Supplementary information

Asymmetric Synthesis of β-Amino ketone by Using Cinchona Alkaloid-based Chiral Phase Transfer Catalyst

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1、General methods

Flash chromatography (FC) was carried out using silica gel (200-300 mesh). Monitoring of reactions was performed by TLC on silica gel pre-coated on glass plates, and spots were visualized with UV light at 254nm.^{1}H, and ^{13}C NMR were recorded in $CDCl_3$ on Bruker AVANCE III (500 MHz for ^{1}H NMR and 125 MHz for ^{13}C NMR). TMS served as internal standard (δ = 0 ppm) for ^{1}H NMR and $CDCl_3$ was used as internal standard (δ = 77.0 ppm) for ^{13}C NMR; ^{1}H NMR data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet), coupling constants (Hz) and integration. HPLC experiments were carried out using a JASCO LC-2000 Plus system with MD-2010 HPLC diode array detector. High resolution mass spectra (HRMS (ESI-TOF)) were obtained on an Agilent 6545 Q-TOF LCMS spectrometer equipped with an ESI source.

2、Material:

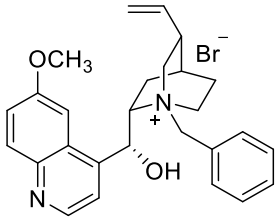
All PTC Catalysts **Q-1 ~ Q-7** were prepared according to the literature procedures.[1] Commercial reagents were purified prior to use following the guidelines of Perrin and Armarego.[2] Flash chromatographic operations were conducted using zcx-II silica (200-300 mesh). Quinine, quinidine, other cinchona alkaloids, aldehydes, aromatic acetophenone and benzyl bromide derivatives were purchased from Aladdin-reagent Co.; Ltd., J&W chemical Co.; Ltd. and Aldirch Inc. 2-amino-4-methyl benzothiazole and 2-amino-6-methoxy benzothiazole were purchased from Sigma-Aldirch Inc.

All the commercial reagents were used as received.

3、Procedure of catalyst preparation:

To a flame-dried flask equipped with a magnetic stirring bar and an air condenser pipe was added cinchona alkaloids (10.0 mmol), toluene (25.0 mL), and desired substituted benzyl bromide derivatives (12.0 mmol). The mixture was heated at 80 °C until a TLC monitoring showed that the raw materials were completely consumed (approx. 12 – 24 hrs) and then cooled to room temperature and poured into dried Et_2O (150 mL) with stirring, the resulting suspension was stirred for 1~2 hrs. Then the precipitate was filtered under vacuum, dried under infrared lamp and purified via recrystallization with ethyl alcohol absolute.

PTC Catalyst (Q-1)



$C_{27}H_{31}BrN_2O_2$

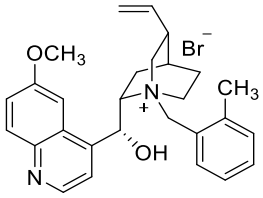
Yellowish solid, m.p 178~180 °C

^{1}H NMR (500 MHz, $CDCl_3$-*d*) δ 8.67 (d, *J* = 4.5 Hz, 1H), 7.95 (d, *J* = 9.0 Hz, 1H), 7.75 (d, *J* = 6.9 Hz, 2H), 7.67 (d, *J* = 4.5 Hz, 1H), 7.40 (t, *J* = 7.5 Hz, 1H), 7.35 – 7.26 (m, 4H), 6.65 (d, *J* = 6.2 Hz, 1H), 6.42 (d, *J* = 6.7 Hz, 1H), 5.96 (d, *J* = 12.0 Hz, 1H), 5.59 (ddd, *J* = 17.3, 10.5, 7.0 Hz, 1H), 5.07 (d, *J* = 17.8 Hz, 1H), 4.94 (d, *J* = 9.8 Hz, 1H), 4.80 (t, *J* = 12.5 Hz, 2H), 3.95 (s, 3H), 3.60 (ddd, *J* = 12.7, 6.1, 2.9 Hz, 1H), 3.44 (dd, *J* = 13.0, 10.7 Hz, 1H), 3.06 (td, *J* = 11.6, 6.5 Hz, 1H), 2.56 – 2.49 (m, 1H), 2.29 (s, 3H), 1.98 (q, *J* = 3.1 Hz, 1H), 1.72 (d, *J* = 10.2 Hz, 1H), 1.57 – 1.49 (m, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 158.06, 147.27, 144.06, 143.28, 136.30, 133.80, 131.74, 130.51, 129.13, 126.91, 126.02, 121.15, 120.44, 117.91, 101.97, 69.57, 63.82, 63.56, 60.68, 56.31, 51.10, 38.03, 26.81, 24.79, 21.48.

$[\alpha]_D^{25}$ = -175.0 (c = 1.68, $CHCl_3$);

PTC Catalyst (Q-2)



$C_{28}H_{33}BrN_2O_2$

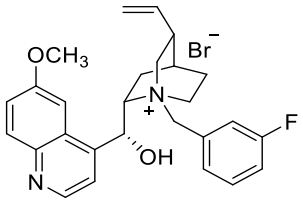
Yellowish solid, m.p 194 °C

^{1}H NMR (500 MHz, $CDCl_3$-*d*) δ 8.65 (d, *J* = 4.6 Hz, 1H), 8.00 (d, *J* = 9.2 Hz, 1H), 7.95 (d, *J* = 7.7 Hz, 1H), 7.83 (d, *J* = 4.6 Hz, 1H), 7.39 (d, *J* = 2.6 Hz, 1H), 7.35 (td, *J* = 7.5, 1.4 Hz, 1H), 7.31 – 7.28 (m, 1H), 7.26 (d, *J* = 7.6 Hz, 1H), 7.23 (d, *J* = 7.2 Hz, 1H), 6.77 – 6.67 (m, 2H), 6.05 (d, *J* = 12.5 Hz, 1H), 5.66 (ddd, *J* = 17.3, 10.4, 7.0 Hz, 1H), 5.15 – 5.03 (m, 2H), 4.96 (t, *J* = 11.5 Hz, 1H), 4.82 (d, *J* = 12.4 Hz, 1H), 4.10 (t, *J* = 8.8 Hz, 1H), 3.97 (s, 3H), 3.48 (dd, *J* = 11.8, 6.5 Hz, 1H), 3.27 (dd, *J* = 12.6, 10.6 Hz, 1H), 3.10 (td, *J* = 11.6, 6.5 Hz, 1H), 2.54 (d, *J* = 8.2 Hz, 1H), 2.46 (s, 3H), 2.37 – 2.28 (m, 1H), 2.24 (dd, *J* = 13.9, 7.0 Hz, 1H), 2.02 (d, *J* = 3.1 Hz, 1H), 1.77 – 1.69 (m, 1H), 1.58 – 1.50 (m, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 158.33, 146.46, 144.44, 143.00, 139.65, 136.28, 135.34, 131.72, 131.01, 130.79, 126.90, 126.26, 125.50, 121.73, 120.70, 118.13, 101.96, 70.34, 64.34, 61.32, 60.29, 56.39, 51.05, 38.33, 26.59, 25.01, 21.87, 20.92.

$[\alpha]_D^{25}$ = -215.5 (c = 2.0, $CHCl_3$);

PTC Catalyst (Q-3)



$C_{27}H_{30}BrFN_2O_2$

Yellowish solid, m.p 205 °C

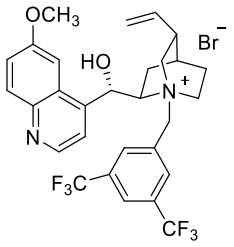
^{1}H NMR (500 MHz, $CDCl_3$-*d*) δ 8.57 (d, *J* = 4.7 Hz, 1H), 7.87 (d, *J* = 9.2 Hz, 1H), 7.75 (d, *J* = 4.7 Hz, 1H), 7.66 (d, *J* = 7.9 Hz, 1H), 7.58 (d, *J* = 8.9 Hz, 1H), 7.38 (td, *J* = 8.1, 5.9 Hz, 1H), 7.32 (d, *J* = 2.6 Hz, 1H), 7.20 – 7.10 (m, 2H), 6.69 – 6.53 (m, 2H), 6.06 (d, *J* = 12.0 Hz, 1H), 5.66 (ddd, *J* = 17.2, 10.5, 6.8 Hz, 1H), 5.18 (d, *J* = 17.0 Hz, 1H), 5.02 (dd, *J* = 23.0, 10.9 Hz, 2H), 4.85 (t, *J* = 11.8 Hz, 1H), 4.08 (t, *J* = 8.7 Hz, 1H), 4.00

(s, 3H), 3.80 (d, *J* = 12.3 Hz, 1H), 3.42 (dd, *J* = 12.9, 10.7 Hz, 1H), 3.15 – 3.05 (m, 1H), 2.58 (d, *J* = 9.4 Hz, 1H), 2.26 (dd, *J* = 12.5, 6.3 Hz, 2H), 2.04 (q, *J* = 3.1 Hz, 1H), 1.82 – 1.71 (m, 1H), 1.58 (dd, *J* = 13.6, 10.6 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 163.54, 161.56, 158.34, 145.74, 144.88, 136.17, 130.87, 129.88, 129.23, 126.25, 121.82, 120.77, 120.54, 118.19, 117.86, 117.69, 102.32, 69.54, 64.25, 62.63, 60.67, 56.51, 51.30, 38.12, 26.77, 24.88, 21.57.

$[\alpha]_D^{25}$ = -149.1 (c = 2.2, $CHCl_3$);

PTC Catalyst (Q-4)



$C_{29}H_{29}BrF_6N_2O_2$

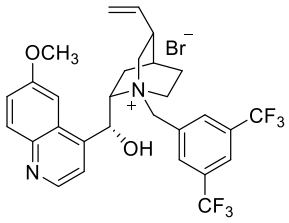
Yellowish solid, m.p 210~215 ˚C

^{1}H NMR (500 MHz, $CDCl_3$-*d*) δ 8.49 (dd, *J* = 11.8, 4.5 Hz, 1H), 8.39 (d, *J* = 14.4 Hz, 2H), 7.87 (s, 1H), 7.78 (d, *J* = 9.2 Hz, 1H), 7.71 (dd, *J* = 7.4, 4.5 Hz, 1H), 7.53 (dd, *J* = 17.5, 2.6 Hz, 1H), 7.05 (dd, *J* = 9.3, 2.4 Hz, 1H), 6.61 (dd, *J* = 26.5, 5.7 Hz, 1H), 6.46 – 6.39 (m, 1H), 6.01 – 5.80 (m, 3H), 5.27 – 5.20 (m, 1H), 4.62 (dq, *J* = 18.4, 10.2 Hz, 1H), 4.18 (dt, *J* = 30.1, 9.9 Hz, 1H), 3.83 (d, *J* = 3.9 Hz, 3H), 3.47 (s, 1H), 3.17 (t, *J* = 11.5 Hz, 1H), 2.71 (p, *J* = 11.1, 10.7 Hz, 1H), 2.47 – 2.32 (m, 1H), 2.07 (s, 2H), 1.90 – 1.72 (m, 3H), 1.03 – 0.89 (m, 1H), 0.85 (t, *J* = 7.3 Hz, 1H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 157.96, 146.79, 143.80, 142.34, 135.00, 134.02, 132.48, 132.21, 131.30, 130.38, 126.11, 123.71, 121.54, 120.48, 118.42, 102.89, 68.13, 66.76, 60.24, 56.41, 56.30, 54.45, 50.68, 38.00, 36.04, 27.08, 24.05, 23.76, 21.78.

$[\alpha]_D^{25}$ = +146.54 (c = 2.02, $CHCl_3$);

PTC Catalyst (Q-5)



$C_{29}H_{29}BrF_6N_2O_2$

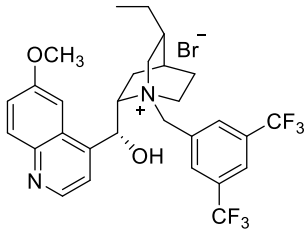
Yellowish solid, m.p 185~190 ˚C

^{1}H NMR (500 MHz, DMSO-d_6) δ 8.83 (d, J = 4.5 Hz, 1H), 8.46 (s, 2H), 8.38 (s, 1H), 8.05 (d, J = 9.2 Hz, 1H), 7.76 (d, J = 4.5 Hz, 1H), 7.53 (dd, J = 9.2, 2.7 Hz, 1H), 7.38 (d, J = 2.6 Hz, 1H), 6.68 (d, J = 4.0 Hz, 1H), 6.52 (s, 1H), 5.77 (ddd, J = 17.3, 10.4, 6.9 Hz, 1H), 5.54 (d, J = 13.1 Hz, 1H), 5.13 (d, J = 17.2 Hz, 1H), 5.03 (dt, J = 10.5, 1.3 Hz, 1H), 4.94 (d, J = 12.3 Hz, 1H), 4.02 (s, 3H), 3.80 (t, J = 8.7 Hz, 1H), 3.73 (s, 1H), 3.45 (dd, J = 12.6, 10.9 Hz, 1H), 3.25 (dd, J = 11.1, 6.0 Hz, 1H), 2.65 (d, J = 9.1 Hz, 1H), 2.26 (dd, J = 13.2, 6.7 Hz, 1H), 2.15 (q, J = 9.8, 8.8 Hz, 1H), 2.02 (q, J = 3.1 Hz, 1H), 1.87 – 1.76 (m, 1H), 1.49 (dd, J = 13.4, 10.3 Hz, 1H).

^{13}C NMR (125 MHz, DMSO-d_6) δ 157.56, 147.43, 143.70, 143.49, 138.03, 134.38, 131.57, 131.12, 130.91, 130.65, 125.37, 124.20, 122.03, 121.14, 120.26, 116.65, 102.10, 68.65, 63.78, 61.48, 59.27, 55.70, 50.79, 37.21, 26.02, 24.23, 20.42.

$[\alpha]_D^{25}$ = -140.95 (c = 2.1, $CHCl_3$);

PTC Catalyst 6 (Q-6)



$C_{29}H_{31}BrF_6N_2O_2$

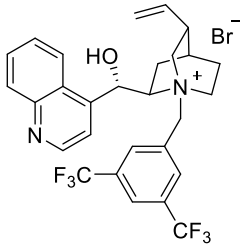
Yellowish solid, m.p 200~205 ˚C

^{1}H NMR (500 MHz, $CDCl_3$-d) δ 8.67 (d, J = 4.5 Hz, 1H), 8.60 (s, 2H), 7.97 – 7.90 (m, 2H), 7.65 (d, J = 4.6 Hz, 1H), 7.29 – 7.21 (m, 3H), 6.62 (d, J = 6.2 Hz, 1H), 6.38 – 6.25 (m, 2H), 5.17 (d, J = 12.0 Hz, 1H), 4.97 (s, 1H), 4.03 (d, J = 8.7 Hz, 1H), 3.94 (s, 3H), 3.83 – 3.76 (m, 1H), 3.33 – 3.25 (m, 1H), 2.92 (td, J = 13.8, 11.3, 5.8 Hz, 1H), 2.36 – 2.23 (m, 2H), 2.03 (s, 4H), 1.80 – 1.64 (m, 2H), 1.34 (dq, J = 14.5, 7.2 Hz, 1H), 1.28 – 1.17 (m, 1H), 0.70 (t, J = 7.3 Hz, 3H).

^{13}C NMR (125 MHz, CDCl3) δ 149.28, 146.83, 144.17, 135.39, 133.88, 132.41, 132.14, 130.13, 129.56, 128.68, 127.47, 123.57, 123.39, 122.77, 121.40, 119.68, 118.24, 67.92, 65.01, 60.57, 60.12, 50.91, 37.74, 26.28, 25.00, 22.44.

$[\alpha]_D^{25}$ = -110.0 (c = 2.3, $CHCl_3$);

PTC Catalyst 7 (Q-7)



$C_{28}H_{27}BrF_6N_2O$

Yellowish to brown solid, m.p 250 ˚C

^{1}H NMR (500 MHz, $CDCl_3$-*d*) δ 8.80 (d, *J* = 4.4 Hz, 1H), 8.34 (s, 2H), 8.25 – 8.18 (m, 1H), 7.83 – 7.74 (m, 2H), 7.68 – 7.62 (m, 1H), 7.15 (dd, *J* = 6.5, 3.2 Hz, 2H), 6.57 – 6.40 (m, 3H), 5.85 (d, *J* = 12.4 Hz, 1H), 5.45 – 5.35 (m, 1H), 5.30 (dd, *J* = 17.3, 1.4 Hz, 1H), 4.93 (dd, *J* = 10.4, 1.5 Hz, 1H), 4.76 (q, *J* = 10.1 Hz, 1H), 4.20 (d, *J* = 9.1 Hz, 1H), 4.01 (dt, *J* = 12.7, 3.3 Hz, 1H), 2.92 (ddd, *J* = 23.2, 12.8, 9.8 Hz, 2H), 2.53 (s, 1H), 2.19 – 2.00 (m, 3H), 1.98 – 1.84 (m, 2H), 1.67 (q, *J* = 11.3 Hz, 1H), 1.29 – 1.24 (m, 1H), 1.09 – 1.00 (m, 1H), 0.93 – 0.82 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 149.28, 146.83, 144.17, 135.39, 133.88, 132.41, 132.14, 130.13, 129.56, 128.68, 127.47, 124.23, 123.57, 123.39, 122.77, 121.40, 119.68, 118.24, 67.92, 65.01, 60.57, 60.12, 50.91, 37.74, 26.28, 25.00, 22.65, 22.44.

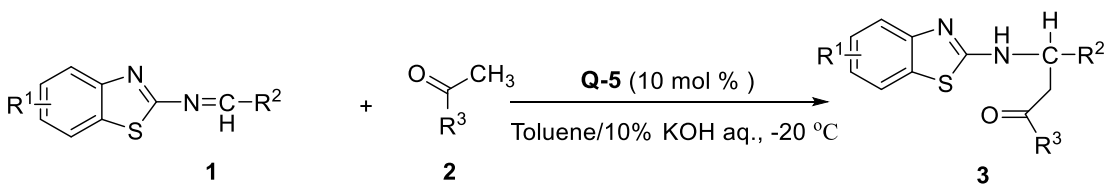
$[\alpha]_D^{25}$ = -130.54(c = 2.03, $CHCl_3$);

Reference

[1] F. Fini, G. Micheletti, L. Bernardi, D. Pettersen, M. Fochi, A. Ricci, *Chem. Commun.* **2008**, 4345-4347.

[2] D. D. Perrin, W. L. F. Armarego, *Purification of Laboratory Chemicals*, 4th ed. Pergamon Press: Oxford, **1997**.

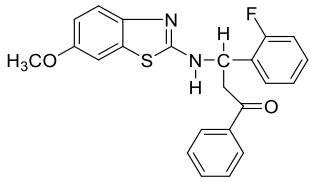
4、Standard procedure for product 3：



To a solution of benzothiazole imine (0.05 mmol) in Toluene (3.0 mL) was added chiral

PTC **Q-5** (10 mol-%) and 10 % KOH aq. solution (1.5 equiv.) sequentially, and the resulting mixture was stirred at -20 °C for 10 mins. Then ketones (0.075 mmol) was added into (a spot of aromatic benzaldehyde was added in order to suppress the decomposition of benzothiazole imine under alkaline ambient). The resulting mixture was vigorously stirred at -20 °C, after completion of the reaction (TLC monitoring), saturated aqueous $NaHCO_3$ (5.0 ml) was added for quenching. The aqueous layer was extracted with dichloromethane (3×10.0 mL). The combined organic layers were washed with pure water, and then dried over with anhydrous Na_2SO_4. The organic solvent was evaporated under reduce pressure, and the resulting crude mixture was purified by flash column chromatography, (SiO_2, eluent: Petroleum ether and ethyl acetate system) to afforded the desired products.

3a:3-(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-phenyl propan-1-one



This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (16.9 mg, 83 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 2 / 1 *v/v*); 96.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 35.17 min, tr (minor) = 23.77 min]; $[\alpha]_D^{20}$ = -35.9 (c = 0.8, CH_2Cl_2);

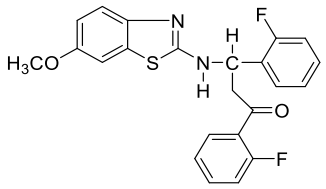
^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.87 (dd, *J* = 8.4, 1.3 Hz, 2H), 7.59 - 7.50 (m, 2H), 7.47 - 7.36 (m, 3H), 7.25 (ddd, *J* = 15.4, 5.3, 1.7 Hz, 1H), 7.15 - 6.99 (m, 3H), 6.88 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.63 (t, *J* = 6.0 Hz, 1H), 3.81 (s, 3H), 3.79 - 3.75 (m, 1H), 3.57 (dd, *J* = 17.1, 5.7 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 197.48, 164.93, 160.46 (d, *J*= 243.7Hz), 155.20, 146.18, 136.35, 133.49, 131.65, 129.35 (d, *J*= 7.5Hz), 128.87 (d, *J*= 3.7Hz), 128.63, 128.10,

127.91, 127.80, 124.38 (d, *J*= 3.7H), 119.43, 115.79, 115.62, 113.52, 105.32, 55.87, 51.33, 43.37.

HR-MS (ESI) m/z Calcd for $C_{23}H_{20}FN_2O_2S$ $[M+H]^+$ 407.1224; found 407.1227.

3b:1,3-bis(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)propan-1-one



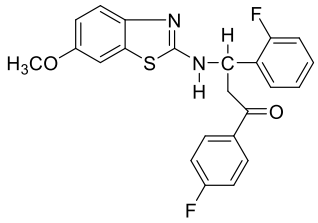
This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (17.2 mg, 81 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 2 / 1 *v/v*); 94.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 36.25 min, tr (minor) = 23.33 min]; $[\alpha]_D^{20}$ = -17.1 (c = 0.6, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.82 (td, *J* = 7.7, 1.9 Hz, 1H), 7.57 (td, *J* = 7.6, 1.8 Hz, 1H), 7.39 (d, *J* = 8.8 Hz, 1H), 7.30 – 7.22 (m, 2H), 7.22 - 7.08 (m, 3H), 7.08 - 7.02 (m, 3H), 6.86 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.65 – 5.58 (m, 1H), 3.80 (s, 3H), 3.79 - 3.72 (m, 1H), 3.58 (ddd, *J* = 17.8, 5.2, 3.0 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 195.40, 165.10, 162.20 (d, *J*= 178.7 Hz), 160.21 (d, *J*= 168.7Hz), 155.16, 146.10, 134.94 (d, *J*= 8.7Hz), 131.53, 130.63 (d, *J*= 2.5Hz), 129.35 (d, *J*= 7.5Hz), 128.85 (d, *J*= 3.7Hz), 127.94, 125.12, 124.53(d, *J*= 3.7Hz), 124.36 (d, *J*= 3.7Hz), 119.33, 116.55 (d, *J*= 22.5Hz), 115.74 (d, *J*= 21.5Hz), 113.51, 105.32, 99.99, 55.88, 51.18, 48.40.

HR-MS (ESI^+) m/z Calcd for $C_{23}H_{19}F_2N_2O_2S$ $[M+H]^+$ 425.1130; found 425.1137.

3c: 3-(2-Fluorophenyl)-1-(4-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino) propan-1-one



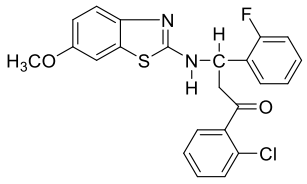
This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (18.0 mg, 85 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 2 / 1 *v/v*); 93.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 0.8 ml·min^{-1}, λ = 270 nm, tr (major) = 28.59 min, tr (minor) = 19.57 min] ; $[\alpha]_D^{20}$ = +15.4 (c = 0.9, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.87 (dd, *J* = 8.9, 5.4 Hz, 2H), 7.55 (td, *J* = 7.7, 1.8 Hz, 1H), 7.42 (d, *J* = 8.8 Hz, 1H), 7.27 (d, *J* = 10.9 Hz, 1H), 7.16 - 7.02 (m, 5H), 6.88 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.59 (t, *J* = 6.1 Hz, 1H), 3.81 (s, 3H), 3.74 (dd, *J* = 16.9, 6.6 Hz, 1H), 3.50 (dd, *J* = 16.9, 5.5 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 195.73, 166.91, 164.95 (d, *J*= 17.5Hz), 160.46 (d, *J*= 243.7Hz) ,155.26, 146.05, 132.81 (d, *J*= 3.7Hz), 131.57, 130.77 (d, *J*= 10.0Hz), 129.46 (d, *J*= 8.7Hz), 128.82 (d, *J*= 3.7Hz), 127.80, 127.70, 124.47, 124.44, 119.36, 115.82 (d, *J*= 6.2Hz), 115.65 (d, *J*= 6.2Hz), 113.62, 113.60, 105.31, 55.87, 51.36, 43.37.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}F_2N_2O_2S$ $[M+H]^+$ 425.1130; found 425.1136.

3d: 1-(2-Chlorophenyl)-3-(2-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino)propan-1-one



This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (18.5 mg, 84 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 3 / 1 *v/v*); 94.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 0.8 ml·min^{-1}, λ = 270 nm, tr (major) = 36.13 min, tr (minor) = 31.40 min]; $[\alpha]_D^{20}$ = -37.8 (c = 1.2,

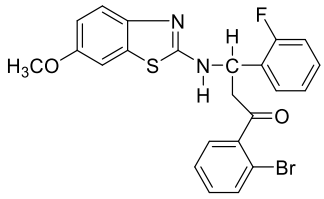
CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.57 - 7.50 (m, 1H), 7.44 - 7.32 (m, 4H), 7.29 - 7.22 (m, 2H), 7.16 - 7.03 (m, 3H), 6.87 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.58 (dd, *J* = 7.3, 5.2 Hz, 1H), 3.81 (s, 4H), 3.58 (dd, *J* = 17.1, 5.3 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 200.47, 164.89, 160.49 (d, *J*= 245 Hz), 155.32, 145.74, 138.48, 132.14, 131.38, 131.02, 130.45, 129.52 (d, *J*= 8.7 Hz), 129.23, 128.81 (d, *J*= 3.7 Hz), 127.01, 124.46 (d, *J*= 3.7 Hz), 119.35, 115.74 (d, *J*= 21.25 Hz), 113.63, 105.36, 55.89, 51.64, 47.68, 29.70.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}ClFN_2O_2S$ $[M+H]^+$ 441.0834; found 441.0837.

3e: 1-(2-Bromophenyl)-3-(2-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino)propan-1-one

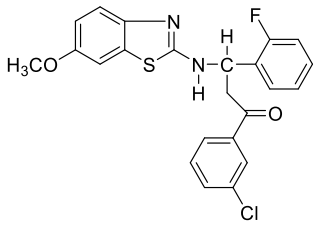


This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (20.8 mg, 86 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 3 / 1 *v/v*); 91.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 0.8 ml·min^{-1}, λ = 270 nm, tr (major) = 33.8 min, tr (minor) = 29.4 min]; $[\alpha]_D^{20}$ = -17.9 (c = 1.7, CH_2Cl_2); ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.58 – 7.50 (m, 2H), 7.46 - 7.39 (m, 2H), 7.33 - 7.23 (m, 5H), 7.16 - 7.02 (m, 3H), 6.88 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.62 - 5.55 (m, 1H), 3.81 (s, 3H), 3.80 - 3.73 (m, 1H), 3.57 (dd, *J* = 17.2, 5.4 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 201.53, 164.60, 160.52 (d, *J*= 243.7 Hz), 155.36, 145.95, 140.77, 133.70, 131.99, 131.54, 129.56 (d, *J*= 8.7 Hz), 128.92 (d, *J*= 3.7 Hz), 128.74, 127.50, 127.35, 124.47 (d, *J*= 2.5 Hz), 119.54, 118.74, 115.75 (d, *J*= 21.2 Hz), 113.64, 105.33, 55.90, 51.60, 47.33.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}FBrN_2O_2S$ $[M+H]^+$ 487.0309; found 487.0311.

3f: 1-(3-Chlorophenyl)-3-(2-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino)propan-1-one



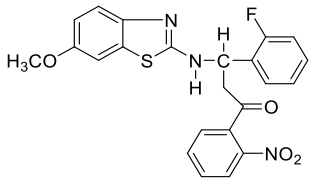
This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (20.9 mg, 95 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 3 / 1 *v/v*); 92.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 39.58 min, tr (minor) = 22.02 min] ; $[\alpha]_D^{20}$ = -70.6 (c = 1.1, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.85 (t, *J* = 1.9 Hz, 1H), 7.58 – 7.48 (m, 2H), 7.43 (d, *J* = 8.8 Hz, 1H), 7.35 (t, *J* = 7.9 Hz, 1H), 7.30 – 7.24 (m, 1H), 7.16 – 7.04 (m, 3H), 6.88 (dd, *J* = 8.8, 2.7 Hz, 1H), 5.61 (t, *J* = 6.1 Hz, 1H), 3.81 (s, 4H), 3.51 (dd, *J* = 17.0, 5.8 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 196.07, 164.92, 160.47 (d, *J* = 243.7 Hz), 155.31, 145.97, 137.86, 135.00, 133.35, 131.54, 129.94, 129.55, 128.86 (d, *J* = 3.7 Hz), 128.21, 127.57, 126.18, 124.48(d, *J* = 3.7 Hz), 119.40, 115.80 (d, *J*= 21.2 Hz), 113.61, 105.38, 55.87, 51.34, 43.64.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}ClFN_2O_2S$ $[M+H]^+$ 441.0834; found 441.0835.

3g: 3-(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-(2-nitrophenyl)propan-1-one



This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (19.4 mg, 86 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 2 / 1 *v/v*); 77.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 21.64 min, tr (minor) = 15.00 min]; $[\alpha]_D^{20}$ = -26.0 (c = 0.6,

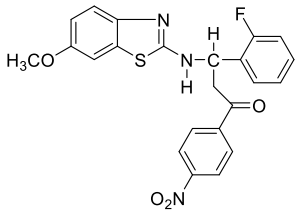
CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.04 (dd, *J* = 8.2, 1.2 Hz, 1H), 7.63 (td, *J* = 7.5, 1.2 Hz, 1H), 7.60 - 7.50 (m, 2H), 7.38 (d, *J* = 8.8 Hz, 1H), 7.22 - 7.04 (m, 4H), 6.86 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.62 (dd, *J* = 7.7, 4.9 Hz, 1H), 5.31 (s, 0H), 3.81 (s, 3H), 3.58 (dd, *J* = 17.2, 7.6 Hz, 1H), 3.46 (dd, *J* = 17.2, 5.0 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 199.71, 164.87, 161 (d, *J*= 245 Hz), 155.33, 145.91, 145.38, 137.09, 134.42, 131.53, 130.77, 129.65 (d, *J*= 7.5 Hz), 128.71 (d, *J*= 5.0 Hz), 127.50, 127.36, 124.53, 124.26, 119.36, 115.81 (d, *J*= 21.2 Hz), 113.61, 105.39, 55.90, 51.30, 47.58.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}FN_2O_4S$ $[M+H]^+$ 452.1075; found 452.1075.

3h: 3-(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-(4-nitro phenyl)propan-1-one



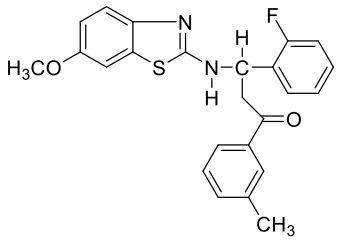
This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (20.3 mg, 90 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 2 / 1 *v/v*); 81.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 80 / 20, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 32.66 min, tr (minor) = 25.49 min]; $[\alpha]_D^{20}$ = +23.9 (c = 1.3, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.20 (dd, *J* = 19.7, 8.3 Hz, 2H), 7.97 (dd, *J* = 21.4, 8.9 Hz, 2H), 7.61 – 7.54 (m, 1H), 7.39 (dd, *J* = 8.8, 4.3 Hz, 1H), 7.32 – 7.28 (m, 1H), 7.20 – 7.09 (m, 2H), 7.01 (d, *J* = 2.5 Hz, 1H), 6.89 (dd, *J* = 8.8, 2.5 Hz, 1H), 5.56 (t, *J* = 6.4 Hz, 1H), 5.31 (s, 1H), 3.90 – 3.82 (m, 2H), 3.82 – 3.77 (m, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 195.51, 159.50, 155.47, 150.30, 140.63, 129.83 (d, *J*= 8.7 Hz), 129.50, 129.09, 128.97, 128.71, 127.35, 124.68 (d, *J*= 3.7 Hz), 123.88, 123.74, 119.04, 115.95 (d, *J*= 21.2 Hz), 114.01, 113.90, 105.21, 55.88, 55.86, 51.38, 44.23.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}FN_2O_4S$ $[M+H]^+$ 452.1075; found 452.1074.

3i: 3-(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-(m-tolyl) propan-1-one



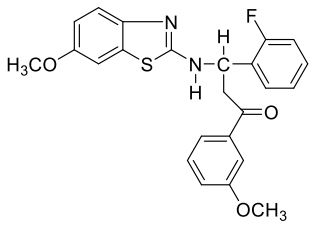
This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (15.8 mg, 75 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 3 / 1 *v/v*); 94.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 42.50 min, tr (minor) = 26.10 min]; $[\alpha]_D^{20}$ = -50.0 (c = 0.4, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.67 (d, *J* = 8.9 Hz, 2H), 7.56 (td, *J* = 7.7, 1.8 Hz, 1H), 7.43 (d, *J* = 8.8 Hz, 1H), 7.36 (d, *J* = 7.4 Hz, 1H), 7.32 - 7.26 (m, 2H), 7.14 - 7.03 (m, 3H), 6.88 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.62 (t, *J* = 6.0 Hz, 1H), 3.81 (s, 4H), 3.57 (dd, *J* = 17.0, 5.7 Hz, 1H), 2.37 (s, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 197.69, 164.93, 160.48 (d, *J*= 245 Hz), 155.20, 146.27, 138.46, 136.41, 134.26, 131.70, 129.31 (d, *J*= 8.7 Hz), 128.88 (d, *J*= 3.7 Hz), 128.57 (d, *J*= 16.2Hz), 127.98, 127.88, 125.34, 124.37, 119.45, 115.68 (d, *J*= 21.2 Hz), 113.51, 105.32, 55.86, 51.37, 43.45, 21.30.

HR-MS (ESI$^+$) m/z Calcd for $C_{24}H_{22}FN_2O_2S$ $[M+H]^+$ 421.1381; found 421.1390.

3j: 3-(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino)-1-(3-methoxy phenyl) propan-1-one



This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (18.5 mg, 85 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 2 / 1 *v/v*); 94.0 % *ee* as determined by

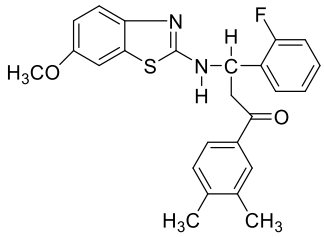
HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 66.78 min, tr (minor) = 38.23 min]; $[\alpha]_D^{20}$ = -11.9 (c = 0.6, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.55 (td, *J* = 7.7, 1.8 Hz, 1H), 7.45 - 7.39 (m, 3H), 7.34 - 7.21 (m, 2H), 7.15 - 7.03 (m, 4H), 6.87 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.62 (t, *J* = 6.1 Hz, 1H), 3.81 (d, *J* = 6.9 Hz, 6H), 3.75 (dd, *J* = 17.0, 6.6 Hz, 1H), 3.55 (dd, *J* = 17.0, 5.6 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 197.22, 164.99, 160. 47(d, *J*= 243.7 Hz), 155.20, 146.18, 137.69, 131.64, 129.60, 129.36 (d, *J*= 16.2 Hz), 128.83 (d, *J*= 5.0 Hz), 127.94, 127.84, 124.41(d, *J*= 3.7 Hz), 120.78, 120.20, 119.40, 115.72 (d, *J*= 21.2 Hz) 113.53, 112.06, 105.34, 55.86, 55.39, 51.38, 43.62.

HR-MS (ESI$^+$) m/z Calcd for $C_{24}H_{22}FN_2O_3S$ $[M+H]^+$ 437.1330; found 437.1337.

3k:1-(3,4-Dimethylphenyl)-3-(2-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)propan-1-one



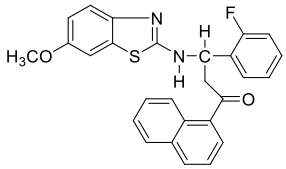
This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 24 hrs; yield (17.4 mg, 80 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 5 / 1 *v/v*); 91 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 40.81 min, tr (minor) = 25.07 min]; $[\alpha]_D^{20}$ = -32.0 (c = 0.9, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.68 - 7.59 (m, 2H), 7.42 (d, *J* = 8.8 Hz, 1H), 7.24 (dt, *J* = 8.2, 6.5 Hz, 1H), 7.17 (d, *J* = 7.9 Hz, 1H), 7.14 – 7.02 (m, 3H), 6.87 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.63 (t, *J* = 5.9 Hz, 1H), 3.80 (s, 4H), 3.55 (dd, *J* = 16.9, 5.6 Hz, 1H), 2.30 (s, 3H), 2.28 (s, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 197.43, 164.84, 161.44, 159.49 (d, *J* = 243.7 Hz), 155.21, 146.24, 143.16, 137.01, 134.36, 131.67, 129.85, 129.26, 128.84 (d, *J* = 3.7 Hz), 127.96, 125.88, 124.37 (d, *J* = 2.5 Hz), 119.45, 115.63 (d, *J* = 21.2 Hz), 113.50, 105.30, 55.86, 51.39, 43.23, 20.03, 19.72.

HR-MS (ESI$^+$) m/z Calcd for $C_{25}H_{24}FN_2O_2S$ $[M+H]^+$ 435.1537; found 435.1542.

3l:3-(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-(naphthalen-1-yl)propan-1-one

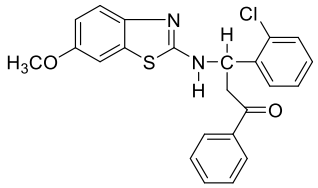


This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (18.0 mg, 79 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 2 / 1 *v/v*); 74.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 45.78 min, tr (minor) = 29.32 min]; $[\alpha]_D^{20}$ = +9.9 (c = 0.5, CH_2Cl_2); ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.51 (d, *J* = 9.5 Hz, 1H), 7.94 (d, *J* = 8.1 Hz, 1H), 7.86 – 7.80 (m, 1H), 7.71 (d, *J* = 7.3 Hz, 1H), 7.57 (t, *J* = 8.6 Hz, 1H), 7.53 – 7.47 (m, 2H), 7.43 – 7.34 (m, 2H), 7.24 (t, *J* = 6.8 Hz, 1H), 7.14 – 7.03 (m, 3H), 6.85 (dd, *J* = 8.8, 2.7 Hz, 1H), 5.66 (t, *J* = 6.3 Hz, 1H), 4.14 (d, *J* = 7.2 Hz, 0H), 3.80 (d, *J* = 2.1 Hz, 3H), 3.64 (dd, *J* = 16.6, 5.4 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 201.22, 165.16, 160.47 (d, *J*= 243.7 Hz), 155.14, 146.10, 134.88, 133.83, 133.19, 131.59, 130.01, 129.39(d, *J*= 8.7 Hz), 128.85(d, *J*= 5.0 Hz), 128.31, 128.09, 127.86, 126.47, 125.64, 124.42 (d, *J*= 3.7 Hz), 124.21,119.31, 115.72(d, *J*= 21.2 Hz), 113.50, 105.30, 60.38, 55.84, 51.82, 46.63.

HR-MS (ESI$^+$) m/z Calcd for $C_{27}H_{22}FN_2O_2S$ $[M+H]^+$ 457.1381; found 457.1382.

3m: 3-(2-Chlorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-phenyl propan-1-one



This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (17.90 mg, 85 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 2 / 1 *v/v*); 96.0 % *ee* as

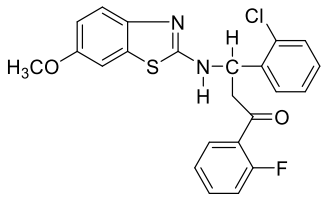
determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 32.46 min, tr (minor) = 21.50 min]; $[\alpha]_D^{20}$ = -43.9 (c = 0.8, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.85 - 7.79 (m, 2H), 7.60 (dd, *J* = 7.5, 2.0 Hz, 1H), 7.52 (t, *J* = 7.4 Hz, 1H), 7.41 – 7.33 (m, 4H), 7.26 - 7.15 (m, 3H), 7.04 (d, *J* = 2.6 Hz, 1H), 6.82 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.66 (dd, *J* = 7.3, 4.5 Hz, 1H), 3.77 (s, 3H), 3.68 (dd, *J* = 16.9, 7.3 Hz, 1H), 3.50 (dd, *J* = 16.9, 4.5 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 197.48, 165.31, 155.15, 146.13, 138.25, 136.34, 133.51, 132.65, 131.70, 129.88, 128.93, 128.62, 128.24, 128.14, 127.37, 119.37, 113.55, 105.32, 55.87, 53.57, 42.79.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{20}ClN_2O_2S$ $[M+H]^+$ 423.0929; found 423.0928.

3n: 3-(2-Chlorophenyl)-1-(2-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino)propan-1-one



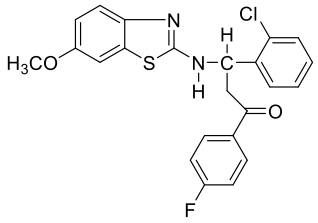
This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (18.3 mg, 83 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 2 / 1 *v/v*); 87.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 28.74 min, tr (minor) = 17.34 min]; $[\alpha]_D^{20}$ = -26.0 (c = 0.7, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.75 (t, *J* = 7.6 Hz, 1H), 7.66 (d, *J* = 7.6 Hz, 1H), 7.45 – 7.38 (m, 2H), 7.32 (d, *J* = 8.8 Hz, 1H), 7.29 – 7.21 (m, 2H), 7.14 (t, *J* = 7.5 Hz, 1H), 6.99 (s, 1H), 6.95 (d, *J* = 11.4 Hz, 1H), 6.81 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.68 (dd, *J* = 8.4, 3.9 Hz, 1H), 3.77 (d, *J* = 9.6 Hz, 3H), 3.66 (ddd, *J* = 17.9, 8.3, 2.9 Hz, 1H), 3.53 – 3.45 (m, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 194.96, 166.15, 161.74 (d, *J*= 253.7 Hz), 155.01, 154.94, 145.97, 138.50, 134.76, 132.78, 130.56, 129.87, 128.91, 128.13, 127.42, 125.15(d, *J*= 12.5 Hz), 124.50, 118.96, 116.33(d, *J*= 23.7 Hz), 113.50, 105.40, 55.86, 53.42, 48.07.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}ClFN_2O_2S$ $[M+H]^+$ 441.0834; found 441.0838.

3o: 3-(2-Chlorophenyl)-1-(4-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino)propan-1-one



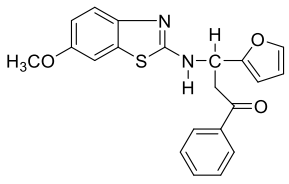
This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (18.9 mg, 86 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 2 / 1 *v/v*); 87.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 26.81 min, tr (minor) = 17.85 min]; $[\alpha]_D^{20}$ = -63.7 (c = 0.6, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.91 – 7.84 (m, 2H), 7.62 (dd, *J* = 7.5, 2.0 Hz, 1H), 7.43 – 7.36 (m, 2H), 7.28 – 7.20 (m, 3H), 7.10 – 7.03 (m, 3H), 6.86 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.67 (dd, *J* = 7.3, 4.5 Hz, 1H), 3.80 (s, 3H), 3.69 (dd, *J* = 16.8, 7.3 Hz, 1H), 3.48 (dd, *J* = 16.8, 4.5 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 195.89, 166.97, 165.20, 155.28, 145.82, 138.04, 132.84, 132.82, 132.63, 131.55, 130.89, 130.81, 129.95, 129.06, 128.23, 127.42, 119.34, 115.76 (d, *J*= 21.2 Hz), 113.68, 105.31, 55.88, 53.61, 42.69.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}ClFN_2O_2S$ $[M+H]^+$ 441.0834; found 441.0838.

3p:3-(furan-2-yl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-phenylpropan-1-one



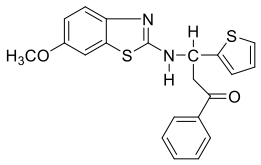
This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 60 hrs; yield (13.4 mg, 71%) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 3 / 1 *v/v*); 75.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 85 / 15, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 51.17 min, tr (minor) = 27.46 min]; $[\alpha]_D^{20}$ = 33.9 (c = 0.6, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.99 – 7.94 (m, 2H), 7.62 – 7.55 (m, 1H), 7.51 – 7.43 (m, 3H), 7.33 (d, *J* = 1.0 Hz, 1H), 7.14 (d, *J* = 2.6 Hz, 1H), 6.91 (dd, *J* = 8.8, 2.6 Hz, 1H), 6.36 – 6.29 (m, 2H), 5.64 (t, *J* = 5.6 Hz, 1H), 3.88 (dd, *J* = 17.2, 5.2 Hz, 1H), 3.83 (s, 3H), 3.62 (dd, *J* = 17.1, 6.0 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 197.65, 164.47, 155.49, 153.19, 145.93, 142.01, 136.59, 133.54, 131.56, 128.71, 128.19, 119.55, 113.64, 110.56, 107.02, 105.42, 55.93, 53.43, 49.92, 41.42.

HR-MS (ESI$^+$) m/z Calcd for $C_{21}H_{18}N_2O_3SNa$ $[M+Na]^+$ 401.0936; found 401.0939.

3q:3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-phenyl-3-(thiophen-2-yl)propan-1-one



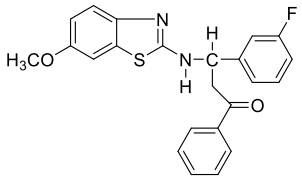
This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 60 hrs; yield (13.79 mg, 70 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 3 / 1 *v/v*); 66.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 85 / 15, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 35.93 min, tr (minor) = 21.37 min]; $[\alpha]_D^{20}$ = 12.6 (c = 0.5, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.98 – 7.93 (m, 2H), 7.62 – 7.55 (m, 1H), 7.50 – 7.43 (m, 3H), 7.31 (dd, *J* = 7.7, 5.7 Hz, 1H), 7.21 (dd, *J* = 5.0, 1.2 Hz, 1H), 7.11 (dd, *J* = 17.9, 3.1 Hz, 2H), 6.94 (dd, *J* = 5.1, 3.6 Hz, 1H), 6.90 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.83 – 5.77 (m, 1H), 3.91 (dd, *J* = 17.3, 5.3 Hz, 1H), 3.82 (s, 3H), 3.66 (dd, *J* = 17.3, 5.9 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 197.62, 164.53, 155.51, 149.80, 145.69, 144.72, 136.60, 133.63, 131.52, 128.75, 128.18, 126.95, 125.03, 124.82, 119.51, 113.69, 105.42, 55.93, 51.76, 44.39.

HR-MS (ESI^+) m/z Calcd for $C_{21}H_{18}N_2O_2S_2Na$ $[M+Na]^+$ 417.0702; found 417.0710.

3r: 3-(3-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-phenyl propan-1-one

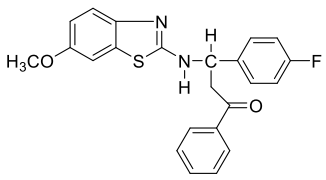


This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 60 hrs; yield (13.4 mg, 66 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 5 / 1 *v/v*); 78.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 44.70 min, tr (minor) = 22.53 min]; $[\alpha]_D^{20}$ = +7.7 (c = 0.4, CH_2Cl_2); ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.89 – 7.84 (m, 2H), 7.57 (t, *J* = 7.4 Hz, 1H), 7.46 – 7.39 (m, 3H), 7.34 – 7.17 (m, 4H), 7.10 (d, *J* = 2.6 Hz, 1H), 6.96 (td, *J* = 8.2, 1.4 Hz, 1H), 6.88 (dd, *J* = 8.8, 2.7 Hz, 1H), 5.45 (t, *J* = 5.8 Hz, 1H), 3.81 – 3.74 (m, 4H), 3.53 (dd, *J* = 17.2, 5.6 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 197.45, 165.00, 164.01, 162.05, 155.37, 145.97, 143.81 (d, *J* = 6.2 Hz), 136.42, 133.63, 131.61, 130.33 (d, *J* = 3.7 Hz), 128.72, 128.12, 122.26 (d, *J* = 2.5 Hz), 119.43, 114.74, 114.57, 113.88, 113.67 (d, *J* = 6.2 Hz), 105.40, 55.91, 55.17, 44.33.

HR-MS (ESI^+) m/z Calcd for $C_{23}H_{19}FN_2O_2SNa$ $[M+Na]^+$ 429.1043; found 429.1044.

3s: 3-(4-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-phenyl propan-1-one



This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%)

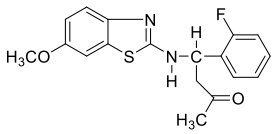
at -20 °C for 60 hrs; yield (14.2 mg, 70 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 5 / 1 *v/v*); 74.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 54.14 min, tr (minor) = 23.33 min]; $[\alpha]_D^{20}$ = +9.7 (c = 0.5, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.84 (dd, *J* = 8.4, 1.4 Hz, 2H), 7.55 (t, *J* = 7.4 Hz, 1H), 7.48 – 7.38 (m, 5H), 7.09 (s, 1H), 7.01 (t, *J* = 8.6 Hz, 2H), 6.88 (dd, *J* = 8.8, 2.6 Hz, 1H), 5.40 (t, *J* = 6.0 Hz, 1H), 3.81 (s, 3H), 3.76 (dd, *J* = 17.0, 6.2 Hz, 1H), 3.50 (dd, *J* = 17.1, 5.9 Hz, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 197.50, 165.18, 163.17, 161.22, 155.30, 146.03, 136.86, 136.84, 136.44, 133.55, 131.65, 128.67, 128.42, 128.35, 128.10, 119.33, 115.72, 115.55, 113.62, 105.41, 55.90, 55.13, 44.68.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}FN_2O_2S$ $[M+Na]^+$ 429.1043; found 429.1046.

3t: 4-(2-fluorophenyl)-4-((6-methoxybenzo[d]thiazol-2-yl)amino)butan-2-one



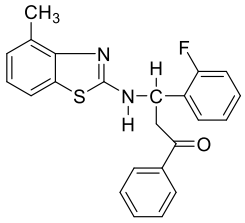
This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 48 hrs; yield (13.9 mg, 81 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 5 / 1 *v/v*); 95.0 % *ee* as determined by HPLC [Daicel Chiralpak AD column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 62.96 min, tr (minor) = 42.54 min]; $[\alpha]_D^{20}$ = +58.6 (c = 1.5, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.48 (td, *J* = 7.7, 1.8 Hz, 1H), 7.43 (d, *J* = 8.8 Hz, 1H), 7.30 – 7.22 (m, 1H), 7.15 – 7.03 (m, 3H), 6.88 (dd, *J* = 8.9, 2.6 Hz, 1H), 5.48 (t, *J* = 6.0 Hz, 1H), 3.81 (s, 3H), 3.24 (dd, *J* = 17.0, 6.4 Hz, 1H), 3.08 (dd, *J* = 17.0, 5.5 Hz, 1H), 2.13 (s, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 206.48, 164.59, 161.39, 159.44, 155.40, 146.02, 131.55, 129.43 (d, *J* = 8.7 Hz), 128.75 (d, *J* = 3.7 Hz), 127.64 (d, *J* = 13.7 Hz), 124.44 (d, *J* = 3.7 Hz), 119.55, 115.74 (d, *J* = 21.2 Hz), 113.64, 105.36, 55.90, 50.94, 48.09, 30.65.

HR-MS (ESI$^+$) m/z Calcd for $C_{18}H_{17}FN_2O_2SNa$ $[M+Na]^+$ 367.0887; found 367.0894.

3u:3-(2-Fluorophenyl)-3-((4-methylbenzo[d]thiazol-2-yl)amino)-1-phenylpropan -1-one



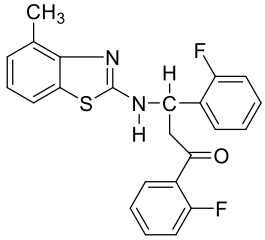
This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 24 hrs; yield (15.8 mg, 81 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 5 / 1 *v/v*); 95.0 % *ee* as determined by HPLC [Daicel Chiralpak AD column, n-hexane / *i*-PrOH = 95 / 5, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 20.77 min, tr (minor) = 23.78 min]; $[\alpha]_D^{20}$ = -35.7 (c = 0.3, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.95 – 7.89 (m, 2H), 7.58 – 7.49 (m, 2H), 7.46 – 7.35 (m, 3H), 7.27 – 7.18 (m, 1H), 7.12 – 7.01 (m, 3H), 6.97 (t, *J* = 7.6 Hz, 1H), 5.64 (t, *J* = 6.1 Hz, 1H), 3.83 (dd, *J* = 16.9, 6.3 Hz, 1H), 3.58 (dd, *J* = 16.8, 5.9 Hz, 1H), 2.53 (s, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 197.46, 165.27, 160.55 (d, *J* = 243.7 Hz), 151.07, 136.39, 133.54, 130.42, 129.42 (d, *J* = 8.7 Hz), 129.04, 128.69, 128.17, 127.66 (d, *J* = 12.5 Hz), 126.64, 124.36 (d, *J* = 3.7 Hz), 121.64, 118.25, 115.69 (d, *J* = 21.2 Hz), 51.57, 43.41, 26.92, 21.05, 18.34, 14.20.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{20}FN_2OS$ $[M+H]^+$ 391.1275; found 391.1289.

3v:1,3-bis(2-Fluorophenyl)-3-((4-methylbenzo[d]thiazol-2-yl)amino)propan-1-one



This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 24 hrs; yield (17.5 mg, 86 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 5 / 1 *v/v*); 94.0 % *ee* as determined by HPLC [Daicel Chiralpak AD column, n-hexane / *i*-PrOH = 95 / 5, 1.0 ml·min^{-1}, λ = 270

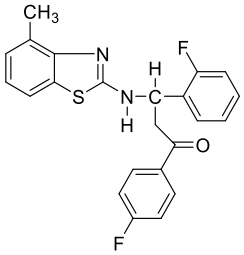
nm, tr (major) = 14.29 min, tr (minor) = 16.20 min]; $[\alpha]_D^{20}$ = -32.6 (c = 0.6, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.83 (td, *J* = 7.7, 1.9 Hz, 1H), 7.61 – 7.48 (m, 2H), 7.30 - 7.17 (m, 3H), 7.17 - 7.04 (m, 4H), 6.98 (t, *J* = 7.6 Hz, 1H), 5.65 (t, *J* = 6.2 Hz, 1H), 3.82 (ddd, *J* = 17.7, 6.8, 2.8 Hz, 1H), 3.66 (ddd, *J* = 17.7, 5.5, 2.9 Hz, 1H), 2.53 (s, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 195.40, 165.37, 162.30 (d, *J* = 181.2 Hz), 160.32 (d, *J* = 172.5 Hz), 151.06, 135.07 (d, *J* = 8.7 Hz), 130.69, 130.41, 129.38 (d, *J* = 8.7 Hz), 129.09, 127.80 (d, *J* = 12.5 Hz), 126.62, 125.09 (d, *J* = 12.5 Hz), 124.56 (d, *J* = 3.7 Hz), 124.30 (d, *J* = 2.5 Hz), 121.59, 118.23, 116.70 (d, *J* = 21.2 Hz), 115.72 (d, *J* = 22.5 Hz), 51.36, 48.42, 48.36, 18.30.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}F_2N_2OS$ $[M+H]^+$ 409.1181; found 409.1192.

3w: 3-(2-Fluorophenyl)-1-(4-fluorophenyl)-3-((4-methylbenzo[d]thiazol-2-yl) amino) propan-1-one



This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 24 hrs; yield (16.9 mg, 83 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 5 / 1 *v/v*); 95.0 % *ee* as determined by HPLC [Daicel Chiralpak AD column, n-hexane / *i*-PrOH = 95 / 5, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 17.17 min, tr (minor) = 25.36 min]; $[\alpha]_D^{20}$ = -9.9 (c = 1.5, CH_2Cl_2);

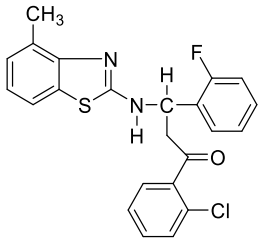
^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.98 (dd, *J* = 8.9, 5.3 Hz, 2H), 7.57 – 7.50 (m, 1H), 7.41 (d, *J* = 7.1 Hz, 1H), 7.31 – 7.23 (m, 1H), 7.15 – 7.04 (m, 5H), 7.00 (t, *J* = 7.6 Hz, 1H), 5.65 (t, *J* = 6.2 Hz, 1H), 3.83 (dd, *J* = 16.7, 6.4 Hz, 1H), 3.55 (dd, *J* = 16.7, 6.0 Hz, 1H), 2.55 (s, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 195.82, 167.00, 165.12 (d, *J* = 37.5 Hz), 161.53 (d, *J* = 243.7 Hz), 150.89, 132.85, 130.89 (d, *J* = 10.0 Hz), 130.32, 129.56 (d, *J* = 7.5 Hz),

129.03, 128.99, 127.53, 127.43, 126.71, 124.43 (d, *J* = 2.5 Hz), 121.75, 118.29, 115.93, 115.83, 115.76, 115.66, 51.62, 43.40, 18.34.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}F_2N_2OS$ $[M+H]^+$ 409.1181; found 409.1191.

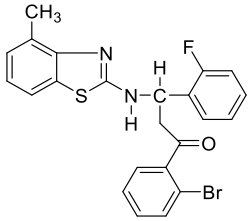
3x: 1-(2-Chlorophenyl)-3-(2-fluorophenyl)-3-((4-methylbenzo[d]thiazol-2-yl) amino)propan-1-one



This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 24 hrs; yield (18.0 mg, 85 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 5 / 1 *v/v*); 97.0 % *ee* as determined by HPLC [Daicel Chiralpak AD column, n-hexane / *i*-PrOH = 95 / 5, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 18.72 min, tr (minor) = 22.41 min]; $[\alpha]_D^{20}$ = -11.9 (c = 1.0, CH_2Cl_2); ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.44 – 7.35 (m, 4H), 7.30 – 7.22 (m, 2H), 7.12 (d, *J* = 7.4 Hz, 1H), 7.11 – 7.03 (m, 2H), 7.00 (t, *J* = 7.6 Hz, 1H), 5.62 (t, *J* = 6.3 Hz, 1H), 3.85 (dd, *J* = 17.1, 7.0 Hz, 1H), 3.63 (dd, *J* = 17.1, 5.8 Hz, 1H), 2.55 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 200.52, 165.07, 160.60 (d, *J* = 243.7 Hz), 151.05, 138.51, 132.18, 131.10, 130.58, 130.44, 129.55 (d, *J* = 8.7 Hz), 129.16, 127.44, 127.34, 127.00, 126.65, 124.37 (d, *J* = 3.7 Hz), 121.71, 118.25, 115.82, 115.65, 51.78, 47.57, 18.32.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}ClFN_2OS$ $[M+H]^+$ 425.0885; found 425.0889.

3y: 1-(2-Bromophenyl)-3-(2-fluorophenyl)-3-((4-methylbenzo[d]thiazol-2-yl)amino)propan-1-one



This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 24 hrs; yield (18.5 mg, 79 %) by preparative flash column chromatography

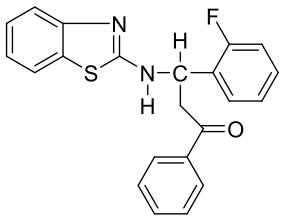
(Silica gel: Petroleum ether / Ethyl acetate = 5 / 1 *v/v*); 96.0 % *ee* as determined by HPLC [Daicel Chiralpak AD column, n-hexane / *i*-PrOH = 95 / 5, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 20.12 min, tr (minor) = 23.16 min]; $[\alpha]_D^{20}$ = +11.5 (c = 1.0, CH_2Cl_2);

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.62 – 7.50 (m, 2H), 7.42 (d, *J* = 7.4 Hz, 1H), 7.36 – 7.26 (m, 4H), 7.16 – 6.97 (m, 4H), 5.60 (t, *J* = 6.3 Hz, 1H), 3.82 (dd, *J* = 17.1, 6.7 Hz, 1H), 3.61 (dd, *J* = 17.1, 5.8 Hz, 1H), 2.55 (s, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 201.40, 165.08, 160.61 (d, *J* = 245 Hz), 150.85, 140.76, 133.75, 132.00, 130.32, 129.60 (d, *J* = 8.7 Hz), 129.18, 129.09, 128.74, 127.50, 126.70, 124.41 (d, *J* = 8.7 Hz), 121.78, 118.78, 118.28, 115.73 (d, *J* = 21.2 Hz), 51.76, 47.28, 18.33.

HR-MS (ESI$^+$) m/z Calcd for $C_{23}H_{19}BrFN_2OS$ $[M+H]^+$ 469.0380; found 469.0380.

3z: 3-(benzo[d]thiazol-2-ylamino)-3-(2-fluorophenyl)-1-phenylpropan-1-one



This product was obtained as a colorless oil from a reaction catalyzed by **Q-5** (10 mol%) at -20 °C for 24 hrs; yield (14.7 mg, 78 %) by preparative flash column chromatography (Silica gel: Petroleum ether / Ethyl acetate = 5 / 1 *v/v*); 96.0 % *ee* as determined by HPLC [Daicel Chiralpak IC column, n-hexane / *i*-PrOH = 90 / 10, 1.0 ml·min^{-1}, λ = 270 nm, tr (major) = 21.25 min, tr (minor) = 15.01 min]; $[\alpha]_D^{20}$ = +5.9 (c = 1.2, CH_2Cl_2);

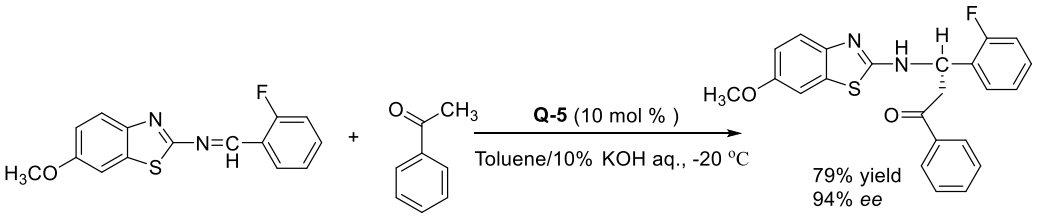
^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.92 – 7.86 (m, 2H), 7.60 – 7.50 (m, 4H), 7.47 – 7.40 (m, 2H), 7.31 – 7.22 (m, 3H), 7.15 – 7.04 (m, 3H), 5.68 (t, *J* = 5.9 Hz, 1H), 3.82 (dd, *J* = 17.1, 6.3 Hz, 1H), 3.60 (dd, *J* = 17.1, 5.6 Hz, 1H).

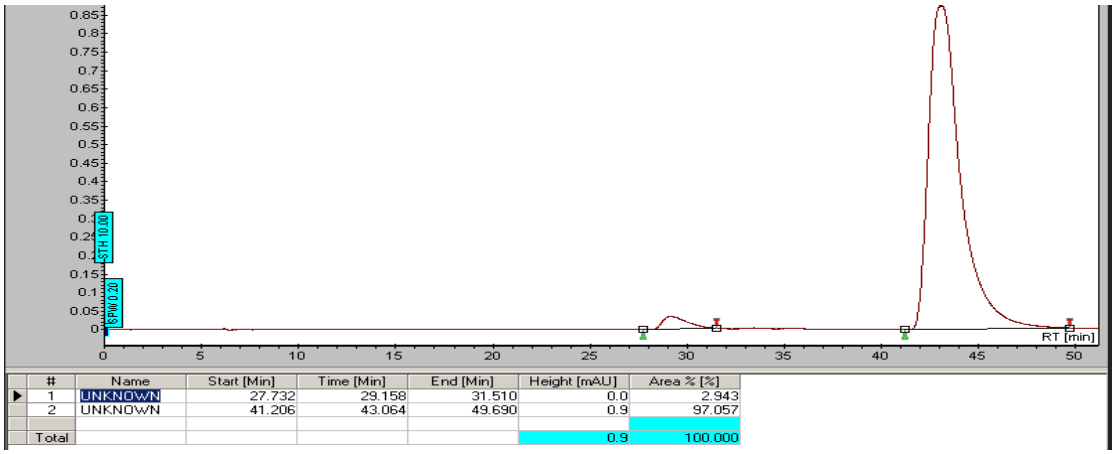
^{13}C NMR (125 MHz, $CDCl_3$) δ 197.53, 161.48, 151.98, 136.42, 133.57, 130.66, 129.48, 129.42, 128.90 (d, *J* = 3.7 Hz), 128.70, 128.15, 127.74, 127.63, 125.93, 124.45 (d, *J* = 3.7 Hz), 121.79, 120.86, 119.15, 115.84, 115.67, 51.45, 43.32.

HR-MS (ESI$^+$) m/z Calcd for $C_{22}H_{17}FN_2OSNa$ $[M+Na]^+$ 399.0938; found 399.0941.

5、Gram (1.0 g) scale reaction instance

To a solution of 1-(2-fluorophenyl)-N-(6-methoxybenzo[*d*]thiazol-2-yl)methanimine (1.0 g, 3.5 mmol) in Toluene (15.0 mL) was added chiral PTC **Q-5** (0.2 g, 10 mol%) and 10% KOH aq. solution (1.5 equiv.) sequentially, and the resulting mixture was stirred at -20 °C for 10 mins. Then acetophenone (0.63 g, 5.25 mmol) was added into (a spot of 2-Fluorobenzaldehyde was added in order to suppress the decomposition of benzothiazole imine under alkaline ambient). The resulting mixture was vigorously stirred at -20 °C, after completion of the reaction (TLC monitoring), saturated aqueous $NaHCO_3$ (30.0 ml) was added for quenching. The aqueous layer was extracted with dichloromethane (3×30.0 mL). The combined organic layers were washed with pure water, and then dried over with anhydrous Na_2SO_4. The organic solvent was evaporated under reduce pressure, and the resulting crude mixture was purified by flash column chromatography, (SiO_2, eluent: Petroleum ether and ethyl acetate system) to afforded the desired product 3a with 79% (1.12 g) yield and 94% *ee*.

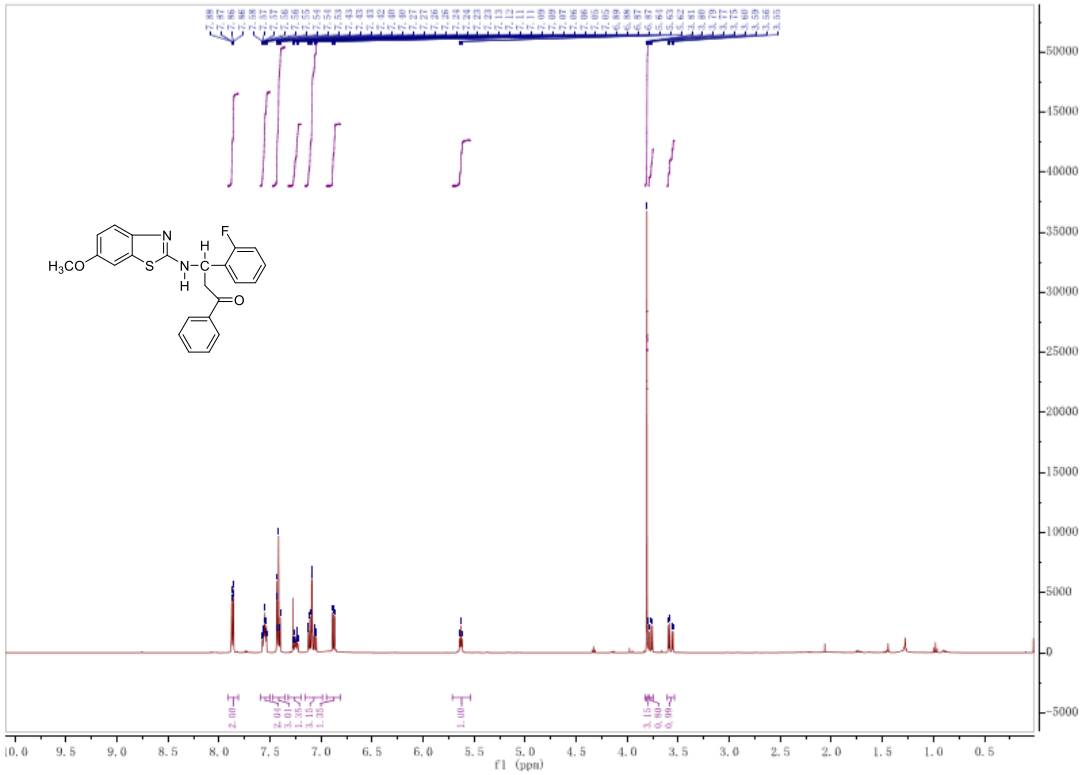


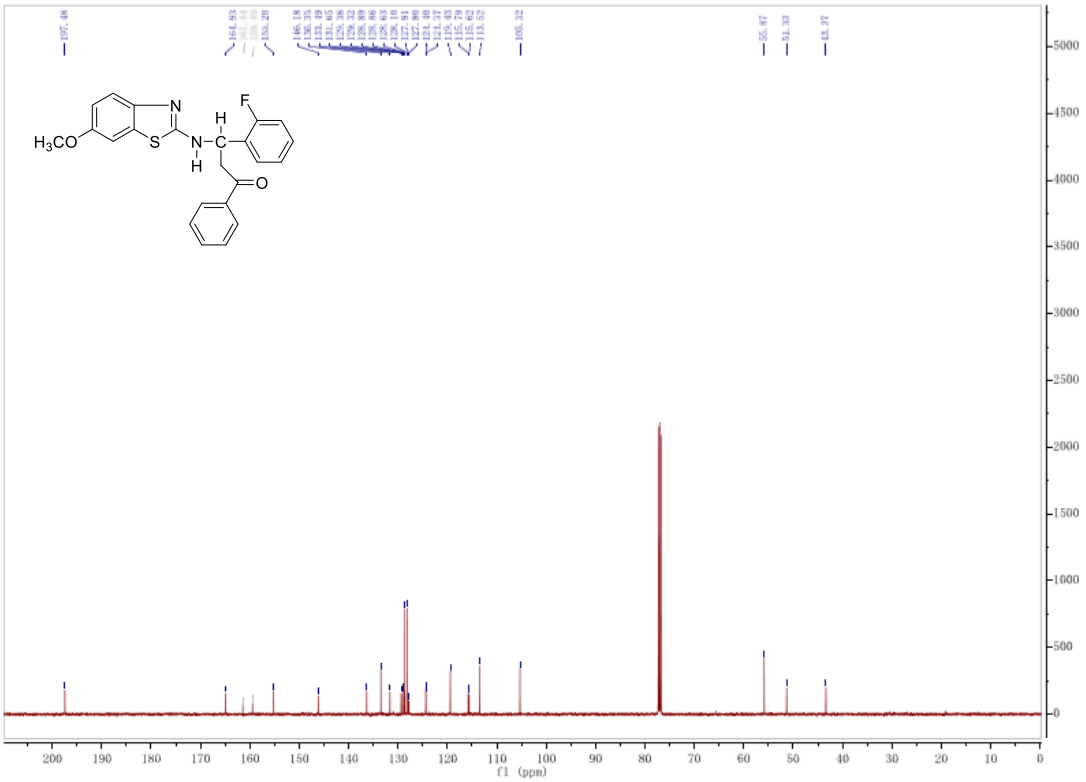


#	Name	Start [Min]	Time [Min]	End [Min]	Height [mAU]	Area % [%]
1	UNKNOWN	27.732	29.158	31.510	0.0	2.943
2	UNKNOWN	41.206	43.064	49.690	0.9	97.057
Total					0.9	100.000

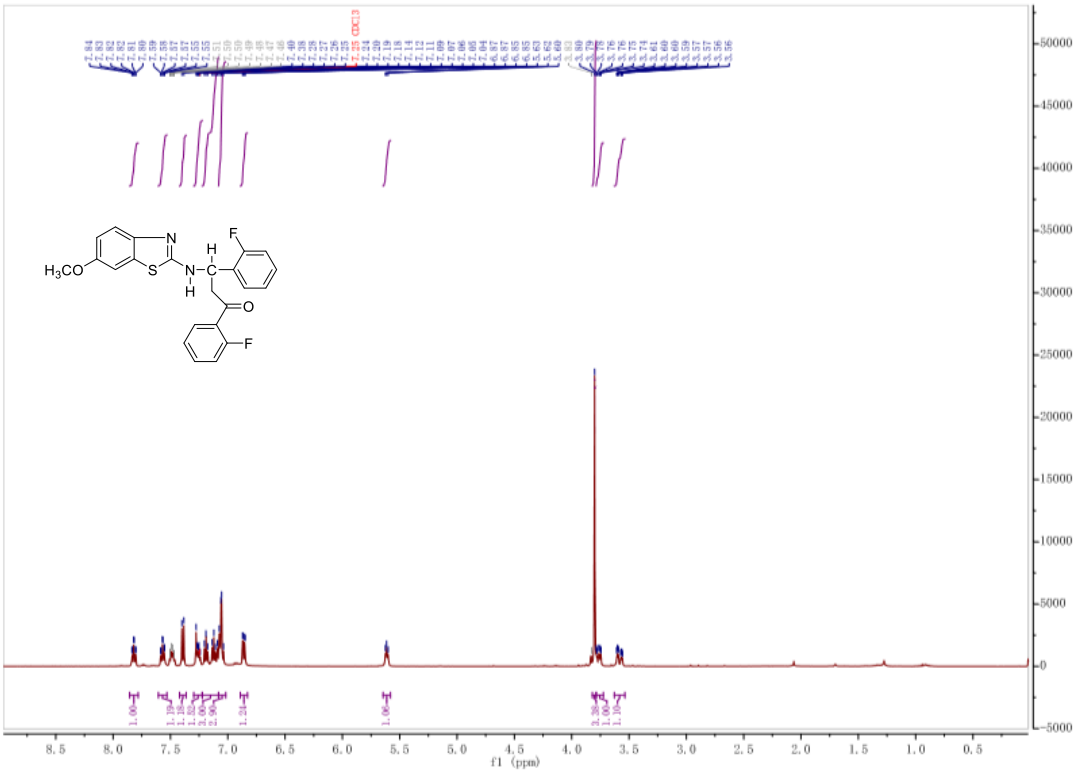
6、The NMR data of product 3a ~ 3z

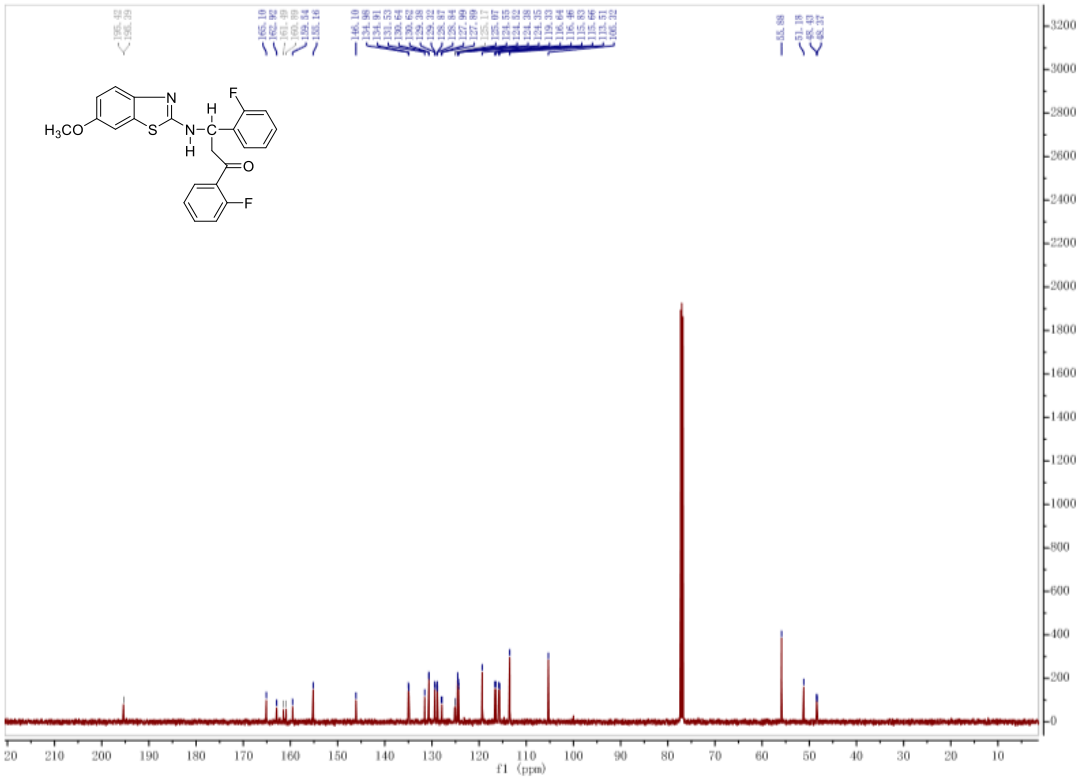
3a 3-(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-phenyl propan-1-one



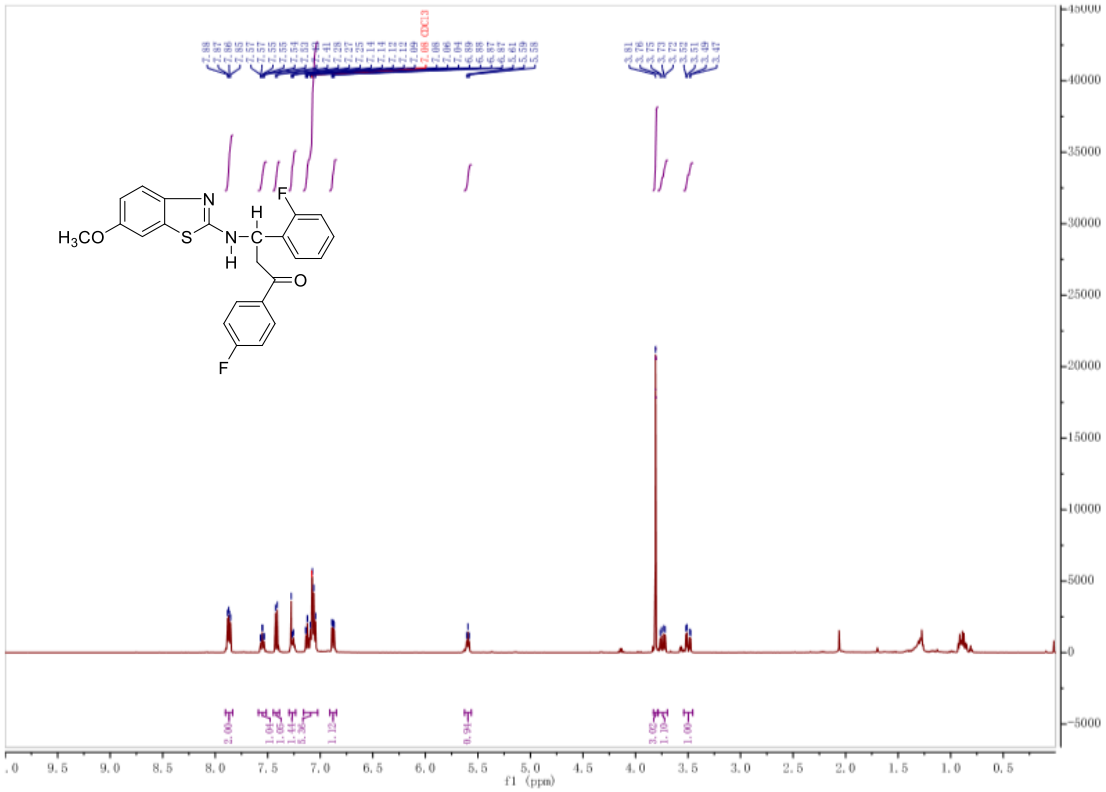


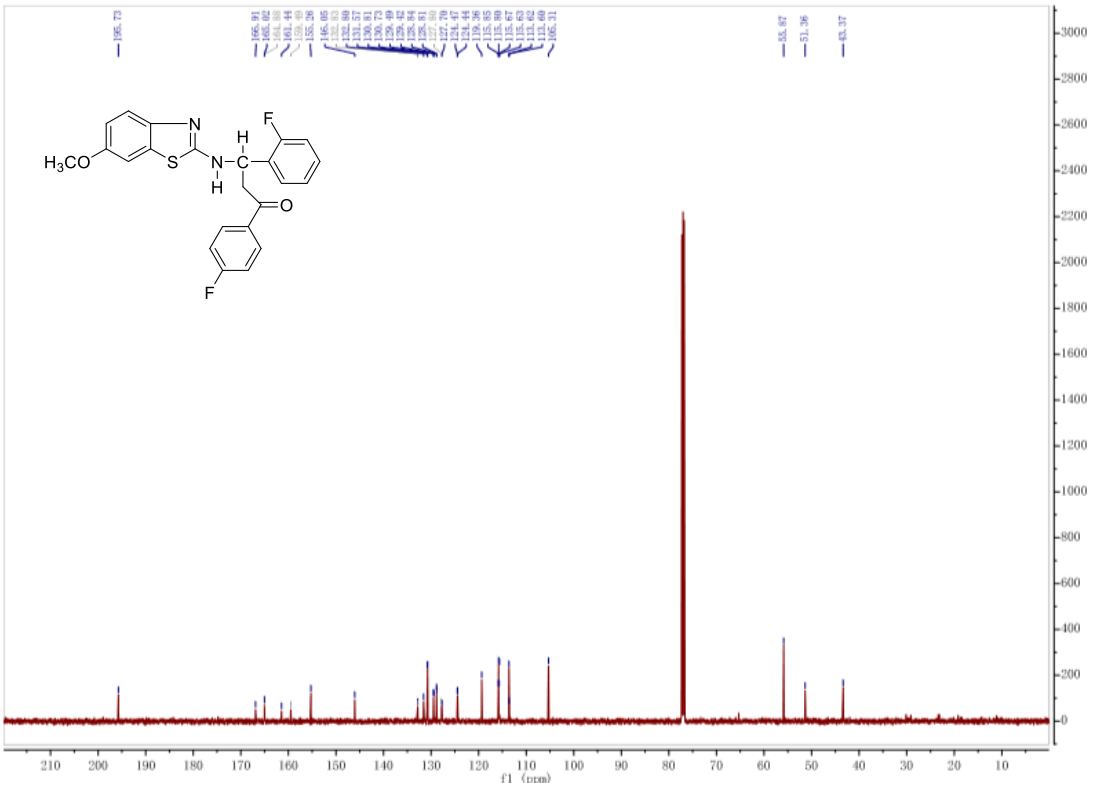
3b 1,3-bis(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)propan-1-one



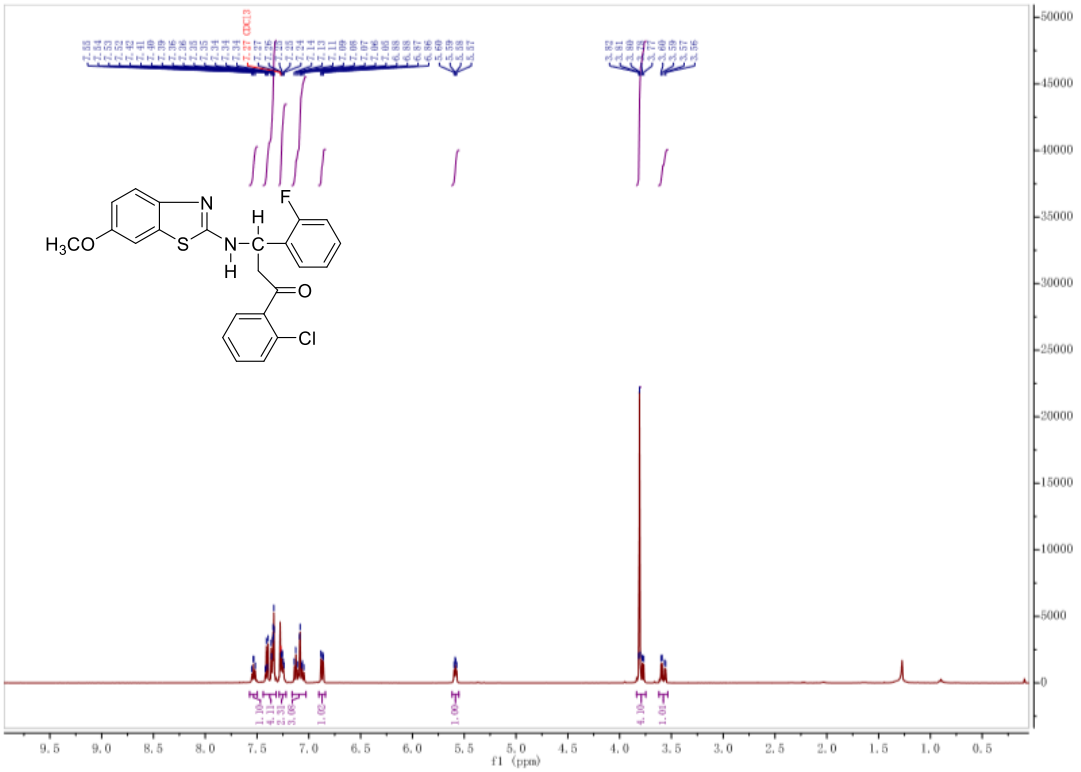


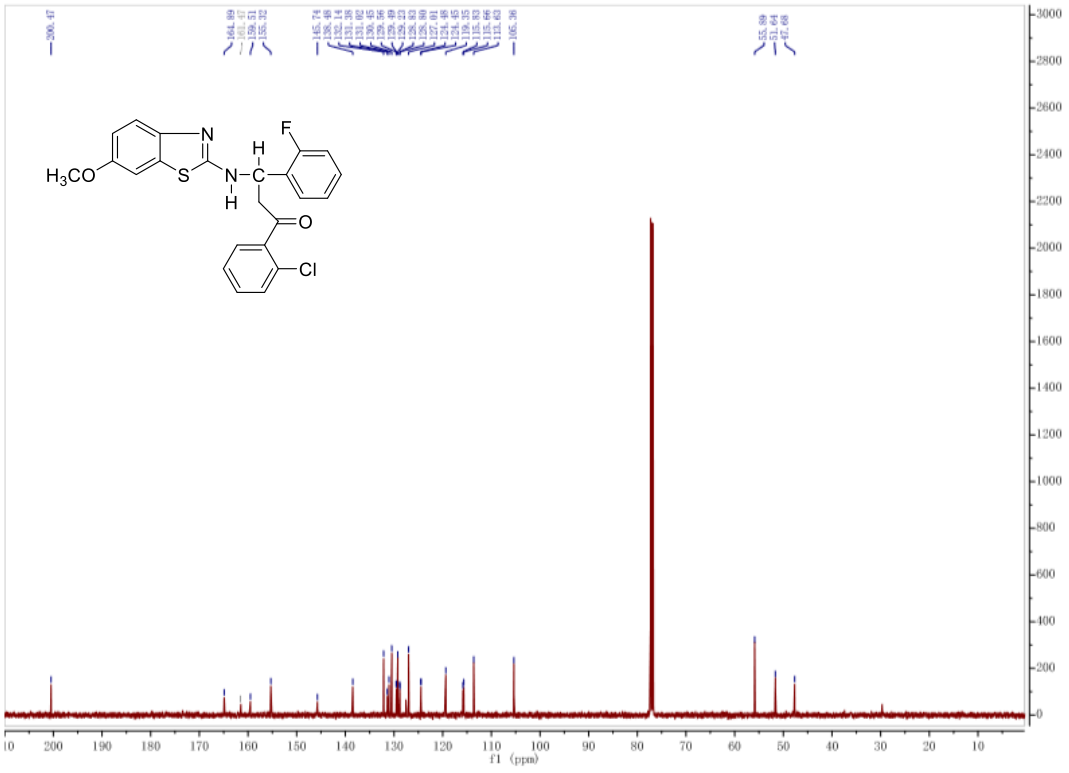
3c 3-(2-Fluorophenyl)-1-(4-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino) propan-1-one



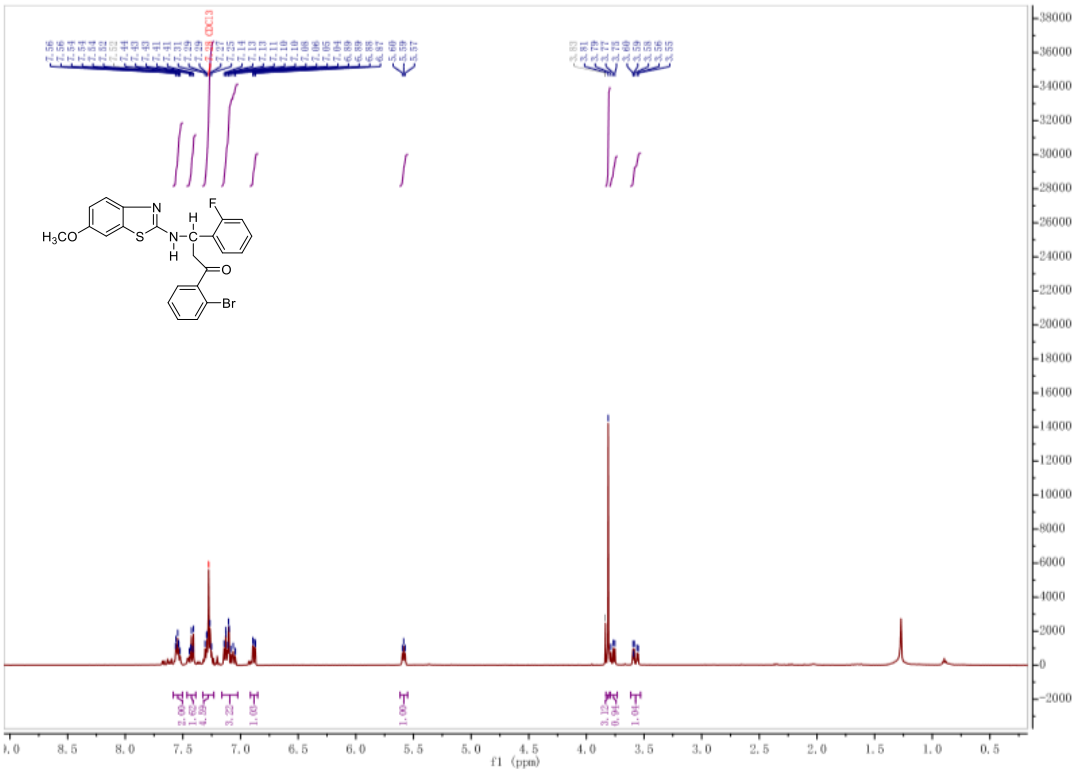


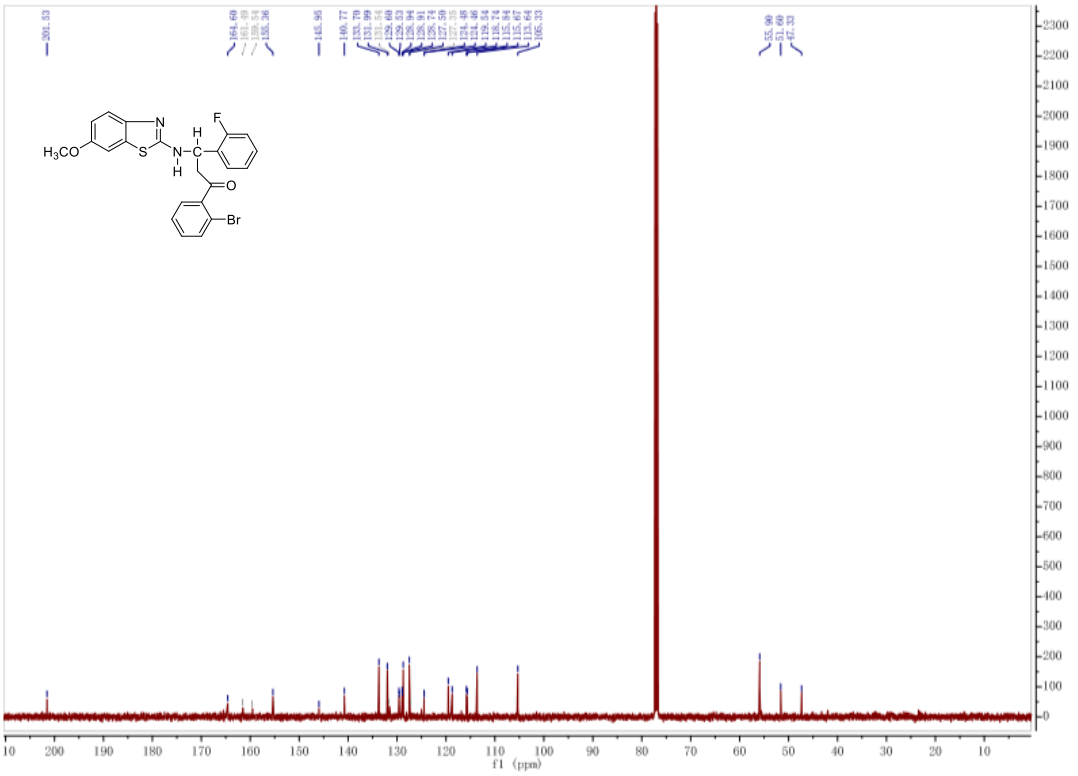
3d 1-(2-Chlorophenyl)-3-(2-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino)propan-1-one



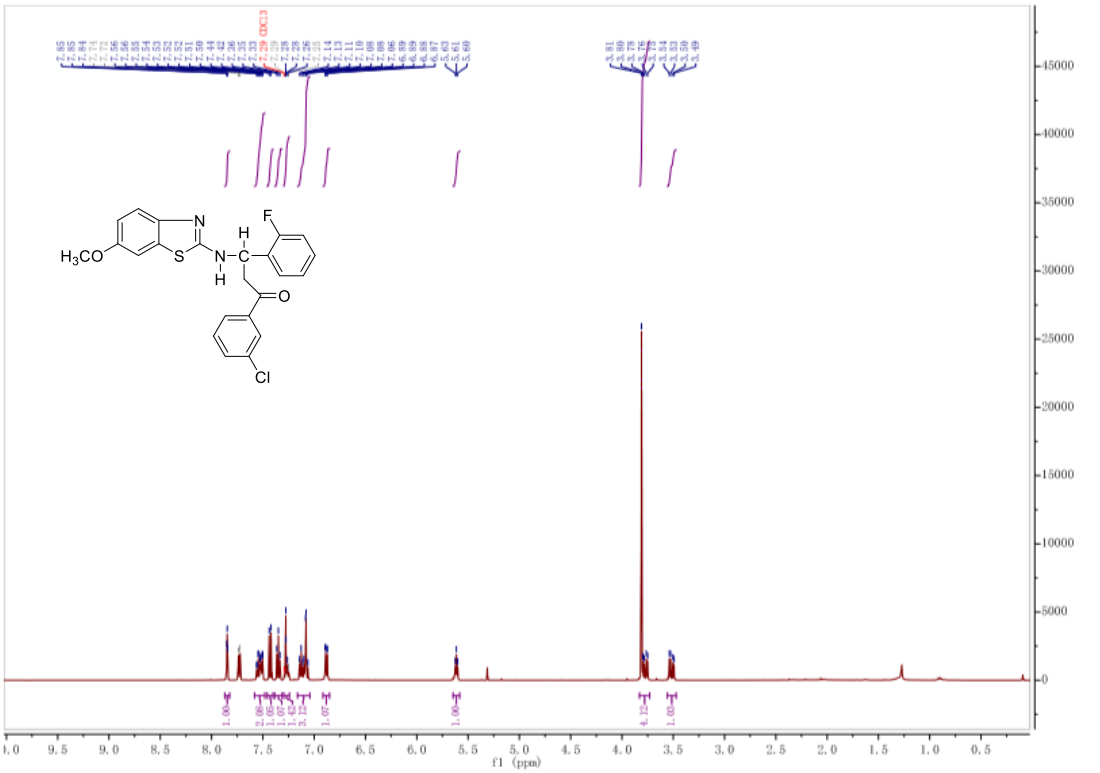


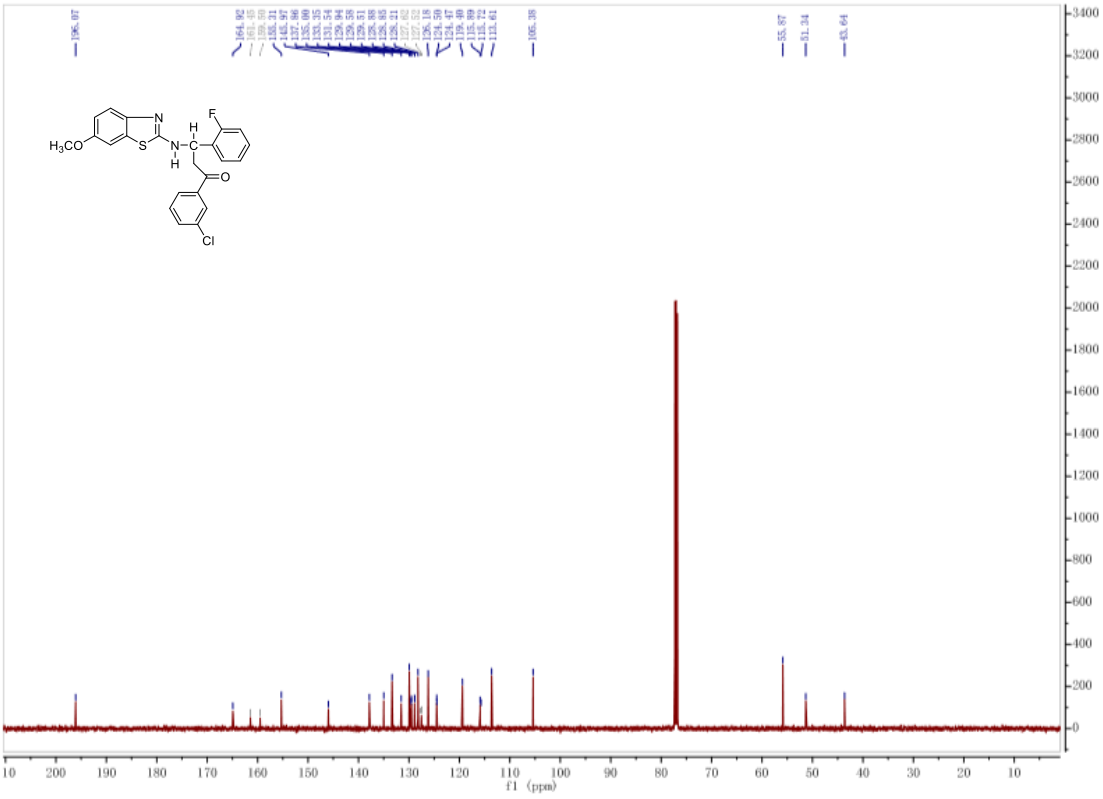
3e 1-(2-Bromophenyl)-3-(2-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino)propan-1-one



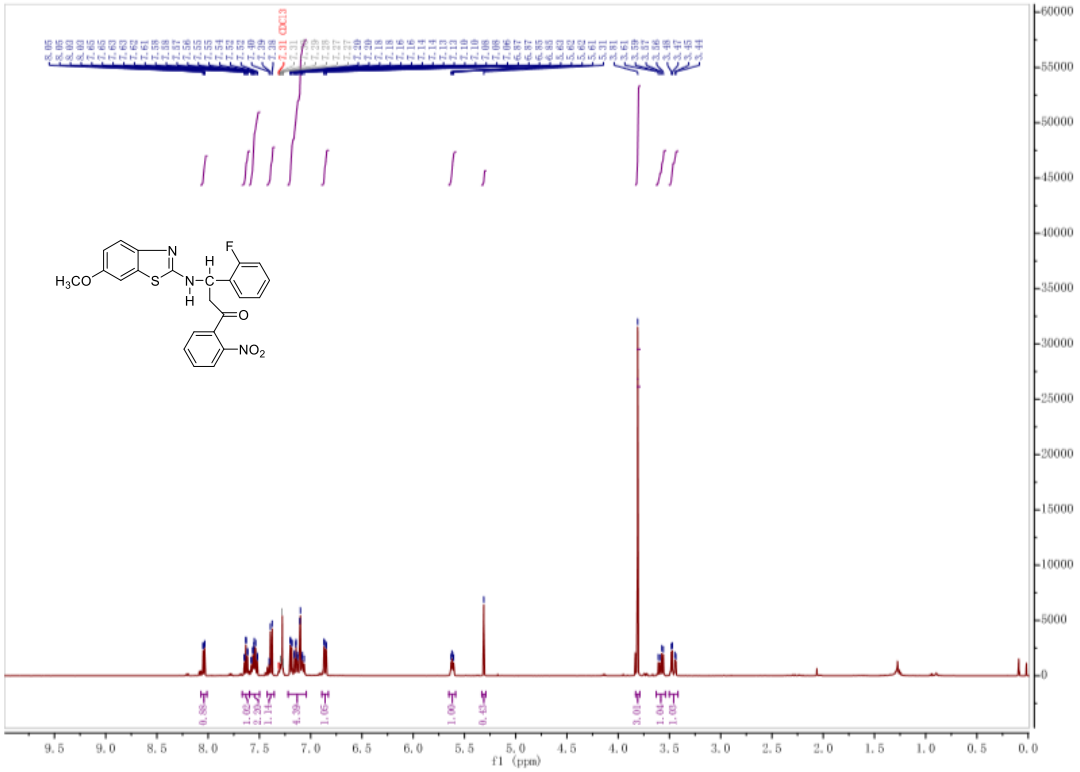


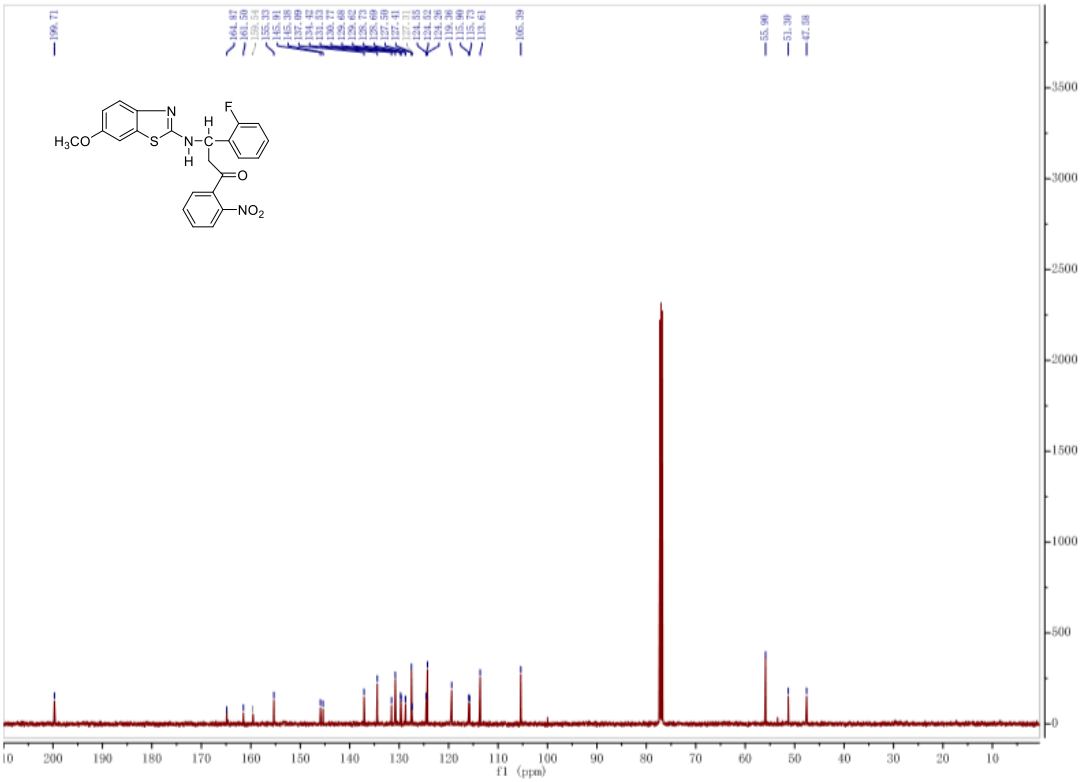
3f 1-(3-Chlorophenyl)-3-(2-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino) propan-1-one



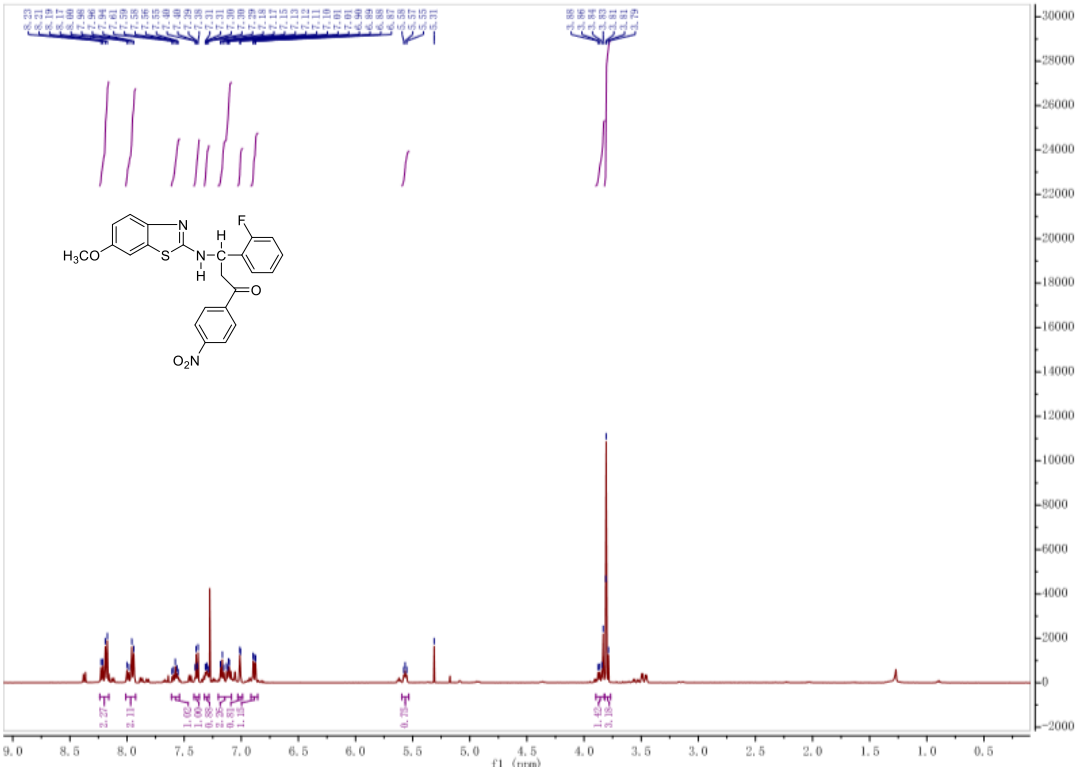


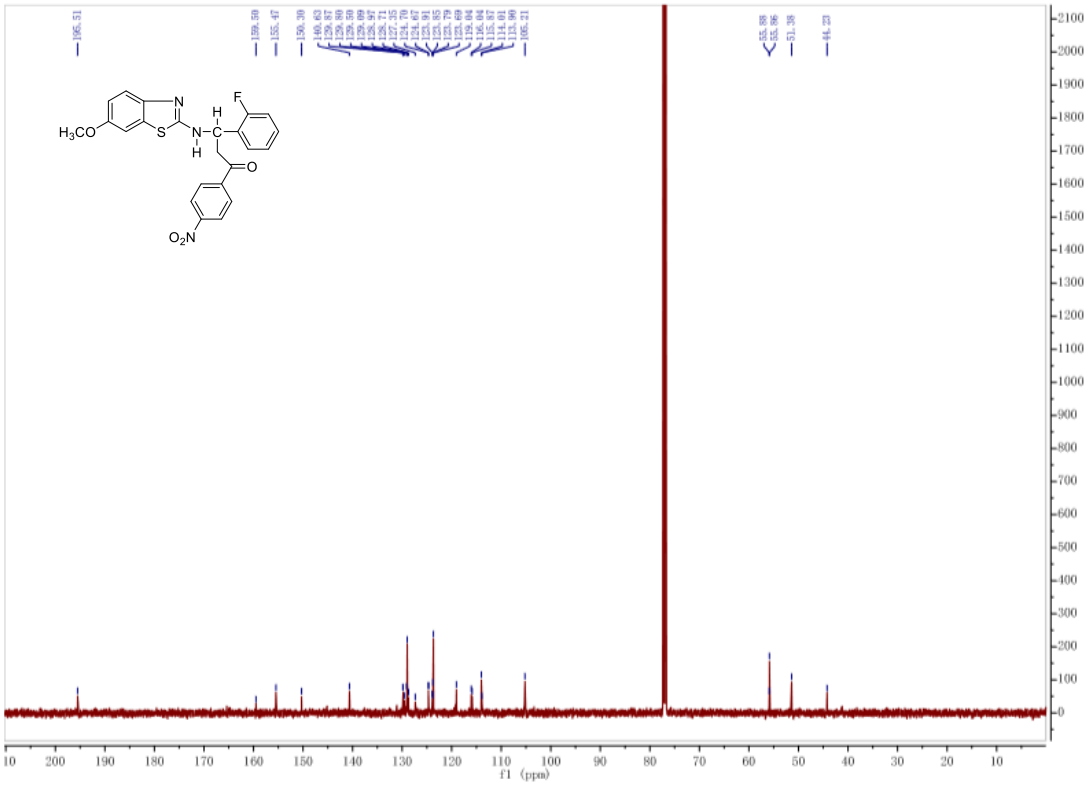
3g 3-(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-(2-nitro-phenyl)propan-1-one



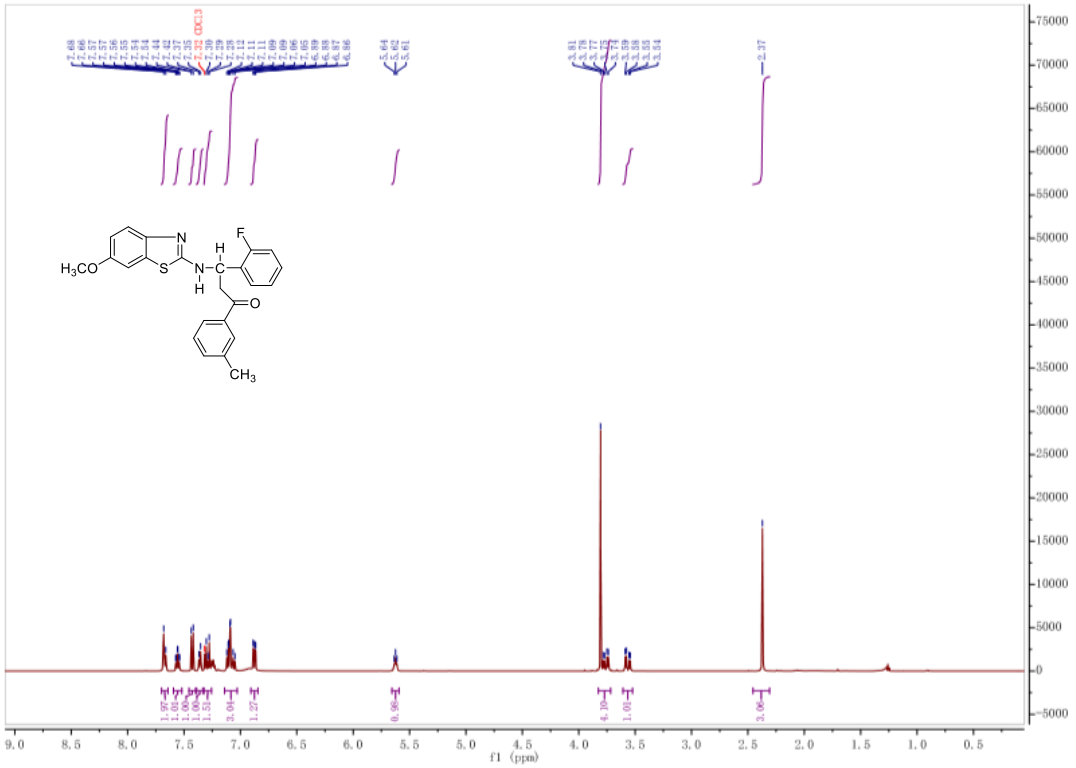


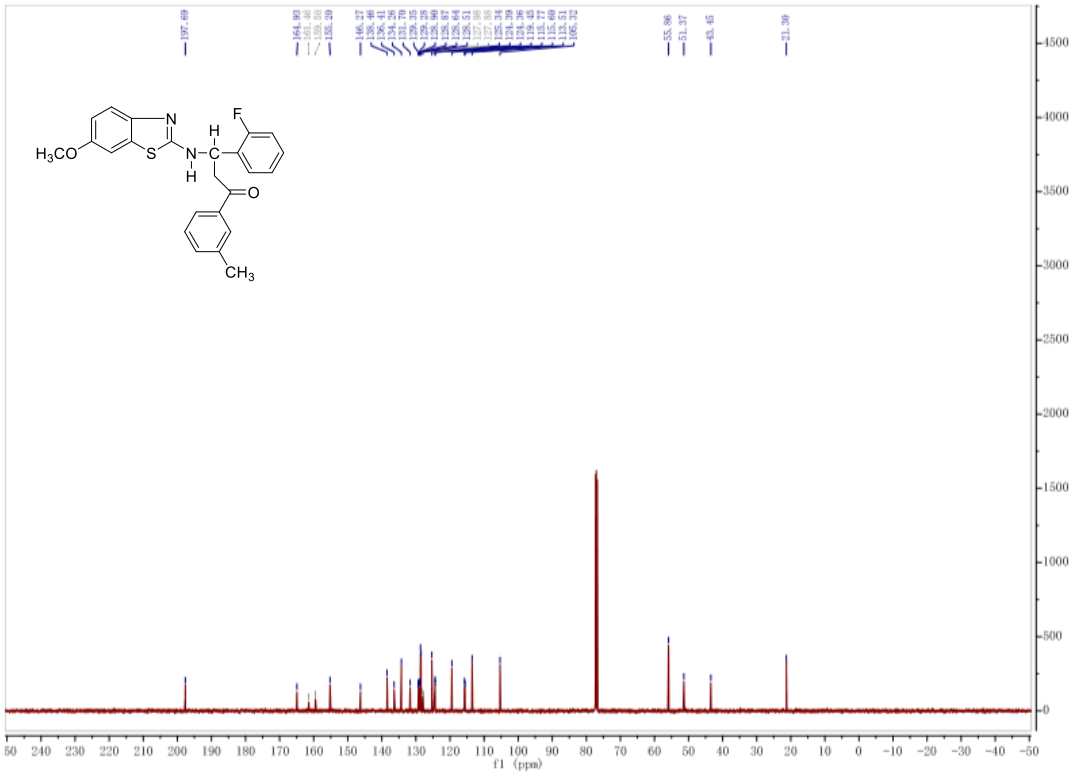
3h 3-(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-(4-nitro phenyl) propan-1-one



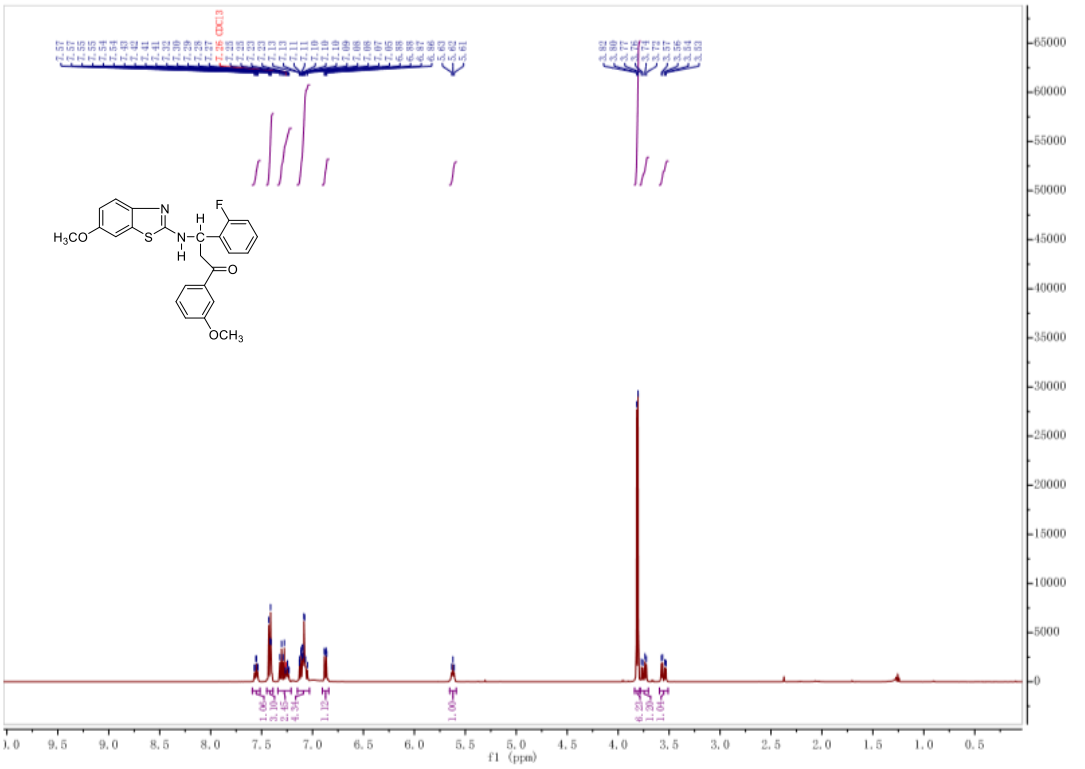


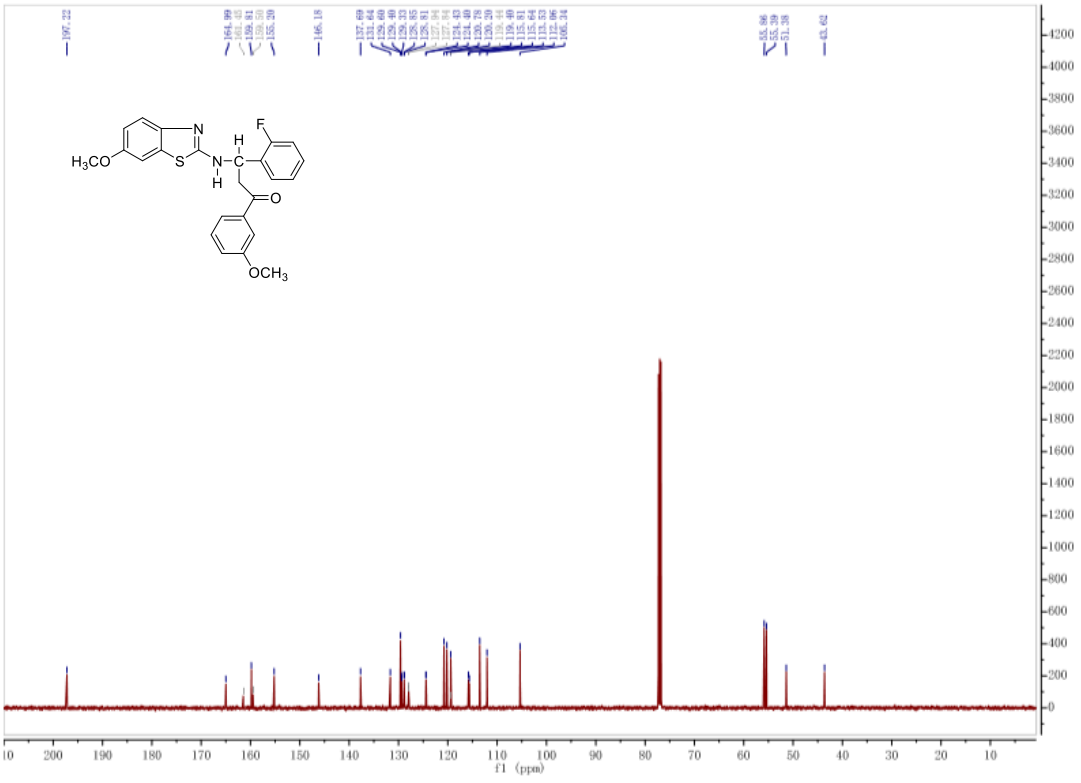
3i 3-(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-(m-tolyl) propan-1-one



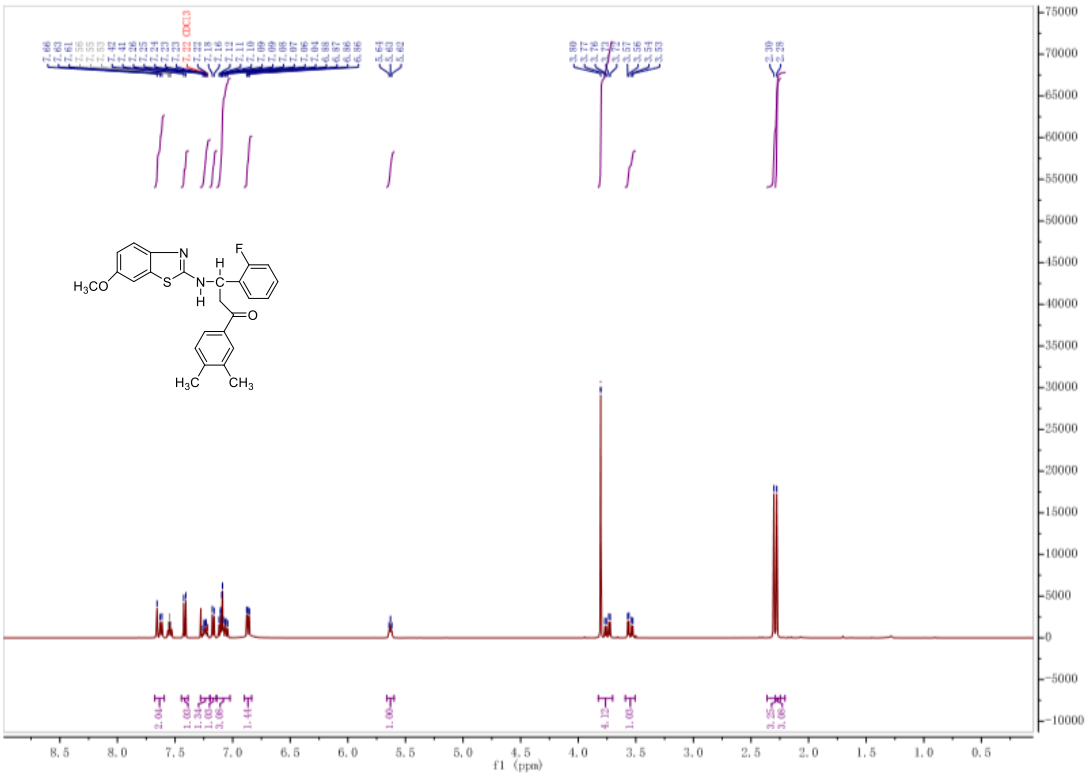


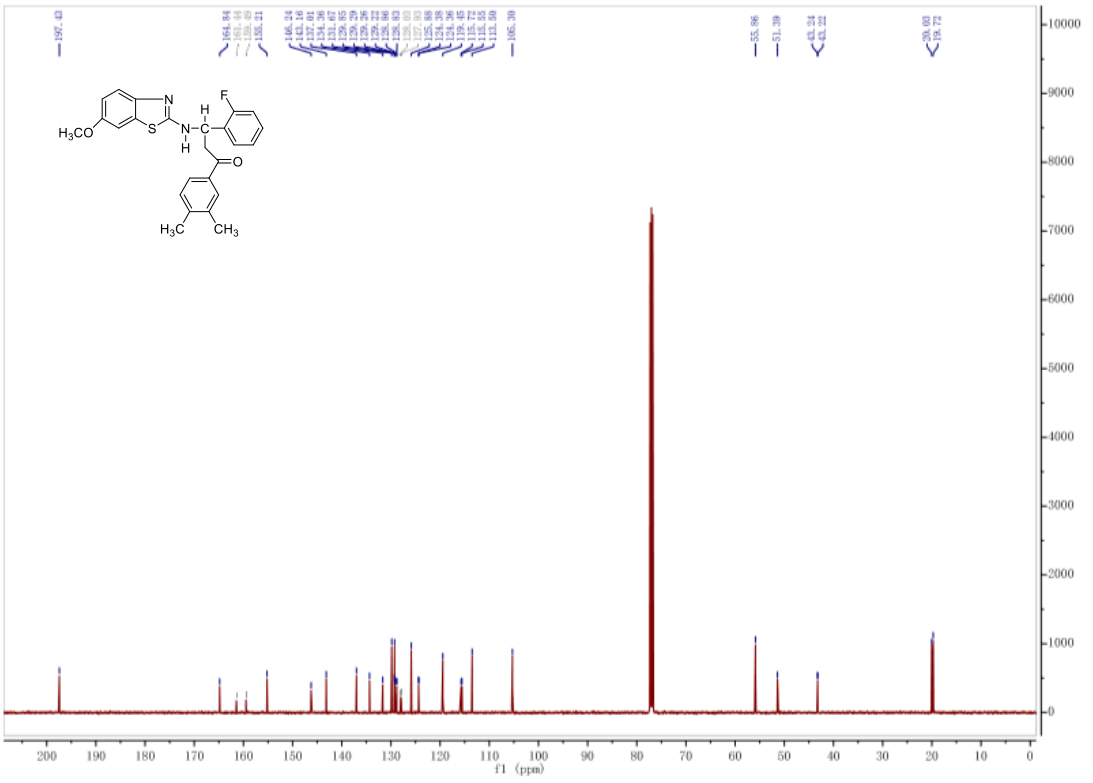
3j 3-(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino)-1-(3-methoxy phenyl) propan-1-one



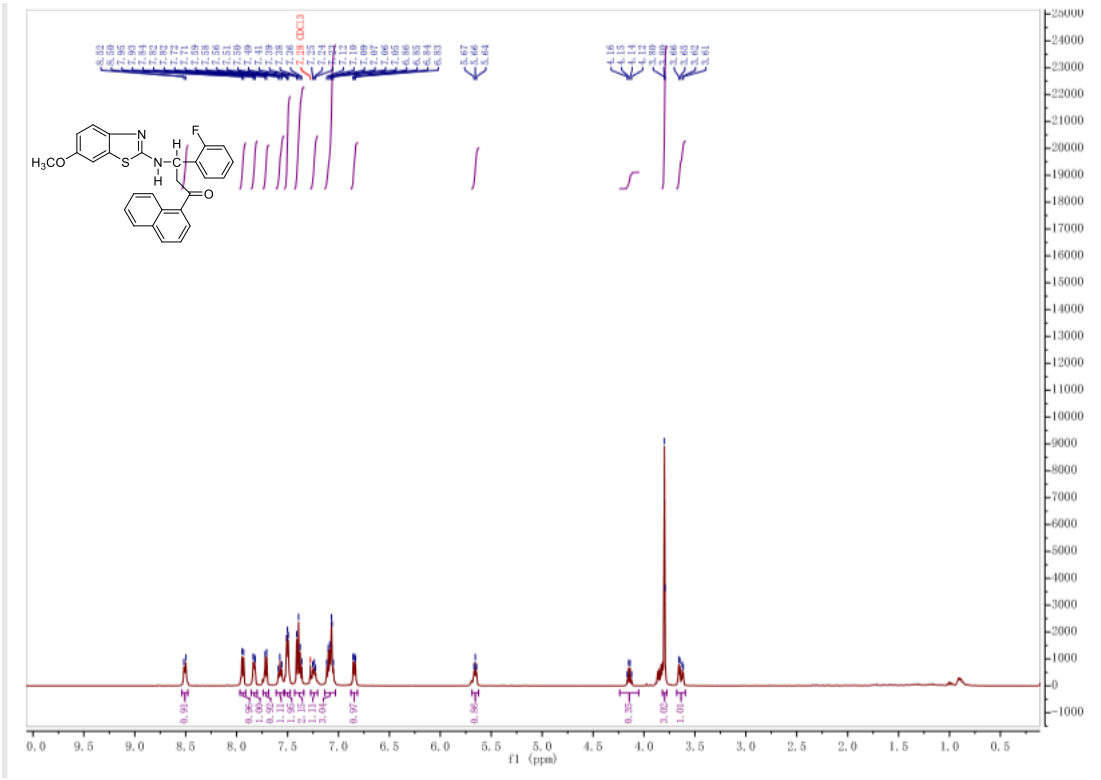


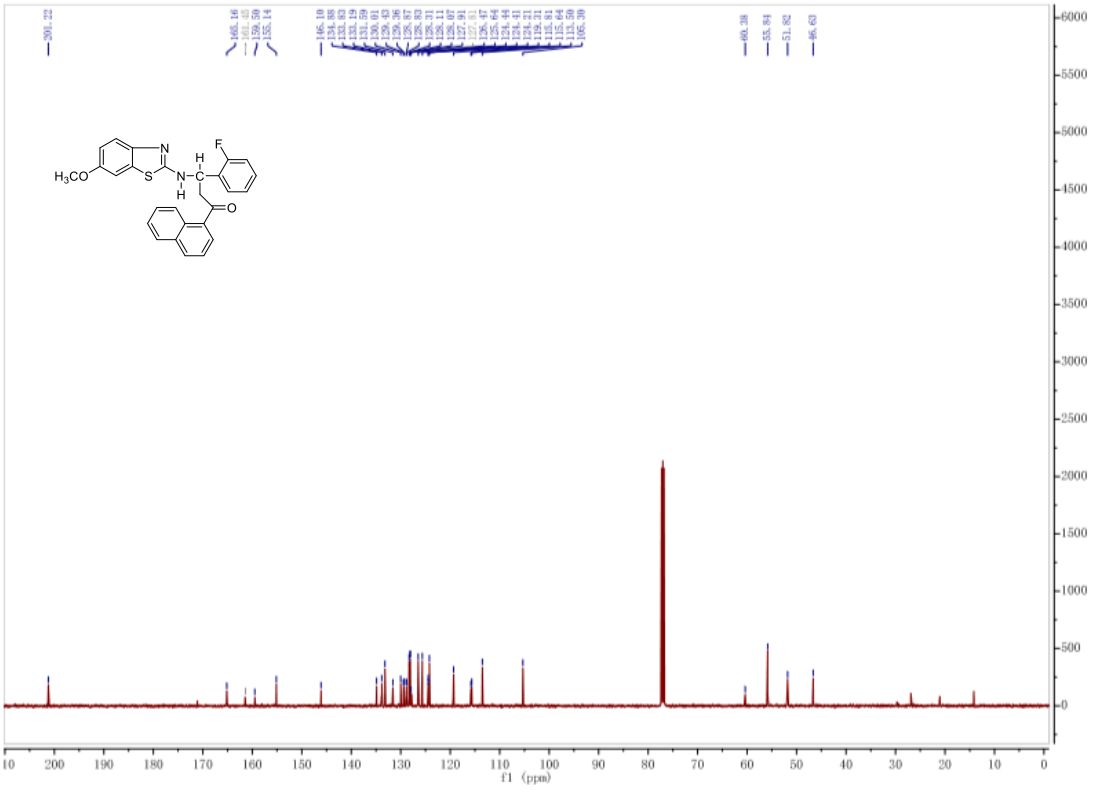
3k1-(3,4-Dimethylphenyl)-3-(2-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)propan-1-one



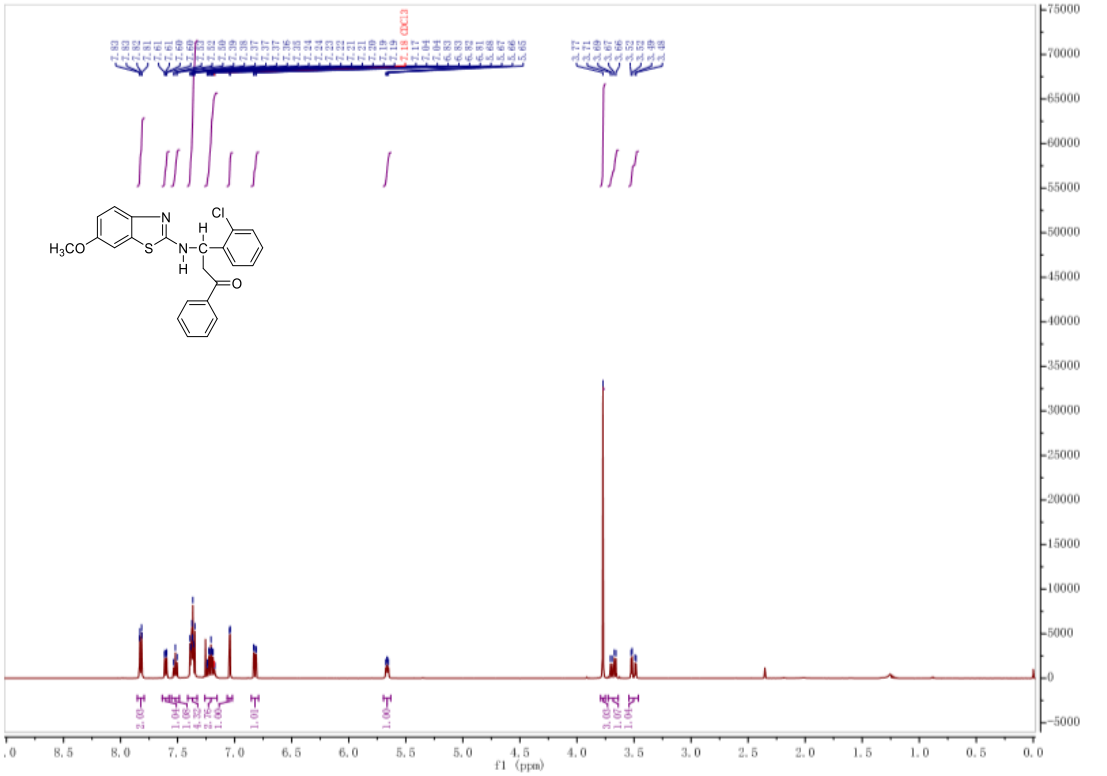


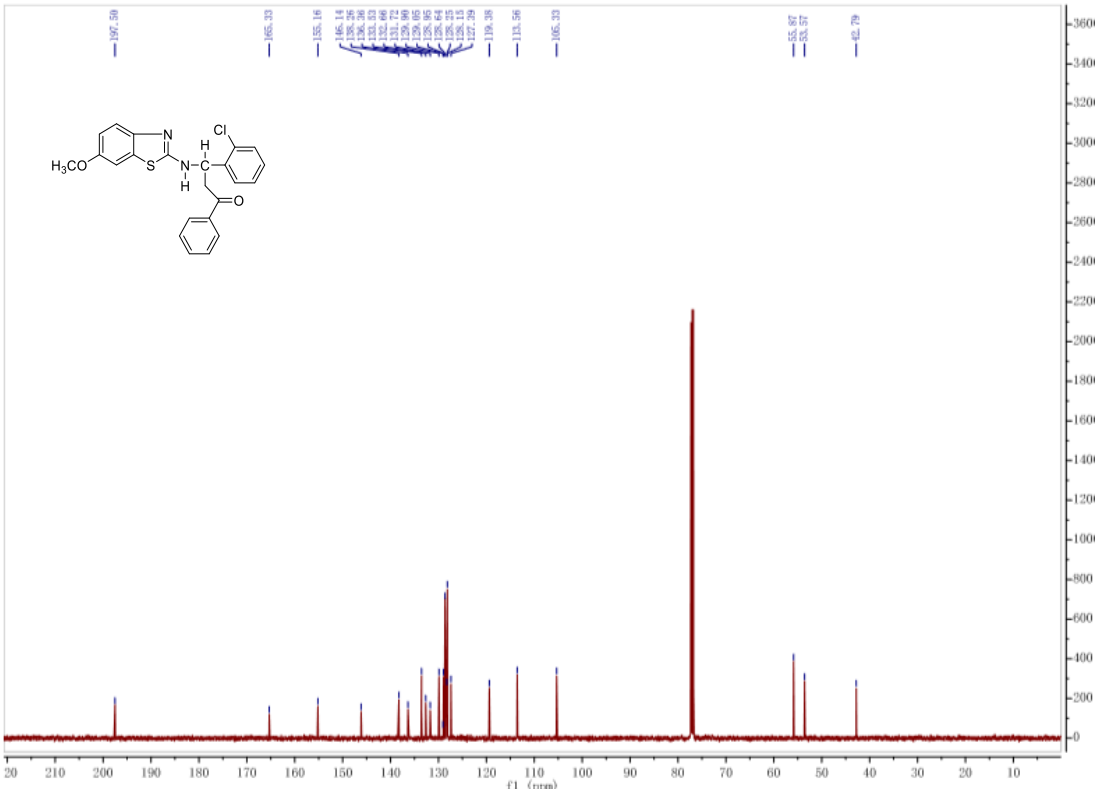
3l 3-(2-Fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-(naphthalen-1-yl)propan-1-one



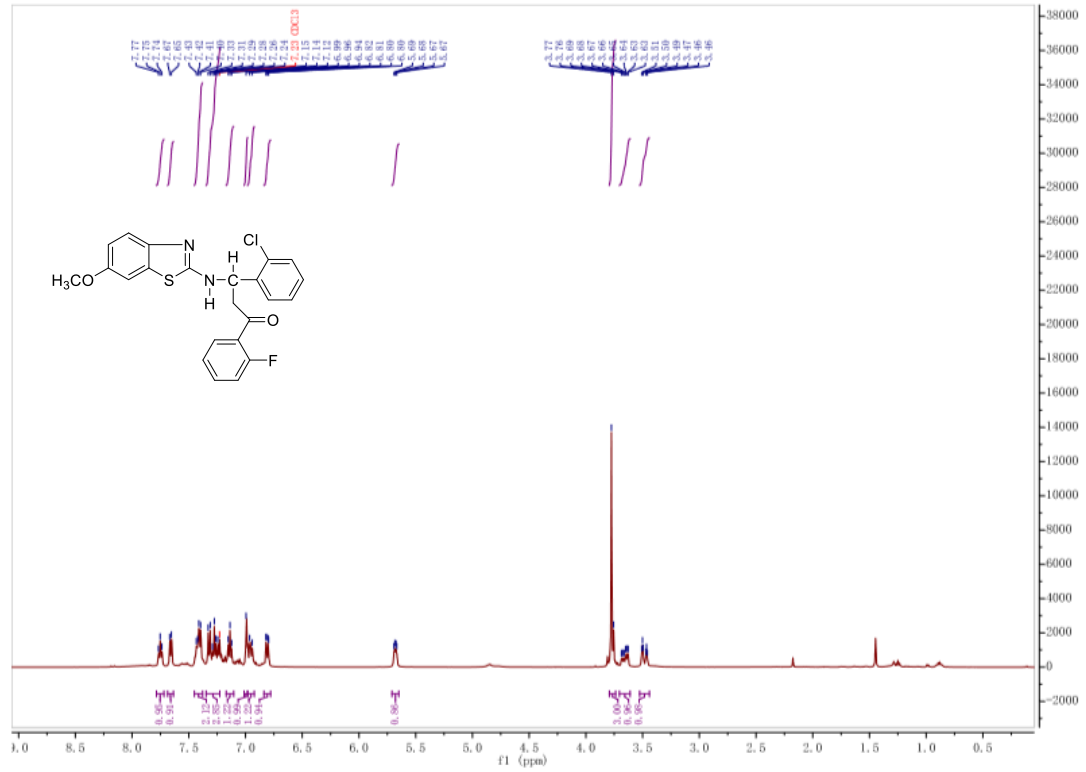


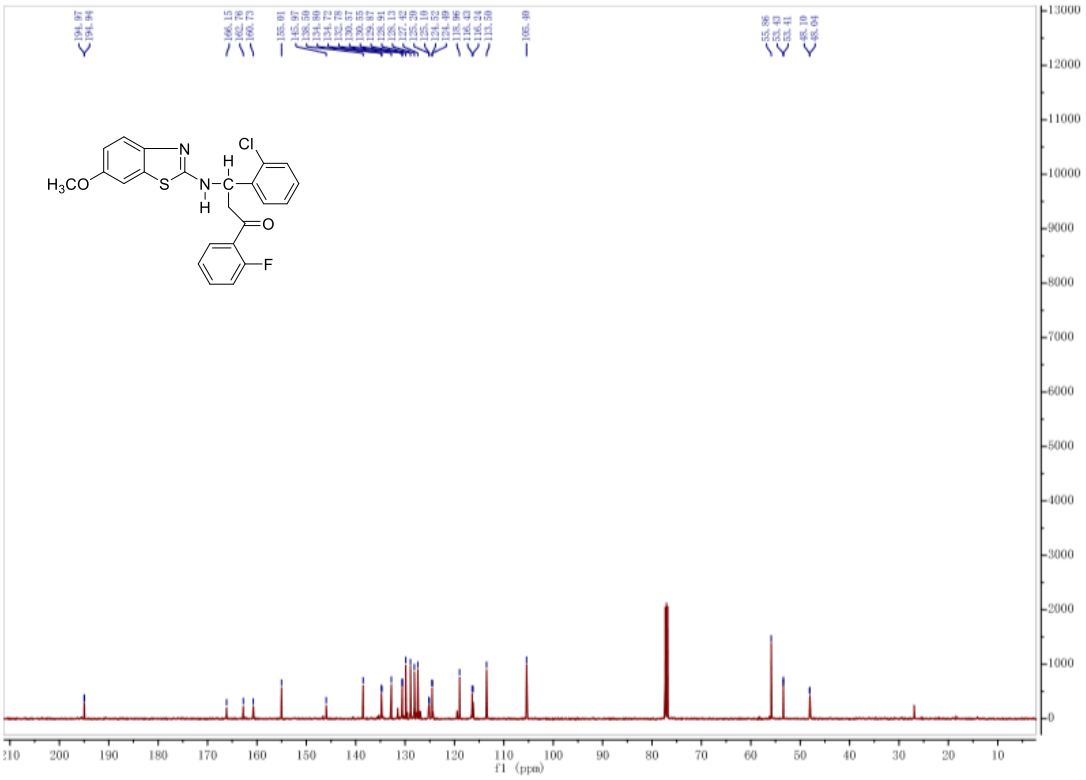
3m 3-(2-Chlorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-phenyl propan-1-one



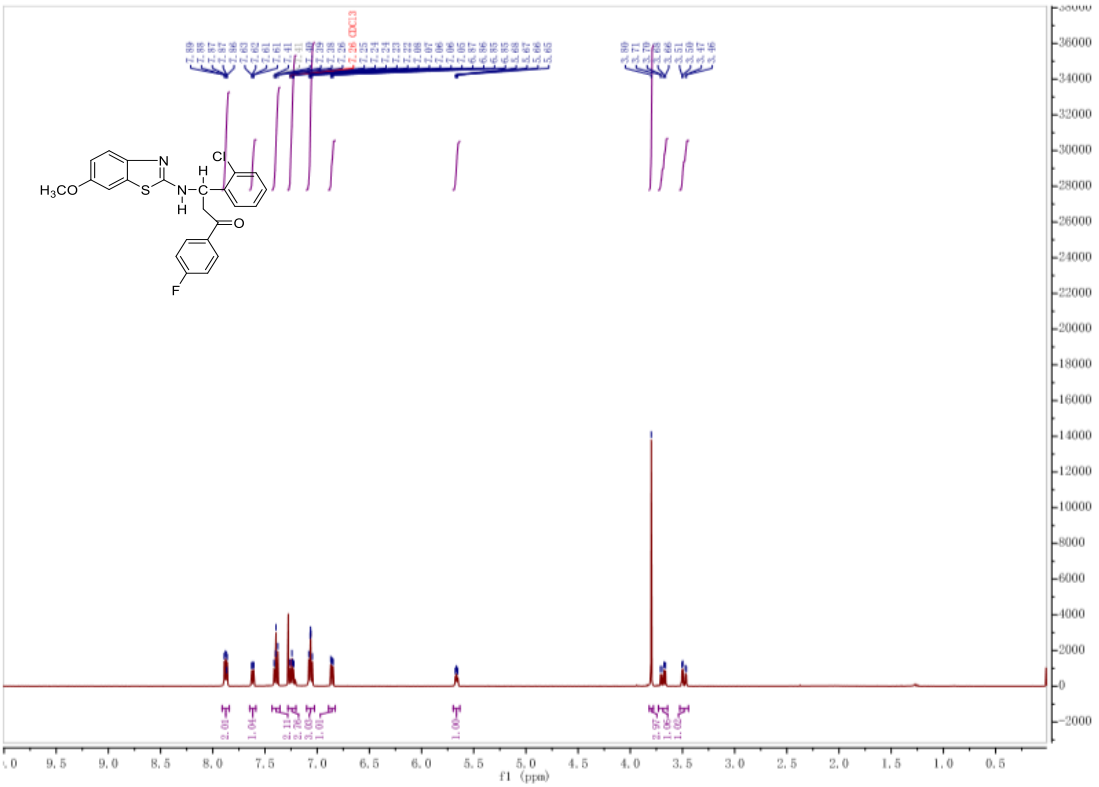


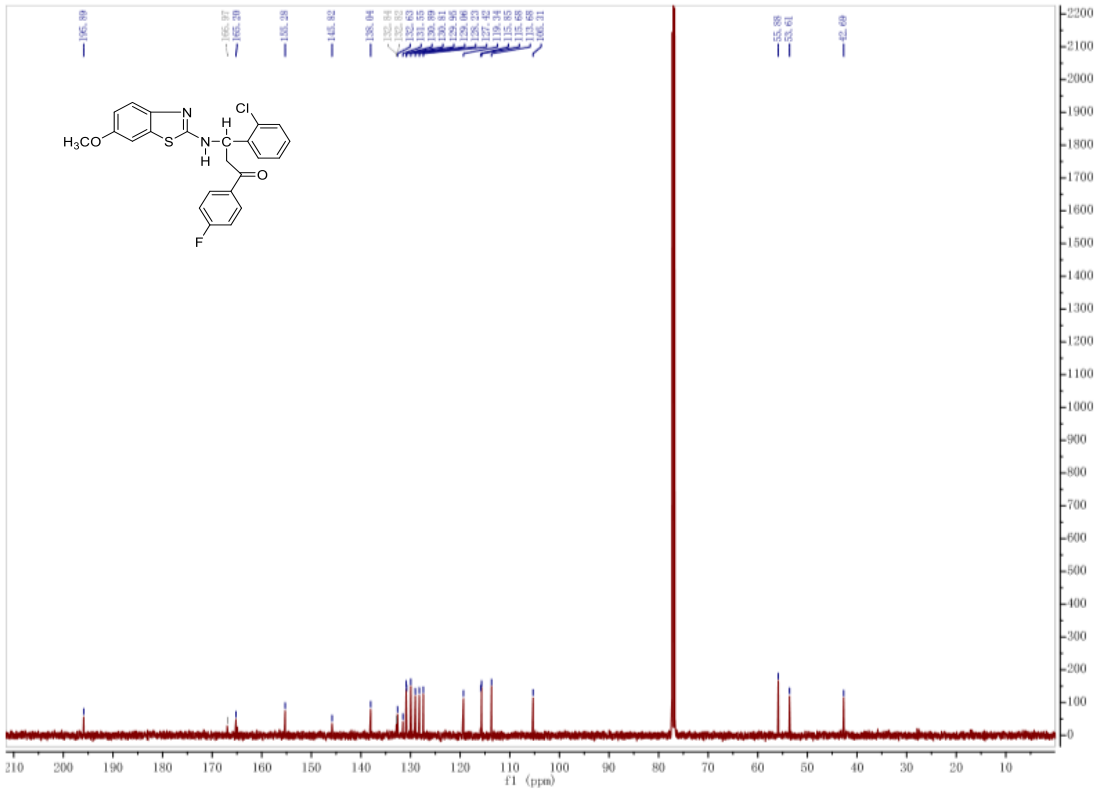
3n 3-(2-Chlorophenyl)-1-(2-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino) propan-1-one



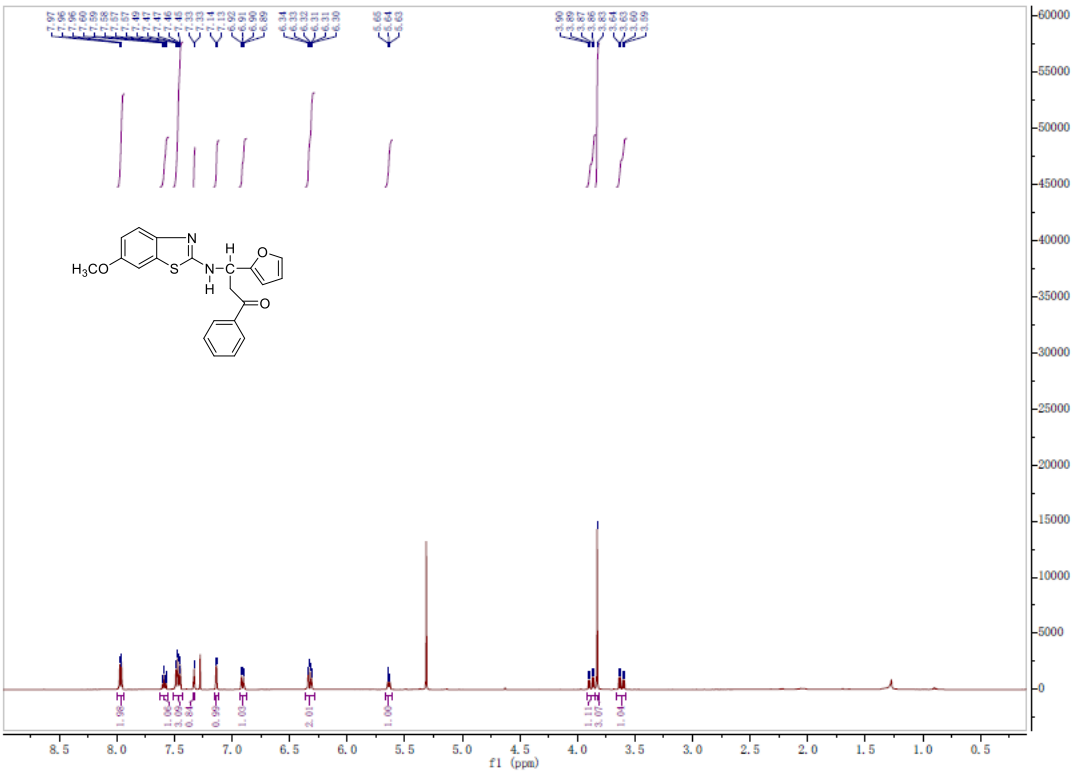


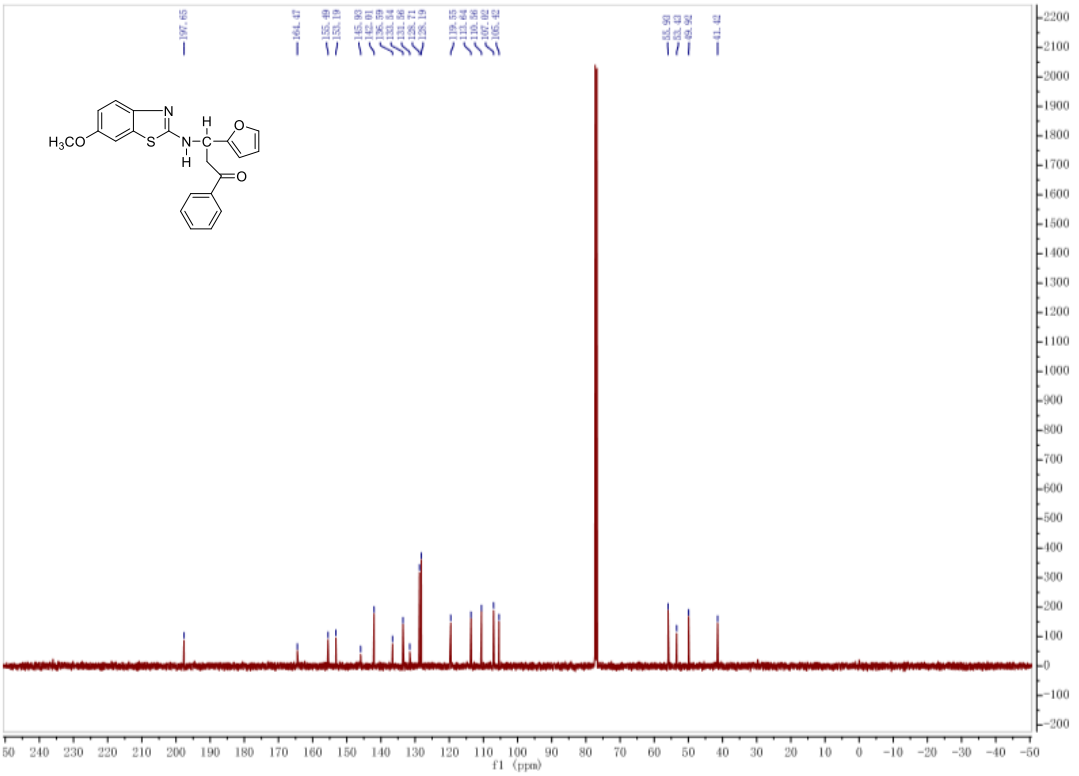
3o 3-(2-Chlorophenyl)-1-(4-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl) amino) propan-1-one



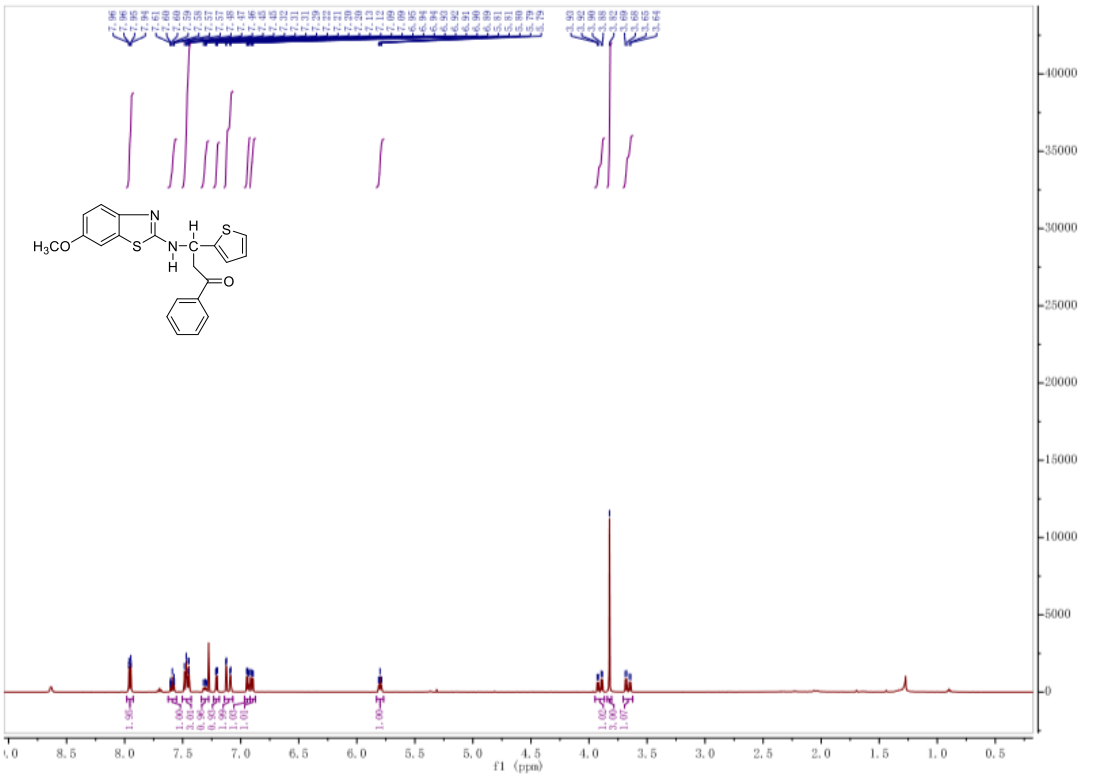


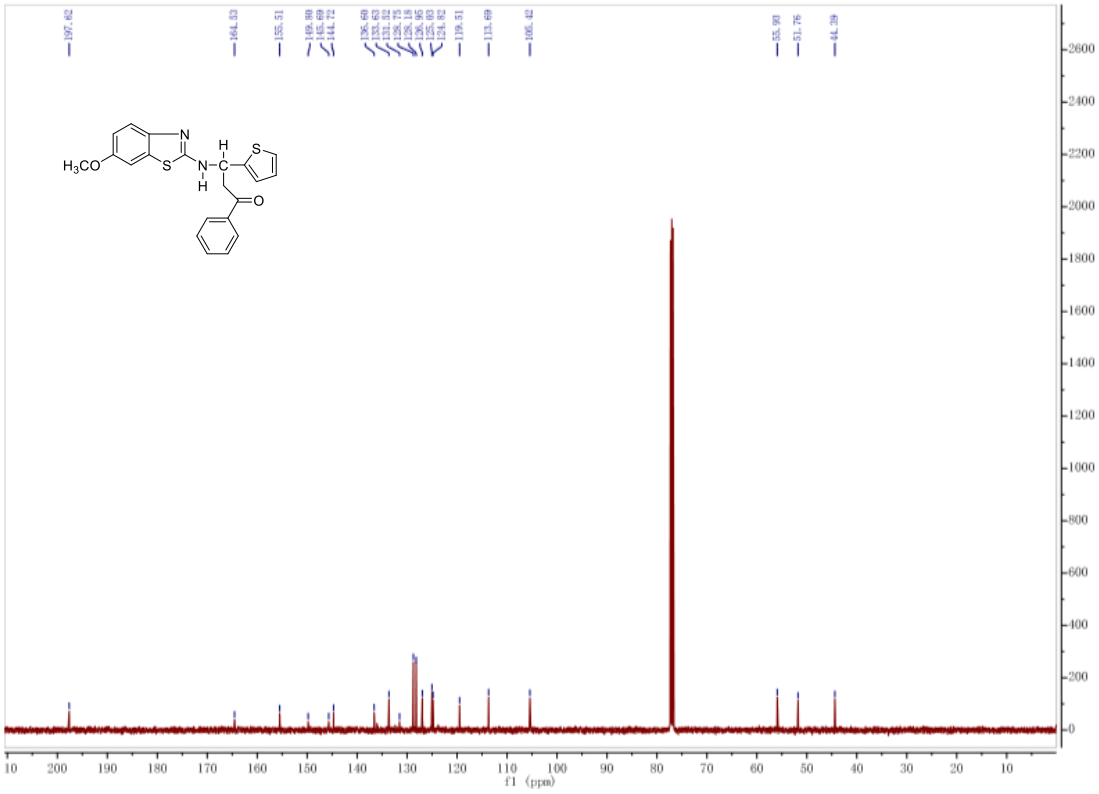
3p 3-(furan-2-yl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-phenylpropan-1-one



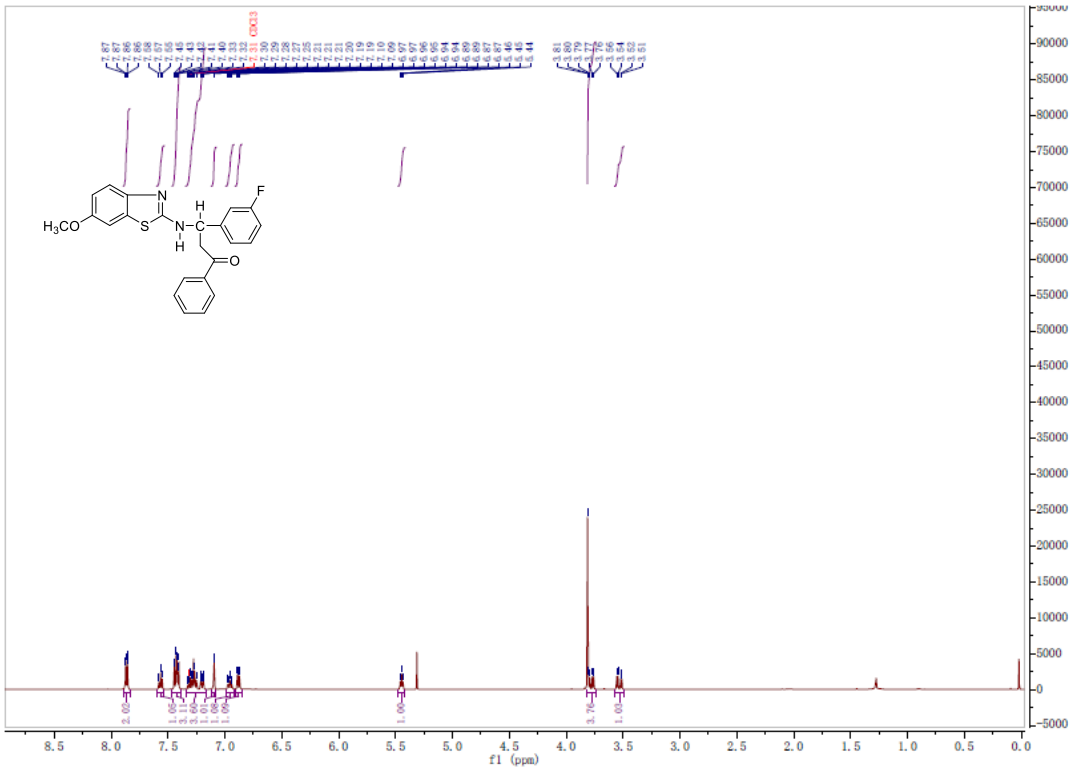


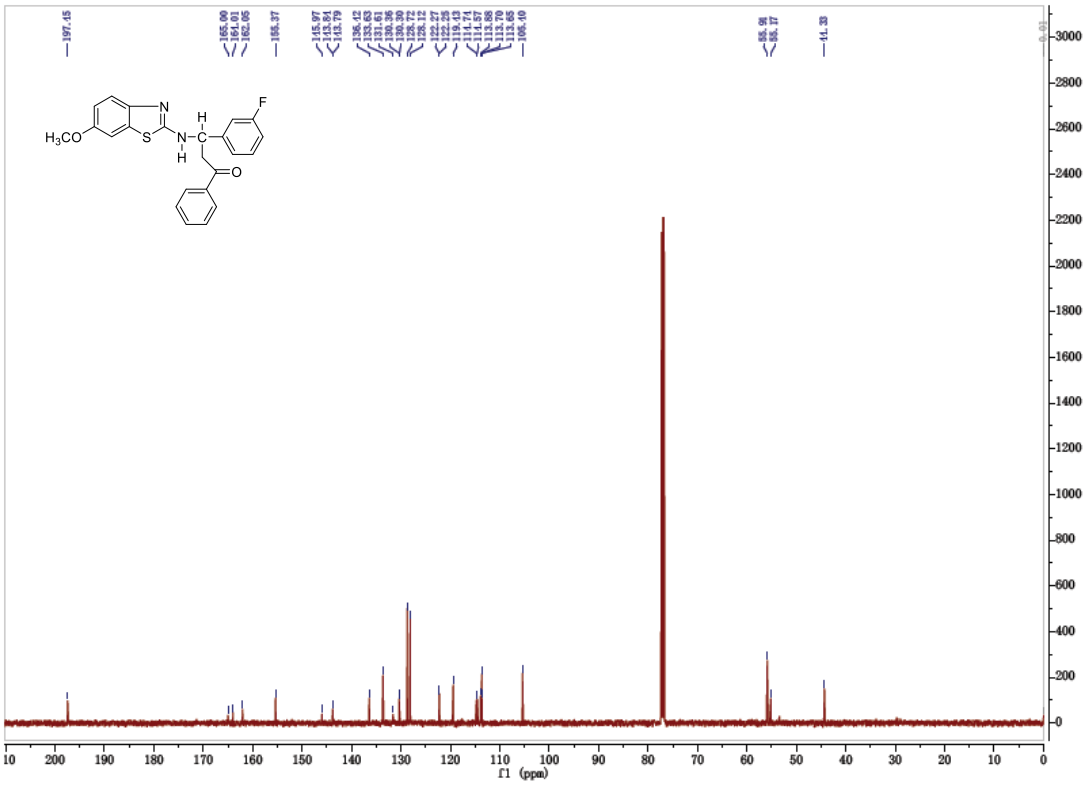
3q 3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-phenyl-3-(thiophen-2-yl)propan-1-one



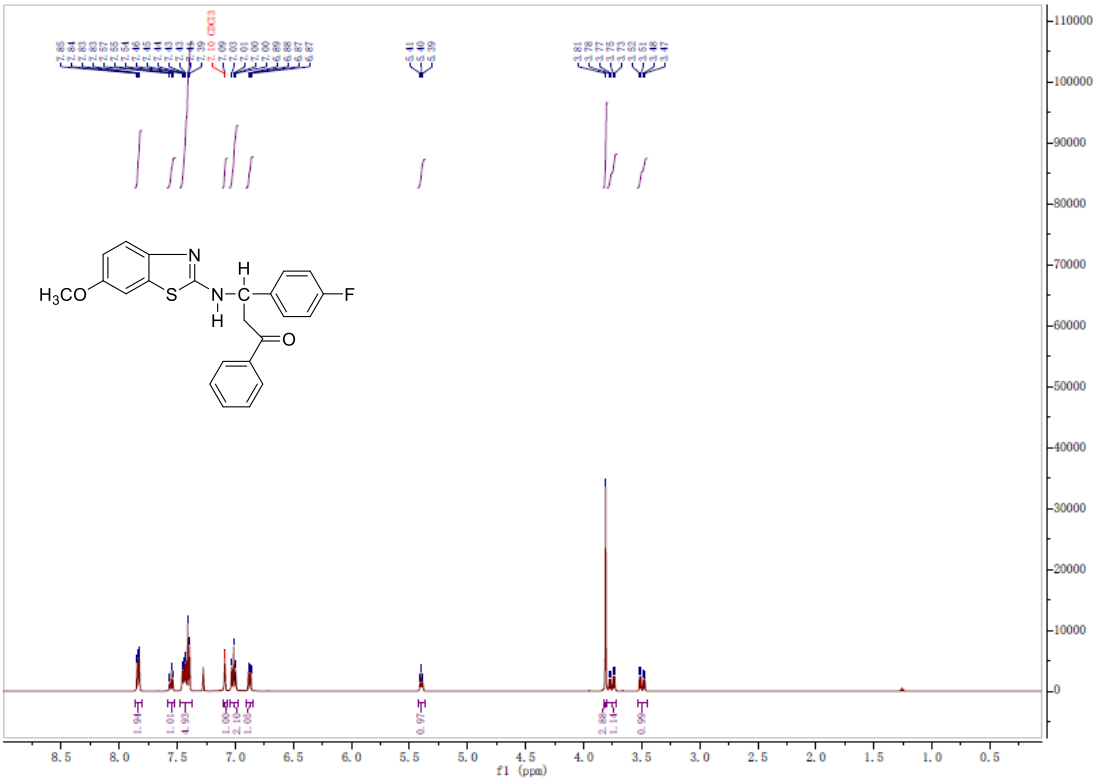


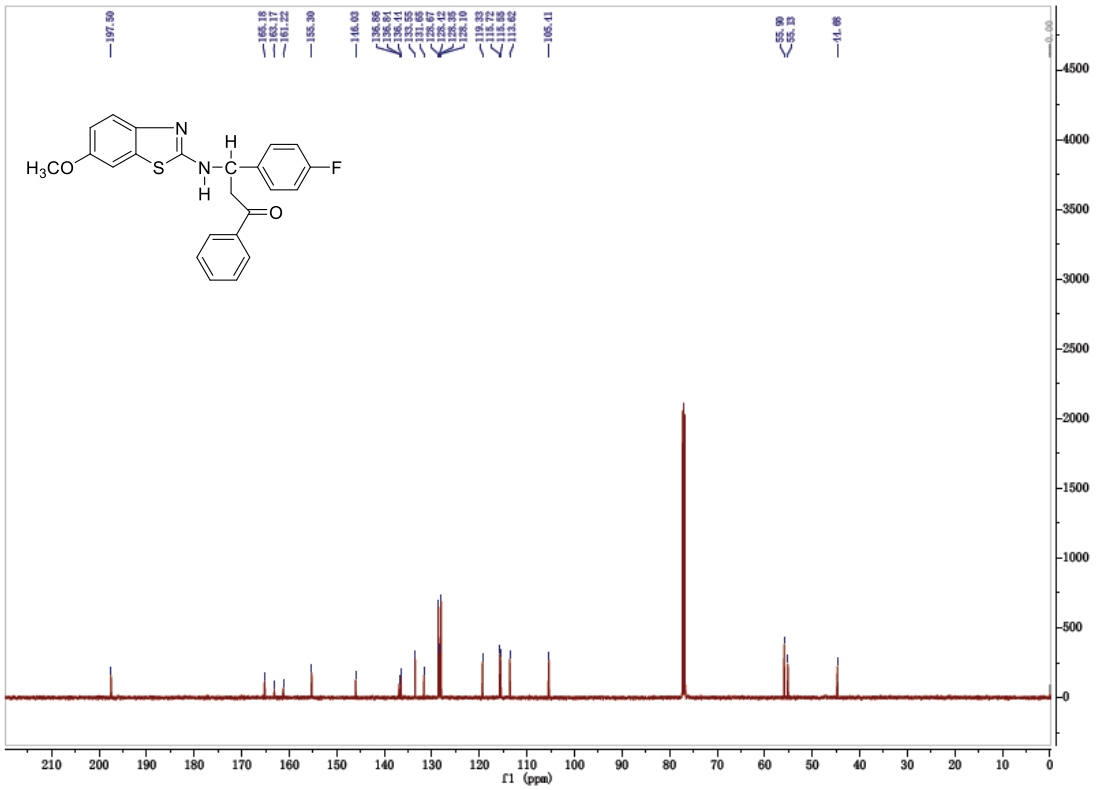
3r 3-(3-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-phenyl propan-1-one



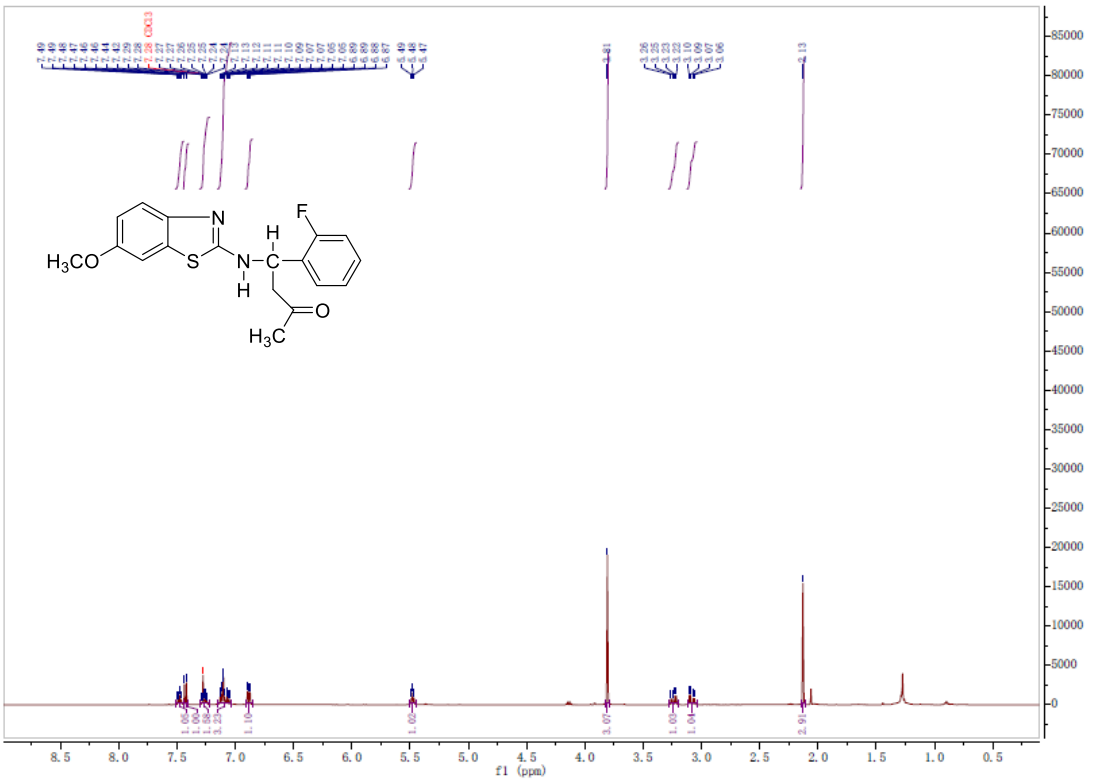


3s 3-(4-fluorophenyl)-3-((6-methoxybenzo[d]thiazol-2-yl)amino)-1-phenyl propan-1-one

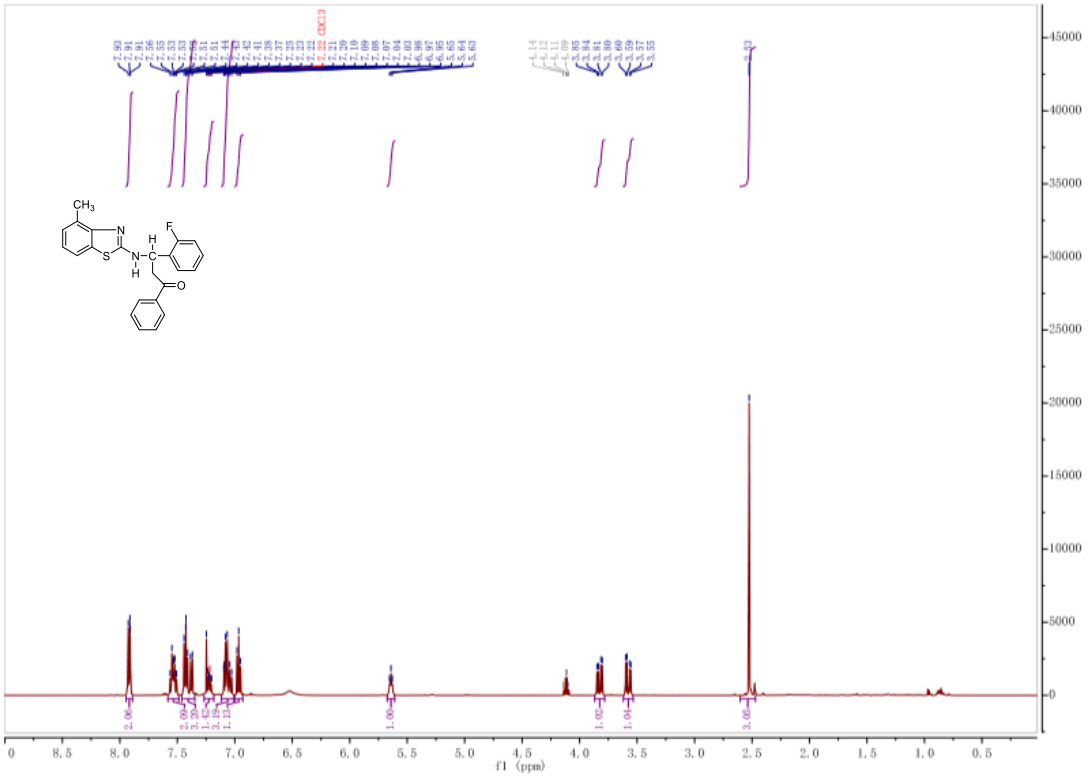


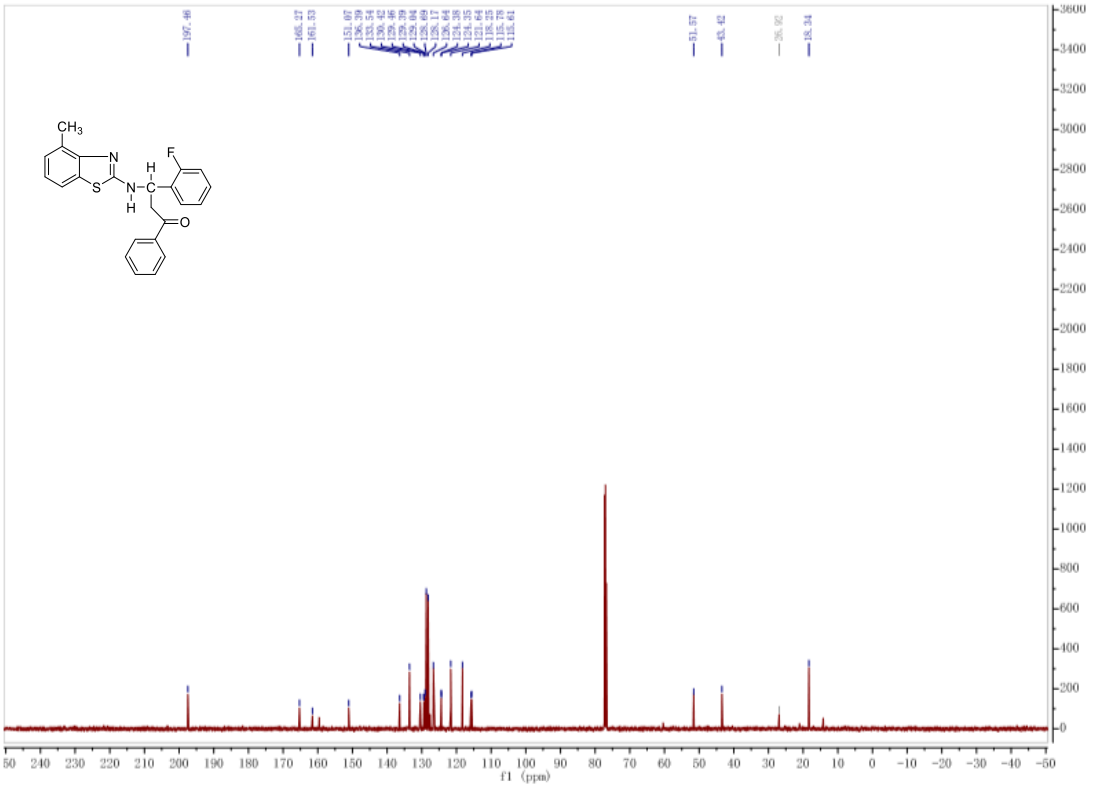


3t 4-(2-fluorophenyl)-4-((6-methoxybenzo[d]thiazol-2-yl)amino)butan-2-one

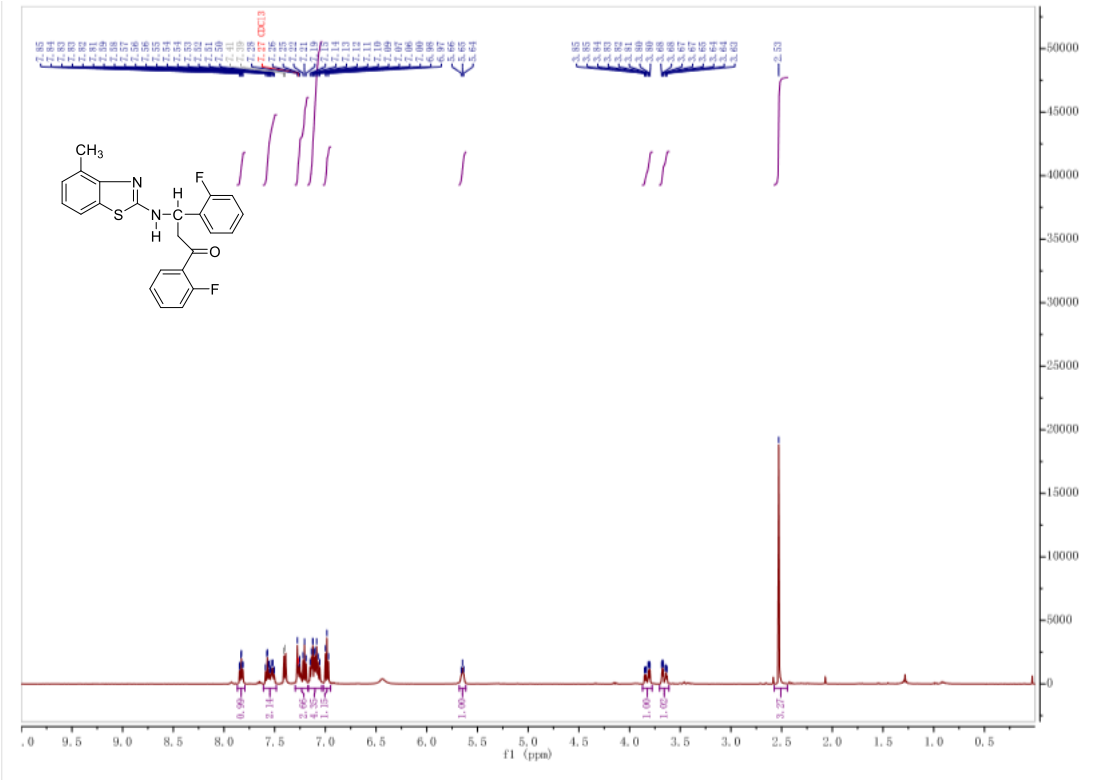


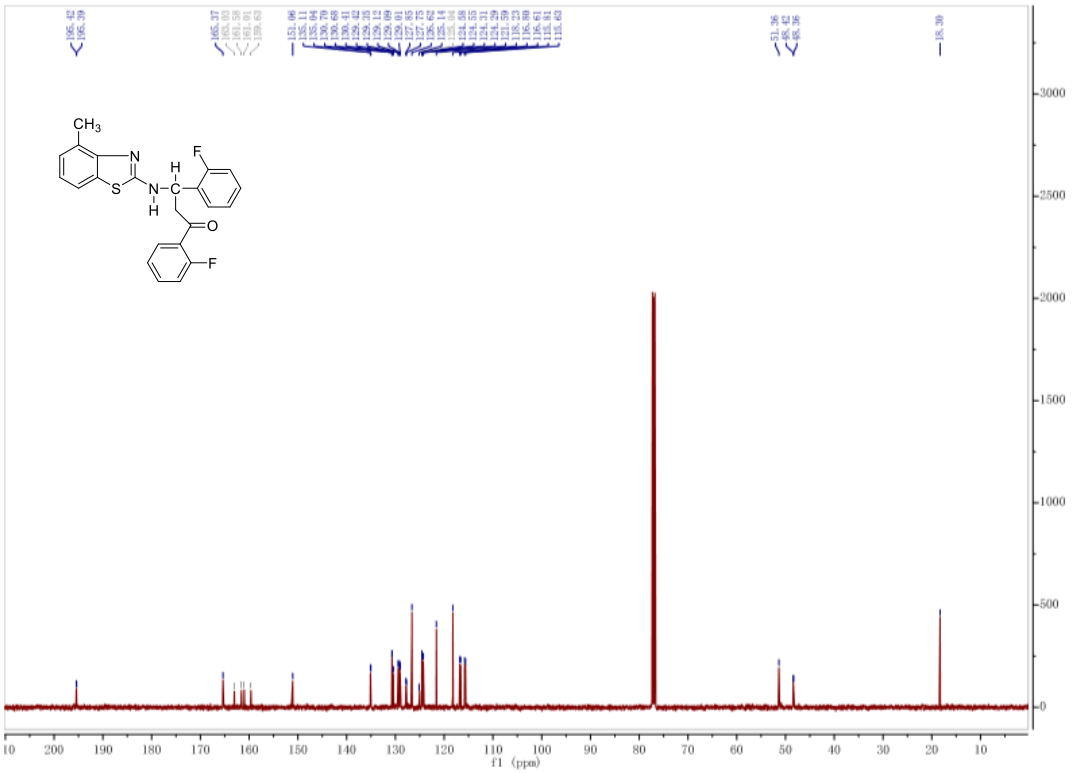
3u 3-(2-Fluorophenyl)-3-((4-methylbenzo[d]thiazol-2-yl)amino)-1-phenylpropan-1-one



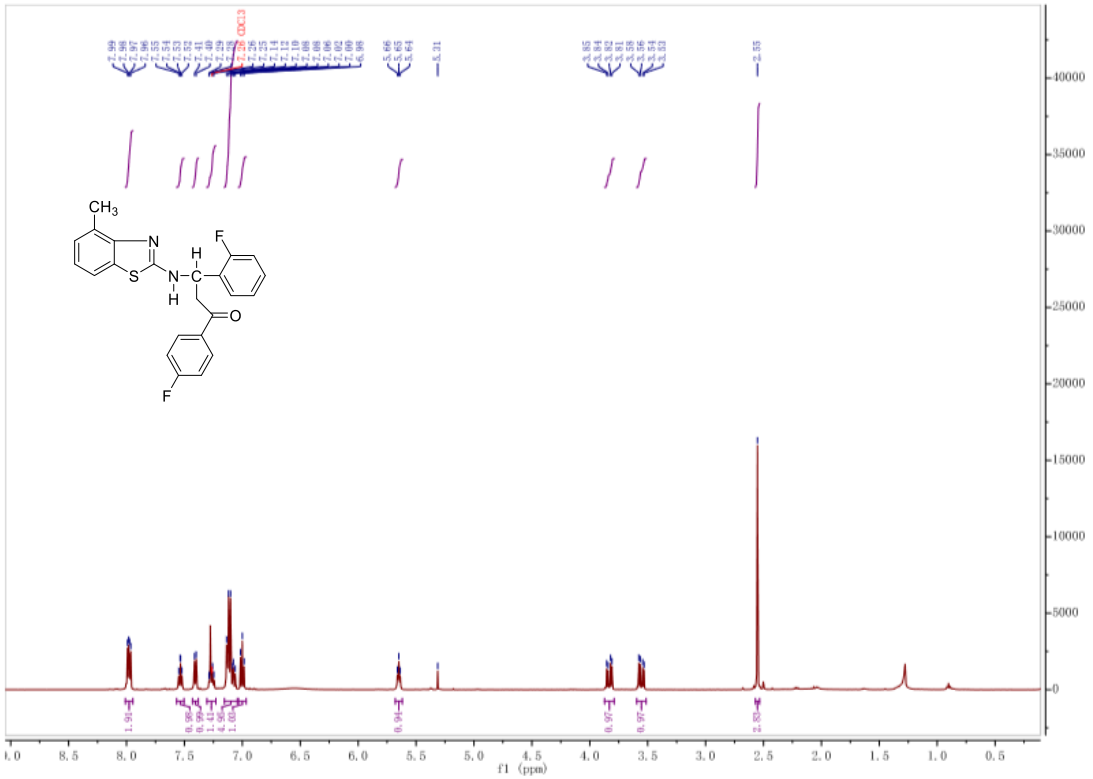


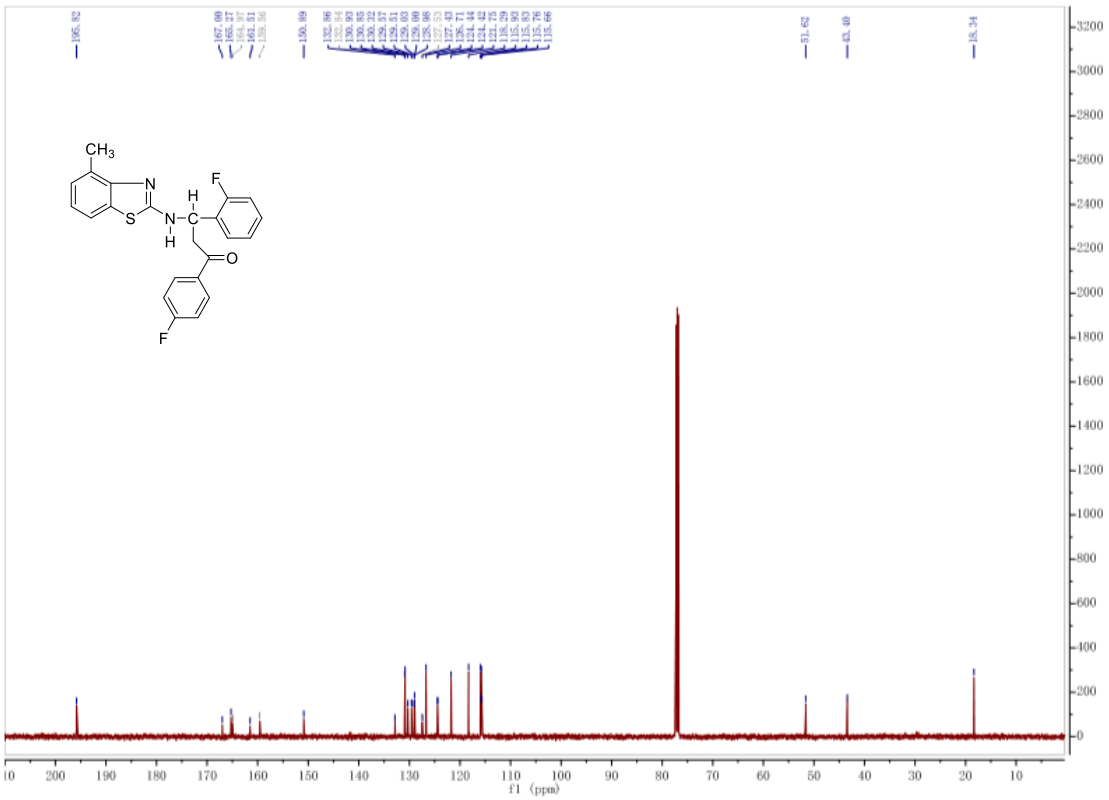
3v 1,3-bis(2-Fluorophenyl)-3-((4-methylbenzo[d]thiazol-2-yl)amino)propan-1-one



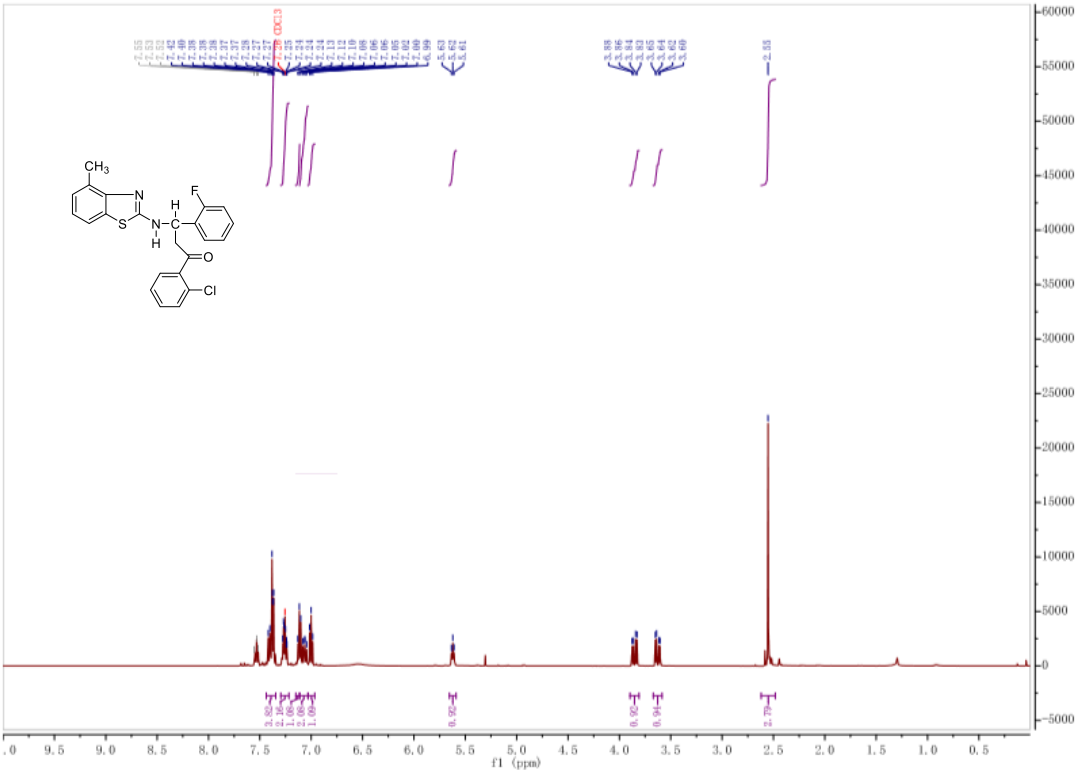


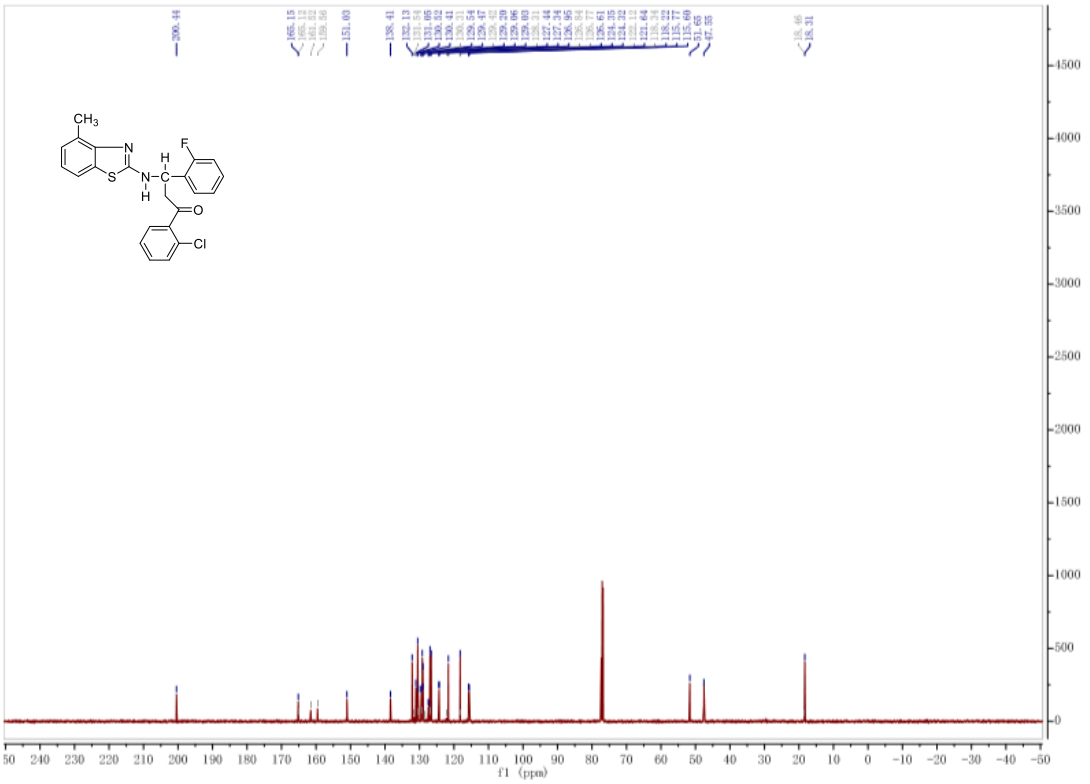
3w 3-(2-Fluorophenyl)-1-(4-fluorophenyl)-3-((4-methylbenzo[d]thiazol-2-yl)amino) propan-1-one



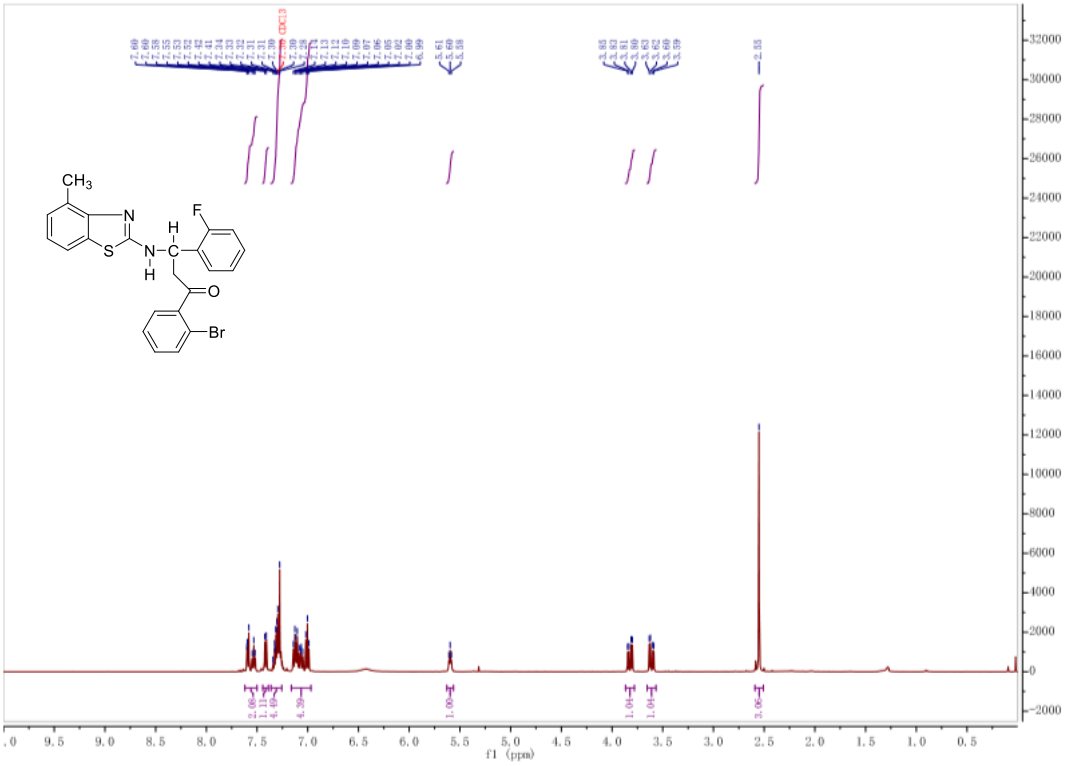


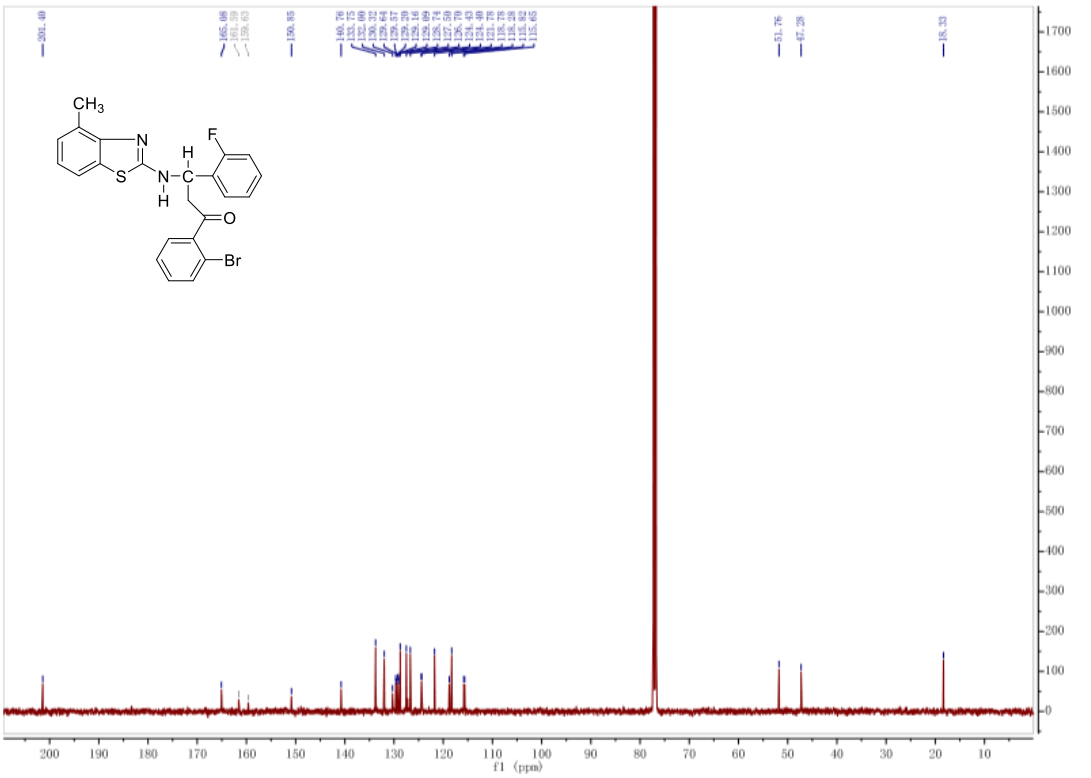
3x 1-(2-Chlorophenyl)-3-(2-fluorophenyl)-3-((4-methylbenzo[d]thiazol-2-yl)amino) propan-1-one

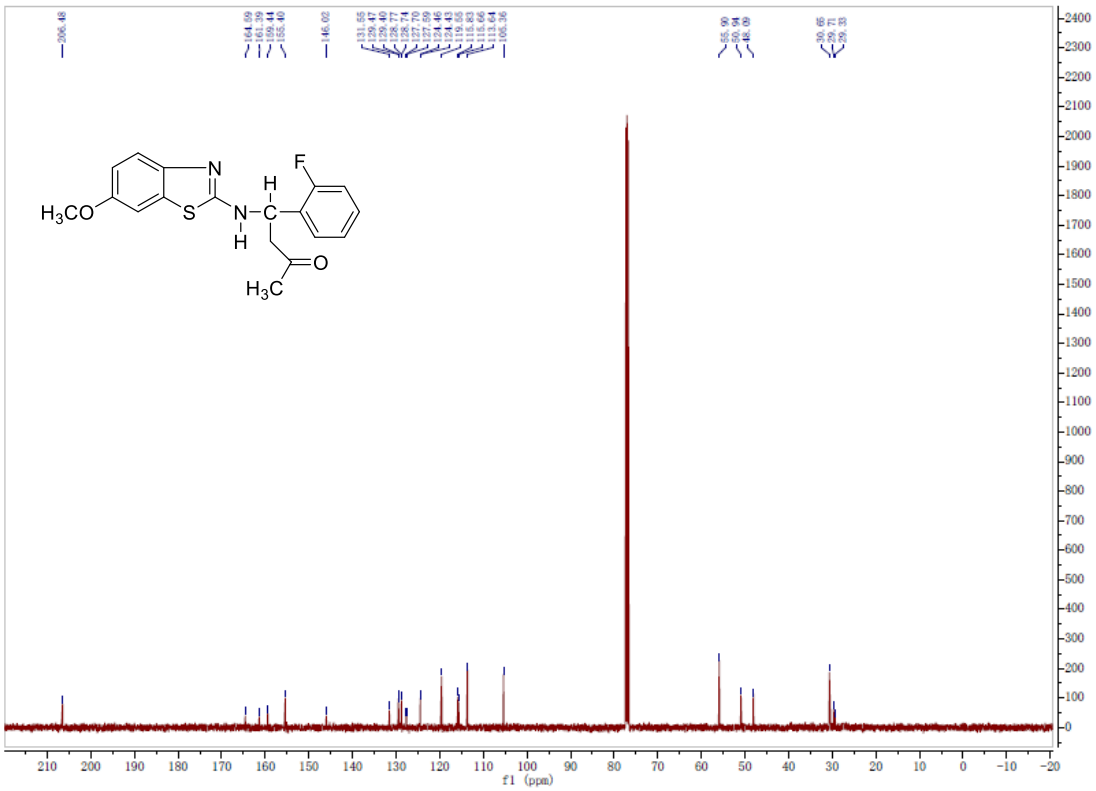




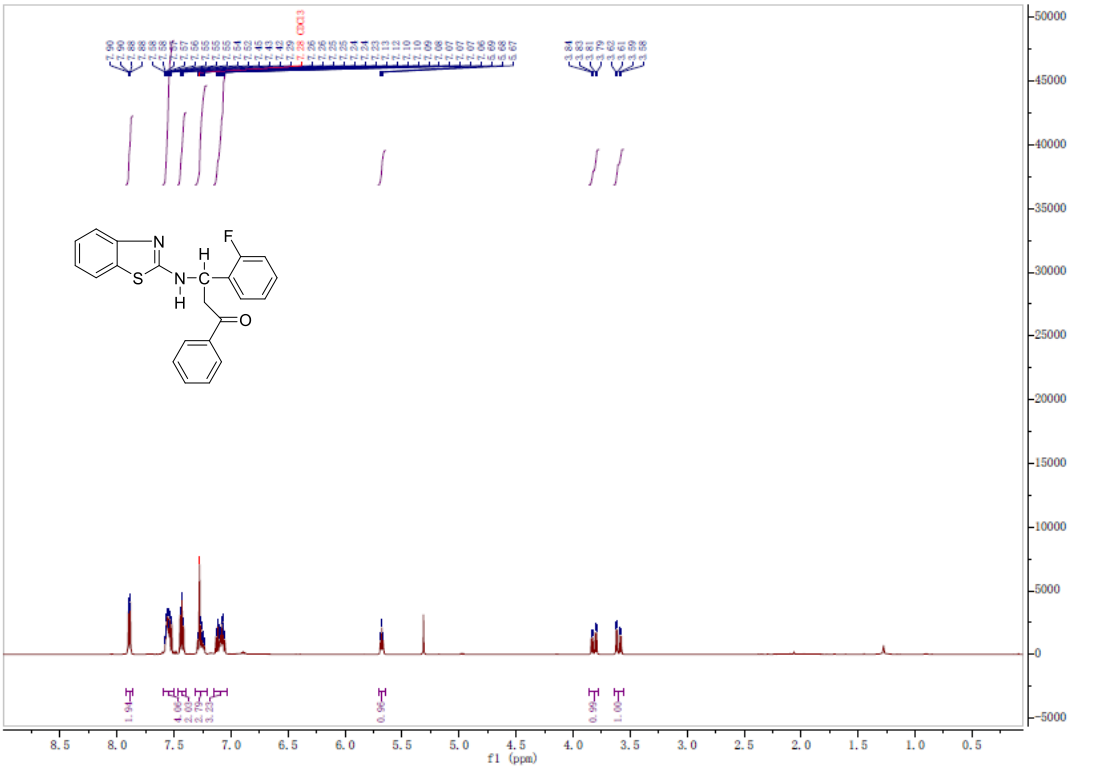
3y 1-(2-Bromophenyl)-3-(2-fluorophenyl)-3-((4-methylbenzo[d]thiazol-2-yl)amino) propan-1-one

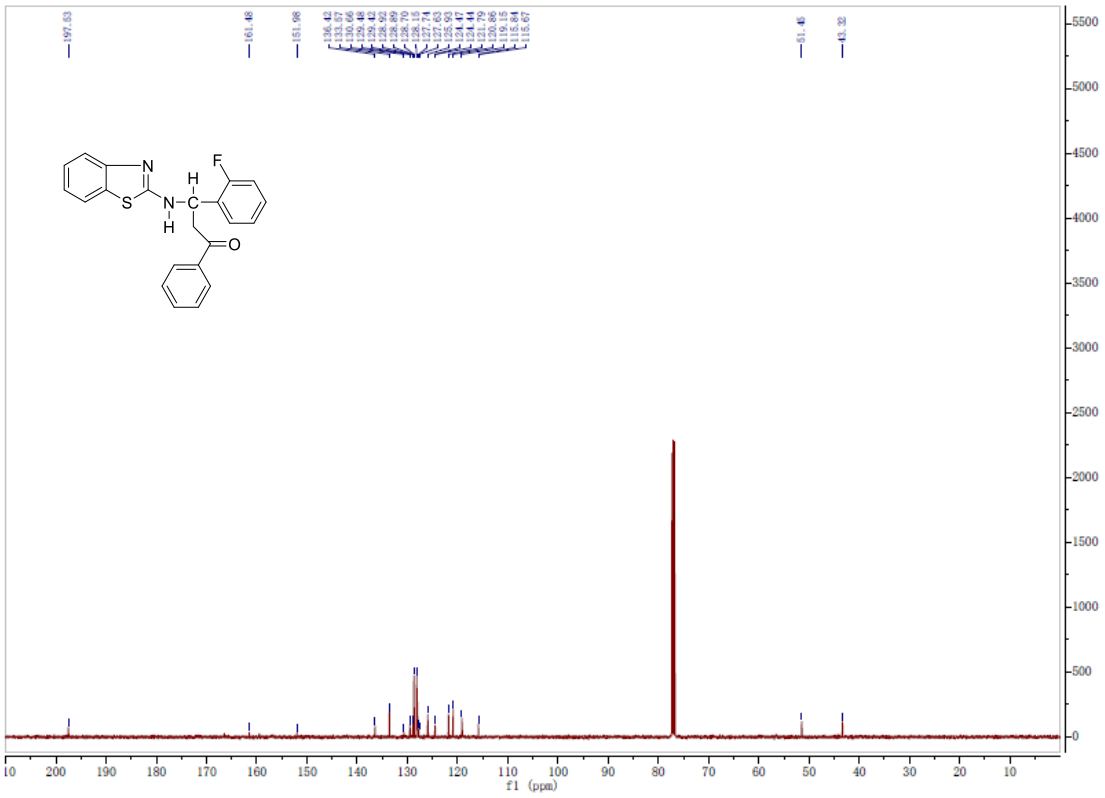






3z 3-(benzo[d]thiazol-2-ylamino)-3-(2-fluorophenyl)-1-phenylpropan-1-one

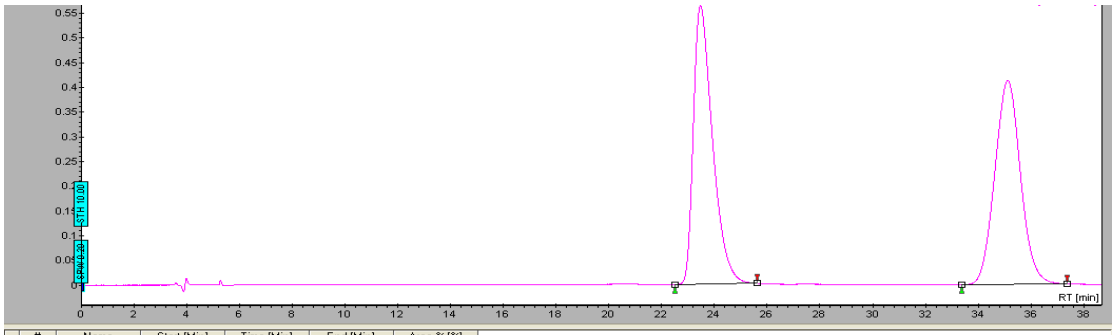




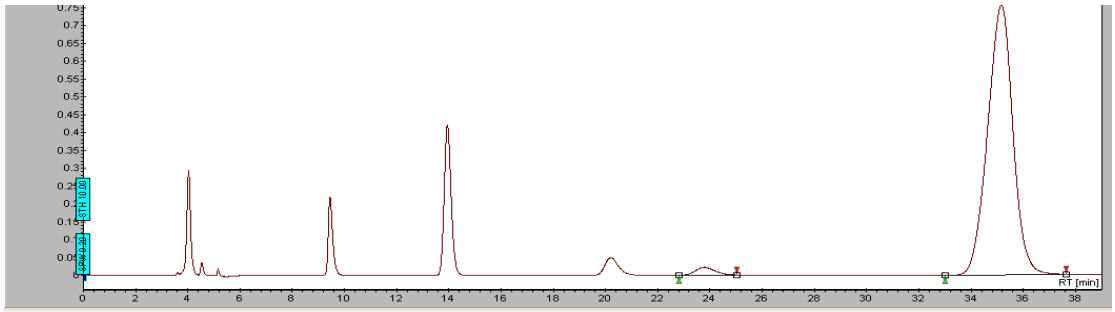
7、Chiral High Performance Liquid Chromatography

3a~3z

3a

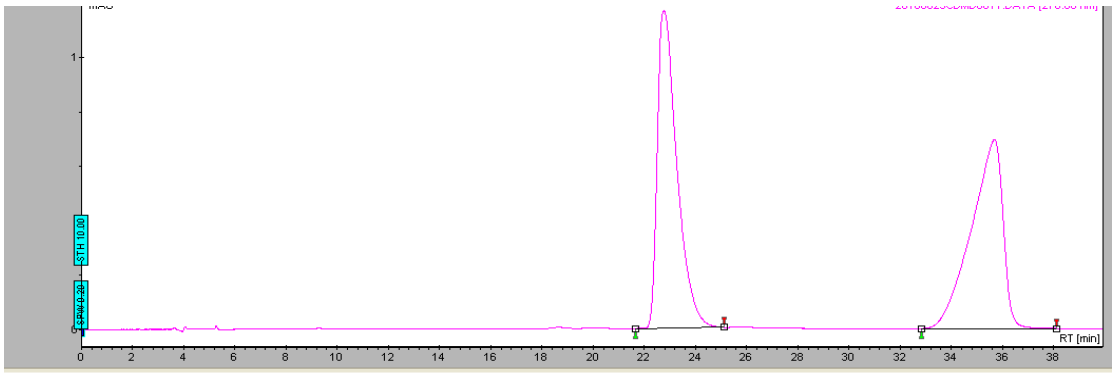


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	22.504	23.465	25.622	50.450
2	UNKNOWN	33.377	35.117	37.374	49.550
Total					100.000

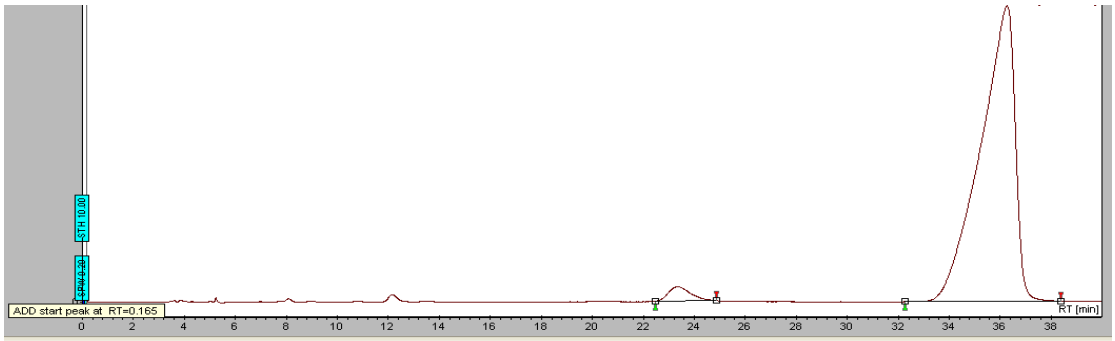


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	22.812	23.772	25.028	2.160
2	UNKNOWN	33.008	35.171	37.643	97.840
Total					100.000

3b

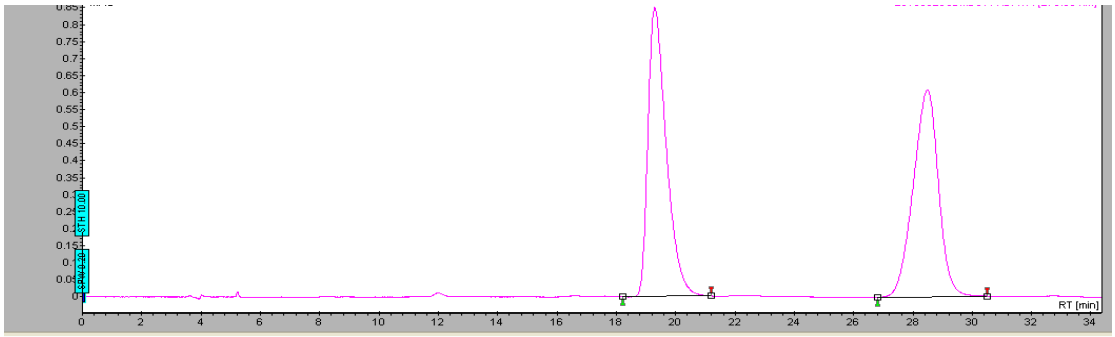


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	21.658	22.758	25.123	51.055
2	UNKNOWN	32.838	35.691	38.118	48.945
Total					100.000

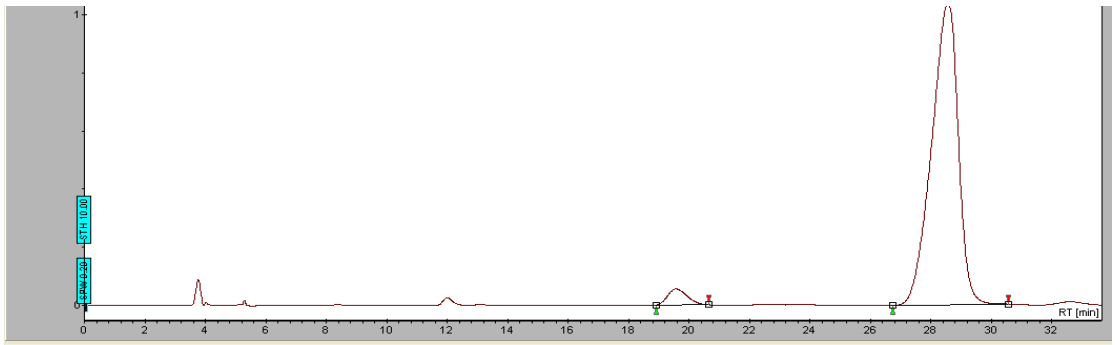


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	22.472	23.332	24.868	3.046
2	UNKNOWN	32.262	36.251	38.376	96.954
Total					100.000

3c

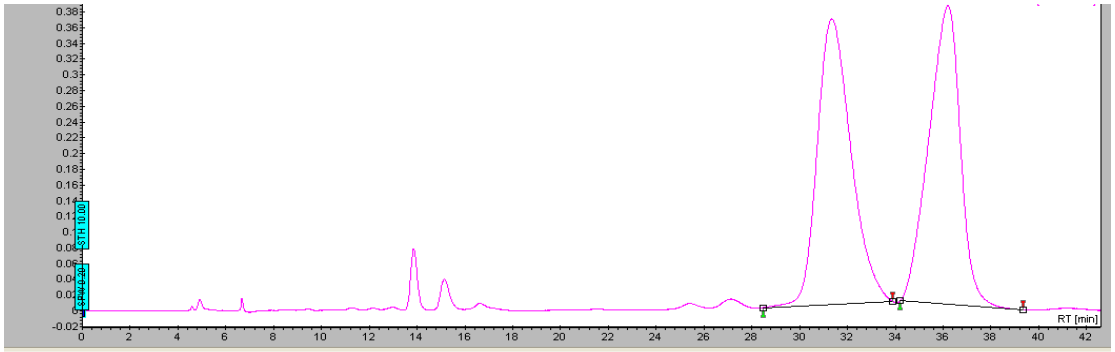


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	18.216	19.292	21.199	50.510
2	UNKNOWN	26.810	28.491	30.503	49.490
Total					100.000

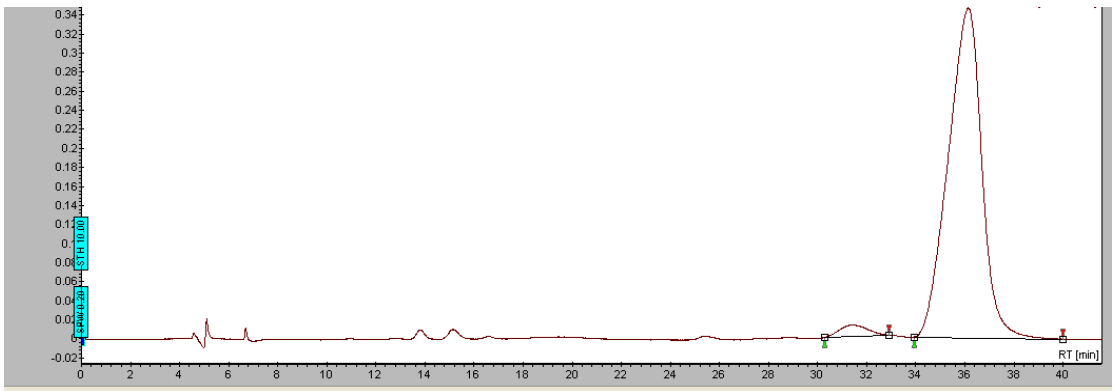


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	18.920	19.572	20.659	3.711
2	UNKNOWN	26.746	28.585	30.571	96.289
Total					100.000

3d

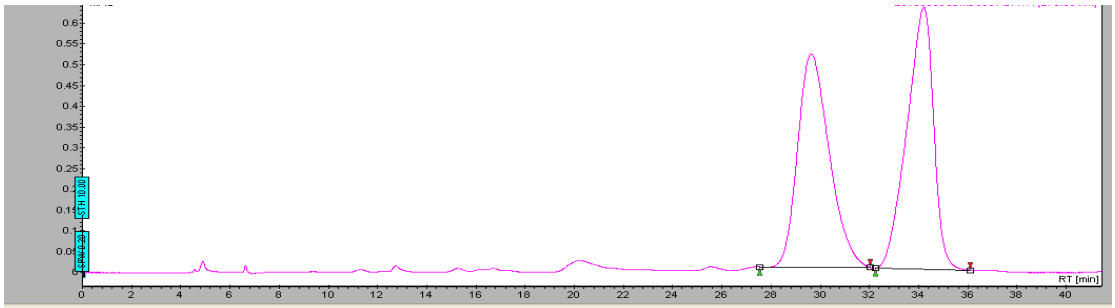


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	28.473	31.344	33.886	50.634
2	UNKNOWN	34.194	36.197	39.343	49.366
Total					100.000

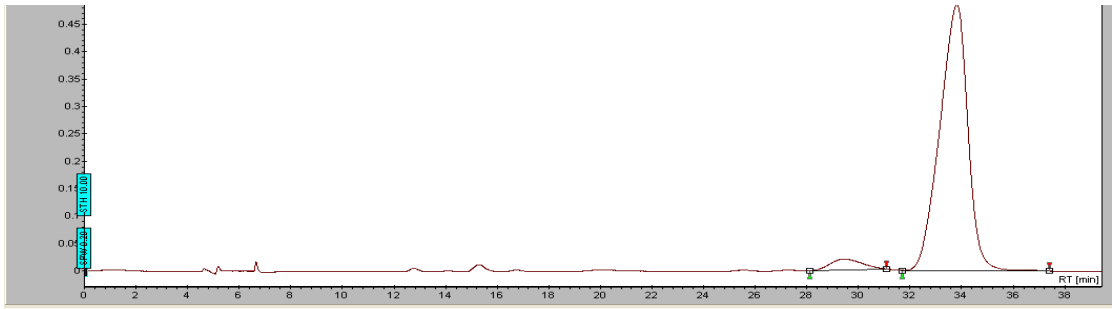


#	Name	Start [Min]	Time [Min]	End [Min]	Ret. time Offset	Quantity [% Area	Height [mAU]	Area [mAU.Min]	Area % [%]
1	UNKNOWN	30.288	31.398	32.908	0.000	2.88	0.0	0.0	2.876
2	UNKNOWN	33.940	36.131	39.997	0.000	97.12	0.3	0.5	97.124
Total						100.00	0.4	0.6	100.000

3e

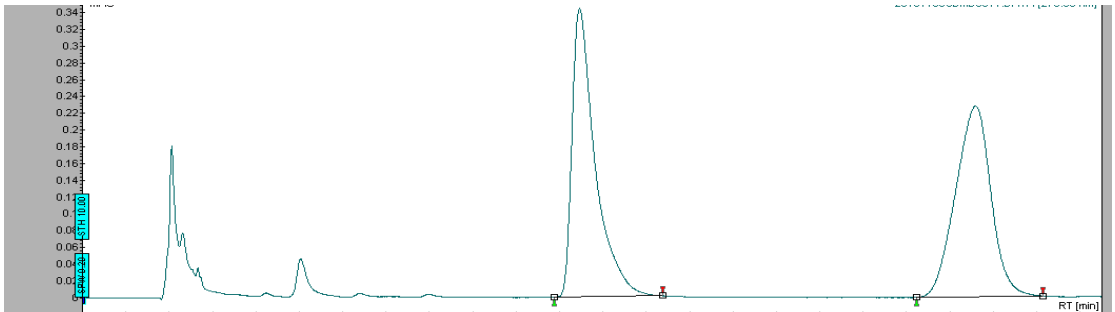


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	27.536	29.625	32.032	49.137
2	UNKNOWN	32.246	34.198	36.100	50.863
Total					100.000

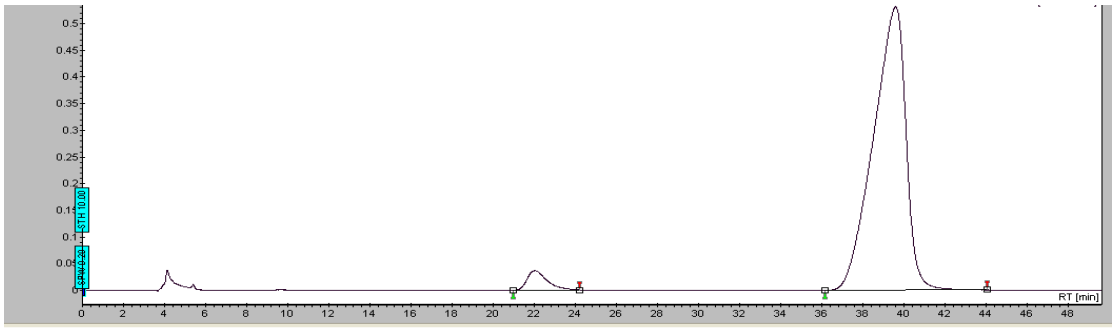


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	28.113	29.438	31.088	4.409
2	UNKNOWN	31.699	33.811	37.403	95.591
Total					100.000

3f

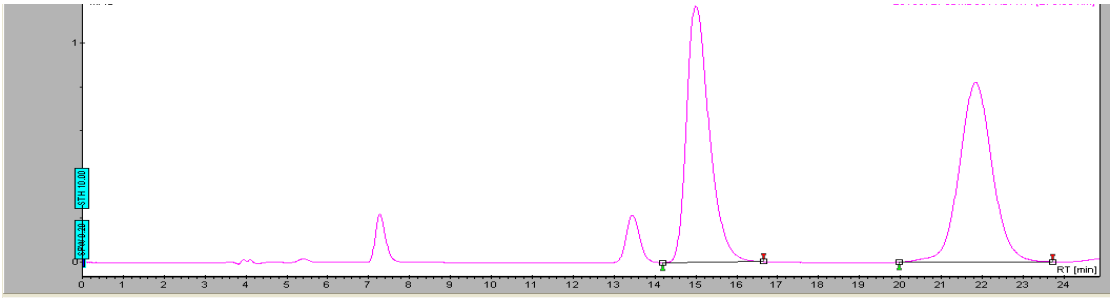


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	21.758	22.918	26.761	49.779
2	UNKNOWN	38.465	41.184	44.294	50.221
Total					100.000

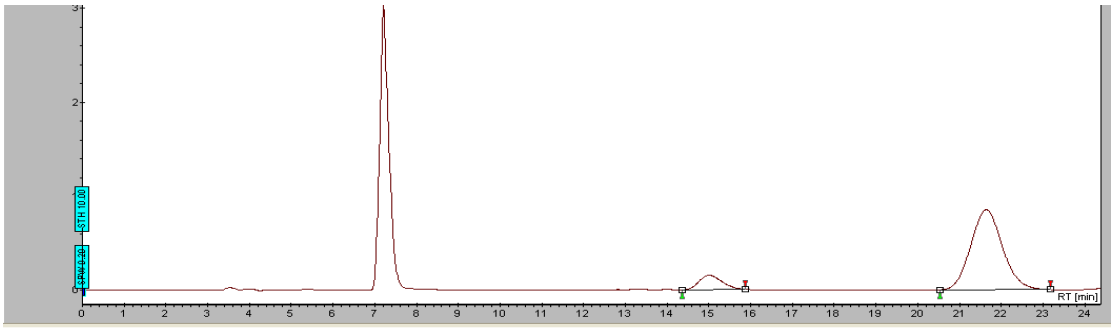


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	20.968	22.025	24.198	4.043
2	UNKNOWN	36.143	39.584	44.039	95.957
Total					100.000

3g

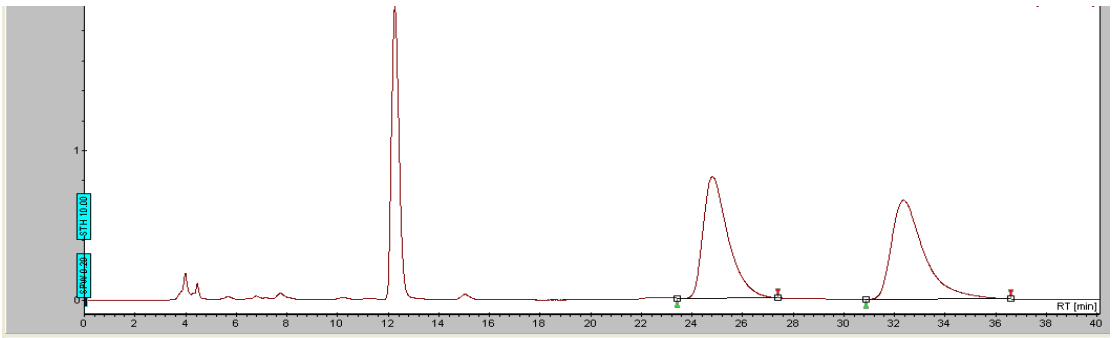


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	14.188	14.986	16.655	49.800
2	UNKNOWN	19.971	21.838	23.723	50.200
Total					100.000

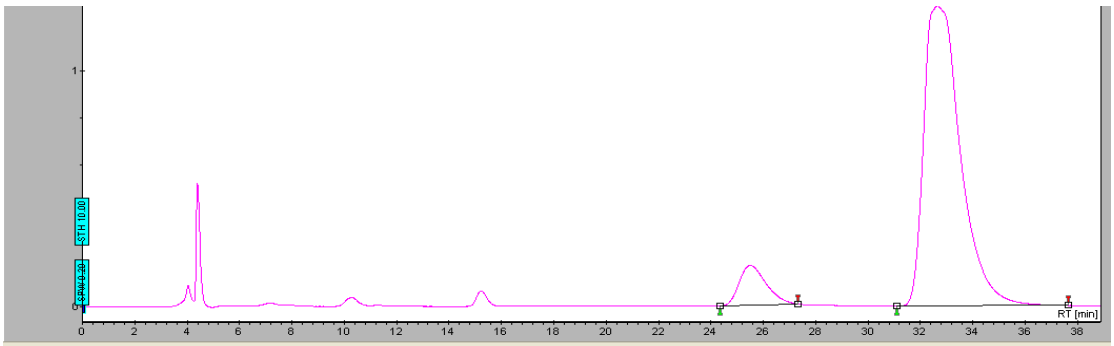


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	14.360	14.999	15.871	11.474
2	UNKNOWN	20.532	21.638	23.177	88.526
Total					100.000

3h

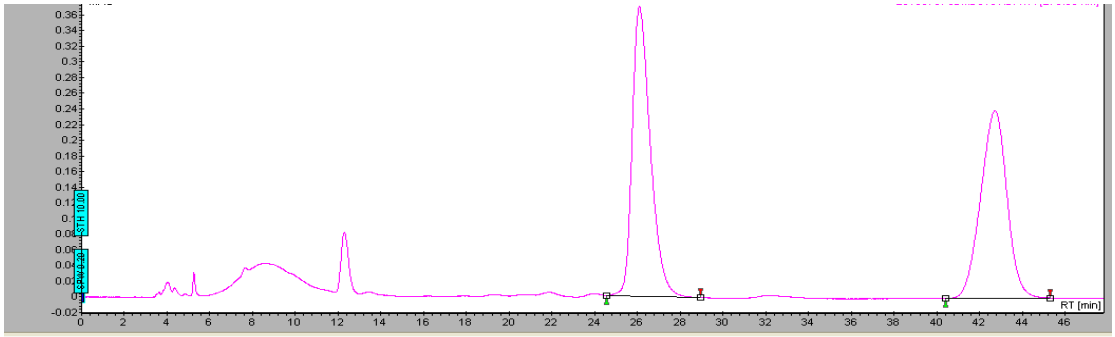


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	23.417	24.798	27.396	48.484
2	UNKNOWN	30.877	32.358	36.597	51.516
Total					100.000

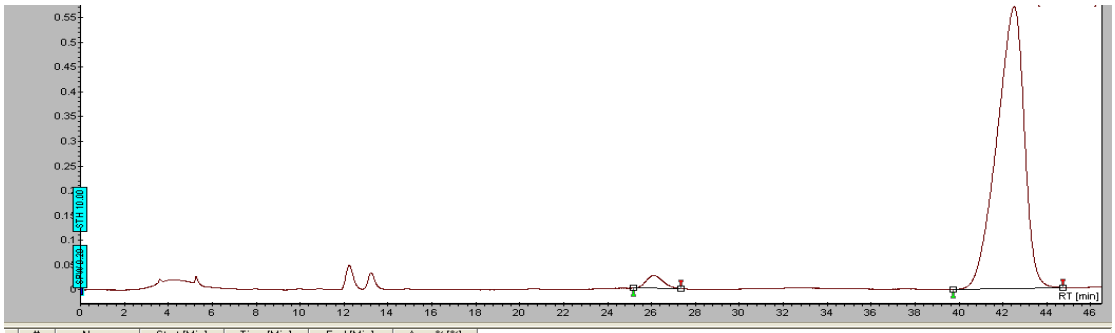


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	24.349	25.491	27.322	8.962
2	UNKNOWN	31.099	32.664	37.648	91.038
Total					100.000

3i

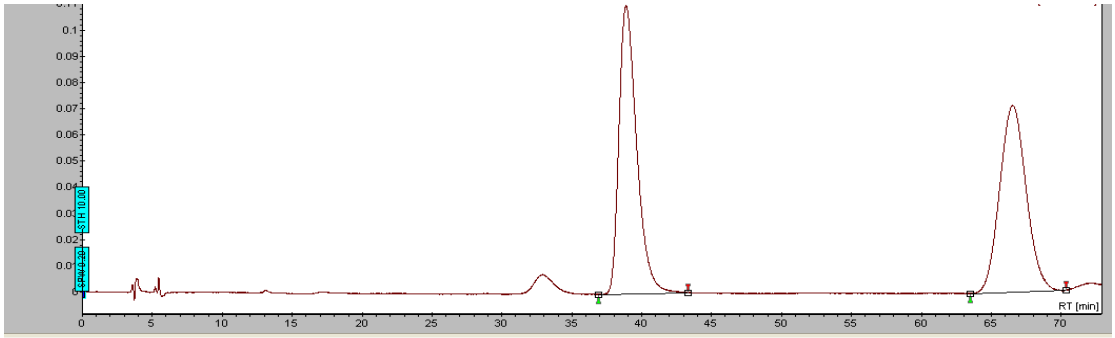


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	24.556	26.091	28.953	51.643
2	UNKNOWN	40.416	42.717	45.307	48.357
Total					100.000

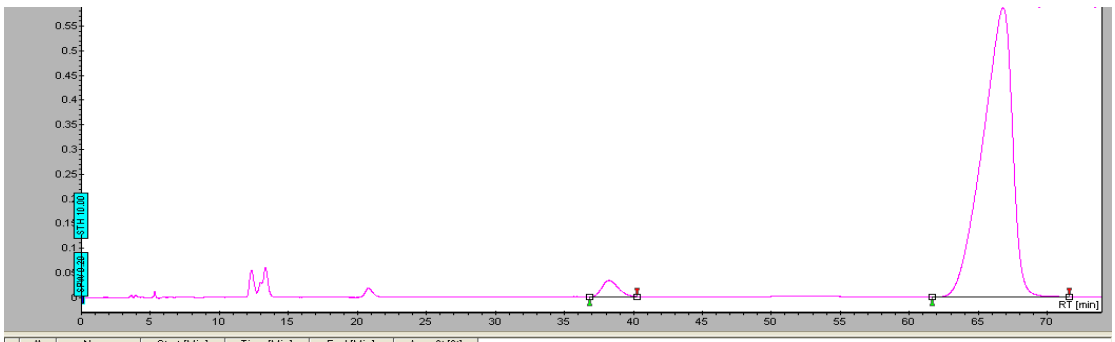


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	25.175	26.105	27.337	2.758
2	UNKNOWN	39.732	42.504	44.729	97.242
Total					100.000

3j

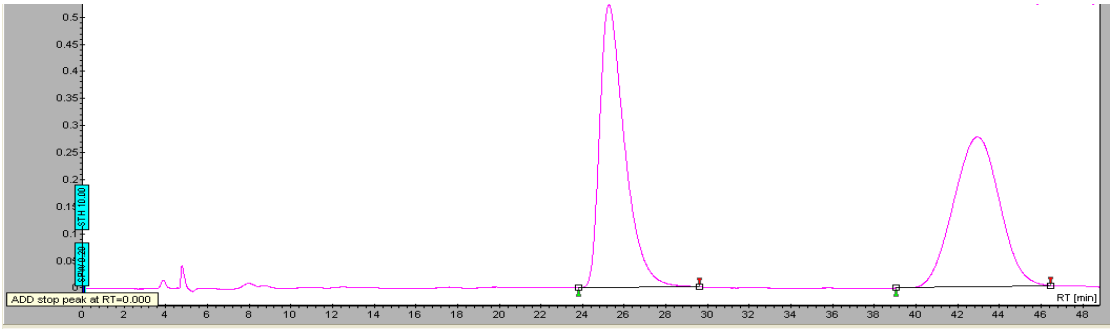


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	36.905	38.879	43.307	50.927
2	UNKNOWN	63.492	66.523	70.346	49.073
Total					100.000

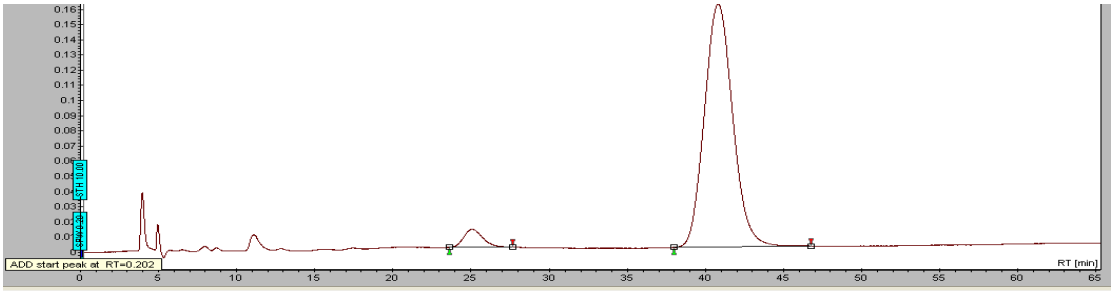


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	36.827	38.226	40.265	2.977
2	UNKNOWN	61.659	66.776	71.591	97.023
Total					100.000

3k

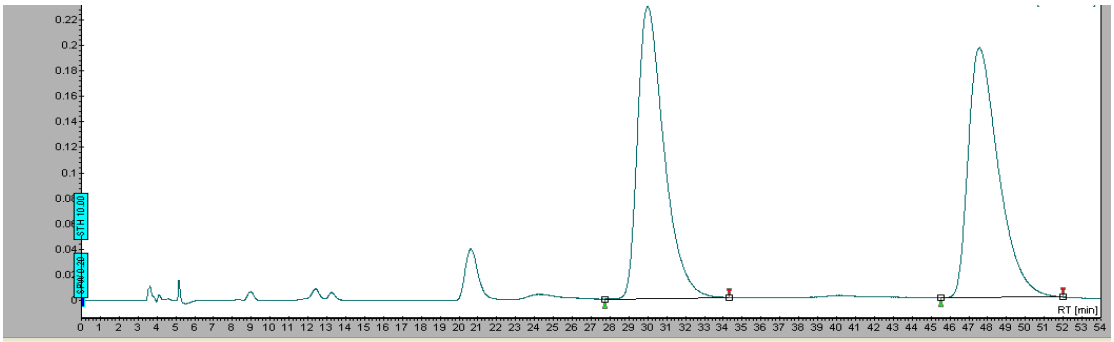


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	23.808	25.265	29.609	50.793
2	UNKNOWN	39.041	42.944	46.456	49.207
Total					100.000

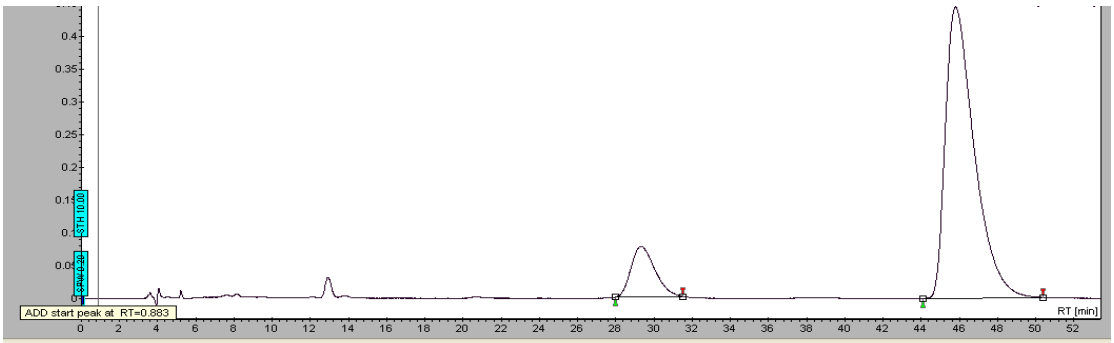


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	23.618	25.071	27.667	4.683
2	UNKNOWN	37.991	40.812	46.763	95.317
Total					100.000

3l

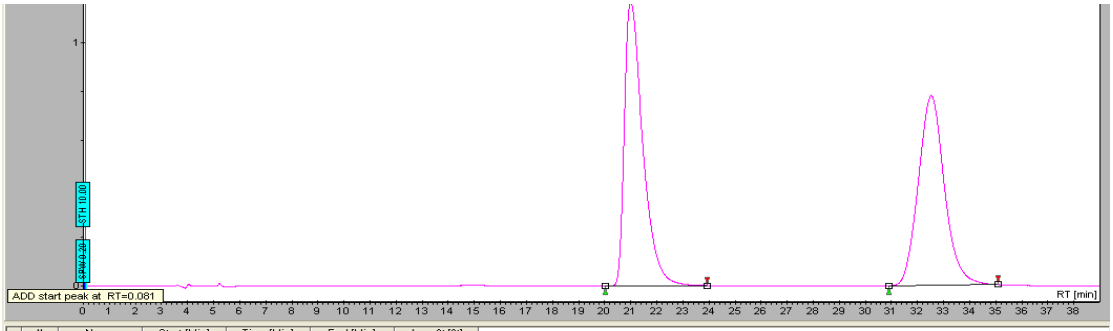


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	27.725	29.984	34.308	50.489
2	UNKNOWN	45.521	47.557	51.992	49.511
Total					100.000

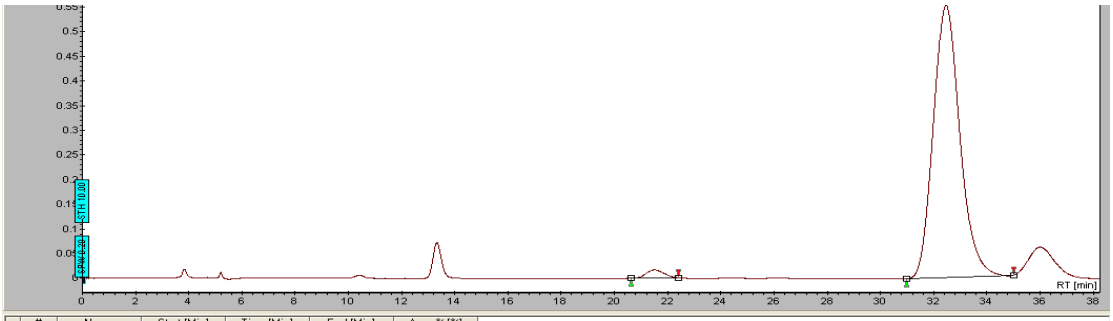


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	27.976	29.318	31.507	12.481
2	UNKNOWN	44.088	45.783	50.378	87.519
Total					100.000

3m

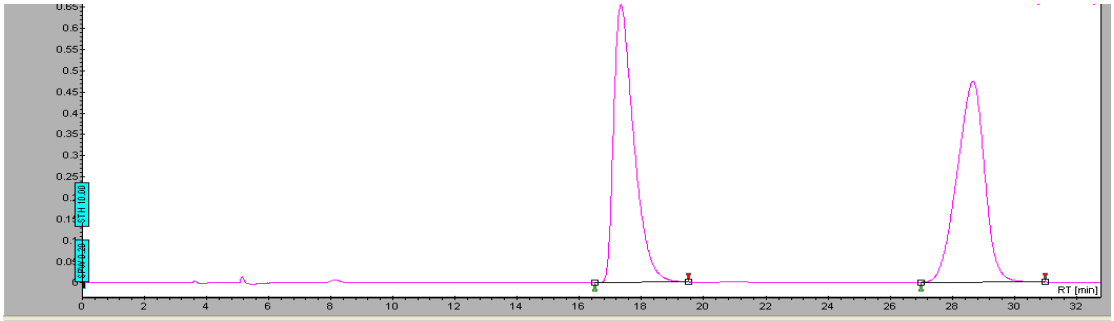


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	20.024	20.998	23.932	51.225
2	UNKNOWN	30.902	32.518	35.092	48.775
Total					100.000

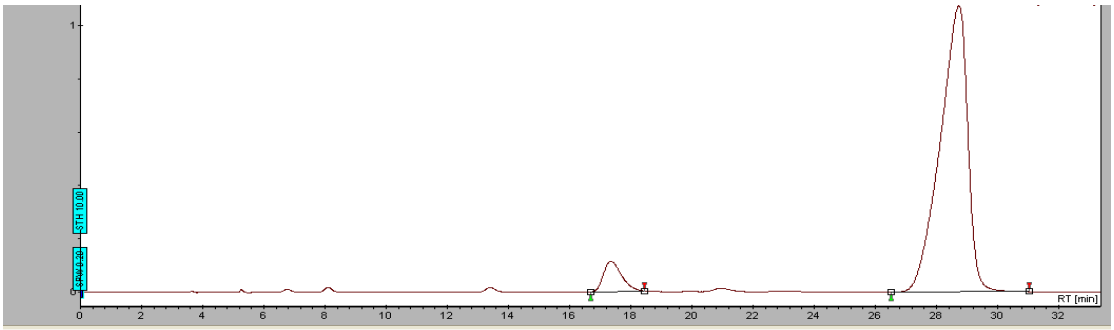


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	20.628	21.505	22.407	1.912
2	UNKNOWN	30.982	32.464	35.013	98.088
Total					100.000

3n

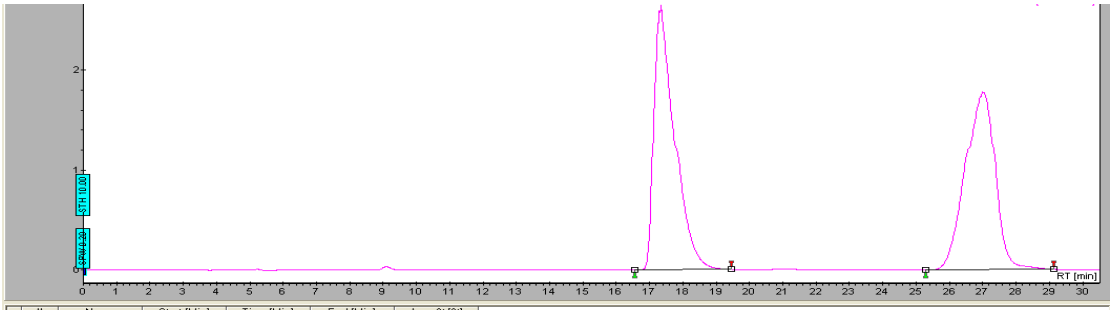


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	16.495	17.332	19.509	50.289
2	UNKNOWN	26.995	28.665	30.992	49.711
Total					100.000

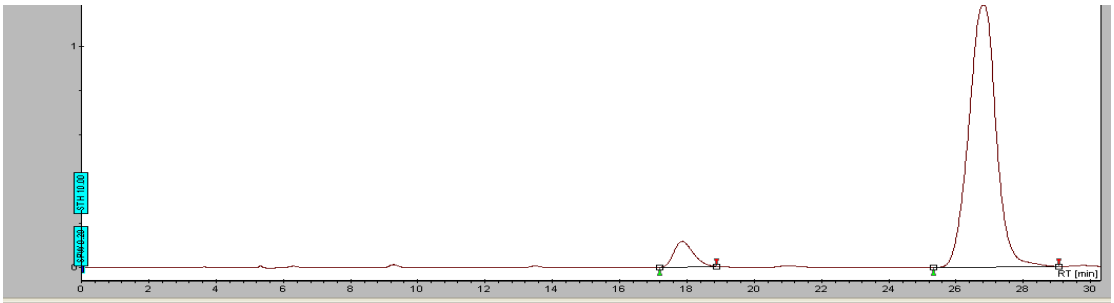


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	16.693	17.345	18.452	6.476
2	UNKNOWN	26.523	28.745	31.041	93.524
Total					100.000

3o

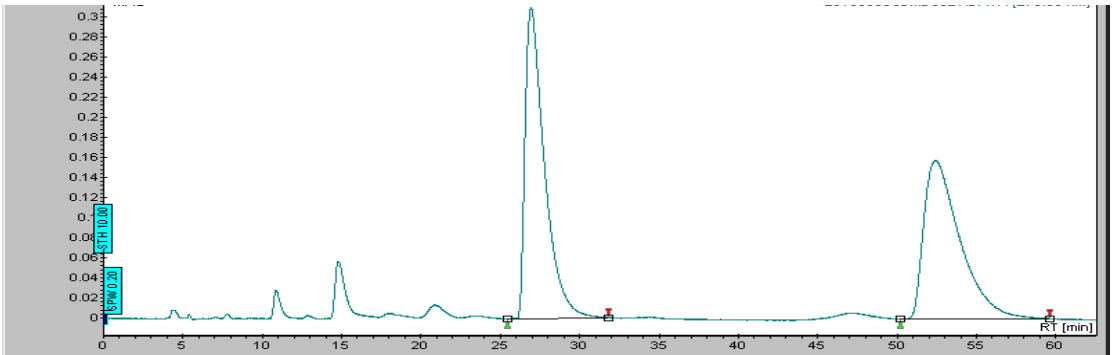


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	16.553	17.345	19.453	50.441
2	UNKNOWN	25.286	26.985	29.133	49.559
Total					100.000

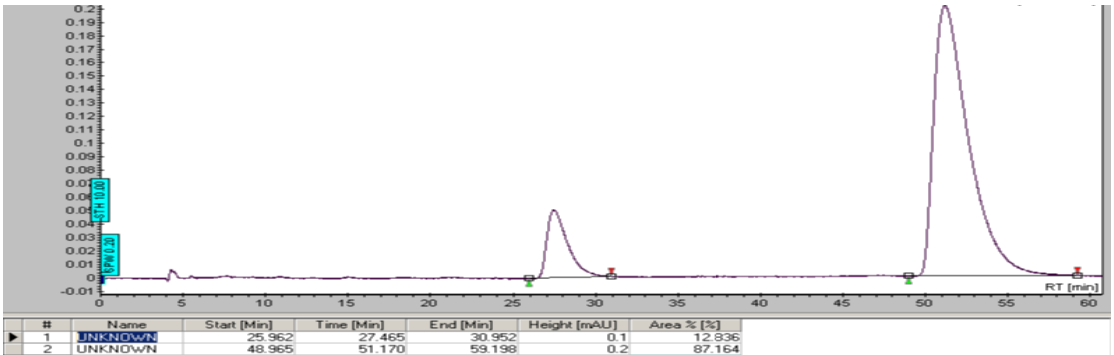


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	17.188	17.852	18.879	6.506
2	UNKNOWN	25.329	26.811	29.054	93.494
Total					100.000

3p

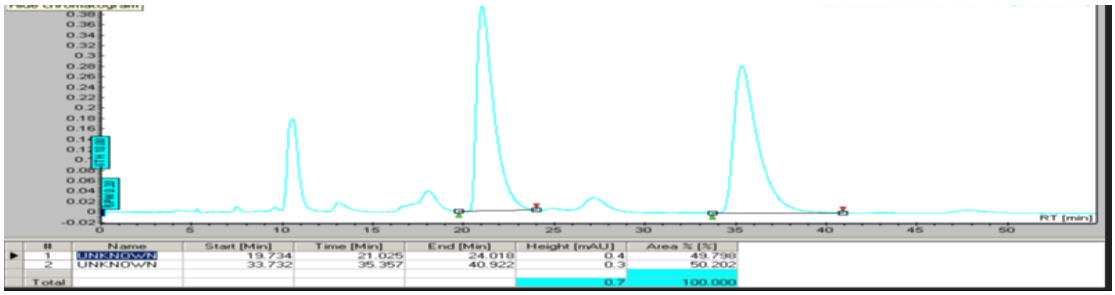


#	Name	Start [Min]	Time [Min]	End [Min]	Height [mAU]	Area % [%]
1	UNKNOWN	25.448	26.918	31.810	0.3	51.263
2	UNKNOWN	50.198	52.410	59.610	0.2	48.737
Total					0.5	100.000

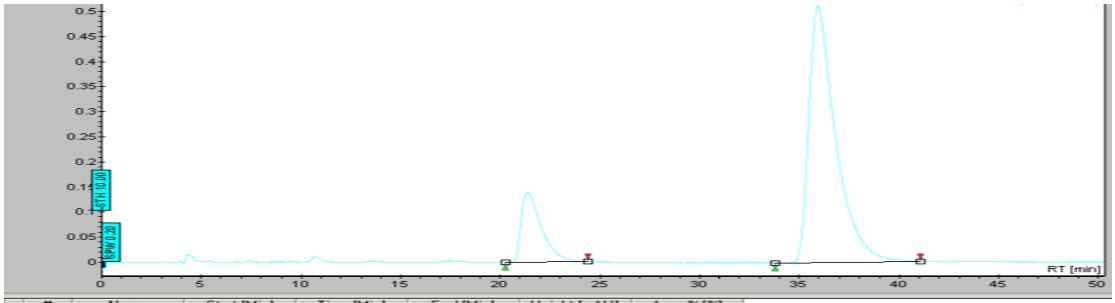


#	Name	Start [Min]	Time [Min]	End [Min]	Height [mAU]	Area % [%]
1	UNKNOWN	25.962	27.465	30.952	0.1	12.836
2	UNKNOWN	48.965	51.170	59.198	0.2	87.164
Total					0.3	100.000

3q

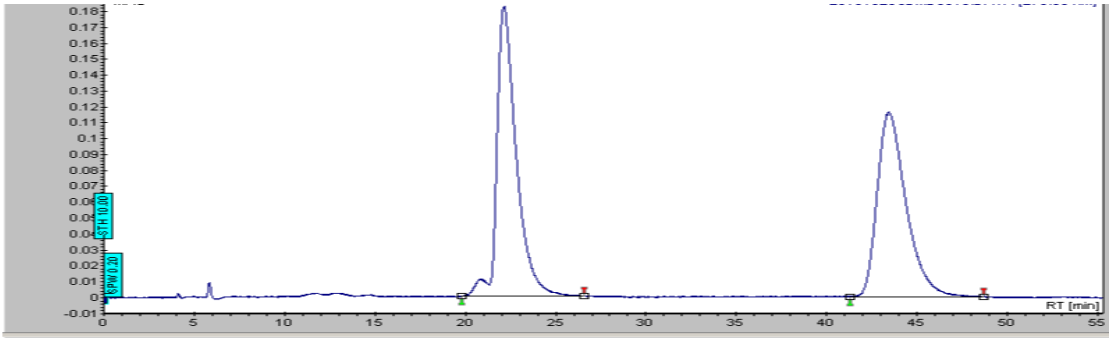


#	Name	Start [Min]	Time [Min]	End [Min]	Height [mAU]	Area % [%]
1	UNKNOWN	19.734	21.025	24.018	0.4	49.798
2	UNKNOWN	33.732	35.357	40.922	0.3	50.202
Total					0.7	100.000

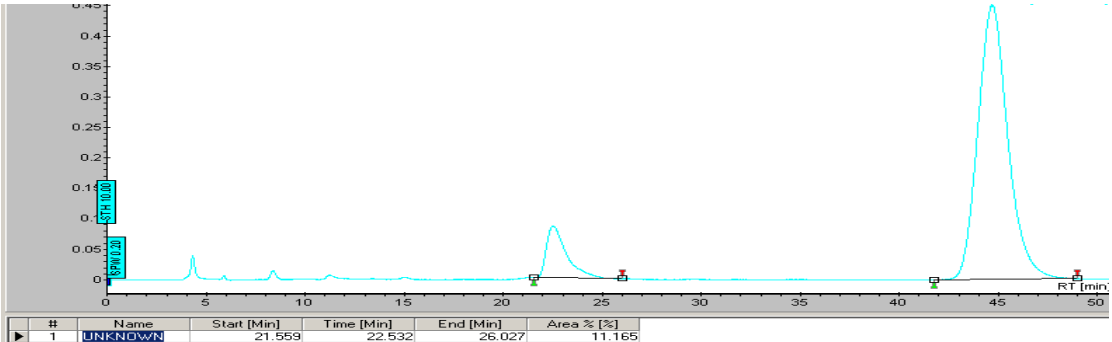


#	Name	Start [Min]	Time [Min]	End [Min]	Height [mAU]	Area % [%]
1	UNKNOWN	20.260	21.372	24.396	0.1	16.921
2	UNKNOWN	33.789	35.931	41.080	0.5	83.079
Total					0.7	100.000

3r

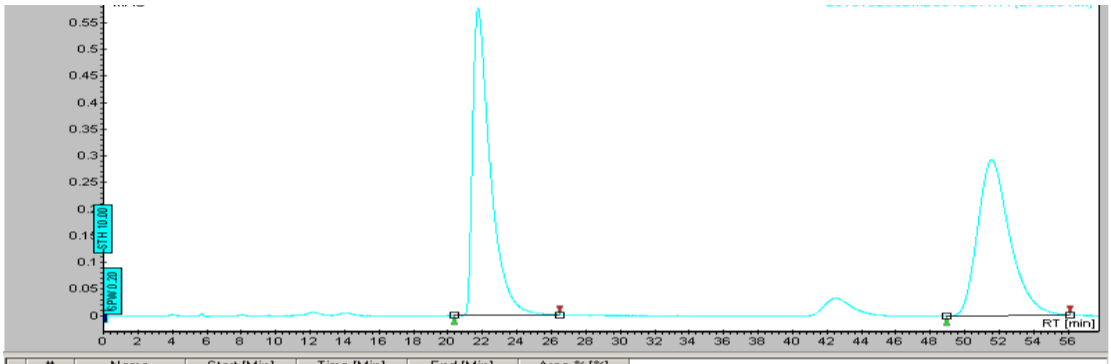


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	19.796	22.132	26.575	51.498
2	UNKNOWN	41.287	43.424	48.682	48.502
Total					100.000

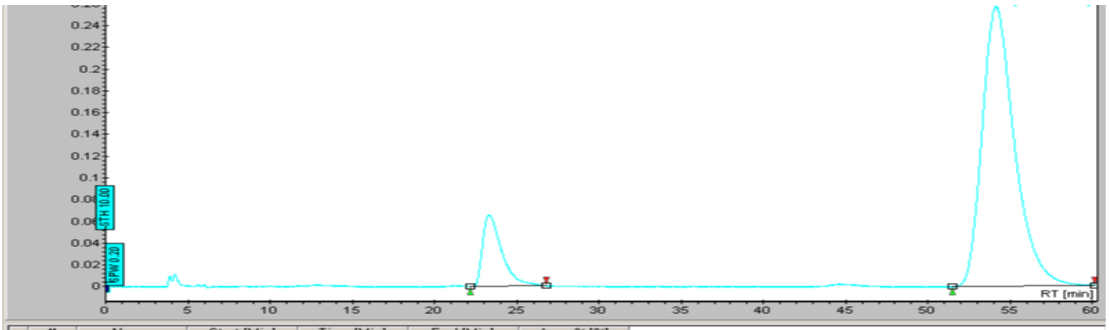


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	21.559	22.532	26.027	11.165
2	UNKNOWN	41.771	44.703	49.005	88.835
Total					100.000

3s

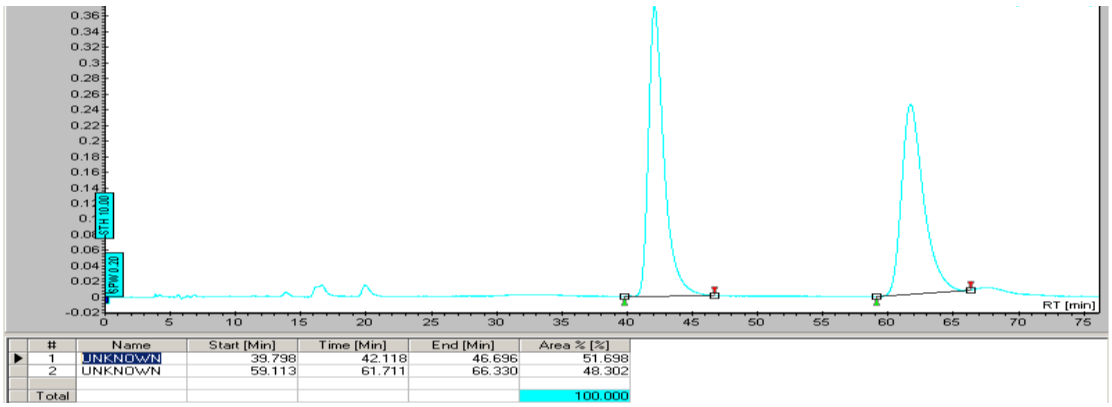


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	20.367	21.758	26.485	51.927
2	UNKNOWN	48.945	51.556	56.109	48.073
Total					100.000

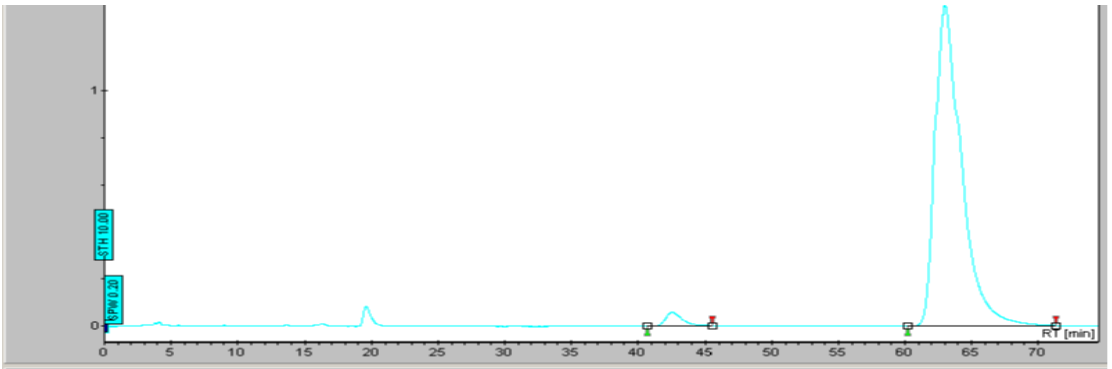


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	22.179	23.332	26.800	13.098
2	UNKNOWN	51.499	54.143	60.152	86.902
Total					100.000

3t

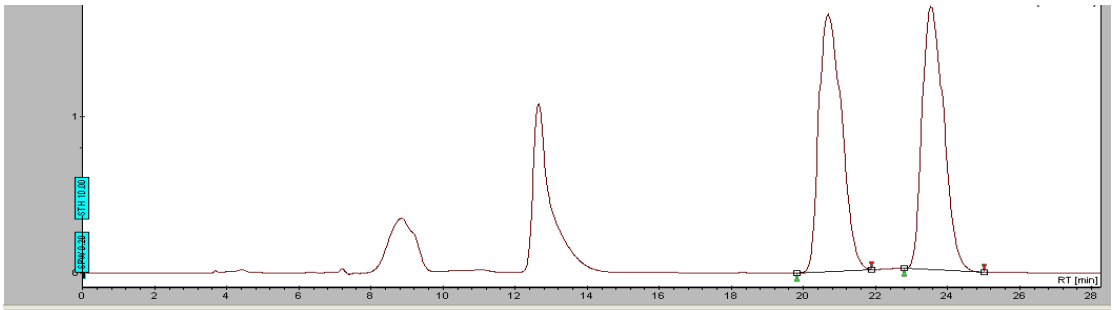


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	39.798	42.118	46.696	51.698
2	UNKNOWN	59.113	61.711	66.330	48.302
Total					100.000

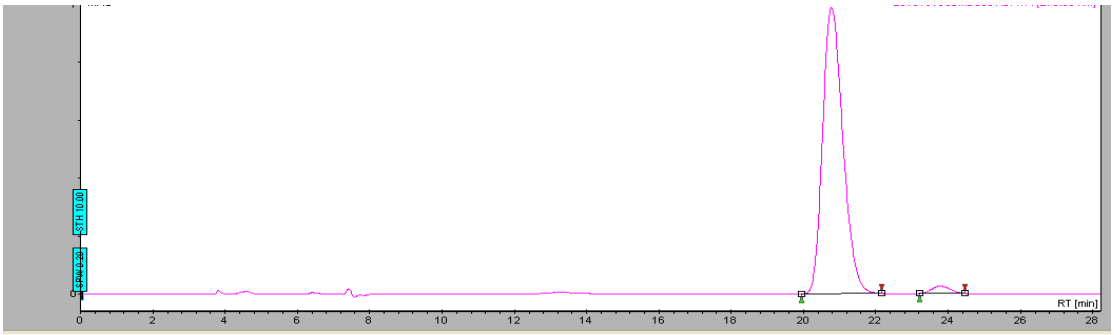


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	40.685	42.545	45.563	2.610
2	UNKNOWN	60.197	62.964	71.303	97.390
Total					100.000

3u

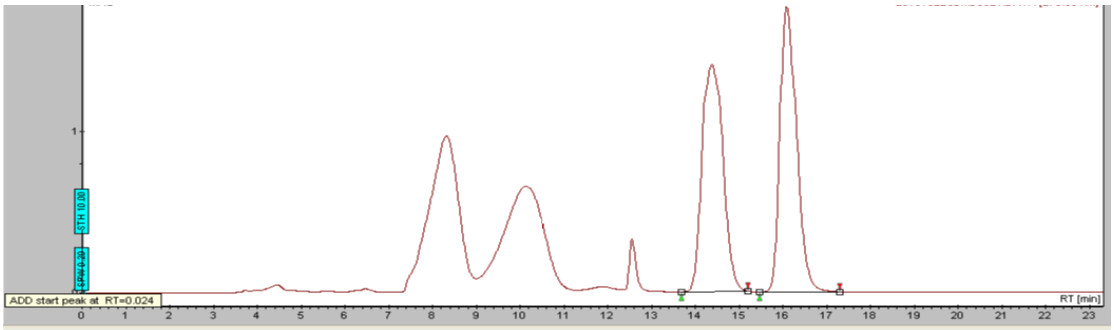


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	19.818	20.692	21.890	50.869
2	UNKNOWN	22.795	23.532	25.014	49.131
Total					100.000

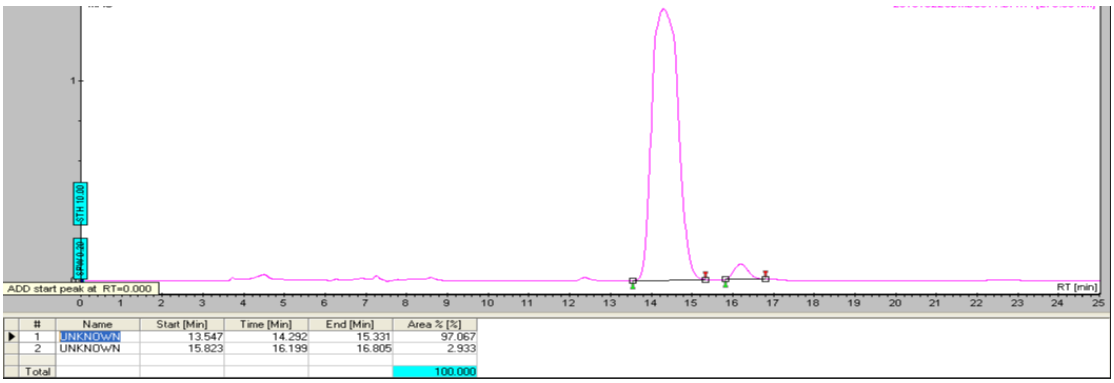


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	19.945	20.772	22.161	97.725
2	UNKNOWN	23.211	23.785	24.465	2.275
Total					100.000

3v

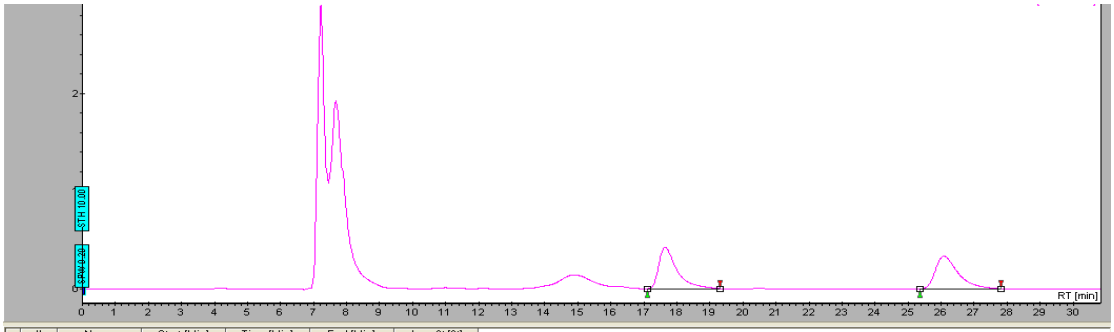


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	13.684	14.386	15.201	50.019
2	UNKNOWN	15.466	16.079	17.297	49.981
Total					100.000

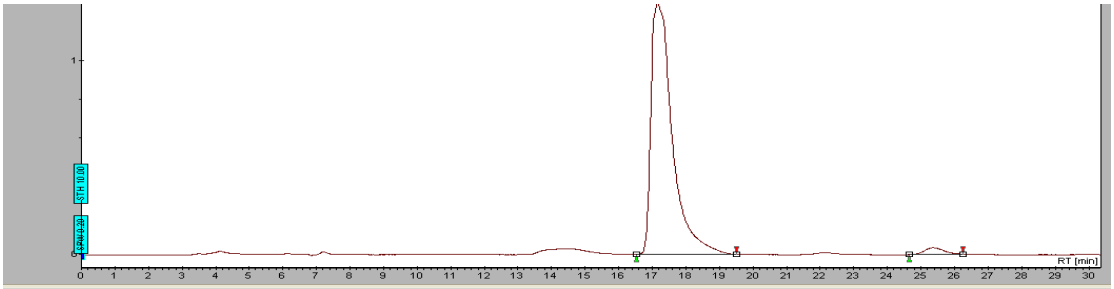


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	13.547	14.292	15.331	97.067
2	UNKNOWN	15.823	16.199	16.805	2.933
Total					100.000

3w

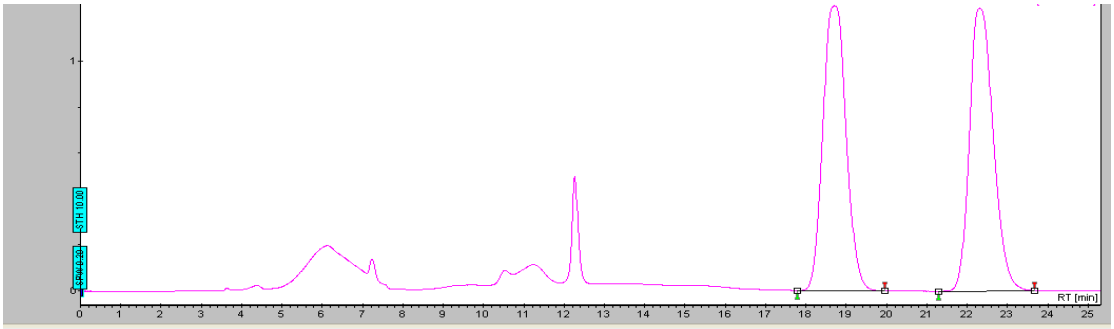


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	17.109	17.639	19.307	49.953
2	UNKNOWN	25.360	26.078	27.813	50.047
Total					100.000

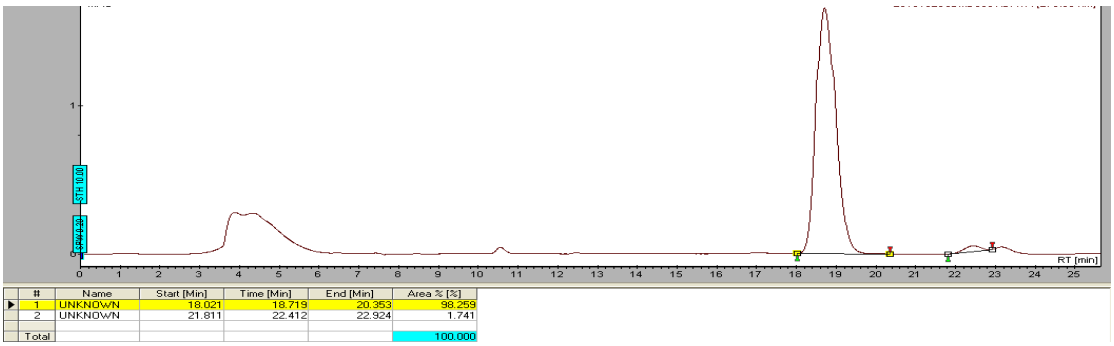


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	16.519	17.172	19.519	97.683
2	UNKNOWN	24.665	25.358	26.238	2.317
Total					100.000

3x

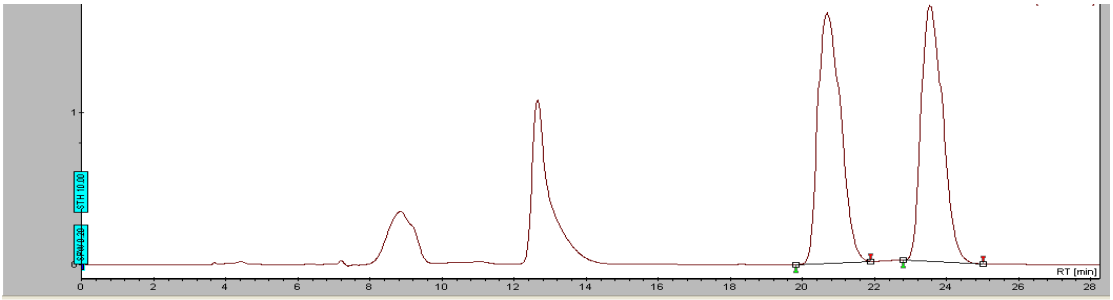


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	17.787	18.705	19.958	49.609
2	UNKNOWN	21.292	22.305	23.672	50.391
Total					100.000

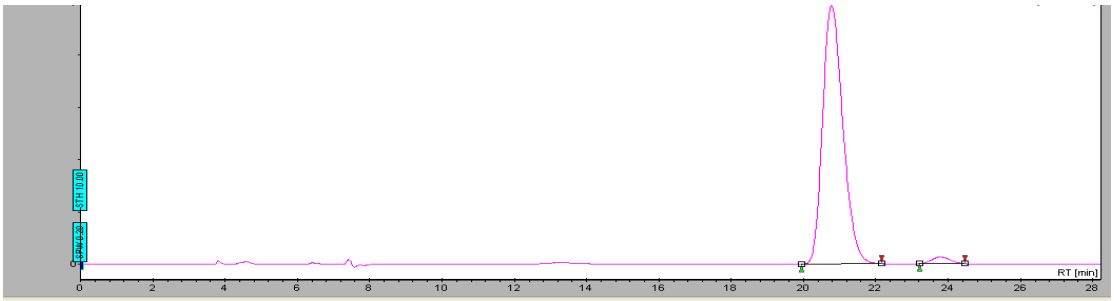


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	18.021	18.719	20.353	98.259
2	UNKNOWN	21.811	22.412	22.924	1.741
Total					100.000

3y

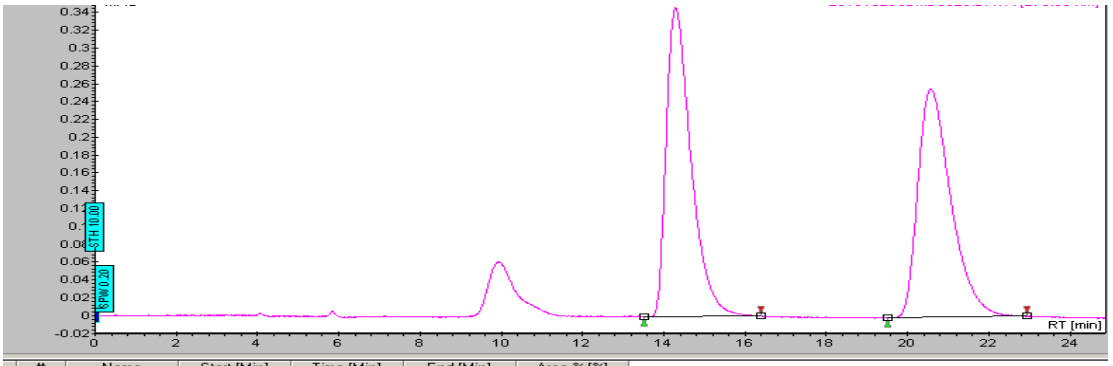


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	19.818	20.692	21.890	50.869
2	UNKNOWN	22.795	23.532	25.014	49.131
Total					100.000

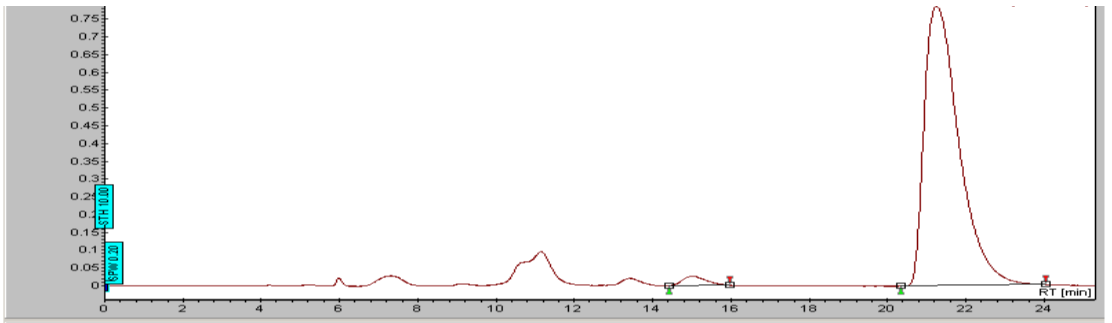


#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	19.945	20.772	22.161	97.725
2	UNKNOWN	23.211	23.785	24.465	2.275
Total					100.000

3z



#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	13.514	14.292	16.390	50.354
2	UNKNOWN	19.509	20.572	22.939	49.646
Total					100.000



#	Name	Start [Min]	Time [Min]	End [Min]	Area % [%]
1	UNKNOWN	14.416	15.012	15.966	2.208
2	UNKNOWN	20.337	21.252	24.038	97.792
Total					100.000

8、Single X-Ray data of compound 3a

Table 1. Crystal data and structure refinement for 20180907y03_0m_a.

Identification code	20180907y03_0m_a	
Empirical formula	C46 H37 F2 N4 O4 S2	
Formula weight	811.91	
Temperature	173(2) K	
Wavelength	0.71073 Å	
Crystal system	Orthorhombic	
Space group	$P2_12_12_1$	
Unit cell dimensions	a = 8.434(7) Å	α= 90°.
	b = 10.662(10) Å	β= 90°.
	c = 44.27(4) Å	γ = 90°.
Volume	3981(6) $Å^3$	
Z	4	
Density (calculated)	1.355 Mg/m^3	
Absorption coefficient	0.194 mm^{-1}	
F(000)	1692	
Crystal size	0.220 x 0.190 x 0.170 mm^3	
Theta range for data collection	2.120 to 25.007°.	
Index ranges	-10<=h<=8, -12<=k<=12, -52<=l<=52	
Reflections collected	29211	
Independent reflections	6998 [R(int) = 0.0405]	
Completeness to theta = 25.007°	99.9 %	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	6998 / 366 / 582	
Goodness-of-fit on F^2	1.026	
Final R indices [I>2sigma(I)]	R1 = 0.0531, wR2 = 0.1260	
R indices (all data)	R1 = 0.0618, wR2 = 0.1309	
Absolute structure parameter	-0.03(3)	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.547 and -0.335 $e.Å^{-3}$	