Electronic Supplementary Information for

A Versatile Access to Vicinal Diamine Motifs by Highly *anti*-Selective Asymmetric Vinylogous Mannich Reactions: An Efficient Total Synthesis of (+)-Absouline

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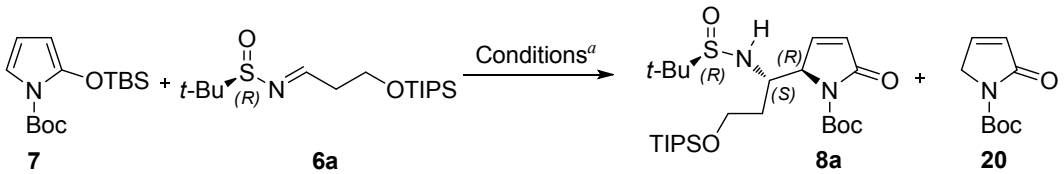
Table S1. Optimization of the Vinylogous Mannich Reaction.



7 **6a** **8a** **20**

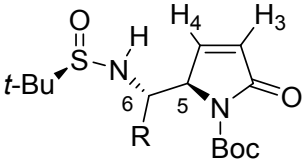
Entry	Lewis acid (equiv)	**7** (equiv)	Resulting (yield)[b]	
			8a	**20**
1	$BF_3 \cdot Et_2O$ (1.5)	1.5	none	85%
2	$TiCl_4$ (1.0)	1.5	none	70%
3	$Sm(OTf)_3$ (0.25)	1.5	trace	64%
4	$Bi(OTf)_3$ (0.25)	1.5	trace	80%
5	$Cu(OTf)_2$ (1.0)	1.5	27%	58%
6	TMSOTf (1.0)	1.5	96%	10%
7	TMSOTf (1.0)	1.0	80%	5%
8	TMSOTf (1.0)	1.3	91%	10%
9[c]	**TMSOTf (1.0)**	**1.4**	**96%**	**10%**
10	TMSOTf (1.0)	2.0	96%	60%

[a] Conditions: **6a** (0.5 mmol), **7** (0.7 mmol), Lewis acid, CH_2Cl_2 (0.1 M), –78 °C, 7 h.

[b] Isolated yield.

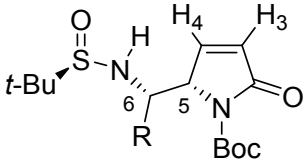
[c] Optimized conditions.

Table S2. Diagnostic resonances of the two diastereomers of 8.



(R_S,5*R*,6*S*)-**8**

major isomer



(R_S,5*S*,6*S*)-**8**

minor isomer

Entry	compound	R	Major isomer (ppm)		Minor isomer (ppm)	
			H3[c]	H4	H3[c]	H4
1	**8a**[a,d]	$TIPSO(CH_2)_2$	**6.21**	**7.18**	[f]	[f]
2	**8b**[a]	Et	6.22	7.10	[f]	[f]
3	**8c**[a]	*n*-Pr	6.21	7.10	[f]	[f]
4	**8d**[a]	*n*-C_5H_{11}	6.22	7.09	[f]	[f]
5	**8e**[a]	$Ph(CH_2)_2$	6.21	7.08	[f]	[f]
6	**8f**[a]	3-Cl-*n*-Pr	6.24	7.15	[f]	[f]
7	**8g**[a]	*i*-Pr	6.20	7.09	[f]	[f]
8	**8h**[a]	*c*-Hex	6.19	7.08	[f]	[f]
9	**8i**[b]	Ph	6.20	6.85	5.94[g]	7.24[g]
10	**8j**[b]	*p*-*i*-PrC_6H_4	6.20	6.88	5.95[g]	7.26[g]
11	**8k**[b]	4-Ph-C_6H_4	6.22	6.91	5.98	7.29
12	**8l**[b]	*p*-$MeOC_6H_4$	6.20	6.88	5.96	7.24
13	**8m**[b,e]	*p*-ClC_6H_4	**6.22**	**6.84**	**5.99**	**7.22**
14	**8n**[b]	*p*-$O_2NC_6H_4$	6.24	6.84	5.99[g]	7.33[g]
15	**8o**[b]	1-Naphthyl	6.18	6.71	[f]	[f]

[a] **8a-h**, VMR products of aliphatic *t*-BS-imines.

[b] **8i-o**, VMR products of aromatic *t*-BS-imines.

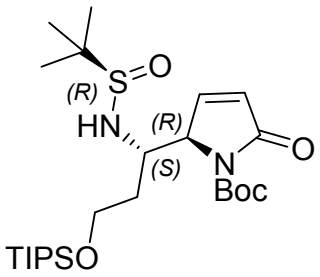
[c] Assignments of H-3 and H-4 in compounds (R_S,5*R*,6*S*)-**8a**, (R_S,5*R*,6*S*)-**8m** and (R_S,5*S*,6*S*)-**8m** were determined using 2D NMR technique including COSY, HSQC and HMBC.

[d] The stereochemistry of major isomer of **8a** was determined to be R_S,5*R*,6*S* (5,6-*anti*) by single-crystal X-ray diffraction crystallographic analysis, see: Figure S1.

[e] The stereochemistry of major isomer of **8m** was determined to be R_S,5*R*,6*S* (5,6-*anti*) by single-crystal X-ray diffraction crystallographic analysis, see: Figure S2.

[f] Minor isomer was not isolated.

[g] Analyzed by ^{1}H NMR of crude product.



(R_S,5*R*,6*S*)-8a

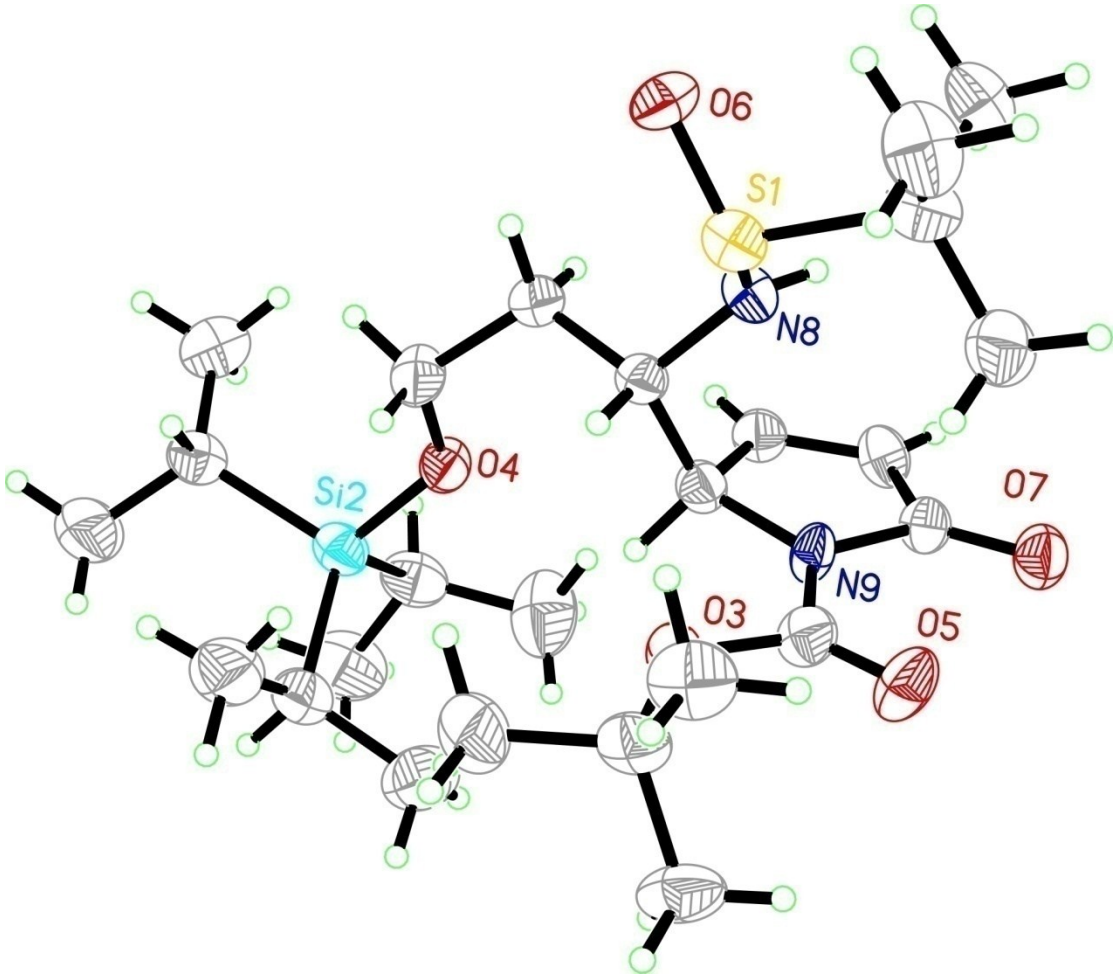


Figure S1. ORTEP of (R_S,5*R*,6*S*)-**8a** (CCDC 1046181), thermal ellipsoids are drawn at 50% probability level.

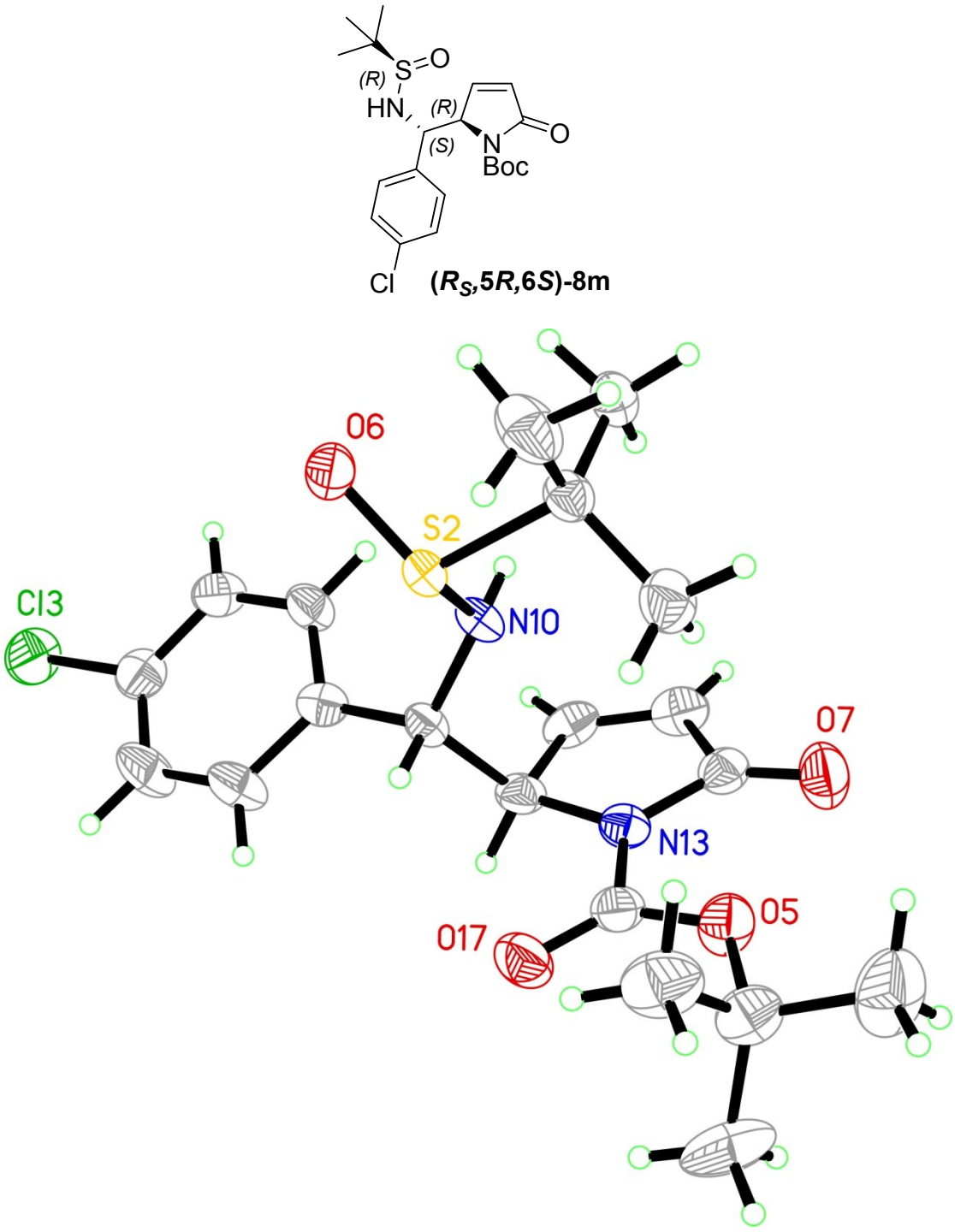


Figure S2. ORTEP of (R_S,5*R*,6*S*)-**8m** (CCDC 1445824), thermal ellipsoids are drawn at 50% probability level.

General procedure A for the synthesis of aliphatic (*Rs*)-*t*-butanesulfinimines (6a-h).

(*Rs*)-*t*-Butanesulfinimines **6a-h** are known compounds, which were prepared from (R_S)-*N*-*t*-butanesulfinamide following Ellman's procedure[2a].

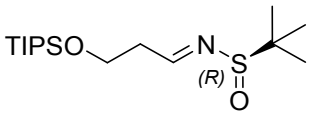
To a stirred suspension of (R_S)-*t*-butanesulfinamide **13** (5.5 mmol) and $CuSO_4$ (10.0 mmol) in anhydrous CH_2Cl_2 (125 mL) was added dropwise an aldehyde (5.0 mmol) at room temperature. After being stirred for 12 h, the mixture was filtered through a pad of silica gel and the filtrates were concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel to give a (*Rs*)-*t*-butanesulfinimine (**6**).

General procedure B for the synthesis of aromatic (*Rs*)-*t*-butanesulfinimines (6i-o).

(*Rs*)-*t*-Butanesulfinimines **6i-o**, **6i** and **6l-o** are known compounds, and were prepared from (R_S)-*N*-*t*-butanesulfinamide following Ellman's procedure[2a].

To a stirred suspension of (R_S)-*t*-butanesulfinamide **13** (5.5 mmol) and an aldehyde (5.0 mmol) in anhydrous CH_2Cl_2 (125 mL) was added $Ti(OEt)_4$ (2.0 mL, 10.0 mmol) slowly at room temperature. After being stirred for 12 h, the reaction was quenched with a saturated aqueous $NaHCO_3$. The mixture was filtered through a Celite pad and extracted with CH_2Cl_2 (15 mL × 3). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by flash chromatography silica gel to give a (R_S)-*t*-butanesulfinimine (**6**).

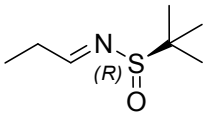
(*R*,*E*)-(−)-*N*-{3-[(Triisopropylsilyl)oxy]propylidene}-*tert*-butanesulfinamide, (R_S)-6a



Following the general procedure A, the condensation between (R_S)-*t*-butanesulfinamide **13** (5.1 g, 42.1 mmol) and benzaldehyde **14a** (8.8 g, 38.3 mmol)

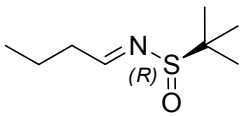
produced, after flash column chromatography on silica gel (eluent: EtOAc/ Hexane = 1/5), (*Rs*)-*t*-butanesulfinimine **6a** (12.0 g, yield: 94%) as a colorless oil. $[\alpha]_D^{20}$ –152.5 (*c* 1.0, CH_2Cl_2) {lit.[3] $[\alpha]_D$ –157 (*c* 0.8, CH_2Cl_2)}. The spectral data of **6a** are identical with those reported in the literature.[3]

(*R*,*E*)-(−)-*N*-Propylidene-*tert*-butanesulfinamide, (R_S)-6b



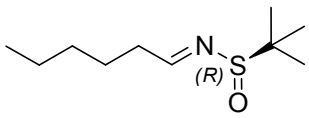
Yield: 93%. Colorless oil. $[\alpha]_D^{20}$ –230.8 (*c* 1.0, $CHCl_3$) {lit.[2b] $[\alpha]_D^{23}$ –328.5 (*c* 1.0, $CHCl_3$)}. The spectral data of **6b** are identical with those reported in the literature.[2b]

(*R*,*E*)-(−)-*N*-Butylidene-*tert*-butanesulfinamide, (R_S)-6c



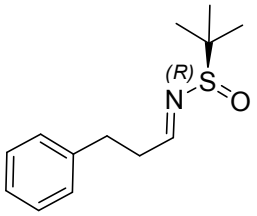
Yield: 90%. Colorless oil. $[\alpha]_D^{20}$ –302.1 (*c* 1.1, $CHCl_3$) {lit.[4] $[\alpha]_D^{23}$ –305.0 (*c* 0.94, $CHCl_3$)}. The spectral data of **6c** are identical with those reported in the literature.[4]

(*R*,*E*)-(−)-*N*-Hexylidene-*tert*-butanesulfinamide, (R_S)-6d



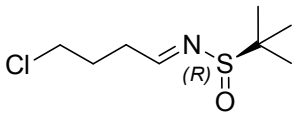
Yield: 95%. Colorless oil. $[\alpha]_D^{20}$ –210.0 (*c* 1.0, $CHCl_3$) [The optical rotation value has not been described in the literature,[5a] $[\alpha]_D^{20}$ +240.0 (*c* 1.0, $CHCl_3$) for its enantiomer (S_S)-**6d**];[5b] The spectral data of **6d** are identical with its enantiomer (S_S)-**6d** reported in the literature.[5b]

(*R*,*E*)-(−)-*N*-(3-Phenylpropylidene)-*tert*-butanesulfinamide, (R_S)-6e



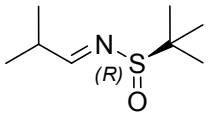
Yield: 94%. Yellow oil. $[\alpha]_D^{20}$ –183.0 (*c* 1.0, $CHCl_3$) {lit.[6] $[\alpha]_D^{20}$ –196 (*c* 1.0, $CHCl_3$)} The spectral data of **6e** are identical with those reported in the literature.[6]

(*R*,*E*)-(−)-*N*-(4-Chlorobutylidene)-*tert*-butanesulfinamide, (R_S)-6f



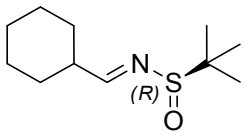
Yield: 85%. Colorless oil. $[\alpha]_D^{20}$ –211.8 (*c* 1.0, $CHCl_3$) {lit.[7] $[\alpha]_D^{25}$ –229.2 (*c* 1.01, $CHCl_3$)}. The spectral data of **6f** are identical with those reported in the literature.[7]

(*R*,*E*)-(−)-*N*-(2-Methylpropylidene)-*tert*-butanesulfinamide, (R_S)-6g



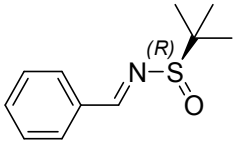
Yield: 94%. Colorless oil. $[\alpha]_D^{20}$ –315.3 (*c* 1.0, $CHCl_3$) {lit.[2b] $[\alpha]_D^{23}$ –259.4 (*c* 1.0, $CHCl_3$)}. The spectral data of **6g** are identical with those reported in the literature.[2b]

(*R*,*E*)-(−)-*N*-(Cyclohexylmethylene)-*tert*-butanesulfinamide, (R_S)-6h



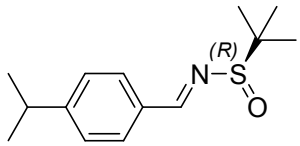
Yield: 94%. Colorless oil. $[\alpha]_D^{20}$ –229.5 (*c* 1.0, $CHCl_3$) {lit.[4] $[\alpha]_D^{20}$ –232.5 (*c* 0.98, $CHCl_3$)}. The spectral data of **6h** are identical with those reported in the literature.[4]

(*R*,*E*)-(−)-*N*-Benzylidene-*tert*-butanesulfinamide, (R_S)-6i



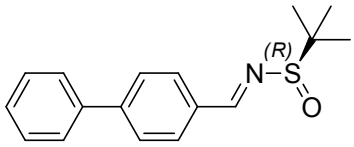
Yield: 95%. Pale yellow oil. $[\alpha]_D^{20}$ −120.8 (*c* 1.1, $CHCl_3$) {lit.[2b] $[\alpha]_D^{23}$ −122 (*c* 1.1, $CHCl_3$)}. The spectral data of **6i** are identical with those reported in the literature.[2b]

(*R*,*E*)-(−)-*N*-(4-Isopropylbenzylidene)-*tert*-butanesulfinamide, (R_S)-6j



Following the general procedure B, the condensation between (R_S)-*t*-butanesulfinamide **13** (667 mg, 5.5 mmol) and benzaldehyde **14j** (741 mg, 5.0 mmol) produced, after flash column chromatography on silica gel (eluent: EtOAc/ Hexane = 1/10), (*Rs*)-*t*-butanesulfinimine **6j** (1.18 g, yield: 94%) as a pale yellow oil. $[\alpha]_D^{20}$ −68.8 (*c* 1.0, $CHCl_3$); IR (film) ν_{max}: 2960, 2926, 1595, 1564, 1456, 1418, 1363, 1196, 1180, 1132, 1084, 1054, 832, 751; ^{1}H NMR (400 MHz, $CDCl_3$): δ 1.26 (s, 9H), 1.28 (d, *J* = 6.8 Hz, 6H), 2.97 (sept, *J* = 6.8 Hz, 1H), 7.34 (d, *J* = 8.2 Hz, 2H), 7.79 (d, *J* = 8.2 Hz, 2H), 8.57 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 22.6 (3C), 23.67, 23.70, 34.3, 57.6, 127.1 (2C), 129.5 (2C), 132.0, 153.9, 162.5; HRMS calcd for $C_{14}H_{21}NOSNa$ $[M+Na]^+$: 274.1231; found: 274.1235.

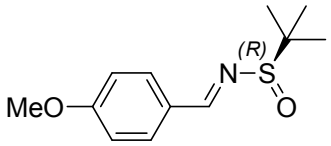
(*R*,*E*)-(−)-*N*-([1,1'-Biphenyl]-4-ylmethylene)-*tert*-butanesulfinamide, (R_S)-6k



Following the general procedure B, the condensation between (R_S)-*t*-butanesulfinamide **13** (667 mg, 5.5 mmol) and benzaldehyde **14k** (911 mg, 5.0 mmol) produced, after flash column chromatography on silica gel (eluent: EtOAc/ Hexane = 1/10), (*Rs*)-*t*-butanesulfinimine **6k** (1.36 g, yield: 95%) as a pale yellow solid. Mp: 114–116 ºC; $[\alpha]_D^{20}$ −11.4 (*c* 1.0, $CHCl_3$); IR (film) ν_{max}: 2961, 2924, 2865, 1593, 1579, 1556, 1486, 1450, 1363, 1261, 1178, 1132, 1086, 1008, 840, 801,7 64, 749, 697; ^{1}H NMR (400 MHz, $CDCl_3$): δ 1.28 (s, 9H), 7.38 (t, *J* = 7.3 Hz, 1H), 7.46 (dd, *J* = 7.4, 7.9 Hz, 2H), 7.62 (d, *J* = 7.6 Hz, 2H), 7.69 (d, *J* = 8.2 Hz, 2H), 7.92 (d, *J* = 8.2 Hz,

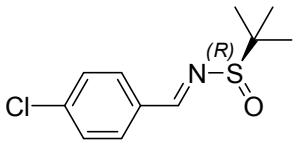
2H), 8.63 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 22.7 (3C), 57.8, 127.2 (2C), 127.6 (2C), 128.2, 129.0 (2C), 130.0 (2C), 133.1, 140.0, 145.2, 162.3; HRMS calcd for $C_{17}H_{19}NOSNa$ $[M+Na]^+$: 308.1075; found: 308.1079.

(*R*,*E*)-(−)-*N*-(4-Methoxybenzylidene)-*tert*-butanesulfinamide, (R_S)-6l



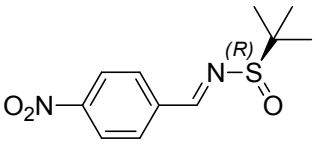
Yield: 94%. White solid. Mp: 90–92 ºC. {lit.[9] mp: 91–93 ºC} $[\alpha]_D^{20}$ –67.5 (*c* 1.0, $CHCl_3$) {lit.[8] $[\alpha]_D^{20}$ –70.2 (*c* 1.1, $CHCl_3$)}. The spectral data of **6l** are identical with those reported in the literature.[8]

(*R*,*E*)-(−)-*N*-(4-Chlorobenzylidene)-*tert*-butanesulfinamide, (R_S)-6m



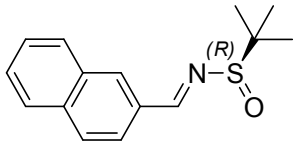
Yield: 91%. Pale yellow solid. Mp: 40–42 ºC {lit.[9,10] mp: 41–42 ºC}； $[\alpha]_D^{20}$ –92.2 (*c* 1.0, $CHCl_3$) {lit.[9,10] $[\alpha]_D^{20}$ –93.1 (*c* 1.0, $CHCl_3$)}. The spectral data of **6m** are identical with those reported in the literature. [9,10]

(*R*,*E*)-(−)-*N*-(4-Nitrobenzylidene)-*tert*-butanesulfinamide, (R_S)-6n



Yield: 90%. Pale yellow solid. Mp: 142–144 ºC {lit.[11] mp: 142–144 ºC}; $[\alpha]_D^{20}$ –57.1 (*c* 1.0, $CHCl_3$) {lit.[11] $[\alpha]_D^{20}$ –58.0 (*c* 1.0, $CHCl_3$)}. The spectral data of **6n** are identical with those reported in the literature.[11]

(*R*,*E*)-(−)-*N*-(Naphthalen-2-ylmethylene)-*tert*-butanesulfinamide, (R_S)-6o



Yield: 93%. Pale yellow solid. Mp: 53–54 ºC {lit.[10] mp: 52–54 ºC}; $[\alpha]_D^{20}$ –3.4 (*c* 1.0, $CHCl_3$) {lit.[10] $[\alpha]_D^{20}$ –4.5 (*c* 1.0, $CHCl_3$)}. The spectral data of **6o** are identical with those reported in the literature.[10]

References

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2. (a) G. Liu, D. A. Cogan, T. D. Owens, T. P. Tang and J. A. Ellman, *J. Org. Chem.,* 1999, **64**, 1278-1284. (b) G.-C. Liu, D. A. Cogan and J. A. Ellman, *J. Am. Chem. Soc.,* 1997*,* **119***,* 9913-9914.
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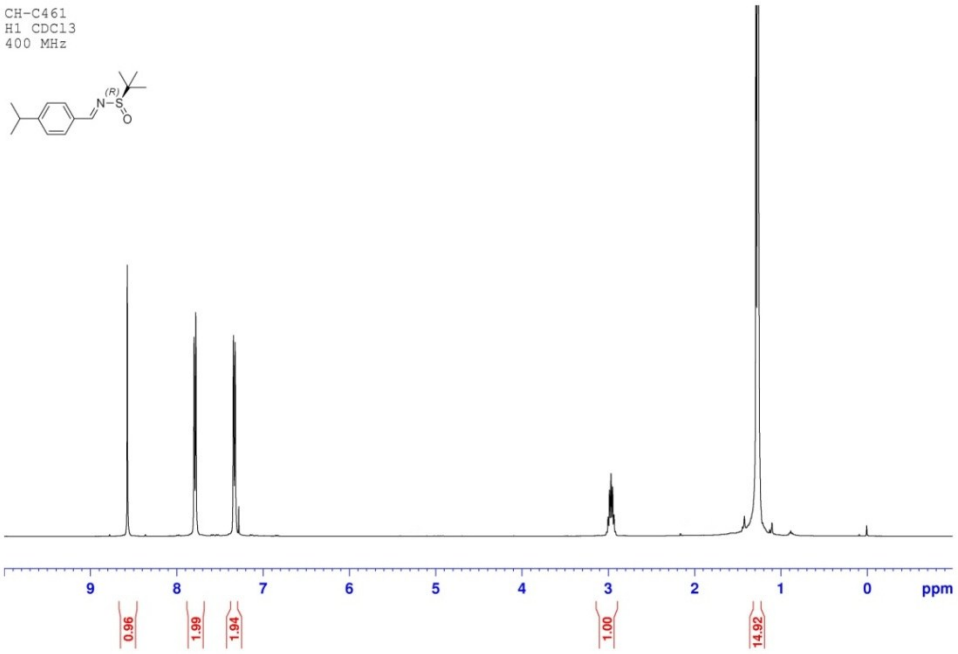
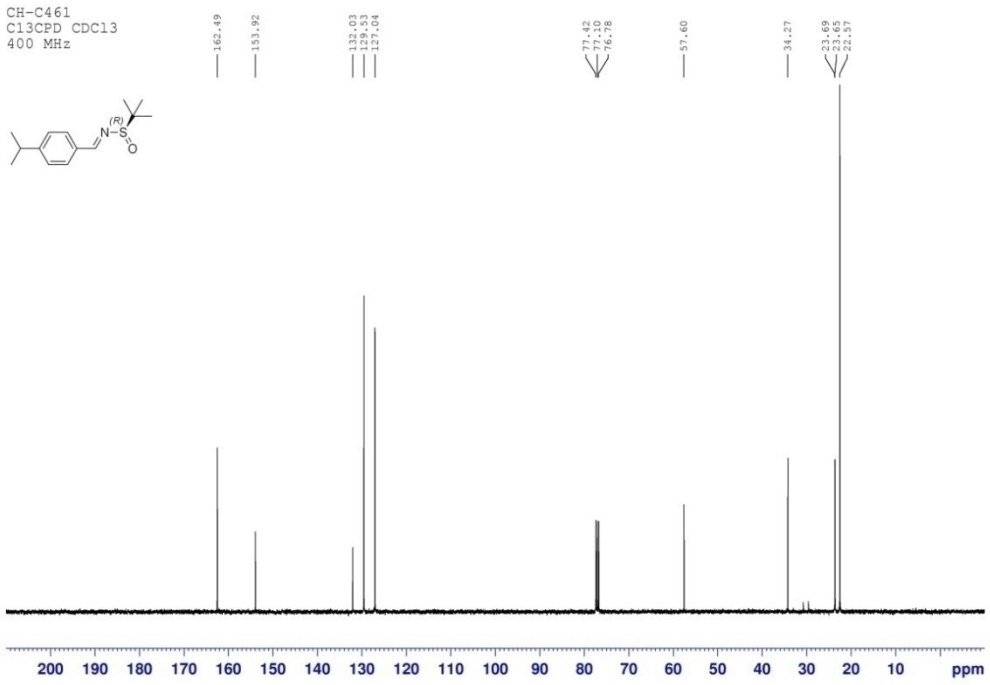
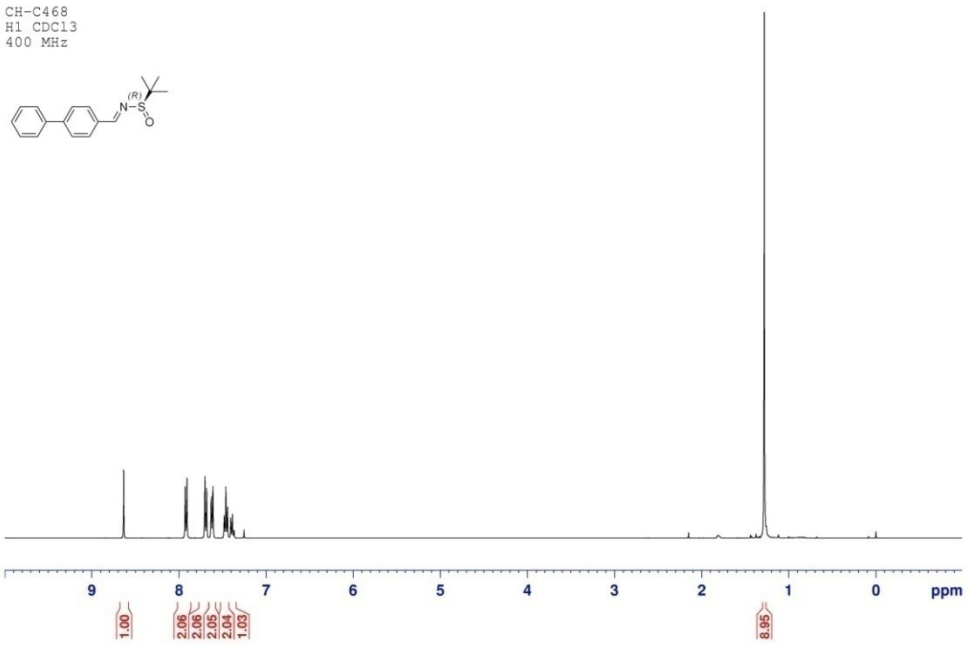
11. L. Cheng, L. Liu, Y. Sui, D. Wang and Y.-J. Chen, *Tetrahedron: Asymmetry*, 2007, **18***,* 1833-1843.

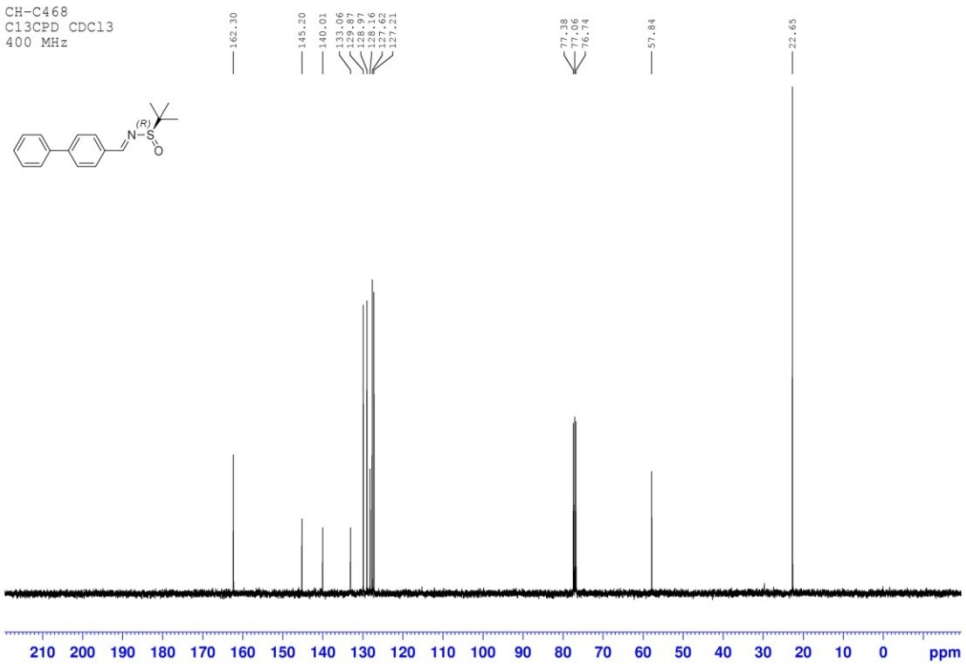
^{1}H and ^{13}C NMR spectra of compound 6j



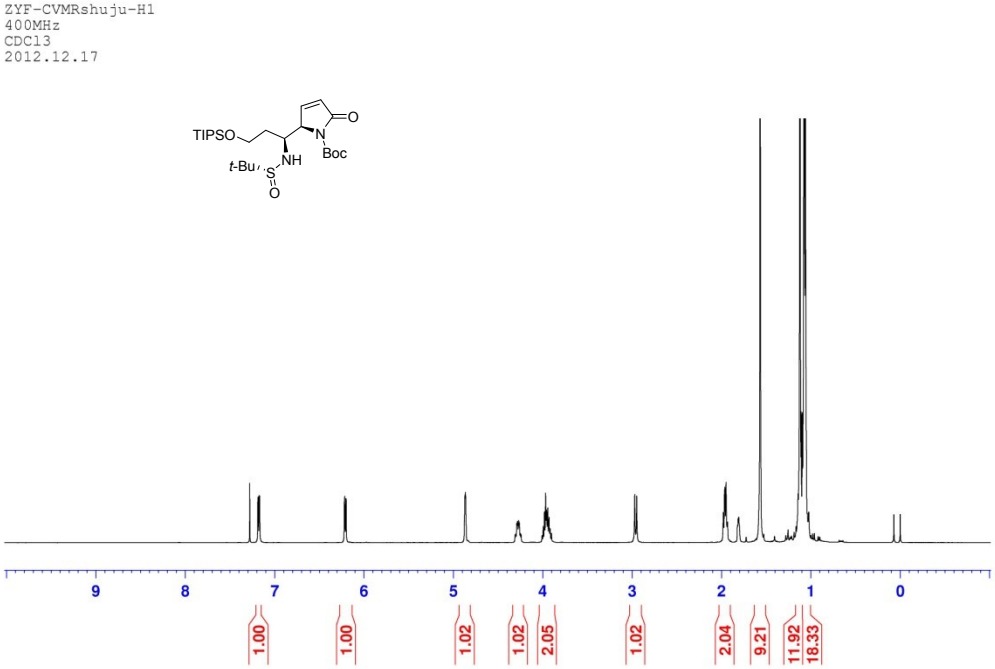


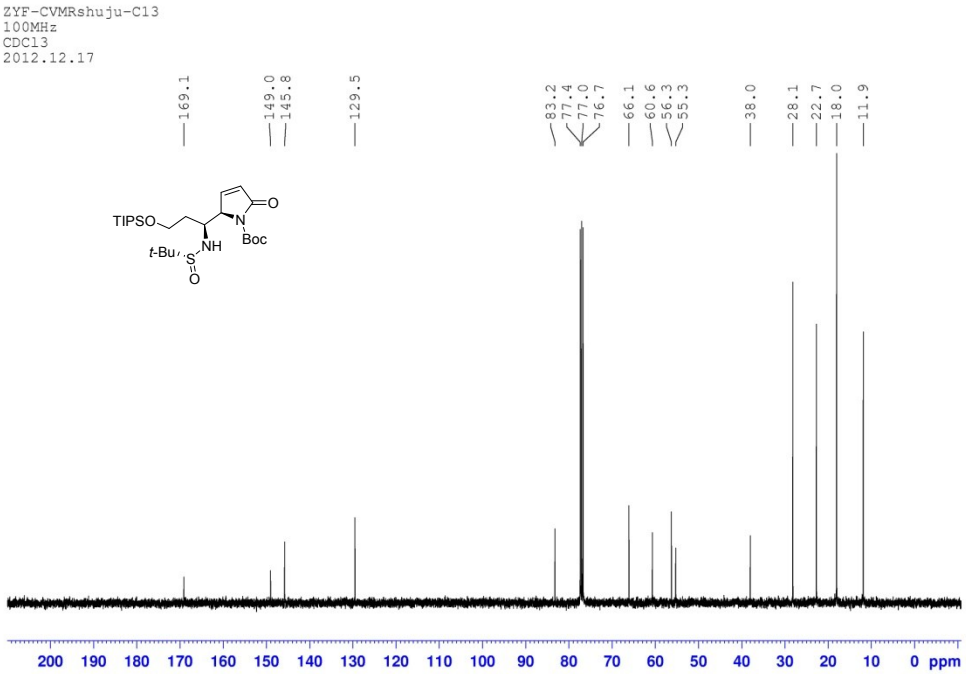
^{1}H and ^{13}C NMR spectra of compound 6k



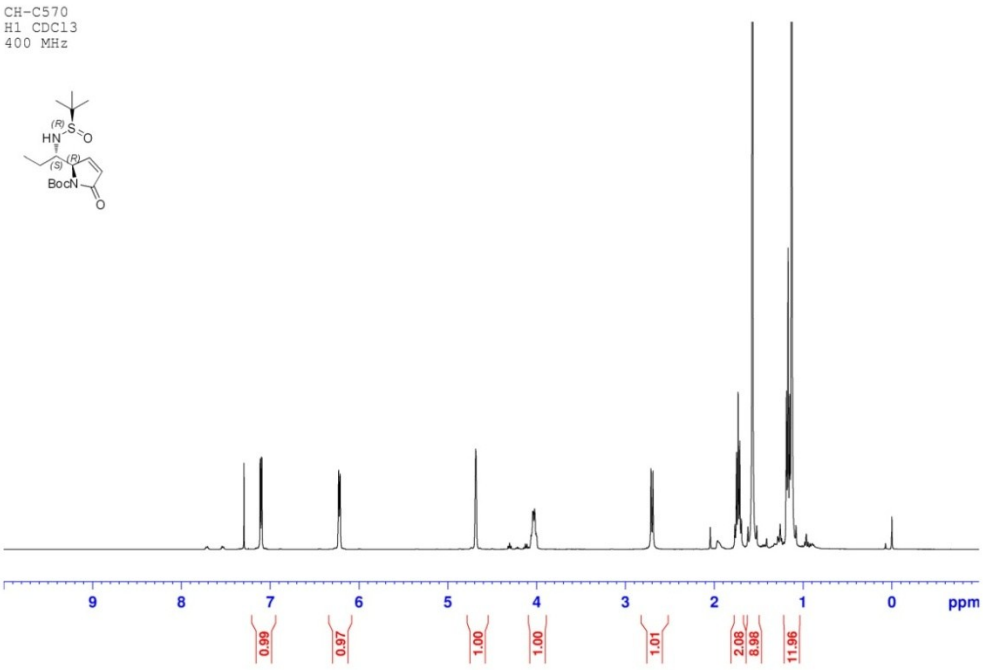


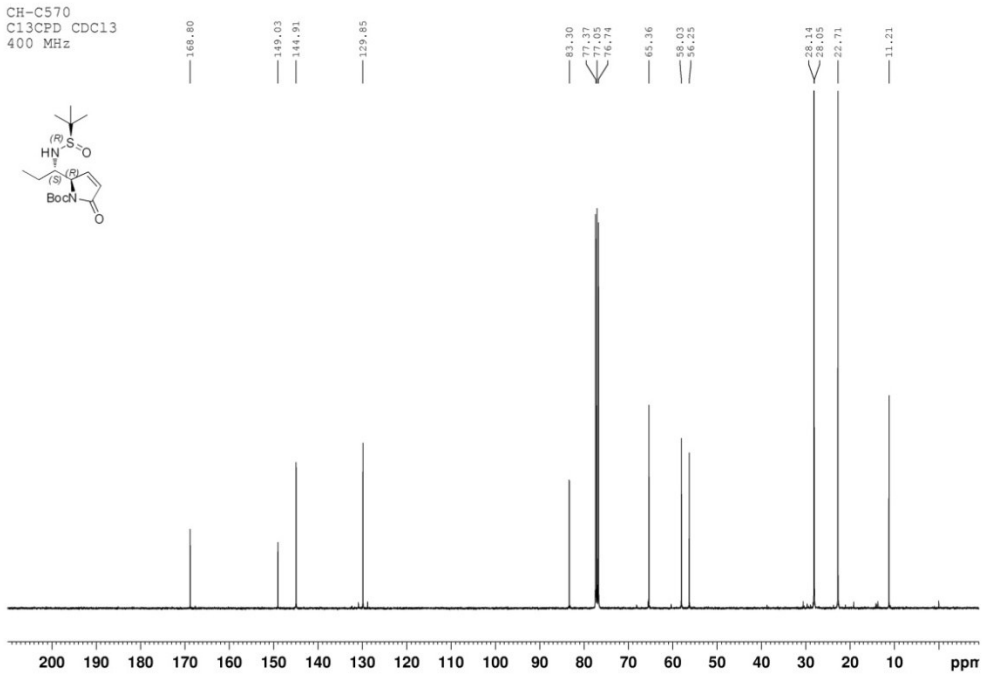
^{1}H and ^{13}C NMR spectra of compound 8a



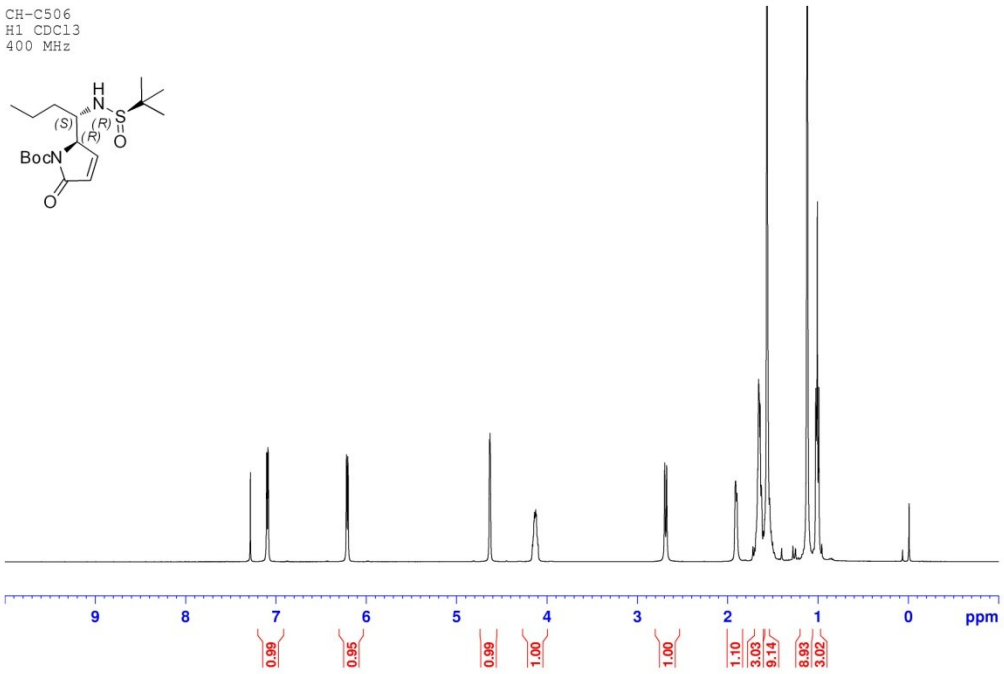


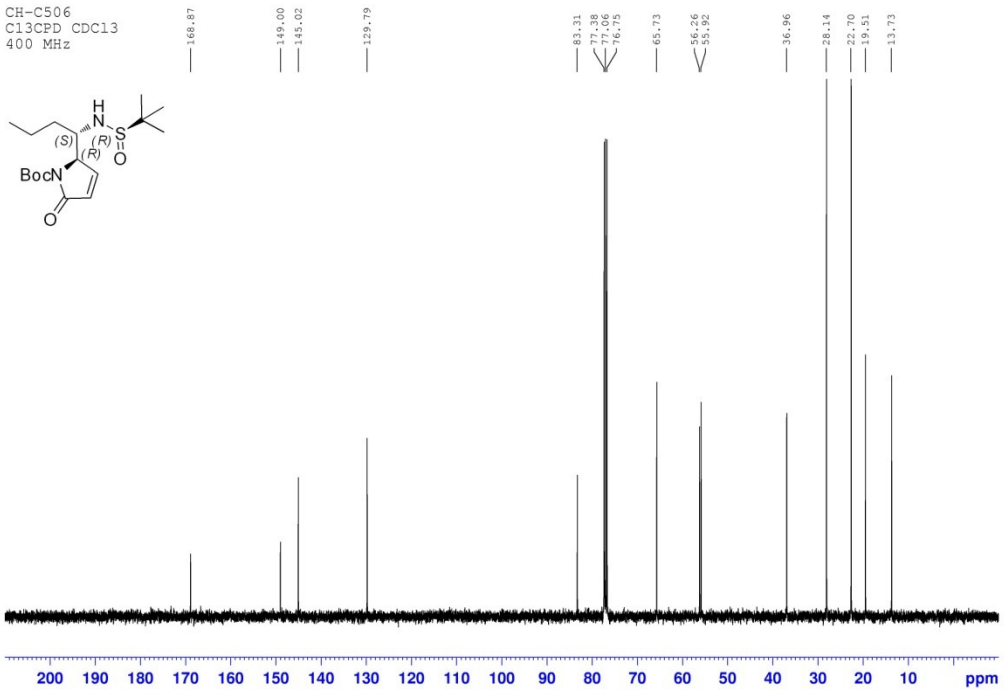
^{1}H and ^{13}C NMR spectra of compound 8b



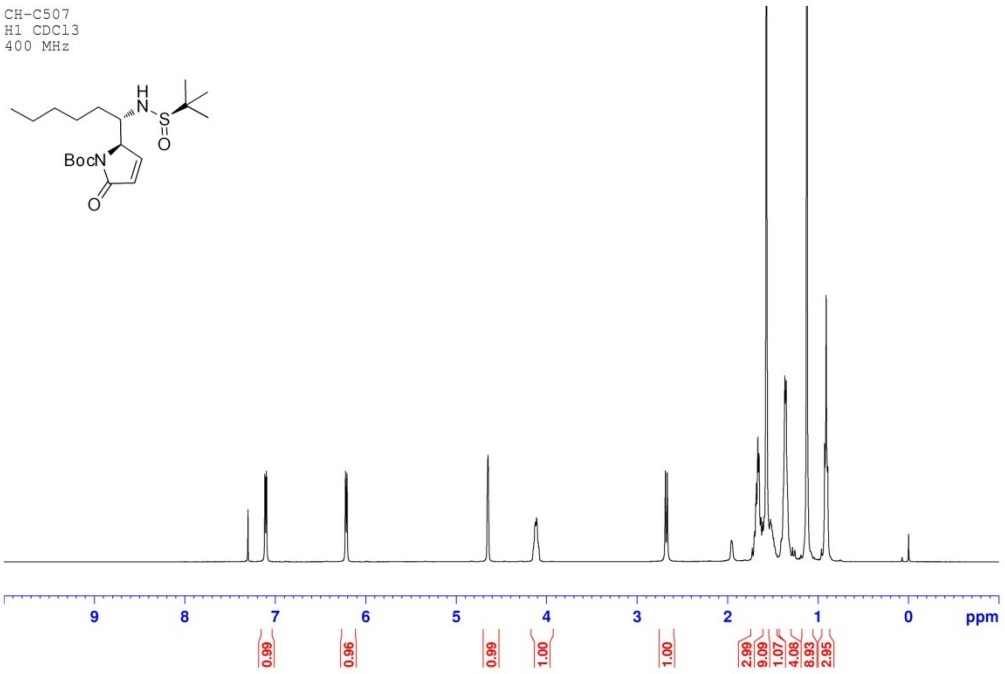


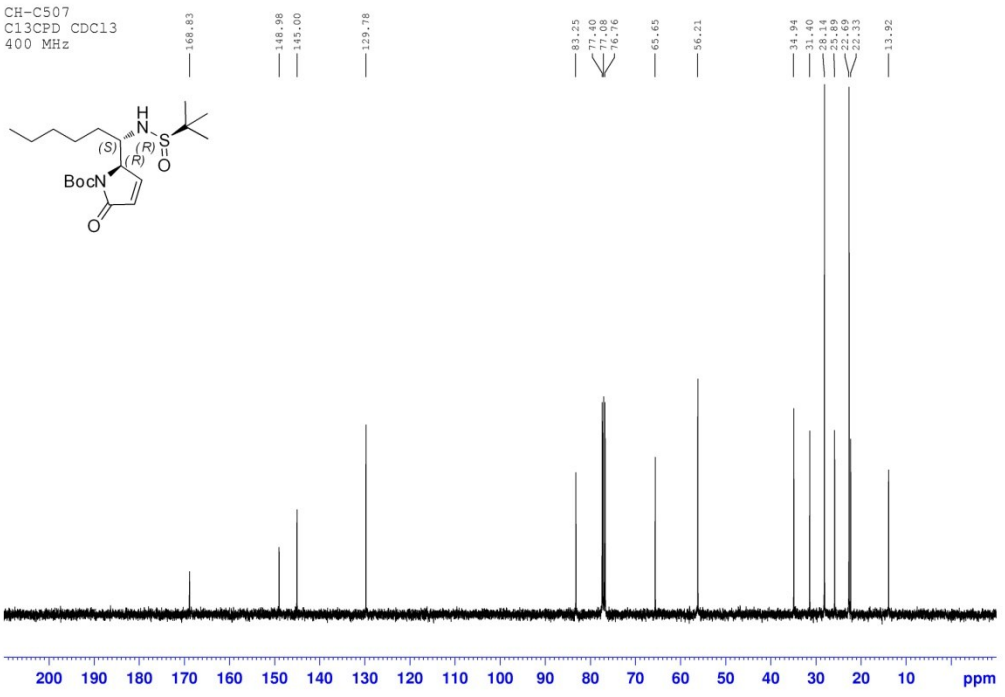
^{1}H and ^{13}C NMR spectra of compound 8c



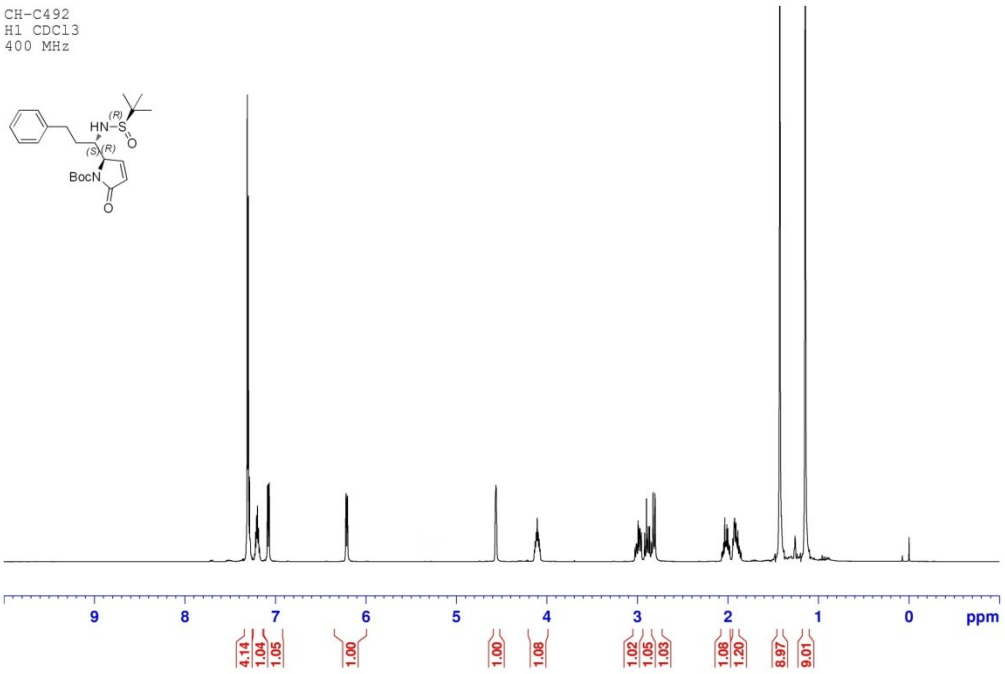


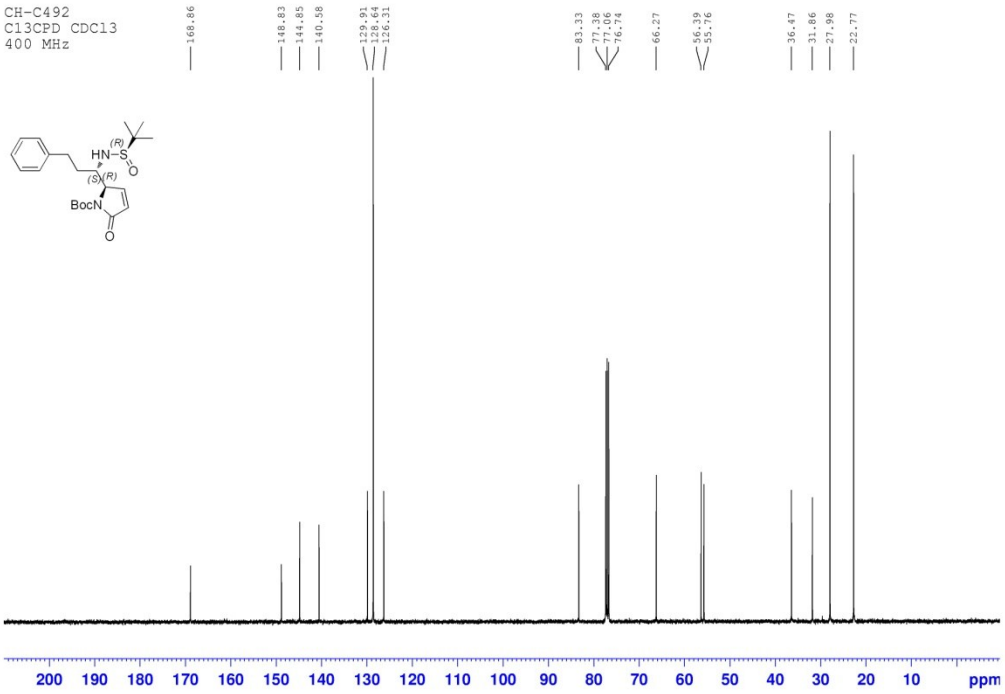
^{1}H and ^{13}C NMR spectra of compound 8d



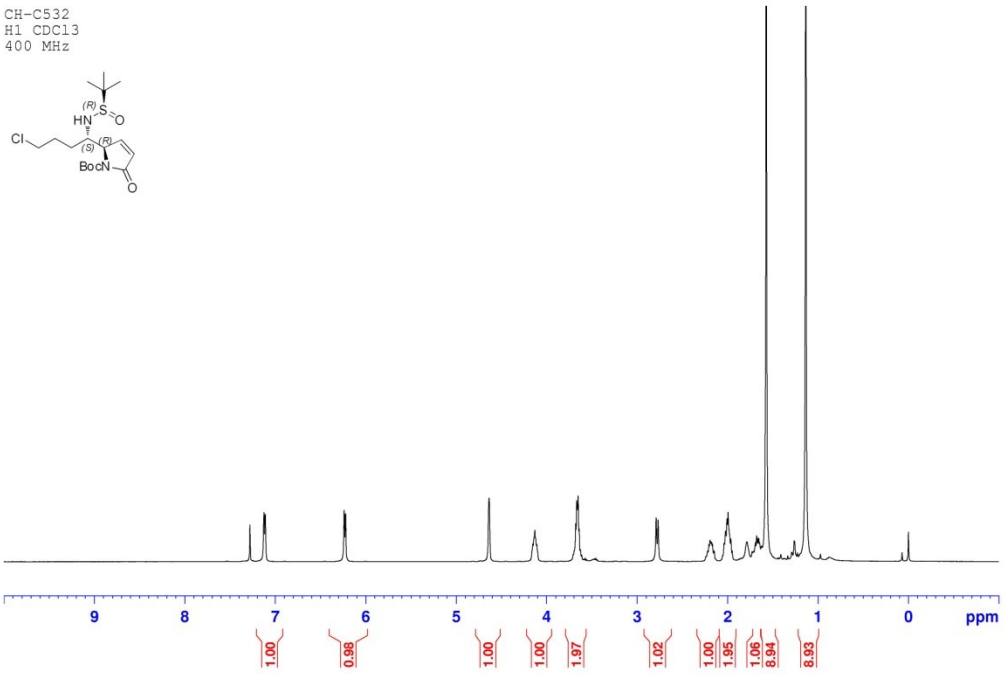


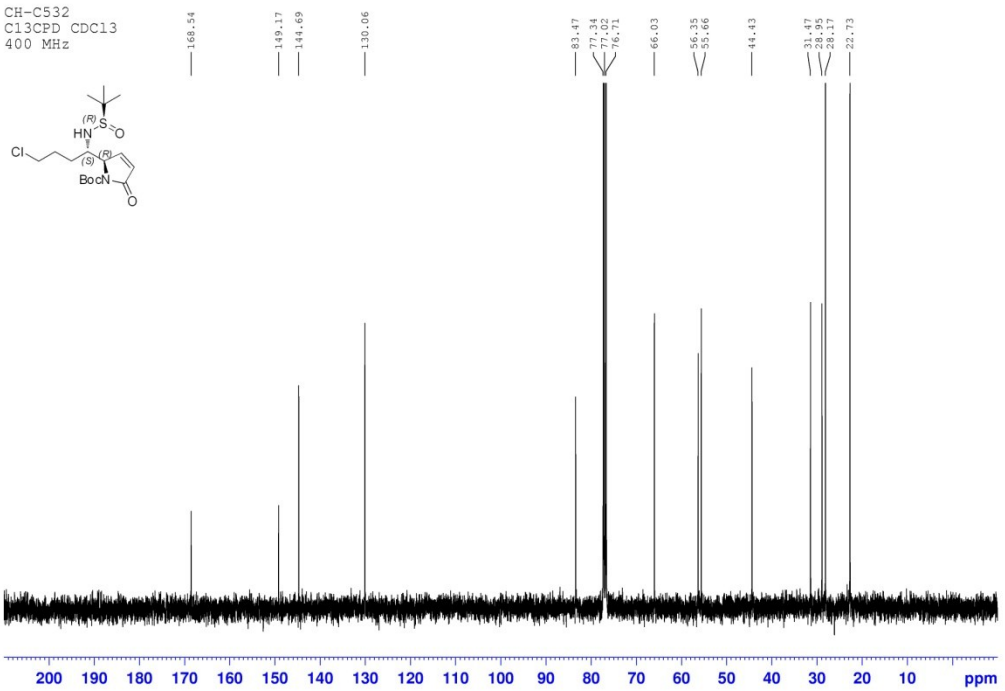
^{1}H and ^{13}C NMR spectra of compound 8e



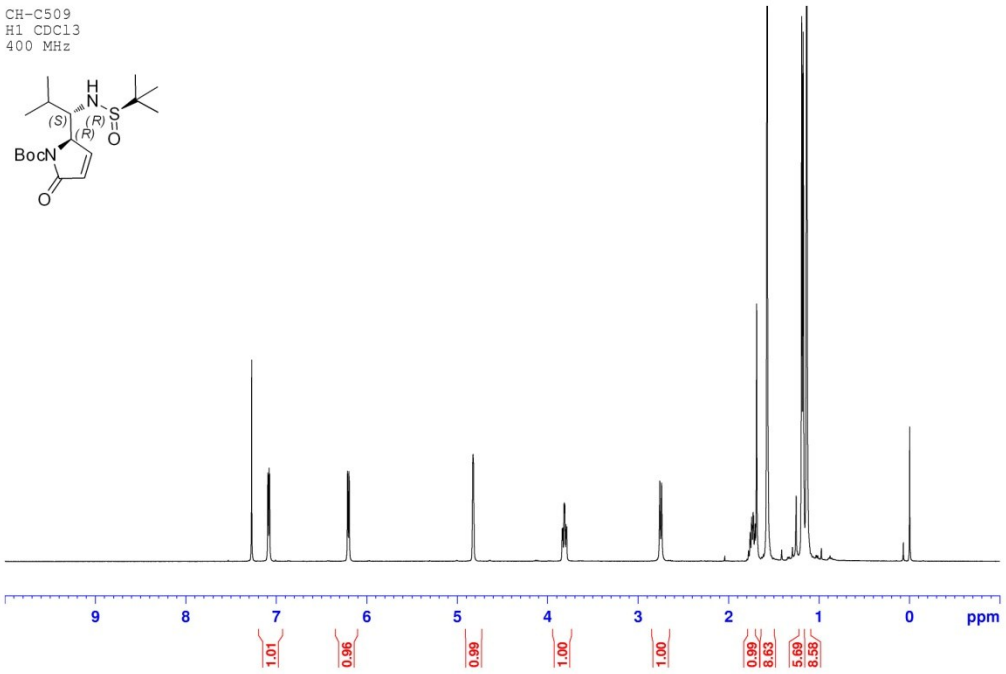


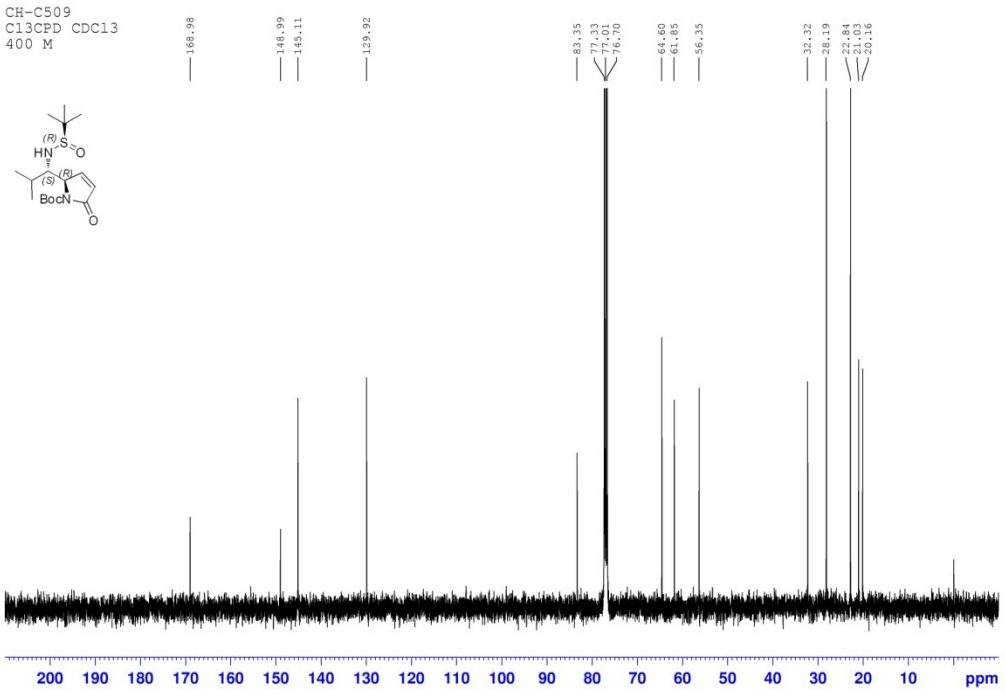
^{1}H and ^{13}C NMR spectra of compound 8f



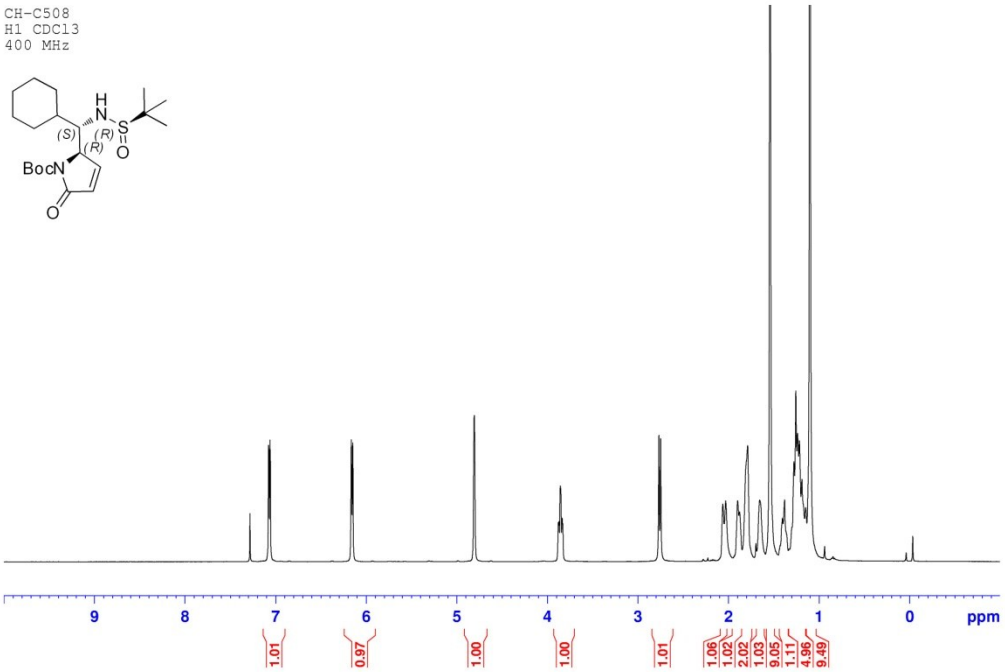


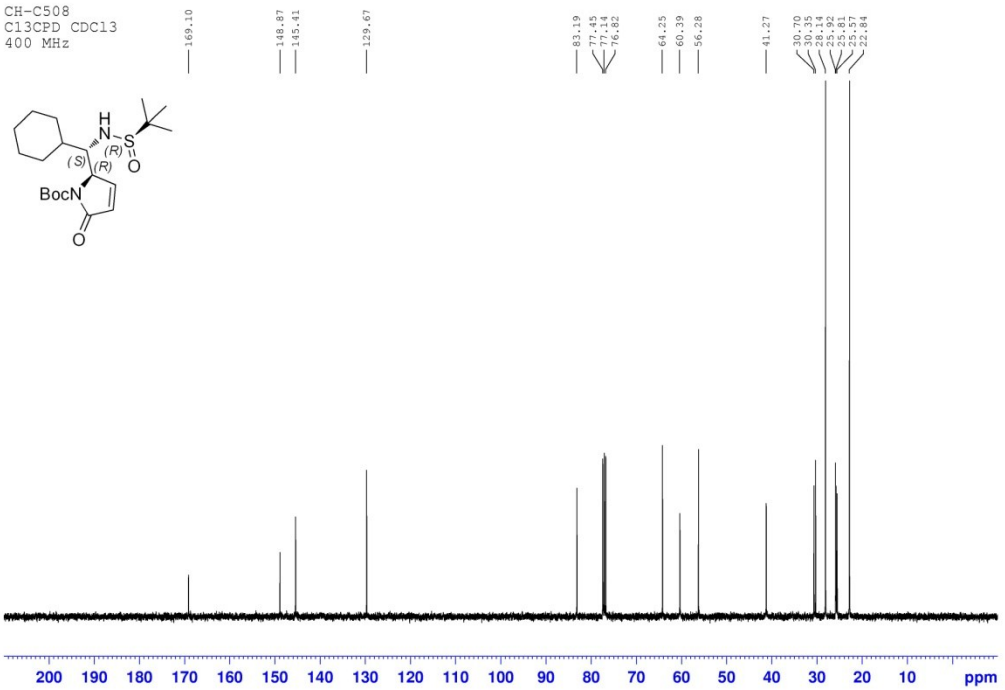
^{1}H and ^{13}C NMR spectra of compound 8g



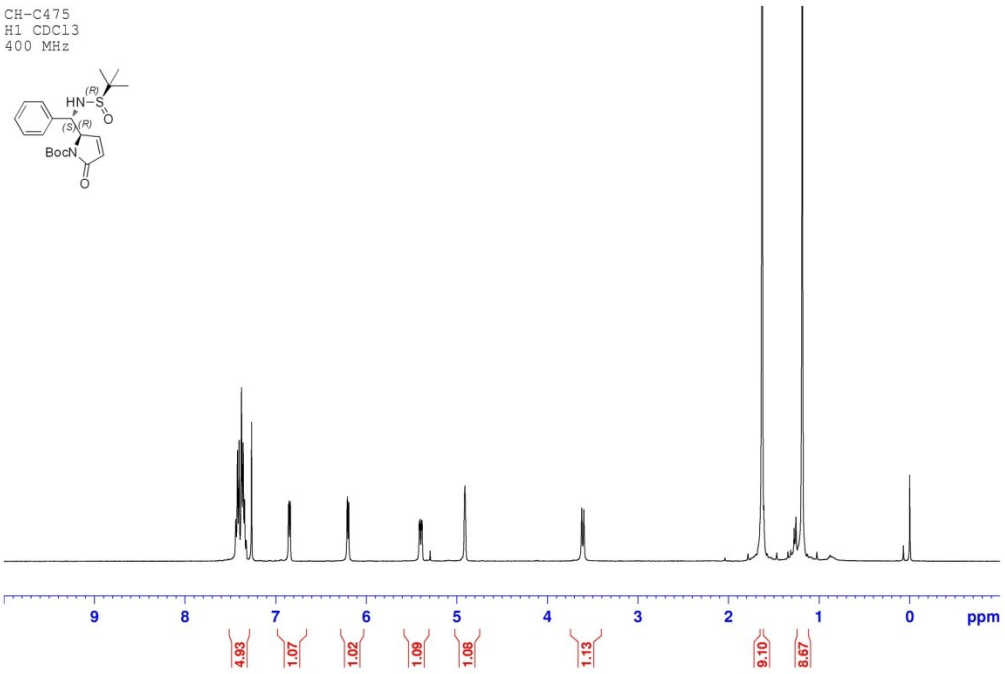


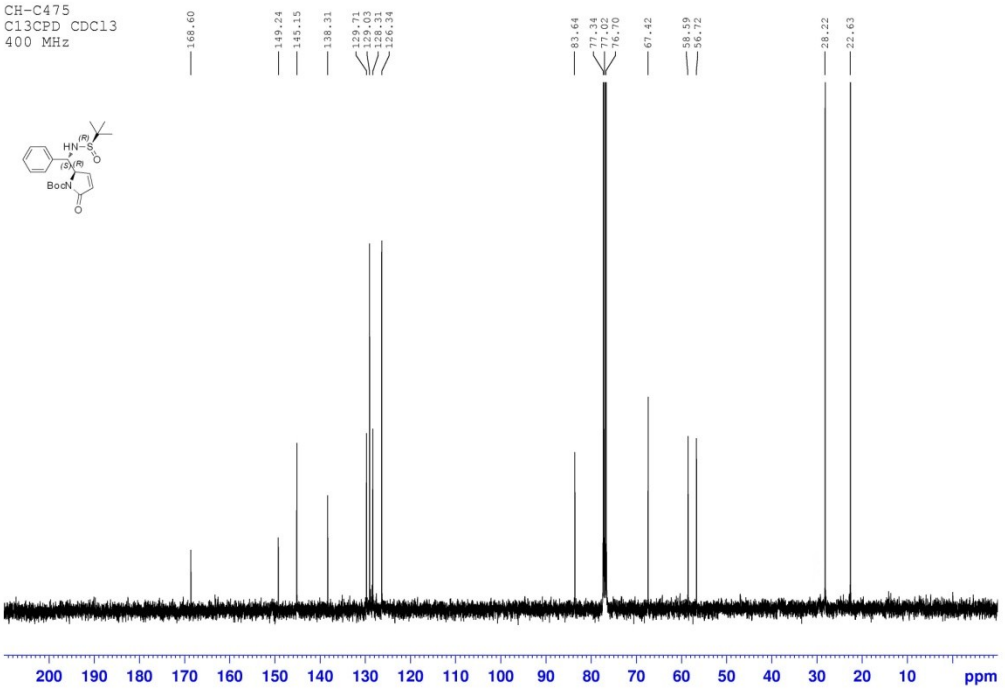
^{1}H and ^{13}C NMR spectra of compound 8h



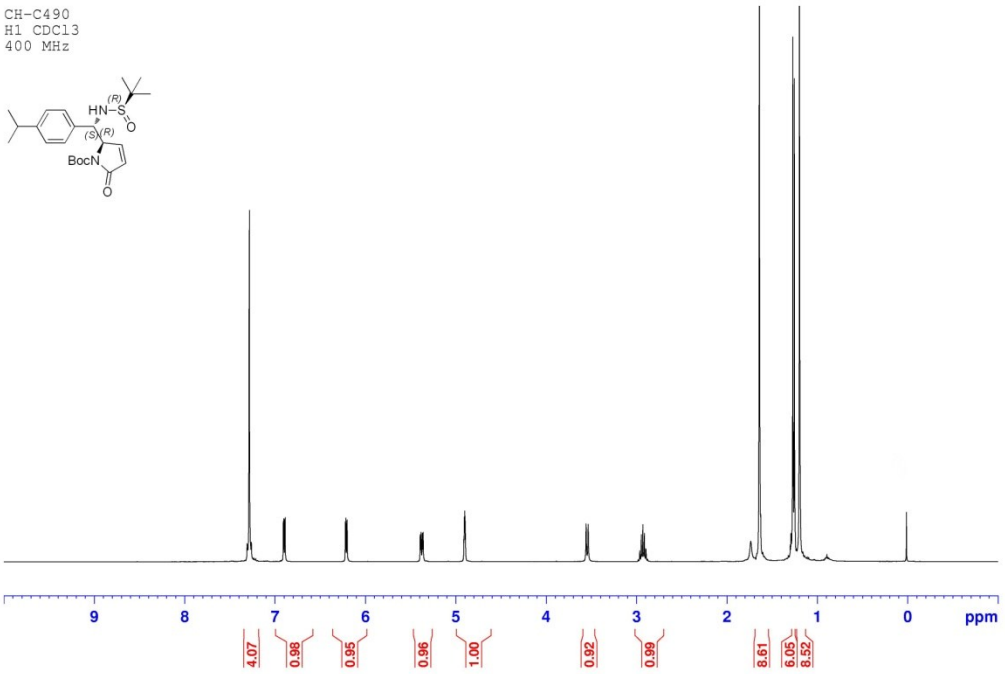


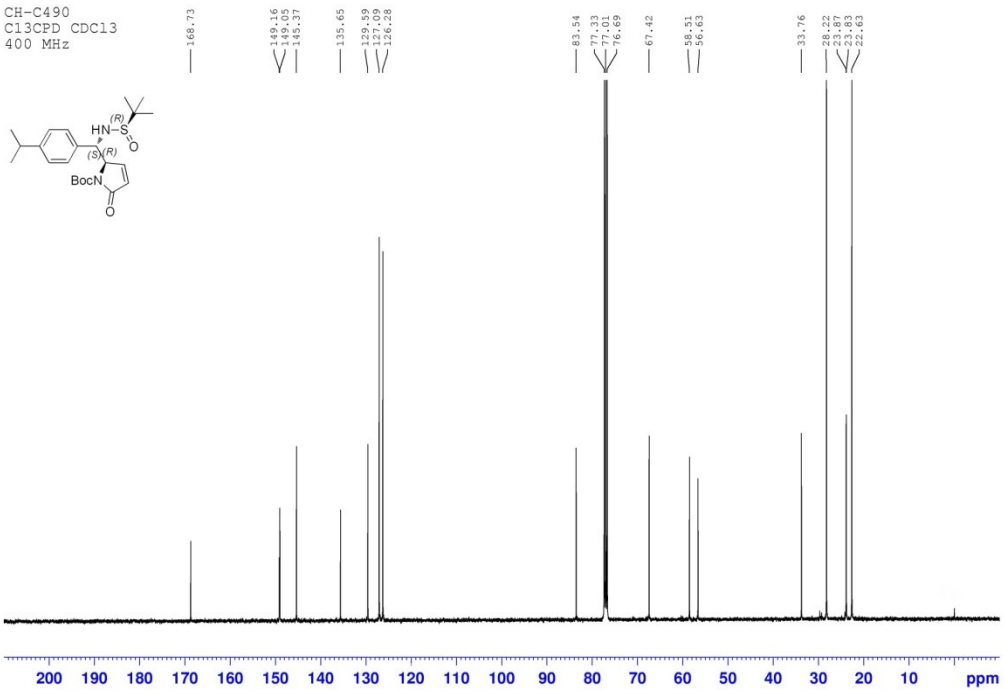
^{1}H and ^{13}C NMR spectra of compound 8i



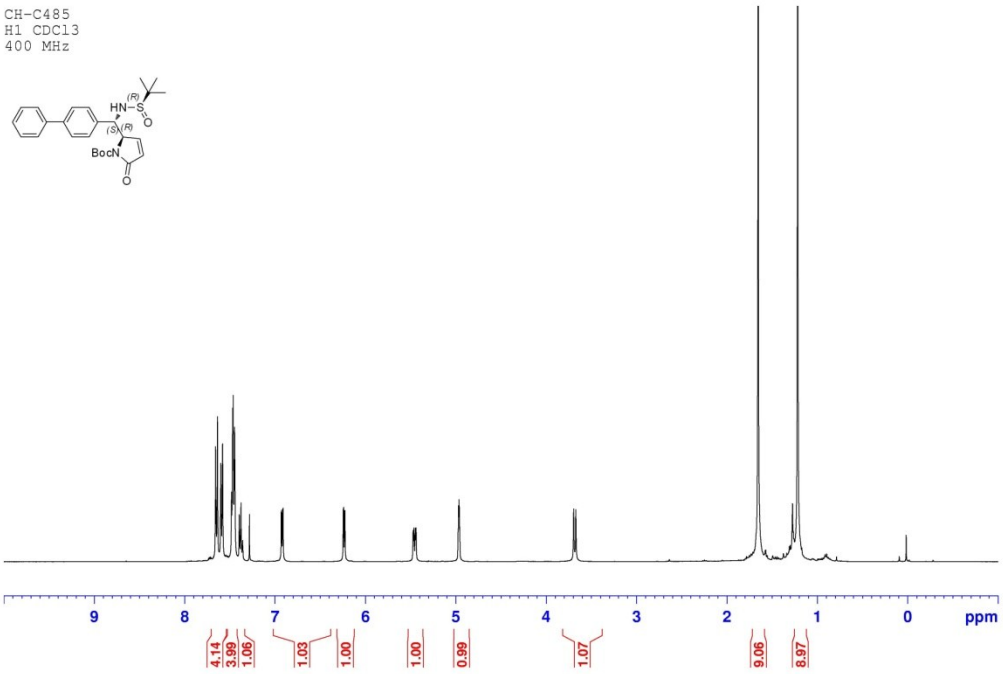


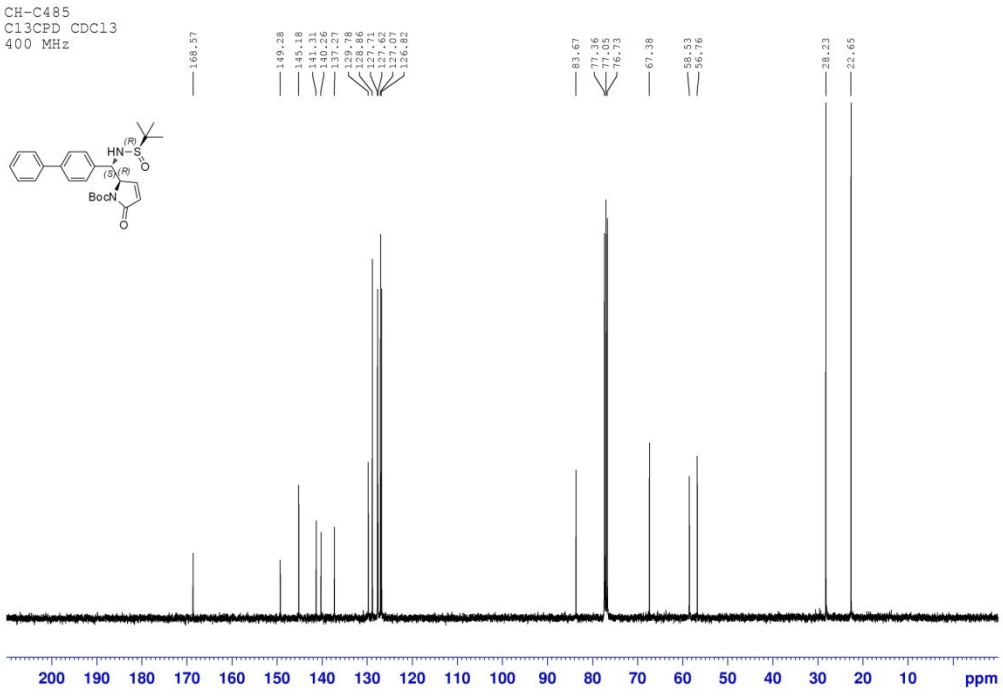
^{1}H and ^{13}C NMR spectra of compound 8j



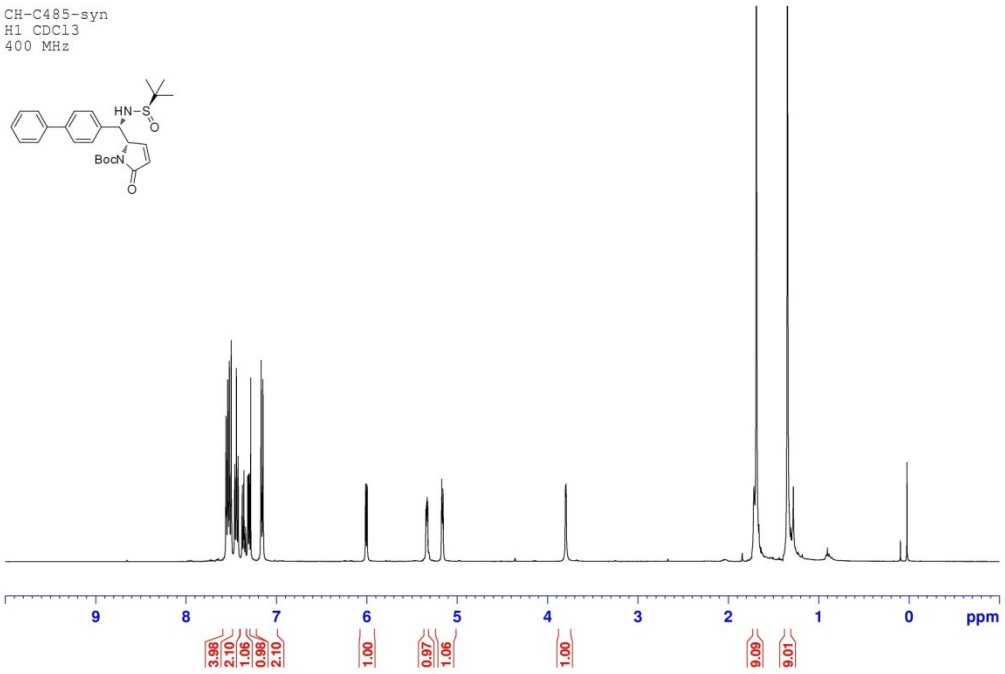


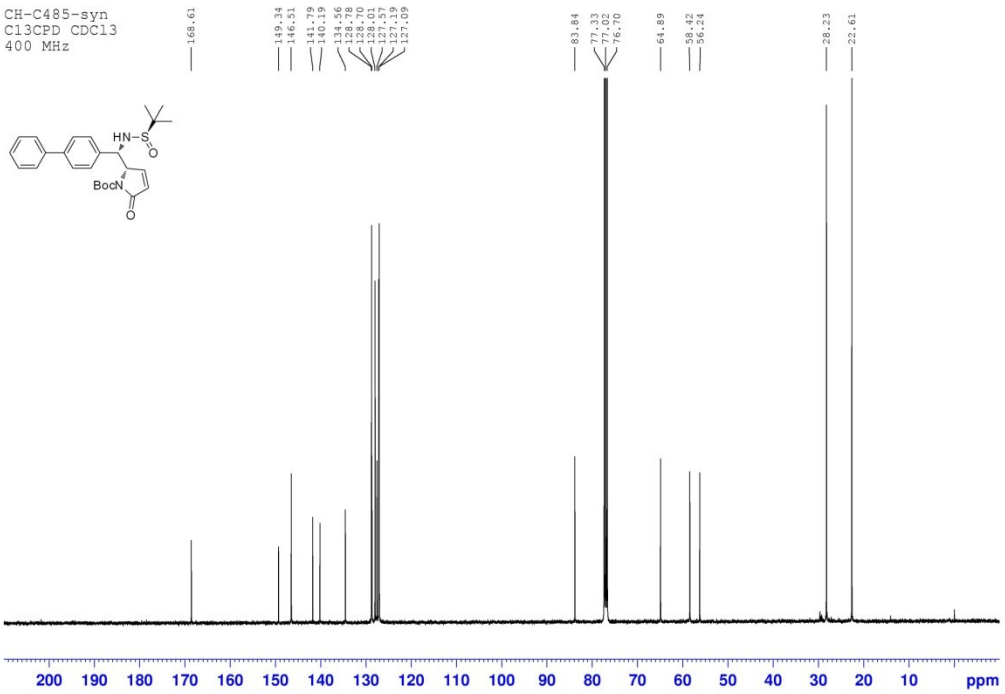
^{1}H and ^{13}C NMR spectra of compound *anti*-8k



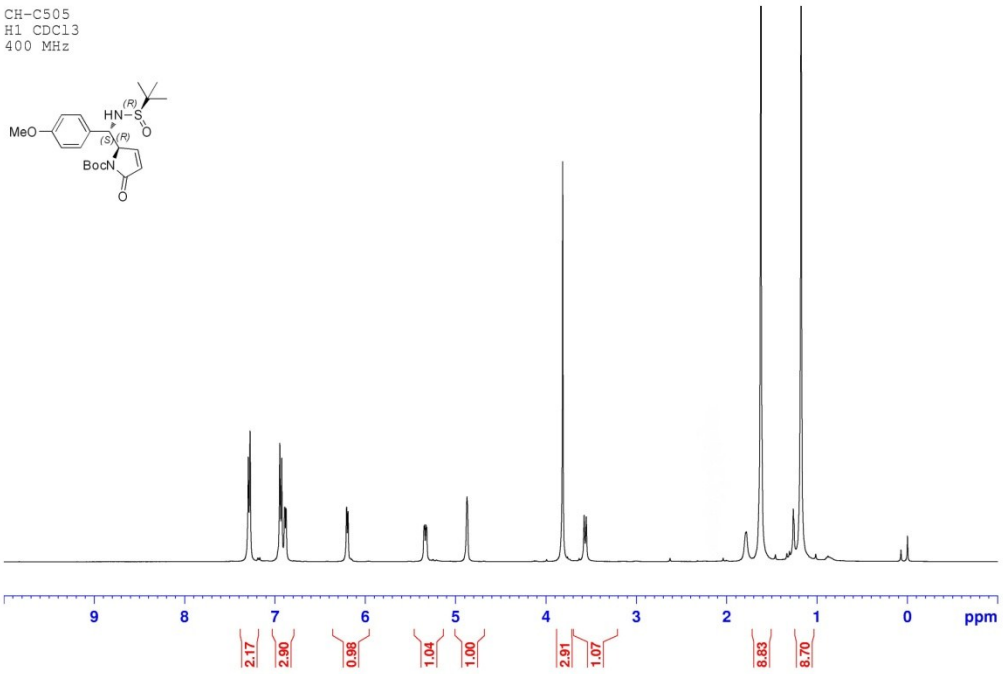


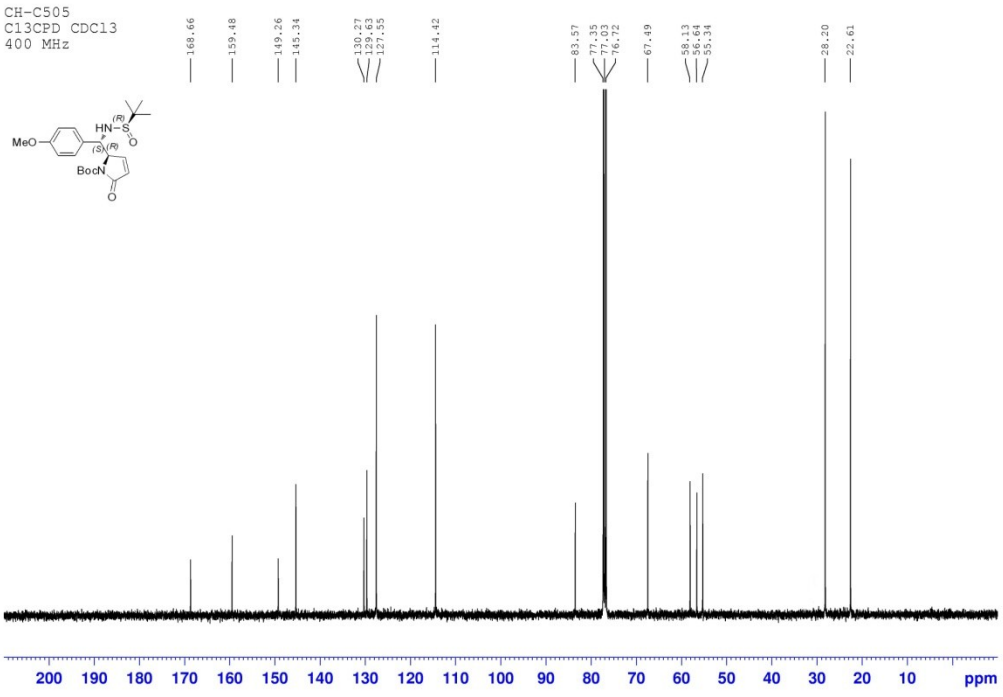
^{1}H and ^{13}C NMR spectra of compound *syn*-8k



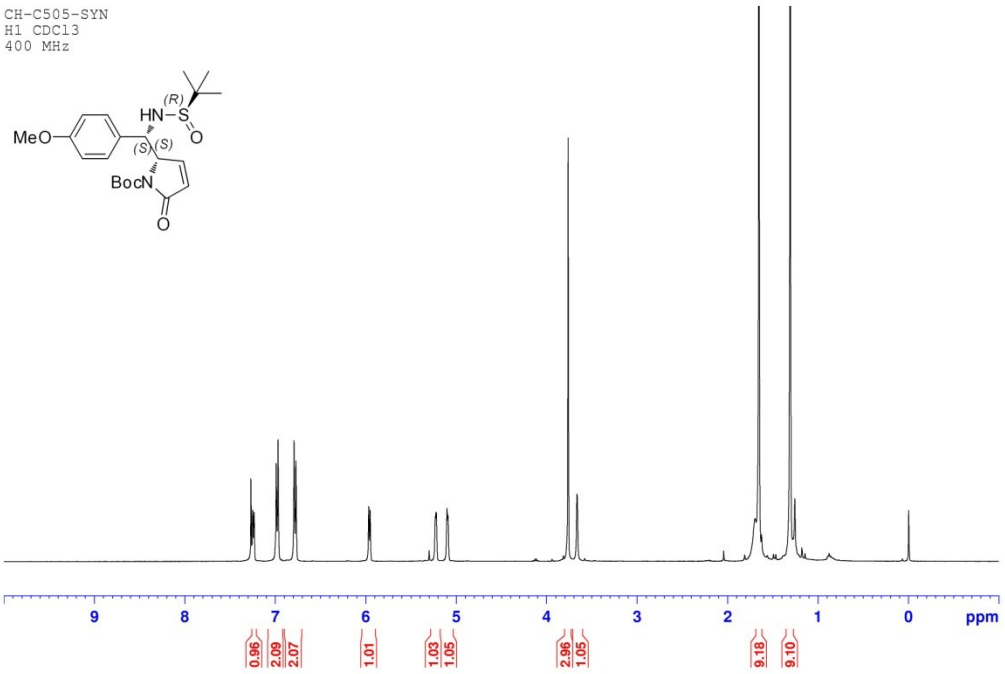


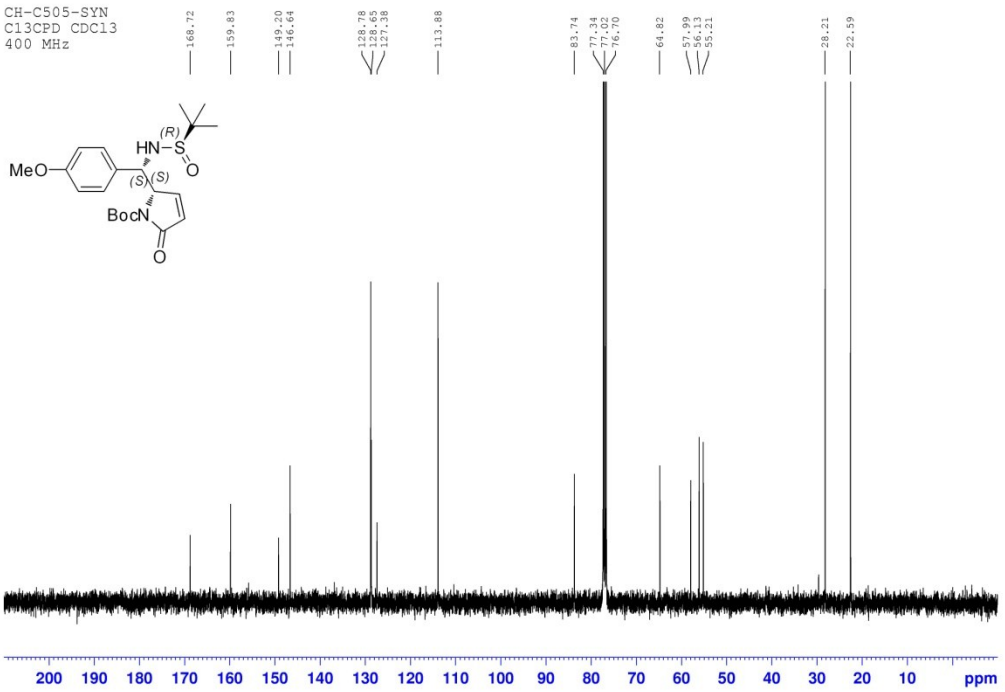
^{1}H and ^{13}C NMR spectra of compound *anti*-8l



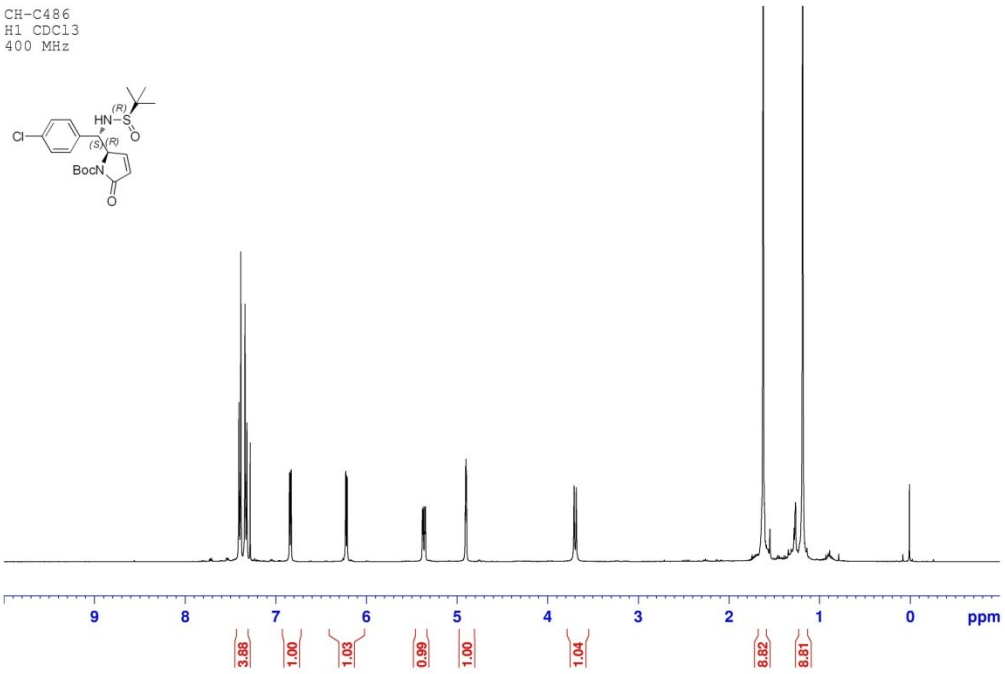


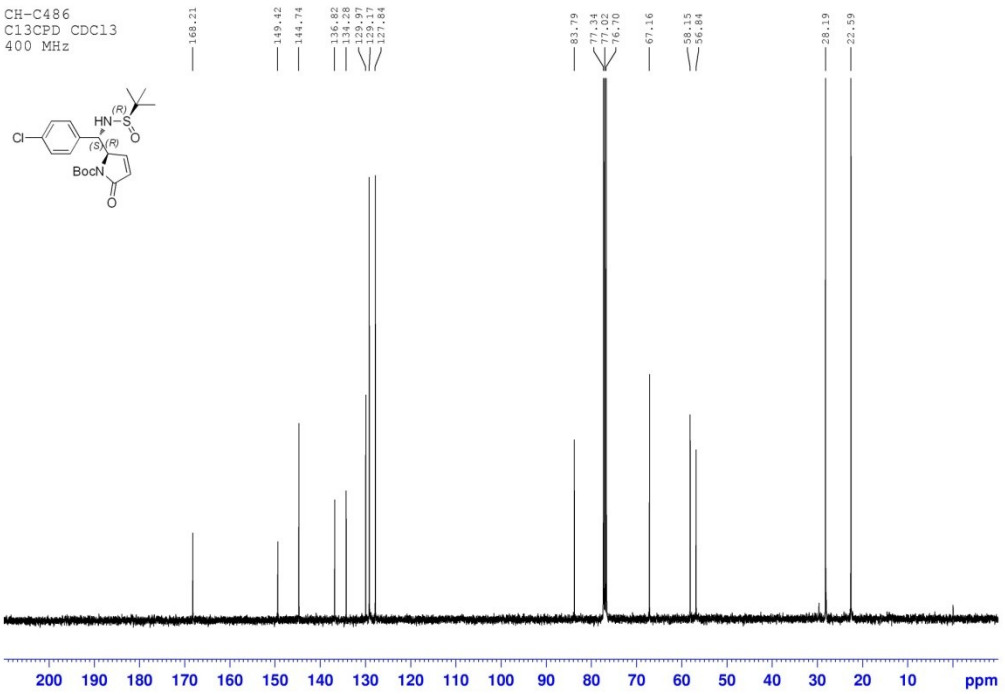
^{1}H and ^{13}C NMR spectra of compound *syn*-8l



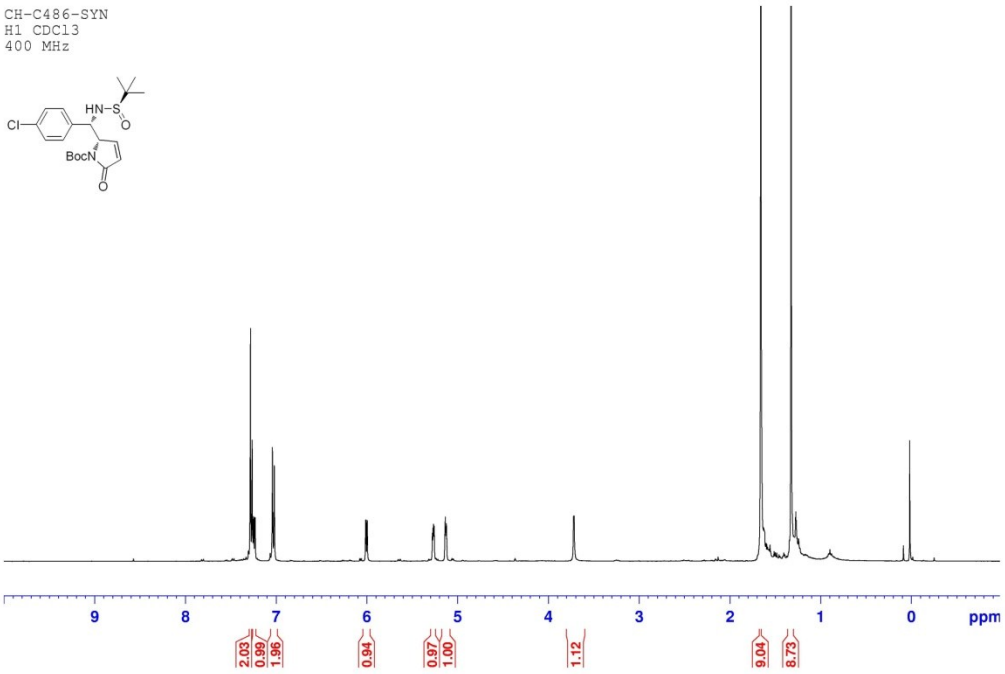


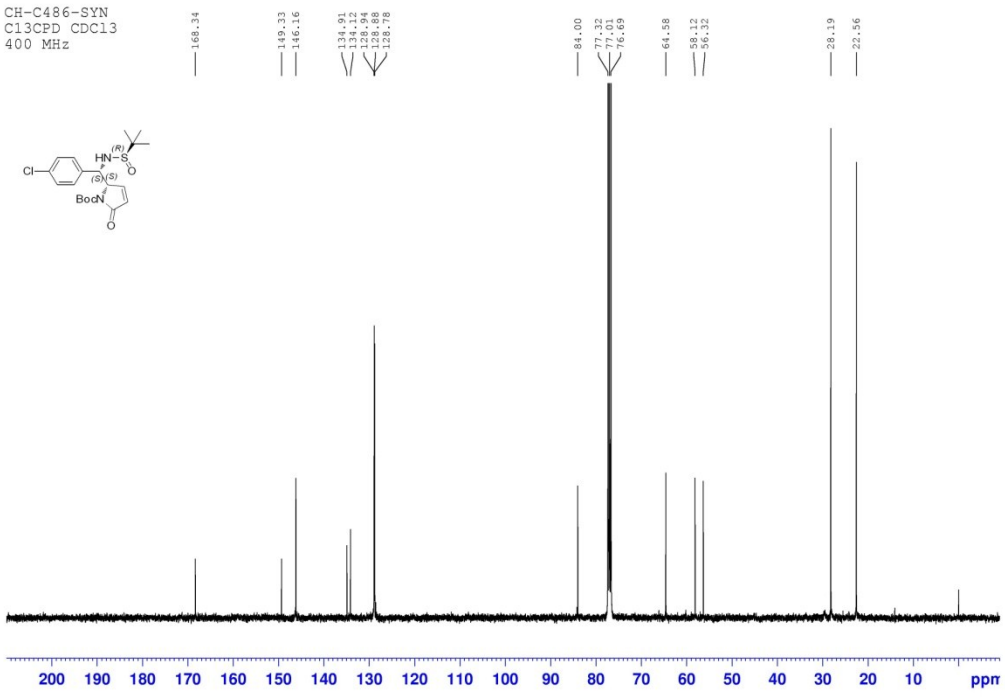
^{1}H and ^{13}C NMR spectra of compound *anti*-8m



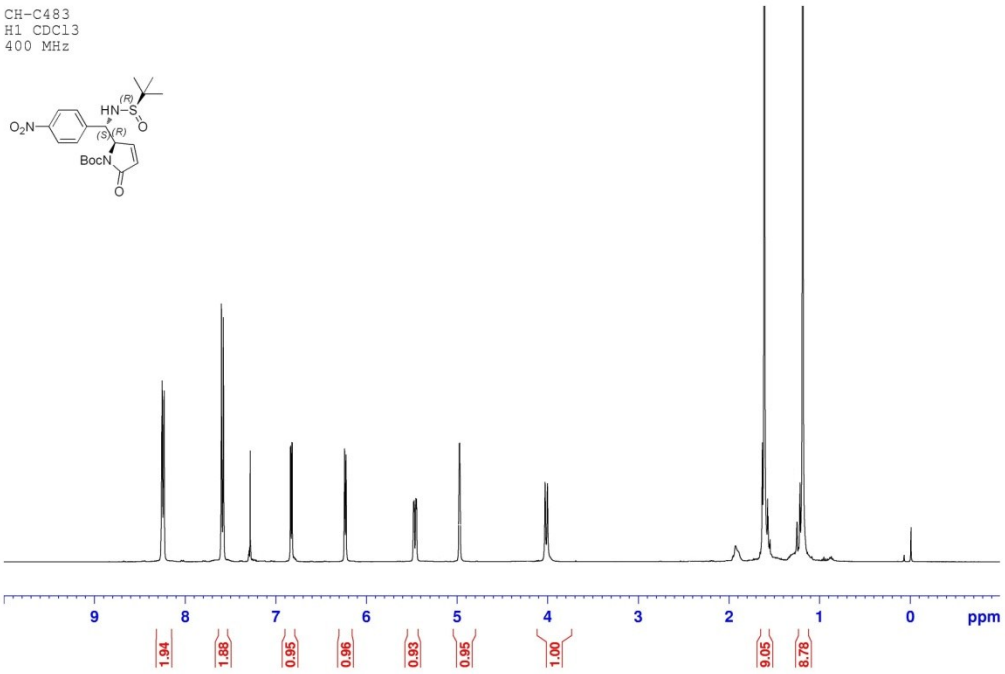


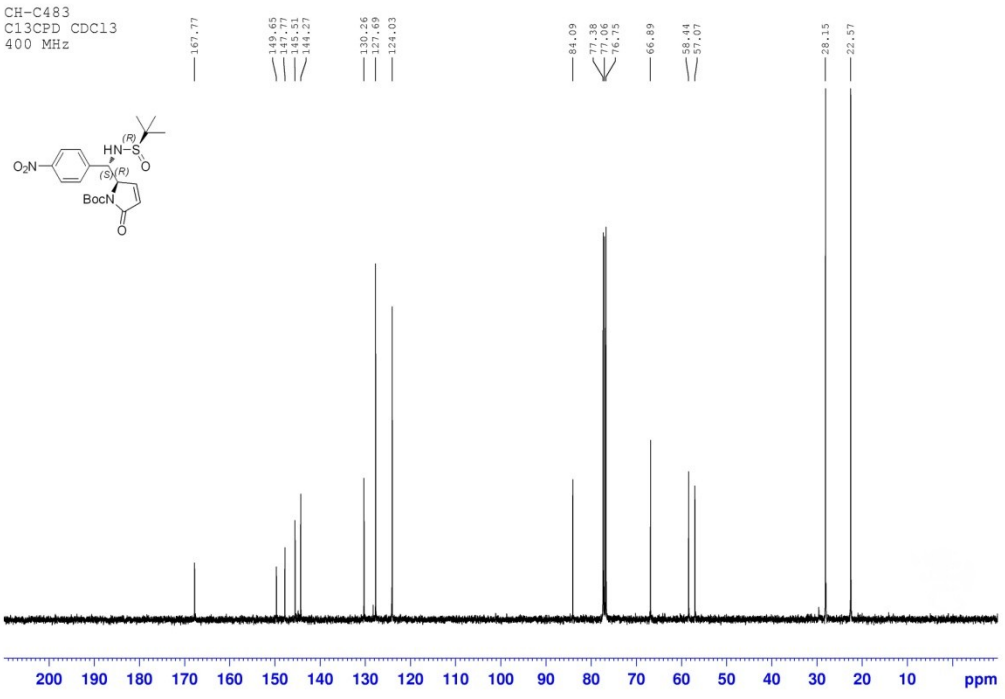
^{1}H and ^{13}C NMR spectra of compound *syn*-8m



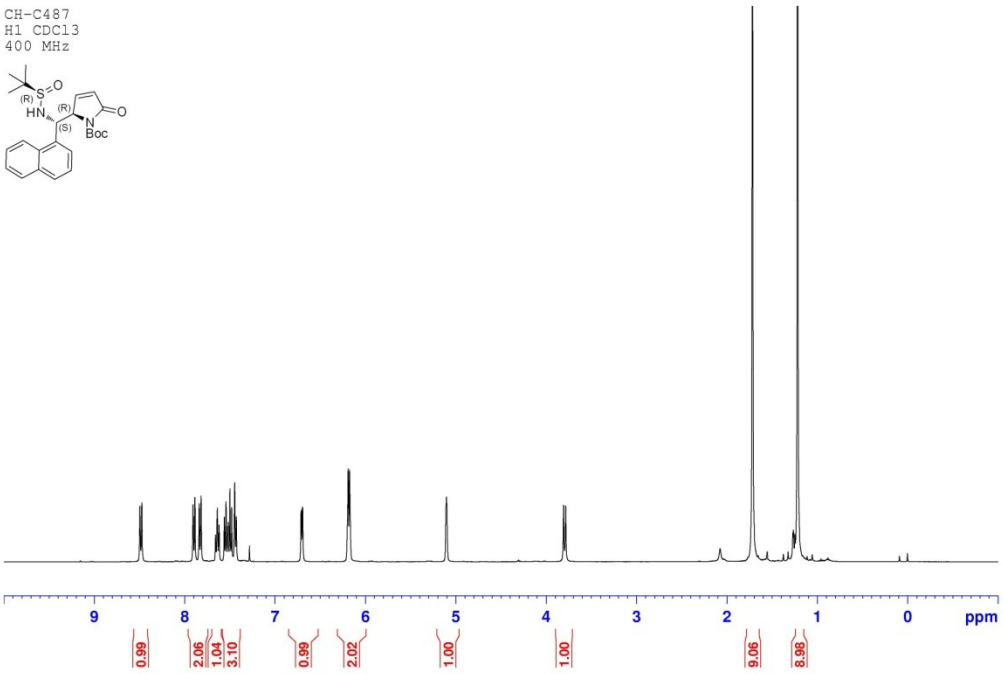


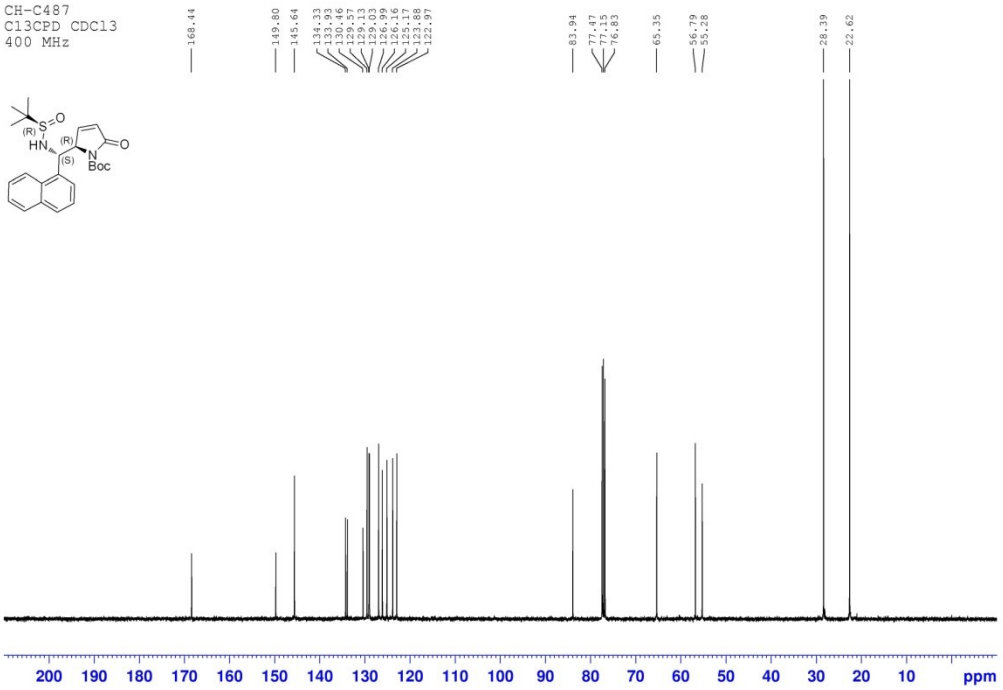
^{1}H and ^{13}C NMR spectra of compound 8n



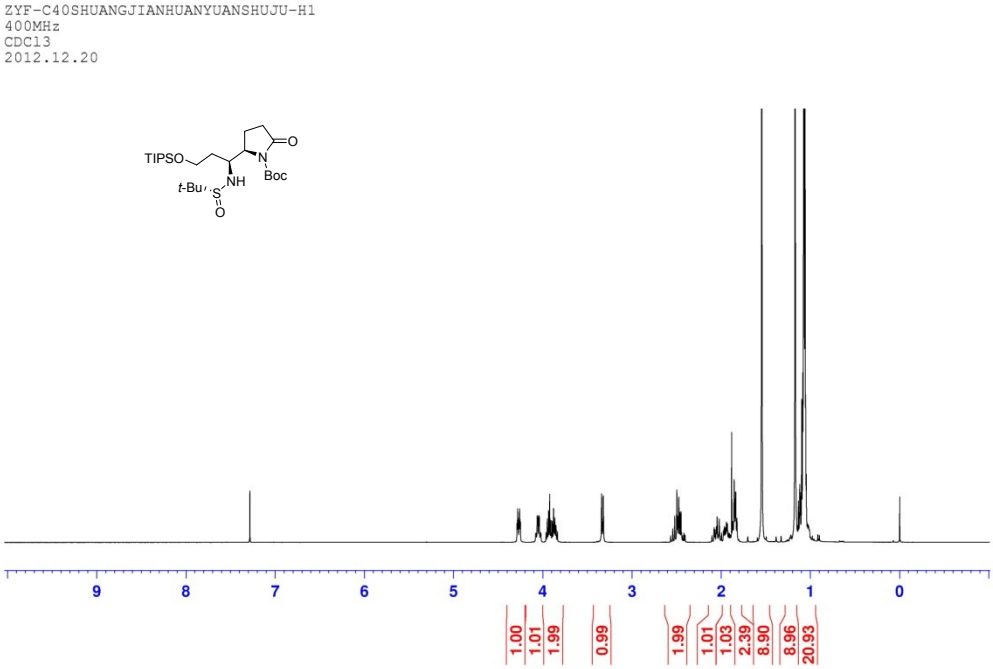


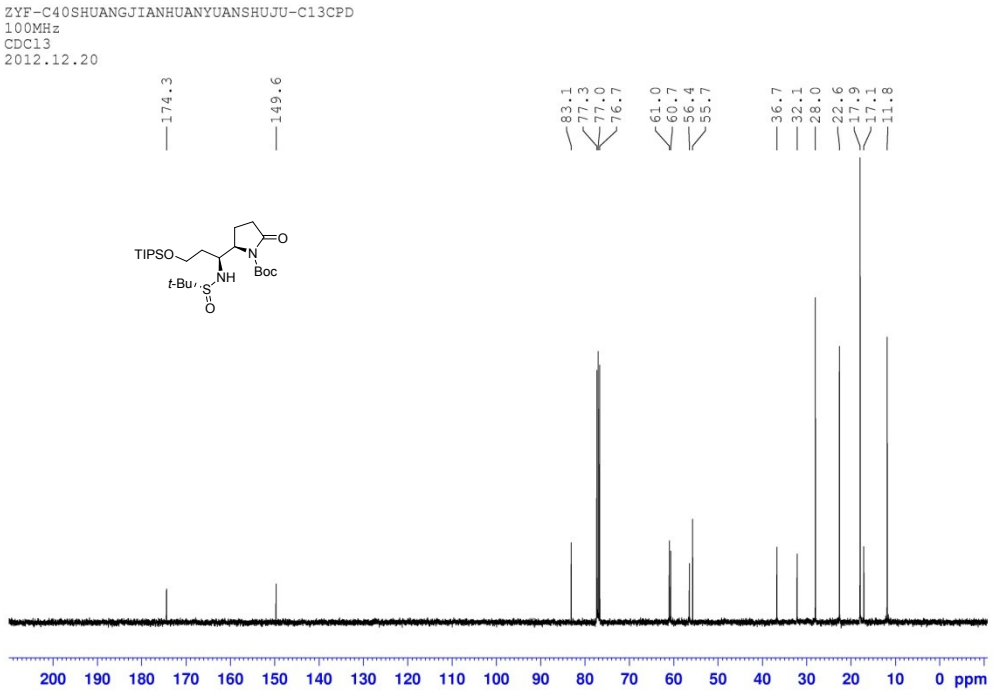
^{1}H and ^{13}C NMR spectra of compound 8o



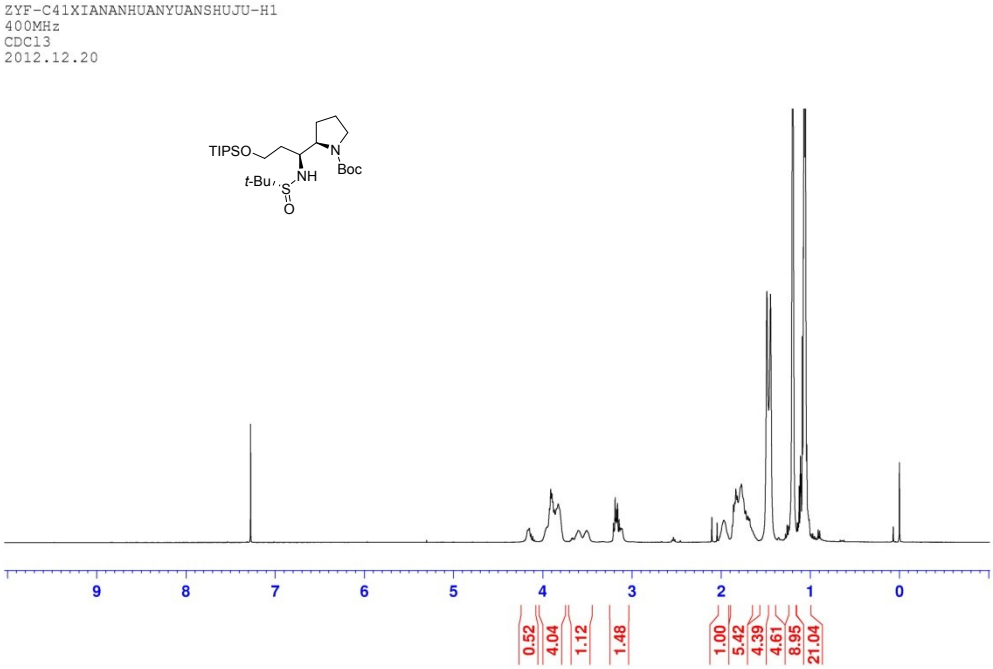


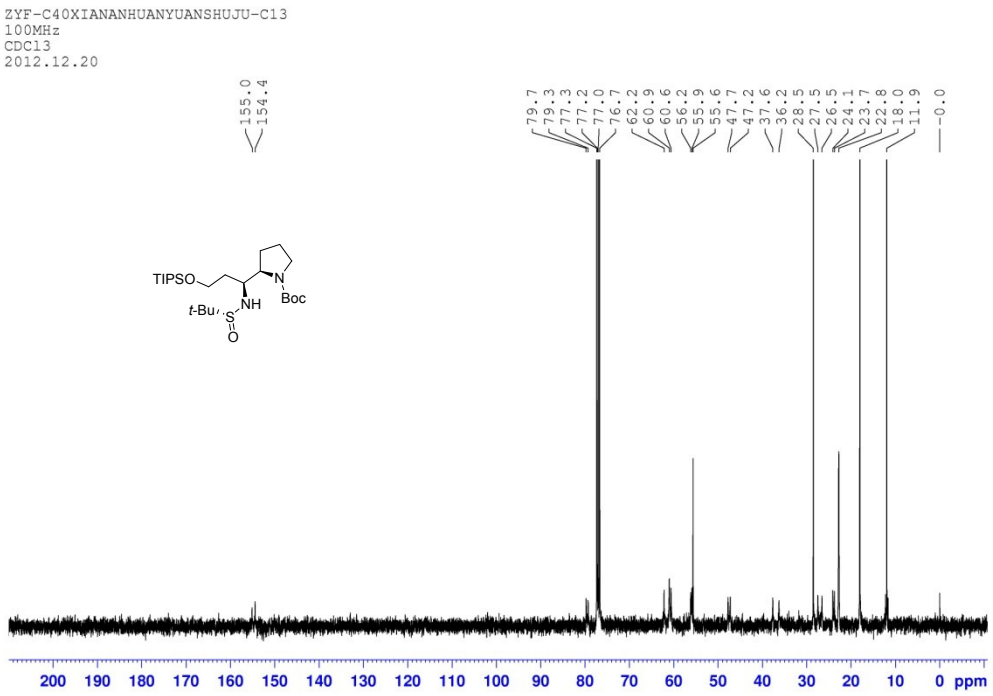
^{1}H and ^{13}C NMR spectra of compound 15



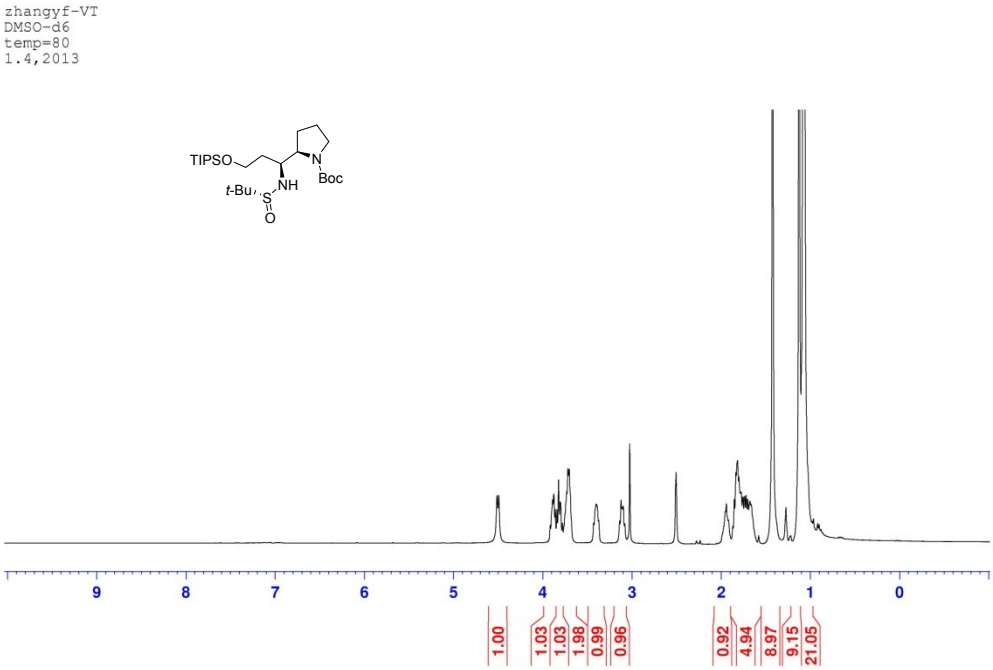


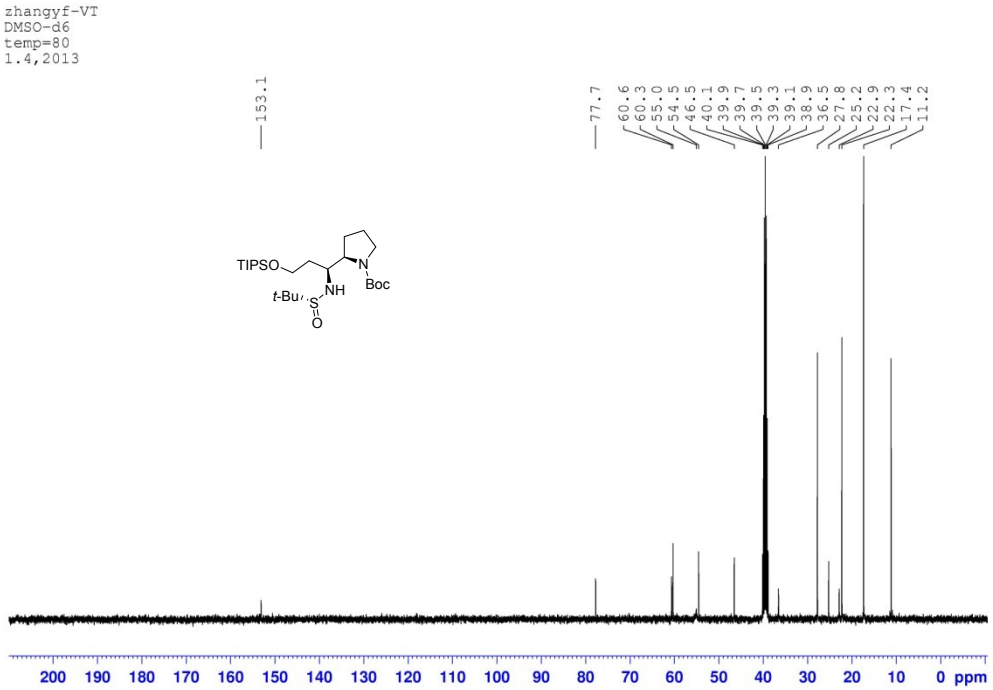
^{1}H and ^{13}C NMR spectra of compound 16



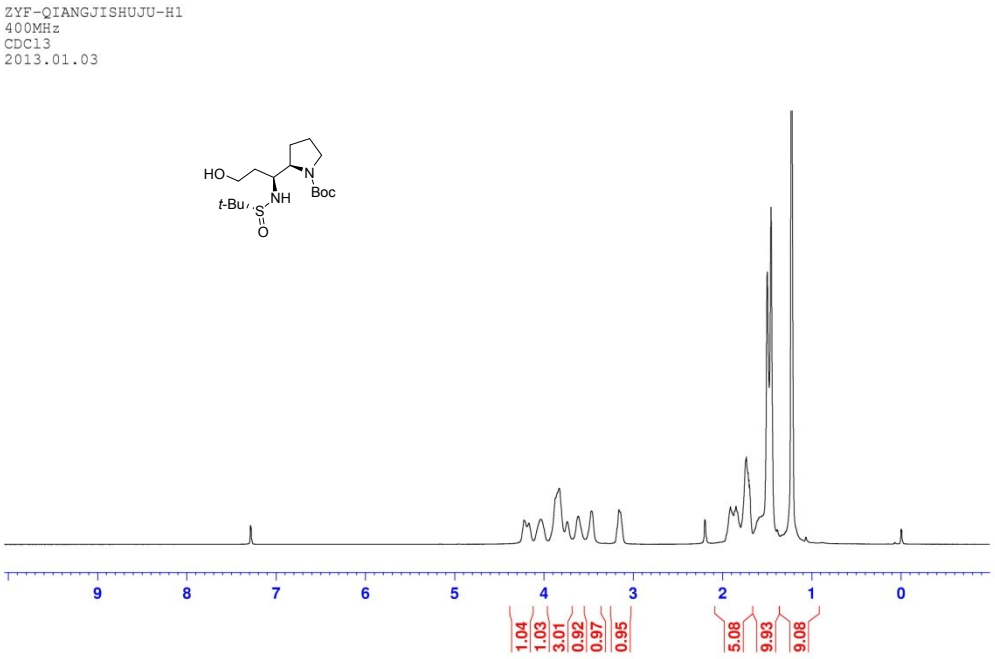


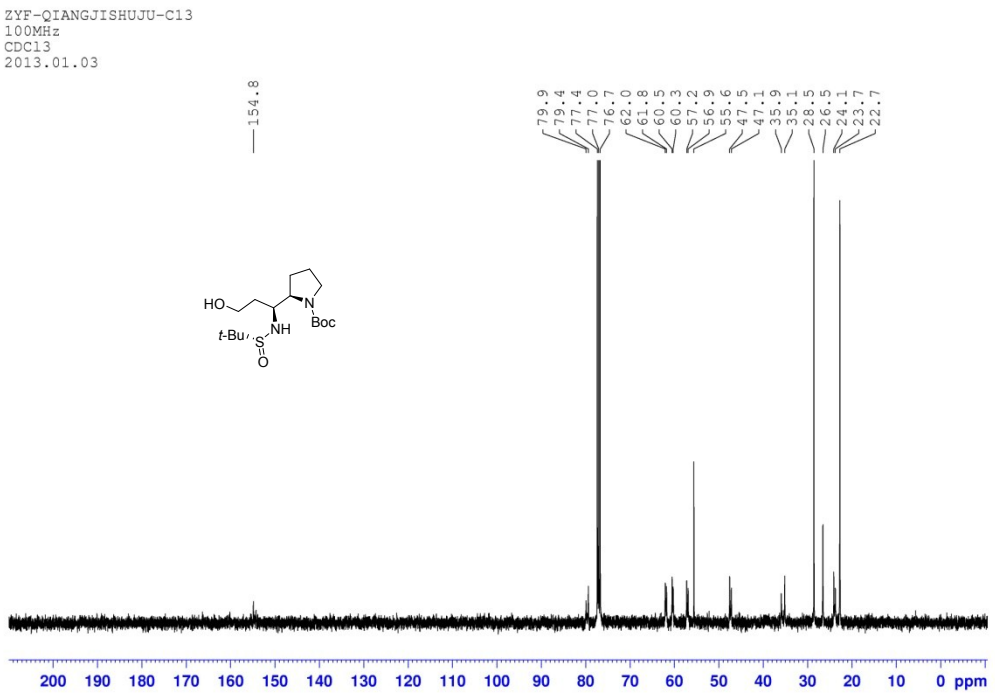
^{1}H and ^{13}C NMR spectra of compound 16 at 80 °C



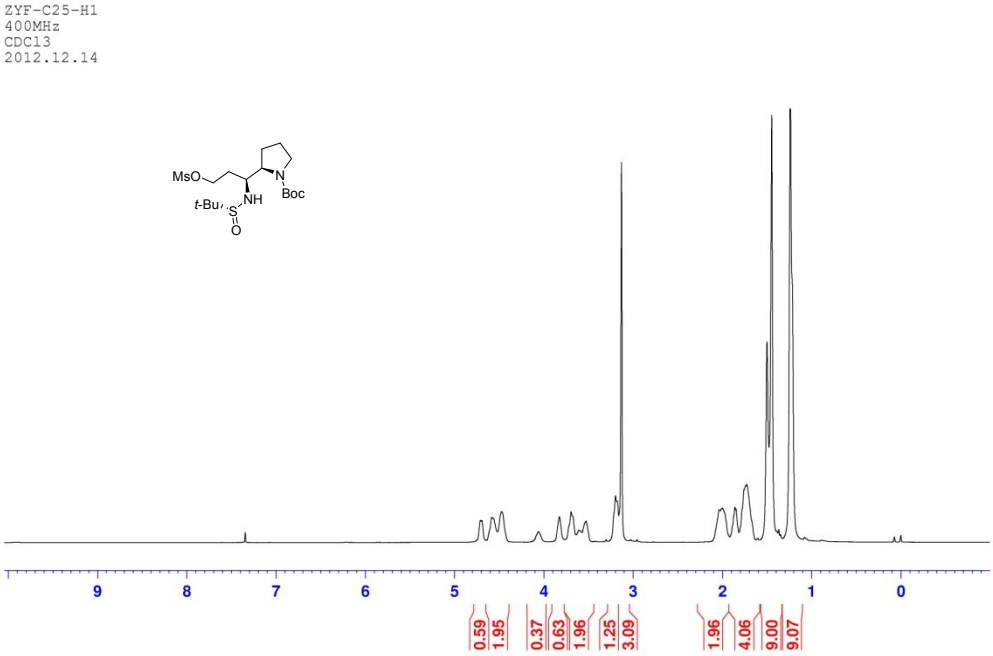


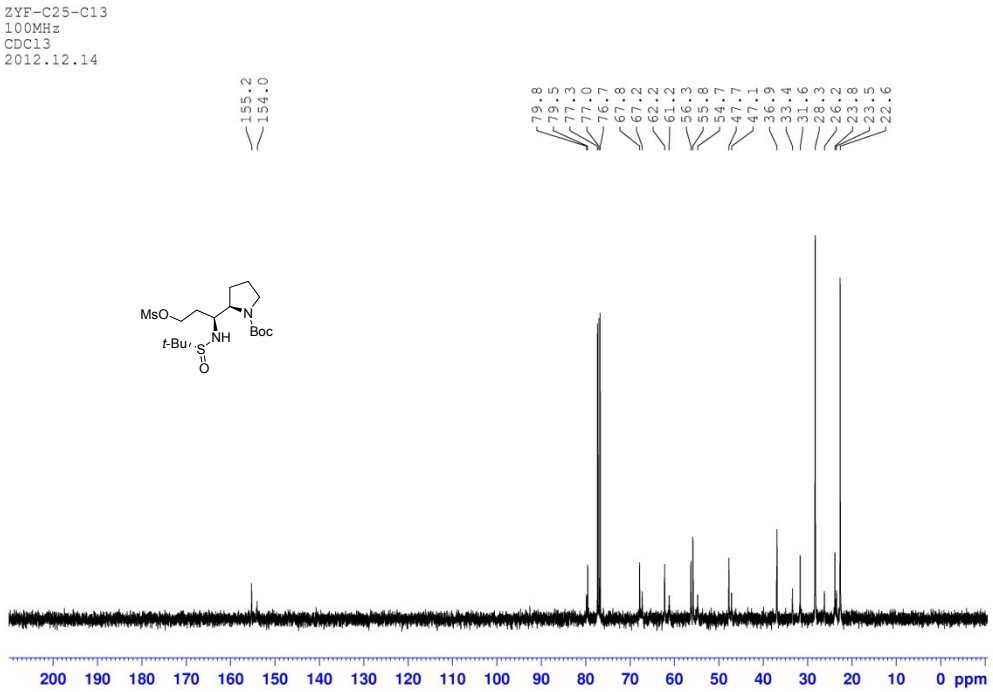
^{1}H and ^{13}C NMR spectra of compound 17



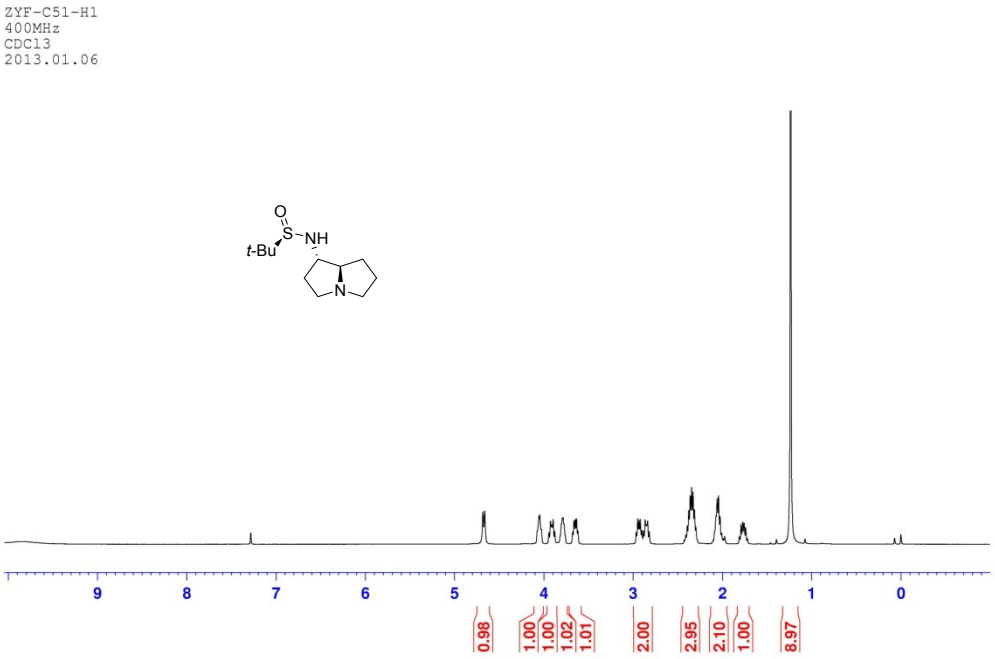


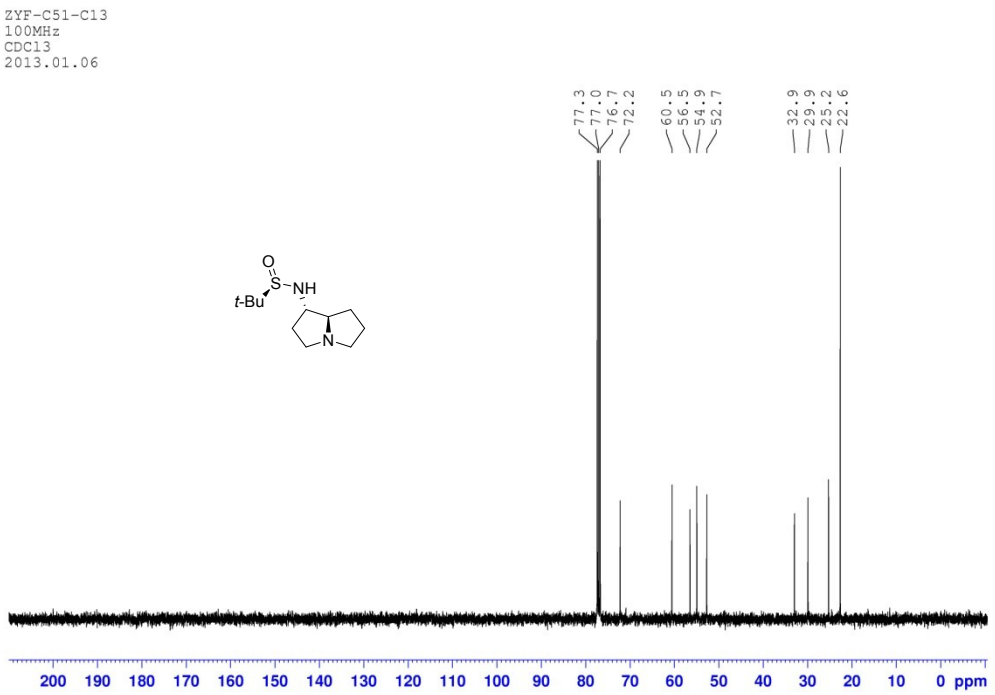
^{1}H and ^{13}C NMR spectra of compound 18





^{1}H and ^{13}C NMR spectra of compound 19





^{1}H and ^{13}C NMR spectra of compound (+)-absouline (*E*-1)