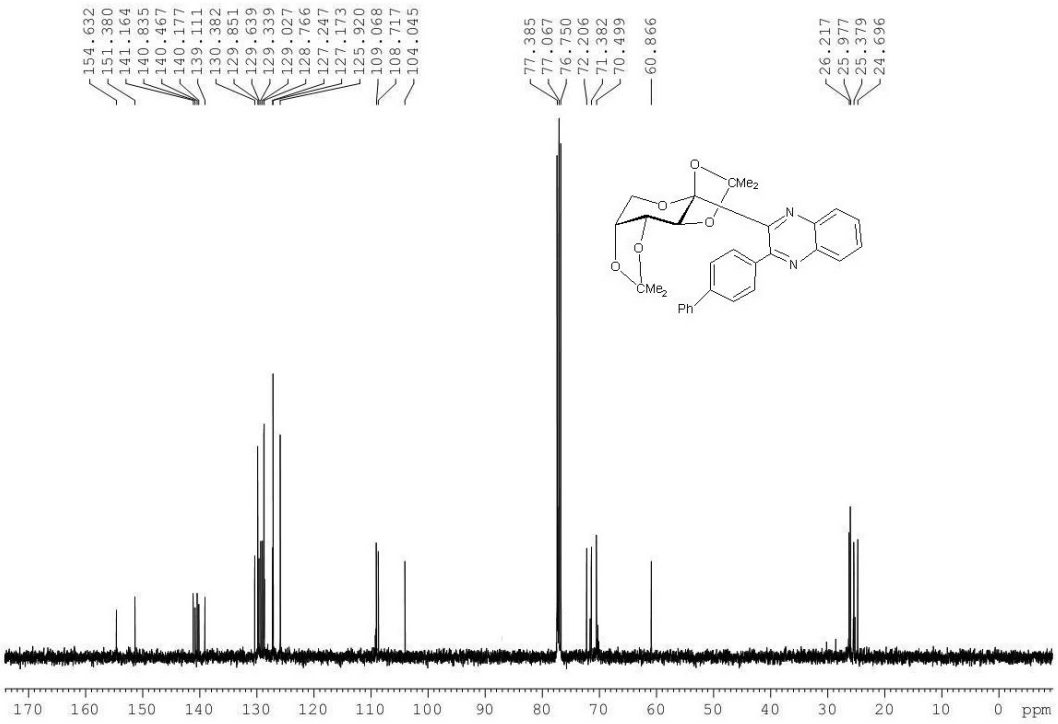
^{1}H NMR and ^{13}C NMR of **2ed**



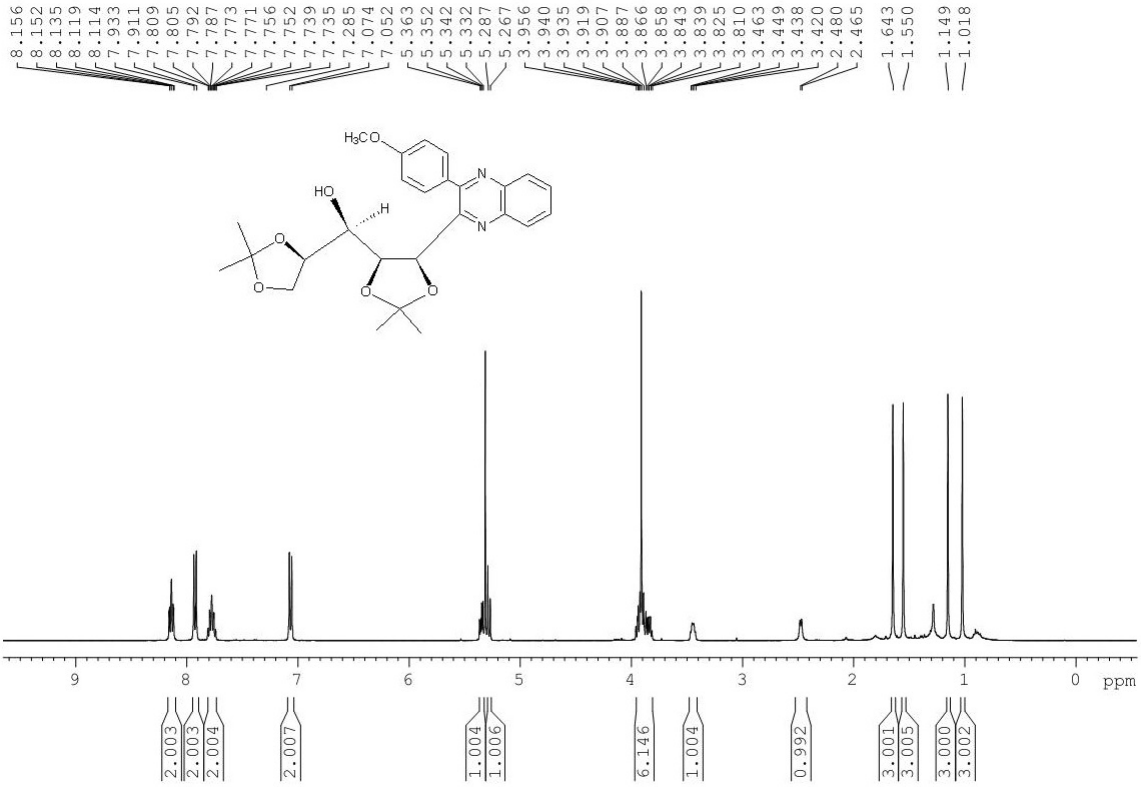


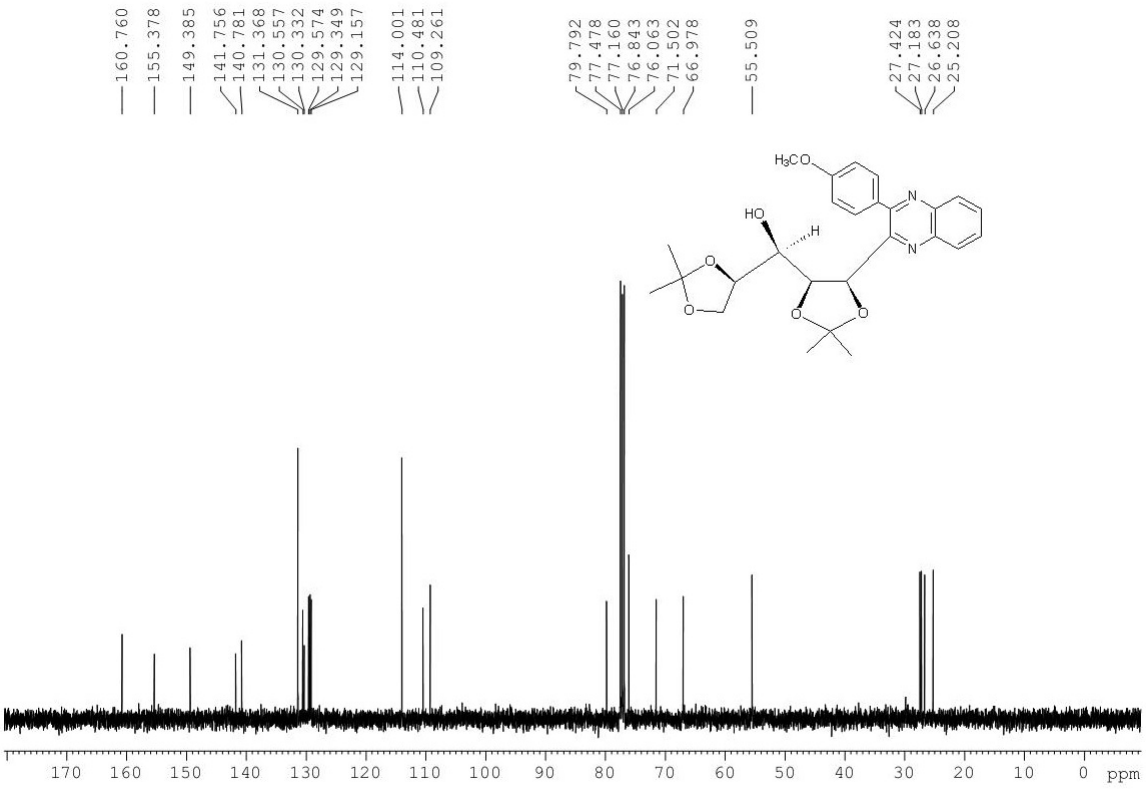
^{1}H NMR and ^{13}C NMR of **2ee**

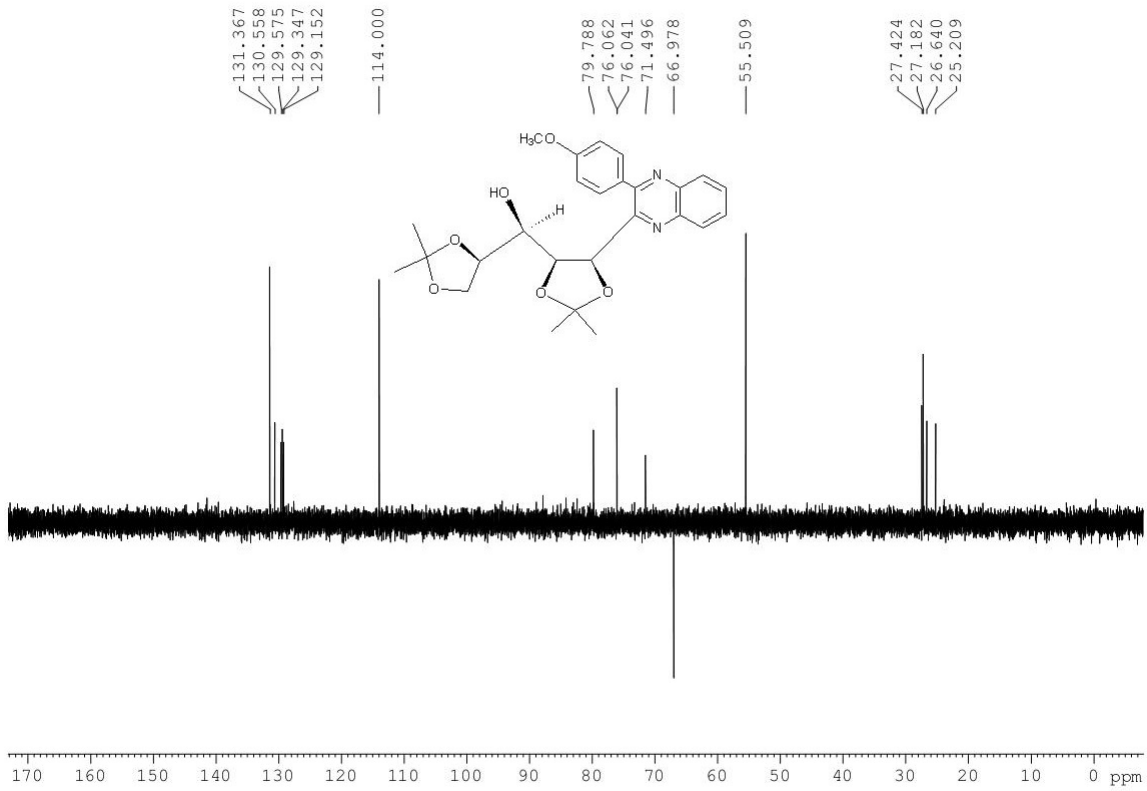


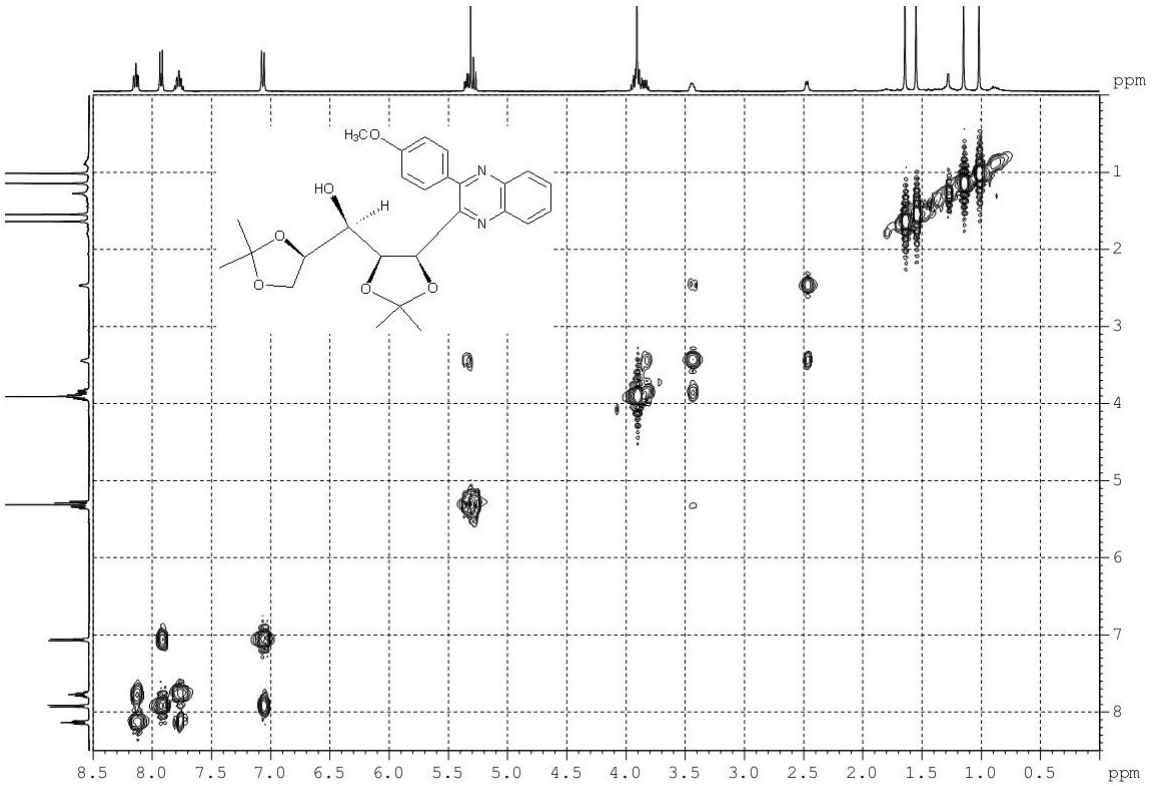


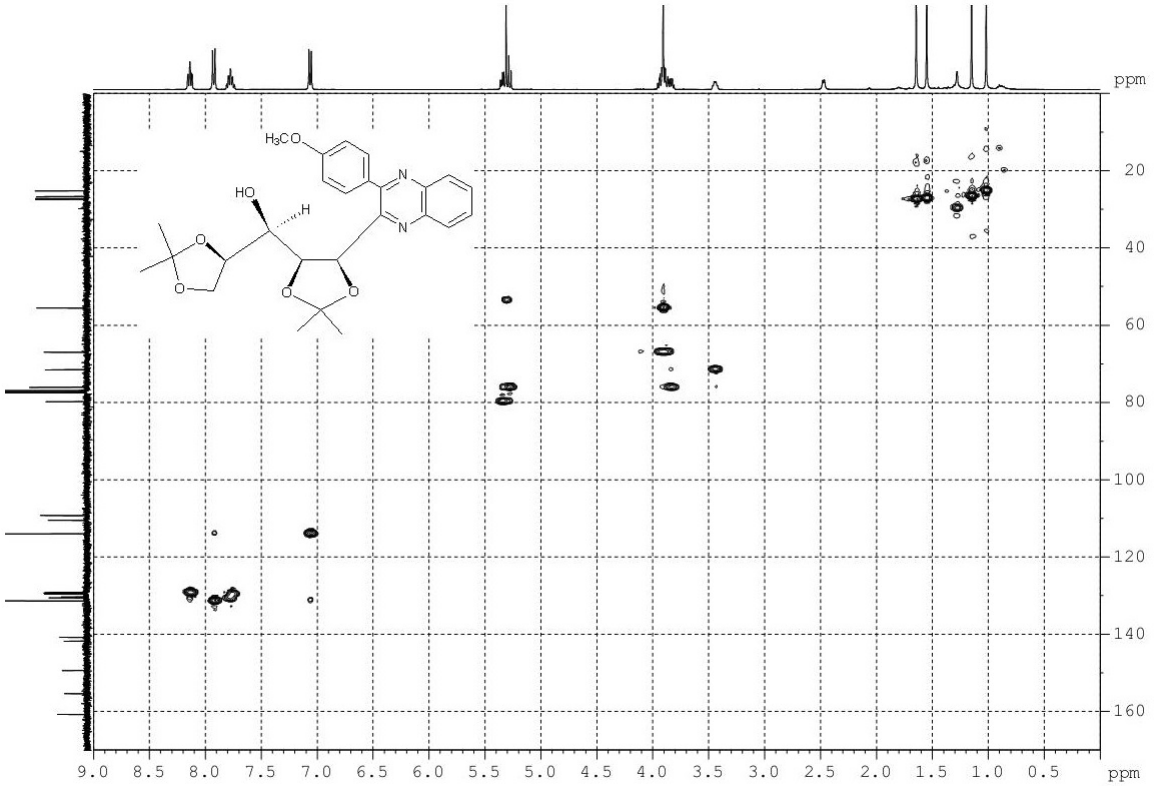
^{1}H NMR, ^{13}C NMR, DEPT-135, ^{1}H-^{1}H COSY, HSQC and HMBC of **2fa**




160.760
155.378
149.385
141.756
140.781
131.368
130.557
130.332
129.574
129.349
129.157
114.001
110.481
109.261
79.792
77.478
77.160
76.843
76.063
71.502
66.978
55.509
27.424
27.183
26.638
25.208
H3CO
HO
H
N
N
O
O
O
O
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


131.367
130.558
129.575
129.347
129.152
114.000
79.788
76.062
76.041
71.496
66.978
55.509
27.424
27.182
26.640
25.209
H3CO
HO
H
N
N
O
O
O
O
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


ppm
H3CO
HO
H
N
N
O
O
O
O
1
2
3
4
5
6
7
8
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
ppm


ppm
H3CO
HO
H
N
N
O
O
O
O
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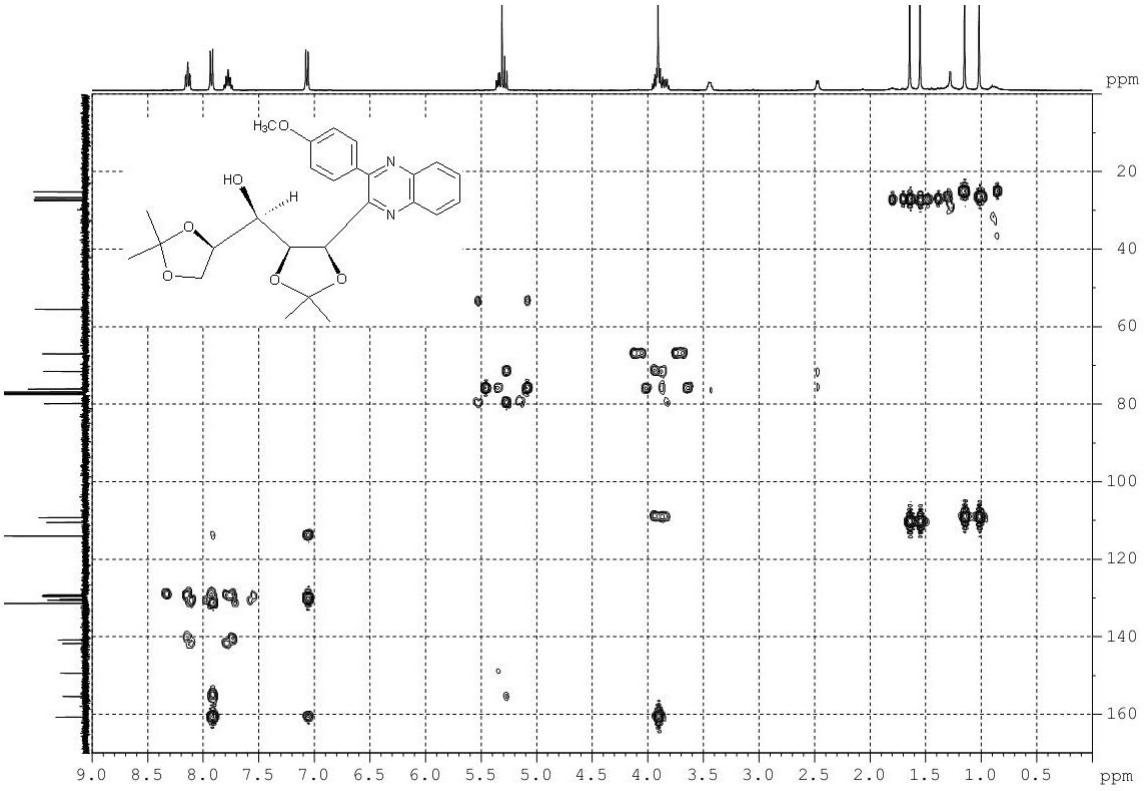
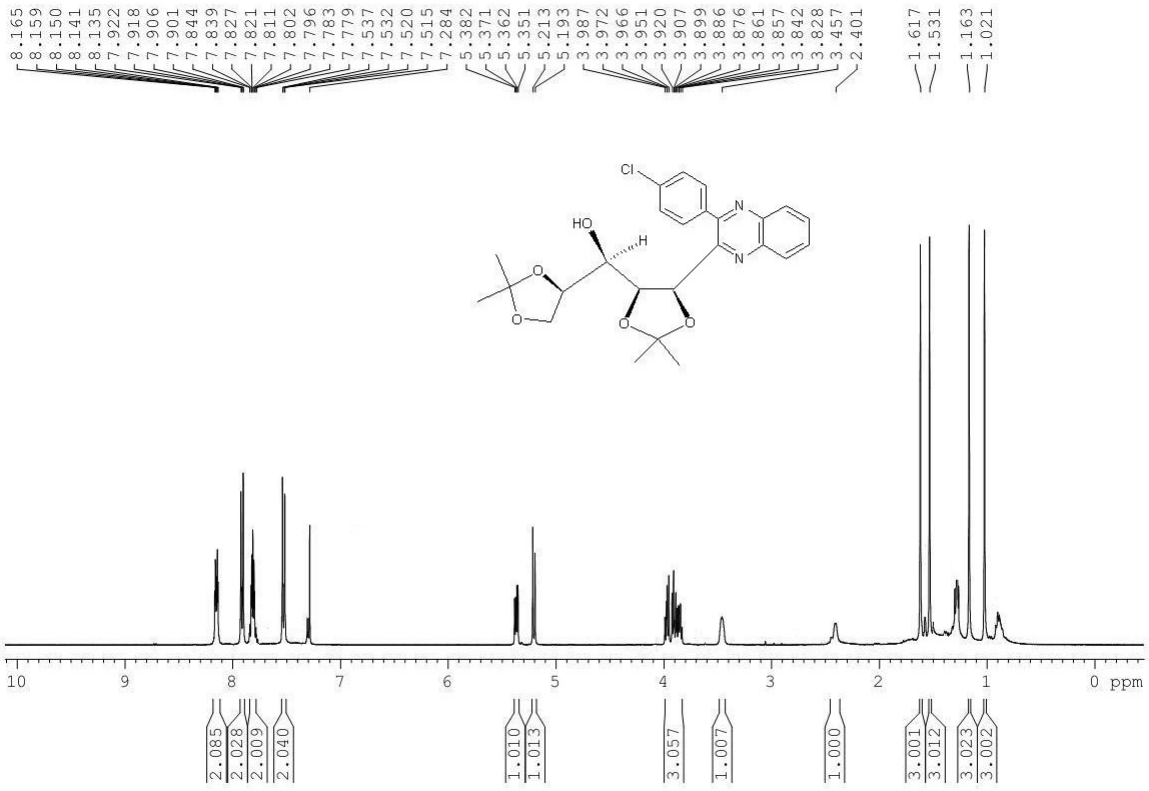
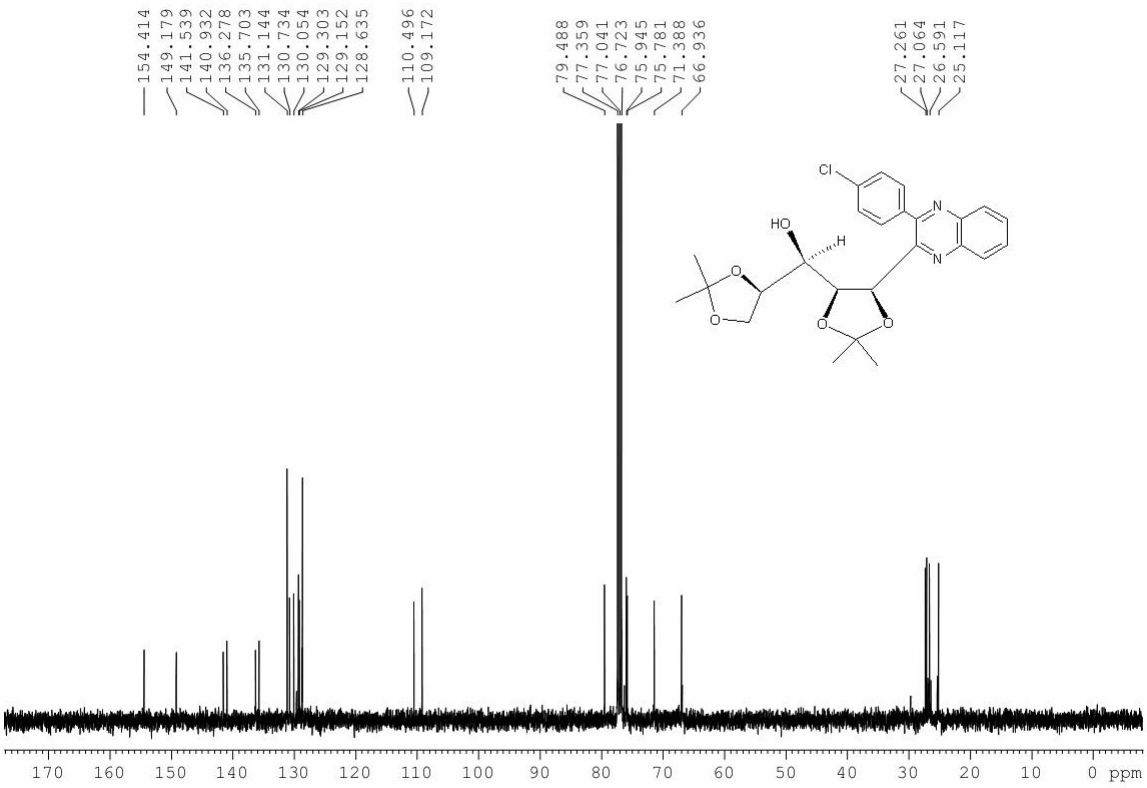
40
60
80
100
120
140
160
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
ppm

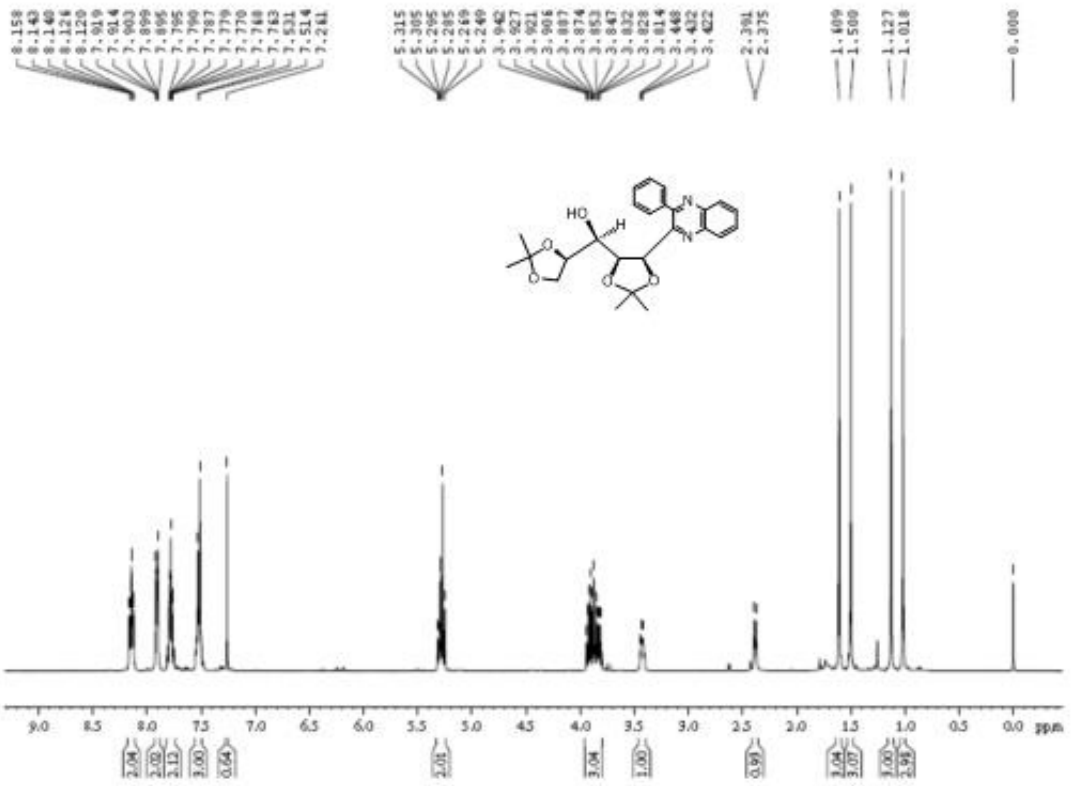


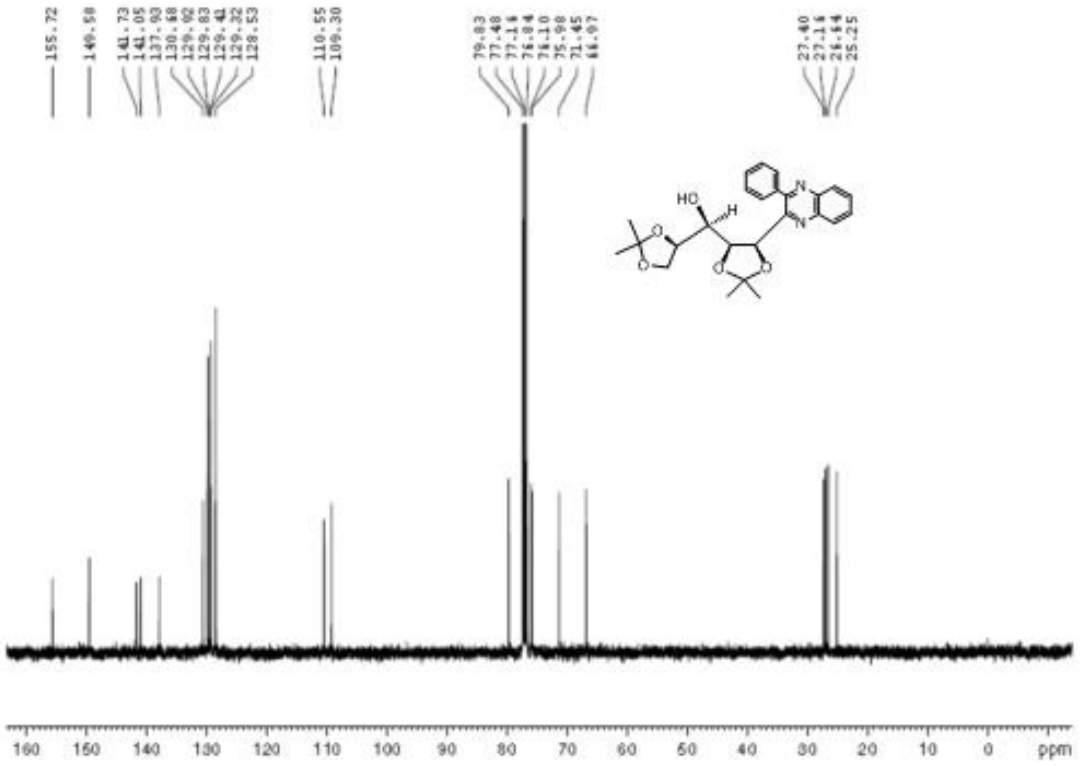
^{1}H NMR and ^{13}C NMR of **2fb**





^{1}H NMR and ^{13}C NMR of **2fc**





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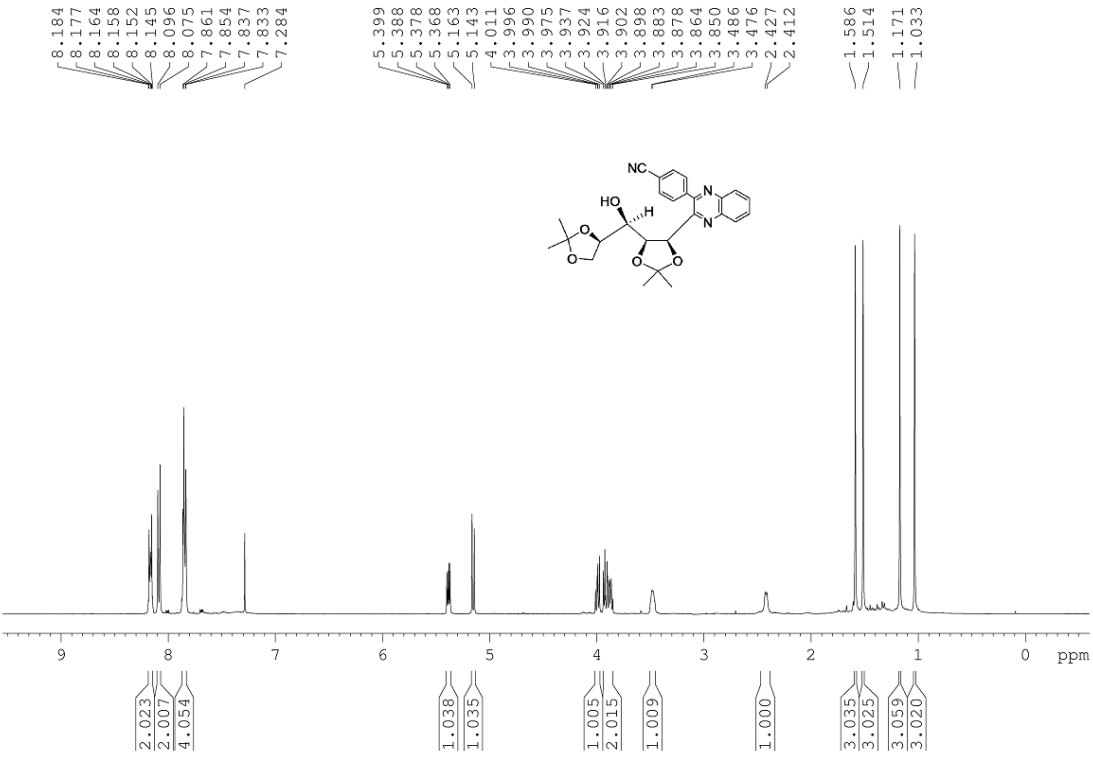
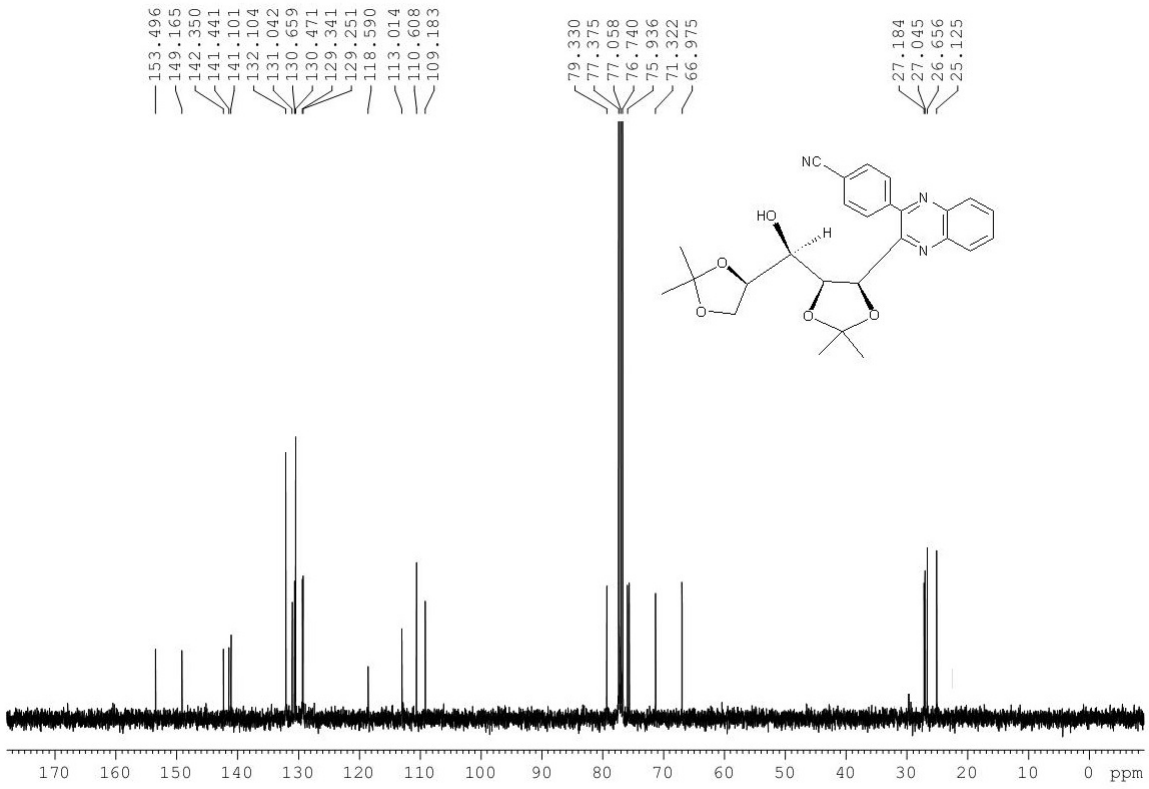
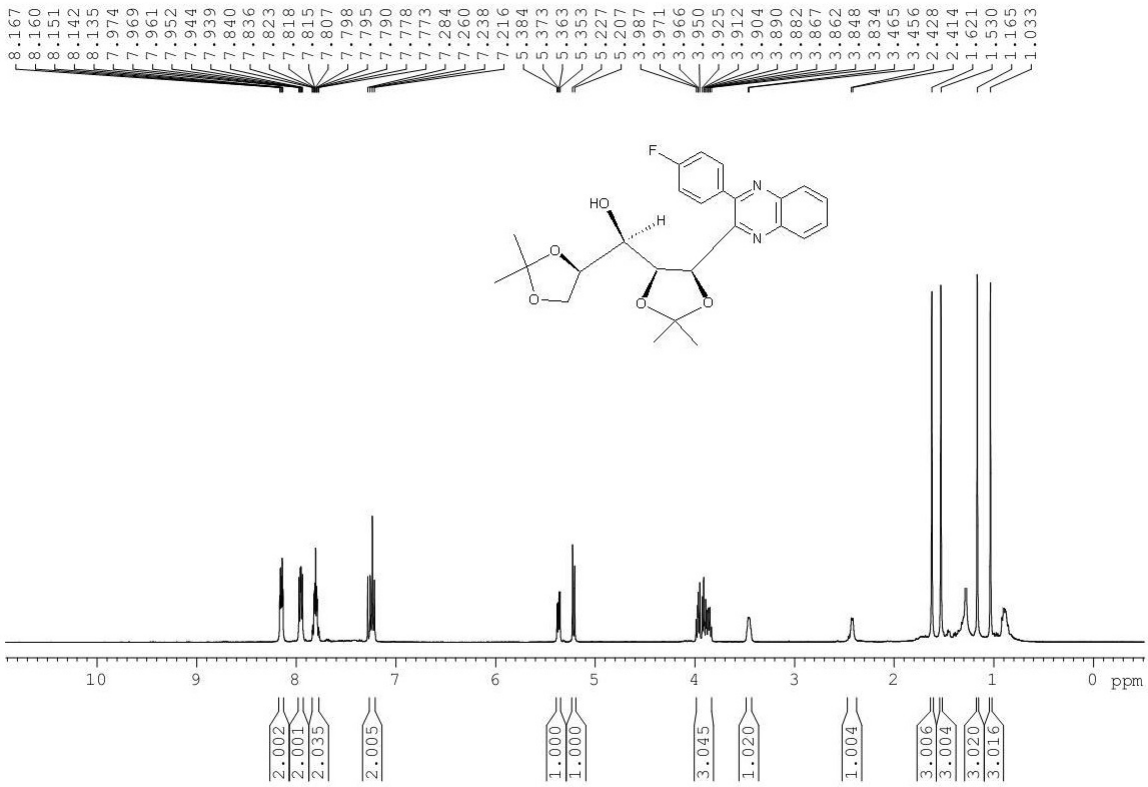
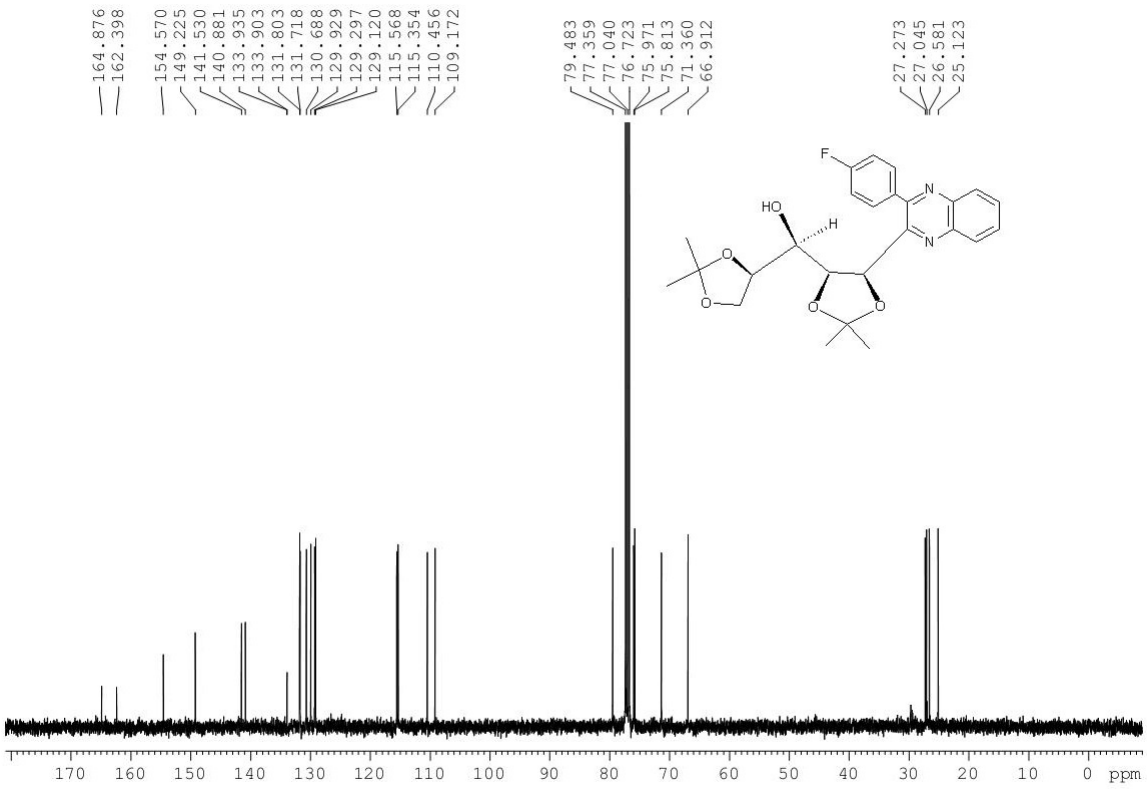


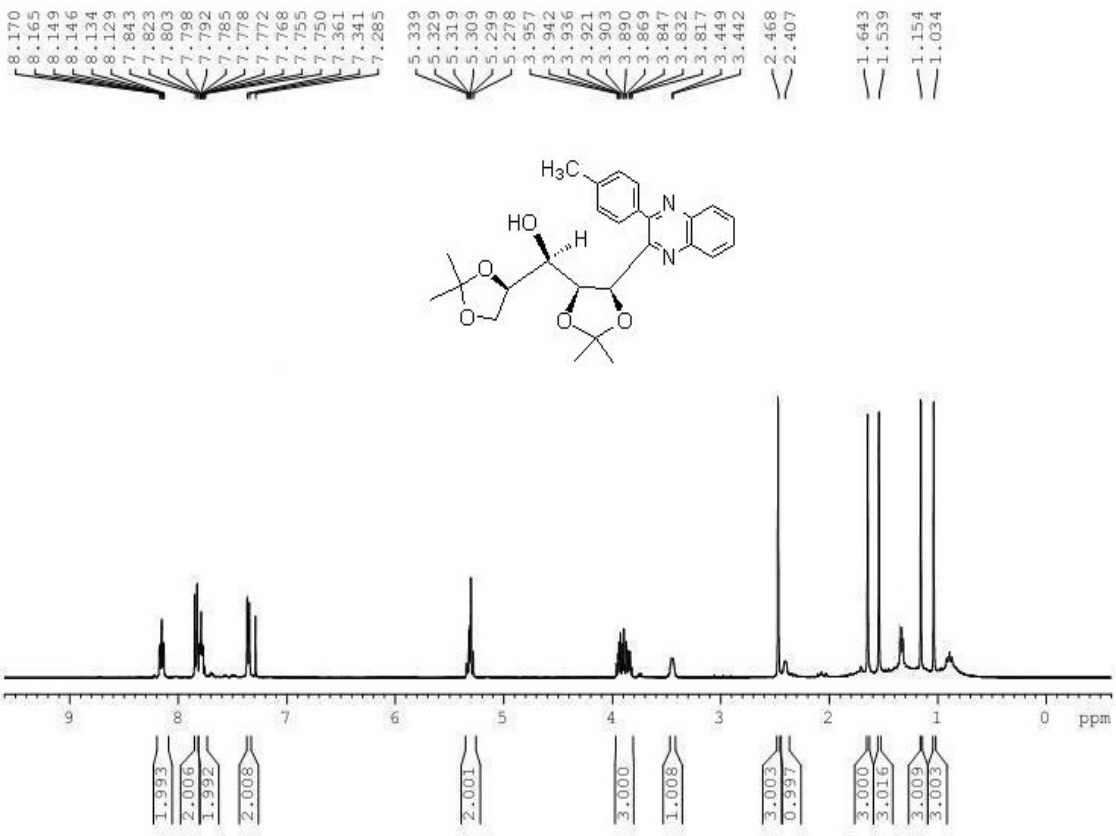


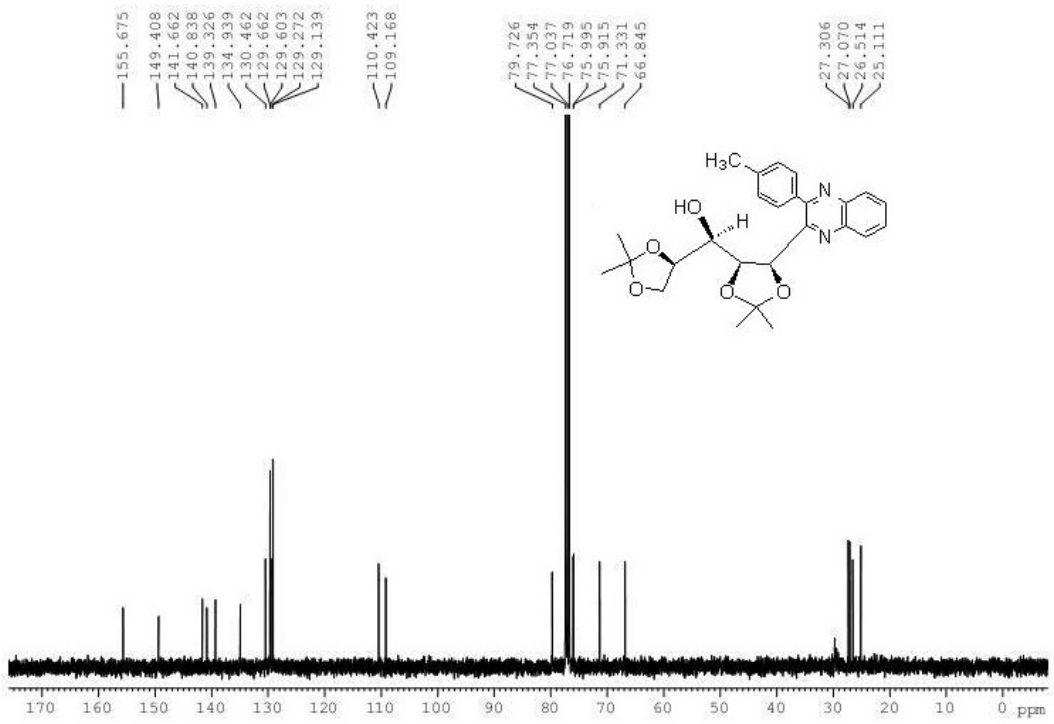
^{1}H NMR and ^{13}C NMR of **2fe**



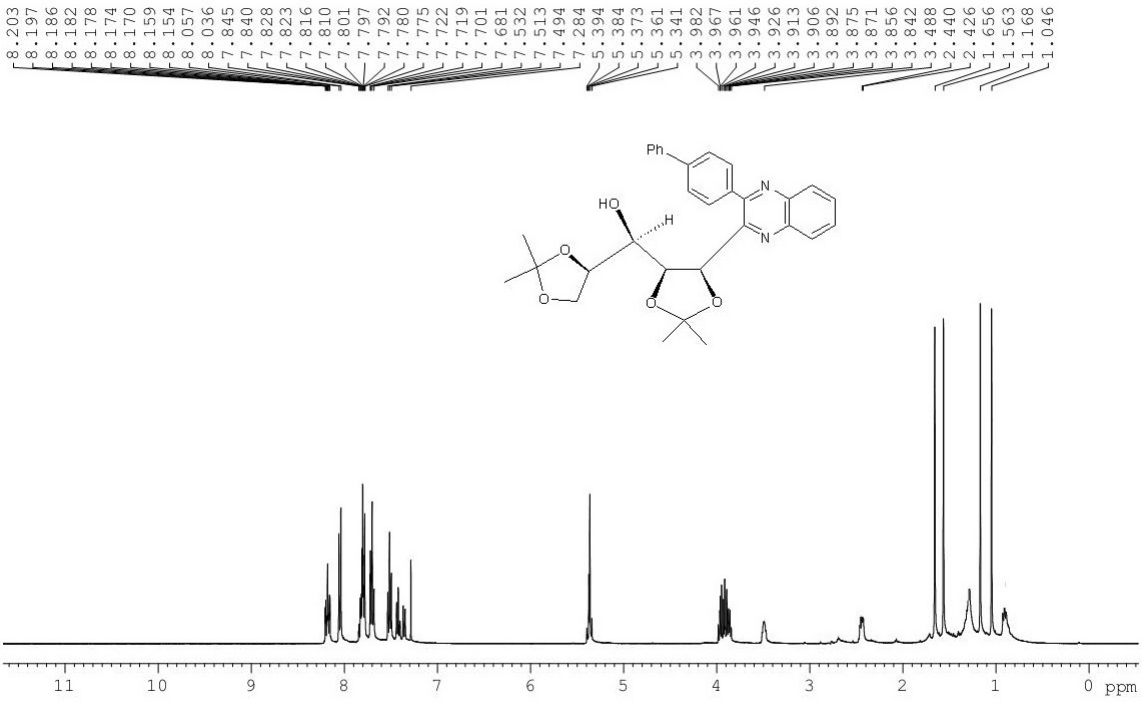


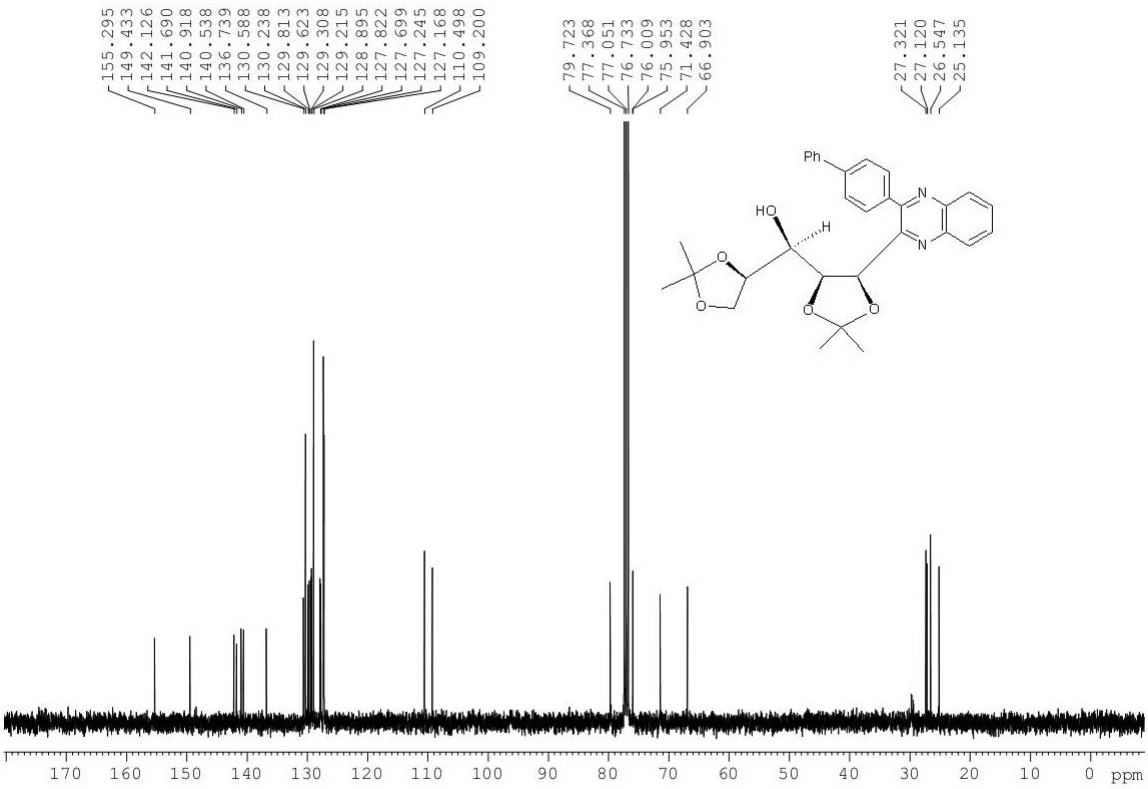
^{1}H NMR and ^{13}C NMR of **2ff**



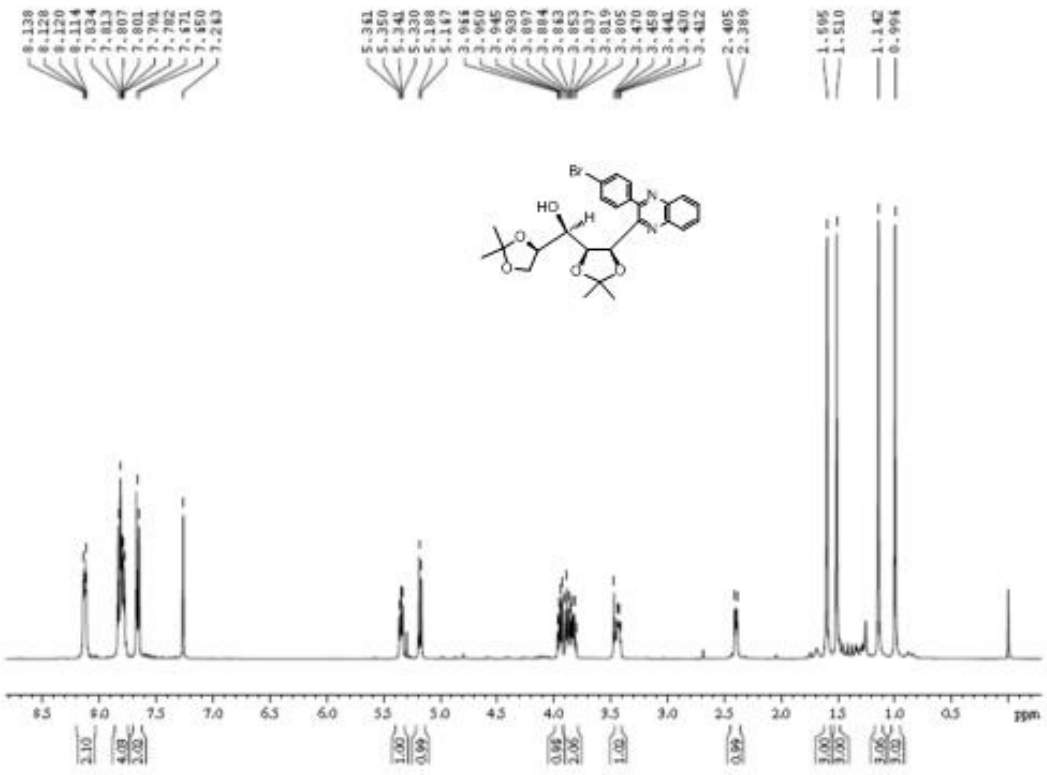


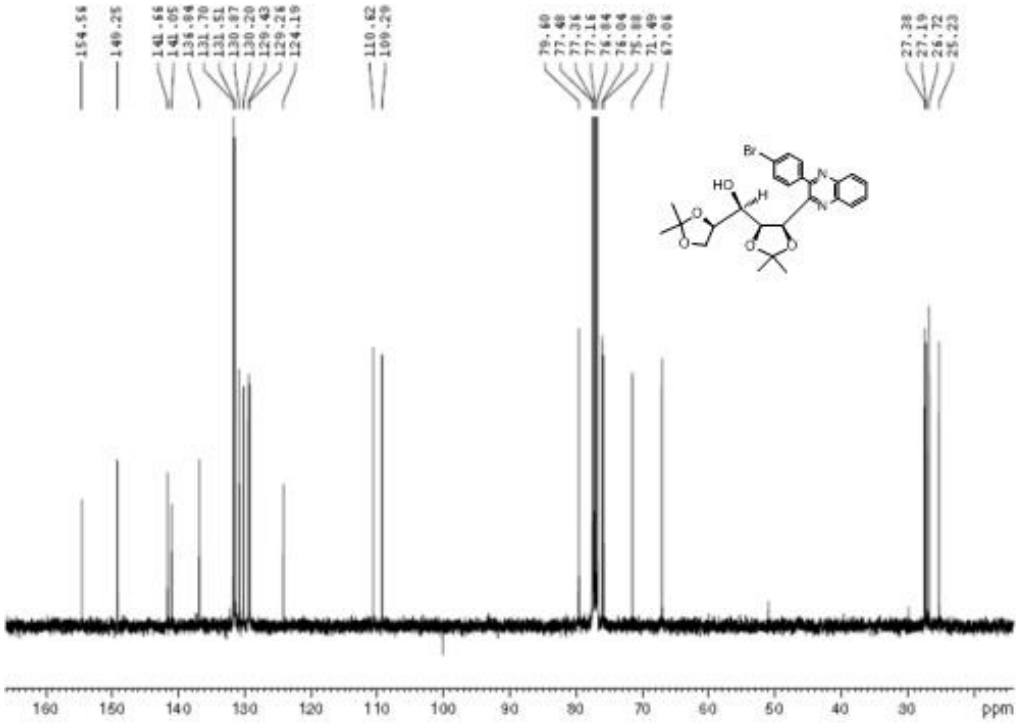
^{1}H NMR and ^{13}C NMR of **2fg**



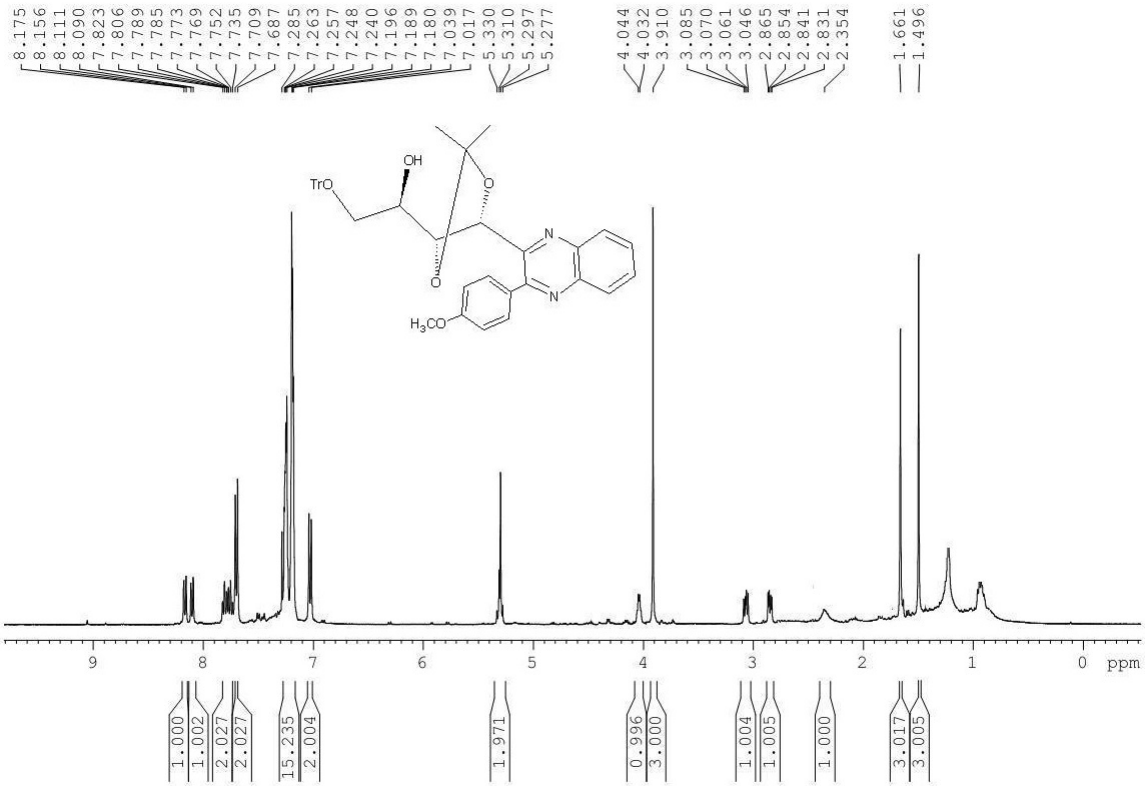


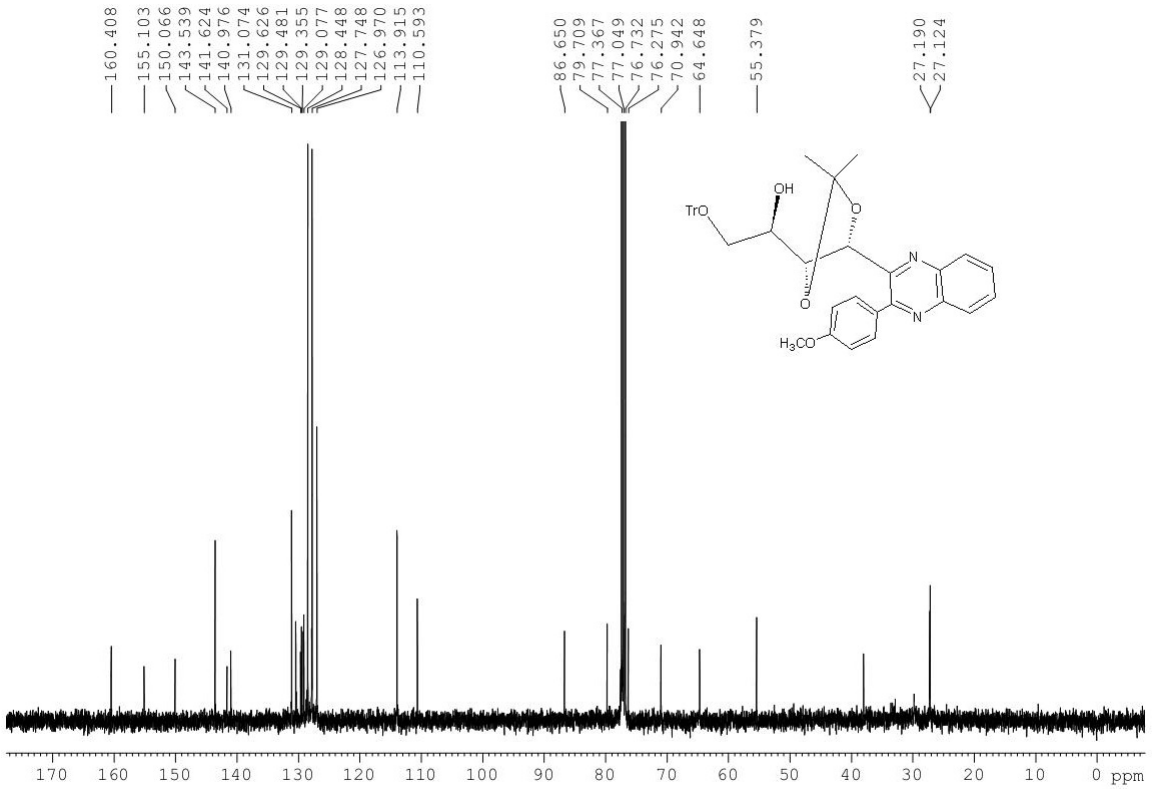
^{1}H NMR and ^{13}C NMR of **2fh**





^{1}H NMR, ^{13}C NMR, DEPT-135, ^{1}H-^{1}H COSY, HSQC and HMBC of **2ga**

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150.066
143.539
141.624
140.976
131.074
129.626
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129.355
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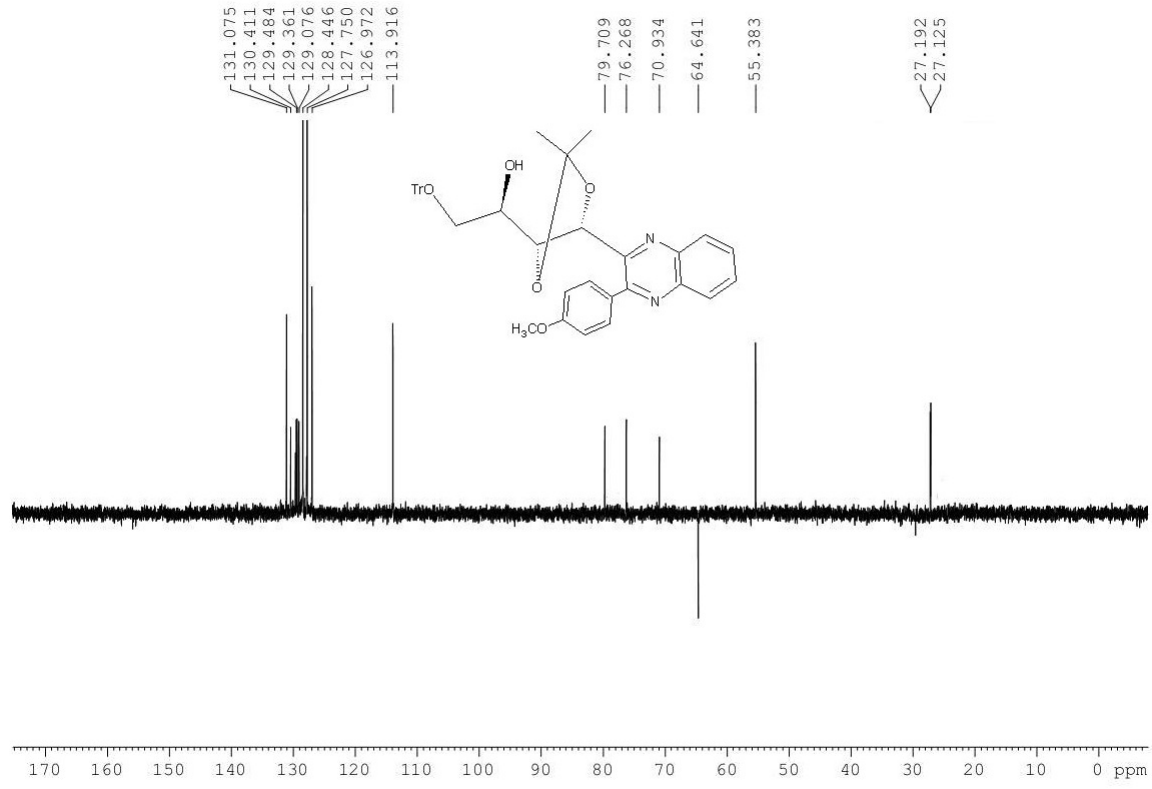
127.748
126.970
113.915
110.593
86.650
79.709
77.367
77.049
76.732
76.275
70.942
64.648
55.379
27.190
27.124
OH
TrO
O
O
N
N
H3CO
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm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129.484
129.361
129.076
128.446
127.750
126.972
113.916
79.709
76.268
70.934
64.641
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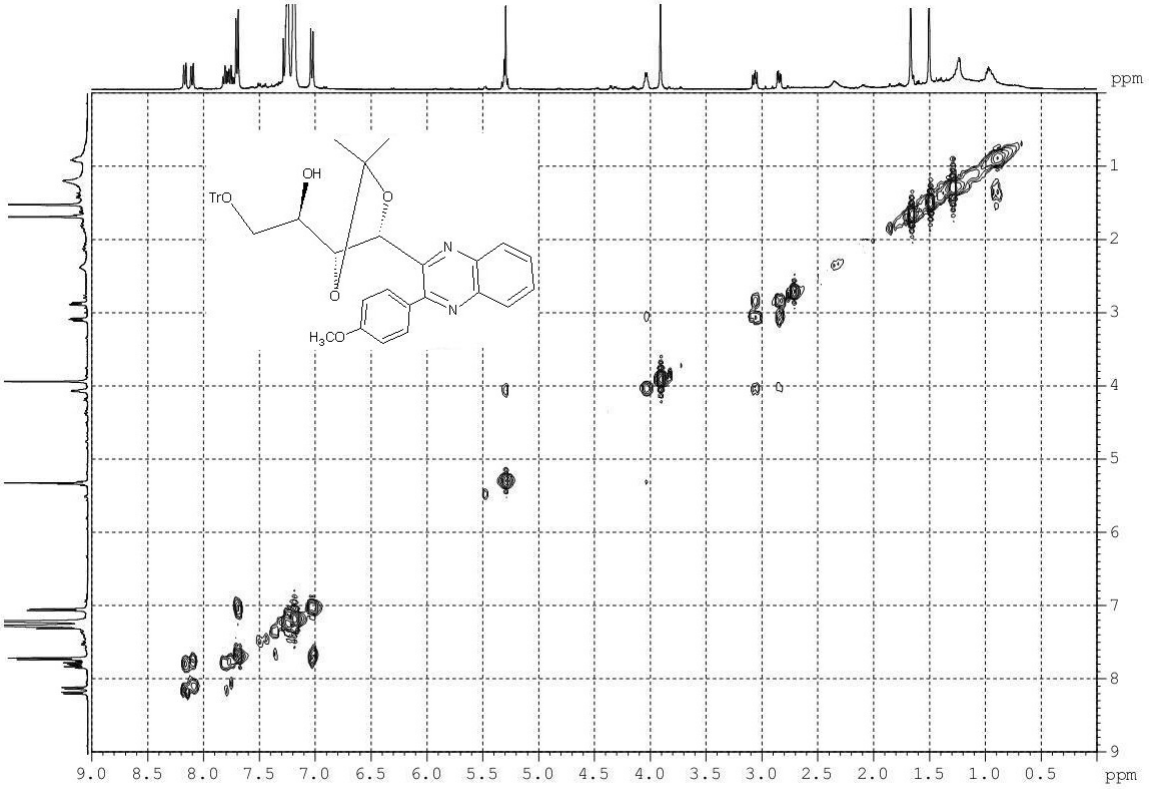
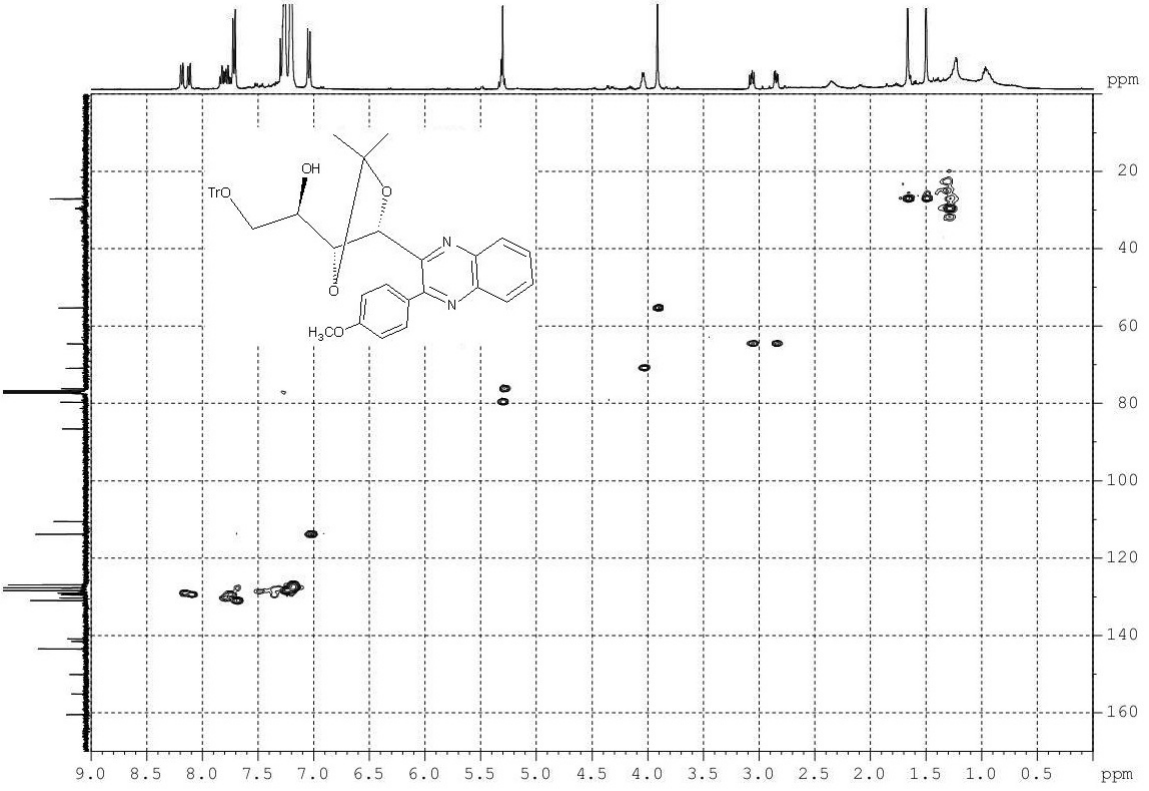
27.192
27.125
OH
TrO
O
O
N
N
H3CO
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


ppm
TrO
OH
O
N
N
O
H3CO
1
2
3
4
5
6
7
8
9
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
ppm


ppm
TrO
OH
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N
N
O
H3CO
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40
60
80
100
120
140
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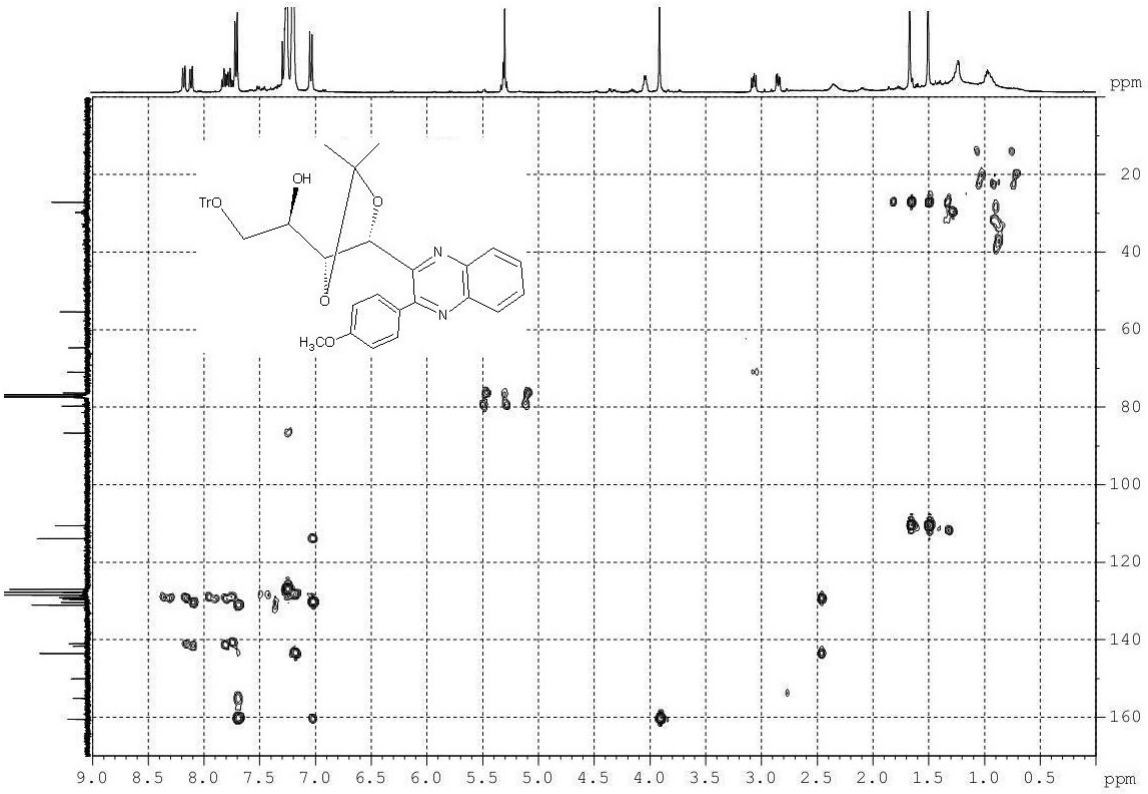
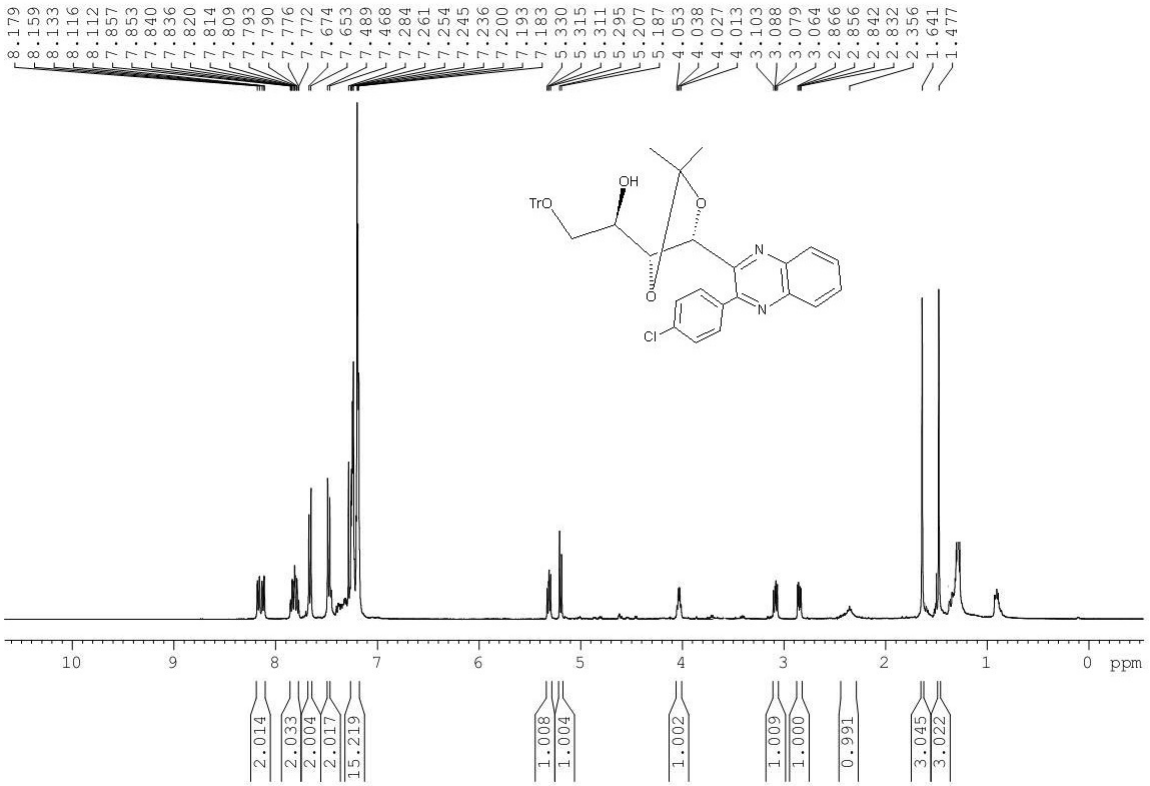
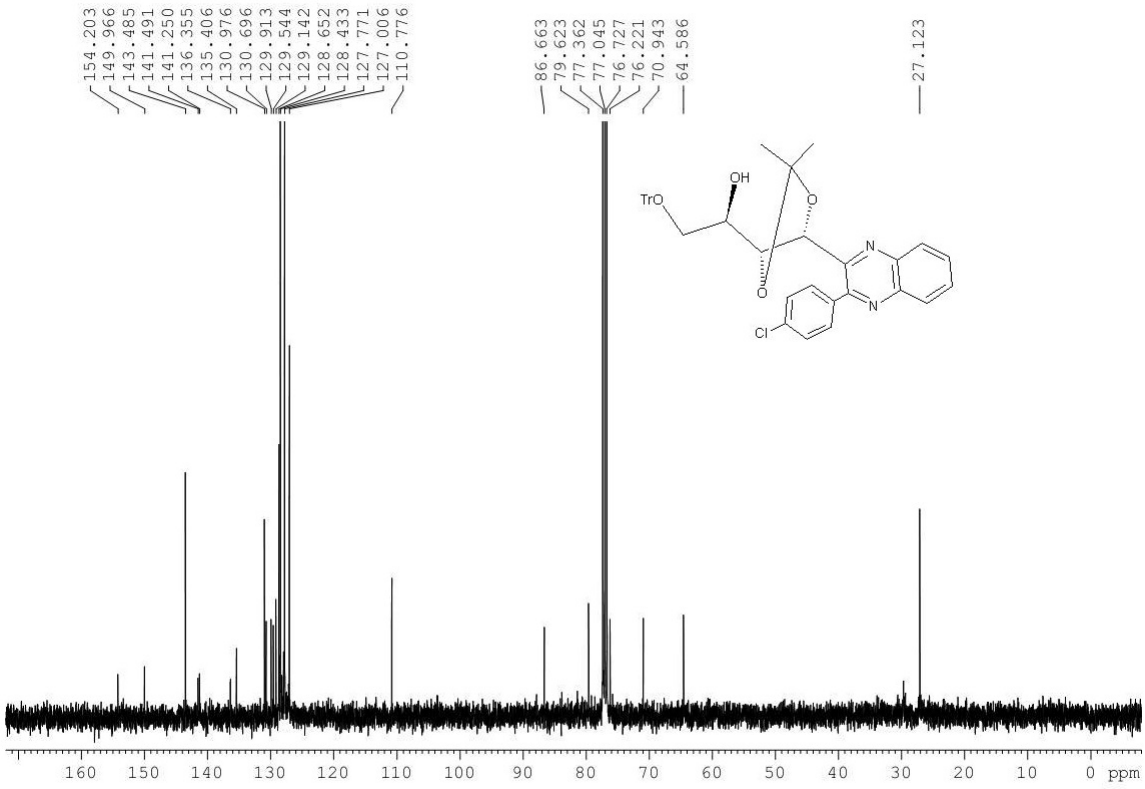
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
ppm

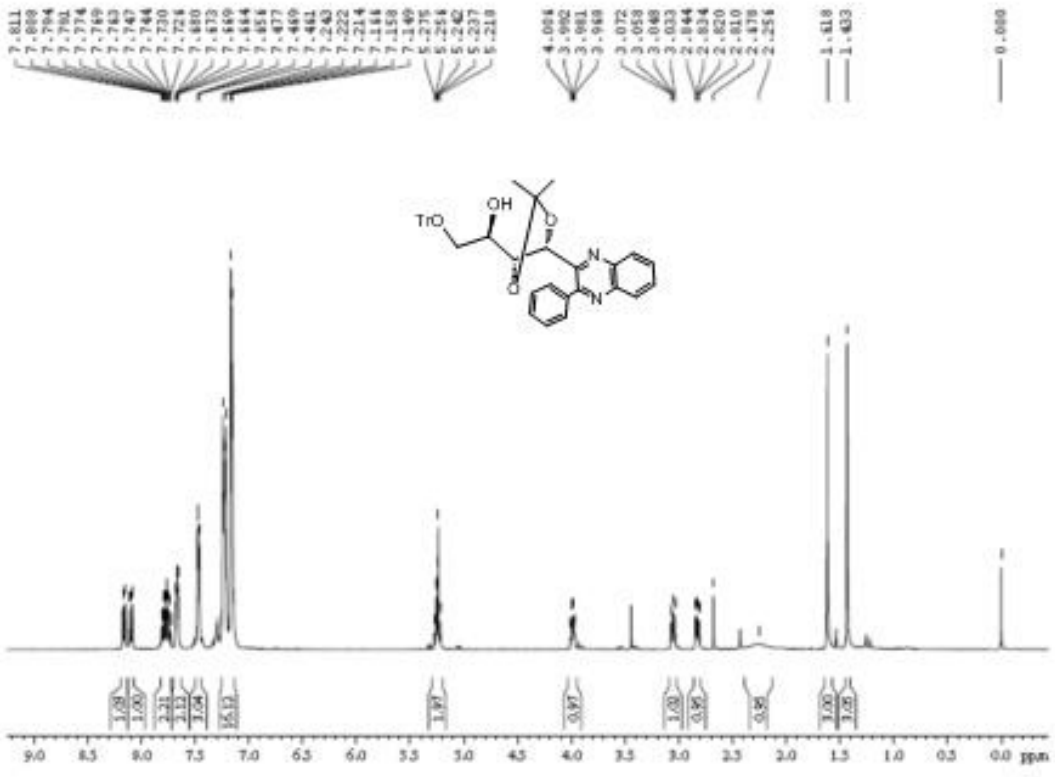


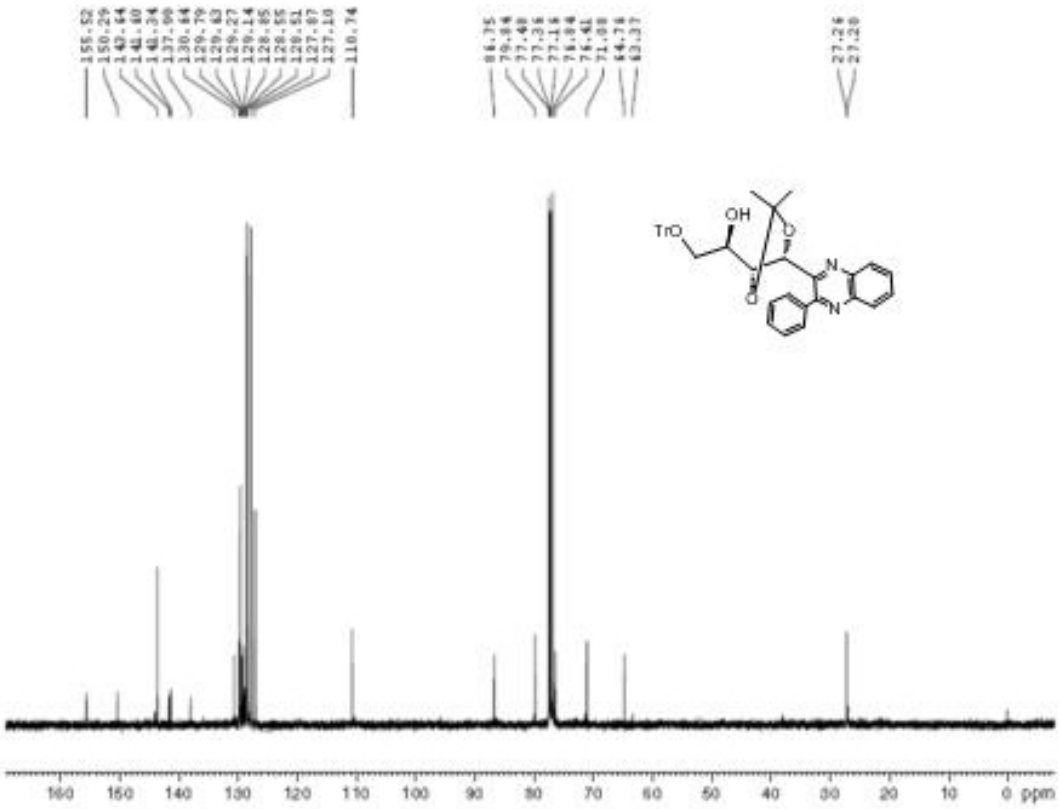
^{1}H NMR and ^{13}C NMR of **2gb**



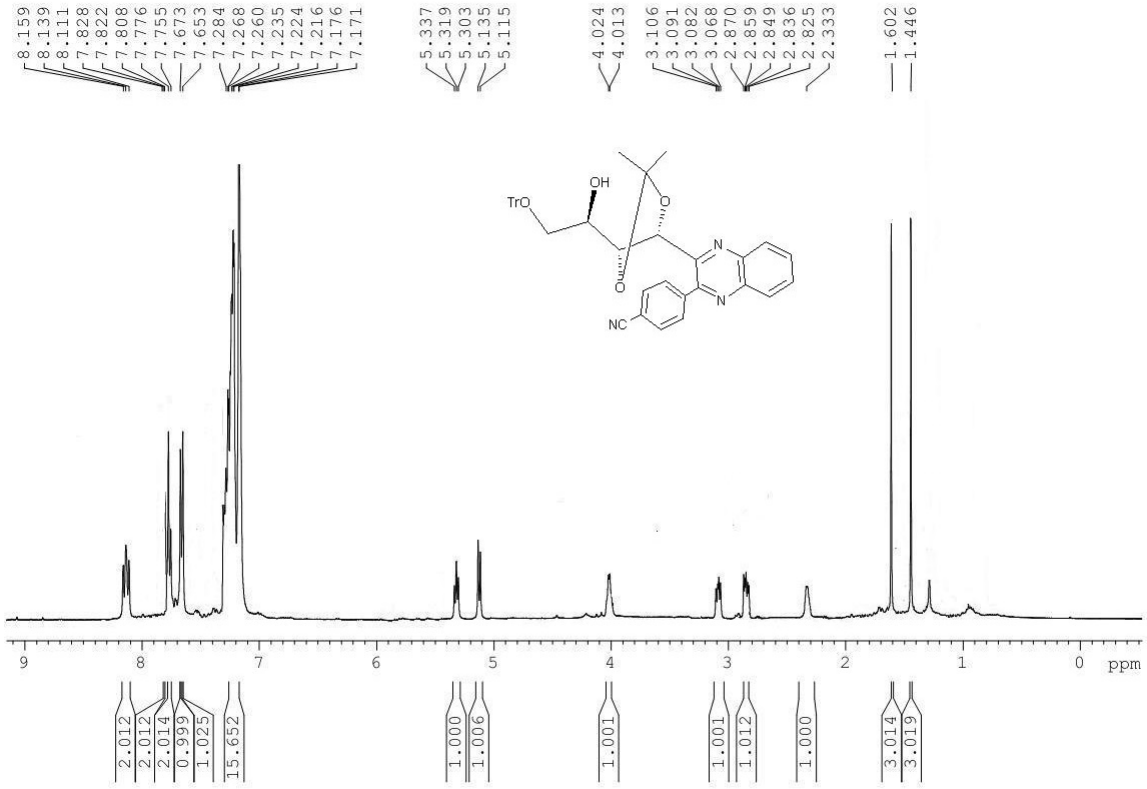


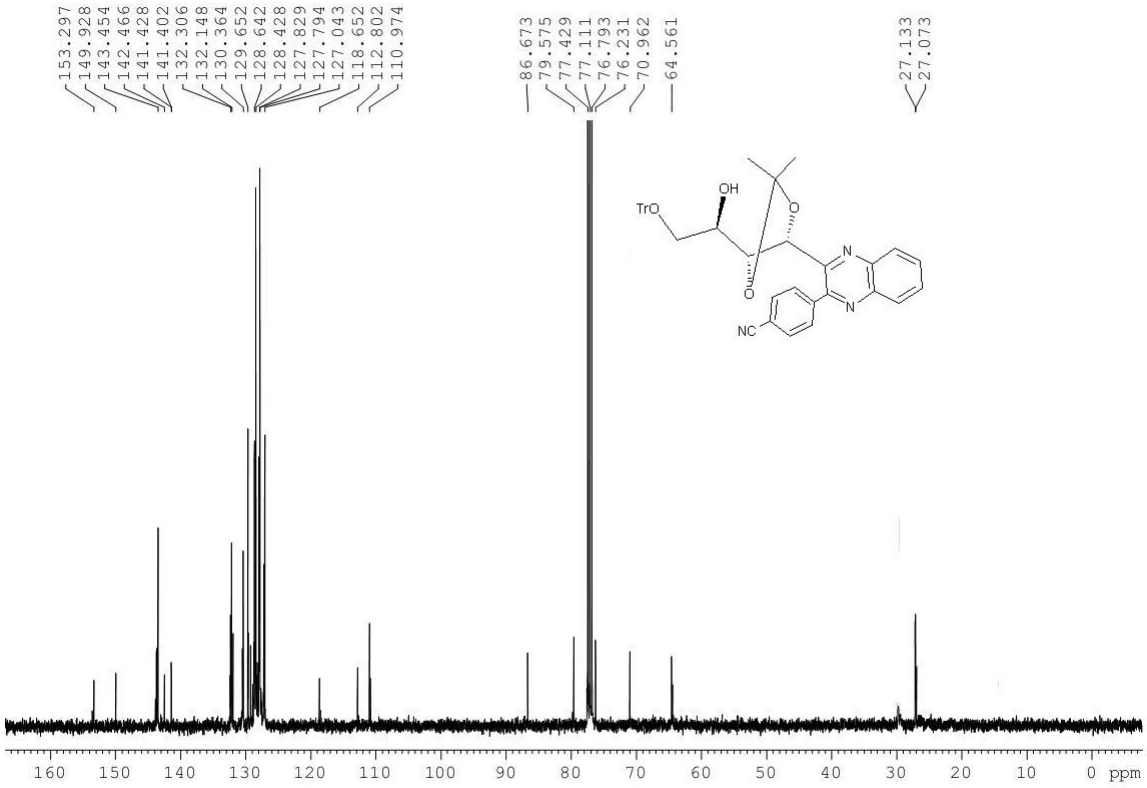
^{1}H NMR and ^{13}C NMR of **2gc**



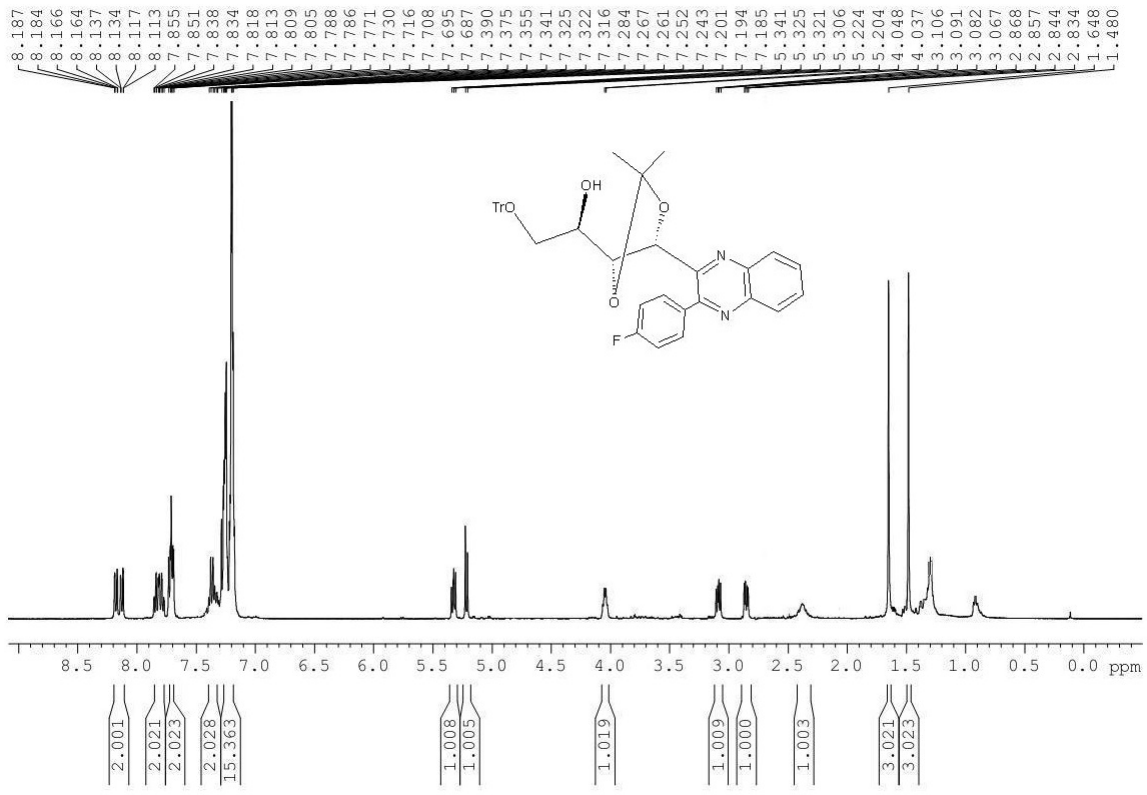


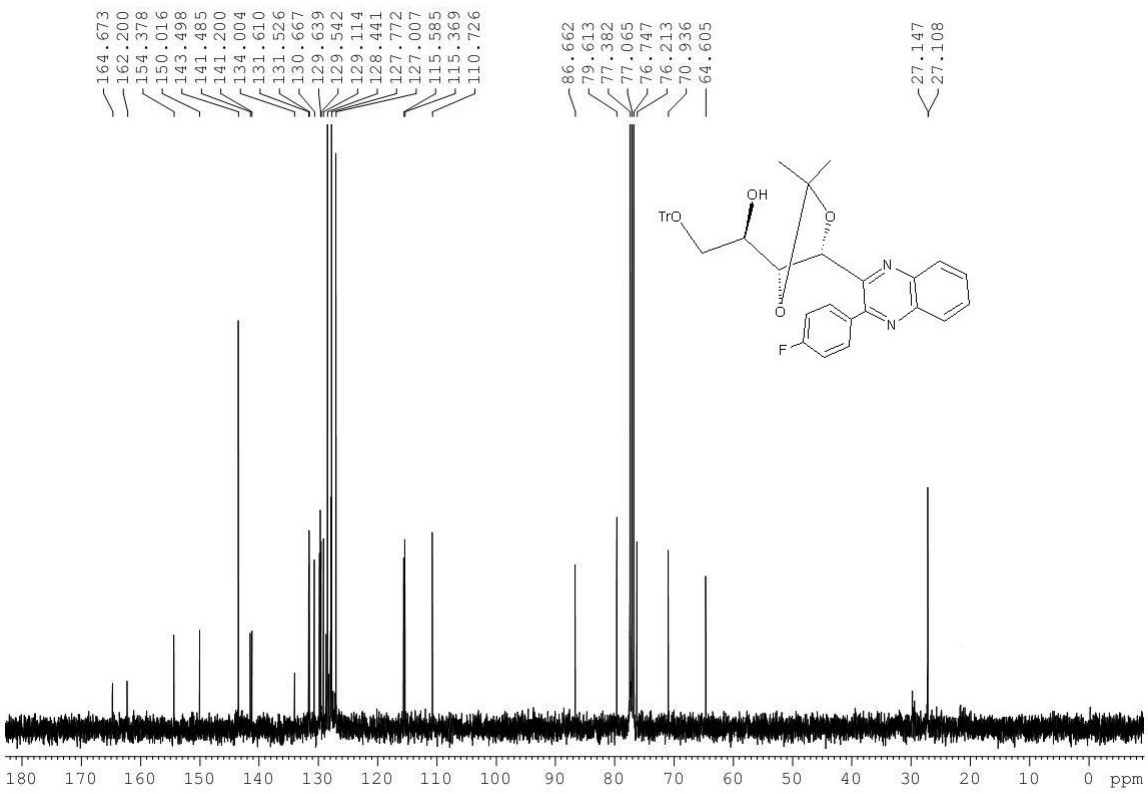
^{1}H NMR and ^{13}C NMR of **2gd**



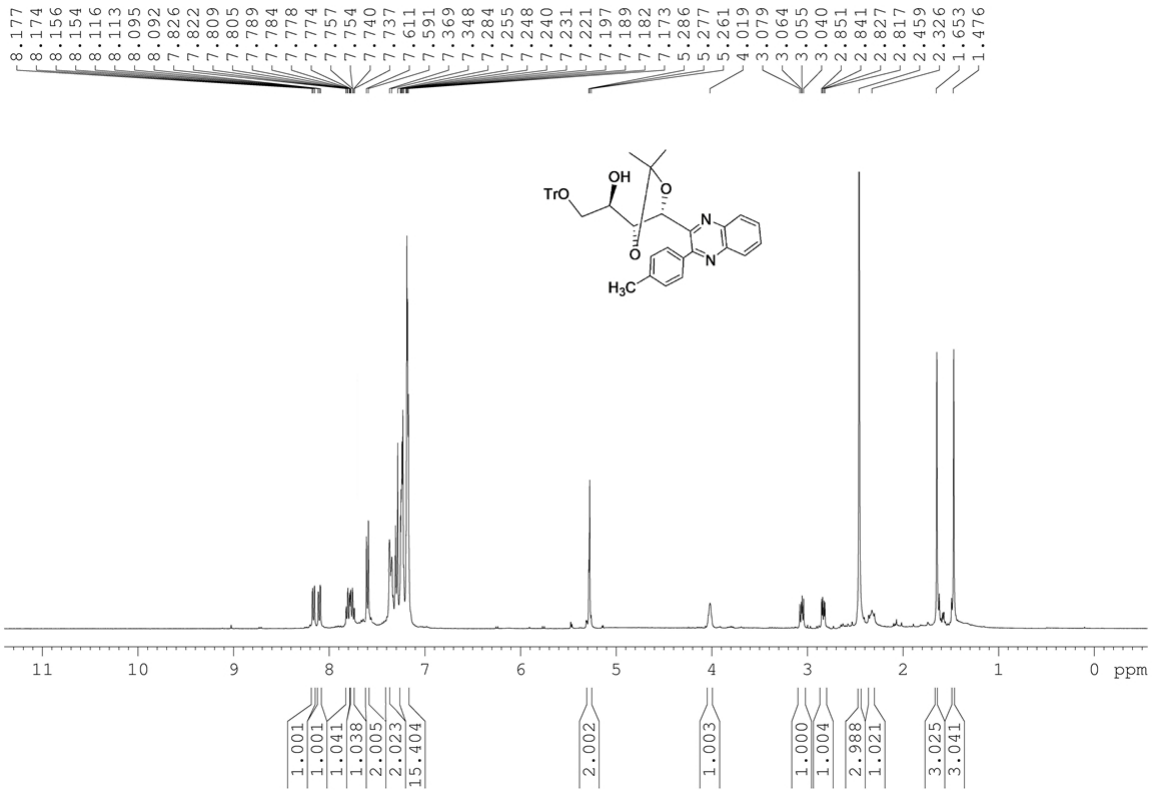


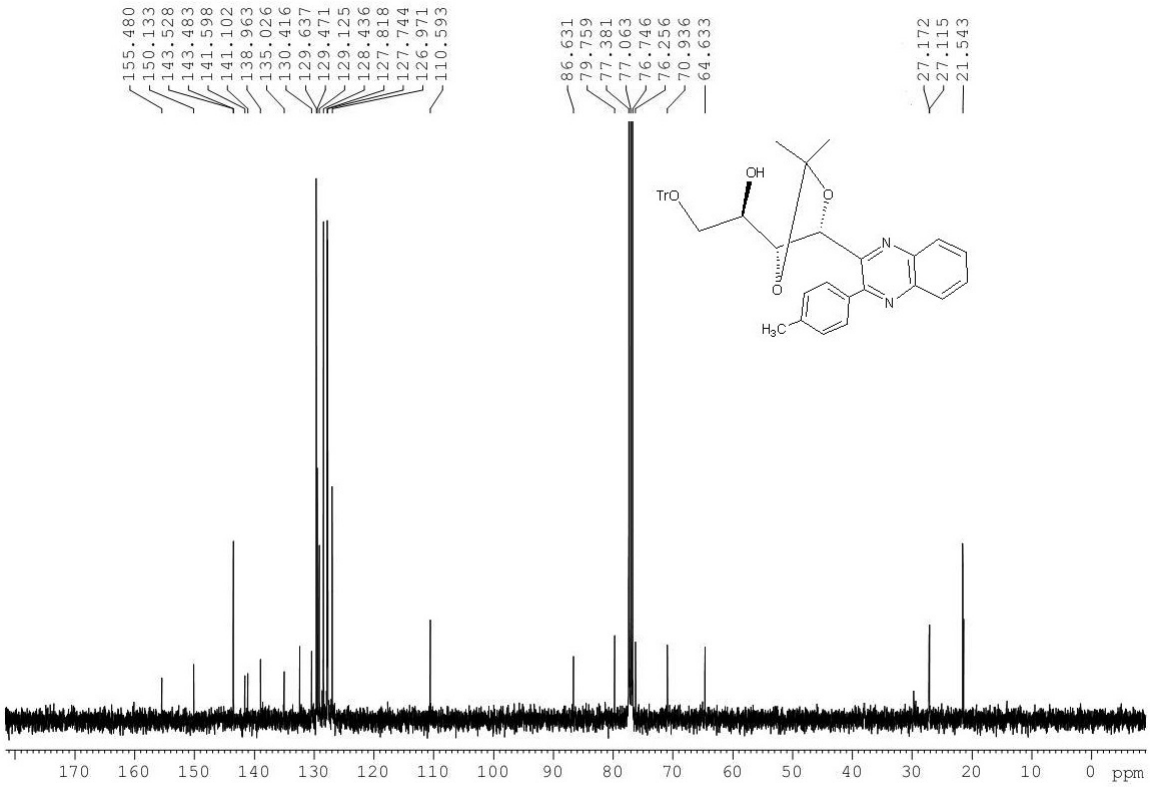
^{1}H NMR and ^{13}C NMR of **2ge**



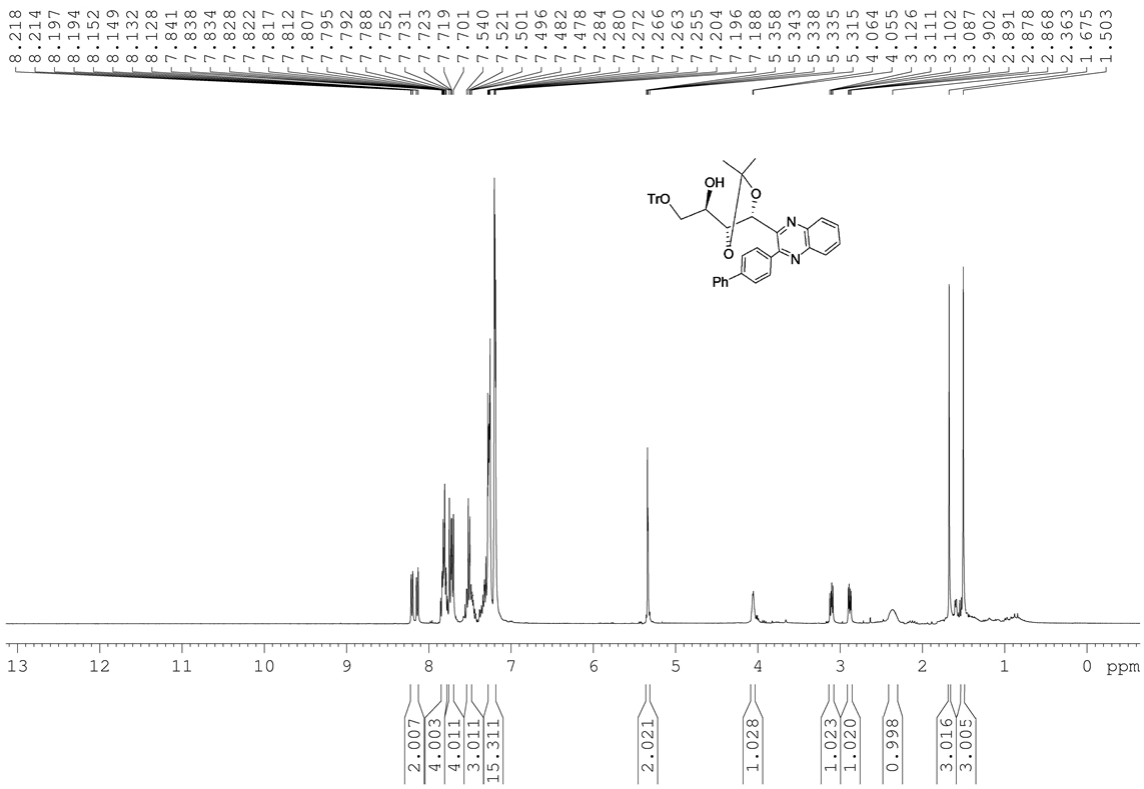


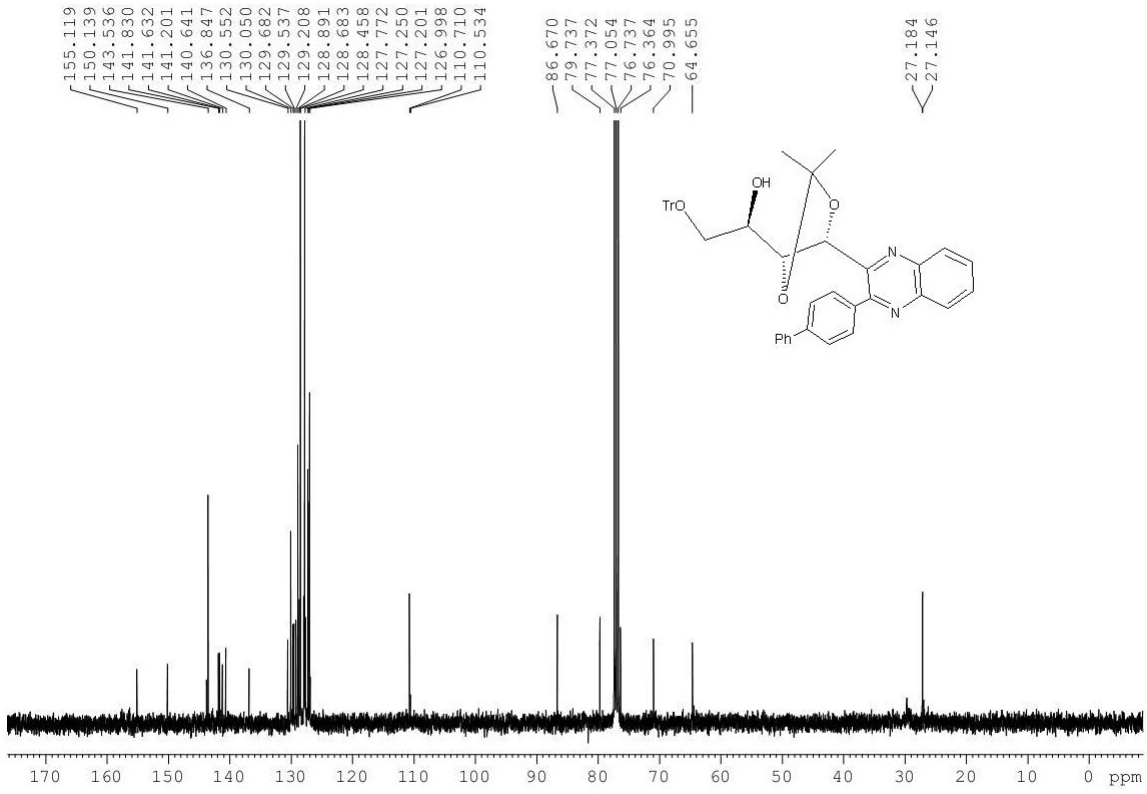
^{1}H NMR and ^{13}C NMR of **2gf**





^{1}H NMR and ^{13}C NMR of **2gg**

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150.139
143.536
141.830
141.632
141.201
140.641
136.847
130.552
130.050
129.682
129.537
129.208
128.891
128.683
128.458
127.772
127.250
127.201
126.998
110.710
110.534
86.670
79.737
77.372
77.054
76.737
76.364
70.995
64.655
27.184
27.146
OH
TrO
O
O
N
N
Ph
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

References

1 (a) E. J. Cory and P. L. Fuchs, *Tetrahedron Lett.*, 1972, **13**, 3769; (b) V. S. Ayyagari, P. Kalanidhi and P. K. Krishna, *Chem. Eur. J.*, 2010, **16**, 8545.

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