Supporting Information

for

Catalytic asymmetric Henry reaction using copper chiral tridentate Schiff-base complexes and their polymer-supported complexes

Qingbao Song, Xiaoxia An, Ting Xia, Xiaocong Zhou, Tianhua Shen*

Address: College of Chemical Engineering, Zhejiang University of Technology, Chaowang Road 18, Hangzhou 310032, China

Email: Tianhua Shen* – shenth@zjut.edu.cn

*Corresponding author

Experimental details and characterization data for all compounds

Contents

1. General remarks

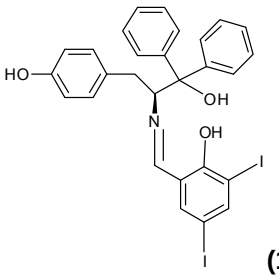
All solvents were dried by standard method. Unless otherwise noted, commercially available reagents were used without further purification. All reactions were monitored by TLC with Haiyang GF254 silica gel coated plates. Column chromatography was carried out using 100-200 mesh silica gel. Liquid aldehydes were freshly distilled before use. Melting points were recorded on X-4 melting point apparatus and the thermometer was uncorrected. NMR spectra were recorded on a Bruker Advance III at 500 MHz for ^{1}H and 126 MHz for ^{13}C using $CDCl_3$ or CD_3SOCD_3 as solvent (with TMS as an internal standard). IR spectra (film) were recorded on a NEXUS FI/IR spectrometer. Mass spectra (MS) were carried out on VARIAN1200 and measured by the EI method. The *ee* value determination was carried out using chiral HPLC with a Daicel Chiracel AD-H or OD-H column.

2. General procedure for the preparation for 4-(2-amino-3-hydroxy-3,3-diphenyl-propyl)-phenol [1a]

L-Tyrosine methyl ester hydrochloride (2.31 g ,10 mmol) was added portionwise to freshly prepared Grignard reagent of PhMgBr (80 mmol) in diethyl ether under an argon atmosphere at 0 ºC. Then the mixture was stirred at ambient temperature overnight, and a cold saturated NH_4Cl was added into it under vigorous stirring. The mixture was extracted with ethyl acetate (50 mL× 3). The combined organic layer was washed with brine and dried with anhydrous Na_2SO_4, and then concentrated in a vacuum. This residue was recrystallized with diethyl ether and gave compound **1a** as a colorless crystal. Yield: 65.3%; mp: 215 ºC (reference [1] m.p.215~217 ºC); $[\alpha]_D^{20}$ = -81.58 (c 0.076, CH_2Cl_2) (reference [1] $[\alpha]_D^{20}$ = -90.8 (c 0.1184, THF)); IR (KBr): 3506, 3357, 3027, 1583, 1511, 1447, 822, 768, 703 cm^{-1}; MS (EI, 70 eV): m/z = 320(M^+, 1), 212(10), 167(17), 136(100), 91(17).

3. General procedure for the preparation for Schiff-base ligands 1-14 [2]

To a solution of 4-(2-amino-3-hydroxy-3,3-diphenyl-propyl)-phenol [**1a**] (2 mmol) in 10 mL 95% EtOH was added substituted salicylaldehyde [**2a-f**] (2 mmol). The resulting solution was vigorously stirred for 24 h at room temperature, then the reaction was vacuum filtered to to remove the solvent. The crude product was purified by silica gel flash column chromatography or recrystallized to give, the resulting chiral Schiff-base(1-14) as a yellow solid, in high yield (>98%).

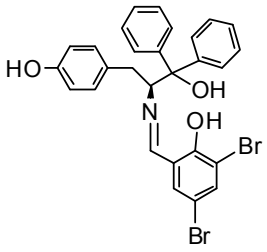


(1)

***2-(((S)-1-hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-4,6-diiodo-phenol* (1):**

Yellow solid; mp: 129~130 ºC; $[\alpha]_D^{20}$ = -115.38 (*c* = 0.0468 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3417, 3057, 1630, 1510, 1444, 1384, 1226, 826, 768, 701; ^{1}H NMR (500 MHz, $CDCl_3$, ppm) δ: 14.24 (br, 1H, Ph-OH), 7.99 (d, *J* = 2.1 Hz, 1H, Ph-H), 7.62 (d, *J* = 7.5 Hz, 2H, Ph-H), 7.45~7.37 (m, 4H, Ph-H), 7.34 (s, 1H, CH=N), 7.30 (t, *J* = 6.7 Hz, 1H, Ph-H), 7.25 (d, *J* = 8.0 Hz, 2H, Ph-H), 7.23~7.07 (m, 2H, Ph-H), 6.82 (d, *J* = 8.4 Hz, 2H, Ph-H), 6.68 (d, *J* = 8.4 Hz, 2H, Ph-H), 5.04 (br, 1H, Ph-OH), 4.33 (dd, *J* = 10.3, 1.6 Hz, 1H, C*H), 2.92 (br, 1H, OH), 2.97(dd, *J* = 14.0, 1.3 Hz, 1H, Ph-CH_2), 2.80 (dd, *J* = 14.0, 10.4 Hz, 1H, Ph-CH_2); ^{13}C NMR (126 MHz, $CDCl_3$, ppm) δ: 164.1, 162.2, 154.4, 149.2, 144.7, 143.7, 140.0, 130.7, 130.2, 128.6, 127.3, 125.9, 118.9, 115.6, 88.9, 79.6, 78.3, 77.7, 77.3, 77.0, 76.8, 36.4; MS (EI, 70 eV) m/z: 676(M^+, 2%),

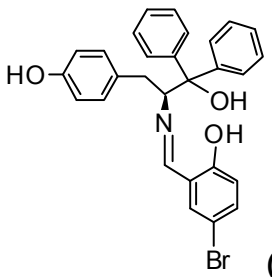
493(100%), 386(30%), 374(52%), 183(48%), 105 (61%), 77(50%); Anal. Calcd for $C_{28}H_{23}I_2NO_3$: C, 49.80; H, 3.43; N, 2.07. Found: C, 49.77; H, 3.41; N, 2.05.



(2)

***2,4-Dibromo-6-(((S)-2-hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-phenol* (2):**

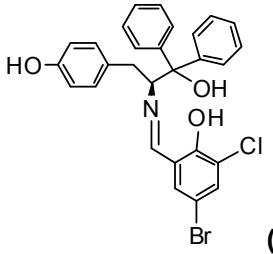
Yellow solid; mp: 105~107 ºC; $[\alpha]_D^{20}$ = -126.25 (*c* = 0.0800 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3385, 3024, 2931, 1631, 1482, 1383, 1273, 824, 767, 702; ^{1}H NMR (500 MHz, $CDCl_3$, ppm) δ: 12.86 (br, 1H, Ph-OH), 7.63 (d, *J* = 7.6 Hz, 2H, Ph-H), 7.53 (s, 1H, CH=N), 7.47 (d, *J* = 7.6 Hz, 2H, Ph-H), 7.41 (t, *J* = 7.8 Hz, 2H, Ph-H), 7.31 (m, 3H, Ph-H), 7.16 (t, *J* = 7.4 Hz, 1H, Ph-H), 7.01 (d, *J* = 2.5 Hz, 1H, Ph-H), 6.80 (m, 3H, Ph-H), 6.67 (d, *J* = 8.4 Hz, 2H, Ph-H), 5.54 (br, 1H, Ph-OH), 4.30 (dd, J = 10.3, 1.8 Hz, 1H, C*H), 3.00 (dd, *J* = 14.0, 1.4 Hz, 1H, Ph-CH_2), 2.90 (br, 1H, OH), 2.77 (dd, *J* = 14.0, 10.3 Hz, 1H, Ph-CH_2); ^{13}C NMR (126 MHz, $CDCl_3$, ppm) δ: 165.1, 160.0, 154.2, 145.1, 144.0, 135.2, 133.53, 130.7, 128. 5, 127.2, 126.1, 119.7, 119.0, 115.4, 110.1, 79.7, 78.9, 77.3, 77.0, 76.8, 36.5; MS (EI, 70 eV) m/z: 542(M^+, 1%), 399(34%), 275(25%), 183(65%), 136(42%), 105(100%), 77(57%); Anal. Calcd for $C_{28}H_{23}Br_2NO_3$: C, 57.85; H, 3.99; N, 2.41. Found: C, 57.83; H, 3.96; N, 2.40.



(3)

***4-Bromo-2-(((S)-2-hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-phenol* (3):**

Yellow solid; mp: 114~116 ºC; $[\alpha]_D^{20}$ = -123.08 (*c* = 0.0520 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3355, 3024, 2933, 1632, 1450, 1446, 1222, 831, 768, 699; ^1H NMR (500 MHz, $CDCl_3$, ppm) δ: 14.16 (br, 1H, Ph-OH), 9.81 (s, 1H, CH=N), 7.62 (m, 3H, Ph-H), 7.42 (m, 5H, Ph-H), 7.28 (m, 3H, Ph-H), 7.15 (t, *J* = 7.3 Hz, 1H, Ph-H), 6.94 (d, *J* = 2.3 Hz, 1H, Ph-H), 6.82 (d, *J* = 8.3 Hz, 2H, Ph-H), 6.68 (d, *J* = 8.4 Hz, 2H, Ph-H), 5.53 (br, 1H, Ph-OH), 4.33 (dd, *J* = 10.3, 1.6 Hz, 1H, C*H), 3.00 (br, 1H, OH), 2.98 (d, br, *J* = 14.0 Hz, 1H, Ph-CH_2), 2.79 (dd, *J* = 14.0, 10.5 Hz, 1H, Ph-CH_2); ^{13}C NMR (126 MHz, $CDCl_3$, ppm) δ: 164.4, 159.1, 154.4, 144.7, 143.7, 138.1, 132.9, 130.7, 130.2, 128.6, 127.3, 125.9, 119.1, 115.5, 112.9, 108.9, 79.6, 77.9, 77.3, 77.0, 76.8, 36.4; MS (EI, 70 eV) m/z: 504(M^+, 2%), 321(68%), 319(100%), 277(30%), 183(75%), 105(87%), 77(44%); Anal. Calcd for $C_{28}H_{24}BrNO_3$: C, 66.94; H, 4.82; N, 2.79. Found: C, 66.92; H, 4.79; N, 2.75.

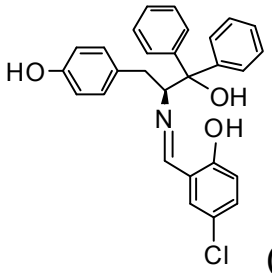


(4)

***2,4-Dichloro-6-(((S)-2-hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-phenol* (4):**

Yellow solid; mp: 96~98 ºC; $[\alpha]_D^{20}$ = -132.28(*c* = 0.0756 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3356, 3026, 2966, 1634, 1505, 1448, 1217, 855, 749, 701; ^1H NMR (500 MHz, $CDCl_3$, ppm) δ: 13.97 (br, 1H, Ph-OH), 7.62 (d, *J* = 7.5 Hz, 2H, CH=N, Ph-H), 7.46~7.39 (m, 5H, Ph-H), 7.34 (d, *J* = 2.4 Hz, 1H, Ph-H), 7.31 (d, *J* = 7.3 Hz, 1H, Ph-H), 7.26 (d, *J* = 8.0 Hz, 2H, Ph-H), 7.16 (t, *J* =

7.3 Hz, 1H, Ph-H), 6.83 (d, *J* = 8.4 Hz, 2H, Ph-H), 6.77 (d, *J* = 2.4 Hz, 1H, Ph-H), 6.68 (d, *J* = 8.4 Hz, 2H, Ph-H), 5.43 (br, 1H, Ph-OH), 4.31 (s, 1H, C*H), 2.99 (d, br, *J* = 14.0 Hz, 1H, Ph-CH_2), 2.98 (br, 1H, OH), 2.79 (dd, *J* = 14.0, 10.5 Hz, 1H, Ph-CH_2); ^{13}C NMR (126 MHz, $CDCl_3$, ppm) δ: 164.6, 158.5, 154.6, 144.6, 143.6, 132.9, 130.7, 129.9, 129.6, 129.2, 128.6, 128.3, 127.4, 126.0, 123.5, 121.7, 118.3, 115.6, 79.6, 77.6, 77.3, 77.0, 76.8, 36.3; MS (EI, 70 eV) m/z: 493(M^+, 1%), 309(67%), 267(39%), 183(57%), 107(37%), 105 (100%), 77(70%); Anal. Calcd for $C_{28}H_{23}Cl_2NO_3$: C, 68.30; H, 4.71; N, 2.84. Found: C, 68.28; H, 4.69; N, 2.82.

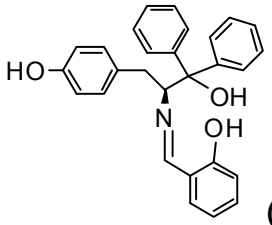


(5)

***4-Chloro-2-(((S)-2-hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-phenol* (5):**

Yellow solid; mp: 98~101 ºC; $[\alpha]_D^{20}$ = -152.63(*c* = 0.0760 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3415, 3028, 1634, 1519, 1479, 1249, 854, 757, 706; ^{1}H NMR (500 MHz, $CDCl_3$, ppm) δ: 12.85 (br, 1H, Ph-OH), 7.63 (d, *J* = 7.4 Hz, 2H, Ph-H), 7.53 (s, 1H, CH=N), 7.49~7.45 (m, 2H, Ph-H), 7.41 (t, *J* = 7.8 Hz, 2H, Ph-H), 7.36~7.28 (m, 2H, Ph-H), 7.26 (s, 1H, Ph-H), 7.21~7.13 (m, 2H, Ph-H), 6.88 (d, *J* = 2.6 Hz, 1H, Ph-H), 6.83 (d, *J* = 8.6 Hz, 3H, Ph-H), 6.72~6.61 (m, 2H, Ph-H), 5.54 (s, 1H, Ph-OH), 4.30 (dd, *J* = 10.3, 1.9 Hz, 1H, C*H), 3.00 (dd, *J* = 14.0, 1.5 Hz, 1H, Ph-CH_2), 2.94 (br, 1H, OH), 2.77 (dd, *J* = 14.0, 10.3 Hz, 1H, Ph-CH_2); ^{13}C NMR (126 MHz, $CDCl_3$, ppm) δ: 165.1, 159.5, 154.2, 145.1, 143.9, 132.3, 130.9, 130.4, 128.5, 128.3, 127.2, 126.1, 123.2, 119.0, 118.5, 115.3, 79.7, 78.9, 77.3, 77.0, 76.7, 36.5; MS (EI, 70 eV) m/z:

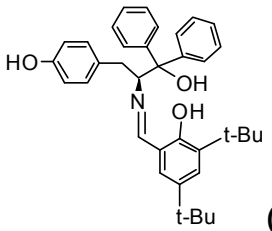
459(M^+, 2%), 275(100%), 233(29%), 183(63%), 167(21%), 105 (84%), 77(50%); Anal. Calcd for $C_{28}H_{24}ClNO_3$: C, 73.44; H, 5.28; N, 3.06. Found: C, 73.41; H, 5.26; N, 3.04.



(6)

***2-(((S)-2-hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-phenol* (6):**

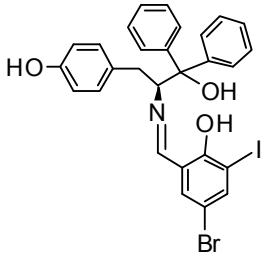
Yellow solid; mp: 237 ºC; $[\alpha]_D^{20}$ = -66.67 (*c* = 0.0636 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3561, 3054, 2970, 2559, 1628, 1456, 1385, 1284, 836, 755, 701; ^{1}H NMR(500 MHz, DMSO, ppm) δ: 13.22 (s, 1H, Ph-OH), 9.12 (s, 1H, Ph-OH), 7.80 (s, 1H, CH=N), 7.70 (d, *J* = 7.7 Hz, 2H, Ph-H), 7.56 (d, *J* = 7.7 Hz, 2H, Ph-H), 7.38 (t, *J* = 7.7 Hz, 2H, Ph-H), 7.22 (m, 4H, Ph-H), 7.07 (t, *J* = 7.3 Hz, 1H, Ph-H), 7.01 (dd, *J* = 7.5, 1.0 Hz, 1H, Ph-H), 6.81 (d, *J* = 8.3 Hz, 2H, Ph-H), 6.77~6.67 (m, 2H, Ph-H), 6.58 (d, *J* = 8.3 Hz, 2H, Ph-H), 6.03 (s, 1H, OH), 4.54 (d, *J* = 9.9 Hz, 1H, C*H), 2.85 (d, br, *J* = 13.9 Hz, 1H, Ph-CH_2), 2.69 (dd, *J* = 13.9, 10.6 Hz, 1H, Ph-CH_2); ^{13}C NMR (126 MHz, DMSO, ppm) δ: 165.6, 160.6, 155.4, 146.1, 146.0, 131.9, 131.4, 130.2, 128.9, 128.0, 127.5, 126.4, 126.3, 126.2, 126.0, 118.3, 117.9, 116.4, 114.9, 79.0, 77.2, 35.9; MS (EI, 70 eV) m/z: 424 (M^+, 7%), 241(100%), 199 (20%), 105(25%), 77(7%); Anal. Calcd for $C_{28}H_{25}NO_3$: C, 79.41; H, 5.95; N, 3.31. Found: C, 79.40; H, 5.94; N, 3.29.



(7)

***2,4-Di-tert-butyl-6-(((S)-2-hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-phenol* (7):**

Yellow solid; mp: 88~90 ºC; $[\alpha]_D^{20}$ = -128.91 (*c* = 0.0768 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3420, 2959, 1623, 1513, 1440, 1361, 1250, 829, 769, 702; ^1H NMR (500 MHz, $CDCl_3$, ppm) δ: 12.91 (br, 1H, Ph-OH), 7.69 (s, 1H, CH=N), 7.59 (d, *J* = 7.6 Hz, 2H, Ph-H), 7.52 (d, *J* = 7.7 Hz, 2H, Ph-H), 7.40 (t, *J* = 7.7 Hz, 2H, Ph-H), 7.34 (d, *J* = 2.3 Hz, 1H, Ph-H), 7.29 (d, *J* = 5.8 Hz, 1H, Ph-H), 7.27~7.21 (m, 2H, Ph-H), 7.14 (t, *J* = 7.3 Hz, 1H, Ph-H), 6.85 (d, *J* = 8.4 Hz, 2H, Ph-H), 6.75 (t, *J* = 7.6 Hz, 1H, Ph-H), 6.66 (d, *J* = 8.4 Hz, 2H, Ph-H), 5.56 (br, 1H, Ph-OH), 4.32 (d, *J* = 8.4 Hz, 1H, C*H), 3.06 (br, 1H, OH), 2.95 (d, br, *J* = 13.9 Hz, 1H, Ph-CH_2), 2.82 (dd, *J* = 13.9, 10.0 Hz, 1H, Ph-CH_2), 1.42 (s, 9H, -CH_3), 1.26 (s, 9H, -CH_3); ^{13}C NMR (126 MHz, $CDCl_3$, ppm) δ: 167.7, 157.6, 154.0, 145.7, 144.3, 140.0, 136.4, 131.3, 130.9, 128.4, 127.2, 126.6, 126.4, 126.0, 117.7, 115.2, 79.9, 78.6, 77.2, 76.8, 76.7, 36.7, 35.0, 34.1, 31.5, 29.4; MS (EI, 70 eV) m/z: 535(M^+, 7%), 353(100%), 219(20%), 105(23%), 77(14%), 57(11%); Anal. Calcd for $C_{28}H_{25}NO_3$: C, 80.71; H, 7.71; N, 2.61. Found: C, 80.69; H, 7.69; N, 2.60.

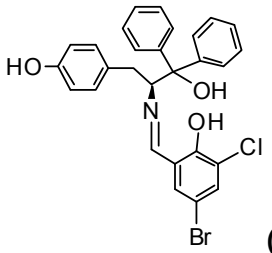


(8)

***4-Bromo-2-(((S)-2-hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-6-iodo-phenol* (8):**

Yellow solid; mp: 118~120 ºC; $[\alpha]_D^{20}$ = -128.75 (*c* = 0.0800 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3450, 3058, 1632, 1509, 1445, 1369, 1223, 827, 769, 702; ^1H NMR (500 MHz, $CDCl_3$, ppm) δ: 14.19 (br, 1H, Ph-OH), 7.83 (d, *J* = 2.3 Hz, 1H, Ph-H), 7.64~7.60 (m, 2H, Ph-H), 7.46~7.39 (m, 4H, Ph-H), 7.35 (s, 1H, CH=N), 7.30 (d, *J* = 7.3 Hz, 1H, Ph-H), 7.25 (d, *J* = 8.0 Hz, 2H, Ph-H), 7.17 (s, 1H, Ph-H), 6.97 (t, *J* = 6.9 Hz, 1H, Ph-H), 6.81 (d, *J* = 8.4 Hz, 2H, Ph-H), 6.67 (d, *J* =

8.4 Hz, 2H, Ph-H), 5.03 (br, 1H, Ph-OH), 4.34 (dd, *J* = 10.4, 1.8 Hz, 1H, C*H), 2.97 (dd, *J* = 14.0, 2.7 Hz, 2H, Ph-CH_2, OH), 2.80 (dd, *J* = 14.0, 10.4 Hz, 1H, Ph-CH_2); ^{13}C NMR (126 MHz, $CDCl_3$, ppm) δ: 164.3, 161.3, 154.4, 144.8, 143.8, 133.9, 130.7, 130.2, 128.6, 127.3, 125.2, 118.0, 115.3, 109.6, 88.2, 79.6, 77.8, 77.3, 77.0, 76.8, 36.4; MS (EI, 70 eV) m/z: 629(M^+, 1%), 445(35%), 353(67%), 183(41%), 105 (100%), 77(69%); Anal. Calcd for $C_{28}H_{23}BrINO_3$: C, 53.53; H, 3.69; N, 2.23. Found: C, 53.51; H, 3.66; N, 2.22.

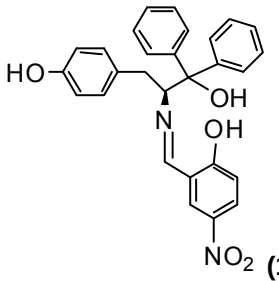


(9)

***4-Bromo-2-chloro-6-(((S)-2-hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-phenol* (9):**

Yellow solid; mp: 115~117 ºC; $[\alpha]_D^{20}$ = -134.18 (*c* = 0.0708 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3059, 1636, 1508, 1448, 1383, 1221, 848, 769, 703 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$, ppm) δ: 14.05 (br, 1H, Ph-OH), 7.62 (m, 2H, Ph-H), 7.46 (m, 2H, Ph-H), 7.44 (d, *J* = 0.6 Hz, 1H, Ph-H), 7.43 (s, 1H, CH=N), 7.41 (d, *J* = 8.0 Hz, 1H, Ph-H), 7.31 (d, *J* = 7.4 Hz, 2H, Ph-H), 7.26 (d, *J* = 8.0 Hz, 2H, Ph-H), 7.17 (d, *J* = 7.3 Hz, 1H, Ph-H), 6.90 (d, *J* = 2.4 Hz, 1H, Ph-H), 6.83 (d, *J* = 8.4 Hz, 2H, Ph-H), 6.71~6.64 (m, 2H, Ph-H), 5.14 (s, 1H, Ph-OH), 4.32 (dd, *J* = 10.4, 1.9 Hz, 1H, C*H), 2.99 (dd, *J* = 14.0, 1.6 Hz, 1H, Ph-CH_2), 2.94 (s, 1H, OH), 2.79 (dd, *J* = 14.0, 10.5 Hz, 1H, Ph-CH_2); ^{13}C NMR (126 MHz, $CDCl_3$, ppm) δ: 164.4, 157.7, 154.4, 144.7, 143.7, 135.1, 132.0, 130.7, 130.3, 128.5, 127.3, 126.0, 123.4, 119.2, 115.5, 108.6, 79.7, 78.2, 77.2, 77.0, 76.7, 36.4； MS (EI, 70 eV) m/z: 537(M^+, 1%), 335(80%), 313 (53%), 312(30%), 183(75%),

105 (100%), 77(56%); Anal. Calcd for $C_{28}H_{23}BrClNO_3$: C, 62.64; H, 4.32; N, 2.61. Found: C, 62.58; H, 4.29; N, 2.60.

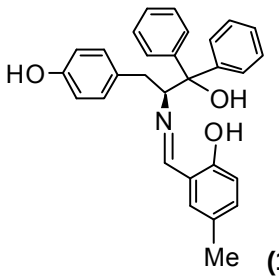


(10)

2-(((S)-2-Hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-4-nitro-phenol

(10):

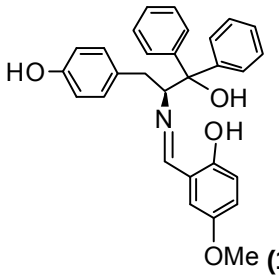
Yellow solid; mp: 127~129 ºC; $[\alpha]_D^{20}$ = -123.13 (*c* = 0.134 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3480, 3059, 1613, 1512, 1447, 1323, 1233, 837, 769, 702; ^{1}H NMR(500 MHz, DMSO, ppm) δ: 14.37 (br, 1H, Ph-OH), 9.23 (br, 1H, Ph- OH), 8.06 (d, *J* = 3.0 Hz, 1H, Ph-H), 8.02 (s, 1H, CH=N), 7.95 (m, 1H, Ph-H), 7.73 (d, *J* = 7.7 Hz, 2H, Ph-H), 7.57 (d, *J* = 7.7 Hz, 2H, Ph-H), 7.44 (t, *J* = 7.7 Hz, 2H, Ph-H), 7.23 (t, *J* = 7.7 Hz, 2H, Ph-H), 7.09 (t, *J* = 7.3 Hz, 1H, Ph-H), 6.93 (d, *J* = 8.4 Hz, 2H, Ph-H), 6.62 (d, *J* = 8.4 Hz, 3H, Ph-H), 6.53 (d, *J* = 9.7 Hz, 1H, Ph-H), 4.94 (t, *J* = 6.7 Hz, 1H, C*H), 3.39 (br, 1H, OH), 2.85 (d, br, *J* = 6.7 Hz, 2H, Ph-H); ^{13}C NMR (126 MHz, DMSO, ppm) δ: 177.1, 166.2, 155.9, 144.9, 144.7, 133.9, 131.7, 130.2, 129.1, 128.3, 127.9, 127.1, 126.9, 126.5, 126.0, 125.8, 122.5, 115.3, 113.1, 78.8, 71.4, 35.1; MS (EI, 70 eV) m/z: 468(M^+, 1%), 269(24%), 182(40%), 136 (39%), 105(100%), 77(66%); Anal. Calcd for $C_{28}H_{24}N_2O_5$: C, 71.78; H, 5.16; N, 5.98. Found: C, 71.69; H, 5.15; N, 5.97.



(11)

***2-(((S)-2-Hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-4-methyl-phenol* (11):**

Yellow solid; mp: 196~198 ºC; $[\alpha]_D^{20}$ = -161.49 (*c* = 0.0644 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3582, 3030, 2967, 1634, 1498, 1447, 1240, 834, 755, 702; ^1H NMR (500 MHz, $CDCl_3$, ppm) δ: 11.35 (br, 1H, Ph-OH), 7.67~7.63 (m, 2H, Ph-H), 7.60 (s, 1H, CH=N), 7.49 (d, *J* = 7.4 Hz, 2H, Ph-H), 7.39 (d, *J* = 8.0 Hz, 2H, Ph-H), 7.29 (s, 1H, Ph-H), 7.25 (d, *J* = 8.0 Hz, 2H, Ph-H), 7.14 (t, *J* = 7.4 Hz, 1H, Ph-H), 7.06 (m, 1H, Ph-H), 6.84 (d, *J* = 8.4 Hz, 2H, Ph-H), 6.79 (d, *J* = 8.4 Hz, 1H, Ph-H), 6.71 (d, *J* = 1.7 Hz, 1H, Ph-H), 6.66 (d, *J* = 8.4 Hz, 2H, Ph-H), 5.55 (br, 1H, Ph-OH), 4.30 (dd, *J* = 10.2, 1.7 Hz, 1H, C*H), 2.99 (dd, *J* = 13.9, 1.5 Hz, 1H, Ph-CH_2), 2.96 (br, 1H, OH), 2.79 (dd, *J* = 13.9, 10.3 Hz, 1H, Ph-CH_2), 2.21 (s, 3H, -CH_3); ^{13}C NMR (126 MHz, $CDCl_3$, ppm) δ: 166.5, 158.5, 154.0, 145.4, 144.1, 133.3, 131.6, 130.8, 128.3, 127.7, 127.0, 126.2, 126.0, 118.0, 116.6, 115.3, 79.8, 78.9, 77.3, 77.0, 76.8, 36.5, 20.2; MS (EI, 70 eV) m/z: 438(M^+, 2%), 255(100%), 183(30%), 105(45%), 77(31%); Anal. Calcd for $C_{29}H_{27}NO_3$: C, 79.61; H, 6.22; N, 3.20. Found: C, 79.58; H, 6.19; N, 3.19.

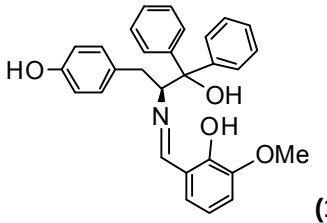


(12)

***2-(((S)-2-Hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-4-methoxy-phenol* (12):**

Yellow solid; mp: 97~99 ºC; $[\alpha]_D^{20}$ = -130 (*c* = 0.120 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3358, 3026, 2929, 1635, 1494, 1448, 1384, 1269, 824, 753, 702; ^1H NMR (500 MHz, DMSO, ppm) δ: 12.55 (s, 1H, Ph-OH), 9.13 (d, *J* = 6.3 Hz, 1H, Ph-OH), 7.77 (s, 1H, CH=N), 7.63 (m, 5H, Ph-H), 7.54

(d, *J* = 7.5 Hz, 2H, Ph-H), 7.37 (t, *J* = 7.7 Hz, 2H, Ph-H), 7.26~7.19 (m, 3H, Ph-H), 7.08 (t, *J* = 7.3 Hz, 1H, Ph-H), 6.88~6.76 (m, 3H, Ph-H), 6.00 (s, 1H, Ph-H), 5.39 (s, 1H, OH), 4.48 (d, *J* = 9.7 Hz, 1H, C*H), 2.83 (d, br, *J* = 13.9 Hz, 1H, Ph-CH_2), 2.65(dd, *J* = 13.9, 10.5 Hz, 1H, Ph-CH_2), 2.53~2.48 (m, 3H, -OCH_3); ^{13}C NMR (126 MHz, DMSO, ppm) δ: 165.3, 155.4, 154.2, 151.2, 146.1, 130.2, 129.9, 128.9, 128.0, 127.5, 126.3, 126.2, 126.0, 125.4, 118.7, 118.2, 117.0, 114.9, 79.5, 79.0, 77.5, 58.6, 55.4, 36.3, 22.0; MS (EI, 70 eV) m/z: 453(M^+, 2%), 271(21%), 182(27%), 136(100%), 105(60%), 77 (50%); Anal. Calcd for $C_{29}H_{27}NO_4$: C, 76.80; H, 6.00; N, 3.09. Found: C, 76.73; H, 5.98; N, 3.07.

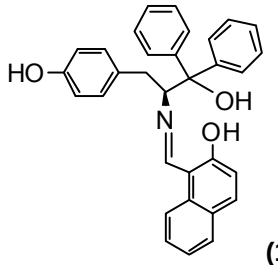


(13)

***2-(((S)-2-Hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-6-methoxy-phenol* (13):**

Yellow solid; mp: 106~109 ºC; $[\alpha]_D^{20}$ = -168.42 (*c* = 0.133 g/mL, CH_2Cl_2). IR (KBr, cm^{-1}): 3405, 3057, 1629, 1510, 1449, 1384, 1251, 838, 738, 702; ^{1}H NMR (500 MHz, $CDCl_3$, ppm) δ: 13.37 (br, 1H, Ph-OH), 7.66~7.62 (m, 2H, Ph-H), 7.57 (s, 1H, CH=N), 7.51~7.46 (m, 2H, Ph-H), 7.39 (t, *J* = 7.8 Hz, 2H, Ph-H), 7.25 (m, 3H, Ph-H), 7.12 (t, *J* = 7.4 Hz, 1H, Ph-H), 6.85 (m, 3H, Ph-H), 6.71~6.62 (m, 3H, Ph-H), 6.53 (d, *J* = 7.8 Hz, 1H, Ph-H), 5.55 (br, 1H, Ph-OH), 4.30 (dd, *J* = 10.2, 1.9 Hz, 1H, C*H), 3.86 (s, 3H, -OCH_3), 2.99 (br, 1H, OH), 2.97 (dd, *J* = 14.0, 1.6 Hz, 1H, Ph-CH_2), 2.80 (dd, *J* = 14.0, 10.3 Hz, 1H, Ph-CH_2); ^{13}C NMR (126 MHz, $CDCl_3$, ppm) δ: 166.5, 154.2, 148.3, 145.2, 144.0, 130.8, 128.4, 127.1, 127.0, 126.1, 126.0, 123.1, 118.1, 117.8, 115.3, 114.0, 79.7, 78.5, 77.3, 77.0, 76.8, 56.0, 36.6; MS (EI, 70 eV) m/z: 453(M^+, 7%),

271(100%), 229 (34%), 152(44%), 105(68%), 77(48%); Anal. Calcd for $C_{29}H_{27}NO_4$: C, 76.80; H, 6.00; N, 3.09. Found: C, 76.72; H, 5.99; N, 3.07.



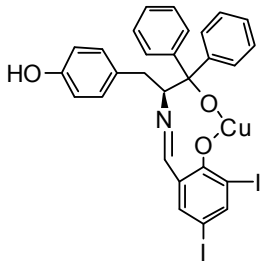
(14)

***1-(((S)-2-Hydroxy-1-(4-hydroxy-benzyl)-2,2-diphenyl-ethylimino)-methyl)-naphthalen-2-ol* (14):**

Yellow solid; mp: 245 ºC; $[\alpha]_D^{20}$ = -178.12 (*c* = 0.141 g/mL, CH_2Cl_2). IR (KBr): 3581, 3081, 3030, 1626, 1444, 1340, 1280, 842, 752, 698 cm^{-1}; ^1H NMR (500 MHz, DMSO, ppm) δ: 13.77~13.64 (m, 1H, naphthyl-OH), 9.12 (s, 1H, Ph-OH), 8.34 (d, *J* = 10.9 Hz, 1H, CH=N), 7.74 (d, *J* = 7.5 Hz, 2H, Ph-H), 7.68 (d, *J* = 7.5 Hz, 2H, Ph-H), 7.59 (d, *J* = 9.4 Hz, 1H, Ph-H), 7.54~7.41 (m, 4H, Ph-H), 7.33~7.26 (m, 2H, Ph-H), 7.19 (t, *J* = 7.8 Hz, 2H, Ph-H), 7.09 (t, *J* = 7.3 Hz, 1H, Ph-H), 7.01 (t, *J* = 7.3 Hz, 1H, Ph-H), 6.94 (d, *J* = 8.4 Hz, 2H, Ph-H), 6.58 (m, 3H, Ph-H), 6.43 (s, 1H, OH), 5.04 (m, 1H, C*H), 2.85~2.65 (m, 2H, Ph-CH_2); ^{13}C NMR (126 MHz, DMSO, ppm) δ: 177.7, 158.2, 155.7, 145.5, 136.8, 134.3, 130.2, 128.7, 128.3, 127.9, 127.7, 126.7, 126.2, 126.1, 125.4, 124.8, 121.7, 117.6, 115.1, 104.8, 79.3, 69.7, 39.5, 35.9; MS (EI, 70 eV) m/z: 474 (M^+, 2%), 291 (71%), 241(31%), 184(100%), 105(81%), 77(60%); Anal. Calcd for $C_{32}H_{27}NO_3$: C, 81.16; H, 5.75; N, 2.96. Found: C, 81.14; H, 5.74; N, 2.95.

4. Preparation and characterization of copper Schiff-base complex 15

General procedure for the preparation of copper Schiff-base complex **15** was consulted the literature[3] method.



(15)

Compound 15: Elemental Anal. Found: C, 45.61; H, 2.86; N, 1.89. IR (KBr, cm^{-1}): 3374, 3012, 2935, 1629, 1439, 1145, 1052, 746, 704, 592, 564, 503, 454.

To a mixture of complex 15 (0.051 g) in Milli-Q water (2 mL) was added HNO_3 (20 ml, 69.2%). The mixture was heated at 150□ and the digested solution was diluted to 25 ml with Milli-Q water. Heavy metal Cu concentrations in the prepared solutions were determined using atomic absorption spectrometry (AA-800, Perkin-Elmer Inc.). Metal Cu concentrations were 5.541mg/L and 5.570 mg/L (panel data which were diluted to 30 times). Metal concentrations had a *n(ligand **1**)*-to-*n(Cu)* ratio of 1.065.

$$m(Cu) = \frac{1}{2} \times (5.541 + 5.570) \times 30 = 166.665\ mg/L$$

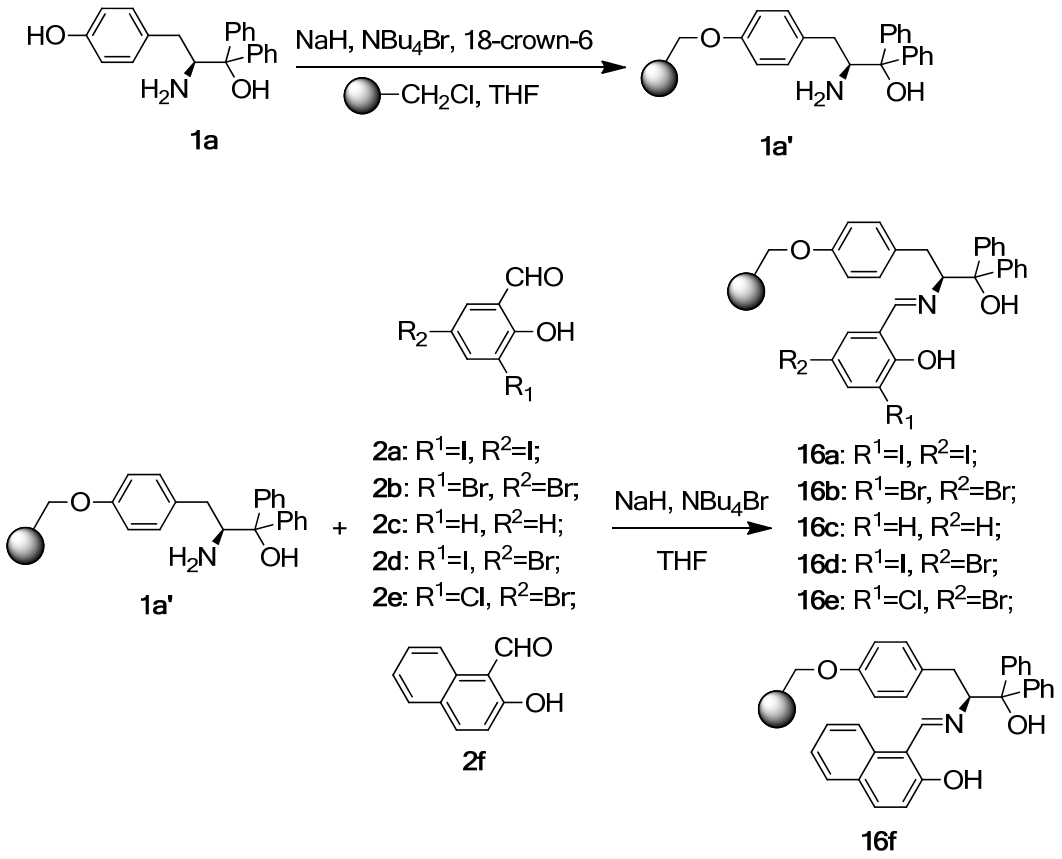
$$n(Cu) = \frac{m(Cu)}{M(Cu)} = \frac{166.665}{64} = 2.604\ mmol/L$$

$$m(ligand\ 1) = m(complex\ 15) - m(Cu) = \frac{0.051 \times 1000}{25 \times 0.001} - 166.665 = 1873.335\ mg/L$$

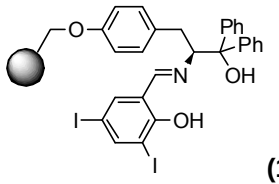
$$n(ligand\ 1) = \frac{m(ligand\ 1)}{M(ligand\ 1)} = \frac{1873.335}{675.30} = 2.774\ mmol/L$$

$$n(Cu) : n(ligand\ 1) = 2.604 : 2.774 = 1 : 1.065$$

5. Preparation of polymer-supported chiral tridentate Schiff-base ligands 16a-f, 17 [4]

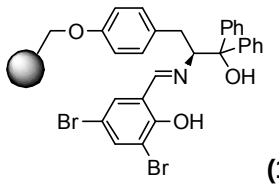


To a stirred mixture of **1a** (0.957 g, 3 mmol) in anhydrous THF (100 mL) was added NaH (0.120g, 3mmol), NBu_4Br (0.115g, 0.3mmol) and 18-crown-6 (0.079g, 0.3mmol). The mixture was stirred for 30 min at room temperature. Then the Merrifield resin (3g, 100~200 mesh, 1.0~1.2 mmol/g) was added and the solution was heated under reflux for 60 h.The solvent was evaporated and washed by THF, THF/H_2O, THF/MeOH, MeOH, CH_2Cl_2 and Et_2O to give **1a'**. Next, to a stirred mixture of **1a'** (1.29 g, 1 mmol) in anhydrous THF (50 mL) was added NaH (0.040g, 1mmol), NBu_4Br (0.038g, 0.1mmol) and 18-crown-6 (0.026g, 0.1mmol). The mixture was stirred for 30 min at room temperature. Then the salicylaldehyde(**2a-2f**) (1 mmol) was added and then the solution was heated under reflux overnight. And the reaction was vacuum filtered and washed by THF. At last, the solution was dried to provide the polymer-supported chiral tridentate Schiff-base ligands **16a-f** and catalyst **17**.



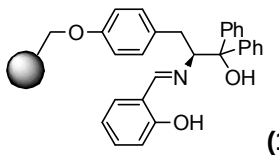
(16a)

Compound 16a: Elemental Anal. Found: C, 51.21; H, 3.86; N, 1.97. IR (KBr, cm^{-1}): 3424, 3058, 3024, 2920, 2848, 1942, 1691, 1600, 1492, 1450, 1383, 1264, 1028, 905, 837, 756, 697, 538.



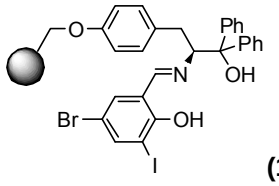
(16b)

Compound 16b: Elemental Anal. Found: C, 59.12; H, 4.42; N, 2.29. IR (KBr, cm^{-1}): 3440, 3058, 3024, 2921, 1943, 1802, 1721, 1600, 1492, 1450, 1370, 1265, 1027, 906, 838, 756, 697, 536.



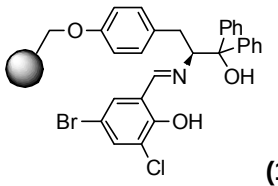
(16c)

Compound 16c: Elemental Anal. Found: C, 79.78; H, 6.46; N, 3.09. IR (KBr, cm^{-1}): 3420, 3059, 3025, 2921, 1944, 1803, 1666, 1601, 1492, 1451, 1383, 1028, 906, 826, 756, 698, 539.



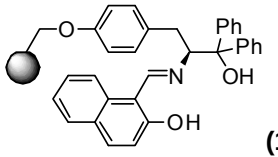
(16d)

Compound 16d: Elemental Anal. Found: C, 54.89; H, 4.14; N, 2.12. IR (KBr, cm^{-1}): 3421, 3058, 3024, 2920, 1943, 1802, 1600, 1492, 1450, 1365, 1265, 1027, 906, 821, 756, 697, 538.



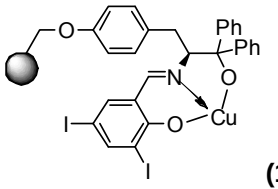
(16e)

Compound 16e: Elemental Anal. Found: C, 63.77; H, 4.81; N, 2.47. IR (KBr, cm^{-1}): 3059, 3025, 2922, 1943, 1802, 1722, 1601, 1492, 1450, 1369, 1265, 1027, 906, 822, 756, 697, 538.



(16f)

Compound 16f: Elemental Anal. Found: C, 81.40; H, 6.22; N, 2.78. IR (KBr, cm^{-1}): 3394, 3058, 3024, 2921, 1943, 1723, 1601, 1492, 1450, 1242, 1076, 1028, 906, 820, 756, 698, 538.



(17)

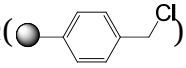
Compound 17: Elemental Anal. Found: C, 52.55; H, 4.27; N, 1.92. IR (KBr, cm^{-1}):3377, 3024, 2922, 1604, 1492, 1442, 1384, 1032, 905, 757, 696, 627, 539.

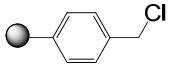
To a mixture of polymers complex 17 (0.052 g) in Milli-Q water (2 mL) was added HNO_3 (20 ml, 69.2%). The mixture was heated at 150□ and the digested solution was diluted to 25 ml with Milli-Q water. Heavy metal Cu concentrations in the prepared solutions were determined using atomic absorption spectrometry. Metal Cu concentrations were 2.651 mg/L and 2.663 mg/L (panel data which were diluted to 30 times). We assumed that the metal coordination of polymers complex 17 work on the same mechanism like complex 15. The amount of chlorobenzyl groups which have been substituted was 79.38%.

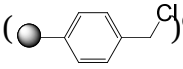
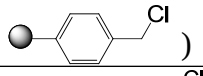
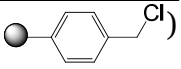
$$n(Cu)=\frac{m(Cu)}{M(Cu)}=\frac{\frac{1}{2}\times(2.651+2.663)\times 30}{64}=1.245\ mmol/L$$

$$\because n(Cu):n(ligand\ 1)=1:1.065$$

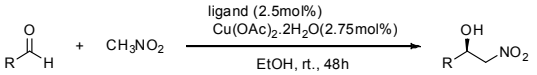
$$\therefore n(ligand\ 1)=1.065\times n(Cu)=1.065\times 1.245=1.651\ mmol/L$$

$$n(\text{  })=n(ligand\ 1)=1.651\ mmol/L$$

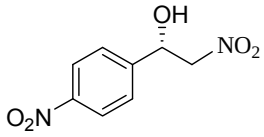
$$n(actual\ \text{  })=0.052\times\frac{1000}{25}=2.08\ mmol/L$$

$$(\text{  })\%=\frac{n(\text{  })}{n(actual\ \text{  })}\times 100\%=\frac{1.651}{2.08}\times 100\%=79.38\%$$

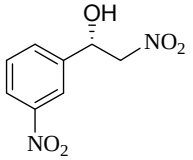
6. Typical procedure for the asymmetric Henry reaction[5]



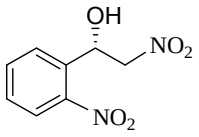
The chiral ligand (0.005 mmol) and metal-salt (0.0055 mmol) were placed in a 10 mL round-bottomed flask. Ethanol (2.0 mL) was added and the mixture was stirred for 3 h at room temperature. Subsequently, aldehyde (0.2 mmol) and nitromethane (0.3 mL, 7.5 mmol) were added. The reaction was stirred at room temperature for 24 h. Purification was obtained by TLC. The *ee* value was determined by HPLC on Chiralcel AD-H or OD-H column.



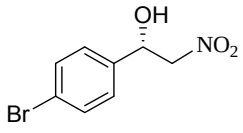
2-Nitro-1-(4-nitro-phenyl)-ethanol: Chiralcel AD-H column, Hex: *i*-Pro =85:15, 1.0 mL/min, 254nm. t_{minor} = 6.590 min, t_{major} = 8.707 min.



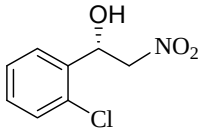
2-Nitro-1-(3-nitro-phenyl)-ethanol: Chiralcel AD-H column, Hex: *i*-Pro =85:15, 1.0 mL/min, 254nm. t_{major} = 11.732 min, t_{minor} = 13.840 min.



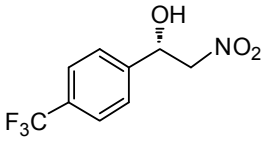
2-Nitro-1-(2-nitro-phenyl)-ethanol: Chiralcel AD-H column, Hex: *i*-Pro =85:15, 1.0 mL/min, 254nm. t_{minor} = 38.000 min, t_{major} = 43.832 min.



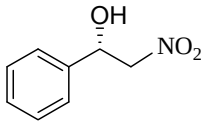
(*S*)-1-(4-bromophenyl)-2-nitroethanol: Chiralcel OD-H column, Hex: *i*-Pro =85:15, 1.0 mL/min, 215nm. t_{minor} = 12.6 min, t_{major} = 16.8 min.



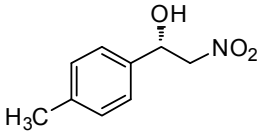
(*S*)-1-(2-Chlorophenyl)-2-nitroethanol: Chiralcel OD-H column, Hex: *i*-Pro =95:5, 0.5 mL/min, 215nm. t_{minor} = 34.9 min, t_{major} = 36.5 min.



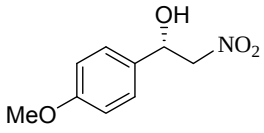
2-Nitro-1-(4-trifluoromethyl-phenyl)-ethanol: Chiralcel AD-H column, Hex: *i*-Pro =95:5, 1.0 mL/min, 254nm. t_{minor} = 19.515 min, t_{major} = 29.287 min.



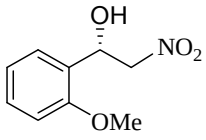
(*S*)-2-Nitro-1-phenylethanol: Chiralcel OD-H column, Hex: *i*-Pro =90:10, 1.0 mL/min, 210 nm. t_{minor} = 12.6 min, t_{major} = 14.2 min.



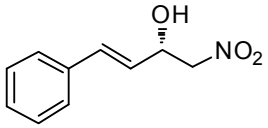
2-Nitro-1-p-tolyl-ethanol: iralcel OD-H column, Hex: *i*-Pro =90:10, 1.0mL/min, 215nm. t_{minor} =16.475, t_{major} = 22.813 min.



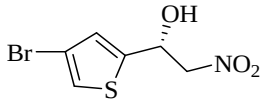
(*S*)-1-(4-Methoxyphenyl)-2-nitroethanol: Chiralcel OD-H column, Hex: *i*-Pro =90:10, 0.5 mL/min, 232nm. t_{major} = 34.7min, t_{minor} = 49.5 min.



(*S*)-1-(2-Methoxyphenyl)-2-nitroethanol: Chiralcel OD-H column, Hex: *i*-Pro =90:10, 1.0 mL/min, 215nm. t_R = 14.528 min, t_R = 18.086 min.



1-Nitro-4-phenyl-but-3-en-2-ol: Chiralcel OD-H column, Hex: *i*-Pro =90:10, 1.0 mL/min, 254 nm. t_{major} = 45.2 min, t_{minor} = 52.1 min.



1-(4-Bromo-thiophen-2-yl)-2-nitro-ethanol: Chiralcel AD-H column, Hex: *i*-Pro =95:5, 1.0 mL/min, 254nm. t_{major} = 27.387 min, t_{minor} = 32.633 min.

References

1. Y. -D. Wan, HuBei University. Master's Thesis (2006) 97.

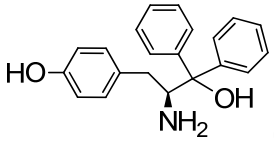
2. (a)S. -P. Xu, H. -L. Zhu, Z. -P. Xiao, W. -D. Wan, CN 101161620, 2008-4-16; (b) A. Vibhute, S. Mokle, K. Karamunge, V. Gurav, Y. Vibhute, Chin. Chem. Lett. 21 (2010) 914–918; (c) X. -J. Liu, Qu Fu Normal University. Master's Thesis 2002 20; (d) A. -X. Hu, Z. Qin, Chen, P. CN 101602761, 2009-12-16; (e) A. -Y. Vibhute, et al. J. Chem. Pharm. Res. 2 (2010) 620-625; (f) S. -S. Mokle, B. -S. Dawane, M. -A. Sayyed, Y. -B. Vibhute, J. Chem. Res. 2006 101.

3. G. -Y. Lai, S. -J. Wang, Z. -Y.Wang, Tetrahedron: Asymmetry. 19 (2008) 1813-1819.

4. C. Chen, L. Hong, B. -Z. Zhang, R. Wang, Tetrahedron: Asymmetry. 19 (2008) 191-196.

5. W. Mansawat, I. Saengswang, P. U-prasitwong, Tetrahedron Lett. 48 (2007) 4151-4308.

MS, ^{1}H NMR, ^{13}C NMR and IR spectra for all compounds



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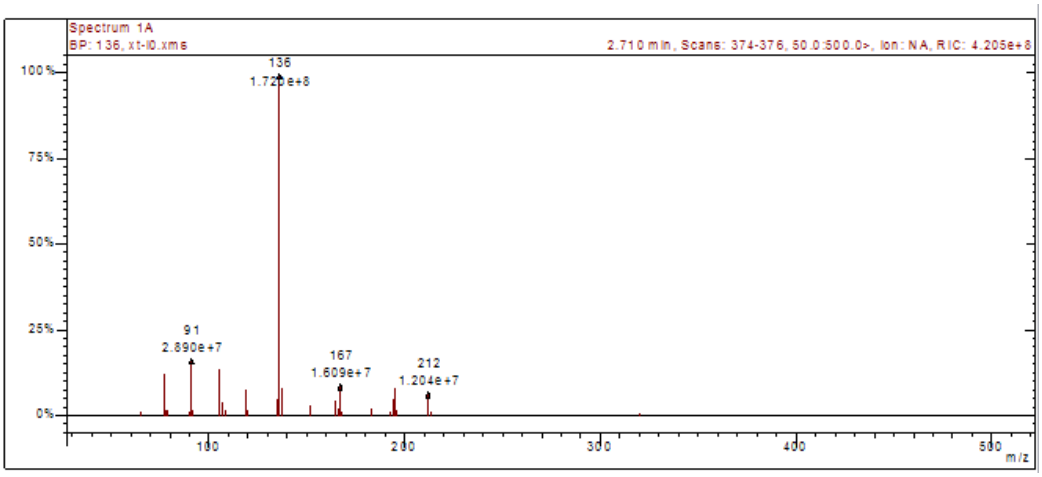

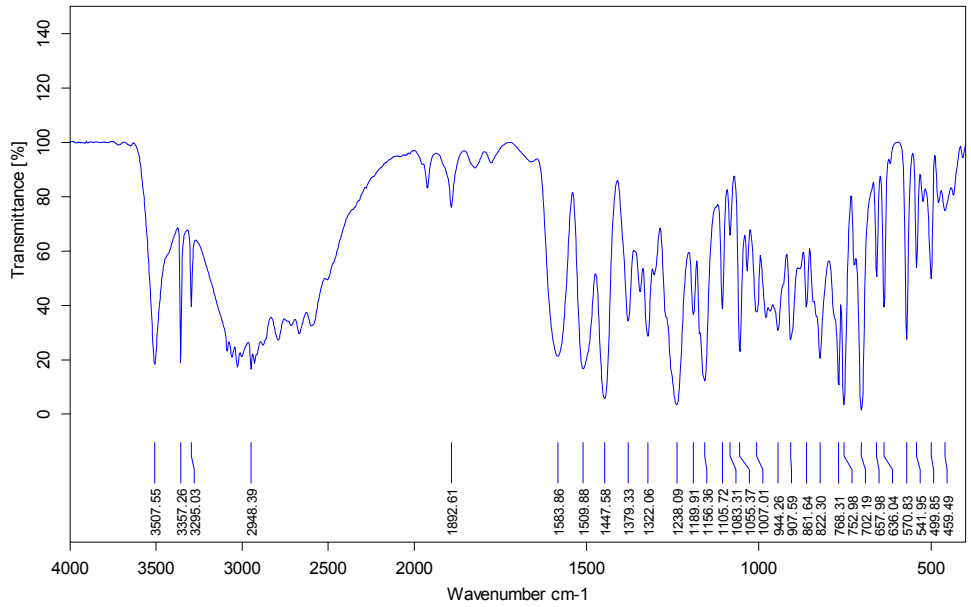

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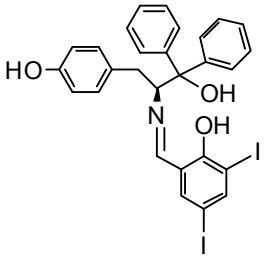
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OH
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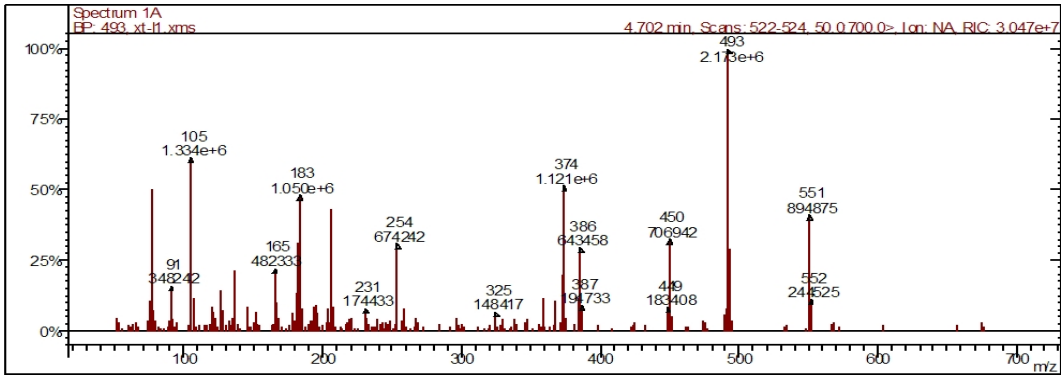
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374
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674242
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231
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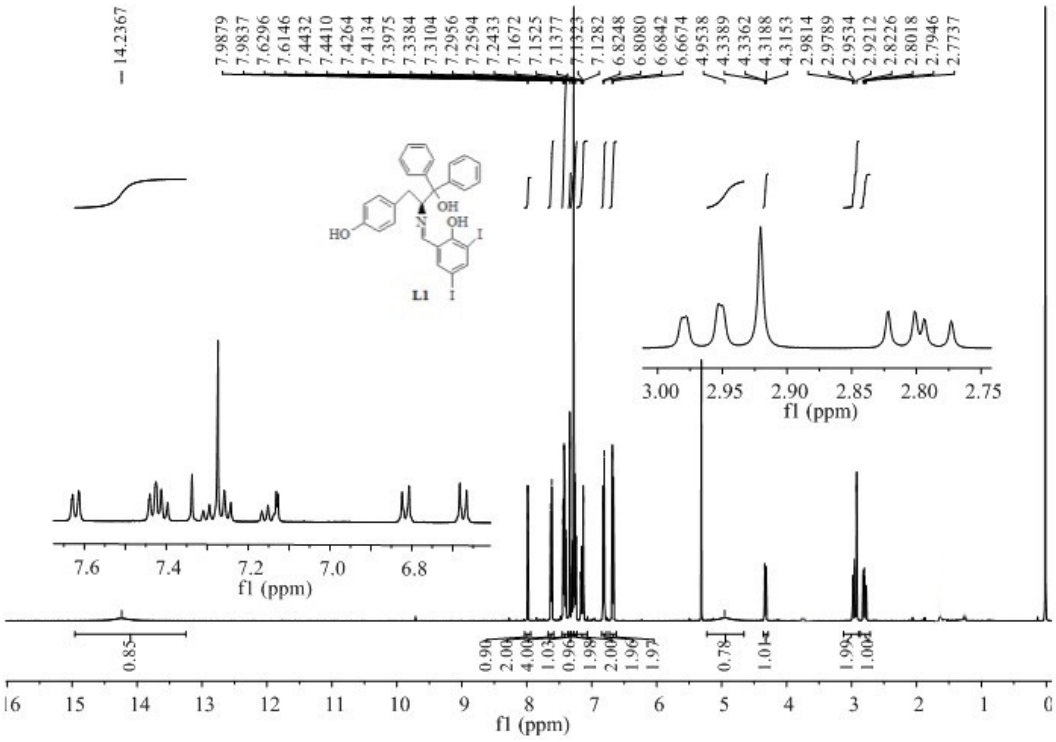
700
m/z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0.90
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1.97
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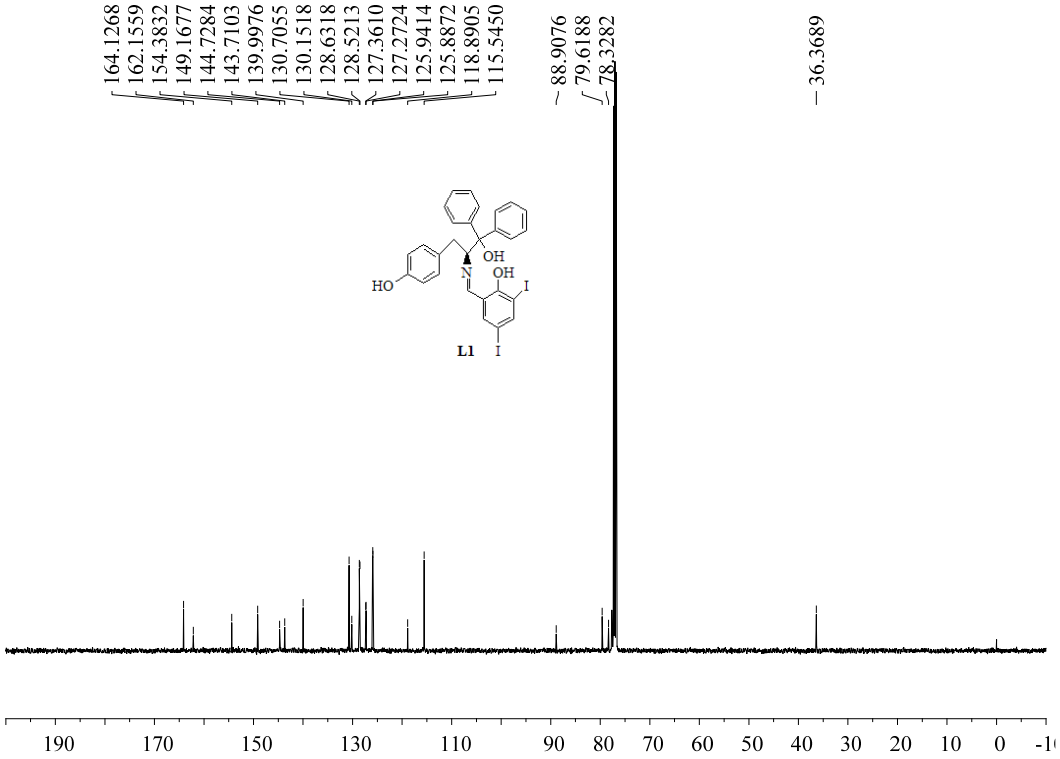
f1 (ppm)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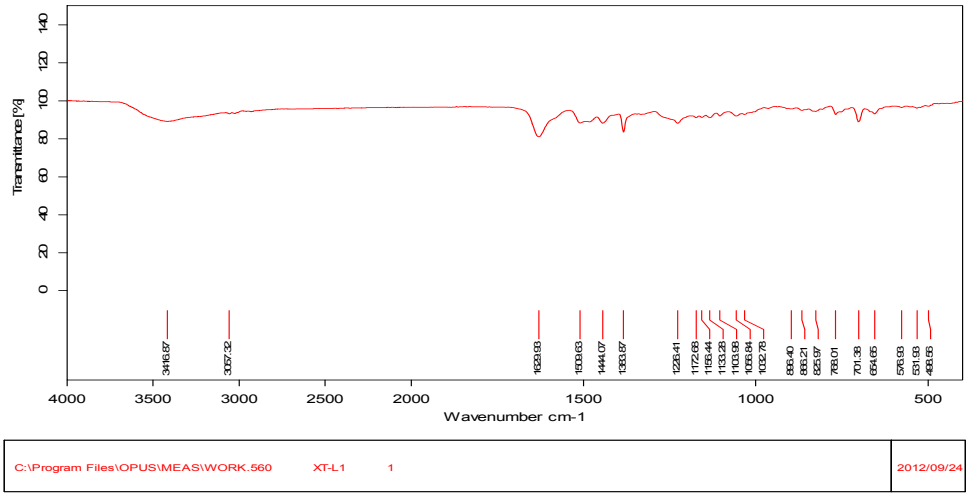
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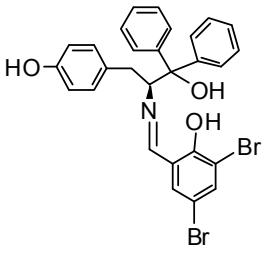
2012/09/24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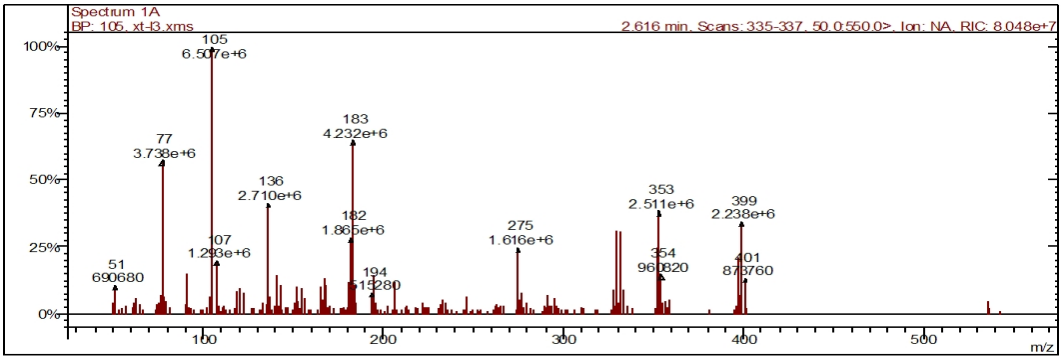
(2)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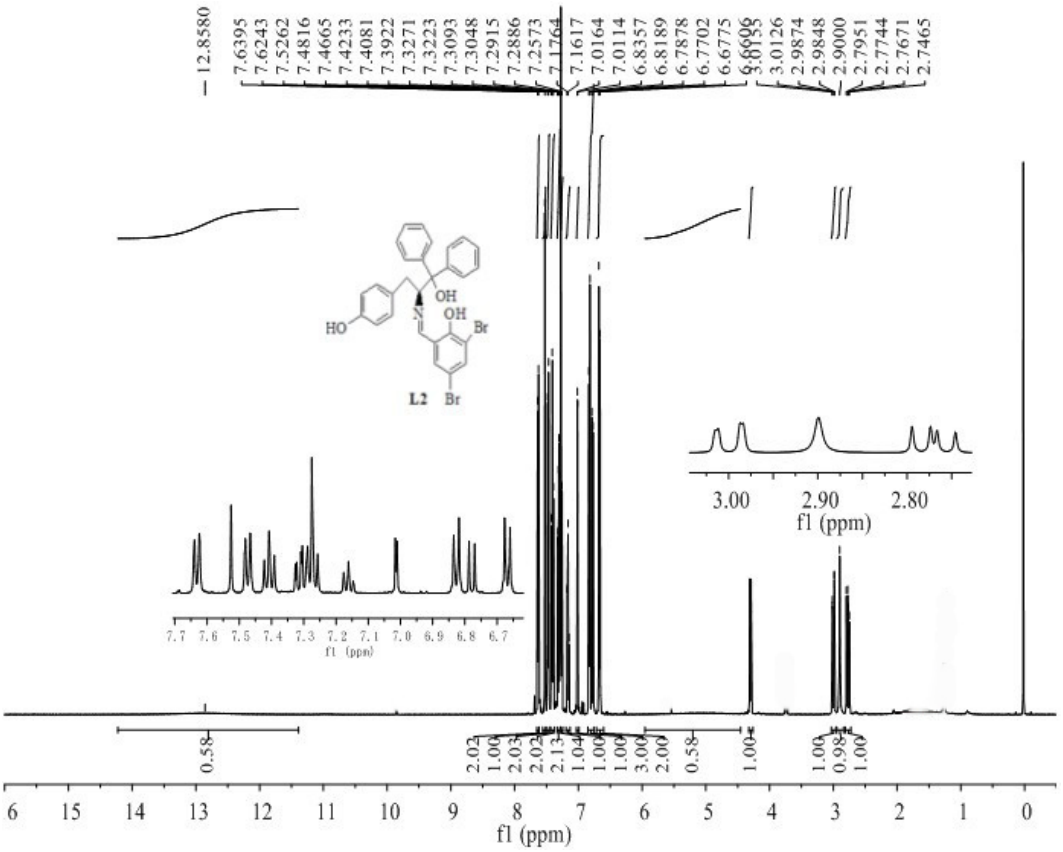
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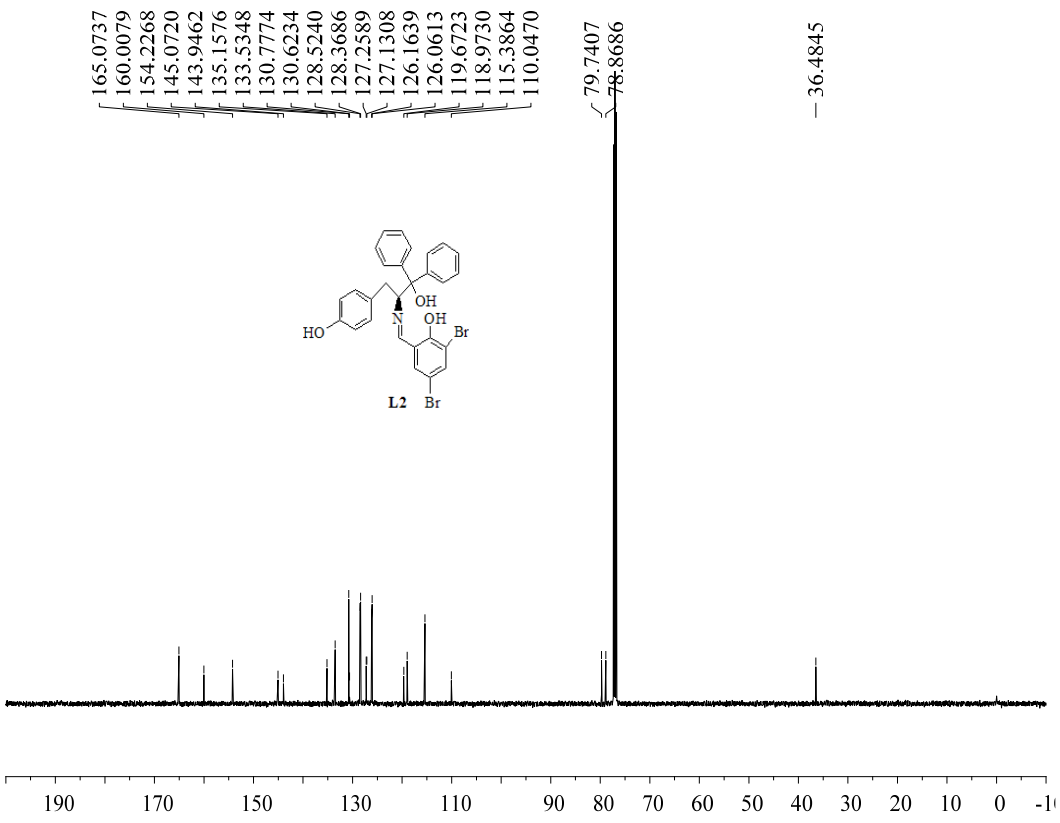
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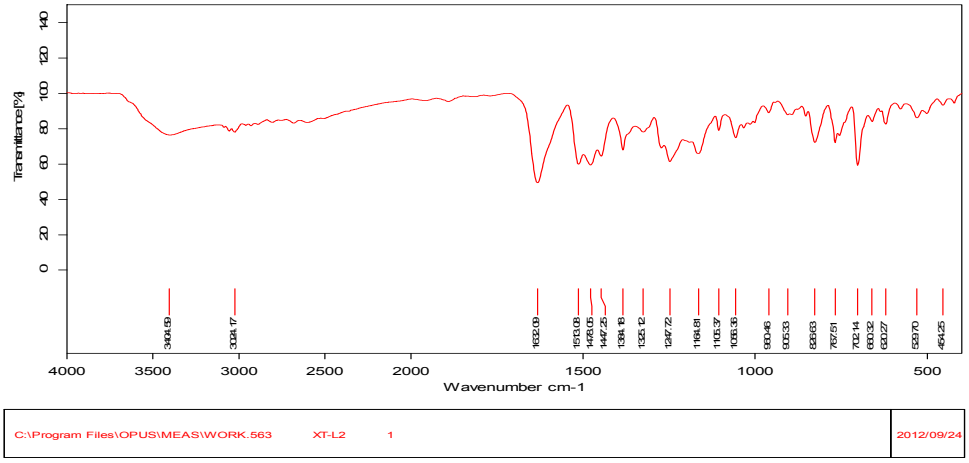
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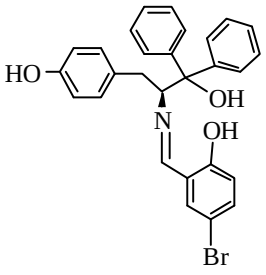
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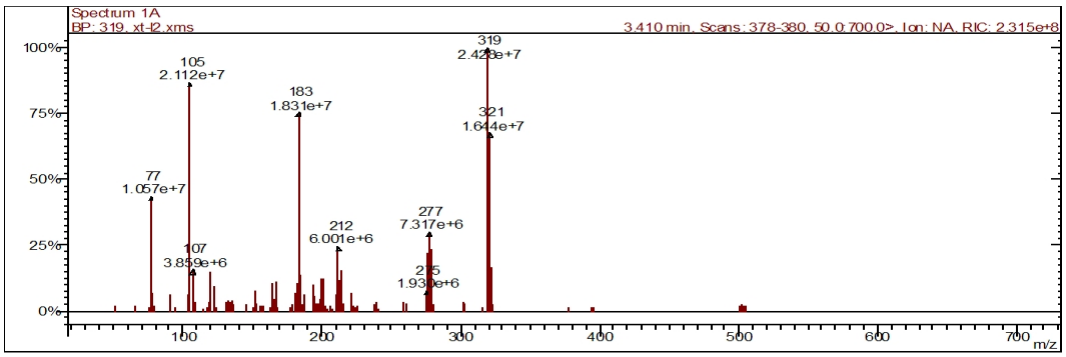
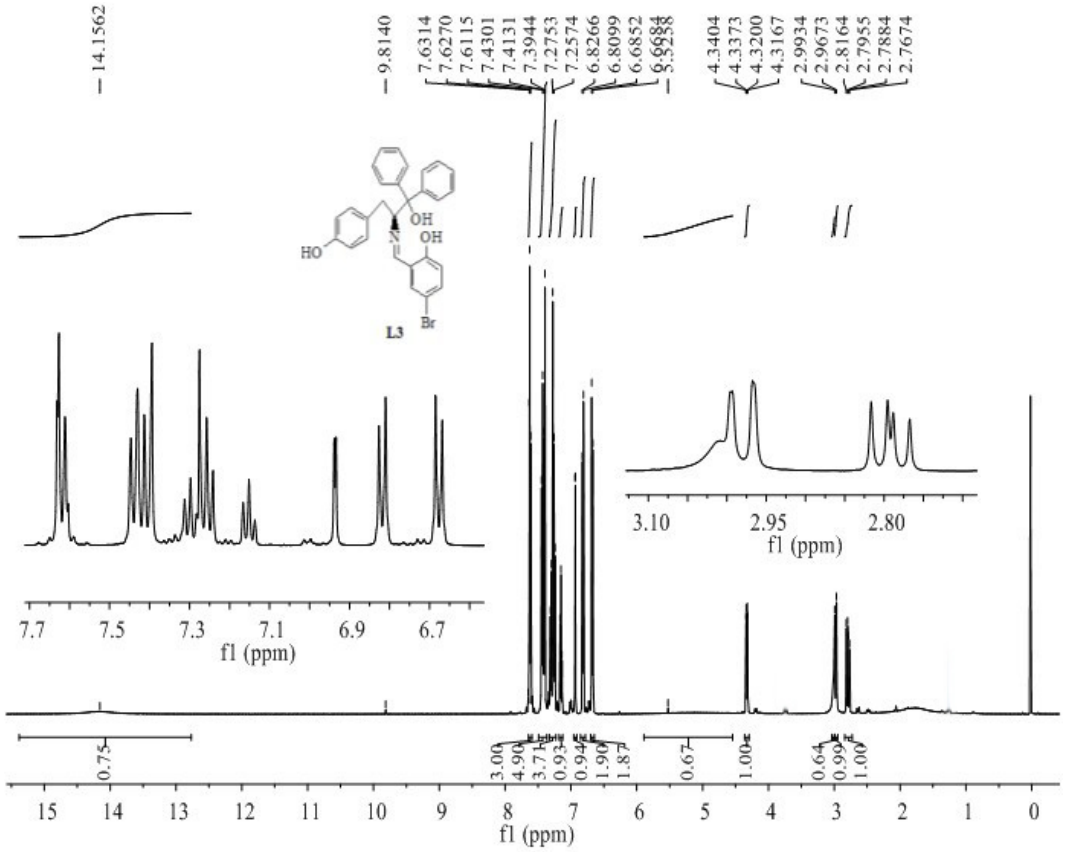
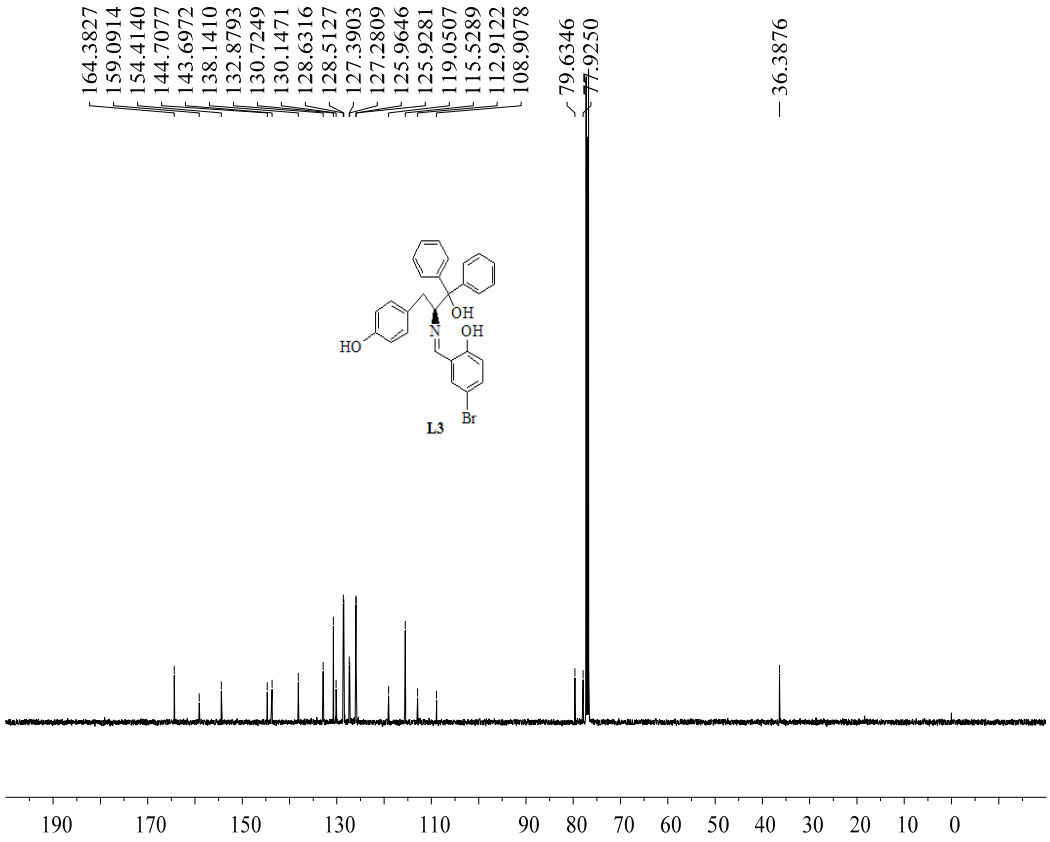
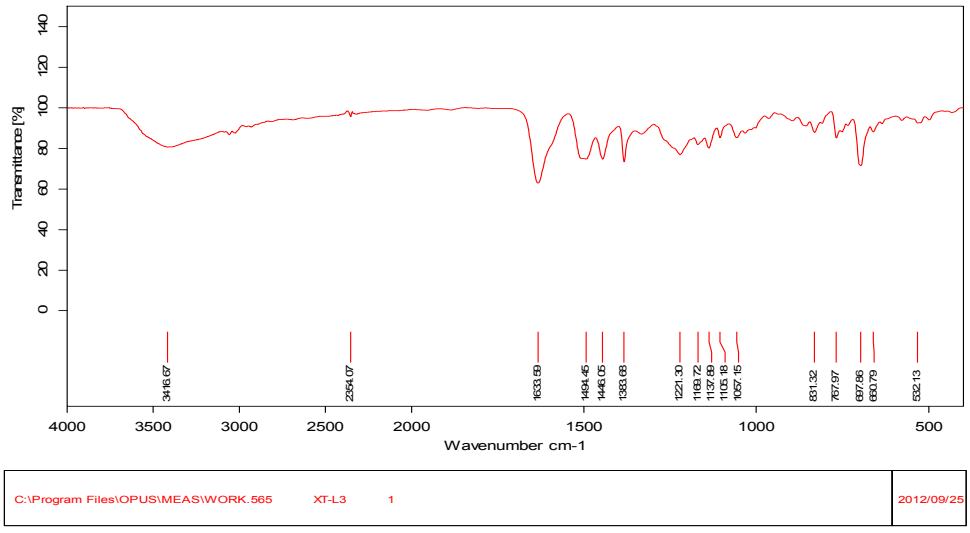
Br

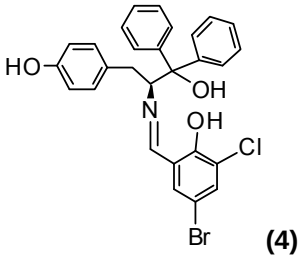
(3)


Spectrum 1A
BP: 319, xt-l2.xms
3.410 min, Scans: 378-380, 50.0:700.0>, Ion: NA, RIC: 2.315e+8
100%
75%
50%
25%
0%
319
2.423e+7
105
2.112e+7
183
1.831e+7
321
1.644e+7
77
1.057e+7
277
7.317e+6
212
6.001e+6
107
3.859e+6
255
1.930e+6
100
200
300
400
500
600
700
m/z

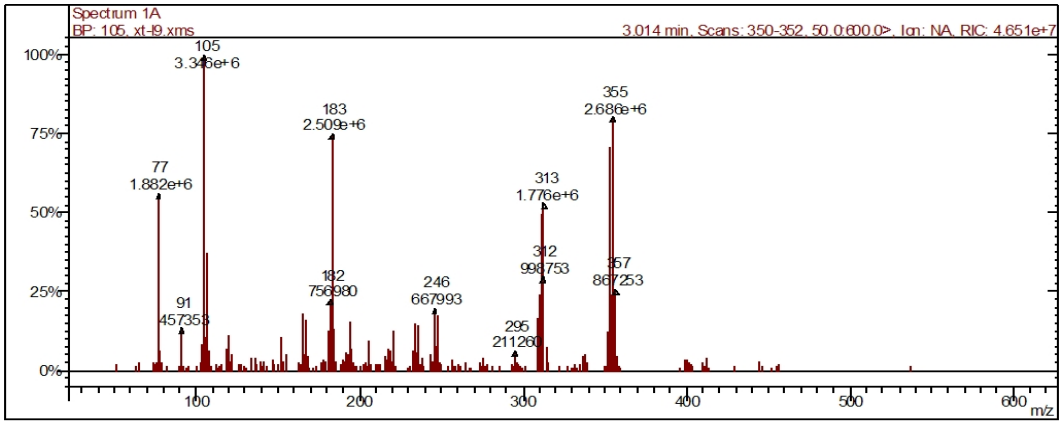

14.1562
9.8140
7.6314
7.6270
7.6115
7.4301
7.4131
7.3944
7.2753
7.2574
6.8266
6.8099
6.6852
4.3404
4.3373
4.3200
4.3167
2.9934
2.9673
2.8164
2.7955
2.7884
2.7674
OH
OH
HO
N
Br
L3
7.7
7.5
7.3
7.1
6.9
6.7
f1 (ppm)
3.10
2.95
2.80
f1 (ppm)
0.75
3.00
4.90
3.71
0.93
0.94
1.90
1.87
0.67
1.00
0.64
0.99
1.00
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

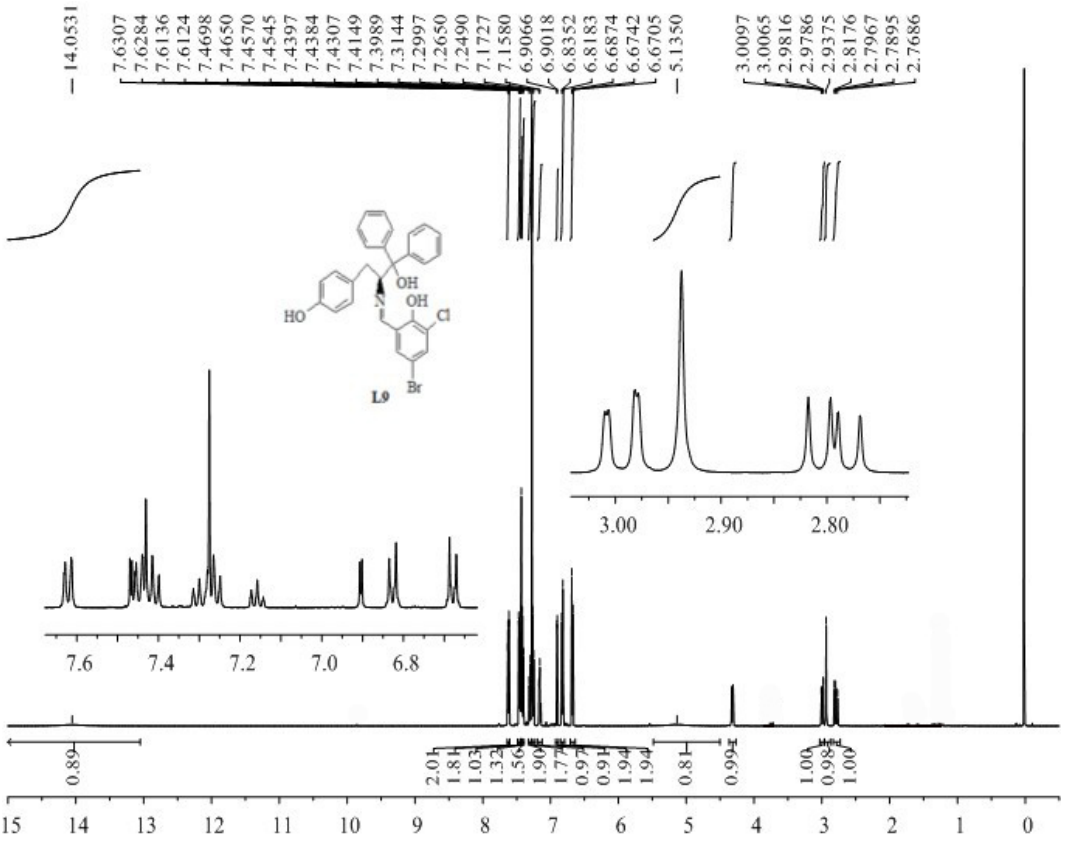

164.3827
159.0914
154.4140
144.7077
143.6972
138.1410
132.8793
130.7249
130.1471
128.6316
128.5127
127.3903
127.2809
125.9646
125.9281
119.0507
115.5289
112.9122
108.9078
79.6346
77.9250
36.3876
HO
OH
N
OH
Br
L3
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

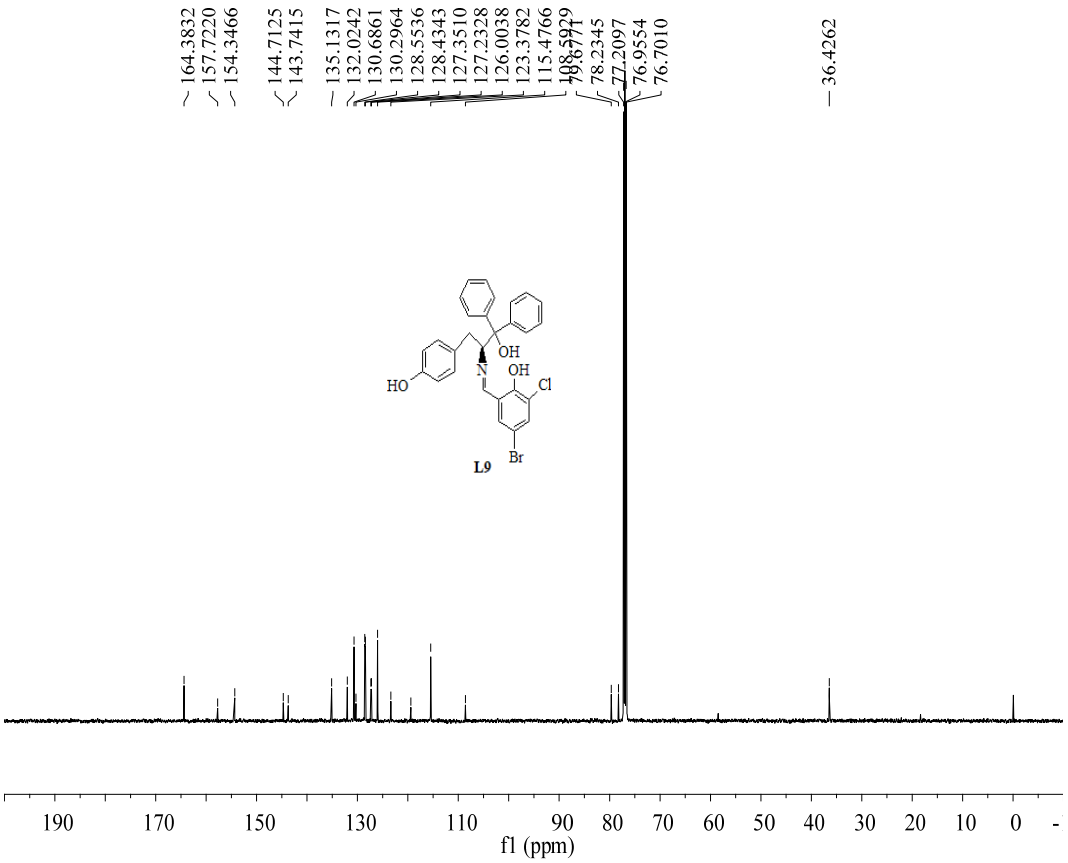

Transmittance [%]
0
20
40
60
80
100
120
140
3416.67
2354.07
1633.59
1494.45
1446.05
1383.68
1221.30
1169.72
1137.69
1105.18
1057.15
831.32
767.97
697.86
660.79
532.13
4000
3500
3000
2500
2000
1500
1000
500
Wavenumber cm-1
C:\Program Files\OPUS\MEAS\WORK.565
XT-L3
1
2012/09/25

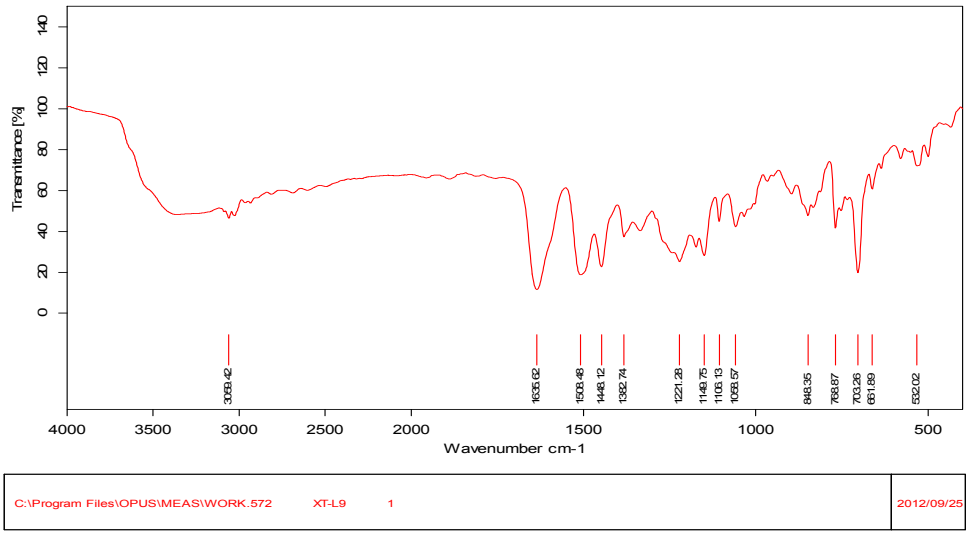

HO
OH
N
OH
Cl
Br

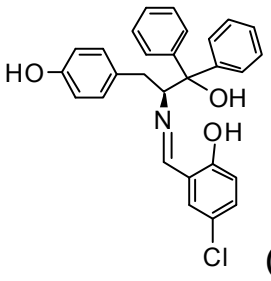
(4)


Spectrum 1A
BP: 105, xt-l9.xms
3.014 min, Scans: 350-352, 50.0:600.0>, Ign: NA, RIC: 4.651e+7
105
3.346e+6
183
2.509e+6
355
2.686e+6
77
1.882e+6
313
1.776e+6
312
998753
357
867253
182
756980
246
667993
91
457353
295
211260
100%
75%
50%
25%
0%
100
200
300
400
500
600
m/z

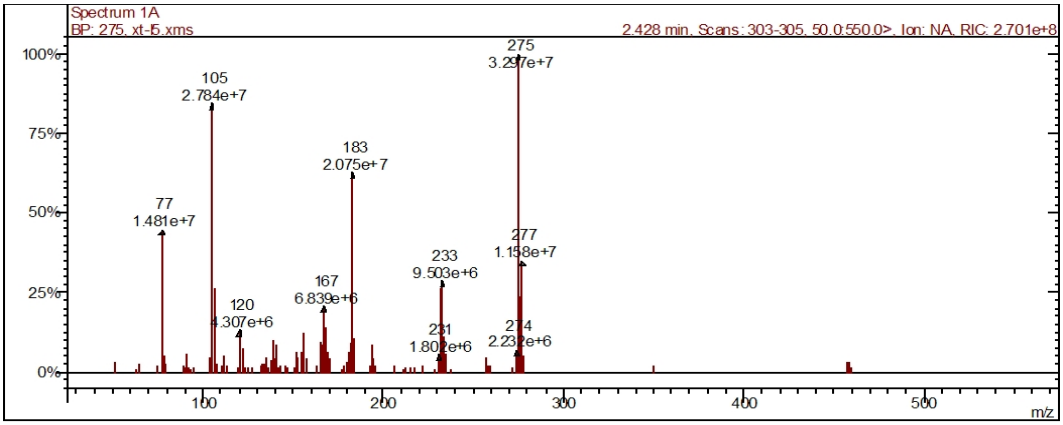

14.0531
7.6307
7.6284
7.6136
7.6124
7.4698
7.4650
7.4570
7.4545
7.4397
7.4384
7.4307
7.4149
7.3989
7.3144
7.2997
7.2650
7.2490
7.1727
7.1580
6.9066
6.9018
6.8352
6.8183
6.6874
6.6742
6.6705
5.1350
3.0097
3.0065
2.9816
2.9786
2.9375
2.8176
2.7967
2.7895
2.7686
OH
OH
HO
N
Cl
Br
L9
3.00
2.90
2.80
7.6
7.4
7.2
7.0
6.8
0.89
2.01
1.84
1.03
1.32
1.56
1.90
1.77
0.97
0.91
1.94
1.94
0.81
0.99
1.00
0.98
1.00
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

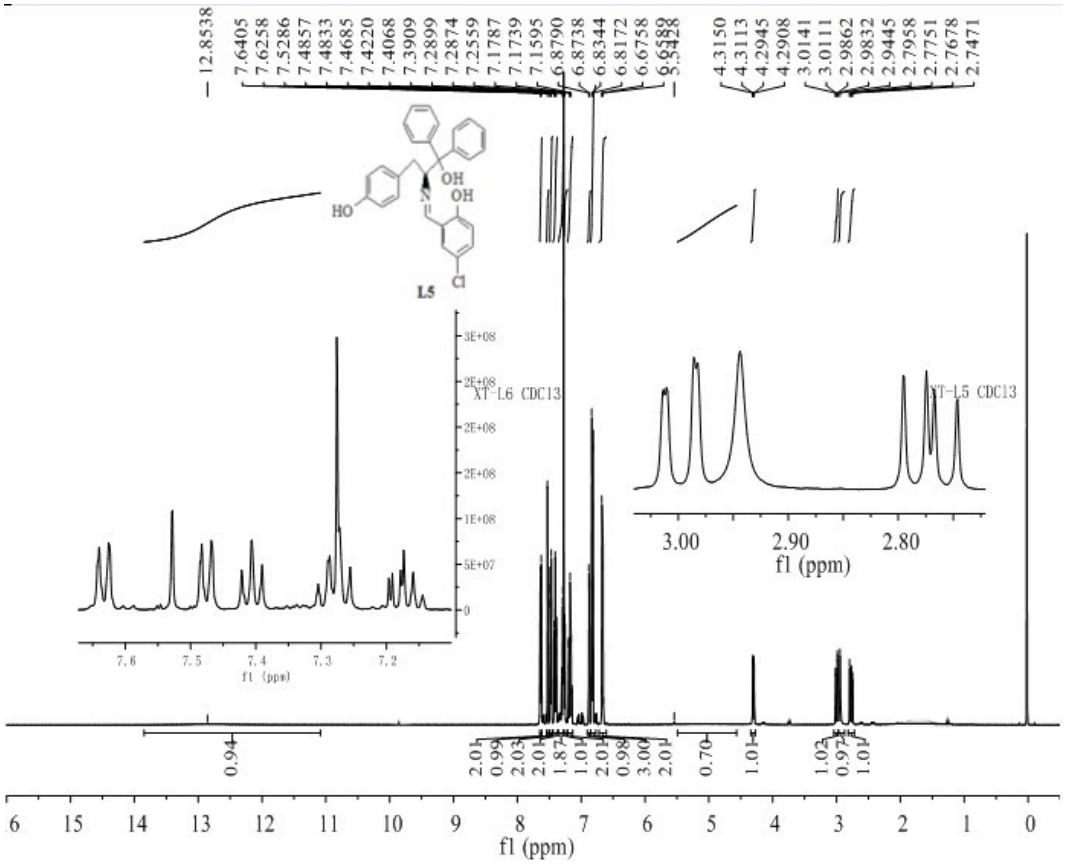

164.3832
157.7220
154.3466
144.7125
143.7415
135.1317
132.0242
130.6861
130.2964
128.5536
128.4343
127.3510
127.2328
126.0038
123.3782
115.4766
108.5929
79.8771
78.2345
77.2097
76.9554
76.7010
36.4262
HO
OH
N
OH
Cl
Br
L9
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

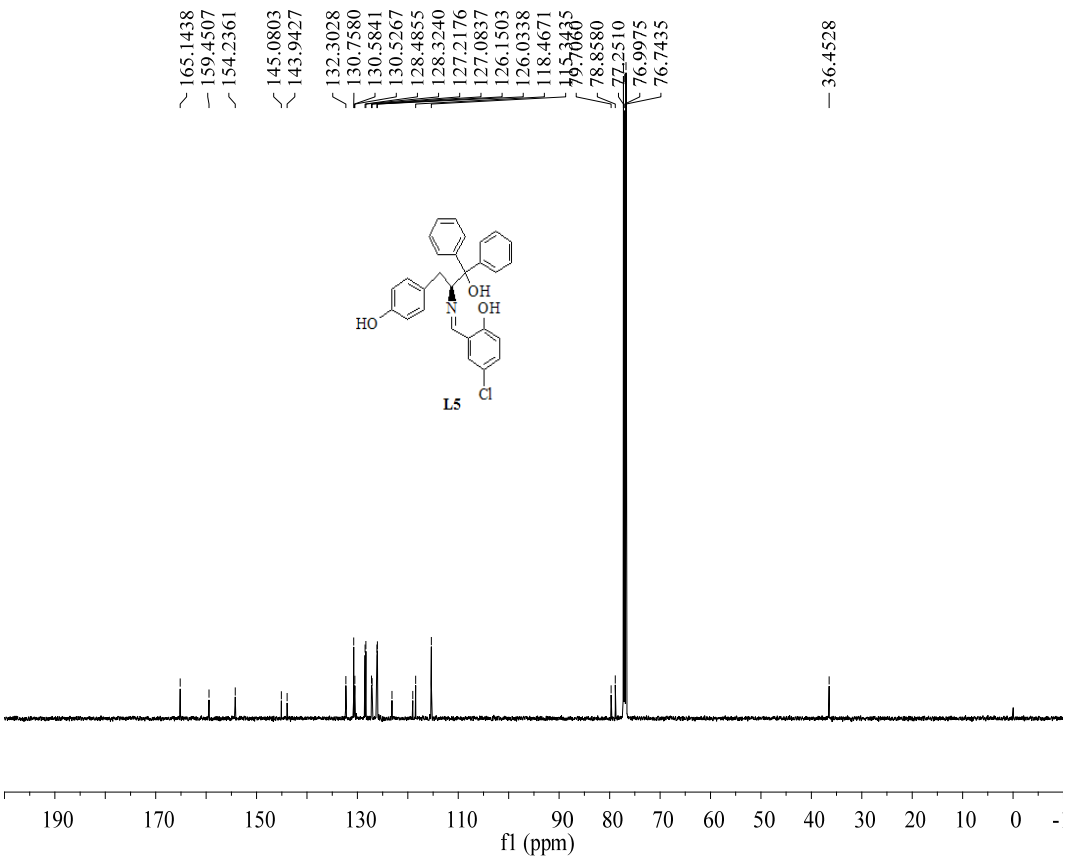

Transmittance [%]
0
20
40
60
80
100
120
140
3059.42
1635.62
1508.48
1448.12
1382.74
1221.28
1149.75
1105.13
1068.57
848.35
768.87
703.26
661.89
532.02
4000
3500
3000
2500
2000
1500
1000
500
Wavenumber cm-1
C:\Program Files\OPUS\MEAS\WORK.572
XT-L9
1
2012/09/25

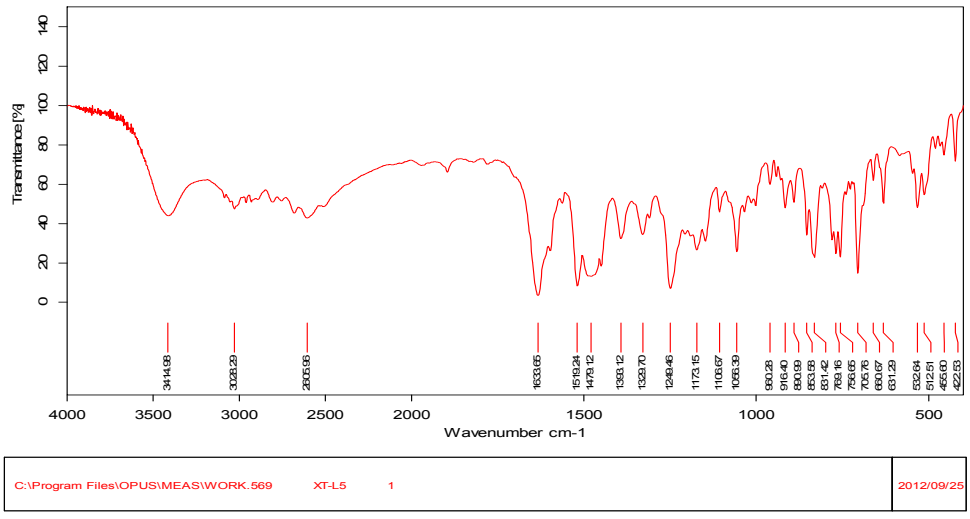

HO
OH
N
OH
Cl

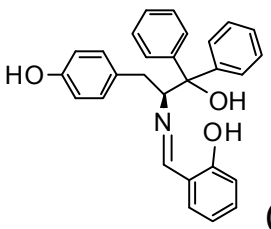
(5)


Spectrum 1A
BP: 275, xt-l5.xms
2.428 min, Scans: 303-305, 50.0:550.0>, Ion: NA, RIC: 2.701e+8
275
3.297e+7
105
2.784e+7
183
2.075e+7
77
1.481e+7
277
1.158e+7
233
9.503e+6
167
6.839e+6
120
4.307e+6
231
1.802e+6
274
2.232e+6
100%
75%
50%
25%
0%
100
200
300
400
500
m/z

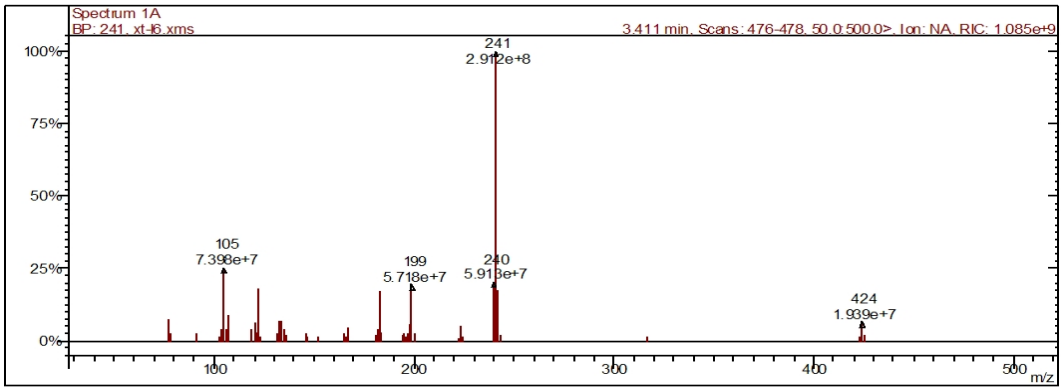

12.8538
7.6405
7.6258
7.5286
7.4857
7.4833
7.4685
7.4220
7.4068
7.3909
7.2899
7.2874
7.2559
7.1787
7.1739
7.1595
6.8790
6.8738
6.8344
6.8172
6.6758
5.3428
4.3150
4.3113
4.2945
4.2908
3.0141
3.0111
2.9862
2.9832
2.9445
2.7958
2.7751
2.7678
2.7471
HO
OH
N
OH
Cl
L5
XT-L6 CDCl3
XT-L5 CDCl3
3.00
2.90
2.80
f1 (ppm)
7.6
7.5
7.4
7.3
7.2
f1 (ppm)
0.94
2.01
0.99
2.03
2.01
1.87
1.01
2.01
0.98
3.00
2.01
0.70
1.01
1.02
0.97
1.01
6
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

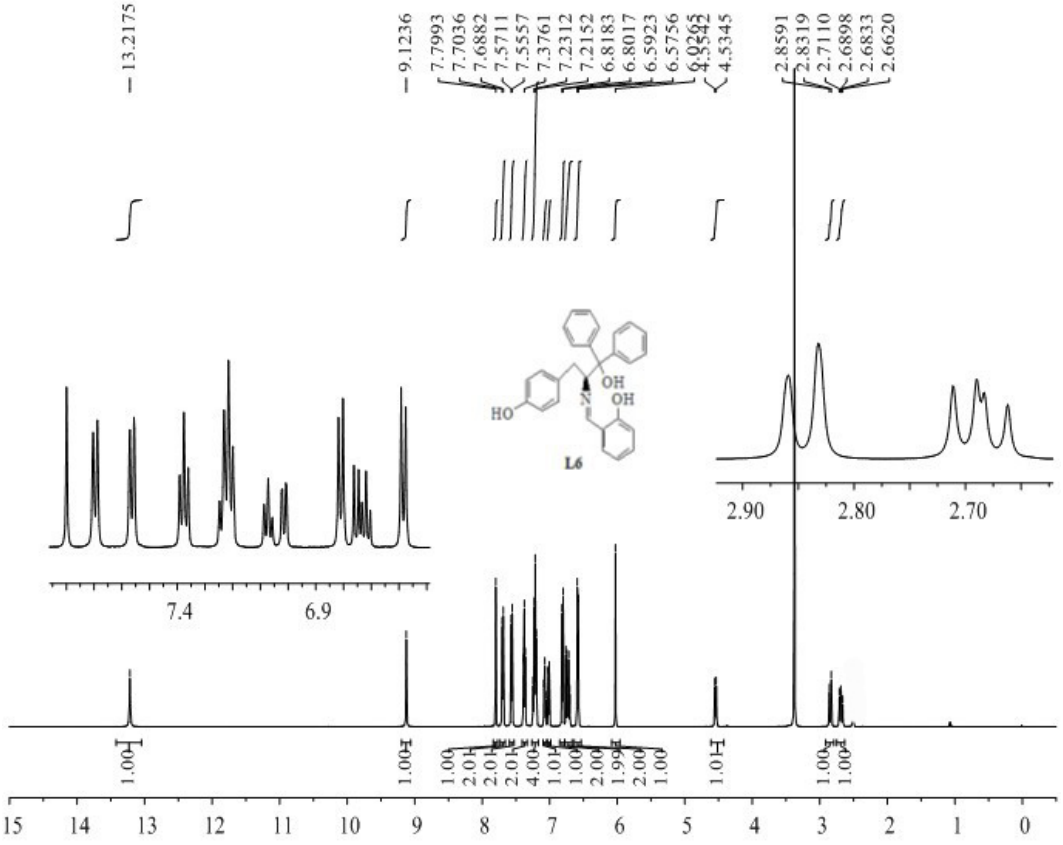

165.1438
159.4507
154.2361
145.0803
143.9427
132.3028
130.7580
130.5841
130.5267
128.4855
128.3240
127.2176
127.0837
126.1503
126.0338
118.4671
115.3435
79.7060
78.8580
77.2510
76.9975
76.7435
36.4528
OH
HO
N
OH
Cl
L5
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

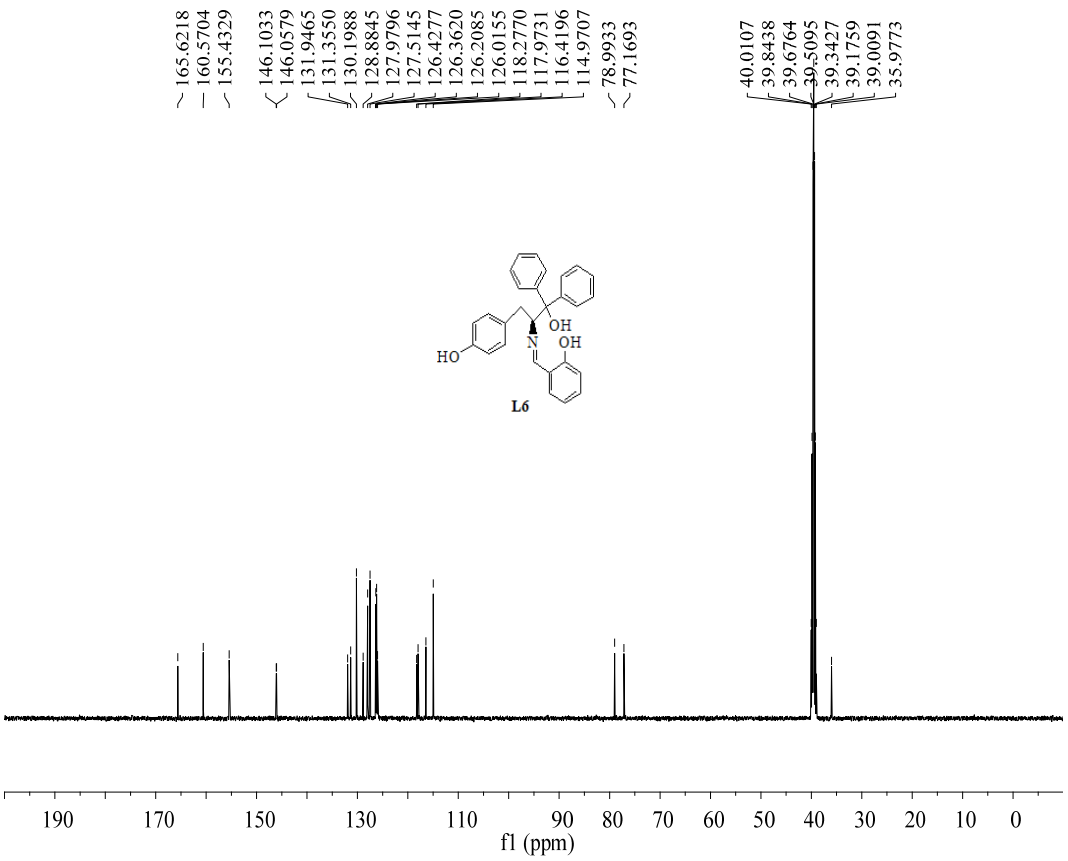

Transmittance [%]
0
20
40
60
80
100
120
140
3414.98
3028.29
2600.66
1633.65
1519.24
1479.12
1393.12
1329.70
1249.46
1173.15
1106.67
1066.39
990.28
916.40
890.99
853.88
831.42
769.16
738.65
705.76
668.67
631.29
532.64
512.51
455.60
422.53
4000
3500
3000
2500
2000
1500
1000
500
Wavenumber cm-1
C:\Program Files\OPUS\MEAS\WORK.569
XT-L5
1
2012/09/25

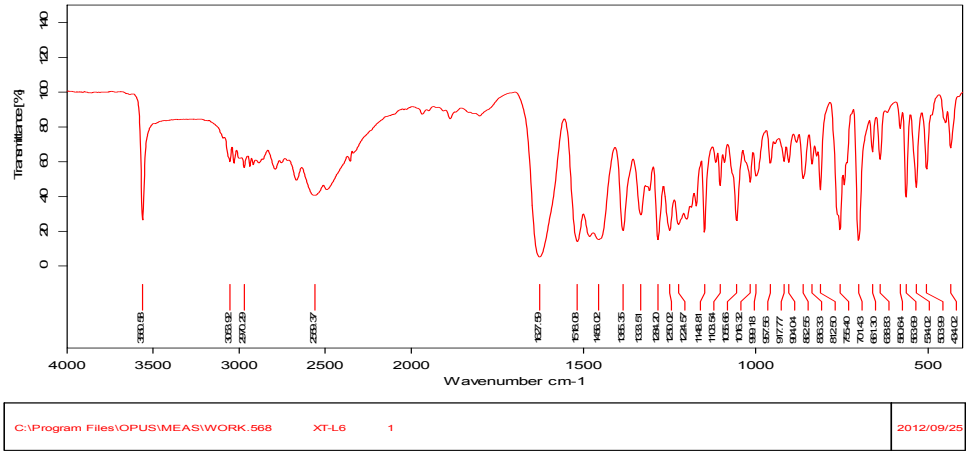

HO
OH
N
OH

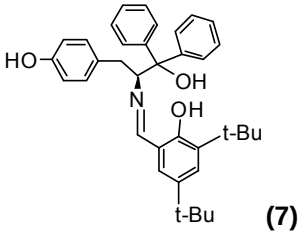
(6)


Spectrum 1A
BP: 241, xt-l6.xms
3.411 min, Scans: 476-478, 50.0:500.0>, Ion: NA, RIC: 1.085e+9
241
2.912e+8
105
7.398e+7
199
5.718e+7
240
5.913e+7
424
1.939e+7
100%
75%
50%
25%
0%
100
200
300
400
500
m/z

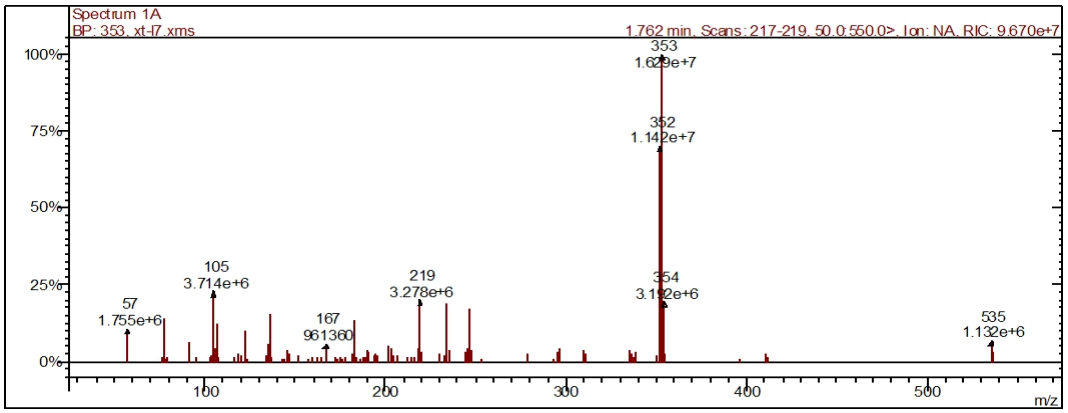

13.2175
9.1236
7.7993
7.7036
7.6882
7.5711
7.5557
7.3761
7.2312
7.2152
6.8183
6.8017
6.5923
6.5756
6.0265
4.5542
4.5345
2.8591
2.8319
2.7110
2.6898
2.6833
2.6620
HO
OH
OH
L6
7.4
6.9
2.90
2.80
2.70
1.00
1.00
1.00
2.01
2.01
2.01
4.00
1.01
1.00
2.00
1.99
2.00
1.00
1.01
1.00
1.00
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

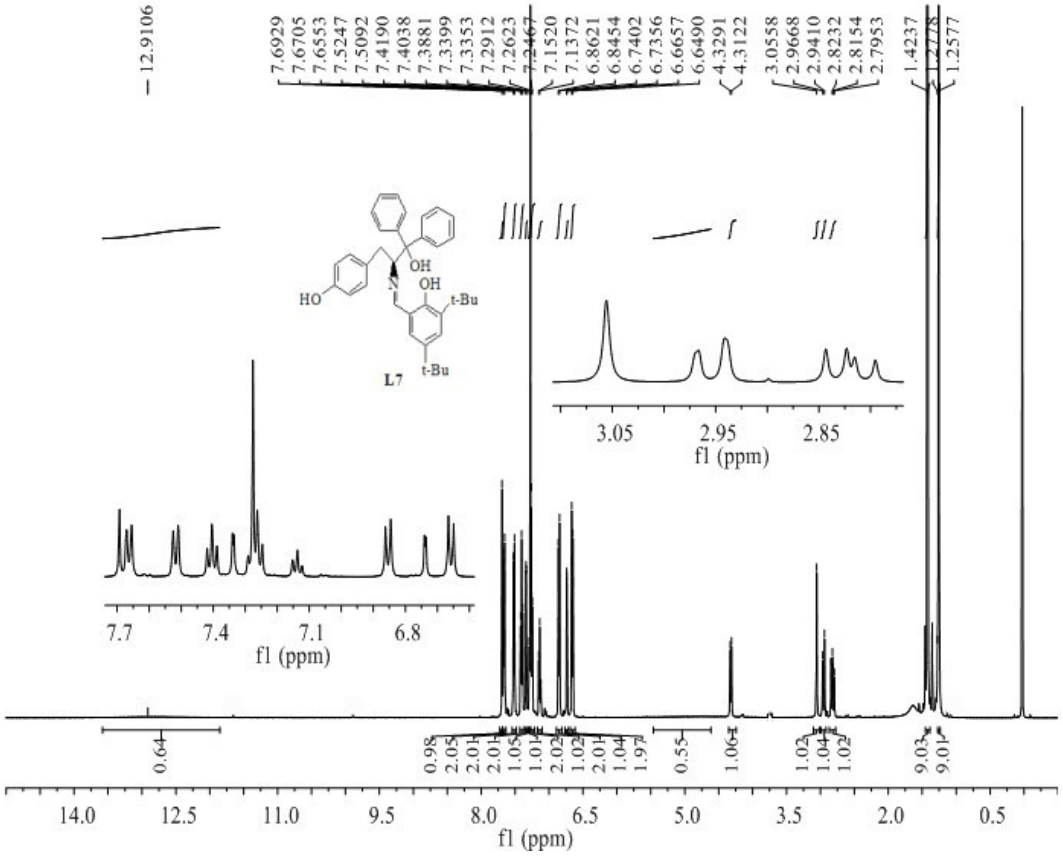

165.6218
160.5704
155.4329
146.1033
146.0579
131.9465
131.3550
130.1988
128.8845
127.9796
127.5145
126.4277
126.3620
126.2085
126.0155
118.2770
117.9731
116.4196
114.9707
78.9933
77.1693
40.0107
39.8438
39.6764
39.5095
39.3427
39.1759
39.0091
35.9773
HO
OH
N
OH
L6
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

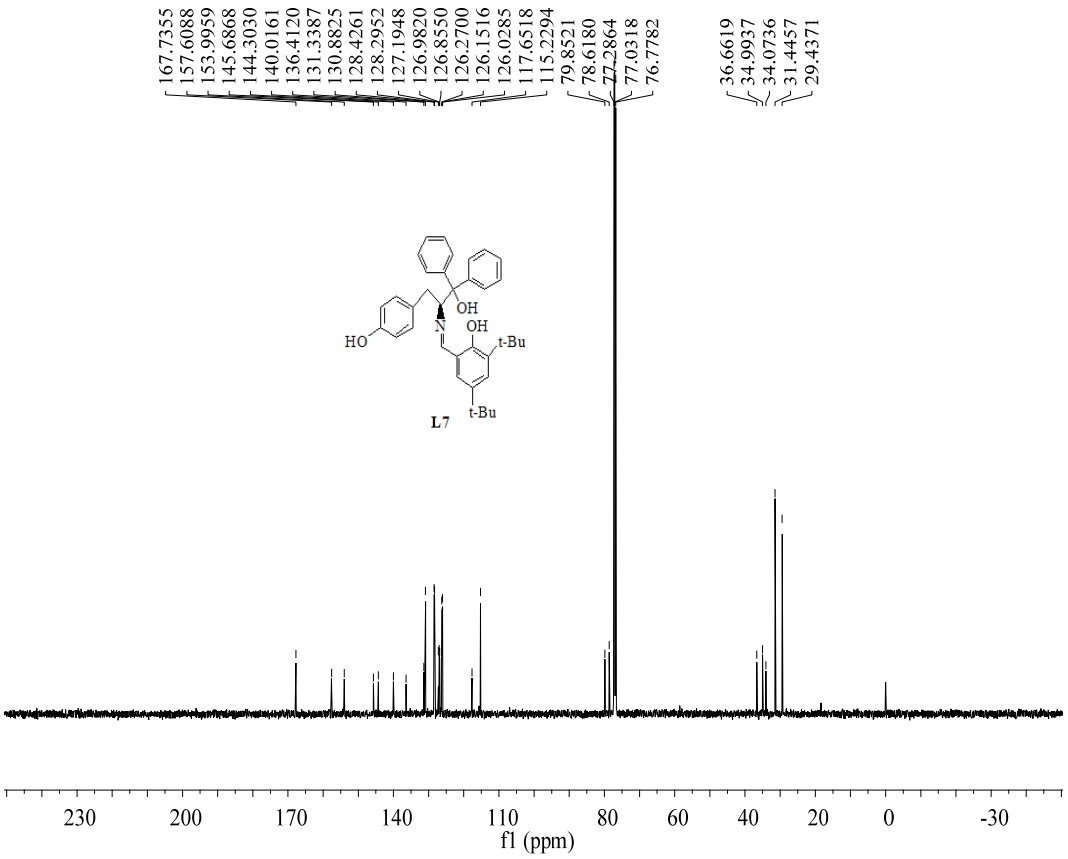

Transmittance[%]
0
20
40
60
80
100
120
140
4000
3500
3000
2500
2000
1500
1000
500
Wavenumber cm-1
C:\Program Files\OPUS\MEAS\WORK.568
XT-L6
1
2012/09/25

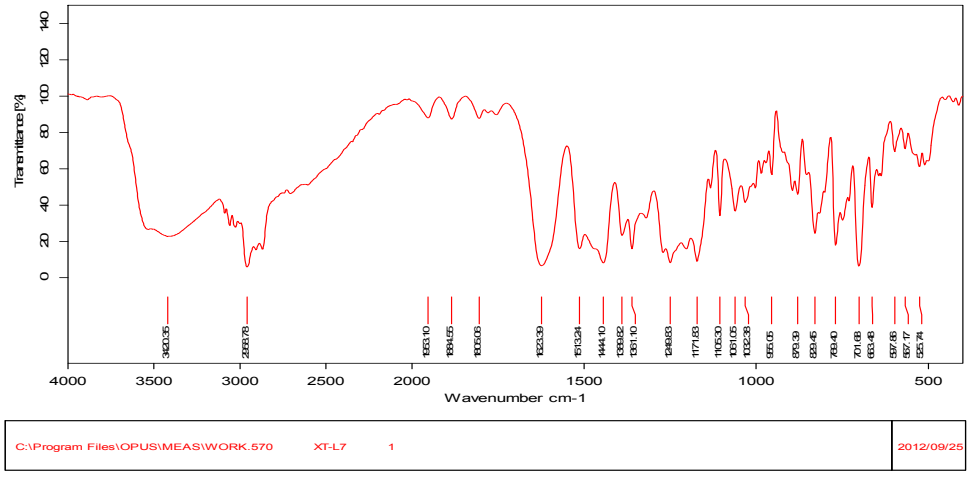

HO
OH
N
OH
t-Bu
t-Bu

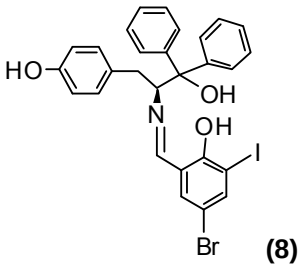
(7)


Spectrum 1A
BP: 353, xt-l7.xms
1.762 min, Scans: 217-219, 50.0:550.0>, Ion: NA, RIC: 9.670e+7
100%
75%
50%
25%
0%
353
1.629e+7
352
1.142e+7
354
3.192e+6
105
3.714e+6
219
3.278e+6
57
1.755e+6
167
961360
535
1.132e+6
100
200
300
400
500
m/z

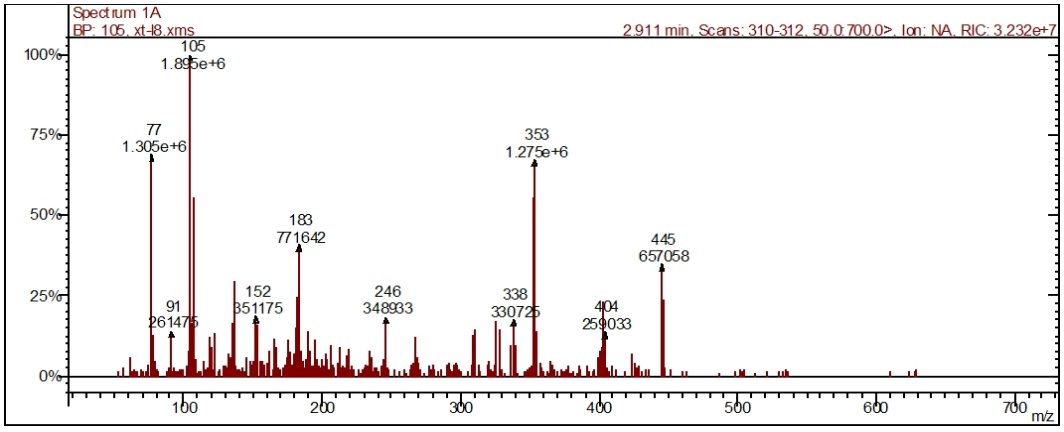

12.9106
7.6929
7.6705
7.6553
7.5247
7.5092
7.4190
7.4038
7.3881
7.3399
7.3353
7.2912
7.2623
7.2467
7.1520
7.1372
6.8621
6.8454
6.7402
6.7356
6.6657
6.6490
4.3291
4.3122
3.0558
2.9668
2.9410
2.8232
2.8154
2.7953
1.4237
1.2778
1.2577
HO
OH
N
OH
t-Bu
t-Bu
L7
3.05
2.95
2.85
f1 (ppm)
7.7
7.4
7.1
6.8
f1 (ppm)
0.64
0.98
2.05
2.01
2.01
1.05
1.01
2.02
1.02
2.01
1.04
1.97
0.55
1.06
1.02
1.04
1.02
9.03
9.01
14.0
12.5
11.0
9.5
8.0
6.5
5.0
3.5
2.0
0.5
f1 (ppm)

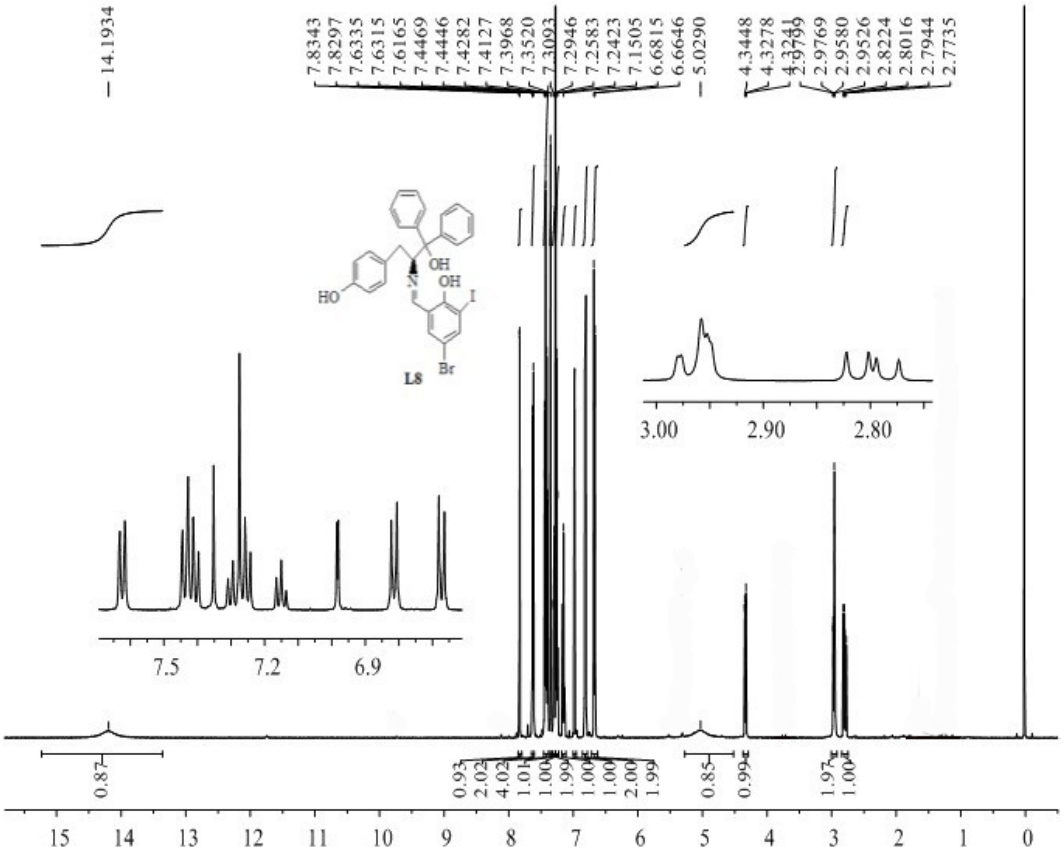

167.7355
157.6088
153.9959
145.6868
144.3030
140.0161
136.4120
131.3387
130.8825
128.4261
128.2952
127.1948
126.9820
126.8550
126.2700
126.1516
126.0285
117.6518
115.2294
79.8521
78.6180
77.2864
77.0318
76.7782
36.6619
34.9937
34.0736
31.4457
29.4371
HO
OH
N
OH
t-Bu
t-Bu
L7
230
200
170
140
110
80
60
40
20
0
-30
f1 (ppm)

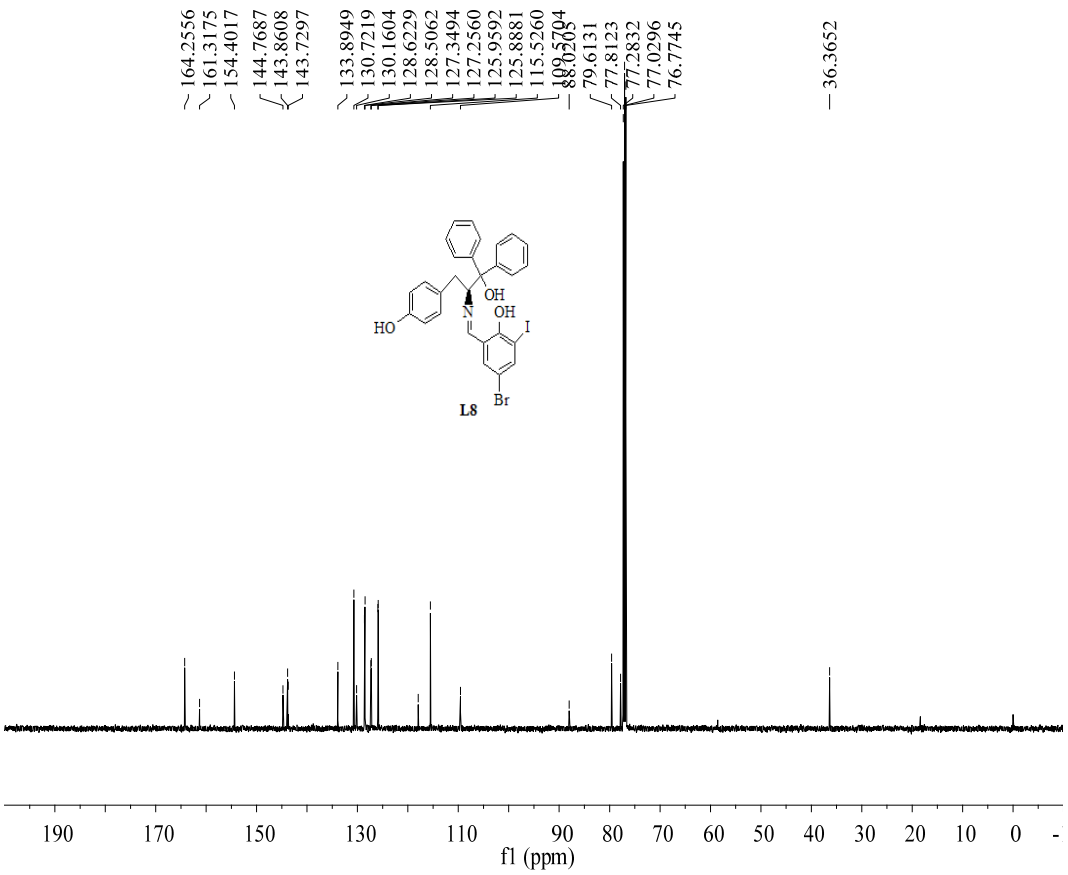

Transmittance [%]
0
20
40
60
80
100
120
140
3403.35
2869.78
1653.10
1594.55
1500.06
1423.39
1513.24
1444.10
1388.82
1361.10
1249.83
1171.63
1105.30
1081.05
1032.38
955.05
873.39
833.46
769.40
701.68
663.48
597.66
557.17
525.74
4000
3500
3000
2500
2000
1500
1000
500
Wavenumber cm-1
C:\Program Files\OPUS\MEAS\WORK.570
XT-L7
1
2012/09/25

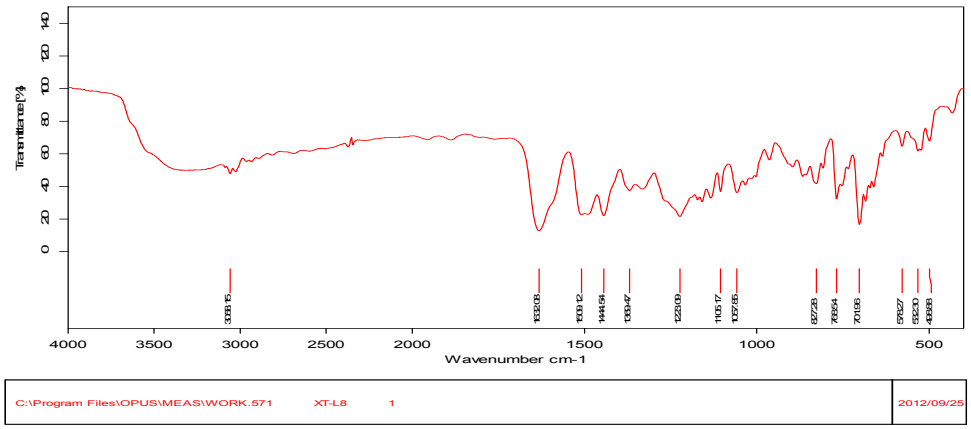

HO
OH
N
OH
I
Br

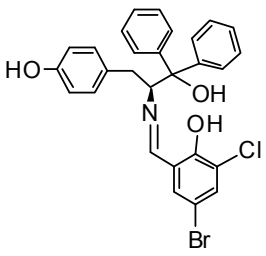
(8)


Spectrum 1A
BP: 105, xt-l8.xms
2.911 min, Scans: 310-312, 50.0:700.0>, Ion: NA, RIC: 3.232e+7
105
1.895e+6
77
1.305e+6
353
1.275e+6
183
771642
445
657058
152
351175
246
348933
338
330725
91
261475
404
259033
100%
75%
50%
25%
0%
100
200
300
400
500
600
700
m/z

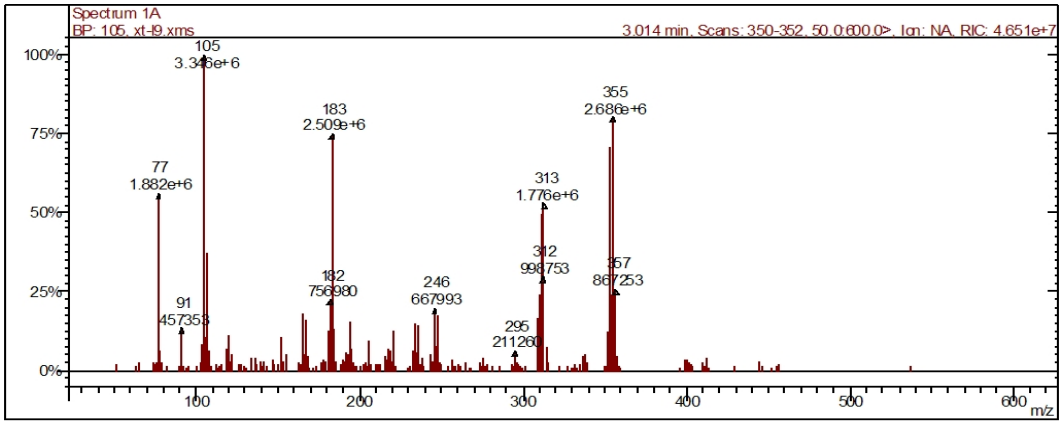

14.1934
7.8343
7.8297
7.6335
7.6315
7.6165
7.4469
7.4446
7.4282
7.4127
7.3968
7.3520
7.3093
7.2946
7.2583
7.2423
7.1505
6.6815
6.6646
5.0290
4.3448
4.3278
2.9769
2.9580
2.9526
2.8224
2.8016
2.7944
2.7735
OH
OH
HO
N
I
Br
L8
3.00
2.90
2.80
7.5
7.2
6.9
0.87
0.93
2.02
4.02
1.01
1.00
1.99
1.00
1.00
2.00
1.99
0.85
0.99
1.97
1.00
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

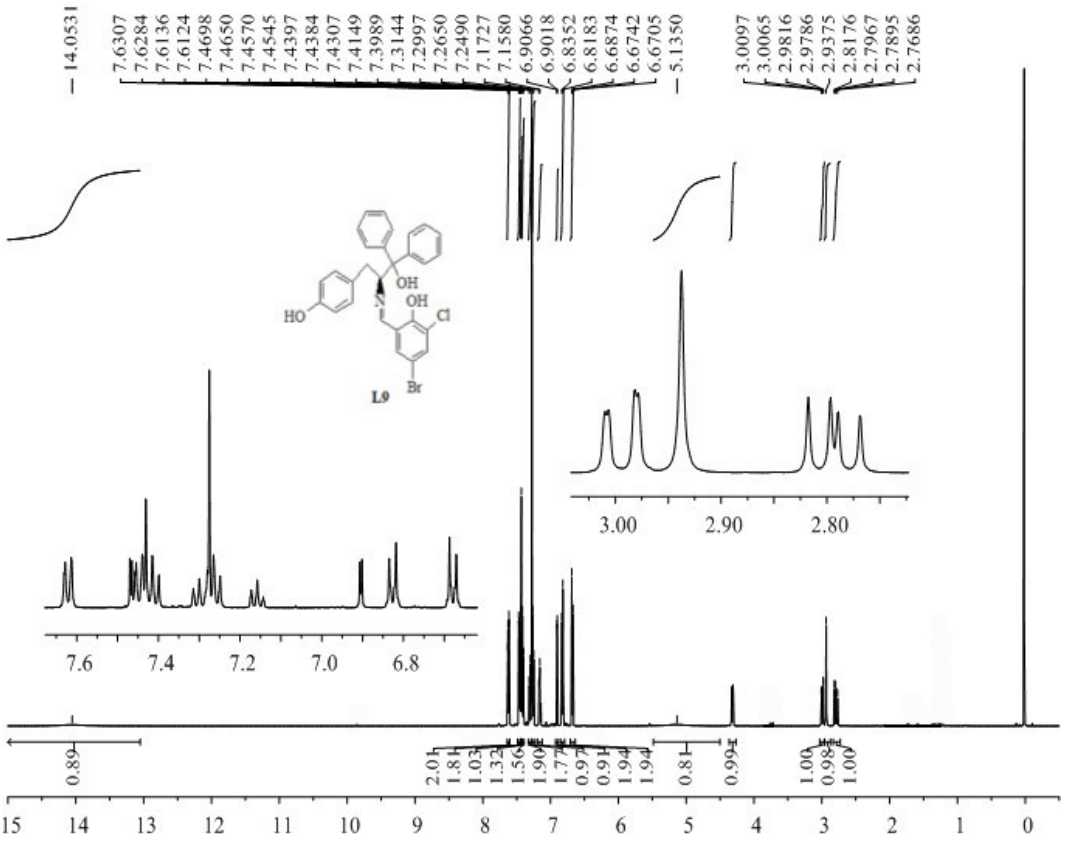

164.2556
161.3175
154.4017
144.7687
143.8608
143.7297
133.8949
130.7219
130.1604
128.6229
128.5062
127.3494
127.2560
125.9592
125.8881
115.5260
109.5704
88.0205
79.6131
77.8123
77.2832
77.0296
76.7745
36.3652
HO
OH
N
OH
I
Br
L8
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

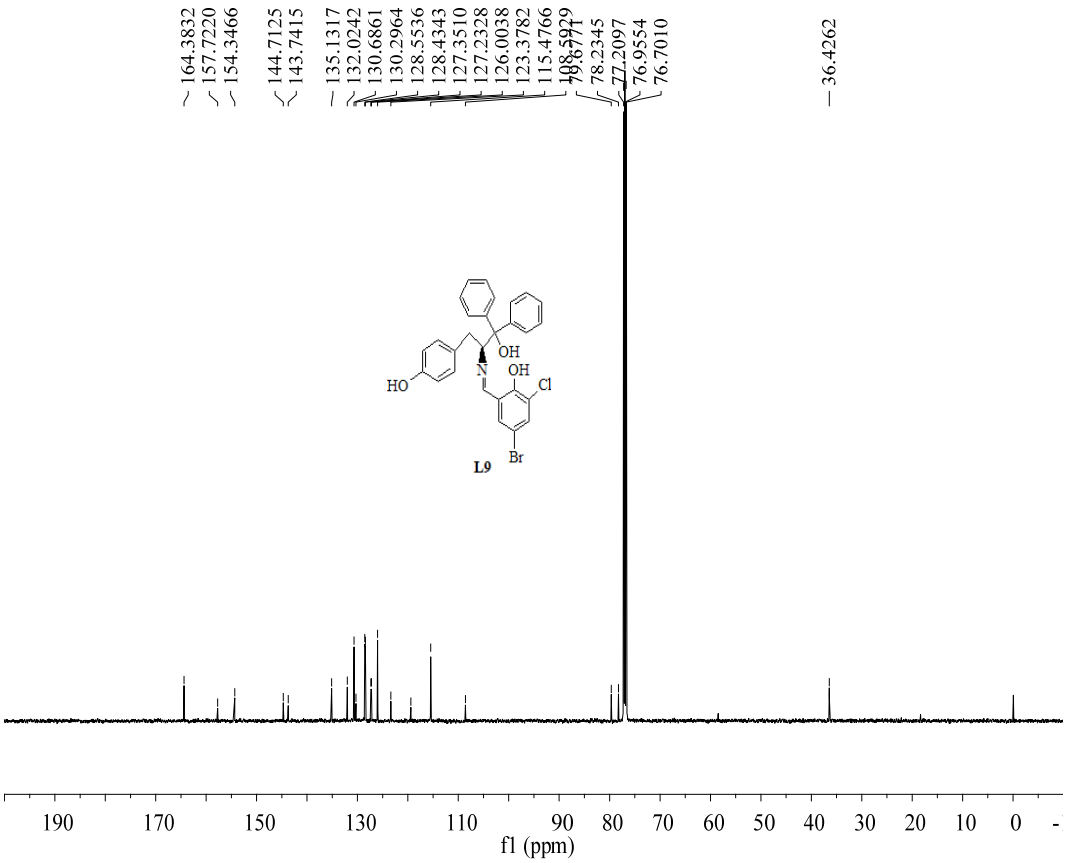

Transmittance[%]
0
20
40
60
80
100
120
140
4000
3500
3000
2500
2000
1500
1000
500
Wavenumber cm-1
C:\Program Files\OPUS\MEAS\WORK.571
XT-L8
1
2012/09/25

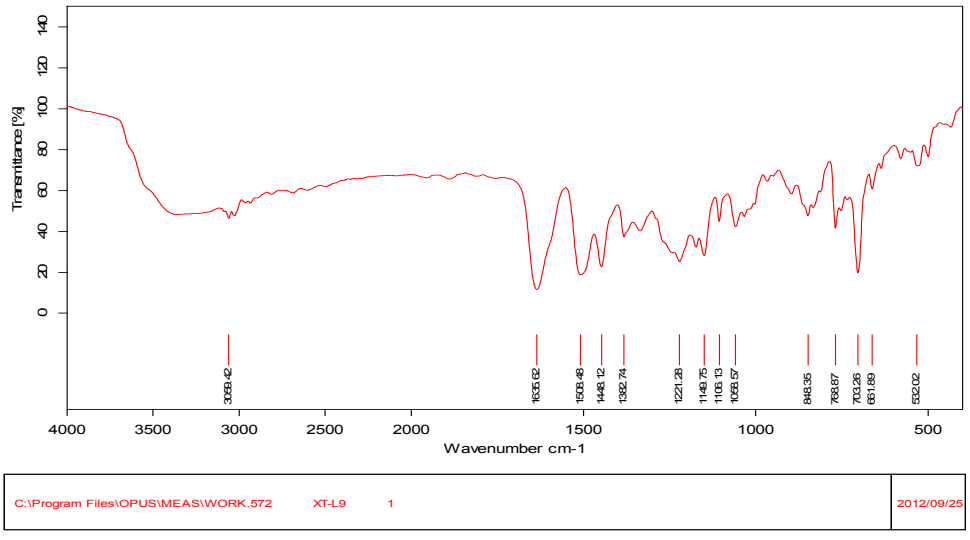

HO
OH
N
OH
Cl
Br

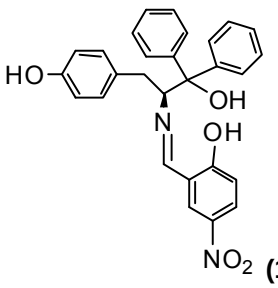
(9)


Spectrum 1A
BP: 105, xt-l9.xms
3.014 min, Scans: 350-352, 50.0:600.0>, Ion: NA, RIC: 4.651e+7
105
3.346e+6
183
2.509e+6
355
2.686e+6
77
1.882e+6
313
1.776e+6
312
998753
357
867253
182
756980
246
667993
91
457353
295
211260
100%
75%
50%
25%
0%
100
200
300
400
500
600
m/z

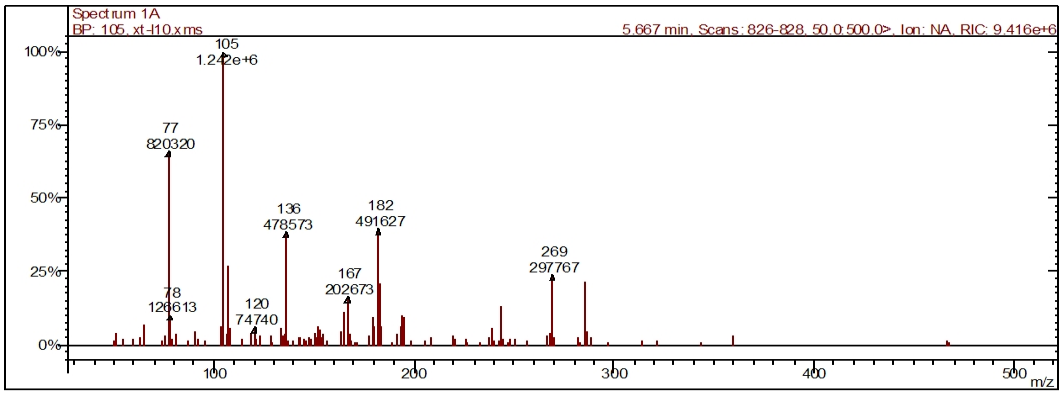

14.0531
7.6307
7.6284
7.6136
7.6124
7.4698
7.4650
7.4570
7.4545
7.4397
7.4384
7.4307
7.4149
7.3989
7.3144
7.2997
7.2650
7.2490
7.1727
7.1580
6.9066
6.9018
6.8352
6.8183
6.6874
6.6742
6.6705
5.1350
3.0097
3.0065
2.9816
2.9786
2.9375
2.8176
2.7967
2.7895
2.7686
OH
OH
HO
N
Cl
Br
L9
3.00
2.90
2.80
7.6
7.4
7.2
7.0
6.8
0.89
2.01
1.84
1.03
1.32
1.56
1.90
1.77
0.97
0.91
1.94
1.94
0.81
0.99
1.00
0.98
1.00
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

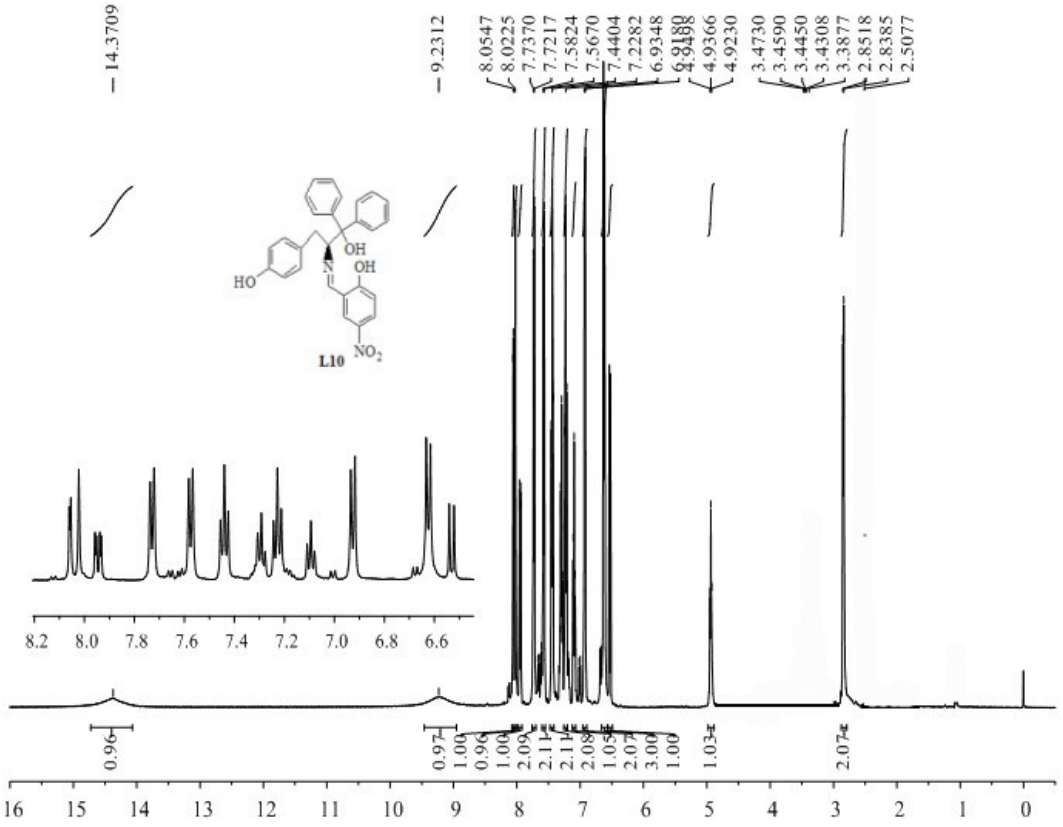

164.3832
157.7220
154.3466
144.7125
143.7415
135.1317
132.0242
130.6861
130.2964
128.5536
128.4343
127.3510
127.2328
126.0038
123.3782
115.4766
108.5929
79.8771
78.2345
77.2097
76.9554
76.7010
36.4262
HO
OH
N
OH
Cl
Br
L9
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

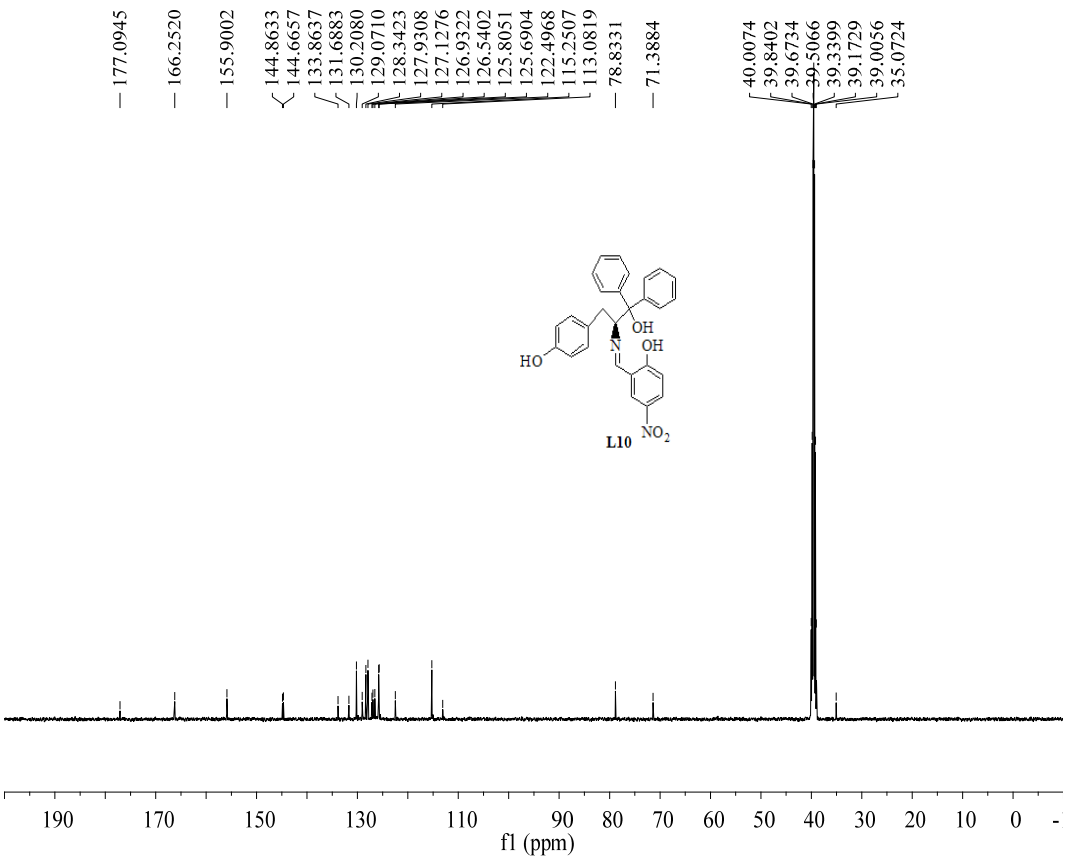

Transmittance [%]
0
20
40
60
80
100
120
140
3059.42
1635.62
1508.48
1448.12
1382.74
1221.28
1149.75
1105.13
1068.57
848.35
768.87
703.26
661.89
532.02
4000
3500
3000
2500
2000
1500
1000
500
Wavenumber cm-1
C:\Program Files\OPUS\MEAS\WORK.572
XT-L9
1
2012/09/25

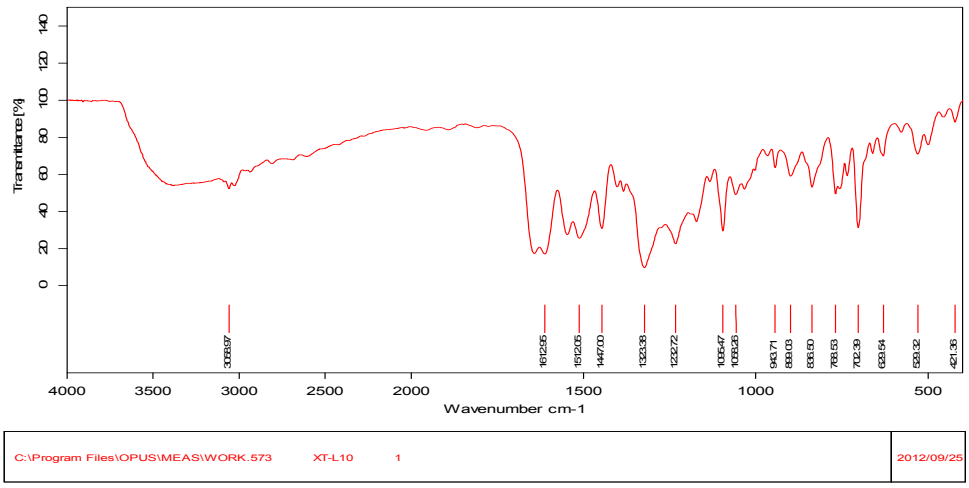

HO
OH
N
OH
NO2

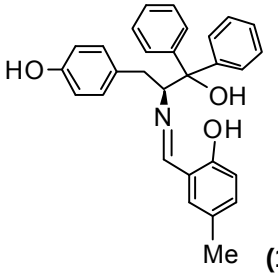
(10)


Spectrum 1A
BP: 105, xt-l10.xms
5.667 min, Scans: 826-828, 50.0:500.0>, Ion: NA, RIC: 9.416e+6
105
1.242e+6
77
820320
136
478573
182
491627
269
297767
167
202673
78
126613
120
74740
100%
75%
50%
25%
0%
100
200
300
400
500
m/z

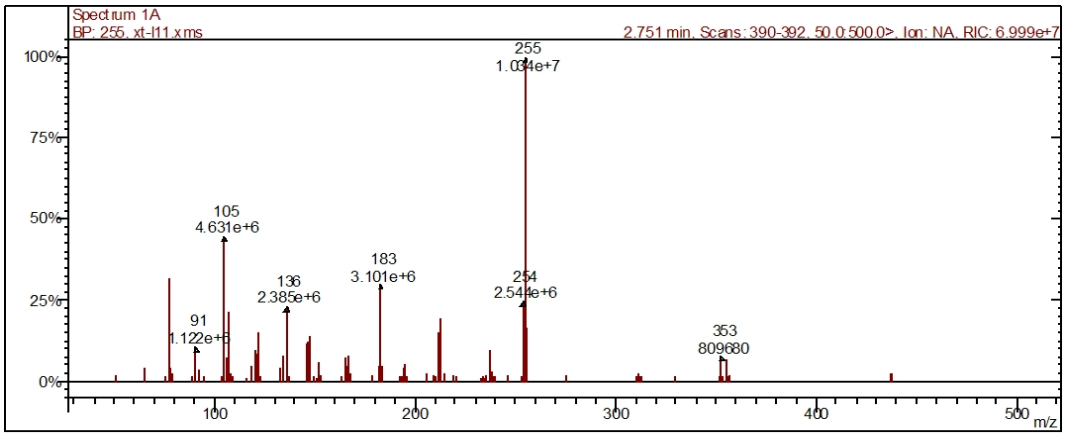

14.3709
9.2312
8.0547
8.0225
7.7370
7.7217
7.5824
7.5670
7.4404
7.2282
6.9348
4.9366
4.9230
3.4730
3.4590
3.4450
3.4308
3.3877
2.8518
2.8385
2.5077
OH
HO
N
OH
NO2
L10
0.96
0.97
1.00
0.96
1.00
2.09
2.11
2.08
1.05
2.07
3.00
1.00
1.03
2.07
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

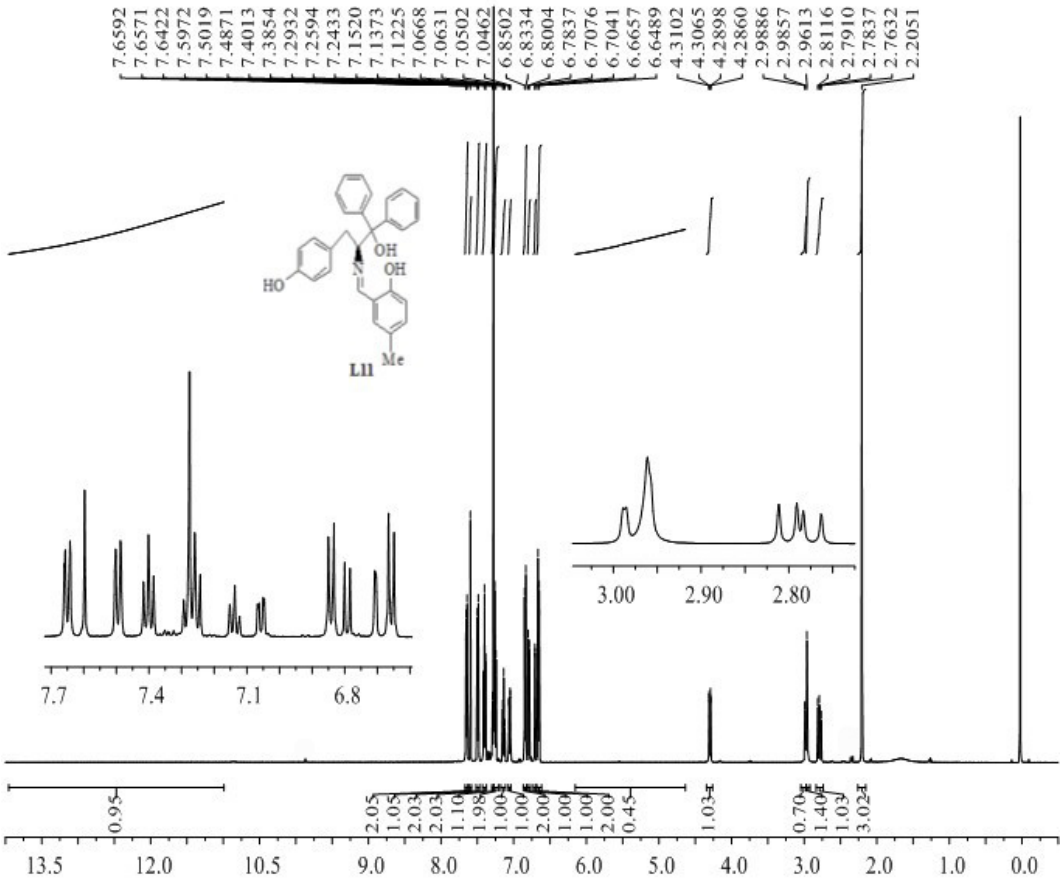

177.0945
166.2520
155.9002
144.8633
144.6657
133.8637
131.6883
130.2080
129.0710
128.3423
127.9308
127.1276
126.9322
126.5402
125.8051
125.6904
122.4968
115.2507
113.0819
78.8331
71.3884
40.0074
39.8402
39.6734
39.5066
39.3399
39.1729
39.0056
35.0724
HO
OH
N
OH
NO2
L10
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

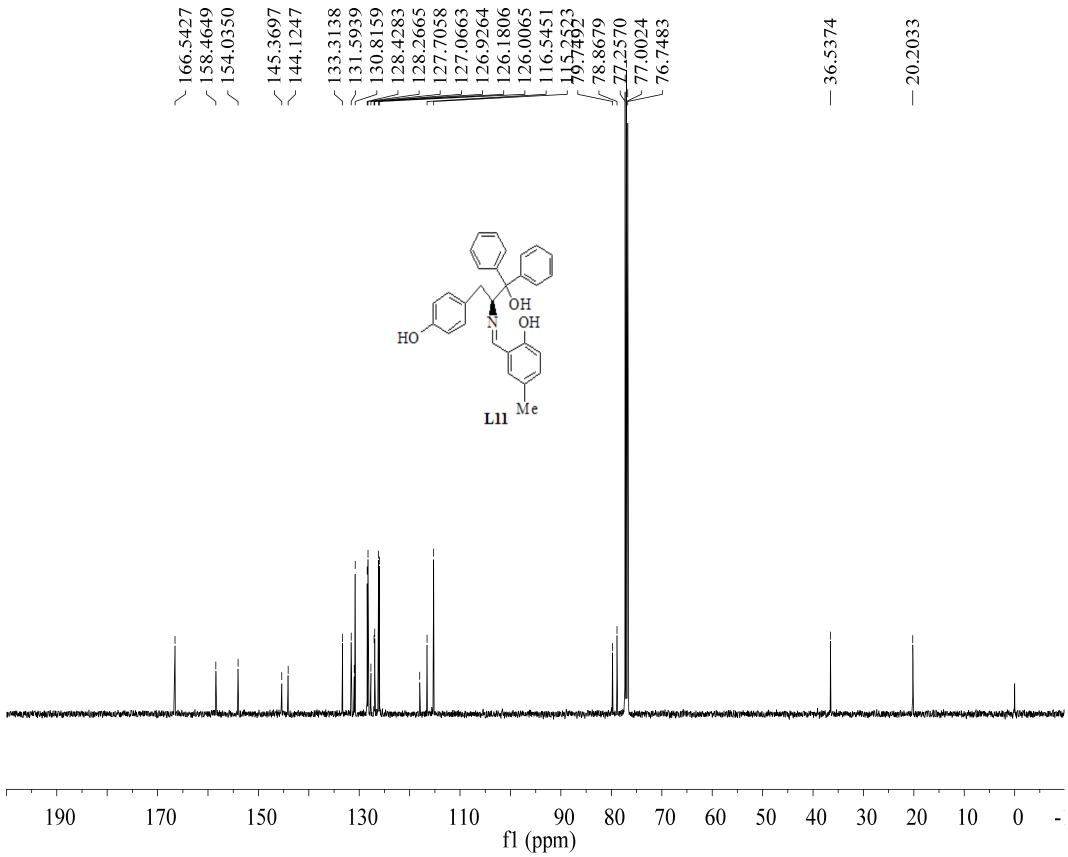

Transmittance [%]
0
20
40
60
80
100
120
140
4000
3500
3000
2500
2000
1500
1000
500
Wavenumber cm-1
C:\Program Files\OPUS\MEAS\WORK.573
XT-L10
1
2012/09/25

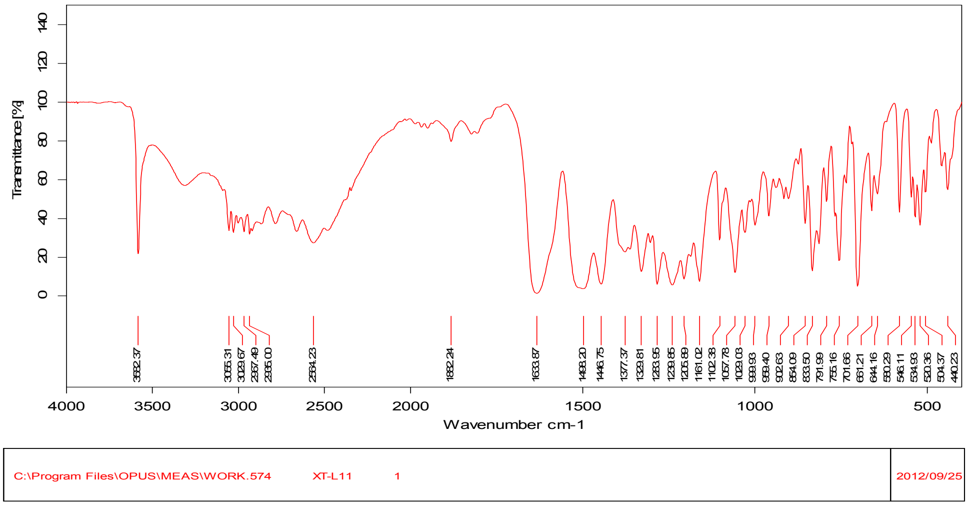

HO
OH
N
OH
Me

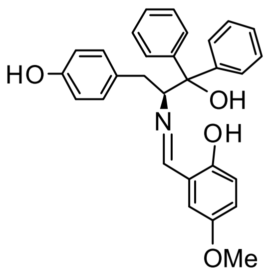
(11)

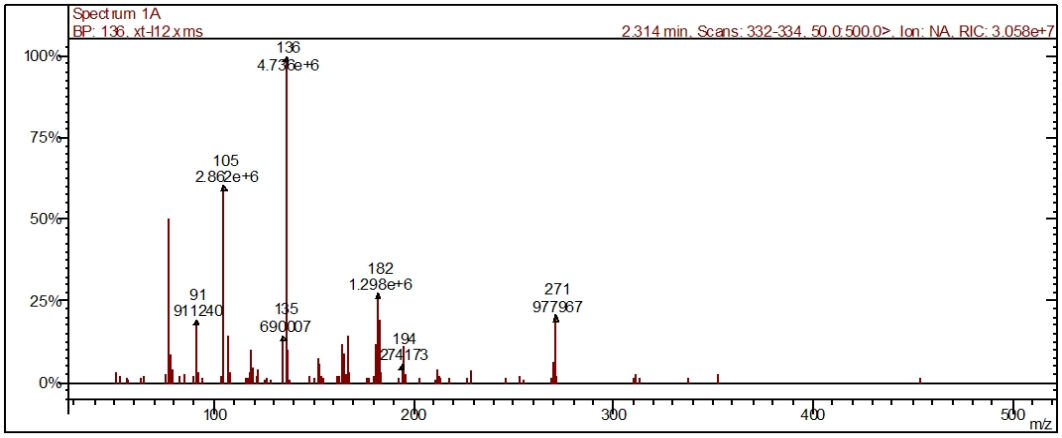

Spectrum 1A
BP: 255, xt-l11.xms
2.751 min, Scans: 390-392, 50.0:500.0>, Ion: NA, RIC: 6.999e+7
255
1.034e+7
105
4.631e+6
183
3.101e+6
136
2.385e+6
254
2.544e+6
91
1.122e+6
353
809680
100%
75%
50%
25%
0%
100
200
300
400
500
m/z

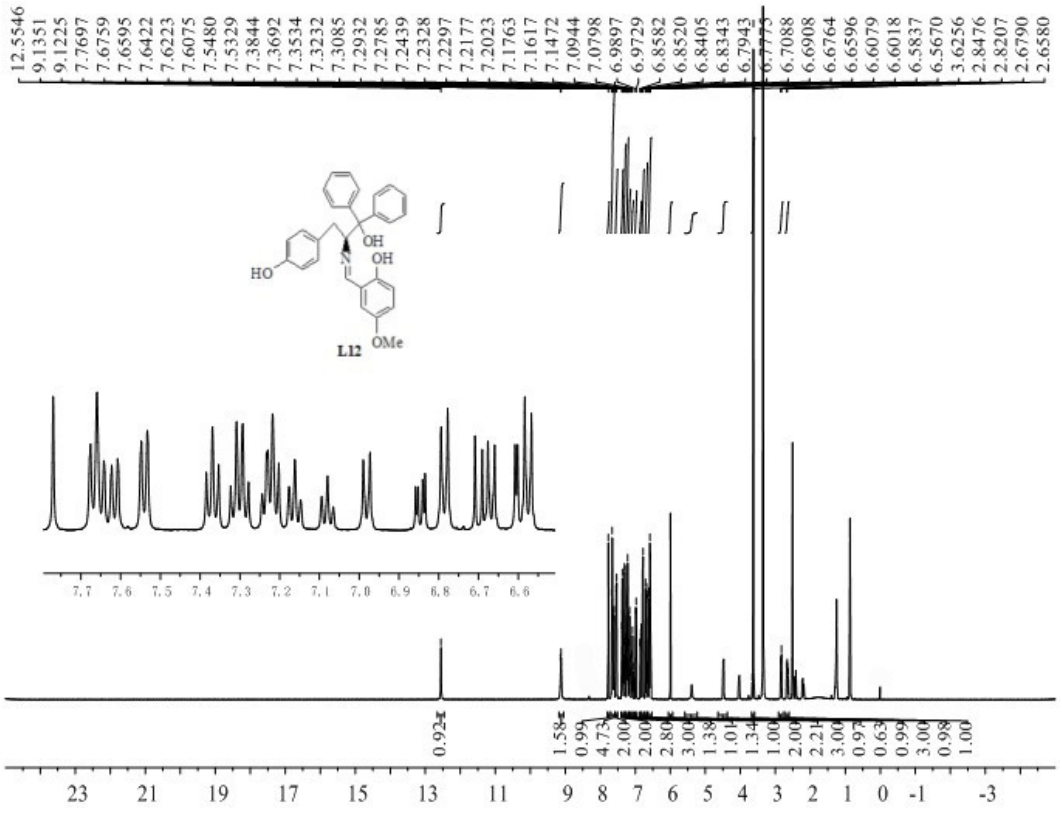

7.6592
7.6571
7.6422
7.5972
7.5019
7.4871
7.4013
7.3854
7.2932
7.2594
7.2433
7.1520
7.1373
7.1225
7.0668
7.0631
7.0502
7.0462
6.8502
6.8334
6.8004
6.7837
6.7076
6.7041
6.6657
6.6489
4.3102
4.3065
4.2898
4.2860
2.9886
2.9857
2.9613
2.8116
2.7910
2.7837
2.7632
2.2051
HO
OH
N
OH
Me
L11
7.7
7.4
7.1
6.8
3.00
2.90
2.80
0.95
2.05
1.05
2.03
2.03
1.10
1.98
1.00
1.00
2.00
1.00
1.00
2.00
0.45
1.03
0.70
1.40
1.03
3.02
13.5
12.0
10.5
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

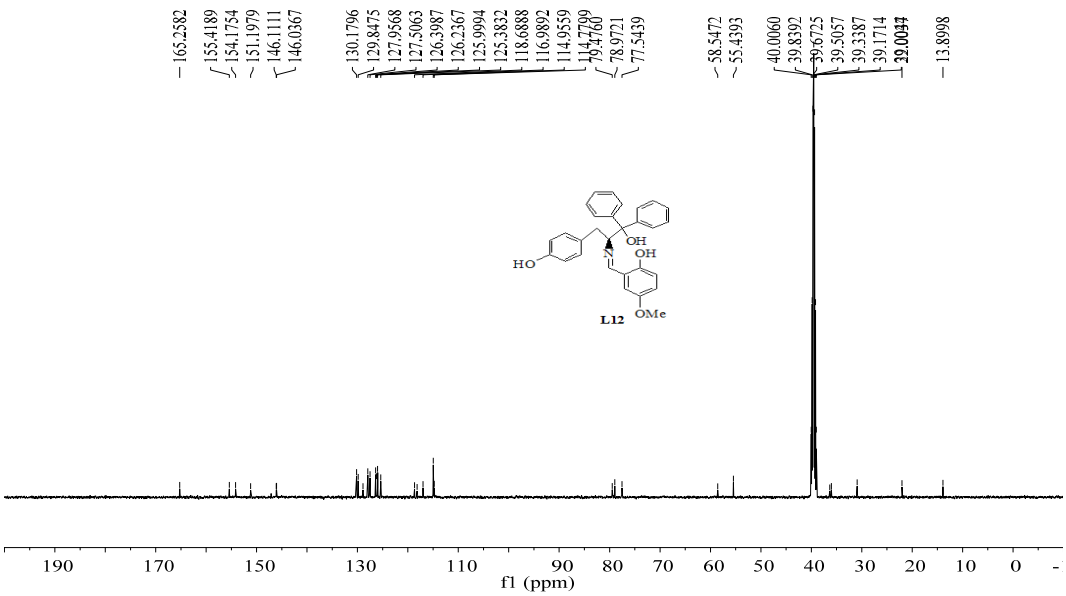

166.5427
158.4649
154.0350
145.3697
144.1247
133.3138
131.5939
130.8159
128.4283
128.2665
127.7058
127.0663
126.9264
126.1806
126.0065
116.5451
115.2523
79.7492
78.8679
77.2570
77.0024
76.7483
36.5374
20.2033
HO
OH
N
OH
Me
L11
f1 (ppm)

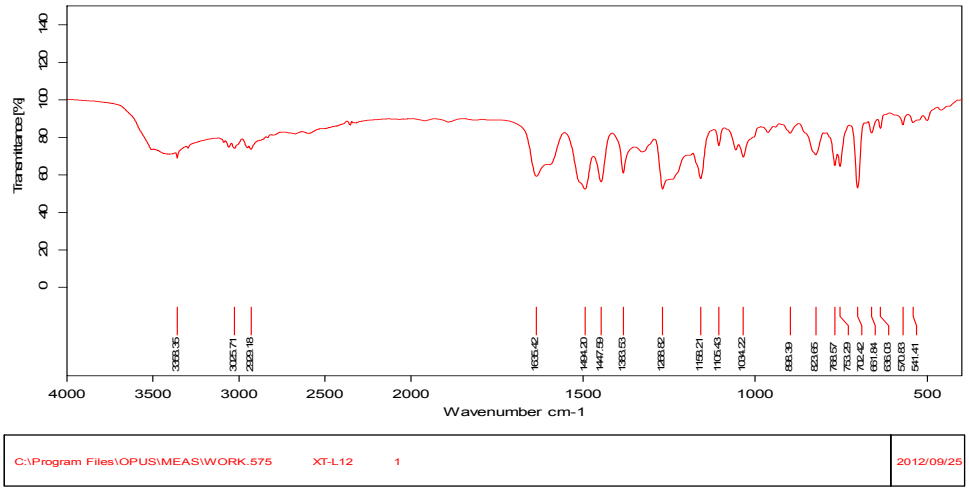

Transmittance [%]
Wavenumber cm-1
C:\Program Files\OPUS\MEAS\WORK.574
XT-L11
1
2012/09/25

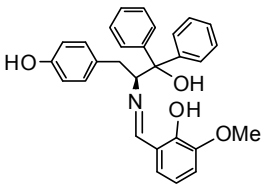

HO
OH
N
OH
OMe
(12)


Spectrum 1A
BP: 136, xt-l12.xms
2.314 min, Scans: 332-334, 50.0:500.0>, Ion: NA, RIC: 3.058e+7
136
4.736e+6
105
2.862e+6
182
1.298e+6
271
977967
91
911240
135
690007
194
274173
100%
75%
50%
25%
0%
100
200
300
400
500
m/z

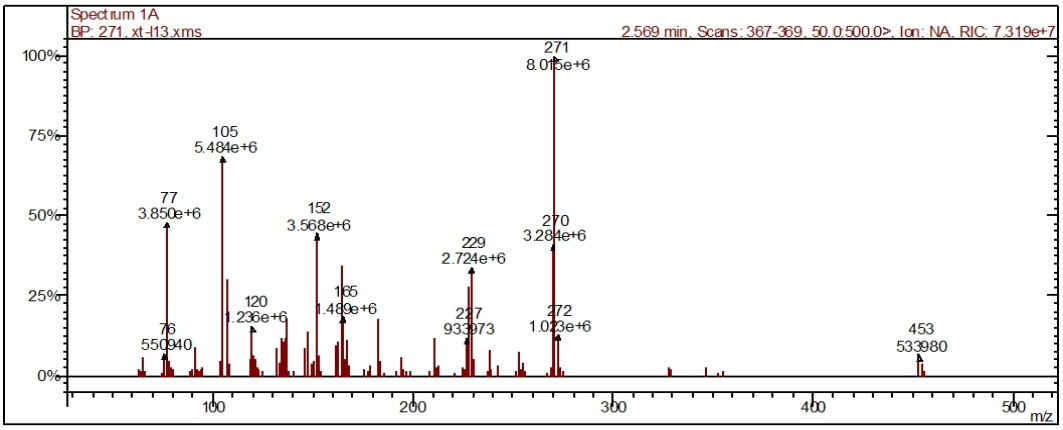

OH
OH
HO
N
OMe
L12

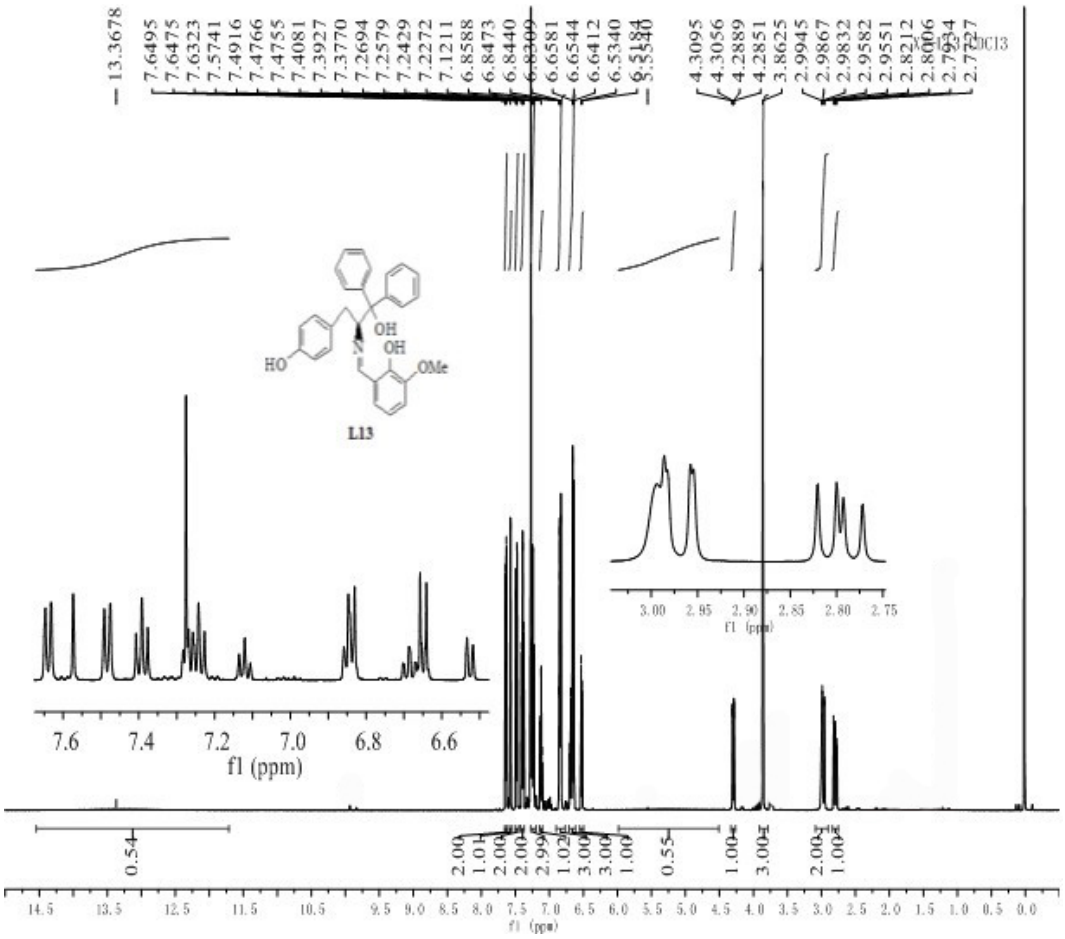

165.2582
155.4189
154.1754
151.1979
146.1111
146.0367
130.1796
129.8475
127.9568
127.5063
126.3987
126.2367
125.9994
125.3832
118.6888
116.9892
114.9559
114.4799
79.4760
78.9721
77.5439
58.5472
55.4393
40.0060
39.8392
39.6725
39.5057
39.3387
39.1714
13.8998
HO
OH
OH
OMe
L12
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

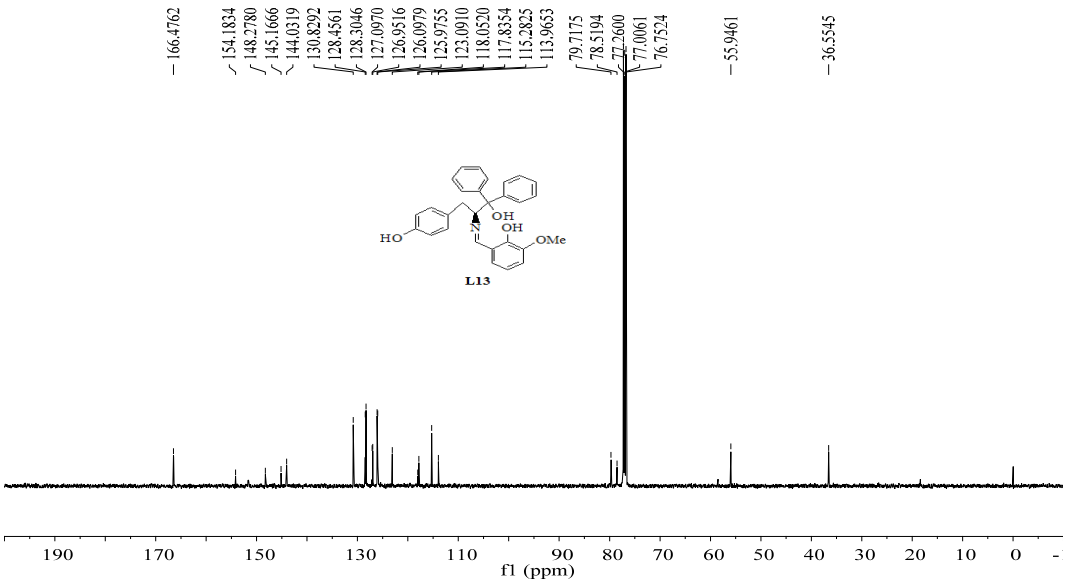

Transmittance [%]
0
20
40
60
80
100
120
140
3368.35
3025.71
2933.18
1635.42
1494.20
1447.89
1383.53
1238.82
1183.21
1105.43
1034.22
868.39
823.65
768.57
753.29
702.42
661.84
636.03
570.83
541.41
4000
3500
3000
2500
2000
1500
1000
500
Wavenumber cm-1
C:\Program Files\OPUS\MEAS\WORK.575
XT-L12
1
2012/09/25

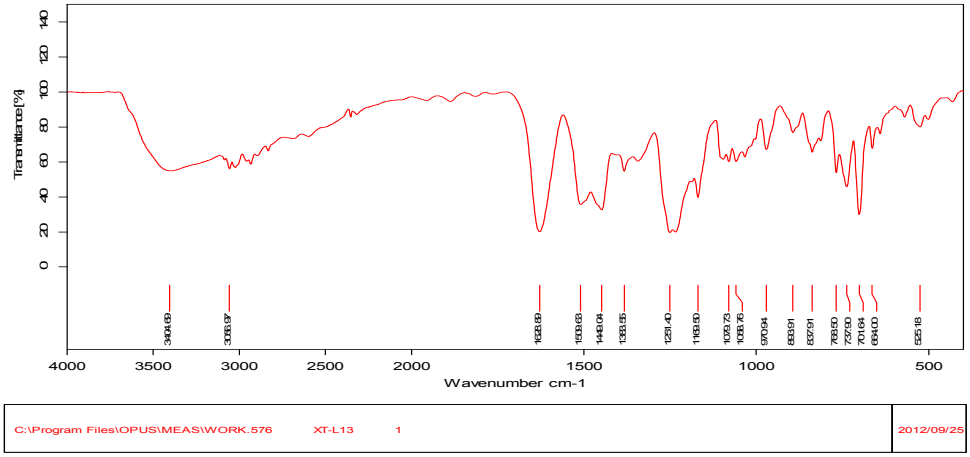

HO
OH
N
OH
OMe

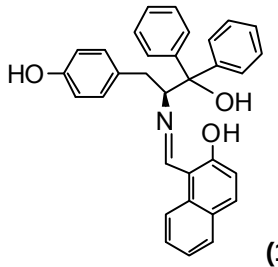
(13)


Spectrum 1A
BP: 271, xt-l13.xms
2.569 min, Scans: 367-369, 50.0:500.0>, Ion: NA, RIC: 7.319e+7
271
8.015e+6
105
5.484e+6
77
3.850e+6
152
3.568e+6
270
3.284e+6
229
2.724e+6
120
1.236e+6
165
1.489e+6
227
933973
272
1.023e+6
76
550940
453
533980
100%
75%
50%
25%
0%
100
200
300
400
500
m/z

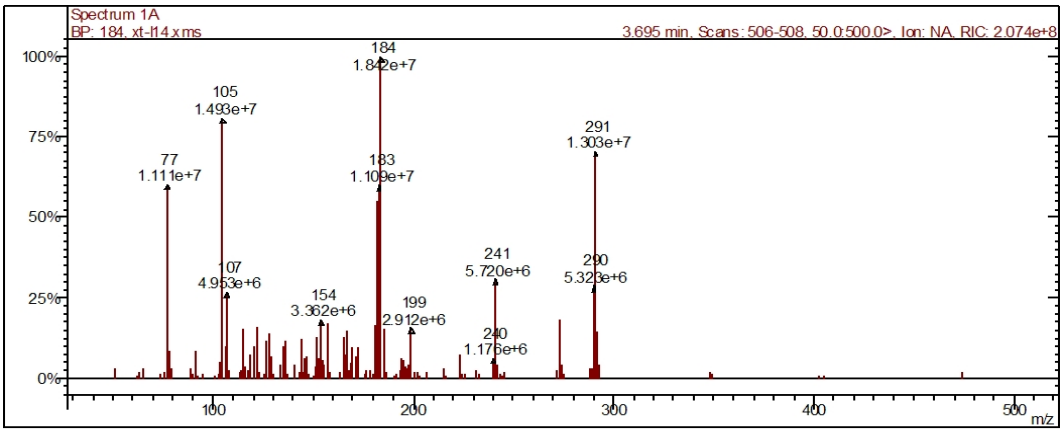

13.3678
7.6495
7.6475
7.6323
7.5741
7.4916
7.4766
7.4755
7.4081
7.3927
7.3770
7.2694
7.2579
7.2429
7.2272
7.1211
6.8588
6.8473
6.8440
6.8309
6.6581
6.6544
6.6412
6.5340
5.5340
4.3095
4.3056
4.2889
4.2851
3.8625
2.9945
2.9867
2.9832
2.9582
2.9551
2.8212
2.8006
2.7934
2.7827
CDCl3
OH
OH
HO
OMe
L13
7.6
7.4
7.2
7.0
6.8
6.6
f1 (ppm)
3.00
2.95
2.90
2.85
2.80
2.75
f1 (ppm)
0.54
2.00
1.01
2.00
2.00
2.99
1.02
3.00
3.00
1.00
0.55
1.00
3.00
2.00
1.00
14.5
13.5
12.5
11.5
10.5
9.5
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
0.0
f1 (ppm)

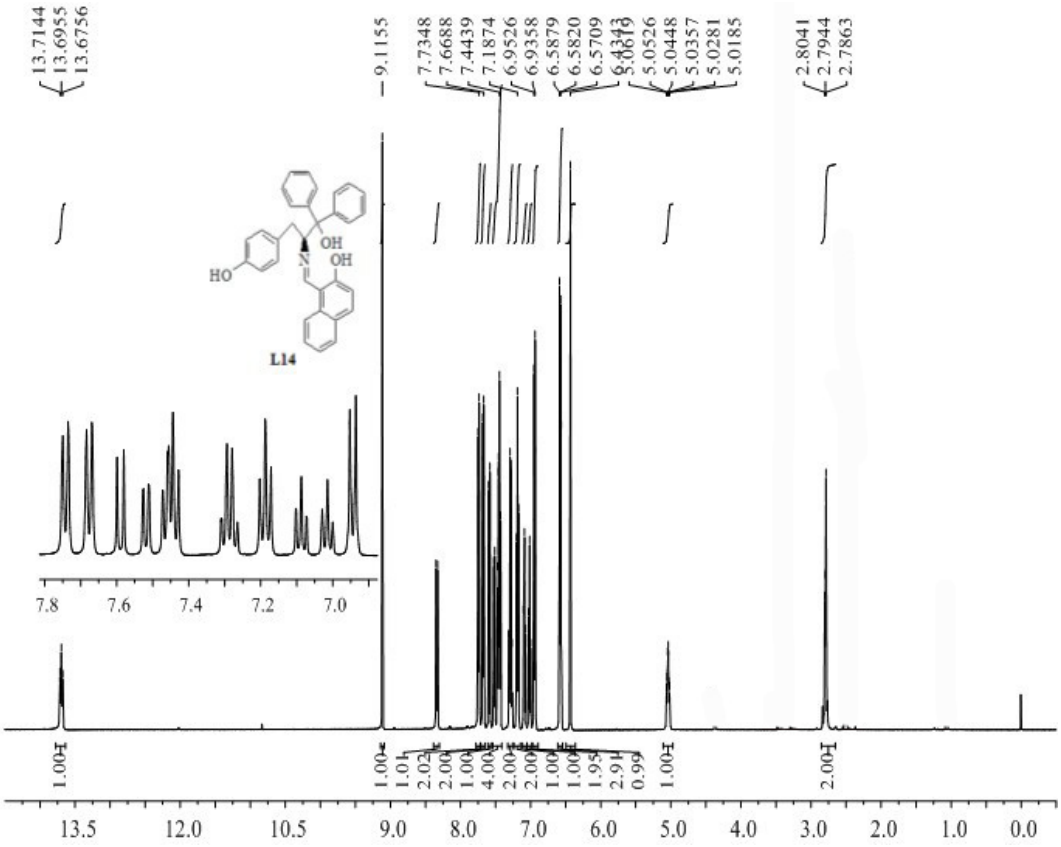

166.4762
154.1834
148.2780
145.1666
144.0319
130.8292
128.4561
128.3046
127.0970
126.9516
126.0979
125.9755
123.0910
118.0520
117.8354
115.2825
113.9653
79.7175
78.5194
77.2600
77.0061
76.7524
55.9461
36.5545
HO
OH
N
OH
OMe
L13
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

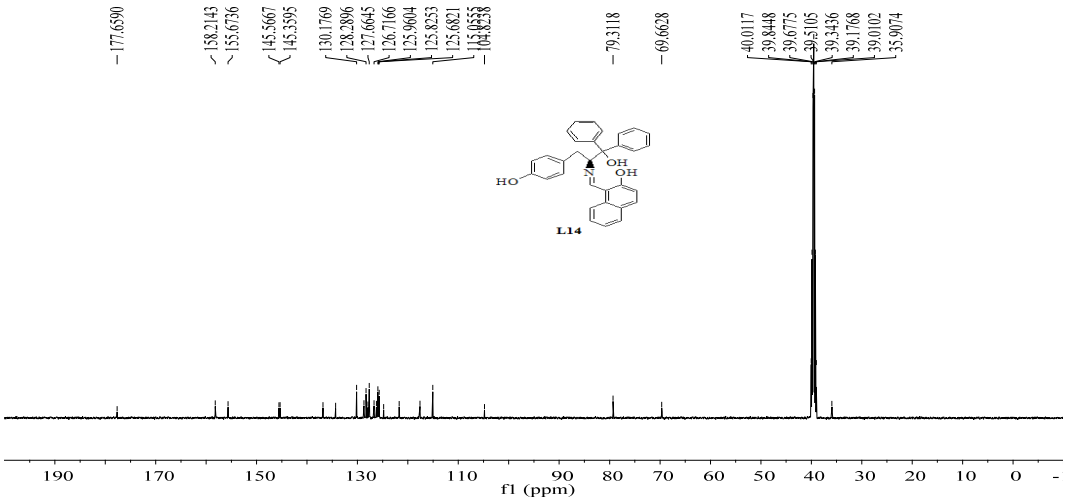

Transmittance [%]
0
20
40
60
80
100
120
140
3424.69
3056.87
1628.89
1593.63
1449.04
1383.65
1251.40
1183.50
1093.73
1068.76
970.94
883.91
837.91
768.60
737.50
701.64
694.00
625.18
4000
3500
3000
2500
2000
1500
1000
500
Wavenumber cm-1
C:\Program Files\OPUS\MEAS\WORK.576
XT-L13
1
2012/09/25

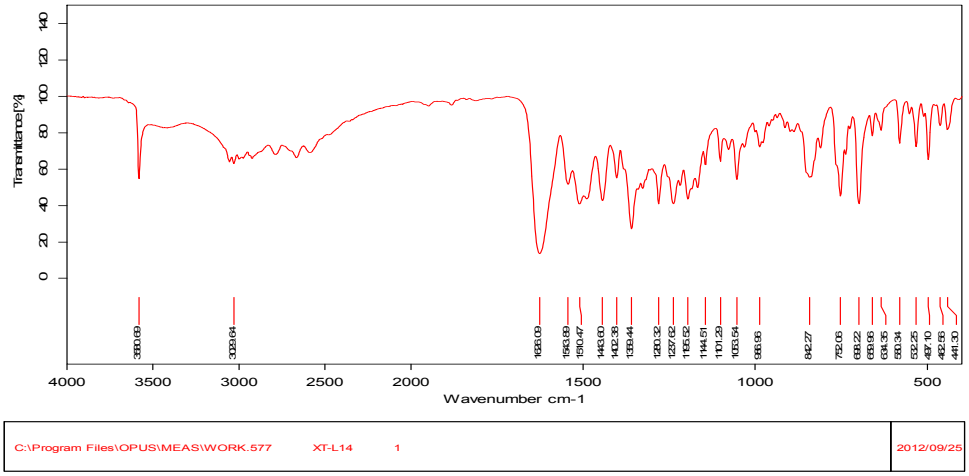

HO
OH
N
OH

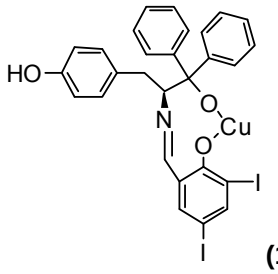
(14)


Spectrum 1A
BP: 184, xt-l14.xms
3.695 min, Scans: 506-508, 50.0:500.0>, Ion: NA, RIC: 2.074e+8
100%
75%
50%
25%
0%
184
1.842e+7
105
1.493e+7
291
1.303e+7
77
1.111e+7
183
1.109e+7
241
5.720e+6
290
5.323e+6
107
4.953e+6
154
3.362e+6
199
2.912e+6
240
1.176e+6
100
200
300
400
500
m/z

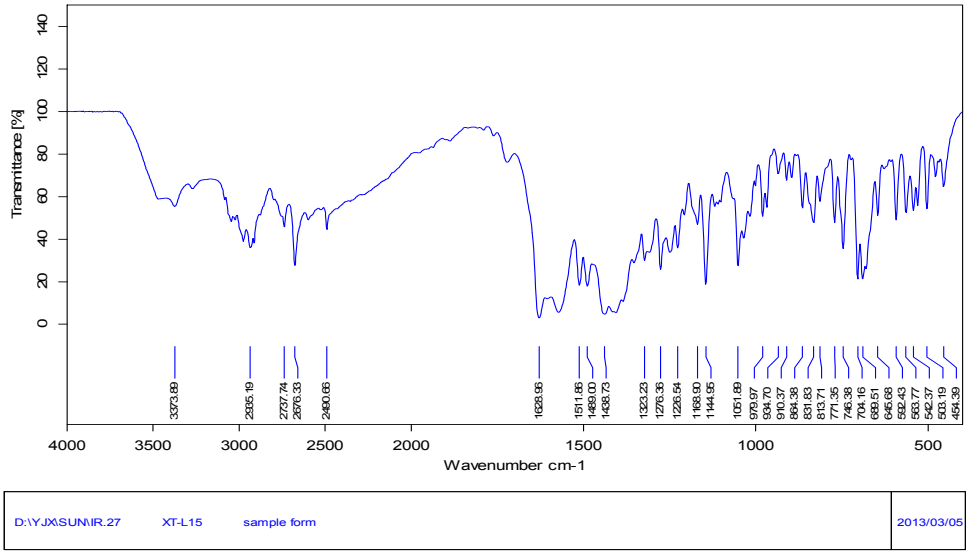

13.7144
13.6955
13.6756
9.1155
7.7348
7.6688
7.4439
7.1874
6.9526
6.9358
6.5879
6.5820
6.5709
5.0526
5.0448
5.0357
5.0281
5.0185
2.8041
2.7944
2.7863
HO
OH
N
OH
L14
7.8
7.6
7.4
7.2
7.0
1.00
1.00
1.01
2.02
2.00
1.00
4.00
2.00
2.00
1.00
1.95
2.91
0.99
1.00
2.00
13.5
12.0
10.5
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0


177.6590
158.2143
155.6736
145.5667
145.3395
130.1769
128.2896
127.6645
126.7166
125.9604
125.8253
125.6821
115.0555
104.8258
79.3118
69.6628
40.0117
39.8448
39.6775
39.5105
39.3436
39.1768
39.0102
35.9074
HO
OH
OH
N
L14
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

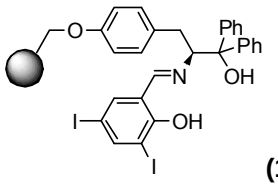

Transmittance[%]
0
20
40
60
80
100
120
140
3360.69
3039.64
1635.09
1580.89
1510.47
1483.00
1402.38
1339.44
1280.32
1237.62
1195.52
1144.51
1107.29
1053.54
996.66
842.27
752.06
698.22
659.66
634.35
580.34
532.25
487.10
462.66
441.30
4000
3500
3000
2500
2000
1500
1000
500
Wavenumber cm-1
C:\Program Files\OPUS\MEAS\WORK.577
XT-L14
1
2012/09/25


HO
N
O
Cu
O
I
I

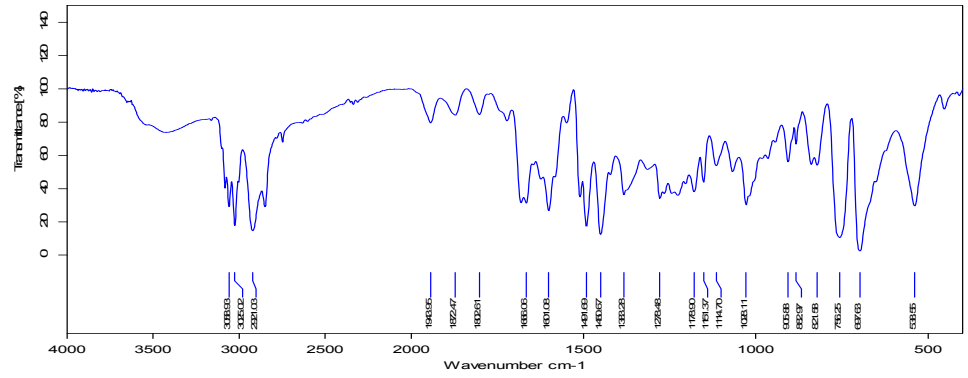
(15)



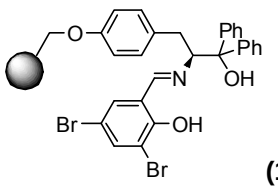
D:\YJX\SUN\IR.27 XT-L15 sample form 2013/03/05



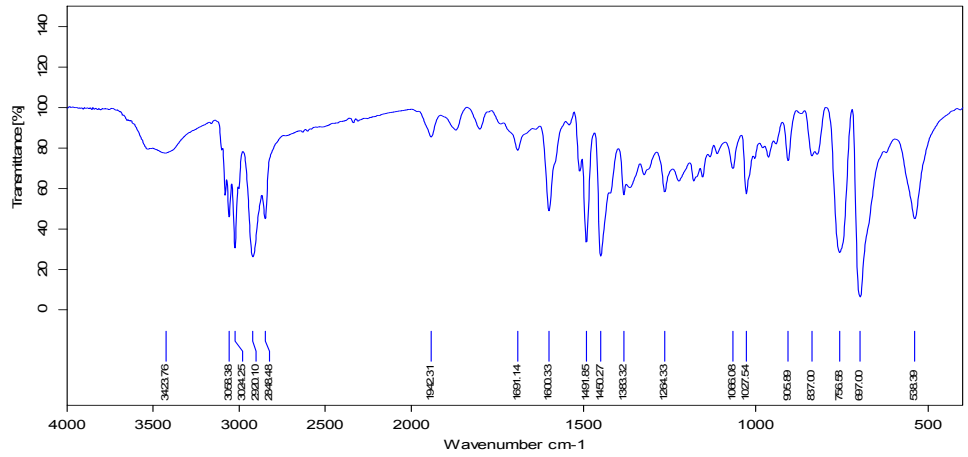
(16a)

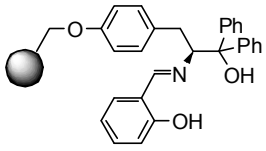


D:\YJX\SUN\IR.39 XT--L16a sample form 2013/03/05

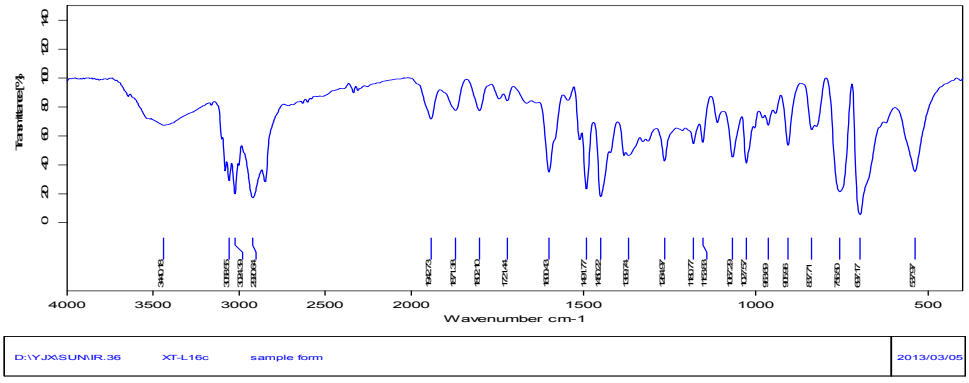


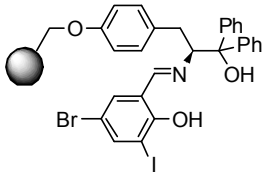
(16b)


Transmittance[%]
Wavenumber cm-1
3423.76
3058.38
3024.25
2920.10
2848.48
1942.31
1691.14
1600.33
1491.85
1450.27
1383.32
1284.33
1068.08
1027.54
905.89
837.00
756.89
697.00
538.39
D:\YJX\SUN\IR.35
XT-L16b
sample form
2013/03/05

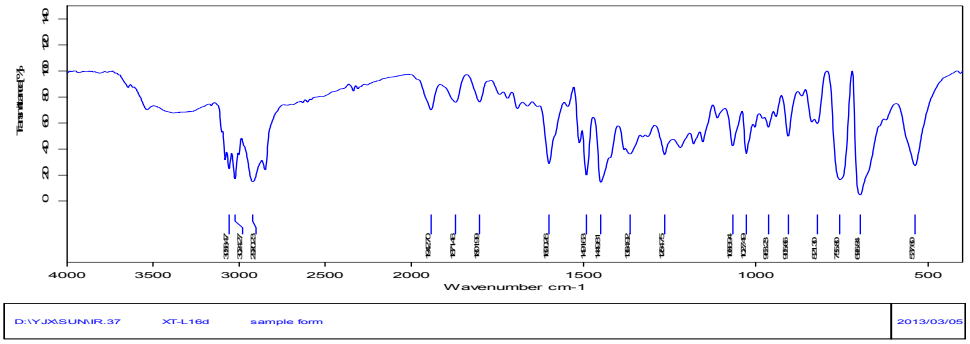


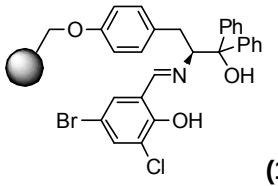
(16c)


Transmittance[%]
Wavenumber cm-1
D:\YJX\SUN\IR.36
XT-L16c
sample form
2013/03/05

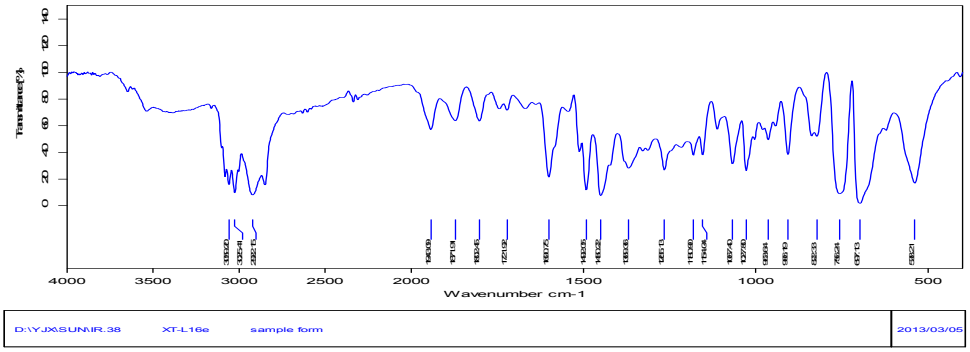


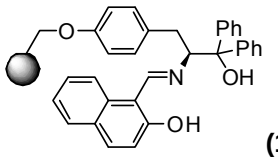
(16d)


Wavenumber cm-1
D:\YJX\SUN\IR.37 XT-L16d sample form 2013/03/05

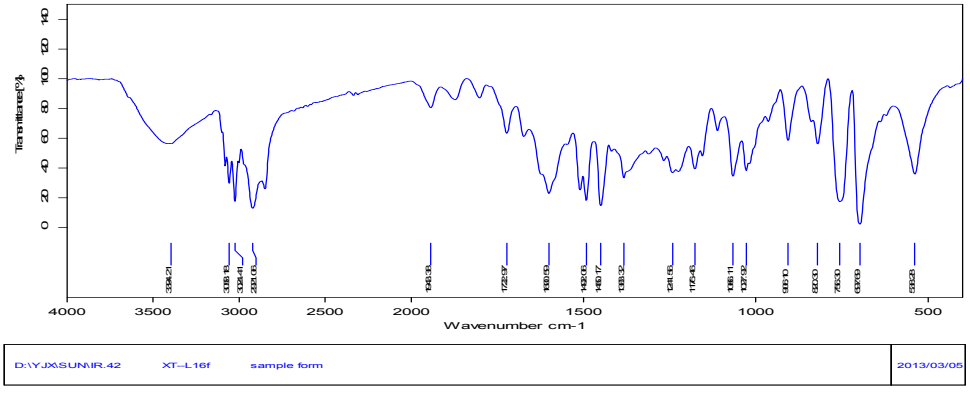

O
Ph
Ph
N
OH
Br
OH
Cl

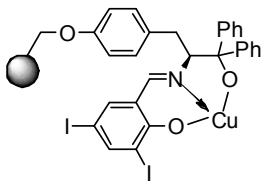
(16e)


Wavenumber cm-1
D:\YJX\SUN\IR.38 XT-L16e sample form 2013/03/05

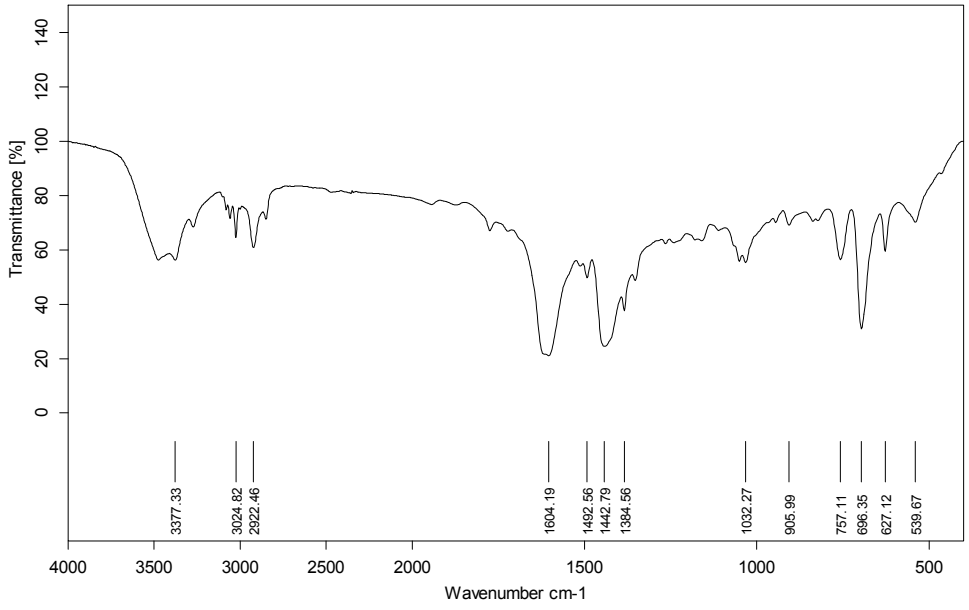

O
Ph
Ph
N
OH
OH

(16f)


Wavenumber cm-1
D:\YJX\SUN\IR.42 XT-L16f sample form 2013/03/05



(17)



D:\321\MGAL-LDHS.85 1	2013/11/13