Supporting Information

Asymmetric Catalytic Mannich-type Reaction of Hydrazones with Difluoroenoxysilanes by using Imidazoline-anchored phosphine Ligand-Zinc(II) Complexes

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CONTENTS

1. General Remarks. ^{1}H and ^{13}C NMR spectra were recorded on a Bruker AM-300 spectrometer for solution in $CDCl_3$ with tetramethylsilane (TMS) as an internal standard; *J*-values are in Hz. Mass spectra were recorded by EI methods, and HRMS was measured on a Finnigan MA^+ mass spectrometer. THF and toluene were distilled from sodium (Na) under argon (Ar) atmosphere. CH_3CN and 1,2-dichloromethane were distilled from CaH_2 under argon (Ar) atmosphere. Commercially obtained reagents were used without further purification. All reactions were monitored by TLC with Huanghai GF_{254} silica gel coated plates. Flash column chromatography was carried out using 300-400 mesh silica gel at increased pressure.

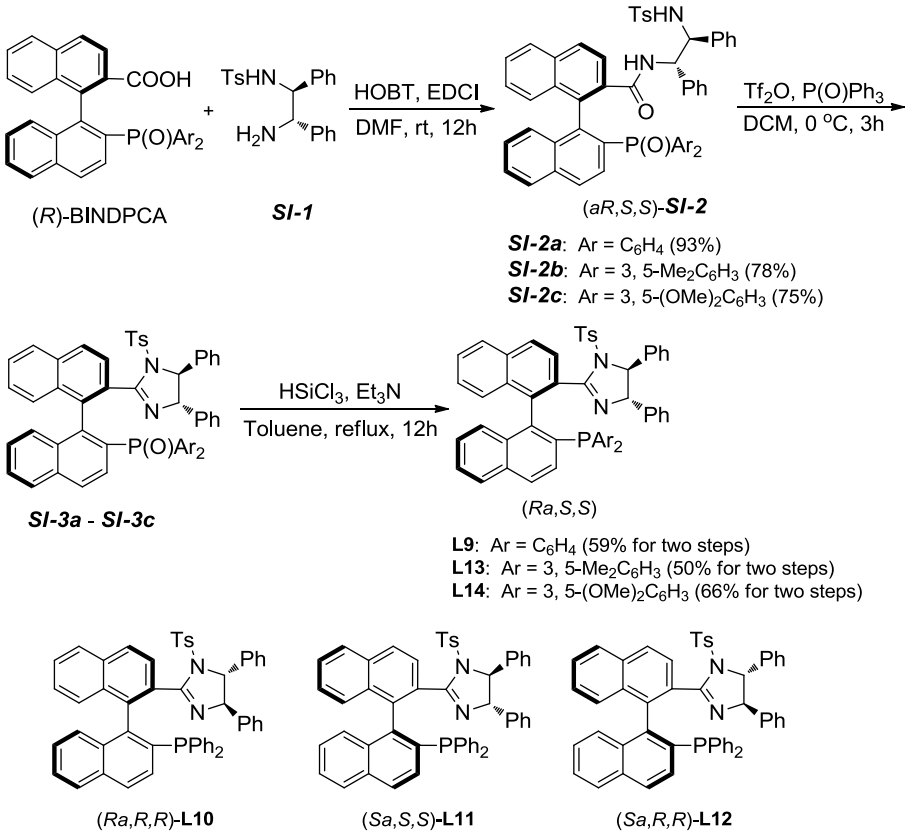
2. General procedure for the preparation of difluoroenoxysilane 2.[1] A mixture of chlorotrimethylsilane (TMSCl) (6.0 mmol), Mg (6.0 mmol) and THF (10 mL) was cooled down to 0 ^{o}C under argon atmosphere. Then trifluoroacetophenone (1.5 mmol) was added dropwise and the resulting mixture was stirred for an additional 1.0 h. After the solvent was removed under vacuum, hexane (15 mL) was added to the residue. The resulting salt was filtered and the filtrate was then concentrated to give the crude product of difluoroenoxysilane **2** under reduced pressure. This crude product **2** was used for the Mukaiyama-aldol type reaction without further purification.

((2,2-difluoro-1-phenylvinyl)oxy)trimethylsilane (2a). ^{1}H NMR (300 MHz, $CDCl_3$, TMS): δ 0.18 (s, 9H, CH_3), 7.25-7.29 (m, 1H, ArH), 7.34-7.39 (m, 2H, ArH), 7.47-7.50 (m, 2H, ArH); ^{19}F NMR (282 MHz, $CDCl_3$, TMS): δ -100.7 (d, 1F, J = 68 Hz), -112.2 (d, 1F, J = 68 Hz).

((2,2-difluoro-1-(p-tolyl)vinyl)oxy)trimethylsilane (2b). ^{1}H NMR (400 MHz, $CDCl_3$, TMS): δ 0.18 (s, 9H, CH_3), 2.35 (s, 3H, CH_3), 7.16 (d, 2H, J = 8.4 Hz, ArH), 7.36 (d, 2H, J = 8.4 Hz, ArH); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -100.7 (d, 1F, J = 69 Hz), -112.2 (d, 1F, J = 69 Hz).

((2,2-difluoro-1-(thiophen-2-yl)vinyl)oxy)trimethylsilane (2c). ^{1}H NMR (400 MHz, $CDCl_3$, TMS): δ 0.24 (s, 9H, CH_3), 7.01-7.04 (m, 1H, ArH), 7.09 (d, 1H, J = 4.0 Hz, ArH), 7.36 (dd, 1H, J = 4.0, 1.2 Hz, ArH); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -102.2 (d, 1F, J = 65 Hz), -112.2 (d, 1F, J = 65 Hz).

3. General procedure of the preparation of chiral imidazoline-phosphine type ligands L9-L14.



Synthesis of the precatalysts *SI-2*. The solution of (*R*)-BINDPCA[2] (0.5 mmol) in DMF (5.0 mL) with 1-ethyl-3-(3-dimethyllaminopropyl)carbodiimide hydrochloride (EDCI) (1.0 mmol) and 1-hydroxy-benzotriazole (HOBt) (1.5 mmol) was stirred at 0 ^{o}C for 10 min, then a solution of ***SI-1*** (0.75 mmol) in 2.0 mL DMF was added into the solution by syringe at 0 ^{o}C. The mixture was stirred at room temperature for 5 h. The reaction mixture was diluted by the addition of 10 mL of EtOAc, then washed with H_2O and brine, dried over anhydrous Na_2SO_4 and the solvent was removed under vacuum. The residue was purified by silica gel column chromatography to give the desired product ***SI-2*** as pale yellow solid.

(*R*)-2-(diphenylphosphoryl)-*N*-((1*S*,2*S*)-2-(4-methylphenylsulfonamido)-1,2-diphenylethyl)-1, 1'-binaphthyl-2-carboxamide ***SI-2a***. Yield: (392 mg, 93%). A pale yellow solid, m.p. 133-136 ^{o}C; IR (CH_2Cl_2) ν 3209, 3059, 2924, 1659, 1566, 1497, 1453, 1439, 1373, 1332, 1262, 1202, 1158, 1114, 1090, 1071, 1029, 1000, 972, 952 cm^{-1}; ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.22 (s, 3H, CH_3), 5.05 (dd, 1H, *J* = 10.0, 4.0 Hz, CH), 5.28 (dd, 1H, *J* = 10.0, 4.0 Hz, CH), 6.35 (d, 2H, *J* = 8.0 Hz, ArH), 6.46 (d, 1H, *J* = 8.4 Hz, ArH), 6.73-6.84 (m, 6H, ArH), 6.94 (br, 2H, ArH), 7.06-7.24 (m, 10H, ArH), 7.36-7.55 (m, 7H, ArH), 7.61 (d, 1H, *J* = 8.0 Hz, ArH),

7.80-7.88 (m, 4H, ArH), 7.95 (dd, 1H, *J* = 8.4, 2.0 Hz, ArH), 10.13 (d, 1H, *J* = 8.0 Hz, NH); ^{31}P NMR ($CDCl_3$, 162 MHz, 85% H_3PO_4) δ 30.34; MS (ESI) *m/z* (%): 847.7 (100) [M^++1]; HRMS (MALDI) Calcd. for $C_{54}H_{44}N_2O_4PS^{+1}$($M^+$+1) requires 847.2755, Found: 847.2753. $[\alpha]^{20}_D$ = +108.6 (c 0.40, $CHCl_3$).

(*R*)-2-(bis(3,5-dimethylphenyl)phosphoryl)-*N*-((1*S*,2*S*)-2-(4-methylphenylsulfonamido)-1,2-diphenylethyl)-1,1'-binaphthyl-2-carboxamide ***SI-2b***. Yield: (297 mg, 78%). A pale yellow solid, m.p. 130-133 ^oC; IR (CH_2Cl_2) ν 3201, 3059, 3031, 2922, 1725, 1660, 1620, 1566, 1498, 1452, 1422, 1375, 1334, 1305, 1272, 1224, 1203, 1159, 1122, 1092, 1065, 1007, 973, 953 cm^{-1}; ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.95 (s, 6H, CH_3), 2.22 (s, 3H, CH_3), 2.38 (s, 6H, CH_3), 4.98 (dd, 1H, *J* = 11.6, 3.6 Hz, CH), 5.29 (dd, 1H, *J* = 11.6, 3.6 Hz, CH), 6.23 (d, 1H, *J* = 7.6 Hz, ArH), 6.45 (s, 1H, ArH), 6.55 (d, 1H, *J* = 7.6 Hz, ArH), 6.70-6.81 (m, 6H, ArH), 6.88-7.03 (m, 3H, ArH), 7.10-7.24 (m, 9H, ArH), 7.39-7.50 (m, 4H, ArH), 7.57-7.72 (m, 4H, ArH), 7.86 (d, 1H, *J* = 8.4 Hz, ArH), 8.02 (dd, 1H, *J* = 8.4, 2.0 Hz, ArH), 8.22 (dd, 1H, *J* = 8.4, 1.6 Hz, ArH), 10.28 (d, 1H, *J* = 9.2 Hz, NH); ^{31}P NMR ($CDCl_3$, 162 MHz, 85% H_3PO_4) δ 29.39; MS (ESI) *m/z* (%): 903.7 (100) [M^++1]; HRMS (MALDI) Calcd. for $C_{58}H_{52}N_2O_4PS^{+1}$($M^+$+1) requires 903.3388, Found: 903.3380. $[\alpha]^{20}_D$ = +48.0 (c 0.15, $CHCl_3$).

(*R*)-2-(bis(3,5-dimethoxyphenyl)phosphoryl)-*N*-((1*S*,2*S*)-2-(4-methylphenylsulfonamido)-1,2-diphenylethyl)-1,1'-binaphthyl-2-carboxamide ***SI-2c***. Yield: (319 mg, 75%). A pale yellow solid, m.p. 137-139 ^oC; IR (CH_2Cl_2) ν 3210, 3060, 3002, 2933, 2838, 1723, 1660, 1585, 1498, 1453, 1419, 1373, 1335, 1303, 1289, 1257, 1206, 1161, 1091, 1063, 973, 953, 925 cm^{-1}; ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.22 (s, 3H, CH_3), 3.22 (s, 6H, OCH_3), 3.78 (s, 6H, OCH_3), 4.99 (dd, 1H, *J* = 9.2, 3.6 Hz, CH), 5.30 (dd, 1H, *J* = 9.2, 3.6 Hz, CH), 5.89 (s, 1H, ArH), 6.25-6.28 (m, 4H, ArH), 6.53 (d, 1H, *J* = 8.4 Hz, ArH), 6.66 (s, 1H, ArH), 6.75-6.91 (m, 4H, ArH), 6.93-7.04 (m, 3H, ArH), 7.14-7.21 (m, 9H, ArH), 7.38-7.45 (m, 3H, ArH), 7.53 (d, 1H, *J* = 8.0 Hz, ArH), 7.65-7.72 (m, 2H, ArH), 7.86 (d, 1H, *J* = 8.0 Hz, ArH), 7.95 (d, 1H, *J* = 9.6 Hz, ArH), 8.02 (d, 1H, *J* = 6.8 Hz, ArH), 10.09 (d, 1H, *J* = 9.2 Hz, NH); ^{31}P NMR ($CDCl_3$, 162 MHz, 85% H_3PO_4) δ 30.61; MS (ESI) *m/z* (%): 967.9 (100) [M^++1]; HRMS (MALDI) Calcd. for $C_{58}H_{52}N_2O_8PS^{+1}$($M^+$+1) requires 967.3192, Found: 967.3177. $[\alpha]^{20}_D$ = +58.3 (c 0.40, $CHCl_3$).

Synthesis of the precatalysts *SI-3*.[3] To a dried Schlenk tube was added triphenylphosphine oxide (1.5 mmol) and trifluoromethanesulfonic anhydride (1.5 mmol) in CH_2Cl_2 (5.0 mL) at 0 ^oC, and the mixture was stirred at 0 ^oC for 0.5 h. Then the solution of precatalyst ***SI-2*** (0.50 mmol) in CH_2Cl_2 (5.0 mL) was added slowly via syringe. After the completion of the addition, the mixture was stirred at 0 ^oC for 3 h. The reaction was quenched with saturated $NaHCO_3$ (aq), and the aqueous layer was extracted with CH_2Cl_2. The combined organic phase was dried over anhydrous Na_2SO_4, and the solvent was removed under vacuum. The residue was purified by silica gel column chromatography (PE/EA=1/1) to give crude product ***SI-3*** (mixed with triphenylphosphine oxide).

Synthesis of the chiral imidazoline-phosphine ligands L9-L14. To a dried Schlenk tube filled with argon was added crude precatalyst ***SI-3*** with Et_3N (10.0 equiv) in 15 mL anhydrous toluene. The mixture was stirred at 0 ^oC for 10 min, and 10.0 equiv of $HSiCl_3$ was added at 0 ^oC and the mixture was stirred at that temperature for 0.5 h. Then the mixture was allowed to warm to room temperature and stirred under reflux overnight. After cooling to room temperature, the reaction was quenched with saturated $NaHCO_3$ (aq), precipitates settled out, and the aqueous layer was extracted with EtOAc. The combined organic phase was washed with brine and dried over anhydrous Na_2SO_4, and the solvent was removed under vacuum. The residue was purified by silica gel column chromatography (PE/EA=5/1) to give the desired product as pale yellow solid.

(4*S*,5*S*)-2-((*R*)-2'-(diphenylphosphino)-1,1'-binaphthyl-2-yl)-4,5-diphenyl-1-tosyl-4,5-dihydro-1H-imidazoline **L9**. Yield: (110 mg, 55% for two steps). A pale yellow solid, m.p. 150-153 ^oC; IR (CH_2Cl_2) ν 3397, 3055, 2973, 2925, 1725, 1642, 1595, 1479, 1433, 1371, 1306, 1277, 1247, 1205, 1185, 1167, 1089, 1026, 963 cm^{-1}; ^1H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.24 (s, 3H, CH_3), 4.49 (d, 1H, *J* = 6.0 Hz, CH), 4.54 (d, 1H, *J* = 6.0 Hz, CH), 5.85 (d, 2H, *J* = 7.2 Hz, ArH), 6.68 (d, 1H, *J* = 8.4 Hz, ArH), 6.78-6.89 (m, 9H, ArH); 6.91-7.01 (m, 5H, ArH), 7.07-7.11 (m, 4H, ArH), 7.12-7.19 (m, 5H, ArH), 7.32 (q, 2H, *J* = 6.0 Hz, ArH), 7.53 (t, 2H, *J* = 8.8 Hz, ArH), 7.80 (d, 1H, *J* = 8.4 Hz, ArH), 7.91 (d, 1H, *J* = 8.4 Hz, ArH), 7.98-8.03 (m, 3H, ArH), 8.15 (d, 1H, *J* = 8.0 Hz, ArH); ^{31}P NMR ($CDCl_3$, 162 MHz, 85% H_3PO_4) δ -14.82; MS (ESI) *m/z* (%): 813.6 (100) [M^++1]; HRMS (MALDI) Calcd. for $C_{54}H_{42}N_2O_2PS^{+1}$($M^+$+1) requires 817.2702, Found: 817.2699. $[\alpha]^{20}_D$ = +36.5 (c 0.45, $CHCl_3$).

(4*R*,5*R*)-2-((*R*)-2'-(diphenylphosphino)-1,1'-binaphthyl-2-yl)-4,5-diphenyl-1-tosyl-4,5-dihydro-1H-imidazoline **L10**. Yield: (199 mg, 63% for two steps). A pale yellow solid, m.p. 147-150 ^{o}C; IR (CH_2Cl_2) ν 3401, 3055, 2970, 2925, 1725, 1655, 1590, 1479, 1433, 1389, 1306, 1271, 1239, 1198, 1185, 1165, 1089, 1026, 969 cm^{-1}; ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.20 (s, 3H, CH_3), 4.51 (d, 1H, *J* = 6.0 Hz, CH), 4.53 (d, 1H, *J* = 6.0 Hz, CH), 5.98 (d, 2H, *J* = 7.8 Hz, ArH), 6.68 (d, 1H, *J* = 7.8 Hz, ArH), 6.78-6.89 (m, 9H, ArH); 6.91-7.03 (m, 6H, ArH), 7.07-7.13 (m, 3H, ArH), 7.12-7.19 (m, 5H, ArH), 7.32 (q, 2H, *J* = 6.0 Hz, ArH), 7.53 (t, 2H, *J* = 8.4 Hz, ArH), 7.80 (d, 1H, *J* = 8.0 Hz, ArH), 7.91 (d, 1H, *J* = 8.0 Hz, ArH), 7.98-8.01 (m, 3H, ArH), 8.15 (d, 1H, *J* = 8.0 Hz, ArH); ^{31}P NMR ($CDCl_3$, 162 MHz, 85% H_3PO_4) δ -14.69; MS (ESI) *m/z* (%): 813.6 (100) [M^++1]; HRMS (MALDI) Calcd. for $C_{54}H_{42}N_2O_2PS^{+1}$($M^+$+1) requires 817.2702, Found: 817.2698. $[\alpha]^{20}_D$ = -19.5 (c 0.35, $CHCl_3$).

(4*S*,5*S*)-2-((*S*)-2'-(diphenylphosphino)-1,1'-binaphthyl-2-yl)-4,5-diphenyl-1-tosyl-4,5-dihydro-1H-imidazoline **L11**. Yield: (237 mg, 49% for two steps). A pale yellow solid, m.p. 151-153 ^{o}C; IR (CH_2Cl_2) ν 3358, 3075, 2900, 1755, 1642, 1602, 1598, 1459, 1430, 1361, 1300, 1277, 1247, 1215, 1195, 1165, 1089, 1007, 960 cm^{-1}; ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.20 (s, 3H, CH_3), 4.50 (d, 1H, *J* = 5.2 Hz, CH), 4.59 (d, 1H, *J* = 5.2 Hz, CH), 5.85 (d, 2H, *J* = 7.2 Hz, ArH), 6.68 (d, 1H, *J* = 8.4 Hz, ArH), 6.78-6.89 (m, 9H, ArH); 6.91-7.01 (m, 5H, ArH), 7.07-7.11 (m, 4H, ArH), 7.12-7.19 (m, 4H, ArH), 7.22 (s, 1H, ArH), 7.32 (q, 2H, *J* = 6.0 Hz, ArH), 7.53 (t, 2H, *J* = 8.4 Hz, ArH), 7.80 (d, 1H, *J* = 8.0 Hz, ArH), 7.91 (d, 1H, *J* = 8.0 Hz, ArH), 7.98-8.03 (m, 3H, ArH), 8.15 (d, 1H, *J* = 8.0 Hz, ArH); ^{31}P NMR ($CDCl_3$, 162 MHz, 85% H_3PO_4) δ -14.70; MS (ESI) *m/z* (%): 813.6 (100) [M^++1]; HRMS (MALDI) Calcd. for $C_{54}H_{42}N_2O_2PS^{+1}$($M^+$+1) requires 817.2702, Found: 817.2698. $[\alpha]^{20}_D$ = +16.8 (c 0.45, $CHCl_3$).

(4*R*,5*R*)-2-((*S*)-2'-(diphenylphosphino)-1,1'-binaphthyl-2-yl)-4,5-diphenyl-1-tosyl-4,5-dihydro-1H-imidazoline **L12**. Yield: (186 mg, 59% for two steps). A pale yellow solid, m.p. 155-158 ^{o}C; IR (CH_2Cl_2) ν 3411, 3380, 3055, 3020, 2973, 2925, 1725, 1642, 1608, 1479, 1433, 1371, 1300, 1277, 1247, 1205, 1175, 1157, 1089, 1026, 960, 895 cm^{-1}; ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.26 (s, 3H, CH_3), 4.48 (d, 1H, *J* = 6.0 Hz, CH), 4.54 (d, 1H, *J* = 6.0 Hz, CH), 5.85 (d, 1H, *J* = 7.2 Hz, ArH), 6.68 (d, 1H, *J* = 7.2 Hz, ArH), 6.79-6.92 (m, 9H, ArH), 6.97-7.03 (m, 5H, ArH), 7.09-7.12 (m, 4H, ArH), 7.18-7.24 (m, 5H, ArH), 7.31-7.36 (m, 2H, ArH), 7.51-7.56 (m, 2H, ArH), 7.80 (d, 1H, *J* = 8.8 Hz, ArH), 7.92 (d, 1H, *J* = 8.4 Hz, ArH), 7.98-8.04 (m, 3H, ArH), 8.16 (d, 1H, *J* = 8.4 Hz, ArH); ^{31}P NMR ($CDCl_3$, 162 MHz, 85%

H_3PO_4) δ -14.84; MS (ESI) *m/z* (%): 813.6 (100) [M^++1]; HRMS (MALDI) Calcd. for $C_{54}H_{42}N_2O_2PS^{+1}$($M^+$+1) requires 817.2702, Found: 817.2700. $[\alpha]^{20}_D$ = -36.1 (c 0.40, $CHCl_3$).

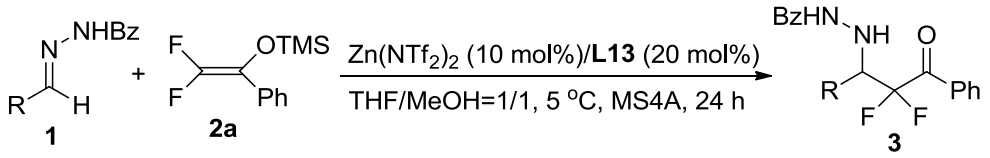
(4*S*,5*S*)-2-((*R*)-2'-(bis(3,5-dimethylphenyl)phosphino)-1,1'-binaphthyl-2-yl)-4,5-diphenyl-1-tosyl-4,5-dihydro-1H-imidazoline **L13**. Yield: (138 mg, 50% for two steps). A pale yellow solid, m.p. 150-153 ^oC; IR (CH_2Cl_2) ν 3395, 3152, 2958, 2925, 1886, 1725, 1642, 1590, 1485, 1433, 1371, 1316, 1277, 1207, 1185, 1167, 1075, 1029, 1001, 903 cm^{-1}; ^1H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.88 (s, 6H, CH_3), 2.01 (s, 6H, CH_3), 2.24 (s, 3H, CH_3), 4.48 (dd, 2H, *J* = 8.0, 6.0 Hz, CH), 5.84 (d, 2H, *J* = 7.2 Hz, ArH), 6.43 (d, 2H, *J* = 7.2 Hz, ArH), 6.69-6.91 (m, 13H, ArH), 7.00 (d, 1H, *J* = 7.2 Hz, ArH), 7.14-7.18 (m, 2H, ArH), 7.40 (d, 1H, *J* = 8.0 Hz, ArH), 7.51-7.66 (m, 1H, ArH), 7.68 (d, 1H, *J* = 8.4 Hz, ArH), 7.82-8.00 (m, 3H, ArH), 8.04 (d, 1H, *J* = 8.4 Hz, ArH), 8.16 (d, 1H, *J* = 8.4 Hz, ArH); ^{31}P NMR ($CDCl_3$, 162 MHz, 85% H_3PO_4) δ -13.79; MS (ESI) *m/z* (%): 869.7 (100) [M^++1]; HRMS (MALDI) Calcd. for $C_{58}H_{50}N_2O_2PS^{+1}$($M^+$+1) requires 869.3357, Found: 869.3325. $[\alpha]^{20}_D$ = +45.8 (c 0.40, $CHCl_3$).

(4*S*,5*S*)-2-((*R*)-2'-(bis(3,5-dimethoxyphenyl)phosphino)-1,1'-binaphthyl-2-yl)-4,5-diphenyl-1-tosyl-4,5-dihydro-1H-imidazoline **L14**. Yield: (185 mg, 66% for two steps). A pale yellow solid, m.p. 156-159 ^oC; IR (CH_2Cl_2) ν 3403, 3295, 3155, 2993, 2725, 1825, 1769, 1642, 1595, 1479, 1333, 1306, 1277, 1219, 1205, 1185, 1167, 1009, 958, 858 cm^{-1}; ^1H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.26 (s, 3H, CH_3), 3.36 (s, 6H, OCH_3), 3.48 (s, 6H, OCH_3), 4.46 (d, 1H, *J* = 6.0 Hz, CH), 4.58 (d, 1H, *J* = 6.0 Hz, CH), 5.79 (d, 1H, *J* = 7.6 Hz, ArH), 6.00 (dd, 2H, *J* = 4.8, 2.4 Hz, ArH), 6.20 (dt, 2H, *J* = 4.8, 2.4 Hz, ArH), 6.34 (dd, 2H, *J* = 7.2, 2.4 Hz, ArH), 6.63 (d, 1H, *J* = 8.0 Hz, ArH), 6.77-6.91 (m, 7H, ArH), 6.99 (t, 1H, *J* = 7.2 Hz, ArH), 7.15-7.24 (m, 5H, ArH), 7.31-7.34 (m, 2H, ArH), 7.35-7.60 (m, 2H, ArH), 7.82 (d, 1H, *J* = 8.4 Hz, ArH), 7.90 (d, 1H, *J* = 8.4 Hz, ArH), 8.00 (t, 1H, *J* = 8.8 Hz, ArH), 8.03 (d, 1H, *J* = 8.4 Hz, ArH), 8.16 (d, 1H, *J* = 8.4 Hz, ArH); ^{31}P NMR ($CDCl_3$, 162 MHz, 85% H_3PO_4) δ -9.88; MS (ESI) *m/z* (%): 934.0 (100) [M^++1]; HRMS (MALDI) Calcd. for $C_{58}H_{50}N_2O_6PS^{+1}$($M^+$+1) requires 933.3131, Found: 933.3122. $[\alpha]^{20}_D$ = +47.0 (c 0.20, $CHCl_3$).

4. Typical procedure for the zinc(II)-catalyzed asymmetric Mannich-type difluorination of hydrazone with difluoroenoxysilane 2. $Zn(NTf_2)_2$ (0.01 mmol) and chiral imidazoline-phosphine ligand **L13** (0.02 mmol) were added into a Shlenk tube and then MeOH/THF (1/1) 1.0 mL was added into the reaction vessel. The resulting solution was allowed to stir for 2.0 h at room temperature (25 ^oC). Then hydrazone 0.10 mmol was added into the mixture, and the reaction mixture was cooled to 5 ^oC. A freshly prepared difluoroenoxysilane **2** (0.30 mmol) was added dropwise by syringe. The reaction mixture was allowed to stir for 24 h at 5 ^oC. After being quenched by addition of a saturated aqueous solution of NH_4Cl (5.0 mL), the mixture was extracted by DCM and washed with brine. The organic layer was dried over anhydrous Na_2SO_4. Then the solvent was removed under reduced pressure and the residue was purified by flash column chromatography (SiO_2) to give the corresponding product **3a**.

In the case of hydrazone **1r**, bearing a 2-chlorobenzene group, the corresponding product **3r** was given in low yield and *ee*, presumably due to the steric effect (Table SI-1, entry 17). However, substrate **1s**, bearing a 3-nitrobenzene group afforded **3s** in lower yield and enantioselectivity relatively (Table SI-1, entry 18). Experiments showed that hydrazone **1p** [R = $CH_3(CH_2)_6$], which bearing a sterically more bulky substituent than **1t**, afforded difluorination product **3p** in 60% *ee*, an increased enantioselectivity was achieved for the comparison of **3t** (Table 3, entry 15 and Table SI-1, entry 19). Similar results were obtained for the comparison of the corresponding adducts **3q** (R = cyclopropyl) and **3u** (R = cyclohexyl) (up to 78% *ee*, Table 3, entry 16 and Table SI-1, entry 20).

Table SI-1. Scope and limitations of $Zn(NTf_2)_2$-catalyzed asymmetric Mannich-type reaction of aromatic hydrazones with difluoroenoxysilane **2a.**

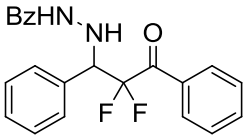


entry[a]	hydrazone **1** (R)	yield[b] (%) **3**	ee[c] (%) **3**	absolute configuration[d]
1	**1b** (4-ClC_6H_4)	**3b**, 75	95	S
2	**1c** (4-BrC_6H_4)	**3c**, 79	96	S
3	**1d** (4-FC_6H_4)	**3d**, 83/67[e]	87/93[e]	S
4	**1e** (4-MeC_6H_4)	**3e**, 73	92	S
5	**1f** (4-$MeOC_6H_4$)	**3f**, 87	94	S
6[f]	**1g** (4-$NO_2C_6H_4$)	**3g**, 79	90	S
7	**1h** (4-CNC_6H_4)	**3h**, 67	91	S
8	**1i** (4-$CF_3C_6H_4$)	**3i**, 69	90	S
9	**1j** (3-ClC_6H_4)	**3j**, 71	94	S
10	**1k** (1-Naphthyl)	**3k**, 69	91	S
11	**1l** (2-Naphthyl)	**3l**, 72	94	S
12	**1m** (2-Furyl)	**3m**, 77	57	S
13	**1n** (2-Thienyl)	**3n**, 59/51[e]	83/90[e]	S
14	**1o** (3-Thienyl)	**3o**, 79/69[e]	87/94[e]	S
15	**1p** [$CH_3(CH_2)_6$]	**3p**, 53	60	S
16	**1q** (Cyclohexyl)	**3q**, 52	78	S
17	**1r** (2-ClC_6H_4)	**3r**, 38/43[g]	36/75[g]	S
18	**1s** (3-$NO_2C_6H_4$)	**3s**, 60	62	S
19	**1t** [$CH_3(CH_2)_2$]	**3t**, 61	48	S
20	**1u** (Cyclopropyl)	**3u**, 59	35	S

[a] Reaction conditions: **1** (0.10 mmol), **2a** (0.30 mmol), $Zn(NTf_2)_2$ (10 mol%), **L13** (20 mol%), THF (0.50 mL), MeOH (0.50 mL) and MS 4A (50 mg), the reaction was carried out at 5 °C for 24 h. [b] Isolated yield after column chromatography. [c] Determined by chiral HPLC analysis. [d] Determined by the X-ray diffraction. [e] The reaction was carried out at 0 °C. [f] The reaction was carried out at 25 °C. [g] **L14** was utilized instead of **L13**.

5. Analytical data for $Zn(NTf_2)_2$-catalyzed Mannich-type adducts 3a-3u

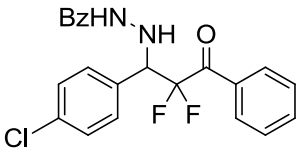
***N*-(2,2-difluoro-3-oxo-1,3-diphenylpropyl)benzohydrazide (3a)**.



A pale yellow oil (79%, 30 mg); IR (acetone): ν 3293, 3064, 2374, 1775, 1702, 1697, 1676, 1655, 1598, 1579, 1528, 1450, 1310, 1283, 1211, 1184, 1066, 907 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, TMS): δ 5.01 (t, 1H, J = 12.6 Hz, NH), 5.46 (br, 1H, CH), 7.34-7.60 (m, 13H, ArH), 7.69 (s, 1H, BzNH), 7.95 (d, 2H, J = 7.8 Hz, ArH); ^{13}C NMR (75 MHz, $CDCl_3$, TMS): δ 66.5 (dd, $J_{C\text{-}F}$ = 23.8, 21.1 Hz), 117.3 (t, $J_{C\text{-}F}$ = 259.1 Hz), 126.8, 128.5, 128.6, 129.1, 129.5, 129.9

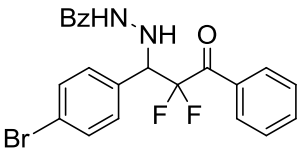
(t, $J_{C\text{-}F}$ = 3.6 Hz), 131.9, 132.1, 132.4 (t, $J_{C\text{-}F}$ = 1.9 Hz), 132.7 (d, $J_{C\text{-}F}$ = 2.3 Hz), 134.2, 167.5, 189.6 (t, $J_{C\text{-}F}$ = 28.7 Hz); ^{19}F NMR (282 MHz, $CDCl_3$, TMS): δ -111.5 (dd, 1F, J = 276, 12 Hz), -114.0 (dd, 1F, J = 276, 14 Hz); MS (ESI) *m/z* (%): 381 (100) [M^++1]; HRMS (MALDI) Calcd. for $C_{22}H_{18}F_2N_2O_2Na^{+1}$($M^+$+1) requires 403.1234, Found: 403.1229. Enantiomeric excess was determined by HPLC with a Chiralcel OJ-H column (hexane/*i*PrOH = 60/40, 0.6 mL/min, 230 nm, t_{minor} = 25.55 min, t_{majorr} = 18.77 min; $[\alpha]^{20}_D$ = +29.3 (c 0.55, $CHCl_3$), 93 % *ee*).

_N_-(1-(4-chlorophenyl)-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3b).



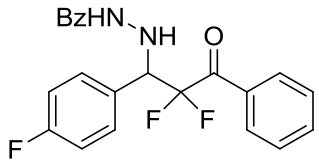
A pale yellow oil (75%, 31 mg); IR (acetone): ν 3293, 3064, 2925, 2854,1777, 1703, 1649, 1598, 1579, 1527, 1492, 1467, 1449, 1310, 1282, 1211, 1184, 1091, 1016, 925, 908 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, TMS): δ 5.02 (t, 1H, J = 12.6 Hz, NH), 5.46 (br, 1H, CH), 7.30-7.51 (m, 9H, ArH), 7.55-7.62 (m, 3H, ArH), 7.76 (d, 1H, J = 4.8 Hz, BzNH), 7.98 (d, 2H, J = 7.8 Hz, ArH); ^{13}C NMR (75 MHz, $CDCl_3$, TMS): δ 65.9 (dd, $J_{C\text{-}F}$ = 23.3, 20.9 Hz), 117.0 (t, $J_{C\text{-}F}$ = 261.1 Hz), 126.8, 128.6, 128.7, 128.8, 130.0 (t, $J_{C\text{-}F}$ = 3.5 Hz), 130.9, 131.4, 132.0, 132.1, 132.3, 134.5, 135.2, 167.6, 189.3 (t, $J_{C\text{-}F}$ = 29.0 Hz); ^{19}F NMR (282 MHz, $CDCl_3$, TMS): δ -111.3 (dd, 1F, J = 278, 12 Hz), -114.3 (dd, 1F, J = 278, 16 Hz); MS (ESI) *m/z* (%): 415 (100) [M^++1]; HRMS (MALDI) Calcd. for $C_{22}H_{17}ClF_2N_2O_2Na^{+1}$($M^+$+1) requires 437.0844, Found: 437.0839. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 80/20, 0.7 mL/min, 214 nm, t_{minor} = 12.70 min, t_{majorr} = 14.85 min; $[\alpha]^{20}_D$ = +39.2 (c 1.05, $CHCl_3$), 95 % *ee*).

_N_-(1-(4-bromophenyl)-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3c).



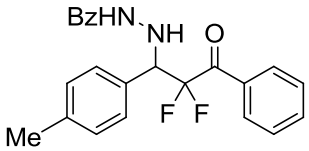
A yellow oil (79%, 36 mg); IR (acetone): ν 3292, 3064, 2924, 2853,1778, 1704, 1645, 1597, 1579, 1528, 1488, 1467, 1449, 1309, 1281, 1212, 1182, 1072, 1012, 925, 908 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, TMS): δ 4.99 (t, 1H, *J* = 12.3 Hz, NH), 5.45 (d, 1H, *J* = 3.3 Hz, CH), 7.36-7.51 (m, 9H, ArH), 7.55-7.63 (m, 3H, ArH), 7.73 (d, 1H, *J* = 6.0 Hz, BzNH), 7.98 (d, 2H, *J* = 7.8 Hz, ArH); ^{13}C NMR (75 MHz, $CDCl_3$, TMS): δ 65.9 (dd, J_{C-F} = 23.6, 20.3 Hz), 116.9 (t, J_{C-F} = 260.0 Hz), 123.4, 126.8, 128.6, 128.7, 130.0 (t, J_{C-F} = 3.4 Hz), 131.2, 131.7, 131.9, 132.1, 132.3, 134.5, 167.6, 189.2 (t, J_{C-F} = 28.7 Hz); ^{19}F NMR (282 MHz, $CDCl_3$, TMS): δ -111.1 (dd, 1F, *J* = 279, 12 Hz), -114.5 (dd, 1F, *J* = 279, 14 Hz); MS (ESI) *m/z* (%): 460 (97) $[M^+ +1]$; HRMS (MALDI) Calcd. for $C_{22}H_{17}BrF_2N_2O_2^{+1}(M^+ +1)$ requires 459.0518, Found: 459.0514. Enantiomeric excess was determined by HPLC with a Chiralcel IC-H column (hexane/*i*PrOH = 90/10, 0.6 mL/min, 214 nm, t_{minor} = 27.45 min, t_{majorr} = 29.36 min; $[\alpha]^{20}_D$ = +55.3 (c 2.00, $CHCl_3$), 96 % *ee*).

_N_-(2,2-difluoro-1-(4-fluorophenyl)-3-oxo-3-phenylpropyl)benzohydrazide (3d).



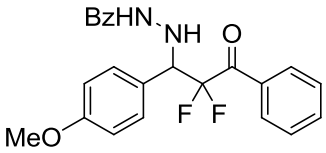
A colorless oil (83%, 33 mg); IR (CH_2Cl_2): ν 3295, 3062, 1698, 1650, 1600, 1579, 1510, 1462, 1450, 1266, 1228, 1161, 1102, 1066, 1027, 1001, 965, 907 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$, TMS): δ 5.03 (td, 1H, *J* = 14.0, 2.0 Hz, CH), 5.59 (dd, 1H, *J* = 5.6, 2.4 Hz, NH), 6.98 (t, 2H, *J* = 7.6 Hz, ArH), 7.33 (t, 2H, *J* = 7.6 Hz, ArH), 7.37-7.46 (m, 5H, ArH), 7.55 (d, 3H, *J* = 8.0 Hz, ArH), 7.94 (d, 2H, *J* = 8.0 Hz, ArH), 8.03 (d, 1H, *J* = 6.0 Hz, BzNH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 65.6 (dd, J_{C-F} = 23.5, 20.3 Hz), 115.4 (d, J_{C-F} = 21.2 Hz), 117.1 (t, J_{C-F} = 258.5 Hz), 126.8, 128.5, 128.6, 129.9 (t, J_{C-F} = 3.4 Hz), 131.3 (d, J_{C-F} = 8.5 Hz), 132.0, 132.3, 134.3, 163.0 (d, J_{C-F} = 247.0 Hz), 167.6, 189.4 (t, J_{C-F} = 28.7 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -106.1 (dd, 1F, *J* = 277, 12 Hz), -108.8 (dd, 1F, *J* = 277, 14 Hz), -112.1; MS (ESI) *m/z* (%): 421.3 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{22}H_{17}F_3N_2O_2Na^{+1}$ $(M+Na)^+$ requires 421.1136, Found: 421.1134. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 80/20, 0.7 mL/min, 230 nm, t_{minor} = 15.08 min, t_{majorr} = 17.47 min; $[\alpha]^{20}_D$ = +22.2 (c 0.85, $CHCl_3$), 93 % *ee*).

***N*-(2,2-difluoro-3-oxo-3-phenyl-1-p-tolylpropyl)benzohydrazide (3e)**.



A pale yellow oil (73%, 29 mg); IR (acetone): ν 3294, 3061, 3030, 2923, 2860, 1779, 1706, 1648, 1598, 1579, 1515, 1449, 1309, 1283, 1183, 1126, 1068, 1026, 925 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, TMS): δ 2.33 (s, 3H, CH_3), 4.96 (t, 1H, J = 13.5 Hz, NH), 5.44 (d, 1H, J = 5.1 Hz, CH), 7.15 (d, 2H, J = 7.8 Hz, ArH), 7.35-7.51 (m, 7H, ArH), 7.57 (d, 3H, J = 6.9 Hz, ArH), 7.63 (d, 1H, J = 4.8 Hz, BzNH), 7.97 (d, 2H, J = 7.5 Hz, ArH); ^{13}C NMR (75 MHz, $CDCl_3$, TMS): δ 21.2, 66.5 (dd, $J_{C\text{-}F}$ = 21.3, 2.4 Hz), 118.2 (t, $J_{C\text{-}F}$ = 302.0 Hz), 126.8, 128.6, 129.3 (d, $J_{C\text{-}F}$ = 3.2 Hz), 129.7, 130.0 (t, $J_{C\text{-}F}$ = 3.5 Hz), 132.0, 132.2, 132.6, 134.3, 139.1, 167.3, 189.7 (t, $J_{C\text{-}F}$ = 29.5 Hz); ^{19}F NMR (282 MHz, $CDCl_3$, TMS): δ -111.7 (dd, 1F, J = 277, 13 Hz), -114.0 (dd, 1F, J = 277, 14 Hz); MS (ESI) *m/z* (%): 395 (100) $[M^{+}+1]$; HRMS (MALDI) Calcd. for $C_{23}H_{21}F_2N_2O_2^{+1}(M^{+}+1)$ requires 395.1574, Found: 395.1565. Enantiomeric excess was determined by HPLC with a Chiralcel AD-H column (hexane/*i*PrOH = 80/20, 0.7 mL/min, 230 nm, t_{minor} = 19.67 min, t_{majorr} = 23.60 min; $[\alpha]^{20}_{D}$ = +37.8 (c 1.50, $CHCl_3$), 92 % *ee*).

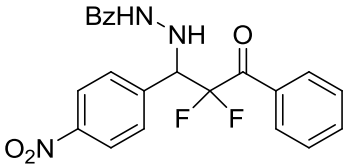
***N*-(2,2-difluoro-1-(4-methoxyphenyl)-3-oxo-3-phenylpropyl)benzohydrazide (3f)**.



A pale yellow oil (87%, 36 mg); IR (acetone): ν 3298, 3065, 3003, 2958, 2934, 2838, 1775, 1709, 1642, 1612, 1580, 1514, 1449, 1363, 1306, 1253, 1179, 1125, 1072, 1027, 925 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, TMS): δ 3.78 (s, 3H, OCH_3), 4.99 (dt, 1H, J = 14.4, 1.8 Hz, NH), 5.41 (d, 1H, J = 4.5 Hz, CH), 6.85 (d, 2H, J = 8.7 Hz, ArH), 7.35-7.50 (m, 7H, ArH), 7.55-7.60 (m, 3H, ArH), 7.69 (d, 1H, J = 6.0 Hz, BzNH), 7.96 (d, 2H, J = 7.2 Hz, ArH); ^{13}C NMR (75 MHz, $CDCl_3$, TMS): δ 55.2, 66.1 (dd, $J_{C\text{-}F}$ = 22.9, 21.0 Hz), 113.9, 119.2 (t, $J_{C\text{-}F}$ = 130.2 Hz), 124.6 (d, $J_{C\text{-}F}$ = 2.7 Hz), 126.8, 128.6, 130.0 (t, $J_{C\text{-}F}$ = 3.4 Hz), 130.7, 131.9, 132.2,

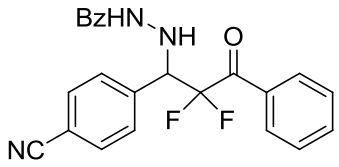
132.5, 134.2, 160.1, 167.3, 189.7 (t, $J_{C\text{-}F}$ = 28.3 Hz); ^{19}F NMR (282 MHz, $CDCl_3$, TMS): δ -112.0 (dd, 1F, *J* = 292, 14 Hz), -113.9 (dd, 1F, *J* = 292, 13 Hz); MS (ESI) *m/z* (%): 411 (100) [M^++1]; HRMS (MALDI) Calcd. for $C_{23}H_{21}F_2N_2O_3^{+1}$($M^+$+1) requires 411.1520, Found: 411.1515. Enantiomeric excess was determined by HPLC with a Chiralcel IC-H column (hexane/*i*PrOH = 85/15, 0.6 mL/min, 214 nm, t_{minor} = 34.63 min, t_{majorr} = 36.93 min; $[\alpha]^{20}_D$ = +50.1 (c 1.50, $CHCl_3$), 94 % *ee*).

_N_-(2,2-difluoro-1-(4-nitrophenyl)-3-oxo-3-phenylpropyl)benzohydrazide (3g).



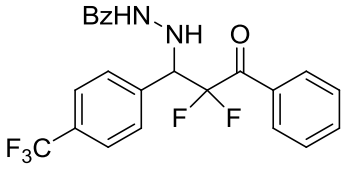
A pale yellow solid, m.p. 130-133 ^oC; (79%, 33 mg); IR (CH_2Cl_2): ν 3294, 3065, 2925, 1924, 1818, 1698, 1650, 1599, 1579, 1522, 1465, 1449, 1346, 1310, 1279, 1209, 1182, 1126, 1068, 1027, 1016, 975, 907 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$, TMS): δ 5.18 (t, 1H, *J* = 12.0 Hz, CH), 5.57 (br, 1H, NH), 7.35 (t, 2H, *J* = 8.0 Hz, ArH), 7.43-7.49 (m, 3H, ArH), 7.55-7.57 (m, 2H, ArH), 7.62 (t, 1H, *J* = 7.2 Hz, ArH), 7.70 (d, 2H, *J* = 8.0 Hz, ArH), 7.94 (d, 1H, *J* = 4.8 Hz, BzNH), 8.01 (d, 2H, *J* = 8.0 Hz, ArH), 8.15 (d, 2H, *J* = 8.0 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 65.6 (dd, $J_{C\text{-}F}$ = 23.7, 20.6 Hz), 116.7 (t, $J_{C\text{-}F}$ = 261.0 Hz), 123.5, 126.8, 128.6, 128.8, 129.9 (t, $J_{C\text{-}F}$ = 4.3 Hz), 130.7, 131.7, 132.0, 132.2, 134.7, 140.3, 148.2, 167.8, 188.7 (t, $J_{C\text{-}F}$ = 28.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -104.3 (dd, 1F, *J* = 287, 11 Hz), -109.1 (dd, 1F, *J* = 287, 16 Hz); MS (ESI) *m/z* (%): 448.4 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{22}H_{17}F_2N_3O_4Na^{+1}$ $(M+Na)^+$ requires 448.1080, Found: 448.1079. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 70/30, 0.7 mL/min, 230 nm, t_{minor} = 15.68 min, t_{majorr} = 21.75 min; $[\alpha]^{20}_D$ = +31.7 (c 1.05, $CHCl_3$), 90 % *ee*).

_N_-(1-(4-cyanophenyl)-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3h).



A pale yellow oil (67%, 27 mg); IR (CH_2Cl_2): ν 3296, 3061, 2925, 2854, 2230, 1969, 1920, 1818, 1698, 1651, 1598, 1579, 1504, 1465, 1450, 1417, 1308, 1266, 1209, 1184, 1126, 1067, 1025, 1001, 925, 907 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 5.12 (td, 1H, J = 11.2, 3.2 Hz, CH), 5.52 (dd, 1H, J = 6.0, 3.2 Hz, NH), 7.38 (t, 2H, J = 7.2 Hz, ArH), 7.43-7.51 (m, 3H, ArH), 7.55 (dd, 2H, J = 7.6, 1.2 Hz, ArH), 7.60-7.66 (m, 5H, ArH), 7.90 (d, 1H, J = 6.0 Hz, BzNH), 8.00 (d, 2H, J = 7.6 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 65.9 (dd, J_{C-F} = 23.9, 20.5 Hz), 112.9, 116.7 (t, J_{C-F} = 260.6 Hz), 118.3, 126.8, 128.6, 128.8, 130.0 (t, J_{C-F} = 3.6 Hz), 130.5, 131.7, 132.0, 132.1, 132.2, 134.7, 138.4, 167.7, 188.8 (t, J_{C-F} = 29.3 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -104.5 (dd, 1F, J = 286, 12 Hz), -109.1 (dd, 1F, J = 286, 15 Hz); MS (ESI) *m/z* (%): 428.4 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{23}H_{17}F_2N_3O_2Na^{+1}$ $(M+Na)^+$ requires 428.1184, Found: 428.1181. Enantiomeric excess was determined by HPLC with a Chiralcel AD-H column (hexane/*i*PrOH = 70/30, 0.6 mL/min, 214 nm, t_{minor} = 22.74 min, t_{majorr} = 28.87 min; $[\alpha]^{20}_D$ = +55.1 (c 1.00, $CHCl_3$), 91 % *ee*).

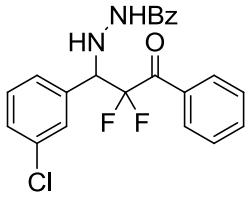
_N_-(2,2-difluoro-3-oxo-3-phenyl-1-(4-(trifluoromethyl)phenyl)propyl)benzohydrazide (3i).



A colorless solid, m.p. 128-131 °C; (69%, 31 mg); IR (CH_2Cl_2): ν 3376, 3242, 3066, 2925, 1920, 1821, 1696, 1671, 1660, 1597, 1580, 1515, 1450, 1423, 1325, 1296, 1270, 1216, 1157, 1121, 1068, 1020, 957, 926, 906 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 5.11 (td, 1H, J = 14.0, 2.0 Hz, CH), 5.51 (br, 1H, NH), 7.33 (t, 2H, J = 7.6 Hz, ArH), 7.40-7.48 (m, 3H, ArH), 7.53-7.64 (m, 7H, ArH), 7.92 (d, 1H, J = 5.6 Hz, BzNH), 7.97 (d, 2H, J = 7.6 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 66.0 (dd, J_{C-F} = 24.1, 21.0 Hz), 116.9 (t, J_{C-F} = 257.6 Hz), 123.7 (q, J_{C-F} = 270.8 Hz), 125.4 (q, J_{C-F} = 3.7 Hz), 126.8, 128.6, 128.7, 130.0 (t, J_{C-F} = 3.6

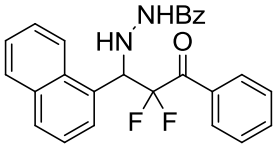
Hz), 130.1, 131.0 (q, $J_{C\text{-}F}$ = 32.5 Hz), 131.8, 132.1, 134.6, 137.0, 167.7, 189.1 (t, $J_{C\text{-}F}$ = 28.9 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -62.8, -104.8 (dd, 1F, *J* = 283, 12 Hz), -108.9 (dd, 1F, *J* = 283, 15 Hz); MS (ESI) *m/z* (%): 471.4 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{23}H_{17}F_5N_2O_2Na^{+1}$ $(M+Na)^+$ requires 471.1104, Found: 471.1102. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 80/20, 0.6 mL/min, 230 nm, t_{minor} = 15.60 min, t_{majorr} = 18.92 min; $[\alpha]^{20}_D$ = +21.6 (c 0.95, $CHCl_3$), 90 % *ee*).

***N*-(1-(3-chlorophenyl)-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3j)**.



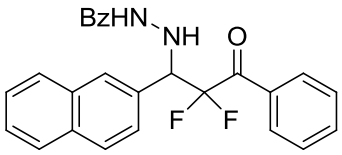
A pale yellow oil (71%, 29 mg); IR (acetone): ν 3303, 3066, 3003, 2922, 1968, 1908, 1818, 1779, 1715, 1638, 1598, 1579, 1528, 1449, 1361, 1309, 1282, 1220, 1186, 1055, 1027, 1001, 933, 910 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, TMS): δ 5.00 (dt, 1H, *J* = 11.4, 1.8 Hz, NH), 5.45 (d, 1H, *J* = 3.9 Hz, CH), 7.26-7.31 (m, 3H, ArH), 7.34-7.41 (m, 3H, ArH), 7.43-7.46 (m, 2H, ArNH), 7.48-7.62 (m, 4H, ArH), 7.77 (d, 1H, *J* = 5.7 Hz, BzNH), 7.98 (d, 2H, *J* = 7.2 Hz, ArH); ^{13}C NMR (75 MHz, $CDCl_3$, TMS): δ 66.0 (dd, $J_{C\text{-}F}$ = 23.5, 20.6 Hz), 116.9 (t, $J_{C\text{-}F}$ = 255 Hz), 126.8, 127.9, 128.6, 128.7, 129.3, 129.6, 129.8, 130.0 (t, $J_{C\text{-}F}$ = 3.3 Hz), 131.9, 132.0, 132.3 (t, $J_{C\text{-}F}$ = 2.6 Hz), 134.4, 134.5, 134.9 (d, $J_{C\text{-}F}$ = 2.6 Hz), 167.6, 189.2 (t, $J_{C\text{-}F}$ = 28.3 Hz); ^{19}F NMR (282 MHz, $CDCl_3$, TMS): δ -110.8 (dd, 1F, *J* = 280, 11 Hz), -114.5 (dd, 1F, *J* = 280, 16 Hz); MS (ESI) *m/z* (%): 415 (100) $[M^+{+}1]$; HRMS (MALDI) Calcd. for $C_{22}H_{17}ClF_2N_2O_2^{+1}(M^+{+}1)$ requires 415.1026, Found: 415.1019. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 90/10, 0.7 mL/min, 214 nm, t_{minor} = 23.63 min, t_{majorr} = 26.93 min; $[\alpha]^{20}_D$ = +33.3 (c 1.55, $CHCl_3$), 94 % *ee*).

***N*-(2,2-difluoro-1-(naphthalen-1-yl)-3-oxo-3-phenylpropyl)benzohydrazide (3k)**.



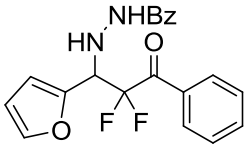
A yellow oil (69%, 29 mg); IR (acetone): ν 3292, 3062, 2925, 1919, 1779, 1704, 1656, 1598, 1579, 1514, 1468, 1449, 1362, 1310, 1277, 1184, 1125, 1069, 1028, 908 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, TMS): δ 5.56 (br, 1H, CH), 5.92 (t, 1H, J = 12.0 Hz, NH), 7.29-7.36 (m, 4H, ArH), 7.40-7.54 (m, 7H, ArH), 7.82-7.89 (m, 6H, ArNH), 8.15 (br, 1H, BzNH); ^{13}C NMR (75 MHz, $CDCl_3$, TMS): δ 60.5 (dd, J_{C-F} = 22.9, 21.2 Hz), 117.9 (t, J_{C-F} = 258.1 Hz), 124.9, 125.7, 126.7, 126.8, 128.4, 128.5, 128.7, 128.9, 129.8, 129.9 (t, J_{C-F} = 3.4 Hz), 131.9, 132.0, 132.2, 132.6, 133.7, 134.2, 167.5, 189.9 (t, J_{C-F} = 43.0 Hz); ^{19}F NMR (282 MHz, $CDCl_3$, TMS): δ -109.1 (dd, 1F, J = 274, 8 Hz), -113.1 (dd, 1F, J = 274, 11 Hz); MS (ESI) *m/z* (%): 431 (100) $[M^{+}+1]$; HRMS (MALDI) Calcd. for $C_{26}H_{21}F_2N_2O_2^{+1}(M^{+}+1)$ requires 431.1570, Found: 431.1565. Enantiomeric excess was determined by HPLC with a Chiralcel IC-H column (hexane/*i*PrOH = 70/30, 0.6 mL/min, 214 nm, t_{minor} = 18.49 min, t_{majorr} = 13.97 min; $[\alpha]^{20}_D$ = -9.5 (c 1.05, $CHCl_3$), 91 % *ee*).

***N*-(2,2-difluoro-1-(naphthalen-2-yl)-3-oxo-3-phenylpropyl)benzohydrazide (3l).**



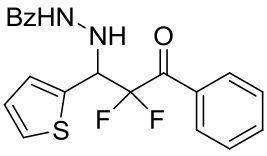
A pale yellow oil (72%, 31 mg); IR (CH_2Cl_2): ν 3293, 3059, 2925, 2852, 1919, 1817, 1698, 1657, 1599, 1580, 1510, 1450, 1372, 1309, 1266, 1184, 1121, 1068, 1027, 1001, 963, 909 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$, TMS): δ 5.20 (td, 1H, J = 14.0, 2.4 Hz, CH), 5.59 (dd, 1H, J = 6.0, 2.4 Hz, NH), 7.28 (t, 2H, J = 8.0 Hz, ArH), 7.34-7.47 (m, 5H, ArH), 7.51-7.53 (m, 3H, ArH), 7.61 (d, 1H, J = 8.0 Hz, BzNH), 7.74-7.80 (m, 3H, ArH), 7.88-7.96 (m, 4H, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 66.6 (dd, J_{C-F} = 23.8, 21.2 Hz), 117.4 (t, J_{C-F} = 257.0 Hz), 126.2, 126.5, 126.6, 126.8, 127.6, 128.1, 128.3, 128.5, 128.6, 129.5, 130.0 (t, J_{C-F} = 3.9 Hz), 130.2, 131.9, 132.1, 132.4, 132.9, 133.5, 134.3, 167.5, 189.5 (t, J_{C-F} = 28.4 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -105.3 (dd, 1F, J = 277, 12 Hz), -108.0 (dd, 1F, J = 277, 15 Hz); MS (ESI) *m/z* (%): 453.5 (100) $[M+Na]^{+}$; HRMS (MALDI) Calcd. for $C_{26}H_{20}F_2N_2O_2Na^{+1}$ $(M+Na)^{+}$ requires 453.1384, Found: 453.1385. Enantiomeric excess was determined by HPLC with a Chiralcel IC-H column (hexane/*i*PrOH = 80/20, 0.6 mL/min, 230 nm, t_{minor} = 25.58 min, t_{majorr} = 23.68 min; $[\alpha]^{20}_D$ = +56.3 (c 0.85, $CHCl_3$), 94 % *ee*).

***N*-(2,2-difluoro-1-(furan-2-yl)-3-oxo-3-phenylpropyl)benzohydrazide (3m)**.



A pale yellow oil (77%, 26 mg); IR (acetone): ν 3293, 3063, 2926, 2285, 1969, 1911, 1707, 1648, 1598, 1580, 1534, 1450, 1311, 1279, 1201, 1185, 1128, 1062, 1027, 1001, 917, 809 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, TMS): δ 5.15 (dt, 1H, *J* = 10.2, 3.0 Hz, NH), 5.59 (br, 1H, CH), 6.35 (dd, 1H, *J* = 3.3, 1.8 Hz, ArH), 6.50 (d, 1H, *J* = 3.3 Hz, ArH), 7.37-7.52 (m, 6H, ArH), 7.59-7.76 (m, 3H, ArH), 7.77 (d, 1H, *J* = 3.6 Hz, BzNH), 8.03 (d, 2H, *J* = 8.1 Hz, ArH); ^{13}C NMR (75 MHz, $CDCl_3$, TMS): δ 60.6 (dd, $J_{C\text{-}F}$ = 24.2, 22.1 Hz), 110.7, 111.3, 120.1 (t, $J_{C\text{-}F}$ = 261 Hz), 126.9, 128.7, 130.0 (t, $J_{C\text{-}F}$ = 3.5 Hz), 132.0, 132.2 (t, $J_{C\text{-}F}$ = 3.8 Hz), 134.4, 143.4, 146.3 (d, $J_{C\text{-}F}$ = 3.5 Hz), 167.4, 189.1 (t, $J_{C\text{-}F}$ = 28.7 Hz); ^{19}F NMR (282 MHz, $CDCl_3$, TMS): δ -109.6 (dd, 1F, *J* = 282, 10 Hz), -114.5 (dd, 1F, *J* = 282, 16 Hz); MS (ESI) *m/z* (%): 371 (100) $[M^{+}+1]$; HRMS (MALDI) Calcd. for $C_{20}H_{17}F_2N_2O_3^{+1}(M^{+}+1)$ requires 371.1213, Found: 371.1202. Enantiomeric excess was determined by HPLC with a Chiralcel OJ-H column (hexane/*i*PrOH = 70/30, 0.6 mL/min, 214 nm, t_{minor} = 24.22 min, t_{majorr} = 21.96 min; $[\alpha]^{20}_{D}$ = +16.7 (c 1.35, $CHCl_3$), 57 % *ee*).

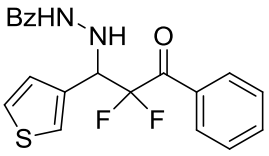
_N_-(2,2-difluoro-3-oxo-3-phenyl-1-(thiophen-2-yl)propyl)benzohydrazide (3n).



A pale yellow oil (59%, 23 mg); IR (CH_2Cl_2): ν 3293, 3063, 2925, 2854, 1818, 1698, 1650, 1598, 1580, 1524, 1462, 1450, 1309, 1276, 1208, 1179, 1122, 1064, 1027, 1001, 974, 920, 908 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$, TMS): δ 5.37 (td, 1H, *J* = 14.0, 2.8 Hz, CH), 5.50 (dd, 1H, *J* = 6.0, 2.8 Hz, NH), 6.97 (dd, 1H, *J* = 4.8, 2.8 Hz, ArH), 7.17 (d, 1H, *J* = 2.8 Hz, ArH), 7.32-7.49 (m, 6H, ArH), 7.59 (d, 3H, *J* = 7.2 Hz, ArH), 7.83 (d, 1H, *J* = 6.0 Hz, BzNH), 7.99 (d, 2H, *J* = 7.2 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 62.0 (dd, $J_{C\text{-}F}$ = 23.7, 21.8 Hz), 116.7 (t, $J_{C\text{-}F}$ = 259.7 Hz), 126.8, 126.9, 127.2, 128.6, 128.7, 129.4, 129.9 (t, $J_{C\text{-}F}$ = 3.4 Hz), 132.0, 132.3, 133.9, 134.4, 167.6, 189.2 (t, $J_{C\text{-}F}$ = 28.4 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -105.6 (dd, 1F, *J* = 278, 12 Hz), -108.6 (dd, 1F, *J* = 278, 13 Hz); MS (ESI) *m/z* (%):

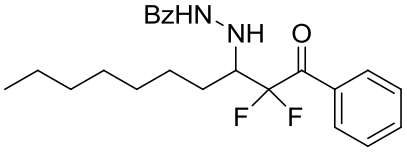
409.4 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{20}H_{16}F_2N_2O_2SNa^{+1}$ $(M+Na)^+$ requires 409.0790, Found: 409.0793. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 70/30, 0.7 mL/min, 230 nm, t_{minor} = 11.05 min, t_{majorr} = 15.27 min; $[\alpha]^{20}_D$ = +33.0 (c 0.25, $CHCl_3$), 90 % *ee*).

_N_-(2,2-difluoro-3-oxo-3-phenyl-1-(thiophen-3-yl)propyl)benzohydrazide (3o).



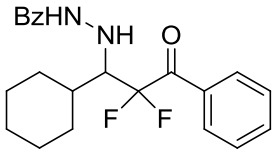
A pale yellow oil (79%, 30 mg); IR (CH_2Cl_2): ν 3292, 3060, 2926, 1818, 1698, 1653, 1598, 1579, 1522, 1450, 1310, 1266, 1201, 1184, 1159, 1126, 1067, 1027, 1001, 912 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 5.15 (td, 1H, *J* = 13.6, 1.6 Hz, CH), 5.38 (br, 1H, NH), 7.21-7.22 (m, 1H, ArH), 7.27-7.29 (m, 1H, ArH), 7.33-7.42 (m, 5H, ArH), 7.47 (t, 1H, *J* = 7.2 Hz, ArH), 7.56-7.59 (m, 3H, ArH and BzNH), 7.93 (d, 2H, *J* = 7.2 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 62.3 (dd, J_{C-F} = 24.0, 21.0 Hz), 117.2 (t, J_{C-F} = 257.0 Hz), 126.0, 126.1, 126.8, 127.9, 128.5, 128.6, 129.9 (t, J_{C-F} = 4.3 Hz), 131.9, 132.1, 132.4, 133.0, 134.3, 167.4, 189.5 (t, J_{C-F} = 28.7 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -106.1 (dd, 1F, *J* = 275, 12 Hz), -108.2 (dd, 1F, *J* = 275, 14 Hz); MS (ESI) *m/z* (%): 409.3 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{20}H_{16}F_2N_2O_2SNa^{+1}$ $(M+Na)^+$ requires 409.0790, Found: 409.0793. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 70/30, 0.7 mL/min, 230 nm, t_{minor} = 11.60 min, t_{majorr} = 17.60 min; $[\alpha]^{20}_D$ = +21.5 (c 0.75, $CHCl_3$), 94 % *ee*).

_N_-(2,2-difluoro-1-oxo-1-phenyldecan-3-yl)benzohydrazide (3p).



A colorless oil (53%, 21 mg); IR (CH_2Cl_2): ν 3299, 3064, 3032, 2955, 2927, 2856, 1968, 1817, 1698, 1644, 1599, 1579, 1526, 1450, 1377, 1347, 1309, 1284, 1249, 1180, 1120, 1071, 1027, 1002, 908 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 0.87 (t, 3H, J = 6.8 Hz, CH_3), 1.27-1.39 (m, 8H, CH), 1.52-1.83 (m, 4H, CH), 3.69 (td, 1H, J = 12.4, 6.4 Hz, CH), 5.09 (d, 1H, J = 6.8 Hz, NH), 7.37 (t, 2H, J = 7.6 Hz, ArH), 7.46 (t, 3H, J = 7.6 Hz, ArH), 7.57-7.62 (m, 5H, ArH), 7.74 (d, 1H, J = 7.2 Hz, BzNH), 8.08 (d, 2H, J = 8.0 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 14.0, 22.5, 26.0, 26.3 (t, J_{C-F} = 3.5 Hz), 28.9, 29.5, 31.7, 63.7 (dd, J_{C-F} = 24.2, 20.6 Hz), 118.6 (t, J_{C-F} = 254.2 Hz), 126.8, 128.5, 128.7, 129.9 (t, J_{C-F} = 3.7 Hz), 131.9, 132.2, 134.3, 167.0, 190.4 (t, J_{C-F} = 29.0 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -105.1 (dd, 1F, J = 277, 10 Hz), -111.6 (dd, 1F, J = 277, 17 Hz); MS (ESI) *m/z* (%): 425.4 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{23}H_{28}F_2N_2O_2Na^{+1}$ $(M+Na)^+$ requires 425.2023, Found: 425.2021. Enantiomeric excess was determined by HPLC with a Chiralcel OJ-H column (hexane/*i*PrOH = 98/2, 0.8 mL/min, 214 nm, t_{minor} = 27.57 min, t_{majorr} = 33.42 min; $[\alpha]^{20}_D$ = -18.0 (c 0.55, $CHCl_3$), 60 % *ee*).

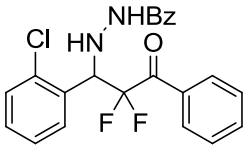
_N_-(1-cyclohexyl-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3q).



A colorless oil (52%, 20 mg); IR (CH_2Cl_2): ν 3225, 3058, 2924, 2854, 1972, 1816, 1699, 1640, 1609, 1573, 1529, 1501, 1479, 1448, 1403, 1368, 1348, 1318, 1301, 1265, 1218, 1183, 1153, 1105, 1073, 1051, 1027, 1003, 968, 949, 916 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 1.48-1.77 (m, 4H, CH), 1.86-1.90 (m, 3H, CH), 2.05-2.08 (m, 1H, CH), 3.38-3.45 (m, 1H, CH), 3.48-3.57 (m, 1H, CH), 4.43 (d, 1H, J = 13.6 Hz, CH), 5.22 (br, 1H, NH), 7.33-7.45 (m, 5H, ArH), 7.49-7.51 (m, 1H, ArH), 7.56 (d, 1H, J = 7.8 Hz, ArH), 7.66 (d, 1H, J = 2.0 Hz, BzNH), 7.75 (d, 1H, J = 7.2 Hz, ArH), 8.03 (d, 1H, J = 7.8 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 14.2, 25.4 (d, J_{C-F} = 14.3 Hz), 26.0 (d, J_{C-F} = 11.5 Hz), 26.4 (d, J_{C-F} = 24.0 Hz), 28.5 (d, J_{C-F} = 9.3 Hz), 30.7, 34.7, 36.9, 65.7 (t, J_{C-F} = 23.2 Hz), 67.8 (dd, J_{C-F} = 23.2, 19.7 Hz), 119.5 (t, J_{C-F} = 255.5 Hz), 126.2, 126.8, 127.8, 128.4, 128.6, 128.7, 129.0, 129.1, 130.0 (t, J_{C-F} = 2.6 Hz), 131.4, 131.9, 132.3, 133.8, 134.2, 135.8, 166.5, 172.1, 190.8 (t, J_{C-F} =

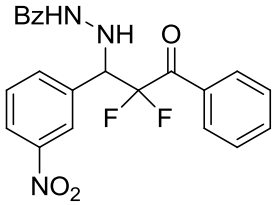
29.3 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -102.8 (dd, 1F, *J* = 276, 9 Hz), -108.0 (dd, 1F, *J* = 276, 19 Hz); MS (ESI) *m/z* (%): 409.4 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{22}H_{24}F_2N_2O_2Na^{+1}$ $(M+Na)^+$ requires 409.1704, Found: 409.1698. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 90/10, 0.5 mL/min, 230 nm, t_{minor} = 27.93 min, t_{majorr} = 21.87 min; $[\alpha]^{20}_D$ = -30.8 (c 0.50, $CHCl_3$), 78 % *ee*).

_N_-(1-(2-chlorophenyl)-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3r).



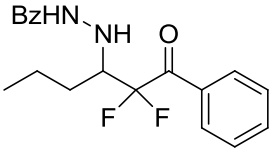
A pale yellow oil (43%, 18 mg); IR (acetone): ν 3291, 3065, 1968, 1901, 1818, 1780, 1703, 1648, 1598, 1579, 1528, 1475, 1449, 1362, 1308, 1282, 1181, 1128, 1070, 1028, 1001, 926, 901 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, TMS): δ 5.52 (br, 1H, NH), 5.66 (dd, 1H, *J* = 18.6, 7.5 Hz, CH), 7.29-7.48 (m, 8H, ArH), 7.50-7.63 (m, 4H, ArH), 7.77 (d, 1H, *J* = 7.5 Hz, BzNH), 8.07 (d, 2H, *J* = 7.5 Hz, ArH); ^{13}C NMR (75 MHz, $CDCl_3$, TMS): δ 62.1 (dd, J_{C-F} = 24.9, 20.6 Hz), 117.1 (t, J_{C-F} = 255 Hz), 126.8, 127.0, 128.5, 128.7, 129.7, 130.0 (t, J_{C-F} = 3.4 Hz), 130.2, 131.0, 131.9, 132.0, 132.2, 134.4, 135.5, 167.4, 189.2 (t, J_{C-F} = 27.9 Hz); ^{19}F NMR (282 MHz, $CDCl_3$, TMS): δ -109.3 (dd, 1F, *J* = 276, 7.6 Hz), -116.6 (dd, 1F, *J* = 276, 18 Hz); MS (ESI) *m/z* (%): 415 (100) $[M^+ +1]$; HRMS (MALDI) Calcd. for $C_{22}H_{17}ClF_2N_2O_2^{+1}(M^+ +1)$ requires 415.1032, Found: 415.1019. Enantiomeric excess was determined by HPLC with a Chiralcel IC-H column (hexane/*i*PrOH = 70/30, 0.6 mL/min, 214 nm, t_{minor} = 15.36 min, t_{majorr} = 13.55 min; $[\alpha]^{20}_D$ = -8.4 (c 1.15, $CHCl_3$), 75 % *ee*).

_N_-(2,2-difluoro-1-(3-nitrophenyl)-3-oxo-3-phenylpropyl)benzohydrazide (3s).



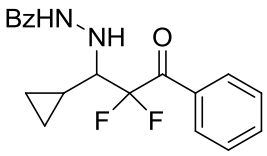
A yellow oil (60%, 25 mg); IR (CH_2Cl_2): ν 3293, 3065, 2956, 2924, 2854, 1970, 1913, 1819, 1698, 1650, 1598, 1580, 1530, 1464, 1450, 1399, 1350, 1308, 1281, 1188, 1161, 1129, 1182, 1066, 1027, 1002, 973, 908 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 5.20 (td, 1H, J = 11.2, 3.2 Hz, CH), 5.59 (br, 1H, NH), 7.32 (t, 2H, J = 8.0 Hz, ArH), 7.41-7.61 (m, 7H, ArH), 7.86 (d, 1H, J = 8.0 Hz, BzNH), 8.00 (d, 2H, J = 8.0 Hz, ArH), 8.15-8.21 (m, 2H, ArH), 8.42 (s, 1H, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 65.4 (dd, $J_{C\text{-}F}$ = 26.0, 24.0 Hz), 116.6 (t, $J_{C\text{-}F}$ = 232.3 Hz), 123.9, 124.5, 126.8, 128.5, 128.7, 129.4, 129.9 (t, $J_{C\text{-}F}$ = 3.4 Hz), 131.6, 131.9, 132.1, 134.6, 135.2, 136.0, 148.0, 167.8, 188.7 (t, $J_{C\text{-}F}$ = 28.3 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -104.1 (dd, 1F, J = 286, 10 Hz), -109.6 (dd, 1F, J = 286, 11 Hz); MS (ESI) *m/z* (%): 448.4 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{22}H_{217}F_2N_3O_4Na^{+1}$ $(M+Na)^+$ requires 448.1089, Found: 448.1079. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 90/10, 0.7 mL/min, 214 nm, t_{minor} = 43.88 min, t_{majorr} = 52.98 min; $[\alpha]^{20}_D$ = +16.0 (c 0.20, $CHCl_3$), 62 % *ee*).

_N_-(2,2-difluoro-1-oxo-1-phenylhexan-3-yl)benzohydrazide (3t).



A colorless oil (61%, 21 mg); IR (CH_2Cl_2): ν 3295, 3064, 2963, 2933, 2874, 1699, 1656, 1643, 1590, 1579, 1530, 1450, 1380, 1308, 1286, 1201, 1183, 1160, 1128, 1056, 1027, 1002, 973, 918 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 0.99 (t, 3H, J = 7.2 Hz, CH_3), 1.58-1.66 (m, 2H, CH_2), 1.76-1.80 (m, 2H, CH_2), 3.65-3.73 (m, 1H, CH), 5.06 (br, 1H, NH), 7.38 (t, 2H, J = 7.2 Hz, ArH), 7.45-7.49 (m, 3H, ArH), 7.61 (d, 3H, J = 7.2 Hz, ArH), 7.69 (d, 1H, J = 4.0 Hz, BzNH), 8.09 (d, 2H, J = 7.2 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 14.0, 19.4, 28.3 (t, $J_{C\text{-}F}$ = 2.1 Hz), 63.5 (dd, $J_{C\text{-}F}$ = 24.8, 21.6 Hz), 118.7 (t, $J_{C\text{-}F}$ = 258.1 Hz), 126.8, 127.8, 128.3, 128.6, 128.7, 129.0, 129.9 (t, $J_{C\text{-}F}$ = 3.6 Hz), 131.9, 132.2, 132.6, 134.3, 167.0, 190.5 (t, $J_{C\text{-}F}$ = 29.0 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -105.3 (dd, 1F, J = 276, 9 Hz), -111.7 (dd, 1F, J = 276, 17 Hz); MS (ESI) *m/z* (%): 369.4 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{19}H_{20}F_2N_2O_2Na^{+1}$ $(M+Na)^+$ requires 369.1379, Found: 369.1385. Enantiomeric excess was determined by HPLC with a Chiralcel OJ-H column (hexane/*i*PrOH = 70/30, 0.6 mL/min, 214 nm, t_{minor} = 8.67 min, t_{majorr} = 10.11 min; $[\alpha]^{20}_D$ = -13.3 (c 1.55, $CHCl_3$), 48 % *ee*).

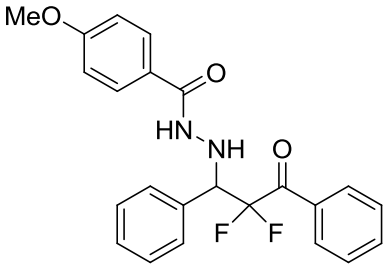
***N*-(1-cyclopropyl-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3u).**



A colorless oil (59%, 20 mg); IR (CH_2Cl_2): ν 3294, 3063, 3010, 1969, 1910, 1818, 1779, 1670, 1650, 1598, 1579, 1524, 1450, 1393, 1308, 1278, 1181, 1126, 1066, 1027, 1001, 967, 899 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 0.36-0.42 (m, 1H, CH), 0.58-0.77 (m, 3H, CH), 1.00-1.10 (m, 1H, CH), 2.96 (dd, 1H, J = 12.0, 8.4 Hz, CH), 5.13 (br, 1H, NH), 7.39 (t, 2H, J = 7.2 Hz, ArH), 7.44-7.51 (m, 3H, ArH), 7.58-7.64 (m, 3H, ArH), 7.91 (br, 1H, BzNH), 8.08 (d, 2H, J = 8.0 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 2.9, 4.6, 8.8 (t, $J_{C\text{-}F}$ = 4.7 Hz), 66.4 (t, $J_{C\text{-}F}$ = 22.0 Hz), 118.8 (t, $J_{C\text{-}F}$ = 256.0 Hz), 126.8, 128.6, 128.7, 129.9 (t, $J_{C\text{-}F}$ = 3.2 Hz), 131.9, 132.2, 132.9, 134.2, 167.4, 190.2 (t, $J_{C\text{-}F}$ = 27.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -107.6 (dd, 1F, J = 268, 13 Hz), -108.7 (dd, 1F, J = 268, 12 Hz); MS (ESI) *m/z* (%): 367.3 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{19}H_{18}F_2N_2O_2Na^{+1}$ $(M+Na)^+$ requires 367.1228, Found: 367.1228. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 80/20, 0.7 mL/min, 230 nm, t_{minor} = 11.25 min, t_{majorr} = 18.07 min; $[\alpha]^{20}_D$ = -15.5 (c 0.45, $CHCl_3$), 35 % *ee*).

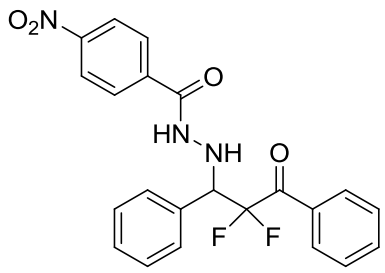
6. Analytical data for $Zn(NTf_2)_2$-catalyzed Mannich-type adducts 5a-5f

***N*-(2,2-difluoro-3-oxo-1,3-diphenylpropyl)-4-methoxybenzohydrazide (5a).**



A pale yellow oil (81%, 33 mg); IR (CH_2Cl_2): ν 3292, 3063, 2936, 2840, 1968, 1907, 1818, 1777, 1699, 1642, 1606, 1578, 1510, 1494, 1453, 1308, 1255, 1210, 1178, 1123, 1065, 1028, 1002, 907 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 3.78 (s, 3H, OCH_3), 4.99 (td, 1H, J = 14.0, 1.6 Hz, CH), 5.43 (d, 1H, J = 8.8 Hz, NH), 6.82 (d, 2H, J = 8.8 Hz, ArH), 7.30-7.32 (m, 3H, ArH), 7.39 (t, 2H, J = 8.0 Hz, ArH), 7.45-7.47 (m, 2H, ArH), 7.51-7.57 (m, 3H, ArH), 7.79 (d, 1H, J = 5.6 Hz, BzNH), 7.93 (d, 2H, J = 8.0 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 55.3, 66.7 (dd, $J_{C\text{-}F}$ = 23.7, 20.4 Hz), 113.7, 117.4 (t, $J_{C\text{-}F}$ = 261.0 Hz), 124.4, 128.5, 128.6, 128.7, 129.1, 129.5, 129.9 (t, $J_{C\text{-}F}$ = 3.2 Hz), 132.5, 132.8, 134.2, 162.5, 167.1, 189.6 (t, $J_{C\text{-}F}$ = 28.1 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -105.8 (dd, 1F, J = 274, 11 Hz), -108.6 (dd, 1F, J = 274, 14 Hz); MS (ESI) *m/z* (%): 433.4 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{23}H_{20}F_2N_2O_3Na^{+1}$ $(M+Na)^+$ requires 433.1342, Found: 433.1334. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 80/20, 0.7 mL/min, 214 nm, t_{minor} = 18.81 min, t_{majorr} = 27.63 min; $[\alpha]^{20}_D$ = +37.3 (c 0.45, $CHCl_3$), 94 % *ee*).

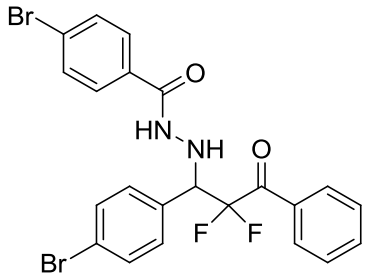
_N_-(2,2-difluoro-3-oxo-1,3-diphenylpropyl)-4-nitrobenzohydrazide (5b).



A yellow solid, m.p. 137-139 ^oC; (59%, 25 mg); IR (CH_2Cl_2): ν 3323, 3298, 3106, 3071, 3034, 2925, 2854, 1690, 1677, 1598, 1579, 1520, 1493, 1482, 1450, 1405, 1346, 1325, 1296, 1263, 1197, 1178, 1123, 1108, 1090, 1072, 1030, 1001, 975, 927, 906 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 5.01 (t, 1H, J = 12.0 Hz, CH), 5.51 (d, 1H, J = 4.0 Hz, NH), 7.36-7.49 (m, 7H, ArH), 7.60 (t, 1H, J = 7.6 Hz, ArH), 7.73 (d, 2H, J = 8.4 Hz, ArH), 7.85 (d, 2H, J = 5.2 Hz, BzNH), 7.94 (d, 2H, J = 7.6 Hz, ArH), 8.22 (d, 2H, J = 8.4 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 66.5 (dd, $J_{C\text{-}F}$ = 23.3, 21.1 Hz), 117.3 (t, $J_{C\text{-}F}$ = 259.1 Hz), 123.9, 128.1, 128.7, 128.8, 129.4, 129.5, 130.1 (t, $J_{C\text{-}F}$ = 3.3 Hz), 132.4, 132.5, 134.5, 137.8, 149.9, 165.4, 189.7 (t, $J_{C\text{-}F}$ = 24.5 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -104.9 (dd, 1F, J = 280, 12

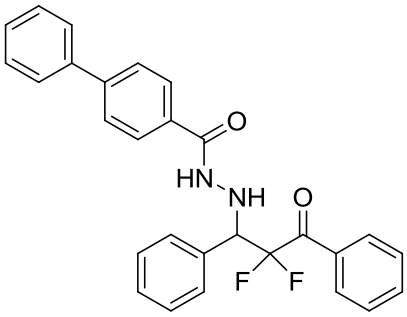
Hz), -108.1 (dd, 1F, J = 280, 15 Hz); MS (ESI) *m/z* (%): 448.4 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{22}H_{17}F_2N_3O_4Na^{+1}$ $(M+Na)^+$ requires 448.1083, Found: 448.1079. Enantiomeric excess was determined by HPLC with a Chiralcel OJ-H column (hexane/*i*PrOH = 70/30, 0.5 mL/min, 214 nm, t_{minor} = 57.61 min, t_{majorr} = 70.23 min; $[\alpha]^{20}_D$ = +19.8 (c 0.75, $CHCl_3$), 92 % *ee*).

4-bromo-*N*-(1-(4-bromophenyl)-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (5c).



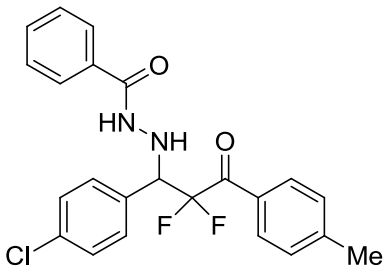
A pale yellow solid, m.p. 139-142 ^oC; (41%, 22 mg); IR (CH_2Cl_2): ν 3399, 3337, 3276, 3071, 2924, 2853, 1924, 1819, 1785, 1696, 1675, 1593, 1568, 1549, 1503, 1471, 1450, 1408, 1311, 1362, 1276, 1203, 1184, 1120, 1105, 1072, 1030, 1011, 925, 901 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 4.97 (t, 1H, J = 12.0 Hz, CH), 5.43 (d, 1H, J = 2.4 Hz, NH), 7.34 (d, 2H, J = 8.4 Hz, ArH), 7.41-7.50 (m, 7H, ArH), 7.60 (tt, 1H, J = 7.6, 0.8 Hz, ArH), 7.83 (d, 1H, J = 5.6 Hz, BzNH), 7.95 (d, 2H, J = 7.6 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 65.8 (dd, J_{C-F} = 23.7, 20.2 Hz), 116.9 (t, J_{C-F} = 258.5 Hz), 123.5, 126.9, 128.4, 128.7, 130.0 (t, J_{C-F} = 3.5 Hz), 130.8, 131.2, 131.8, 131.9, 134.6, 166.7, 189.2 (t, J_{C-F} = 28.9 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -105.1 (dd, 1F, J = 280, 11 Hz), -108.8 (dd, 1F, J = 280, 15 Hz); MS (ESI) *m/z* (%): 537.3 (100) $[M+H]^+$; HRMS (MALDI) Calcd. for $C_{22}H_{16}Br_2F_2N_2O_2H^{+1}$ $(M+H)^+$ requires 536.9615, Found: 536.9619. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 80/20, 0.7 mL/min, 214 nm, t_{minor} = 15.64 min, t_{majorr} = 23.08 min; $[\alpha]^{20}_D$ = +56.0 (c 0.20, $CHCl_3$), 95 % *ee*).

***N*-(2,2-difluoro-3-oxo-1,3-diphenylpropyl)biphenyl-4-carbohydrazide (5d).**



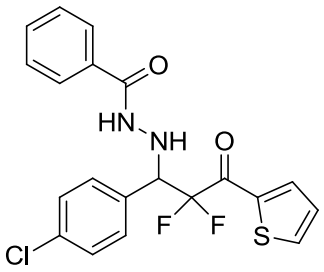
A white solid, m.p. 142-145 ^{o}C; (72%, 33 mg); IR (CH_2Cl_2): ν 3307, 3262, 3062, 3032, 2925, 2853, 1966, 1925, 1817, 1703, 1629, 1608, 1598, 1580, 1529, 1495, 1448, 1402, 1308, 1267, 1223, 1210, 1186, 1125, 1050, 1006, 972, 901 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$, TMS): δ 5.03 (t, 1H, J = 12.8 Hz, CH), 5.49 (d, 1H, J = 4.8 Hz, NH), 7.34-7.46 (m, 8H, ArH), 7.50 (t, 2H, J = 3.6 Hz, ArH), 7.56 (d, 2H, J = 5.2 Hz, ArH), 7.58 (d, 2H, J = 5.2 Hz, ArH), 7.63 (d, 2H, J = 8.4 Hz, ArH), 7.73 (br, 1H, BzNH), 7.96 (d, 2H, J = 7.6 Hz, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 66.7 (dd, $J_{C\text{-}F}$ = 22.8, 20.2 Hz), 117.4 (t, $J_{C\text{-}F}$ = 257.3 Hz), 127.1, 127.2, 127.3, 128.1, 128.6, 128.9, 129.2, 129.6, 130.0 (t, $J_{C\text{-}F}$ = 3.5 Hz), 130.8, 132.6, 132.8, 134.3, 139.8, 144.8, 166.1, 189.7 (t, $J_{C\text{-}F}$ = 28.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -105.8 (dd, 1F, J = 276, 12 Hz), -108.3 (dd, 1F, J = 276, 15 Hz); MS (ESI) *m/z* (%): 479.5 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{28}H_{22}F_2N_2O_2Na^{+1}$ $(M+Na)^+$ requires 479.1549, Found: 479.1542. Enantiomeric excess was determined by HPLC with a Chiralcel AD-H column (hexane/*i*PrOH = 70/30, 0.7 mL/min, 230 nm, t_{minor} = 43.99 min, t_{majorr} = 36.87 min; $[\alpha]^{20}_{D}$ = +34.0 (c 0.60, $CHCl_3$), 96 % *ee*).

_N_-(1-(4-chlorophenyl)-2,2-difluoro-3-oxo-3-p-tolylpropyl)benzohydrazide (5e).



A yellow oil (81%, 35 mg); IR (CH_2Cl_2): ν 3292, 3062, 3001, 2925, 2856, 1912, 1767, 1695, 1650, 1606, 1580, 1526, 1492, 1466, 1412, 1311, 1284, 1211, 1183, 1127, 1091, 1070, 1027, 1017, 969, 925, 908 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 2.37 (s, 3H, CH_3), 5.00 (t, 1H, J = 12.0 Hz, CH), 5.45 (br, 1H, NH), 7.19 (d, 2H, J = 8.4 Hz, ArH), 7.27 (d, 2H, J = 8.4 Hz, ArH), 7.33 (t, 2H, J = 7.2 Hz, ArH), 7.39-7.47 (m, 3H, ArH), 7.54 (d, 2H, J = 8.0 Hz, ArH), 7.86 (d, 2H, J = 8.0 Hz, ArH), 7.93 (d, 2H, J = 3.2 Hz, BzNH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 21.7, 65.8 (dd, $J_{C\text{-}F}$ = 24.6, 21.0 Hz), 117.1 (t, $J_{C\text{-}F}$ = 260.0 Hz), 126.8, 128.5, 128.7, 129.4, 129.7, 130.1 (t, $J_{C\text{-}F}$ = 3.4 Hz), 130.9, 131.5, 131.9, 132.0, 135.0, 145.7, 167.5, 188.7 (t, $J_{C\text{-}F}$ = 28.7 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -105.5 (dd, 1F, J = 279, 12 Hz), -108.9 (dd, 1F, J = 279, 14 Hz); MS (ESI) *m/z* (%): 451.4 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{23}H_{19}ClF_2N_2O_2Na^{+1}$ $(M+Na)^+$ requires 451.1002, Found: 451.0995. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 90/10, 0.7 mL/min, 230 nm, t_{minor} = 32.32 min, t_{majorr} = 37.96min; $[\alpha]^{20}_D$ = +39.3 (c 0.75, $CHCl_3$), 92 % *ee*).

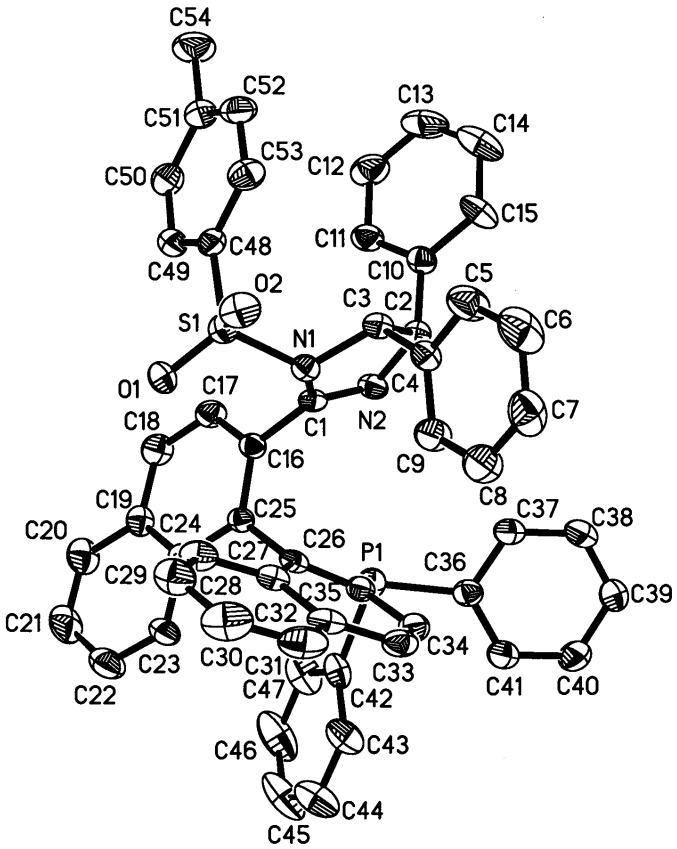
_N_-(1-(4-chlorophenyl)-2,2-difluoro-3-oxo-3-(thiophen-2-yl)propyl)benzohydrazide (5f).



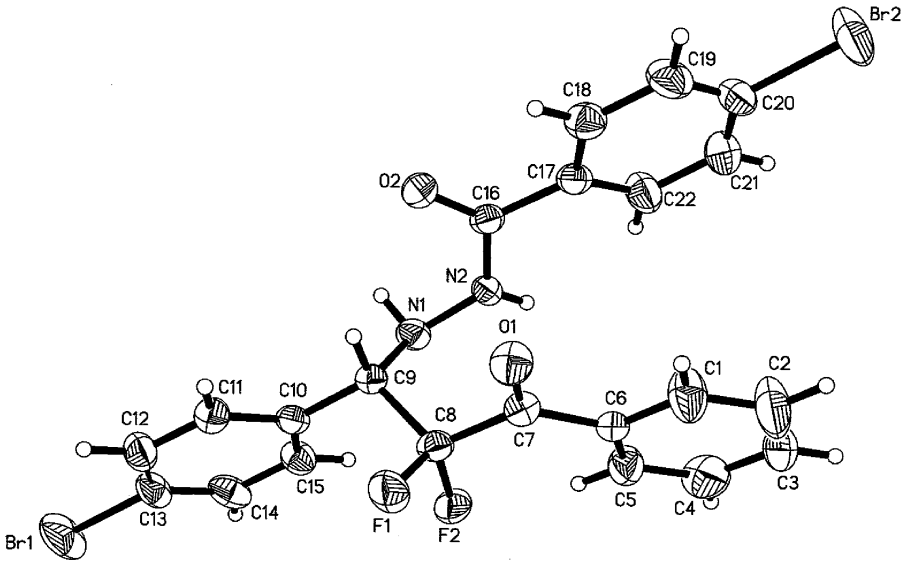
A pale yellow solid, m.p. 137-139 ^oC; (88%, 37 mg); IR (CH_2Cl_2): ν 3293, 3065, 2925, 2854, 1965, 1908, 1660, 1600, 1580, 1513, 1492, 1464, 1409, 1357, 1309, 1286, 1242, 1208, 1183, 1123, 1090, 1063, 1027, 1016, 972, 908 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 4.93 (t, 1H, J = 12.8 Hz, CH), 5.37 (br, 1H, NH), 7.12 (t, 1H, J = 4.0 Hz, ArH), 7.30 (d, 2H, J = 8.4 Hz, ArH), 7.36-7.43 (m, 4H, ArH), 7.49 (t, 1H, J = 7.2 Hz, ArH), 7.59 (d, 2H, J = 8.8 Hz, ArH), 7.75 (d, 2H, J = 5.2 Hz, ArH), 7.85 (d, 1H, J = 2.4 Hz, BzNH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 66.1 (dd, $J_{C\text{-}F}$ = 23.8, 21.2 Hz), 116.9 (t, $J_{C\text{-}F}$ = 257.0 Hz), 126.9, 128.6, 128.8, 128.9, 130.8, 131.2, 132.0, 132.1, 135.2, 136.0 (t, $J_{C\text{-}F}$ = 5.5 Hz), 136.9, 138.6, 167.5, 182.4 (t, $J_{C\text{-}F}$ = 30.0 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -106.6 (dd, 1F, J = 269, 11

Hz), -110.2 (dd, 1F, J = 269, 14 Hz); MS (ESI) *m/z* (%): 443.3 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{20}H_{15}ClF_2N_2O_2Na^{+1}$ $(M+Na)^+$ requires 443.0409, Found: 43.0403. Enantiomeric excess was determined by HPLC with a Chiralcel OD-H column (hexane/*i*PrOH = 90/10, 0.7 mL/min, 230 nm, t_{minor} = 46.47 min, t_{majorr} = 54.88 min; $[\alpha]^{20}_D$ = +23.1 (c 0.50, $CHCl_3$), 76 % *ee*).

7. X-ray crystal structure and crystal data of ligand L9 and Mannich-type adduct 5c



The crystal data of **L9** have been deposited in CCDC with number 785244. Empirical Formula: $C_{55}H_{43}Cl_2N_2O_2PS$; Formula Weight: 897.84; Crystal Color, Habit: colorless, prismatic; Crystal Dimensions: 0.397 x 0.365 x 0.258 mm; Crystal System: Orthorhombic; Lattice Type: Primitive; Lattice Parameters: a = 13.5209(9)Å, b = 16.5318(12)Å, c = 41.077(3)Å, $\alpha = 90^o$, $\beta = 90^o$, $\gamma = 90^o$, V = 9181.8(11)Å^3; Space group: C222(1); Z = 8; D_{calc}= 1.299 g/cm^3; F_{000} = 3744; Diffractometer: Bruker Smart CCD; Residuals: R; Rw: 0.0472, 0.0976.



The crystal data of **5c** have been deposited in CCDC with number 798183. Empirical Formula: $C_{22}H_{16}Br_2F_2N_2O_2$; Formula Weight: 538.19; Crystal Color, Habit: colorless, prismatic; Crystal System: Monoclinic; Lattice Type: Primitive; Lattice Parameters: a = 12.2490(4)Å, b = 5.5446(19)Å, c = 16.2080(6)Å, $\alpha = 90^{o}$, $\beta = 104.895(4)^{o}$, $\gamma = 90^{o}$, V = 1063.8(6)Å^3; Space group: P2(1); Z = 2; D_{calc} = 1.680 g/cm^3; F_{000} = 532; Diffractometer: Bruker Smart CCD; Residuals: R; Rw: 0.0519, 0.1386.

8. ^{1}H NMR and ^{31}P NMR spectroscopic studies of the potential active species

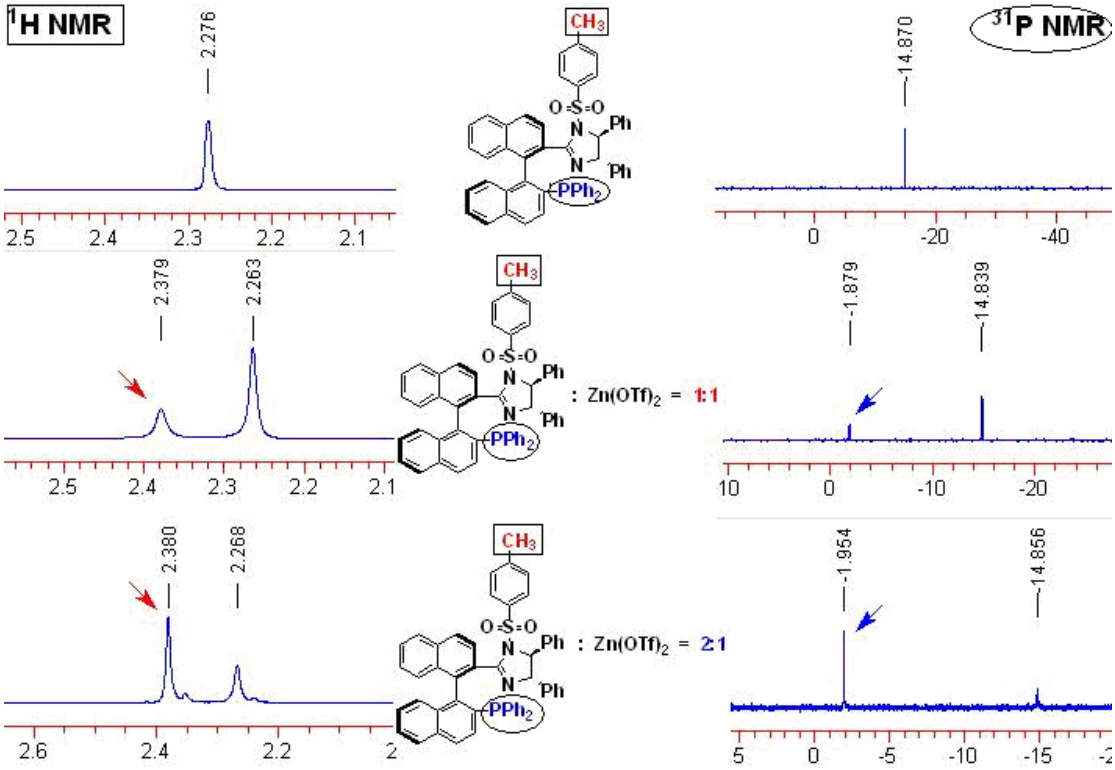


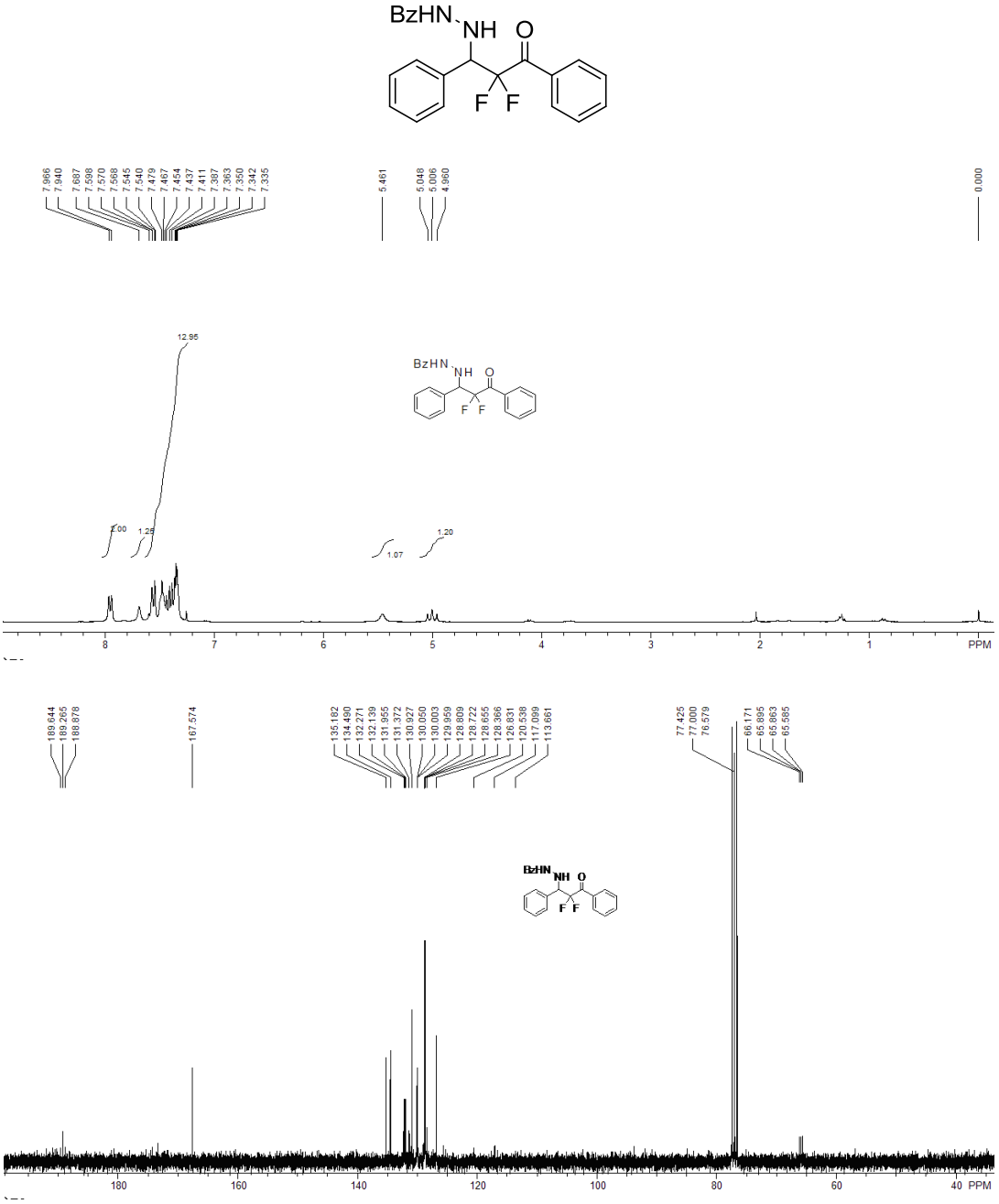
Figure SI-2. ^{1}H NMR and ^{31}P NMR spectroscopic studies of the potential active specie in the catalytic enantioselective difluorination.

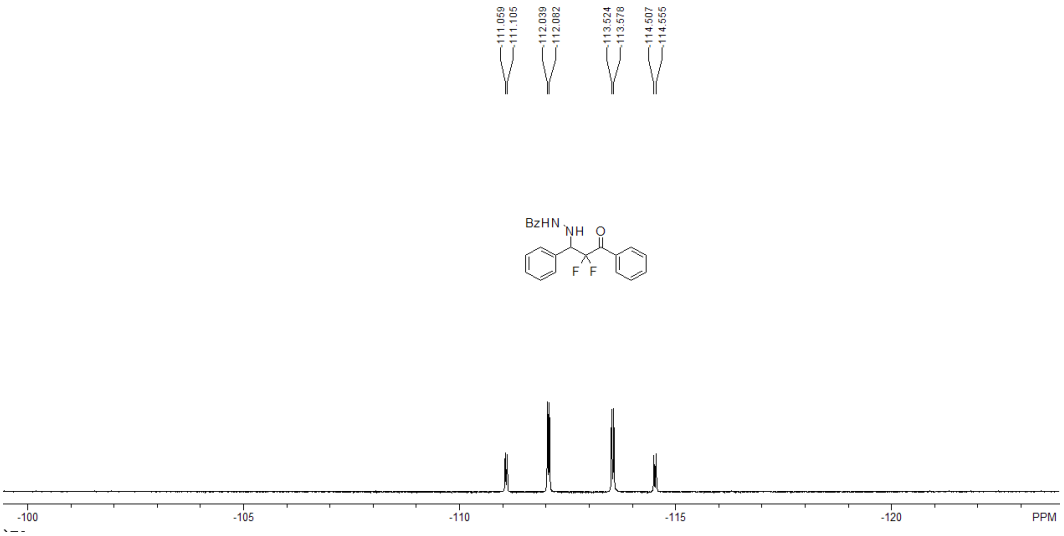
9. References:

(1) Amii, H.; Kobayashi, T.; Hatamoto, Y.; Uneyama, K. *Chem. Commun.* **1999**, 1323-1324.
(2) (a) Deng, H. P.; Wei, Y.; Shi, M. *Adv. Synth. Catal.* **2009,** *351***,** 2897-2902; (b) Ogasawara, M.; Yoshida, K.; Kamei, H.; Kato, K.; Uozumi, Y.; Hayashi, T. *Tetrahedron Asymmetry* **1998**, *9*, 1779-1787; (c) Hatano, M.; Yamanaka, M.; Mikami, K. *Eur. J. Org. Chem.* **2003**, 2552-2555. (d) Uozumi, Y.; Suzuki, N.; Ogiwara, A.; Hayashi, T. *Tetrahedron* **1994**, *50*, 4293-4302. (e) Zhao, Q. Y.; Yuan, Z. L.; Shi, M. *Tetrahedron: Asymmetry* **2010**, *21*, 943-951.
(3) (a) You, S. L.; Kelly, J. W. *Org. Lett.* **2004**, *6*, 1681-1683. (b) Liu, H.; Du, D. M. *Adv. Synth. Catal.* **2010**, *353*, 1113-1118.

10. NMR and HPLC data for $Zn(NTf_2)_2$-catalyzed Mannich-type adducts 3a-3u.

N-(2,2-difluoro-3-oxo-1,3-diphenylpropyl)benzohydrazide (3a).





实验时间: 2010-08-28,16:54:09
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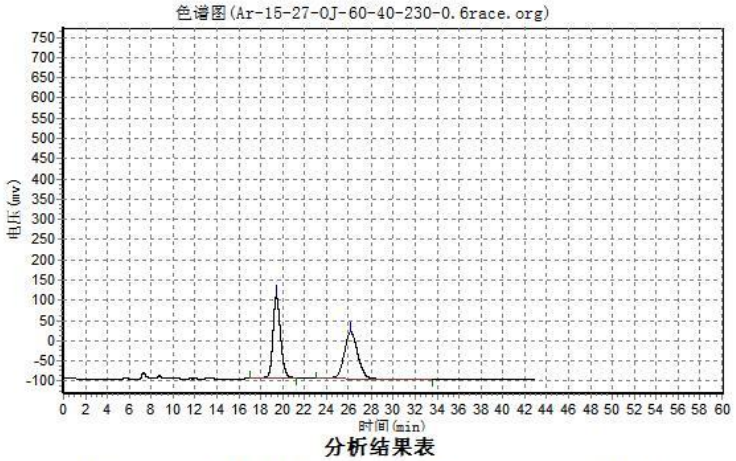
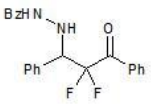
实验者:
报告时间: 2010-08-30,8:40:45
积分方法:面积归一法

色谱图(Ar-15-27-OJ-60-40-230-0.6race.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		19.428	202118.000	9785959.000	50.2689
2		26.210	114781.047	9681261.000	49.7311
总计			316899.047	19467220.000	100.0000



OJ-H
hexane/^{i}PrOH = 60/40
230nm
0.6mL/min

racemic sample

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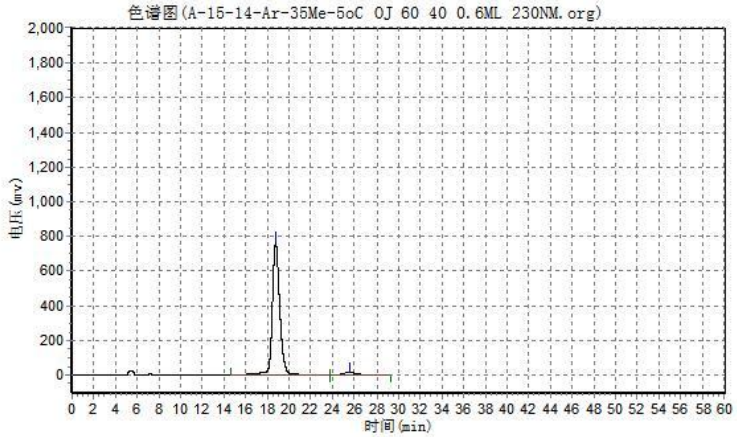
实验时间：2010-07-15,19:39:48
谱图文件:D:\HPLC\Yzl\15\A-15-14-Ar-35Me-5oC OJ 60 40 0.6ML 230NM.org

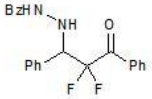
实验者：
报告时间：2010-08-30,8:51:25
积分方法:面积归一法

色谱图(A-15-14-Ar-35Me-5oC OJ 60 40 0.6ML 230NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		18.765	761012.688	36794476.000	96.6175
2		25.553	14144.771	1288141.125	3.3825
总计			775157.458	38082617.125	100.0000



OJ-H
hexane/^{i}PrOH = 60/40
230nm
0.6mL/min

ee = 93%

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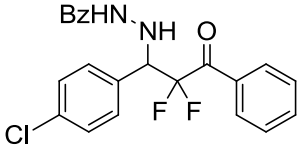
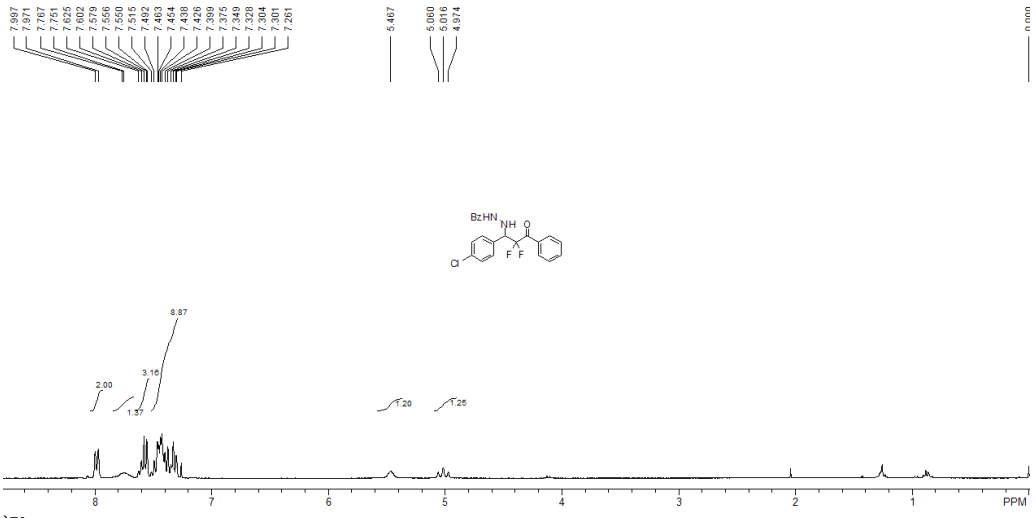
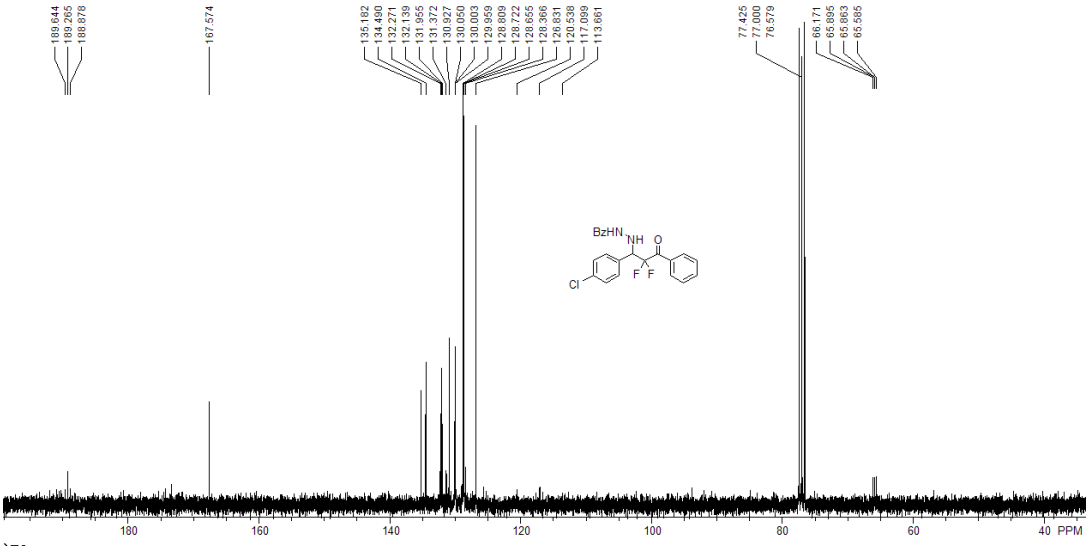
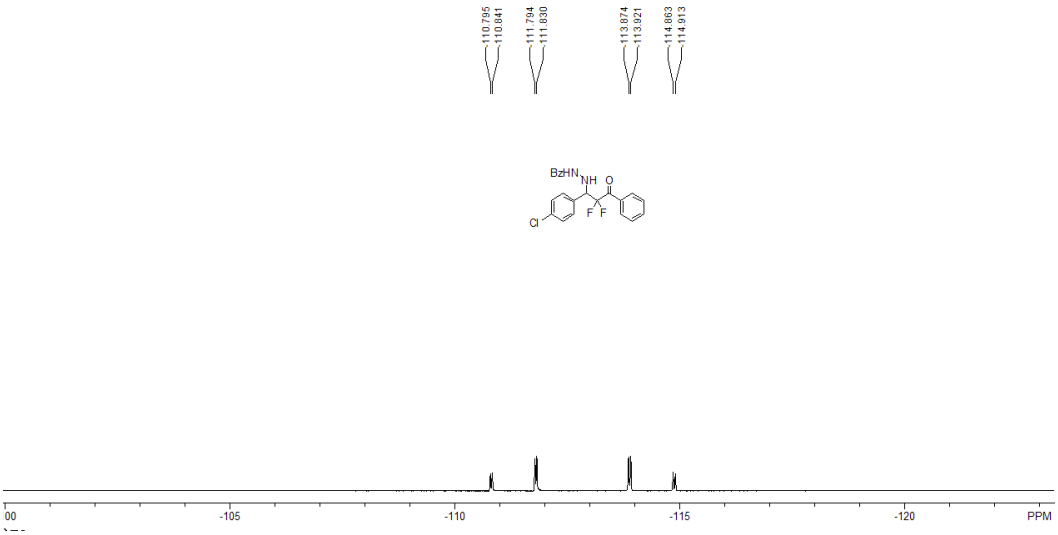
N-(1-(4-chlorophenyl)-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3b).









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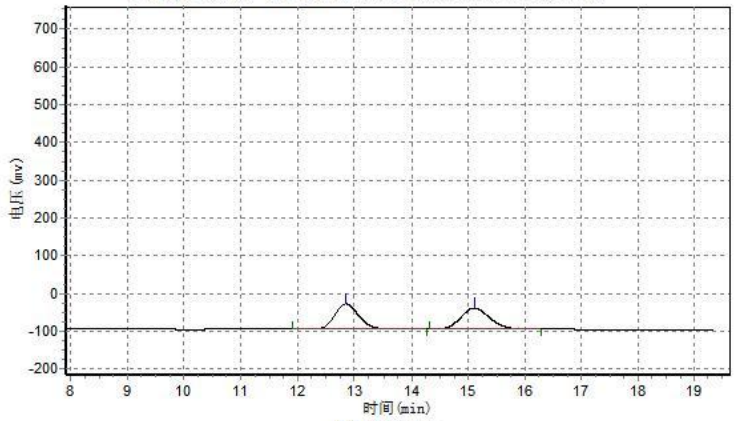
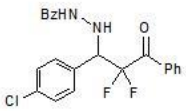
实验者:
报告时间: 2010-08-30,8:55:01
积分方法:面积归一法

色谱图(A-15-44-4Cl-RACEMIC OD 80 20 0.7ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		12.858	67189.055	1969842.375	49.9368
2		15.105	55577.645	1974825.250	50.0632
总计			122766.699	3944667.625	100.0000



OD-H
hexane/^{i}PrOH = 80/20
214nm
0.7mL/min

racemic sample

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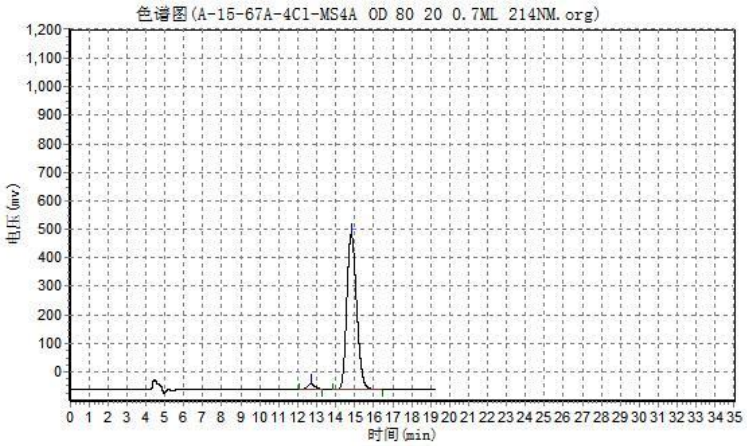
N2000 数据工作站 1

实验时间: 2010-09-06,11:50:27
谱图文件:D:\HPLC\Yzl\15\A-15-67A-4Cl-MS4A OD 80 20 0.7ML 214NM.org

实验者:
报告时间: 2010-09-06,11:55:52
积分方法:面积归一法



分析结果表

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1		12.702	18441.945	523733.281	2.5877
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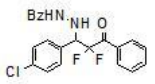
总计			563710.633	20239057.281	100.0000

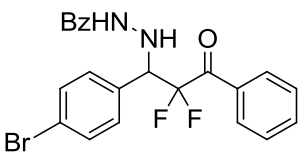


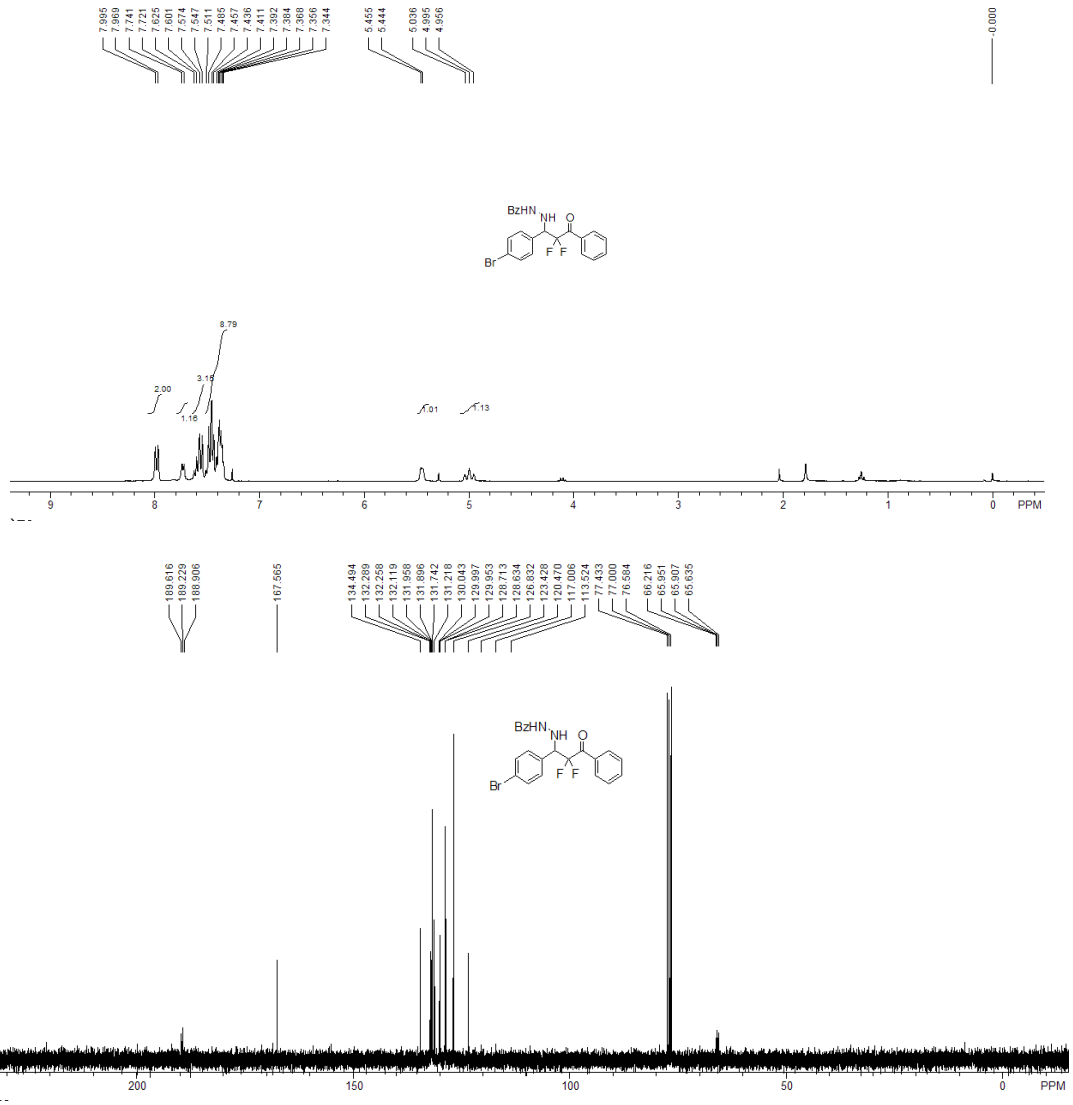
OD-H
HEXANE/iPrOH = 80/20
0.7 ML/MIN
214NM

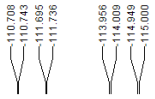
EE = 95%

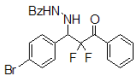
2010-09-06 浙江大学智能信息研究所

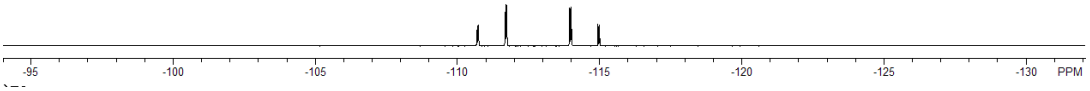
N-(1-(4-bromophenyl)-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3c).







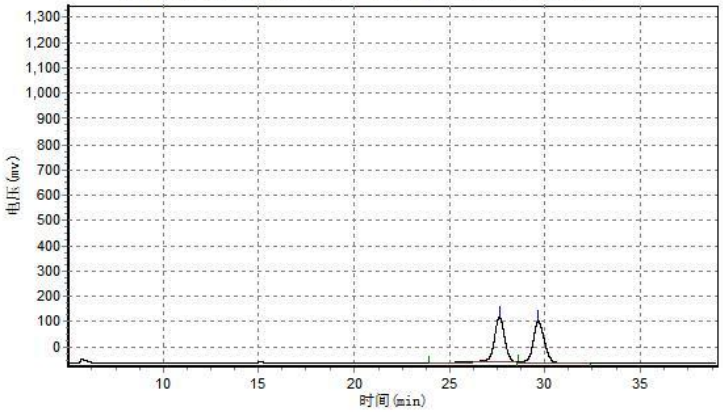




N2000 数据工作站 1

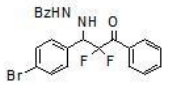
积分方法:面积归一法

色谱图(A-15-49-4Br-RACEMIC IC 90 10 0.6ML 214NM.org)



分析结果表

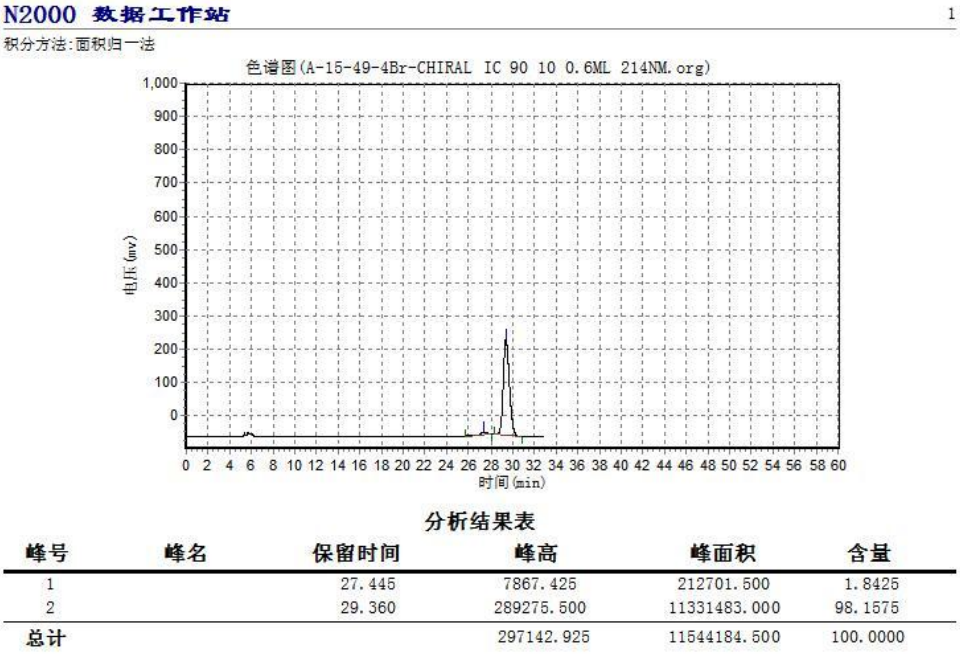
峰号	峰名	保留时间	峰高	峰面积	含量
1		27.597	177831.391	6714844.500	49.8043
2		29.645	164126.109	6767607.500	50.1957
总计			341957.500	13482452.000	100.0000



IC-H
HEXANE/iPrOH = 90/10
214NM
0.6 ML/MIN

RACEMIC SAMPLE

2010-09-06 浙江大学智能信息研究所



分析结果表

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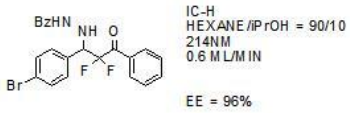
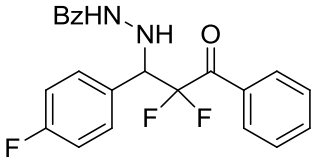
2		29.360	289275.500	11331483.000	98.1575
总计			297142.925	11544184.500	100.0000

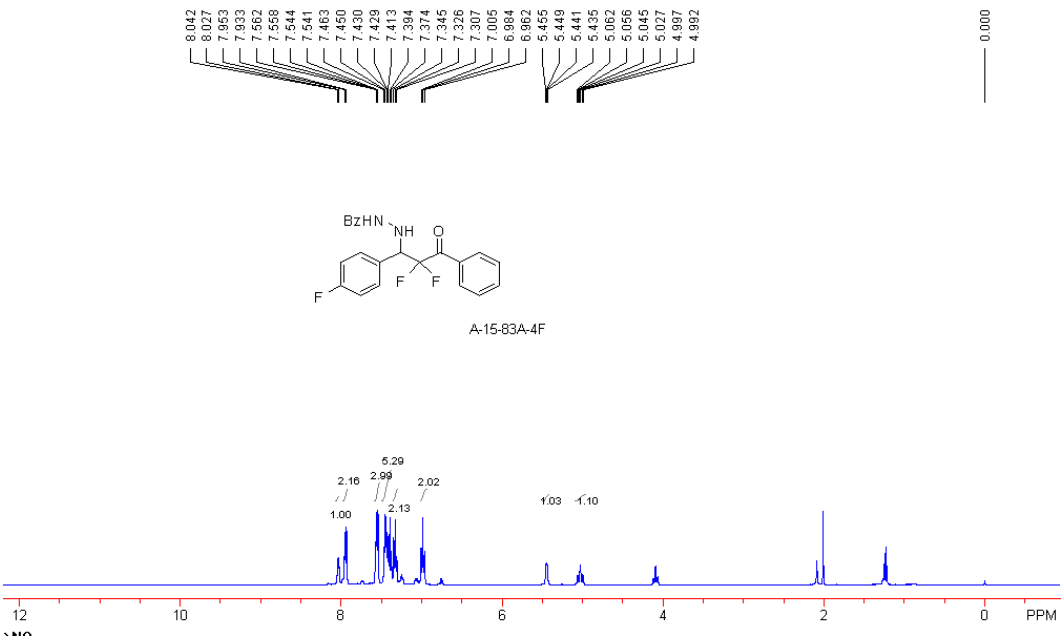


2010-09-06

浙江大学智能信息研究所

N-(2,2-difluoro-1-(4-fluorophenyl)-3-oxo-3-phenylpropyl)benzohydrazide (3d).

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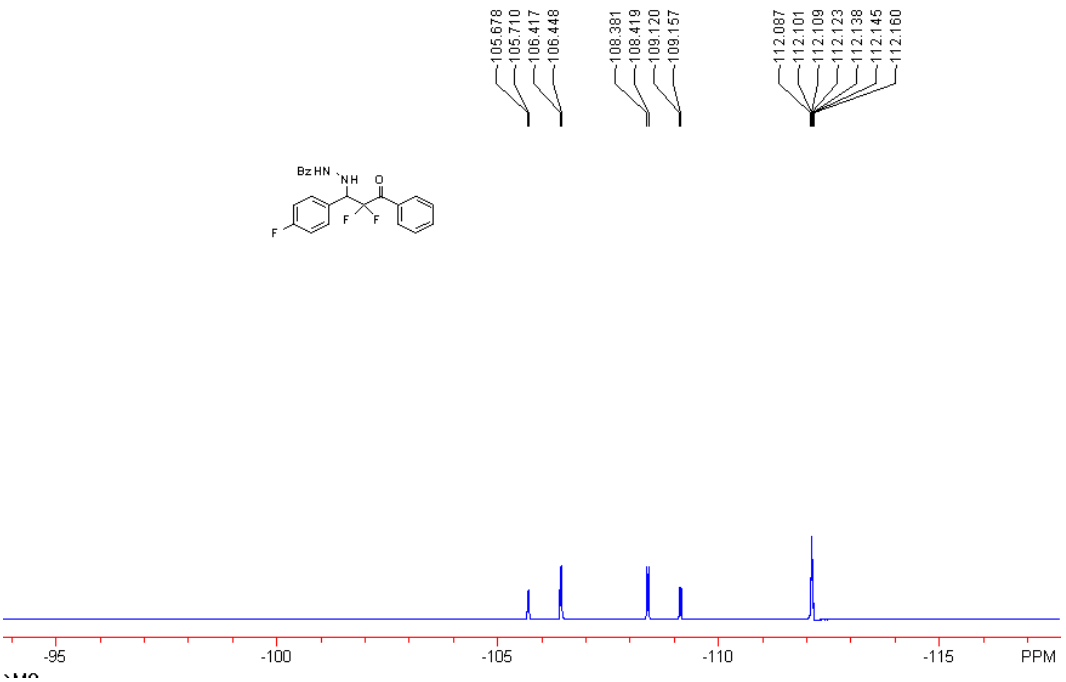
7.558
7.544
7.541
7.463
7.450
7.430
7.429
7.413
7.394
7.374
7.345
7.326
7.307
7.005
6.984
6.962
5.455
5.449
5.441
5.435
5.062
5.056
5.045
5.027
4.997
4.992
0.000
BzHN
NH
O
F
F
F
A-15-83A-4F
5.29
2.16
2.99
2.02
2.13
1.00
1.03
1.10
12
10
8
6
4
2
0
PPM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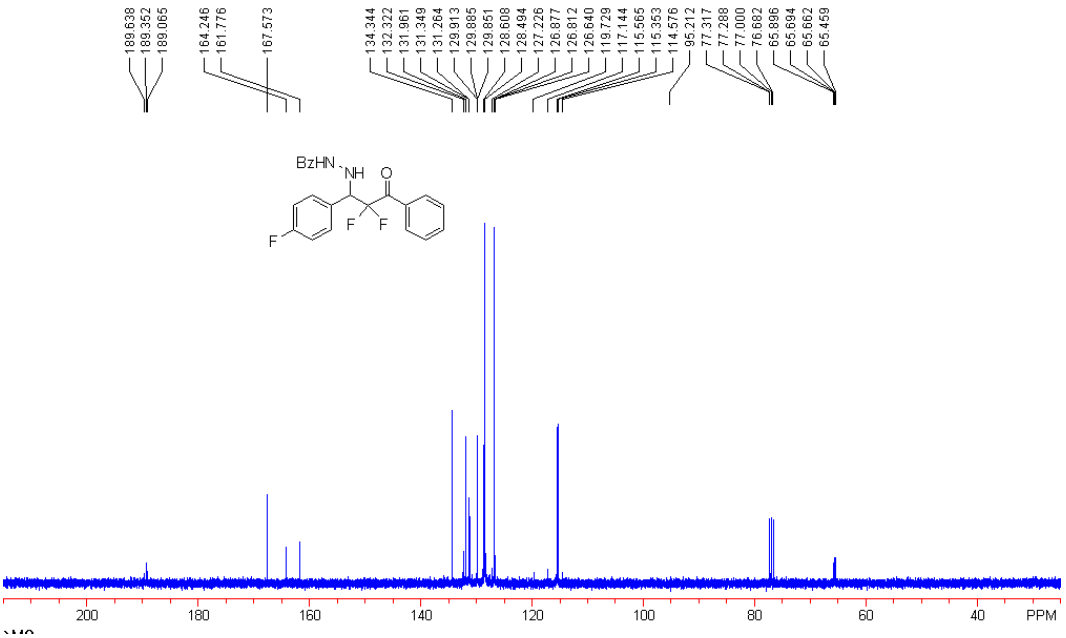
F
F
-95
-100
-105
-110
-115
PPM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126.812
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117.144
115.565
115.353
114.576
95.212
77.317
77.288
77.000
76.682
65.886
65.694
65.662
65.459
BzHN
NH
O
F
F
F
200
180
160
140
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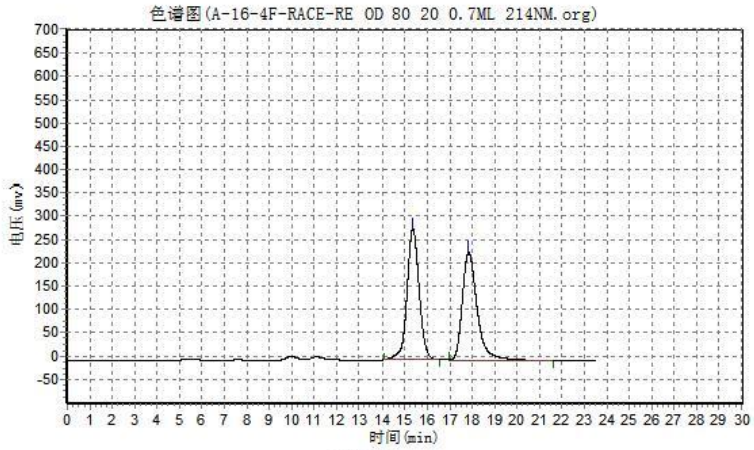
100
80
60
40
PPM

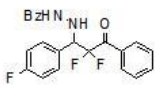
实验时间: 2010-12-24,14:36:33
谱图文件:D:\HPLC\Yzl\16\A-16-4F-RACE-RE OD 80 20 0.7ML 214NM.org

实验者:
报告时间: 2010-12-24,14:37:28
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		15.345	281098.688	10578736.000	49.6781
2		17.835	232390.422	10715810.000	50.3219
总计			513489.109	21294546.000	100.0000



OD-H
Hexane/iPrOH = 80/20
0.7 mL/min
214 nm

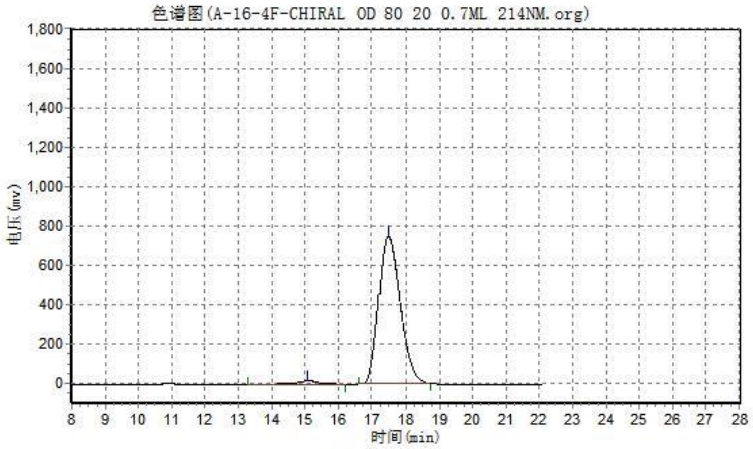
RACEMIC SAMPLE

2010-12-24 浙江大学智能信息研究所

N2000 数据工作站 1

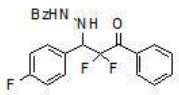
实验时间: 2010-12-22,9:41:31
谱图文件:D:\HPLC\Yzl\16\A-16-4F-CHIRAL OD 80 20 0.7ML 214NM.org
实验者:
报告时间: 2010-12-24,14:23:51
积分方法:面积归一法

色谱图(A-16-4F-CHIRAL OD 80 20 0.7ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		15.083	18821.295	1094652.375	3.1774
2		17.475	751496.438	33356836.000	96.8226
总计			770317.732	34451488.375	100.0000

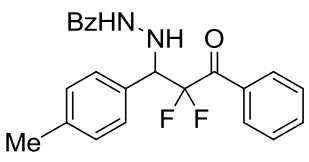


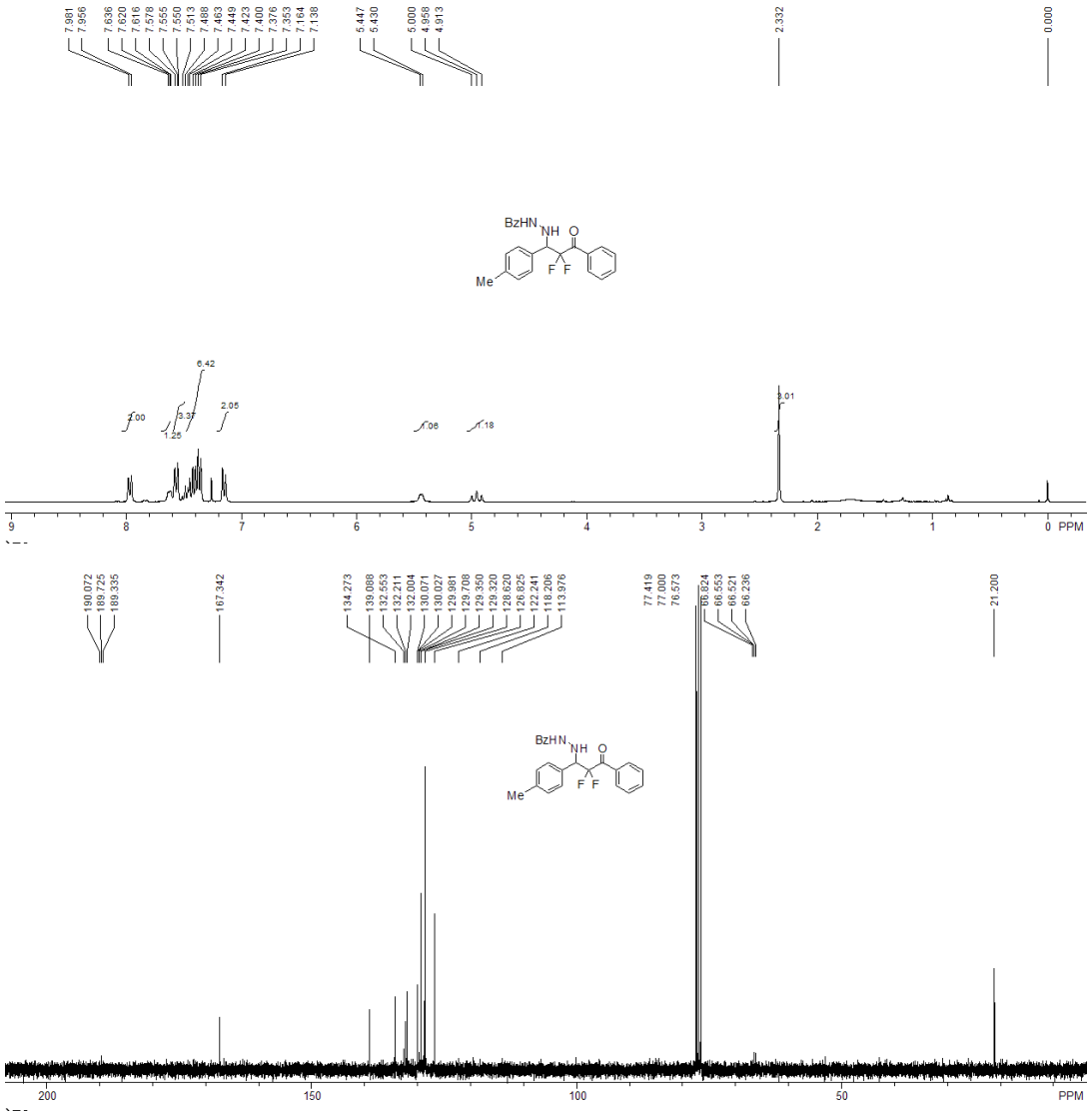
OD-H
Hexane/iPrOH = 80/20
0.7 mL/min
214 nm

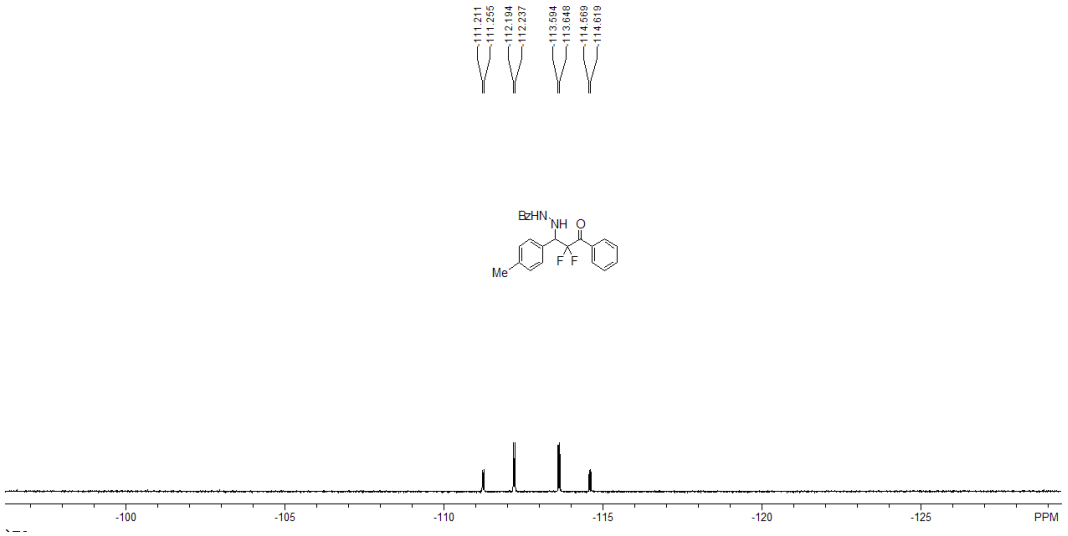
ee = 93%

2010-12-24 浙江大学智能信息研究所

N-(2,2-difluoro-3-oxo-3-phenyl-1-p-tolylpropyl)benzohydrazide (3e).





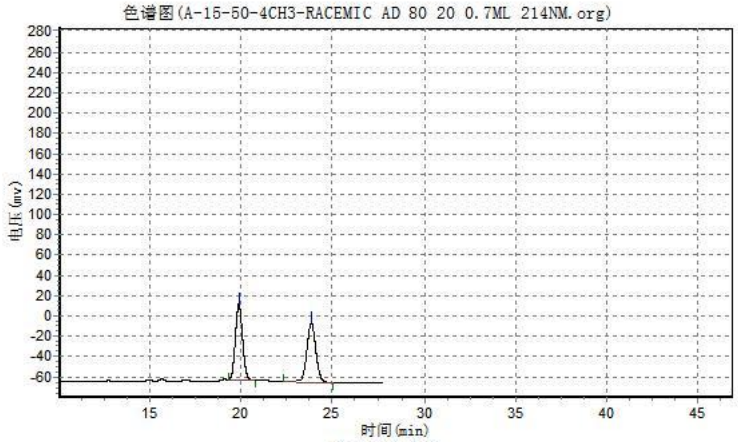


N2000 数据工作站 1

实验时间: 2010-09-06,10:17:27
谱图文件:D:\HPLC\Yzl\15\A-15-50-4CH3-RACEMIC AD 80 20 0.7ML 214NM.org

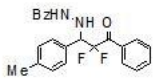
实验者:
报告时间: 2010-09-06,10:26:05
积分方法:面积归一法

色谱图(A-15-50-4CH3-RACEMIC AD 80 20 0.7ML 214NM.org)



分析结果表

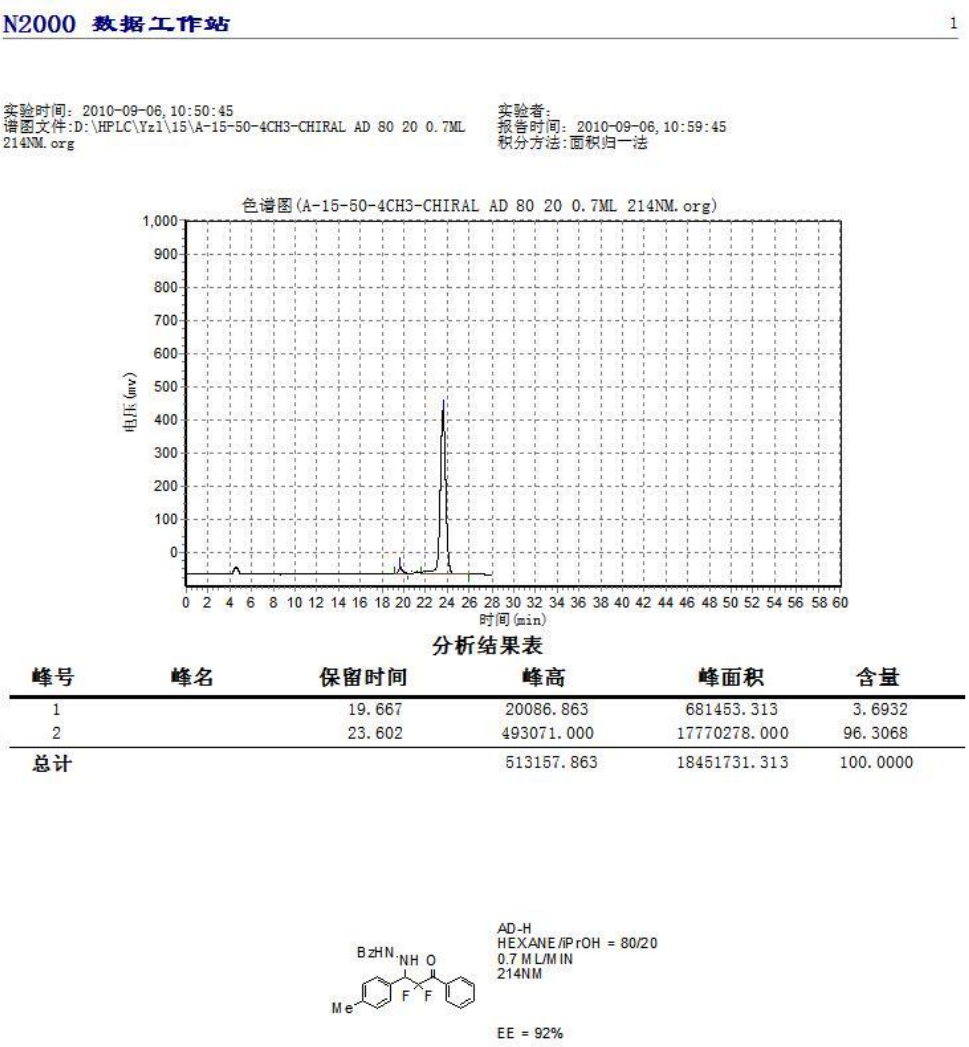
峰号	峰名	保留时间	峰高	峰面积	含量
1		19.868	74447.617	2049282.875	50.5470
2		23.848	58151.207	2004931.875	49.4530
总计			132598.824	4054214.750	100.0000



AD-H
HEXANE/iPrOH = 80/20
0.7 ML/MIN
214NM

RACEMIC SAMPLE

2010-09-06 *浙江大学智能信息研究所*



N2000 数据工作站 1

实验时间: 2010-09-06,10:50:45
谱图文件:D:\HPLC\Yz1\15\A-15-50-4CH3-CHIRAL AD 80 20 0.7ML 214NM.org
实验者:
报告时间: 2010-09-06,10:59:45
积分方法:面积归一法

色谱图(A-15-50-4CH3-CHIRAL AD 80 20 0.7ML 214NM.org)

电压(mv)
时间(min)

分析结果表

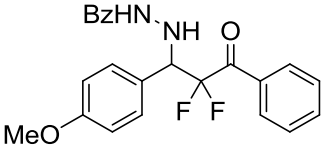
峰号	峰名	保留时间	峰高	峰面积	含量
1		19.667	20086.863	681453.313	3.6932
2		23.602	493071.000	17770278.000	96.3068
总计			513157.863	18451731.313	100.0000

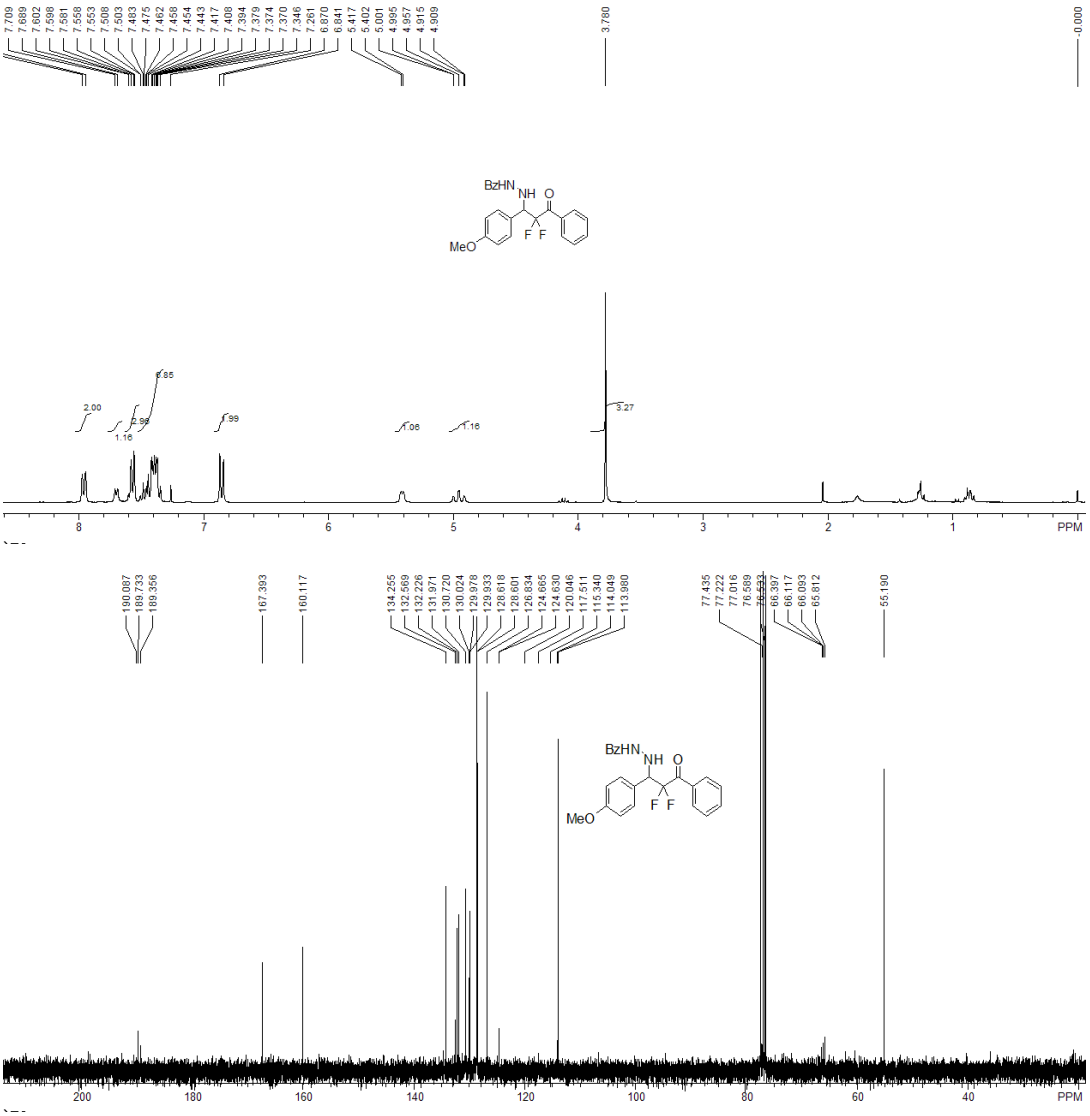
AD-H
HEXANE/iPrOH = 80/20
0.7 ML/MIN
214NM

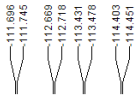
EE = 92%

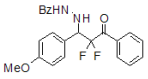
2010-09-06 浙江大学智能信息研究所

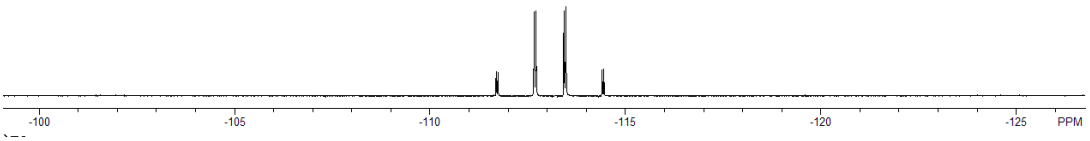
N-(2,2-difluoro-1-(4-methoxyphenyl)-3-oxo-3-phenylpropyl)benzohydrazide (3f).











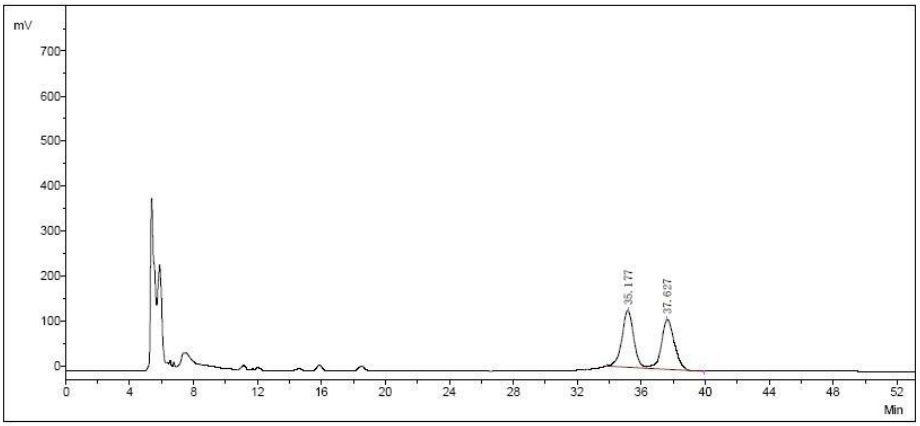
HPLC REPORT

Sample Name:yzl-a-15-51-40rac ic 85 0.6.che Date:2010-08-26

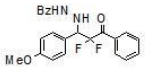
Time:10:12 Method:

column: the mobile phase:

Velocity: the detection wavelength:



No.	PeakNo	R.Time	PeakHeight	PeakArea	PerCent
1	1	35.177	126362.2	6465841.9	50.9118
2	2	37.627	111172.1	6234252.9	49.0882
Total			237534.3	12700094.8	100.0000

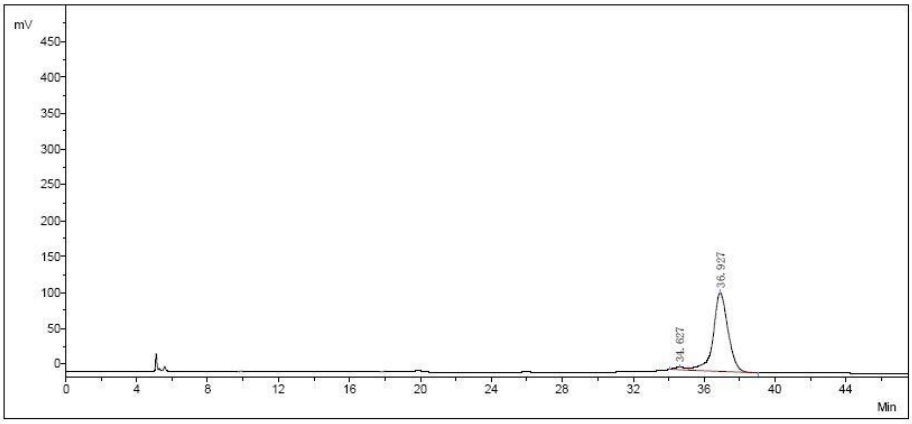


IC-H
HEXANE/iPrOH = 85/15
0.6 ML/MIN
214NM

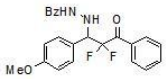
RACEMIC SAMPLE

HPLC REPORT

Sample Name:yzl-a-15-51-40.che
Date:2010-08-26
Time:11:08
Method:
column:
the mobile phase:
Velocity:
the detection wavelength:



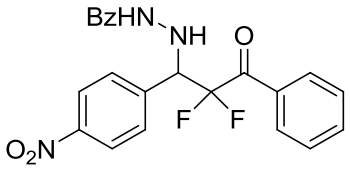
No.	PeakNo	R.Time	PeakHeight	PeakArea	PerCent
1	1	34.627	3946.4	182524.4	2.7899
2	2	36.927	109325.1	6359785.8	97.2101
Total			113271.5	6542310.2	100.0000

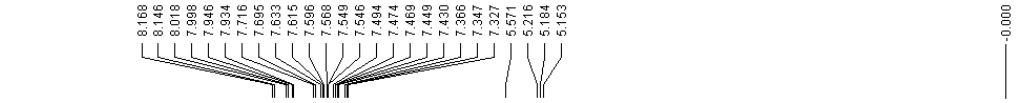


IC-H
HEXANE/iPrOH = 85/15
0.6 ML/MIN
214NM

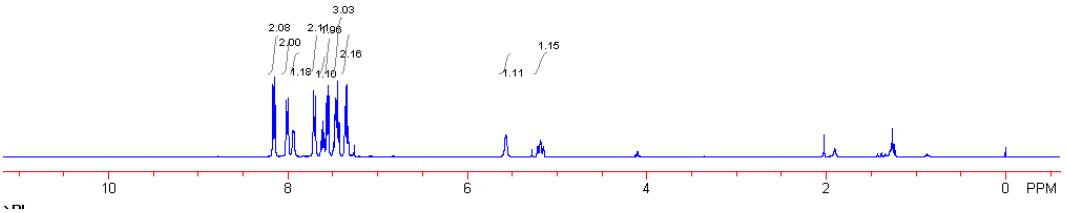
EE = 94%

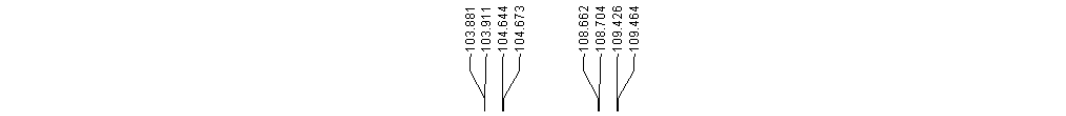
N-(2,2-difluoro-1-(4-nitrophenyl)-3-oxo-3-phenylpropyl)benzohydrazide (3g).



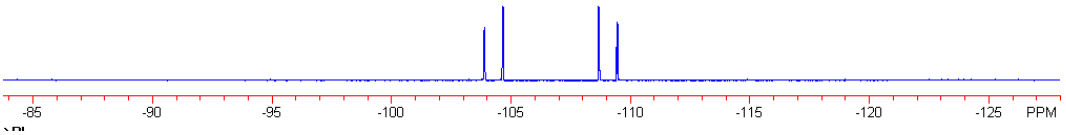


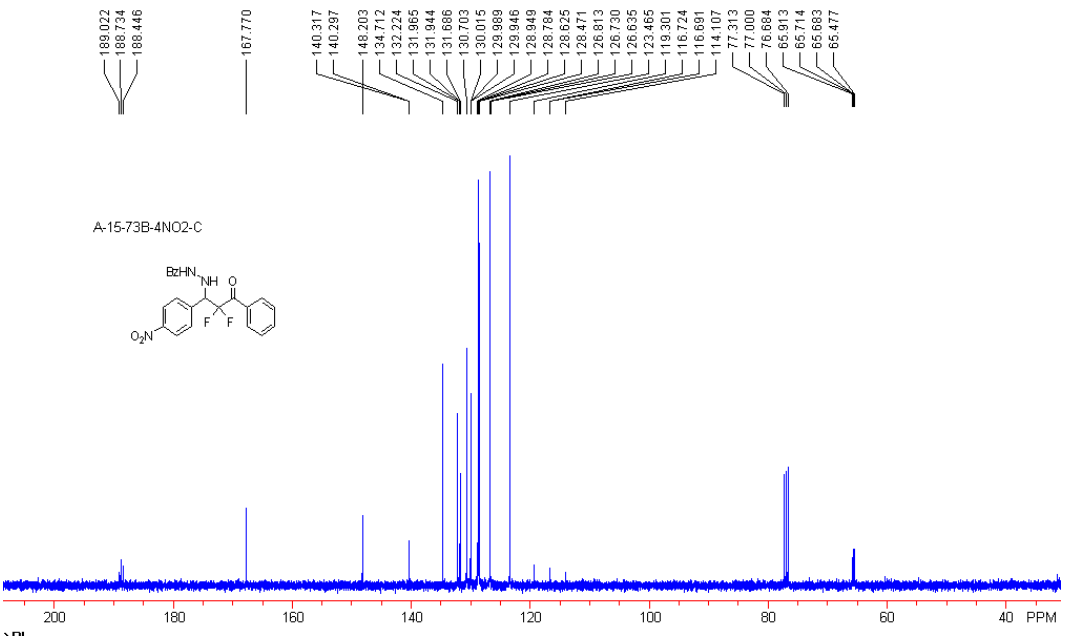
A-15-73B-4NO2





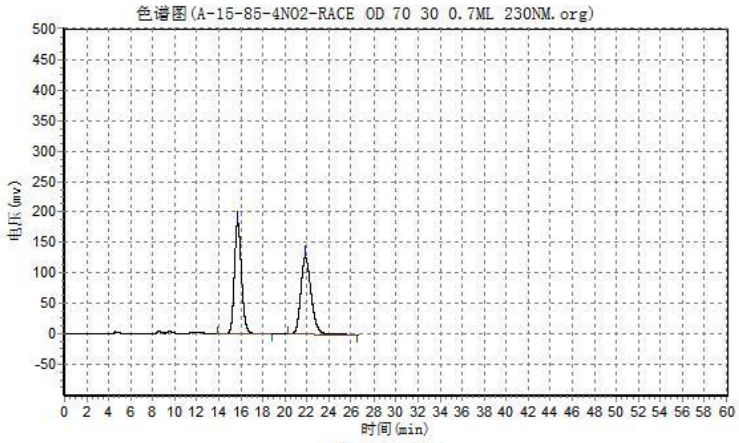
A-15-73B-4NO2-F




189.022
188.734
188.446
167.770
140.317
140.297
149.203
134.712
132.224
131.965
131.944
131.686
130.703
130.015
129.989
129.946
128.949
128.784
128.625
128.471
126.813
126.730
126.635
123.465
119.301
116.724
116.691
114.107
77.313
77.000
76.684
65.913
65.714
65.683
65.477
A-15-73B-4NO2-C
BzHN
NH
O
F
F
O2N
200
180
160
140
120
100
80
60
40
PPM

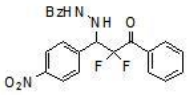
实验时间: 2010-09-19,19:46:10
谱图文件:D:\HPLC\Yz1\15\A-15-85-4NO2-RACE OD 70 30 0.7ML 230NM.org

实验者:
报告时间: 2010-09-19,19:50:06
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		15.715	183407.734	8286749.500	50.1968
2		21.868	126219.859	8221784.000	49.8032
总计			309627.594	16508533.500	100.0000



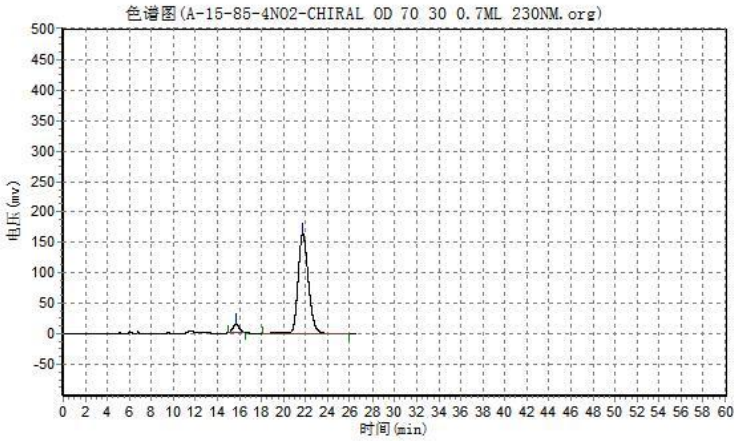
OD-H
HEXANE/IPA = 70/30
0.7 ML/MIN
230NM

RACEMIC SAMPLE

2010-09-19 浙江大学智能信息研究所

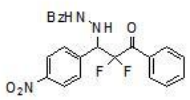
N2000 数据工作站 1

实验时间: 2010-09-19,20:14:19
谱图文件:D:\HPLC\Yzl\15\A-15-85-4NO2-CHIRAL OD 70 30 0.7ML 230NM.org
实验者:
报告时间: 2010-09-19,20:15:20
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		15.675	13566.926	564488.625	5.0758
2		21.750	163434.469	10556652.000	94.9242
总计			177001.395	11121140.625	100.0000

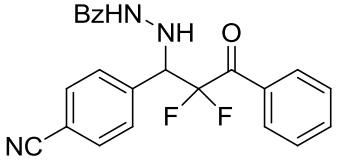


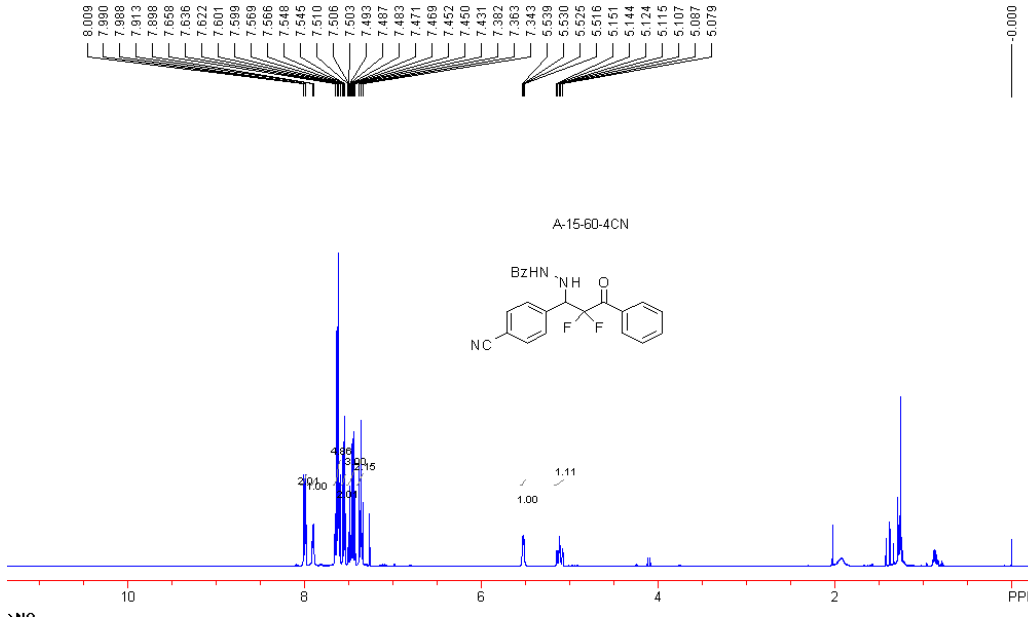
OD-H
HEXANE/IPA = 70/30
0.7 ML/MIN
230NM

EE = 90%

2010-09-19 浙江大学智能信息研究所

N-(1-(4-cyanophenyl)-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3h).

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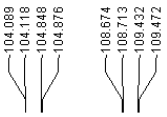
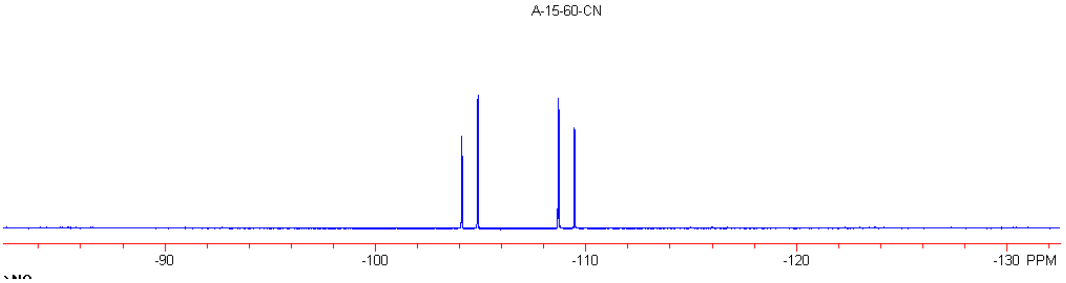
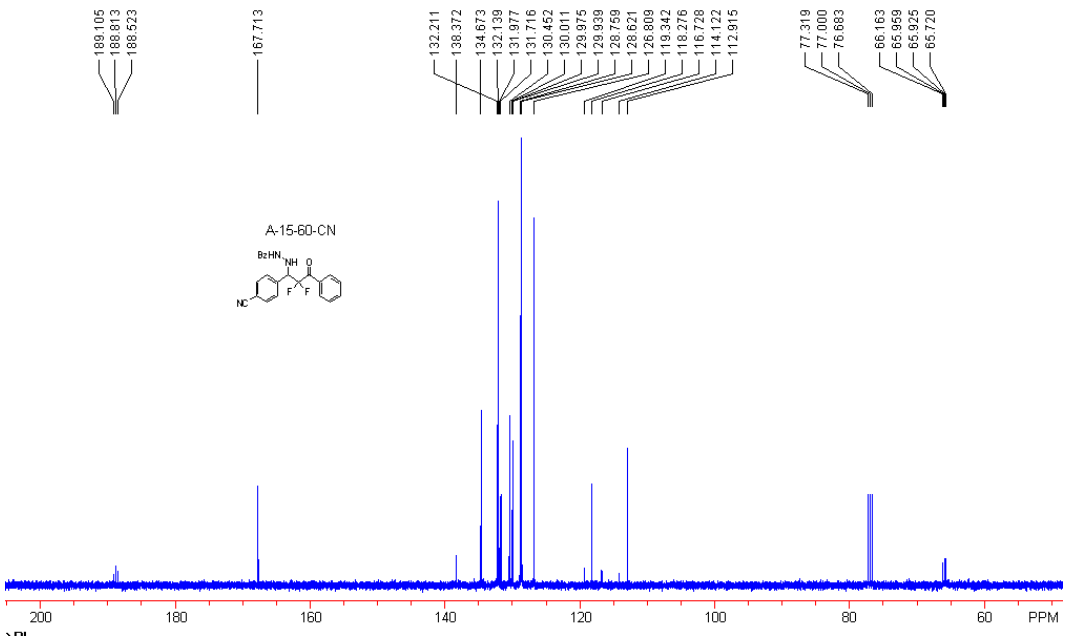
7.913
7.898
7.658
7.636
7.622
7.601
7.599
7.569
7.566
7.548
7.545
7.510
7.506
7.503
7.493
7.487
7.483
7.471
7.469
7.452
7.450
7.431
7.382
7.363
7.343
5.539
5.530
5.525
5.516
5.151
5.144
5.124
5.115
5.107
5.087
5.079
0.000

A-15-60-4CN
BzHN
NH
O
F
F
NC
1.11
1.00
10
8
6
4
2
PPM


104.089
104.118
104.848
104.876
108.674
108.713
109.432
109.472


A-15-60-CN
-90
-100
-110
-120
-130 PPM


189.105
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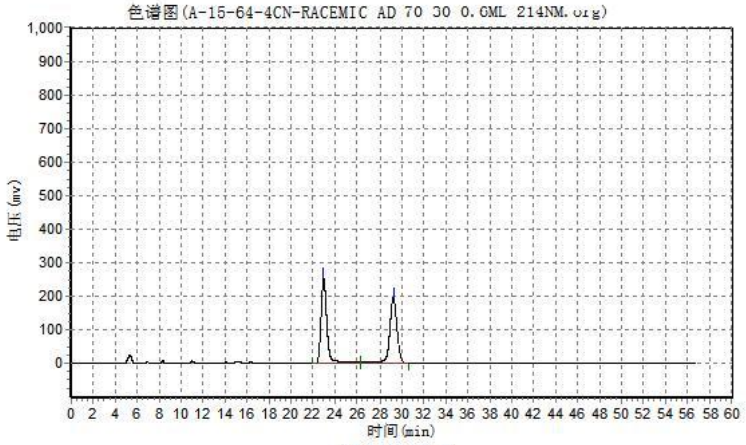
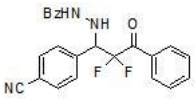
188.523
167.713
132.211
138.372
134.673
132.139
131.977
131.716
130.452
130.011
129.975
129.939
128.759
128.621
126.809
119.342
118.276
116.728
114.122
112.915
77.319
77.000
76.683
66.163
65.959
65.925
65.720
A-15-60-CN
BzHN
NH
O
F
F
NC
200
180
160
140
120
100
80
60
PPM

实验时间: 2010-09-08,21:17:05
谱图文件:D:\HPLC\Yz1\15\A-15-64-4CN-RACEMIC AD 70 30 0.6ML 214NM.org
实验者:
报告时间: 2010-09-09,8:49:30
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		22.985	251797.047	9564685.000	50.6327
2		29.210	196986.125	9325645.000	49.3673
总计			448783.172	18890330.000	100.0000



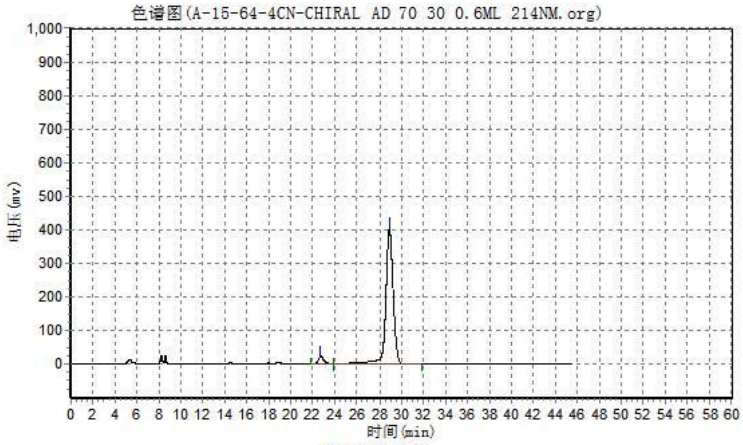
AD-H
HEXANE/iPrOH = 70/30
214 NM
0.6 ML/MIN

RACEMIC SAMPLE

2010-09-09 浙江大学智能信息研究所

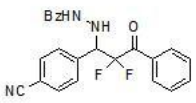
实验时间: 2010-09-08,22:04:09
谱图文件:D:\HPLC\Yzl\15\A-15-64-4CN-CHIRAL AD 70 30 0.6ML 214NM.org

实验者:
报告时间: 2010-09-09,8:54:09
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		22.743	22482.209	854534.688	4.2594
2		28.873	403938.344	19207556.000	95.7405
总计			426420.553	20062090.688	100.0000

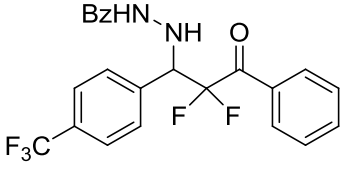


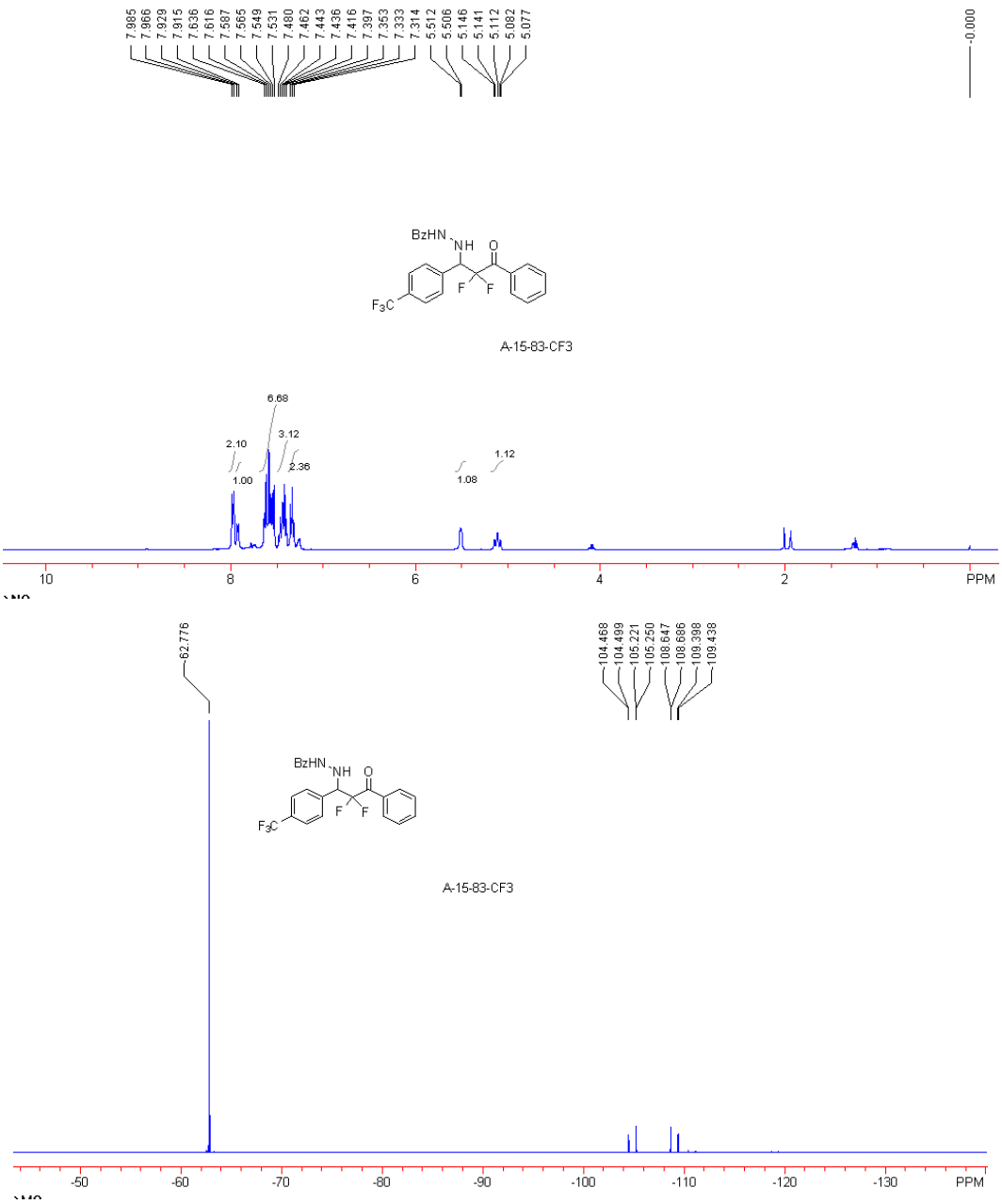
AD-H
HEXANE/iPrOH = 70/30
214 NM
0.6 ML/MIN

EE = 91%

2010-09-09 浙江大学智能信息研究所

N-(2,2-difluoro-3-oxo-3-phenyl-1-(4-(trifluoromethyl)phenyl)propyl)benzohydrazide (3i).

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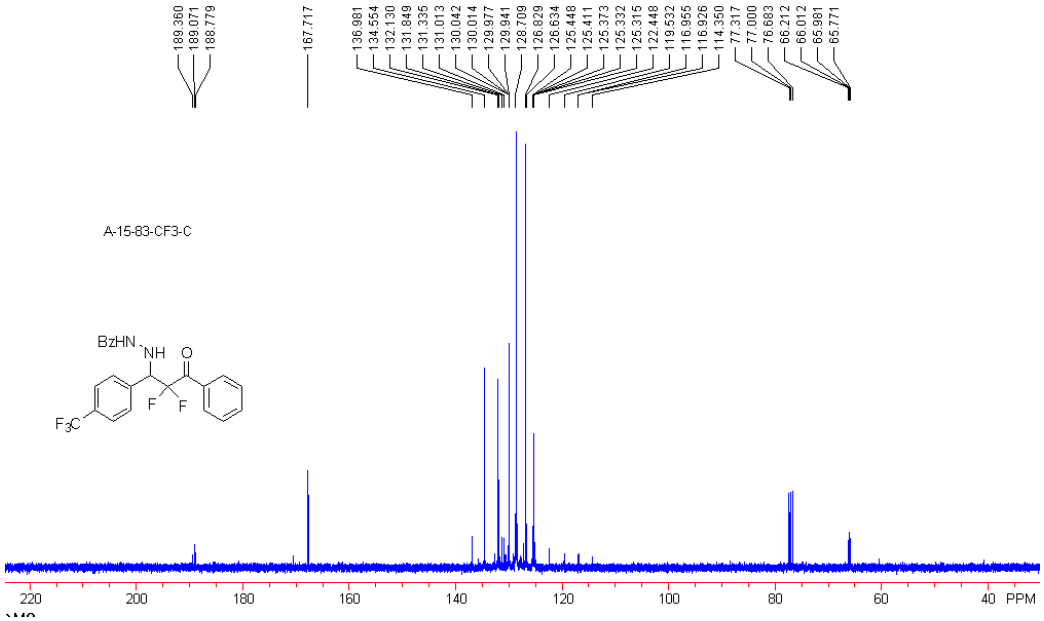
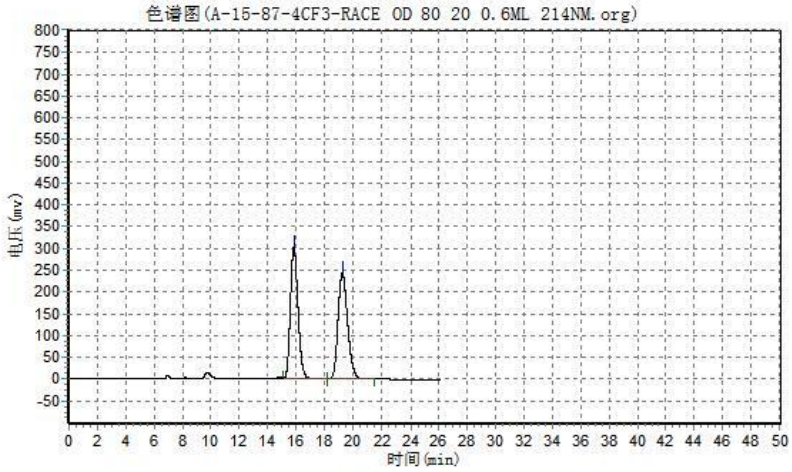
7.966
7.929
7.915
7.636
7.616
7.587
7.565
7.549
7.531
7.480
7.462
7.443
7.436
7.416
7.397
7.353
7.333
7.314
5.512
5.506
5.146
5.141
5.112
5.082
5.077
-0.000
BzHN
NH
O
F
F
F3C
A-15-83-CF3
6.68
3.12
2.36
2.10
1.00
1.08
1.12
10
8
6
4
2
PPM
62.776
104.468
104.499
105.221
105.250
108.647
108.686
109.398
109.438
BzHN
NH
O
F
F
F3C
A-15-83-CF3
-50
-60
-70
-80
-90
-100
-110
-120
-130
PPM


189.360
189.071
188.779
167.717
136.981
134.554
132.130
131.849
131.335
131.013
130.042
130.014
129.977
129.941
128.709
126.829
126.634
125.448
125.411
125.373
125.332
125.315
122.448
119.532
116.955
116.926
114.350
77.317
77.000
76.683
66.212
66.012
65.981
65.771
A-15-83-CF3-C
BzHN
NH
O
F
F
F3C
220
200
180
160
140
120
100
80
60
40
PPM

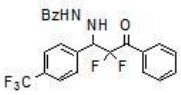
实验时间: 2010-09-26,14:36:14
谱图文件:D:\HPLC\Yz1\15\A-15-87-4CF3-RACE OD 80 20 0.6ML 214NM.org

实验者:
报告时间: 2010-09-26,14:42:54
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		15.855	302481.719	11493144.000	50.0295
2		19.275	242312.594	11479578.000	49.9705
总计			544794.313	22972722.000	100.0000



OD-H
HEXANE/IPA = 80/20
230 NM
0.6 ML/MIN

RACEMIC SAMPLE

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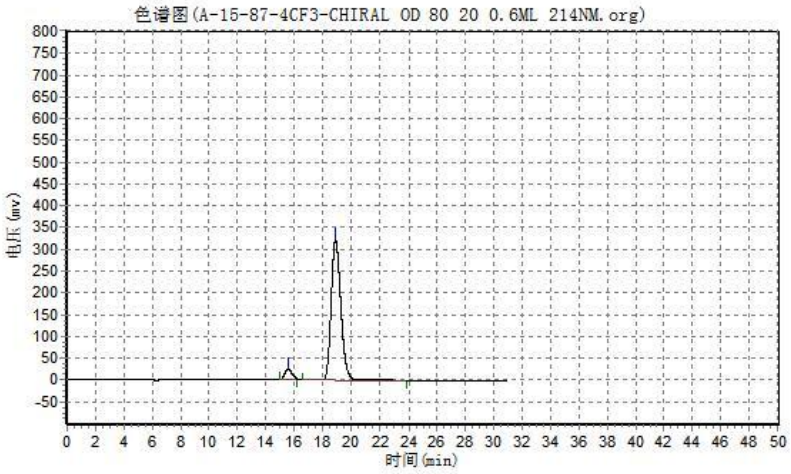
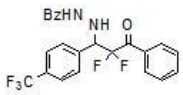
N2000 数据工作站 1

实验时间：2010-09-26,15:11:18
谱图文件:D:\HPLC\Yzl\15\A-15-87-4CF3-CHIRAL OD 80 20 0.6ML 214NM.org
实验者:
报告时间：2010-09-26,15:12:28
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		15.603	23197.463	788739.250	4.9631
2		18.923	321974.875	15103458.000	95.0369
总计			345172.338	15892197.250	100.0000



OD-H
HEXANE/IPA = 80/20
230 NM
0.6 ML/MIN

EE = 90%

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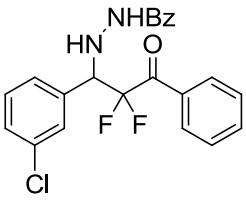
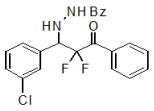
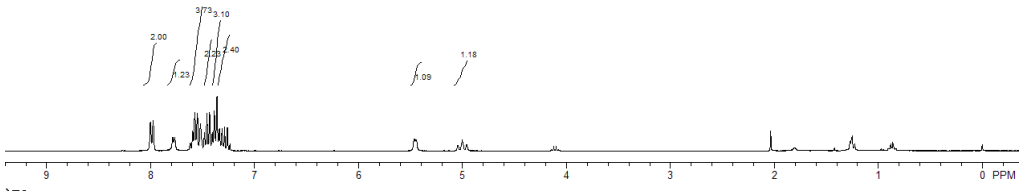
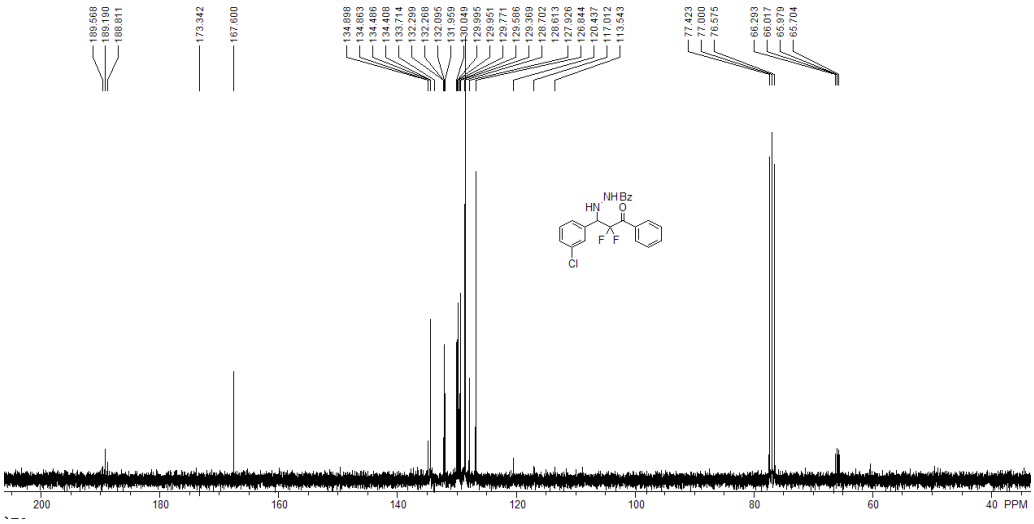
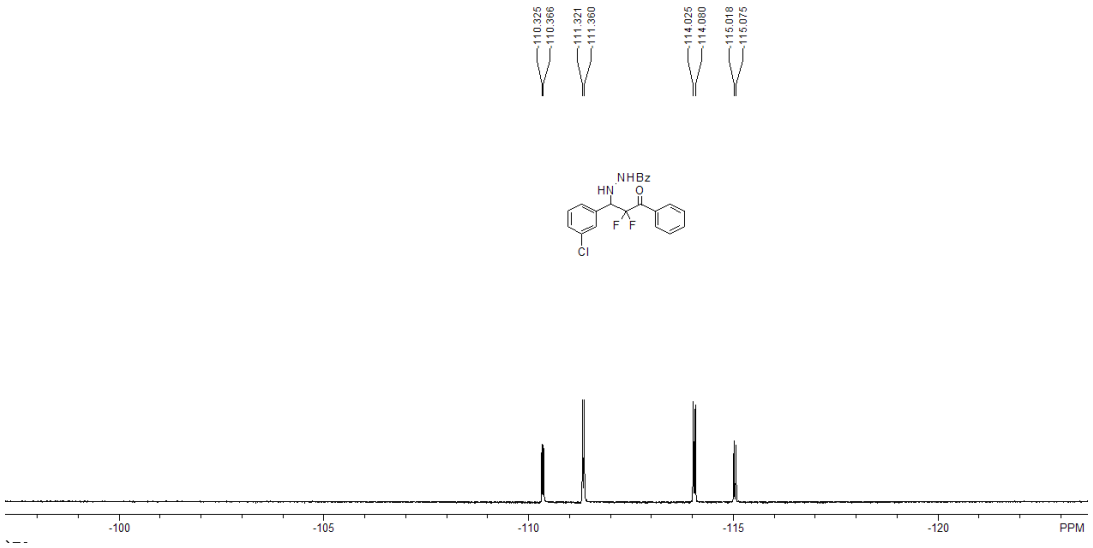
N-(1-(3-chlorophenyl)-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3j).











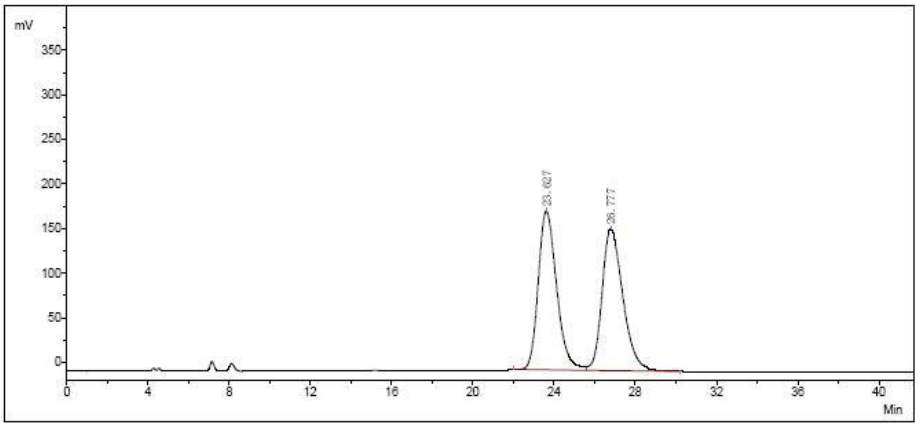
HPLC REPORT

Sample Name:yzl-a-10-46-3clrac od250 90.che Date:2010-10-27

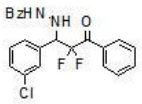
Time:14:26 Method:

column: the mobile phase:

Velocity: the detection wavelength:



No.	PeakNo	R.Time	PeakHeight	PeakArea	PerCent
1	1	23.627	178200.5	11241378.6	49.8272
2	2	26.777	158565.0	11319333.0	50.1728
Total			336765.5	22560711.6	100.0000

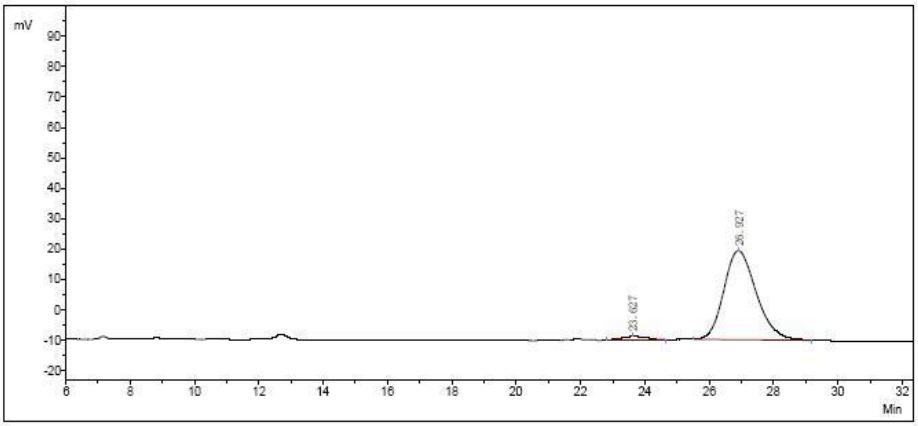


OD-H
Hexane/iPrOH = 90/10
0.7 mL/min
214 nm

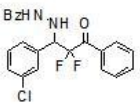
racemic sample

HPLC REPORT

Sample Name:yzl-a-15-48-3cl.che
Date:2010-10-27
Time:15:08
Method:
column:
the mobile phase:
Velocity:
the detection wavelength:



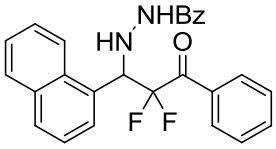
No.	PeakNo	R.Time	PeakHeight	PeakArea	PerCent
1	1	23.627	1164.1	62419.8	2.9728
2	2	26.927	29160.1	2037288.0	97.0272
Total			30324.2	2099707.8	100.0000

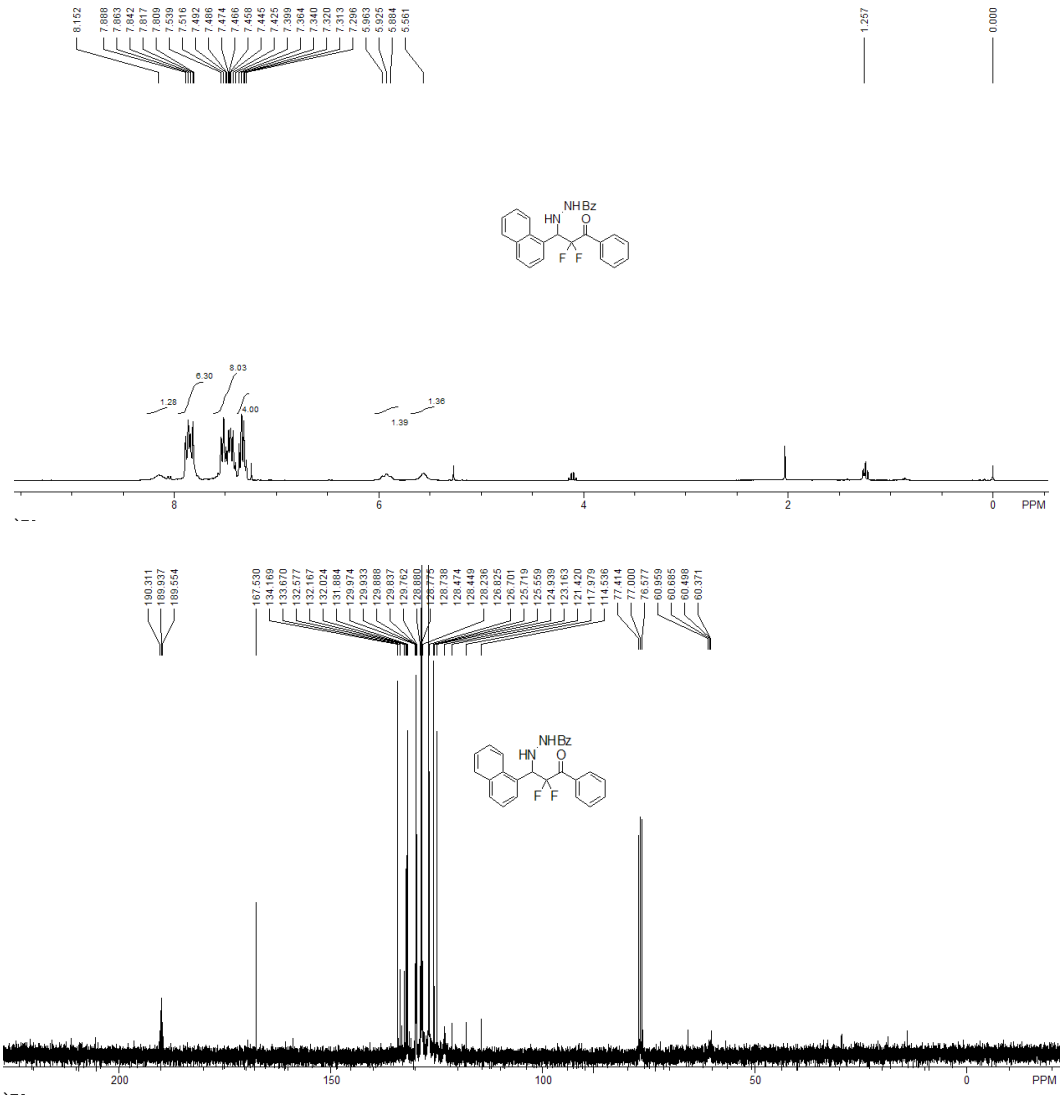


OD-H
Hexane/iPrOH = 90/10
0.7 mL/min
214 nm

ee = 94%

N-(2,2-difluoro-1-(naphthalen-1-yl)-3-oxo-3-phenylpropyl)benzohydrazide (3k).

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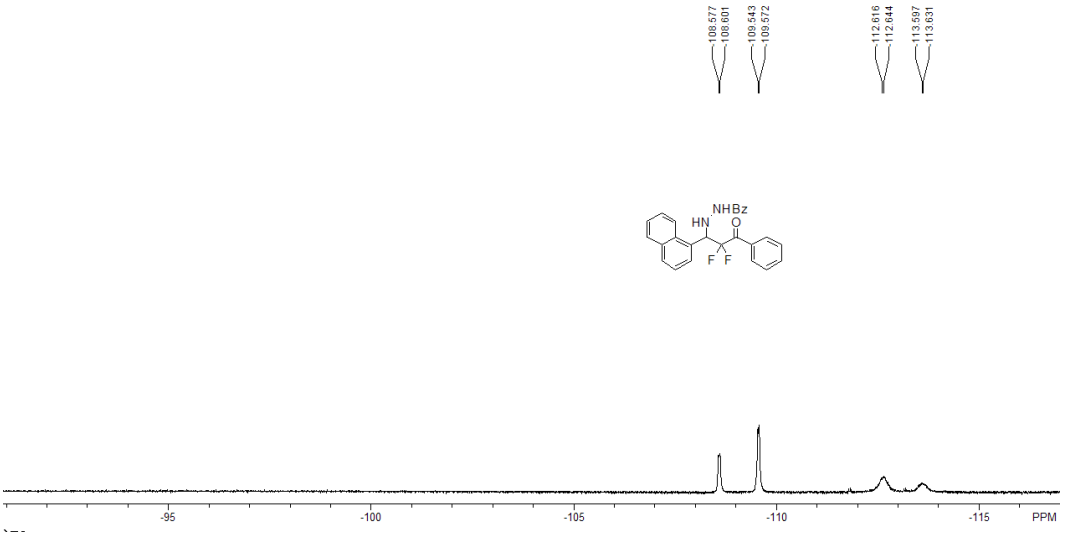
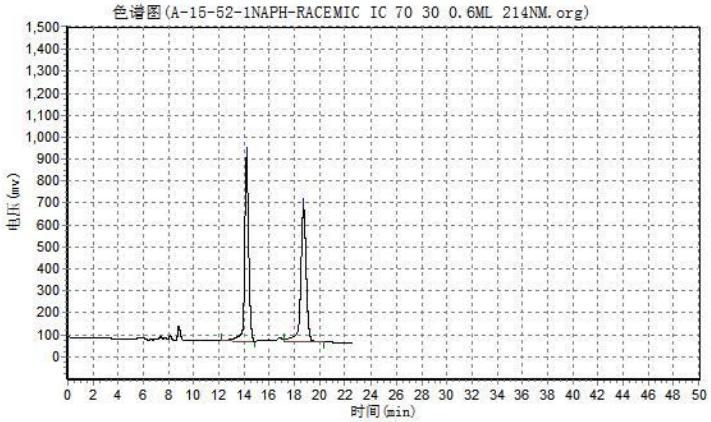
7.863
7.842
7.817
7.809
7.539
7.516
7.492
7.486
7.474
7.466
7.458
7.445
7.425
7.399
7.364
7.340
7.320
7.313
7.296
5.963
5.925
5.884
5.561
1.257
0.000
NHBz
HN
O
F F
6.30
8.03
1.28
4.00
1.39
1.36
8
6
4
2
0
PPM
190.311
189.937
189.554
167.530
134.169
133.670
132.577
132.167
132.024
131.884
129.974
129.933
129.888
129.837
129.762
128.880
128.775
128.738
128.474
128.449
128.236
126.825
126.701
125.719
125.559
124.939
123.163
121.420
117.979
114.536
77.414
77.000
76.577
60.959
60.685
60.498
60.371
NHBz
HN
O
F F
200
150
100
50
0
PPM

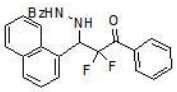


实验时间: 2010-09-07,9:12:39
谱图文件:D:\HPLC\Yzl\15\A-15-52-1NAPH-RACEMIC IC 70 30 0.6ML 214NM.org
实验者:
报告时间: 2010-09-07,17:18:30
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		14.183	835936.125	18770868.000	50.1056
2		18.717	608046.875	18691750.000	49.8944
总计			1443983.000	37462618.000	100.0000



IC-H
HEXANE/IPrOH = 70/30
214NM
0.6 ML/MIN

RACEMIC SAMPLE

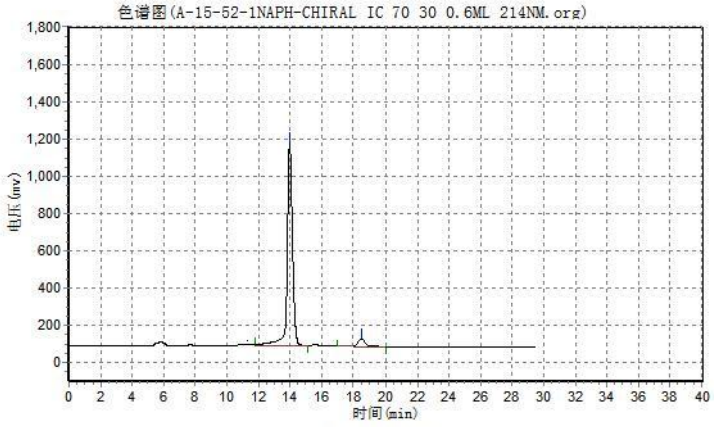
2010-09-07 浙江大学智能信息研究所

N2000 数据工作站 1

实验时间: 2010-09-07,9:43:44
谱图文件:D:\HPLC\Yzl\15\A-15-52-1NAPH-CHIRAL IC 70 30 0.6ML 214NM.org

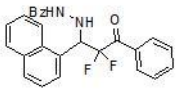
实验者:
报告时间: 2010-09-07,17:24:41
积分方法:面积归一法

色谱图(A-15-52-1NAPH-CHIRAL IC 70 30 0.6ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		13.973	1094568.625	25866078.000	95.4724
2		18.487	41133.895	1226640.125	4.5276
总计			1135702.520	27092718.125	100.0000

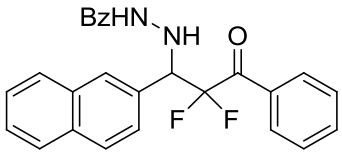


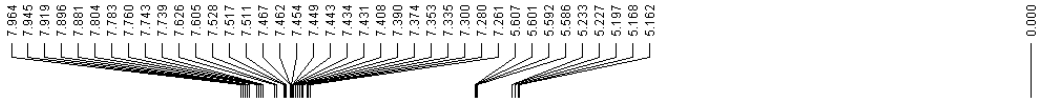
IC-H
HEXANE/iPrOH = 70/30
214NM
0.6 ML/MIN

EE = 91%

2010-09-07 浙江大学智能信息研究所

N-(2,2-difluoro-1-(naphthalen-2-yl)-3-oxo-3-phenylpropyl)benzohydrazide (3l).

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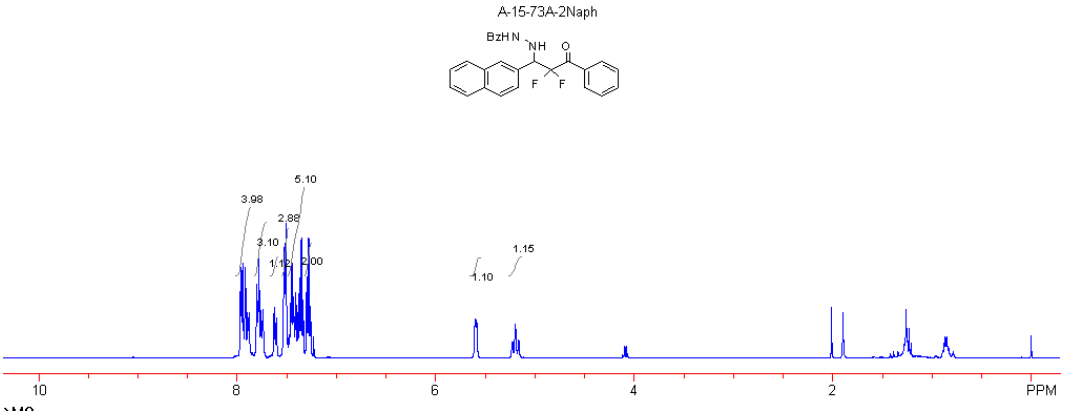
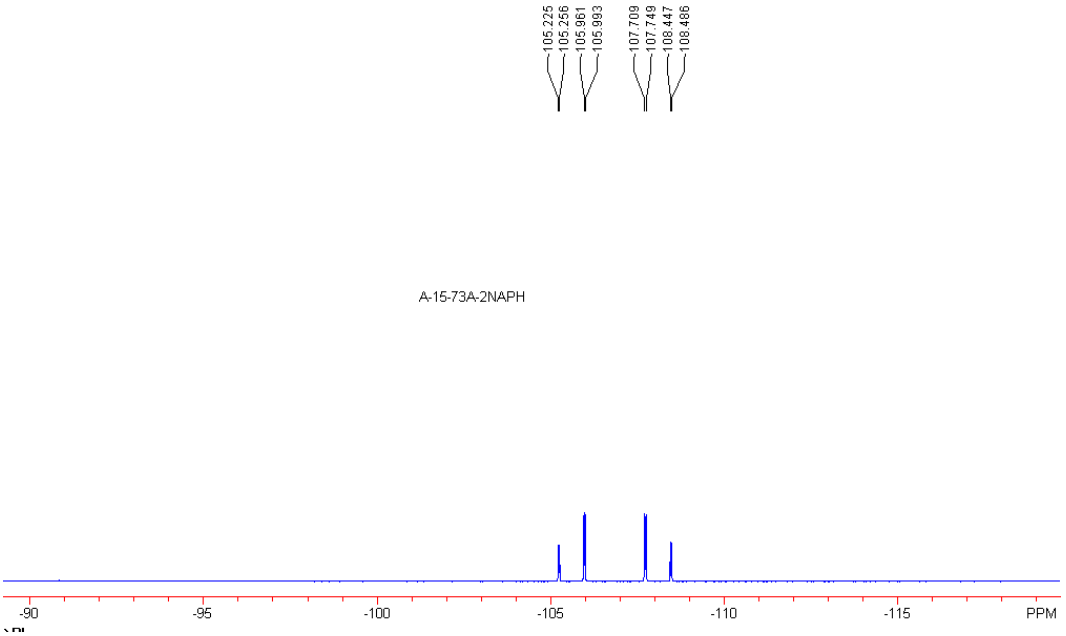
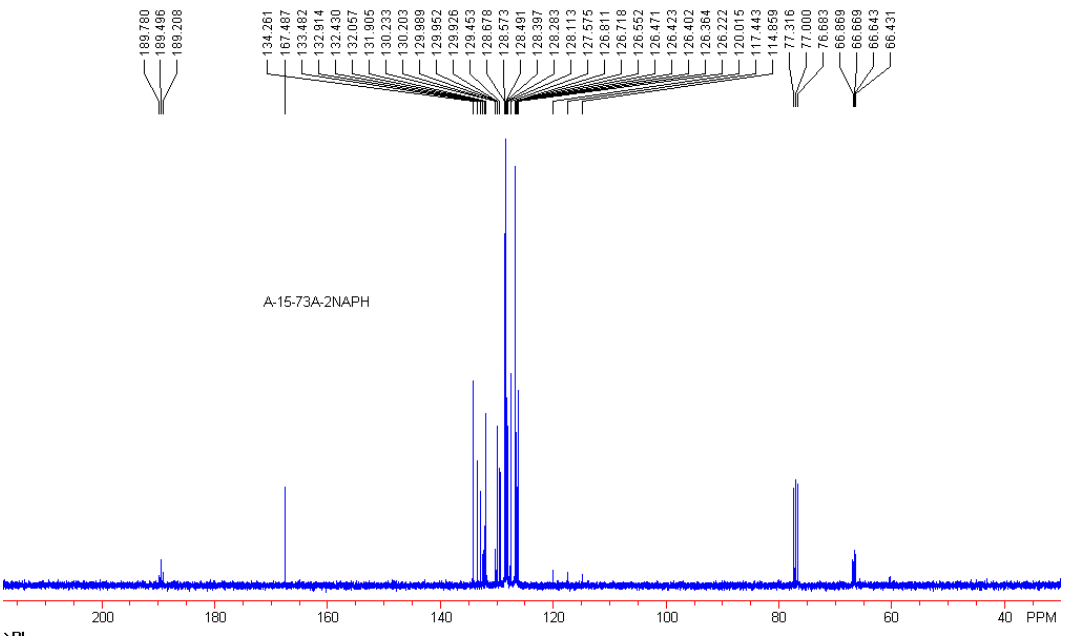
7.896
7.881
7.804
7.783
7.760
7.743
7.739
7.626
7.605
7.528
7.517
7.511
7.467
7.462
7.454
7.449
7.443
7.434
7.431
7.408
7.390
7.374
7.353
7.335
7.300
7.280
7.261
5.607
5.601
5.592
5.586
5.233
5.227
5.197
5.168
5.162
0.000

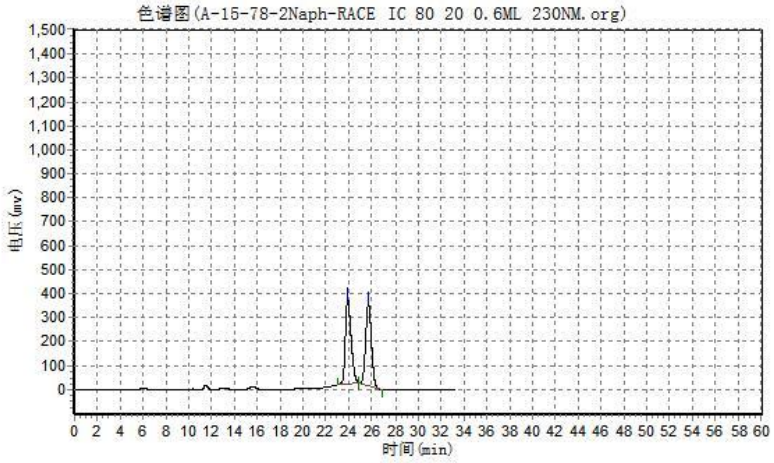

A-15-73A-2Naph
BzHN
NH
O
F
F
5.10
3.98
2.88
3.10
1.12
2.00
1.10
1.15
10
8
6
4
2
PPM


105.225
105.256
105.961
105.993
107.709
107.749
108.447
108.486
A-15-73A-2NAPH
-90
-95
-100
-105
-110
-115
PPM


189.780
189.496
189.208
134.261
167.487
133.482
132.914
132.430
132.057
131.905
130.233
130.203
129.989
129.952
129.926
129.453
128.678
128.573
128.491
128.397
128.283
128.113
127.575
126.811
126.718
126.552
126.471
126.423
126.402
126.364
126.222
120.015
117.443
114.859
77.316
77.000
76.683
66.869
66.669
66.643
66.431
A-15-73A-2NAPH
200
180
160
140
120
100
80
60
40
PPM

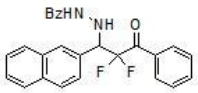
实验时间: 2010-09-20,10:09:04
谱图文件:D:\HPLC\Yzl\15\A-15-78-2Naph-RACE IC 80 20 0.6ML 230NM.org

实验者:
报告时间: 2010-09-20,10:54:34
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		23.917	355107.000	12437103.000	50.7360
2		25.737	343454.594	12076252.000	49.2640
总计			698561.594	24513355.000	100.0000

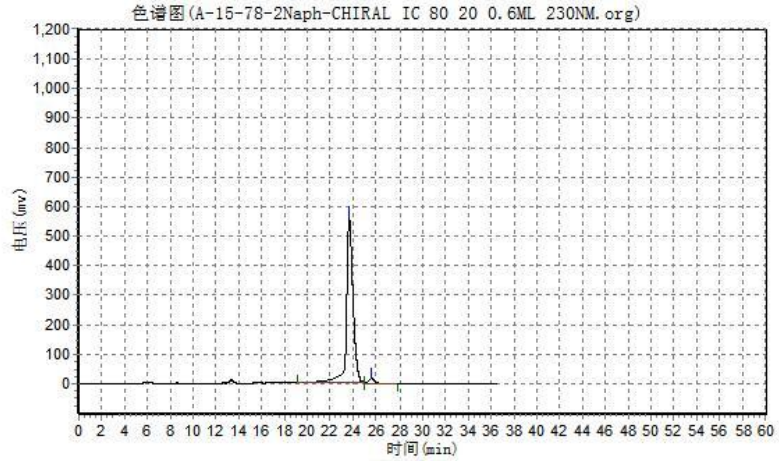


IC-H
HEXANE/IPA = 80/20
0.6 ML/MIN
230NM

RACEMIC SAMPLE

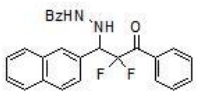
2010-09-20 浙江大学智能信息研究所

实验时间: 2010-09-20,10:49:23
谱图文件:D:\HPLC\Yzl\15\A-15-78-2Naph-CHIRAL IC 80 20 0.6ML 230NM.org
实验者:
报告时间: 2010-09-20,10:58:43
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		23.680	555360.063	22219690.000	97.1003
2		25.577	17194.152	663542.875	2.8997
总计			572554.215	22883232.875	100.0000

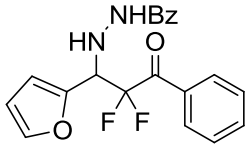


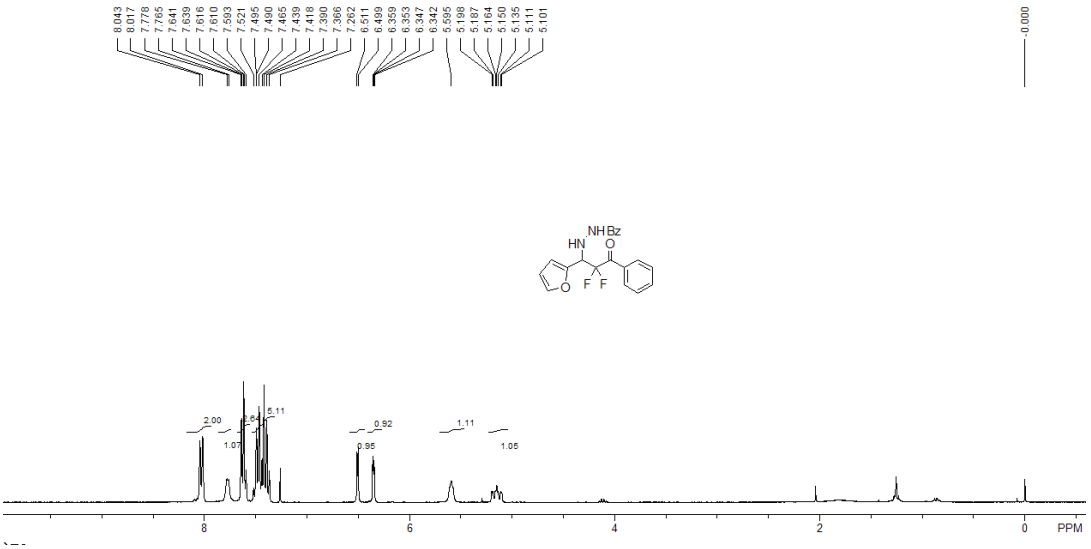
IC-H
HEXANE/IPA = 80/20
0.6 ML/MIN
230NM

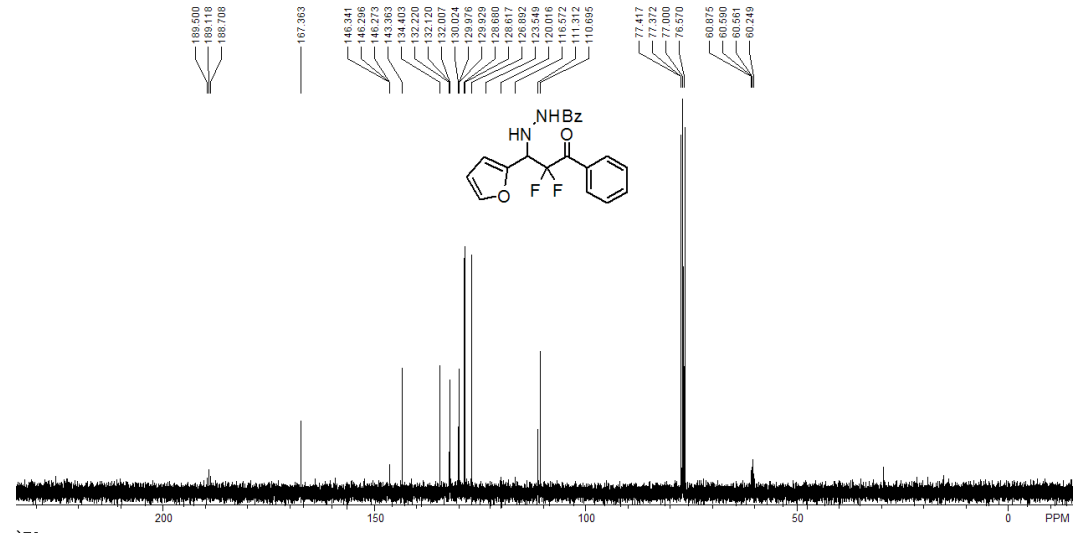
EE = 94%

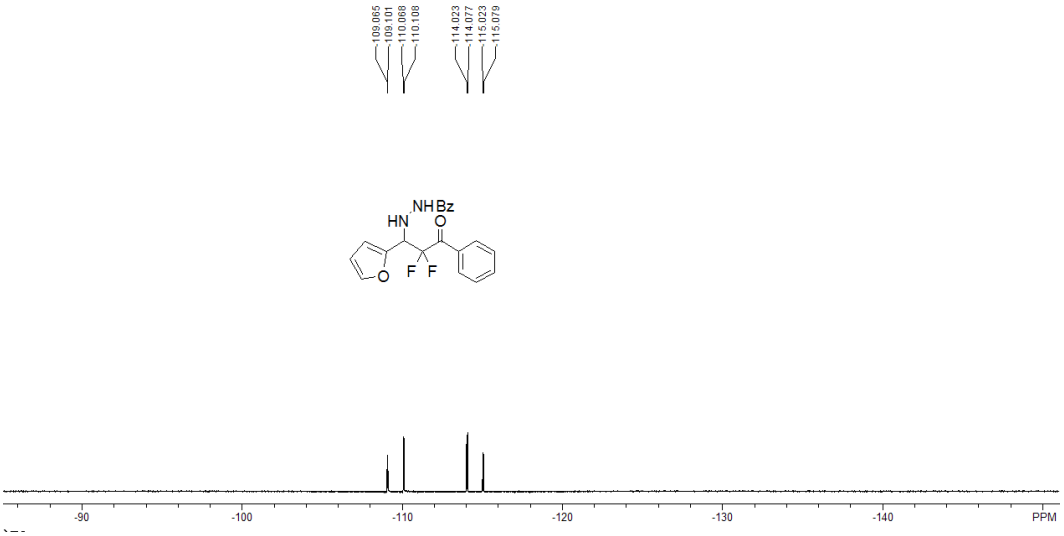
2010-09-20 浙江大学智能信息研究所

N-(2,2-difluoro-1-(furan-2-yl)-3-oxo-3-phenylpropyl)benzohydrazide (3m).





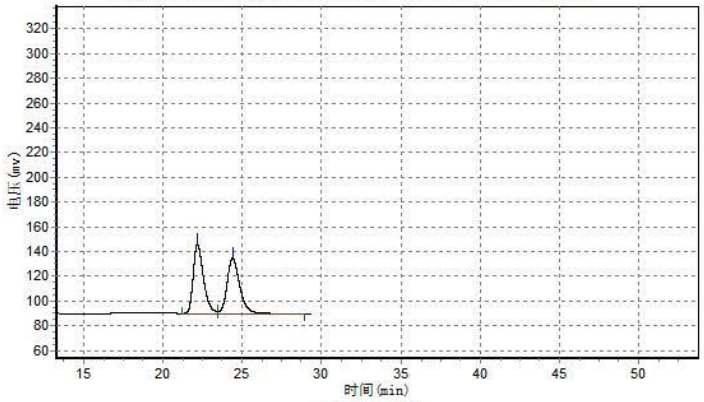



-109.065
-109.101
-110.068
-110.108
-114.023
-114.077
-115.023
-115.079
NHBz
HN
O
O
F F
-90
-100
-110
-120
-130
-140
PPM

实验时间: 2010-09-07,11:45:21
谱图文件:D:\HPLC\Yz1\15\A-15-53-2FURAN-RACEMIC OJ 70 30 0.6ML 214NM.org

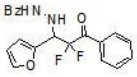
实验者:
报告时间: 2010-09-07,17:28:21
积分方法:面积归一法

色谱图(A-15-53-2FURAN-RACEMIC OJ 70 30 0.6ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		22.155	56277.191	2544090.500	50.2751
2		24.373	45111.152	2516244.500	49.7249
总计			101388.344	5060335.000	100.0000



OJ-H
HEXANE/IPrOH = 70/30
214NM
0.6 ML/MIN

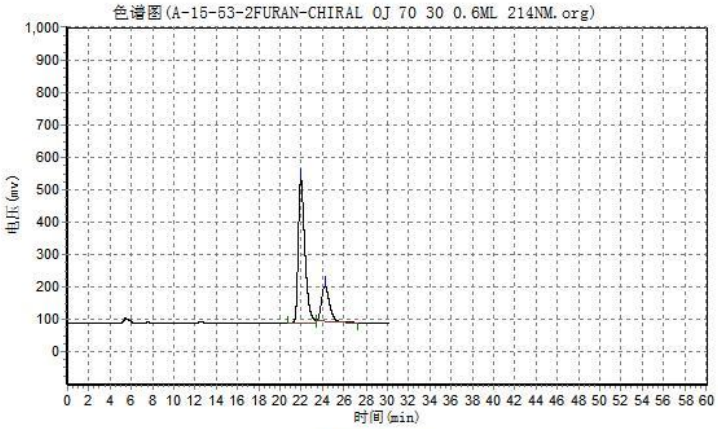
RACEMIC SAMPLE

2010-09-07

浙江大学智能信息研究所

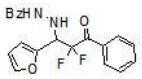
N2000 数据工作站 1

实验时间: 2010-09-07,12:16:46
谱图文件:D:\HPLC\Yzl\15\A-15-53-2FURAN-CHIRAL OJ 70 30 0.6ML 214NM.org
实验者:
报告时间: 2010-09-07,17:31:28
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		21.963	444206.719	19358546.000	78.4482
2		24.220	109538.734	5318316.500	21.5518
总计			553745.453	24676862.500	100.0000

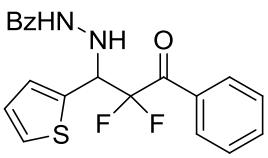


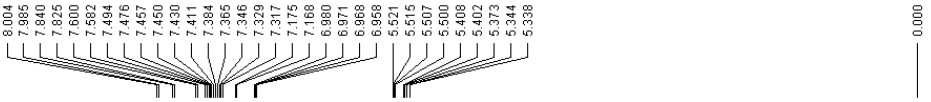
OJ-H
HEXANE/iPrOH = 70/30
214NM
0.6 ML/MIN

EE = 57%

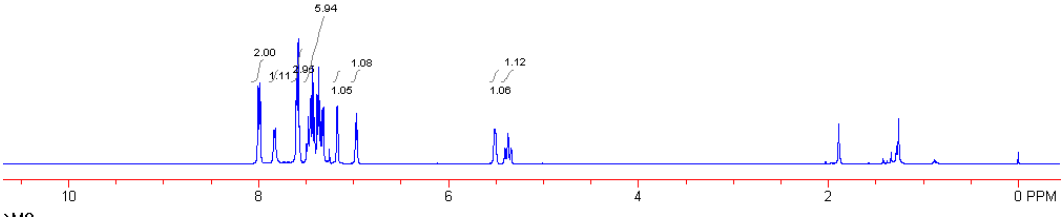
2010-09-07 浙江大学智能信息研究所

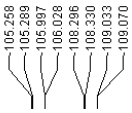
N-(2,2-difluoro-3-oxo-3-phenyl-1-(thiophen-2-yl)propyl)benzohydrazide (3n).



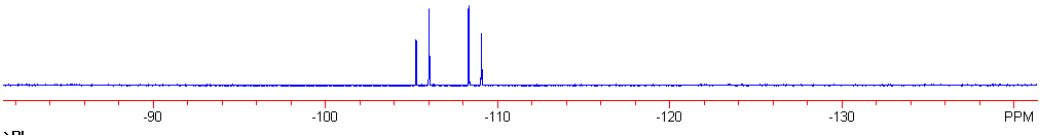


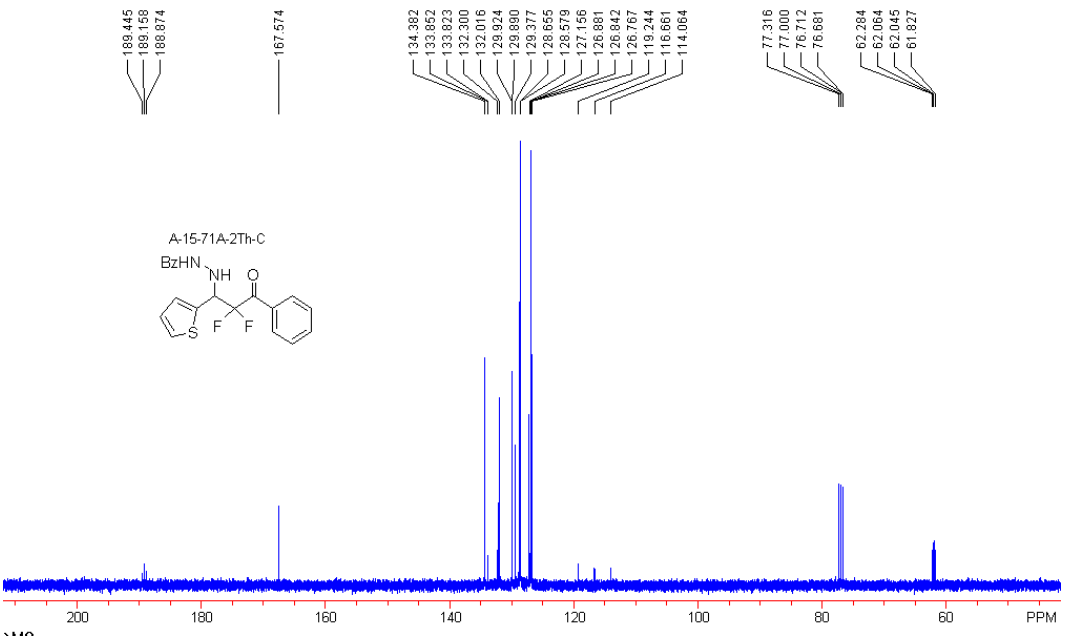
A-15-71A-2Th





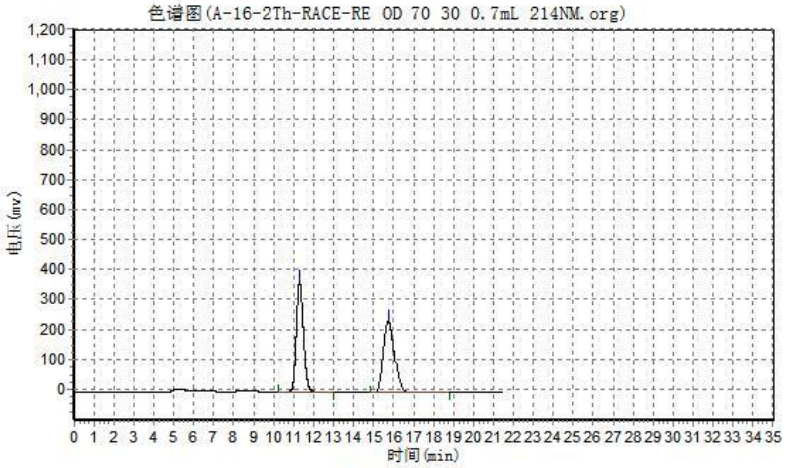
A-15-71A-2Th-F




189.445
189.158
188.874
167.574
134.382
133.852
133.823
132.300
132.016
129.924
129.890
129.377
128.655
128.579
127.156
126.881
126.842
126.767
119.244
116.661
114.064
77.316
77.000
76.712
76.681
62.284
62.064
62.045
61.827
A-15-71A-2Th-C
BzHN
NH
O
S
F
F
200
180
160
140
120
100
80
60
PPM

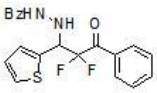
实验时间: 2010-12-24, 11:13:44
谱图文件:D:\HPLC\Yzl\16\A-16-2Th-RACE-RE OD 70 30 0.7mL 214NM.org

实验者:
报告时间: 2010-12-24, 11:20:01
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		11.312	366463.000	9215501.000	50.2451
2		15.765	241081.813	9125594.000	49.7549
总计			607544.813	18341095.000	100.0000



OD-H
Hexane/iPrOH = 70/30
0.7 mL/min
214 nm

RACEMIC SAMPLE

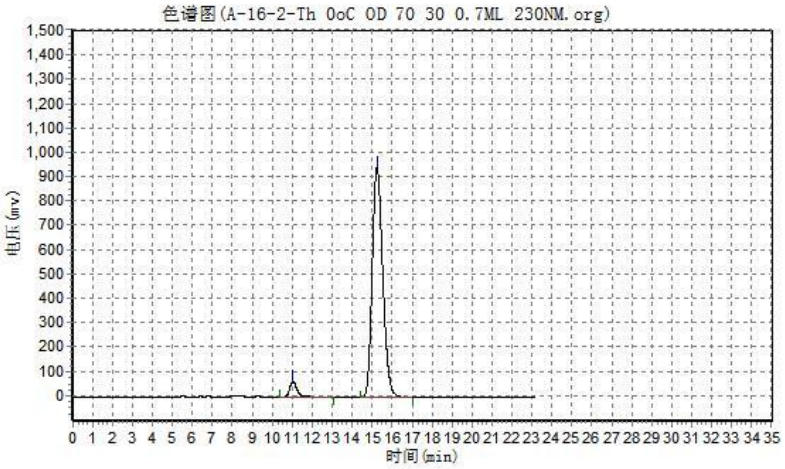
2010-12-24 浙江大学智能信息研究所

N2000 数据工作站 1

实验时间：2010-12-22,11:20:49
谱图文件:D:\HPLC\Yzl\16\A-16-2-Th 0oC OD 70 30 0.7ML 230NM.org

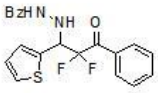
实验者:
报告时间：2010-12-24,11:05:00
积分方法:面积归一法

色谱图(A-16-2-Th 0oC OD 70 30 0.7ML 230NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		11.048	63167.289	1720983.125	4.7175
2		15.270	942892.063	34759576.000	95.2825
总计			1006059.352	36480559.125	100.0000

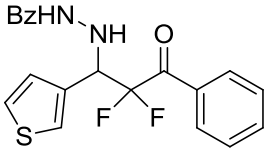


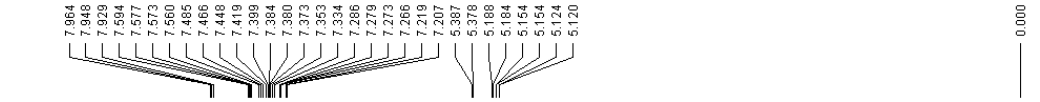
OD-H
Hexane/iPrOH = 70/30
0.7 mL/min
214 nm

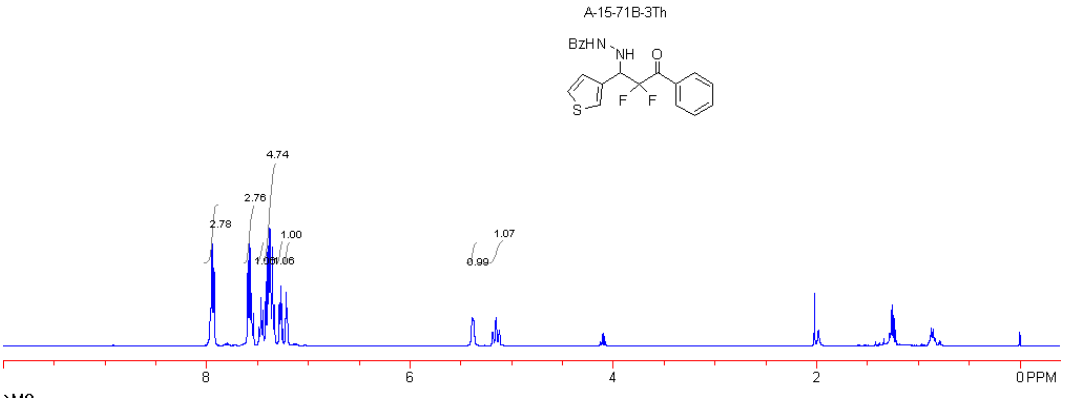
ee = 90%

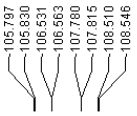
2010-12-24 浙江大学智能信息研究所

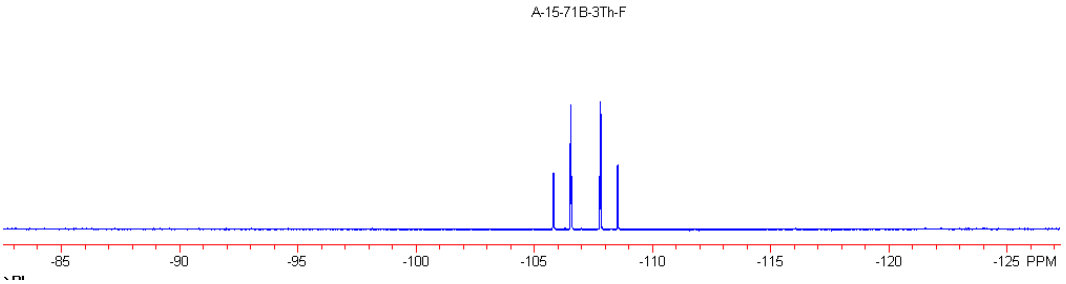
N-(2,2-difluoro-3-oxo-3-phenyl-1-(thiophen-3-yl)propyl)benzohydrazide (3o).

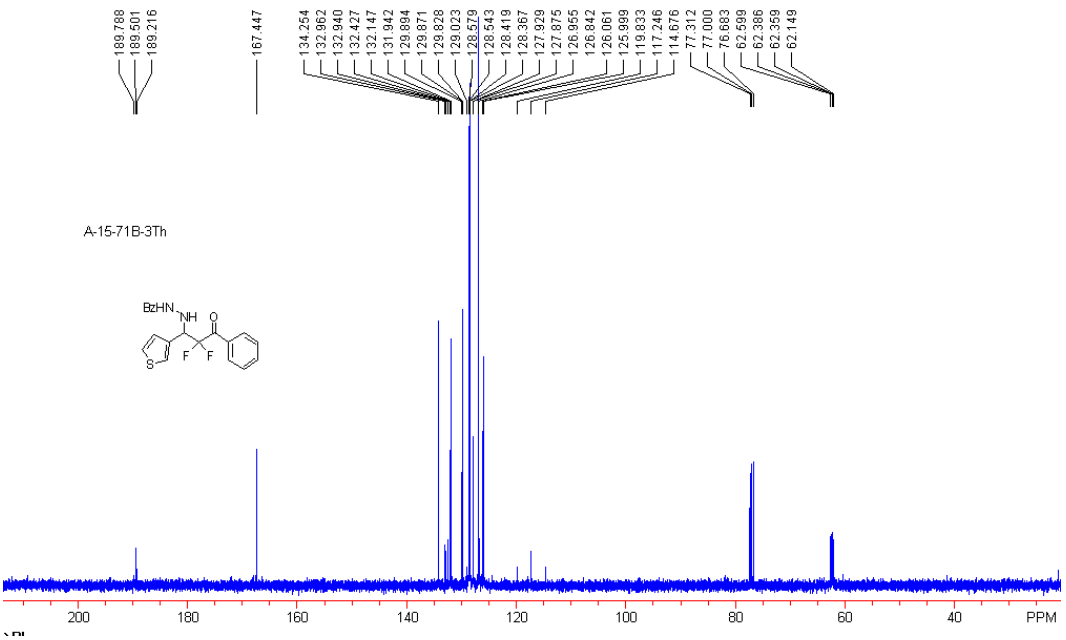



7.964
7.948
7.929
7.594
7.577
7.573
7.560
7.485
7.466
7.448
7.419
7.399
7.384
7.380
7.373
7.353
7.334
7.286
7.279
7.273
7.266
7.219
7.207
5.387
5.378
5.188
5.184
5.154
5.154
5.124
5.120
0.000


A-15-71B-3Th
BzHN
NH
O
F
F
S
4.74
2.76
2.78
1.00
1.07
0.99
8
6
4
2
0 PPM

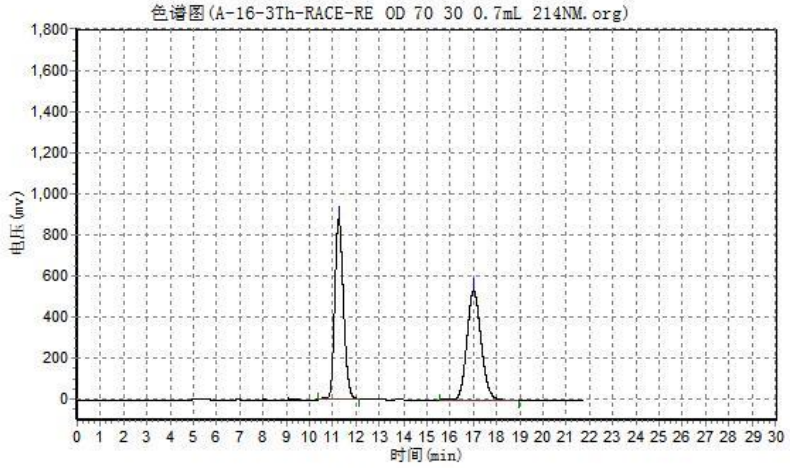

105.797
105.830
106.531
106.563
107.780
107.815
108.510
108.546


A-15-71B-3Th-F
-85
-90
-95
-100
-105
-110
-115
-120
-125 PPM



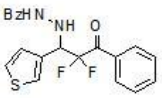
实验时间: 2010-12-24,11:39:59
谱图文件:D:\HPLC\Yzl\16\A-16-3Th-RACE-RE OD 70 30 0.7mL 214NM.org

实验者:
报告时间: 2010-12-24,11:41:24
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		11.258	882909.813	23192580.000	50.5669
2		17.007	533581.125	22672546.000	49.4331
总计			1416490.938	45865126.000	100.0000



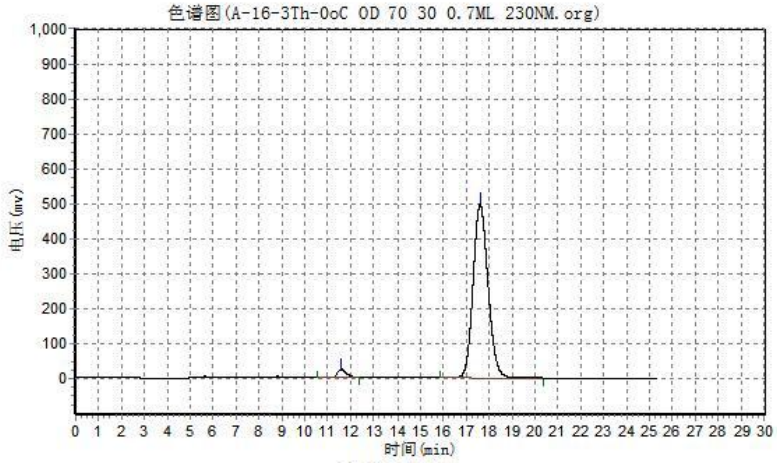
OD-H
Hexane/iPrOH = 70/30
0.7 mL/min
214 nm

RACEMIC SAMPLE

2010-12-24 浙江大学智能信息研究所

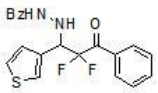
N2000 数据工作站 1

实验时间: 2010-12-22,15:00:13
谱图文件:D:\HPLC\Yzl\16\A-16-3Th-0oC OD 70 30 0.7ML 230NM.org
实验者:
报告时间: 2010-12-24,11:01:55
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		11.595	23335.131	661870.500	2.8589
2		17.600	496327.281	22489560.000	97.1411
总计			519662.412	23151430.500	100.0000

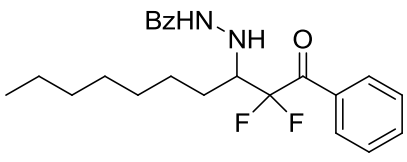


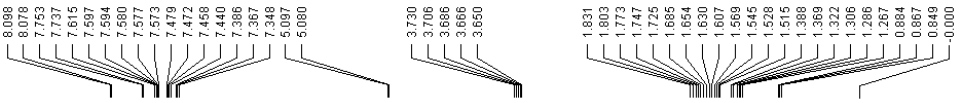
OD-H
Hexane/iPrOH = 70/30
0.7 mL/min
214 nm

ee = 94%

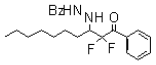
2010-12-24 浙江大学智能信息研究所

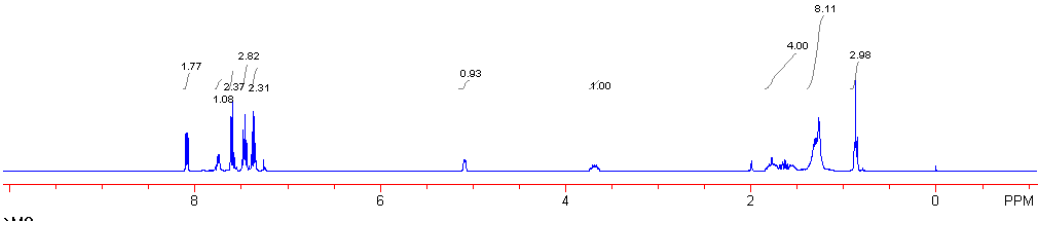
N-(2,2-difluoro-1-oxo-1-phenyldecan-3-yl)benzohydrazide (3p).



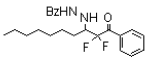


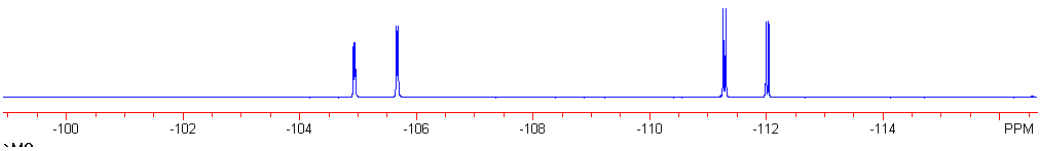
A-15-95B-OCTANE

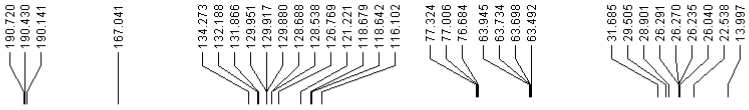




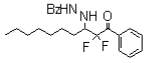
A-15-95B-OCTANE-F





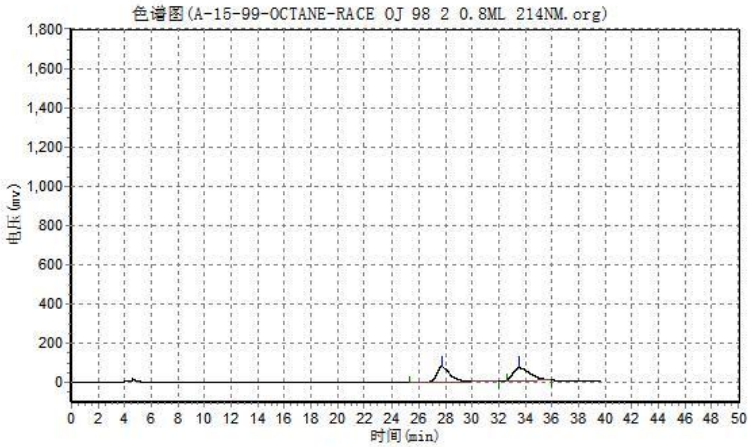


A-15-95B-OCTANE-C



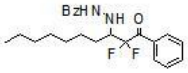
实验时间: 2010-09-30,21:56:20
谱图文件:D:\HPLC\Yzl\15\A-15-99-OCTANE-RACE OJ 98 2 0.8ML 214NM.org

实验者:
报告时间: 2010-09-30,22:00:58
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		27.758	78751.359	5426528.000	49.6199
2		33.577	62914.160	5509669.500	50.3801
总计			141665.520	10936197.500	100.0000



OJ-H
HEXANE/IPA = 98/2
214 NM
0.8 ML/MIN

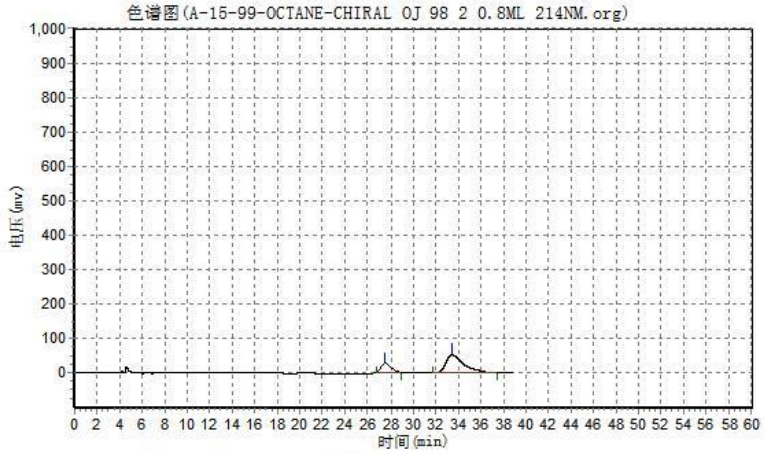
RACEMIC SAMPLE

2010-09-30 浙江大学智能信息研究所

N2000 数据工作站 1

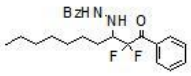
实验时间: 2010-09-30,22:36:37
谱图文件:D:\HPLC\Yzl\15\A-15-99-OCTANE-CHIRAL OJ 98 2 0.8ML 214NM.org
实验者:
报告时间: 2010-09-30,22:38:31
积分方法:面积归一法

色谱图(A-15-99-OCTANE-CHIRAL OJ 98 2 0.8ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		27.570	25197.705	1466224.750	20.0885
2		33.417	52341.676	5832609.000	79.9115
总计			77539.381	7298833.750	100.0000

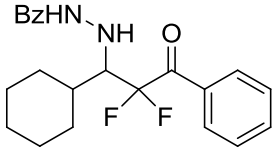


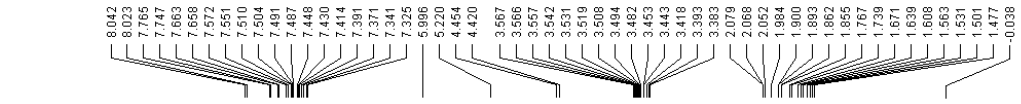
OJ-H
HEXANE/IPA = 98/2
214 NM
0.8 ML/MIN

EE = 60%

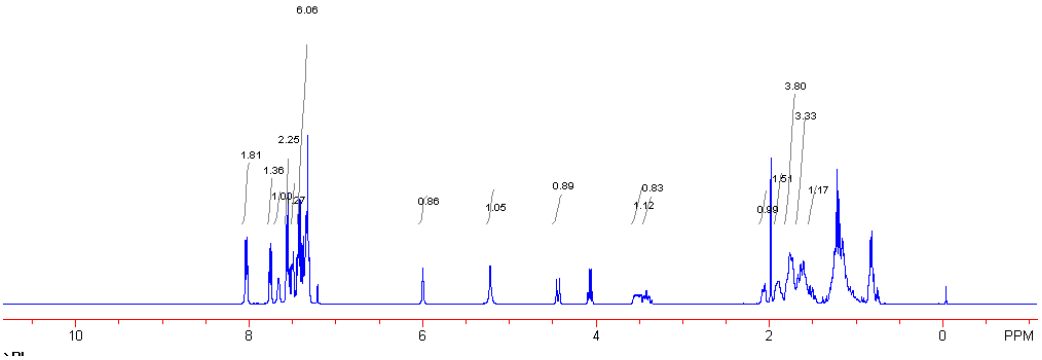
2010-09-30 浙江大学智能信息研究所

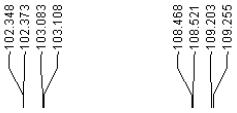
N-(1-cyclohexyl-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3q).



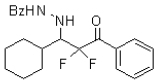


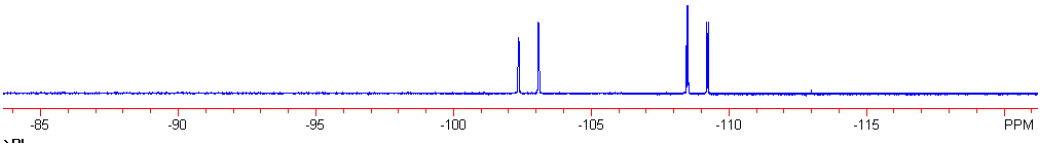
A-15-72A-CYCHEX

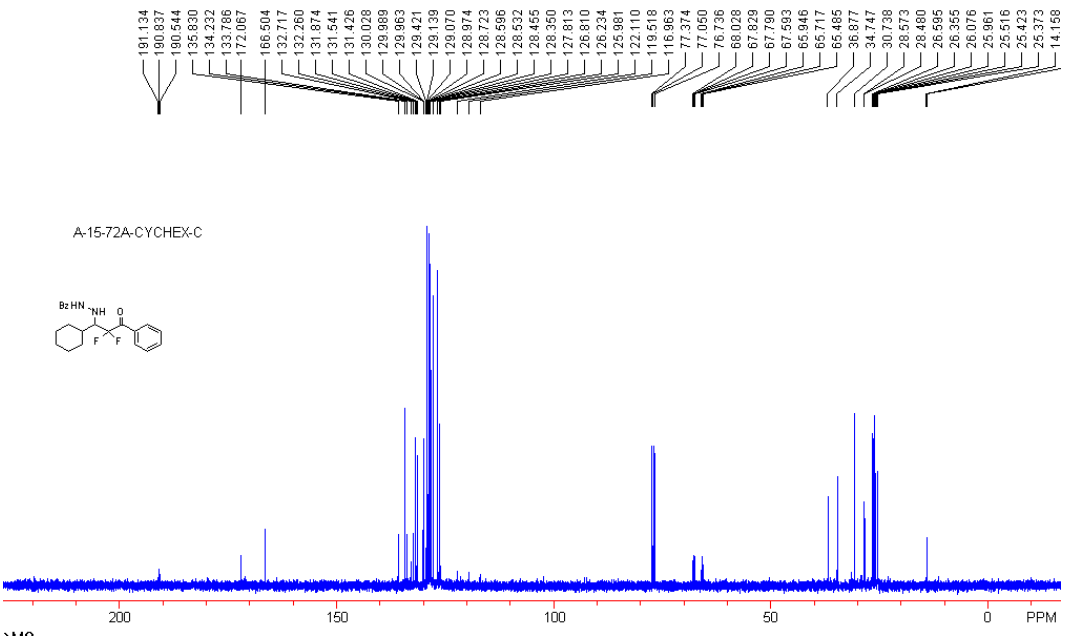




A-15-72A-CYCHEX-F

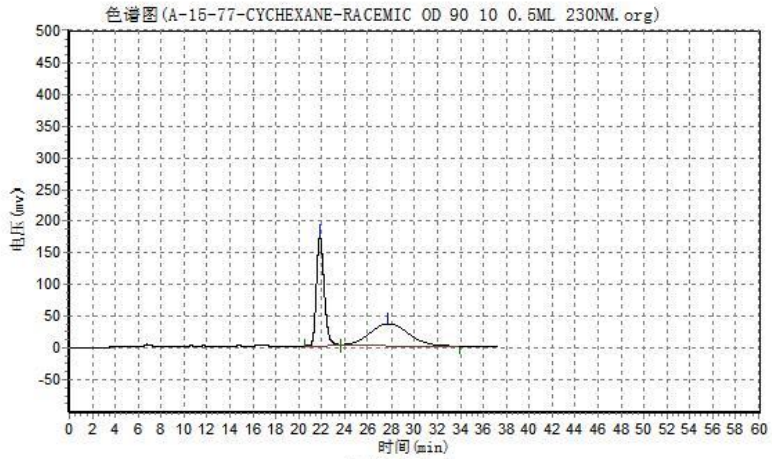





191.134
190.837
190.544
135.830
134.232
133.786
172.067
166.504
132.717
132.260
131.874
131.541
131.426
130.028
129.989
129.963
129.421
129.139
129.070
128.974
128.723
128.596
128.532
128.455
128.350
127.813
126.810
126.234
125.981
122.110
119.518
116.963
77.374
77.050
76.736
68.028
67.829
67.790
67.593
65.946
65.717
65.485
36.877
34.747
30.738
28.573
28.480
26.595
26.355
26.076
25.961
25.516
25.423
25.373
14.158
A-15-72A-CYCHEX-C
Bz HN
NH
O
F
F
200
150
100
50
0
PPM

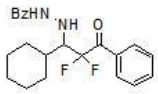
实验时间：2010-09-19,21:31:59
谱图文件:D:\HPLC\Yz1\15\A-15-77-CYCHEXANE-RACEMIC OD 90 10 0.5ML 230NM.org

实验者：
报告时间：2010-09-19,21:36:05
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		21.848	171842.609	7963535.000	50.7880
2		27.748	33851.406	7716429.000	49.2120
总计			205694.016	15679964.000	100.0000



OD-H
HEXANE/IPA = 90/10
0.5 ML/MIN
230NM

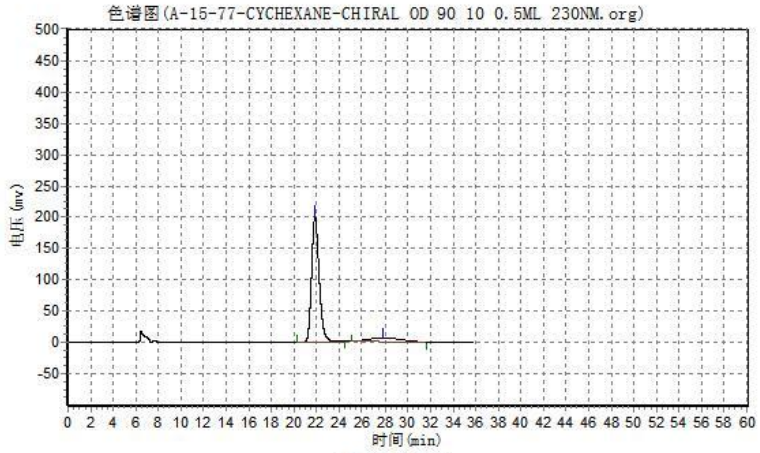
RACEMIC SAMPLE

2010-09-19

浙江大学智能信息研究所

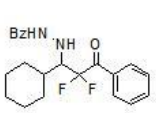
实验时间: 2010-09-19,22:09:43
谱图文件:D:\HPLC\Yz1\15\A-15-77-CYCHEXANE-CHIRAL OD 90 10 0.5ML 230NM.org

实验者:
报告时间: 2010-09-19,22:10:19
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		21.868	200060.063	9531575.000	88.9461
2		27.925	5871.546	1184555.125	11.0539
总计			205931.609	10716130.125	100.0000

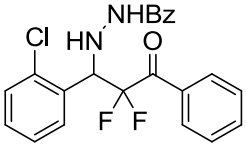


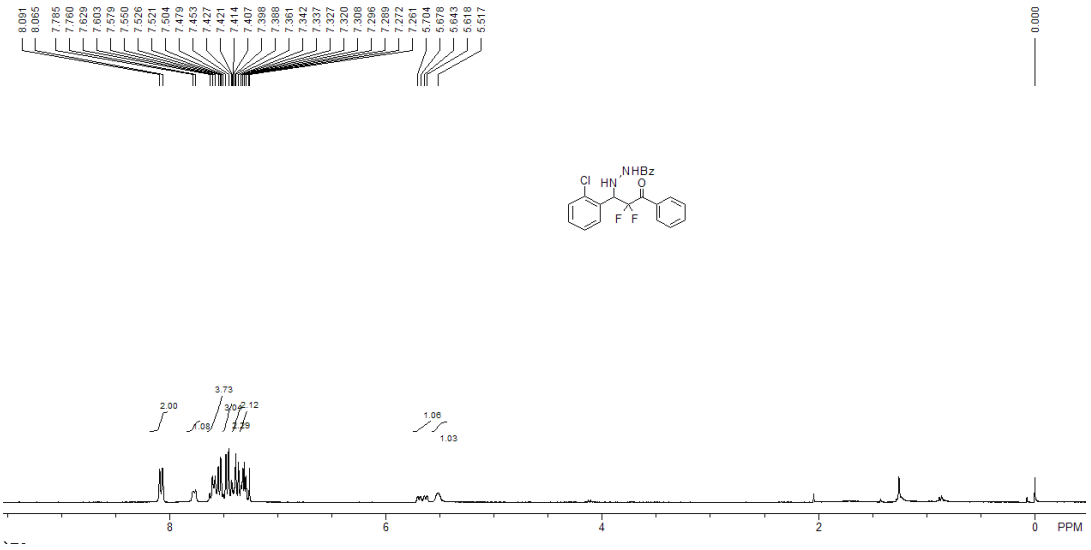
OD-H
HEXANE/IPA = 90/10
0.5 ML/MIN
230NM

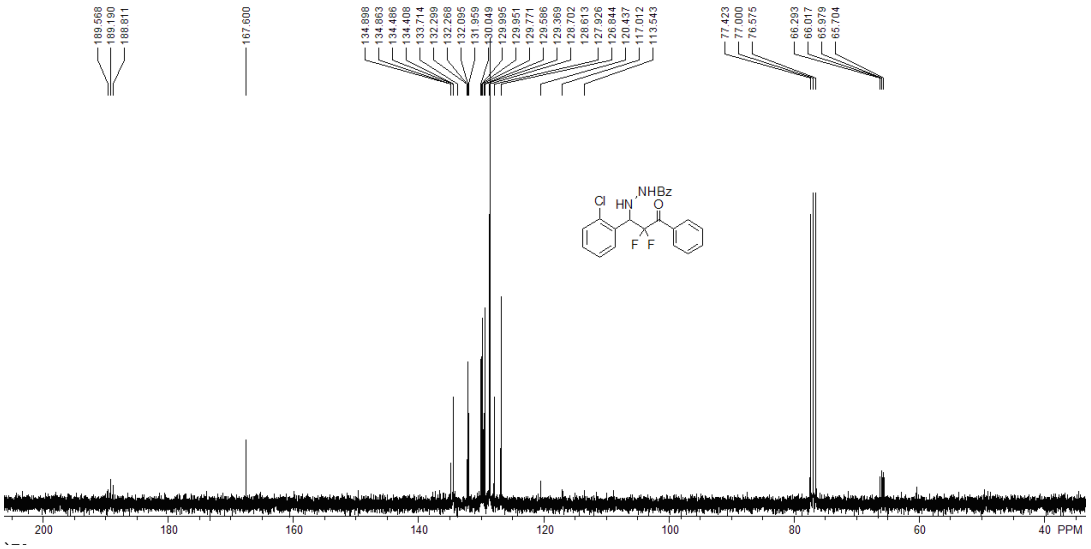
EE = 78%

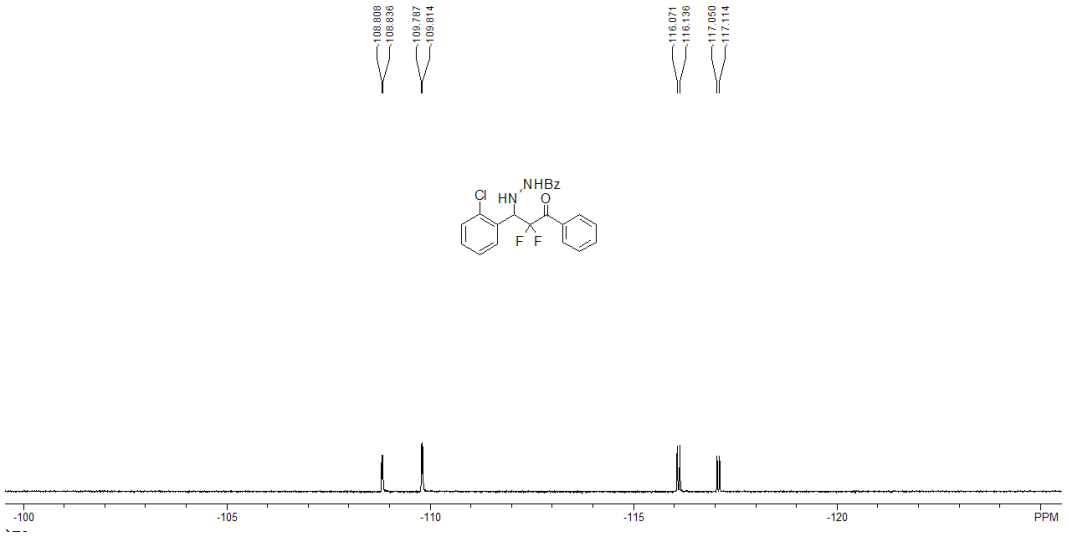
2010-09-19 浙江大学智能信息研究所

N-(1-(2-chlorophenyl)-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3r).



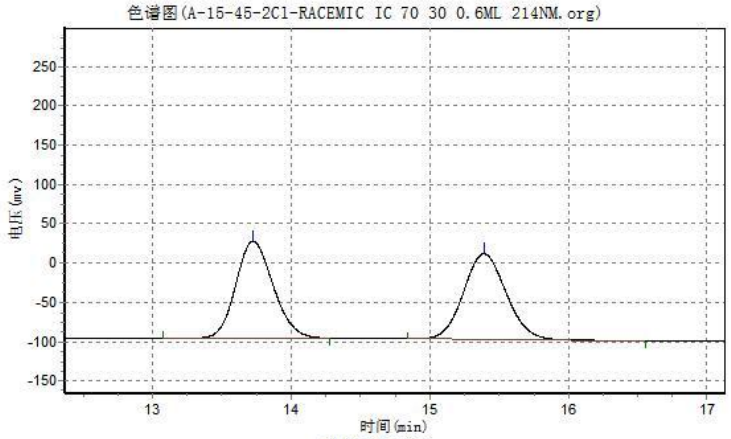






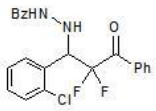
实验时间: 2010-08-26,19:57:14
谱图文件:D:\HPLC\Yzl\15\A-15-45-2Cl-RACEMIC IC 70 30 0.6ML 214NM.org
实验者:
报告时间: 2010-08-30,9:08:37
积分方法:面积归一法

色谱图(A-15-45-2Cl-RACEMIC IC 70 30 0.6ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		13.727	123505.945	2328971.500	50.2600
2		15.387	108636.086	2304880.000	49.7400
总计			232142.031	4633851.500	100.0000



IC-H
hexane/^{i}PrOH = 70/30
214nm
0.6mL/min

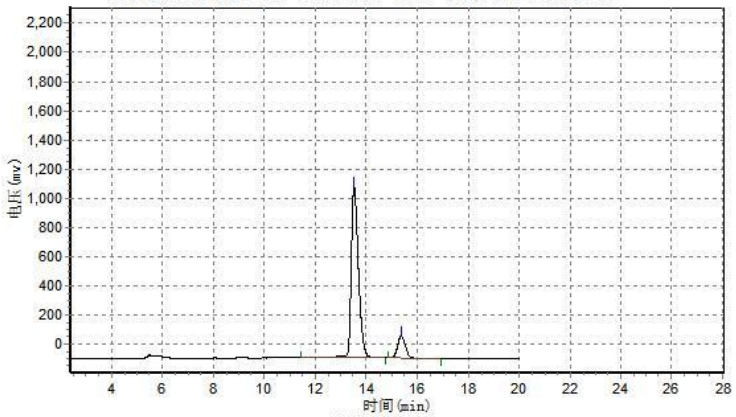
racemic sample

2010-08-30 浙江大学智能信息研究所

N2000 数据工作站 1

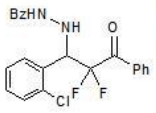
实验时间：2010-08-26,20:49:42
谱图文件:D:\HPLC\Yzl\15\A-15-54-2-2Cl-RSS-350Me IC 70 30 0.6ML 214NM.org
实验者：
报告时间：2010-08-30,9:11:44
积分方法:面积归一法

色谱图(A-15-54-2-2Cl-RSS-350Me IC 70 30 0.6ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		13.545	1166733.875	23195926.000	87.5935
2		15.357	153599.719	3285412.500	12.4065
总计			1320333.594	26481338.500	100.0000



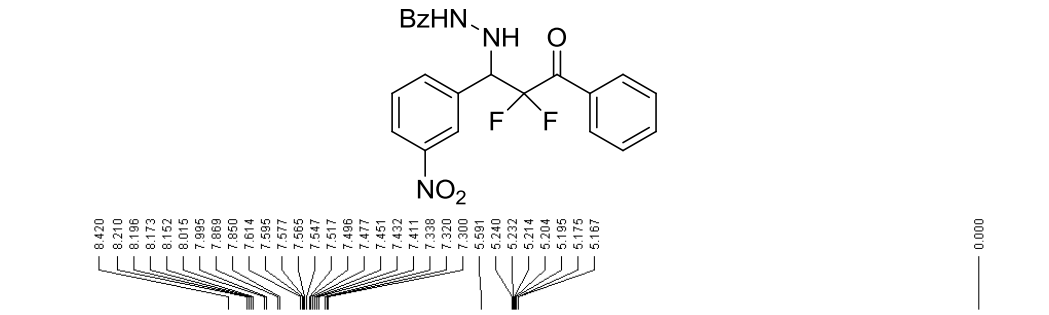
IC-H
hexane/^{i}PrOH = 70/30
214nm
0.6mL/min

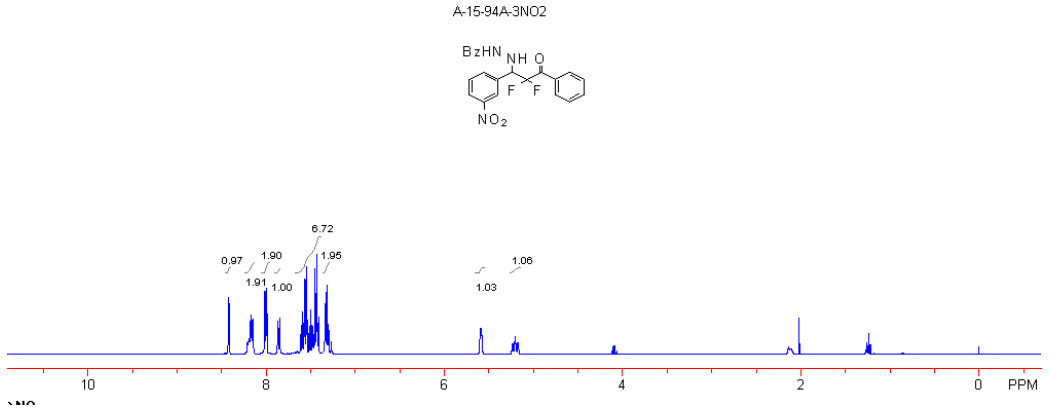
ee = 75%

2010-08-30

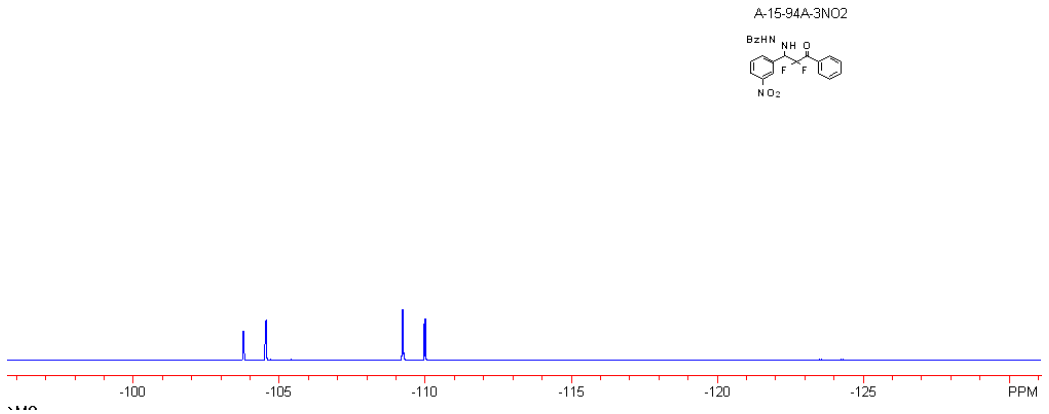
浙江大学智能信息研究所

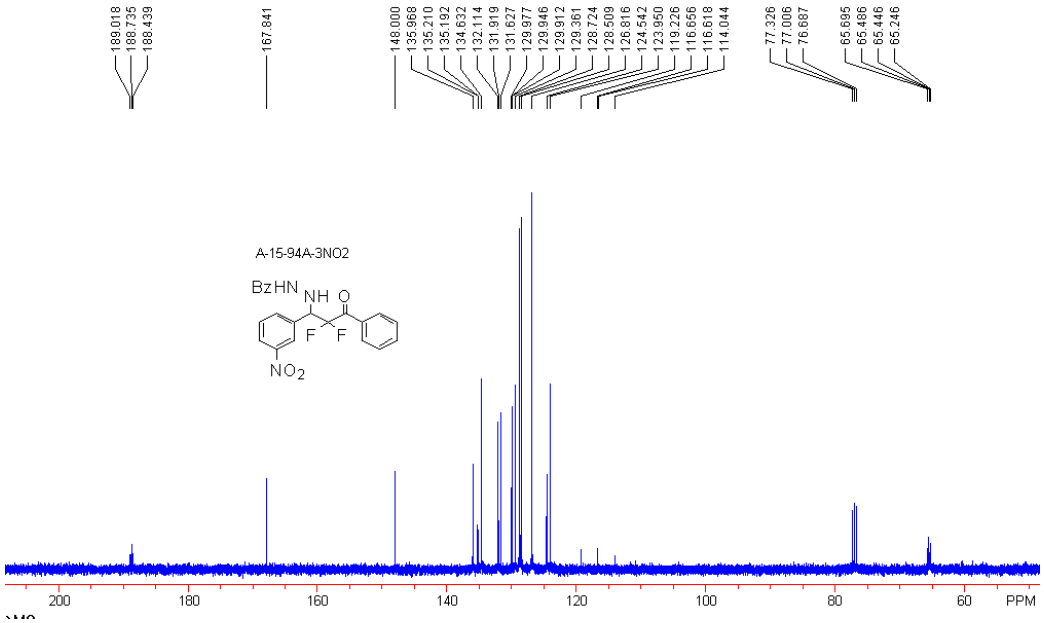
N-(2,2-difluoro-1-(3-nitrophenyl)-3-oxo-3-phenylpropyl)benzohydrazide (3s).


BzHN
NH
O
F
F
NO2
8.420
8.210
8.196
8.173
8.152
8.015
7.995
7.869
7.850
7.614
7.595
7.577
7.565
7.547
7.517
7.496
7.477
7.451
7.432
7.411
7.338
7.320
7.300
5.591
5.240
5.232
5.214
5.204
5.195
5.175
5.167
0.000


A-15-94A-3NO2
BzHN
NH
O
F
F
NO2
6.72
0.97
1.90
1.95
1.91
1.00
1.06
1.03
10
8
6
4
2
0
PPM

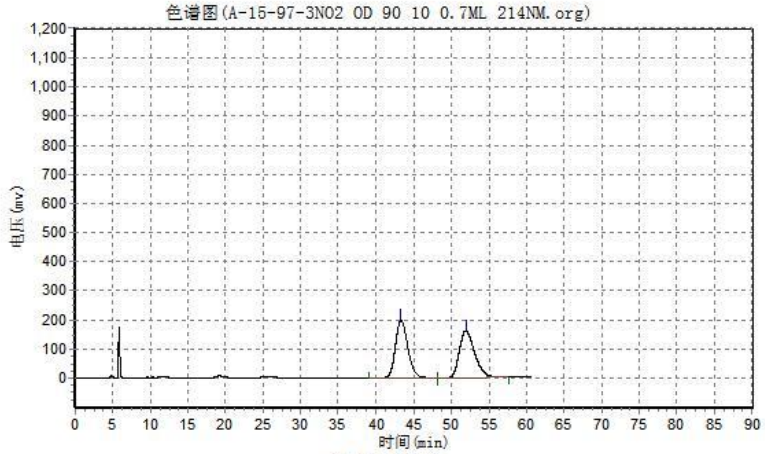

103.761
103.787
104.521
104.549
109.207
109.247
109.967
110.009


A-15-94A-3NO2
BzHN
NH
O
F
F
NO2
-100
-105
-110
-115
-120
-125
PPM


189.018
188.735
188.439
167.841
148.000
135.968
135.210
135.192
134.632
132.114
131.919
131.627
129.977
129.946
129.912
129.361
128.724
128.509
126.816
124.542
123.950
119.226
116.656
116.618
114.044
77.326
77.006
76.687
65.695
65.486
65.446
65.246
A-15-94A-3NO2
BzHN
NH
O
F
F
NO2
200
180
160
140
120
100
80
60
PPM

实验时间: 2010-09-30,17:02:35
谱图文件:D:\HPLC\Yzl\15\A-15-97-3NO2 OD 90 10 0.7ML 214NM.org
实验者:
报告时间: 2010-09-30,17:07:17
积分方法:面积归一法

色谱图(A-15-97-3NO2 OD 90 10 0.7ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		43.257	200060.250	22841770.000	50.1783
2		51.872	160781.219	22679468.000	49.8217
总计			360841.469	45521238.000	100.0000

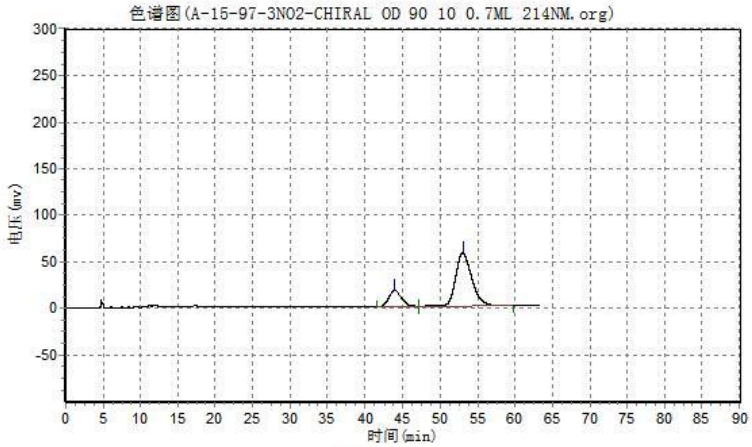
OD-H
HEXANE/IPA = 90/10
214 NM
0.7 ML/MIN

RACEMIC SAMPLE

2010-09-30 浙江大学智能信息研究所

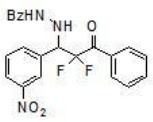
N2000 数据工作站 1

实验时间: 2010-09-30,18:07:40
谱图文件:D:\HPLC\Yz1\15\A-15-97-3NO2-CHIRAL OD 90 10 0.7ML 214NM.org
实验者:
报告时间: 2010-09-30,18:08:25
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		43.883	17068.590	1972338.250	18.7989
2		52.977	57067.211	8519443.000	81.2011
总计			74135.801	10491781.250	100.0000



OD-H
HEXANE/IPA = 90/10
214 NM
0.7 ML/MIN

EE = 62%

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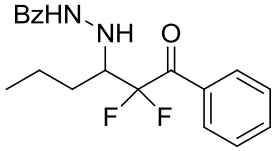
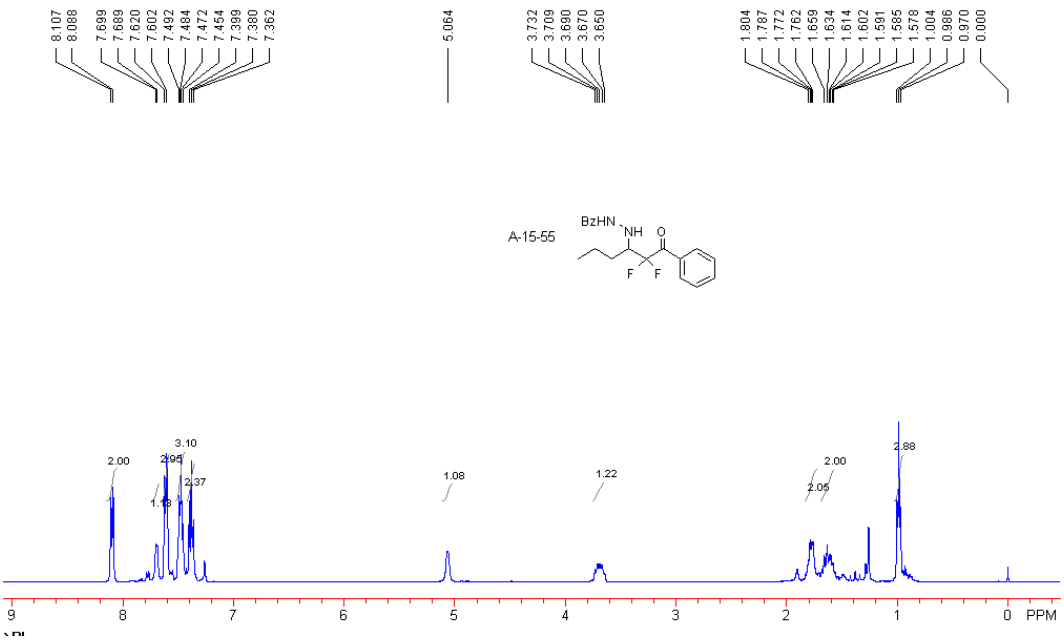
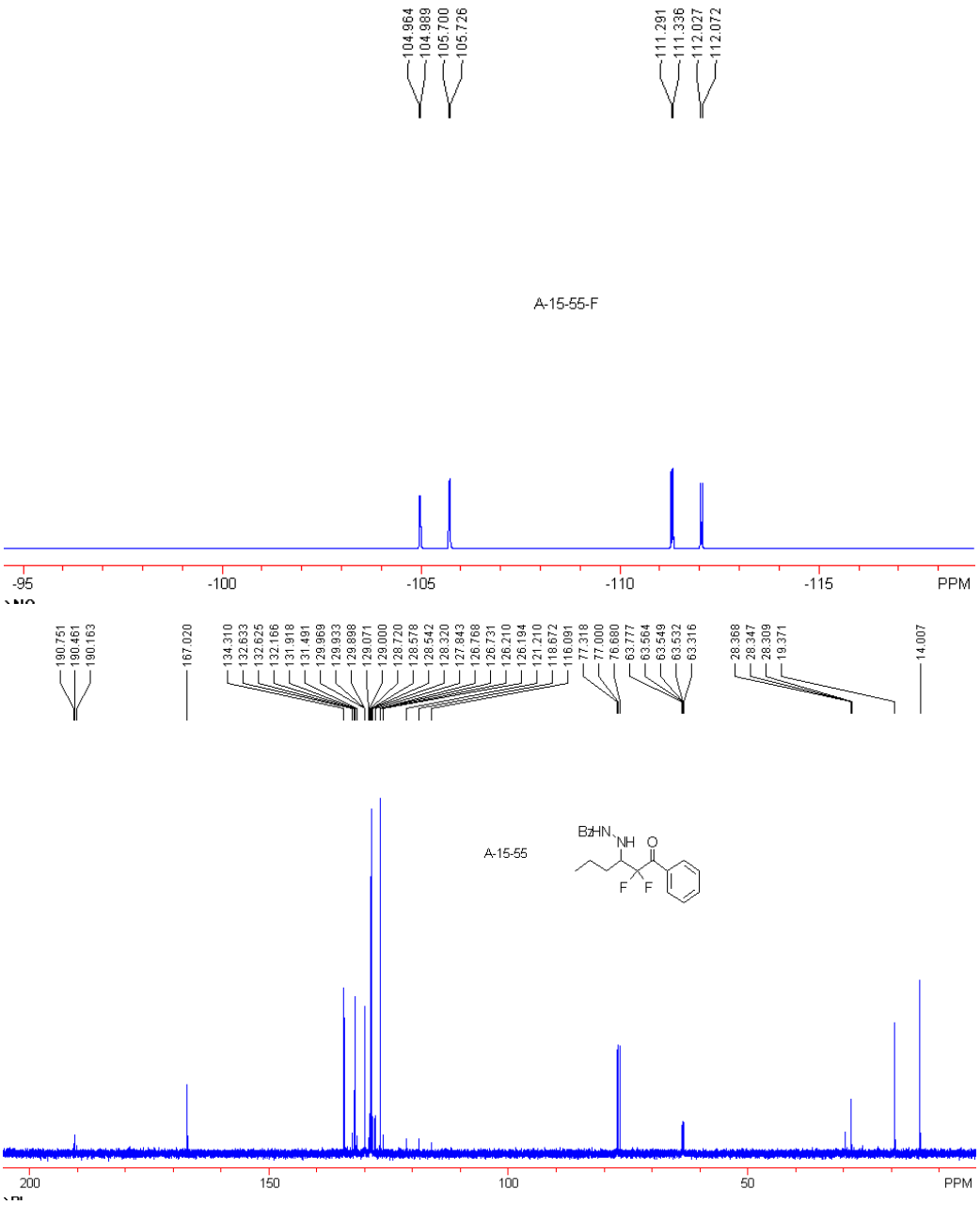
N-(2,2-difluoro-1-oxo-1-phenylhexan-3-yl)benzohydrazide (3t).



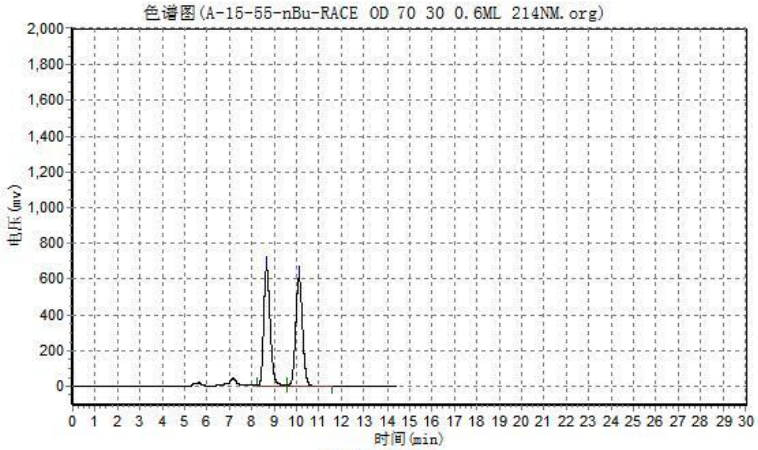



104.964
104.989
105.700
105.726
111.291
111.336
112.027
112.072
A-15-55-F
-95
-100
-105
-110
-115
PPM
190.751
190.461
190.163
167.020
134.310
132.633
132.625
132.166
131.918
131.491
129.969
129.933
129.898
129.071
129.000
128.720
128.578
128.542
128.320
127.843
126.768
126.731
126.210
126.194
121.210
118.672
116.091
77.318
77.000
76.680
63.777
63.564
63.549
63.532
63.316
28.368
28.347
28.309
19.371
14.007
A-15-55
BzHN
NH
O
F
F
200
150
100
50
PPM

实验时间: 2010-09-21,17:55:15
谱图文件:D:\HPLC\Yz1\15\A-15-55-nBu-RACE OD 70 30 0.6ML 214NM.org

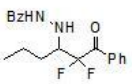
实验者:
报告时间: 2010-09-21,17:58:12
积分方法:面积归一法

色谱图(A-15-55-nBu-RACE OD 70 30 0.6ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		8.658	664566.000	13470453.000	50.6515
2		10.110	610632.563	13123906.000	49.3485
总计			1275198.563	26594359.000	100.0000



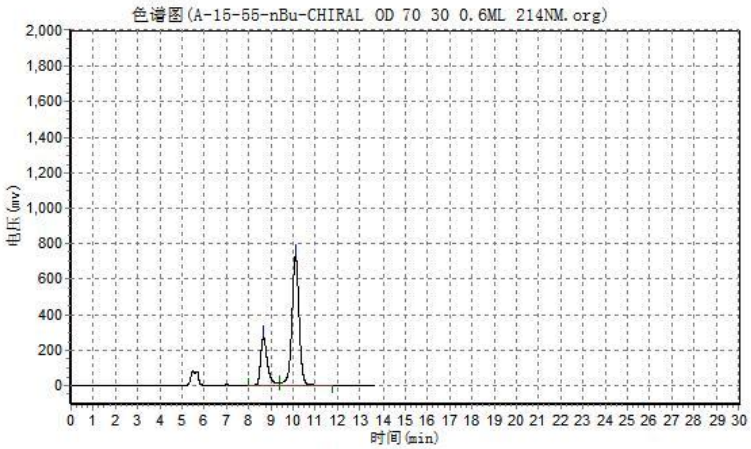
OD-H
HEXANE/IPA = 70/30
0.6 ML/MIN
214NM

RACEMIC SAMPLE

2010-09-21 浙江大学智能信息研究所

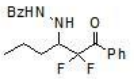
实验时间: 2010-09-21,18:10:15
谱图文件:D:\HPLC\Yzl\15\A-15-55-nBu-CHIRAL OD 70 30 0.6ML 214NM.org

实验者:
报告时间: 2010-09-21,18:11:17
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		8.665	271411.031	5857656.500	26.0824
2		10.110	731466.813	16600576.000	73.9176
总计			1002877.844	22458232.500	100.0000



OD-H
HEXANE/IPA = 70/30
0.6 ML/MIN
214NM

EE = 48%

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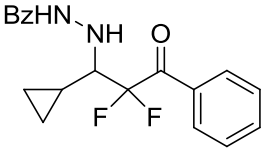
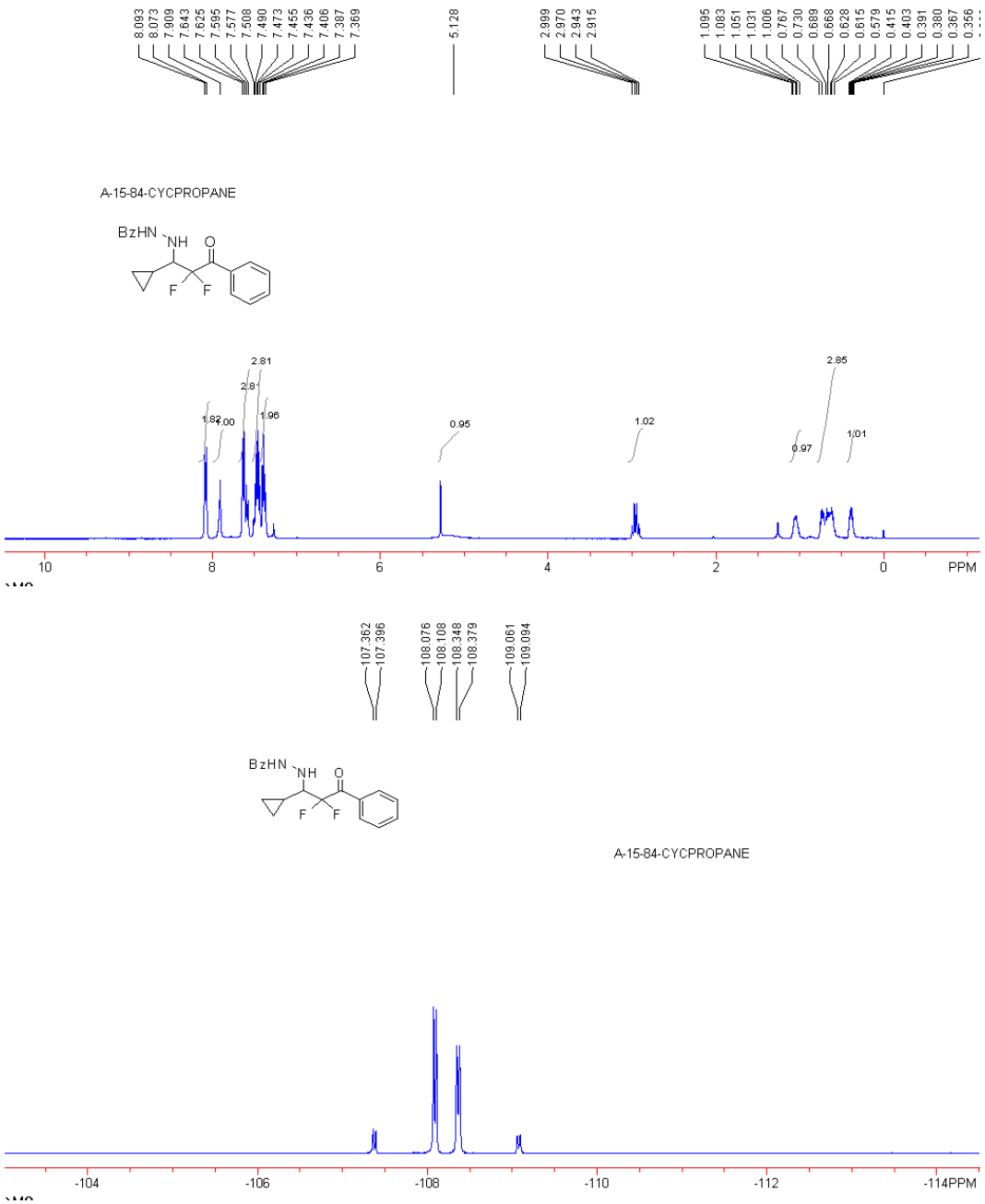
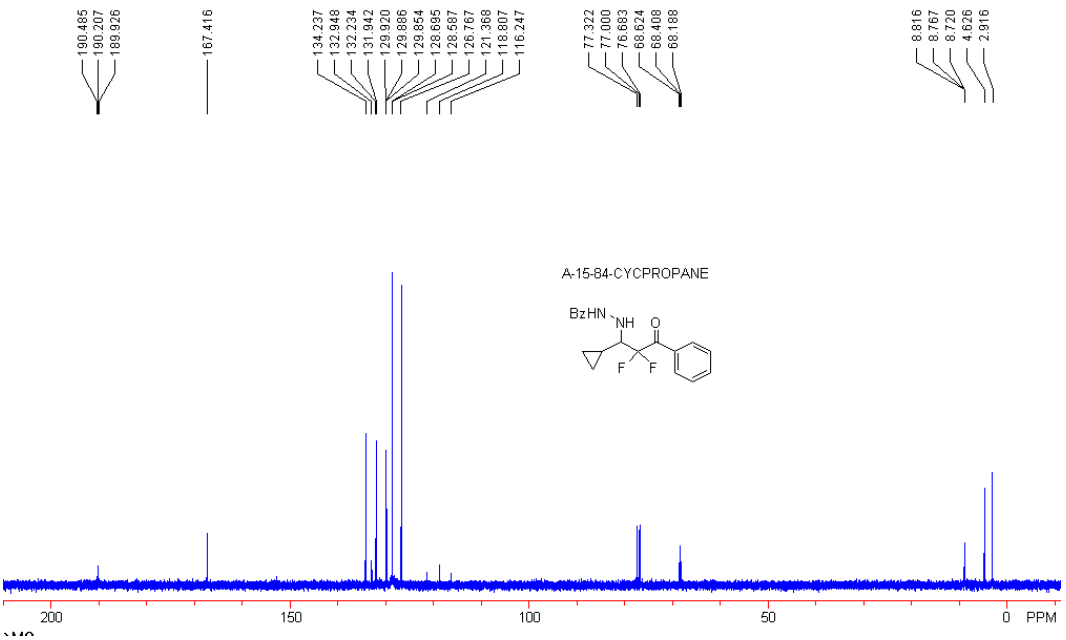
N-(1-cyclopropyl-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (3u).




8.093
8.073
7.909
7.643
7.625
7.595
7.577
7.508
7.490
7.473
7.455
7.436
7.406
7.387
7.369
5.128
2.999
2.970
2.943
2.915
1.095
1.083
1.051
1.031
1.006
0.767
0.730
0.689
0.668
0.628
0.615
0.579
0.415
0.403
0.391
0.380
0.367
0.356
A-15-84-CYCPROPANE
BzHN
NH
O
F
F
2.81
2.81
1.82
2.00
1.96
0.95
1.02
2.85
0.97
1.01
10
8
6
4
2
0
PPM
107.362
107.396
108.076
108.108
108.348
108.379
109.061
109.094
BzHN
NH
O
F
F
A-15-84-CYCPROPANE
-104
-106
-108
-110
-112
-114PPM

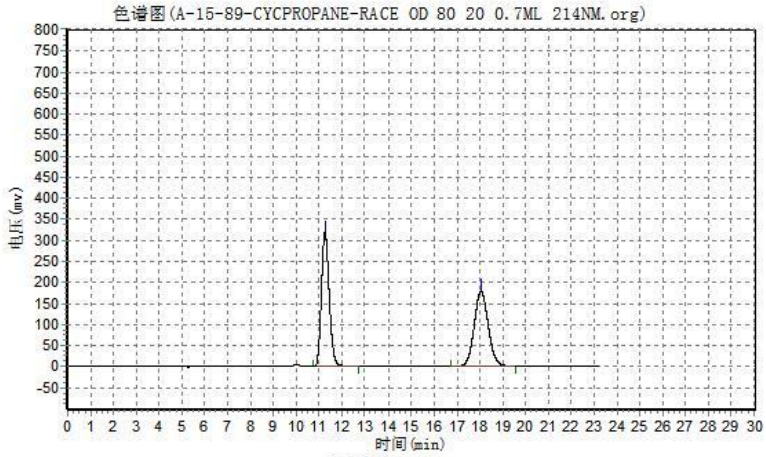


N2000 数据工作站 1

实验时间: 2010-09-26,11:10:57
谱图文件:D:\HPLC\Yzl\15\A-15-89-CYCPROPANE-RACE OD 80 20 0.7ML 214NM.org

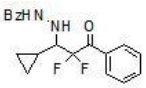
实验者:
报告时间: 2010-09-26,11:15:48
积分方法:面积归一法

色谱图(A-15-89-CYCPROPANE-RACE OD 80 20 0.7ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		11.267	317527.438	7598663.000	49.8684
2		18.038	179014.016	7638769.500	50.1316
总计			496541.453	15237432.500	100.0000



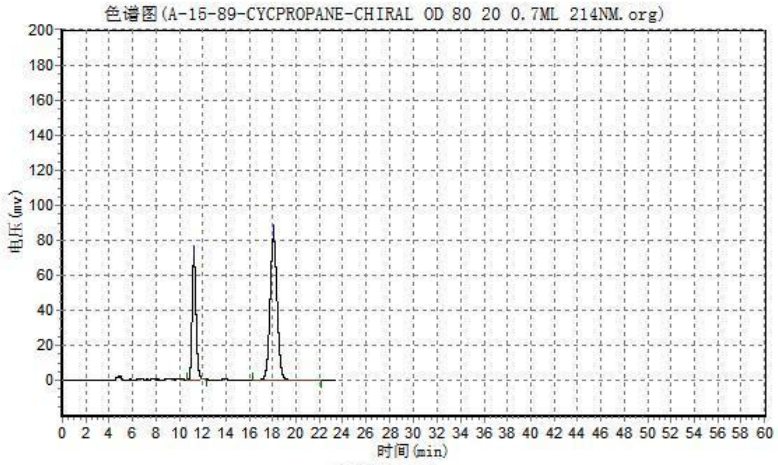
OD-H
HEXANE/IPA = 80/20
230NM
0.7 ML/MIN

RACEMIC SAMPLE

2010-09-26 浙江大学智能信息研究所

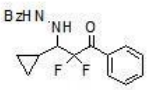
实验时间: 2010-09-26,11:36:02
谱图文件:D:\HPLC\Yz1\15\A-15-89-CYCPROPANE-CHIRAL OD 80 20 0.7ML 214NM.org

实验者:
报告时间: 2010-09-26,11:37:03
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		11.253	69784.258	1655735.500	32.3324
2		18.070	81896.859	3465247.000	67.6676
总计			151681.117	5120982.500	100.0000



OD-H
HEXANE/IPA = 80/20
230NM
0.7 ML/MIN

EE = 35%

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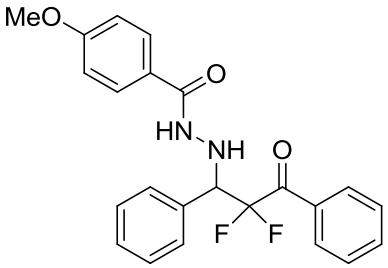
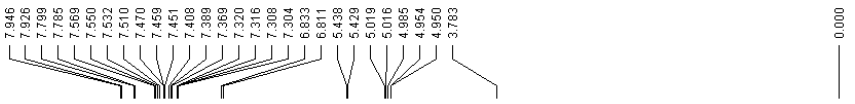
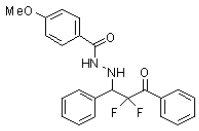
11. NMR and HPLC data for $Zn(NTf_2)_2$-catalyzed Mannich-type adducts 5a-5f.

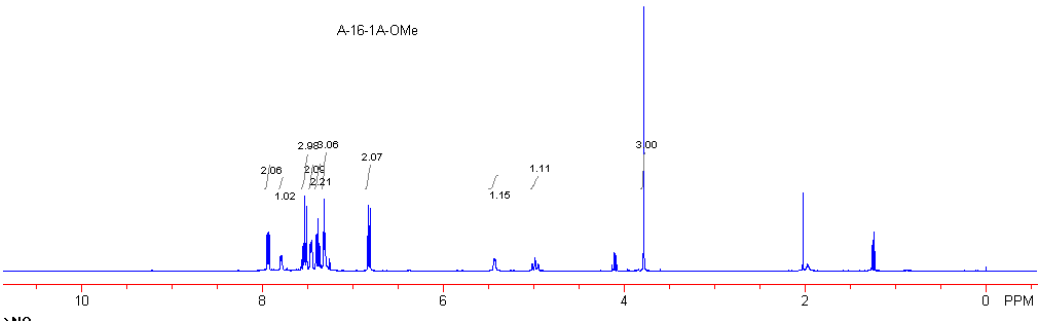
N-(2,2-difluoro-3-oxo-1,3-diphenylpropyl)-4-methoxybenzohydrazide (5a).

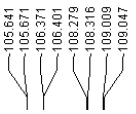


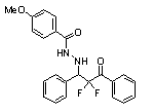




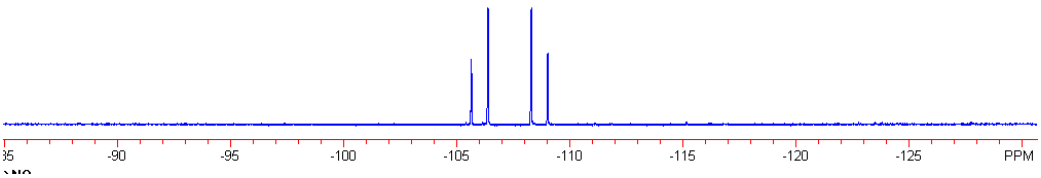
A-16-1A-OMe

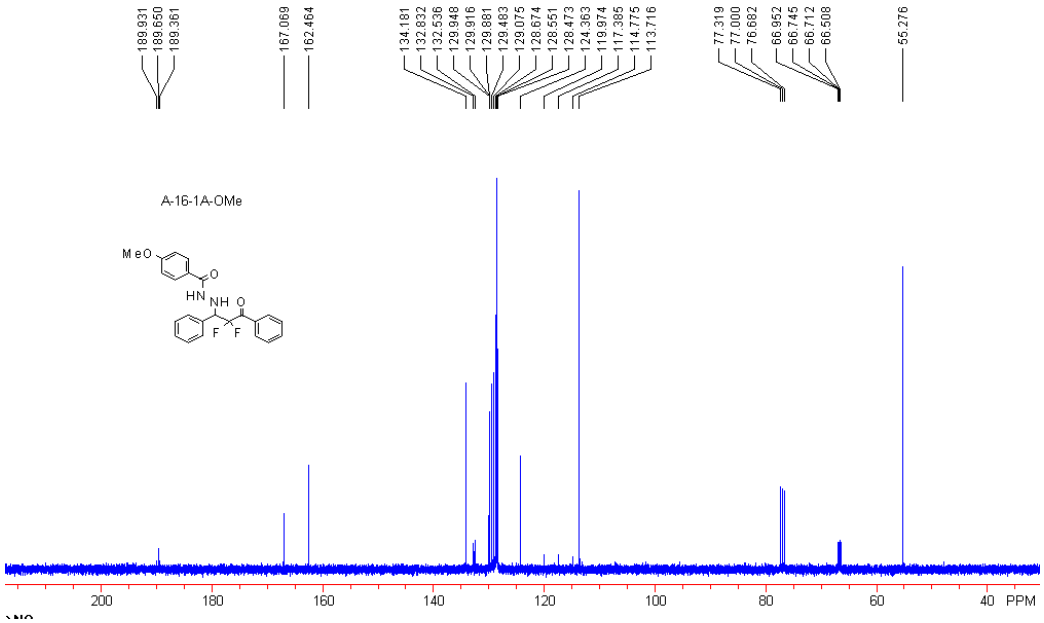






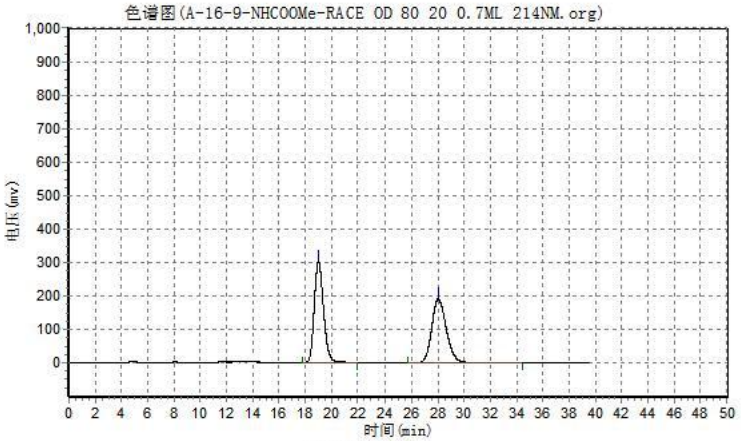
A-16-1A-OMe





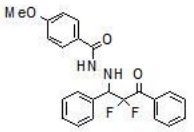
实验时间: 2010-10-12,20:50:09
谱图文件:D:\HPLC\Yzl\16\A-16-9-NHCOOMe-RACE OD 80 20 0.7ML 214NM.org

实验者:
报告时间: 2010-10-12,20:54:43
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		19.000	301128.313	14738642.000	50.3107
2		28.038	190378.500	14556627.000	49.6893
总计			491506.813	29295269.000	100.0000



OD-H
hexane/iPrOH = 80/20
0.7 mL/min
214 nm

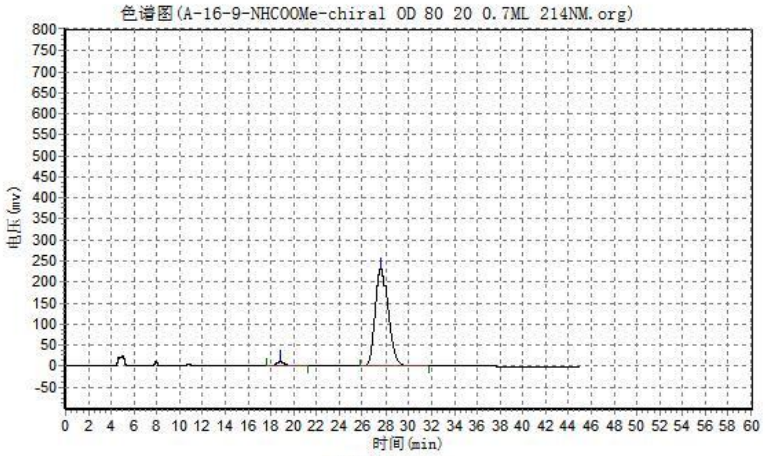
race sample

2010-10-12 浙江大学智能信息研究所

N2000 数据工作站 1

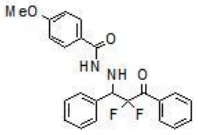
实验时间: 2010-10-12,21:36:44
谱图文件:D:\HPLC\Yzl\16\A-16-9-NHCOOMe-chiral OD 80 20 0.7ML 214NM.org

实验者:
报告时间: 2010-10-12,21:38:44
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		18.812	10412.025	494918.313	2.7378
2		27.633	231241.078	17582448.000	97.2622
总计			241653.104	18077366.313	100.0000

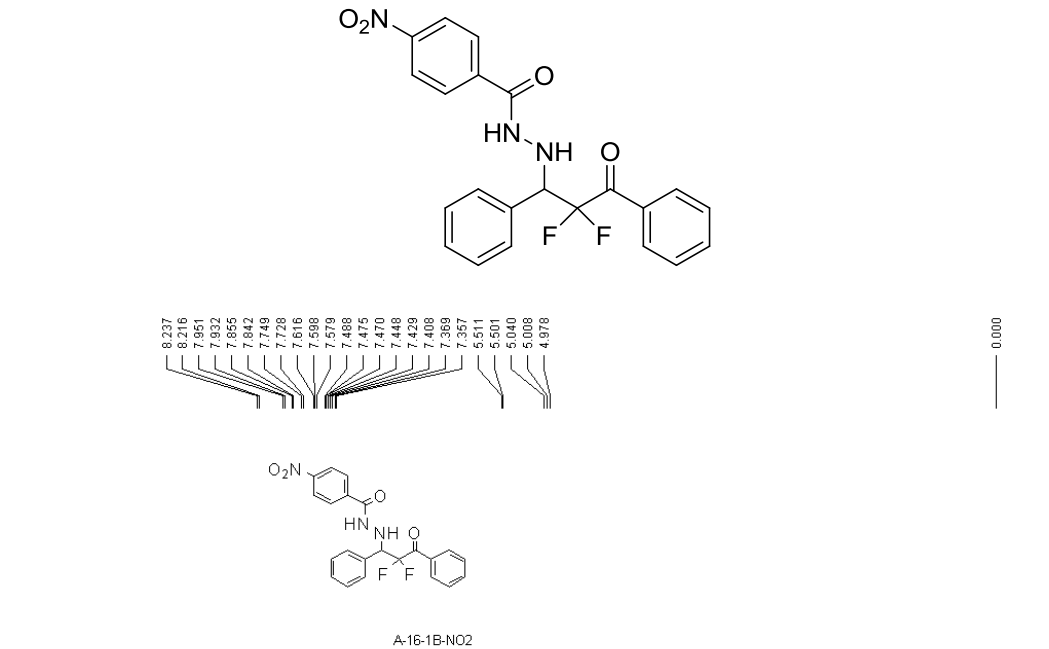


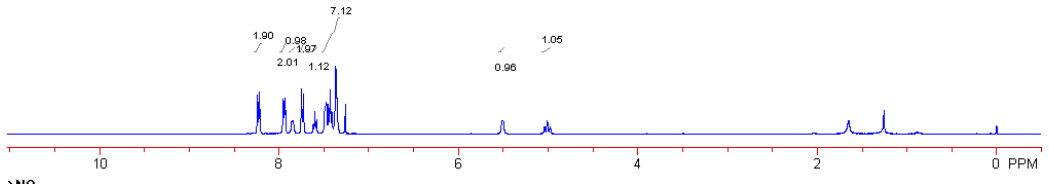
OD-H
hexane/iPrOH = 80/20
0.7 mL/min
214 nm

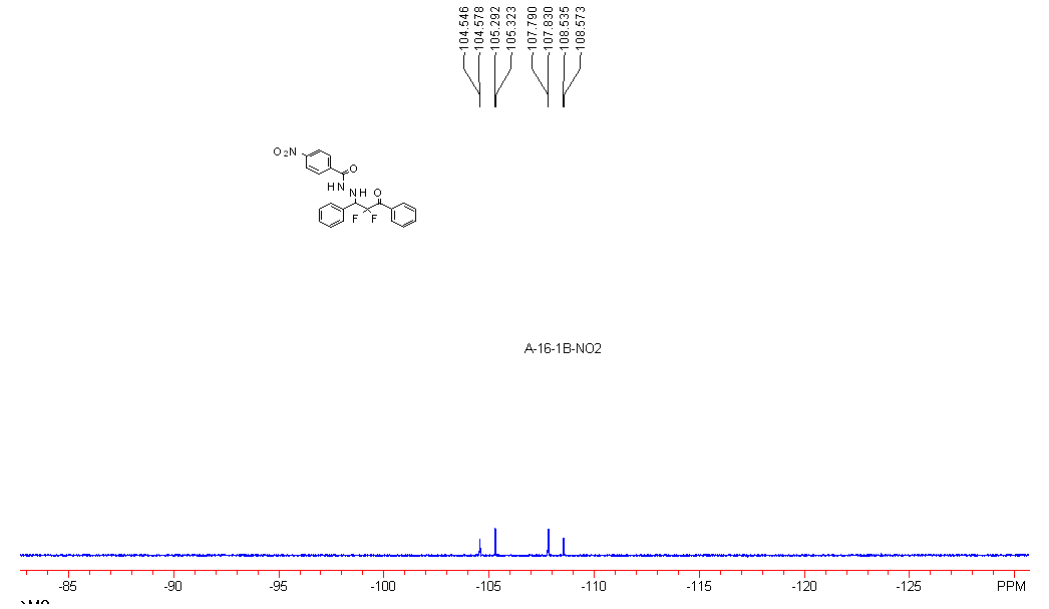
ee = 94%

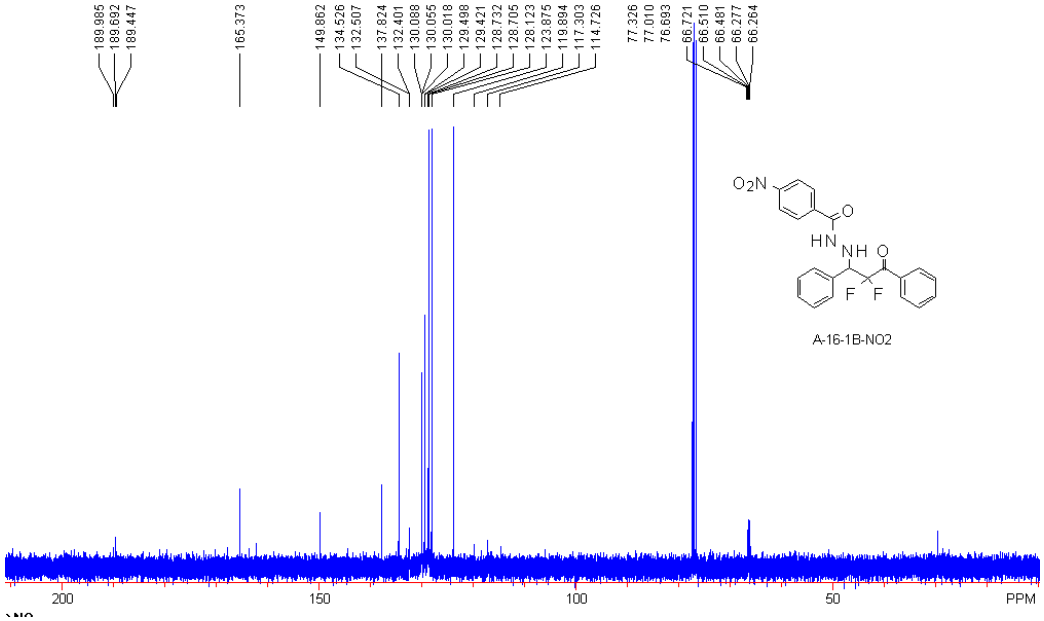
2010-10-12 浙江大学智能信息研究所

N-(2,2-difluoro-3-oxo-1,3-diphenylpropyl)-4-nitrobenzohydrazide (5b).

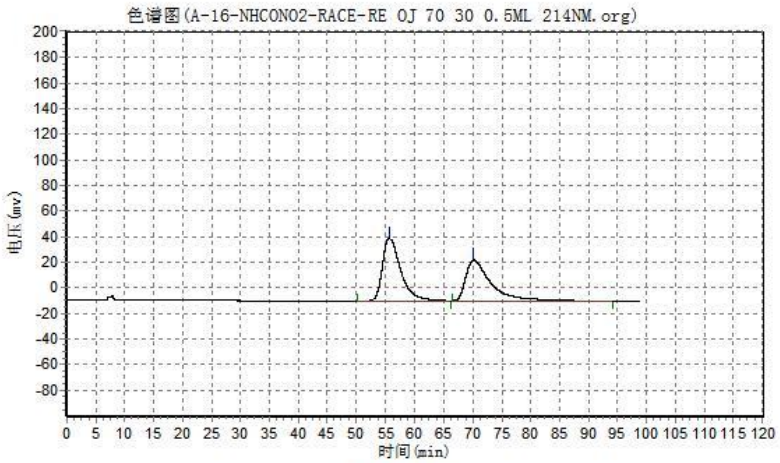

8.237
8.216
7.951
7.932
7.855
7.842
7.749
7.728
7.616
7.598
7.579
7.488
7.475
7.470
7.448
7.429
7.408
7.369
7.357
5.511
5.501
5.040
5.008
4.978
0.000
A-16-1B-NO2


7.12
1.90
0.98
1.97
2.01
1.12
0.96
1.05
10
8
6
4
2
0 PPM


104.546
104.578
105.292
105.323
107.790
107.830
108.535
108.573
A-16-1B-NO2
-85
-90
-95
-100
-105
-110
-115
-120
-125
PPM

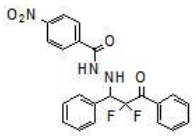


实验时间: 2010-12-25,15:12:11
谱图文件:D:\HPLC\Yz1\16\A-16-NHCONO2-RACE-RE OJ 70 30 0.5ML 214NM.org
实验者:
报告时间: 2010-12-25,15:13:56
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		55.678	48849.922	10218331.000	50.4641
2		70.138	31912.703	10030384.000	49.5359
总计			80762.625	20248715.000	100.0000



OJ-H
Hexane/iPrOH = 70/30
0.5 mL/min
214 nm

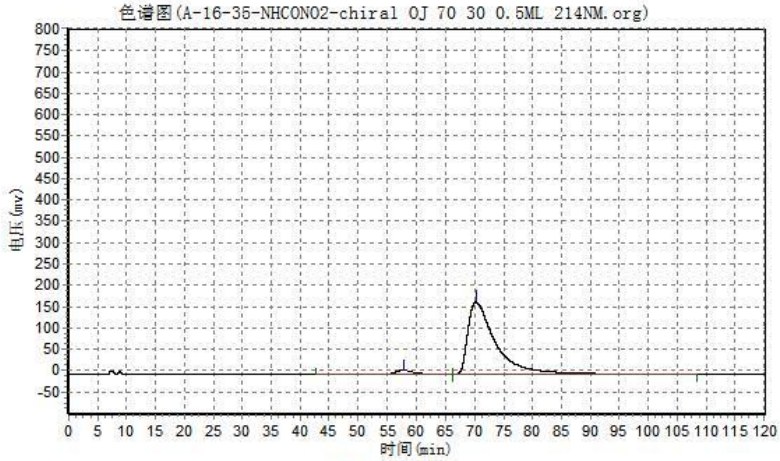
RACEMIC SAMPLE

2010-12-25 浙江大学智能信息研究所

N2000 数据工作站 1

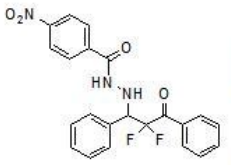
实验时间: 2010-12-10,19:15:04
谱图文件:D:\HPLC\Yzl\16\A-16-35-NHCONO2-chiral OJ 70 30 0.5ML 214NM.org
实验者:
报告时间: 2010-12-24,11:23:13
积分方法:面积归一法

色谱图(A-16-35-NHCONO2-chiral OJ 70 30 0.5ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		57.610	9756.423	2413599.000	4.0765
2		70.233	168909.813	56794280.000	95.9235
总计			178666.235	59207879.000	100.0000

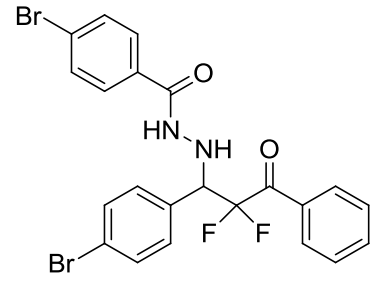


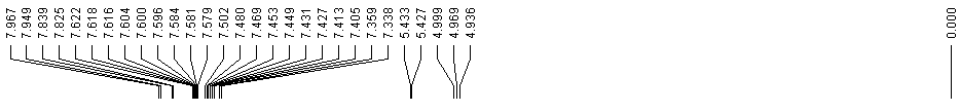
OJ-H
Hexane/iPrOH = 70/30
0.5 mL/min
214 nm

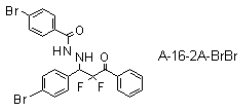
ee = 92%

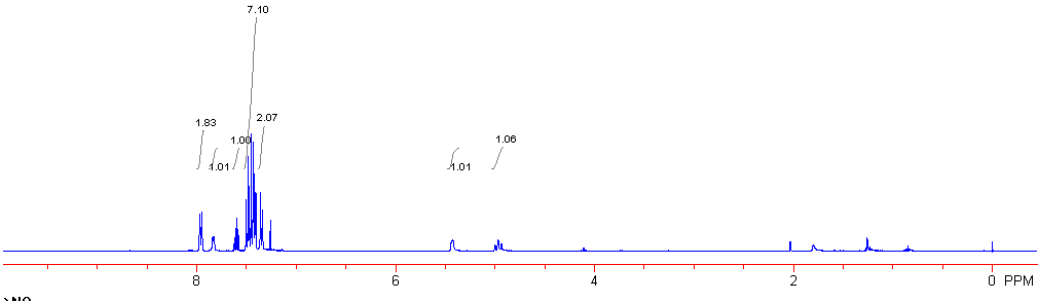
2010-12-24 浙江大学智能信息研究所

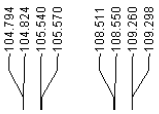
4-bromo-N-(1-(4-bromophenyl)-2,2-difluoro-3-oxo-3-phenylpropyl)benzohydrazide (5c).

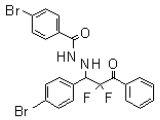

Br
O
HN
NH
O
F
F
Br


7.967
7.949
7.839
7.825
7.622
7.618
7.616
7.604
7.600
7.596
7.584
7.581
7.579
7.502
7.480
7.469
7.453
7.449
7.431
7.427
7.413
7.405
7.359
7.338
5.433
5.427
4.999
4.969
4.936
0.000

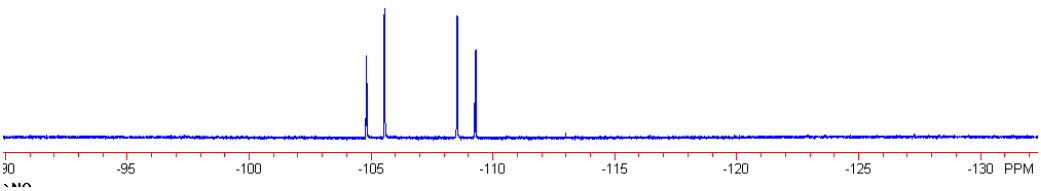

Br
O
HN
NH
O
F
F
Br
A-16-2A-BrBr

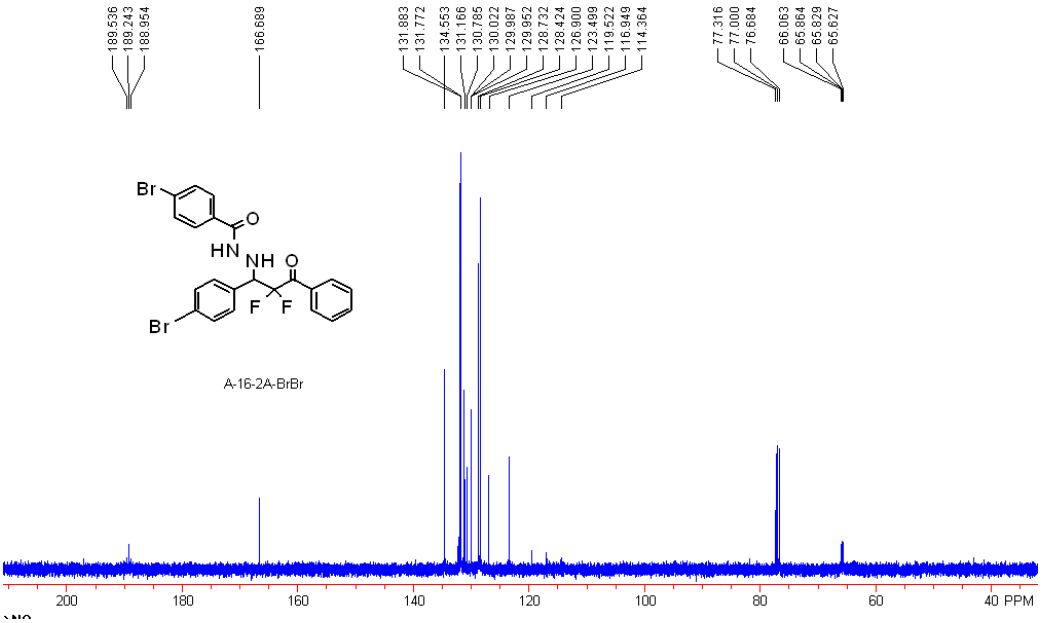

7.10
1.83
2.07
1.00
1.01
1.01
1.06
8
6
4
2
0 PPM


104.794
104.824
105.540
105.570
108.511
108.550
109.260
109.298


Br
O
HN
NH
O
F
F
Br

A-16-2A-BrBr

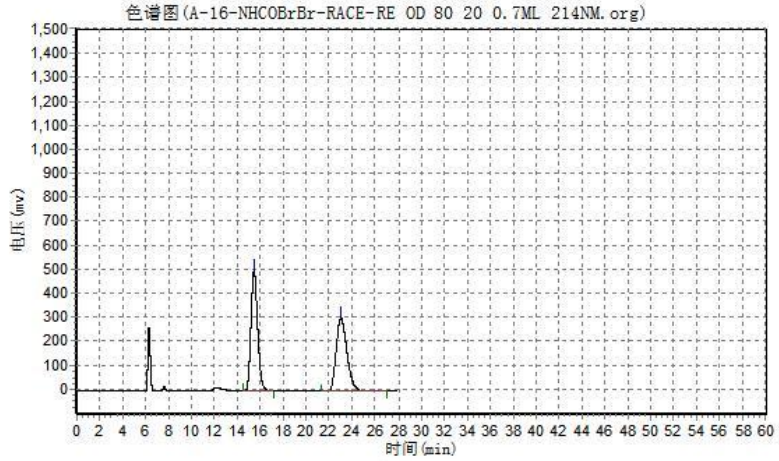

-95
-100
-105
-110
-115
-120
-125
-130 PPM


189.536
189.243
188.954
166.689
131.883
131.772
134.553
131.166
130.785
130.022
129.987
129.952
128.732
128.424
126.900
123.499
119.522
116.949
114.364
77.316
77.000
76.684
66.063
65.864
65.829
65.627
Br
O
HN
NH
O
F
F
Br
A-16-2A-BrBr
200
180
160
140
120
100
80
60
40 PPM

实验时间: 2010-12-24,15:15:46
谱图文件:D:\HPLC\Yzl\16\A-16-NHCOBrBr-RACE-RE OD 80 20 0.7ML 214NM.org

实验者:
报告时间: 2010-12-24,15:17:56
积分方法:面积归一法

色谱图(A-16-NHCOBrBr-RACE-RE OD 80 20 0.7ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		15.463	501588.594	20538432.000	50.4261
2		23.060	305213.125	20191308.000	49.5739
总计			806801.719	40729740.000	100.0000

OD-H
Hexane/iPrOH = 80/20
0.7 mL/min
214 nm

RACEMIC SAMPLE

2010-12-24

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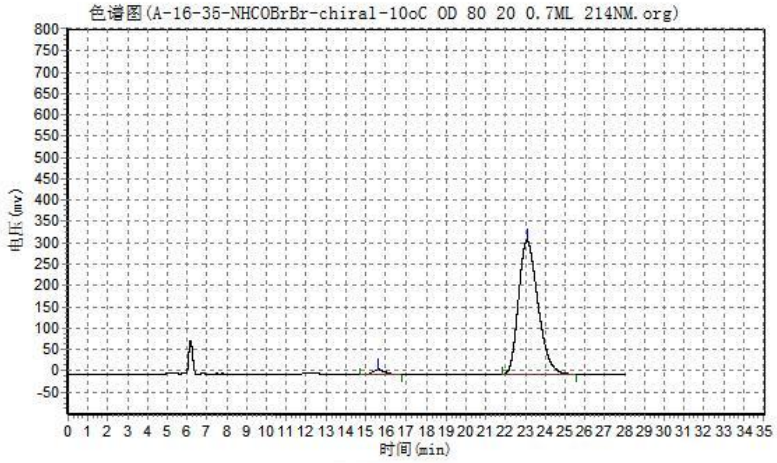
N2000 数据工作站 1

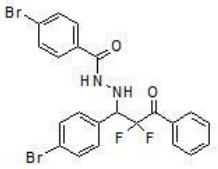
实验时间：2010-12-10,15:34:44
谱图文件:D:\HPLC\Yzl\16\A-16-35-NHCOBrBr-chiral-10oC OD 80 20 0.7ML 214NM.org
实验者:
报告时间：2010-12-24,11:27:11
积分方法:面积归一法

色谱图(A-16-35-NHCOBrBr-chiral-10oC OD 80 20 0.7ML 214NM.org)



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		15.635	11647.218	482698.469	2.2173
2		23.075	312835.719	21287338.000	97.7827
总计			324482.937	21770036.469	100.0000



OD-H
Hexane/iPrOH = 80/20
0.7 mL/min
214 nm

ee = 95%

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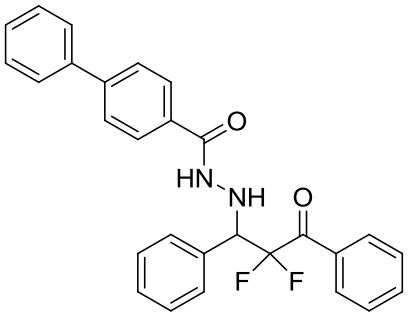
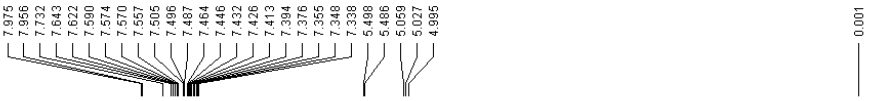
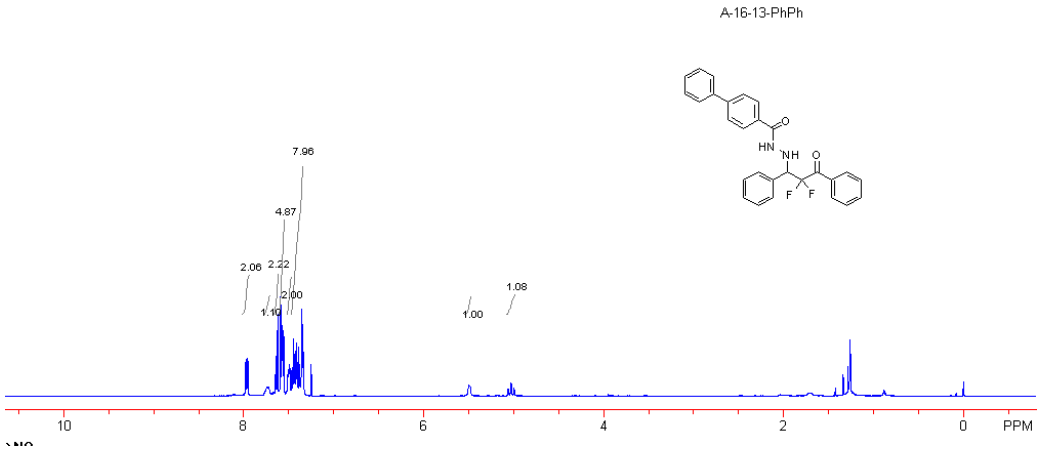
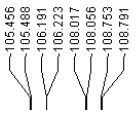
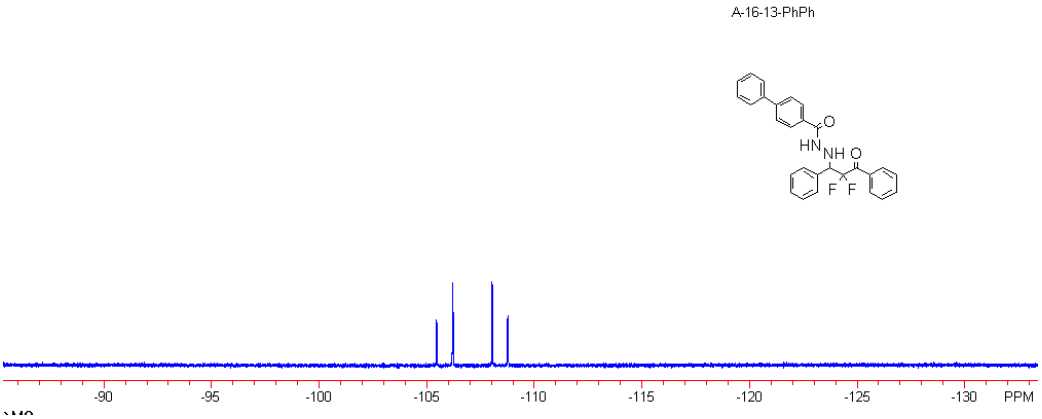
N-(2,2-difluoro-3-oxo-1,3-diphenylpropyl)biphenyl-4-carbohydrazide (5d).

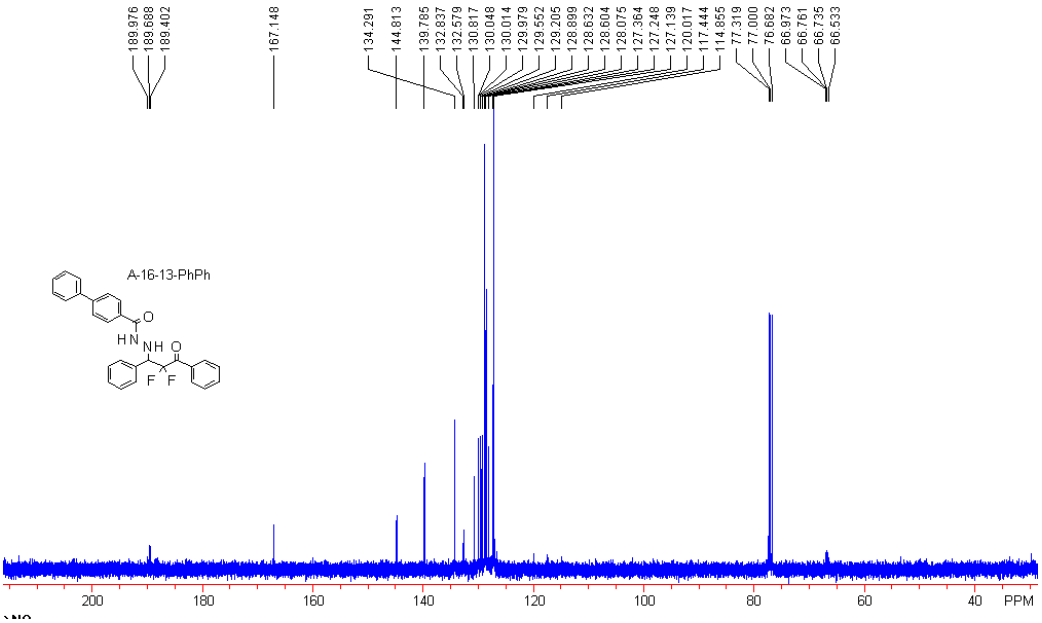

O
HN
NH
O
F
F


7.975
7.956
7.732
7.643
7.622
7.590
7.574
7.570
7.557
7.505
7.496
7.487
7.464
7.446
7.432
7.426
7.413
7.394
7.376
7.355
7.348
7.338
5.498
5.486
5.059
5.027
4.995
0.001


A-16-13-PhPh
7.96
4.87
2.06
2.22
2.00
1.10
1.00
1.08
10
8
6
4
2
0
PPM

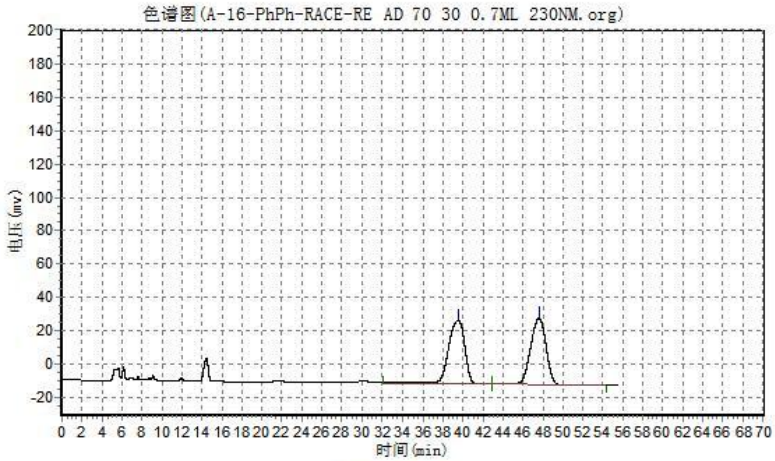

105.456
105.488
106.191
106.223
108.017
108.056
108.753
108.791


A-16-13-PhPh
-90
-95
-100
-105
-110
-115
-120
-125
-130
PPM



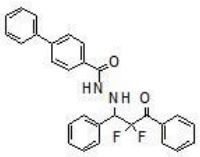
实验时间: 2010-12-25,10:43:21
谱图文件:D:\HPLC\Yz1\16\A-16-PhPh-RACE-RE AD 70 30 0.7ML 230NM.org

实验者:
报告时间: 2010-12-25,10:45:01
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		39.493	37859.750	4394245.500	50.5255
2		47.602	39790.465	4302833.000	49.4745
总计			77650.215	8697078.500	100.0000



AD-H
Hexane/iPrOH = 70/30
0.7 mL/min
230 nm

RACEMIC SAMPLE

2010-12-25

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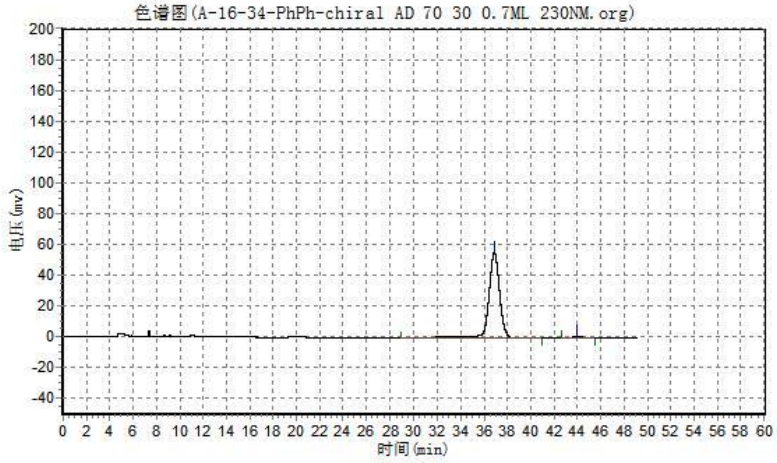
N2000 数据工作站 1

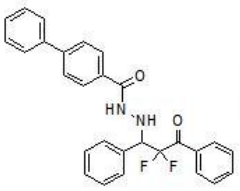
实验时间: 2010-12-08,15:26:19
谱图文件:D:\HPLC\Yzl\16\A-16-34-PhPh-chiral AD 70 30 0.7ML 230NM.org

实验者:
报告时间: 2010-12-24,11:31:16
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		36.865	55506.793	3603882.750	98.0284
2		43.993	1049.692	72482.398	1.9716
总计			56556.485	3676365.148	100.0000



AD-H
Hexane/iPrOH = 70/30
0.7 mL/min
230 nm

ee = 96%

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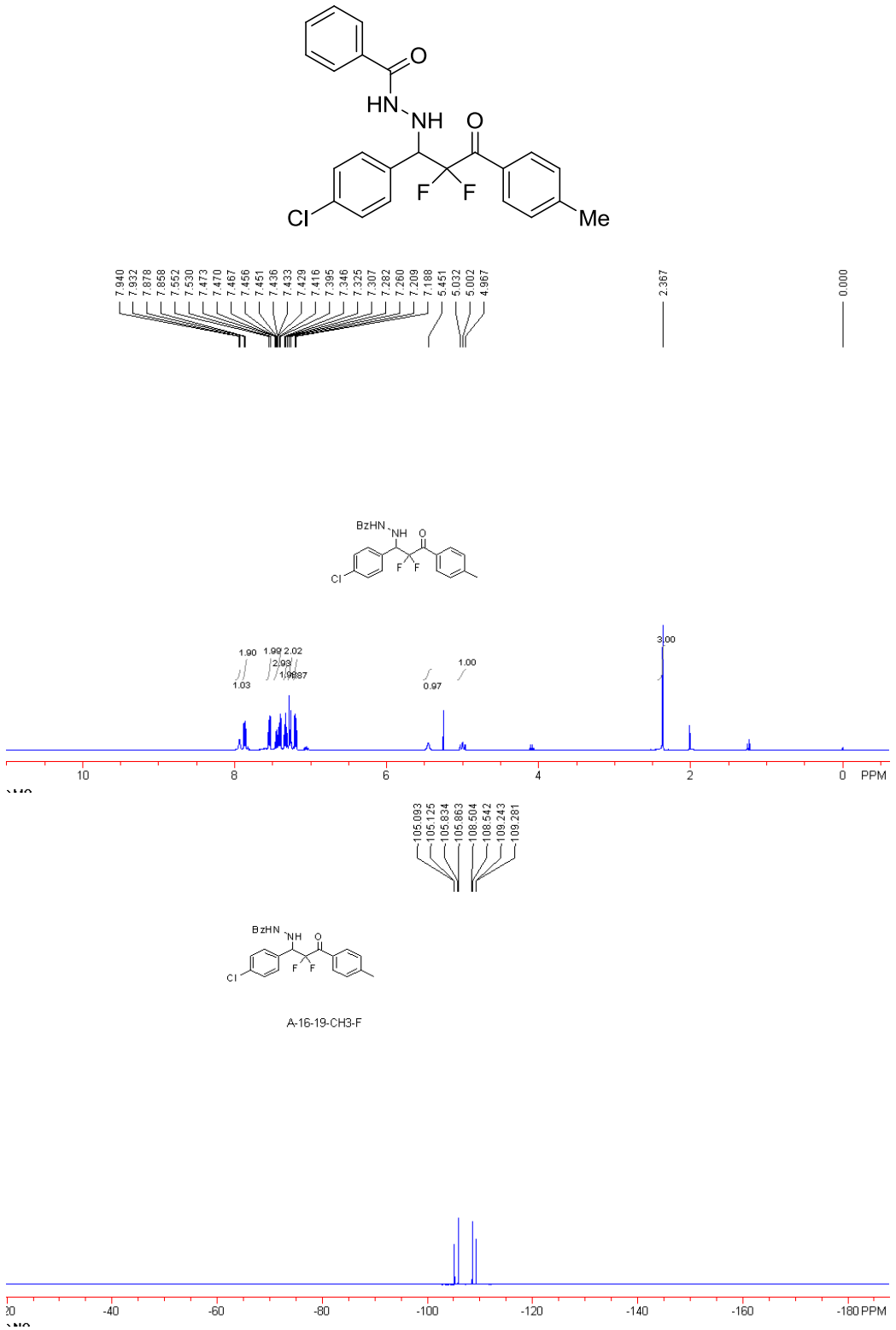
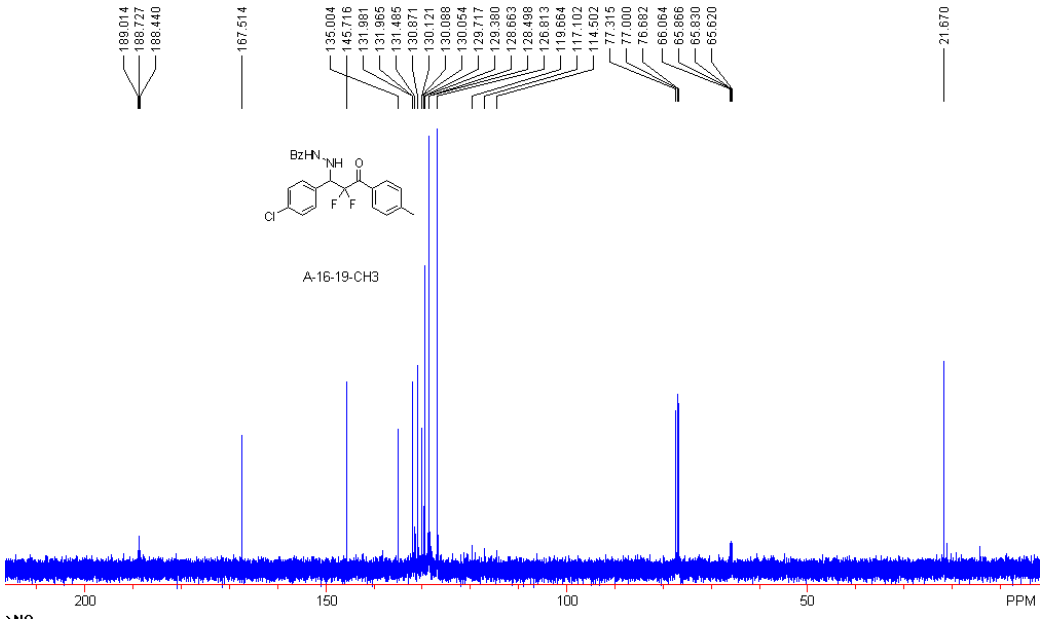
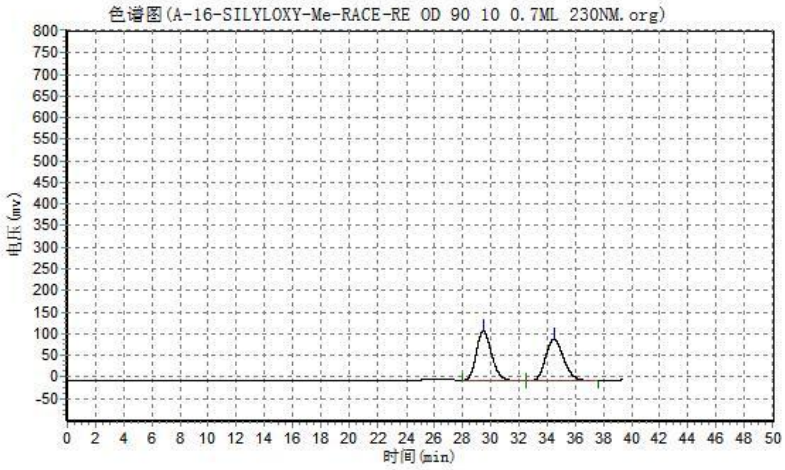
N-(1-(4-chlorophenyl)-2,2-difluoro-3-oxo-3-p-tolylpropyl)benzohydrazide (5e).


O
HN
NH
O
F
F
Cl
Me
7.940
7.932
7.878
7.858
7.552
7.530
7.473
7.470
7.467
7.456
7.451
7.436
7.433
7.429
7.416
7.395
7.346
7.325
7.307
7.282
7.260
7.209
7.188
5.451
5.032
5.002
4.967
2.367
0.000
BzHN
NH
O
F
F
Cl
1.90
1.99
2.02
2.93
1.9887
1.03
0.97
1.00
3.00
10
8
6
4
2
0
PPM
105.093
105.125
105.834
105.863
108.504
108.542
109.243
109.281
BzHN
NH
O
F
F
Cl
A-16-19-CH3-F
-40
-60
-80
-100
-120
-140
-160
-180 PPM



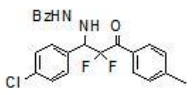
实验时间: 2010-12-24,16:28:13
谱图文件:D:\HPLC\Yzl\16\A-16-SILYLOXY-Me-RACE-RE OD 90 10 0.7ML 230NM.org

实验者:
报告时间: 2010-12-24,16:29:44
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		29.452	115648.281	8813487.000	50.4831
2		34.462	96605.164	8644817.000	49.5169
总计			212253.445	17458304.000	100.0000



OD-H
Hexane/iPrOH = 90/10
0.7 mL/min
230 nm

RACEMIC SAMPLE

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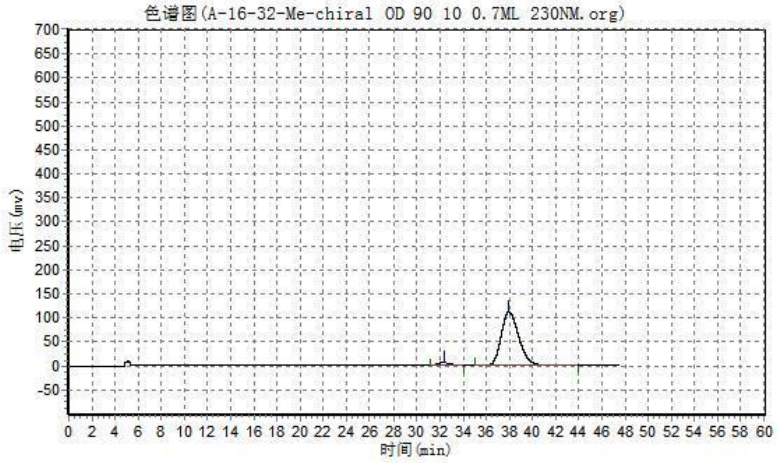
N2000 数据工作站 1

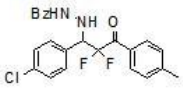
实验时间: 2010-12-04,15:21:28
谱图文件:D:\HPLC\Yzl\16\A-16-32-Me-chiral OD 90 10 0.7ML 230NM.org

实验者:
报告时间: 2010-12-24,11:38:44
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		32.318	6081.983	503632.813	4.0657
2		37.955	112181.297	11883689.000	95.9343
总计			118263.280	12387321.813	100.0000



OD-H
Hexane/iPrOH = 90/10
0.7 mL/min
230 nm

ee = 92%

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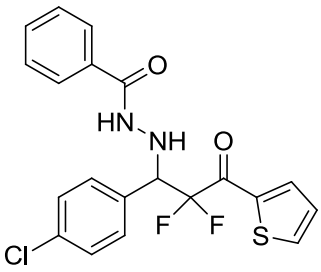
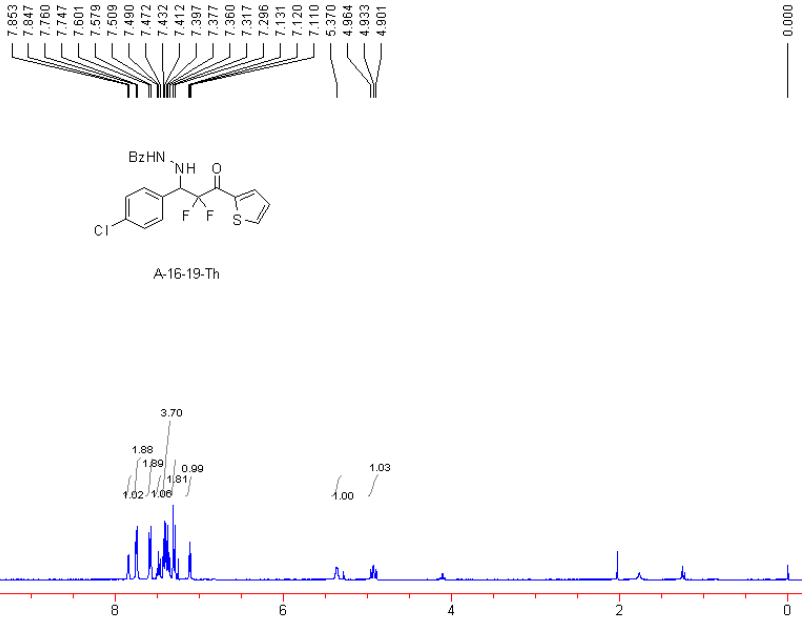
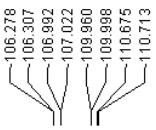
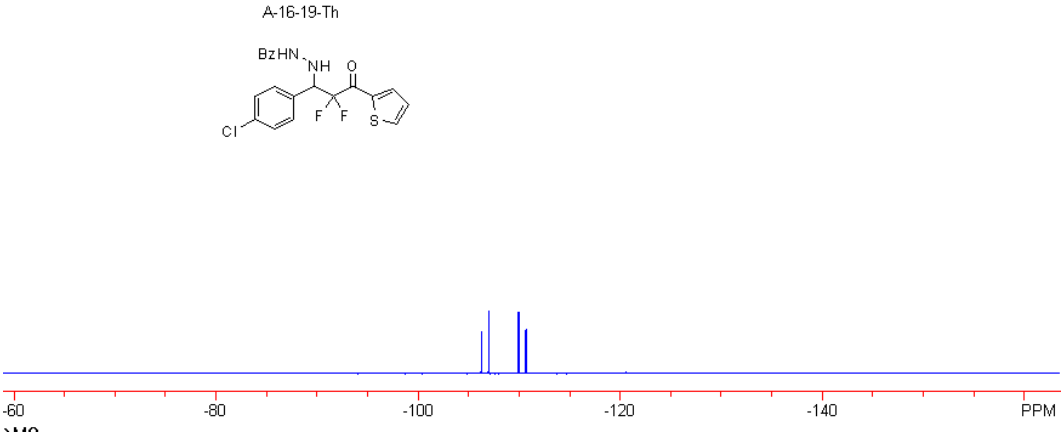
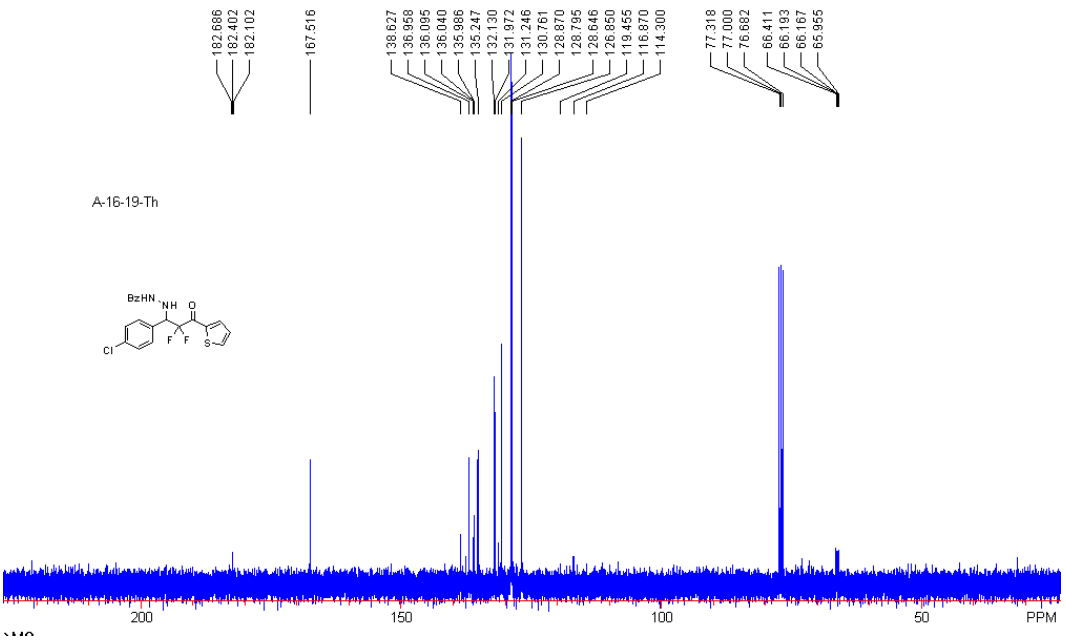
N-(1-(4-chlorophenyl)-2,2-difluoro-3-oxo-3-(thiophen-2-yl)propyl)benzohydrazide (5f).



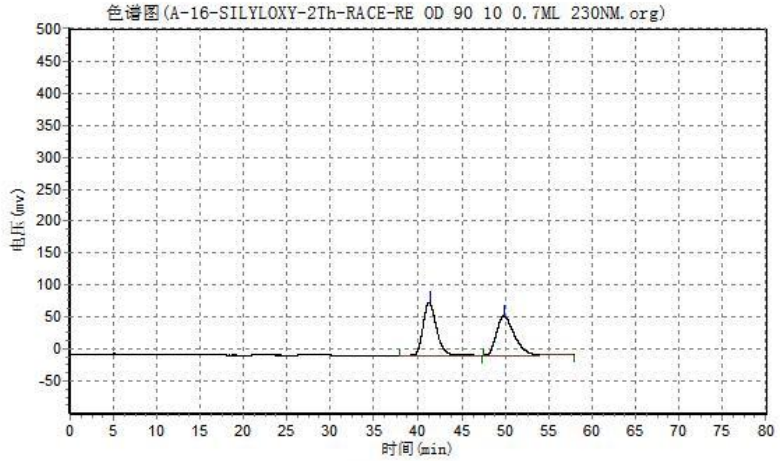

7.853
7.847
7.760
7.747
7.601
7.579
7.509
7.490
7.472
7.432
7.412
7.397
7.377
7.360
7.317
7.296
7.131
7.120
7.110
5.370
4.964
4.933
4.901
0.000
BzHN
NH
O
F
F
S
Cl
A-16-19-Th
3.70
1.88
1.89
0.99
1.81
1.02
1.06
1.03
1.00
10
8
6
4
2
0
PPM


106.278
106.307
106.992
107.022
109.960
109.998
110.675
110.713


A-16-19-Th
BzHN
NH
O
F
F
S
Cl
-60
-80
-100
-120
-140
PPM

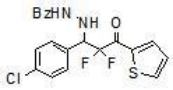

182.686
182.402
182.102
167.516
138.627
136.958
136.095
136.040
135.986
135.247
132.130
131.972
131.246
130.761
128.870
128.795
128.646
126.850
119.455
116.870
114.300
77.318
77.000
76.682
66.411
66.193
66.167
65.955
A-16-19-Th
BzHN
NH
O
F
F
S
Cl
200
150
100
50
PPM

实验时间：2010-12-24,17:39:07
谱图文件:D:\HPLC\Yzl\16\A-16-SILYLOXY-2Th-RACE-RE OD 90 10 0.7ML 230NM.org
实验者:
报告时间：2010-12-24,17:39:27
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		41.298	82425.133	8763509.000	50.0748
2		49.965	61377.184	8737342.000	49.9252
总计			143802.316	17500851.000	100.0000



OD-H
Hexane/iPrOH = 90/10
0.7 mL/min
230 nm

RACEMIC SAMPLE

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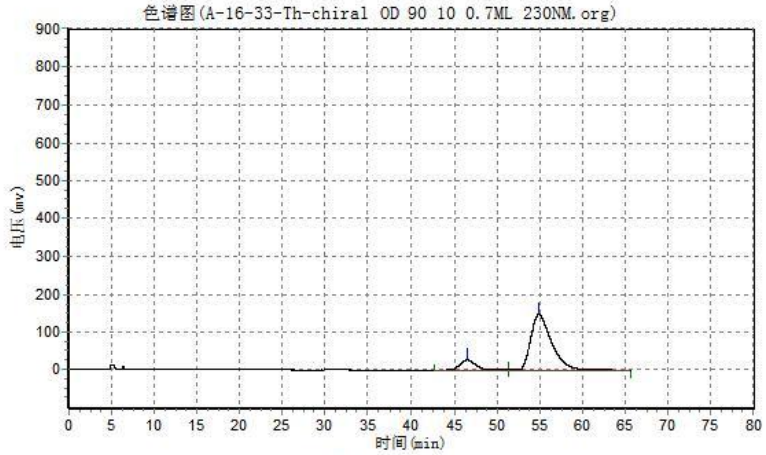
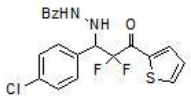
实验时间: 2010-12-04,16:45:54
谱图文件:D:\HPLC\Yzl\16\A-16-33-Th-chiral OD 90 10 0.7ML 230NM.org

实验者:
报告时间: 2010-12-24,11:34:01
积分方法:面积归一法



分析结果表

峰号	峰名	保留时间	峰高	峰面积	含量
1		46.473	26114.361	3290087.000	11.8223
2		54.882	146218.375	24539528.000	88.1777
总计			172332.736	27829615.000	100.0000



OD-H
Hexane/iPrOH = 90/10
0.7 mL/min
230 nm

ee = 76%

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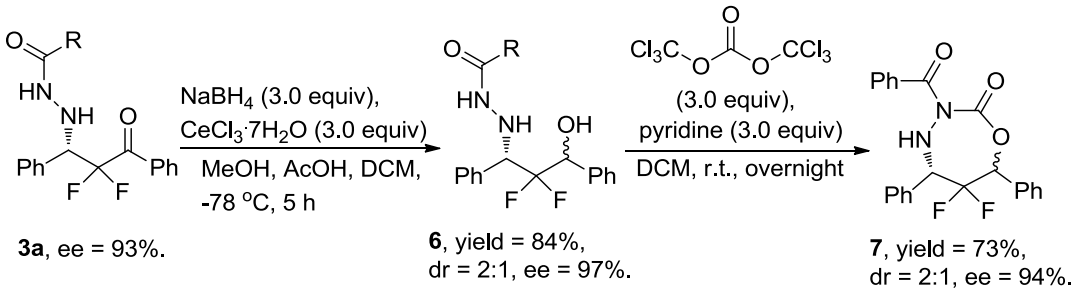
12. Transformation of product 3a

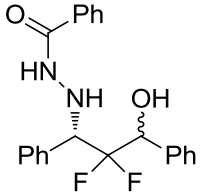
Scheme 1. Transformation of **3a**



The synthesis of compound 6. The solution of **3a** (0.32 mmol) in DCM (3.0 mL) was stirred at -78 °C, then a solution of $CeCl_3 \cdot 7H_2O$ (3.0 equiv) in 3.0 mL methanol was added into the solution at -78 °C. After stirring for 5 mins, $NaBH_4$ (3.0 equiv) was added into the mixture in several portions under argon atmosphere at -78 °C and followed by the addition of AcOH (0.25 mL) via syringe. The mixture was stirred at the same temperature for additional 5 h. The reaction was quenched by H_2O, then neutralized with saturated K_2CO_3 (aq) to pH= 7-8. The mixture was extracted with DCM. The combined organic phase was washed with H_2O and brine, dried over anhydrous Na_2SO_4, and the solvent was removed under vacuum. The residue was purified by silica gel column chromatography (PE/EA=3/1) to give the desired product as a white solid.

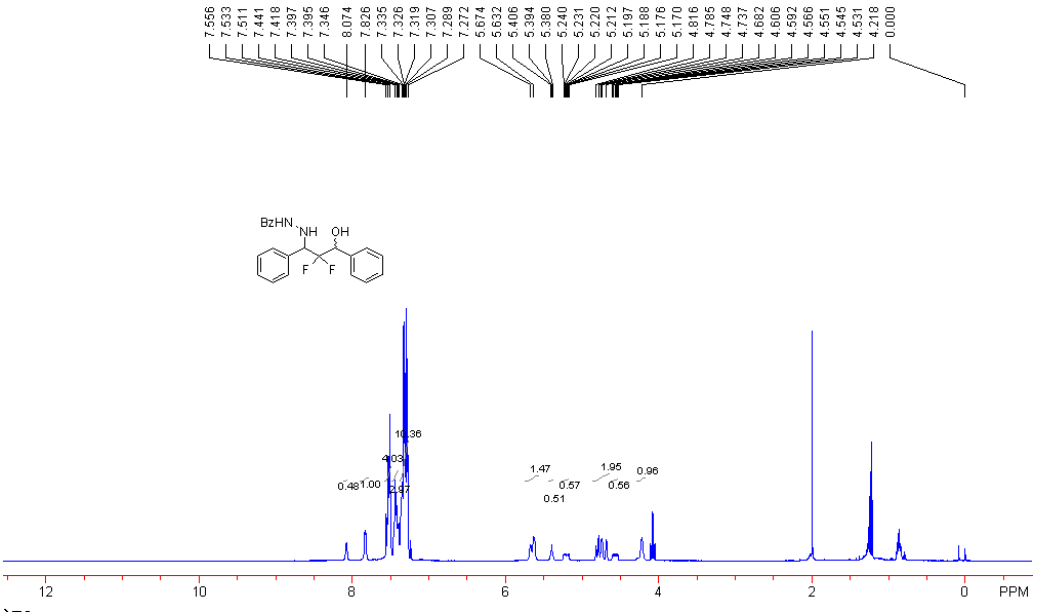
The synthesis of compound 7. To a solution of **6** (0.13 mmol) and triphosgene (3.0 equiv) in DCM (2.0 mL), a solution of pyridine (3.0 equiv) in 1.0 mL DCM was added into the solution carefully at room temperature via syringe. After stirring overnight at room temperature, the solvent was removed under vacuum and the residue was purified by silica gel column chromatography (PE/EA=8/1) to give the desired product as white solid.

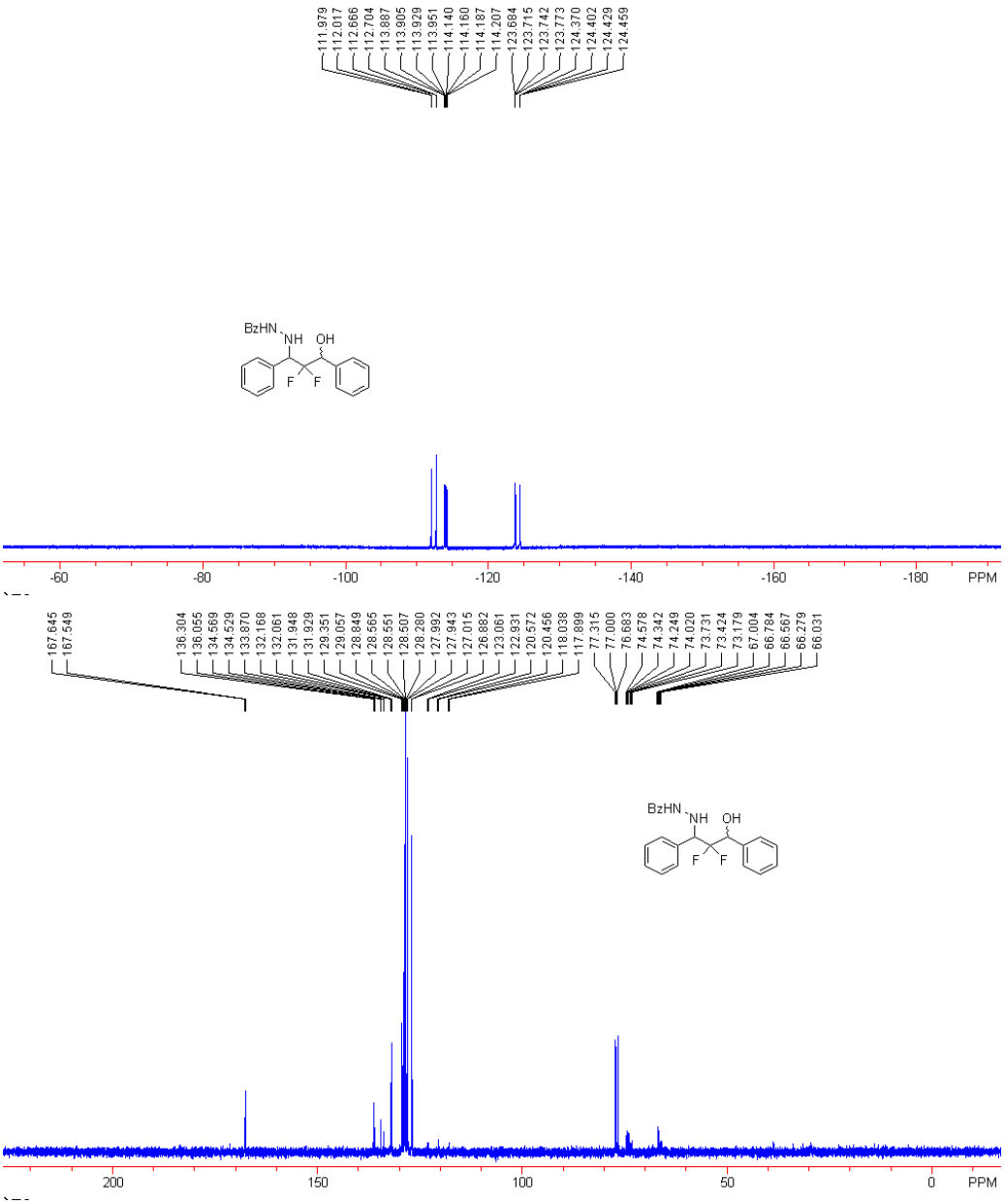
***N*-((1*S*)-2,2-difluoro-3-hydroxy-1,3-diphenylpropyl)benzohydrazide 6a** [major/minor (2:1) isomers].



A white solid, m.p. 155-158 °C; (84%, 102 mg); IR (acetone): ν 3395, 3296, 3033, 1782, 1627, 1575, 1509, 1482, 1454, 1404, 1334, 1166, 1124, 1063, 1029, 1009, 926, 899 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, TMS): δ 4.22 (major, br, 1H, NH), 4.57 (minor, dd, 0.5H, *J* = 7.2,

1.6 Hz, CH), 4.74 (major, d, 1H, J = 14.0 Hz, CH), 4.79 (major, t, 1H, J = 14.0 Hz, CH), 5.20 (minor, td, 0.5H, J = 7.2, 2.4 Hz, CH), 5.38 (minor, t, 0.5H, J = 1.6 Hz, NH), 5.63 (major, br, 1H, OH), 5.67 (minor, br, 0.5H, OH), 7.29-7.56 (m, 15H, ArH), 7.83 (major, d, 1H, J = 4.4 Hz, NH), 8.07 (minor, br, 0.5H, NH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 62.3 (minor, t, $J_{C\text{-}F}$ = 24.8 Hz), 66.8 (major, t, $J_{C\text{-}F}$ = 22.4 Hz), 73.4 (minor, dd, $J_{C\text{-}F}$ = 30.7, 24.5 Hz), 74.3 (major, dd, $J_{C\text{-}F}$ = 32.2, 22.9 Hz), 120.3 (major, t, $J_{C\text{-}F}$ = 254.0 Hz), 120.5 (minor, t, $J_{C\text{-}F}$ = 241.0 Hz), 126.9, 127.0, 127.9, 128.0, 128.3, 128.5, 128.6, 128.7, 128.8, 129.1, 129.4, 131.9, 132.1, 132.2, 133.9, 134.6, 136.1 (minor), 136.3 (major), 167.5 (major), 167.6 (minor); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -112.3 (major, dd, 1F, J = 258, 69 Hz), -124.0 (minor, ddd, 1F, J = 258, 21, 12 Hz), -113.9 (minor, dd, 1F, J = 16, 8 Hz), -114.1 (major, ddd, 1F, J = 16, 7 Hz); MS (ESI) *m/z* (%): 405.2 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{22}H_{20}F_2N_2O_2Na^{+1}$ $(M+Na)^+$ requires 405.1398, Found: 405.1385. Enantiomeric excess was determined by HPLC with a Chiralcel AD-H column (hexane/*i*PrOH = 60/40, 0.5 mL/min, 214 nm, for minor product: t_{major} = 7.79 min, t_{minor} = 8.88 min, 97% *ee*; for major product: t_{minor} = 11.04 min, t_{major} = 14.29 min, 97 % *ee*; $[\alpha]^{20}_D$ = +59.0 (c 2.60, $CHCl_3$)).





HPLC REPORT

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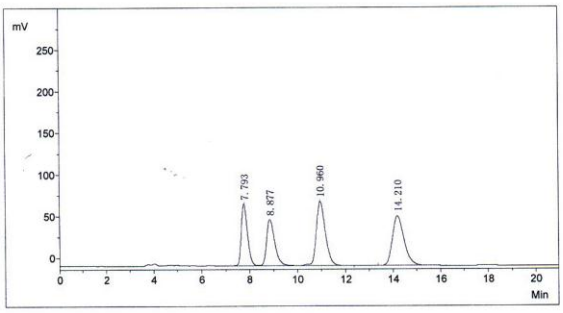
Column: Flow Rate:
Wave Length: Mobile Phase:



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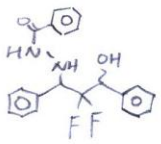
2	2	Unknown	8.877	55188.7	1315502.1	19.5664
3	3	Unknown	10.960	77308.6	2039566.5	30.3359
4	4	Unknown	14.210	59648.0	2037001.4	30.2977
Total				266023.8	6723285.4	100.0000

race

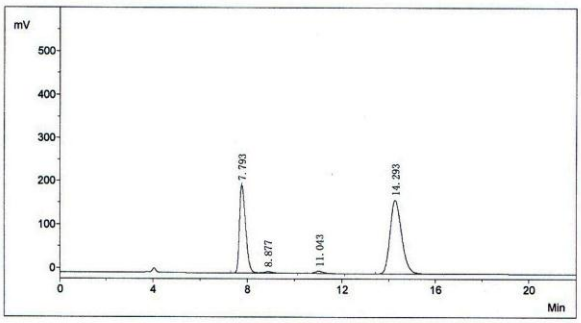


AD-H (150 mm)
hexane/ ^{i}PrOH = 60/40
0.5 mL/min
214 nm

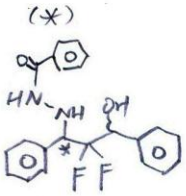
minor t_1 = 7.793 min
t_2 = 8.877 min
major t_1 = 10.960 min
t_2 = 14.210 min

HPLC REPORT

Sample Name:mly-16-92.che
Date:2011-04-10
Time:09:04
Method:
Column:
Flow Rate:
Wave Length:
Mobile Phase:

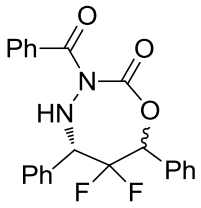


No.	PeakNo	ID. Name	R. Time	PeakHeight	PeakArea	PerCent
1	1	Unknown	7.793	201791.6	3627409.5	37.5467
2	2	Unknown	8.877	3568.8	99505.8	1.0300
3	3	Unknown	11.043	4912.7	128314.5	1.3282
4	4	Unknown	14.293	168824.9	5805824.7	60.0951
Total				379097.9	9661054.5	100.0000

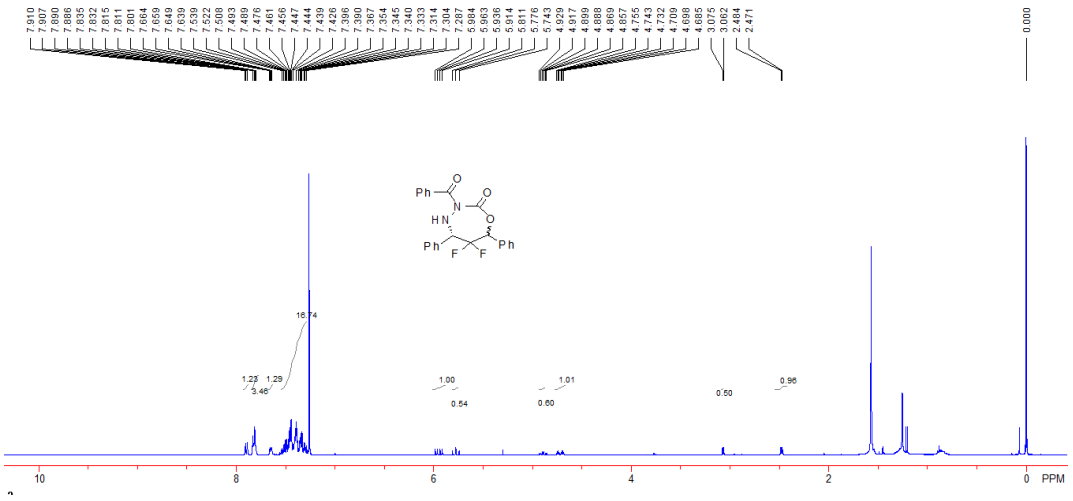


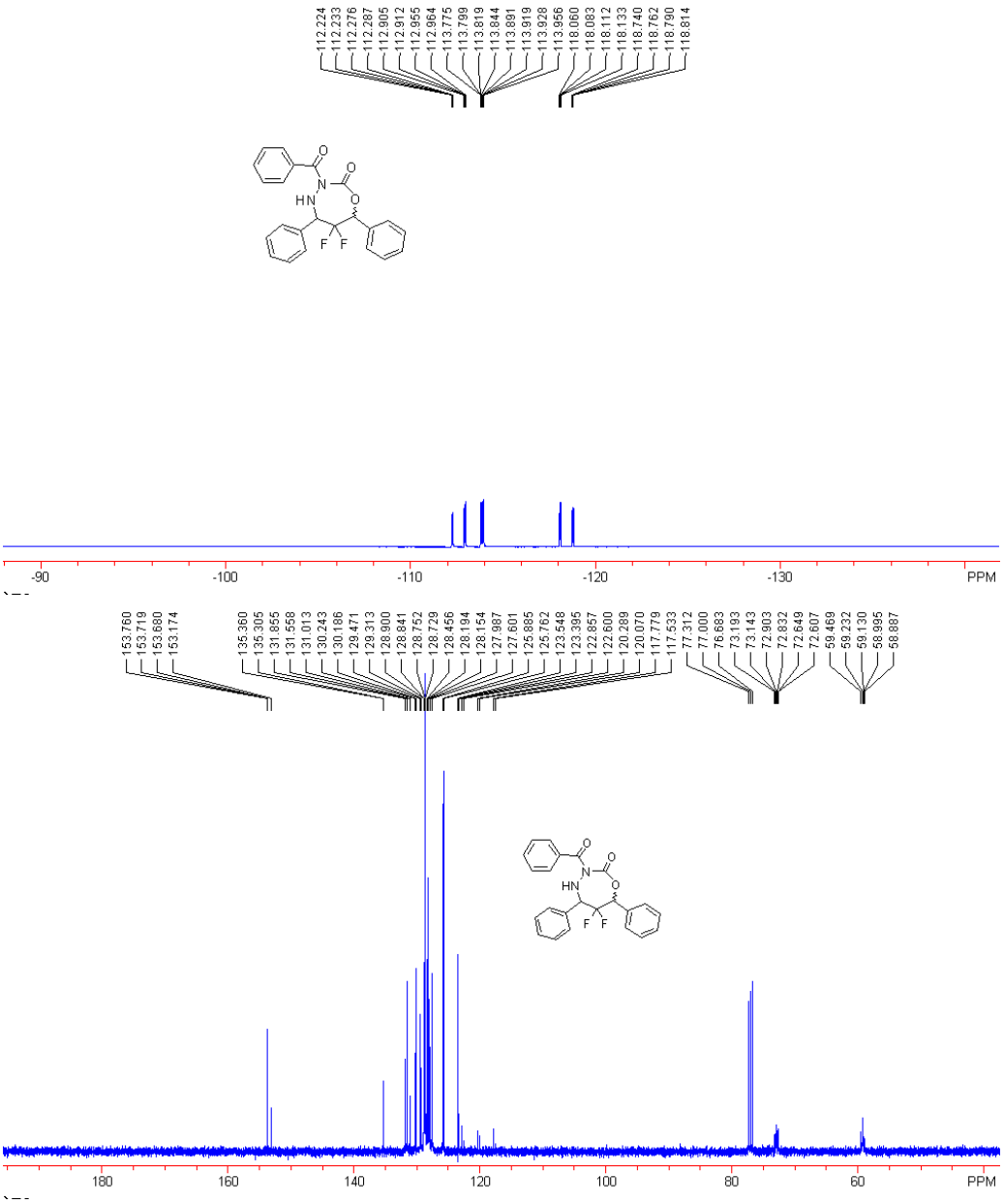
AD-H (150 mm)
hexane / iPrOH = 60/40
0.5 mL/min
214 nm
minor t_1 = 7.793 min
t_2 = 8.877 min
ee = 97%
major t_1 = 11.043 min
t_2 = 14.293 min
ee = 97%

(5*S*)-3-benzoyl-6,6-difluoro-5,7-diphenyl-1,3,4-oxadiazepan-2-one 7a [major/minor (2:1) isomers].

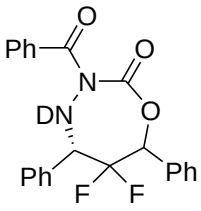


A white solid, m.p. 122-125 ^{o}C; (73%, 39 mg); IR (CH_2Cl_2): ν 3375, 3037, 1781, 1620, 1489, 1454, 1389, 1353, 1189, 1148, 1129, 1067, 1042, 991, 923, 899; ^{1}H NMR (400 MHz, $CDCl_3$, TMS): δ 3.18 (major, d, 1H, J = 5.2 Hz, NH), 3.49 (minor, d, 0.5H, J = 5.2 Hz, NH), 4.72 (major, dt, 1H, J = 18.8, 5.2 Hz, CH), 4.89 (minor, dt, 0.5H, J = 11.6, 5.2 Hz, CH), 5.78 (minor, t, 0.5H, J = 13.2 Hz, CH), 5.95 (major, dd, 1H, J = 18.8, 8.8 Hz, CH), 7.28-7.54 (m, 17H, ArH), 7.63-7.67 (m, 1H, ArH), 7.80-7.84 (m, 3H, ArH), 7.88-7.91 (m, 1H, ArH); ^{13}C NMR (100 MHz, $CDCl_3$, TMS): δ 59.1 (dd, $J_{C\text{-}F}$ = 34.5, 10.8 Hz), 72.8 (dd, $J_{C\text{-}F}$ = 29.7, 12.5 Hz), 120.2 (major, t, $J_{C\text{-}F}$ = 251.0 Hz), 120.3 (minor, t, $J_{C\text{-}F}$ = 251.5 Hz), 123.4, 123.5, 125.8, 125.9, 127.6, 128.0, 128.2, 128.5, 128.7, 128.8, 128.9, 129.3, 129.5, 130.2, 131.0, 131.5, 131.6, 131.9, 135.3, 135.4, 153.1 (minor), 153.7 (major, t, $J_{C\text{-}F}$ = 2.9 Hz); ^{19}F NMR (376 MHz, $CDCl_3$, TMS): δ -112.5 (major, ddd, 1F, J = 255, 20, 4 Hz), -118.4 (minor, ddd, 1F, J = 255, 19, 9 Hz), -113.8 (minor, dd, 1F, J = 17, 9 Hz), -113.9 (major, ddd, 1F, J = 17, 11 Hz); MS (ESI) *m/z* (%): 431.2 (100) $[M+Na]^+$; HRMS (MALDI) Calcd. for $C_{23}H_{18}F_2N_2O_3Na^{+1}$ $(M+Na)^+$ requires 431.1172, Found: 431.1178. Enantiomeric excess was determined by HPLC with a Chiralcel AD-H column (hexane/*i*PrOH = 60/40, 0.5 mL/min, 214 nm, for major product: t_{minor} = 10.21 min, t_{majorr} = 14.38 min, 94% *ee*; for minor product: t_{major} = 17.46 min, t_{minor} = 35.21 min, 94% *ee*; $[\alpha]^{20}_{D}$ = -63.2 (c 1.00, $CHCl_3$)).

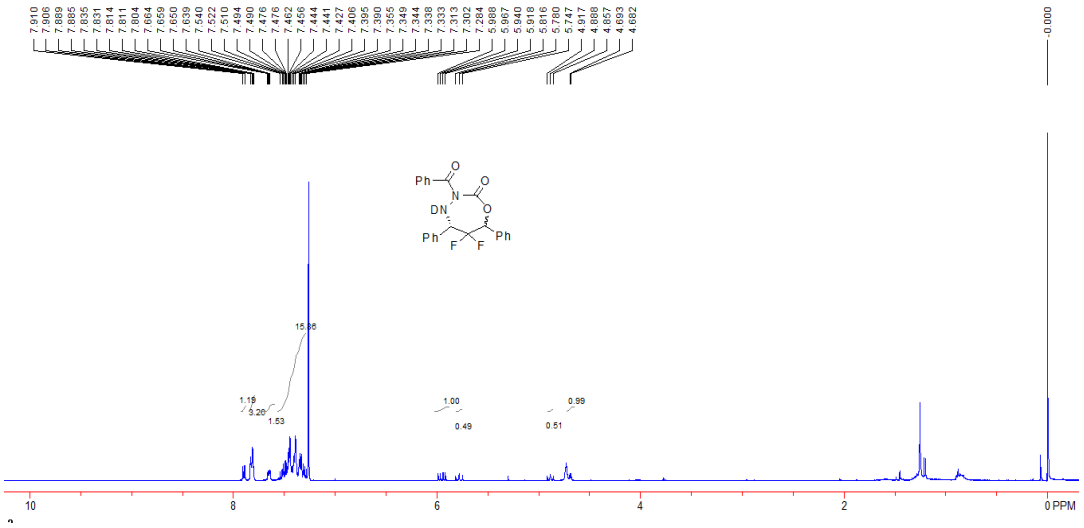




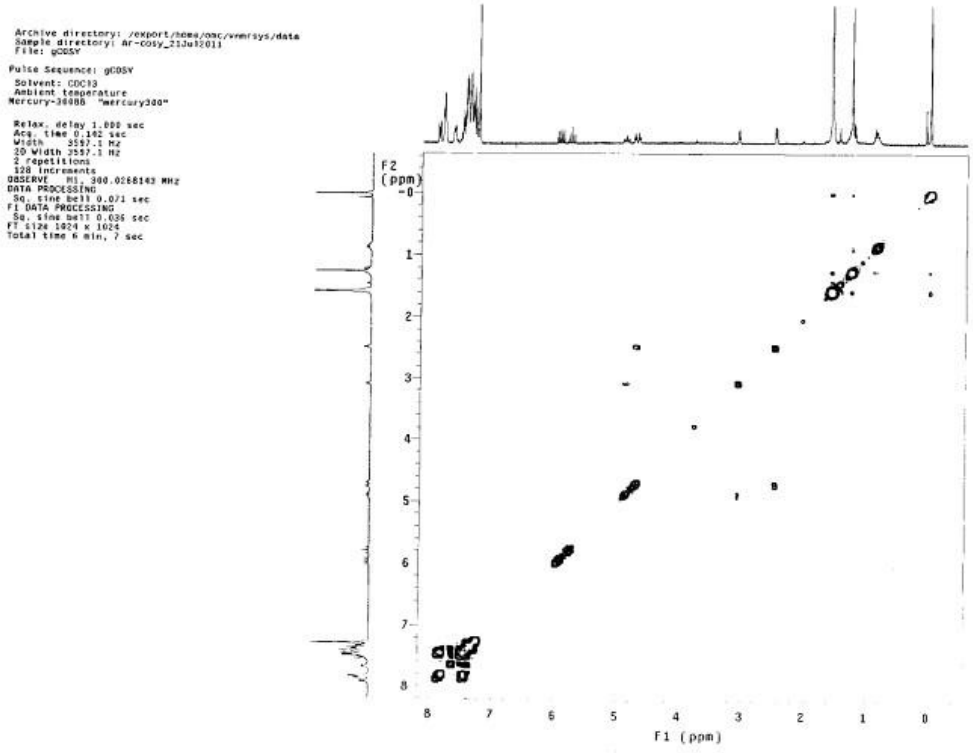
(5*S*)-3-benzoyl-6,6-difluoro-5,7-diphenyl-1,3,4-oxadiazepan-2-one 7a with the addition of D_2O [major/minor (2:1) isomers]. The protons at δ 3.18 (major, d, 1H, *J* = 5.2 Hz, NH), 3.49 (minor, d, 0.5H, *J* = 5.2 Hz, NH) have been identified as the N-H for the two diastereoisomers.

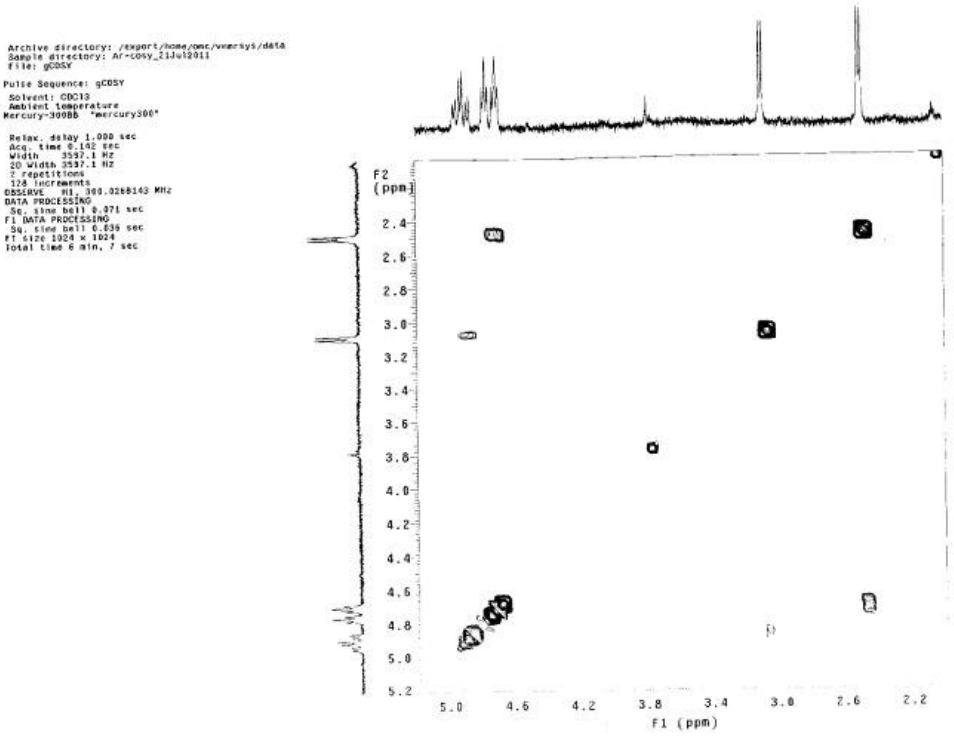


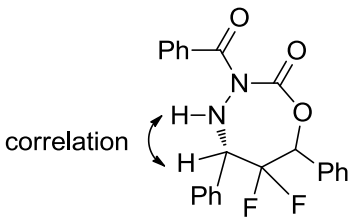
^{1}H NMR (400 MHz, $CDCl_3$, TMS): δ 4.69 (major, d, 1H, *J* = 4.4 Hz, CH), 4.89 (minor, t, 0.5H, *J* = 11.6 Hz, CH), 5.78 (minor, t, 0.5H, *J* = 13.2 Hz, CH), 5.95 (major, dd, 1H, *J* = 18.8, 8.8 Hz, CH), 7.28-7.54 (m, 16H, ArH), 7.63-7.67 (m, 2H, ArH), 7.80-7.84 (m, 3H, ArH), 7.88-7.91 (m, 1H, ArH).



^{1}H-^{1}H cosy spectrum







HPLC REPORT

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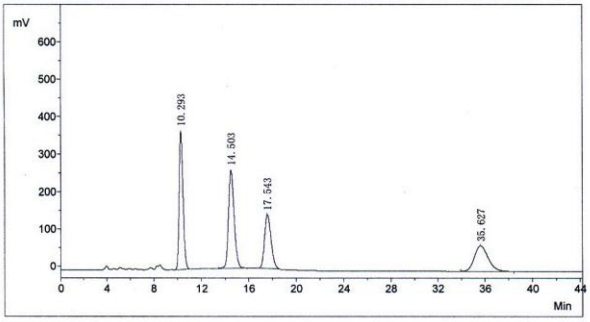
Wave Length: Mobile Phase:



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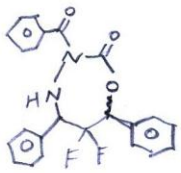
3	3	Unknown	17.543	144187.7	5597312.4	19.8669
4	4	Unknown	35.627	69244.8	5582428.0	19.8141
Total				846878.9	28174073.2	100.0000



race.

AD-H (150mm)
hexane/iPrOH = 60/40
0.5mL/min
214 nm
major t_1=10.293
t_2=14.503
minor t_1=17.543
t_2=35.627