Supporting information for

Enantioselective Addition of Oxazolones to *N*-Protected Imines Catalyzed by Chiral Thioureas

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Contents

1. General Information

All reactions were carried out in oven-dried glassware under argon. The commercially available chemicals were used without purification. THF, toluene and dioxane were distilled from Na/benzophenone, CH_2Cl_2 and MeCN from CaH_2 under argon at 760 Torr. Thin layer chromatography (TLC) was performed on pre-coated aluminium-backed plates (Merck Kieselgel 60 F254) and visualized by ultraviolet irradiation, potassium permanganate or phosphomolybdic acid solution dip. Column and flash chromatography were performed on silica gel with particle size 0.040-0.065 mm in diameter.

NMR spectra were acquired on Varian NMR System 300 and 600 spectrometers, running at 300 or 600 MHz for ^{1}H and 75 or 150 MHz for ^{13}C and DEPT, respectively. Chemical shifts (δ) are reported in ppm relative to tetramethylsilane (TMS) as an internal standard. The following abbreviations are used to indicate the multiplicity in ^{1}H NMR spectra: s, singlet; bs, broad singlet; d, doublet; dd, double doublet; ddd, double double doublet; t, triplet; dt, double triplet; q, quartet; dq, double quartet; p, pentet; m, multiplet. IR spectra were measured at Nikolet IS10 spectrometer. HRMS was measured on a mass spectrometer with H-ESI Orbitrap ionization in positive mode. HPLC was performed on Daicel Chiralpak AD-H and IA columns with UV detection at 240 nm. Optical rotation measurements were performed on Jasco P-2000 polarimeter. CD spectra were measured on Jasco J-815 CD spectrometer.

Catalysts **1a**,[1] **1b**,[2] **2a**,[3] **2b**,[4] **3**,[5] **4** – **5**,[6] **6**,[7] and **7**[8] were synthesized following the corresponding literature procedures.

Azlactones **9a**[9] and **9b**[10] were synthesized from the corresponding *N*-benzoyl amino acids. *N*-benzoyl alanine, *N*-benzoyl phenylalanine9 and *N*-benzoyl valine[11] were prepared following the literature procedures.

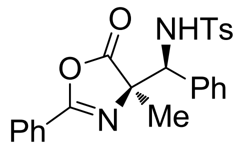
N-benzylidenemethanesulfonamide,[12] *N*-benzylidene-2,4,6-trimethylbenzenesulfonamide, *N*-benzylidene-2,4,6-tris(isopropyl)benzenesulfonamide[13] and *N*-benzylidenenaphthalene-2-sulfonamide[14] were synthesized utilizing the corresponding literature procedures.

2. General Procedure for the Mannich Reaction

An oven-dried Schlenk tube was charged with imine (0.1 mmol), azlactone (0.12 mmol, 1.2 eq.), catalyst (0.01 mmol, 10 mol %) and acid co-catalyst (0.01 mmol, 10 mol %) if not stated otherwise. The solvent (0.5 mL) was then added. After stirring at room temperature for 18 h, the solution was concentrated *in vacuo* and the residue was purified by silica gel column chromatography (eluant petroleum ether/EtOAc) to afford the product.

[1] (a) Wenzel, A. G.; Jacobsen, E. N. *J. Am. Chem. Soc.* **2002**, *124*, 12964-12965; (b) Puglisi, A.; Raimondi, A.; Benaglia, M.; Bonsignore, M; Rossi, S. *Tet. Lett.* **2009**, *50*, 4340-4342.
[2] Reisman, S. E.; Doyle, A. G.; Jacobsen, E. N. *J. Am. Chem. Soc.* **2008**, *130*, 7198-7199.
[3] Dudziński, K.; Pakulska, A. M.; Kwiatkowski, P. *Org. Lett.* **2012**, *14*, 4222-4226.
[4] Berkessel, A.; Seelig, B. *Synthesis* **2009**, 2113-2115.
[5] Reisman, S. E.; Doyle, A. G.; Jacobsen, E. N. *J. Am. Chem. Soc.* **2008**, *130*, 7198-7199.
[6] Vakulya, B.; Varga, S.; Csámpai, A.; Soós, T. *Org. Lett.* **2005**, *7*, 1967-1969.
[7] Konishi, H.; Lam, T. Y.; Malerich, J. P.; Rawal, V. H. *Org. Lett.* **2010**, *12*, 2028-2031.
[8] Yang, W.; Du, D.-M. *Org. Lett.* **2010**, *12*, 5450-5453.
[9] Weber M.; Jautze, S.; Frey, W.; Peters, R. *J. Am. Chem. Soc.* **2010**, *132*, 12222-12225.
[10] Hugener, M.; Heimgartner, H. *Helv. Chim. Acta.* **1995**, 1863-1878.
[11] Wang, M. X.; Lin, S. J. *J. Org. Chem.* **2002**, *67*, 6542-6545.
[12] Shaghafi, M. B.; Grote, R. E.; Jarvo, E. R. *Org. Lett.* **2011**, *13*, 5188-5191.
[13] Kavanagh, S. A.; Piccinini, A.; Connon, S. J. *Org. Biomol. Chem.* **2013**, *11*, 3535-3540.
[14] Vishwakarma, L. C.; Stringer, O. D.; Davis, F. A. *Org. Synth.* **1988**, *66*, 203-210.

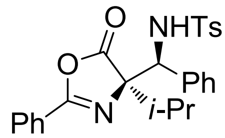
N-((S)-((R)-4-methyl-5-oxo-2-phenyl-4,5-dihydrooxazol-4-yl)(phenyl)methyl) benzenesulfonamide (10a)



Following the general procedure, **10a** was isolated after silica gel chromatography (eluant petroleum ether/EtOAc 4:1 - 3:1) as a white solid. $\mathbf{R_F}$ = 0.28 (petroleum ether/EtOAc 3:1). **^{1}H NMR (300 MHz, $CDCl_3$):** δ 7.95 – 7.85 (m, 2H), 7.65 – 7.48 (m, 2H), 7.48 – 7.31 (m, 4H), 7.18 – 7.04 (m, 4H), 6.96 (d, *J* = 8.0 Hz, 2H), 5.37 – 5.23 (m, 1H), 4.68 (d, *J* = 10.8 Hz, 1H), 2.29 (s, 3H), 1.33 (s, 3H). **^{13}C NMR (75 MHz, $CDCl_3$):** 179.2 (Cq), 161.8 (Cq), 143.2 (Cq), 136.7 (Cq), 135.3 (Cq), 133.1 (CH), 129.1 (CH), 129.0 (CH), 128.7 (CH), 128.2 (CH), 128.1 (CH), 127.9 (CH), 127.1 (CH), 125.3 (Cq), 72.9 (Cq), 62.3 (CH), 21.7 (CH_3), 21.4 (CH_3). **IR** (cm^{-1})**:** 3257, 2959, 2920, 1819, 1651, 1451, 1328, 1292, 1162, 1089, 1001, 911, 874, 811. **MS:** *m/z* 457.1 $[M+Na]^+$. **HPLC:** Chiralpak AD-H column, eluant = hexane/*i*-PrOH 85:15, flow rate = 0.8 mL.min^{-1}; *t* (major) = 19.8 min; *t* (minor) = 22.5 min.

The spectral data are in agreement with the literature data.[15]

N-((S)-((R)-4-isopropyl-5-oxo-2-phenyl-4,5-dihydrooxazol-4-yl)(phenyl)methyl)-4-methylbenzenesulfonamide (10b)



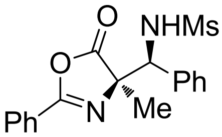
Following the general procedure, **10b** was isolated after silica gel chromatography (eluant petroleum ether/EtOAc 6:1 – 5:1) as a white solid. $\mathbf{R_F}$ = 0.41 (petroleum ether/EtOAc 3:1). $[\alpha]_D^{20}$ = +38.5 (*c* 1.4, $CHCl_3$, 90:10 *er*). **^{1}H NMR (300 MHz, $CDCl_3$):** δ 7.87 – 7.80 (m, 2H), 7.58 – 7.50 (m, 1H), 7.46 – 7.35 (m, 4H), 7.07 – 6.92 (m, 7H), 5.48 (d, *J* = 10.7 Hz, 1H), 4.98 (d, *J* = 10.8 Hz, 1H), 2.45 – 2.34 (m, 1H), 2.27 (s, 3H), 1.10 (d, *J* = 6.8 Hz, 3H), 0.90 (d, *J* = 6.8 Hz, 3H). **^{13}C NMR (75 MHz, $CDCl_3$):** δ 179.2 (Cq), 161.2 (Cq), 143.0 (Cq), 137.2 (Cq), 135.1 (Cq), 132.9 (CH), 129.1 (CH), 128.7 (CH), 128.0 (CH), 127.9 (CH), 127.83 (CH), 127.78

[15] Shi, S.-H.; Huang, F.-P.; Zhu, P.; Dong, Z.-W.; Hui, X.-P. *Org. Lett.* **2012**, *14*, 2010-2013.

(CH), 126.9 (CH), 125.1 (Cq), 79.9 (Cq), 59.4 (CH), 32.1 (CH), 21.4 (CH_3), 16.6 (CH_3), 16.3 (CH_3). **IR** (cm^{-1})**:** 3266, 2961, 1816, 1646, 1455, 1334, 1262, 1159, 1095, 1081, 1022, 944, 861. **MS:** *m/z* 485.2 $[M+Na]^+$. **HPLC:** Chiralpak AD-H column, eluant = hexane/*i*-PrOH 85:15, flow rate = 0.8 mL.min^{-1}; *t* (major) = 17.9 min; *t* (minor) = 22.1 min.

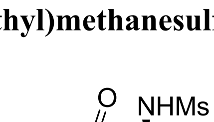
The spectral data are in agreement with the literature data.[16]

N-((*S*)-((*R*)-4-methyl-5-oxo-2-phenyl-4,5-dihydrooxazol-4-yl)(phenyl)methyl) methanesulfonamide (10c)



Following the general procedure, **10c** was isolated after silica gel chromatography (eluant petroleum ether/EtOAc 3:1 – 2:1) as a white solid. $\mathbf{R_F}$ = 0.13 (petroleum ether/EtOAc 3:1). **^{1}H NMR (300 MHz, DMSO-*d$_6$*):** δ 8.08 – 7.96 (m, 3H), 7.76 – 7.58 (m, 5H), 7.49 – 7.32 (m, 3H), 4.69 (d, *J* = 10.8 Hz, 1H), 2.30 (s, 3H), 1.20 (s, 3H). **^{13}C NMR (75 MHz, DMSO-*d$_6$*):** 179.6 (Cq), 160.8 (Cq), 136.7 (Cq), 133.5 (CH), 129.6 (CH), 129.4 (CH), 128.8 (CH), 128.7 (CH), 128.6 (CH), 126.2 (Cq), 73.7 (Cq), 63.2 (CH), 41.4 (CH_3), 21.3 (CH_3). **IR** (cm^{-1})**:** 3273, 3031, 2936, 1827, 1652, 1454, 1441, 1307, 1298, 1162, 1004, 976, 901, 877, 703. **MS:** *m/z* 381.1 $[M+Na]^+$. **HRMS:** calcd. for $[C_{18}H_{18}N_2O_4S+H]^+$ ($[M+H]^+$): *m/z* 359.1066, found: 359.1053. **HPLC:** Daicel IA column, eluant = hexane/ *i*-PrOH 85:15, flow rate = 1.0 mL.min^{-1}; *t* (major) = 8.2 min; *t* (minor) = 10.6 min.

N-((*S*)-((*R*)-4-isopropyl-5-oxo-2-phenyl-4,5-dihydrooxazol-4-yl)(phenyl)methyl)methanesulfonamide (10d)

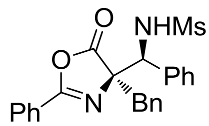


Following the general procedure, **10d** was isolated after silica gel chromatography (eluant petroleum ether/EtOAc 3:1) as a white solid. $\mathbf{R_F}$ = 0.50 (petroleum ether/EtOAc 3:1). **^{1}H NMR (300 MHz, $CDCl_3$):** δ 7.90 (d, *J* = 7.3 Hz, 2H), 7.62 – 7.51 (m, 1H), 7.50 – 7.40 (m, 4H), 7.36

[16] Liu, X.; Deng, L.; Jiang, X.; Yan, W.; Liu, C.; Wang, R. *Org. Lett.* **2010**, *12*, 876-879.

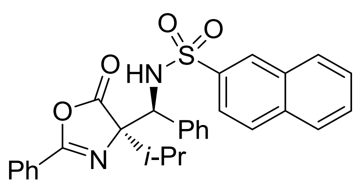
– 7.27 (m, 3H), 5.40 (d, *J* = 10.6 Hz, 1H), 5.04 (d, *J* = 10.7 Hz, 1H), 2.53 (s, 3H), 2.40 – 2.26 (m, 1H), 1.07 (d, *J* = 6.8 Hz, 3H), 0.97 (d, *J* = 6.8 Hz, 3H). **^{13}C NMR (75 MHz, $CDCl_3$):** δ 179.1 (Cq), 161.5 (Cq), 136.2 (Cq), 133.0 (CH), 128.8 (CH), 128.7 (CH), 128.1 (CH), 128.0 (CH), 125.1 (Cq), 79.9 (Cq), 59.6 (CH), 41.7 (CH_3), 32.1 (CH), 16.5 (CH_3), 16.3 (CH_3). **IR** (cm^{-1})**:** 3288, 2968, 2915, 2881, 1811, 1652, 1460, 1320, 1289, 1153, 1093, 1065, 1013, 969, 881, 763, 705, 696. **MS:** *m/z* 409.1 [M+Na]$^+$. **HRMS:** calcd. for [$C_{20}H_{22}N_2O_4S$+H]$^+$ ([M+H]$^+$): *m/z* 387.1379, found: 387.1367. **HPLC:** Daicel IA column, eluant = hexane/*i*-PrOH 80:20, flow rate = 1 mL.min^{-1}; *t* (major) = 6.8 min; *t* (minor) = 14.6 min.

N-((*S*)-((*R*)-4-benzyl-5-oxo-2-phenyl-4,5-dihydrooxazol-4-yl)(phenyl)methyl)methanesulfonamide (10e)



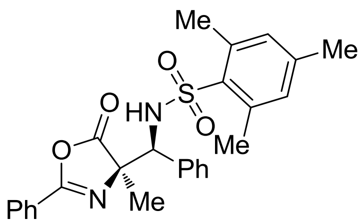
Following the general procedure, **10e** was isolated after silica gel chromatography (eluant petroleum ether/EtOAc 3:1) as a white solid. **R_F** = 0.41 (petroleum ether/EtOAc 3:1). **^{1}H NMR (300 MHz, $CDCl_3$):** δ 7.79 (d, *J* = 7.3 Hz, 2H), 7.61 – 7.48 (m, 3H), 7.45 – 7.32 (m, 5H), 7.15 – 6.99 (m, 5H), 5.37 (d, *J* = 10.8 Hz, 1H), 4.98 (d, *J* = 10.8 Hz, 1H), 3.21 (d, *J* = 13.4 Hz, 1H), 2.86 (d, *J* = 13.3 Hz, 1H), 2.50 (s, 3H). **^{13}C NMR (75 MHz, $CDCl_3$):** δ 178.3 (Cq), 161.9 (Cq), 136.4 (Cq), 133.3 (Cq), 133.0 (CH), 130.1 (CH), 129.1 (CH), 129.0 (CH), 128.7 (CH), 128.2 (CH), 128.1 (CH), 128.0 (CH), 127.3 (CH), 125.0 (Cq), 78.2 (Cq), 62.1 (CH), 41.7 (CH_3), 41.3 (CH_2). **IR** (cm^{-1})**:** 3273, 3030, 2922, 1816, 1651, 1495, 1320, 1289, 1157, 1057, 980, 878, 710. **MS:** *m/z* 435.1 [M+H]$^+$. **HRMS:** calcd. for [$C_{24}H_{22}N_2O_4S$+H]$^+$ ([M+H]$^+$): *m/z* 435.1379, found: 435.1371. **HPLC:** Daicel IA column, eluant = hexane/*i*-PrOH 80:20, flow rate = 1 mL.min^{-1}; *t* (major) = 9.4 min; *t* (minor) = 11.3 min.

N-((*S*)-((*R*)-4-methyl-5-oxo-2-phenyl-4,5-dihydrooxazol-4-yl)(phenyl)methyl) naphthalene-2-sulfonamide (10f)



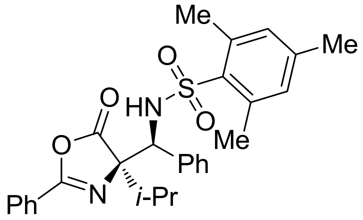
Following the general procedure, **10f** was isolated after silica gel chromatography (eluant petroleum ether/EtOAc 3:1) as a white solid. $\mathbf{R_F}$ = 0.20 (petroleum ether/EtOAc 3:1). **^{1}H NMR (300 MHz, CDCl$_3$):** δ 8.05 (d, *J* = 1.3 Hz, 1H), 7.83 – 7.76 (m, 2H), 7.76 – 7.69 (m, 2H), 7.63 – 7.30 (m, 7H), 7.01 – 6.94 (m, 2H), 6.81 – 6.68 (m, 3H), 5.66 (d, *J* = 10.8 Hz, 1H), 5.04 (d, *J* = 10.8 Hz, 1H), 2.42 – 2.28 (m, 1H), 1.07 (d, *J* = 6.8 Hz, 3H), 0.91 (d, *J* = 6.8 Hz, 3H). **^{13}C NMR (150 MHz, CDCl$_3$):** δ 179.2 (Cq), 161.3 (Cq), 137.0 (Cq), 134.8 (Cq), 134.5 (Cq), 132.9 (CH), 131.8 (Cq), 129.1 (CH), 128.9 (CH), 128.7 (CH), 128.54 (CH), 128.53 (CH), 128.0 (CH), 127.9 (CH), 127.8 (CH), 127.63 (CH), 127.61 (CH), 127.1 (CH), 125.1 (Cq), 122.0 (CH), 79.8 (Cq), 59.6 (CH), 32.1 (CH), 16.6 (CH_3), 16.4 (CH_3). **IR** (cm^{-1})**:** 3253, 3059, 2972, 2928, 1827, 1812, 1653, 1494, 1329, 1294, 1160, 1132, 1060, 1021, 939, 881, 710, 864. **MS:** *m/z* 521.2 $[M+Na]^+$. **HRMS:** calcd. for $[C_{29}H_{26}N_2O_4S+H]^+$ ($[M+H]^+$): *m/z* 499.1692, found: 499.1685. **HPLC:** Chiralpak AD-H column, eluant = hexane/*i*-PrOH 85:15, flow rate = 1.0 mL.min^{-1}; *t* (major) = 17.6 min; *t* (minor) = 21.8 min.

2,4,6-trimethyl-*N*-((*S*)-((*R*)-4-methyl-5-oxo-2-phenyl-4,5-dihydrooxazol-4-yl)(phenyl)methyl)benzenesulfonamide (10g)



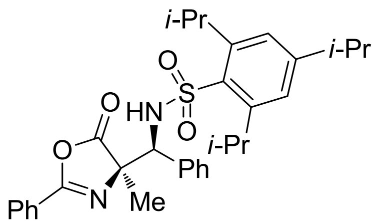
Following the general procedure, **10g** was isolated after silica gel chromatography (eluant petroleum ether/EtOAc 6:1) as a white solid. $\mathbf{R_F}$ = 0.21 (petroleum ether/EtOAc 6:1). **^{1}H NMR (300 MHz, CDCl$_3$):** δ 8.00 – 7.93 (m, 2H), 7.63 – 7.56 (m, 1H), 7.53 – 7.45 (m, 2H), 7.19 – 7.11 (m, 5H), 6.75 (s, 2H), 5.30 (d, *J* = 10.4 Hz, 1H), 4.56 (d, *J* = 10.4 Hz, 1H), 2.47 (s, 6H), 2.22 (s, 3H), 1.31 (s, 3H). **^{13}C NMR (75 MHz, CDCl$_3$):** δ 179.2 (Cq), 161.7 (Cq), 142.2 (Cq), 138.7 (Cq), 135.7 (Cq), 133.7 (Cq), 133.1 (CH), 131.7 (CH), 128.8 (CH), 128.3 (CH), 128.2 (CH), 128.1 (CH), 127.6 (CH), 125.3 (Cq), 72.8 (Cq), 62.3 (CH), 22.9 (CH_3), 21.7 (CH_3), 20.8 (CH_3). **IR** (cm^{-1})**:** 3317, 3033, 2937, 1818, 1654, 1450, 1330, 1319, 1158, 1001, 913, 685, 661. **MS:** *m/z* 485.2 $[M+Na]^+$. **HRMS:** calcd. for $[C_{26}H_{26}N_2O_4S+H]^+$ ($[M+H]^+$): *m/z* 463.1692, found: 463.1686. **HPLC:** Daicel IA column, eluant = hexane/*i*-PrOH 95:5, flow rate = 0.8 mL.min^{-1}; t_R (minor) = 17.7 min; t_R (major) = 19.1 min.

N-((S)-((R)-4-isopropyl-5-oxo-2-phenyl-4,5-dihydrooxazol-4-yl)(phenyl)methyl)-2,4,6-trimethylbenzenesulfonamide (10h)



Following the general procedure, **10h** was isolated after silica gel chromatography (eluant petroleum ether/EtOAc 6:1) as a white solid. $\mathbf{R_F}$ = 0.30 (petroleum ether/EtOAc 6:1). **^{1}H NMR (300 MHz, CDCl$_3$):** δ 7.88 – 7.81 (m, 2H), 7.59 – 7.50 (m, 1H), 7.47 – 7.39 (m, 2H), 7.14 – 6.92 (m, 5H), 6.70 (s, 2H), 5.56 (d, J = 10.4 Hz, 1H), 4.89 (d, J = 10.4 Hz, 1H), 2.47 (s, 6H), 2.38 – 2.24 (m, 1H), 2.19 (s, 3H), 1.01 (d, J = 6.8 Hz, 3H), 0.90 (d, J = 6.8 Hz, 3H). **^{13}C NMR (75 MHz, CDCl$_3$):** δ 179.1 (Cq), 161.3 (Cq), 141.9 (Cq), 138.3 (Cq), 135.5 (Cq), 134.5 (Cq), 132.9 (CH), 131.6 (CH), 128.7 (CH), 127.9 (2xCH), 127.8 (CH), 127.5 (CH), 125.2 (Cq), 79.8 (Cq), 59.5 (CH), 32.1 (CH), 22.9 (CH_3), 20.8 (CH_3), 16.4 (CH_3), 16.3 (CH_3). **IR** (cm^{-1})**:** 3030, 2935, 1809, 1651, 1603, 1452, 1331, 1291, 1175, 1021, 882, 701, 660. **MS:** *m/z* 513.2 [M+Na]$^+$. **HRMS:** calcd. for [$C_{28}H_{30}N_2O_4S$+H]$^+$ ([M+H]$^+$): *m/z* 491.2005, found: 491.1998. **HPLC:** Daicel IA column, eluant = hexane/*i*-PrOH 97:3, flow rate = 0.75 mL.min^{-1}; *t* (major) = 14.6 min; *t* (minor) = 15.9 min.

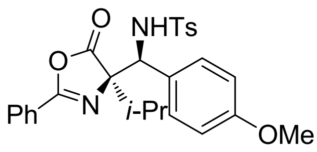
2,4,6-triisopropyl-N-((S)-((R)-4-methyl-5-oxo-2-phenyl-4,5-dihydrooxazol-4-yl)(phenyl)methyl)benzenesulfonamide (10i)



Following the general procedure, **10i** was isolated after silica gel chromatography (eluant petroleum ether/EtOAc 6:1) as a colorless oil. $\mathbf{R_F}$ = 0.35 (petroleum ether/EtOAc 6:1). **^{1}H NMR (300 MHz, CDCl$_3$):** δ 7.85 – 7.78 (m, 2H), 7.60 – 7.51 (m, 1H), 7.50 – 7.38 (m, 2H), 7.07 – 6.83 (m, 7H), 5.66 (d, J = 9.5 Hz, 1H), 4.86 (d, J = 9.5 Hz, 1H), 4.06 – 3.88 (m, 2H), 2.88 – 2.69 (m, 1H), 1.77 (s, 3H), 1.21 (d, J = 6.7 Hz, 6H), 1.17 (d, J = 6.9 Hz, 12H). **^{13}C NMR (75 MHz, CDCl$_3$):** δ 179.3 (Cq), 161.7 (Cq), 152.7 (Cq), 149.6 (Cq), 135.8 (Cq), 133.3 (Cq), 132.1

(CH), 128.8 (CH), 128.4 (CH), 128.3 (CH), 128.1 (CH), 127.8 (CH), 125.3 (Cq), 123.4 (CH), 72.8 (Cq), 62.0 (CH), 34.1 (CH), 30.0 (CH), 24.8 (CH_3), 24.7 (CH_3), 23.6 (CH_3), 21.9 (CH_3). **IR** (cm^{-1})**:** 3061, 2956, 2926, 1821, 1650, 1600, 1451, 1321, 1293, 1178, 1004, 875, 700, 661. **MS:** *m/z* 569.3 $[M+Na]^+$. **HRMS:** calcd. for $[C_{32}H_{38}N_2O_4S+H]^+$ ($[M+H]^+$): *m/z* 547.2631, found: 547.2623. **HPLC:** Daicel IA column, eluant = hexane/*i*-PrOH 94:6, flow rate = 0.8 $mL.min^{-1}$; *t* (minor) = 8.9 min; *t* (major) = 9.6 min.

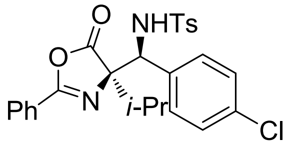
_N_-((_S_)-((_R_)-4-isopropyl-5-oxo-2-phenyl-4,5-dihydrooxazol-4-yl)(4-methoxyphenyl)methyl)-4-methylbenzenesulfonamide (10j)



Following the general procedure, **10k** was isolated after silica gel chromatography (eluant petroleum ether/EtOAc 5:1 to 4:1) as a white solid. $\mathbf{R_F}$ = 0.29 (petroleum ether/EtOAc 3:1). **^{1}H NMR (300 MHz, $CDCl_3$):** δ 7.91 – 7.81 (m, 2H), 7.56 – 7.52 (m, 1H), 7.45 – 7.36 (m, 4H), 6.99 (d, *J* = 8.1 Hz, 2H), 6.96 (d, *J* = 8.3 Hz, 2H), 6.50 (d, *J* = 8.5 Hz, 2H), 5.40 (d, *J* = 1.5 Hz, 1H), 4.93 (d, *J* = 10.7 Hz, 1H), 3.65 (s, 3H), 2.38 – 2.31 (m, 1H), 2.29 (s, 3H), 1.05 (d, *J* = 6.7 Hz, 3H), 0,90 (d, *J* = 6.8 Hz, 3H). **^{13}C NMR (150 MHz, $CDCl_3$):** δ 179.2 (Cq), 161.3 (Cq), 159.1 (Cq), 142.9 (Cq), 137.4 (Cq), 132.9 (CH), 129.1 (CH), 129.0 (CH), 128.0 (CH), 127.3 (Cq), 127.0 (CH), 125.2 (Cq), 113.3 (CH), 80.0 (Cq), 59.0 (CH), 55.1 (CH_3), 32.1 (CH), 21.4 (CH_3),16.4 (CH_3), 16.3 (CH_3). **IR** (cm^{-1})**:** 3242, 2957, 2931, 1815, 1647, 1612, 1513, 1324, 1241, 1159, 1023, 945, 849, 690. **MS:** 515.1 $[M+Na]^+$. **HRMS:** calcd. for $[C_{27}H_{28}N_2O_5S+H]^+$ ($[M+H]^+$): *m/z* 493.1797, found: 493.1788. **HPLC:** Daicel IA column, eluant = hexane/*i*-PrOH 90:10, flow rate = 1 $mL.min^{-1}$; *t* (major) = 21.8 min; *t* (minor) = 26.1 min.

The spectral data are in agreement with the literature data.[16]

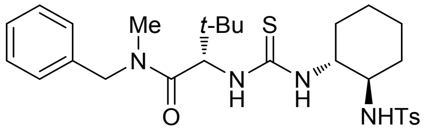
_N_-((_S_)-(4-chlorophenyl)((_R_)-4-isopropyl-5-oxo-2-phenyl-4,5-dihydrooxazol-4-yl)methyl)-4-methylbenzenesulfonamide (10k)



Following the general procedure, **10k** was isolated after silica gel chromatography (eluant petroleum ether/EtOAc 5:1 to 4:1) as a white solid. $\mathbf{R_F}$ = 0.47 (petroleum ether/EtOAc 3:1). **^{1}H NMR (600 MHz, $CDCl_3$):** δ 7.81 (d, *J* = 8.1 Hz, 2H), 7.52 (t, *J* = 7.4 Hz, 1H), 7.40 (t, *J* = 7.7 Hz, 2H), 7.35 (d, *J* = 8.1 Hz, 2H), 6.99 – 6.89 (m, 6H), 5.61 (d, *J* = 10.7 Hz, 1H), 4.93 (d, *J* = 10.7 Hz, 1H), 2.36 – 2.26 (m, 2H), 1.03 (d, *J* = 6.7 Hz, 3H), 0.90 (d, *J* = 6.8 Hz, 3H). **^{13}C NMR (150 MHz, $CDCl_3$):** δ 178.8 (Cq), 161.5 (Cq), 143.4 (Cq), 137.1 (Cq), 133.9 (Cq), 133.7 (Cq), 133.0 (CH), 129.3 (CH), 129.1 (CH), 128.7 (CH), 128.1 (CH), 128.0 (CH), 126.9 (CH), 124.9 (Cq), 79.6 (Cq), 58.8 (CH), 32.1 (CH), 21.4 (CH_3), 16.4 (CH_3), 16.3 (CH_3). **IR** (cm^{-1})**:** 3263, 2968, 2924, 1809, 1651, 1493, 1450, 1331, 1290, 1160, 1090, 1014, 880, 696. **MS:** 519.1 $[M+Na]^+$. **HRMS:** calcd. for $[C_{26}H_{25}ClN_2O_4S+H]^+$ ($[M+H]^+$): *m/z* 497.1302, found: 497.1293. **HPLC:** Daicel IA column, eluant = hexane/*i*-PrOH 90:10, flow rate = 1 $mL.min^{-1}$; *t* (major) = 16.1 min; *t* (minor) = 26.1 min.

The spectral data are in agreement with the literature data.[16]

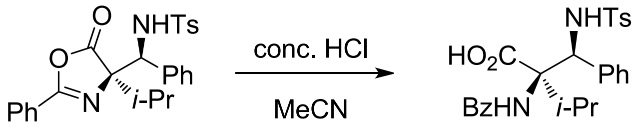
(*S*)-2-[[(1*R*,2*R*)-2-(*N'*-(*p*-toluenesulfonyl)cyclohexyl]thioureido]-*N*-benzyl-*N*,3,3-trimethylbutaneamide (1c)



(*S*)-2-(3-((1*R*,2*R*)-2-aminocyclohexyl)thioureido)-*N*-benzyl-*N*,3,3-trimethylbutanamide (100 mg, 0.26 mmol) was dissolved in dry THF (3.5 mL) and Et_3N (43 µL, 0.31 mmol, 1.2 eq.) was added. A solution of TsCl (53.7 mg, 0.28 mmol, 1.1 eq.) in THF (1 mL) was added dropwise and the reacion was stirred at room temperature. After 2 hours, the solvent was evaporated *in vacuo* and the residue was purified by silica gel column chromatography (petroleum ether/ethyl acetate 1.2:1) to give thiourea **1c** (120 mg, 86 % yield) as a white crystalline solid.

Mp. 109 – 113 °C. **$[\alpha]_D^{20}$** = +5.2 (*c* 1.00, $CHCl_3$). **^{1}H NMR (300 MHz, $CDCl_3$**; compound exists as a 2.4:1 mixture of rotamers, the major rotamer is denoted by ***)**: 7.70 (d, *J* = 8.2 Hz, 2H*), 7.65 (d, *J* = 8.1 Hz, 2H), 7.45 – 7.27 (m, 4H* + 4H), 7.26 – 7.19 (m, 3H* + 3H), 6.83 (d, *J* = 9.4 Hz, 1H*), 6.80 – 6.70 (m, 1H* + 1H), 6.36 (d, *J* = 8.3 Hz, 1H*), 6.18 (d, *J* = 8.1 Hz, 1H), 5.82 (s, 1H), 5.76 (d, *J* = 9.4 Hz, 1H*), 5.18 (d, *J* = 14.9 Hz, 1H*), 5.05 (d, *J* = 15.3 Hz, 1H), 4.53 (d, *J* = 15.6 Hz, 1H), 4.27 (ddd, *J* = 13.8, 11.3, 3.6 Hz, 1H* + 1H), 4.06 (d, *J* = 15.0 Hz, 1H*), 3.19 (s, 3H*), 2.86 (s, 3H), 2.85 – 2.77 (m, 1H* + 1H), 2.41 (s, 3H*), 2.39 (s, 3H), 2.07 – 1.80 (m, 4H* + 4H), 1.64 – 1.49 (m, 3H* + 3H), 1.34 – 1.14 (m, 4H* + 3H), 1.08 (s, 9H*), 1.03 (s, 9H), 0.98 – 0.83 (m, 2H* + 2H). **^{13}C NMR (75 MHz, $CDCl_3$):** δ 183.8 (Cq), 183.4 (Cq), 172.4 (Cq), 171.9 (Cq), 143.0 (Cq), 143.0 (Cq), 138.4 (Cq), 138.2 (Cq), 136.5 (Cq), 135.8 (Cq), 129.6 (CH), 129.5 (CH), 129.0 (CH), 128.8 (CH), 128.1 (CH), 128.0 (CH), 127.9 (CH), 127.6 (CH), 127.0 (CH), 127.0 (CH), 60.0 (CH), 59.7 (CH), 59.1 (CH), 58.8 (CH), 56.7 (CH), 54.5 (CH_2), 51.27 (CH_2), 37.0 (Cq), 36.7 (Cq), 36.3 (CH_3), 33.9 (CH_2), 33.7 (CH_2), 33.4 (CH_3), 32.7 (CH_2), 32.6 (CH_2), 27.0 (CH_3), 24.6 (CH_2), 24.2 (CH_2), 21.7 (CH_3), 21.6 (CH_3). **IR** (cm^{-1})**:** 3320, 3086, 2933, 2859, 1619, 1527, 1495, 1449, 1416, 1398, 1317, 1234, 1155, 1091, 1071, 961, 899, 700, 661. **MS:** *m/z* 567.2 $[M+Na]^+$. **HRMS:** calcd. for $[C_{28}H_{40}N_4O_3S+Na]^+$ ($[M+Na]^+$): *m/z* 567.2440, found: 567.2430.

3. Hydrolysis of the adduct **10b**



10b **11**

(*R*)-2-benzamido-3-methyl-2-((*S*)-(4-methylphenylsulfonamido)(phenyl)methyl)butanoic acid (11)

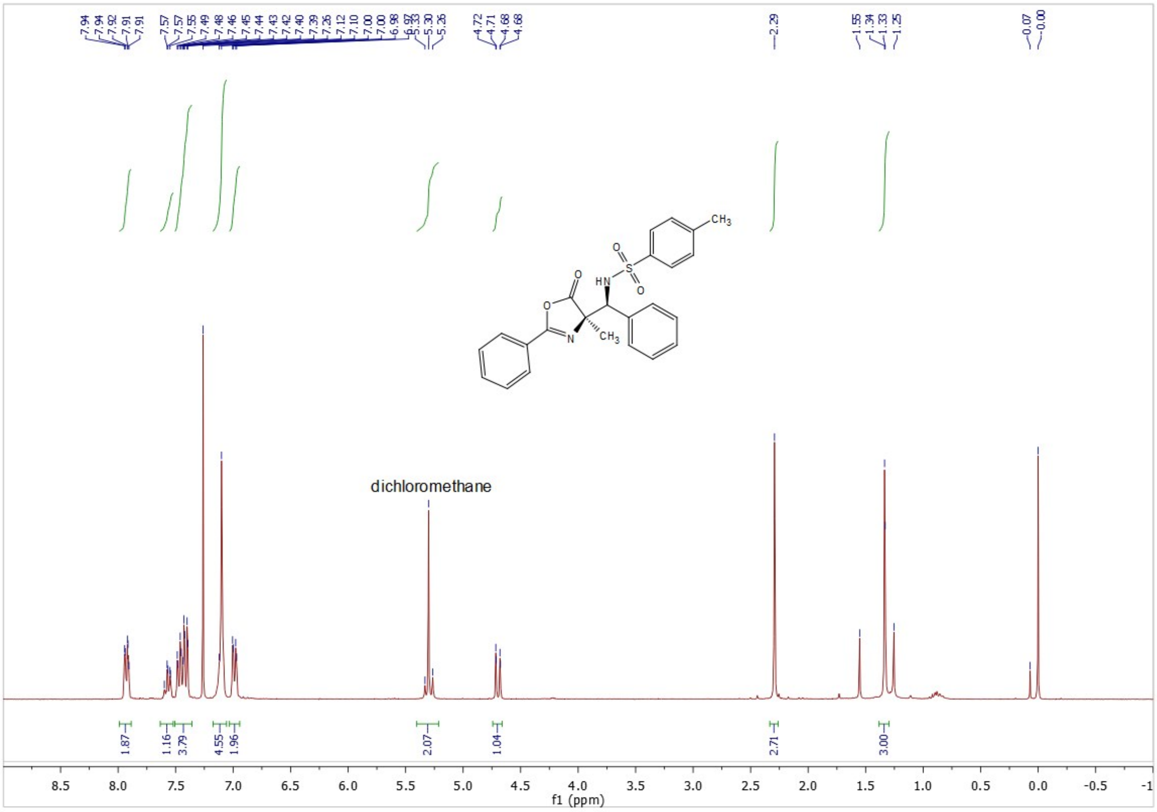
Adduct **10b** (50 mg, 1.1 mmol, 1 eq.) was dissolved in MeCN (1.0 mL) and conc. HCl (0.17 ml, 2.2 mmol, 2 eq.) was added. The mixture was stirred at rt for 3 h, then rinsed with MeCN (1 mL). The solvent was evaporated to give **11** as a pale yellow solid (52 mg, quantitative yield).

$[\alpha]_D^{20}$ = +85.5 (*c* 0.5, EtOH). **^{1}H NMR (600 MHz, DMSO-d_6):** δ 8.36 (bs, 1H), 7.66 (d, *J* = 7.5 Hz, 2H), 7.56 – 7.52 (m, 2H), 7.46 (t, *J* = 7.6 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 7.06 – 6.91 (m, 7H), 6.67 (bs, 1H), 5.66 (d, *J* = 7.8 Hz, 1H), 2.45 (bs, 1H), 2.21 (s, 3H), 1.07 (d, *J* = 6.6 Hz, 3H), 1.02 (d, *J* = 6.7 Hz, 3H). **^{13}C NMR (150 MHz, DMSO-d_6):** δ 172.0, 168.3, 142.0, 138.8, 137.4, 135.6 132.0, 129.1, 129.0, 128.4, 127.8, 127.5, 127.4, 126.9, 71.4, 32.6, 21.3, 18.9, 18.7. **IR** (cm^{-1})**:** 3351 (broad), 3060, 2969, 2932, 1713, 1652, 1599, 1516, 1487, 1318, 1148, 1089, 809, 702, 667. **MS:** 481.2 $[M+H]^+$.

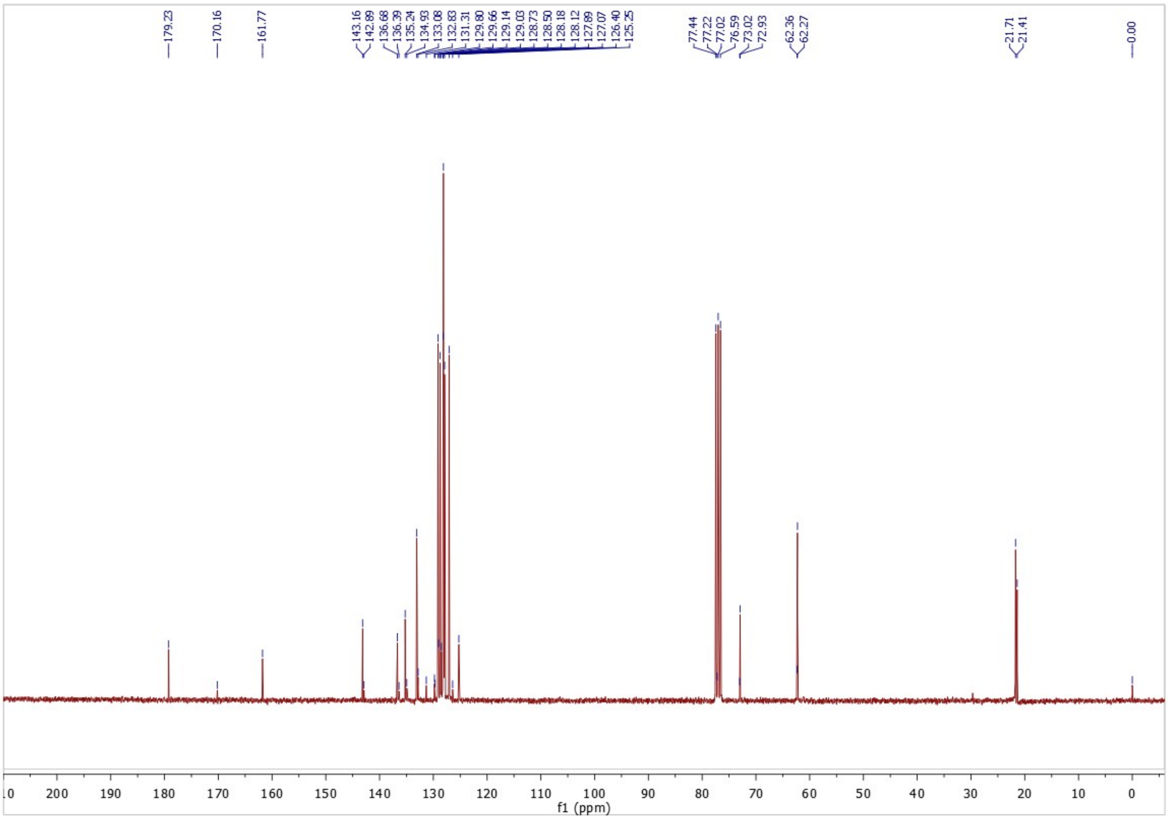
The spectral data are in agreement with the literature data.[16]

4. Copies of NMR spectra

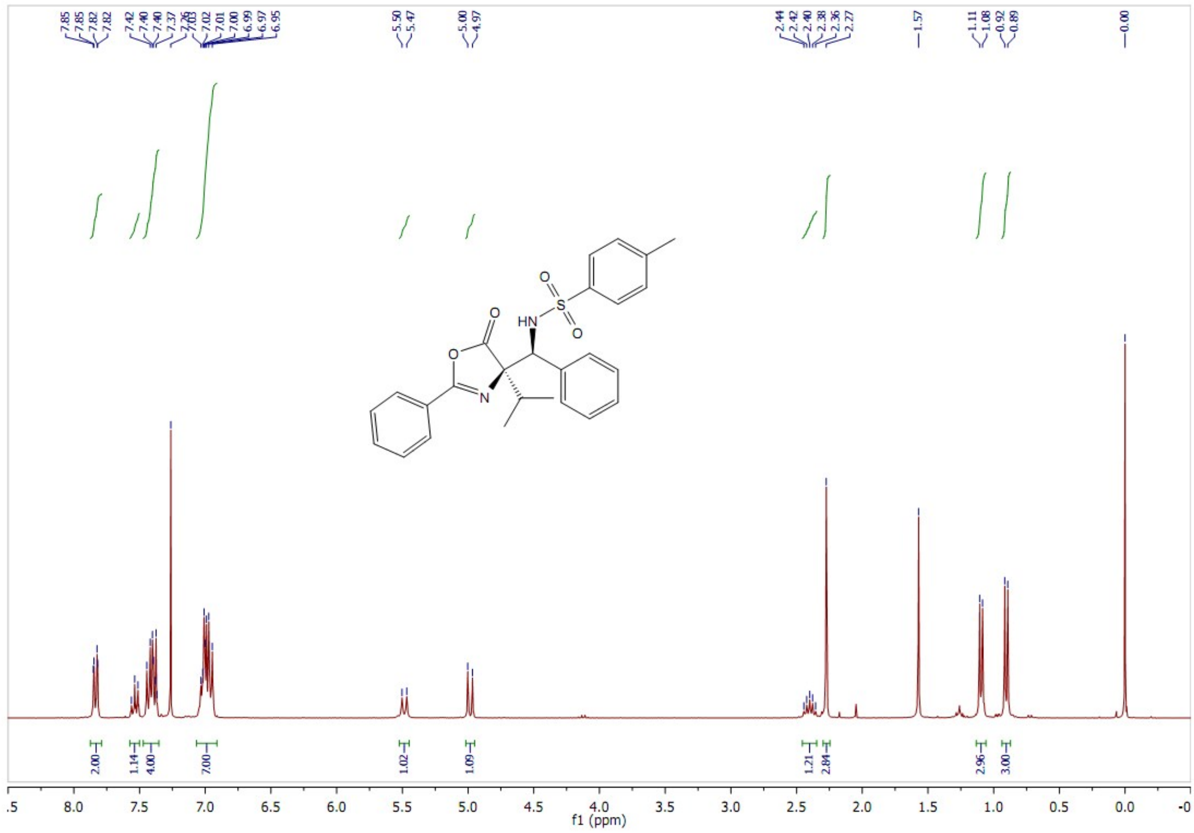
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of 10a



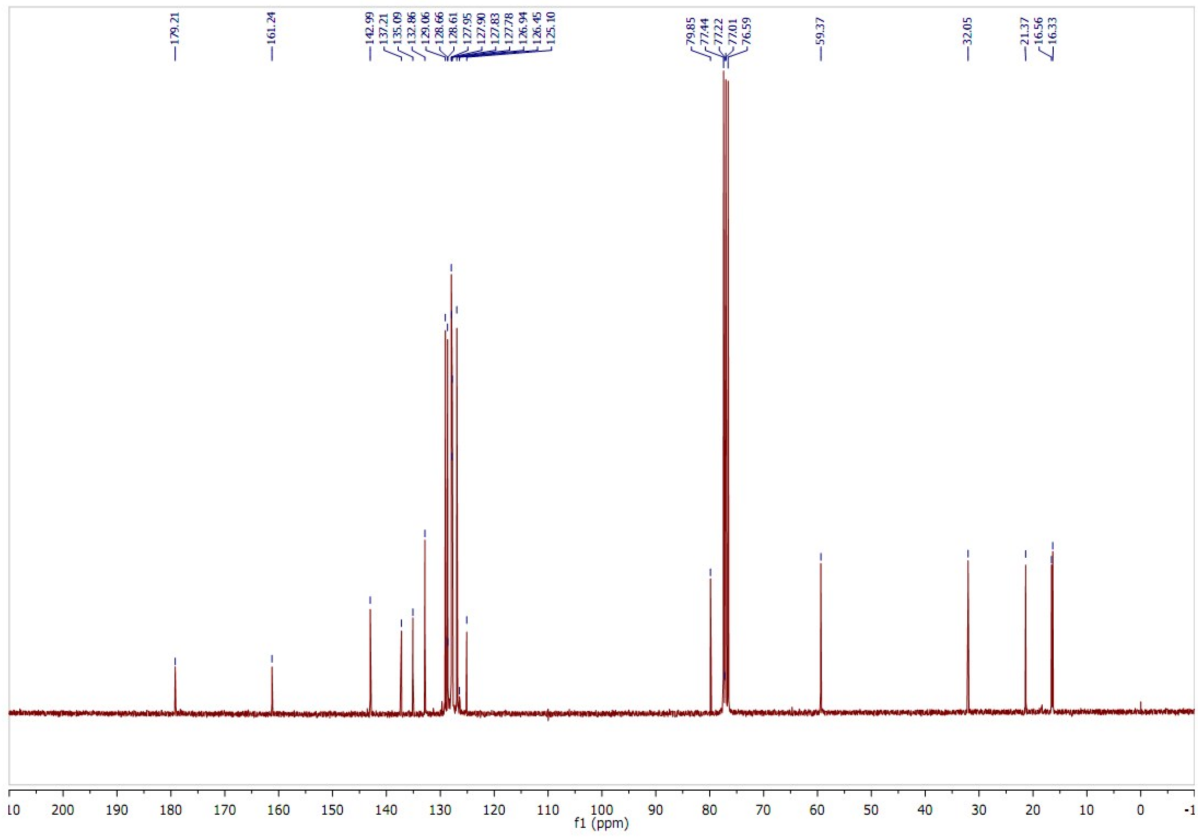
^{13}C NMR (75 MHz, $CDCl_3$) spectrum of 10a



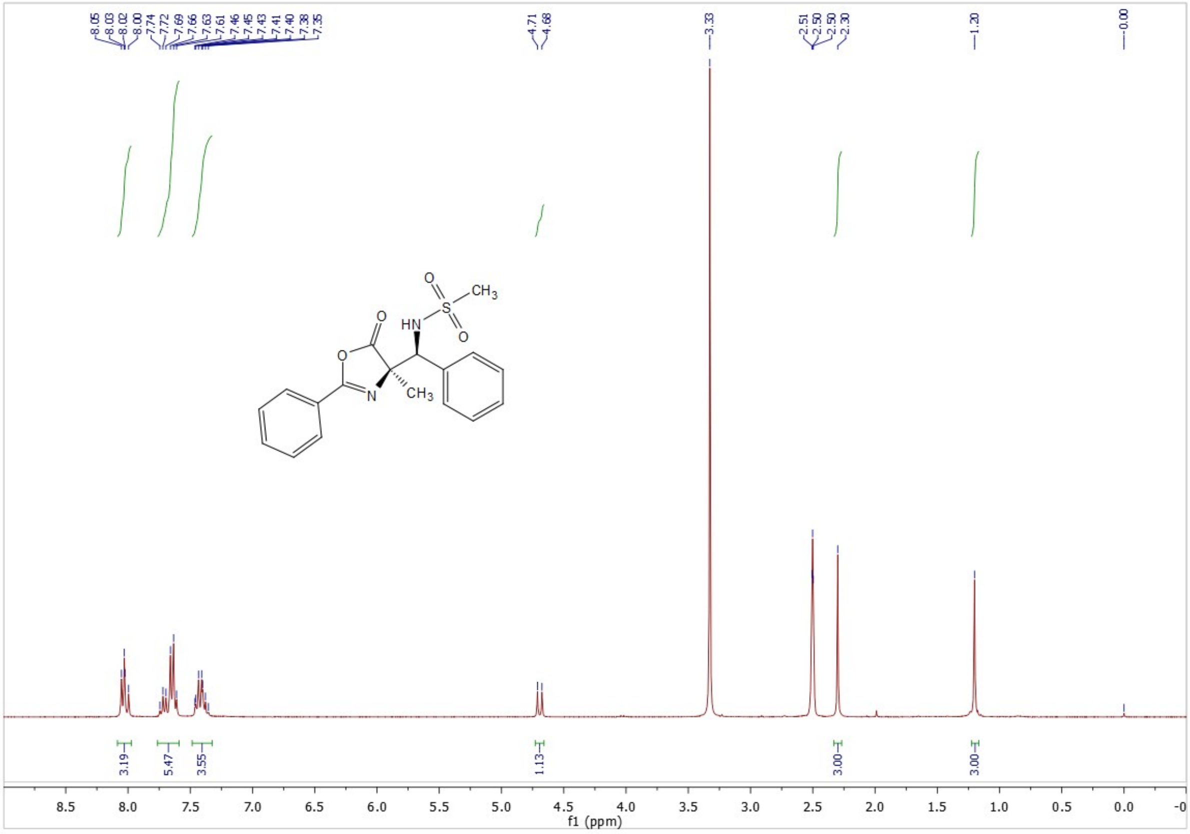
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of 10b



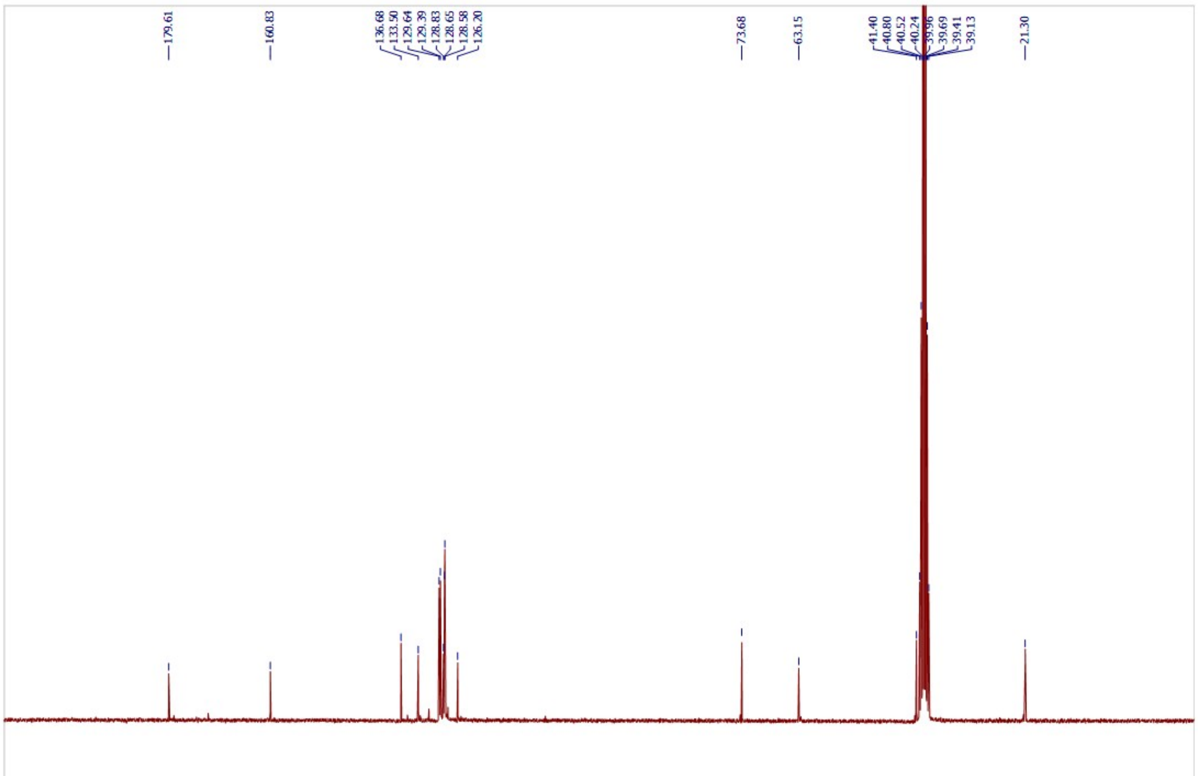
^{13}C NMR (75 MHz, $CDCl_3$) spectrum of 10b



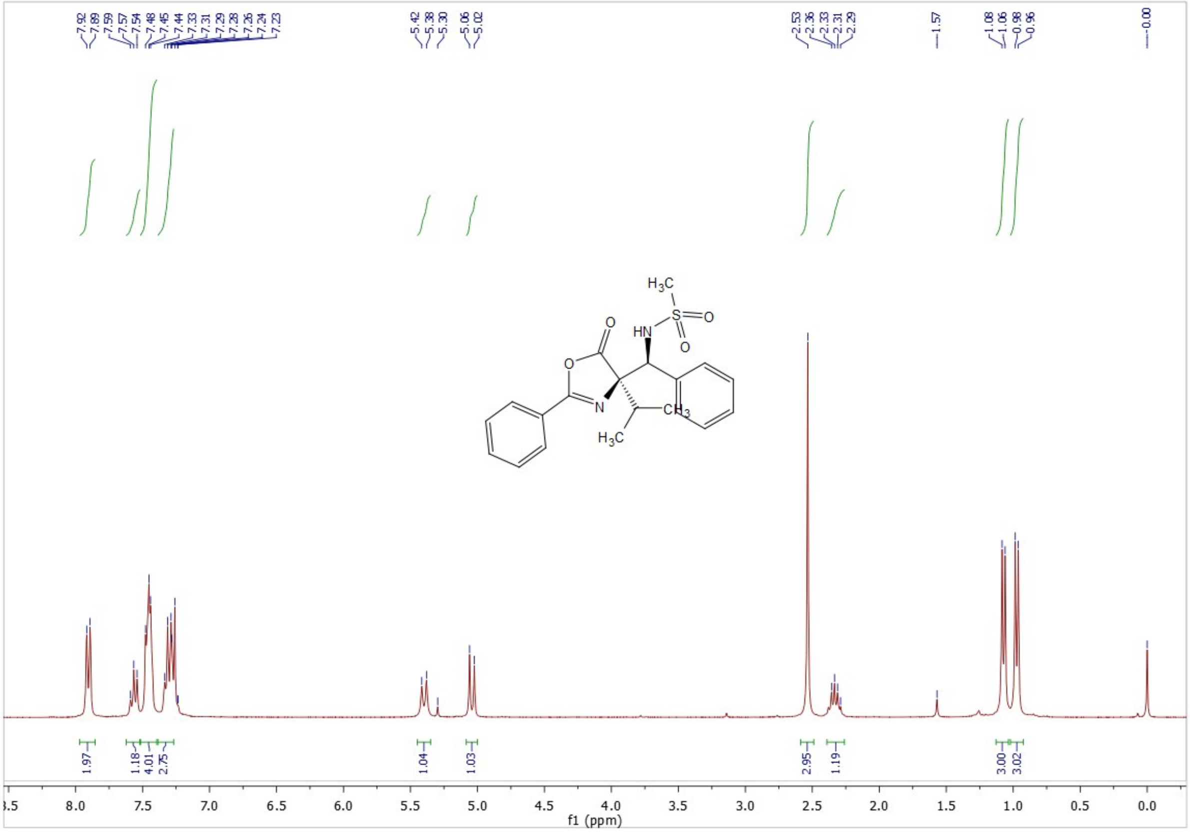
^{1}H NMR (300 MHz, DMSO-d_6) spectrum of 10c



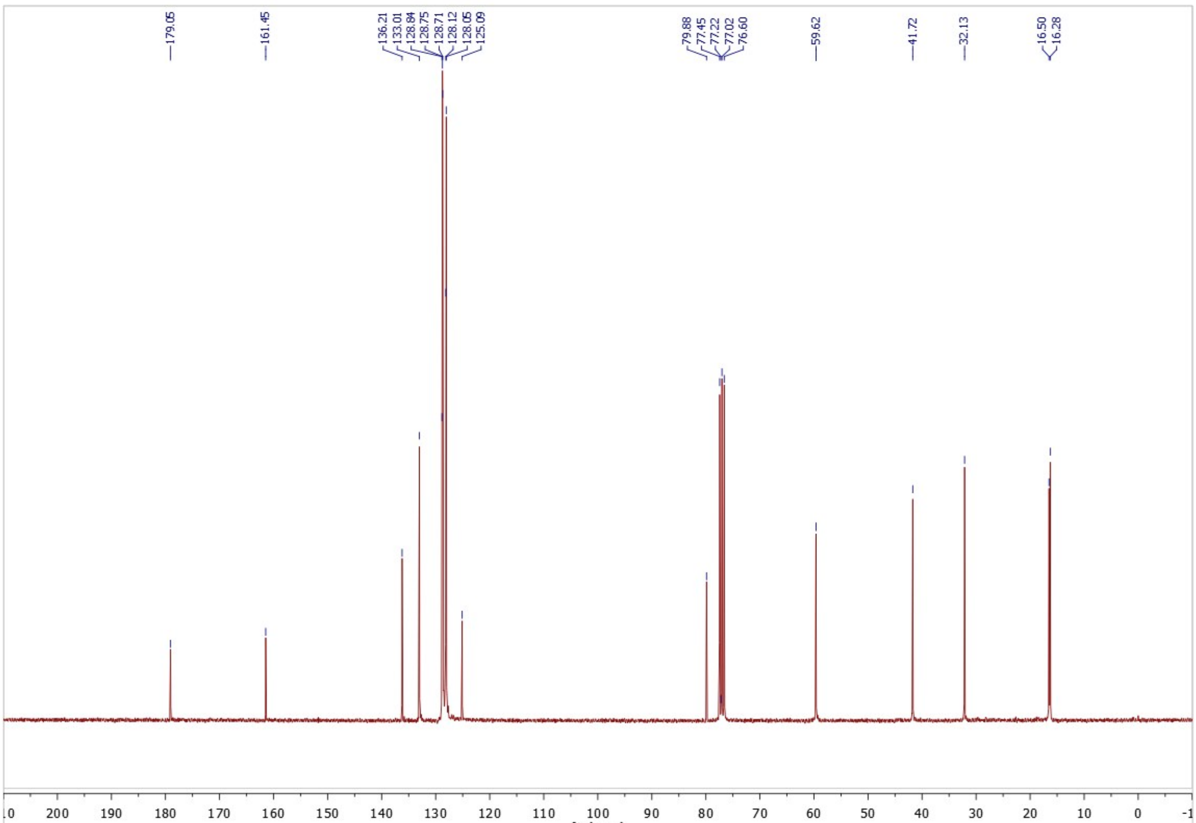
^{13}C NMR (75 MHz, DMSO-d_6) spectrum of 10c



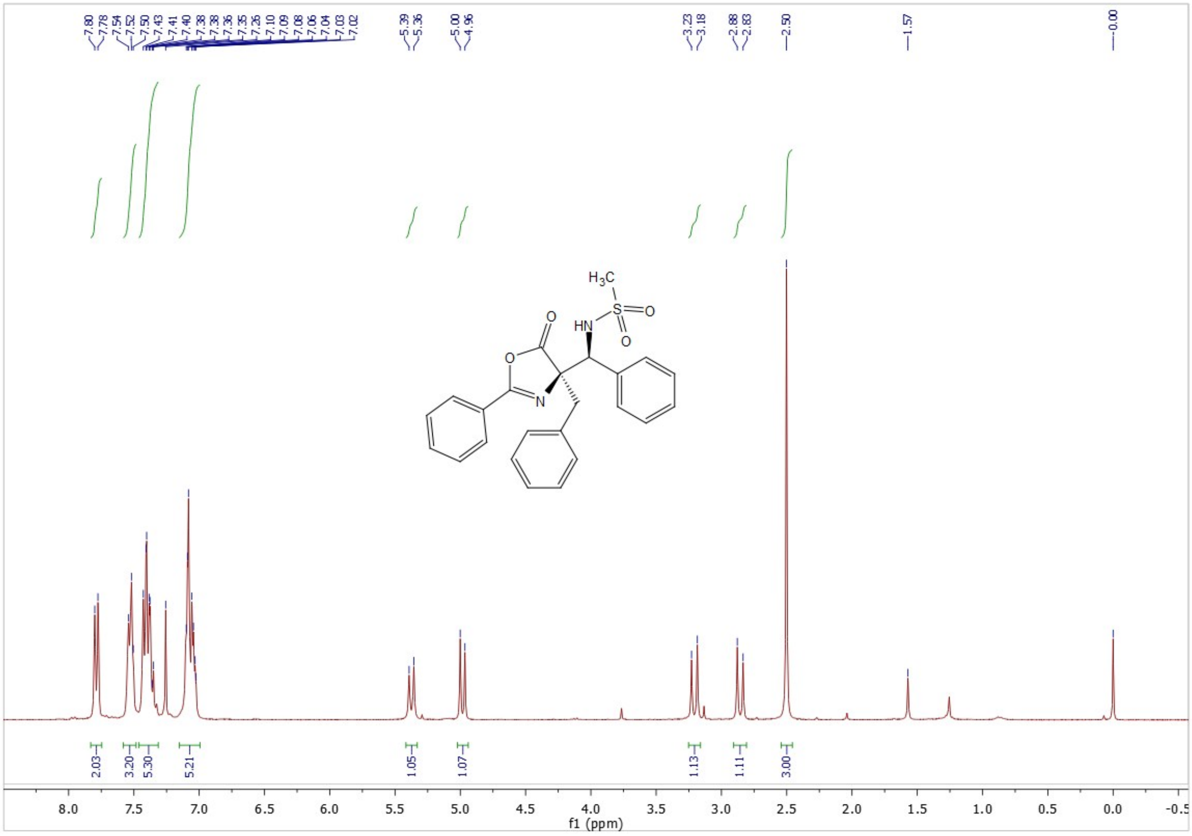
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of 10d



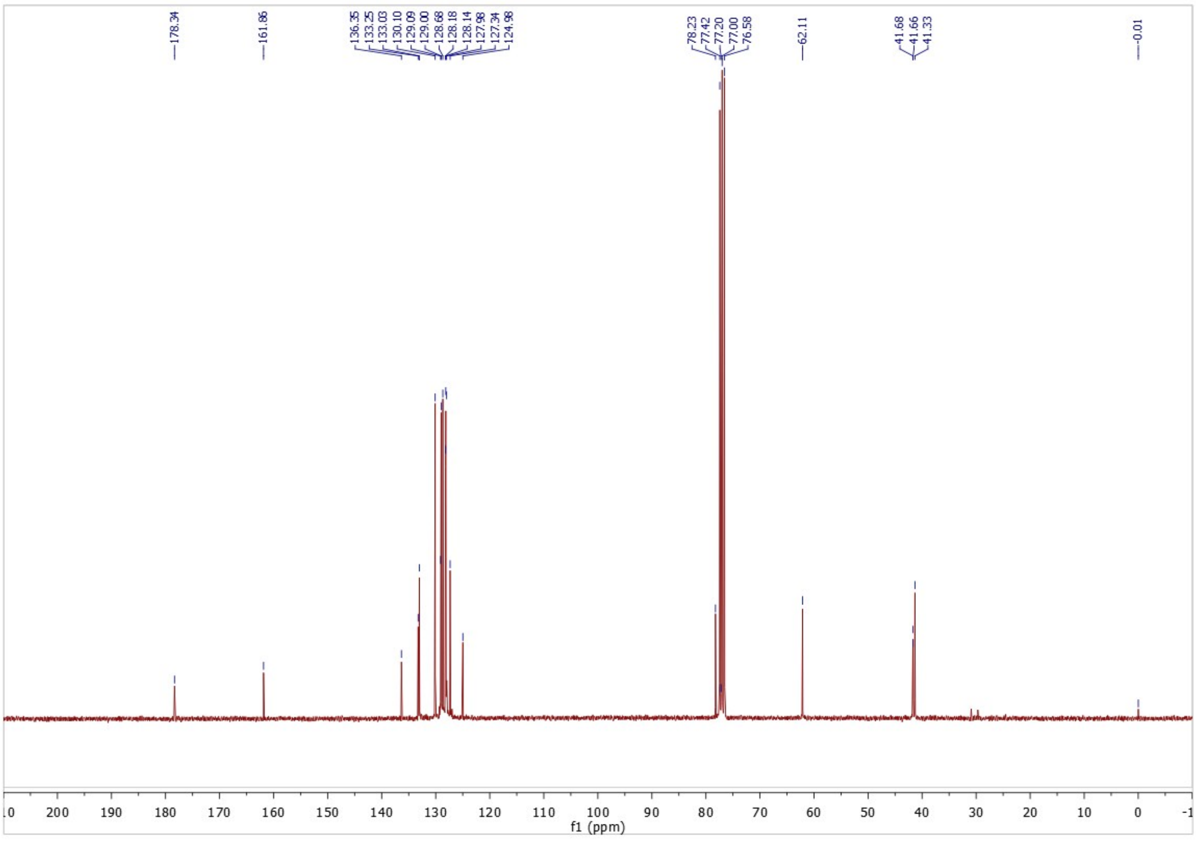
^{13}C NMR (75 MHz, $CDCl_3$) spectrum of 10d



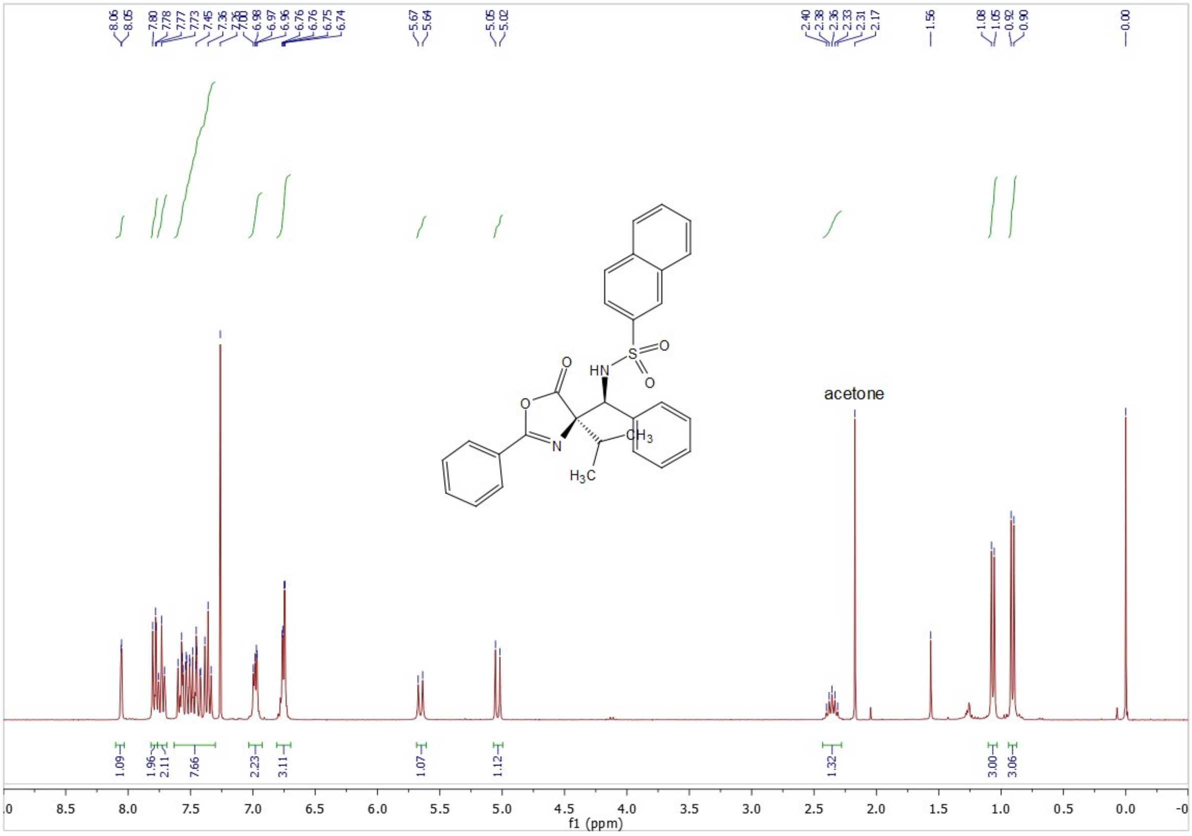
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of 10e



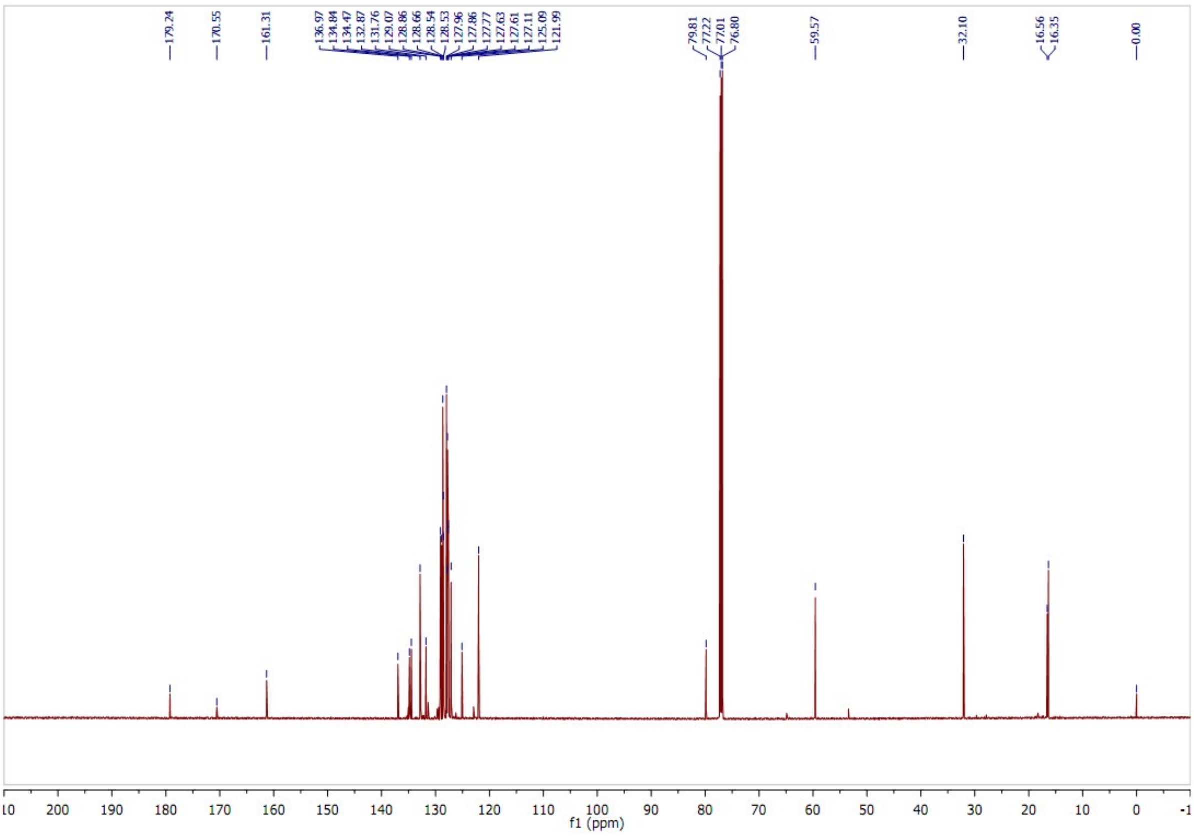
^{13}C NMR (75 MHz, $CDCl_3$) spectrum of 10e



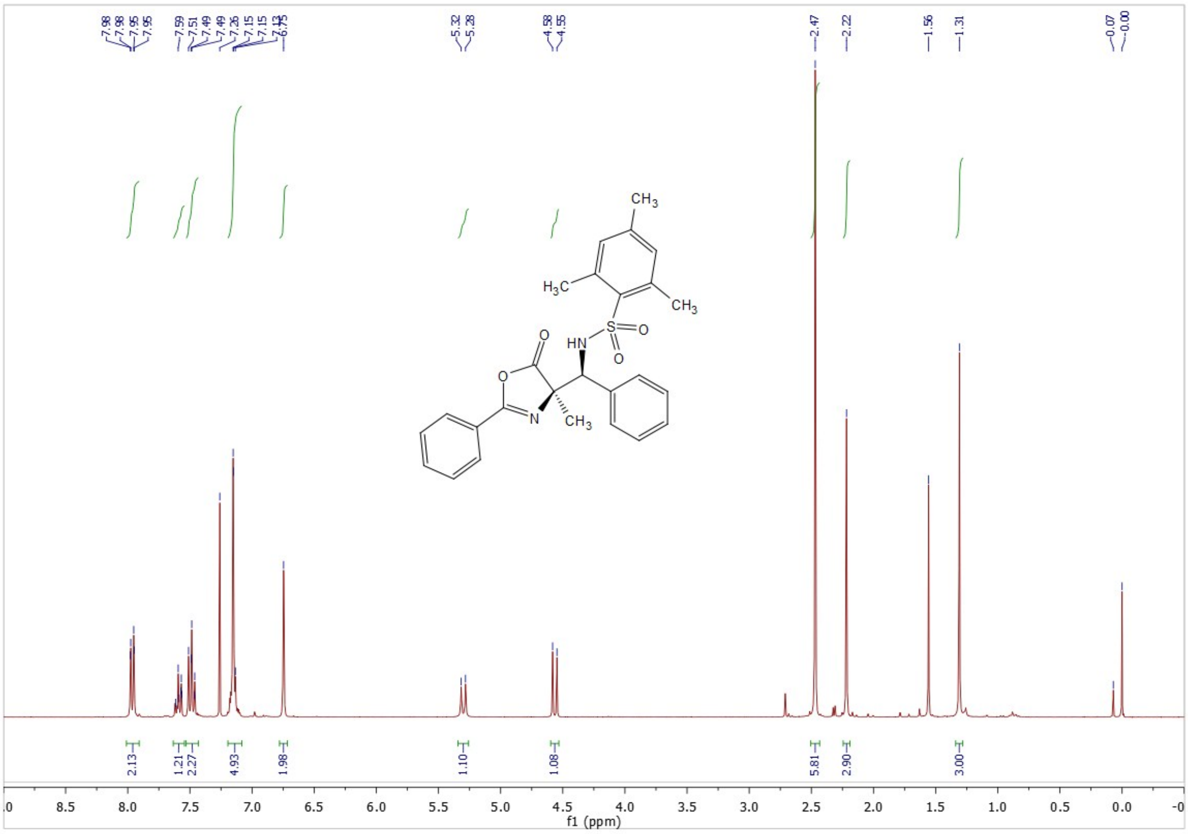
^{1}H NMR (300 MHz, CDCl$_3$) spectrum of 10f



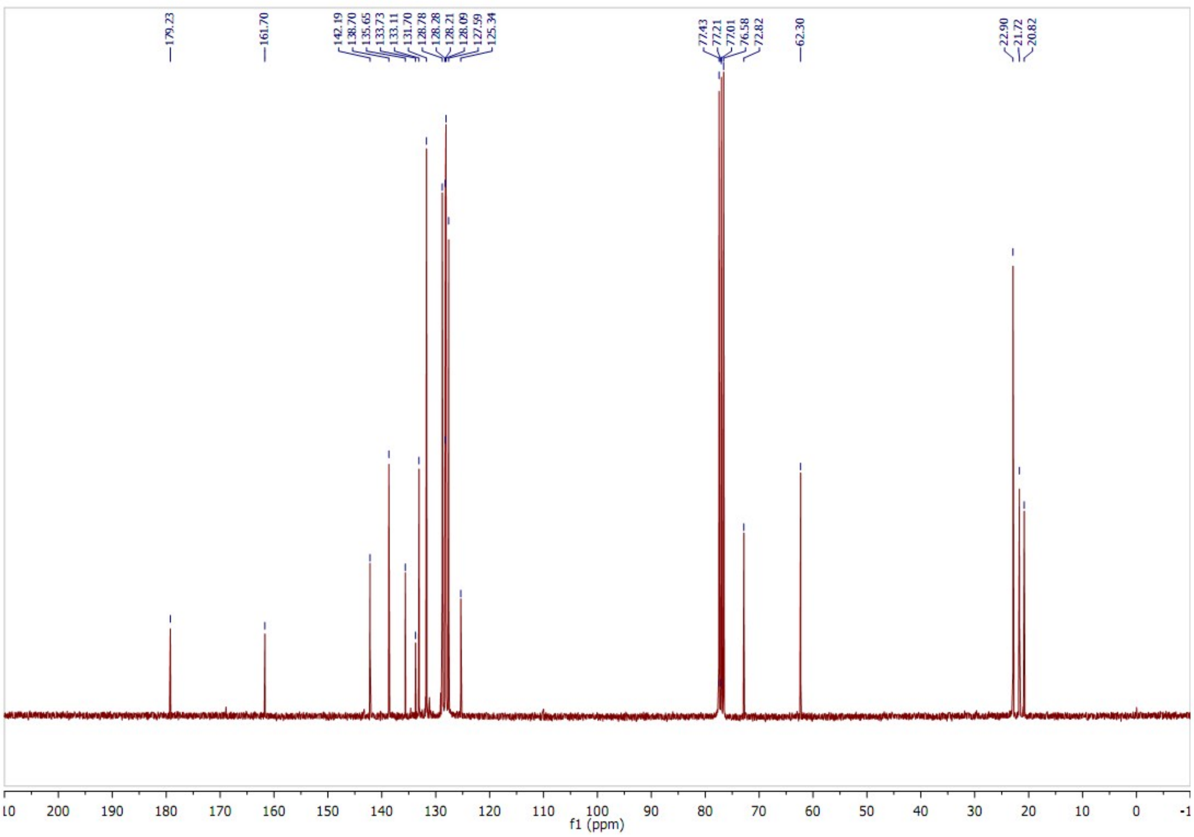
^{13}C NMR (75 MHz, CDCl$_3$) spectrum of 10f



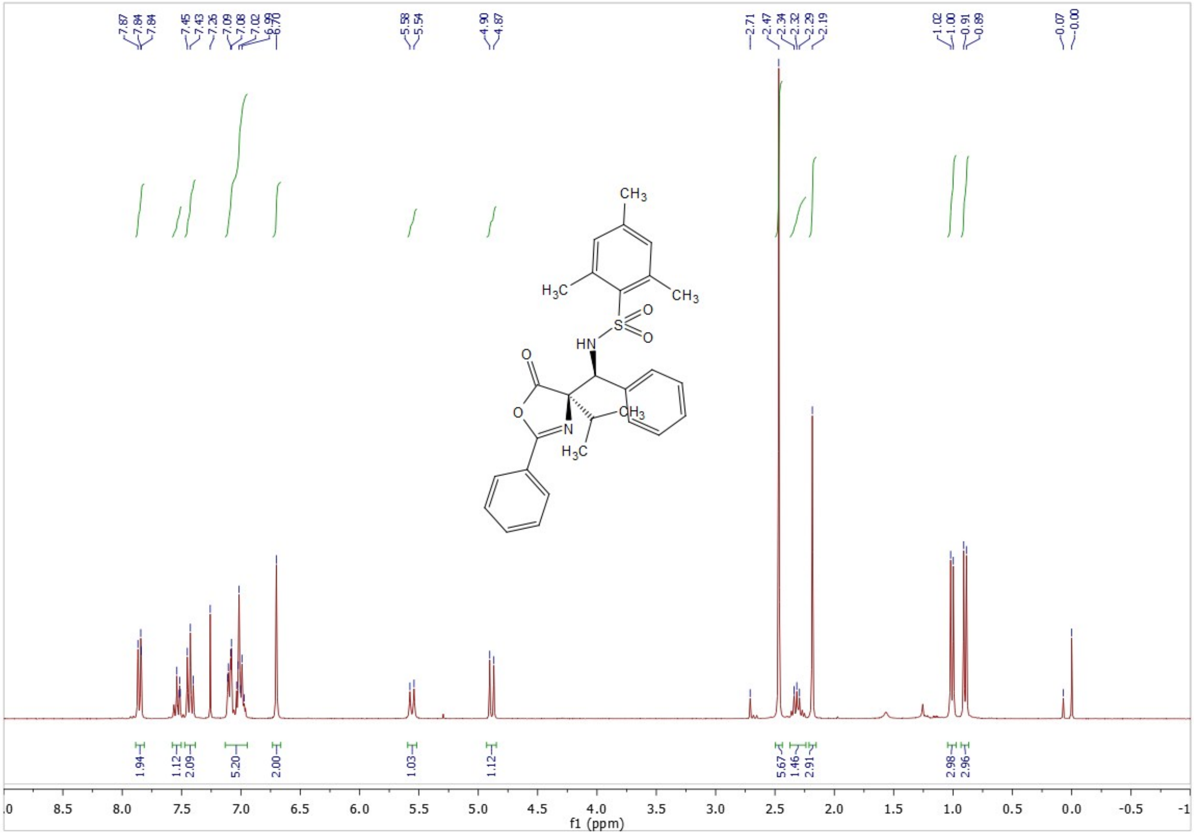
^1H NMR (300 MHz, $CDCl_3$) spectrum of 10g



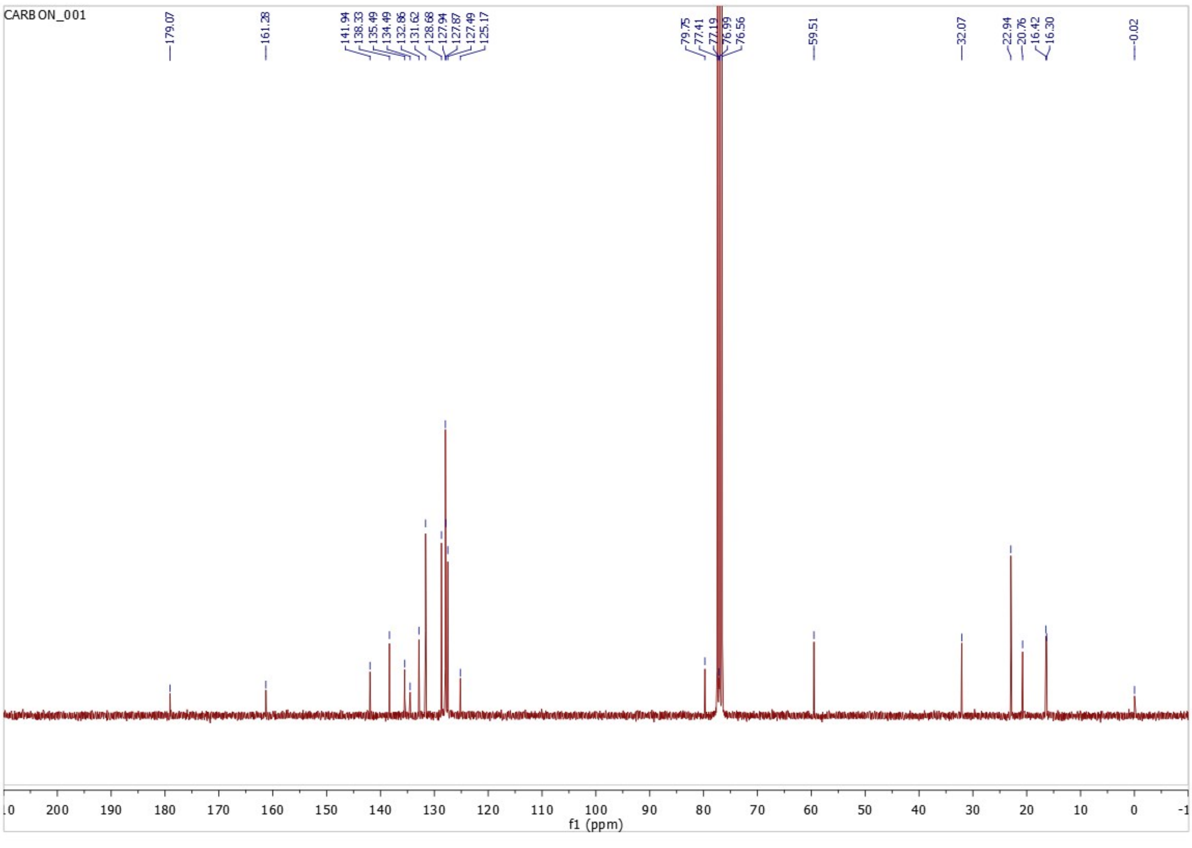
^{13}C NMR (75 MHz, $CDCl_3$) spectrum of 10g



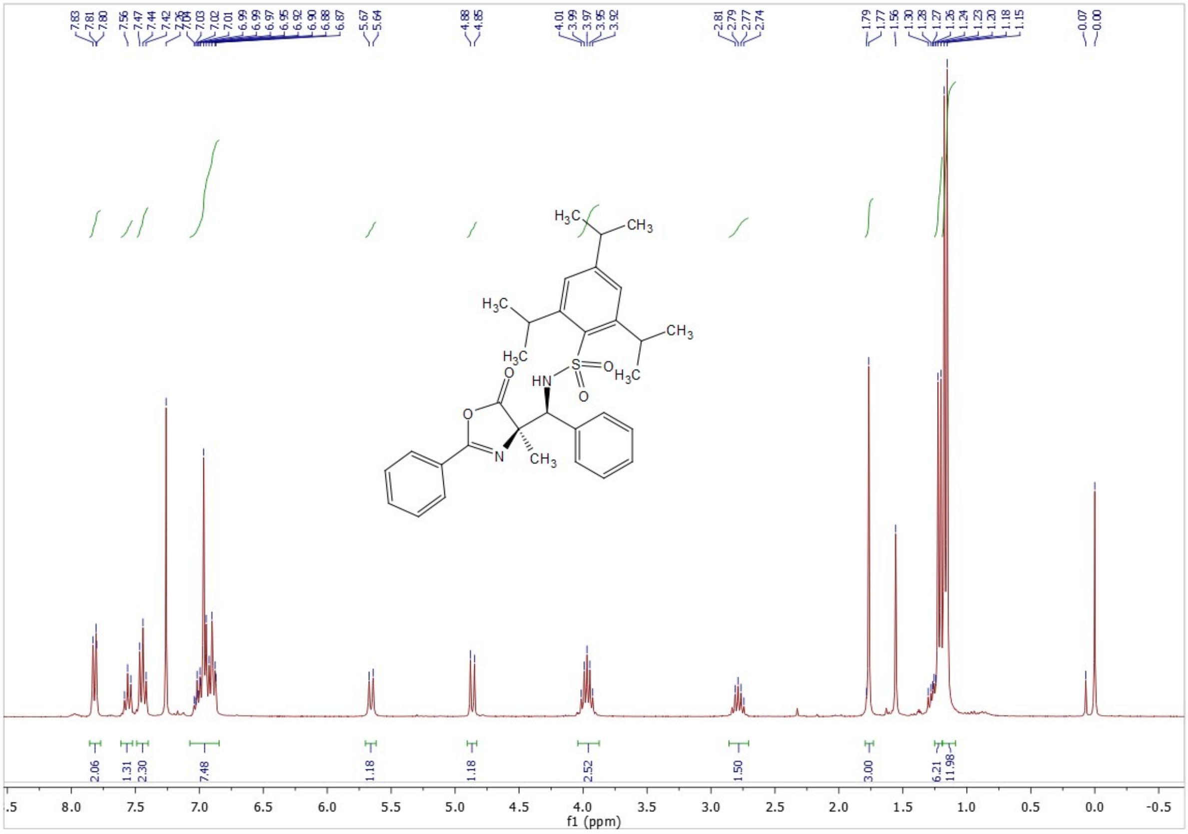
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of 10h



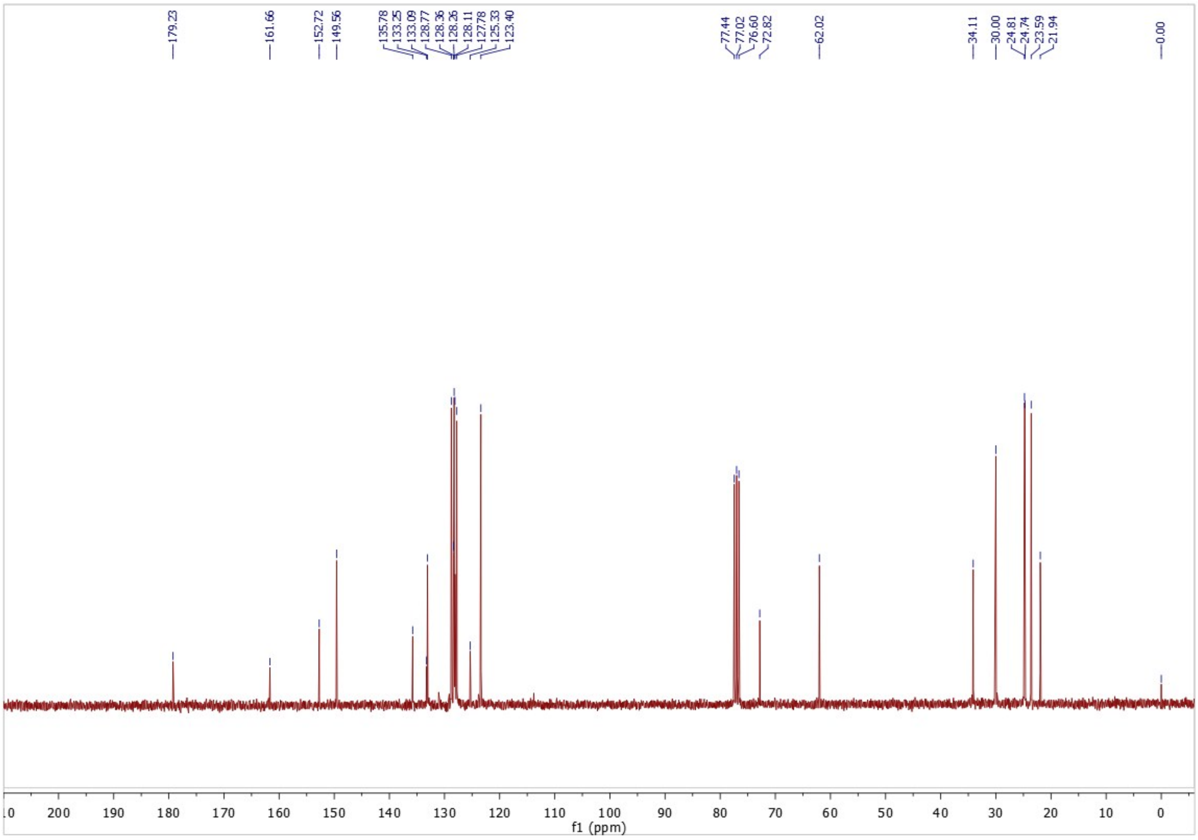
^{13}C NMR (75 MHz, $CDCl_3$) spectrum of 10h



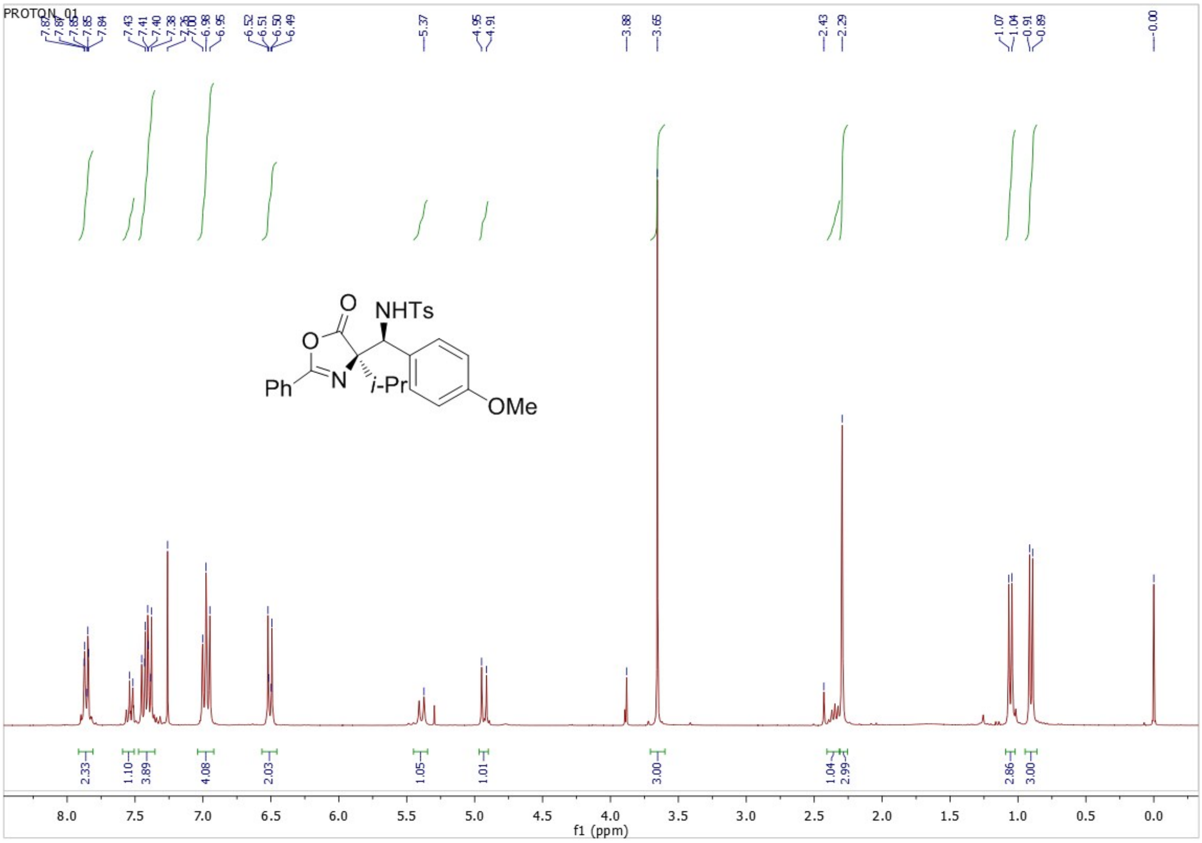
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of 10i



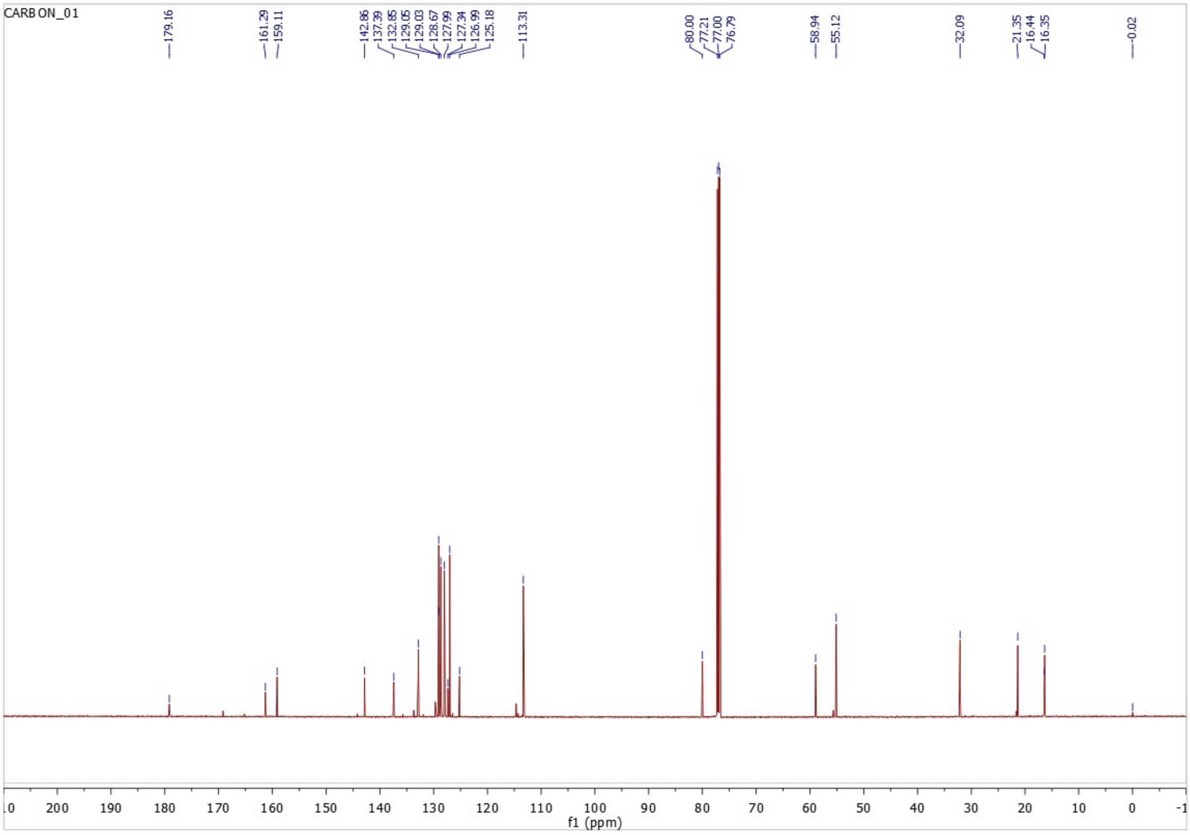
^{13}C NMR (75 MHz, $CDCl_3$) spectrum of 10i



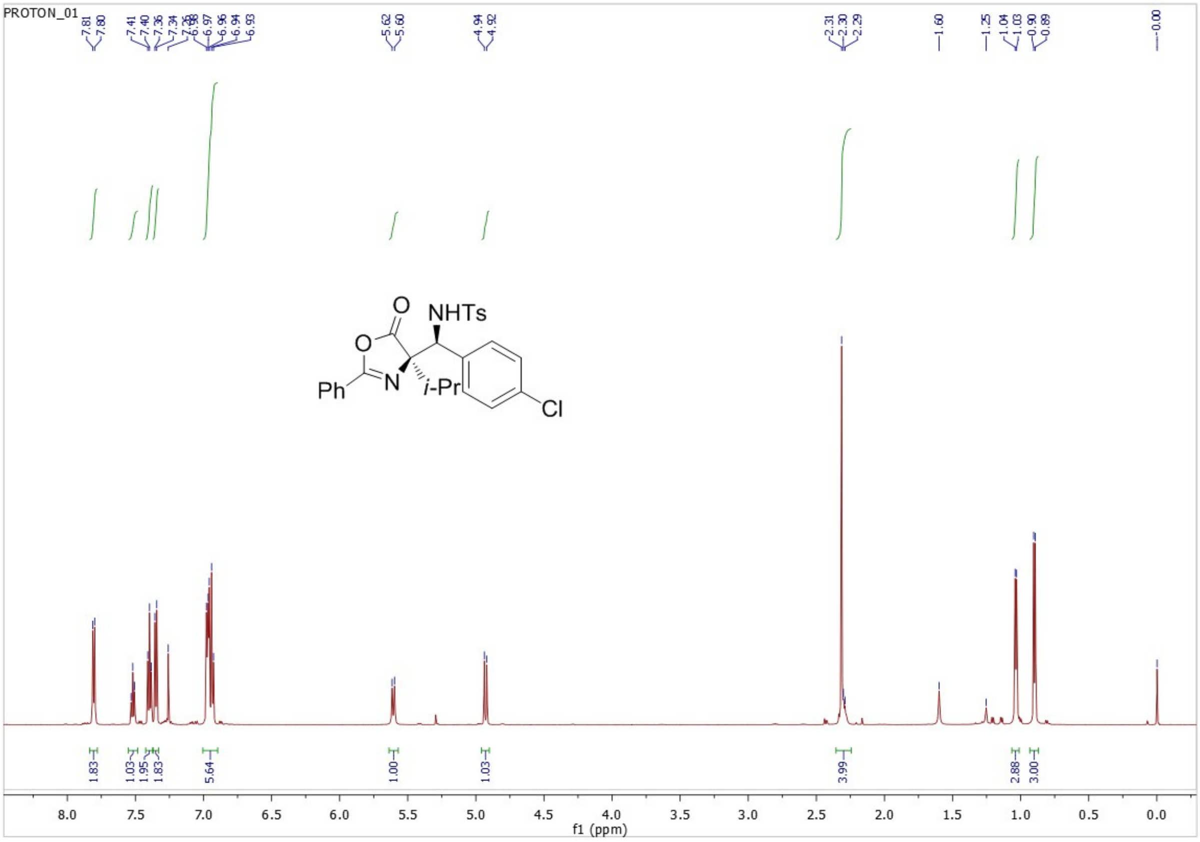
^{1}H NMR (300 MHz, $CDCl_3$) spectrum of 10j



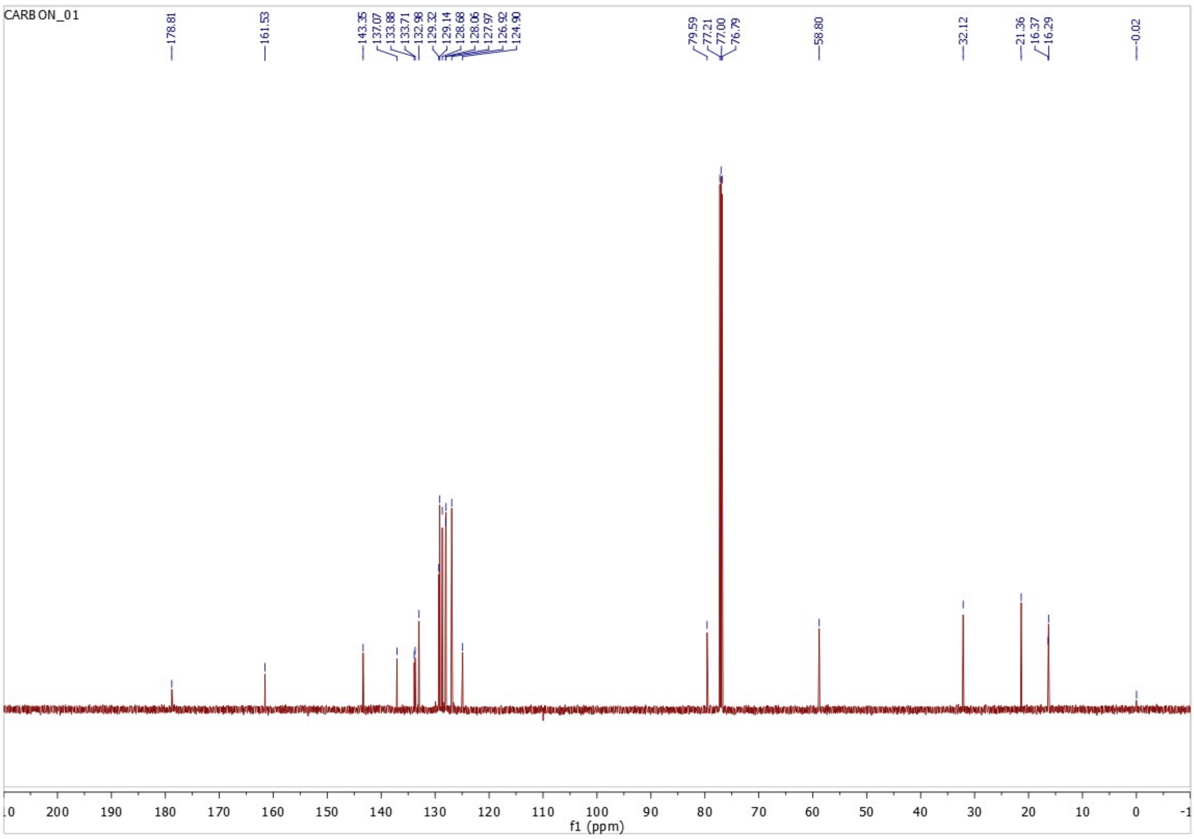
^{13}C NMR (150 MHz, $CDCl_3$) spectrum of 10j



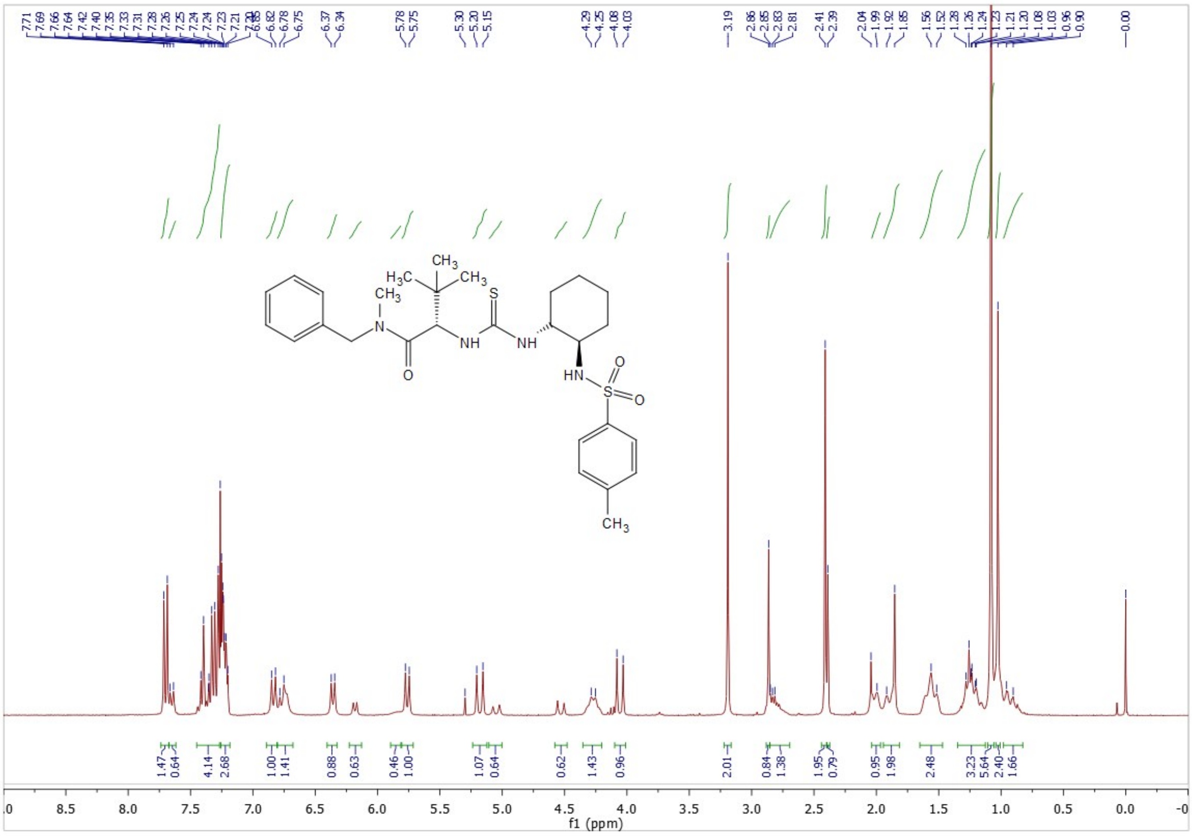
^{1}H NMR (600 MHz, $CDCl_3$) spectrum of 10k



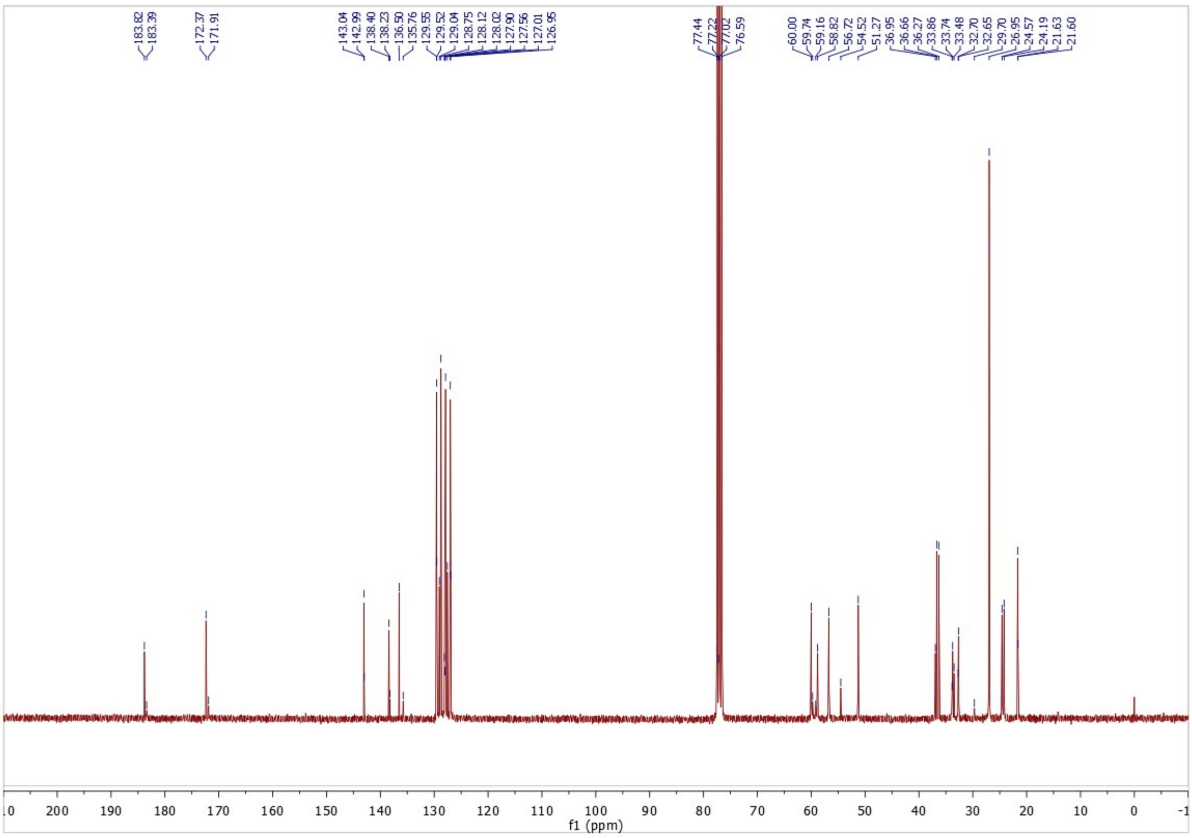
^{13}C NMR (150 MHz, $CDCl_3$) spectrum of 10k



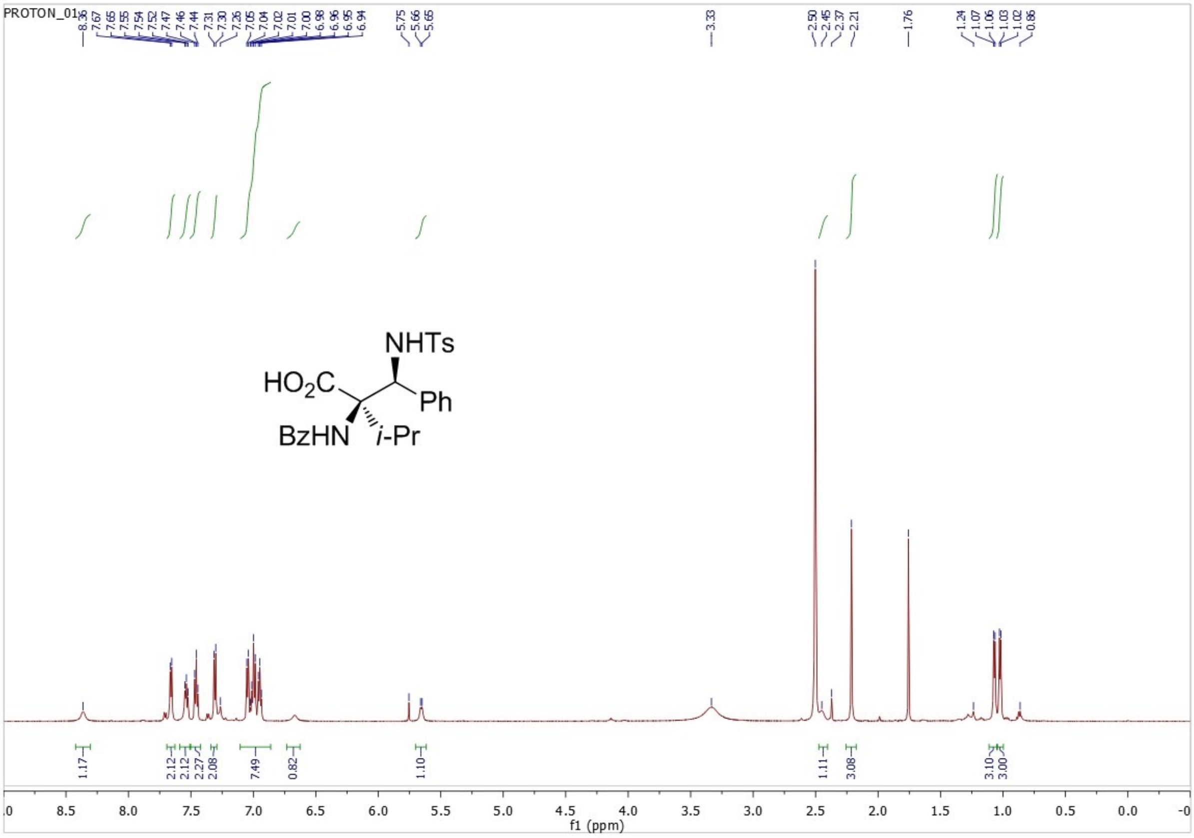
[1]H NMR (300 MHz, $CDCl_3$) spectrum of 1c



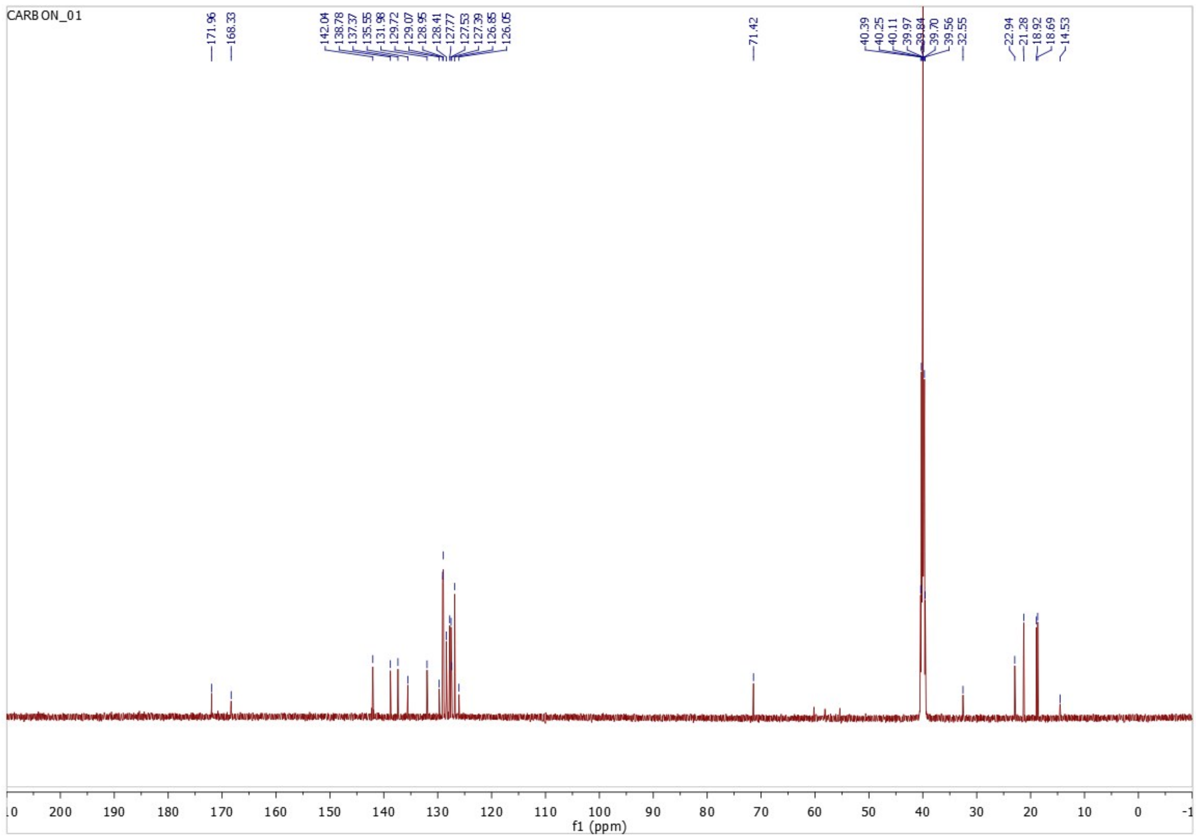
[13]C NMR (75 MHz, $CDCl_3$) spectrum of 1c



^{1}H NMR (600 MHz, DMSO-d_6) spectrum of 11

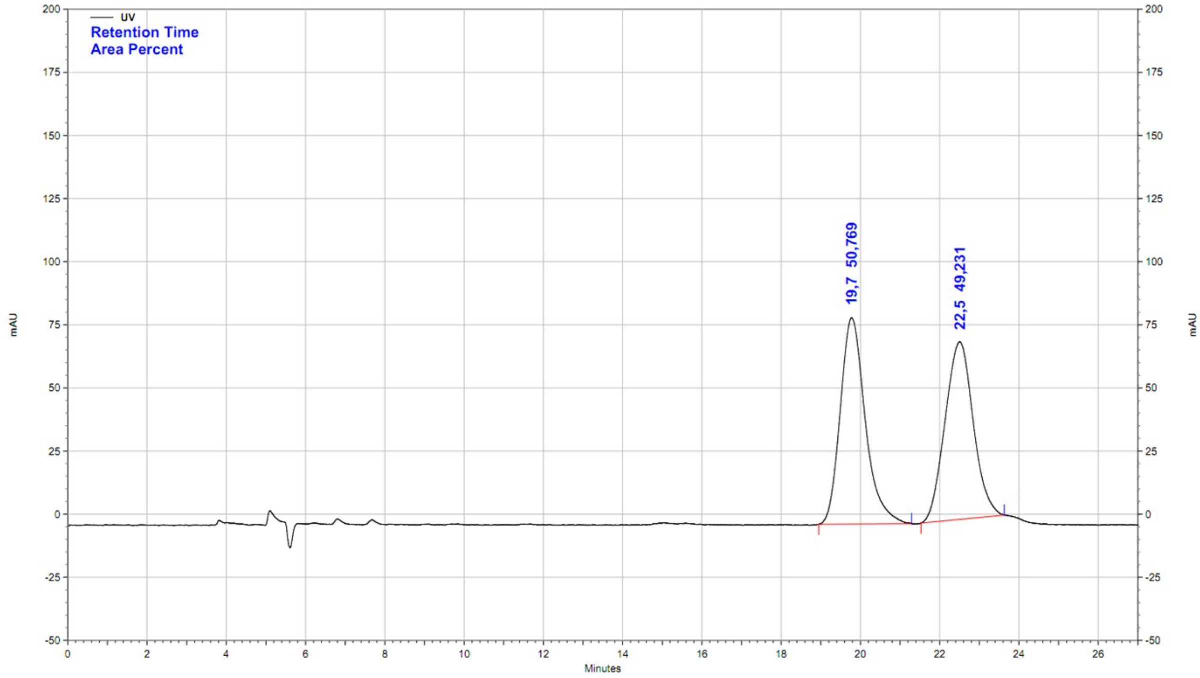


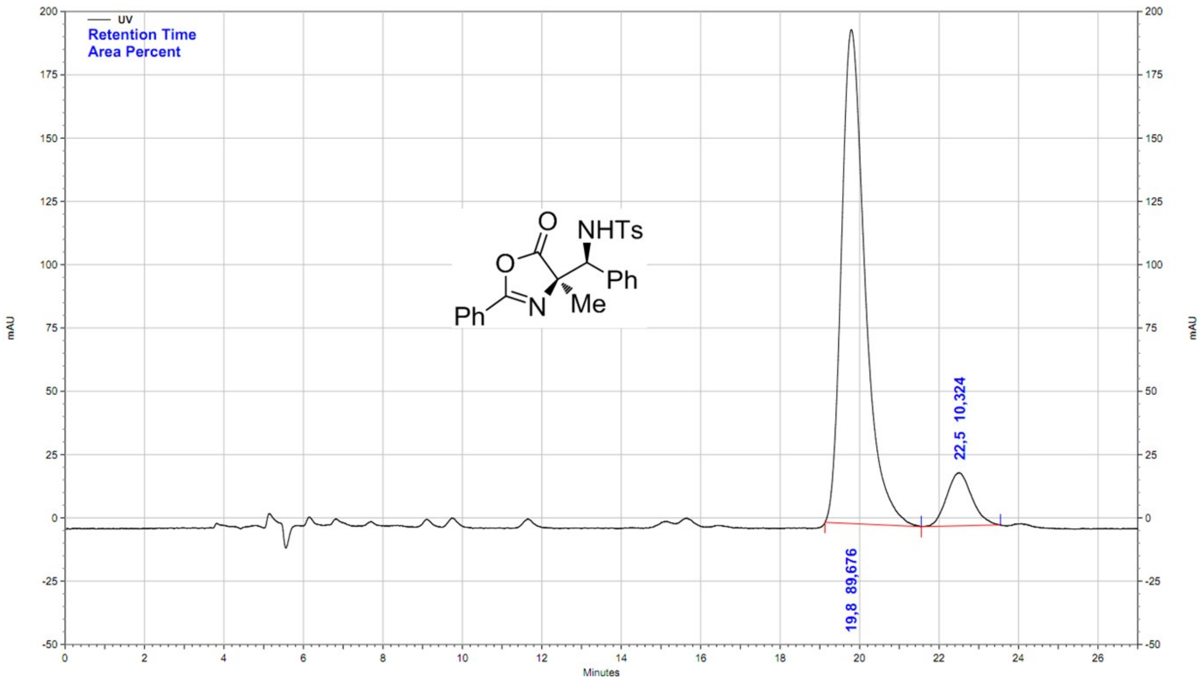
^{13}C NMR (150 MHz, DMSO-d_6) spectrum of 11



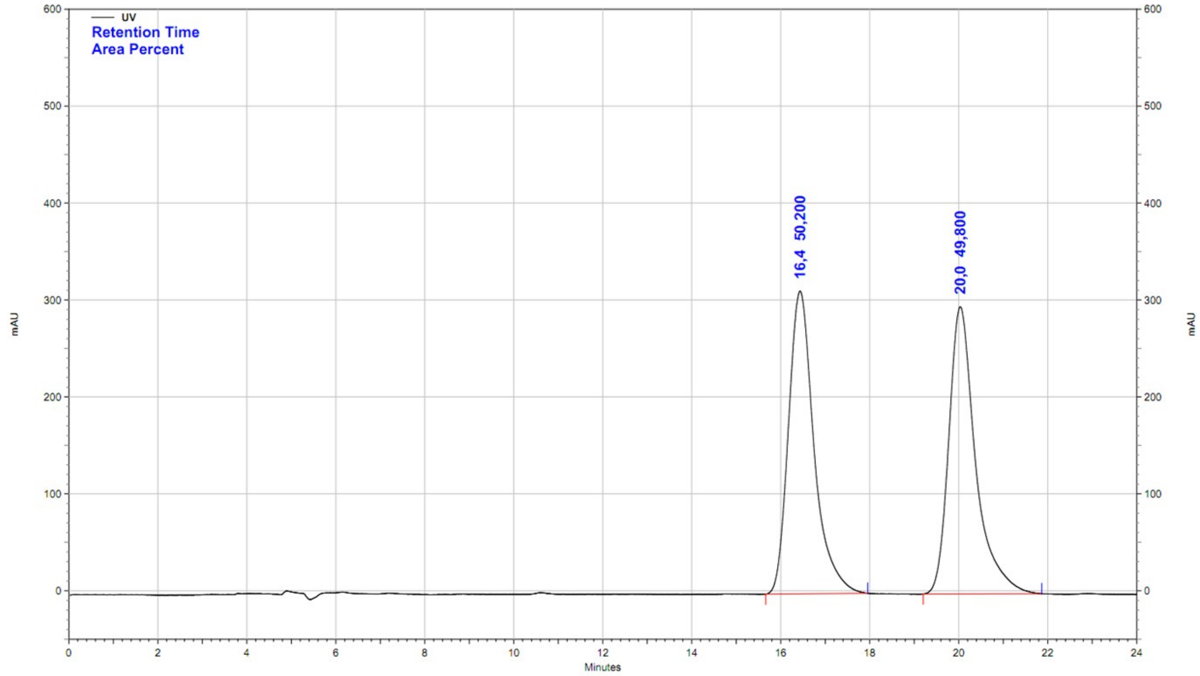
5. HPLC Spectra

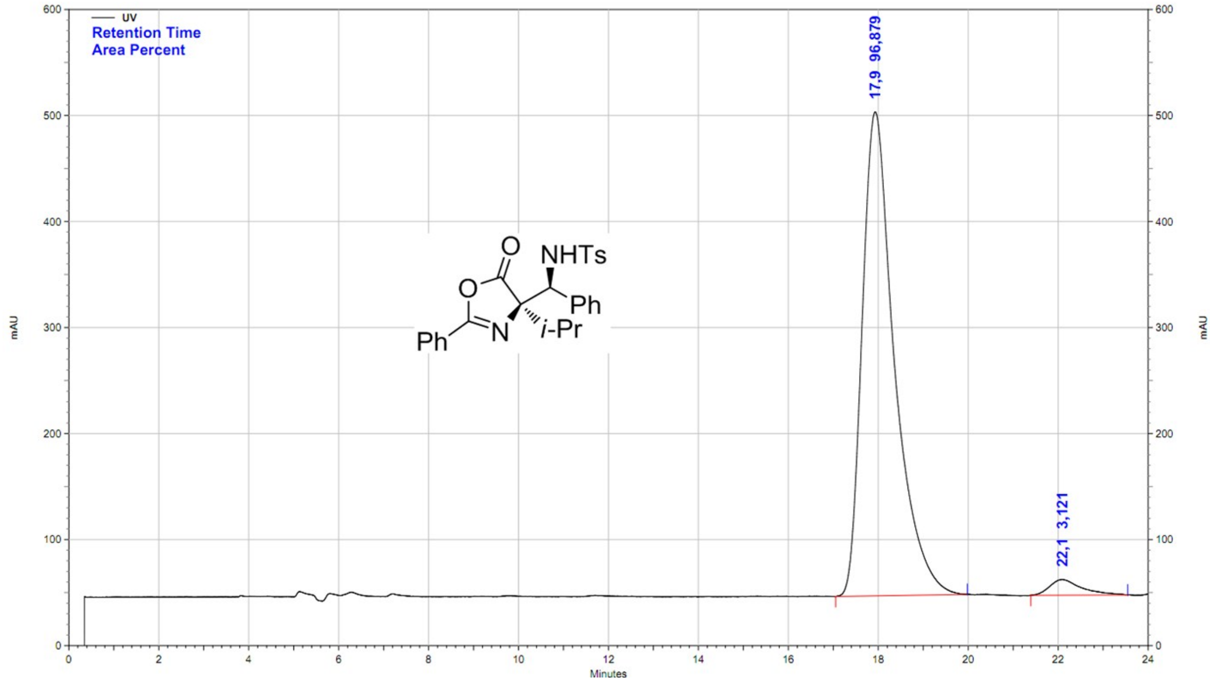
HPLC Trace of 10a



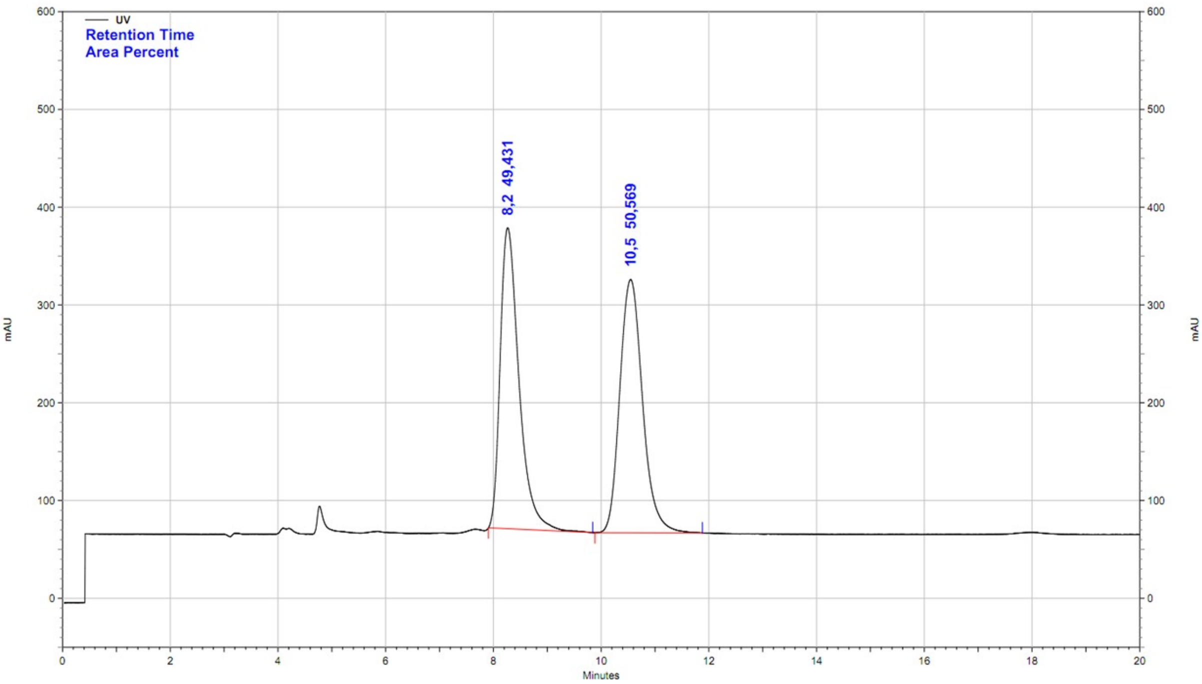


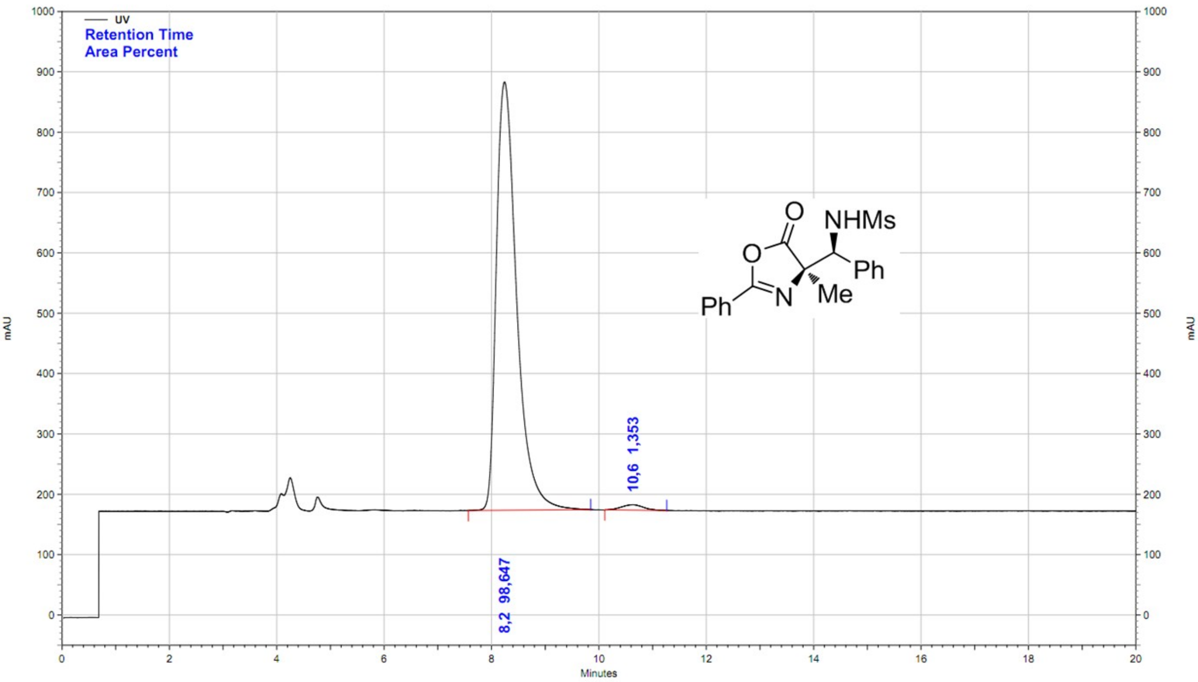
HPLC Trace of 10b



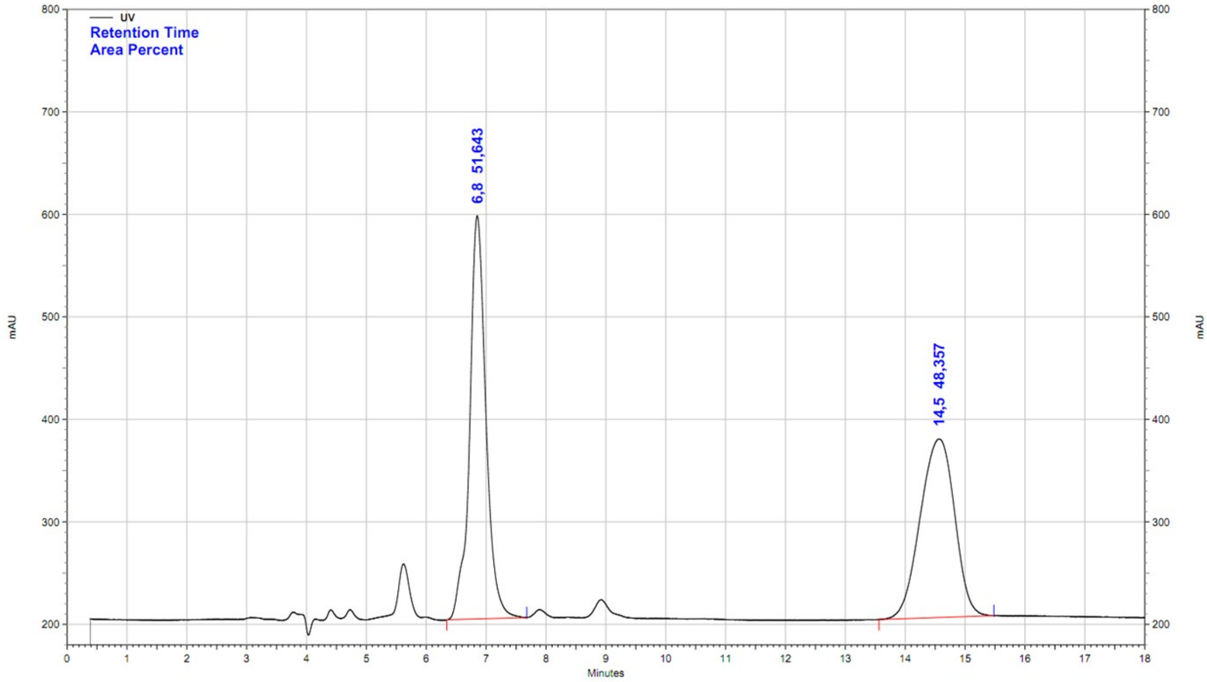


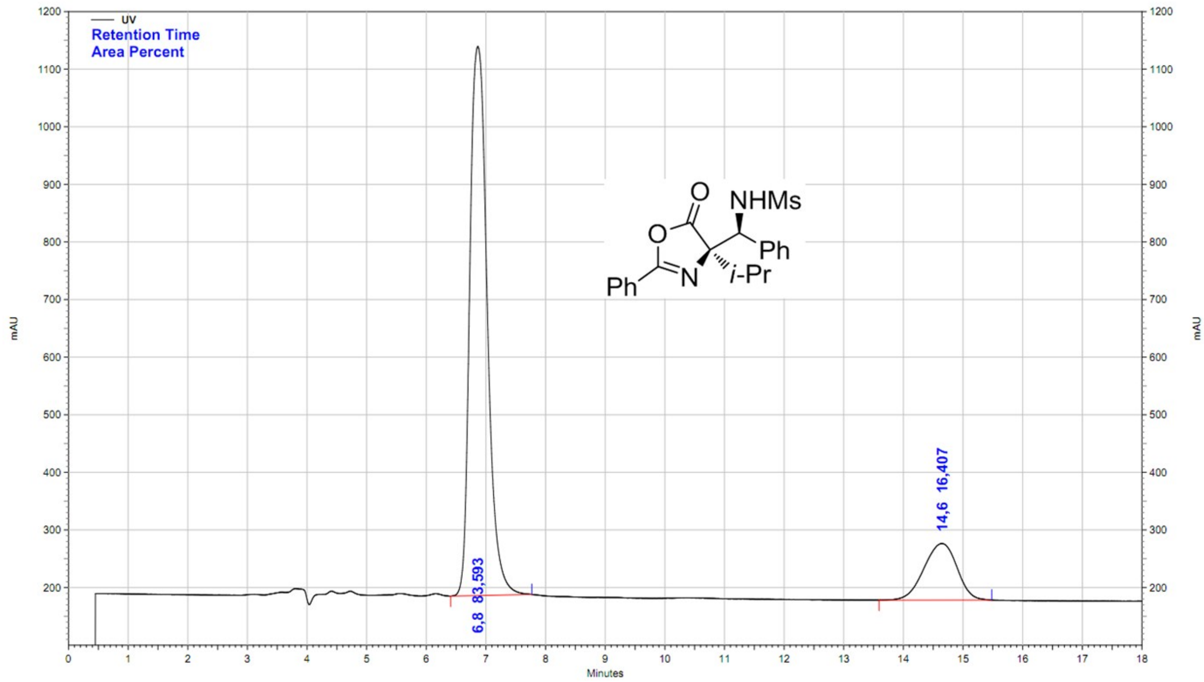
HPLC Trace of 10c



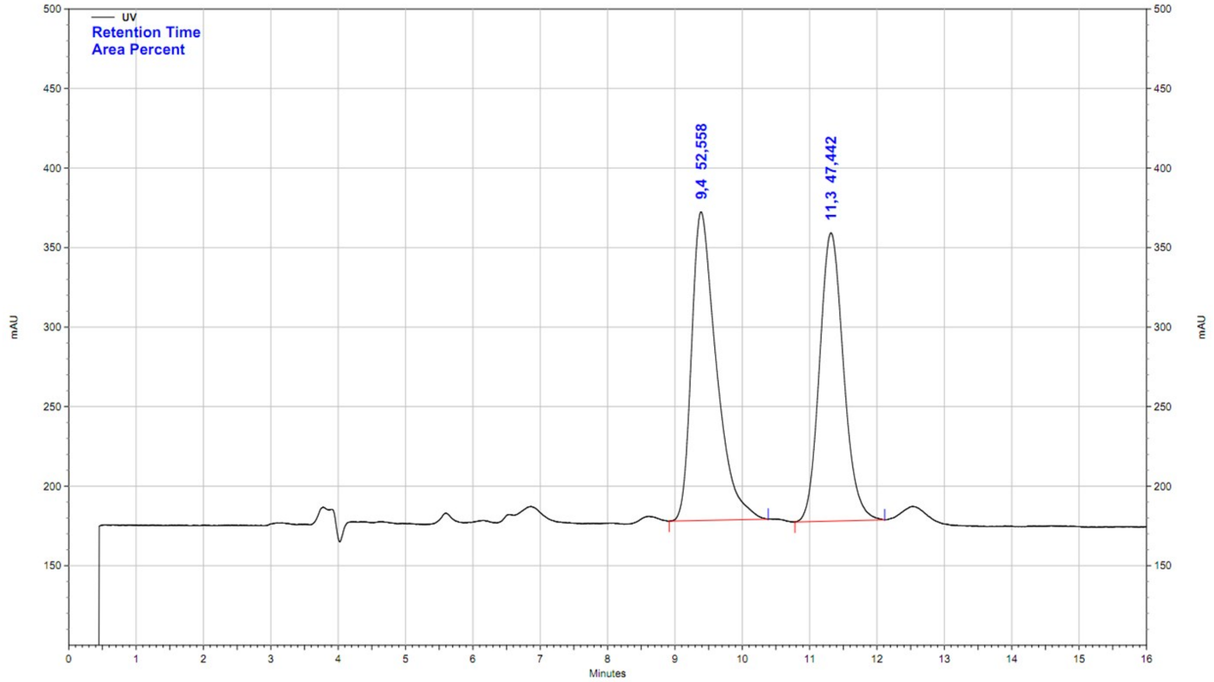


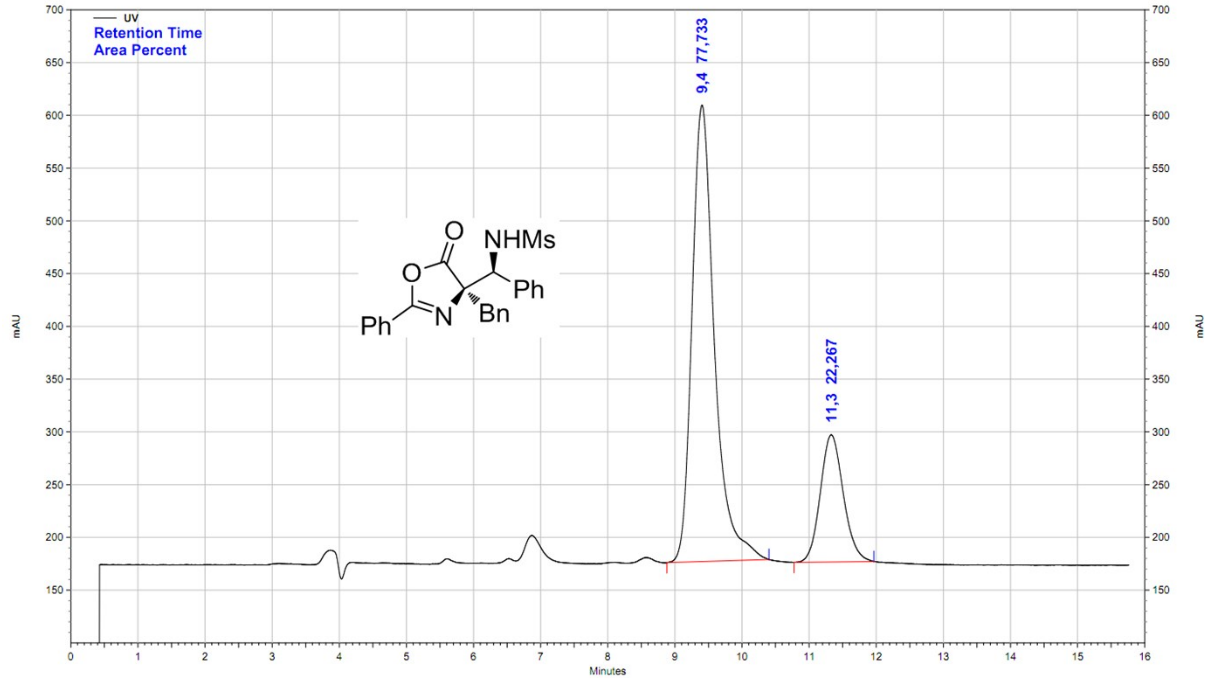
HPLC Trace of 10d



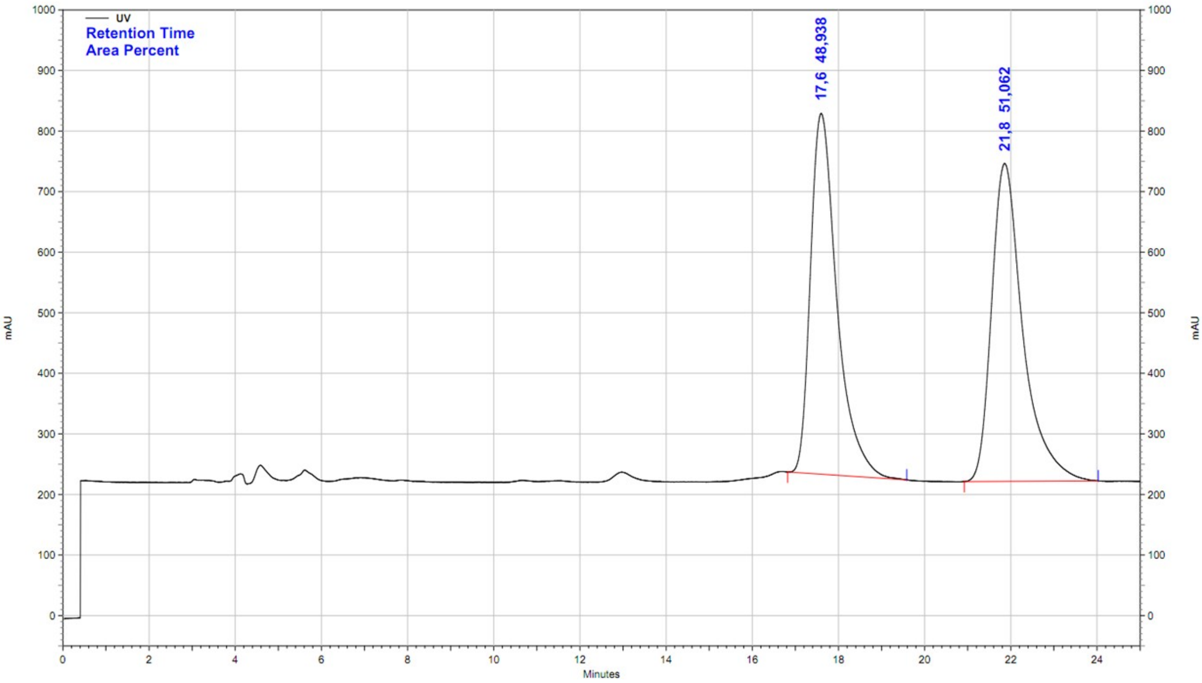


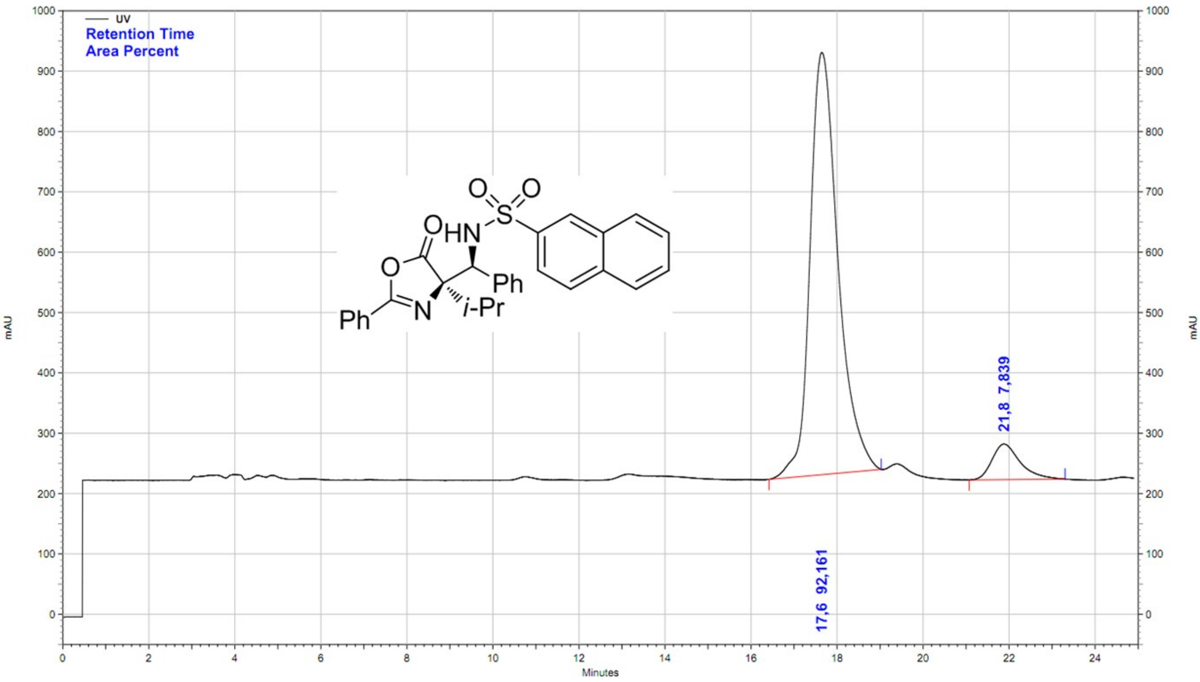
HPLC Trace of 10e



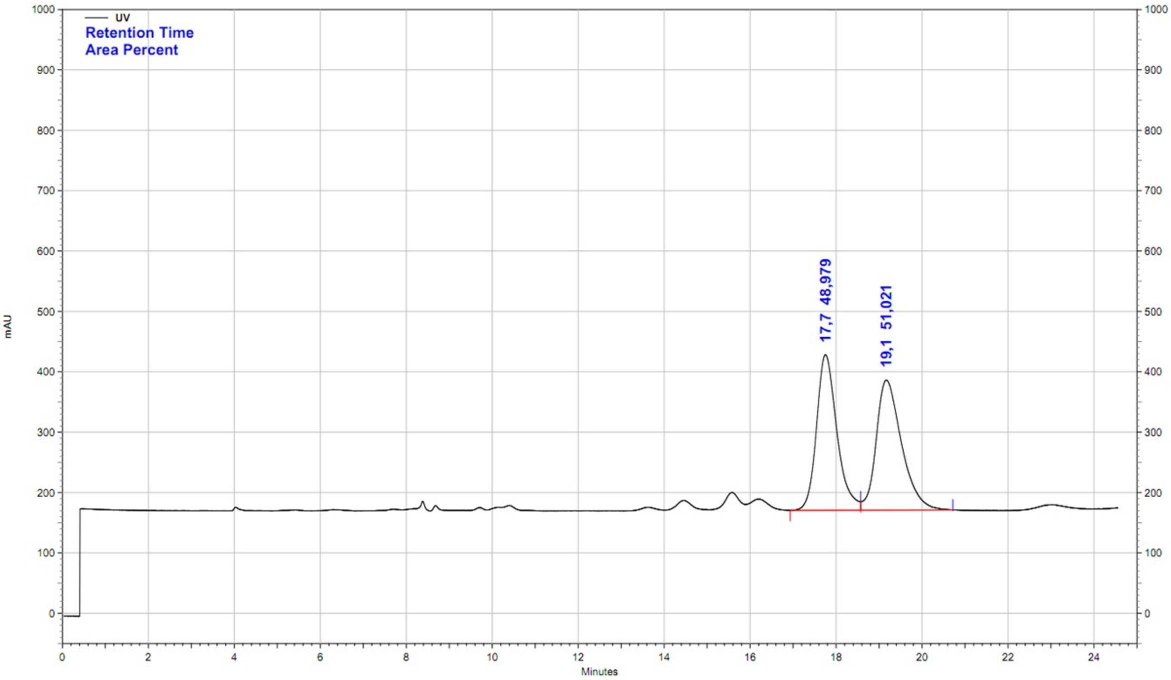


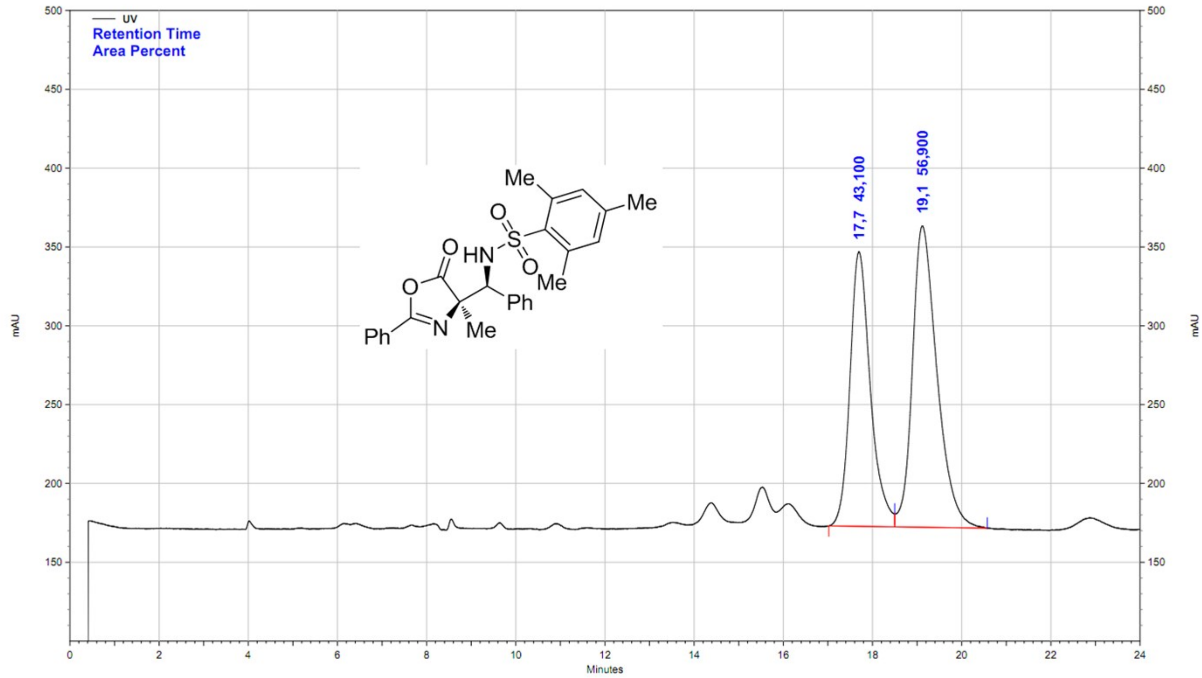
HPLC Trace of 10f



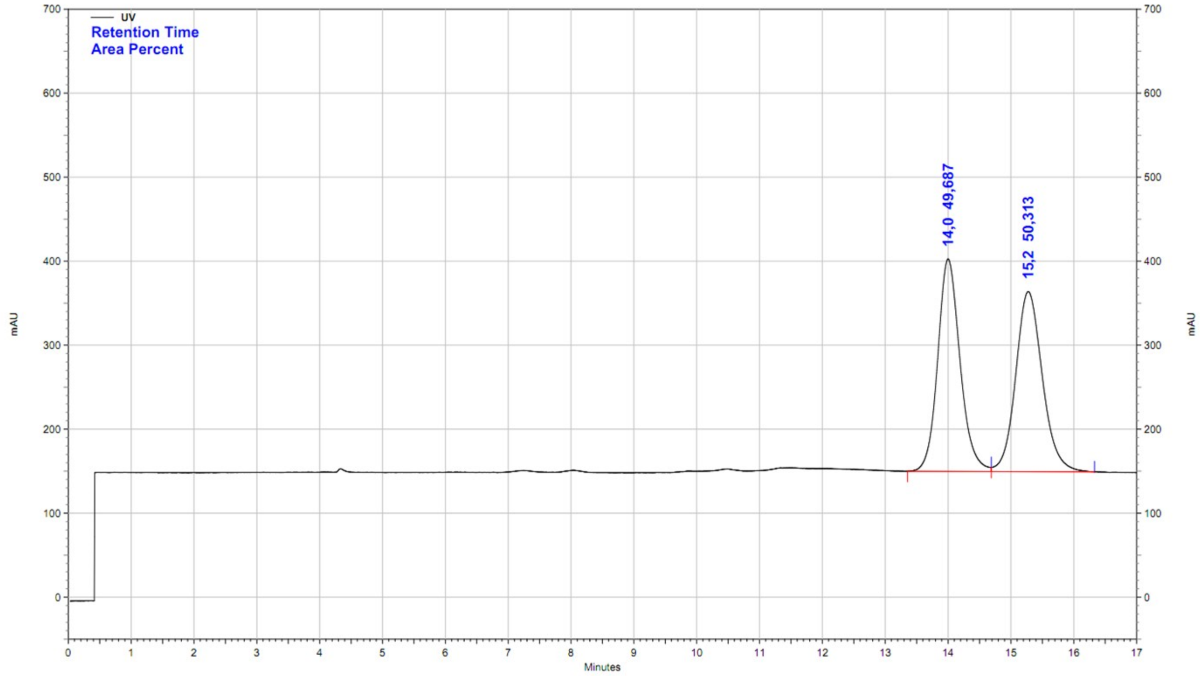


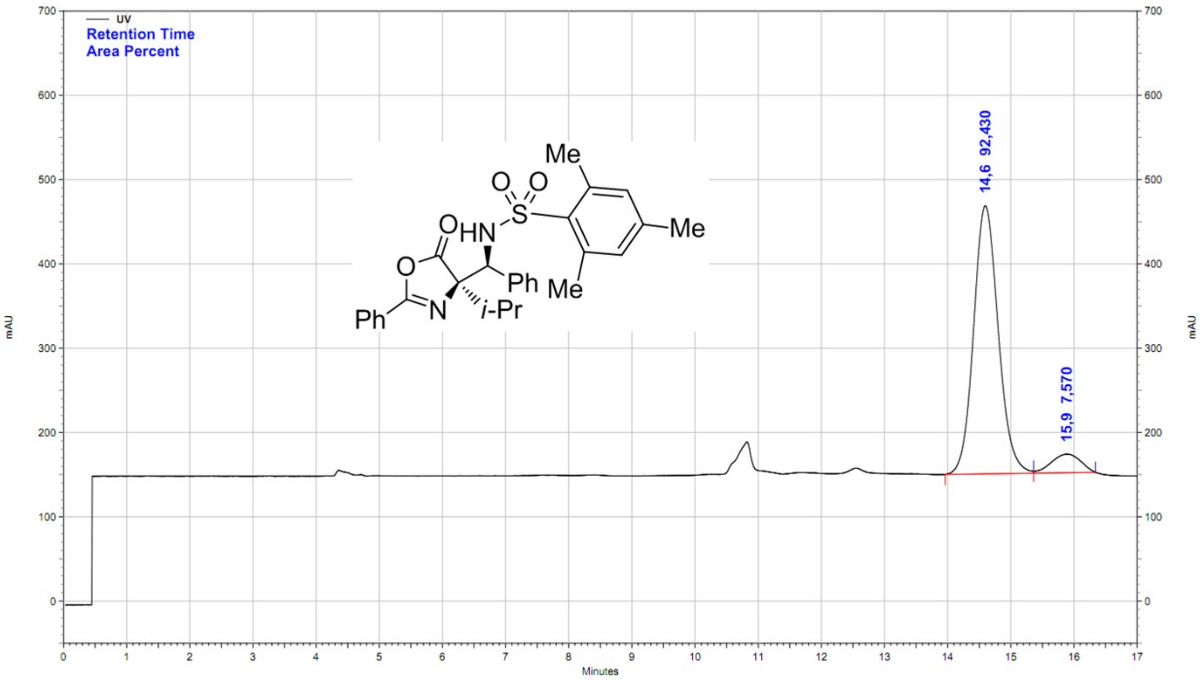
HPLC Trace of 10g



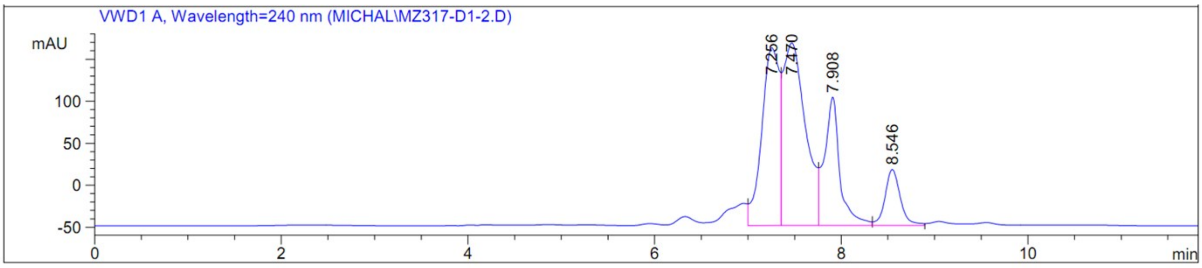


HPLC Trace of 10h



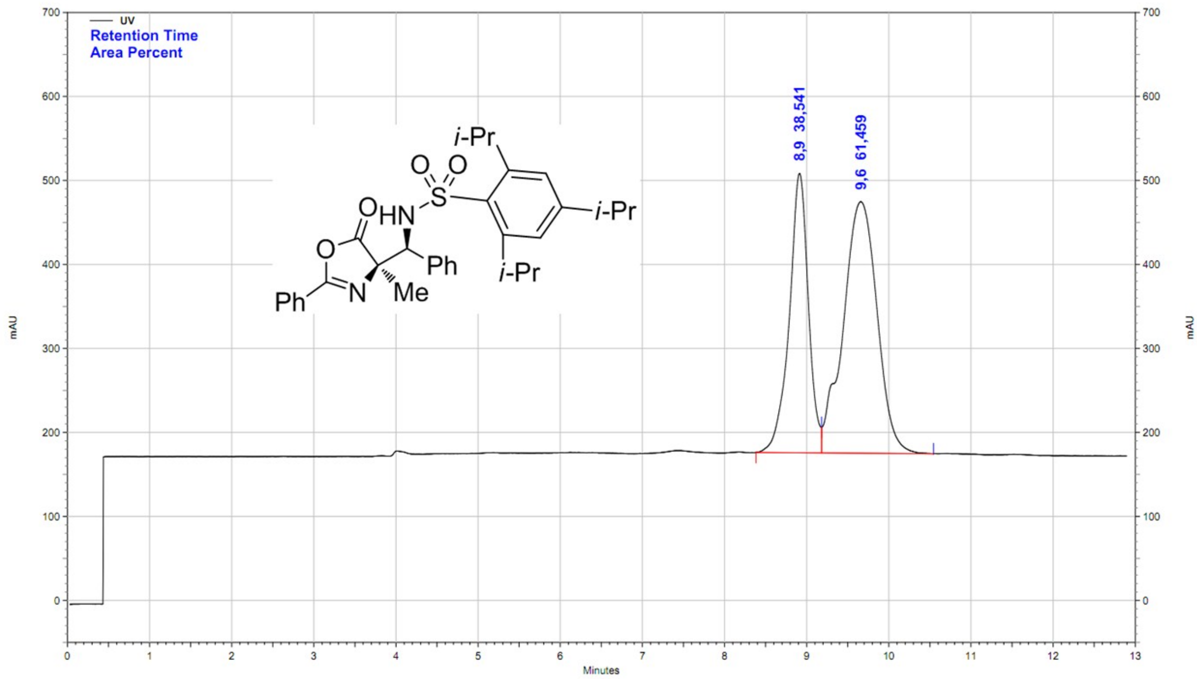


HPLC Trace of 10i

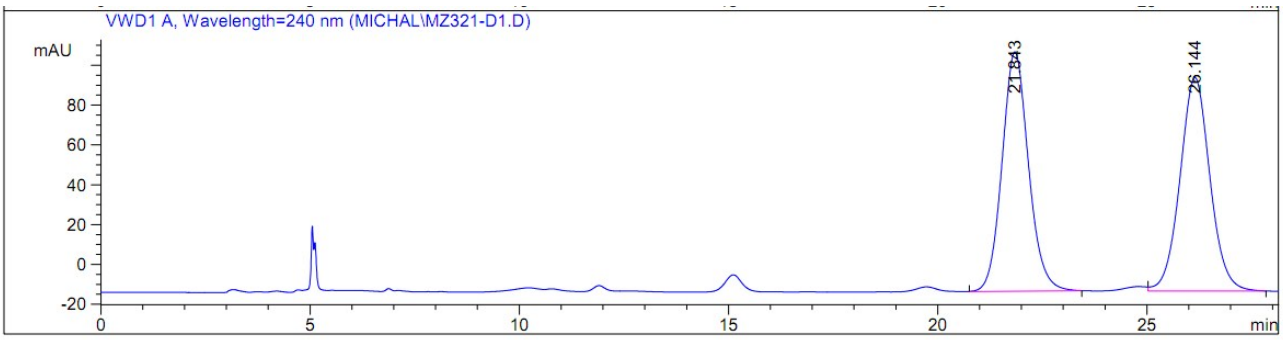


Signal 3: VWD1 A, Wavelength=240 nm

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.256	VV	0.1958	2785.01318	211.58266	31.3186
2	7.470	VV	0.2403	3606.66479	217.19028	40.5584
3	7.908	VV	0.1628	1748.85168	152.66356	19.6665
4	8.546	VV	0.1711	751.99091	66.55000	8.4564
Totals :				8892.52057	647.98649	



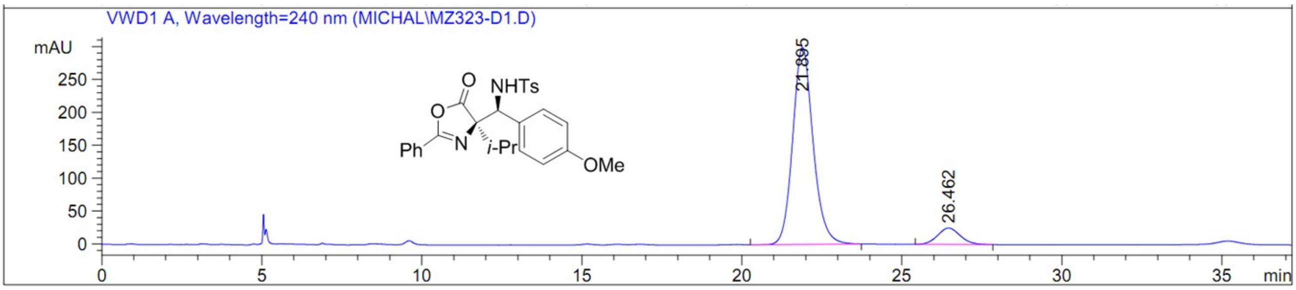
HPLC Trace of 10k



Signal 2: VWD1 A, Wavelength=240 nm

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	21.843	BB	0.6742	5296.04443	120.19579	49.7991
2	26.144	VB	0.7584	5338.78516	107.24803	50.2009

Totals : 1.06348e4 227.44382

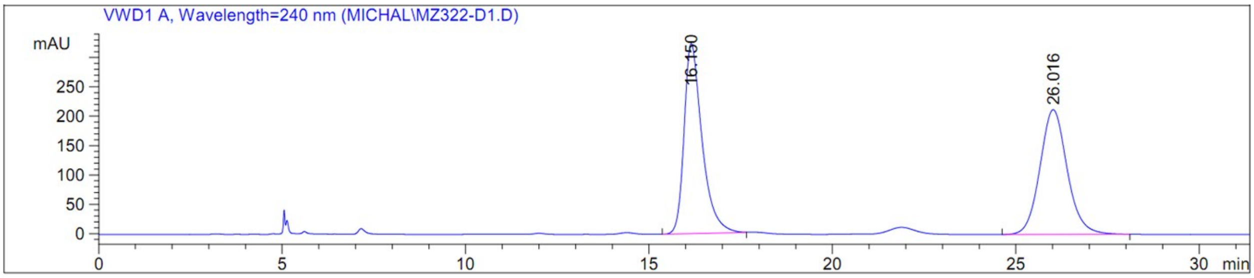


Signal 3: VWD1 A, Wavelength=240 nm

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	21.895	VB	0.6757	1.32747e4	299.57764	91.4540
2	26.462	BB	0.7578	1240.46533	25.07267	8.5460

Totals : 1.45152e4 324.65030

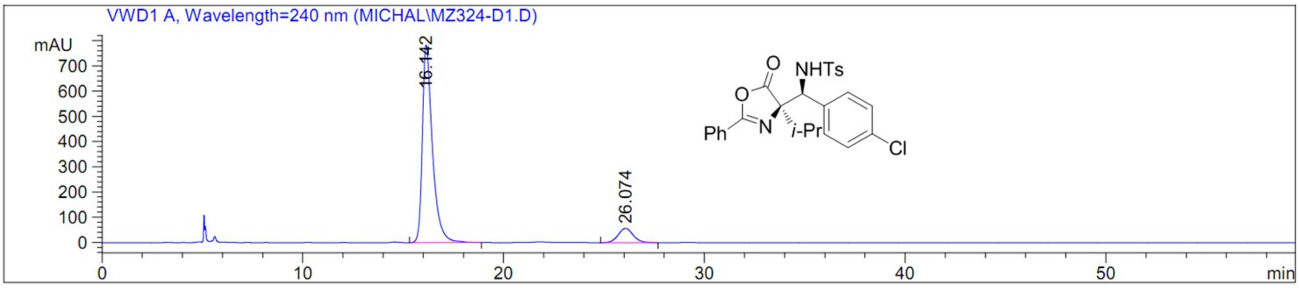
HPLC Trace of 10l



Signal 3: VWD1 A, Wavelength=240 nm

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	16.150	BB	0.5087	1.10123e4	323.92801	50.0486
2	26.016	BB	0.7895	1.09909e4	212.61414	49.9514

Totals : 2.20033e4 536.54214



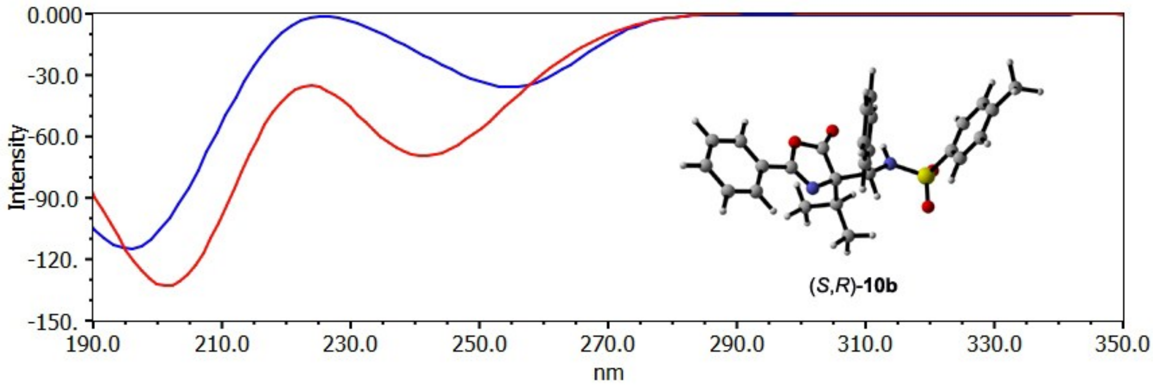
Signal 3: VWD1 A, Wavelength=240 nm

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	16.142	BB	0.5166	2.73001e4	784.62091	90.1855
2	26.074	BB	0.7941	2970.97119	57.17003	9.8145

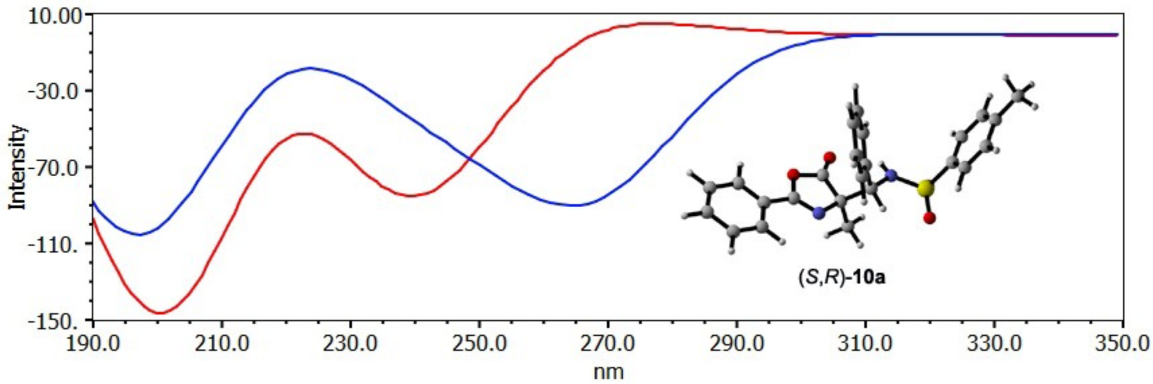
Totals : 3.02711e4 841.79094

6. Computational data

CD spectra



Comparison of theoretical and experimental ECD spectra of derivate (*S*,*R*)-**10b**; red curve - experimental spectrum; blue curve - calculated conformationally averaged spectrum (DFT, M06, def2_TZVP).



Comparison of theoretical and experimental ECD spectra of derivate (*S*,*R*)-**10a**; red curve - experimental spectrum; blue curve - calculated conformationally averaged spectrum (DFT, M06, def2_TZVP).

Method:

The structure of derivates **10a,b** were drawn and optimized by AM1 method in Spartan 8.[17] Then the conformation search was done using AM1 method. The conformers with $\Delta E<20$ kJ/mol were optimized at HF level using base 3-21G.[18] After geometry optimization, which

[17] Spartan ´08, Wavefunction, Inc., Irvine, CA.

[18] Y. Shao, L. F. Molnar, Y. Jung, J. Kussmann, C. Ochsenfeld, S. T. Brown, A. T. B. Gilbert, L. V. Slipchenko, S. V. Levchenko, D. P. ONeill, R. A. D. Jr, R. C. Lochan, T. Wang, G. J. O. Beran, N. A. Besley, J. M. Herbert, C. Y. Lin, T. V. Voorhis, S. H. Chien, A. Sodt, R. P. Steele, V. A. Rassolov, P. E. Maslen, P. P. Korambath, R. D. Adamson, B. Austin, J. Baker, E. F. C. Byrd, H. Dachsel, R. J. Doerksen, A. Dreuw, B. D. Dunietz, A. D. Dutoi, T. R. Furlani, S. R. Gwaltney, A. Heyden, S. Hirata, C.-P. Hsu, G. Kedziora, R. Z. Khalliulin, P. Klunzinger, A. M. Lee, M. S. Lee, W. Liang, I. Lotan, N. Nair, B. Peters, E. I. Proynov, P. A. Pieniazek, Y. M. Rhee, J. Ritchie, E. Rosta, C. D. Sherrill, A. C. Simmonett, J. E. Subotnik, H. L. Woodcock III, W. Zhang, A. T.

was done at DFT,[19] B3-LYP, def2_TZVP level in Turbomole[20], calculation of Boltzmann distribution of conformers was performed.[20] Two most stable conformers accounted for 88% and 7% (more than 95% all conformers) for compound (*S*,*R*)-**10a** and 86% and 9% for compound (*S*,*R*)-**10b**. ECD spectra of these conformers were calculated at DFT level using functional M06 and basis set def2-TZVP.[21] The resulted calculated ECD spectrum is conformationally averaged spectrum. The transition states **TS1** and **TS2** were pre-optimized by AM1 method and then optimized by HF using 3-21G bases set in program Spartan 8.[17] They were confirmed by one negative vibration corresponding to formation of C-C bond.

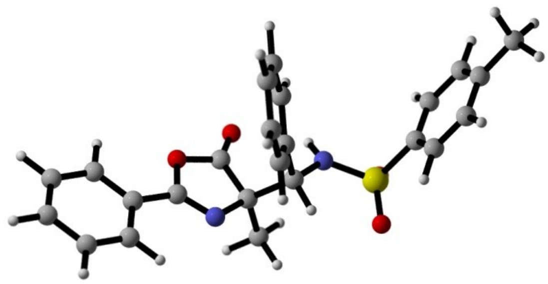
Bell and A. K. Chakraborty, *Phys. Chem. Chem. Phys*., **2006**, *8*, 3172 - 3191.

[19] K. Eichkorn, O. Treutler, H. Öhm, M. Häser and R. Ahlrichs, *Chem. Phys. Lett*., **1995**, *242*, 652-660; Eichkorn, K.; Weigend, F.; Treutler, O.; Ahlrichs, R. Theor. Chem. Acc. **1997**, *97*, 119-124.

[20] TURBOMOLE V6.6, TURBOMOLE GmbH, Karlsruhe, 2014.

[21] Furche, F.; Rappoport D. Ch. III of "Computational Photochemistry", Ed. by M. Olivucci, Vol. 16 of "Computational and Theoretical Chemistry", Elsevier, Amsterdam, 2005; Bauernschmitt, R.; Ahlrichs R. *Chem. Phys. Lett.* **1996**, *256*, 454-464; Bauernschmitt, R.; Häser, M.; Treutler, O.; Ahlrichs; R. *Chem. Phys. Lett.* **1997**, *264*, 573-701; Grimme, S.; Furche, F.; Ahlrichs, R. *Chem. Phys. Lett*. **2002**, *361*, 321-328.
Kuehn, M.; Weigend, F. J. *Chem. Theory Comput*. **2013**, 9, 5341-5348; van Setten, M.J.; Weigend, F.; Evers, F. J. *Chem. Theory Comput*. **2013**, *9*, 232-246; Bates, J. E.; Furche, F. *J. Chem. Phys*. **2012**, *137*, 164105.
Kuehn, M.; Weigend, F. *ChemPhysChem*. **2011**, *12*, 3331-3336.

(*S*,*R*)- **10a** conf1



E = -1736.08689377407 au

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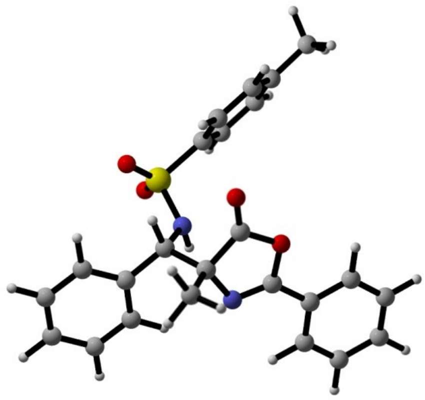
2 c	2.30759420281860	-2.82038948921984	-0.32512277231771
3 n	4.48825281665314	-1.63887239655638	-1.53023201919524
4 c	6.08982879734090	-1.15722262282046	0.18865412147667
5 o	5.38000140955355	-1.77851932567186	2.65204346506722
6 o	1.80663984057417	-3.43568562044883	4.29351953948101
7 c	8.60104309488673	-0.04124859854788	-0.10031296548615
8 c	13.37617164888845	2.07569527329682	-0.74174945389353
9 c	10.13782641323535	0.42142829697119	1.99673122137785
10 c	9.47140423331508	0.56251366995984	-2.52343172834094
11 c	11.84786037874797	1.61492855800679	-2.83602981362611
12 c	12.51797145904824	1.47850758343506	1.66809939214595
13 h	9.46640814284088	-0.04534232348457	3.86862108249392
14 h	8.26557874447010	0.18937423366231	-4.13085854611748
15 h	12.51601076067648	2.07680237245976	-4.71369779155672
16 h	13.70263683081126	1.83432066310155	3.29751887366572
17 h	15.23379281334454	2.89697625171612	-0.99188668380391
18 c	2.03786416140488	-5.55818993498378	-1.25305296072970
19 h	3.79879212760490	-6.58567020574707	-0.95304780924287
20 h	1.61806217020437	-5.55266661431713	-3.26887774960388
21 h	0.52424830962651	-6.52871072261841	-0.25562637677337
22 c	-0.16730018020479	-1.26334611340978	-0.84572950448080
23 h	-0.50624441639949	-1.45746499459614	-2.86793169734120
24 n	-2.27574400417923	-2.47454646522578	0.43952463404803
25 h	-2.02426262059363	-3.11562616774822	2.22230066652482
26 c	0.09902622448569	1.53893394776085	-0.23968081388175
27 c	0.66131352821993	6.70733583965701	0.76660719799799
28 c	-0.43639837429730	2.50770417813335	2.15295130460756
29 c	0.90901786915697	3.19819728203414	-2.12249846174955
30 c	1.18724190217353	5.76246754409261	-1.62840821672409
31 c	-0.15195783819938	5.07171618311426	2.65432041480137
32 h	-1.10335137261992	1.26732203020030	3.63582762275900
33 h	1.32868716677028	2.47301057794857	-3.99011271985780
34 h	1.80777169988250	7.02258741150605	-3.11704619586321
35 h	-0.57758971634682	5.79008022941622	4.52266203458342
36 h	0.87320790373849	8.70522980432371	1.15582356943665
37 s	-4.88075438582726	-3.44448253519671	-0.93334746852583
38 o	-5.71231929796933	-5.59207027943957	0.51131488005188
39 o	-4.37097085178251	-3.60902091352015	-3.60156926342053

40 c	-10.73808128274786	2.82061241602423	0.19677341931486
41 c	-7.16168730720037	-1.00781271421112	-0.50225765454847
42 c	-9.20863880755169	2.77094015817484	-1.95249526748783
43 c	-10.44972512932250	0.89346975296436	1.97806255831081
44 c	-8.68049849525682	-1.01313538464565	1.64453659939456
45 c	-7.43045174900293	0.87648047257324	-2.31489613941121
46 h	-9.42211263734703	4.22759454623033	-3.37622208452664
47 h	-11.64196479607989	0.87054856640244	3.64338499531267
48 h	-8.50242336697177	-2.52149431126095	3.01181079156843
49 h	-6.28507496333234	0.83509426857211	-4.00644128172475
50 c	-12.62546005967699	4.91096915113021	0.59905663465202
51 h	-13.30845278741135	5.66484526149824	-1.19391748994898
52 h	-11.77147290270036	6.47840508329632	1.64277035207617
53 h	-14.25020506208727	4.25871977243164	1.68703051428132

(*S*,*R*)- **10a** conf2

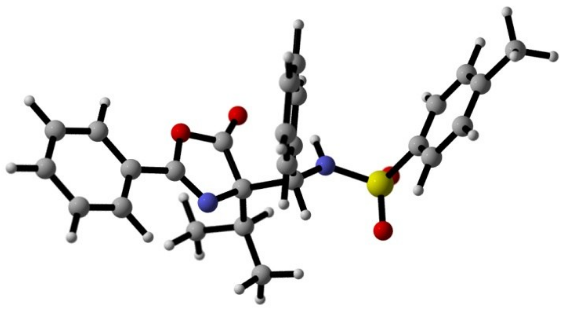


E = -1735.97559848424 au

1 c	-0.05463780616621	1.15367472049747	3.86822770561560
2 c	2.54632008847714	1.23826857514399	2.59895026447482
3 n	2.35099120420046	3.39976510690217	0.88644732641616
4 c	0.17225345814356	4.36407768973782	1.18784549076344
5 o	-1.39423248012593	3.19871801974721	2.93970126829794
6 o	-0.90821207713028	-0.26626562018940	5.38894417263136
7 c	-0.88183921766824	6.57256355757458	-0.10247644534513
8 c	-2.82635767915114	10.76582065229296	-2.62100615798335
9 c	-3.37645272240496	7.33104676908106	0.31603132583767
10 c	0.63652420291967	7.93338100598516	-1.78655426263490
11 c	-0.33603621125714	10.01804023479512	-3.03673849395506
12 c	-4.33921902019090	9.42223071622502	-0.94577292186152
13 h	-4.54858364298468	6.28109060304415	1.61845457884292
14 h	2.56836911497469	7.33679025828726	-2.08528827132240
15 h	0.84511281000267	11.06637831503339	-4.33727825638637
16 h	-6.27408143984394	10.00056510227005	-0.61927248077091
17 h	-3.58216449812929	12.39513569656755	-3.60159959238756
18 c	4.58652810435680	1.68577521555995	4.60985980227808
19 h	4.18488891634533	3.40785986249210	5.66835719674438
20 h	6.42527468913237	1.88290010558079	3.71086430293363
21 h	4.64134966960220	0.10204313450026	5.92824394888476
22 c	2.97508744076705	-1.29758088346143	1.16300210204245

23 h	2.65530314188584	-2.78317205717758	2.55057358970401
24 n	0.95446669291772	-1.57145142085444	-0.73501634705634
25 h	1.21285361624884	-0.51813654968048	-2.31240712268985
26 c	5.61605375026113	-1.64499815594711	0.08765072859522
27 c	10.44808566469427	-2.47685424683681	-1.90845232916851
28 c	6.64971596446395	0.03067979042677	-1.67237454859481
29 c	7.03665077783793	-3.73849612313231	0.82696686805158
30 c	9.43662877426775	-4.15343476656882	-0.15984633269616
31 c	9.04593133546538	-0.38451146638304	-2.66130188852008
32 h	5.59151604477527	1.68426343186746	-2.24406498249803
33 h	6.24191596566905	-5.07668384957142	2.15669135798119
34 h	10.50607665175884	-5.79583253075665	0.42940958185233
35 h	9.82098960858518	0.93158863928268	-4.02390743016933
36 h	12.31327725030987	-2.80000475209584	-2.68608508692190
37 s	-0.17094561620234	-4.41430946387959	-1.51941317279185
38 o	0.84535525226358	-6.19070995838749	0.27191432185741
39 o	0.18831263087845	-4.72070809989350	-4.19853121394752
40 c	-8.68504444646204	-3.87066152141927	-0.14791385060981
41 c	-3.48005374975915	-4.17317315494024	-0.97814279537871
42 c	-7.69691934951701	-3.74848716841025	-2.58843575548493
43 c	-7.00263956414005	-4.14499003317896	1.87177667081475
44 c	-4.41883857345687	-4.30441581571178	1.47753515075503
45 c	-5.11032637767902	-3.90036285274448	-3.01815734485560
46 h	-8.96486519357677	-3.54159733535230	-4.18320172491184
47 h	-7.72631814752021	-4.23711151389930	3.78529169134038
48 h	-3.14573739743633	-4.52419137837590	3.06032167057232
49 h	-4.35659582748434	-3.83157870581062	-4.91575459705466
50 c	-11.49125233463321	-3.76466064918501	0.30760647521207
51 h	-12.48490520625542	-2.93446603823430	-1.29549724662649
52 h	-11.93739326020287	-2.65766015728619	1.98980667493392
53 h	-12.25844996367797	-5.66183548365258	0.60204045913064

(*S,R*)- **10b** conf1

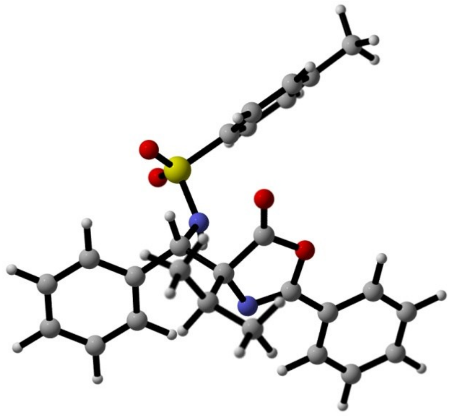


E = -1814.68148128048 au

1 c	-2.78914382489206	2.08133552944096	2.85447050335637
2 c	-2.23069789706413	2.62729554638183	0.07059238553372
3 n	-4.32938872194844	1.42146502489586	-1.24597513976217
4 c	-5.78566654831811	0.48234017659571	0.41142564939462
5 o	-5.03849902990001	0.77771705095660	2.92188048690323
6 o	-1.62076138410131	2.58732668787603	4.72006647453695

7 c	-8.16490731301535	-0.86459420955871	0.00804229435833
8 c	-12.69780414430446	-3.39947452418461	-0.84724537663210
9 c	-9.56252399831310	-1.80436852208089	2.04225866618586
10 c	-9.05155700091043	-1.20475649253445	-2.46012089968272
11 c	-11.30695755453170	-2.46613518891971	-2.87921504725470
12 c	-11.82233263517276	-3.06746747389923	1.60699046445594
13 h	-8.87751289062085	-1.54415899251643	3.94907507606712
14 h	-7.95309748826957	-0.46743600310331	-4.01786664367749
15 h	-11.98749577939786	-2.72406884480111	-4.79128113970144
16 h	-12.89936403431247	-3.79199856389947	3.18813998049055
17 h	-14.46141457818129	-4.38243786809807	-1.18056489934849
18 c	-2.21145878065453	5.54365930325121	-0.41248742168217
19 h	-0.63764868371355	6.28090960492108	0.69962185807131
20 c	0.34259668903697	1.33309401576225	-0.69165569958846
21 h	0.62632554306744	1.78161117809470	-2.67735832407276
22 n	2.38057539564819	2.54631455730705	0.70037154489176
23 h	2.18702429010991	2.81025582458710	2.58315776684404
24 c	0.27759490930501	-1.53819564088879	-0.44288877431696
25 c	0.09279299053432	-6.82159484415562	-0.11319672392141
26 c	0.90458828265616	-2.76783526931676	1.80278809396791
27 c	-0.43045581906441	-2.99596156192296	-2.52336307056276
28 c	-0.52345772675129	-5.61550560303723	-2.36508589226219
29 c	0.80827080048230	-5.38884223493018	1.96866523142635
30 h	1.49206092159526	-1.68795349073410	3.43759247239850
31 h	-0.91809554193540	-2.06779053958772	-4.28151585864068
32 h	-1.07090207157070	-6.71365271009506	-4.00315836175078
33 h	1.30299569495819	-6.30935466732581	3.72821070032815
34 h	0.02561166529984	-8.86287034452619	0.01491230891167
35 s	5.14350119018408	3.31155281647315	-0.47185341542284
36 o	6.11872947775672	5.23438560237211	1.18194691512694
37 o	4.76734357540503	3.74431895152982	-3.13222818873311
38 c	10.35902354871907	-3.54650075616282	0.30660413171290
39 c	7.16929303894817	0.63920362788354	-0.17811559923167
40 c	8.93762745987908	-3.17342013125487	-1.88224507703755
41 c	10.14949463845064	-1.76981762064110	2.24985907087115
42 c	8.57586079185388	0.31273675355548	2.02215431052077
43 c	7.35276323980429	-1.09720018689914	-2.14022664512485
44 h	9.07668057307353	-4.52144688089157	-3.41784636179584
45 h	11.24721960620369	-2.01177019818947	3.96257408300646
46 h	8.46078487233381	1.70103780894850	3.51803807366137
47 h	6.28632491688418	-0.81039615209178	-3.85897923558931
48 c	12.12057126695775	-5.76644600543678	0.55422579582514
49 h	11.67239493016200	-7.23969190728720	-0.81459468365267
50 h	12.02977825706028	-6.59066670319953	2.44320016992209
51 h	14.07961055670157	-5.18932350189727	0.23283764920848
52 c	-4.64314978277178	6.80086781350361	0.53925765543491
53 h	-4.97272773928206	6.46136829985954	2.54831474333937
54 h	-6.29280046168306	6.14735216131941	-0.51357150843387
55 h	-4.50723664686608	8.84246335517943	0.28308682586811
56 c	-1.75774738855733	6.19176846953327	-3.19648940174101
57 h	-1.85993791601426	8.23791951092887	-3.44125610143506
58 h	-3.19733083249704	5.33471697691639	-4.39909793343042
59 h	0.09986400725031	5.59664466103375	-3.85383466834722

(*S*,*R*)- **10b** conf2



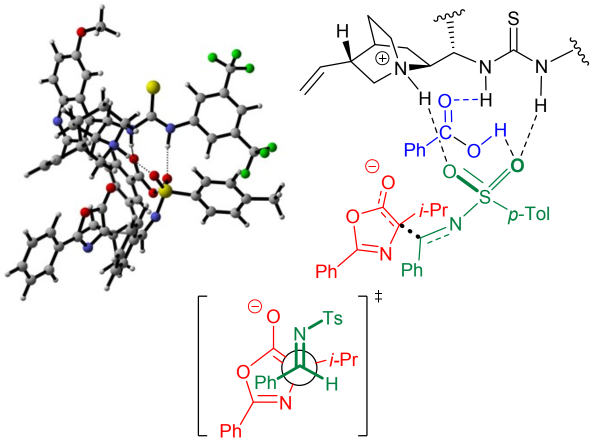
E = -1814.67947911740 au

1 c	-0.07253896230980	1.03768857683761	3.51280559824877
2 c	2.40541134475358	1.37365569662763	2.04453651704672
3 n	1.82475283540422	3.45261532677169	0.31233805744655
4 c	-0.42133531468702	4.17167908019238	0.75881446849058
5 o	-1.70307172151612	2.89140490523464	2.64931079570415
6 o	-0.67216324155020	-0.43050618483089	5.10989021438427
7 c	-1.81218631082716	6.21823959589982	-0.48010687282574
8 c	-4.39633579744588	10.13050444656252	-2.87604441704380
9 c	-4.32477680924392	6.73091458705829	0.15206583332512
10 c	-0.60030656125758	7.68268519120871	-2.31852530126733
11 c	-1.89011912700978	9.62671446073662	-3.50716854636786
12 c	-5.60624267643677	8.68296224199453	-1.04792836118268
13 h	-5.26162669502903	5.60115278679363	1.57254717155974
14 h	1.34801658961353	7.27787612802079	-2.78396833607817
15 h	-0.94356571849742	10.75602104933912	-4.92631652245159
16 h	-7.55255791797655	9.07261351754335	-0.55271817819825
17 h	-5.39973055194244	11.65115634967459	-3.80781327028904
18 c	4.62428220745041	2.13074616781847	3.84449957285245
19 h	6.20580785512014	2.52655438499058	2.57822859899124
20 c	2.93297448829707	-1.12510762365355	0.56183459679258
21 h	2.88972036982435	-2.63839244275478	1.95295624992940
22 n	0.76325607514817	-1.60074694368494	-1.12729889033632
23 h	0.79818157842886	-0.58014908603823	-2.74596164334991
24 c	5.45534292146931	-1.25253255350854	-0.81623895526257
25 c	10.03915042155192	-1.74168296240794	-3.42861651763434
26 c	6.25485273862884	0.62496506546984	-2.49445690212589
27 c	6.98099276416560	-3.37894258690572	-0.48086228885828
28 c	9.25580863576088	-3.62361451165008	-1.77305785727222
29 c	8.52896998562079	0.37955765771987	-3.78636371545685
30 h	5.10652102411963	2.29286554694154	-2.76941807408448
31 h	6.35999337330215	-4.87692216022692	0.76803221615116
32 h	10.40729501056247	-5.29175886672080	-1.49201407107248
33 h	9.12266003495470	1.85379038729740	-5.07644636947356
34 h	11.80846849073423	-1.92879846741355	-4.43987058967050
35 s	-0.22868119536826	-4.53528846345366	-1.72970909670801

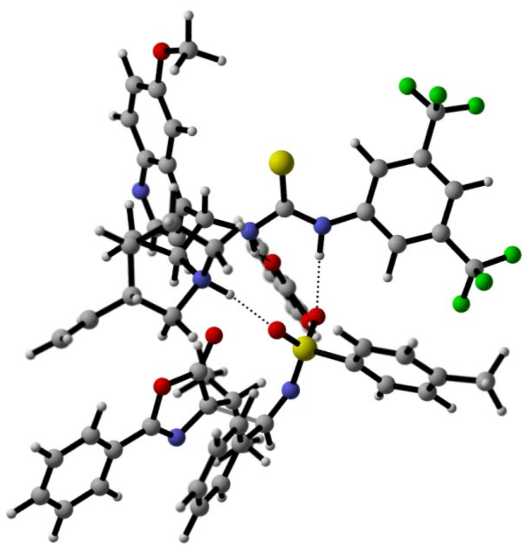
36 o	1.00384743049636	-6.17237640561751	0.06042141211226
37 o	-0.01719655598091	-4.94029478212935	-4.41179765033303
38 c	-8.66497806693192	-4.41371990891829	0.13822741523886
39 c	-3.50815642789188	-4.46323051259665	-0.99314867829518
40 c	-6.85740906520356	-4.54327636291353	2.05786331236293
41 c	-7.82774422187093	-4.30801955383361	-2.36211158141723
42 c	-5.26895818990560	-4.33500816901865	-2.94054807598056
43 c	-4.29284296813443	-4.57396822984721	1.51424656967672
44 h	-7.46204884738858	-4.62177978337101	4.01245105497669
45 h	-9.19586390219342	-4.21320171299018	-3.88363260353703
46 h	-4.63162084261311	-4.28129723564757	-4.88074755245902
47 h	-2.91948831586699	-4.67751581286059	3.02336889654698
48 c	-11.44540198023384	-4.44550698262473	0.74069308483997
49 h	-11.79938089714622	-3.89059828763794	2.69321467917496
50 h	-12.23106180270494	-6.34027447940449	0.48013798684468
51 h	-12.49776032298449	-3.17256211982511	-0.49490922340513
52 c	5.40843780074136	0.01578311280871	5.66197069063664
53 h	6.09343139224024	-1.65723397377251	4.67687479982478
54 h	3.85173809208522	-0.54640225203295	6.88976941385394
55 h	6.94848589866890	0.69081323148413	6.85754131665565
56 c	4.04277426719995	4.55660942515576	5.31935118216297
57 h	5.70367324880417	5.11878459398860	6.40498232960780
58 h	2.49935253443878	4.27853871394493	6.66484471297121
59 h	3.55270860074028	6.11970919899506	4.07136703903182

Transition state model:

The observed stereochemistry of the products can be rationalized by the help of quantum chemical calculations. Based on Hartree-Fock calculations (HF, 3-21G), following model of the transition state was devised. The anion of oxazolone approaches imine in *synclinal* arrangement due to steric interactions in the transition state. The oxazolone attacks imine from *re*-face via its *re*-face. The catalyst and benzoic acid helps in activating the imine through oxygen atoms.



(*S*,*R*)-**TS1**



Transition state was optimized at AM1 level in Spartan and finally it was refined at HF level using 3-21G base. The transition state was confirmed by one negative vibration corresponding to formation of C-C bond (verified by visualisation).

$$E = -4600.3450078 \text{ au}$$
$$i = -190 \text{ cm}^{-1}$$

1 s	-5.84492293221843	-3.63583308166448	4.01755776071658
2 c	-4.31613448987613	2.16184669720591	1.60626721383306
3 n	-5.22887221256010	-0.12472192483880	0.37416577451641
4 c	-7.56079426181892	1.12816650195098	0.59904318445304
5 c	-12.04700410374790	3.89661528814562	0.73321373996145
6 c	-9.83791425319403	0.05858151015156	1.11493841901353
7 c	-7.56268398795284	3.71142212702133	0.12472192483880
8 c	-9.78500192144424	5.06257631277503	0.19464179179389
9 c	-12.03566574694440	1.33792610281624	1.19808636890607
10 h	-9.90027521561343	-2.04468367690279	1.43619186178015
11 h	-5.82224621861137	4.63171875424098	-0.32881234730230
12 h	-13.77610351628590	4.93974411407015	0.74077264449713
13 c	-14.44128711542620	0.05102260561587	1.85949051577851
14 c	-9.73775876809621	7.83291482510358	-0.24188494514192
15 f	-14.45640492449750	-2.37916520260685	1.08470280087079
16 f	-16.44628654351660	1.23399116545057	0.80502333305045
17 f	-14.87403440009410	0.01322808293745	4.37849545229554
18 f	-11.95629724931970	8.67006350243070	-1.19052746437038
19 f	-7.88015797845162	8.51321623331523	-1.85193161124282
20 f	-9.34469573224059	9.16706147565199	1.91618229979614
21 n	-1.99177134515299	-2.81758166567658	0.79179525011300
22 c	-0.58392537538167	-5.00588452875739	1.71020215119873
23 h	-1.64028228424364	-5.77500306526334	3.25599812874631
24 c	-0.26267193261505	-6.98064833870510	-0.38361440518601
25 n	0.62738907646186	-10.48609031712900	-4.21975845704615
26 c	1.15273294169196	-6.38916405878775	-2.45286452182978
27 c	1.54957542981542	-8.20897032575391	-4.35203928642064
28 h	1.96153572701025	-4.54857080434845	-2.66829330109680
29 h	2.66640357496288	-7.74031824454144	-5.97342430932507
30 c	2.09570628251866	-4.29534750240300	2.63049877841838
31 c	0.47999043801600	-2.16373642333983	6.59325448125124
32 c	3.73598856676231	-5.61059689161219	6.92206682855354
33 c	1.22076308251312	-4.61849067130353	7.99921072488865
34 c	3.29946182982650	-6.47231200868028	4.17818448209988
35 n	2.11649326999180	-1.93696928726928	4.26700161039418
36 h	-0.24755412354368	-6.02633664107487	7.76866413655026
37 h	2.05980148597416	-8.09936620998648	4.16873585143028
38 h	0.84092812959496	-0.49510824708737	7.71386207866654
39 h	4.42195915337572	-7.17340040436507	8.04645387823669
40 h	1.40784596977133	-4.23676599225144	10.00043070071120
41 h	5.05501740823934	-7.05812711019587	3.31457963889787
42 c	-0.82958977279143	-11.12859720266220	-2.21097957668786
43 c	-3.97598378577031	-12.60069386098690	1.75177612614500
44 c	-1.84059325443929	-13.60791789036690	-2.11460354385788
45 c	-1.37950007776251	-9.42784368213312	-0.24188494514192
46 c	-3.01033373133655	-10.22719783678180	1.74043776934147
47 c	-3.35426388771022	-14.33168299965870	-0.19653151792781
48 h	-1.36249254255722	-14.85702686488880	-3.63016390326272
49 h	-3.56780294084332	-8.91005872143870	3.15962209591633
50 h	-4.15172831622499	-16.18550433703550	-0.09259658056214
51 o	-5.58980990413906	-13.52665966660830	3.54134677496842

52 c	-6.57246749377811	-11.90149519143600	5.48965441904123
53 h	-5.07958384798032	-11.24764994909920	6.72742503675965
54 h	-7.88393743071946	-13.04855895472620	6.54223187563537
55 h	-7.53811754821187	-10.28766907306720	4.68652081212470
56 c	5.67862703243336	-3.42607348079922	6.99387642164255
57 h	5.64650168815670	-2.61916042161485	8.87793337716204
58 h	-1.46831720605681	-2.17129532787551	6.02066746267310
59 c	4.82069136763311	-1.40217679136956	5.05501740823934
60 h	4.83580917670448	0.47054180734639	5.85626128902195
61 h	5.94696814345017	-1.38894870843212	3.36182279224590
62 c	8.32802307219095	-4.31613448987613	6.44396611667146
63 h	8.64927651495756	-5.07013521731071	4.58447560089295
64 c	10.19885194477290	-4.23109681384968	8.08235867478119
65 h	12.04889382988190	-4.92273657886486	7.61748604583656
66 h	9.96074645189891	-3.47898581254902	9.95318754736323
67 h	-1.42674323111054	-2.08625765184906	-0.88439183067515
68 h	-3.96086597669894	0.78801579784516	-0.71809593089008
69 h	3.22765223673749	-3.75110637583368	1.04312882592453
70 h	1.54768570368150	-0.41007057106091	3.20308579699652
71 c	5.20619549895304	5.51800031105005	-1.45319939698544
72 n	2.75333097712326	5.20052632055128	-1.34359528121800
73 c	7.03545039658882	5.75799553005805	0.62738907646186
74 c	10.60325333743210	6.61026201645653	4.38416463069730
75 c	9.47130738321331	6.53278324496576	0.00944863066961
76 c	6.40617159399304	5.41028592141654	3.15962209591633
77 c	8.18062443374509	5.84114347995058	5.01911261169484
78 c	11.24576022296530	6.95419217283020	1.87838777711772
79 c	6.76521955943808	1.94074873953712	-3.72087075769094
80 n	9.42406422986528	2.02767614169750	-3.51111115682568
81 c	10.03822522338960	0.92785553175533	-1.46075830152112
82 o	7.95952647607631	-0.04913287948195	-0.19653151792781
83 c	5.82224621861137	0.48565961641776	-1.72909941253794
84 o	3.70197349635173	-0.26267193261505	-1.07147471793334
85 c	5.48020578837163	2.26956108683942	-6.23231678967228
86 c	12.54589180310310	0.56502811404245	-0.40818084492699
87 c	14.64159808562180	1.27178568812900	-1.82925489763577
88 c	17.03966054956790	0.94675279309455	-0.86360484320201
89 c	17.37225234913800	-0.08125822375861	1.52500899007445
90 c	15.28599469728900	-0.77667744104163	2.94041386438146
91 c	12.87659387653940	-0.45542399827502	1.98043298834947
92 h	4.55235025661629	4.79801465402605	3.66039952140546
93 h	7.67606755598812	5.58980990413906	6.96553052963373
94 h	11.97708423679280	6.93718463762491	5.83736402768274
95 h	13.12036854781520	7.52488946527442	1.37383089936075
96 h	9.97586426097028	6.77088873783984	-1.93507956113536
97 h	5.83547430154882	6.37215652358246	-3.17096045271986
98 h	3.52433923976313	2.76466933392679	-5.91673252530743
99 h	14.35058026099790	2.05413230757240	-3.67173787820899
100 h	11.26276775817060	-0.97131923283552	3.07836387215771
101 h	19.23930176945220	-0.33637125183798	2.26956108683942
102 h	18.65159694180270	1.48343501512818	-1.96720490541202
103 h	15.53165909469870	-1.56280351275287	4.79045574949037
104 s	0.52912331749795	4.34448038188495	0.31369453823093

105 o	-1.34926445961977	3.14639401297888	-1.34548500735193
106 o	1.03745964752276	2.89128098489951	2.61160151707916
107 c	-0.86549456933593	7.14694423849017	1.34548500735193
108 c	-3.56591321470940	11.37804105233980	2.87427344969422
109 c	-1.35682336415545	9.07068544282200	-0.36471714384680
110 c	-1.66862817625246	7.35292438708759	3.82291596892269
111 c	-3.00277482680086	9.46752793094547	4.57691669635727
112 c	-2.69852891923954	11.16450199920670	0.40251166652523
113 c	-5.21564412962265	13.58146172449200	3.64717143846801
114 h	-0.71053702635439	8.90816899530478	-2.27523026524118
115 h	-3.10859949030045	12.63092947912960	-0.93163498402318
116 h	-1.27367541426292	5.85815101515588	5.12115782292659
117 h	-3.64528171233409	9.60925739098956	6.49309899615342
118 h	-7.16962095209723	13.07879457286890	3.28623374688905
119 h	-4.76210985748155	15.26331798368190	2.57380699440074
120 h	-5.00966398102523	14.00287065235640	5.63894278362101
121 c	5.56524346439808	-0.26267193261505	-7.69496481732733
122 h	7.51166138233697	-0.80880278531830	-8.02188743849571
123 h	4.60904204063393	-0.09637603282998	-9.50154300135605
124 h	4.64116738491059	-1.74043776934147	-6.61971064712614
125 c	6.77277846397376	4.32747284667966	-7.83669427737143
126 h	6.62915927779575	6.18129418405641	-6.97875861257118
127 h	5.89216608556646	4.42951805791141	-9.68484643634641
128 h	8.75510117845716	3.87960775294032	-8.06724086570982
129 h	-2.49254877064213	-5.07391466957856	-7.67984700825596
130 c	-2.21664875508962	-3.89094610974385	-9.29745257889255
131 c	-1.48343501512818	-0.72943428769360	-13.40571719403730
132 c	-1.72720968640402	-1.34737473348585	-8.93651488731360
133 c	-2.33759122766058	-4.86037561644545	-11.71819175644560
134 c	-1.97098435767986	-3.27678511621945	-13.77043433788410
135 c	-1.36249254255722	0.24188494514192	-10.98497801648420
136 h	-2.71364672831091	-6.82758052185748	-12.00354040266770
137 h	-2.06547066437592	-4.02511666525226	-15.65071184113580
138 h	-0.99399594644258	2.20153094601825	-10.65805539531580
139 h	-1.20375554730783	0.48754934255168	-15.00064605106680
140 c	-1.60815693996698	-0.38361440518601	-6.32491337023442
141 o	-1.93885901340320	-1.70831242506481	-4.46920230672376
142 o	-1.12060759741530	2.07491929504553	-6.16617637498504
143 h	-1.06769526566550	2.68719056243601	-4.39550298750083