

Supporting Information for

Accessing Highly Functionalized Cyclopentanoids via Cascade Palladation Approach: Unprecedented Benzylic C-H Activation towards Cyclopentenoindanes

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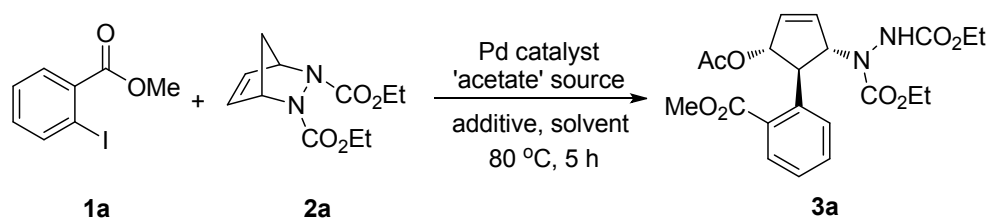
1. General methods

All chemicals were of the best grade commercially available and are used without further purification. All solvents were purified according to standard procedure; dry solvents were obtained according to the literature methods and stored over molecular sieves. Analytical thin layer chromatography was performed on glass plates coated with silica gel containing calcium sulfate binder. Gravity column chromatography was performed using neutral alumina and mixtures of hexane-ethyl acetate were used for elution. Melting points were determined on a Buchi melting point apparatus and are uncorrected. Proton nuclear magnetic resonance spectra (^1H NMR) were recorded on a Bruker AMX 500 spectrophotometer (CDCl_3 and CD_3CN as solvents). Chemical shifts for ^1H NMR spectra are reported as δ in units of parts per million (ppm) downfield from SiMe_4 (δ 0.0) and relative to the signal of chloroform-d (δ 7.25ppm). Multiplicities were given as: s (singlet); d (doublet); t (triplet); q (quadret); dd (double doublet); m (multiplet). Coupling constants are reported as J value in Hz. Carbon nuclear magnetic resonance spectra (^{13}C NMR) are reported as δ in units of parts per million (ppm) downfield from SiMe_4 (δ 0.0) and relative to the signal of chloroform-d (δ 77.03 ppm) CD_3CN (1.32 ppm). In some of the cases, the ^{13}C of compound were recorded in a 7:3 mixture of CDCl_3 and CCl_4 . In those ^{13}C a spectrum, the peak seen at δ 96.0 ppm corresponds to the carbon of CCl_4 . Mass spectra were recorded under ESI/HRMS at 60,000 resolution using Thermo Scientific Exactive mass spectrometer with orbitrap analyzer.

- *All the synthesized compounds bear a hydrazide moiety and the ^1H & ^{13}C NMR of these compounds were broadened due to the presence of rotamers.* Hu, D.; Grice, P.; Ley S. V. *J. Org. Chem.*, **2012**, *77*, 5198.

2. Optimization studies for the Pd catalysed reaction of o-iodobenzoate with diazabicyclic alkene

Encouraged by the unprecedented formation of 3,4,5-trisubstituted cyclopentene, our efforts were focused on optimizing the reaction conditions with **1a** and **2a** as substrates. To begin with, different acetate sources such as NaOAc, KOAc, NH_4OAc , $\text{Cu}(\text{OAc})_2$ and CsOAc were tried (Table 1, entries 1-5). The highest yield of 41% was obtained with CsOAc and the reaction failed with NH_4OAc and $\text{Cu}(\text{OAc})_2$. It is to be noted that the trisubstituted cyclopentene was not formed in the absence of the acetate source (Table 1, entry 6). Next, the additives were changed between Bu_4NCl , Bu_4NBr , Bu_4NI and LiCl from which Bu_4NCl was found to be the best (Table 1, entries 5, 7-9). The efficiency of different Pd-catalysts were then examined and the $[\text{Pd}(\text{allyl})\text{Cl}]_2$ catalyzed reaction afforded **3a** in 83% yield (Table 1, entries 5, 10-13). Different solvents such as toluene, CH_3CN , MeOH, THF and DMF were tested and the best medium for the present reaction was found to be toluene (Table 1, entries 13-17). Finally, we performed a reaction without $[\text{Pd}(\text{allyl})\text{Cl}]_2$ which failed to proceed, thereby proving the essentiality of Pd-catalyst for the reaction.

Table 1. Optimization studies

Entry	Catalyst	Acetate source	Additive	Solvent	Yield (%)
1	Pd(OAc) ₂	NaOAc	Bu ₄ NCl	Toluene	30%
2	Pd(OAc) ₂	KOAc	Bu ₄ NCl	Toluene	35%
3	Pd(OAc) ₂	NH ₄ OAc	Bu ₄ NCl	Toluene	-
4	Pd(OAc) ₂	Cu(OAc) ₂	Bu ₄ NCl	Toluene	-
5	Pd(OAc) ₂	CsOAc	Bu ₄ NCl	Toluene	41%
6	Pd(OAc) ₂	-	Bu ₄ NCl	Toluene	-
7	Pd(OAc) ₂	CsOAc	Bu ₄ NBr	Toluene	40%
8	Pd(OAc) ₂	CsOAc	Bu ₄ NI	Toluene	12%
9	Pd(OAc) ₂	CsOAc	LiCl	Toluene	-
10	Pd(Cl) ₂	CsOAc	Bu ₄ NCl	Toluene	56%
11	Pd(TFA) ₂	CsOAc	Bu ₄ NCl	Toluene	50%
12	Pd(PPh ₃) ₂ Cl ₂	CsOAc	Bu ₄ NCl	Toluene	28%
13	[Pd(allylCl)]₂	CsOAc	Bu₄NCl	Toluene	83%
14	[Pd(allylCl)] ₂	CsOAc	Bu ₄ NCl	CH ₃ CN	55%
15	[Pd(allylCl)] ₂	CsOAc	Bu ₄ NCl	MeOH	35%
16	[Pd(allylCl)] ₂	CsOAc	Bu ₄ NCl	THF	77%
17	[Pd(allylCl)] ₂	CsOAc	Bu ₄ NCl	DMF	45%
18	-	CsOAc	Bu ₄ NCl	Toluene	-
19	[Pd(allylCl)] ₂	-	Bu ₄ NOAc	Toluene	48%

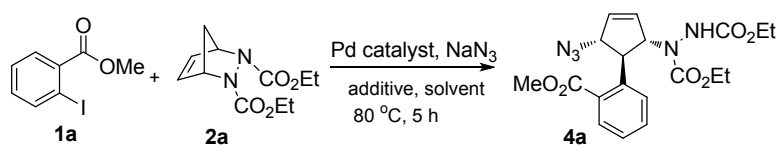
Reaction conditions: **1a** (1.0 equiv.), **2a** (1.0 equiv.), catalyst (10.0 mol%), acetate source (2.0 equiv.), additive (1.0 equiv.), solvent (1.0 mL), 5 h, 80 °C.

On the basis of these investigations, the optimal conditions for this reaction are as follows: 2-iodobenzoate **1** (1.0 equiv.), bicyclic alkene **2** (1.0 equiv.), [Pd(allyl)Cl]₂ (10 mol%), CsOAc (2.0 equiv), Bu₄NCl (1.0 equiv.), toluene as solvent at 80 °C for 5 h.

3. Optimization studies for the Pd catalysed reaction of *o*-iodobenzoate and diazabicyclic alkene with azide as nucleophile

Detailed optimization studies were performed by choosing **1a** and **2a** as model substrates to accomplish optimal reaction condition and our efforts are summarised in the table 2. Among the various solvents surveyed, DMSO gave better yield compared to the other solvents such as DMF, Toluene, CH₃CN, THF, and 1,4 dioxane (Table 2, entries 1-6). Next, the additives were changed between Bu₄NCl, Bu₄NBr, Bu₄NI and LiCl from which Bu₄NCl was found to be the best (Table 2, entries 6-9). Further experiments showed that [Pd(allyl)Cl]₂ was the best choice for the catalyst precursor. Other palladium salts such as PdCl₂, Pd(TFA)₂, Pd(PPh₃)₂Cl₂, and Pd(OAc)₂ were inferior (Table 2, entries 6, 9-11).

Table 2 Optimization for a Suitable Catalyst System

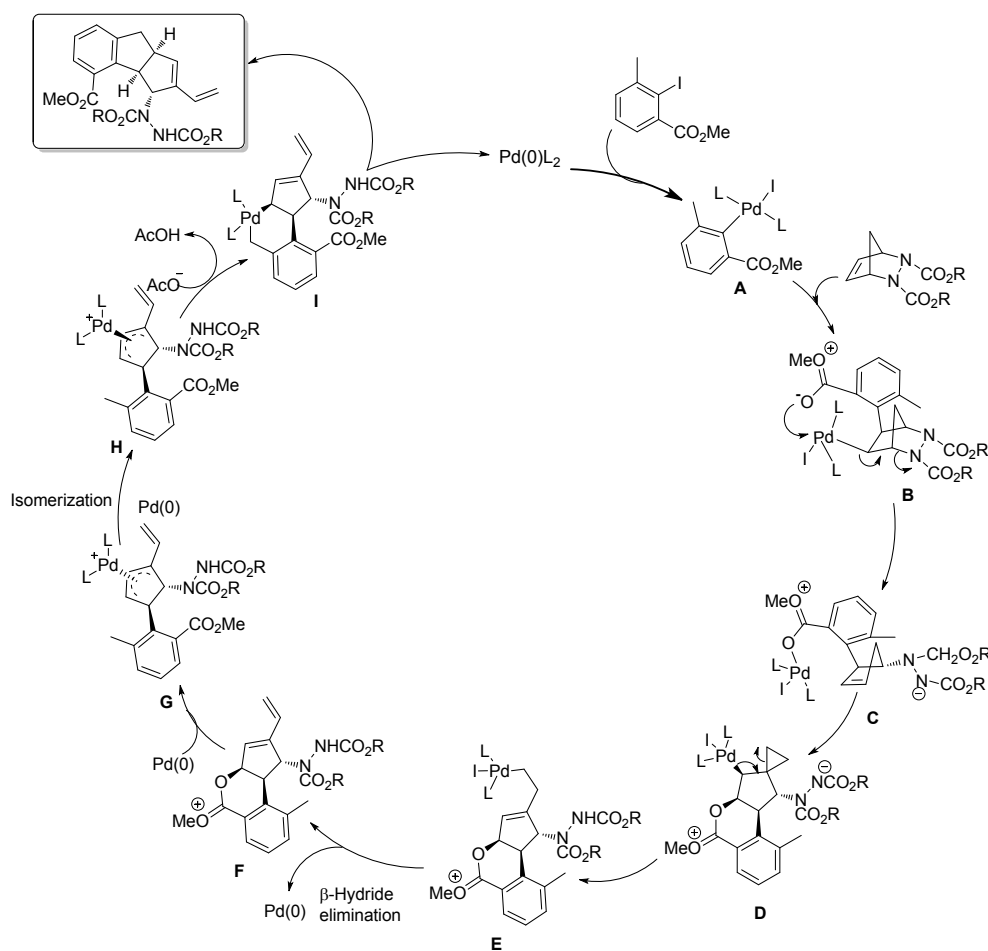


Entry	Catalyst	Additive	Solvent	Yield (%)
1	[Pd(allyl)Cl] ₂	Bu ₄ NCl	Toluene	50%
2	[Pd(allyl)Cl] ₂	Bu ₄ NCl	CH ₃ CN	60%
3	[Pd(allyl)Cl] ₂	Bu ₄ NCl	THF	65%
4	[Pd(allyl)Cl] ₂	Bu ₄ NCl	1,4 dioxane	35%
5	[Pd(allyl)Cl] ₂	Bu ₄ NCl	DMF	60%
6	[Pd(allyl)Cl]₂	Bu₄NCl	DMSO	70%
7	Pd(OAc) ₂	Bu ₄ NBr	DMSO	34%
8	Pd(OAc) ₂	Bu ₄ NI	DMSO	8%
9	Pd(OAc) ₂	LiCl	DMSO	No Reaction
10	PdCl ₂	Bu ₄ NCl	DMSO	50%
11	Pd(TFA) ₂	Bu ₄ NCl	DMSO	45%

Reaction conditions: **1a** (1.0 equiv.), **2a** (1.0 equiv.), Catalyst (10.0 mol %), NaN₃ (2 equiv.) Additive (1.0 equiv.), Solvent (1.0 mL), 5 h, 80 °C.

On the basis of these investigations, the optimal conditions for this reaction are as follows: 1:1 mixture of 2-iodobenzoate/bicyclic olefin with 10 mol% [Pd(allyl)Cl]₂, 2.0 equiv. of NaN₃, 1.0 equiv. of Bu₄NCl and 1 mL of DMSO for 5 h at 80 °C.

4. Mechanism for the formation of vinyl substituted cyclopentene fused indanes 8f & 8g



Scheme 1

Based on the results, we propose a plausible mechanism (Scheme 1). The first stage commences with the oxidative addition of Pd(0) into the Ar-I bond forming intermediate **A**. The Pd-species then coordinates the double bond of the diazabicyclic olefin leading to carbopalladation furnishing the intermediate **B**. Oxypalladation and subsequent ring opening of the bicyclic ring occurs to form **C**. The second stage starts when the oxypalladated species adds to the double bond of **C** leading to the intermediate **D**. The ring-opening of cyclopropylcarbinyl palladium species leads to the intermediate (**E**). β -Hydride elimination occurs on the species **E** affording the vinyl appended cyclopentene fused lactone species **F**. In the final stage, coordination of the Pd(0)-catalyst to the double bond of **F** followed by oxidative addition, during which the lactone ring is opened furnishing an η^3 π -allyl complex **G**.¹⁰ This is followed by isomerization by the nucleophilic attack of a transient Pd(0) to furnish the opposite stereoisomeric Pd-intermediate **H**, which would undergo cyclopalladation with the benzylic C-H bond cleavage to form a six membered palladium

intermediate **I**. Reductive elimination of Pd-species occurs to furnish the final cyclopentannulated indane and Pd(0) species to continue the catalytic cycle (Scheme1).

5. Synthetic procedure for the Pd-catalyzed reaction of *o*-iodobenzoate and diazabicyclic alkene with ‘acetate’ as nucleophile and benzylic C-H activation (Procedure A)

A mixture of Methyl 2-Iodobenzoate **1a** (54 mg, 0.208 mmol), azabicyclic olefin **2a** (50 mg, 0.208 mmol.), [Pd(allyl)Cl]₂ (7.6 mg, 0.021), cesium acetate (80 mg, 0.416 mmol) and Bu₄NCl (58 mg, 0.208 mmol) were weighed into a Schlenk tube and degassed for 10 minutes. Dry toluene (1 mL) was added and the reaction mixture was purged with argon and allowed to stir at 80 °C for 12 hours. The solvent was evaporated in *vacuo* and the residue on column chromatography (activated neutral alumina) with hexane-ethylacetate mixtures yielded functionalized cyclopentenes.

6. Synthetic procedure for the Pd-catalyzed reaction of *o*-iodobenzoate and diazabicyclic alkene with ‘azide’ as nucleophile. (Procedure B)

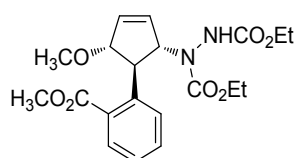
A mixture of Methyl 2-Iodobenzoate **1a** (54 mg, 0.208 mmol), azabicyclic olefin **2a** (50 mg, 0.208 mmol.), [Pd(allyl)Cl]₂ (7.6 mg, 0.021), sodium azide (27 mg, 0.416 mmol) and Bu₄NCl (58 mg, 0.208 mmol) were weighed into a Schlenk tube and degassed for 10 minutes. Dry DMSO (1 mL) was added and the reaction mixture was purged with argon and allowed to stir at 80 °C for 5 hours. The solvent was evaporated in *vacuo* and the residue on column chromatography (activated neutral alumina) with hexane-ethylacetate mixtures yielded functionalized cyclopentenes.

7. Synthetic procedure for the Pd-catalyzed reaction of *o*-iodobenzoate and diazabicyclic alkene with ‘methoxide’ as nucleophile. (Procedure C)

A mixture of methyl 2-iodobenzoate **1a** (54 mg, 0.208 mmol), azabicyclic olefin **2a** (50 mg, 0.208 mmol.), [Pd(allyl)Cl]₂ (7.6 mg, 0.021), sodium methoxide (23 mg, 0.416 mmol) and Bu₄NCl (58 mg, 0.208 mmol) were weighed into a Schlenk tube and degassed for 10 minutes. Dry toluene (1mL) was added and the reaction mixture was purged with argon and allowed to stir at 80 °C for 5 hours. The solvent was evaporated in *vacuo* and the residue on column chromatography (activated neutral alumina) with hexane-ethylacetate mixtures yielded functionalized cyclopentenes

8. Synthesis and characterisation of functionalized cyclopentenes

Diethyl 1-((1S,4R,5R)-4-acetoxy-5-(2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (**3a**)



The reaction was performed according to procedure **A** with methyl 2-iodobenzoate **1a** (54 mg, 0.208 mmol), azabicyclic olefin **2a** (50 mg, 0.208 mmol.), [Pd(allyl)Cl]₂ (7.6 mg, 0.021), cesium acetate (80 mg, 0.416 mmol), Bu₄NCl (58 mg, 0.208 mmol), in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (25% ethyl acetate in hexane) to afford the desired product as 1:1 mixture of diastereomers (from ¹H-NMR analysis) and appeared as a viscous liquid (75 mg, 83%).

Analytical Data of 3a:

TLC (SiO₂): R_f: 0.26 (25% ethyl acetate in hexane).

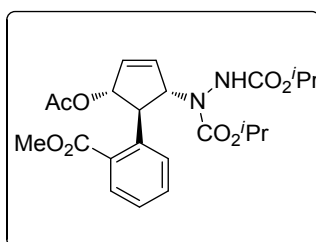
IR (neat) ν_{\max} : 3284, 3058, 2982, 2935, 1709, 1654, 1519, 1386, 1319, 1257, 1224, 934, 762 cm⁻¹.

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.85 (d, *J* = 6.5 Hz, 1H), 7.54-7.41 (m, 2H), 7.30-7.28 (m, 1H), 7.18-7.13 (m, 1H), 6.13-5.99 (m, 2H), 5.84-5.79 (m, 1H), 5.40-5.21 (m, 1H), 4.37-3.99 (m, 4H), 3.90 (s, 3H), 3.81-3.69 (m, 1H), 1.99 (s, 3H), 1.32-1.15 (m, 5H), 0.72 (s, 1H).

¹³C NMR (125 MHz, CDCl₃): 170.7, 168.5, 168.3, 157.3, 156.7, 155.7, 141.8, 134.5, 133.9, 132.7, 132.5, 132.0, 130.5, 130.2, 128.3, 126.8, 84.0, 83.3, 70.6, 69.7, 62.3, 62.0, 52.4, 49.5, 48.3, 21.1, 14.5, 13.8.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₁H₂₆N₂O₈Na 457.1581; Found: 457.1578.

Diisopropyl 1-((1S,4R,5R)-4-acetoxy-5-(2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (3b)



The reaction was performed according to procedure **A** with methyl 2-iodobenzoate **1a** (49 mg, 0.186 mmol), azabicyclic olefin **2b** (50 mg, 0.186 mmol.), [Pd(allyl)Cl]₂ (6.8 mg, 0.019), cesium acetate (71 mg, 0.372 mmol) and Bu₄NCl (52 mg, 0.186 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (20% ethyl acetate in hexane) to afford the desired product as 0.8:1 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a viscous liquid (67 mg, 78%).

Analytical Data of 3b:

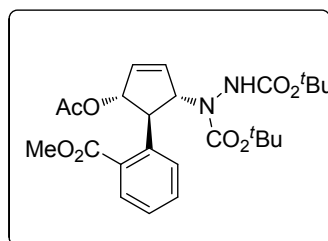
TLC (SiO₂): R_f: 0.40 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.84 (s, 1H), 7.53-7.41(m, 2H), 7.30-7.28 (m, 1H), 7.07 (brs, 1H), 6.13-5.98 (m, 2H), 5.83-5.78 (m, 1H), 5.37-5.23 (m, 1H), 4.99-4.98 (m, 1H), 4.74-4.62 (m, 1H), 4.36-4.31 (m, 1H), 3.90 (s, 3H), 1.98 (s, 3H), 1.28-1.00 (m, 11H), 0.52 (s, 1H).

¹³C NMR (125 MHz, CDCl₃): δ 170.5, 168.1, 157.1, 156.4, 155.2, 149.5, 142.1, 141.9, 134.7, 134.1, 132.7, 132.4, 131.7, 130.5, 130.1, 128.2, 126.7, 84.0, 83.5, 70.3, 70.3, 69.9, 69.6, 52.4, 51.9, 49.8, 22.0, 21.9, 21.1.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₃H₃₀N₂O₈Na 485.1894; Found: 485.1893.

Di-tert-butyl 1-((1S,4R,5R)-4-acetoxy-5-(2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (3c)



The reaction was performed according to procedure **A** with methyl 2-iodobenzoate **1a** (49 mg, 0.169 mmol), azabicyclic olefin **2c** (50 mg, 0.169 mmol.), [Pd(allyl)Cl]₂ (6.1 mg, 0.017), cesium acetate (65 mg, 0.338 mmol) and Bu₄NCl (47 mg, 0.169 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (15% ethyl acetate in hexane) to afford the desired product as 1:0.8 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a viscous liquid (63 mg, 76%).

Analytical Data of 3c:

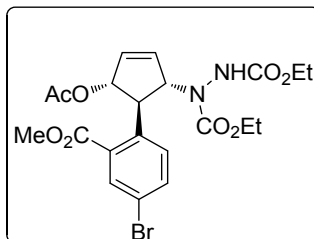
TLC (SiO₂): R_f: 0.51 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.88-7.81 (m, 1H), 7.53-7.39 (m, 2H), 7.32-7.28 (m, 1H), 6.82-6.76 (m, 1H), 6.12-5.94 (m, 2H), 5.82-5.72 (m, 1H), 5.30 -5.15 (m, 1H), 4.36-4.34 (m, 1H), 3.90 (s, 3H), 1.99 (s, 3H), 1.50-1.33 (m, 14H), 1.01 (s, 4H).

¹³C NMR (125 MHz, CDCl₃): δ 170.4, 168.2, 167.77, 156.2, 154.5, 154.4, 154.2, 142.5, 142.2, 134.4, 132.7, 132.3, 131.2, 130.5, 130.3, 129.9, 128.0, 126.5, 96.1, 83.6, 80.9, 80.7, 70.7, 68.8, 52.3, 49.8, 48.0, 28.2, 28.0, 27.5, 21.0.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₅H₃₄N₂O₈Na 513.2207; Found: 513.2220.

Diethyl 1-((1S,4R,5R)-4-acetoxy-5-(4-bromo-2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (3d)



The reaction was performed according to procedure **A** with methyl 2-iodo 5-bromobenzoate **1b** (71 mg, 0.208 mmol), azabicyclic olefin **2a** (50 mg, 0.208 mmol.), [Pd(allyl)Cl]₂ (7.6 mg, 0.021), cesium acetate (80 mg, 0.416 mmol) and Bu₄NCl (58 mg, 0.208 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (20% ethyl acetate in hexane) to afford the desired product as 1:1 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a viscous liquid (87 mg, 81%).

Analytical Data of 3d:

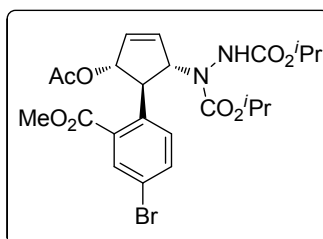
TLC (SiO₂): R_f: 0.29 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 8.00-7.97 (m, 1H), 7.64 (dd, *J*₁ = 8.5 Hz, *J*₂ = 2 Hz, 1H), 7.33 (d, *J* = 8.0 Hz, 1H), 7.14-7.01 (m, 1H), 6.11- 5.96 (m, 2H), 5.78-5.69 (m, 1H), 5.36-5.15 (m, 1H), 4.30-4.21 (m, 3H), 4.08-4.02 (m, 1H), 3.92 (s, 3H), 3.85-3.83 (m, 1H), 1.99 (s, 3H), 1.33-1.17 (m, 5H), 0.81 (s, 1H).

¹³C NMR (125 MHz, CDCl₃): δ 170.4, 167.0, 166.8, 157.1, 156.5, 155.6, 141.0, 135.7, 135.3, 134.4, 133.8, 133.3, 132.3, 132.0, 131.7, 130.1, 129.8, 120.5, 83.7, 82.9, 70.4, 69.4, 62.3, 61.9, 52.7, 48.2, 47.9, 20.9, 14.4, 13.8.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₁H₂₅BrN₂O₈Na 535.0686; Found: 535.0672.

Diisopropyl 1-((1S,4R,5R)-4-acetoxy-5-(4-bromo-2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (3e)



The reaction was performed according to procedure **A** with methyl 2-iodo 5-bromobenzoate **1b** (63 mg, 0.186 mmol), azabicyclic olefin **2b** (50 mg, 0.186 mmol.), [Pd(allyl)Cl]₂ (6.8 mg, 0.019), cesium acetate (71 mg, 0.372 mmol) and Bu₄NCl (52 mg, 0.186 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (20% ethyl acetate in hexane) to afford the desired product as 1:0.9 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a viscous liquid (74 mg, 73%).

Analytical Data of 3e:

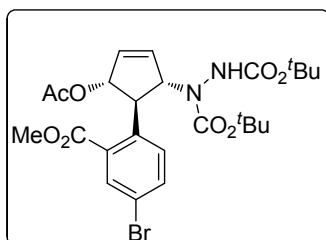
TLC (SiO₂): R_f: 0.44 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.99 (s, 1H), 7.63 (d, *J* = 7.5 Hz, 1H), 7.34-7.31 (m, 1H), 6.96 (brs, 1H), 6.12-5.97 (m, 2H), 5.79-5.72 (m, 1H), 5.34-5.19 (m, 1H), 4.98-4.97 (m, 1H), 4.76-4.65 (m, 1H), 4.32 (brs, 1H), 3.91 (s, 3H), 1.99 (s, 3H), 1.31-1.04 (m, 11H), 0.61 (s, 1H).

¹³C NMR (125 MHz, CDCl₃): δ 170.4, 167.2, 166.9, 156.9, 156.6, 155.6, 141.3, 135.7, 135.3, 134.6, 134.1, 133.4, 132.2, 131.8, 130.5, 129.8, 120.5, 83.8, 83.2, 70.2, 70.2, 70.1, 69.8, 69.5, 52.7, 48.4, 22.0, 21.9, 21.0.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₃H₂₉BrN₂O₈Na 563.1000; Found: 563.1023.

Di-tert-butyl 1-((1S,4R,5R)-4-acetoxy-5-(4-bromo-2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (3f)



The reaction was performed according to procedure **A** with methyl 2-iodo 5-bromobenzoate **1b** (58 mg, 0.169 mmol), azabicyclic olefin **2c** (50 mg, 0.169 mmol.), [Pd(allyl)Cl]₂ (6.1 mg, 0.017), cesium acetate (65 mg, 0.338 mmol) and Bu₄NCl (47 mg, 0.169 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (18% ethyl acetate in hexane) to afford the desired product as 1:0.8 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a colorless amorphous solid (67 mg, 70%).

Analytical Data of 3f:

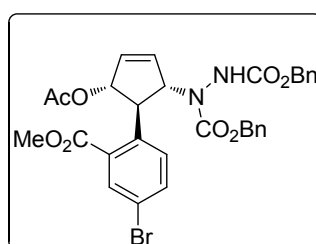
TLC (SiO₂): R_f: 0.48 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 8.02-7.96 (m, 1H), 7.63-7.62 (m, 1H), 7.32-7.28 (m, 1H), 6.78-6.57 (m, 1H), 6.12-5.94 (m, 2H), 5.78-5.73 (m, 1H), 5.30-5.13 (m, 1H), 4.31-4.29 (m, 1H), 3.90 (s, 3H), 1.99 (s, 3H), 1.49-1.36 (m, 14H), 1.07 (s, 4H).

¹³C NMR (125 MHz, CDCl₃): δ 170.7, 167.1, 166.7, 156.4, 155.7, 154.7, 154.3, 141.5, 135.7, 135.3, 134.9, 134.4, 133.4, 132.0, 131.6, 131.3, 129.8, 129.0, 128.2, 125.3, 120.3, 83.7, 83.4, 81.1, 80.9, 70.7, 68.8, 52.7, 50.0, 48.8, 28.2, 28.0, 27.7, 21.0.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₅H₃₃BrN₂O₈Na 591.1312; Found: 591.1317.

Dibenzyl 1-((1S,4R,5R)-4-acetoxy-5-(4-bromo-2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (3g)



The reaction was performed according to procedure A with methyl 2-iodo 5-bromobenzoate **1b** (47 mg, 0.137 mmol), azabicyclic olefin **2d** (50 mg, 0.137 mmol.), [Pd(allyl)Cl]₂ (5.0 mg, 0.014), cesium acetate (53 mg, 0.274 mmol) and Bu₄NCl (38 mg, 0.137 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (18% ethyl acetate in hexane) to afford the desired product as a viscous liquid (63 mg, 72%).

Analytical Data of 3g:

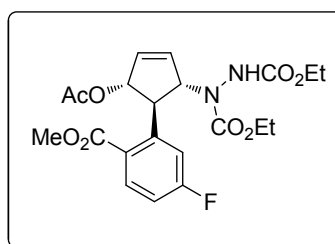
Mp: 112-115 °C

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.80 (d, *J* = 7.5 Hz, 1H), 7.53-7.34 (m, 10H), 7.20 (s, 2H), 6.79 (s, 1H), 6.15-5.79 (m, 3H), 5.43-5.13 (m, 3H), 5.04-5.00 (m, 1H), 4.82 (s, 1H), 4.37 (s, 1H), 3.84 (s, 3H), 1.96 (s, 3H).

¹³C NMR (125 MHz, CDCl₃): δ 170.7, 168.4, 168.2, 157.1, 156.5, 155.5, 141.8, 135.9, 135.4, 134.3, 133.8, 132.8, 132.5, 132.3, 130.5, 130.1, 128.6, 128.3, 127.9, 127.7, 126.8, 84.0, 83.5, 70.9, 70.1, 69.7, 67.9, 67.7, 67.6, 52.5, 48.4, 48.0, 21.0.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₃₁H₂₉BrN₂O₈Na 659.0999; Found: 659.1011.

Diethyl 1-((1S,4R,5R)-4-acetoxy-5-(4-fluoro-2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (3h)



The reaction was performed according to procedure **A** with methyl 2-iodo 5-fluorobenzoate **1c** (58 mg, 0.208 mmol), azabicyclic olefin **2a** (50 mg, 0.208 mmol.), [Pd(allyl)Cl]₂ (7.6 mg, 0.021), cesium acetate (80 mg, 0.416 mmol) and Bu₄NCl (58 mg, 0.208 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (25% ethyl acetate in hexane) to afford the desired product as a viscous liquid (66 mg, 70%).

Analytical Data of 3h:

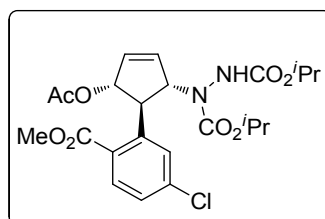
TLC (SiO₂): R_f: 0.26 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.54 (s, 1H), 7.45-42 (m, 1H), 7.24-7.22 (m, 1H), 7.05-6.97 (m, 1H), 6.12-5.97 (m, 2H), 5.79-5.74 (m, 1H), 5.35-5.14 (m, 1H), 4.34-4.21 (m, 3H), 4.06-4.02 (m, 1H), 3.91 (s, 3H), 3.86-3.81(m, 1H), 1.99 (s, 3H), 1.32-1.16 (m, 5H), 0.81 (s, 1H).

¹³C NMR (125 MHz, CDCl₃): δ 170.7, 167.1, 157.3, 156.8, 155.7, 137.8, 134.6, 134.5, 134.0, 132.1, 132.1, 130.1, 117.4, 117.2, 109.5, 83.9, 83.0, 70.5, 69.6, 67.6, 62.4, 62.0, 52.6, 50.1, 21.0, 14.5, 14.4, 14.1.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₁H₂₅FN₂O₈Na 475.1487; Found: 475.1473.

Diisopropyl 1-((1S,4R,5R)-4-acetoxy-5-(5-chloro-2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (3i)



The reaction was performed according to procedure **A** with methyl 2-iodo 4-chlorobenzoate **1d** (55 mg, 0.186 mmol), azabicyclic olefin **2b** (50 mg, 0.186 mmol.), [Pd(allyl)Cl]₂ (6.8 mg, 0.019), cesium acetate (71 mg, 0.372 mmol) and Bu₄NCl (52 mg, 0.186 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (18% ethyl acetate in hexane) to afford the desired product as 1:1 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a viscous liquid (67 mg, 72%).

Analytical Data of 3i:

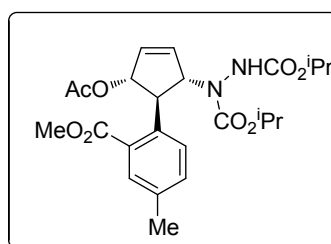
TLC (SiO₂): R_f: 0.42 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.81 (d, *J* = 8 Hz, 1H), 7.43-7.37 (m, 1H), 7.29-7.27 (m, 1H), 6.93-6.89 (m, 1H), 6.12 (s, 1H), 6.00-5.97 (m, 1H), 5.74-5.71 (m, 1H), 5.32-5.22 (m, 1H), 4.98 (s, 1H), 4.75-4.64 (m, 1H), 4.39 (s, 1H), 3.90 (s, 3H), 2.00 (s, 3H), 1.30-1.05 (m, 11H), 0.60 (s, 1H).

¹³C NMR (125 MHz, CDCl₃): δ 170.6, 167.4, 157.0, 156.4, 155.1, 144.9, 144.4, 139.1, 138.7, 134.8, 134.2, 134.1, 132.1, 131.8, 128.8, 128.3, 128.1, 127.0, 116.2, 84.1, 83.4, 70.2, 70.1, 69.8, 52.6, 50.1, 48.6, 21.9, 21.8, 21.0.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₃H₂₉ClN₂O₈Na 519.1505; Found: 519.1506.

Diisopropyl 1-((1*S*,4*R*,5*R*)-4-acetoxy-5-(2-(methoxycarbonyl)-4-methylphenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (3j)



The reaction was performed according to procedure **A** with methyl 2-iodo 5-methylbenzoate **1e** (51 mg, 0.186 mmol), azabicyclic olefin **2b** (50 mg, 0.186 mmol.), [Pd(allyl)Cl]₂ (6.8 mg, 0.019), cesium acetate (71 mg, 0.372 mmol) and Bu₄NCl (52 mg, 0.186 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (20% ethyl acetate in hexane) to afford the desired product as 1:0.9 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a viscous liquid (75 mg, 85%).

Analytical Data of 3j:

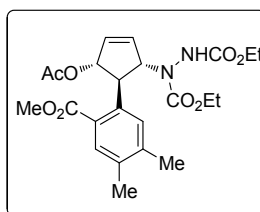
TLC (SiO₂): R_f: 0.37 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.64 (d, *J* = 10 Hz, 1H), 7.35-7.33 (m, 2H), 7.04-6.94 (m, 1H), 6.11-5.96 (m, 2H), 5.80-5.77 (m, 1H), 5.32-5.17 (m, 1H), 4.97 (s, 1H), 4.75-4.62 (m, 1H), 4.28 (s, 1H), 3.90 (s, 3H), 2.35 (s, 3H), 1.98 (s, 3H), 1.30-1.02 (m, 11H), 0.53 (s, 1H).

¹³C NMR (125 MHz, CDCl₃): δ 170.5, 168.5, 168.3, 156.9, 156.3, 155.2, 138.9, 136.3, 134.7, 134.1, 133.6, 133.1, 132.2, 131.9, 131.0, 130.2, 129.9, 128.5, 128.1, 96.1, 84.1, 83.4, 70.2, 69.8, 69.5, 52.3, 49.4, 48.2, 22.1, 21.9, 21.0, 20.9.

HRMS (ESI-Orbitrap) m/z : (M+Na)⁺ calcd for C₂₄H₃₂N₂O₈Na 499.2051; Found: 499.2058.

Diethyl 1-((1S,4R,5R)-4-acetoxy-5-(2-(methoxycarbonyl)-4,5-dimethylphenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (3k)



The reaction was performed according to procedure A with methyl 2-iodo 4,5-dimethylbenzoate **1f** (60 mg, 0.208 mmol), azabicyclic olefin **2a** (50 mg, 0.208 mmol.), [Pd(allyl)Cl]₂ (7.6 mg, 0.021), cesium acetate (80 mg, 0.416 mmol), Bu₄NCl (58 mg, 0.208 mmol) and in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (25% ethyl acetate in hexane) to afford the desired product as 1:0.9 mixture of diastereomers (from ¹H-NMR analysis) and appeared as a viscous liquid (80 mg, 83%).

Analytical Data of 3k:

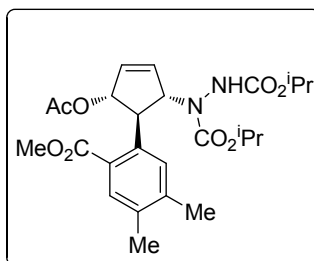
TLC (SiO₂): R_f; 0.29 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.63 (s, 1H), 7.17-7.14 (m, 1H), 6.13-5.99 (m, 2H), 5.80 (s, 1H), 5.34-5.18 (m, 1H), 4.38-4.01 (m, 4H), 3.87 (s, 3H), 3.82 (s, 1H), 2.28 (s, 3H), 2.25 (s, 3H), 1.98 (s, 3H), 1.31-1.14 (m, 5H), 0.73 (s, 1H).

¹³C NMR (125 MHz, CDCl₃): δ 170.8, 168.4, 157.1, 156.7, 155.8, 142.1, 141.8, 139.4, 135.2, 134.6, 134.2, 132.5, 132.1, 131.6, 129.4, 127.6, 125.9, 84.2, 83.5, 70.6, 69.7, 62.2, 61.9, 52.2, 49.0, 47.5, 21.1, 20.0, 19.2, 14.5, 14.3.

HRMS (ESI-Orbitrap) m/z : (M+Na)⁺ calcd for C₂₃H₃₀N₂O₈Na 485.1894; Found: 485.1908.

Diisopropyl 1-((1S,4R,5R)-4-acetoxy-5-(2-(methoxycarbonyl)-4,5-dimethylphenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (3l)



The reaction was performed according to procedure A with methyl 2-iodo 4,5-dimethylbenzoate **1f** (54 mg, 0.186 mmol), azabicyclic olefin **2b** (50 mg, 0.186 mmol.), [Pd(allyl)Cl]₂ (6.8 mg, 0.019), cesium acetate (71 mg, 0.372 mmol) and Bu₄NCl (52 mg,

0.186 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (18% ethyl acetate in hexane) to afford the desired product as 1:1 mixture of diastereomers (from ¹H-NMR analysis) and appeared as a viscous liquid (75 mg, 82%).

Analytical Data of 3l:

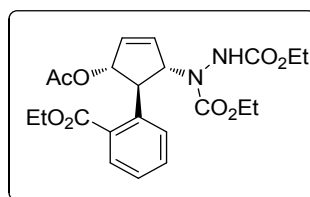
TLC (SiO₂): R_f: 0.42 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.62 (s, 1H), 7.17-7.12 (m, 1H), 6.12-5.97 (m, 2H), 5.80-5.77 (m, 1H), 5.31-5.19 (m, 1H), 4.97 (s, 1H), 4.77-4.60 (m, 1H), 4.36-4.30 (m, 1H), 3.87 (s, 3H), 2.28 (s, 3H), 2.24 (s, 3H), 1.98 (s, 3H), 1.29-1.01 (m, 11H), 0.50 (s, 1H).

¹³C NMR (125 MHz, CDCl₃): δ 170.7, 168.5, 168.4, 164.5, 164.2, 157.0, 156.5, 155.5, 155.3, 141.7, 138.8, 137.9, 137.4, 136.5, 134.9, 134.2, 133.6, 133.0, 131.8, 130.9, 130.7, 128.1, 84.1, 83.5, 82.9, 70.2, 69.6, 69.4, 52.3, 48.3, 48.0, 29.7, 22.0, 21.9, 21.8, 21.1, 20.9.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₅H₃₄N₂O₈Na 513.2207; Found: 513.2209.

Diethyl 1-((1S,4R,5R)-4-acetoxy-5-(2-(ethoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (3m)



The reaction was performed according to procedure **A** with ethyl 2-Iodobenzoate (57 mg, 0.208 mmol), azabicyclic olefin **2a** (50 mg, 0.208 mmol.), [Pd(allyl)Cl]₂ (7.6 mg, 0.021), cesium acetate (80 mg, 0.416 mmol) and Bu₄NCl (58 mg, 0.208 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (20% ethyl acetate in hexane) to afford the desired product as 1:1 mixture of diastereomers (from ¹H-NMR analysis) and appeared as a viscous liquid (56 mg, 70%).

Analytical Data of 3m:

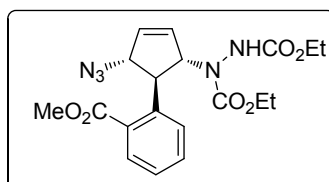
TLC (SiO₂): R_f: 0.31 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.84 (s, 1H), 7.53-7.52 (m, 1H), 7.45 (d, *J* = 8 Hz, 1H), 7.32-7.30 (m, 1H), 6.13- 5.99 (m, 2H), 5.85-5.79 (m, 1H), 5.40-5.22 (m, 1H), 4.39-4.35 (m, 3H), 4.24-4.21 (m, 2H), 4.08-4.00 (m, 1H), 3.80 (s, 1H), 1.98 (s, 3H), 1.39 (t, *J* = 7.0 Hz, 3H), 1.32-1.16 (m, 5H), 0.73 (s, 1H).

^{13}C NMR (125 MHz, CDCl_3): δ 170.7, 167.9, 157.3, 156.5, 155.8, 141.7, 134.7, 134.0, 132.4, 132.0, 130.7, 130.4, 128.2, 126.7, 84.1, 83.5, 70.6, 69.6, 62.2, 62.0, 61.4, 49.6, 48.3, 21.1, 14.5, 14.2.

HRMS (ESI-Orbitrap) m/z : $(\text{M}+\text{Na})^+$ calcd for $\text{C}_{22}\text{H}_{28}\text{N}_2\text{O}_8\text{Na}$ 471.1738; Found: 471.1750.

Diethyl 1-((1S,4R,5R)-4-azido-5-(2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (4a)



The reaction was performed according to procedure **B** with Methyl 2-Iodobenzoate **1a** (54 mg, 0.208 mmol), azabicyclic olefin **2a** (50 mg, 0.208 mmol.), $[\text{Pd}(\text{allyl})\text{Cl}]_2$ (7.6 mg, 0.021), sodium azide (27 mg, 0.416 mmol) and Bu_4NCl (58 mg, 0.208 mmol) in 1 mL of DMSO at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (20% ethyl acetate in hexane) to afford the desired product as 1:0.9 mixture of diastereomers (from ^1H -NMR analysis) and appeared as a viscous liquid (61 mg, 70%).

Analytical Data of 4a:

TLC (SiO_2): R_f : 0.29 (25% ethyl acetate in hexane).

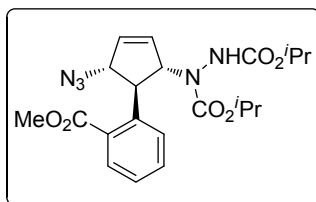
IR (neat) ν_{max} : 3363, 3307, 2982, 2931, 2096, 1749, 1715, 1490, 1409, 1384, 1298, 1265, 1229, 1135, 1063, 760 cm^{-1} .

^1H NMR (500 MHz, CDCl_3 , TMS): δ 7.87 (s, 1H), 7.53 (t, $J = 8$ Hz, 1H), 7.42 (d, $J = 8$ Hz, 1H), 7.32 (t, $J = 7.5$ Hz, 1H), 6.15-6.02 (m, 1H), 5.94-5.93 (m, 1H), 5.48-5.27 (m, 1H), 4.50-4.42 (m, 1H), 4.32-4.20 (m, 3H), 4.07-4.00 (m, 1H), 3.92 (s, 3H), 3.85-3.82 (m, 1H), 1.33-1.16 (m, 5H), 0.75 (s, 1H).

^{13}C NMR (125 MHz, CDCl_3): δ 168.49, 157.32, 156.72, 155.74, 141.58, 134.66, 134.01, 132.60, 131.23, 130.77, 130.72, 128.26, 127.03, 77.30, 77.05, 76.80, 72.57, 71.96, 71.35, 70.57, 62.33, 62.04, 52.60, 50.34, 49.02, 14.46, 13.83.

HRMS (ESI-Orbitrap) m/z : $(\text{M}+\text{Na})^+$ calcd for $\text{C}_{19}\text{H}_{23}\text{N}_5\text{O}_6\text{Na}$ 440.1540; Found: 440.1547.

Diisopropyl 1-((1S,4R,5R)-4-azido-5-(2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (4b)



The reaction was performed according to procedure **A** with methyl 2-iodobenzoate **1a** (49 mg, 0.186 mmol), azabicyclic olefin **2b** (50 mg, 0.186 mmol.), [Pd(allyl)Cl]₂ (6.8 mg, 0.019), sodium azide (24 mg, 0.372 mmol) and Bu₄NCl (52 mg, 0.186 mmol) in 1 mL of DMSO at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (15% ethyl acetate in hexane) to afford the desired product as 1:0.9 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a viscous liquid (54 mg, 65%).

Analytical Data of 4b:

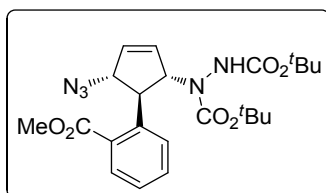
TLC (SiO₂): R_f: 0.40 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.88-7.84 (m, 1H), 7.52 (t, *J* = 7.5 Hz, 1H), 7.41-7.40 (m, 1H), 7.32-7.31 (m, 1H), 7.05-6.91 (m, 1H), 6.15-6.02 (m, 1H), 5.92 (d, *J* = 5.5 Hz, 1H), 5.45-5.28 (m, 1H), 4.97-4.96 (m, 1H), 4.74-4.63 (m, 1H), 4.48-4.30 (m, 2H), 3.92 (s, 3H), 1.20-1.01 (m, 11H), 0.52 (s, 1H).

¹³C NMR (125 MHz, CDCl₃): δ 168.43, 168.10, 156.98, 156.34, 155.19, 141.82, 141.63, 134.77, 134.10, 132.69, 132.40, 130.99, 130.62, 130.58, 128.21, 126.98, 77.29, 77.03, 76.78, 72.66, 71.15, 71.13, 70.05, 69.68, 52.64, 50.22, 49.13, 21.89, 21.77, 21.08.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₁H₂₇N₅O₆Na 468.1853; Found: 468.1861.

Di-tert-butyl 1-((1S,4R,5R)-4-azido-5-(2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (4c)



The reaction was performed according to procedure **B** with methyl 2-iodobenzoate **1a** (49 mg, 0.169 mmol), azabicyclic olefin **2c** (50 mg, 0.169 mmol.), [Pd(allyl)Cl]₂ (6.2 mg, 0.017), sodium azide (22 mg, 0.338 mmol) and Bu₄NCl (47 mg, 0.169 mmol) in 1 mL of DMSO at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (15% ethyl acetate in hexane) to afford the desired product as 1:1 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a colourless solid (50 mg, 63%).

Analytical Data of 4c:

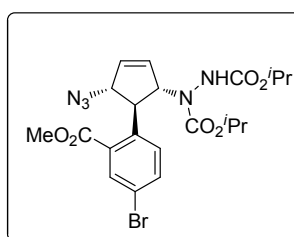
Mp; 108-110 °C.

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.91-7.83 (m, 1H), 7.54-7.51 (m, 1H), 7.42-7.33 (m, 2H), 6.84-6.74 (m, 1H), 6.15-6.03 (m, 1H), 5.91-5.90 (m, 1H), 5.38-5.24 (m, 1H), 4.48-4.24 (m, 2H), 3.91 (s, 3H), 1.54-1.25 (m, 14H), 1.02 (s, 4H).

¹³C NMR (125 MHz, CDCl₃): δ 167.9, 156.3, 154.5, 142.2, 137.8, 134.6, 132.6, 130.9, 130.5, 128.3, 126.9, 126.2, 81.1, 81.0, 72.6, 72.2, 71.6, 70.0, 52.5, 50.9, 49.3, 28.2, 28.0, 27.6.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₃H₃₁N₅O₆Na 496.2166; Found: 496.2175.

Diisopropyl 1-(1S,4R,5R)-4-azido-5-(4-bromo-2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (4d)



The reaction was performed according to procedure **B** with methyl 2-iodo 5-bromobenzoate **1b** (63 mg, 0.186 mmol), azabicyclic olefin **2b** (50 mg, 0.186 mmol.), [Pd(allyl)Cl]₂ (6.8 mg, 0.019), sodium azide (24 mg, 0.372 mmol) and Bu₄NCl (52 mg, 0.186 mmol) in 1 mL of DMSO at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (20% ethyl acetate in hexane) to afford the desired product as 1:0.8 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a colourless solid (64 mg, 65%).

Analytical Data of 4d:

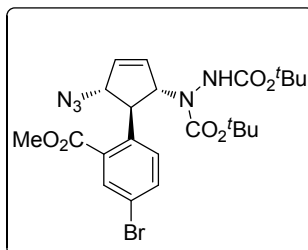
Mp: 103-105 °C

¹H NMR (500 MHz, CDCl₃, TMS): δ 8.02-8.00 (m, 1H), 7.64 (d, *J* = 8.0 Hz, 1H), 7.30-7.28 (m, 1H), 6.93-6.83 (m, 1H), 6.12-6.01 (m, 1H), 5.93-5.92 (m, 1H), 5.42-5.26 (m, 1H), 4.96 (s, 1H), 4.75-4.66 (m, 1H), 4.43-4.26 (m, 2H), 3.93 (s, 3H), 1.30-1.05 (m, 11H), 0.62 (s, 1H).

¹³C NMR (125 MHz, CDCl₃): δ 166.9, 166.6, 156.8, 156.1, 155.1, 154.8, 140.9, 135.5, 135.2, 134.7, 134.0, 133.9, 133.4, 132.1, 130.9, 129.8, 120.6, 96.1, 72.3, 70.8, 69.9, 69.4, 52.7, 50.3, 48.7, 21.9, 21.8, 21.0.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₁H₂₆BrN₅O₆Na 546.0959; Found: 546.0976.

Di-tert-butyl 1-((1S,4R,5R)-4-azido-5-(2-(methoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (4e)



The reaction was performed according to procedure **B** with methyl 2-iodo 5-bromobenzoate **1b** (58 mg, 0.169 mmol), azabicyclic olefin **2c** (50 mg, 0.169 mmol.), [Pd(allyl)Cl]₂ (6.2 mg, 0.017), sodium azide (22 mg, 0.338 mmol) and Bu₄NCl (47 mg, 0.169 mmol) in 1 mL of DMSO at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (18% ethyl acetate in hexane) to afford the desired product as 1:0.9 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a white solid (56 mg, 60%).

Analytical Data of 4e:

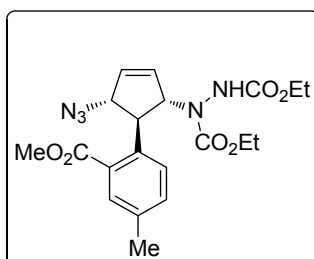
Mp: 113-115 °C

¹H NMR (500 MHz, CDCl₃, TMS): δ 8.06-8.00 (m, 1H), 7.65 (d, *J* = 16.5 Hz, 1H), 7.32-7.30 (m, 1H), 6.76-6.66 (m, 1H), 6.15-6.01 (m, 1H), 5.92 (s, 1H), 5.40-5.22 (m, 1H), 4.44- 4.26 (m, 2H), 3.92 (s, 3H), 1.48 (s, 8H), 1.35-1.25 (m, 6H), 1.07 (s, 4H).

¹³C NMR (125 MHz, CDCl₃): δ 167.0, 166.7, 156.3, 155.6, 154.8, 154.2, 141.3, 135.7, 135.4, 135.1, 134.5, 133.6, 133.4, 132.0, 130.5, 129.8, 129.0, 128.2, 125.3, 120.6, 81.6, 81.2, 72.5, 72.1, 71.4, 69.7, 52.9, 52.8, 49.0, 28.2, 28.0, 27.7.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₃H₃₀N₅O₆Na 574.1272; Found: 574.1284.

Diethyl 1-((1S,4R,5R)-4-azido-5-(2-(methoxycarbonyl)-4-methylphenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (4f)



The reaction was performed according to procedure **B** with methyl 2-iodo 5-methylbenzoate **1e** (60 mg, 0.208 mmol), azabicyclic olefin **2a** (50 mg, 0.208 mmol.), [Pd(allyl)Cl]₂ (7.6 mg, 0.021), sodium azide (27 mg, 0.416 mmol) and Bu₄NCl (58 mg, 0.208 mmol) in 1 mL of

DMSO at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (20% ethyl acetate in hexane) to afford the desired product as 1:0.8 mixture of diastereomers (from ¹H-NMR analysis) and appeared as a viscous liquid (56 mg, 68%).

Analytical Data of 4f:

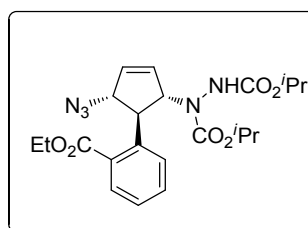
TLC (SiO₂): R_f: 0.30 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.68-7.64 (m, 1H), 7.34-7.29 (m, 2H), 6.13-5.92 (m, 2H), 5.46-5.25 (m, 1H), 4.48-4.41 (m, 1H), 4.25-4.19 (m, 3H), 4.09-3.98 (m, 1H), 3.91 (s, 3H), 3.85 (s, 1H), 2.37 (s, 3H), 1.32-1.25 (m, 5H), 0.77 (s, 1H).

¹³C NMR (125 MHz, CDCl₃): δ 168.7, 156.8, 155.8, 138.3, 136.8, 134.6, 133.9, 133.2, 131.9, 131.2, 130.5, 128.0, 72.6, 71.3, 70.4, 62.3, 62.0, 52.5, 52.3, 48.8, 29.7, 20.9, 14.4, 14.2, 13.8.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₀H₂₅N₅O₆Na 454.1702; Found: 454.1705.

Diisopropyl 1-((1S,4R,5R)-4-azido-5-(2-(ethoxycarbonyl)phenyl)cyclopent-2-en-1-yl)hydrazine-1,2-dicarboxylate (4g)



The reaction was performed according to procedure **B** with ethyl 2-Iodobenzoate (51 mg, 0.186 mmol), azabicyclic olefin **2b** (50 mg, 0.186 mmol.), [Pd(allyl)Cl]₂ (6.8 mg, 0.019), sodium azide (24 mg, 0.372 mmol) and Bu₄NCl (52 mg, 0.186 mmol), in 1 mL of DMSO at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (18% ethyl acetate in hexane) to afford the desired product as 1:0.8 mixture of diastereomers (from ¹H-NMR analysis) and appeared as a viscous liquid (51 mg, 60%).

Analytical Data of 4g:

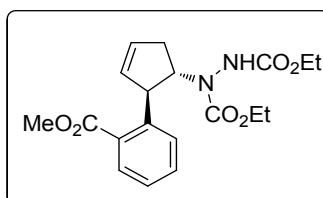
TLC (SiO₂): R_f: 0.48 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.87 (s, 1H), 7.52 (t, *J* = 7.5 Hz, 1H), 7.41-7.40 (m, 1H), 7.33-7.31 (m, 1H), 7.08-6.94 (m, 1H), 6.16-6.02 (m, 1H), 5.93-5.92 (m, 1H), 5.46-5.32 (m, 1H), 5.02-4.97 (m, 1H), 4.74-4.63 (m, 1H), 4.51-4.37 (m, 4H), 1.39 (t, *J* = 7 Hz, 3H), 1.30-1.01 (m, 11H), 0.53 (s, 1H).

^{13}C NMR (125 MHz, CDCl_3): δ 167.7, 156.6, 156.3, 155.1, 141.7, 141.5, 134.9, 134.2, 132.5, 132.2, 131.0, 130.4, 128.1, 126.9, 72.7, 72.1, 71.1, 70.4, 70.0, 69.7, 61.4, 50.8, 49.0, 22.0, 21.9, 21.0, 14.2.

HRMS (ESI-Orbitrap) m/z : $(\text{M}+\text{Na})^+$ calcd for $\text{C}_{22}\text{H}_{29}\text{N}_5\text{O}_6\text{Na}$ 482.2010; Found: 482.2013.

Diethyl 1-((1R,2S)-2-(2-(methoxycarbonyl)phenyl)cyclopent-3-en-1-yl)hydrazine-1,2-dicarboxylate (5)



The reaction was performed according to procedure C with methyl 2-iodobenzoate **1a** (54 mg, 0.208 mmol), azabicyclic olefin **2a** (50 mg, 0.208 mmol.), $[\text{Pd}(\text{allyl})\text{Cl}]_2$ (7.6 mg, 0.021), sodium methoxide (23 mg, 0.416 mmol) and Bu_4NCl (58 mg, 0.208 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 5 hours. The crude product was purified by activated neutral alumina column chromatography (15% ethyl acetate in hexane) to afford the desired product as a viscous liquid (35 mg, 45%).

Analytical Data of 5:

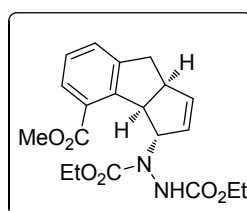
TLC (SiO_2): R_f : 0.30 (25% ethyl acetate in hexane).

^1H NMR (500 MHz, CDCl_3 , TMS): δ 7.82 (d, $J = 8.0$ Hz, 1H), 7.50 (t, $J = 7$ Hz, 1H), 7.40 (d, $J = 7.5$ Hz, 1H), 7.32 (s, 1H), 7.28-7.25(m, 1H), 5.90 (s, 1H), 5.66-5.58 (m, 1H), 4.98-4.74 (m, 2H), 4.25-4.21 (m, 2H), 4.04-3.99 (m, 1H), 3.89 (s, 3H), 3.77 (s, 1H), 2.68-2.61 (m, 2H), 1.34-1.14 (m, 5H), 0.72 (s, 1H).

^{13}C NMR (125 MHz, CDCl_3): δ 168.5, 157.0, 156.2, 145.7, 132.5, 130.6, 130.1, 128.7, 126.3, 69.2, 62.0, 61.8, 52.4, 47.4, 34.8, 14.5.

HRMS (ESI-Orbitrap) m/z : $(\text{M}+\text{Na})^+$ calcd for $\text{C}_{19}\text{H}_{24}\text{N}_2\text{O}_6\text{Na}$ 399.1527; Found: 399.1542.

Diethyl 1-((3S,3aR,8aS)-4-(methoxycarbonyl)-3,3a,8,8a-tetrahydrocyclopenta[a]inden-3-yl)hydrazine-1,2-dicarboxylate (8a)



The reaction was performed according to procedure **A** with methyl 2-iodo 3-methylbenzoate **1g** (57 mg, 0.208 mmol), azabicyclic olefin **2a** (50 mg, 0.208 mmol.), [Pd(allyl)Cl]₂ (7.6 mg, 0.021), cesium acetate (80 mg, 0.416 mmol) and Bu₄NCl (58 mg, 0.208 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 12 hours. The crude product was purified by activated neutral alumina column chromatography (20% ethyl acetate in hexane) to afford the desired product as 1:0.8 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a viscous liquid (61 mg, 76%).

Analytical Data of 8a:

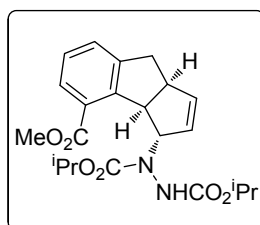
TLC (SiO₂): R_f: 0.29 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.84 (s, 1H), 7.33-7.32 (m, 1H), 7.24-7.23 (m, 1H), 6.70-6.47 (m, 1H), 5.98-5.93 (m, 1H), 5.58 -5.51 (m, 1H), 5.26-5.08 (m, 1H), 4.49-4.48 (m, 1H), 4.21-4.18 (m, 4H), 3.89 (s, 3H), 3.70 (s, 1H), 3.18-3.09 (m, 1H), 2.82-2.79 (m, 1H), 1.30 -1.26 (m, 6H).

¹³C NMR (125 MHz, CDCl₃): δ 167.7, 156.7, 155.5, 146.1, 143.9, 138.8, 137.7, 129.6, 129.1, 127.4, 126.7, 72.8, 70.7, 62.3, 61.9, 53.1, 52.0, 47.8, 36.8, 14.5.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₀H₂₄N₂O₆Na 411.1527; Found: 411.1505.

Diisopropyl 1-((3S,3aR,8aS)-4-(methoxycarbonyl)-3,3a,8,8a-tetrahydrocyclopenta[a]inden-3-yl)hydrazine-1,2-dicarboxylate (8b)



The reaction was performed according to procedure **A** with methyl 2-Iodo 3-methylbenzoate **1g** (51 mg, 0.186 mmol), azabicyclic olefin **2b** (50 mg, 0.186 mmol.), [Pd(allyl)Cl]₂ (6.8 mg, 0.019), cesium acetate (71 mg, 0.372 mmol) and Bu₄NCl (52 mg, 0.186 mmol) in 1 mL of toluene at 80 °C under argon atmosphere for 12 hours. The crude product was purified by activated neutral alumina column chromatography (18% ethyl acetate in hexane) to afford the desired product as an amorphous solid (58 mg, 75%).

Analytical Data of 8b:

TLC (SiO₂): R_f: 0.43(25% ethyl acetate in hexane).

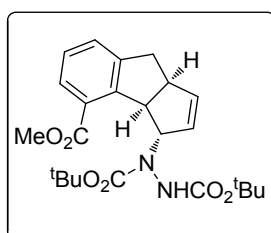
¹H NMR (500 MHz, CDCl₃, TMS): δ 7.84-7.80 (m, 1H), 7.32-7.31 (m, 1H), 7.24 (brs, 1H), 6.65-6.58 (m, 1H), 5.92-5.89 (m, 1H), 5.57 (brs, 1H), 5.25-4.93 (m, 3H), 4.47 (s, 1H), 3.91 (s,

3H), 3.69 (s, 1H), 3.14 (dd, $J_1 = 16.5$, $J_2 = 10$ Hz, 1H), 2.81 (d, $J = 16.0$ Hz, 1H), 1.28-1.23(m, 12H).

^{13}C NMR (125 MHz, CDCl_3): δ 167.6, 156.4, 155.5, 155.0, 146.1, 143.8, 137.4, 129.5, 129.1, 127.4, 72.8, 70.5, 69.5, 53.2, 52.0, 47.7, 37.2, 36.8, 22.2, 22.0.

HRMS (ESI-Orbitrap) m/z : ($\text{M}+\text{Na}$) $^+$ calcd for $\text{C}_{22}\text{H}_{28}\text{N}_2\text{O}_6\text{Na}$ 439.1840; Found: 439.1817.

Di-tert-butyl-1-((3S,3aR,8aS)-4-(methoxycarbonyl)-3,3a,8,8a-tetrahydrocyclopenta[a]inden-3-yl)hydrazine-1,2-dicarboxylate (8c)



The reaction was performed according to procedure **A** with methyl 2-Iodo 3-methylbenzoate **1g** (47 mg, 0.169 mmol), azabicyclic olefin **2c** (50 mg, 0.169 mmol.), $[\text{Pd}(\text{allyl})\text{Cl}]_2$ (6.2 mg, 0.017), cesium acetate (65 mg, 0.338 mmol) and Bu_4NCl (47 mg, 0.169 mmol) in 1mL of toluene at 80 °C under argon atmosphere for 12 hours. The crude product was purified by activated neutral alumina column chromatography (15% ethyl acetate in hexane) to afford the desired product as 1:0.9 mixture of diastereomers (from ^1H - NMR analysis) and appeared as a colorless solid (55 mg, 73%).

Analytical Data of 8c:

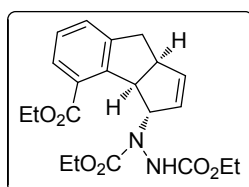
Mp; 118-121 °C

^1H NMR (500 MHz, CDCl_3 , TMS): δ 7.84-7.79 (m, 1H), 7.31-7.30 (m, 1H), 7.25-7.15 (m, 1H), 6.55-6.41 (m, 1H), 5.88 (s, 1H), 5.56-5.52 (m, 1H), 5.17-5.00 (m, 1H), 4.38 (s, 1H), 3.94 (s, 3H), 3.68 (s, 1H), 3.17-3.11 (m, 1H), 2.83-2.79 (m, 1H), 1.48 (s, 18H).

^{13}C NMR (125 MHz, CDCl_3): δ 167.6, 156.0, 155.7, 154.2, 146.3, 143.9, 137.4, 129.4, 129.1, 128.9, 127.3, 81.1, 80.6, 72.8, 70.0, 53.3, 52.2, 52.0, 47.7, 37.1, 36.6, 28.3, 28.2.

HRMS (ESI-Orbitrap) m/z : ($\text{M}+\text{Na}$) $^+$ calcd for $\text{C}_{24}\text{H}_{32}\text{N}_2\text{O}_6\text{Na}$ 467.2153; Found: 467.2129.

Diethyl 1-((3S,3aR,8aS)-4-(ethoxycarbonyl)-3,3a,8,8a-tetrahydrocyclopenta[a]inden-3-yl)hydrazine-1,2-dicarboxylate (8d)



The reaction was performed according to procedure **A** with ethyl 2-iodo 3-methylbenzoate **1h** (60 mg, 0.208 mmol) azabicyclic olefin **2a** (50 mg, 0.208 mmol.), [Pd(allyl)Cl]₂ (7.6 mg, 0.021), cesium acetate (80 mg, 0.416 mmol) and Bu₄NCl (58 mg, 0.208 mmol), in 1mL of toluene at 80 °C under argon atmosphere for 12 hours. The crude product was purified by activated neutral alumina column chromatography (20% ethyl acetate in hexane) to afford the desired product as 1:0.8 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a viscous liquid (62 mg, 74%).

Analytical Data of 8d:

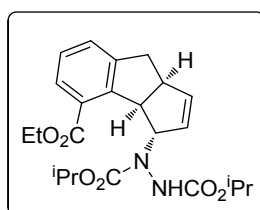
TLC (SiO₂): Rf; 0.28 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.83 (s, 1H), 7.32 (d, *J* = 7.5 Hz, 1H), 7.25-7.22 (m, 1H), 6.83-6.72 (m, 1H), 5.93 (d, *J* = 5 Hz, 1H), 5.65-5.58 (m, 1H), 5.25-5.07 (m, 1H), 4.52-4.16 (m, 7H), 3.71 (s, 1H), 3.18-3.12 (m, 1H), 2.80 (d, *J* = 16.5 Hz, 1H), 1.37 (t, *J* = 7 Hz, 3H), 1.30-1.24 (m, 6H).

¹³C NMR (125 MHz, CDCl₃): δ 167.1, 157.1, 156.7, 155.6, 146.3, 144.1, 138.6, 137.6, 129.4, 128.9, 127.3, 72.6, 70.7, 62.2, 61.8, 60.9, 53.1, 52.4, 48.0, 36.9, 36.6, 14.5, 14.3.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₁H₂₆N₂O₆Na 425.1683; Found: 425.1684.

Diisopropyl 1-((3*S*,3*aR*,8*aS*)-4-(ethoxycarbonyl)-3,3*a*,8,8*a*-tetrahydrocyclopenta[*a*]inden-3-yl)hydrazine-1,2-dicarboxylate (8e)



The reaction was performed according to procedure **A** with ethyl 2-Iodo 3-methylbenzoate **1h** (54 mg, 0.186 mmol) azabicyclic olefin **2b** (50 mg, 0.186 mmol.), [Pd(allyl)Cl]₂ (6.8 mg, 0.019), cesium acetate (71 mg, 0.372 mmol) and Bu₄NCl (52 mg, 0.186 mmol) in 1mL of toluene at 80 °C under argon atmosphere for 12 hours. The crude product was purified by activated neutral alumina column chromatography (15% ethyl acetate in hexane) to afford the desired product as 1:0.7 mixture of diastereomers (from ¹H- NMR analysis) and appeared as a viscous liquid (56 mg, 70%).

Analytical Data of 8e:

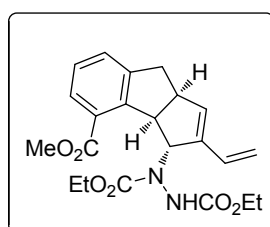
TLC (SiO₂): R_f: 0.49 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.82 (s, 1H), 7.32 (d, *J* = 7.0 Hz, 1H), 7.24-7.22 (m, 1H), 6.68-6.64 (m, 1H), 5.91 (s, 1H), 5.64-5.58 (m, 1H), 5.24-4.91 (m, 3H), 4.50- 4.30 (m, 3H), 3.70 (s, 1H), 3.17-3.12 (m, 1H), 2.80 (d, *J* = 15 Hz, 1H), 1.39-1.36 (m, 3H), 1.27-1.26 (m, 12H).

¹³C NMR (125 MHz, CDCl₃): δ 167.0, 156.4, 155.1, 146.4, 144.1, 137.9, 137.3, 129.9, 129.4, 128.8, 127.3, 69.6, 69.3, 60.8, 53.3, 52.1, 48.1, 37.1, 36.9, 22.2, 22.0, 14.3.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₃H₃₀N₂O₆Na 453.1996; Found: 453.1991.

Diethyl 1-((3*S*,3*aS*,8*aR*)-4-(methoxycarbonyl)-2-vinyl-3,3*a*,8,8*a*-tetrahydrocyclopenta[*a*]inden-3-yl)hydrazine-1,2-dicarboxylate (8f)



The reaction was performed according to procedure **A** with methyl 2-iodo-3-methylbenzoate **1g** (52 mg, 0.188 mmol), spiro tricyclic olefin **2e** (50 mg, 0.188 mmol.), [Pd(allyl)Cl]₂ (7.6 mg, 0.021), cesium acetate (80 mg, 0.416 mmol) and Bu₄NCl (58 mg, 0.208 mmol) in 1mL of toluene at 80 °C under argon atmosphere for 12 hours. The crude product was purified by activated neutral alumina column chromatography (20% ethyl acetate in hexane) to afford the desired product as a viscous liquid (53 mg, 68%).

Analytical Data of 8f:

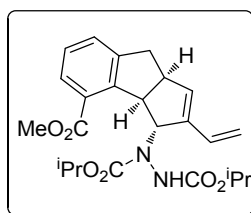
TLC (SiO₂): R_f: 0.30 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.87-7.86 (m, 1H), 7.32 (s, 1H), 7.24-7.15 (m, 2H), 6.33-6.28 (m, 1H), 5.91-5.84 (m, 1H), 5.39-5.16 (m, 2H), 5.03-5.01 (m, 1H), 4.61-4.20 (m, 5H), 3.94 (s, 3H), 3.73-3.69 (m, 1H), 3.18- 3.13 (m, 1H), 2.87-2.82 (m, 1H), 1.31-1.25 (m, 6H).

¹³C NMR (125 MHz, CDCl₃): δ 167.8, 156.9, 155.1, 145.3, 143.1, 140.0, 137.8, 130.9, 129.4, 127.45, 116.8, 71.2, 69.6, 62.9, 62.3, 61.9, 54.5, 52.2, 51.9, 46.4, 36.9, 29.7, 14.5.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₂H₂₆N₂O₆Na 437.1683; Found: 437.1675.

Diisopropyl 1-((3*S*,3*aS*,8*aR*)-4-(methoxycarbonyl)-2-vinyl-3,3*a*,8,8*a*-tetrahydrocyclopenta[*a*]inden-3-yl)hydrazine-1,2-dicarboxylate (8g)



The reaction was performed according to procedure **A** with spiro tricyclic olefin **2f** (50 mg, 0.170 mmol.), methyl 2-iodo-3-methylbenzoate **2a** (47 mg, 0.170 mmol) [Pd(allyl)Cl]₂ (6.2 mg, 0.017), cesium acetate (65 mg, 0.340 mmol), Bu₄NCl (47 mg, 0.170 mmol), in 1mL of toluene at 80 °C under argon atmosphere for 12 hours. The crude product was purified by activated neutral alumina column chromatography (20% ethyl acetate in hexane) to afford the desired product as a viscous liquid (45 mg, 60%).

Analytical Data of 8g:

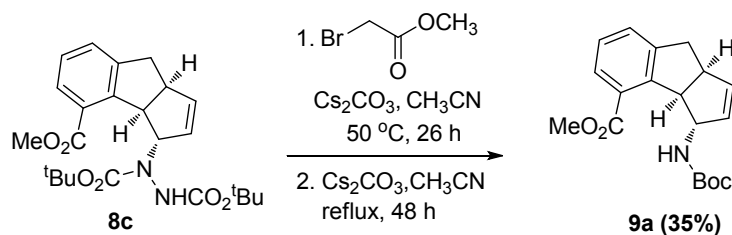
TLC (SiO₂): R_f: 0.34 (25% ethyl acetate in hexane).

¹H NMR (500 MHz, CDCl₃, TMS): δ 7.87-7.79 (m, 1H), 7.31-7.30 (m, 1H), 7.23- 7.22 (m, 2H), 6.42- 6.27 (m, 1H), 5.89-5.82 (m, 1H), 5.39-5.20 (m, 2H), 5.01-4.96 (m, 3H), 4.66-4.55 (m, 1H), 3.95 (s, 3H), 3.67 (s, 1H), 3.18-3.12 (m, 1H), 2.85-2.82 (m, 1H), 1.28-1.19 (m, 12H).

¹³C NMR (125 MHz, CDCl₃): δ 167.7, 156.3, 154.6, 145.4, 143.0, 130.8, 130.7, 129.5, 129.2, 127.3, 116.6, 71.2, 69.8, 69.4, 54.2, 52.4, 52.1, 46.4, 36.9, 36.8, 22.2, 22.0.

HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₂₄H₃₀N₂O₆Na 465.1996; Found: 465.1991.

9. Synthesis and characterization of *N*-Boc protected indane fused cyclopentenyl amine derivative



Scheme 2

These transformations were done following reported procedures (S. Demerzhan, S. R. Gilbertson, *Tetrahedron Lett.* 2015, **56**, 3633). To a suspension of compound **8c** (1 g, 0.002 mol) and Cs₂CO₃ (1.832 g, 0.005 mol) in CH₃CN (0.2 M) at 23 °C was added methyl bromoacetate (0.683 g, 0.004 mol). The mixture was heated to 50 °C until the starting material was consumed, as indicated by TLC. The reaction was quenched with saturated NH₄Cl (aq.), extracted with EtOAc, and the extracts were combined and washed with brine,

dried over MgSO₄ and concentrated *in vacuo*. The residue was used without further purification. To the solution of carbamate in CH₃CN (0.2 M), Cs₂CO₃ was added (2.195 g, 0.006 mol) and the mixture was heated at 82 °C until all starting material was consumed, as indicated by TLC. The reaction was quenched with saturated NH₄Cl (aq.), extracted with EtOAc, washed with brine and the combined extracts dried over MgSO₄. The solvent was evaporated *in vacuo* and the residue purified by silica gel column chromatography to afford the desired –Boc protected amine **9a** as a white solid (0.259 g, 35% yield).

Analytical Data of 9a:

Mp: 158 °C

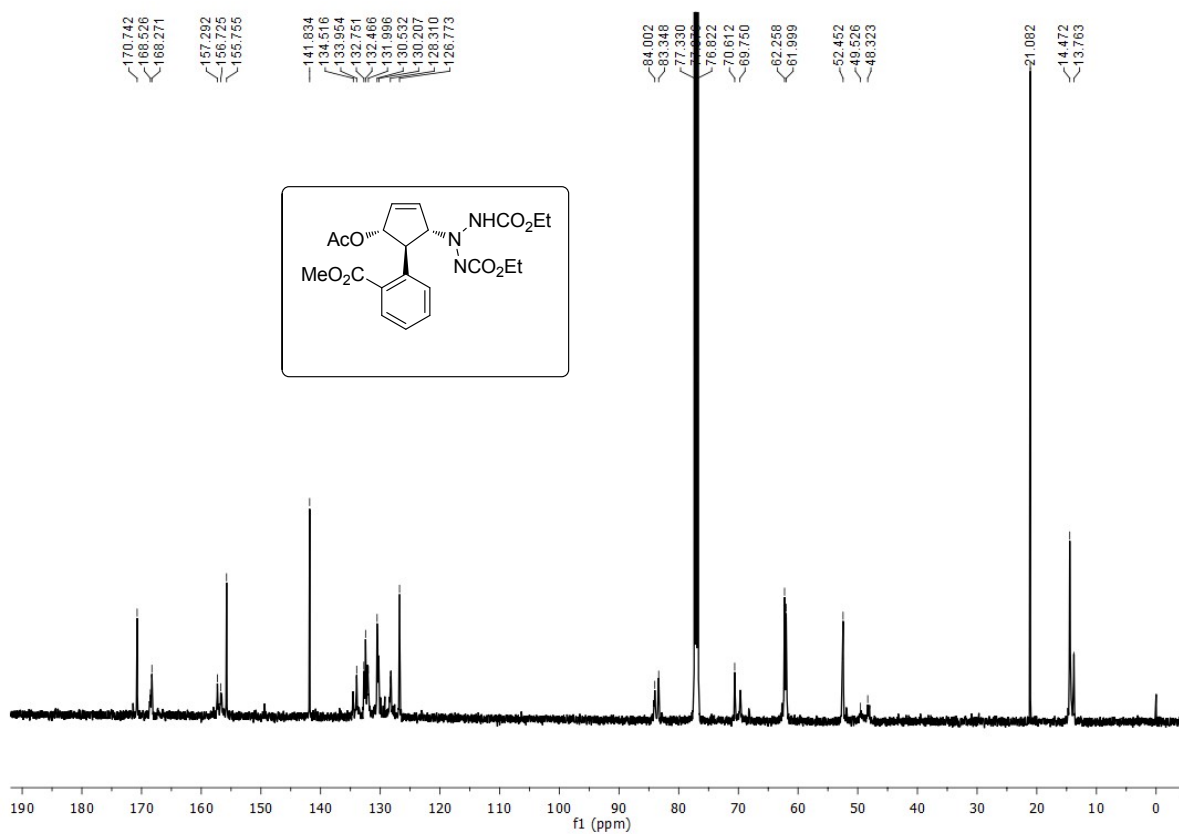
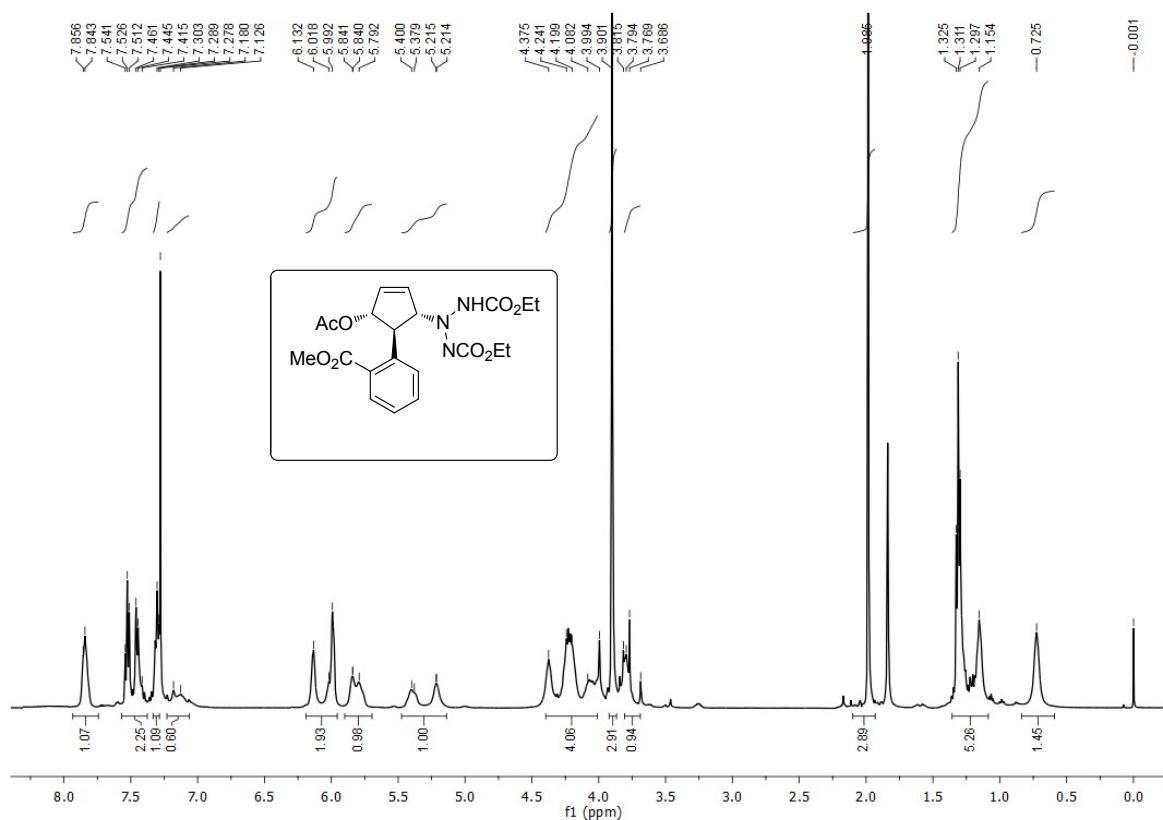
¹H NMR (500 MHz, Acetone, TMS): δ 7.77 (d, *J* = 8 Hz, 1H), 7.42 (d, *J* = 7.5 Hz, 1H), 7.31 (t, *J* = 7.5 Hz, 1H), 6.31 (brs, 1H), 5.80-5.77 (m, 1H), 5.60 (brs, 1H), 4.46-4.44 (m, 1H), 4.23 (d, *J* = 7.5 Hz, 1H), 3.89 (s, 3H), 3.80 – 3.76 (m, 1H), 3.20 (dd, *J* = 16.5, 10 Hz, 1H), 2.89-2.83 (m, 1H), 1.45 (s, 9H).

¹³C NMR (125 MHz, Acetone): δ 167.3, 154.8, 143.5, 136.7, 130.6, 129.3, 128.6, 128.2, 127.3, 77.6, 64.7, 56.2, 51.5, 46.8, 36.3, 27.8.

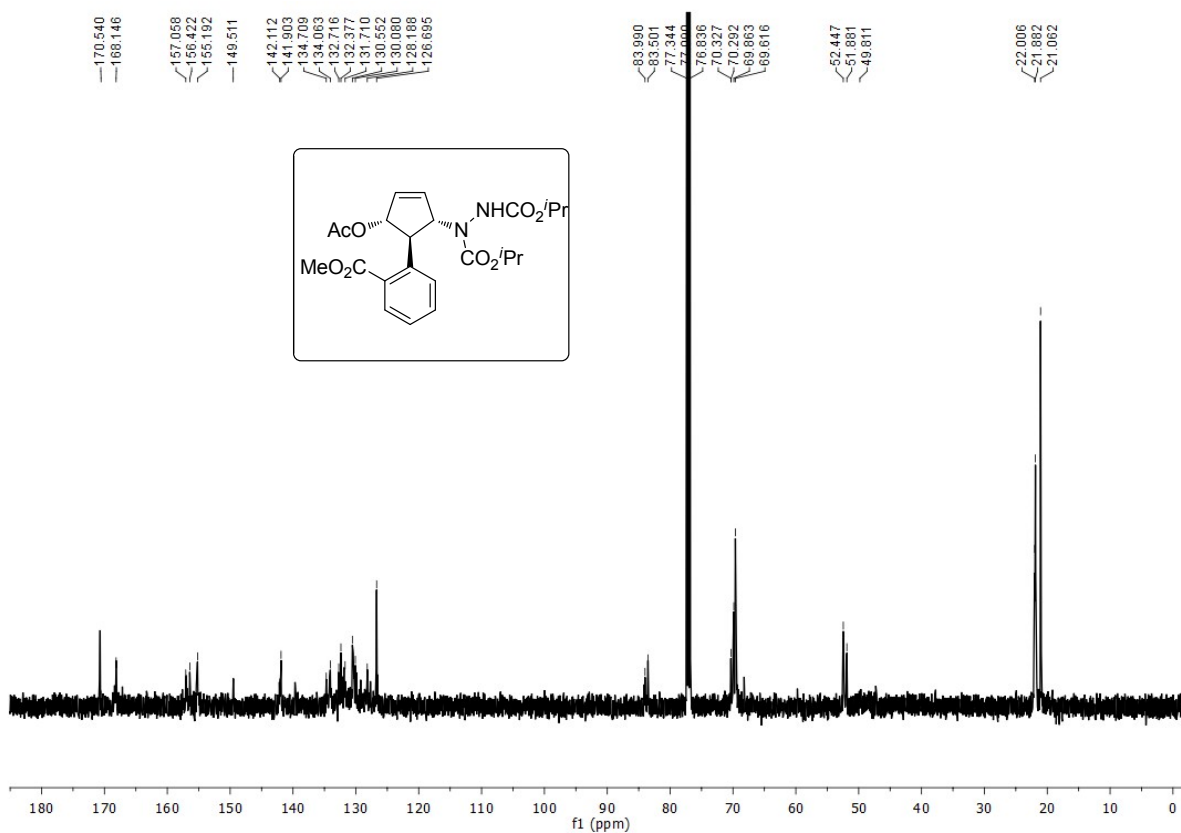
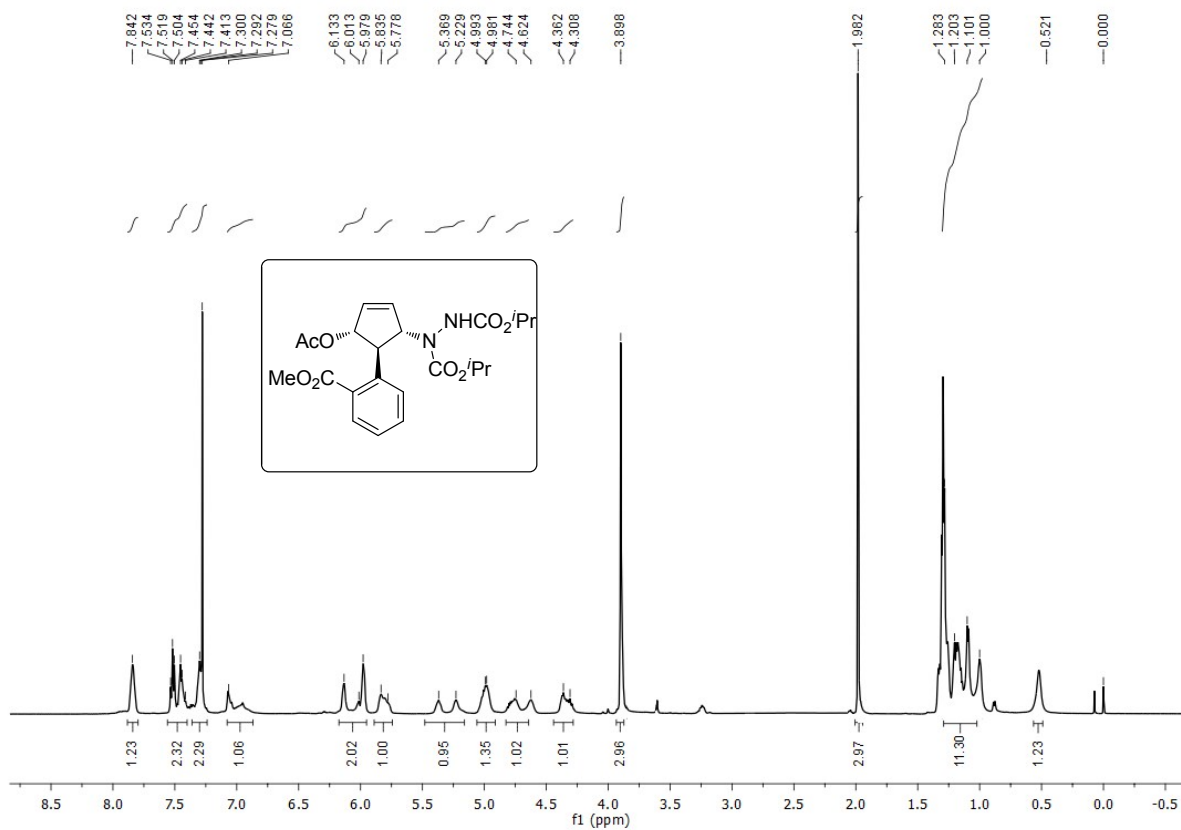
HRMS (ESI-Orbitrap) *m/z*: (M+Na)⁺ calcd for C₁₉H₂₃NO₄Na 352.1519; Found: 352.1466.

10. ¹H and ¹³C NMR spectra

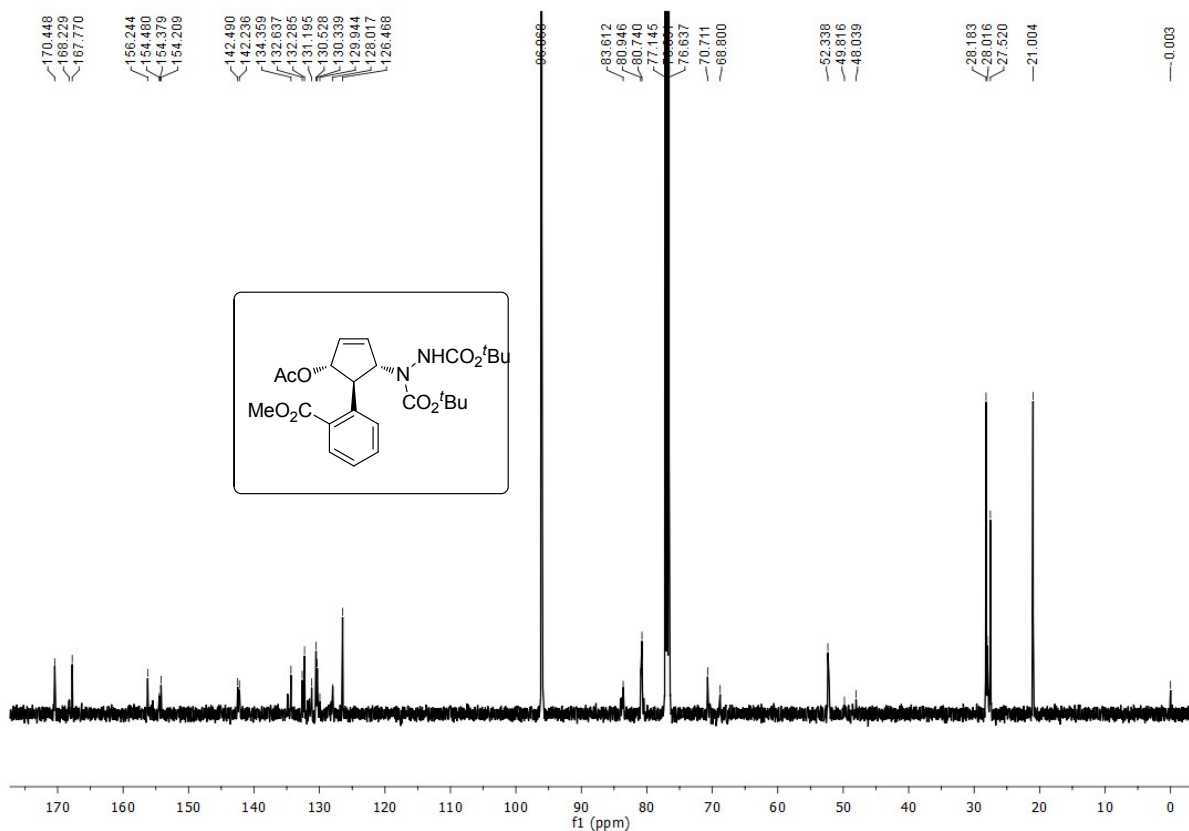
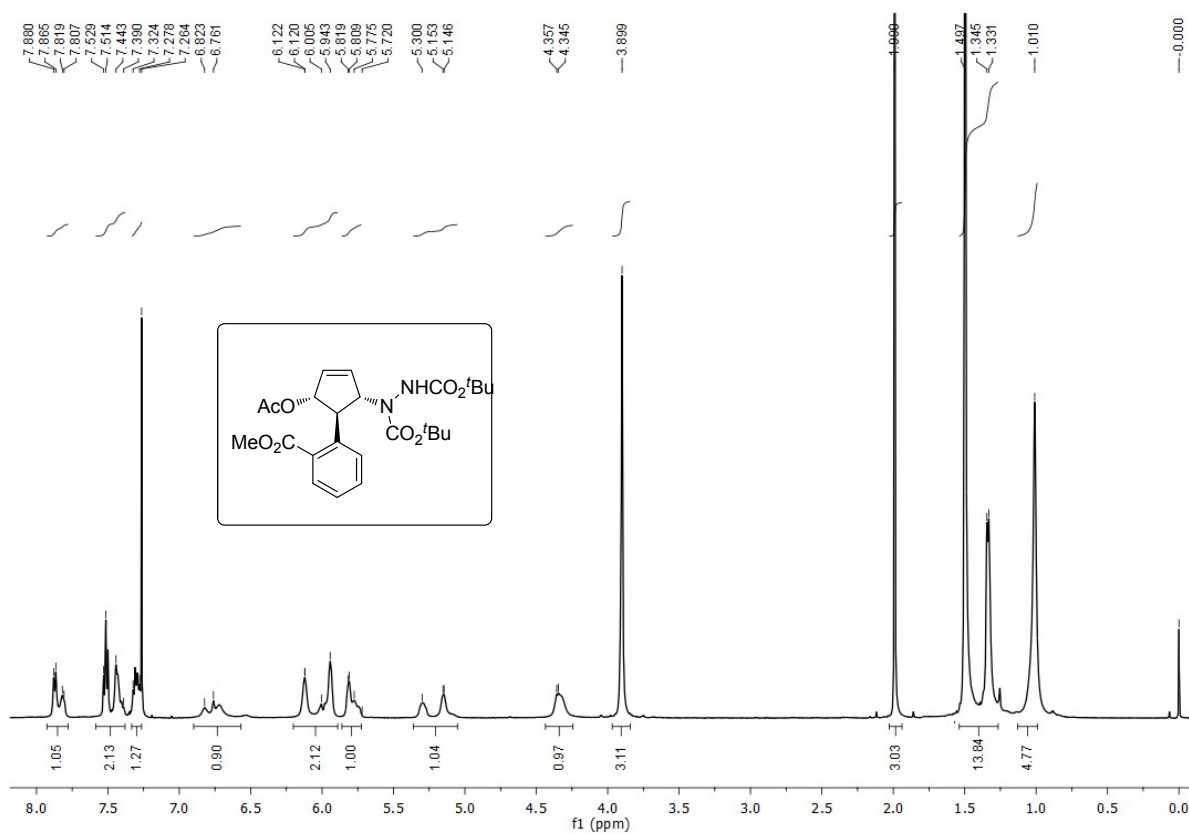
¹H and ¹³C NMR of 3a



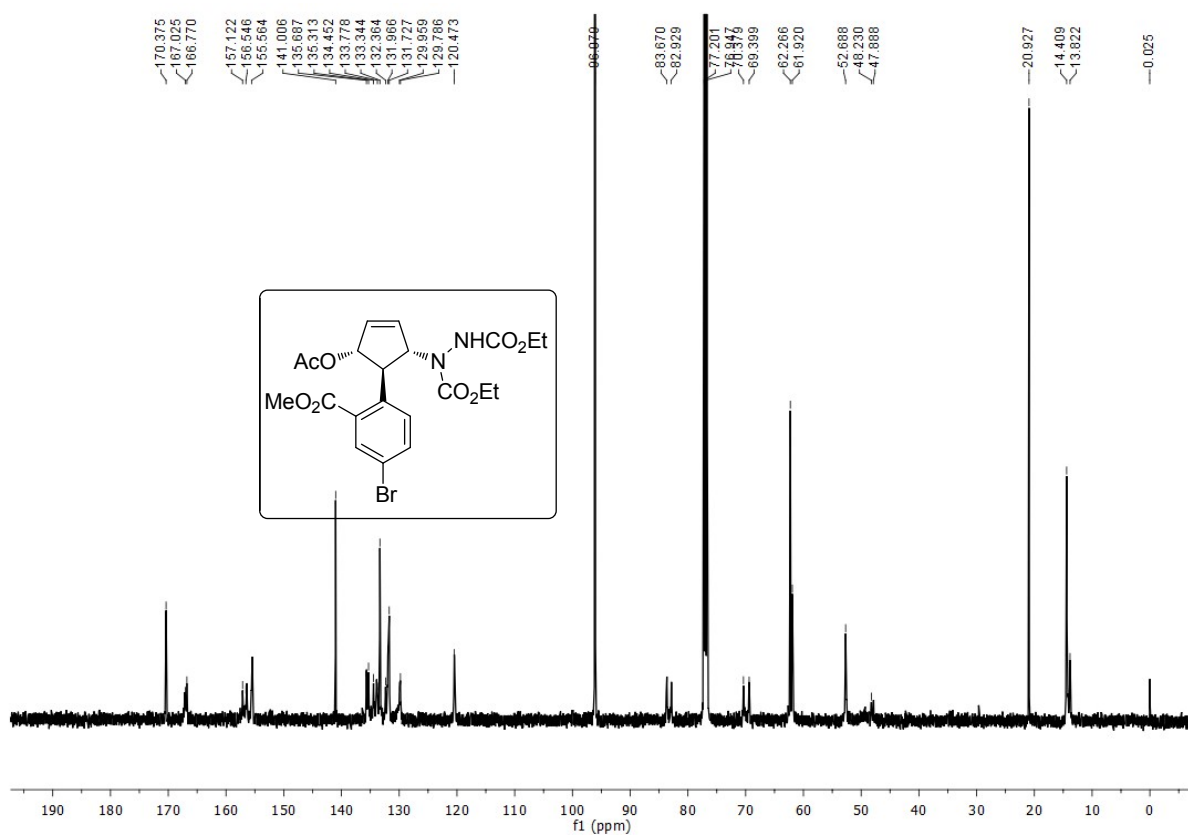
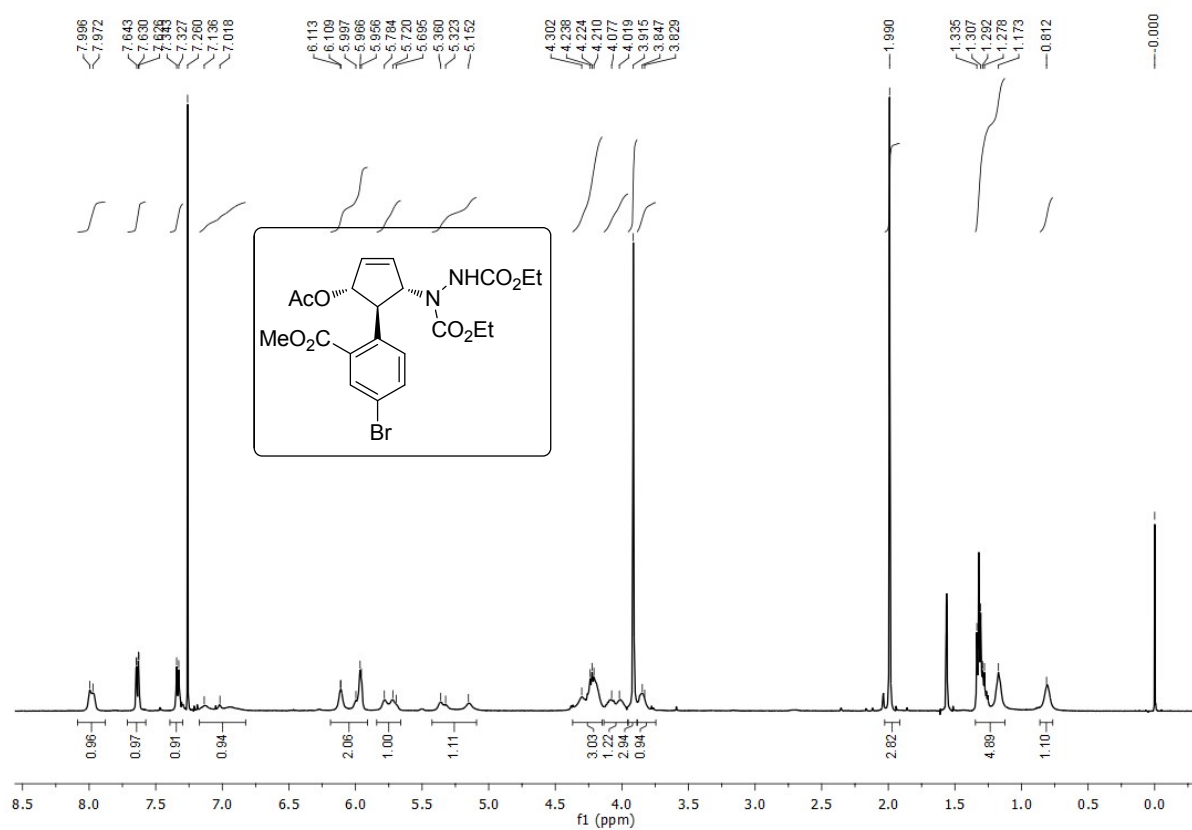
^1H and ^{13}C NMR of **3b**



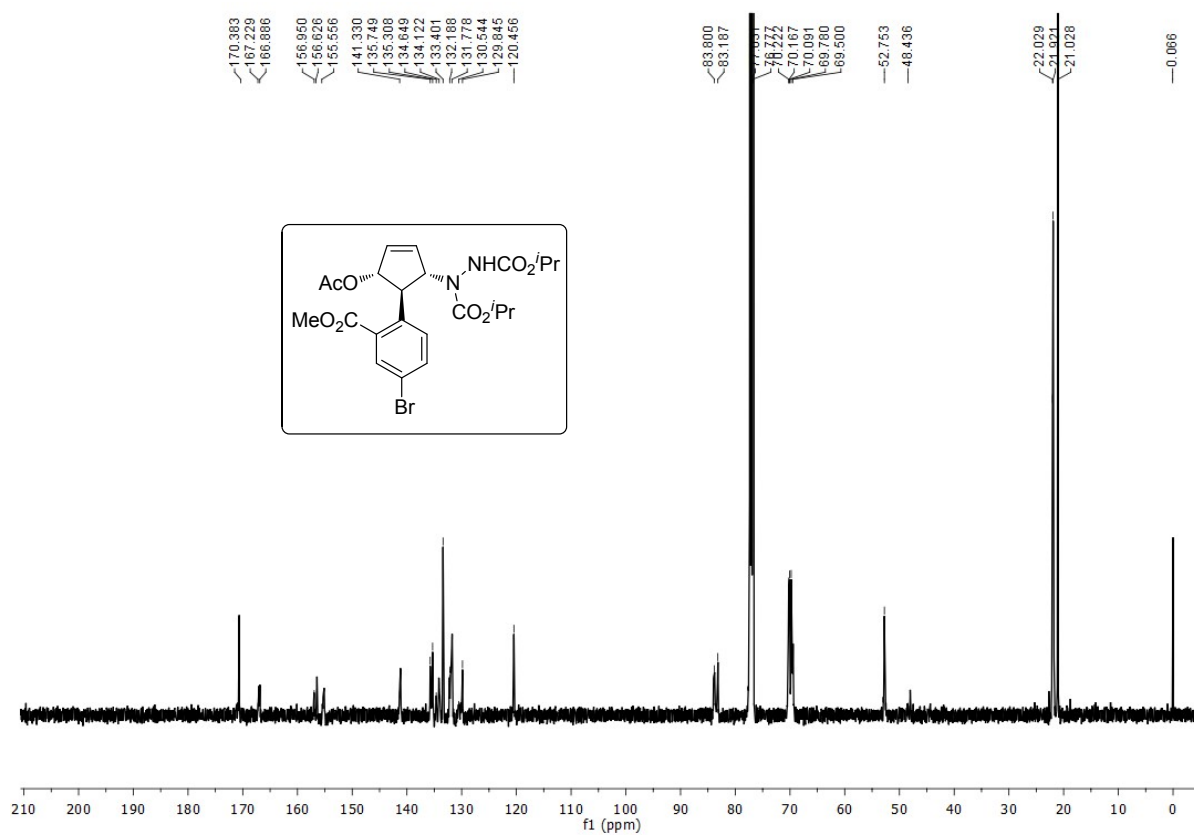
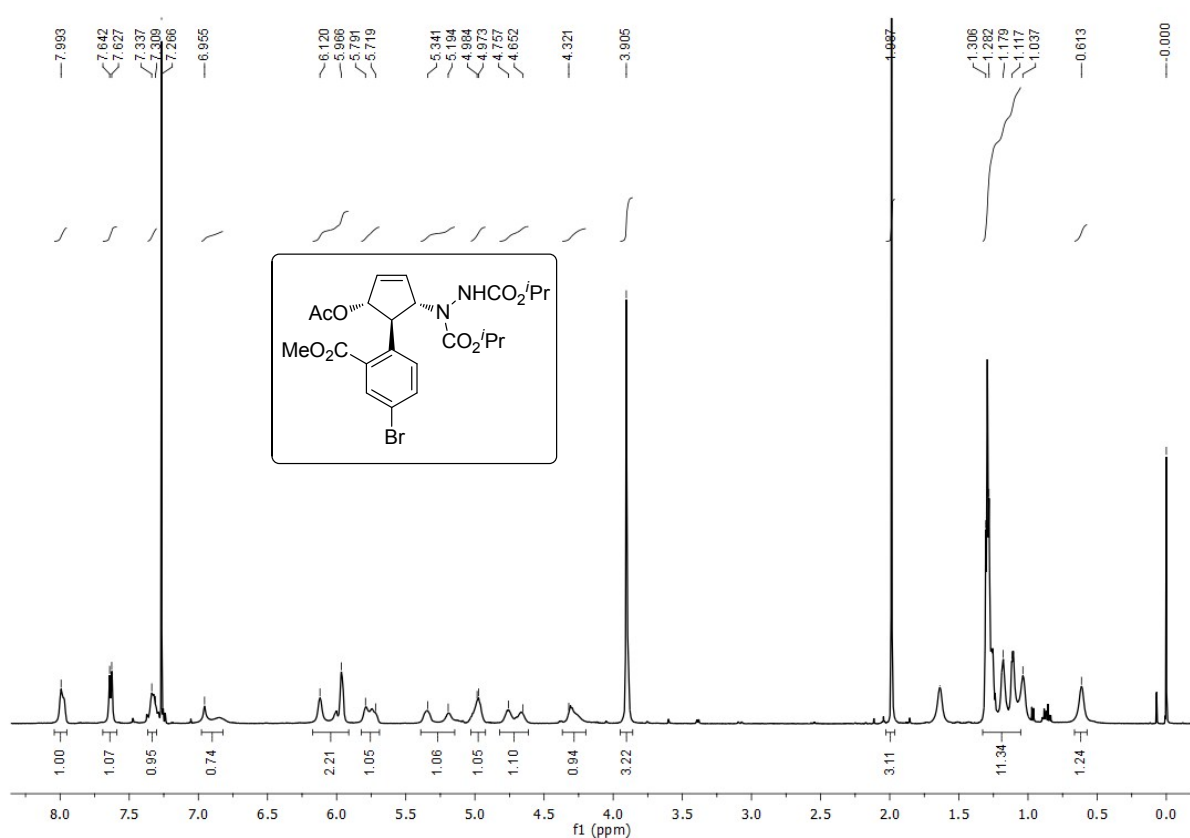
^1H and ^{13}C NMR of **3c**



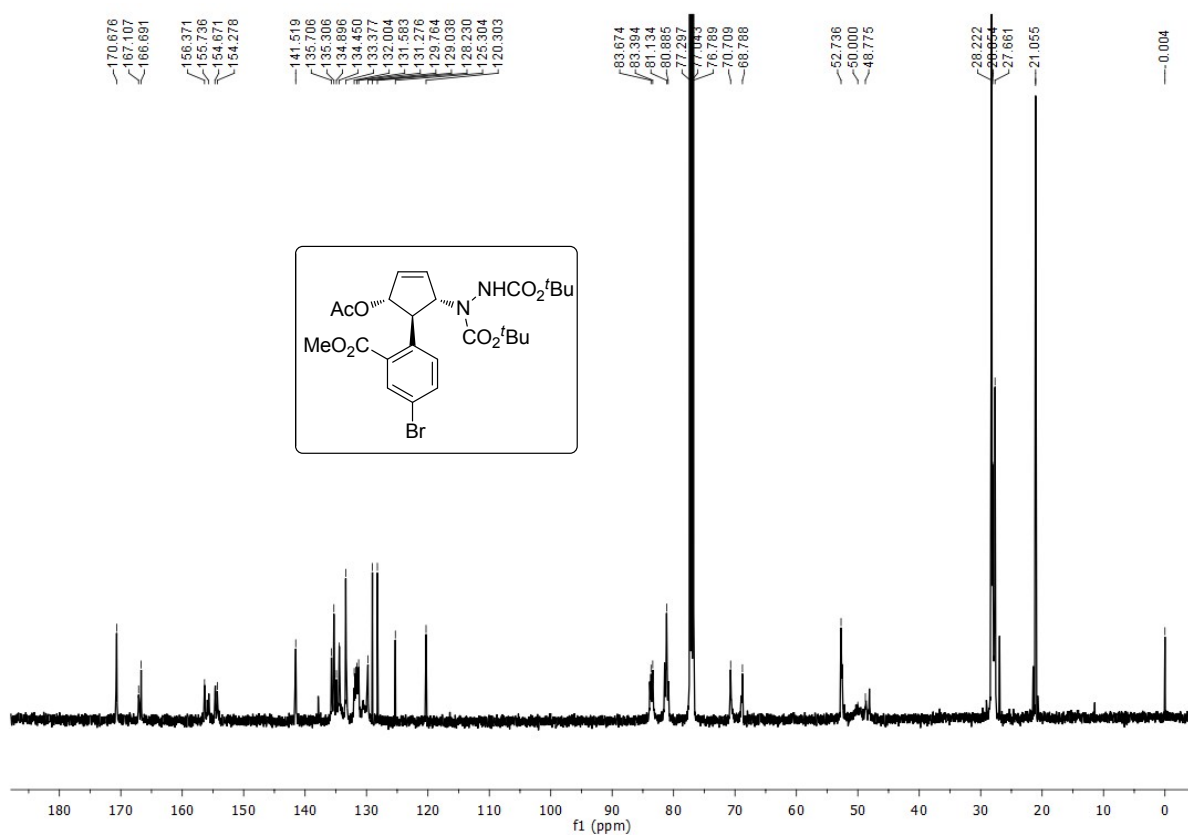
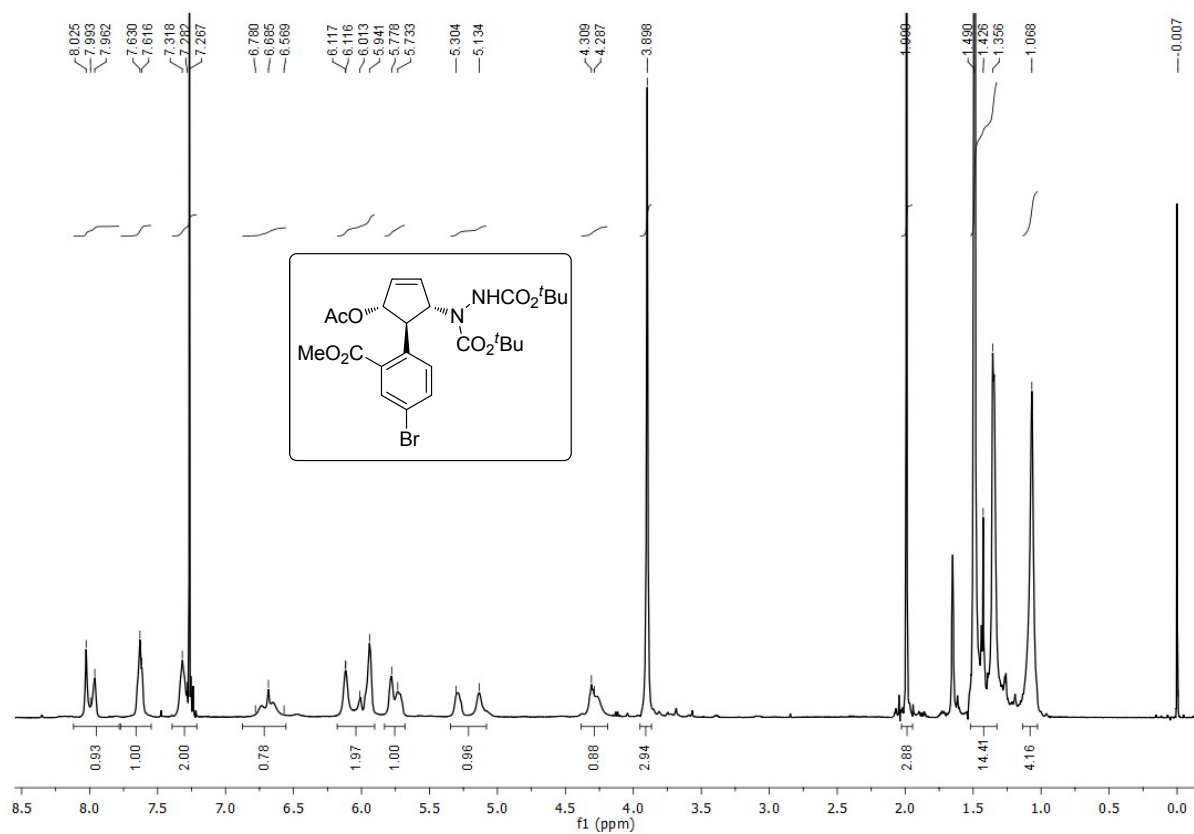
^1H and ^{13}C NMR of **3d**



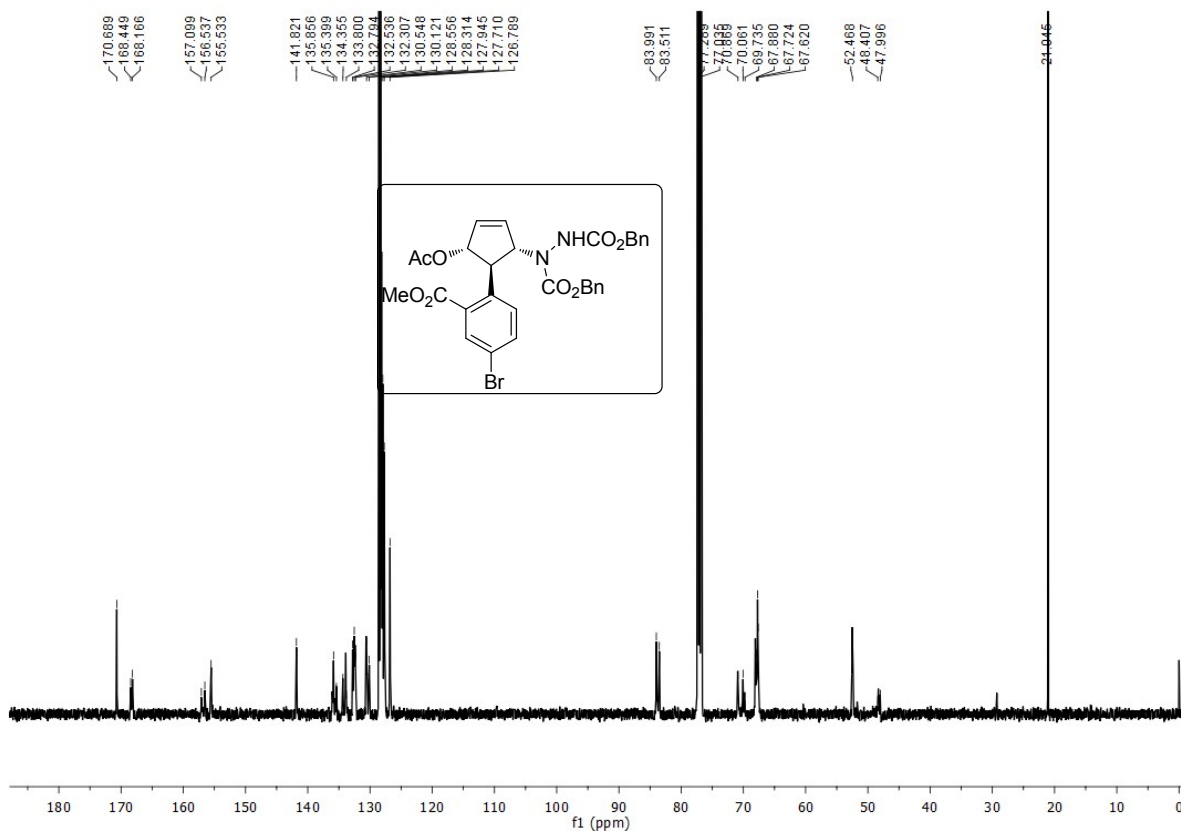
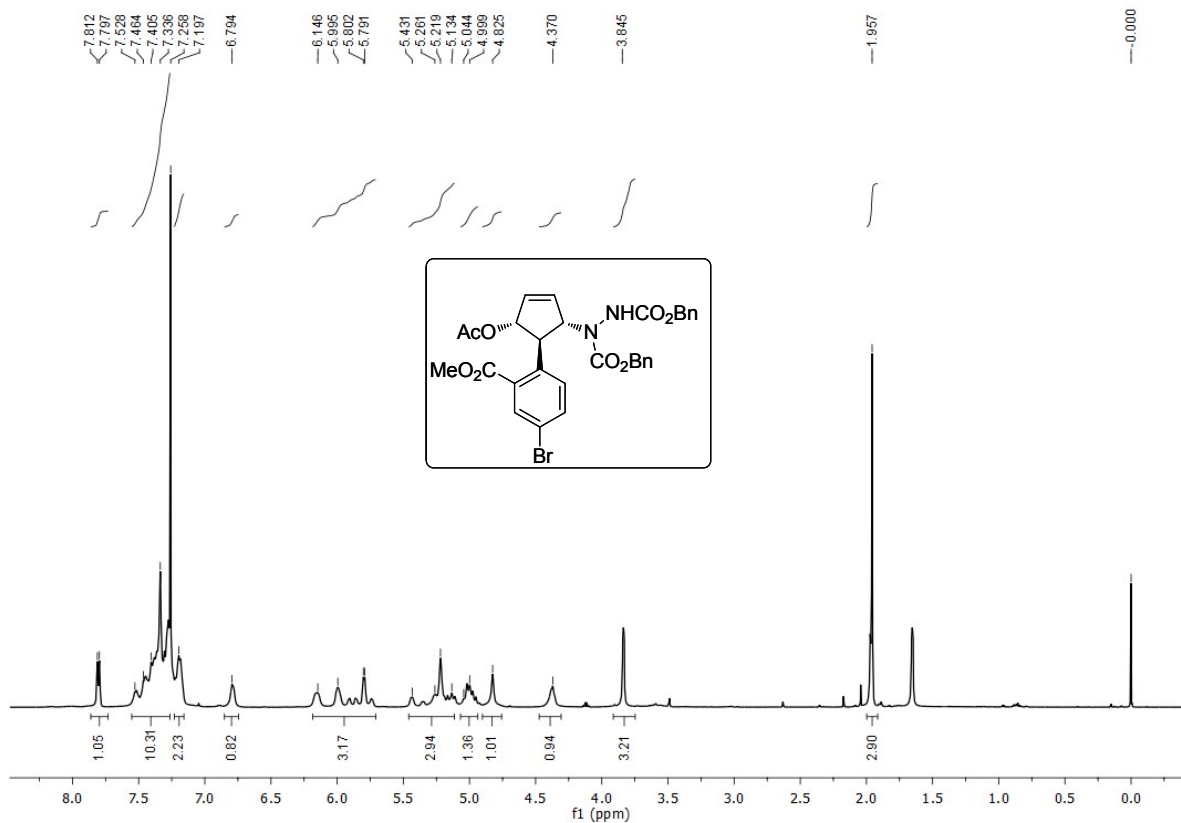
^1H and ^{13}C NMR of **3e**



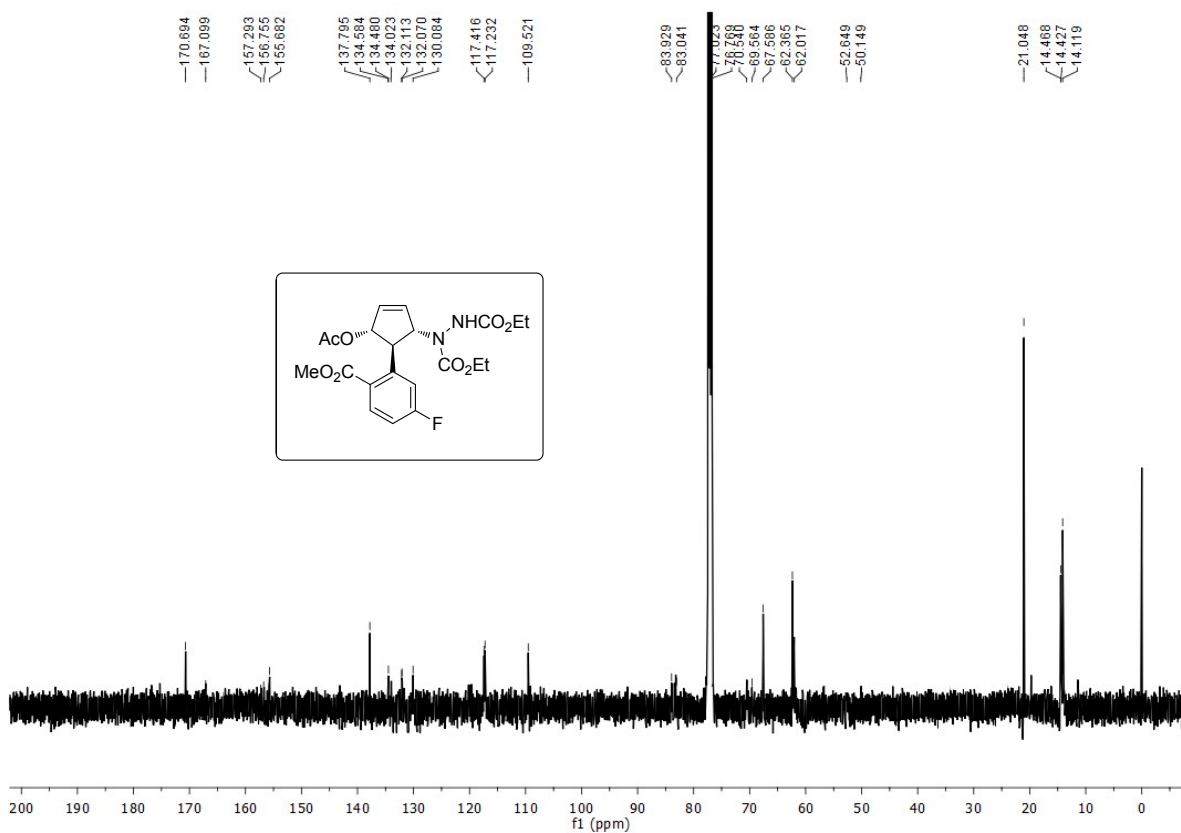
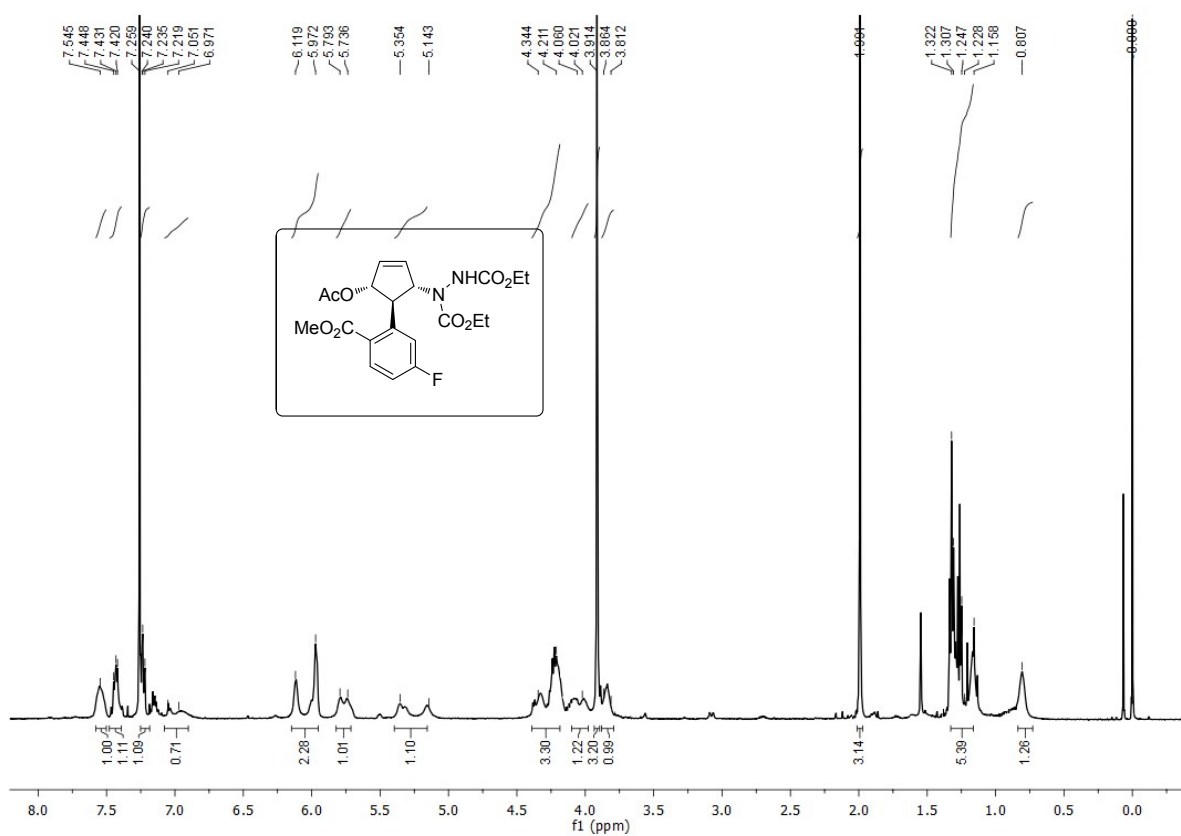
^1H and ^{13}C NMR of **3f**



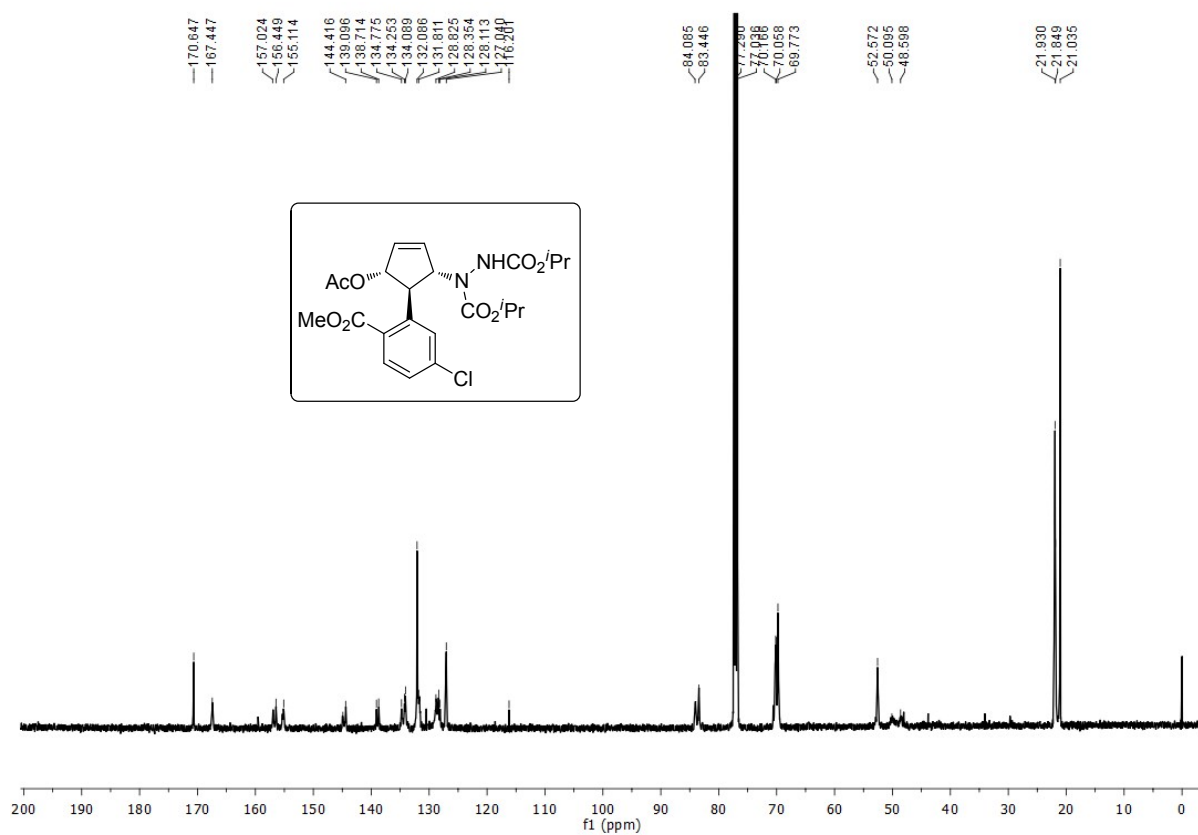
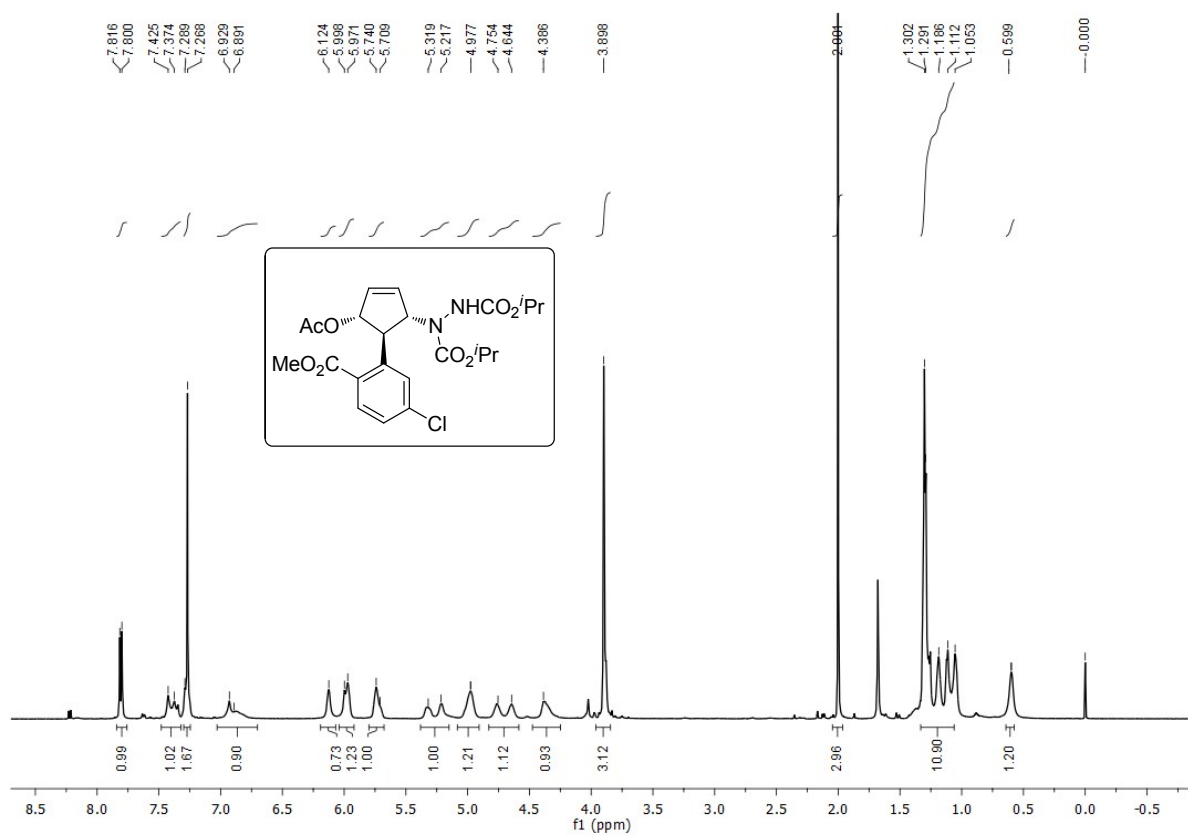
^1H and ^{13}C NMR of **3g**



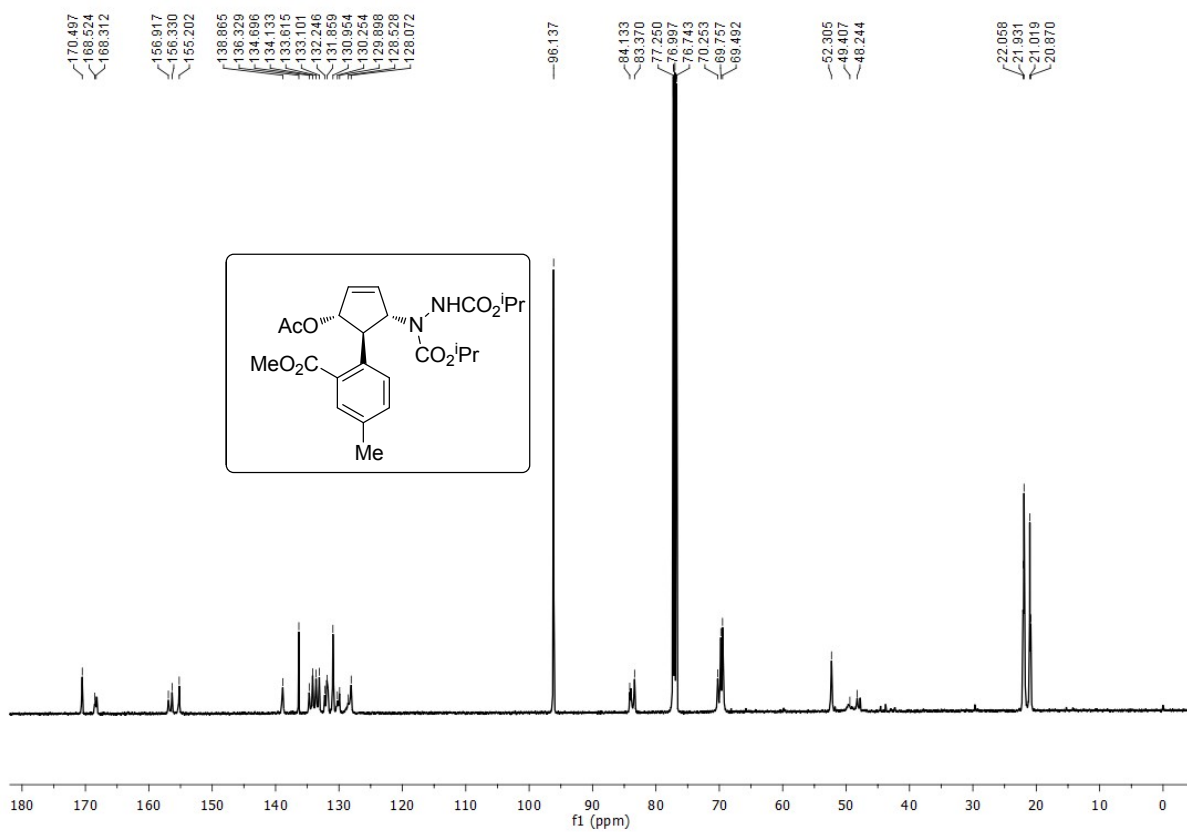
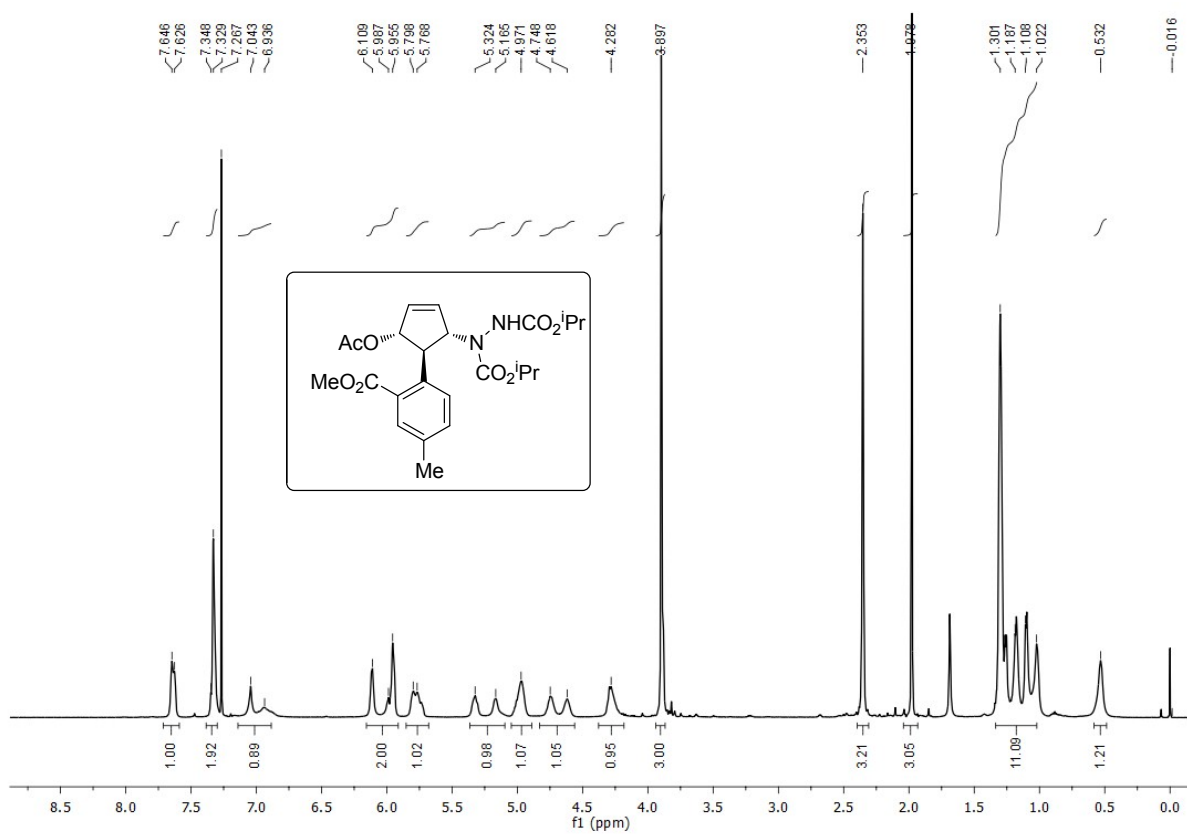
^1H and ^{13}C NMR of **3h**



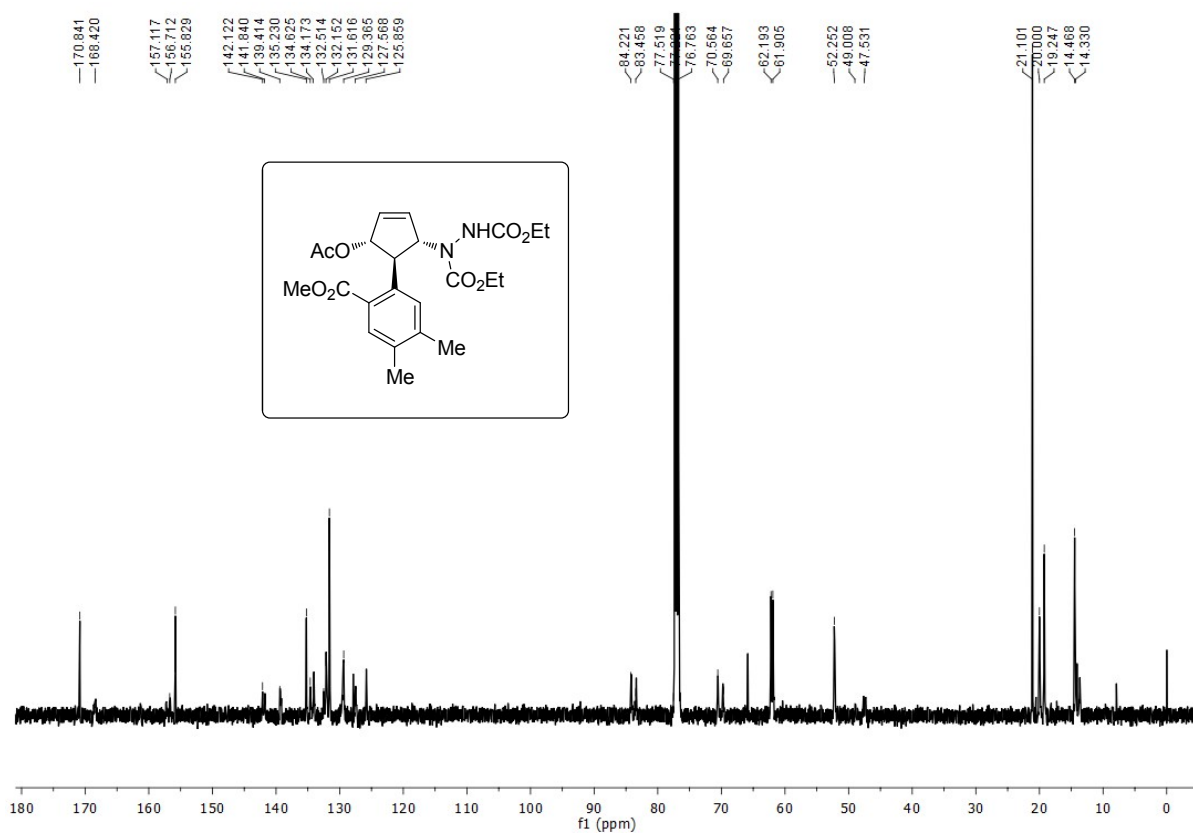
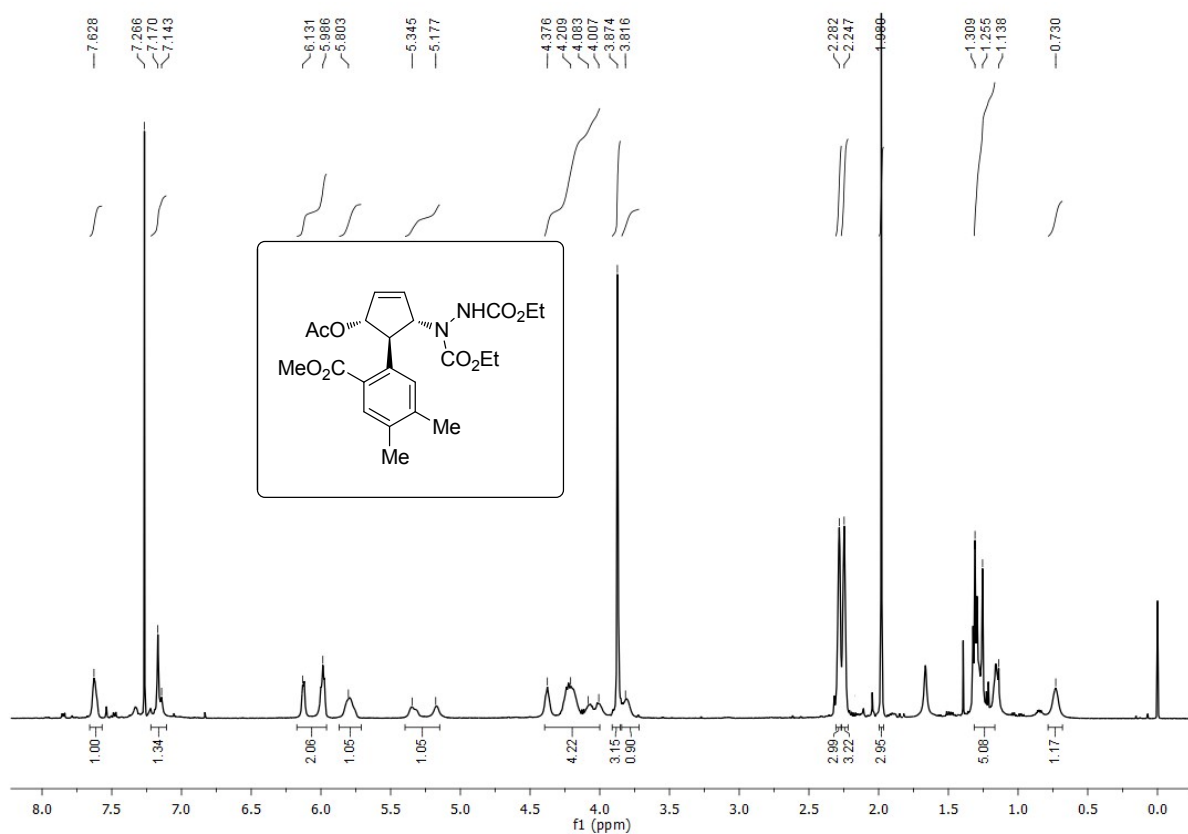
^1H and ^{13}C NMR of **3i**



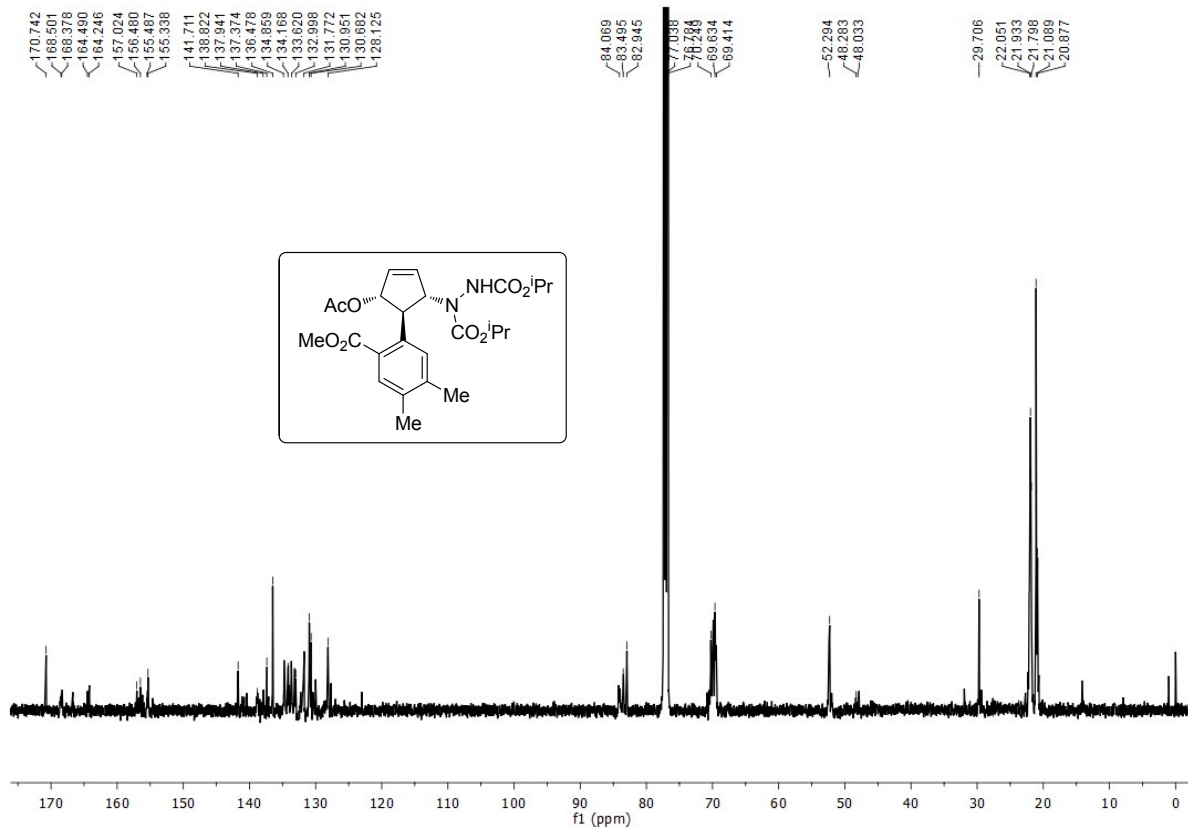
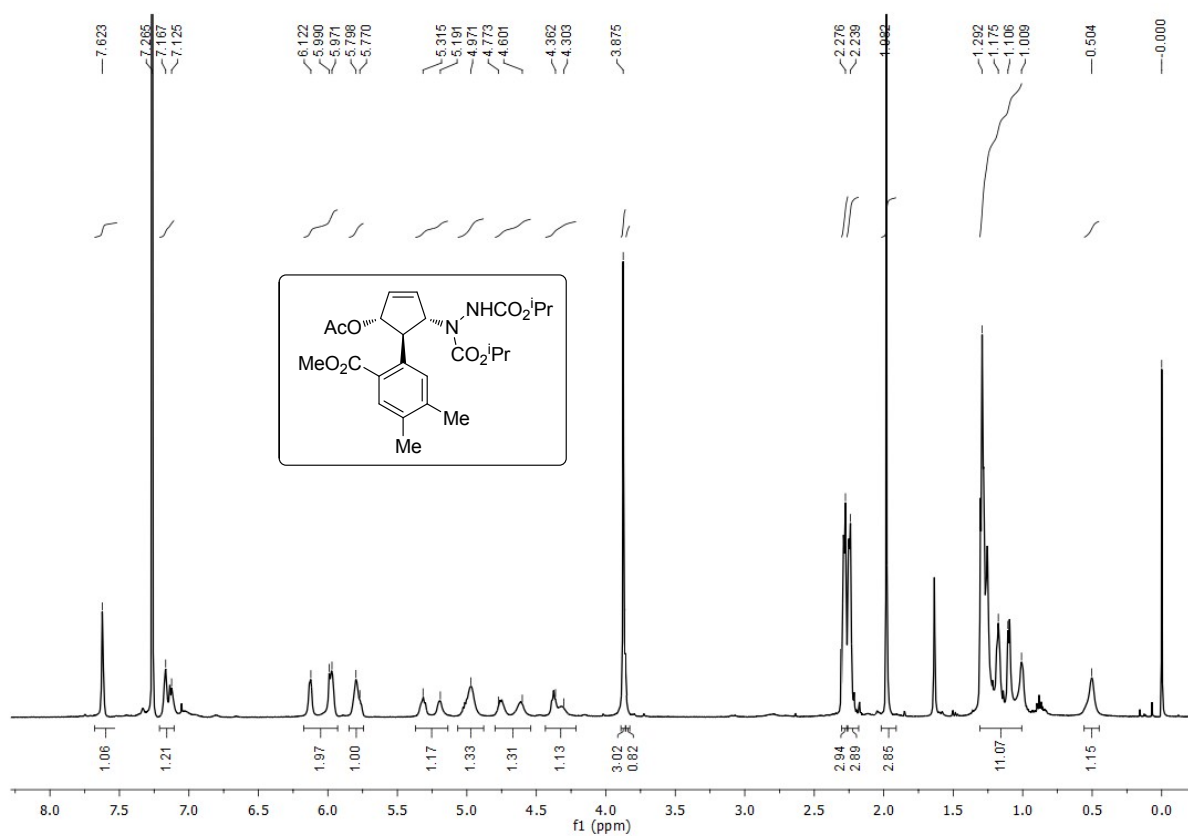
^1H and ^{13}C NMR of **3j**



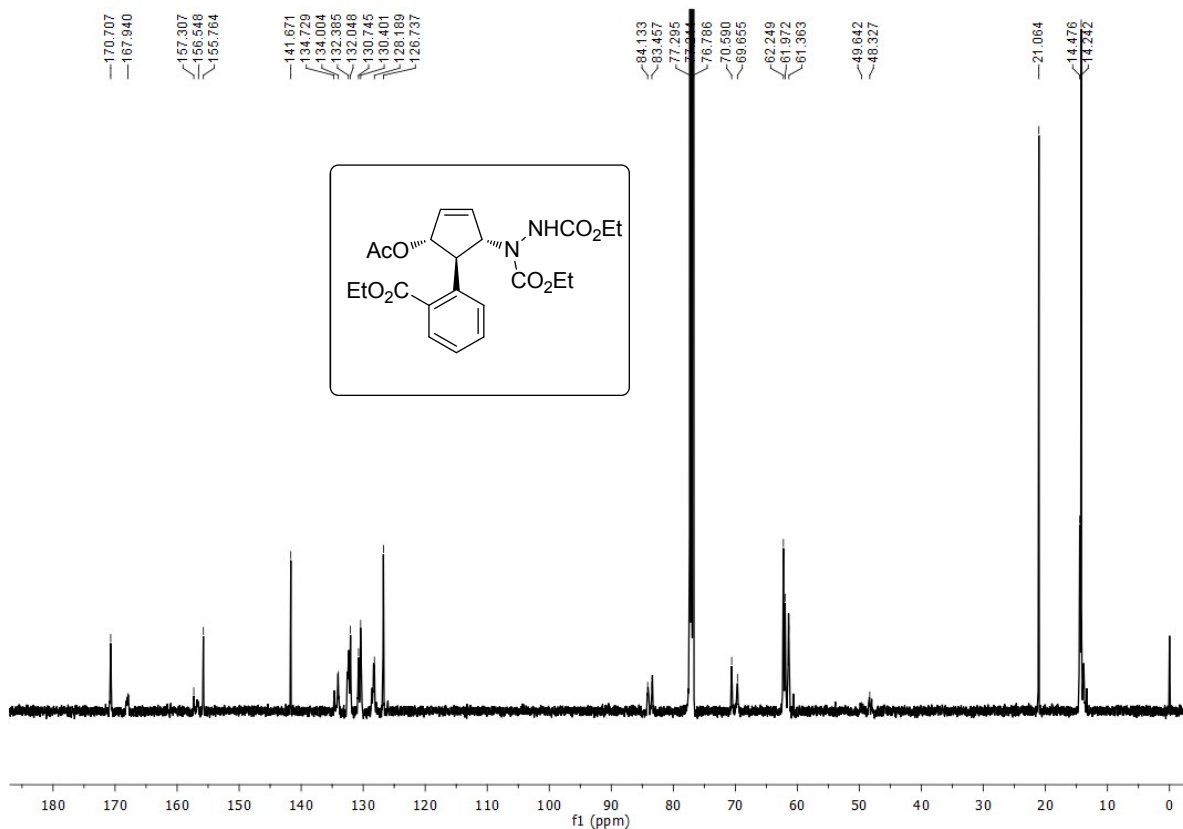
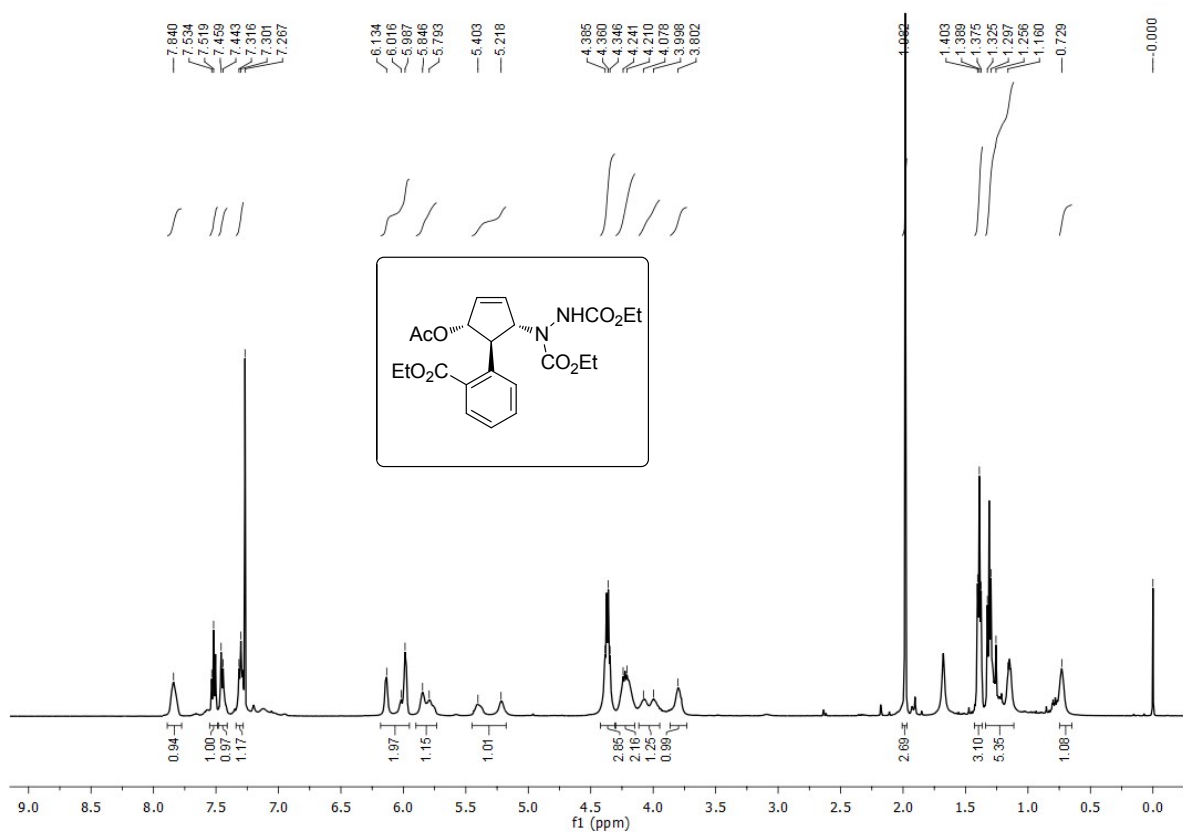
^1H and ^{13}C NMR of **3k**



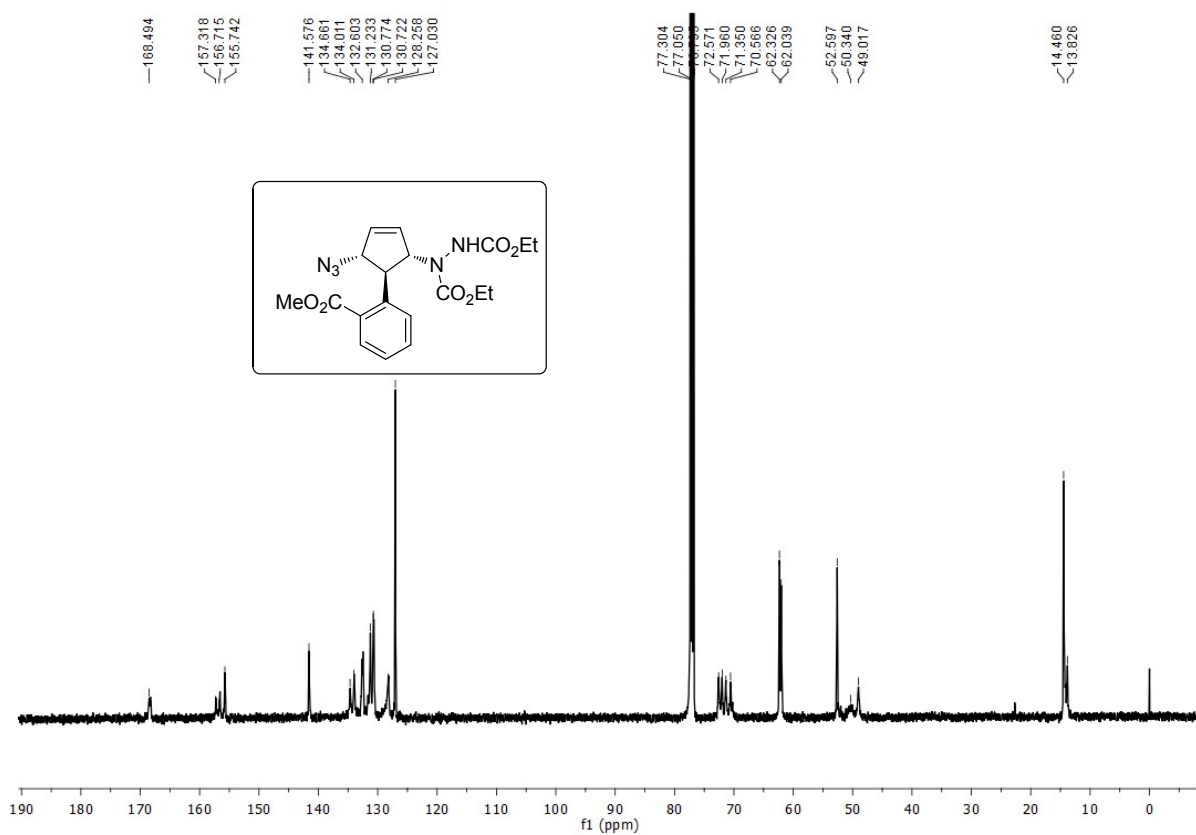
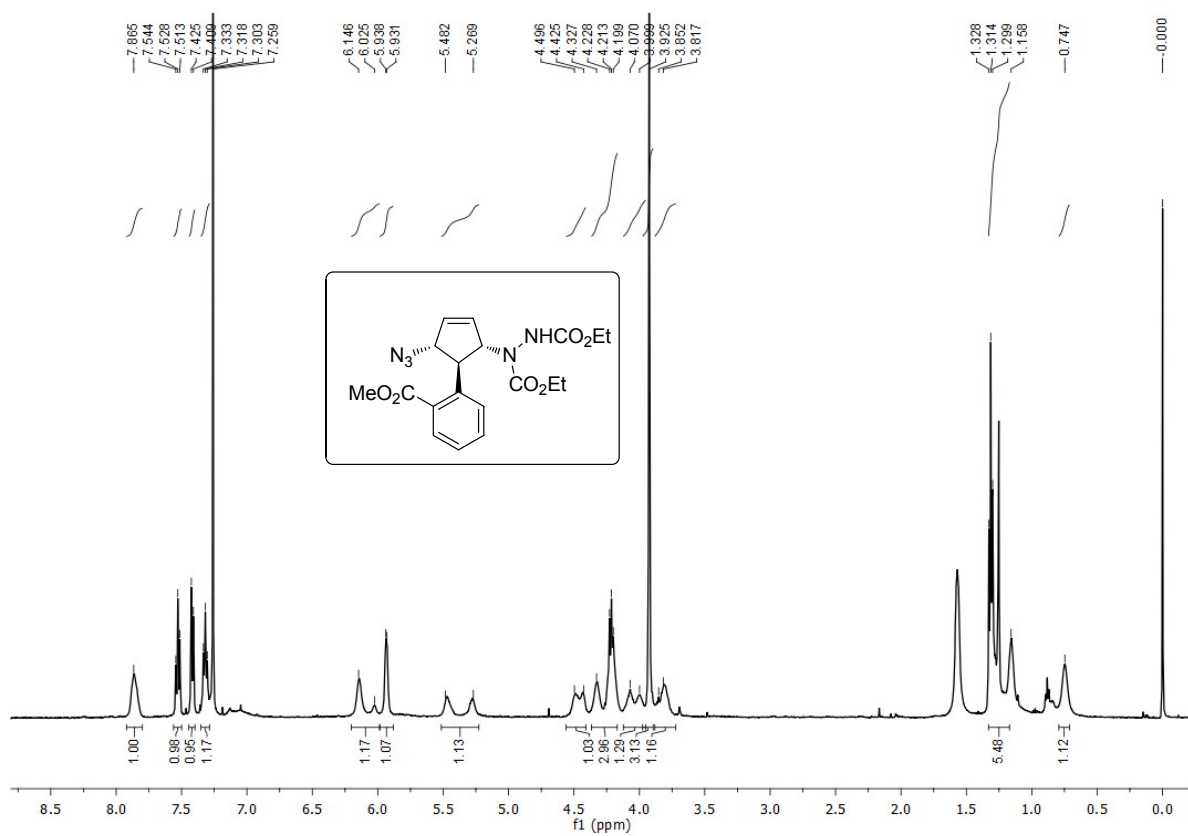
^1H and ^{13}C NMR of **31**



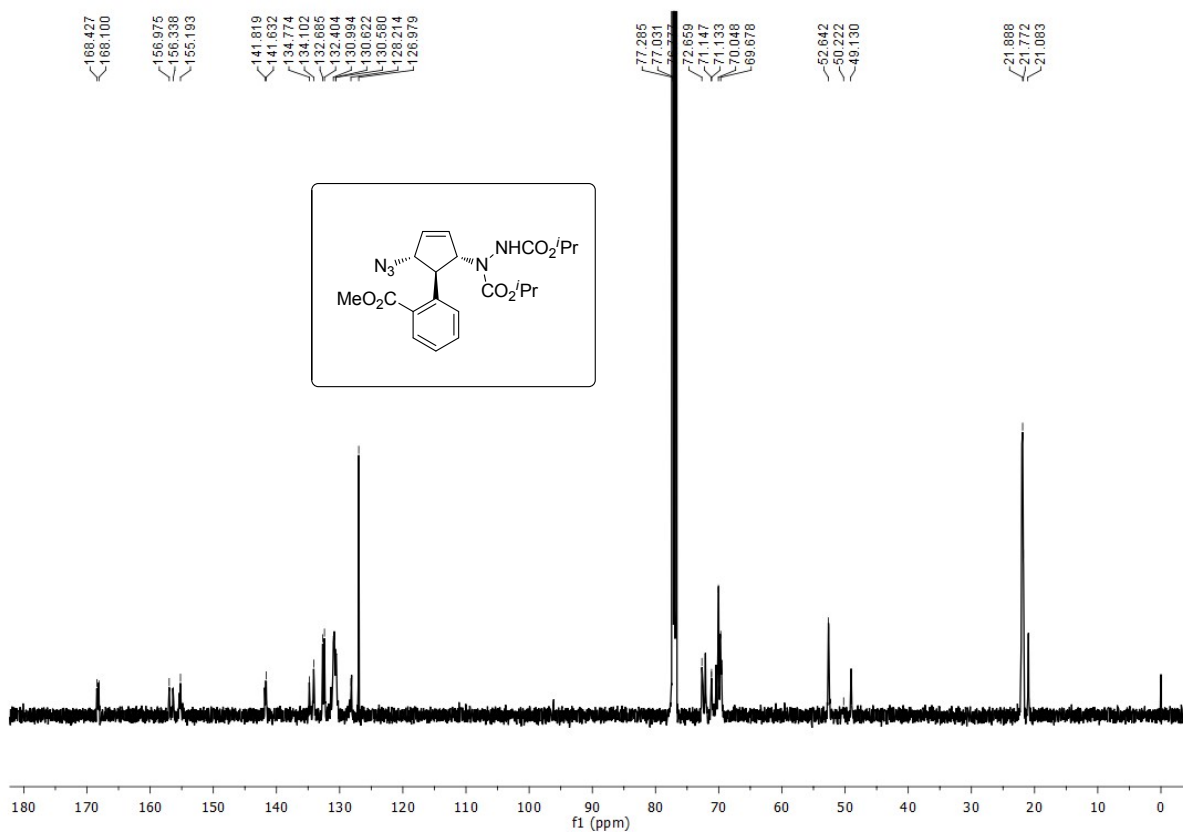
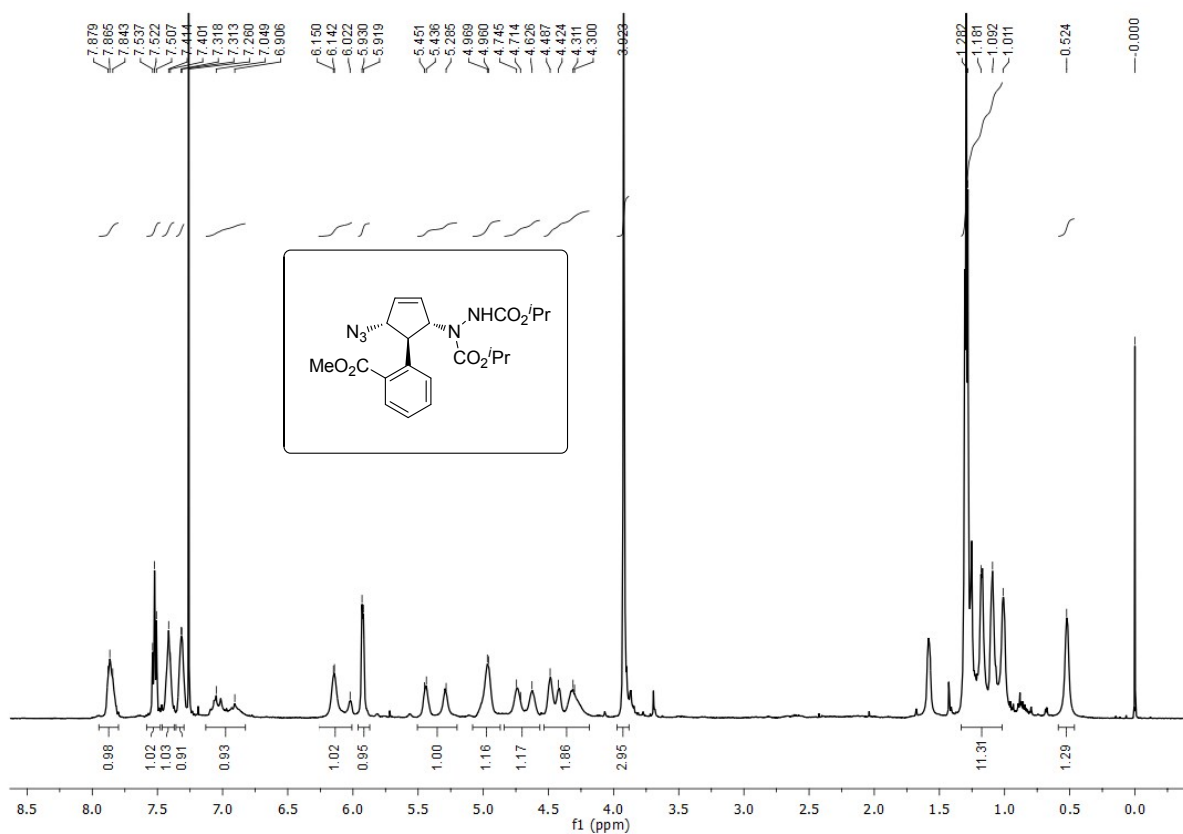
^1H and ^{13}C NMR of **3m**



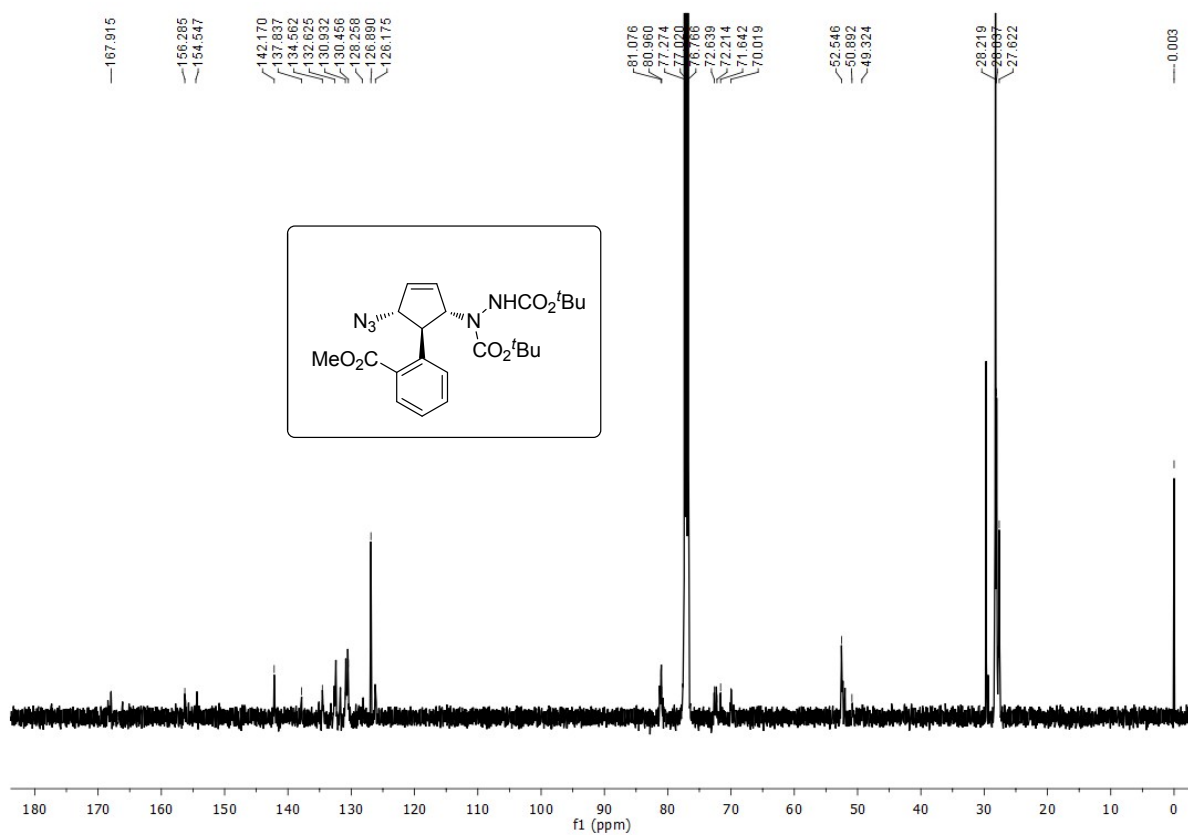
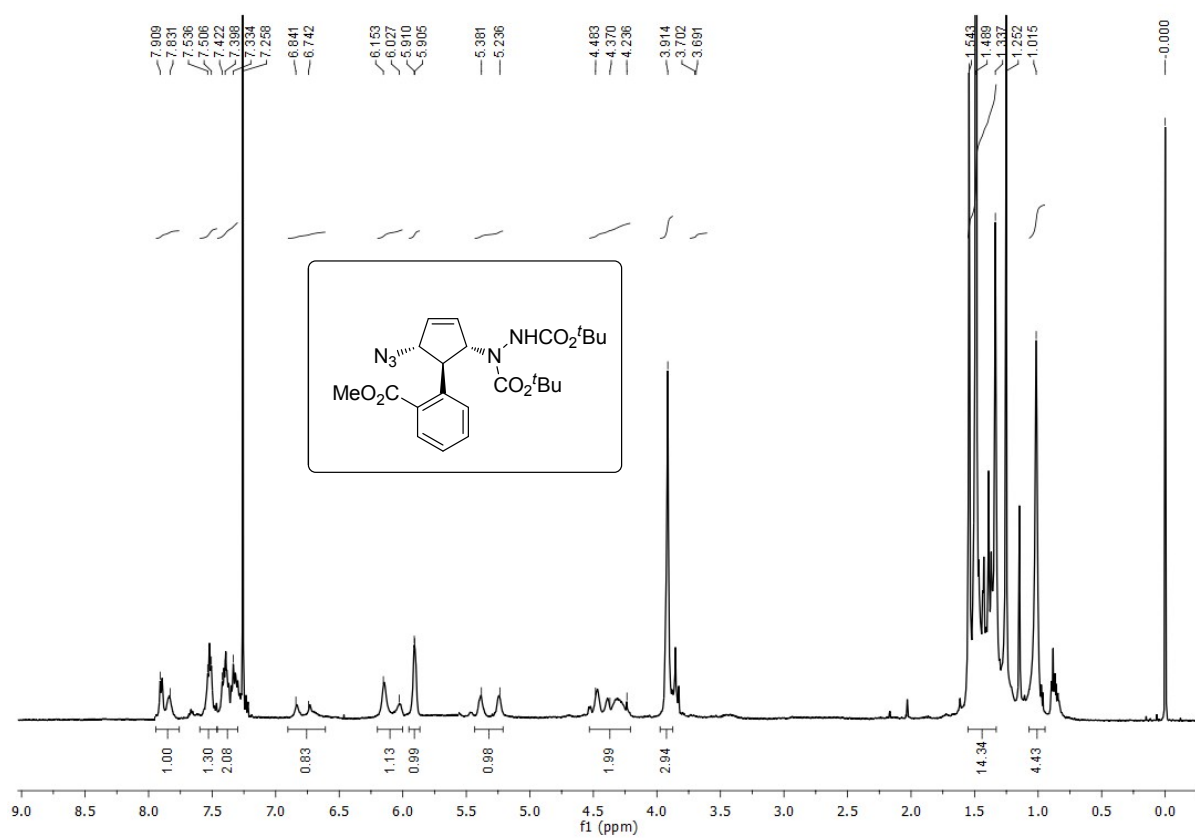
^1H and ^{13}C NMR of **4a**



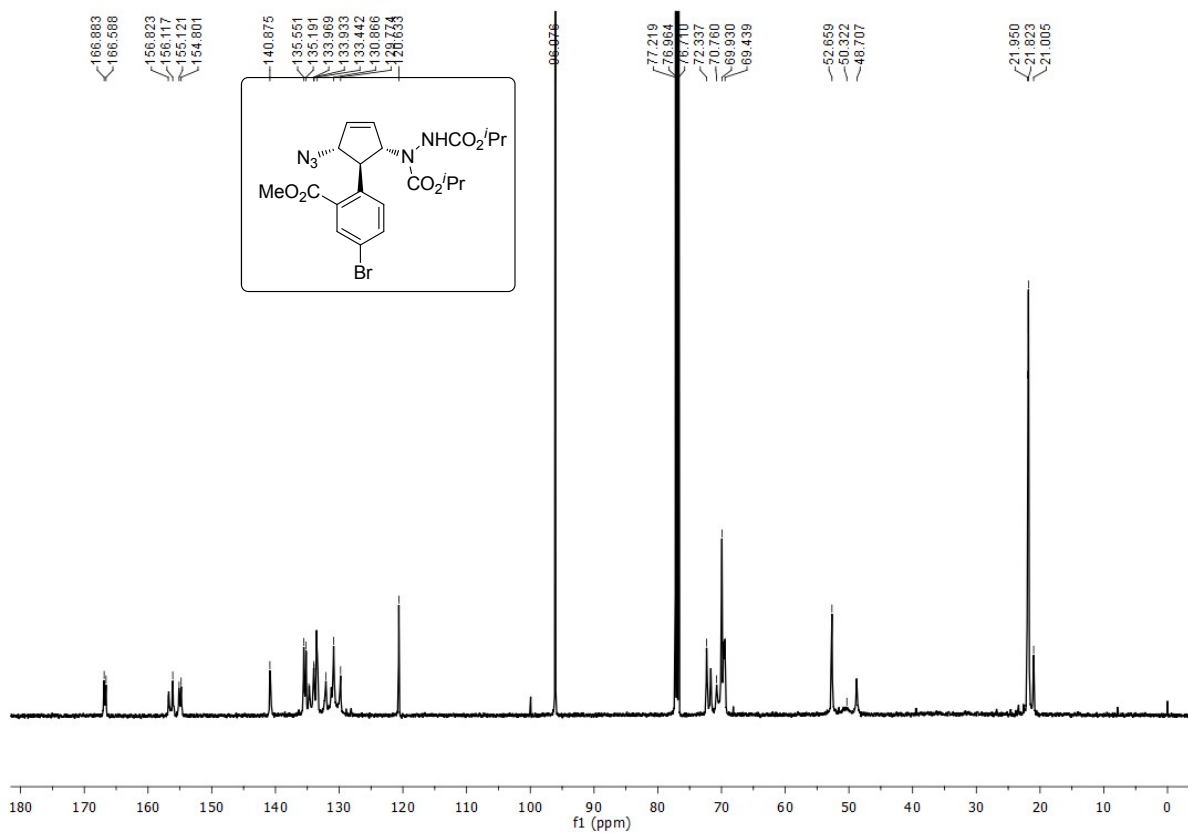
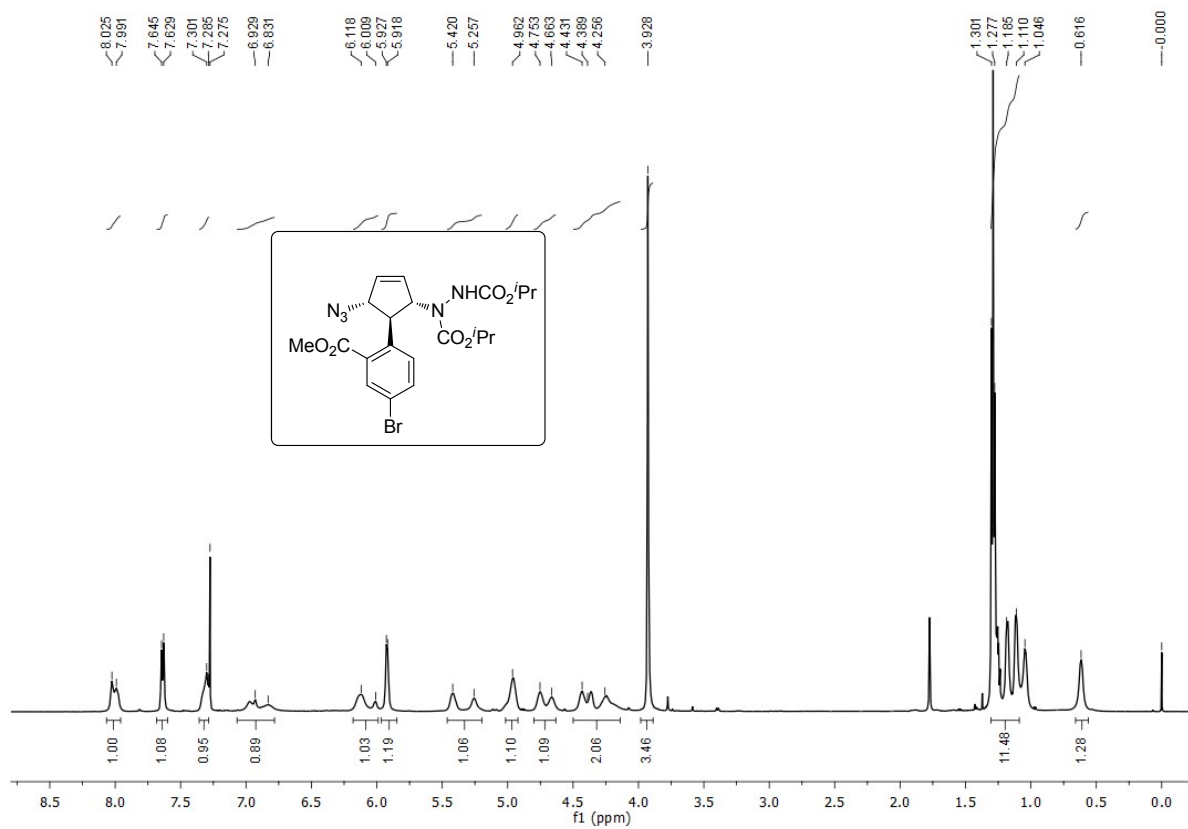
^1H and ^{13}C NMR of **4b**



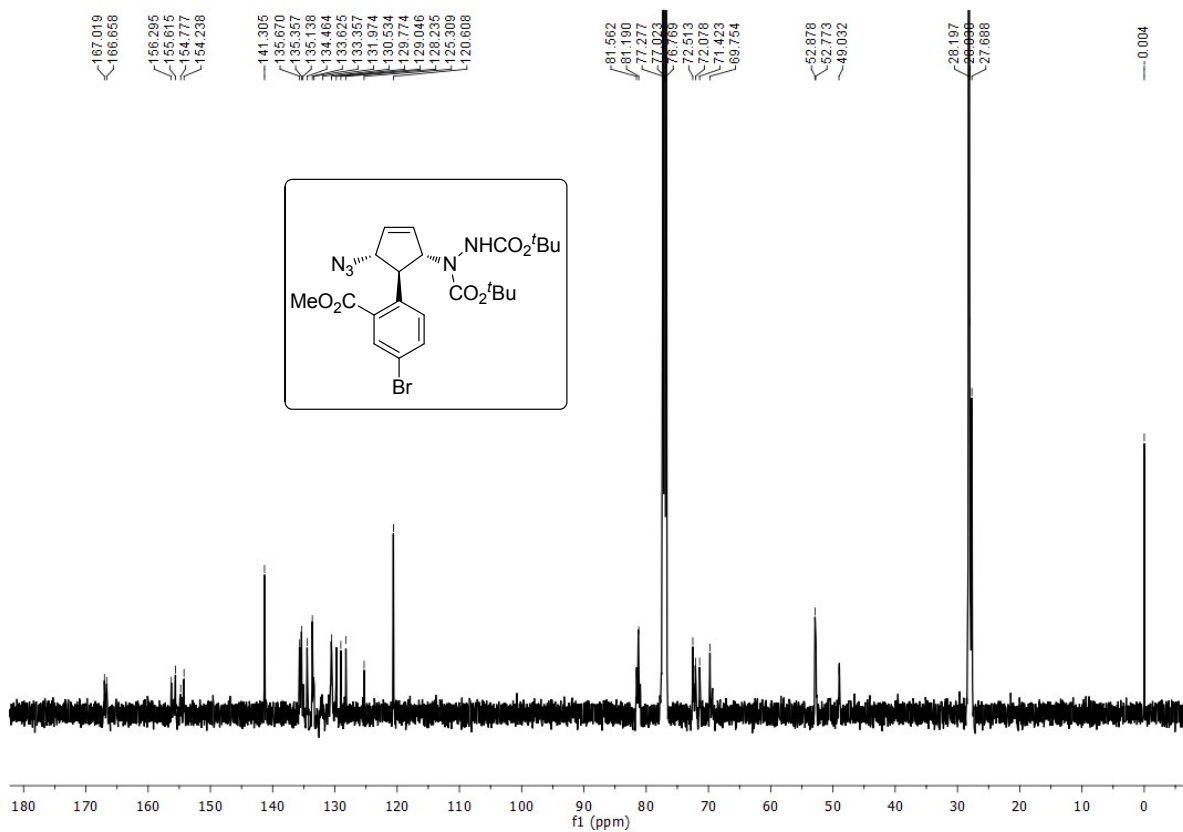
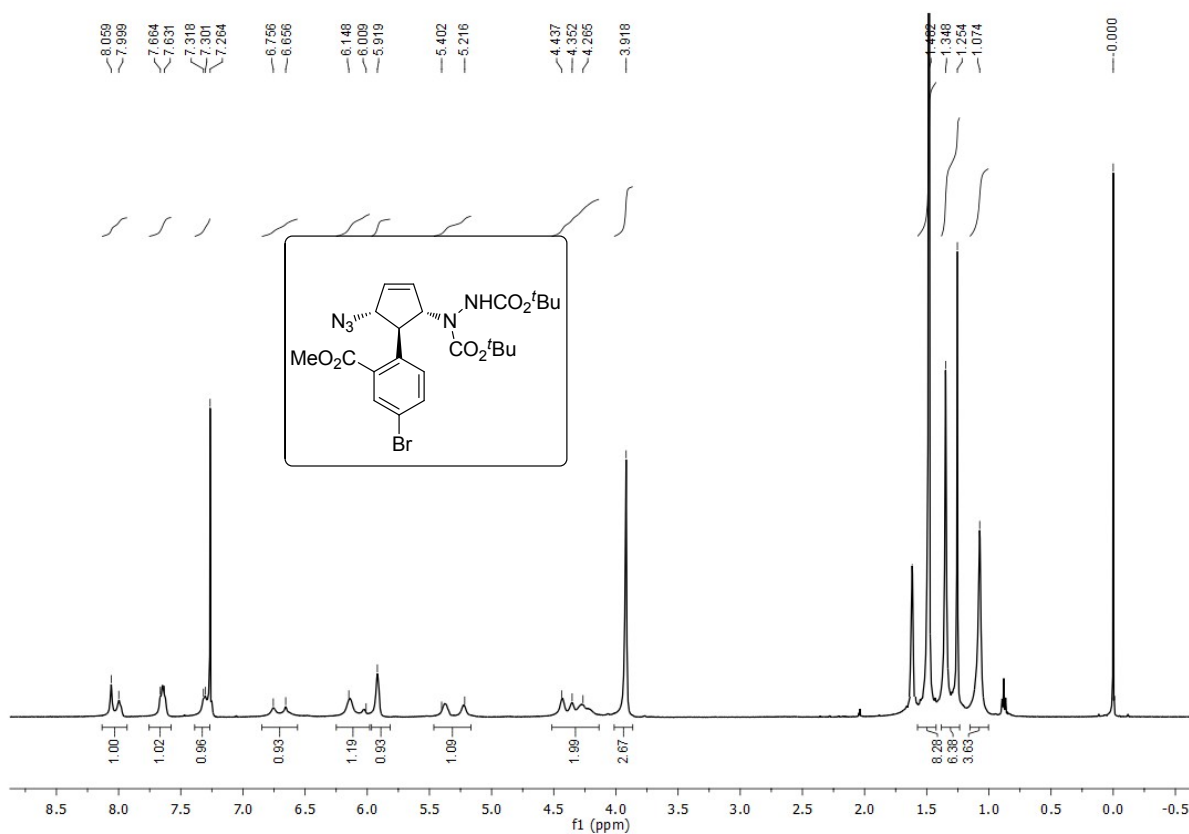
^1H and ^{13}C NMR of **4c**



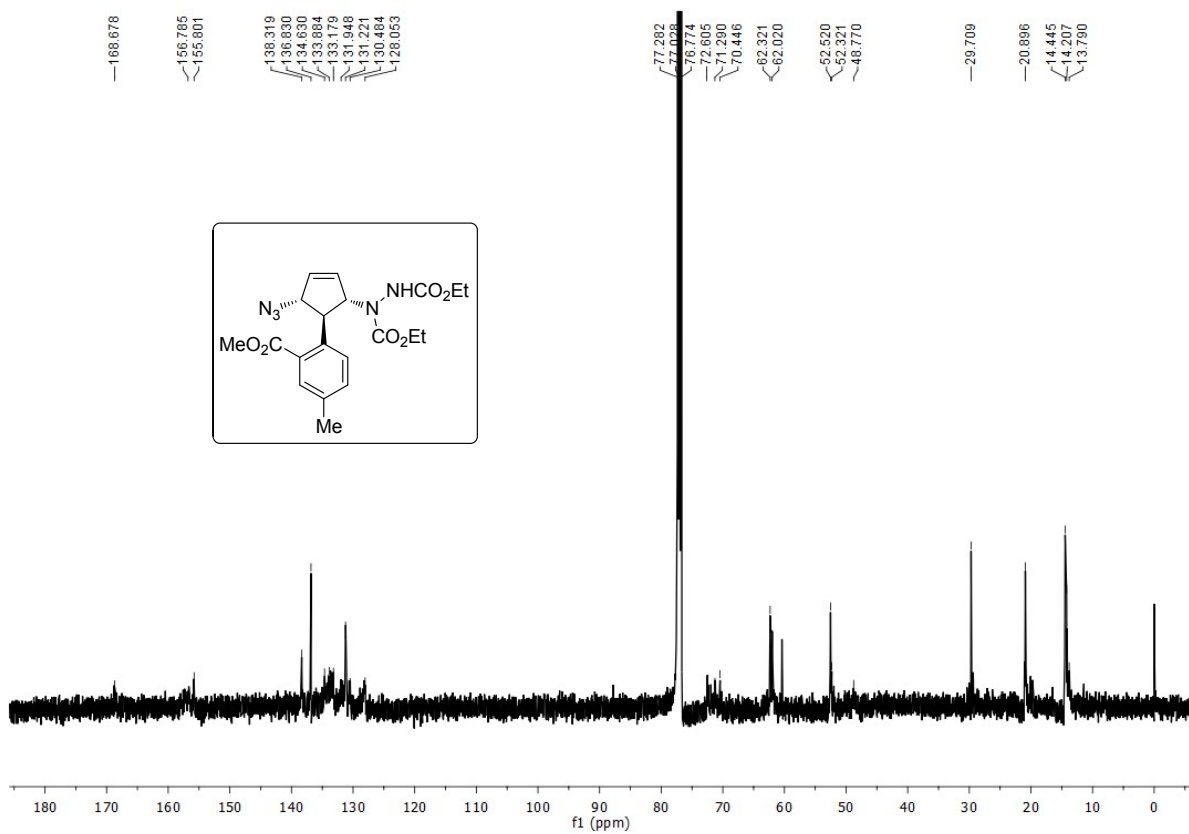
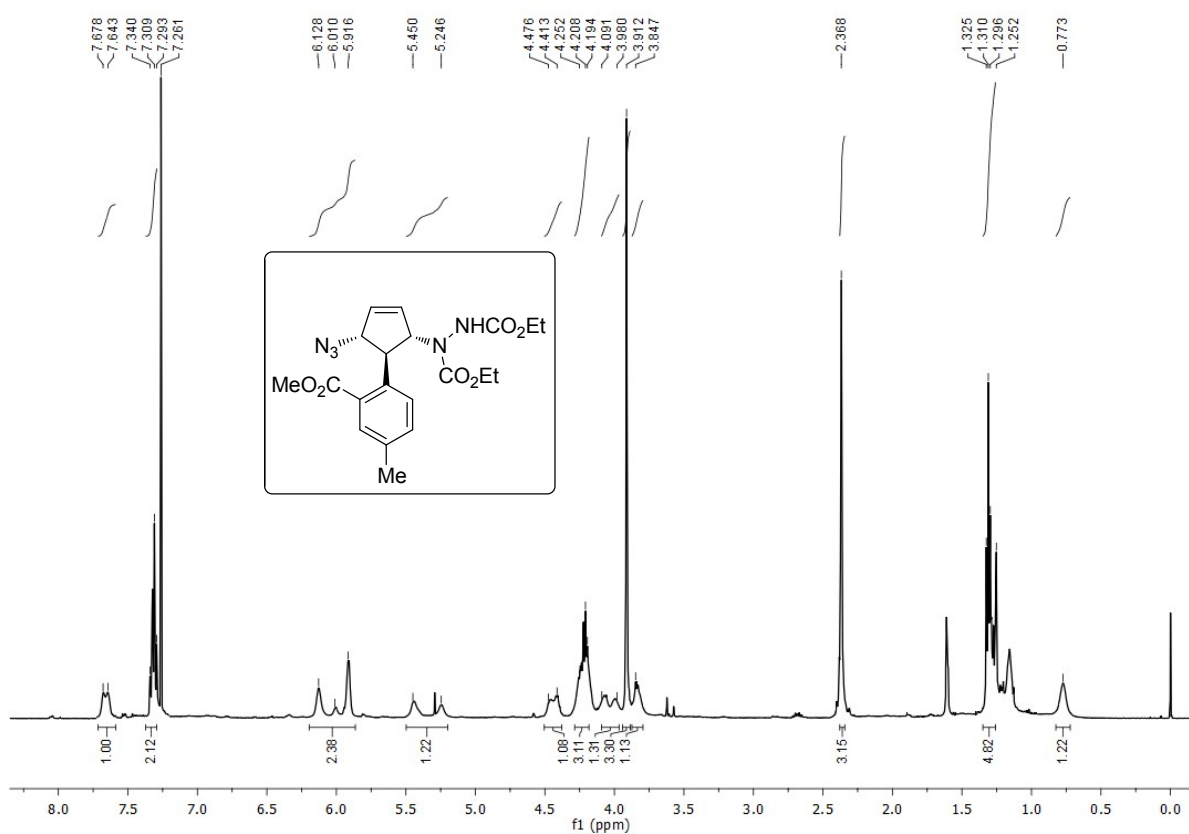
^1H and ^{13}C NMR of **4d**



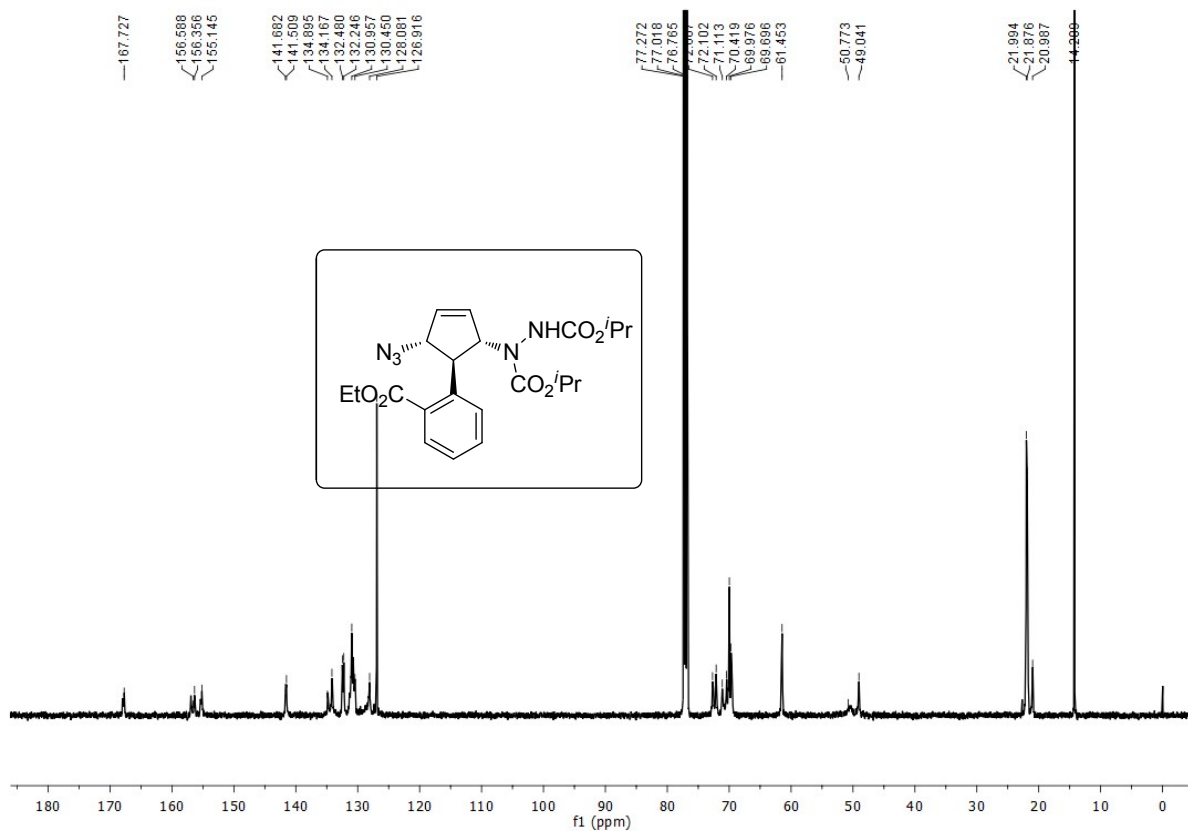
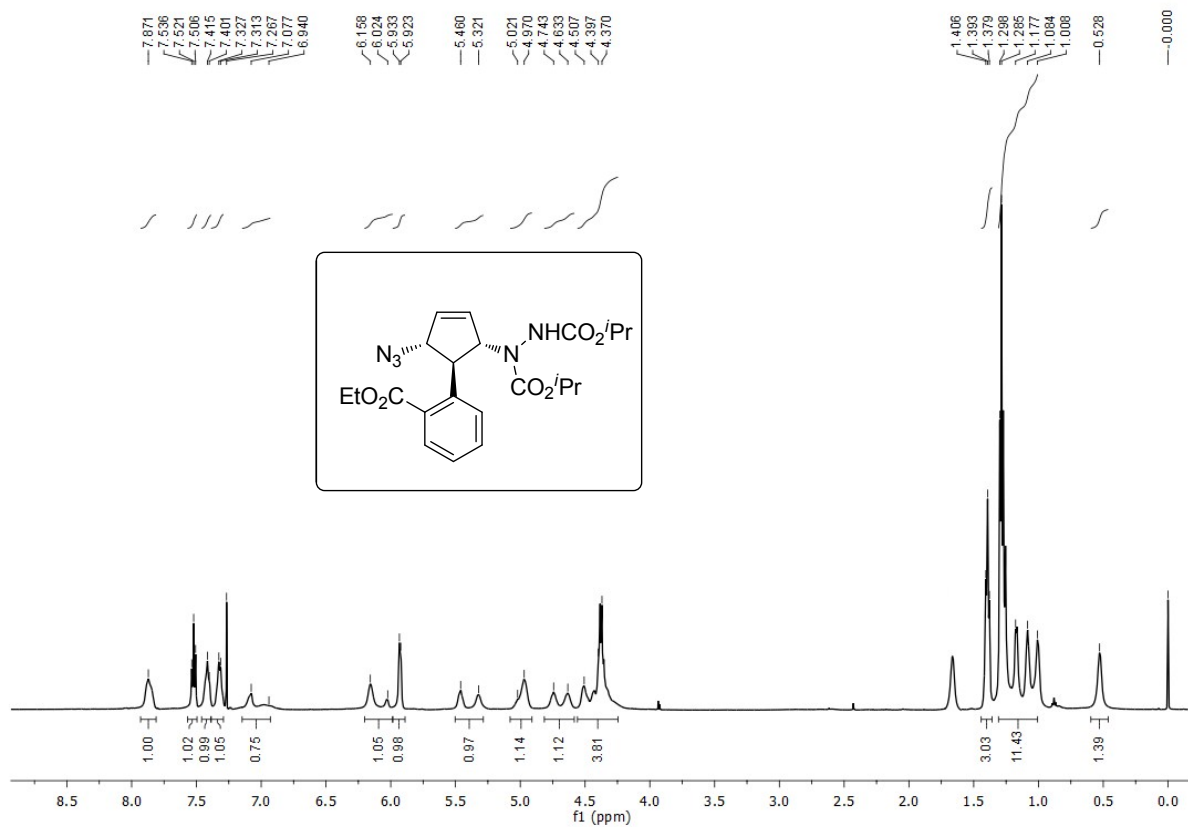
^1H and ^{13}C NMR of **4e**



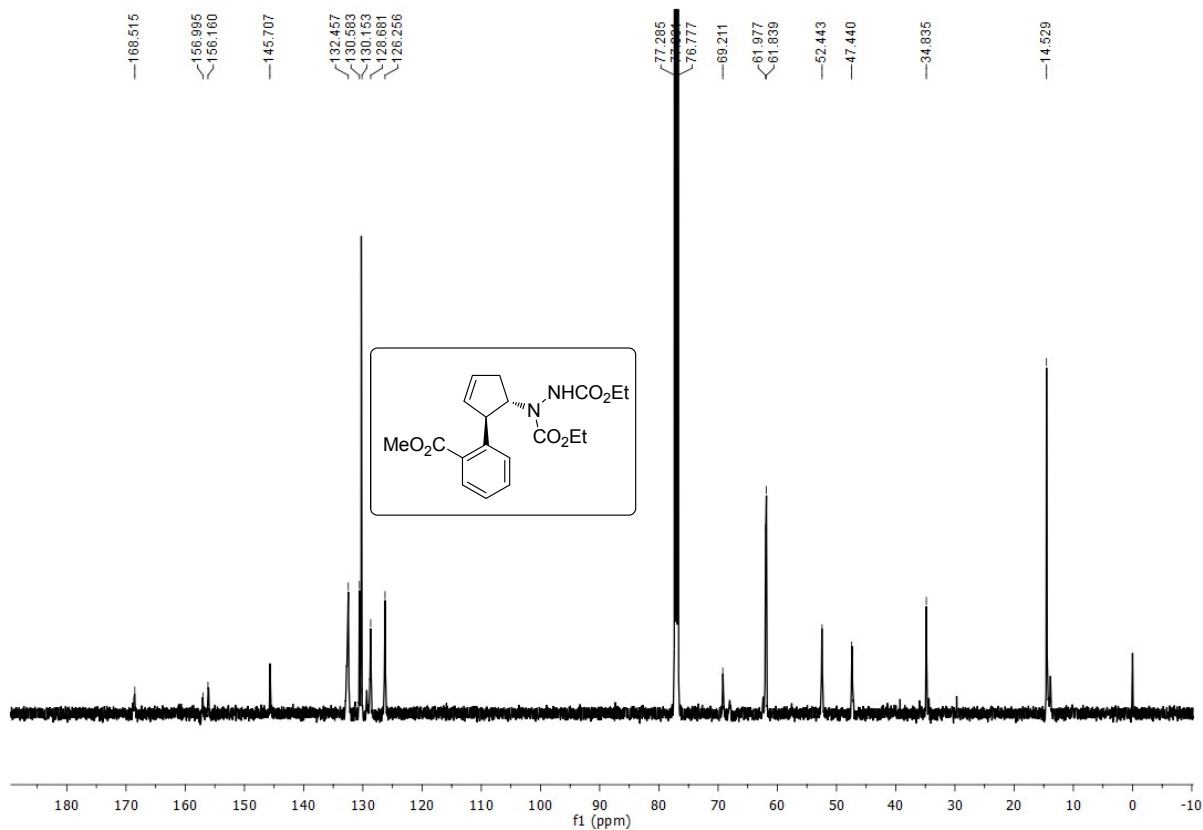
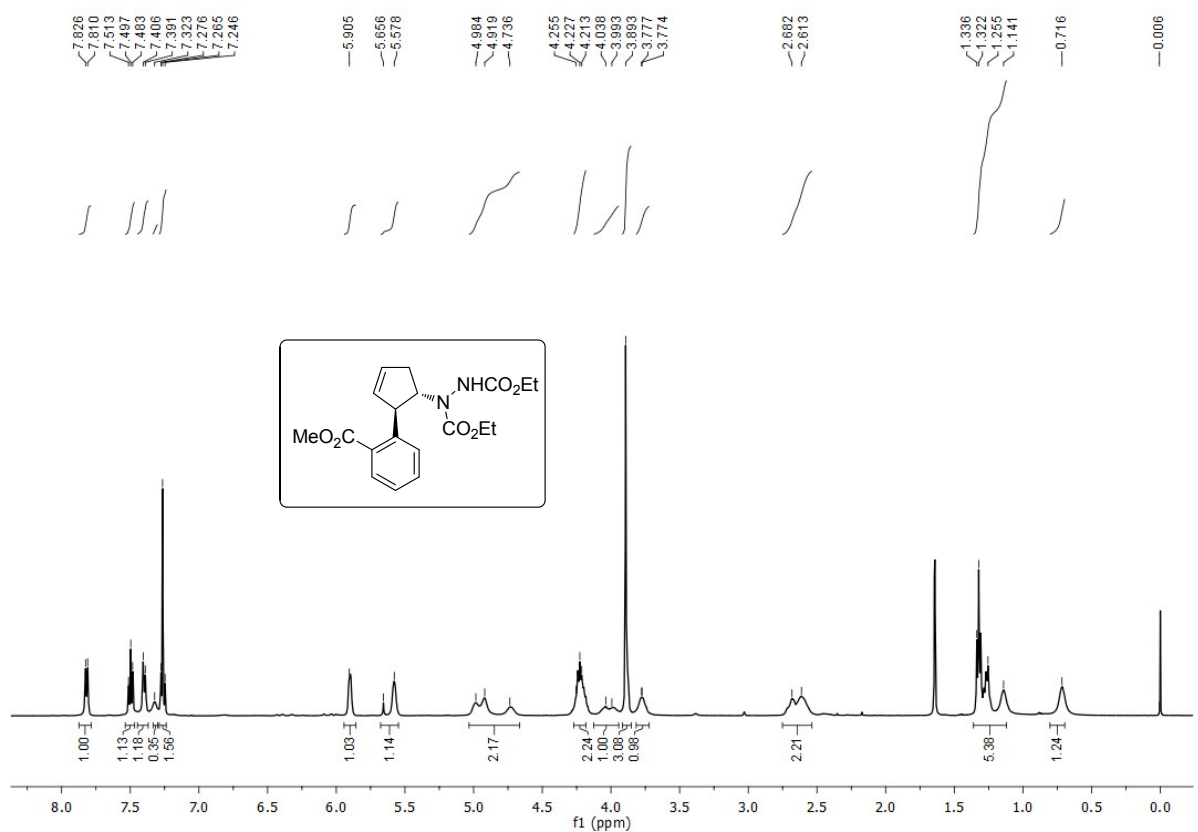
^1H and ^{13}C NMR of **4f**



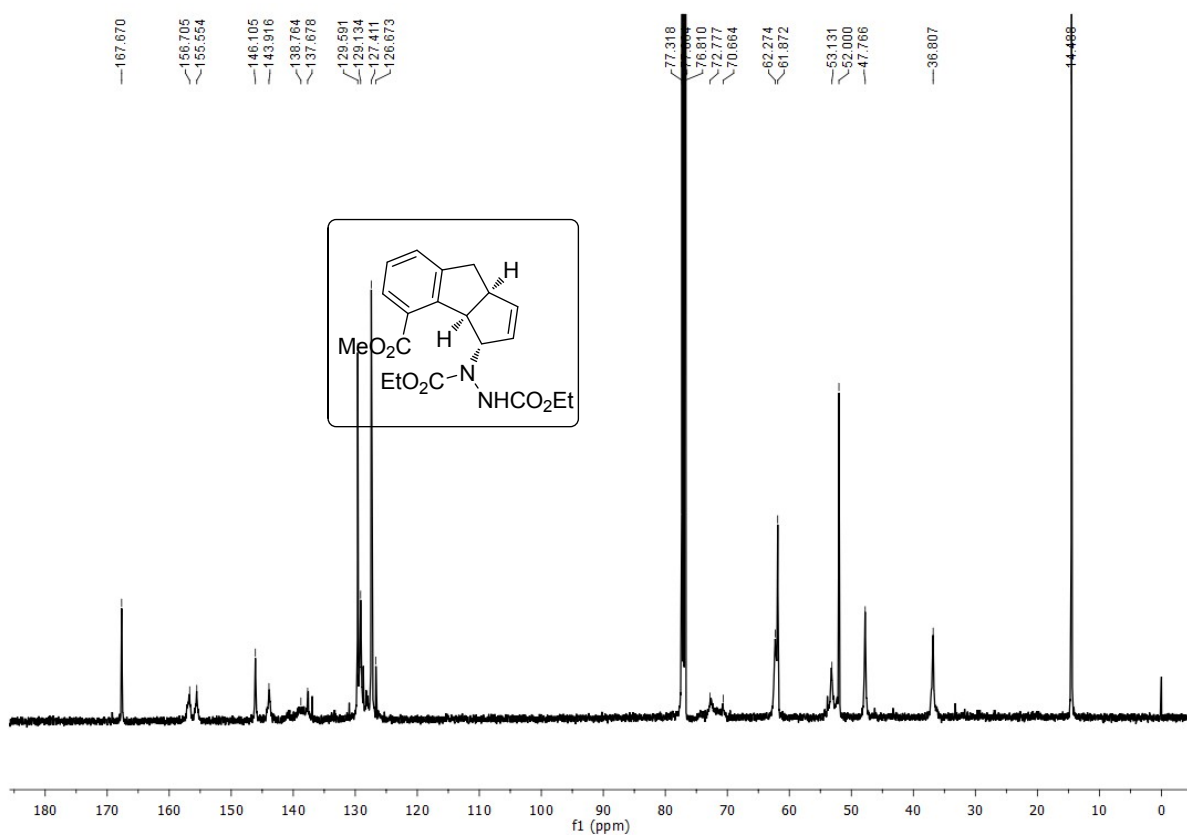
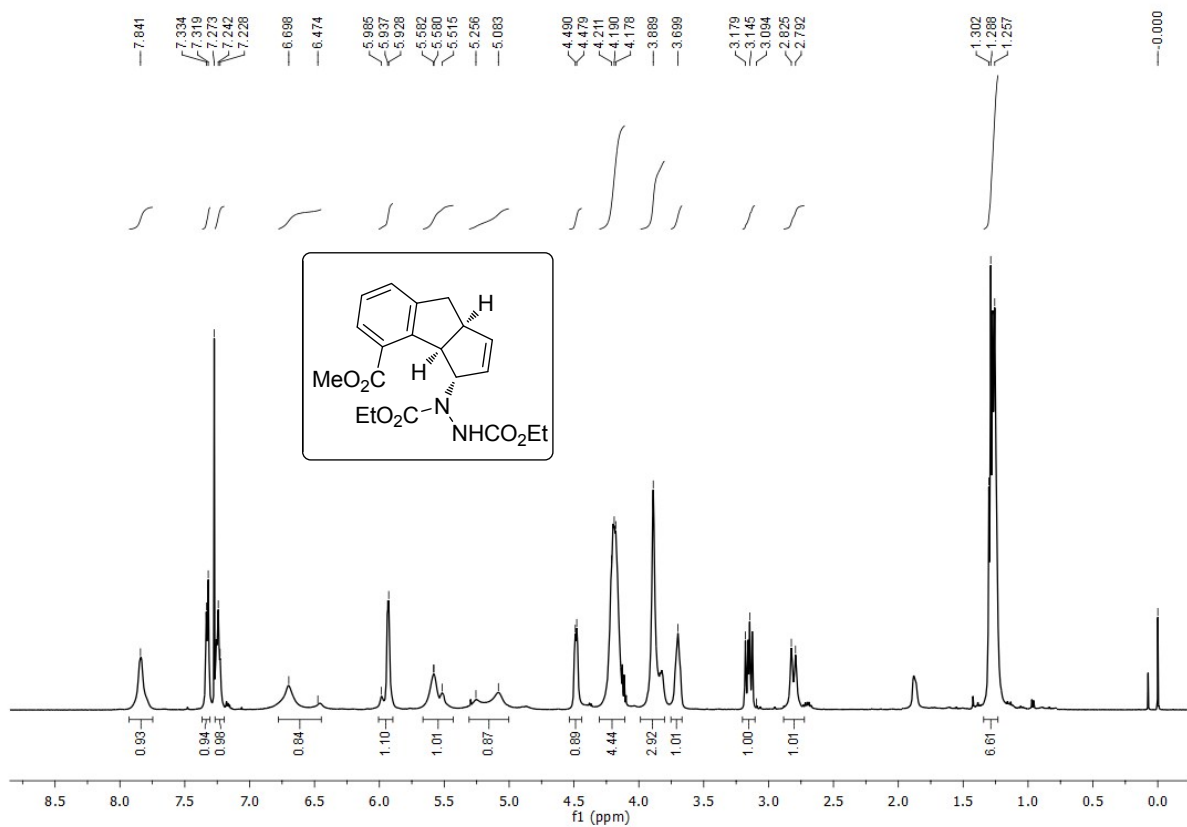
^1H and ^{13}C NMR of **4g**



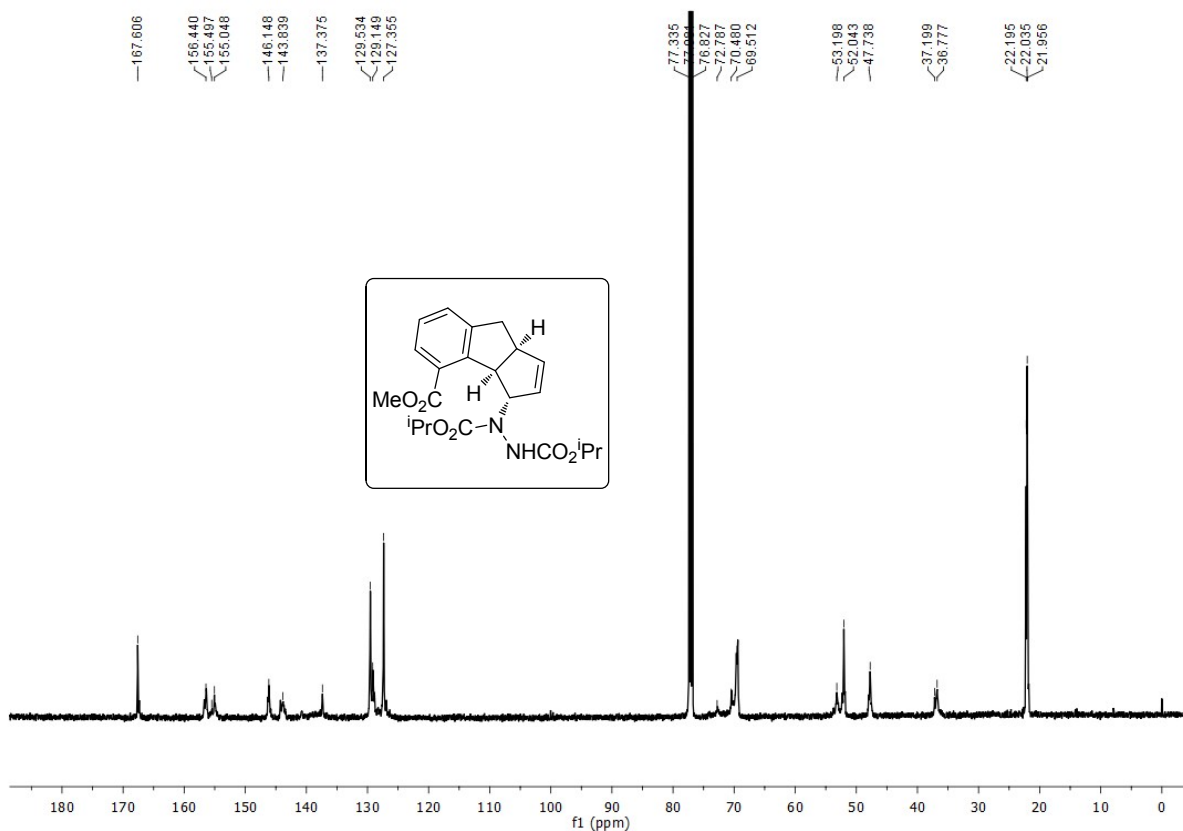
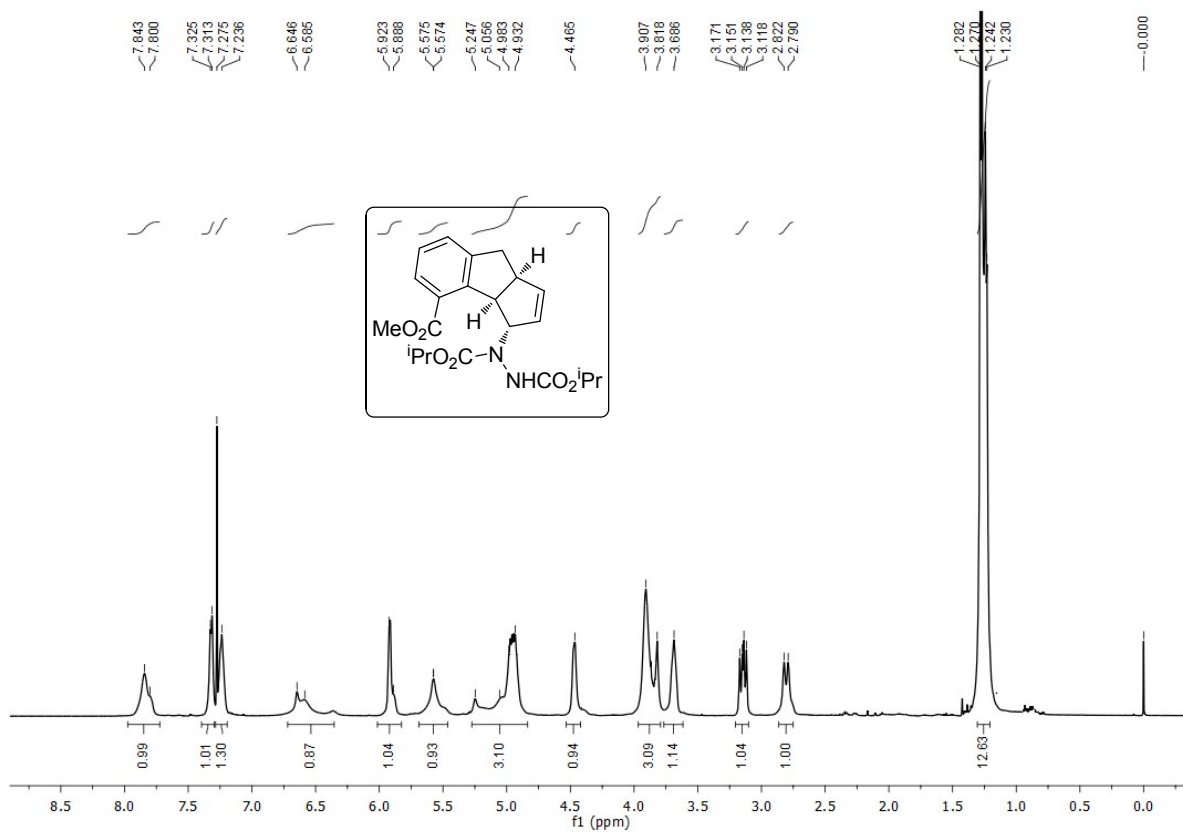
^1H and ^{13}C NMR of **5**



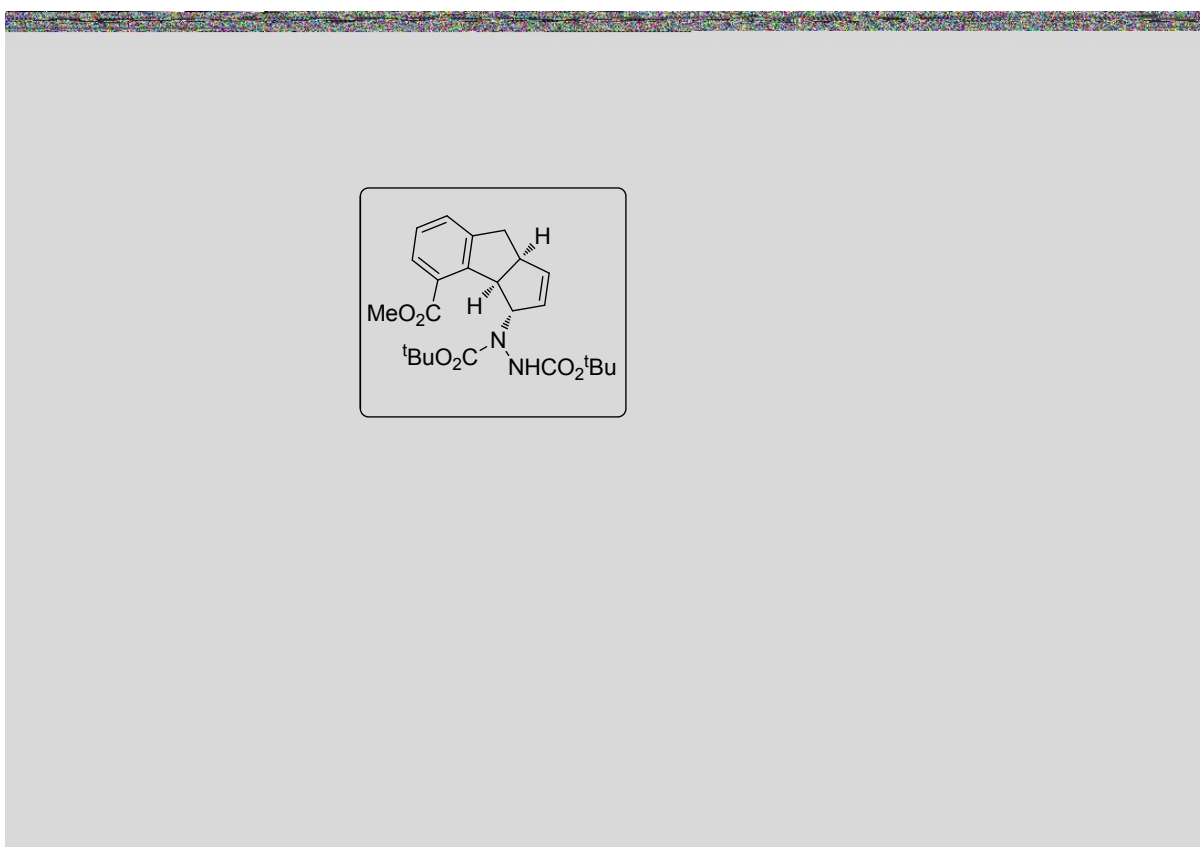
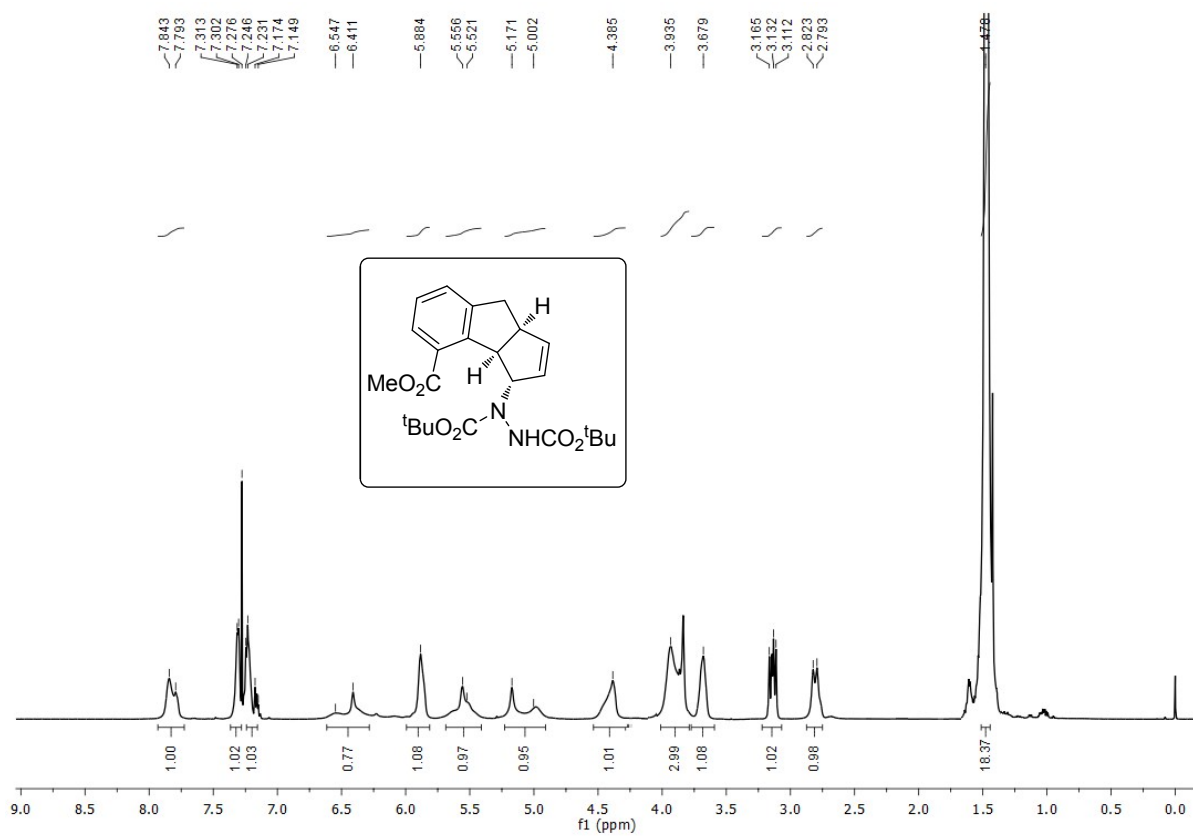
^1H and ^{13}C NMR of **8a**



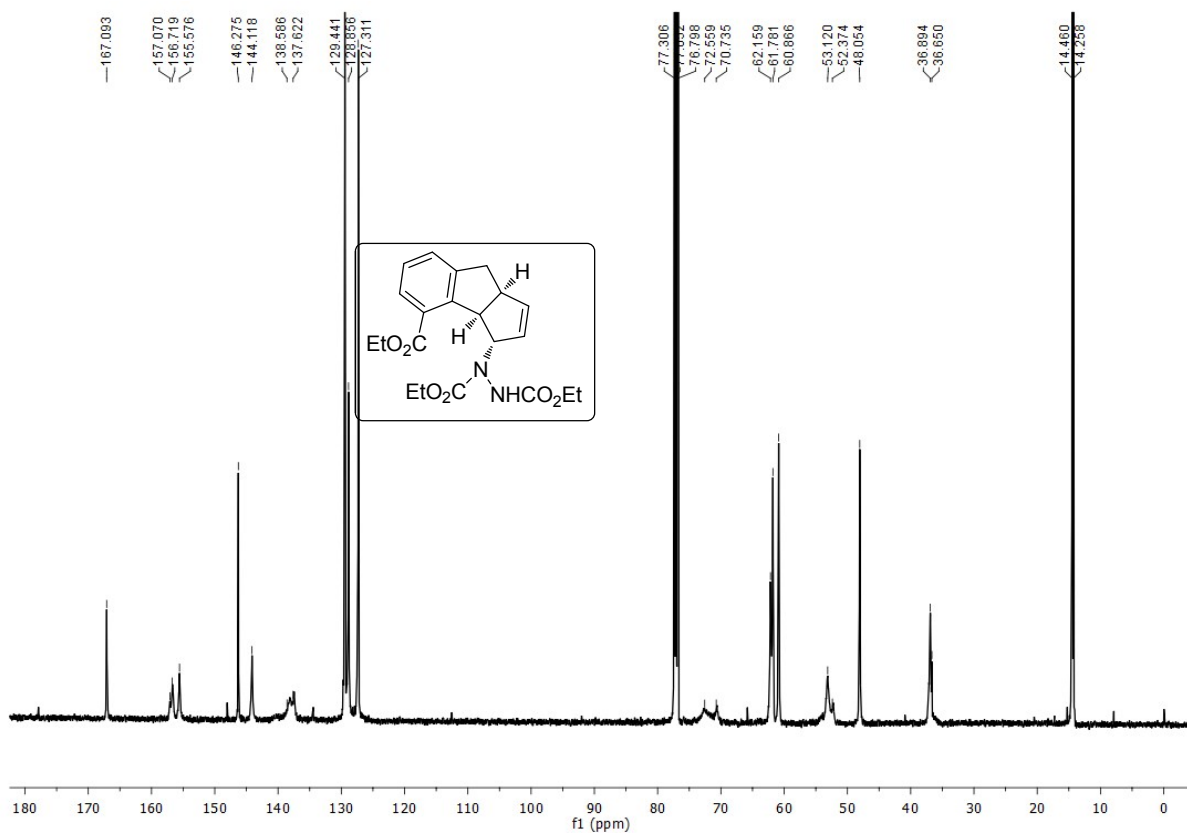
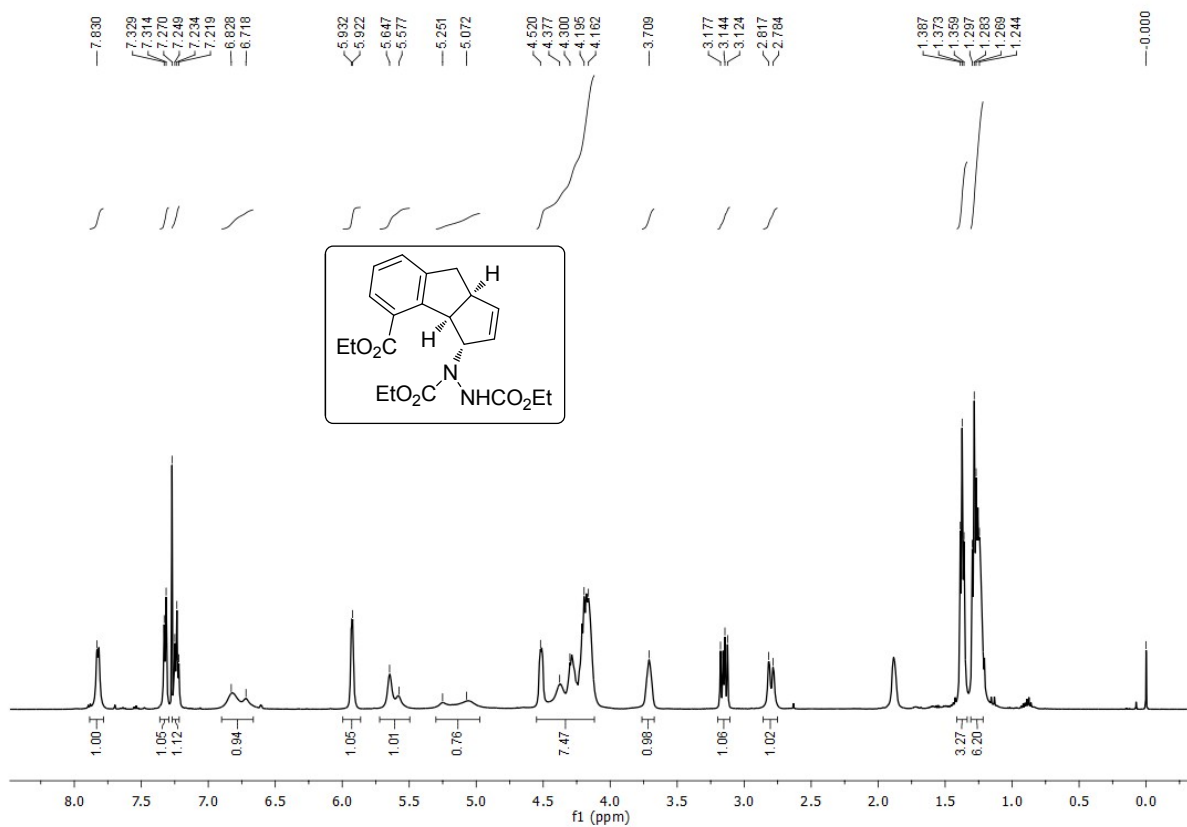
^1H and ^{13}C NMR of **8b**



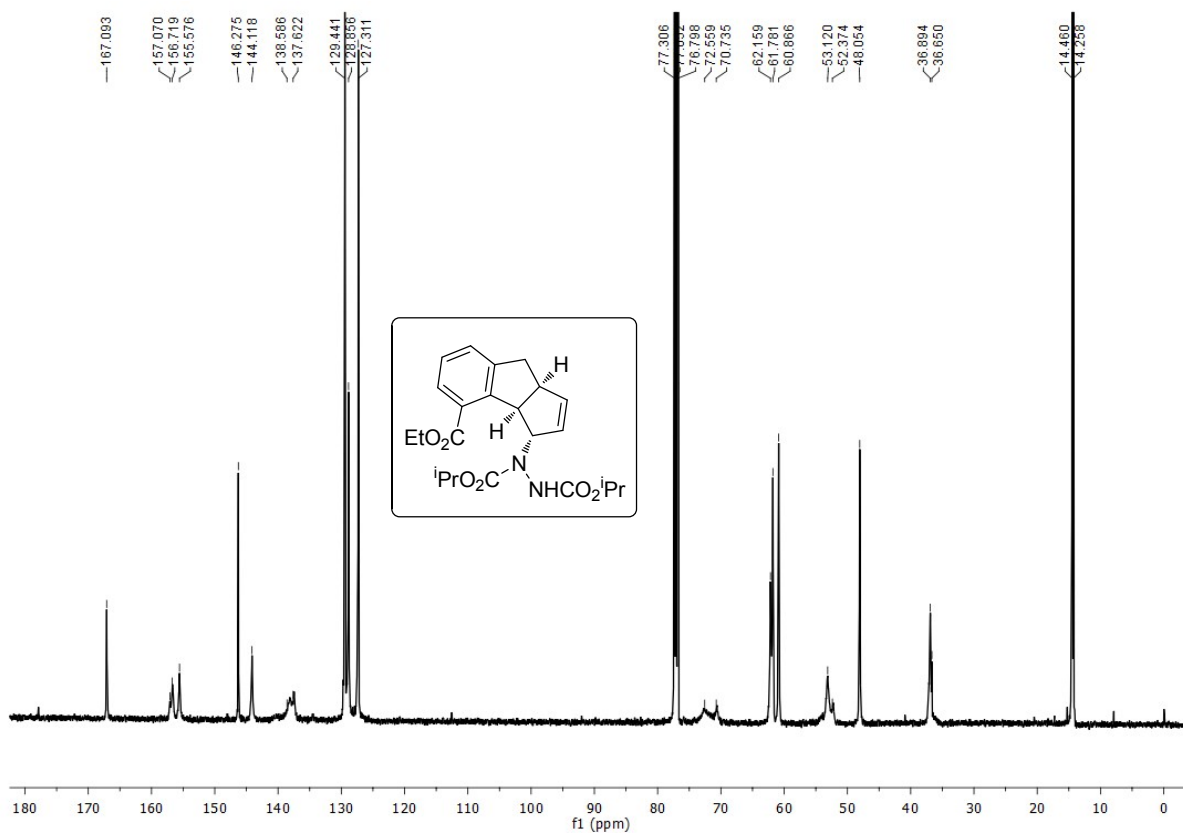
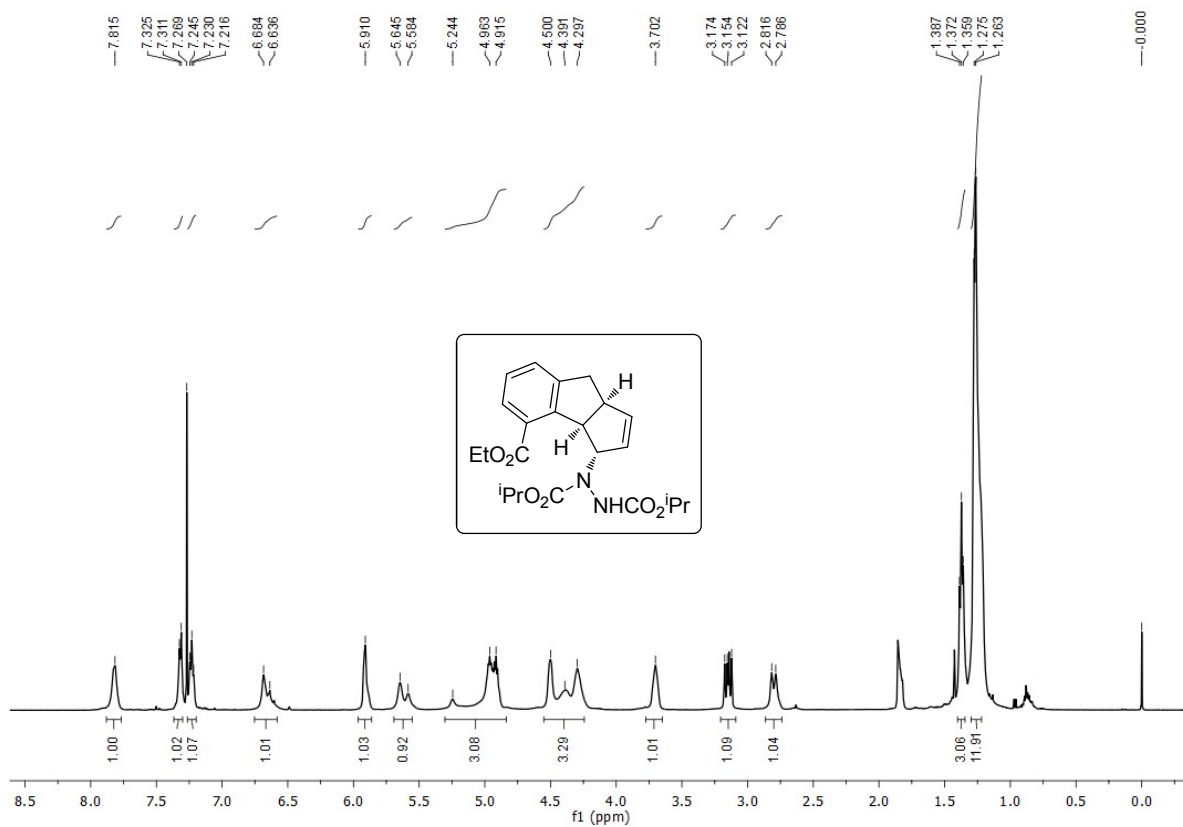
^1H and ^{13}C NMR of **8c**



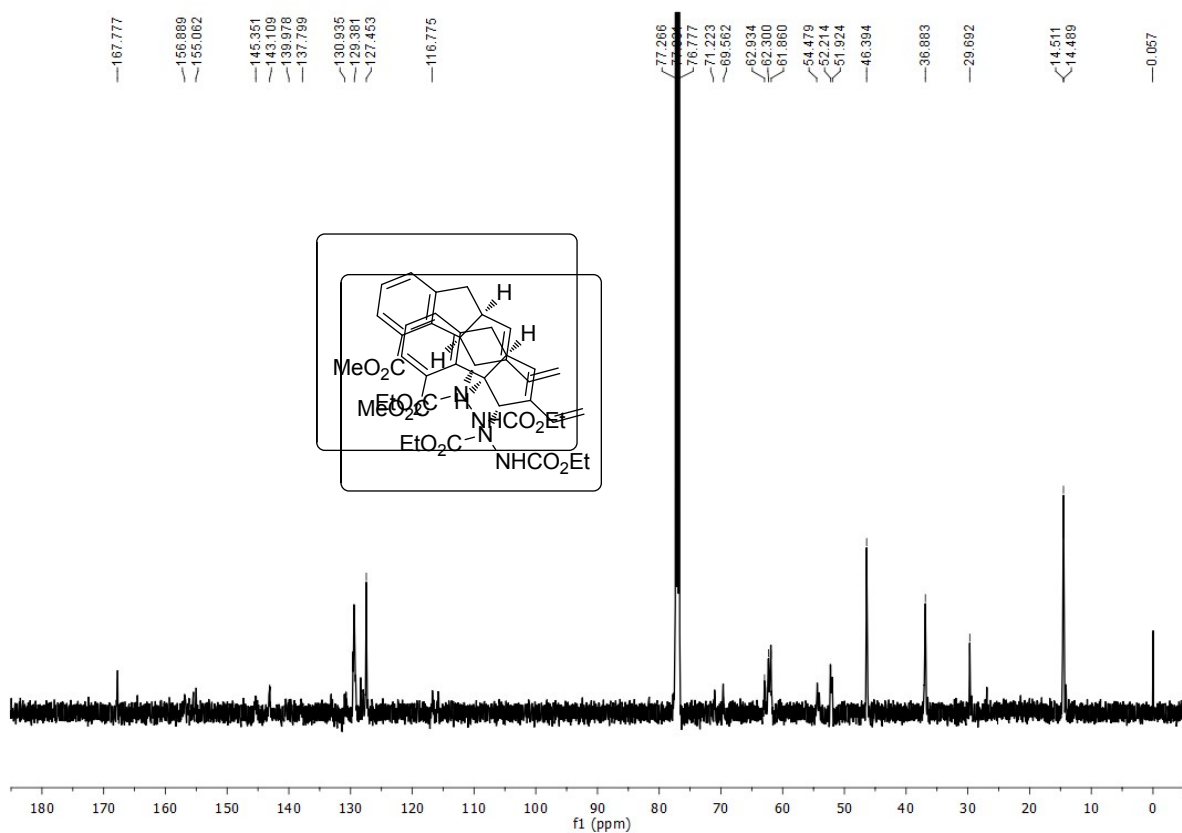
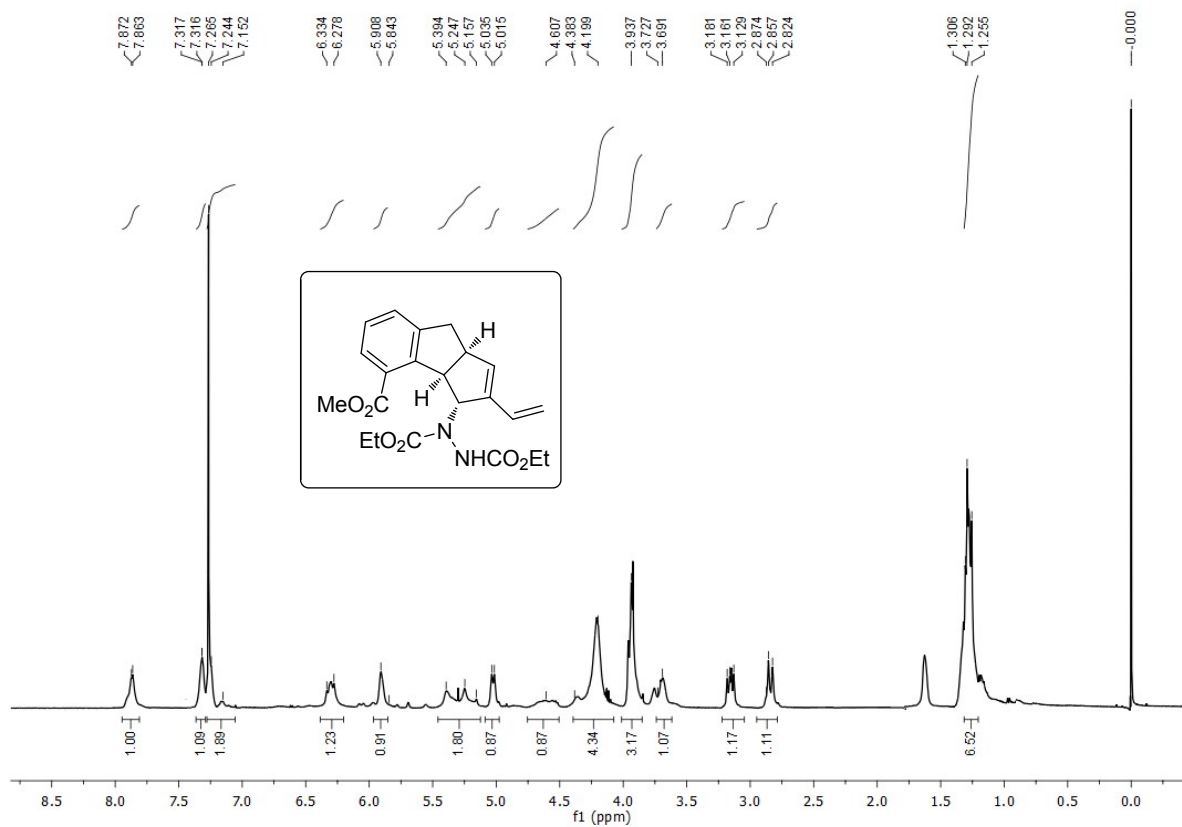
^1H and ^{13}C NMR of **8d**



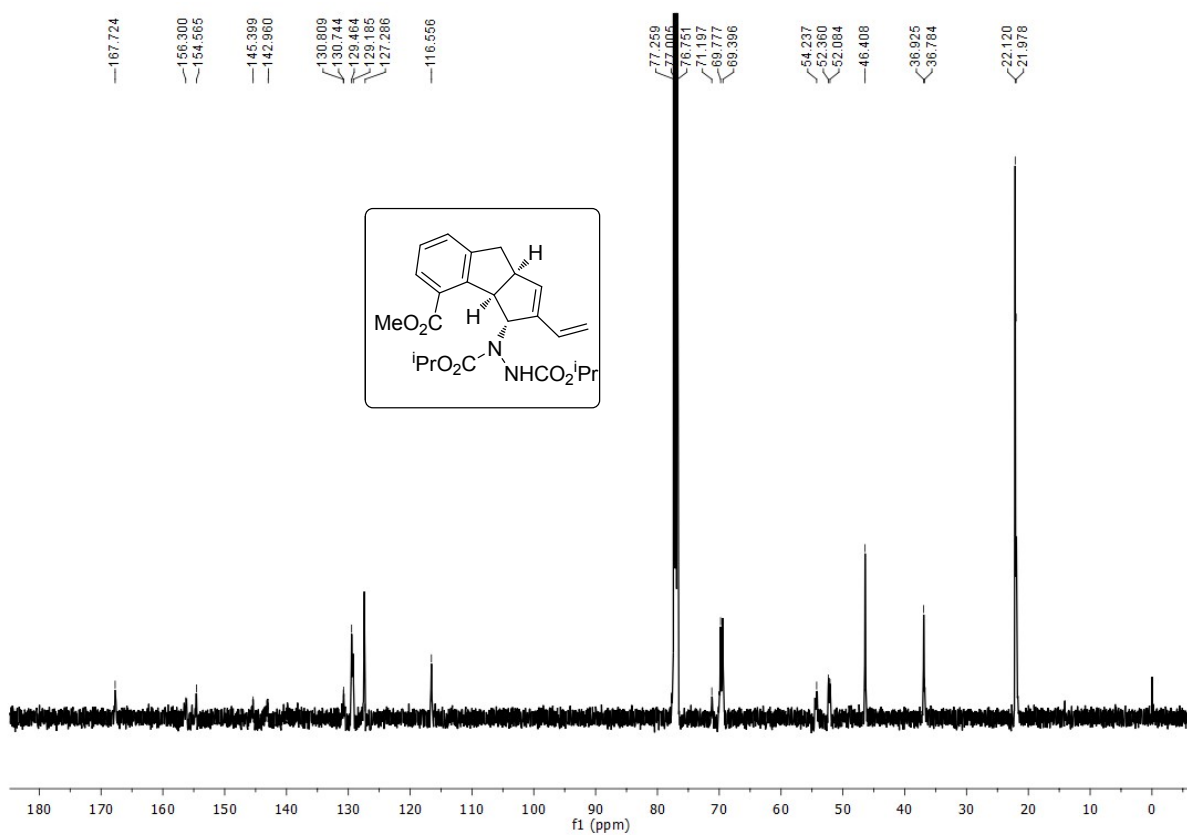
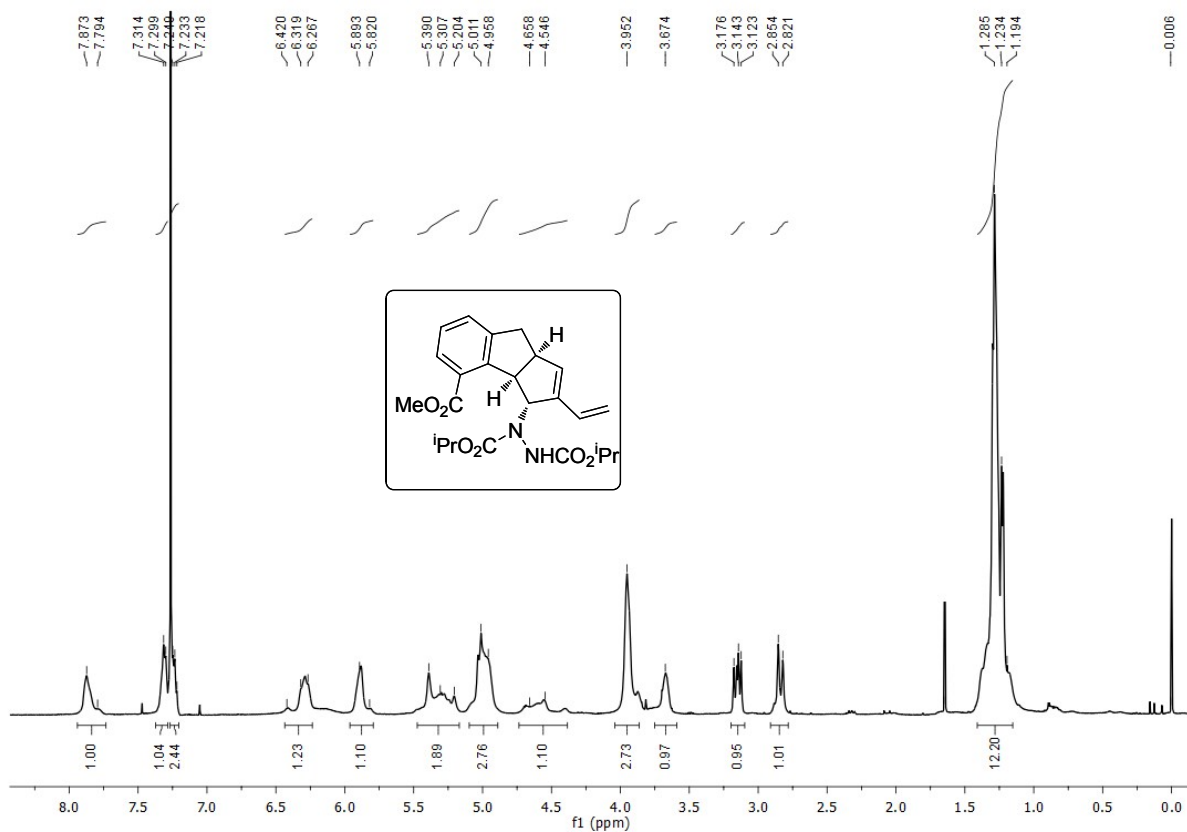
^1H and ^{13}C NMR of **8e**



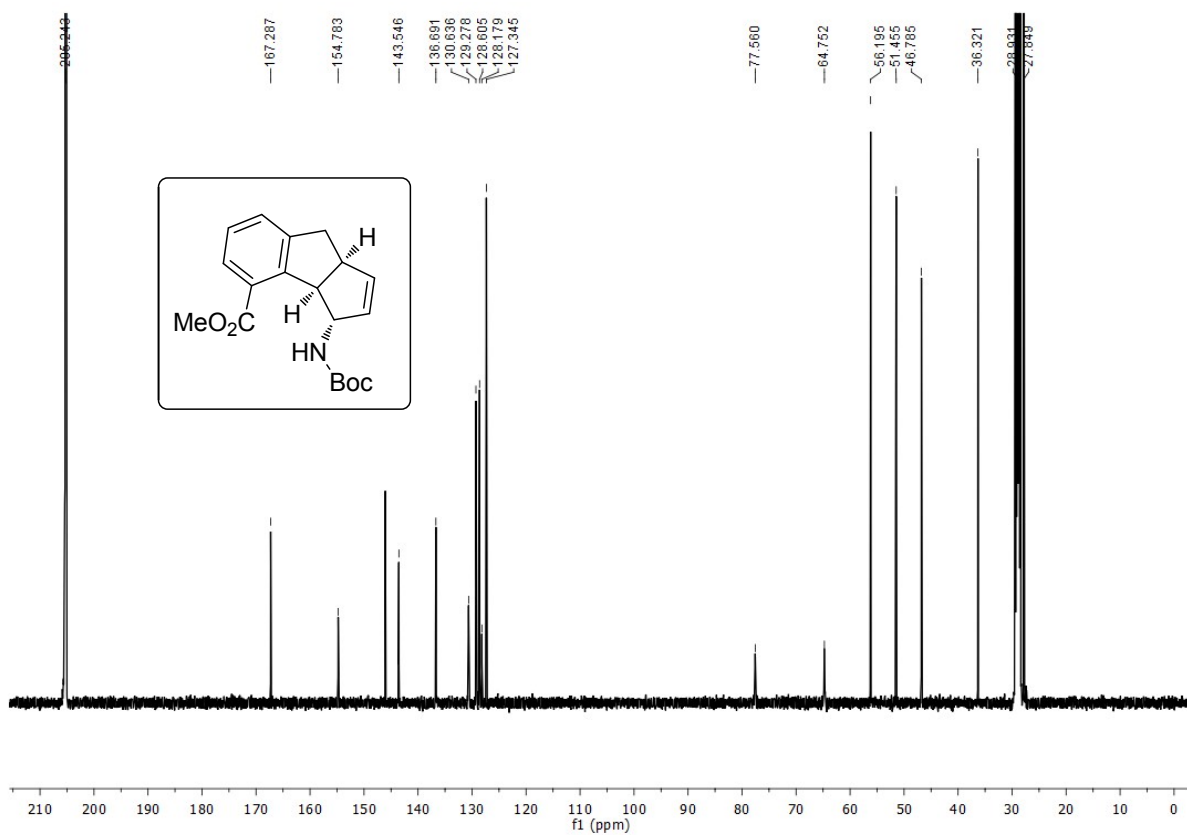
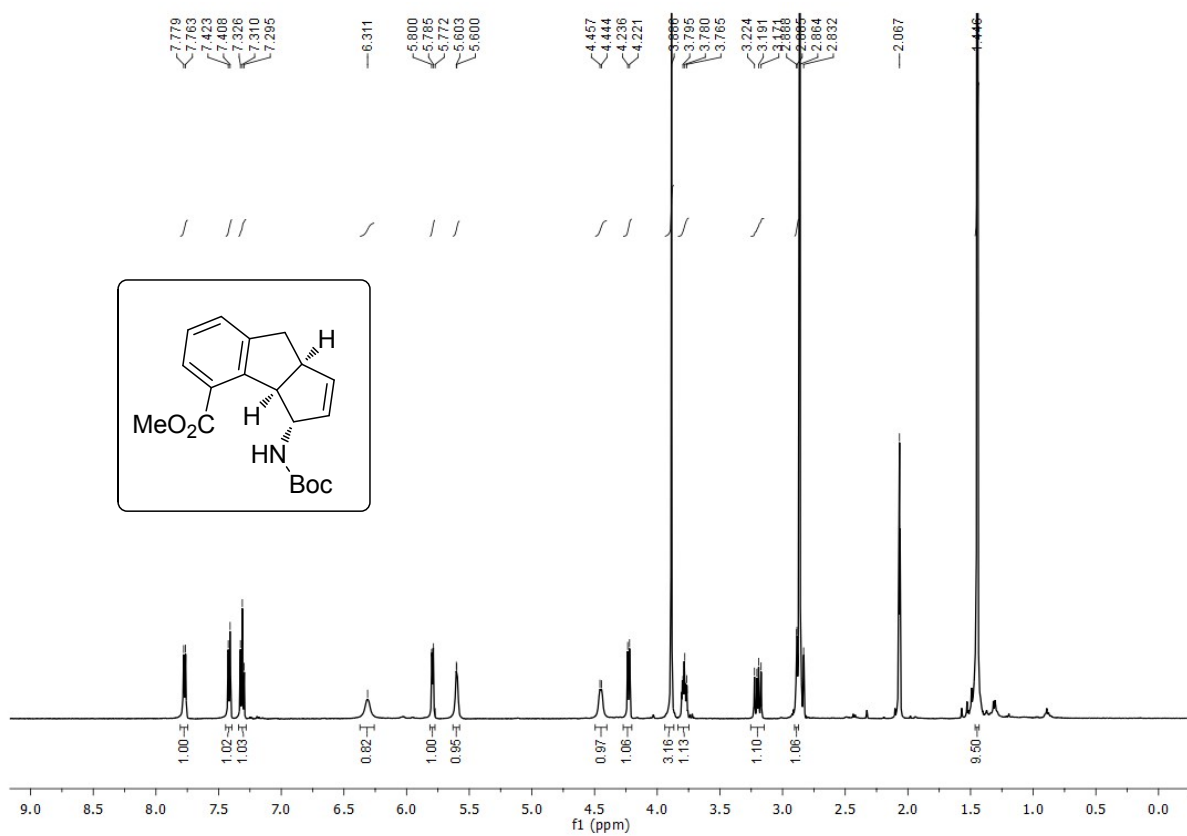
^1H and ^{13}C NMR of **8f**



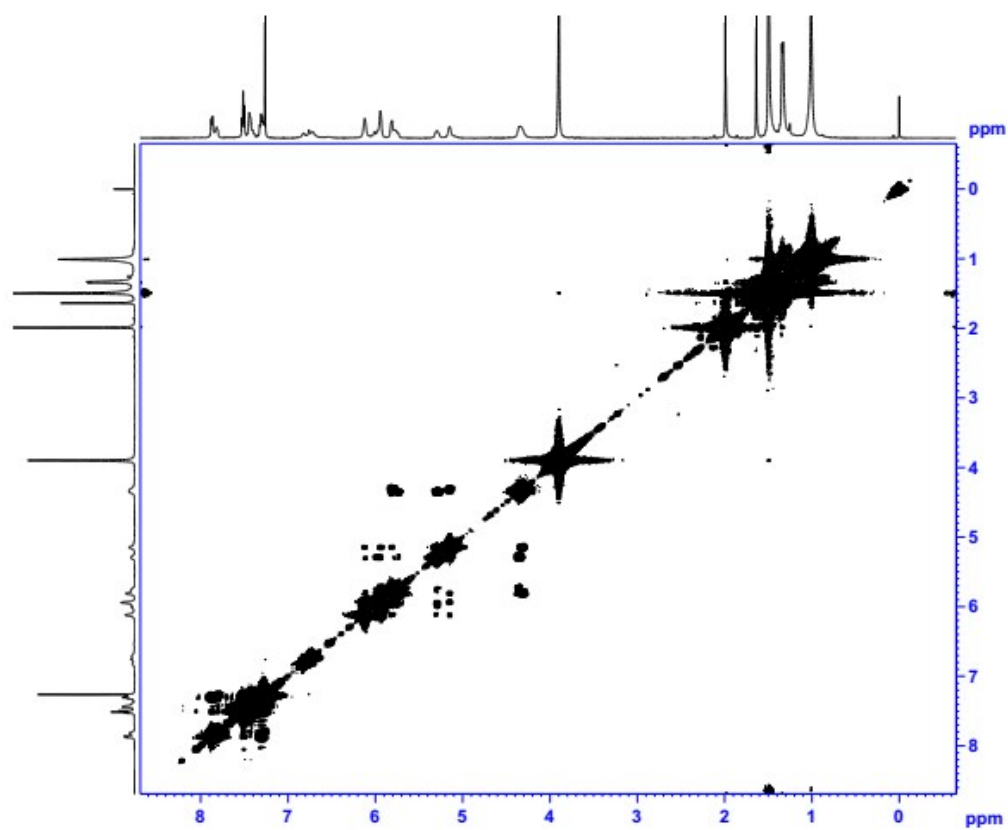
^1H and ^{13}C NMR of **8g**



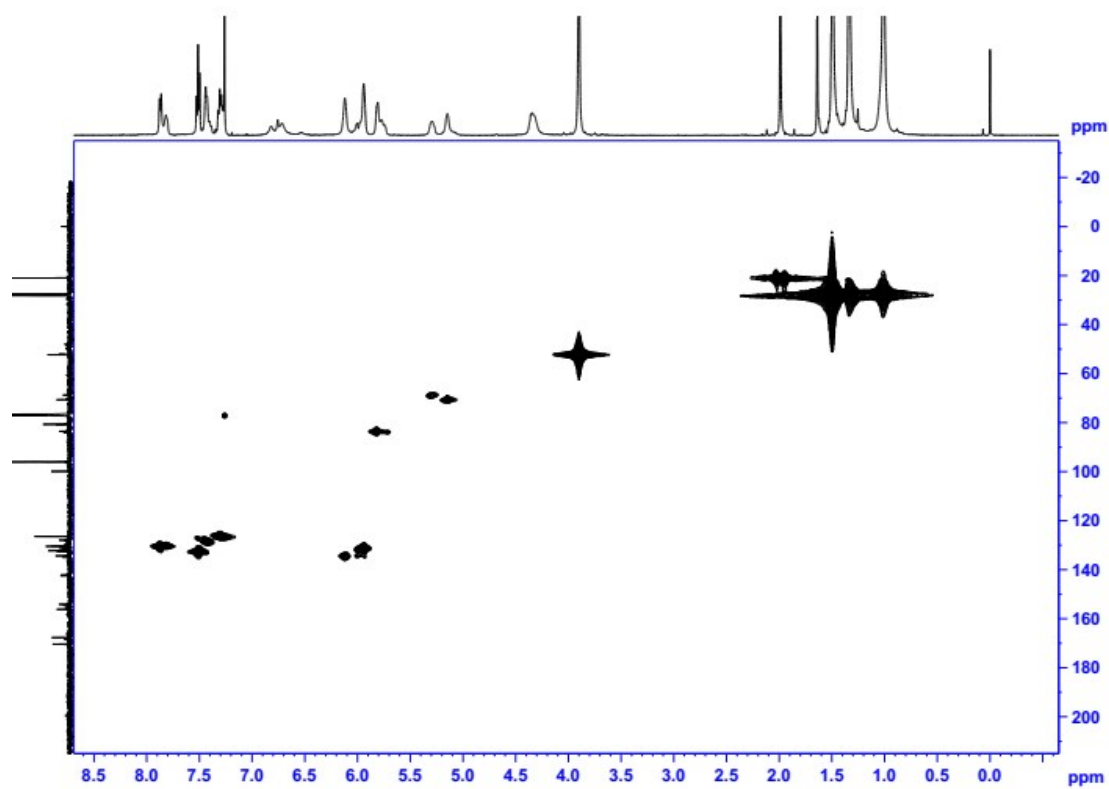
^1H and ^{13}C NMR of **9a**



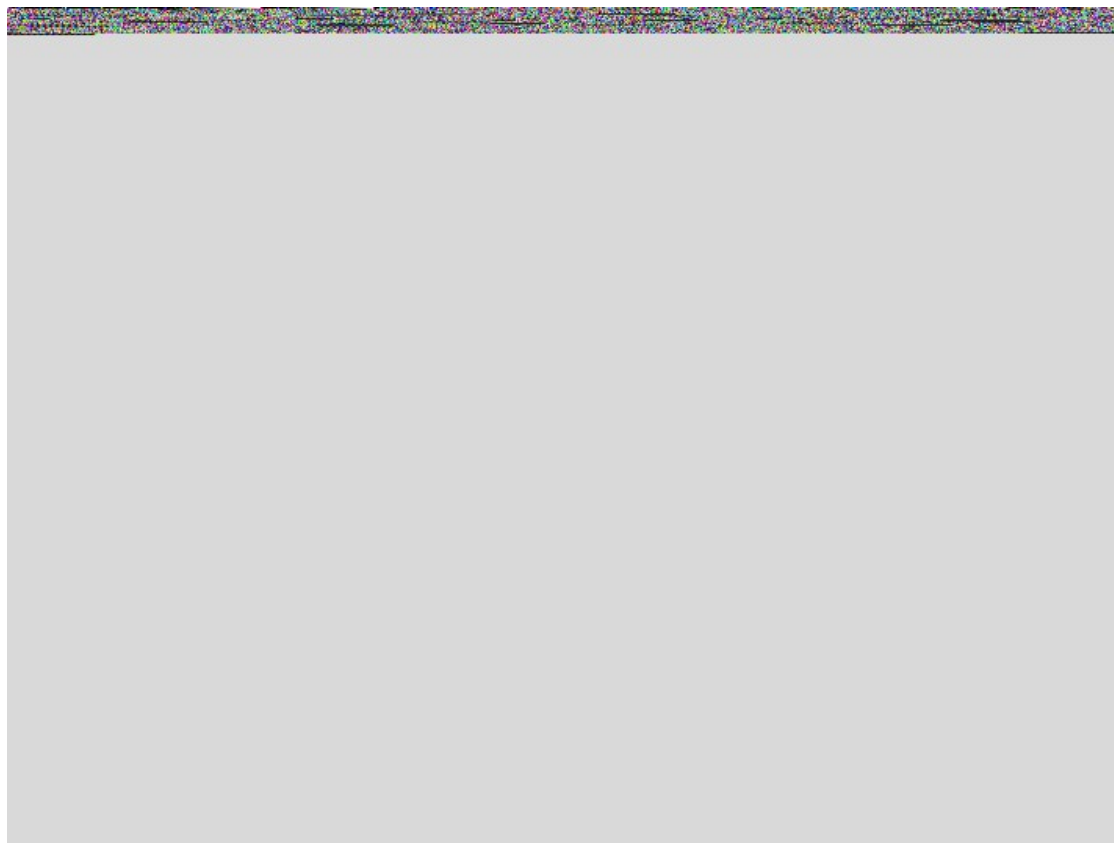
COSY of compound 3c



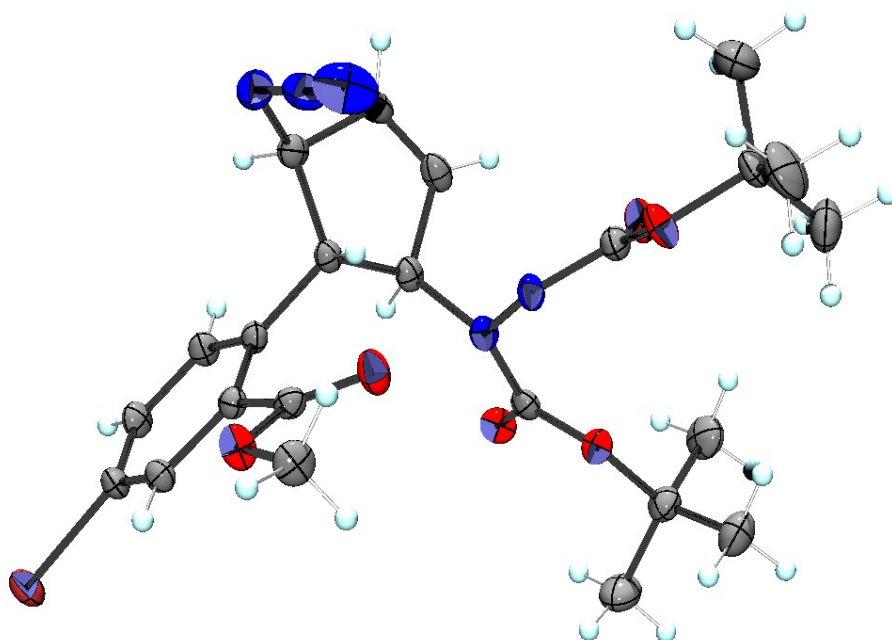
HSQC of compound 3c



HMBC of compound 3c

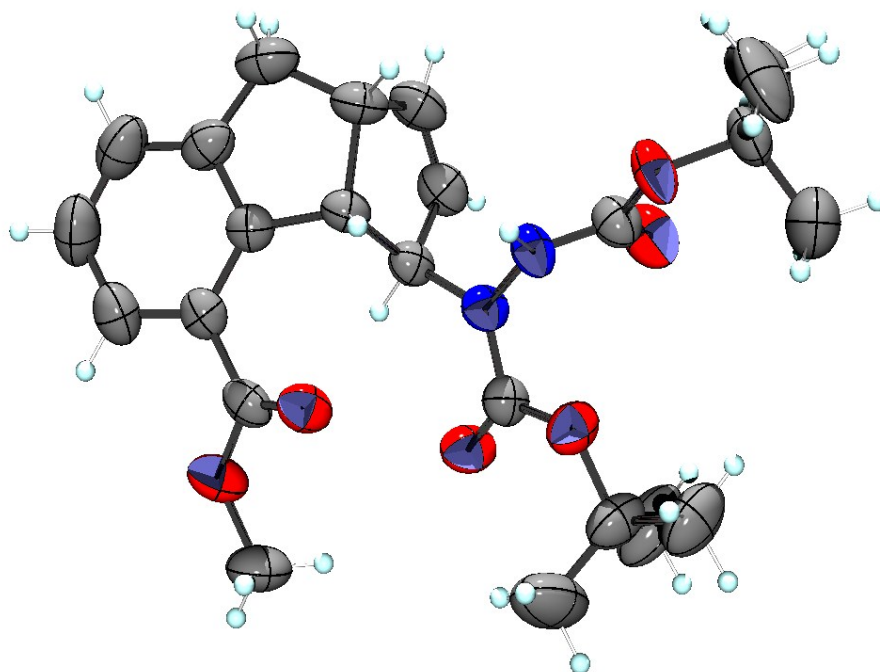


11. Single Crystal X-ray of 4e



Thermal ellipsoid plot of the organic compound **4e** (CCDC 1577519) with atom numbering scheme (50% probability factor for the thermal ellipsoids).

12. Single Crystal X-ray of 8c



Thermal ellipsoid plot of the organic compound **8c** (CCDC 1577520) with atom numbering scheme (50% probability factor for the thermal ellipsoids).