Supporting Information 1

Stereoselective Radical Amination of Electron-Deficient C(sp^3)–H Bonds by Co(II)-Based Metalloradical Catalysis: Direct Synthesis of α-Amino Acid Derivatives via α-C–H Amination

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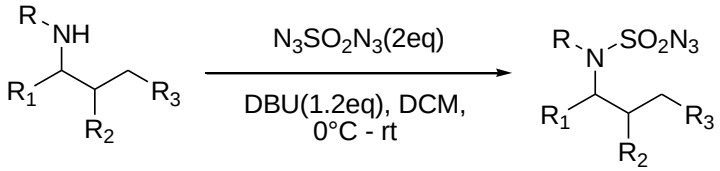
General Considerations. All cross-coupling and C-H amination reactions were performed under nitrogen in oven-dried glassware following standard Schlenk techniques. 4 Å molecular sieves were dried in a vacuum oven prior to use. Anhydrous benzene was purchased from Sigma-Aldrich and used without further purification. [Co(**P1**)] and [Co(**P2**)] was prepared by following the literature.[1] Thin layer chromatography was performed on Merck TLC plates (silica gel 60 F254). Flash column chromatography was performed with ICN silica gel (60 Å, 230-400 mesh, 32-63 μm). ^{1}H NMR and ^{13}C NMR were recorded on a Varian Inova400 (400 MHz), Inova500 (500 MHz), Inova600 (600 MHz) or Bruker250 (250 MHz) instrument with chemical shifts reported relative to residual solvent. Infrared spectra were measured with a Nicolet Avatar 320 spectrometer with a Smart Miracle accessory. HRMS data was obtained on an Agilent 1100 LC/MS/TOF mass spectrometer.

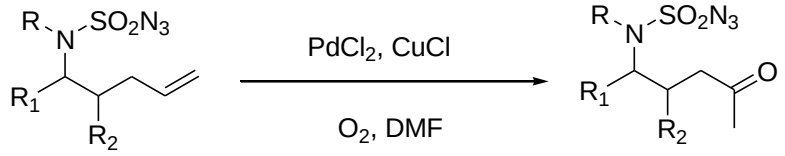
General Experimental Procedures for Preparation of Sulfamoyl Azides
Method A



Sulphuryl Azide.[2] To a solution of sodium azide (2.6 g, 40 mmol) and pyridine (1.58 g, 20 mmol) in acetonitrile (50 ml) at 0 ^{o}C, sulphuryl chloride (1.34 g, 10 mmol) in acetonitrile (20 ml) was added dropwise for 10 min. Then the reaction mixture was stirred for a further 1 h at room temperature. After addition of 30 ml DCM, the mixture was poured into ice-cold water and extracted with DCM (3 x 20 mL) The combined organic layer was washed with hydrochloric acid (1 mol/L in H_2O), water, potassium hydroxide (1 mol/L in H_2O), hydrochloric acid (1 mol/L in H_2O), and water. After drying (Na_2SO_4), the sulphuryl azide solution was used directly for the subsequent reaction. This solution can be stored in the refrigerator for at least two months without significant decomposition.

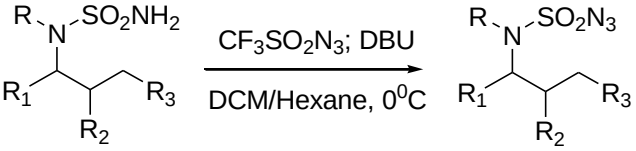
To a solution of $N_3SO_2N_3$ (2 eq, 0.25 mol/L in DCM) at 0 °C, a mixture of amine (1 eq) and DBU (1.2 eq) in DCM was added dropwise via syringe. The reaction showed almost complete consumption of the starting amine after 5 min to 3 hours when monitored by TLC, then the majority of the solvent was removed under reduced pressure at room temperature. Purification of this mixture by chromatography on silica gel (as given below) afforded the sulfamoyl azide. Note: Some azides could be explosive and should be handled carefully. Based on DSC experiments (see Page S24, DSC spectrogram of azide **1a**), this type of azide is stable under the reaction conditions used.

Method B



A solution of *N*-bishomoallylic sulfamoyl azides[3] (0.5 mmol) in a 10:1 DMF/H_2O mixture (11 ml) was treated with $PdCl_2$ (35 mg, 0.2 mmol) and CuCl (248 mg, 2.5 mmol), then the reaction mixture was stirred under O_2 at room temperature for 6h. 30ml H_2O was added to the reaction mixture. Extracted with Et_2O(3 x 30ml). The combined organic layer was washed by water. After drying (Na_2SO_4), removing most of solvent at room temperature, the reaction mixture was purified by chromatography on silica gel (as given below) to afford desired azides. Note: Some azides could be explosive and should be handled carefully. Based on DSC experiments (see Page S24, DSC spectrogram of azide **1a**), this type of azide is stable under the reaction conditions used.

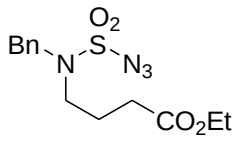
Method C



To a solution of the sulfamoyl amide (1eq) and DBU (1.2eq) in DCM at 0 ^{0}C, a solution of $CF_3SO_2N_3$ (about 2eq) in hexane was added drop wise. The reaction showed almost complete consumption of the starting sulfamoyl amide after five minutes to one hour when monitored by TLC. Then the majority of the DCM was removed carefully under reduced pressure at room temperature. Purification of this mixture by chromatography on silica gel (as given below) afforded the corresponding sulfamoyl azide. Note: Some azides could be explosive and should be handled carefully. Based on DSC experiments (see Page S24, DSC spectrogram of azide **1a**), this type of azide is stable under the reaction conditions used.

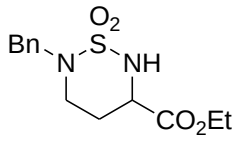
General Procedure for C–H Amination of Sulfamoyl Azides

An oven dried Schlenk tube was charged with catalyst (0.002 mmol) and 4Å MS (50 mg), then evacuated and back filled with nitrogen. The Teflon screw cap was replaced with a rubber septum and then an approximately 0.5 ml portion of benzene was added, then azide (0.1 mmol), followed by the remaining benzene (total 1 mL). The Schlenk tube was then purged with nitrogen for 2 minutes and the rubber septum was replaced with a Teflon screw cap. The Schlenk tube was then placed in an oil bath for the desired time and temperature. After completion of the reaction, the reaction mixture was purified by flash column chromatography. The fractions containing product were collected and concentrated by rotary evaporation to afford the target compound.



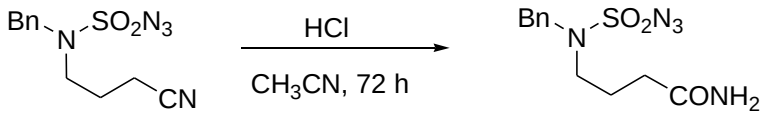
1a

Prepared according to METHOD A (yield: 74%). Purified by chromatography on silica gel (4:1 hexanes/EtOAc), colorless liquid, TLC R_f = 0.43 (4:1 hexanes/EtOAc). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.36-7.32 (m, 5H), 4.44 (s, 2H), 4.08 (q, *J* = 7.3 Hz, 2H), 3.29-3.22 (m, 2H), 2.24 (t, *J* = 7.3 Hz, 2H), 1.90-1.77 (m, 2H), 1.21 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR (62.9 MHz, $CDCl_3$): δ 172.4, 134.5, 128.9, 128.6, 128.5, 60.6, 52.6, 47.8, 30.7, 22.5, 14.1. IR (neat, cm^{-1}): 2125, 1731, 1375, 1164, 1099, 737, 699.



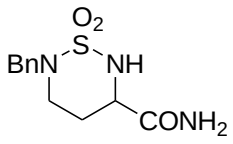
2a

Yield: 98%. Purified by chromatography on silica gel (gradient elution: 4:1-2:1 hexanes/EtOAc), white solid, TLC R_f = 0.17 (4:1 hexanes/EtOAc). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.34-7.25 (m, 5H), 4.71 (d, *J* = 8.8 Hz, 1H), 4.44, 4.00 (AB q, *J* = 13.8 Hz, each 1H), 4.39-4.32 (m, 1H), 4.23 (q, *J* = 7.0 Hz, 2H), 3.40 (dt, *J* = 3.3, 13.3 Hz, 1H), 3.19-3.09 (m, 1H), 1.94-1.67 (m, 2H), 1.27 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (62.9 MHz, $CDCl_3$): δ 169.5, 135.1, 128.7, 128.1, 62.2, 57.4, 51.6, 47.0, 25.9, 14.1. IR (neat, cm^{-1}): 1742, 1331, 1306, 1206, 1165, 1144, 1114, 1036, 861, 776, 747, 694. HRMS (ESI) ([M+Na]$^+$) Calcd. for $C_{13}H_{18}N_2O_4SNa$ 321.0880, Found 321.0875.



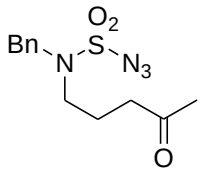
1d **1b**

To a solution of conc. HCl (1 ml) and CH_3CN (1 ml) was added azide **1d** (279.0mg, 1.0 mmol), the reaction continued for 3 days. The reaction mixture was then diluted with CH_2Cl_2 (10 mL) and added to a separatory funnel. H_2O (10 mL) was added and the aqueous and organic layers were separated. The aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layer was then dried over Na_2SO_4, filtered, and concentrated *in vacuo*. Purified by chromatography on silica gel (gradient elution: 1:1(hexanes/EtOAc)-1/20 (EtOAc/MeOH)) to afford **1b** (59.4mg, 0.2mmol) in 20% yield, colorless liquid, TLC R_f = 0.38 (EtOAc). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.36 (s, 5H), 5.40 (brs, 2H), 4.45 (s, 2H), 3.27 (t, *J* = 7.0 Hz, 2H), 2.17 (t, *J* = 7.0 Hz, 2H), 1.92-1.80 (m, 2H). ^{13}C NMR (62.9 MHz, $CDCl_3$): δ 173.8, 134.5, 128.9, 128.8, 128.5, 52.6, 47.9, 31.8, 22.7. IR (neat, cm^{-1}): 3356, 2126, 1666, 1375, 1205, 1163, 1012, 784, 737, 698.



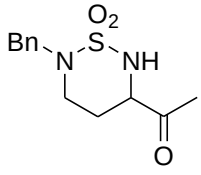
2b

Yield: 97%. Purified by chromatography on silica gel (gradient elution: 30:1-15:1 $CHCl_3$/MeOH), white solid, TLC R_f = 0.50 (10:1 DCM/MeOH). ^{1}H NMR (250 MHz, $(CD_3)_2CO$): δ 7.42-7.28 (m, 5H), 7.10 (brs, 1H), 6.68 (brs, 1H), 5.75 (brs, 1H), 4.40, 4.07 (AB q, *J* = 14.3 Hz, each 1H), 4.27 (dd, *J* = 6.5, 8,5 Hz, 1H), 3.44-3.31(m, 1H), 3.19 (dt, *J* = 13.5, 4.0 Hz, 1H), 1.92-1.82 (m, 2H). ^{13}C NMR (62.9 MHz, $(CD_3)_2CO$): δ 171.4, 137.4, 129.4, 129.3, 128.5, 59.1, 52.0, 48.4, 25.7. IR (neat, cm^{-1}): 1674, 1326, 1204, 1142, 1099, 810, 781, 752, 699. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{11}H_{16}N_3O_3S$ 270.0907, Found 270.0905.



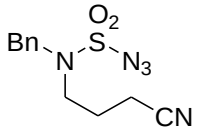
1c

Prepared according to METHOD B (yield: 47%). Purified by chromatography on silica gel (the gradient elution: 4:1-2:1 Hexanes/ EtOAc), colorless liquid, TLC R_f = 0.70 (1:1 Hexane/EtOAc). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.35 (brs, 5H), 4.43 (s, 2H), 3.21 (t, *J* = 7.3 Hz, 2H), 2.38 (t, *J* = 6.8 Hz, 2H), 2.06 (s, 3H), 1.83-1.70 (m, 2H). ^{13}C NMR (62.9 MHz, $CDCl_3$): δ 207.4, 134.5, 128.9, 128.7, 128.5, 52.6, 47.8, 39.5, 29.9, 20.9. IR (neat, cm^{-1}): 2124, 1714, 1373, 1163, 1025, 774, 735, 698.



2c

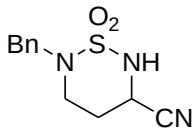
Yield: 99%. Purified by chromatography on silica gel (the gradient elution: 4:1-2:1 Hexanes/ EtOAc), colorless liquid, TLC R_f = 0.39 (1:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.35-7.27 (m, 5H), 4.79 (d, *J* = 9.6 Hz, 1H), 4.47-4.39 (m, 1H), 4.41, 4.00 (AB q, *J* = 14.0 Hz, each 1H), 3.42 (dt, *J* = 2.8, 13.2Hz, 1H), 3.18 (dq, *J* = 13.2, 3.2 Hz, 1H), 2.24 (s, 3H), 1.86 (dq, *J* = 14.0, 3.2 Hz, 1H), 1.66-1.54 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 202.4, 135.0, 128.7, 128.1, 63.2, 51.6, 47.1, 26.8, 25.2. IR (neat, cm^{-1}): 1717, 1336, 1160, 1105, 808, 767, 725, 697. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{12}H_{17}N_2O_3S$ 269.0954, Found 269.0950.



1d

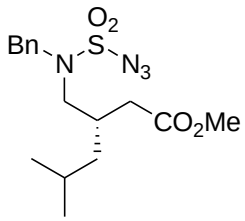
Prepared according to METHOD A (yield: 59%). Purified by chromatography on

silica gel (4:1 hexanes/EtOAc), colorless liquid, TLC R_f = 0.50 (4:1 hexanes/EtOAc). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.44-7.31 (m, 5H), 4.43 (s, 2H), 3.32 (t, *J* = 7.0 Hz, 2H), 2.23 (t, *J* = 7.3 Hz, 2H), 1.85-1.73 (m, 2H). ^{13}C NMR (62.9 MHz, $CDCl_3$): δ 134.1, 129.1, 128.9, 128.7, 118.5, 53.8, 47.7, 24.0, 14.4. IR (neat, cm^{-1}): 2128, 1376, 1200, 1164, 1104, 782, 736, 698.



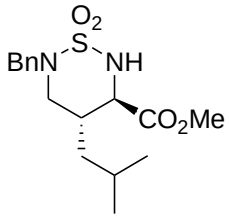
2d

Yield: 99%. Purified by chromatography on silica gel (4:1 hexanes/EtOAc), white liquid; TLC R_f = 0.30 (4/1 hexanes/EtOAc). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.41-7.28 (m, 5H), 4.66 (br, 2H), 4.41, 4.11 (AB q, *J* = 13.8 Hz, each 1H), 3.44-3.23 (m, 2H), 2.03-1.96 (m, 2H). ^{13}C NMR (62.9 MHz, $CDCl_3$): δ 134.3, 128.9, 128.7, 128.4, 116.0, 51.9, 46.1, 46.0, 26.3. IR (neat, cm^{-1}): 1363, 1168, 1120, 754, 735, 695. HRMS (ESI) ($[M+Na]^+$) Calcd. for $C_{11}H_{13}N_3O_2SNa$ 274.0621, Found 274.0618.



1e

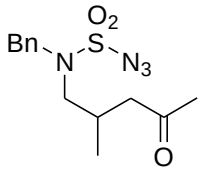
Prepared according to METHOD A (yield 20%). Purified by chromatography on silica gel (the gradient elution: 10:1-4:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.45 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.34 (brs, 5H), 4.46 (dd, *J* = 35.2, 15.2 Hz, 2H), 3.63 (s, 3H), 3.23-3.01 (m, 2H), 2.30-2.14 (m, 3H), 1.49-1.42 (m, 1H), 1.11-1.05 (m, 2H), 0.80 (d, *J* = 6.8 Hz, 3H), 0.73 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 172.9, 134.3, 129.0, 128.8, 128.5, 53.4, 53.0, 51.6, 41.1, 36.2, 31.1, 25.1, 22.8, 22.1. IR: 2124, 1730, 1375, 1163, 1099, 1018, 735, 698.



(cis/trans75/25)**2e**

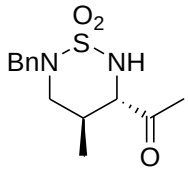
Yield: 90%. Purified by chromatography on silica gel (4:1 Hexane/ EtOAc), pale yellow solid, TLC R_f = 0.28 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36-7.27 (m, 5H), 4.83 (d, *J* = 11.2 Hz, 0.25H), 4.78 (d, *J* = 13.2 Hz, 0.25H), 4.62-4.55 (m, 1H), 4.46 (d, *J* = 13.6 Hz, 0.75H), 4.05 (t, *J* = 8.1 Hz, 0.75H), 3.98 (d, *J* = 14.0 Hz, 0.75H), 3.77 (s, 2.25H), 3.75 (s, 0.75H), 3.51 (d, *J* = 13.6 Hz, 0.25H), 3.21-3.16 (m, 0.25H), 3.10-2.91 (m, 1.75H), 2.03-1.96 (m, 0.25H), 1.93-1.84 (m, 0.75H), 1.61-1.48 (m, 0.25H), 1.29-1.22 (m, 1H), 1.06-0.92 (m, 1.5H), 0.90-0.81 (m,

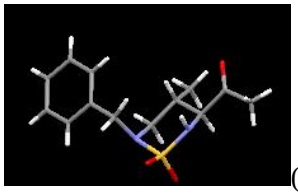
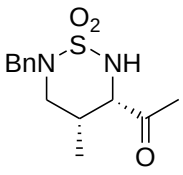
0.25H), 0.76 (d, *J* = 6.4 Hz, 2.25H), 0.65 (d, *J* = 6.4 Hz, 3H), 0.61 (d, *J* = 6.4 Hz, 0.75H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.8, 169.0, 135.0, 134.9, 129.0, 128.7, 128.6, 128.5, 128.1, 63.0, 61.2, 52.7, 52.0, 51.9, 51.3, 50.0, 37.5, 34.4, 33.7, 33. 4, 25.1, 24.6, 23.4, 23.3, 21.1, 20.9. IR (neat, cm^{-1}): 1739, 1345, 1297, 1169, 1098, 784, 742, 700. HRMS (ESI) ($[M+Na]^+$) Calcd. for $C_{16}H_{24}N_2O_4SNa$ 363.1349, Found 363.1358.



(≈95% pure) **1f**

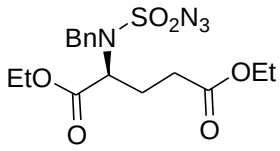
Prepared according to METHOD B (yield 53%). Purified by chromatography on silica gel (4:1 Hexanes/ EtOAc), colorless liquid, TLC R_f = 0.26 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.37-7.31 (m, 5H), 4.44 (d, *J* = 3.6 Hz, 2H), 3.14 (dd, *J* = 7.6, 14.0 Hz, 1H), 3.01 (dd, *J* = 6.8, 14.0 Hz, 1H), 2.45 (dd, *J* = 5.2, 16.8 Hz, 1H), 2.31-2.16 (m, 2H), 2.05 (s, 3H), 0.86 (t, *J* = 6.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 207.2, 134.3, 129.0, 128.8, 128.5, 54.1, 53.1, 47.4, 30.3, 27.1, 17.6. IR (neat, cm^{-1}): 2125, 1713, 1373, 1205, 1165, 1024, 779, 737.




(major) **2f**


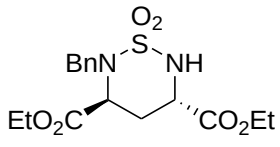
(minor) **2f**

Yield: 91(major/minor = 5.3/1). Purified by chromatography on silica gel (the gradient elution: 4:1-2:1 Hexane/ EtOAc). Major one: white solid, TLC R_f = 0.64 (1:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.35-7.28 (m, 5H), 4.52 (d, *J* = 10.4 Hz, 1H), 4.45, 3.93 (AB q, *J* = 14.0 Hz, each 1H), 4.10 (t, *J* = 10.4 Hz, 1H), 3.05-2.94 (m, 2H), 2.32 (s, 3H), 2.00-1.91 (m, 1H), 0.88 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 204.1, 135.0, 128.7, 128.1, 67.7, 54.1, 51.8, 31.3, 30.5, 14.6. IR (neat, cm^{-1}): 1718, 1346, 1167, 1107, 1033, 1011, 894, 780, 736, 699. HRMS (ESI) ($[M+Na]^+$) Calcd. for $C_{13}H_{18}N_2O_3SNa$ 305.0930, Found 305.0927. Minor one: white solid, TLC R_f = 0.57 (1:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36-7.26 (m, 5H), 4.99 (d, *J* = 10.0 Hz, 1H), 4.76, 3.57 (AB q, *J* = 14.0 Hz, each 1H), 4.59 (dd, *J* = 10.4, 3.2 Hz, 1H), 3.36 (dd, *J* = 12.4, 2.8 Hz, 1H), 2.85 (dd, *J* = 12.4, 2.4 Hz, 1H), 2.22-2.16 (m, 1H), 2.18 (s, 3H), 0.89 (d, *J* = 6.8 Hz, 3h). ^{13}C NMR (100 MHz, $CDCl_3$): δ 201.4, 135.0, 128.8, 128.7, 128.0, 66.3, 54.0, 51.5, 29.9, 26.7, 11.2. IR (neat, cm^{-1}): 1725, 1359, 1333, 1293, 1171, 1091, 1033, 1009, 774, 742, 701. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{13}H_{19}N_2O_3S$ 283.1111, Found 283.1107.



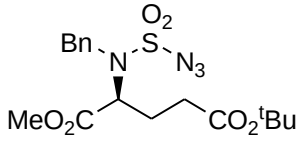
1g

Prepared according to METHOD A (yield 12%). Purified by chromatography on silica gel (gradient elution: 10:1-6:1 Hexanes/ EtOAc), colorless liquid, TLC R_f = 0.39 (4:1 Hexane/EtOAc). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.39-7.26 (m, 5H), 4.68, 4.41 (AB q, *J* = 15.8 Hz, each 1H), 4.52-4.45 (m, 1H), 4.22-3.98 (m, 4H), 2.26-2.08 (m, 3H), 1.97-1.78 (m, 1H), 1.25 (t, *J* = 7.0 Hz, 3H), 1.18 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (63.9 MHz, $CDCl_3$): δ 172.2, 169.6, 135.3, 128.8, 128.7, 128.4, 62.2, 60.9, 60.6, 51.6, 30.0, 24.8, 14.2, 14.0. IR (neat, cm^{-1}): 2129, 1733, 1377, 1164, 1021, 805, 743.



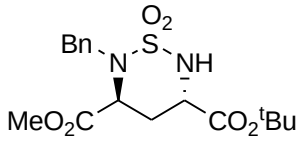
2g (trans/trans = 85/15)

Yield: 99%. Purified by chromatography on silica gel (1:2 Hexanes/ EtOAc), colorless liquid, TLC R_f = 0.6 (1:1 Hexane/EtOAc). Major One: ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.40-7.28 (m, 5H), 4.76-4.52 (m, 4H), 4.27-4.20 (m, 4H), 3.85 (dd, *J* = 2.4, 5.2 Hz, 1H), 2.40 (dt, *J* = 13.6, 2.8 Hz, 1H), 1.69-1.60 (m, 1H), 1.33 (t, *J* = 6.8 Hz, 3H), 1.28 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.8, 169.7, 134.9, 128.8, 128.3, 62.3, 61.9, 56.4, 55.1, 51.9, 26.1, 14.1, 14.0. IR (neat, cm^{-1}): 1732, 1372, 1210, 1167, 1112, 1026, 774, 734, 697. HRMS (ESI) ([M+H]$^+$) Calcd. for $C_{16}H_{23}N_2O_6S$ 371.1271, Found 371.1263.



1h

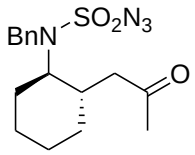
Prepared according to METHOD C (yield 56%). Purified by chromatography on silica gel (the gradient elution: 10:1-4:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.45 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.40-7.25 (m, 5H), 4.68 (d, *J* = 16.0 Hz, 1H), 4.57-4.52 (m, 1H), 4.43 (d, *J* = 16.0 Hz, 1H), 3.68 (s, 3H), 2.21-2.06 (m, 3H), 1.88-1.81 (m, 1H), 1.38 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.3, 170.1, 135.3, 128.7, 128.4, 80.8, 60.8, 52.7, 51.3, 31.0, 28.0, 24.8. IR (neat, cm^{-1}): 2129, 1725, 1367, 1205, 1154, 744, 699.



2h (trans/cis = 94/6)

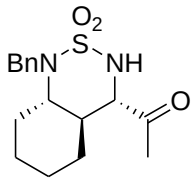
Yield: 94%. Purified by chromatography on silica gel (4:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.17 (4:1 Hexane/EtOAc). Major One: ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.40-7.25 (m, 5H), 4.68-4.50 (m, 4H), 3.86 (dd, *J* = 5.6, 2.4 Hz, 1H), 3.78 (s, 3H),

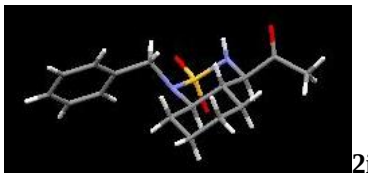
2.38-2.33 (m, 1H), 1.66-1.58 (m, 1H), 1.45 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$): 170.4, 168.8, 134.8, 128.9, 128.8, 128.3, 83.5, 56.4, 55.5, 52.7, 51.9, 27.9, 25.8. IR (neat, cm^{-1}): 1731, 1367, 1220, 1154, 1116, 753, 697. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{17}H_{25}N_2O_6S$ 385.1428, Found 385.1447.



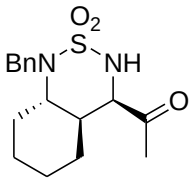
1i

Prepared according to METHOD B (yield 12%). Purified by chromatography on silica gel (10:1 Hexane/ EtOAc), white solid, TLC R_f = 0.19 (10:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.41-7.27 (m, 5H), 4.49-4.19 (m, 2H), 3.44 (brs, 1H), 2.61-2.55 (m, 1H), 1.98-1.92 (m, 2H), 1.89 (s, 3H), 1.85-1.78 (m, 2H), 1.63-1.56 (m, 2H), 1.30-1.10 (m, 3H), 0.92-0.79 (m, 1H). ^{13}C NMR(100 MHz, $CDCl_3$): δ 207.3, 135.8, 129.0, 128.8, 128.3, 64.2, 46.5, 36.3, 32.7, 30.5, 30.1, 25.9, 25.1. IR (neat, cm^{-1}): 2123, 1716, 1371, 1203, 1165, 1026, 737.



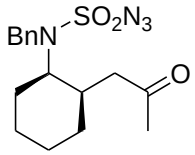


2i(major)



2i(minor)

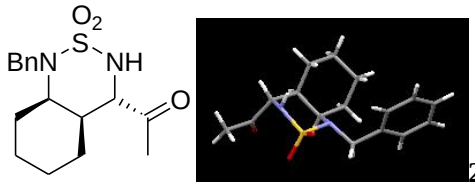
Yield: 91% (Major/minor = 3.2/1). Purified by chromatography on silica gel (the gradient elution: 4:1-2:1 Hexane/ EtOAc). Major one: white solid, TLC R_f = 0.42 (2:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36-7.28 (m, 4H), 7.25-7.20 (m, 1H), 4.40 (d, *J* = 10.4 Hz, 1H), 4.39, 4.26 (AB q, *J* = 16.4 Hz, each 1H), 4.19 (t, *J* = 10.4 Hz, 1H), 3.62 (dt, *J* = 3.6, 11.2 Hz, 1H), 2.31 (s, 3H), 1.82-1.76 (m, 1H), 1.73-1.59 (m, 4H), 1.23-1.09 (m, 4H). ^{13}C NMR(62.9 MHz, $CDCl_3$): δ 204.9, 138.7, 128.5, 127.2, 127.1, 66.6, 63.7, 48.2, 39.6, 31.3, 31.1, 27.6, 24.8, 24.7. IR (neat, cm^{-1}): 1719, 1357, 1169, 1128, 1016, 830, 787, 735, 698. HRMS (ESI) ($[M+Na]^+$) Calcd. for $C_{16}H_{22}N_2O_3SNa$ 345.1243, Found 345.1253. Minor one: white solid, TLC R_f = 0.32 (2:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.35-7.28 (m, 4H), 7.26-7.21 (m, 1H), 4.40 (d, *J* = 6.4 Hz, 1H), 4.55, 4.22 (AB q, *J* = 16.4 Hz, each 1H), 3.97 (t, *J* = 6.4 Hz, 1H), 3.51 (dt, *J* = 3.6, 10.8 Hz, 1H), 2.28 (s, 3H), 2.13-2.02 (m, 1H), 1.87-1.83 (m, 1H), 1.73-1.52 (m, 3H), 1.23-1.09 (m, 4H). ^{13}C NMR(100 MHz, $CDCl_3$): δ 203.8, 138.5, 128.5, 127.4, 127.3, 63.9, 60.9, 49.3, 41.5, 31.6, 29.1, 27.5, 25.8, 24.6. IR (neat, cm^{-1}): 1716, 1453, 1347, 1180, 1163, 1135, 1015, 860, 795, 733, 699. HRMS (ESI) ($[M+Na]^+$) Calcd. for $C_{16}H_{22}N_2O_3SNa$ 345.1243, Found 345.1254.



1j

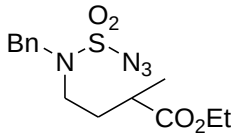
Prepared according to METHOD B (yield 59%). Purified by chromatography on silica

gel (the gradient elution: 10:1-4:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.29 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.38-7.28 (m, 5H), 4.54, 4.47 (AB q, *J* = 16.4 Hz, each 1H), 3.75-3.69 (m, 1H), 2.75-2.69 (m, 1H), 2.51 (dd, *J* = 4.0, 16.4 Hz, 1H), 2.41 (dd, *J* = 9.6, 16.4 Hz, 1H), 2.05 (s, 3H), 1.82-1.73 (m, 3H), 1.59-1.53 (m, 1H), 1.46-1.37 (m, 2H), 1.28-1.20 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 207.5, 136.4, 128.8, 128.0, 127.8, 63.6, 51.9, 40.6, 33.0, 30.1, 29.3, 26.3, 25.8, 19.6. IR (neat, cm^{-1}): 2123, 1715, 1375, 1205, 1165, 735.



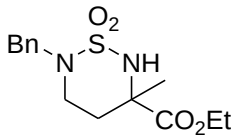
2j

Yield: 95%. Purified by chromatography on silica gel (the gradient elution: 4:1-2:1 Hexane/ EtOAc), white solid, TLC R_f = 0.57 (1:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36-7.26 (m, 5H), 4.57, 4.13 (AB q, *J* = 14.8 Hz, each 1H), 4.59-4.48 (m, 2H), 3.16 (dt, *J* = 11.6, 4.0 Hz, 1H), 2.34 (s, 3H), 2.24-2.06 (m, 2H), 1.95-1.88 (m, 1H), 1.77-1.70 (m, 1H), 1.66-1.60 (m, 1H), 1.53-1.48 (m, 1H), 1.38-1.33 (m, 2H), 1.10-1.04 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 204.7, 135.9, 128.7, 128.3, 127.9, 61.1, 59.2, 49.1, 38.1, 30.6, 26.9, 24.7, 24.2, 21.4. IR (neat, cm^{-1}): 1715, 1306, 1180, 1150, 1121, 1035, 1027, 838, 795, 720, 696. HRMS (ESI) ($[M+Na]^+$) Calcd. for $C_{16}H_{22}N_2O_3SNa$ 345.1243, Found 345.1252.



1k

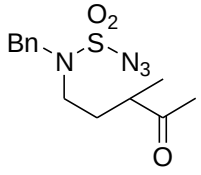
Prepared according to METHOD A (yield 69%). Purified by chromatography on silica gel (the gradient elution: 10:1-4:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.44 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.37-7.28 (m, 5H), 4.42 (s, 2H), 4.06 (q, *J* = 7.2 Hz, 2H), 3.30-3.15 (m, 2H), 2.39-2.30 (m, 1H), 1.97-1.86 (m, 1H), 1.66-1.56 (m, 1H), 1.19 (t, *J* = 7.2 Hz, 3H), 1.08 (d, J = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.3, 134.5, 128.8, 128.5, 128.4, 60.4, 52.4, 46.5, 36.6, 30.8, 17.1, 14.0. IR (neat, cm^{-1}): 2124, 1728, 1377, 1188, 1166, 1026, 735, 699.



2k

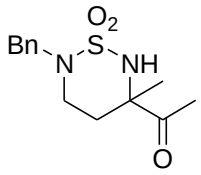
Yield: 99%. Purified by chromatography on silica gel (the gradient elution: 4:1-2:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.22 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): 7.34-7.28 (m, 5H), 4.94 (s, 1H), 4.44, 4.04 (AB q, *J* = 14.0 Hz, each 1H), 4.24 (q, *J* = 7.2 Hz, 2H), 3.51-3.43 (m, 1H), 3.25-3.18 (m, 1H), 2.06-1.99 (m, 1H), 1.73-1.65 (m, 1H), 1.54 (s, 3H), 1.29 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz,

$CDCl_3$): δ 172.8, 135.3, 128.7, 128.6, 128.0, 62.2, 61.9, 51.6, 44.7, 28.5, 25.3, 14.0. IR (neat, cm^{-1}): 1732, 1348, 1331, 1165, 1109, 1020, 857, 768, 723, 670. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{14}H_{21}N_2O_4S_3$ 13.1217, Found 313.1217.



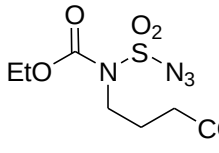
1l

Prepared according to METHOD B (yield 60%). Purified by chromatography on silica gel (the gradient elution: 10:1-4:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.31 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.37-7.31 (m, 5H), 4.44, 4.39 (AB q, *J* = 15.2 Hz, each 1H), 3.26-3.09 (m, 2H), 2.50-2.42 (m, 1H), 2.05 (s, 3H), 1.97-1.87 (m, 1H), 1.48-1.39 (m, 1H), 1.01 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 211.0, 134.6, 128.9, 128.7, 128.5, 52.8, 46.8, 43.8, 29.7, 28.1, 16.6. IR (neat, cm^{-1}): 2125, 1171, 1376, 1205, 1165, 1033, 735, 699.



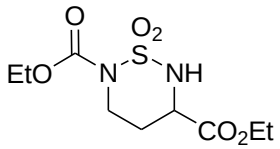
2l

Yield: 91%. Purified by chromatography on silica gel (the gradient elution: 2:1-1:1 Hexane/ EtOAc), white solid, TLC R_f = 0.45 (1:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36-7.28 (m, 5H), 4.72 (s, 1H), 4.34, 3.99 (AB q, *J* = 14.0 Hz, each 1H), 3.28-3.20 (m, 1H), 3.09 (dq, *J* = 13.6, 4.8 Hz, 1H), 2.34 (s, 3H), 2.25-2.18 (m, 1H), 1.51-1.42 (m 1H), 1.38 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 207.0, 135.1, 128.8, 128.7, 128.1, 66.7, 51.6, 45.3, 29.2, 25.3, 23.8. IR (neat, cm^{-1}): 1720, 1332, 1157, 1136, 1104, 932, 861, 776, 725, 697. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{13}H_{19}N_2O_3S$ 283.1111, Found 283.1116.



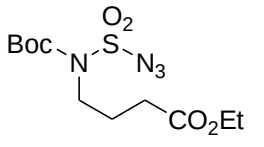
1m

Prepared according to METHOD C (yield 89%). Purified by chromatography on silica gel (the gradient elution: 10:1-4:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.32 (10:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 4.33 (q, *J* = 7.2 Hz, 2H), 4.09 (q, *J* = 7.2 Hz, 2H), 3.81 (t, *J* = 7.2 Hz, 2H), 2.31 (t, *J* = 7.2 Hz, 2H), 1.99-1.88 (m, 2H), 1.34 (t, *J* = 7.2 Hz, 3H), 1.21 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 172.2, 152.1, 64.6, 60.5, 48.5, 30.8, 24.3, 14.1. IR (neat, cm^{-1}): 2153, 1734, 1398, 1262, 1168, 1097, 1027, 766.



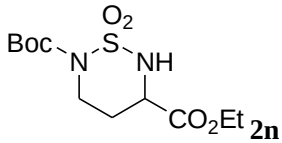
2m

Yield: 65%. Purified by chromatography on silica gel (4:1 Hexane/ EtOAc), white solid, TLC R_f = 0.23 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.11 (d, *J* = 9.6 Hz, 1H), 4.41-4.20 (m, 6H), 3.80 (ddd, *J* = 2.8, 10.8, 13.6 Hz, 1H), 2.30-2.22 (m, 1H), 1.93-1.82 (m, 1H), 1.33 (t, *J* = 7.2 Hz, 3H), 1.28 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.3, 152.6, 64.0, 62.6, 56.3, 45.7, 28.2, 14.2, 14.0. IR (neat, cm^{-1}): 1724, 1376, 1311, 1281, 1199, 1171, 1125, 1020, 758. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_9H_{17}N_2O_6S$ 281.0802, Found 281.0795.



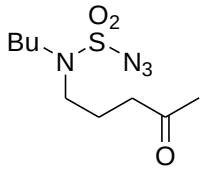
1n

Prepared according to METHOD C (yield 91%). Purified by chromatography on silica gel (the gradient elution: 10:1-4:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.41 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 4.10 (q, *J* = 7.2 Hz, 2H), 3.76 (t, *J* = 7.2 Hz, 2H), 2.31 (t, *J* = 7.2 Hz, 2H), 1.97-1.89 (m, 2H), 1.53 (s, 9H), 1.22 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 172.3, 150.6, 86.1, 60.5, 48.4, 30.9, 27.9, 24.4, 14.1. IR (neat, cm^{-1}): 2149, 1730, 1671, 1395, 1372, 1262, 1176, 1142, 1098, 714.



2n

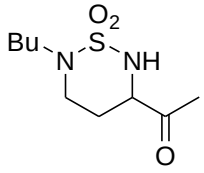
Yield: 72%. Purified by chromatography on silica gel (2:1 Hexane/ EtOAc), white solid, TLC R_f = 0.57 (1:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 4.99 (d, *J* = 9.2 Hz, 1H), 4.38-4.11 (m, 4H), 3.78-3.70 (m, 1H), 2.31-2.22 (m, 1H), 1.91-1.80 (m, 1H), 1.51 (s, 9H), 1.29 (t, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.4, 151.1, 84.6, 62.6, 56.2, 45.2, 28.4, 28.0, 14.1. IR (neat, cm^{-1}): 2924, 1723, 1465, 1362, 1317, 1290, 1259, 1178, 1147, 1124, 1032, 1021, 802. HRMS (ESI) ($[M+Na]^+$) Calcd. for $C_{11}H_{20}N_2O_6SNa$ 331.0934, Found 331.0928.



1o

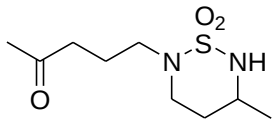
Prepared according to METHOD B (yield 53%). Purified by chromatography on silica gel (the gradient elution: 10:1-4:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.32 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 3.20 (t, *J* = 7.6 Hz, 4H), 2.47 (t,

J = 6.8 Hz, 2H), 2.10 (s, 3H), 1.86-1.78 (m, 2H), 1.60-1.51 (m, 2H), 1.34-1.24 (m, 2H), 0.89 (t, J = 7.6 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 207.3, 49.1, 48.2, 39.6, 29.9, 29.6, 21.6, 19.7, 13.5. IR (neat, cm^{-1}): 2121, 1716, 1378, 1204, 1160, 762, 731.



2oA

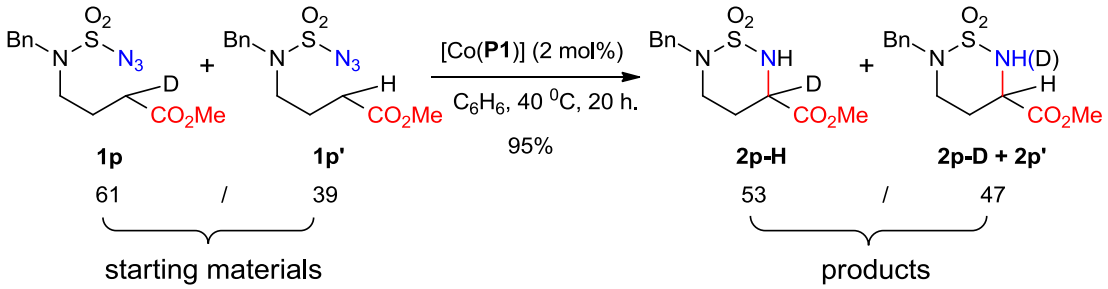
Yield: 80%. Purified by chromatography on silica gel (the gradient elution: 2:1-1:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.34 (1:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 4.68 (d, J = 9.2 Hz, 1H), 4.39 (ddd, J = 3.2, 9.2, 12.0 Hz, 1H), 3.59-3.50 (m, 1H), 3.36-3.29 (m, 1H), 3.12-3.04 (m, 1H), 2.99-2.91 (m, 1H), 2.24 (s, 3H), 1.94-1.87 (m, 1H), 1.70-1.58 (m, 1H), 1.56-1.47 (m, 2H), 1.38-1.27 (m, 2H), 0.90 (t, J = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 202.7, 63.2, 48.2, 48.1, 29.6, 26.8, 25.0, 19.8, 13.6. IR (neat, cm^{-1}): 1718, 1404, 1354, 1162, 1092, 813, 751, 700. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_9H_{19}N_2O_3S$ 235.1111, Found 235.1115.



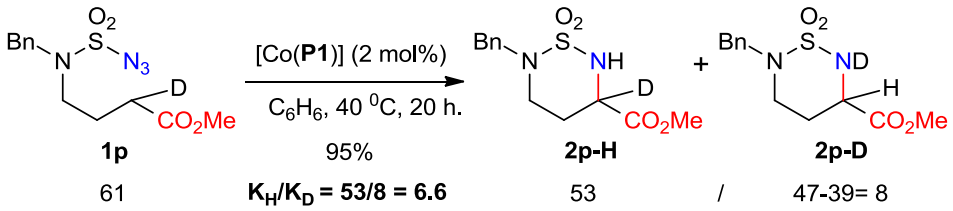
2oB

Yield: 12%. Purified by chromatography on silica gel (the gradient elution: 2:1-1:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.32 (1:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 3.76-3.66 (m, 1H), 3.63-3.60 (m, 1H), 3.38 (dt, J = 2.8, 12.8 Hz, 1H), 3.25-3.13 (m, 2H), 2.92-2.84 (m, 1H), 2.51 (t, J = 6.8 Hz, 2H), 2.14 (s, 3H), 1.86-1.77 (m, 2H), 1.68-1.62 (m, 1H), 1.51-1.45 (m, 1H), 1.20 (d, J = 6.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 208.2, 52.3, 48.8, 47.7, 40.4, 31.0, 30.2, 21.5, 21.3. IR (neat, cm^{-1}): 1713, 1331, 1164, 1134, 1082, 735, 669. HRMS (ESI) ($[M+Na]^+$) Calcd. $C_9H_{18}N_2O_3SNa$ 257.0930, Found 257.0929.

Detailed Experimental Results for Kinetic Isotopic Effect (Scheme 3)

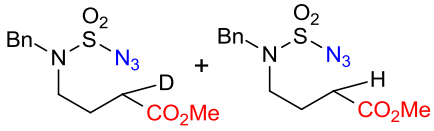


Calculated Results after Removing 39% Non-deuterated Substrate 1p' and Corresponding Product 2p'(Scheme 3)



1p 95% **2p-H** **2p-D**

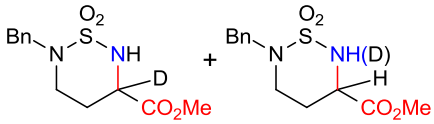
61 **K_H/K_D = 53/8 = 6.6** 53 / 47-39= 8



1p **1p'**

61 / 39

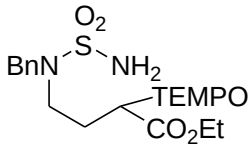
Prepared according to METHOD A (yield 96%). Purified by chromatography on silica gel (the gradient elution: 10:1-4:1 Hexane/ EtOAc), colorless liquid, TLC R_f = 0.43 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 (brs, 5H), 4.43 (s, 2H), 3.62 (s, 3H), 3.25 (t, *J* = 7.2 Hz, 2H), 2.27-2.21 (m, 1.39H), 1.88-1.80 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 172.8, 134.5, 128.9, 128.6, 128.5, 52.7, 51.6, 47.8, 30.5, 30.4, 30.2, 30.0, 22.5, 22.4. IR (neat, cm^{-1}): 2126, 1735, 1378, 1202, 1164, 1101, 736, 698. HRMS (ESI) ($[M+Na]^+$) Calcd. for $C_{12}H_{15}DN_4O_4SNa$ 336.0847, Found 336.0857; for $C_{12}H_{16}N_4O_4SNa$ 335.0785, Found 335.0798.



2p-H **2p-D+2p'**

53 / 47

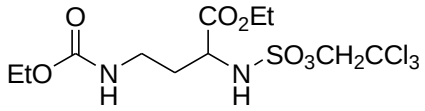
Yield: 95%. Purified by chromatography on silica gel (4:1 Hexane/ EtOAc), white solid, TLC R_f = 0.18 (4:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42-7.24 (m, 5H), 4.75-4.71 (m, 1H), 4.51-4.34 (m, 1.47H), 4.01 (dd, *J* = 10.0, 2.0 Hz, 1H), 3.78 (s, 3H), 3.48-3.32 (m, 1H), 3.18-3.12 (m, 1H), 2.00-1.70 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.0, 135.0, 128.7, 128.1, 57.3, 53.0, 51.7, 47.0, 25.8, 25.7. IR (neat, cm^{-1}): 1735, 1341, 1284, 1256, 1152, 1131, 1109, 1006, 848, 764, 738, 697. HRMS (ESI) ($[M+Na]^+$) Calcd. for $C_{12}H_{15}DN_2O_4SNa$ 308.0786, Found 308.0805; for $C_{12}H_{16}N_2O_4S$ 307.0723, Found 307.0744.



3a

Purified by chromatography on silica gel (20:1 DCM/ EtOAc), white solid, TLC R_f = 0.27 (10:1 DCM/EtOAc). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.36-7.25 (m, 5H), 4.55 (s, 2H), 4.41, 4.31 (AB q, *J* = 15.0 Hz, each 1H), 4.25 (dd, *J* = 3.5, 8.5 Hz, 1H), 4.16-4.07 (m, 2H), 3.30-3.23 (m, 1H), 3.20-3.13 (m, 1H), 2.19-2.11 (m, 1H), 2.09-2.02 (m, 1H), 1.63-1.46 (m, 2H), 1.40 (brs, 4H), 1.23 (t, *J* = 7.0 Hz, 3H),

1.08-0.98 (m, 12H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 173.0, 135.7, 128.7, 128.6, 128.0, 83.2, 60.9, 60.1, 59.8, 51.4, 42.8, 40.3, 40.2, 33.8, 32.9, 29.9, 20.2, 20.1, 17.0, 14.1. IR (neat, cm^{-1}): 1718, 1459, 1354, 1196, 1141, 1046, 1008, 890, 774, 732, 697. HRMS (ESI) ($[M+Na]^+$) Calcd. for $C_{22}H_{37}N_3O_5SNa$ 478.2346, Found 478.2354.



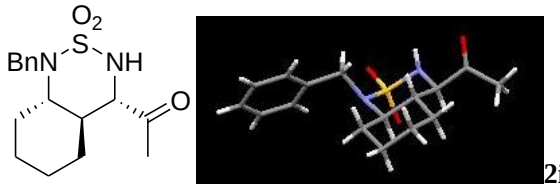
4m

To a solution of cyclic sulfamide **2m** (0.2 mmol, 1.0 equiv) in 2.0 mL of 1,4-dioxane and 0.5 mL of 2,2,2-trichloroethanol was added DMAP (0.3 mmol, 1.5 equiv). The mixture was stirred at 80 °C for 3 h. The reaction was then cooled to 23 °C and the solution concentrated under reduced pressure to an oily residue. Purified by chromatography on silica gel (the gradient elution: 2:1-1:1 Hexane/ EtOAc), Yield 88%. colorless liquid, TLC R_f = 0.62 (1:1 Hexane/EtOAc). ^{1}H NMR (400 MHz, $CDCl_3$): δ 6.23 (d, *J* = 8.4 Hz, 1H), 4.95 (t, *J* = 6.0 Hz, 1H), 4.64 (s, 2H), 4.25-4.17 (m, 3H), 4.12-4.06 (m, 2H), 3.53-3.45 (m, 1H), 3.26-3.17 (m, 1H), 2.6-2.08 (m, 1H), 1.94-1.85 (m, 1H), 1.27 (t, *J* = 7.2 Hz, 3H), 1.22 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.4, 156.9, 93.2, 78.1, 62.4, 61.1, 54.1, 36.5, 32.6, 14.5, 14.0. IR (neat, cm^{-1}): 1693, 1525, 1372, 1261, 1183, 1090, 1016, 854, 757, 722. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{11}H_{20}Cl_3N_2O_7S$ 429.0051, Found 429.0044.

X-ray Crystallography

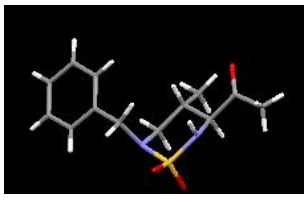
The X-ray diffraction data were collected using Bruker-AXS SMART-APEXII CCD diffractometer (CuKα, λ = 1.54178 Å). Indexing was performed using *APEX2* [1] (Difference Vectors method). Data integration and reduction were performed using SaintPlus 6.01 [2]. Absorption correction was performed by multi-scan method implemented in SADABS [3]. Space groups were determined using XPREP implemented in APEX2 [1]. Structures were solved using SHELXS-97 (direct methods) and refined using SHELXL-97 (full-matrix least-squares on F^2) contained in APEX2 [1] and WinGX v1.70.01 [4,5,6,7] programs packages. All non-hydrogen atoms were refined anisotropically. **2i:** The H1N atom was found in the Fourier difference map and refined using distance restraint with Uiso(H) = 1.2Ueq(-NH). **2f:** The H1N atom was found in the Fourier difference map and freely refined. **2j:** The H1N atom was found in the Fourier difference map and freely refined. **2p:** Atom H2N has been found on the difference Fourier map and freely refined. The rest of hydrogen atoms were placed in geometrically calculated positions and were included in the refinement process using riding model with isotropic thermal parameters: Uiso(H) = 1.5Ueq(-CH3), Uiso(H) = 1.2Ueq(-CH,-CH2). Crystal data and refinement conditions are shown in Tables 1 - 4.

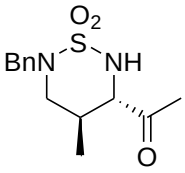
[1] Bruker (2010). *APEX2*). Bruker AXS Inc., Madison, Wisconsin, USA.
[2] Bruker (2009). SAINT. Data Reduction Software. Bruker AXS Inc., Madison, Wisconsin, USA.
[3] Sheldrick, G. M. (2008). *SADABS. Program for Empirical Absorption Correction.* University of Gottingen, Germany.
[4] Farrugia L.J. Appl. Cryst. (1999). 32, 837±838
[5] Sheldrick, G.M. (1997) SHELXL-97. Program for the Refinement of Crystal
[6] Sheldrick, G.M. (1990) Acta Cryst. A46, 467-473
[7] Sheldrick, G. M. (2008). Acta Cryst. A64, 112-122.



2i(major)

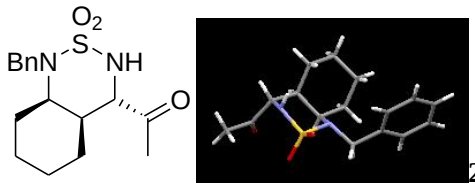
Table 1. Crystal data and structure refinement for compound **2i**	
Identification code	**2i**
Empirical formula	C16 H22 N2 O3 S
Formula weight	322.42
Temperature	100(2) K
Wavelength	1.54178 A
Crystal system, space group	Monoclinic, P21/n
Unit cell dimensions	a = 5.0990(2) A alpha = 90 deg.
	b = 15.0874(7) A beta = 96.234(3) deg.
	c = 20.8353(10) A gamma = 90 deg.
Volume	1593.39(12) A^3
Z, Calculated density	4, 1.344 Mg/m^3
Absorption coefficient	1.928 mm^-1
F(000)	688
Crystal size	0.20 x 0.18 x 0.15 mm
Theta range for data collection	3.62 to 65.79 deg.
Limiting indices	-4<=h<=5, -17<=k<=17, -24<=l<=24
Reflections collected / unique	13569 / 2685 [R(int) = 0.0922]
Completeness to theta = 65.79	97.8 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7608 and 0.6991
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	2685 / 1 / 204
Goodness-of-fit on F^2	1.008
Final R indices [I>2sigma(I)]	R1 = 0.0461, wR2 = 0.1119
R indices (all data)	R1 = 0.0664, wR2 = 0.1239
Largest diff. peak and hole	0.257 and -0.455 e.A^-3





2f(major)

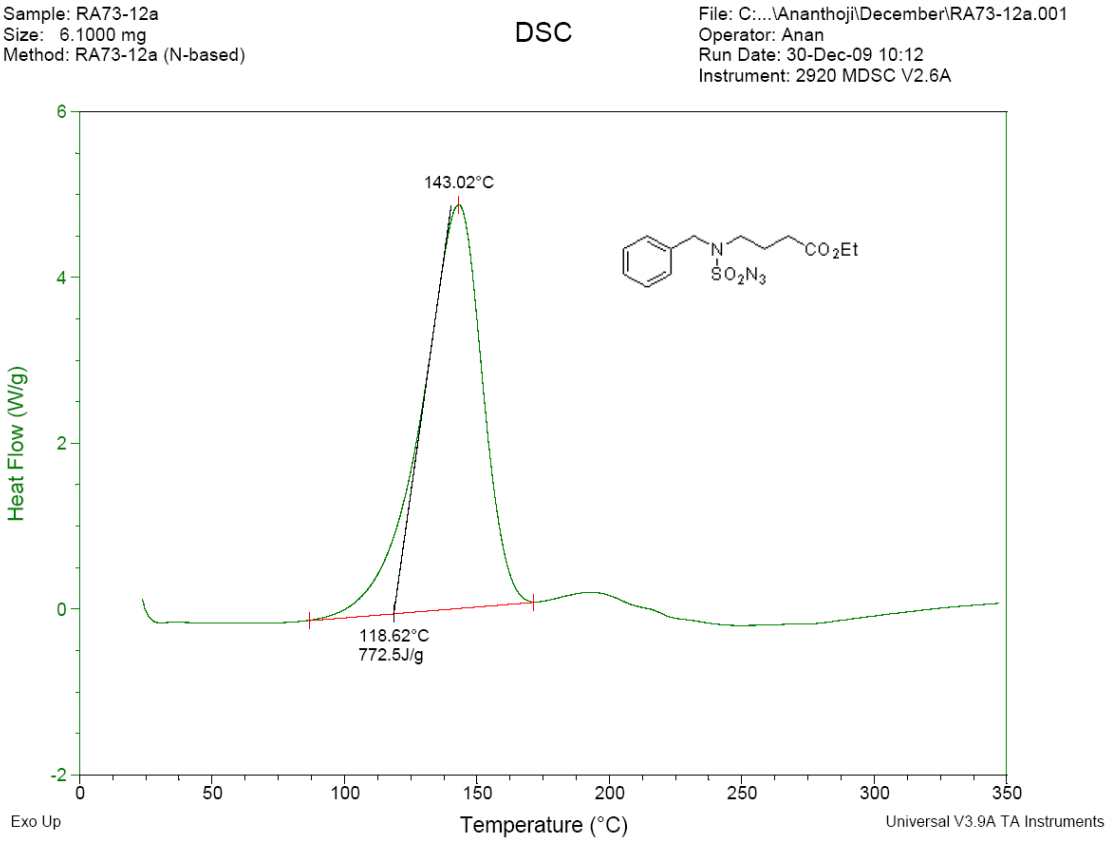
Table 2. Crystal data and structure refinement for compound **2f**	
Identification code	**2f**
Empirical formula	C13 H18 N2 O3 S
Formula weight	282.35
Temperature	100(2) K
Wavelength	1.54178 A
Crystal system, space group	Monoclinic, P21/c
Unit cell dimensions	a = 10.1217(2) A alpha = 90 deg.
	b = 5.26760(10) A beta = 98.6910(10) deg.
	c = 25.2607(5) A gamma = 90 deg.
Volume	1331.36(5) A^3
Z, Calculated density	4, 1.409 Mg/m^3
Absorption coefficient	2.226 mm^-1
F(000)	600
Crystal size	0.20 x 0.18 x 0.15 mm
Theta range for data collection	3.54 to 66.59 deg.
Limiting indices	-12<=h<=11, -6<=k<=5, -29<=l<=30
Reflections collected / unique	12939 / 2342 [R(int) = 0.0499]
Completeness to theta = 66.59	99.2 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7313 and 0.6645
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	2342 / 0 / 179
Goodness-of-fit on F^2	1.079
Final R indices [I>2sigma(I)]	R1 = 0.0364, wR2 = 0.0941
R indices (all data)	R1 = 0.0414, wR2 = 0.0969
Extinction coefficient	0.0031(4)
Largest diff. peak and hole	0.389 and -0.379 e.A^-3



2j

Table 3. Crystal data and structure refinement for compound **2j**	
Identification code	**2j**
Empirical formula	C16 H22 N2 O3 S
Formula weight	322.42
Temperature	100(2) K
Wavelength	1.54178 A
Crystal system, space group	Monoclinic, P21/c
Unit cell dimensions	a = 10.5533(2) A alpha = 90 deg.
	b = 14.5967(2) A beta = 96.7800(10) deg.
	c = 10.1764(2) A gamma = 90 deg.
Volume	1556.64(5) A^3
Z, Calculated density	4, 1.376 Mg/m^3
Absorption coefficient	1.974 mm^-1
F(000)	688
Crystal size	0.20 x 0.20 x 0.18 mm
Theta range for data collection	4.22 to 66.56 deg.
Limiting indices	-12<=h<=12, -17<=k<=17, -12<=l<=12
Reflections collected / unique	19566 / 2740 [R(int) = 0.0569]
Completeness to theta = 66.56	99.3 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7177 and 0.6936
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	2740 / 0 / 205
Goodness-of-fit on F^2	1.044
Final R indices [I>2sigma(I)]	R1 = 0.0351, wR2 = 0.0904
R indices (all data)	R1 = 0.0404, wR2 = 0.0941
Extinction coefficient	0.0038(3)
Largest diff. peak and hole	0.354 and -0.453 e.A^-3

DSC of compound **1a**



References

1) (a) Lu, H.; Tao, J; Jones, J. E.; Wojtas, L.; Zhang, X. P. *Org. Lett.* **2010**, *12*, 1248. (b) Xu, X.; Lu, H.; Ruppel, J. V.; Cui, X.; Lopez de Mesa, S.; Wojtas, L.; Zhang, X. P. *J. Am. Chem. Soc.* **2011**, *133*, 15292.

2) Nojima, M. *J. Chem. Soc., Perkin Trans. 1*, **1979**, 1811.

3) Lu, H.; Jiang, H.; Yang, H.; Wojtas, L.; Zhang, X. P. *Chem. Sci.* **2011**, *2*, 2361.

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