Visible-Light-Mediated Installation of Unactivated Alkyl Groups Enabling Access to Non-Natural Amino Acid Derivatives: Detailed Mechanistic Insights

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Supporting Information

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1. General Information:

1. General Information

All the reagents and solvents used in the present study were purchased from Sigma-Aldrich, TCI and Thermo Fischer Scientific, respectively. All reactions were carried out in an oven-dried reaction tube under an air atmosphere. Silica gel TLC plate was used to perform TLC analysis. All the ^{1}H spectra were recorded in a 600 MHz spectrometer and all the ^{13}C NMR spectra were recorded in a 400 MHz. ESI mass spectral analysis was done using the LCQ-ORBITRAP-XL instrument. Bruker Kappa Apex II X-ray crystallography machine was used to solve the crystal structure. Singlet (s), doublet (d), triplet (t), and multiplet (m) were designated as ^{1}H NMR multiplicity patterns. Silica gel (100−200 mesh) and (230−400 mesh) were used for column chromatographic separations. Single crystals of products were obtained through slow evaporation (at room temperature) of a solution in chloroform.

Photo reaction setup:

All photoredox reactions were performed with Kessil PR160L-blue LED lamp 390 nm (30 W), 427 nm (30 W), 440 nm (30 W), 456nm (30 W), 525 nm (30 W) Kessil LED lamps.

The lamp was placed 4.0 cm away from the reaction vials with keeping a cooling fan to maintain the reaction temperature between 25-30^{o} C during the course of the irradiation.

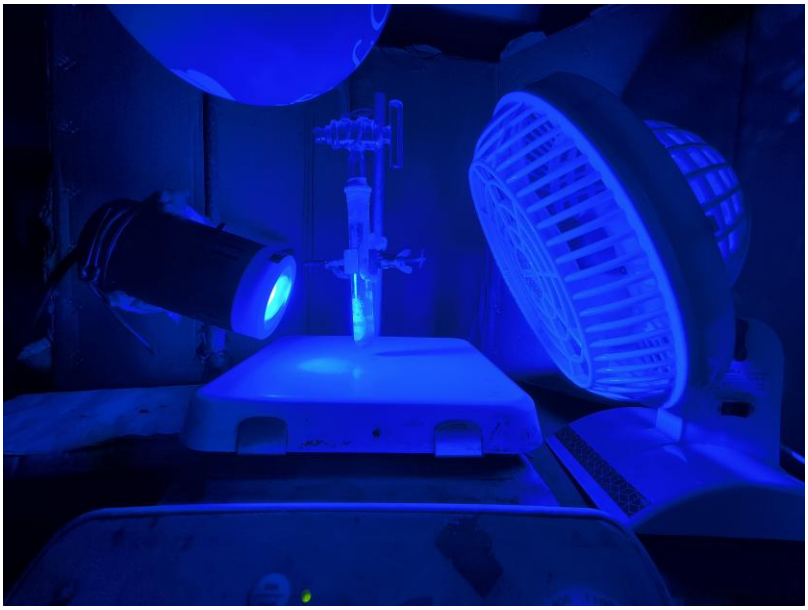
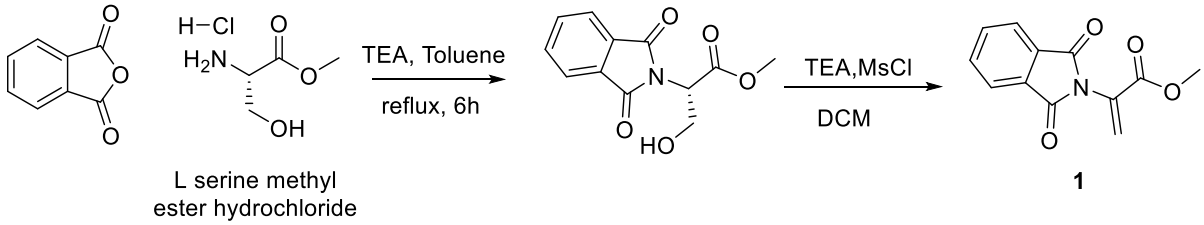


Fig S1: Photochemical reaction setup

2. General procedure A for the synthesis of olefin 1



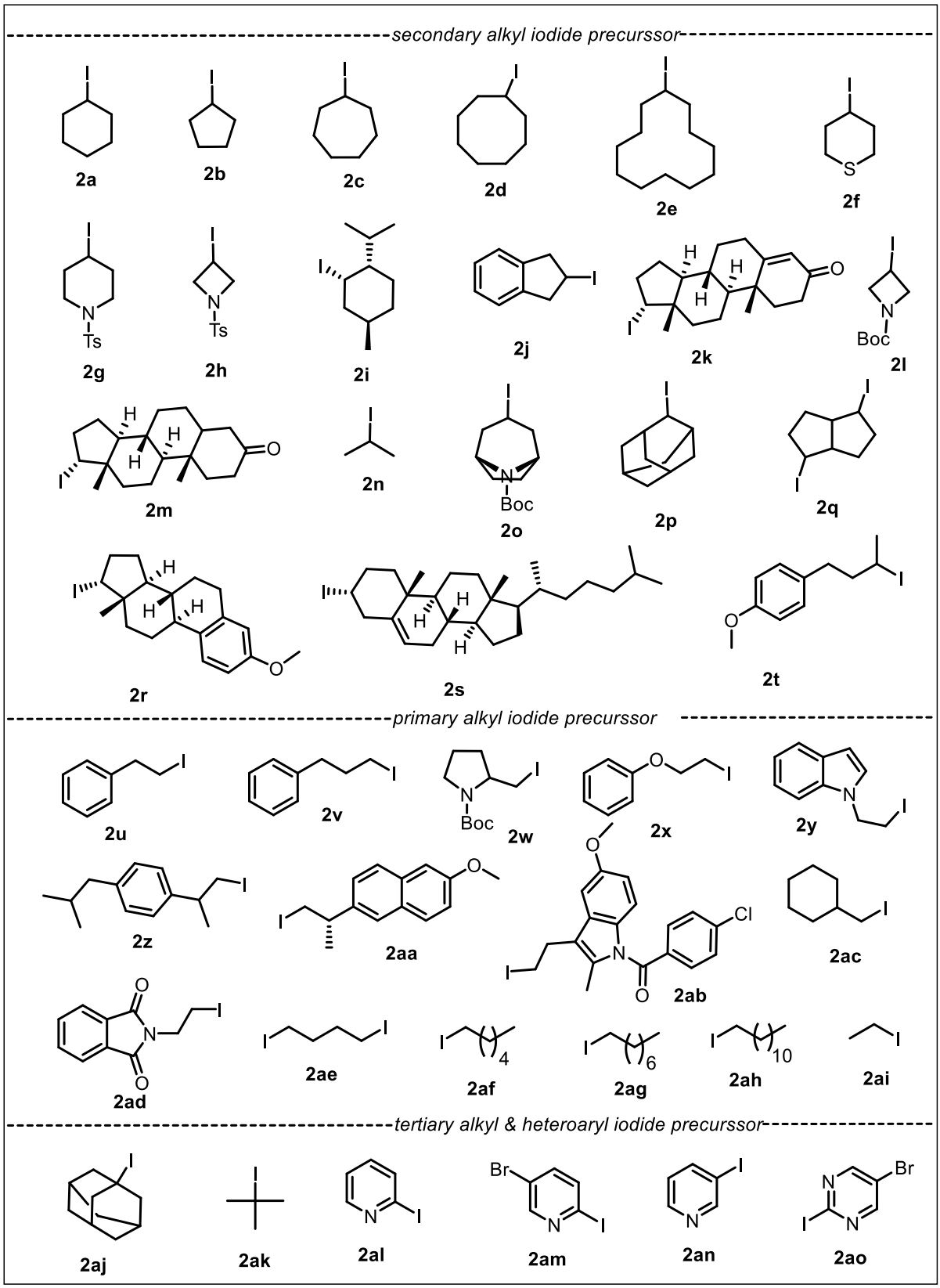
L serine methyl ester hydrochloride

1

To a solution of L-serine methyl ester hydrochloride (1.5g, 10 mmol) and phthalic anhydride (1.48g, 10 mmol) in toluene was added triethylamine (2.7ml, 20 mmol). The reaction mixture was refluxed for 6 hours. After the completion of the reaction volatiles were evaporated under reduced pressure and the residue was dissolved in EA, washed with 10% citric acid, H_2O, saturated $NaHCO_3$ and brine. Organic layer was dried over Na_2SO_4, filtered and concentrated to give the product, which was used directly in next step without further purification.

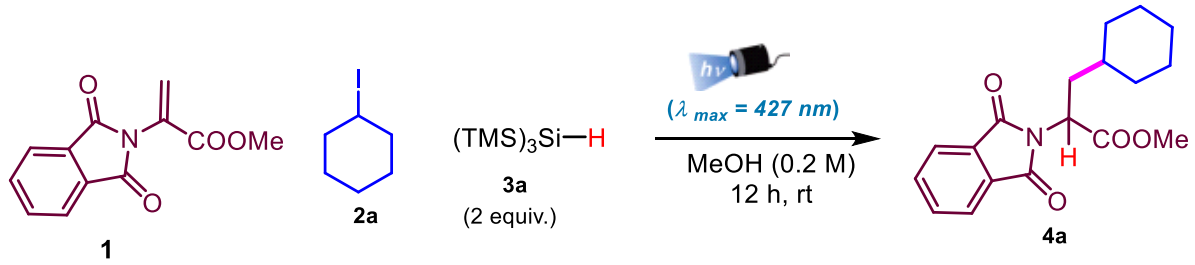
Triethyl amine (4.2ml, 30 mmol) is added during 30 min to a solution of methyl (S)-2-(1,3-dioxoisoindolin-2-yl)-3-hydroxypropanoate (2.5 g, 10 mmol) and MsCl (1.5ml, 13 mmol) in CH_2Cl_2 (20 mL) at 0°C. The reaction mixture was stirred for another 15 min at this temperature and then at rt for overnight. The solution was then washed with 0.5% aq. $KHSO_4$ until neutral. The organic phase is dried over Na_2SO_4. The solvent is evaporated; the residue was purified by flash column chromatography on silica gel (PE/EA = 10: 1) to give the desired olefin **1.** Spectral data are in accordance with reported literature data.[1]

3. Total list of alkyl and heteroaryl iodides



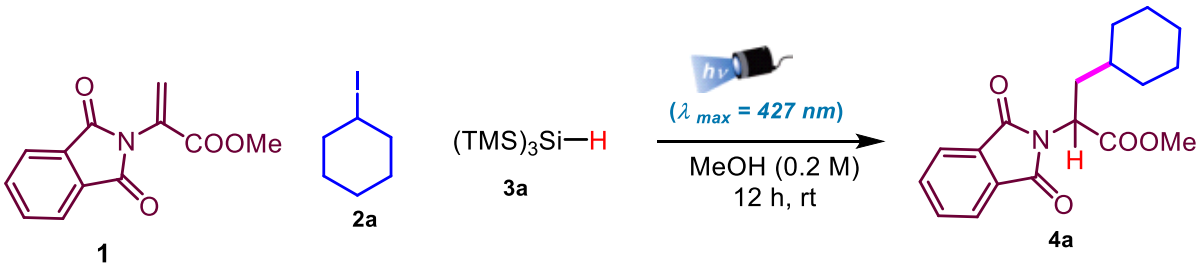
4. Optimization study:

Table S1: Optimization by varying different silanes



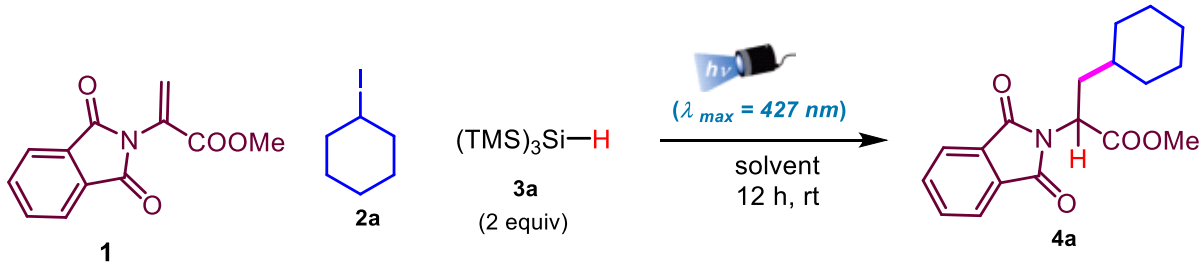
Entry	Silane source	Isolated Yield (%)
1	**$(TMS)_3SiH$ (3a)**	**77**
2	$(TMS)_3SiOH$ (3b)	nd
3	Et_3SiH (3c)	nd
4	Ph_3SiH (3d)	nd
5	$(^{i}Pr)_3SiH$ (3e)	nd

Table S2: Optimization by varying amount of silane:



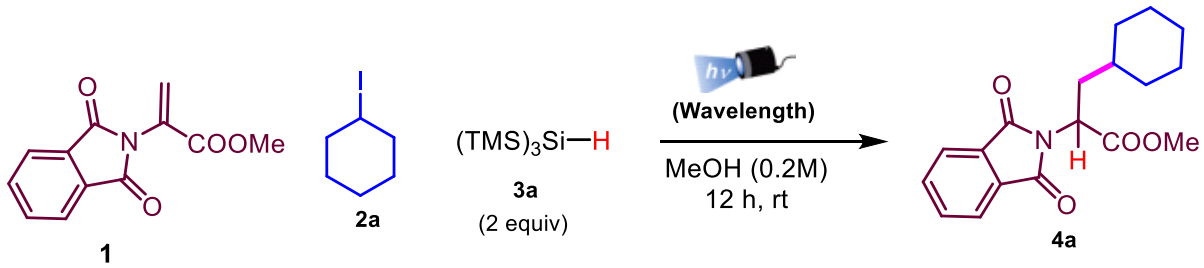
Entry	Silane (equiv.)	Isolated Yield (%)
1	1	50
2	1.5	65
3	**2**	**77**
4	2.5	75
5	3	72

Table S3: Optimization of solvents:



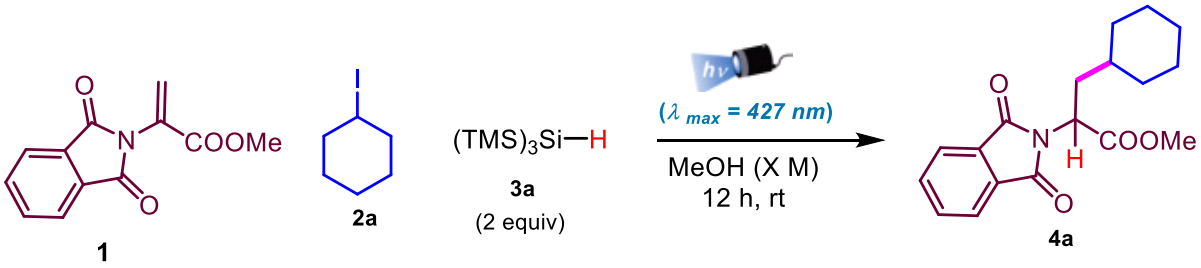
Entry	Solvent	Isolated Yield(%)
1	DCM	50
2	MeCN	65
3	EtOH	75
4	**MeOH**	**77**
5	Acetone	40
6	DCE	20
7	DMF	17
8	THF	Trace

Table S4: Optimization by varying different wavelength:



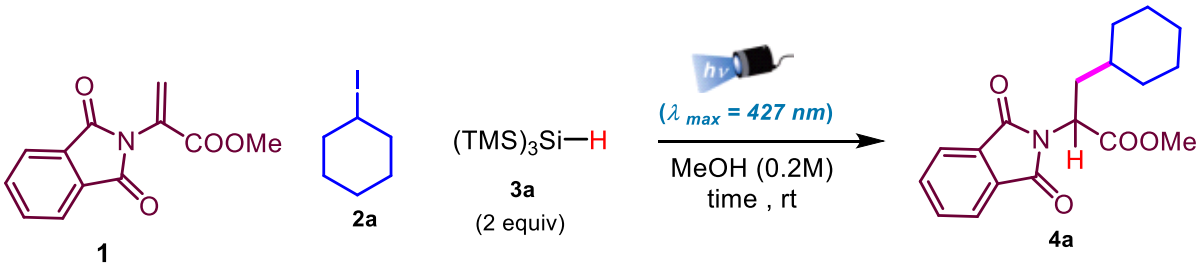
Entry	Wavelength(nm)	Isolated Yield(%)
1	Blue LED Kessil 390	60
2	**Blue LED Kessil 427**	**77**
3	Blue LED Kessil 440	30
4	Blue LED Kessil 456	75
5	Green LED Kessil 525	nd
6	No Light	trace

Table S5: Optimization of solvent concentration:



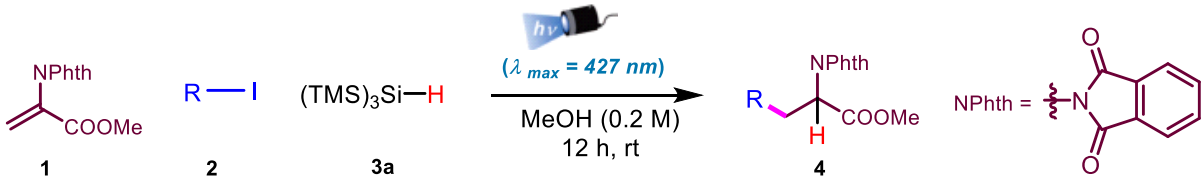
Entry	Solvent (X M)	Isolated Yield
1	0.05	50
2	0.1	62
3	**0.2**	**77**
4	0.3	65
5	0.4	64

Table S6: Reaction time optimization:



Entry	Reaction time (h)	Isolated Yield (%)
1	2	35
2	4	50
3	6	70
4	8	75
5	**12**	**77**
6	14	77

5. General procedure B:



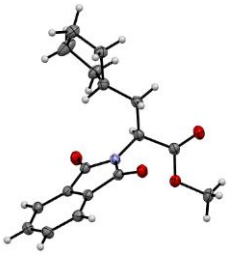
To a solution of olefin **1** (0.2 mmol, 1.0 equiv), different alkyl/hetero aryl iodides (**2a-2ao**) (0.4 mmol, 2 equiv) in dry MeOH was added (tristrimethyl)silyl silane (0.4 mmol, 2 equiv.) in a reaction tube. The reaction tube sealed and the whole mixture was de-gassed and re-filled with inert gas (3 times). The reaction mixture was stirred under 30W blue LED kessil (427 nm) for 12 hours (light irradiation needed up to 4-5 h). After completion the solvent was evaporated under reduced pressure and it was then extracted with ethyl acetate (30 ml), H_2O (10 ml × 2), washed with brine (10 ml), dried over anhydrous Na_2SO_4 and the solvent was evaporated under reduced pressure. Then the crude product subjected to Flash chromatography (silica gel 230−400 mesh size, ethyl acetate: pet ether) for further purification to get the desired products.

6. Scale up experiment:

To a solution of olefin **1** (0.24g,1 mmol), cyclohexyl iodide **2a** (0.26 ml, 2 equiv.) in dry MeOH was added (tristrimethyl)silyl silane (0.57 ml, 2 equiv.) in a reaction tube. The reaction tube sealed and the whole mixture was de-gassed and re-filled with inert gas (3 times). The reaction mixture was stirred under 30W blue LED kessil (427 nm) for 12 hours (light irradiation needed up to 4-5 h). After completion the solvent was evaporated under reduced pressure and it was then extracted with ethyl acetate (30 ml), H_2O (10 ml × 2), washed with brine (10 ml), dried over anhydrous Na_2SO_4 and the solvent was evaporated under reduced pressure. Then the crude product subjected to Flash chromatography (silica gel 230−400 mesh size, ethyl acetate: pet ether) for further purification to get the desired product 4a as colourless oil (0.22g,70% yield).

7. Crystal structure of 4b:

Thermal ellipsoid plot of 4b. Ellipsoids are represented with 50% probability.



Empirical formula	$C_{17}\ H_{19}\ N\ O_4$
Formula weight	301.345
Crystallizing solvent	$CHCl_3$

Temperature	296K
Wavelength	1.54178
Crystal system	triclinic
Space group	P-1
a [Å] b [Å] c [Å]	8.6663(7) 9.3358(7) 11.2322(9)
Angles [α, β, γ]	114.105(2) 95.762(2) 108.060(2)
Volume [Å3]	761.19(11)
Z	2
Density [g/cm3][calc.]	1.315
F(000)	321.137
Radiation	Cu K\a
Θ Range [°]	4.47-68.19
Measured reflections	2708
Observed reflections with I >= 2σ(I)	2691
Goodness-offit on F2	1.0534
restraints / parameters	0/201
Final R indexes [I>=2σ (I)]	R1 = 0.0461 wR2 = 0.1275
Final R indexes [all data]	R1 = 0.0462 Wr2 = 0.1276
Solvent system	Chloroform
Method for crystal growth	Solvent evaporation
CCDC No.	**2515509**

8. Computational study & Mechanistic Discussion:

All geometries under investigation were fully optimized using the wB97X-D[2] in combination with the def2-TZVPP basis set.[3] Solvent effects were modeled using the COSMO solvation model [4], with methanol as the solvent. Vibrational frequency analyses were then performed at the same level of theory to confirm the nature of each stationary point—minima (no imaginary frequencies) or transition states (one imaginary frequency). All computations were carried out with Gaussian 16.[5]

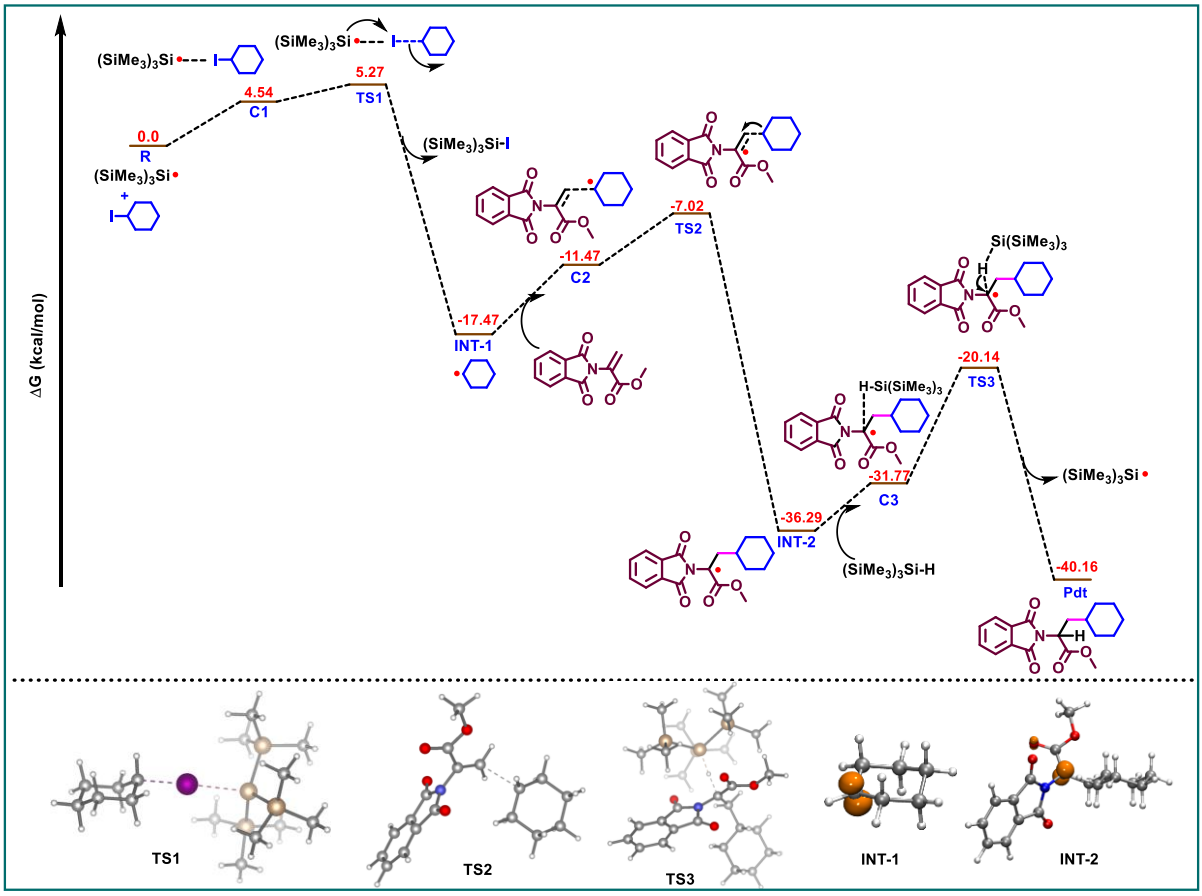
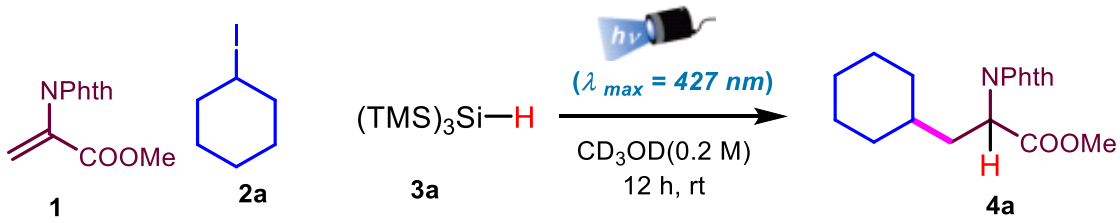


Fig S2: optimized geometries of the transition states, along with the corresponding spin density distributions for the radical intermediate

Mechanistic Discussion: The reaction proceeds through three sequential steps: (i) an XAT process, (ii) radical addition to the olefin, and (iii) a subsequent HAT step. In the proposed mechanism, a free-energy profile was constructed with the alkyl iodide and the silyl radical as the reactive species. The generated silyl radical initially associates with the alkyl iodide to form a weakly bound pre-reactive complex (**C1**). Halogen abstraction via an XAT process proceeds through the transition state **TS1**, which corresponds to the cleavage of the C–I bond and the

formation of the Si–I bond (DFT study depicts the optimized transition state geometries). In **TS1**, the Si–I bond is formed at 2.942 Å, while the C–I bond is elongated to 2.313 Å, consistent with an SN^2-type reaction pathway. The free energy profile shows that bond cleavage through **TS1** occurs with an activation barrier of 5.27 kcal/mol relative to the reactants. The resulting cycloalkyl radical intermediate (**INT-1**), together with tristrimethylsilyl iodide as a by-product, is thermodynamically stabilized. The calculated Gibbs free energy profile indicates that formation of **INT-1** is favourable, with a relative stabilization of ΔG = 12.20 kcal/mol compared to the preceding transition state, consistent with efficient radical generation. In the next step, the radical attacks the open end of the alkene. Subsequently, the carbon centred radical (**INT-1**) associates with the olefin to form a second pre-coordination complex (**C2**), which then undergoes C–C bond formation through transition state **TS2**. The activation barrier is calculated to be 10.45 kcal/mol relative to **INT-1**. In the corresponding transition state, the forming C-C bond distance is 2.514 Å. This step affords intermediate **INT-2**, which features a tertiary radical centre. Spin density analysis further confirms the localization of the unpaired electron at the tertiary carbon. The enhanced stability of **INT-2** can be attributed to hyperconjugative and inductive stabilization associated with the tertiary radical framework. Computed Gibbs free energy differences reveal that **Int-2** is significantly more stable than **TS-2** (ΔG = 29.27kcal/mol), highlighting the thermodynamic driving force for radical addition and C–C bond formation. In the subsequent propagation step, a hydrogen atom is transferred from another equivalent of TTMS to the tertiary radical (**INT-2**). This process proceeds via the coordinated intermediate **C3** and transition state **TS3**.The calculated activation barrier is 16.15Kcal/mol, which is the highest among the all steps indicating that the HAT process is the rate-determining step of the reaction pathway. In the corresponding transition state, the Si–H bond is elongated to 1.661 Å, while the forming C–H bond measures 1.515 Å. This step furnishes the final alkylated product **4a** and regenerates the silyl radical, thereby sustaining the radical chain process. The formation of **4a** is highly exergonic and entropically favorable, with an overall stabilization of $\Delta G = -40.16$ kcal/mol relative to the reactants, consistent with the formation of a strong C–H bond and a neutral, stable product framework.

9.Light On/Off experiment:



To a solution of olefin **1** (0.2 mmol, 1.0 equiv), **2a** (0.4 mmol, 2 equiv) in CD_3OD was added (tristrimethyl)silyl silane (0.4 mmol, 2 equiv.) in a reaction tube and mesitylene (0.2 mmol, 1equiv) as internal standard were added. The reaction tube sealed and the whole mixture was de-gassed and re-filled with inert gas. Before start of the reaction, ^1H NMR data was recorded. The reaction mixture was stirred under 30W blue LED kessil for 1h. Then another data was taken and allowed the reaction to stir under dark condition for another 1h. Few sets of data were taken and plotted using origin software. The NMR yield was determined using internal standard. The yield of the product with respect to time is shown below.

Entry	Time (h)	Light source	NMR Yield (%)
1	1	On	33
2	2	Off	45
3	3	On	68
4	4	Off	78
5	5	On	80
6	6	Off	82
7	7	On	84
8	8	Off	85
9	9	On	87

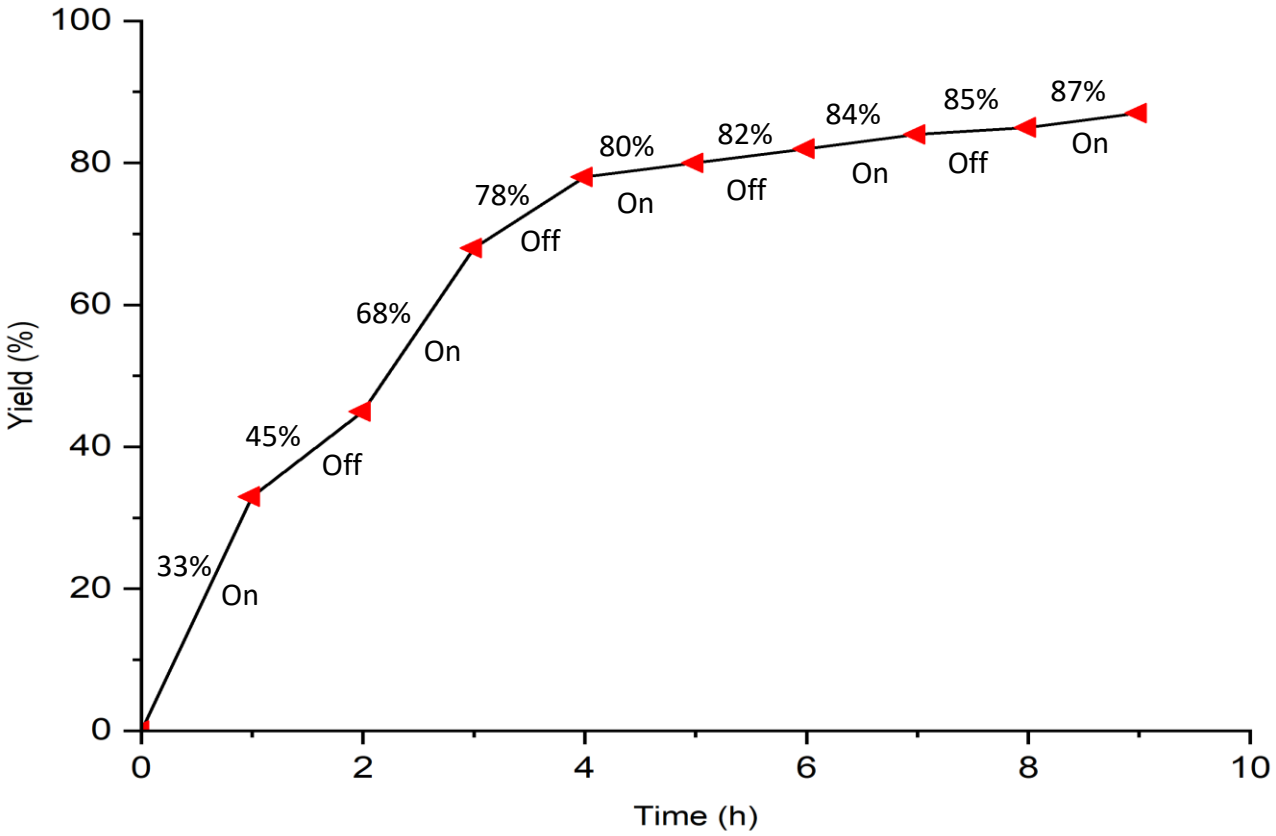
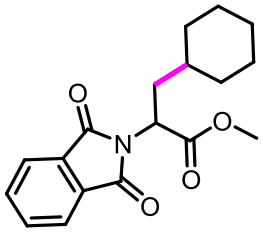


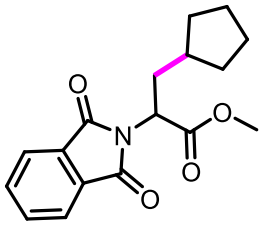
Fig.S3: Light On/Off experiment plot

9. Spectral Data:



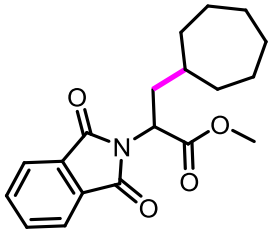
methyl 3-cyclohexyl-2-(1,3-dioxoisoindolin-2-yl)propanoate(4a):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 15% ethyl acetate/pet ether) afforded the desired product as colourless oil (48.5 mg, 77% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.0 Hz, 2H), 7.74 (d, *J* = 8.0 Hz, 2H), 4.98 (dd, *J* = 12.0, 4.O Hz, 1H), 3.70 (s, 3H), 2.29-2.22 (m, 1H), 2.05-1.97 (m, 1H), 1.88 – 1.85 (m, 1H), 1.66 – 1.58 (m, 4H), 1.18 – 1.07 (m, 4H), 1.02 – 0.83 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.50, 167.85, 134.25, 131.96, 123.64, 52.80, 50.03, 36.01, 34.42, 33.78, 31.78, 26.46, 26.21, 25.95. **HRMS (ESI)** m/z: $[M+H]^+$ Calcd for $C_{18}H_{22}NO_4$: 316.1549, found: 316.1542.

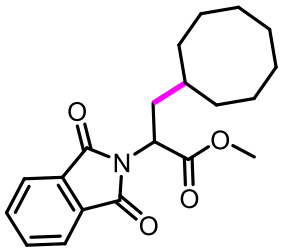


methyl 3-cyclopentyl-2-(1,3-dioxoisoindolin-2-yl)propanoate(4b):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 15% ethyl acetate/pet ether) afforded the desired product as colourless gummy (45.1 mg, 75% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 8.0 Hz, 2H), 7.74 (d, *J* = 8.0 Hz, 2H), 4.89 (dd, *J* = 12.0, 4.0 Hz, 1H), 3.71 (s, 3H), 2.45-2.38 (m, 1H), 2.14-2.07 (m, 1H), 1.85-1.77 (m, 1H), 1.72-1.63 (m, 2H), 1.61 – 1.56 (m, 2H), 1.53 – 1.42 (m, 2H), 1.24 – 1.09 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.22, 167.83, 134.24, 131.98, 123.63, 52.79, 51.89, 37.09, 34.66, 32.84, 32.03, 25.24, 25.08. **HRMS (ESI)** m/z: $[M+H]^+$ Calcd for $C_{17}H_{20}NO_4$: 302.1392, found: 302.1404.



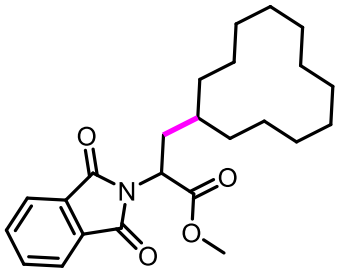
methyl 3-cycloheptyl-2-(1,3-dioxoisoindolin-2-yl) propanoate(4c):
The same general procedure B was followed. Column chromatography (SiO_2, eluting with 15% ethyl acetate/pet ether) afforded the desired product as colourless oil (78.7 mg, 74% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 8.0 Hz, 2H), 7.74 (d, *J* = 8.0 Hz, 2H), 4.95 (dd, *J* = 12.0, 4.0 Hz, 1H), 3.71 (s, 3H), 2.27-2.20 (m, 1H), 2.13-2.04 (m, 1H), 1.82 – 1.75 (m, 1H), 1.66 – 1.54 (m, 3H), 1.52 – 1.41 (m, 4H), 1.38 – 1.28 (m, 3H), 1.25-1.15 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.47, 167.85, 134.25, 131.96, 123.64, 52.80, 50.61, 36.48, 35.84, 35.34, 32.64, 28.72, 28.39, 26.32, 25.96. **HRMS (ESI)** m/z: $[M+H]^+$ Calcd for $C_{19}H_{24}NO_4$: 330.1705, found: 330.1713.



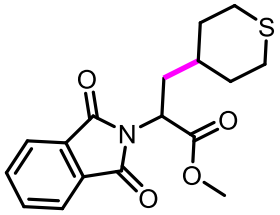
methyl 3-cyclooctyl-2-(1,3-dioxoisoindolin-2-yl)propanoate(4d):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 15% ethyl acetate/pet ether) afforded the desired product as colourless oil (48.7 mg, 71% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (d, J = 8.0 Hz, 2H), 7.75 (d, *J* = 8.0 Hz, 2H), 4.94 (dd, *J* = 12.0, 4.0 Hz, 1H), 3.71 (s, 3H), 2.25-2.18 (m, 1H), 2.13-2.07 (m, 1H), 1.74 – 1.60 (m, 3H), 1.59 – 1.48 (m, 5H),1.43 – 1.29 (m, 7H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.49, 167.88,

134.25, 131.94, 123.65, 52.81, 50.61, 36.21, 34.10, 33.17, 29.82, 27.54, 27.17, 26.21, 25.25, 25.01. **HRMS (ESI)** m/z: $[M+H]^+$ Calcd for $C_{20}H_{26}NO_4$: 344.1862, found: 344.1858.

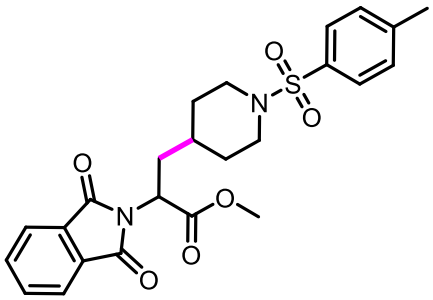


methyl 3-cyclododecyl-2-(1,3-dioxoisoindolin-2-yl)propanoate(4e):
The same general procedure B was followed. Column chromatography (SiO_2, eluting with 15% ethyl acetate/pet ether) afforded the desired product as colourless oil (55.8 mg, 70% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.0 Hz, 2H), 7.73 (d, *J* = 8.0 Hz, 2H), 4.94 (dd, *J* = 12.0, 4.0 Hz, 1H), 3.71 (s, 3H), 2.29-2.22 (m, 1H), 2.08-2.01 (m 1H), 1.43 – 1.35 (m, 3H), 1.32-1.29 (m, 7H), 1.27-1.21 (m, 7H), 1.19-1.10 (m, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.45, 167.78, 134.24, 131.94, 123.56, 52.78, 50.51, 33.51, 31.17, 28.91, 27.83, 24.83, 24.77, 24.28, 23.81, 23.62, 22.66, 22.47, 21.82, 20.75. **HRMS (ESI)** m/z: $[M+H]^+$ Calcd for $C_{24}H_{34}NO_4$: 400.2488, found: 400.2494.



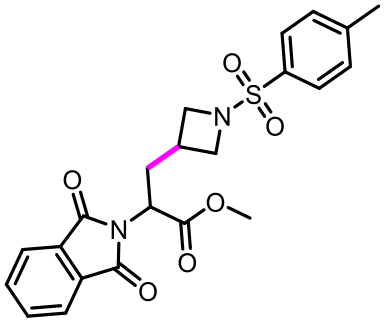
methyl 2-(1,3-dioxoisoindolin-2-yl)-3-(tetrahydro-2H-thiopyran-4-yl)propanoate(4f):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 15% ethyl acetate/pet ether) afforded the desired product as colourless oil (47.9 mg, 72% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.76 (d, *J* = 8.0 Hz, 2H), 4.96 (dd, *J* = 12.0, 4.0 Hz, 1H), 3.71 (s, 3H), 2.60-2.51 (m, 4H), 2.31 – 2.07 (m, 3H), 1.94 – 1.89 (m, 1H), 1.49 – 1.33 (m, 2H), 1.25-1.18 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.12, 167.82, 134.41, 131.85, 123.75, 52.94, 49.39, 35.99, 34.61, 34.06, 32.70, 28.55, 28.40. **HRMS (ESI)** m/z: $[M+H]^+$ Calcd for $C_{17}H_{20}NO_4S$: 334.1113, found: 334.1101.



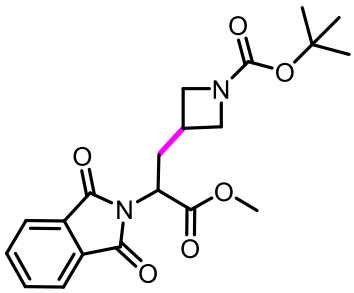
methyl 2-(1,3-dioxoisoindolin-2-yl)-3-(1-tosylpiperidin-4-yl)propanoate(4g):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as colourless oil (69.5 mg, 74% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.83-7.81 (m, 2H), 7.75 – 7.71 (m, 2H), 7.59 – 7.56 (m, 2H), 7.27 (d, *J* = 8.0 Hz, 2H), 4.88 (dd, *J* = 12.0, 4.0 Hz, 1H), 3.76 – 3.69 (m, 4H), 2.37 (s, 3H), 2.31-2.23 (m, 1H), 2.15 – 2.01 (m, 3H), 1.92 (dt, *J* = 16.0, 4.0 Hz, 1H), 1.65 – 1.59 (m, 2H), 1.40 – 1.24 (m, 2H), 1.14-1.03 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.82, 167.74, 143.47, 134.43, 133.15, 131.77, 129.66, 127.81, 123.73, 52.97, 49.59, 46.29, 46.21, 34.93, 32.10, 31.85, 30.25, 21.56. **HRMS (ESI)** m/z: $[M+H]^+$ Calcd for $C_{24}H_{27}N_2O_6S$: 471.1590, found: 471.1588



methyl 2-(1,3-dioxoisoindolin-2-yl)-3-(1-tosylazetidin-3-yl)propanoate(4h):

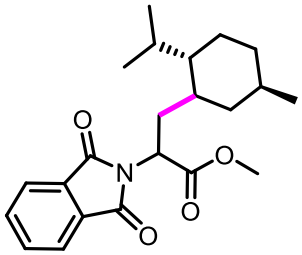
The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as colourless oil (61.8 mg, 70% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 – 7.83 (m, 2H), 7.77-7.74 (m, 2H), 7.67 (d, *J* = 8.0 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 4.64 (dd, *J* = 8.0, 4.0 Hz, 1H), 3.84 – 3.69 (m, 5H), 3.46 (dd, *J* = 8.0, 4.0 Hz, 1H), 3.38 (t, *J* = 8.0 Hz, 1H), 2.42 (d, *J* = 4.0 Hz, 3H), 2.38 (t, J = 4.0 Hz, 1H), 2.27-2.22 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.00, 167.42, 144.23, 134.62, 131.59, 129.87, 128.42, 127.27, 123.84, 55.54, 55.43, 53.03, 49.81, 32.69, 26.24, 21.67.
HRMS (ESI) m/z: [M+H]+ Calcd for $C_{22}H_{23}N_2O_6S$: 443.1277, found: 443.1260.



tert-butyl 3-(2-(1,3-dioxoisoindolin-2-yl)-3-methoxy-3-oxopropyl)azetidine-1-carboxylate(4i):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 18% ethyl acetate/pet ether) afforded the desired product as colourless oil (52.7 mg, 68% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (dd, J = 8.0, 4.0 Hz, 2H), 7.76 (dd, J = 8.0, 4.0 Hz, 2H), 4.78 (dd, J = 8.0, 4.0 Hz, 1H), 3.98 (t, J = 8.0 Hz, 1H), 3.91 (d, J = 8.0 Hz, 2H), 3.73 (s, 3H), 3.65

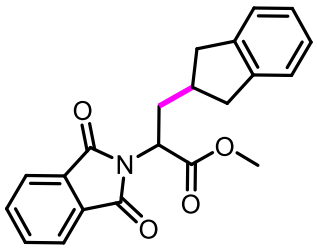
(dd, J = 8.0, 4.0 Hz, 1H), 3.57-3.49 (m, 1H), 2.49 (d, J = 4.0 Hz, 2H), 1.39 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.28, 167.55, 156.28, 134.52, 131.70, 123.81, 79.60, 53.21, 53.01, 50.20, 43.90, 33.30, 28.45, 26.38, 23.81. **HRMS (ESI)** m/z: [M+Na]+ Calcd for $C_{20}H_{24}N_2NaO_6$: 411.1532, found: 411.1523.



dr 1:2

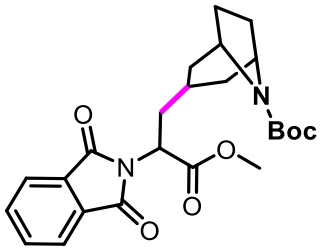
methyl2-(1,3-dioxoisoindolin-2-yl)-3-((1S,2S,5R)-2-isopropyl-5-methylcyclohexyl)propanoate(4j):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 15% ethyl acetate/pet ether) afforded the desired product as colourless oil (50.4 mg, 68% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 – 7.84 (m, 2H), 7.74 – 7.72 (m, 2H), 5.03-4.94 (m, 0.3H), 4.93-4.83 (m, 0.6H), 3.71 – 3.70 (m, 3H), 2.84-2.77 (m, 0.19H), 2.71-2.64 (0.37H), 2.32-2.32 (0.23H), 2.30-2.18 (m, 0.12H), 2.18-2.10 (m, 0.29H), 2.04-1.96 (m, 0.8H), 1.95-1.90 (m, 0.41H), 1.81 – 1.72 (m, 0.87H), 1.70-1.64 (m, 1.80H), 1.62-1.54 (m, 2.22H), 0.97 – 0.94 (m, 1.39H), 0.92-0.72 (m, 10.65H), 0.71-0.59 (m, 1.59H), 0.51-0.49 (m, 0.73H). **^{13}C NMR** (101 MHz, $CDCl_3$) $^{\delta}$ 170.33, 167.71, 134.25, 131.92, 123.63, 52.76, 51.72, 50.38, 48.73, 47.70, 41.71, 40.60, 37.20, 35.13, 33.53, 32.77, 31.79, 26.74, 24.39, 22.73, 21.70, 15.37.
HRMS (ESI) m/z: [M+H]+ Calcd for $C_{22}H_{30}NO_4$: 372.2175, found: 372.2162.



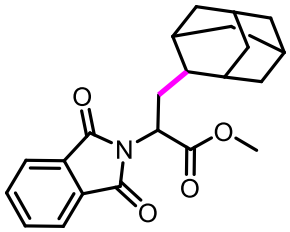
methyl 3-(2,3-dihydro-1H-inden-2-yl)-2-(1,3-dioxoisoindolin-2-yl)propanoate(4k):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 18% ethyl acetate/pet ether) afforded the desired product as colourless oil (48.8 mg, 70% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.74 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.18 – 7.07 (m, 4H), 5.01 (dd, *J* = 12.0, 4.0 Hz, 1H), 3.73 (s, 3H), 3.11 – 2.95 (m, 2H), 2.72 – 2.57 (m, 3H), 2.40 – 2.32 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.97, 167.83, 142.95, 142.70, 134.36, 131.88, 126.35, 124.59, 124.40, 123.70, 52.90, 51.35, 39.31, 38.40, 37.31, 34.15.
HRMS (ESI) m/z: [M+H]+ Calcd for $C_{21}H_{20}NO_4$: 350.1392, found: 350.1374.



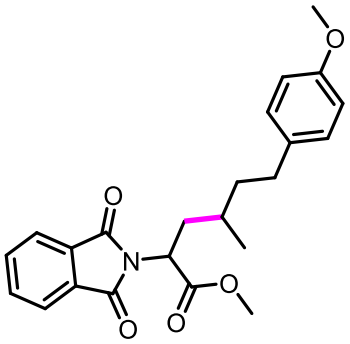
tert-butyl 3-(2-(1,3-dioxoisoindolin-2-yl)-3-methoxy-3-oxopropyl)-8-azabicyclo[3.2.1]octane-8-carboxylate(4l):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as colourless oil (57.4 mg, 65% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 8.0 Hz, 2H), 7.76 (d, *J* = 8.0 Hz, 2H), 4.90 (dd, *J* = 12.0, 4.0 Hz, 1H), 4.18-4.10 (m, 2H), 3.70 (s, 3H), 2.24-2.17 (m, 1H), 2.06-1.99 (m, 1H), 1.86-1.81 (m, 2H), 1.77-1.65 (m, 3H), 1.50-1.46 (m, 2H), 1.44 (s, 9H), 1.41-1.35 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.02, 167.80, 153.42, 134.42, 131.83, 123.75, 79.20, 53.41, 53.28, 52.91, 49.86, 37.75, 36.72, 35.77, 28.61, 28.39, 28.23, 28.11, 25.76. **HRMS (ESI)** m/z: [M+Na]+ Calcd for $C_{24}H_{30}NaN_2O_6$: 465.2002, found: 465.2008.



methyl 3-(adamantan-2-yl)-2-(1,3-dioxoisoindolin-2-yl)propanoate(4m):

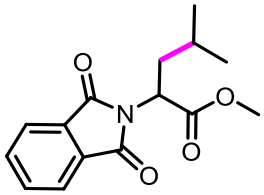
The same general procedure B was followed. Column chromatography (SiO_2, eluting with 15% ethyl acetate/pet ether) afforded the desired product as colourless oil (49.9 mg, 68% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 4.0 Hz, 2H), 7.73 (dd, *J* = 8.0, 4.0 Hz, 2H), 4.89 (dd, *J* = 12.0, 4.0 Hz, 1H), 3.72 (s, 3H), 2.58-2.50 (m, 1H), 2.29 – 2.21 (m, 1H), 1.95 – 1.84 (m, 3H), 1.83-1.78 (m, 3H), 1.77-1.72 (m, 1H), 1.70-1.67 (m, 2H), 1.61-1.56 (m, 4H), 1.54-1.47 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.53, 167.90, 134.25, 131.94, 123.66, 52.83, 50.62, 41.03, 39.16, 38.90, 38.29, 32.99, 31.91, 31.58, 31.36, 29.88, 28.12, 27.99. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{22}H_{26}NO_4$: 368.1862, found: 368.1856.



dr 1:1.1

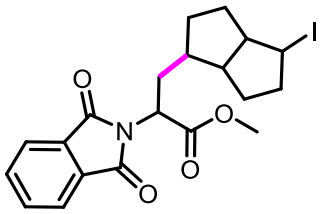
methyl (4R)-2-(1,3-dioxoisoindolin-2-yl)-6-(4-methoxyphenyl)-4-methylhexanoate(4n):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as colourless oil (52.1 mg, 66% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86-7.82 (m, 2H), 7.75-7.71 (m, 2H), 7.03-6.96 (m, 2H), 6.70 – 6.65 (m, 2H), 4.99 – 4.96 (m, 0.45H), 4.95-4.93 (m, 0.45H), 3.72 (d, *J* = 8.0 Hz, 3H), 3.70 (s, 3H), 2.65 – 2.56 (m, 0.65H), 2.54 – 2.49 (m, 0.97H), 2.47-2.38 (0.74H), 2.27-2.11 (m, 1H), 1.96-1.88 (m, 0.42H), 1.80 – 1.75 (m, 0.53H), 1.75-1.68 (m, 0.49H), 1.60-1.46 (m, 0.85H), 1.40-1.28 (m, 1.18H), 0.99 (t, *J* = 8.0 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.39, 167.83, 157.61, 134.46, 134.33, 134.25, 134.19, 131.91, 131.87, 129.35, 129.23, 123.63, 123.59, 55.22, 52.82, 50.45, 50.30, 39.44, 36.92, 35.83, 35.15, 32.20, 31.96, 29.21, 19.82, 18.87. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{23}H_{26}NO_5$: 396.1811, found: 396.1823.



methyl 2-(1,3-dioxoisoindolin-2-yl)-4-methylpentanoate(4o):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 15% ethyl acetate/pet ether) afforded the desired product as colourless oil (33.6 mg, 66% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 4.0 Hz, 2H), 7.73 (dd, *J* = 8.0, 4.0 Hz, 2H), 4.95 (dd, *J* = 12.0, 8.0 Hz, 1H), 3.70 (s, 3H), 2.34-2.27 (m, 1H), 1.97-1.90 (m, 1H), 1.51-1.41 (m, 1H), 0.93 (dd, *J* = 12.0, 4.0 Hz, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.37, 167.84, 134.26, 131.94, 123.62, 52.81, 50.70, 37.35, 25.14, 23.25, 21.09. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{15}H_{18}NO_4$: 276.1236, found: 276.1241.

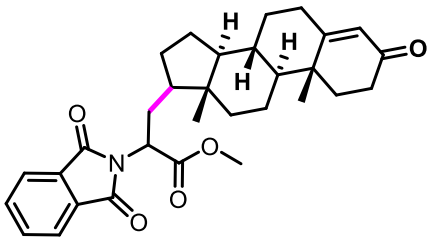


dr 1:1.1

Methyl 2-(1,3-dioxoisoindolin-2-yl)-3-((1R)-4-iodooctahydropentalen-1-yl)propanoate(4p):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as light-brown gummy (59.7 mg, 64% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.88-7.84 (m, 2H), 7.76 – 7.71 (m, 2H), 4.90 – 4.87 (m, 0.45H), 4.86-4.83 (m, 0.48H), 4.09 – 4.01 (m, 0.42H), 4.00-3.90 (m, 0.41H), 3.71 (s, 3H), 2.40-2.31 (m, 0.49H), 2.30-2.22 (m, 0.51H), 2.13-2.03 (m, 1.45H), 2.01-1.91 (m, 1.42H), 1.90-1.76 (m, 2H), 1.75-1.64 (m, 1H), 1.59-1.56 (m, 1H), 1.53-1.43 (m, 0.73H), 1.41-1.34 (m, 0.58), 1.32-1.18 (m, 2H), 1.15 – 0.99 (m, 0.95H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.01, 167.88, 134.37, 131.87, 123.74, 57.11, 52.90, 51.46, 48.60, 47.76, 47.29, 46.62, 36.47, 35.44, 34.80,

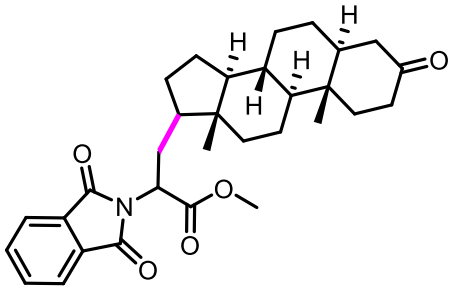
34.09, 33.32, 32.04, 31.66, 31.47. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{20}H_{23}INO_4$: 468.0672, found: 468.0667.



dr 1:2.7:1.7

methyl3-((8S,9S,10R,13R,14S,17R)-10,13-dimethyl-3-oxo-2,3,6,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[a]phenanthren-17-yl)-2-(1,3-dioxoisoindolin-2-yl)propanoate(4q):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 18% ethyl acetate/pet ether) afforded the desired product as colourless oil (65.4 mg, 65% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87-7.84 (m, 2H), 7.76-7.72 (m, 2H), 6.22 – 6.15 (m, 0.5H), 5.71-5.69 (m, 0.37H), 5.15-5.11 (m, 0.31H), 4.88 – 4.86 (m, 0.17H), 4.86-4.83 (m, 0.46H), 4.82-4.81 (m, 0.29H), 3.71-3.69 (m, 3H), 3.57 (d, *J* = 12.0 Hz, 1H), 2.58 – 2.46 (m, 2H), 2.43 – 2.34 (m, 2H), 2.26-2.12 (m, 1H), 2.05-1.95 (m, 2H), 1.93-1.79 (m, 3H), 1.74 – 1.61 (m, 4H), 1.57 – 1.45 (m, 2H), 1.40-1.23 (m, 4H), 1.16 – 1.13 (m, 3H), 1.09 (d, *J* = 4.0 Hz, 1H), 0.86 – 0.83 (m, 1H), 0.79-0.67 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 199.69, 171.47, 169.91, 167.74, 159.23, 150.10, 134.31, 131.89, 123.67, 109.18, 54.78, 53.67, 52.86, 51.74, 50.45, 49.12, 44.84, 43.03, 38.72, 36.54, 35.89, 34.04, 33.75, 32.99, 32.67, 32.50, 29.26, 25.95, 20.83, 17.47, 16.54.
HRMS (ESI) m/z: [M+H]+ Calcd for $C_{31}H_{38}NO_5$: 504.2750, found: 504.2744.

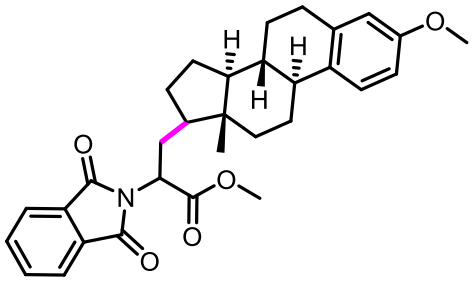


dr 1:3

methyl 3-((5S,8S,9S,10S,13R,14S,17R)-10,13-dimethyl-3-oxohexadecahydro-1H-cyclopenta[a]phenanthren-17-yl)-2-(1,3-dioxoisoindolin-2-yl)propanoate(4r):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as colourless oil (64.6 mg, 64% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.74 (dd, *J* = 8.0, 4.0 Hz, 2H), 4.88-4.85 (m, 0.4H), 7.84-7.82 (m, 0.52H), 3.71 (d, *J* = 4.0 Hz, 3H), 2.55 – 2.50 (m, 0.49H), 2.48-2.40 (m, 0.84H), 2.36 – 2.26 (m, 2H), 2.24-2.20 (m, 1H), 2.09-2.07 (m, 0.64H), 2.06-2.01 (m, 1H), 1.99-1.93 (m, 1H), 1.89-1.83 (m, 0.59H), 1.81 – 1.74 (m, 1.3H), 1.72-1.70 (m, 1H), 1.68 – 1.65 (m, 1H), 1.63-1.58 (m, 2.7H), 1.51-1.47 (m, 1H), 1.46-1.40 (m, 2H), 1.38-1.35 (m,

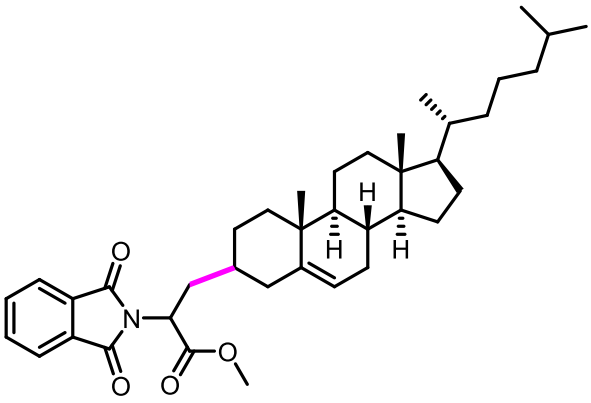
1.7H), 1.33-29 (m, 3.23H), 1.27-1.24 (m, 0.68), 1.18 – 1.13 (m, 1.33H), 1.12-1.08 (m, 1.25), 0.99 (d, *J* = 8.0 Hz, 3H), 0.75 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 212.18, 170.56, 170.06, 167.76, 134.27, 131.93, 123.65, 53.67, 52.76, 51.89, 50.84, 46.73, 44.77, 44.34, 43.69, 43.22, 38.67, 38.24, 35.82, 34.23, 33.86, 32.71, 32.25, 30.41, 29.49, 29.02, 27.23, 25.87, 21.38, 20.98, 11.53. **HRMS (ESI)** m/z: $[M+H]^+$ Calcd for $C_{31}H_{40}NO_5$: 506.2906, found: 506.2914.



dr 1:1.7

methyl 2-(1,3-dioxoisoindolin-2-yl)-3-((8S,9S,13R,14S,17R)-3-methoxy-13-methyl-7,8,9,11,12,13,14,15,16,17-decahydro-6H-cyclopenta[a]phenanthren-17-yl)propanoate(4s):

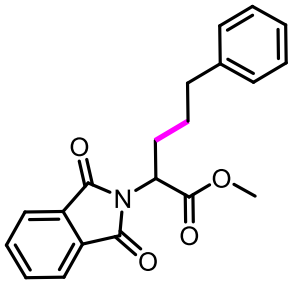
The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as colourless oil (60.1 mg, 60% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.89 – 7.85 (m, 2H), 7.76 – 7.74 (m, 2H), 7.25 – 7.18 (m, 1H), 6.72 – 6.67 (m, 1H), 6.61 (s, 1H), 4.93-4.92 (m, 0.27H), 4.90-4.88 (m, 0.46H), 3.76 (s, 3H), 3.73 (s, 3H), 2.83-2.73 (m, 1.89H), 2.62-2.49 (m, 0.84H), 2.35 – 2.27 (m, 0.92H), 2.22 – 2.16 (m, 1H), 2.08-2.04 (m, 0.75H), 1.95-1.89 (m, 1H), 1.89-87 (m, 0.97H), 1.85-1.80 (m, 0.51H), 1.81-1.75 (m, 0.73H), 1.75-1.69 (m, 1H), 1.69-1.55 (m, 2.20H), 1.52-1.41 (m, 1.40H), 1.39-1.14 (m, 4.9H), 0.87 – 0.70 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.10, 167.87, 157.50, 138.10, 134.41, 132.77, 131.99, 126.46, 123.69, 113.86, 111.51, 55.29, 52.81, 51.96, 50.88, 50.00, 45.16, 44.49, 43.95, 43.69, 43.48, 39.28, 34.32, 32.75, 30.03, 29.56, 28.30, 27.29, 26.66, 25.58, 21.03.
HRMS (ESI) m/z: [M+H]+ Calcd for $C_{31}H_{36}NO_5$: 502.2593, found: 502.2547.



dr 1:1.7:1.04

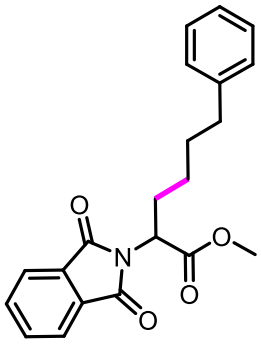
methyl 3-((3S,8S,9S,10R,13R,14S,17R)-10,13-dimethyl-17-((R)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[a]phenanthren-3-yl)-2-(1,3-dioxoisoindolin-2-yl)propanoate(4t):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as colourless oil (60.1 mg, 50% yield). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.88 (d, J = 6.0 Hz, 2H), 7.76 (d, J = 6.0 Hz, 2H), 5.42 – 5.39 (m, 0.46H), 5.30-5.29 (m, 0.15H), 5.23-5.21 (m, 0.36H), 5.02-5.0 (m, 0.23H), 4.91-4.89 (m, 0.4H), 4.87-4.85 (m, 0.24H), 3.73 (s, 3H), 2.40 – 2.35 (m, 0.68H), 2.34-2.31 (m, 0.52H), 2.29-2.23 (m, 0.28H), 2.16-2.09 (m, 0.44H), 2.07-2.05 (m, 0.64H), 2.02 – 1.98 (m, 1.15H), 1.96-1.92 (m, 1H), 1.90-1.87 (m, 0.57H), 1.87-1.81 (m, 1H), 1.79-1.75 (m, 1H), 1.72-1.70 (m, 1H), 1.66-1.60 (m, 2H), 1.58 – 1.50 (m, 4H), 1.45-1.40 (m, 1.67H), 1.34-1.29 (m, 4H), 1.27-1.24 (m, 3H), 1.19-1.14 (m, 2H), 1.12 – 1.09 (m, 2H), 1.09 – 1.07 (m, 2H), 1.05 – 1.02 (m, 2H), 0.99 – 0.97 (m, 4H), 0.93 – 0.92 (m, 2H), 0.90-0.89 (m, 2H), 0.88-0.86 (m, 7H), 0.85-0.84 (m, 1H), 0.69 – 0.66 (m, 3H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.41, 167.85, 139.66, 134.21, 131.96, 123.63, 122.18, 56.90, 56.21, 52.78, 50.69, 50.45, 42.38, 39.88, 39.60, 36.28, 35.91, 34.84, 34.42, 31.96, 31.67, 30.99, 29.67, 28.30, 28.08, 27.39, 24.35, 23.95, 22.89, 22.63, 20.83, 19.43, 18.79, 14.19, 11.91. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{39}H_{56}NO_4$: 602.4209, found: 602.2547.



methyl 2-(1,3-dioxoisoindolin-2-yl)-5-phenylpentanoate(4u):

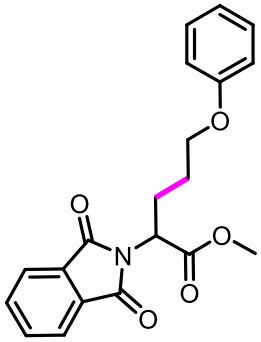
The same general procedure B was followed. Column chromatography (SiO_2, eluting with 16% ethyl acetate/pet ether) afforded the desired product as colourless oil (52.6 mg, 78% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.74 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.25 (t, *J* = 8.0 Hz, 2H), 7.16-7.12 (m, 3H), 4.90 (dd, *J* = 8.0, 4.0 Hz, 1H), 3.72 (s, 3H), 2.71-2.56 (m, 2H), 2.33 – 2.26 (m, 2H), 1.70 – 1.58 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.88, 167.78, 141.94, 134.32, 131.88, 128.46, 126.00, 123.67, 52.83, 52.03, 35.25, 28.48, 28.28. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{20}H_{20}NO_4$: 338.1392, found: 338.1386.



methyl 2-(1,3-dioxoisoindolin-2-yl)-6-phenylhexanoate(4v):

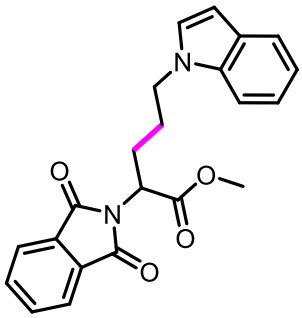
The same general procedure B was followed. Column chromatography (SiO_2, eluting with 16% ethyl acetate/pet ether) afforded the desired product as colourless oil (53.3 mg, 76% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.75 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.22 (t, *J* = 8.0 Hz, 2H), 7.12-7.09 (m, 3H), 4.86 (dd, *J* = 12.0, 8.0 Hz, 1H), 3.72 (s, 3H), 2.61 – 2.53

(m, 2H), 2.32 – 2.23 (m, 2H), 1.71 – 1.60 (m, 2H), 1.39 – 1.31 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.99, 167.79, 142.24, 134.28, 131.89, 128.43, 128.33, 125.76, 123.65, 52.81, 52.13, 35.59, 30.70, 28.55, 25.92. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{21}H_{22}NO_4$: 352.1549, found: 352.1544.



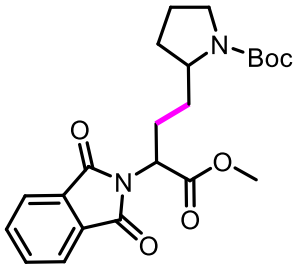
methyl 2-(1,3-dioxoisoindolin-2-yl)-5-phenoxypentanoate(4w):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 16% ethyl acetate/pet ether) afforded the desired product as colourless oil (52.2 mg, 74% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.74 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.25 – 7.21 (m, 2H), 6.91 – 6.84 (m, 3H), 4.95 (dd, *J* = 8.0, 4.0 Hz, 1H), 3.97 (t, *J* = 4.0 Hz, 2H), 3.73 (s, 3H), 2.48-2.40 (m, 2H), 1.87-1.77 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.76, 167.78, 158.86, 134.35, 131.88, 129.50, 123.69, 120.79, 114.55, 66.81, 52.88, 51.95, 26.26, 25.71. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{20}H_{20}NO_5$: 354.1341, found: 354.1334.



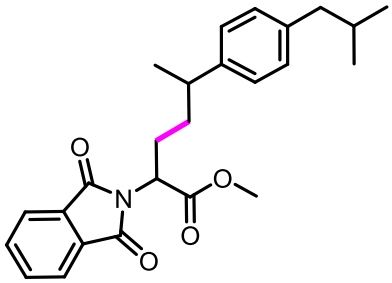
methyl 2-(1,3-dioxoisoindolin-2-yl)-5-(1H-indol-1-yl)pentanoate(4x):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as colourless oil (56.4 mg, 75% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 – 7.84 (m, 2H), 7.75-7.72 (m, 2H), 7.60 (d, *J* = 8.0 Hz, 1H), 7.30 – 7.25 (m, 1H), 7.16 (t, *J* = 8.0 Hz, 1H), 7.07 – 7.04 (m, 2H), 6.46 (d, *J* = 4.0 Hz, 1H), 4.87 (dd, *J* = 8.0, 4.0 Hz, 1H), 4.16 (t, *J* = 8.0 Hz, 2H), 3.71 (s, 3H), 2.31 – 2.23 (m, 2H), 1.94-1.79 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.49, 167.73, 135.88, 134.56, 131.76, 128.70, 127.76, 123.75, 121.58, 121.08, 119.40, 109.32, 101.41, 52.94, 51.62, 45.66, 27.11, 26.39. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{22}H_{21}N_2O_4$: 377.1501, found: 377.1499.



tert-butyl 2-(3-(1,3-dioxoisoindolin-2-yl)-4-methoxy-4-oxobutyl)pyrrolidine-1-carboxylate(4y):

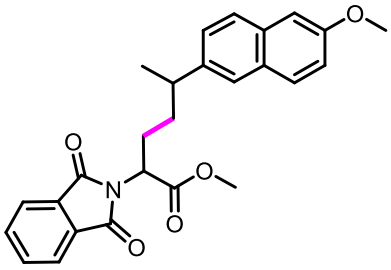
The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as colourless oil (64.9 mg, 78% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.85 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.74 (dd, *J* = 8.0, 4.0 Hz, 2H), 4.87-4.79 (m, 1H), 3.79-3.73 (m, 1H), 3.71 (s, 3H), 3.38 – 3.19 (m, 2H), 2.28-2.14 (m, 2H), 1.96 – 1.87 (m, 1H), 1.83-1.70 (m, 4H), 1.67-1.54 (m, 1H), 1.39-1.31 (m, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.81, 167.77, 167.65, 154.68, 134.31, 131.90, 123.66, 79.25, 79.17, 56.81, 52.81, 52.40, 52.17, 46.39, 46.28, 31.49, 30.65, 28.53, 28.45, 25.78, 25.70, 23.50. **HRMS (ESI)** m/z: [M+Na]+ Calcd for $C_{22}H_{28}N_2NaO_6$: 439.1845, found: 439.1838.



dr 1:1

methyl 2-(1,3-dioxoisoindolin-2-yl)-5-(4-isobutylphenyl)hexanoate(4z):

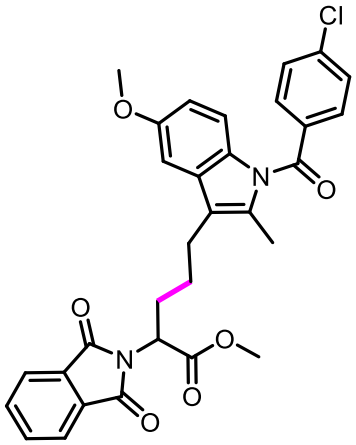
The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as colourless oil (59.4 mg, 73% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87-7.83 (m, 2H), 7.74-7.71 (m, 2H), 7.05-6.99 (m, 4H), 4.88-4.76 (m, 1H), 3.68 (s, 3H), 2.70-2.64 (m, 1H), 2.43-2.39 (m, 2H), 2.29 – 2.07 (m, 2H), 1.85-1.78 (m, 1H), 1.66 – 1.47 (m, 2H), 1.21-1.18 (m, 3H), 0.87 (dd, *J* = 8.0, 4.0 Hz, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.89, 167.79, 167.74, 144.12, 143.95, 139.42, 134.28, 131.91, 129.22, 126.65, 123.65, 52.75, 52.35, 52.22, 45.13, 39.06, 38.93, 35.16, 34.68, 30.28, 27.15, 26.96, 22.51, 22.03. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{25}H_{30}NO_4$: 408.2175, found: 408.2168.



dr 1:1

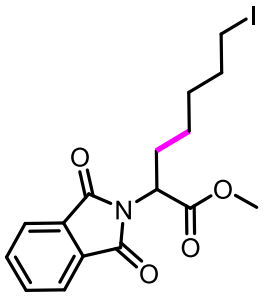
methyl 2-(1,3-dioxoisoindolin-2-yl)-5-(6-methoxynaphthalen-2-yl)hexanoate(4aa):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as light-yellow oil (62.1 mg, 72% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87-7.80 (m, 2H), 7.75-7.70 (m, 2H), 7.63 (t, *J* = 8.0 Hz, 2H), 7.49 (d, *J* = 8.0 Hz, 1H), 7.27 – 7.22 (m, 1H), 7.11 – 7.06 (m, 2H), 4.86-4.77 (m, 1H), 3.89 (s, 3H), 3.66 (s, 3H), 2.87-2.80 (m, 1H), 2.31 – 2.07 (m, 2H), 1.76 – 1.51 (m, 2H), 1.29 (dd, *J* = 8.0, 4.0 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.87, 167.80, 167.73, 157.29, 142.00, 141.81, 134.25, 133.30, 131.89, 129.13, 127.08, 126.05, 125.17, 123.64, 118.73, 105.72, 55.39, 52.77, 52.18, 39.32, 35.03, 34.59, 27.19, 27.02, 22.64, 22.22. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{26}H_{26}NO_5$: 432.1811, found: 432.1804.



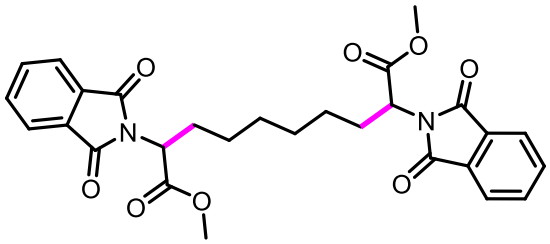
methyl 5-(1-(4-chlorobenzoyl)-5-methoxy-2-methyl-1H-indol-3-yl)-2-(1,3-dioxoisoindolin-2-yl)pentanoate(4ab):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as colourless oil (78.1 mg, 70% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.82-7.80 (m, 2H), 7.73 – 7.71 (m, 2H), 7.65– 7.63 (m, 2H), 7.47 – 7.44 (m, 2H), 6.89 – 6.80 (m, 2H), 6.58-6.55 (m, 1H), 4.90 (dd, *J* = 8.0, 4.0 Hz, 1H), 3.76 (s, 3H), 3.72 (s, 3H), 2.77 – 2.59 (m, 2H), 2.43 – 2.31 (m, 2H), 2.26 (s, 3H), 1.72 – 1.60 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.82, 168.40, 167.77, 155.91, 139.05, 134.32, 134.22, 131.76, 131.48, 131.20, 131.07, 130.93, 129.14, 123.66, 119.08, 115.06, 111.34, 101.15, 55.73, 52.87, 51.95, 28.40, 26.17, 23.38, 13.40, 1.10. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{31}H_{28}ClN_2O_6$: 559.1636, found: 559.1628.



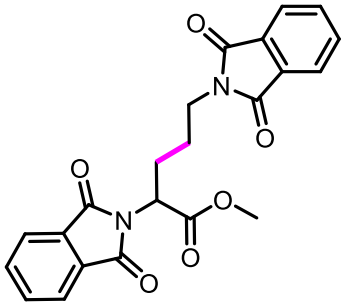
methyl 2-(1,3-dioxoisoindolin-2-yl)-7-iodoheptanoate(4ac):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 20% ethyl acetate/pet ether) afforded the desired product as light brown oil (56.4 mg, 68% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.85-7.83 (m, 2H), 7.73-7.71 (m, 2H), 4.81 (dd, *J* = 12.0, 8.0 Hz, 1H), 3.70 (s, 3H), 3.10 (t, *J* = 8.0 Hz, 2H), 2.26 – 2.17 (m, 2H), 1.79– 1.72 (m, 2H), 1.46 – 1.19 (m, 4H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.84, 167.77, 134.35, 131.85, 123.68, 52.84, 52.05, 33.20, 29.87, 28.59, 25.35, 6.71. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{16}H_{19}INO_4$: 416.0359, found: 416.0362.



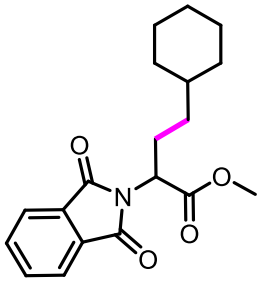
dimethyl (2S,9S)-2,9-bis(1,3-dioxoisoindolin-2-yl)decanedioate(4ac´):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 25% ethyl acetate/pet ether) afforded the desired product as light brown oil (67.6 mg, 65% yield). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.84-7.82 (m, 4H), 7.72-7.71 (m, 4H), 4.78 (m, 2H), 3.69 (s, 6H), 2.23 – 2.11 (m, 4H), 1.33 – 1.24 (m, 6H), 1.22-1,18 (m, 2H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 169.98, 167.77, 134.26, 131.88, 123.63, 52.74, 52.16, 28.74, 28.63, 26.24. **HRMS (ESI)** m/z: $[M+H]^+$ Calcd for $C_{28}H_{29}N_2O_8$: 521.1924, found: 521.1920.



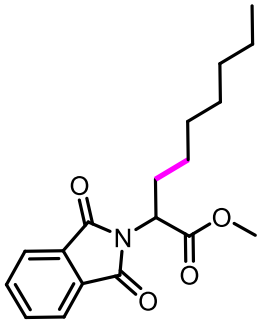
methyl 2,5-bis(1,3-dioxoisoindolin-2-yl)pentanoate(4ad):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 25% ethyl acetate/pet ether) afforded the desired product as brown coloured gummy (56.0 mg, 69% yield). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.88 (dd, J = 12.0, 6.0 Hz, 2H), 7.82 (d, J = 6.0 Hz, 2H), 7.77 (m, 2H), 7.72 (d, J = 6.0 Hz, 2H), 4.96 (t, J = 12.0 Hz, 1H), 3.74 (s, 3H), 3.72 – 3.69 (m, 1H), 2.32 (q, J = 6.0 Hz, 2H), 1.77-1.68 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.53, 168.38, 167.70, 134.33, 134.02, 132.15, 131.85, 123.71, 123.34, 52.89, 51.60, 37.13, 26.15, 25.52. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{22}H_{19}N_2O_6$: 407.1243, found: 407.1236.



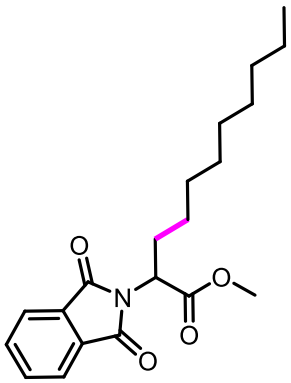
methyl 4-cyclohexyl-2-(1,3-dioxoisoindolin-2-yl)butanoate(4ae):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 12% ethyl acetate/pet ether) afforded the desired product as colourless oil (46.7 mg, 71% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.73 (dd, *J* = 8.0, 4.0 Hz, 2H), 4.78 (dd, *J* = 8.0, 4.0 Hz, 1H), 3.70 (s, 3H), 2.26 – 2.20 (m, 2H), 1.67 – 1.58 (m, 5H), 1.24 – 1.04 (m, 6H), 0.88 – 0.78 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.07, 167.80, 134.25, 131.90, 123.62, 52.75, 52.62, 37.25, 33.98, 33.43, 33.05, 26.62, 26.35, 26.29, 26.24. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{19}H_{24}NO_4$: 330.1705, found: 330.1713.



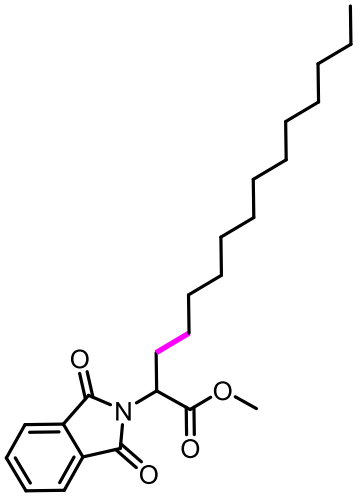
methyl 2-(1,3-dioxoisoindolin-2-yl)nonanoate(4af):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 16% ethyl acetate/pet ether) afforded the desired product as colourless oil (41.8 mg, 66% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.73 (dd, *J* = 8.0, 4.0 Hz, 2H), 4.82 (dd, *J* = 12.0, 4.0 Hz, 1H), 3.70 (s, 3H), 2.29 – 2.13 (m, 2H), 1.31 – 1.20 (m, 10H), 0.83 (t, *J* = 8.0 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.07, 167.79, 134.25, 131.90, 123.57, 52.74, 52.26, 31.76, 29.07, 28.92, 28.71, 26.38, 22.63, 14.09. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{18}H_{24}NO_4$: 318.1705, found: 318.1695.



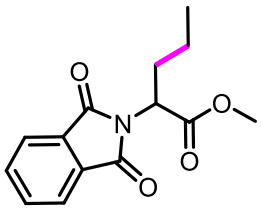
methyl 2-(1,3-dioxoisoindolin-2-yl)undecanoate(4ag):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 16% ethyl acetate/pet ether) afforded the desired product as colourless oil (44.8 mg, 65% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86 – 7.83 (m, 2H), 7.74 – 7.71 (m, 2H), 4.84 (dd, *J* = 12.0, 8.0 Hz, 1H), 3.71 (t, *J* = 4.0 Hz, 3H), 2.29 – 2.15 (m, 2H), 1.30 – 1.19 (m, 14H), 0.86-0.80 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.07, 167.79, 134.24, 131.91, 123.57, 52.74, 52.26, 31.89, 29.50, 29.39, 29.27, 28.95, 28.71, 26.43, 22.70, 14.14. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{20}H_{28}NO_4$: 346.2018, found: 346.2008.



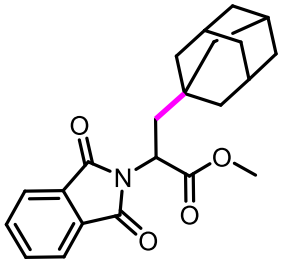
methyl 2-(1,3-dioxoisoindolin-2-yl)pentadecanoate(4ah):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 16% ethyl acetate/pet ether) afforded the desired product as colourless oil (49.7 mg, 62% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86 – 7.84 (m, 2H), 7.74 – 7.71 (m, 2H), 4.82 (dd, *J* = 8.0, 4.0 Hz, 1H), 3.71 (s, 3H), 2.29 – 2.14 (m, 2H), 1.29 – 1.19 (m, 22H), 0.87 – 0.83 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.06, 167.77, 134.23, 131.91, 123.59, 52.73, 52.26, 31.97, 29.72, 29.68, 29.63, 29.56, 29.40, 28.96, 28.71, 26.38, 22.74, 14.17. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{24}H_{36}NO_4$: 402.2644, found: 402.2634.



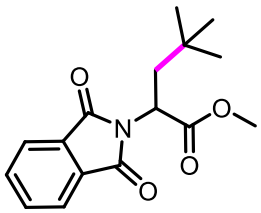
methyl 2-(1,3-dioxoisoindolin-2-yl)pentanoate(4ai):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 12% ethyl acetate/pet ether) afforded the desired product as colourless oil (31.3 mg, 60% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.85-7.84 (m, 2H), 7.74 – 7.72 (m, 2H), 4.98 – 4.69 (dd, *J* = 12.0, 8.0 Hz, 1H), 3.72 (s, 3H), 2.31 – 2.11 (m, 2H), 1.36 – 1.26 (m, 2H), 0.94 (t, *J* = 8.0 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.09, 167.81, 134.26, 131.91, 123.61, 52.77, 51.96, 30.72, 19.62, 13.43. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{14}H_{16}NO_4$: 262.1079, found: 262.1052.



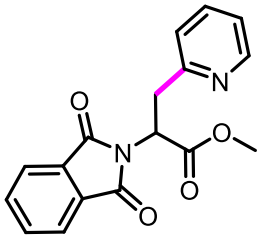
methyl 3-(adamantan-1-yl)-2-(1,3-dioxoisoindolin-2-yl)propanoate(4aj):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 16% ethyl acetate/pet ether) afforded the desired product as colourless oil (41.8 mg, 57% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.74 (dd, *J* = 8.0, 4.0 Hz, 2H), 4.99 (dd, *J* = 12.0, 4.0 Hz, 1H), 3.69 (s, 3H), 2.19 – 2.05 (m, 2H), 1.91-1.88 (m, 3H), 1.66 – 1.62 (m, 3H), 1.59-1.53 (m, 4H), 1.51-1.44 (m, 5H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.89, 167.83, 134.24, 132.02, 123.64, 52.97, 48.04, 42.31, 41.96, 36.88, 32.41, 28.52. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{22}H_{26}NO_4$: 368.1862, found: 368.1856.



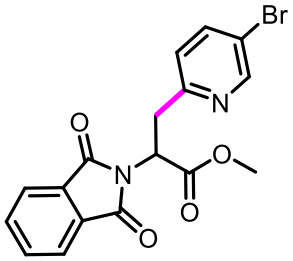
methyl 2-(1,3-dioxoisoindolin-2-yl)-4,4-dimethylpentanoate(4ak):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 35% ethyl acetate/pet ether) afforded the desired product as colourless oil (33.5 mg, 58% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.72 (dd, *J* = 8.0, 4.0 Hz, 2H), 4.95 (dd, *J* = 8.0, 4.0 Hz, 1H), 3.69 (s, 3H), 2.30 – 2.18 (m, 2H), 0.90 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.66, 167.86, 134.27, 131.99, 123.62, 52.97, 49.65, 41.33, 30.46, 29.26. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{16}H_{20}NO_4$: 290.1392, found: 290.1380.



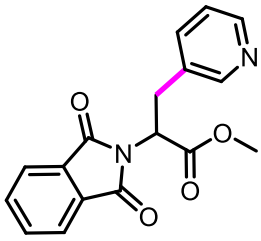
methyl 2-(1,3-dioxoisoindolin-2-yl)-3-(pyridin-2-yl)propanoate(4al):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 25% ethyl acetate/pet ether) afforded the desired product as brown coloured gummy (40.9 mg, 66% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.46 (d, *J* = 8.0 Hz, 1H), 7.80-7.78 (m, 2H), 7.70 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.59 (t, *J* = 8.0 Hz, 1H), 7.19 (d, *J* = 4.0 Hz, 1H), 7.13 (dd, *J* = 8.0, 4.0 Hz, 1H), 5.55 (dd, *J* = 12.0, 8.0 Hz, 1H), 3.83 (dd, *J* = 12.0, 4.0 Hz, 1H), 3.75 (s, 3H), 3.72-3.66 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.58, 167.51, 156.95, 149.37, 136.82, 134.17, 131.80, 123.82, 123.58, 122.00, 52.99, 51.97, 36.87. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{17}H_{15}N_2O_4$: 311.1032, found: 311.1020.



methyl 3-(5-bromopyridin-2-yl)-2-(1,3-dioxoisoindolin-2-yl)propanoate(4am):

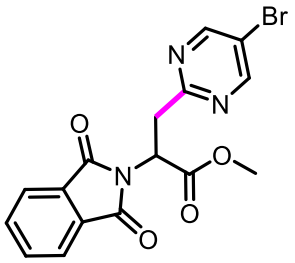
The same general procedure B was followed. Column chromatography (SiO_2, eluting with 25% ethyl acetate/pet ether) afforded the desired product as brown coloured gummy (49.6 mg, 64% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.49 (d, *J* = 4.0 Hz, 1H), 7.81 – 7.79 (m, 2H), 7.71 (dd, *J* = 8.0, 4.0 Hz, 2H), 7.64 (d, *J* = 8.0 Hz, 1H), 7.06 (d, *J* = 8.0 Hz, 1H), 5.51 (dd, *J* = 8.0, 4.0 Hz, 1H), 3.74 (s, 3H), 3.72 – 3.60 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.34, 167.50, 155.37, 150.05, 139.80, 134.30, 131.76, 125.34, 123.69, 119.12, 53.08, 51.56, 36.07.
HRMS (ESI) m/z: [M+H]+ Calcd for $C_{17}H_{14}BrN_2O_4$: 389.0137, found: 389.0130.



methyl 2-(1,3-dioxoisoindolin-2-yl)-3-(pyridin-3-yl)propanoate(4an):

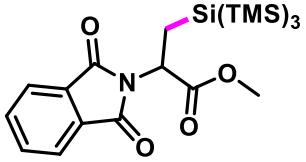
The same general procedure B was followed. Column chromatography (SiO_2, eluting with 25% ethyl acetate/pet ether) afforded the desired product as brown coloured gummy (40.3 mg, 65% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.44 (s, 2H), 7.80-7.78 (m, 2H), 7.74-7.70 (m, 3H), 7.32 (d, *J* = 8.0 Hz, 1H), 5.14 (dd, *J* = 12.0, 8.0 Hz, 1H), 3.77 (s, 3H), 3.64-3.54 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 168.75, 167.43, 147.96, 146.25, 138.97, 134.57, 131.45, 124.46, 123.88,

53.26, 52.51, 32.29, 29.77. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{17}H_{15}N_2O_4$: 311.1032, found: 311.1025.



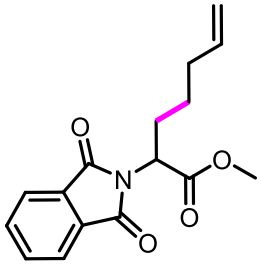
methyl 3-(5-bromopyrimidin-2-yl)-2-(1,3-dioxoisoindolin-2-yl)propanoate(4ao):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 25% ethyl acetate/pet ether) afforded the desired product as brown coloured gummy (52.9 mg, 68% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.62 (d, *J* = 8.0 Hz, 2H), 7.83-7.80 (m, 2H), 7.73-7.69 (m, 2H), 5.62-5.58 (m, 1H), 3.94 – 3.76 (m, 2H), 3.74 (d, *J* = 4.0 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.21, 167.42, 165.30, 157.88, 134.29, 131.86, 123.70, 118.55, 53.12, 50.67, 37.75. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{16}H_{13}BrN_3O_4$: 390.0089, found: 390.0082.



methyl 2-(1,3-dioxoisoindolin-2-yl)-3-(1,1,1,3,3,3-hexamethyl-2-(trimethylsilyl)trisilan-2-yl)propanoate(5a):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 10% ethyl acetate/pet ether) afforded the desired product as colourless liquid (57.5 mg, 60% yield). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.89-7.87 (m, 2H), 7.76-7.75 (m, 2H), 4.90 (t, *J* = 12.0 Hz, 1H), 3.72 (s, 3H), 2.00 (m, 1H), 1.62 (m, 1H), 0.18 (s, 27H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.54, 167.72, 134.26, 132.13, 123.56, 52.88, 52.28, 1.19. **HRMS (ESI)** m/z: [M+H]+ Calcd for $C_{21}H_{38}NO_4Si_4$: 480.1878, found: 480.1870.



methyl 2-(1,3-dioxoisoindolin-2-yl)hept-6-enoate(6a):

The same general procedure B was followed. Column chromatography (SiO_2, eluting with 12% ethyl acetate/pet ether) afforded the desired product as colourless liquid (37.8 mg, 66% yield). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.89-7.87 (m, 2H), 7.77 (t, *J* = 6.0 Hz, 2H), 5.79 – 5.72 (m, 1H), 5.02 (d, *J* = 18.0 Hz, 1H), 4.96 (d, *J* = 12.0 Hz, 1H), 4.88 – 4.85 (m, 1H), 3.74 (s, 3H), 2.32-2.22 (m, 2H), 2.15-2.04 (m, 2H), 1.48 – 1.36 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 169.91, 167.77, 137.94, 134.28, 131.87, 123.64, 115.23, 52.79, 52.07, 33.02, 28.23, 25.67.

10. References

[1] Chiappini, N.D., Geunes, E.P., Bodak, E.T. and Knowles, R.R., *ACS catalysis*. 2024,*14, 4, 2664–2670*.

[2] J-D. Chai and M. Head-Gordon, *J. Chem. Phys*., **2008**, *128*, 084106.

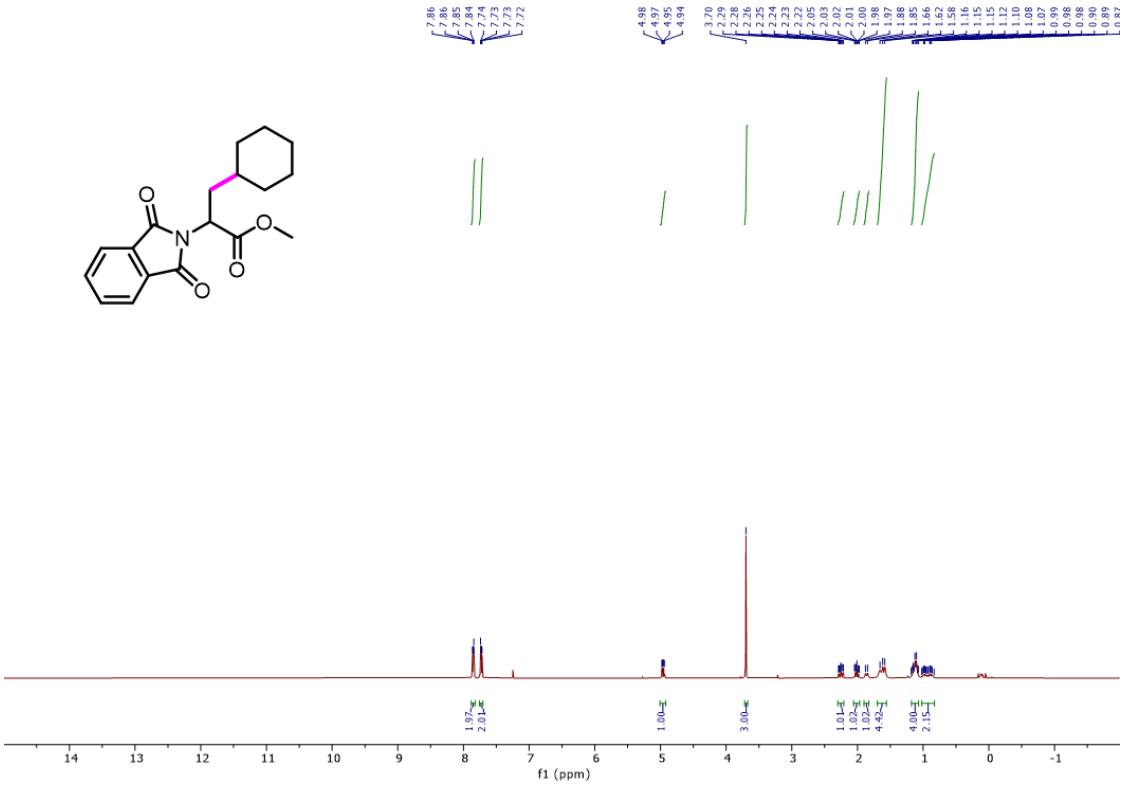
[3] (a) F. Weigend and R. Ahlrichs, *Phys. Chem. Chem. Phys.* **2005**, *7*, 3297-3305. (b) F. Weigend, *Phys. Chem. Chem. Phys*. **2006**, *8*, 1057-1065.

[4] A. Klamt and G. Schüürmann, *J. Chem. Soc. Perkin Trans.2*. **1993**, *2*,799–805.

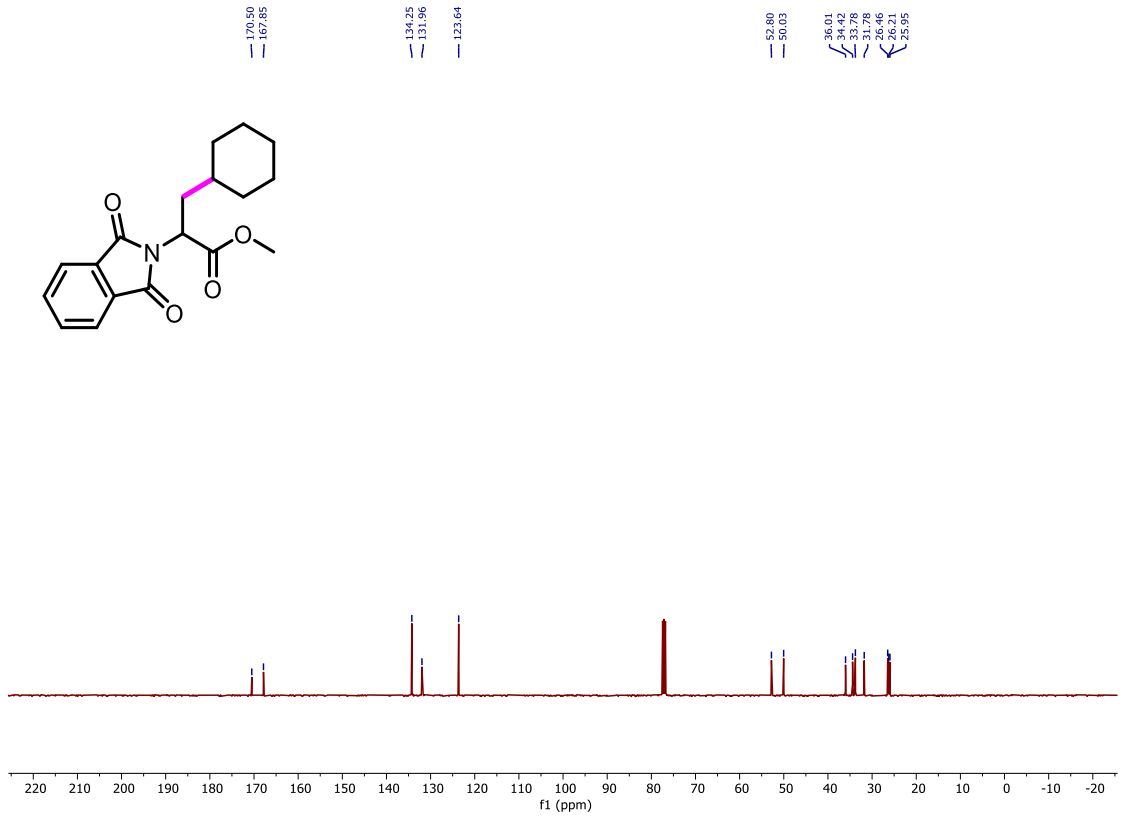
[5] Gaussian 16, Revision A.03, M. J. Frisch, et al. Gaussian, Inc., Wallingford CT, **2016**.

11. NMR Spectra

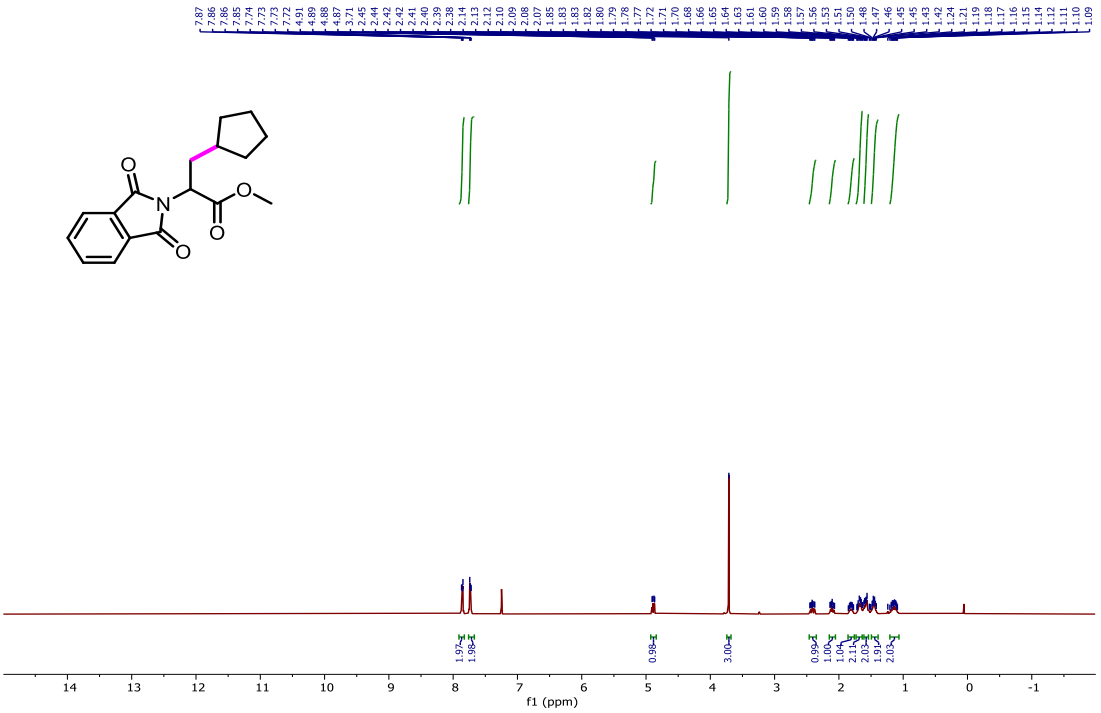
^{1}H NMR in $CDCl_3$ (4a)



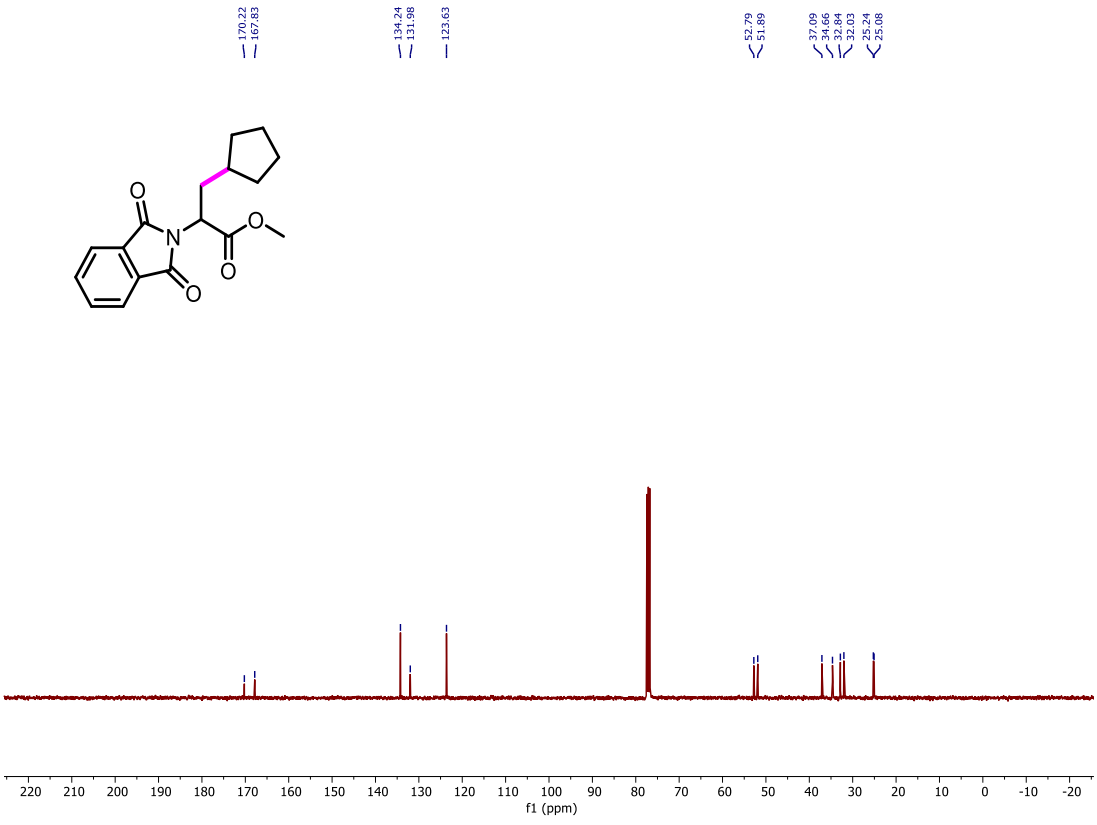
^{13}C NMR in CDCl3 (4a)



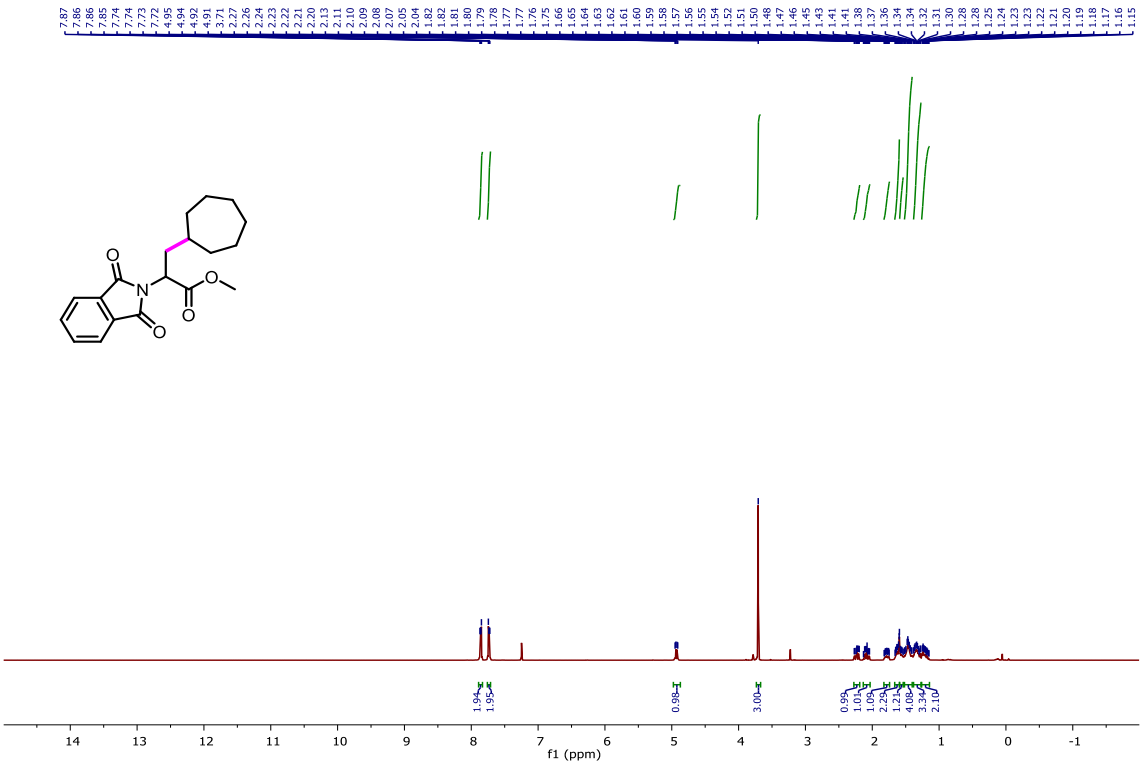
^{1}H NMR in $CDCl_3$ (4b)



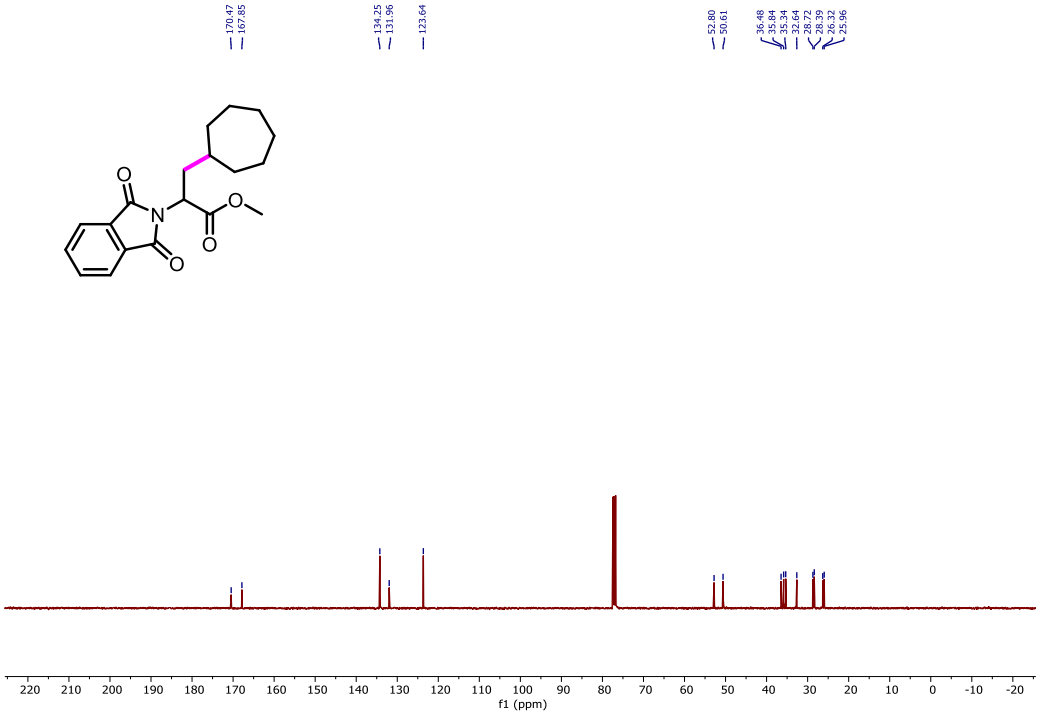
^{13}C NMR in $CDCl_3$ (4b)



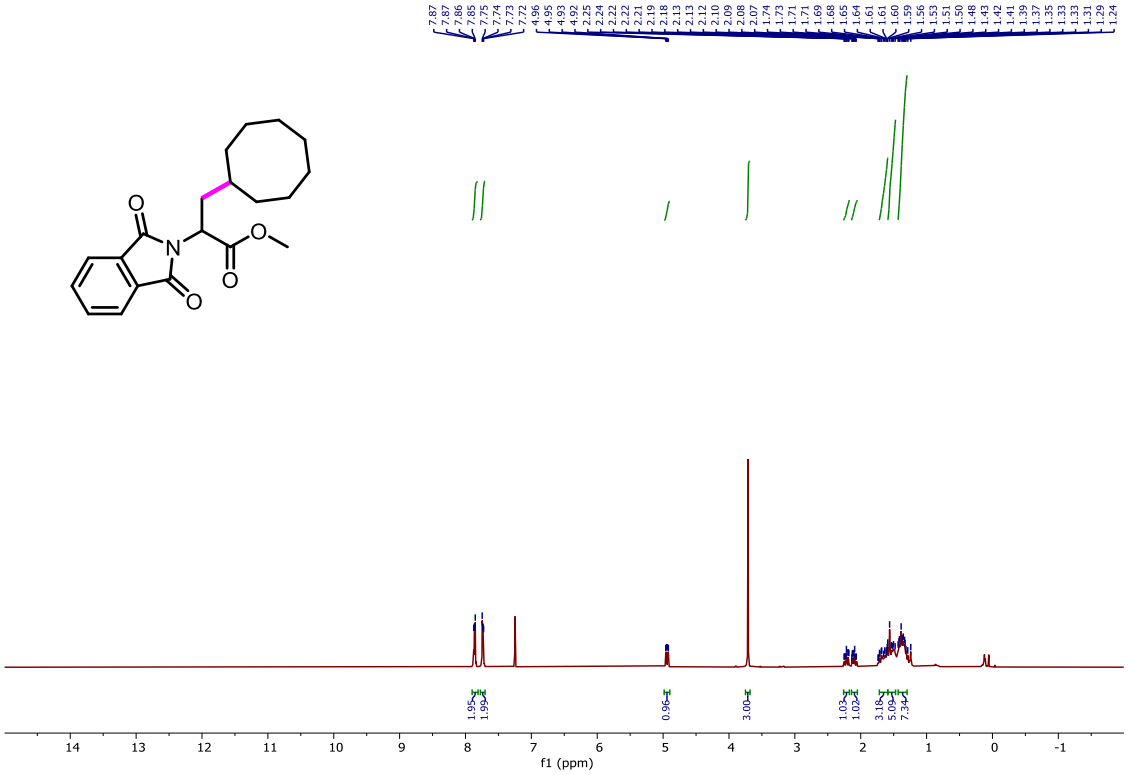
^{1}H NMR in $CDCl_3$ (4c)



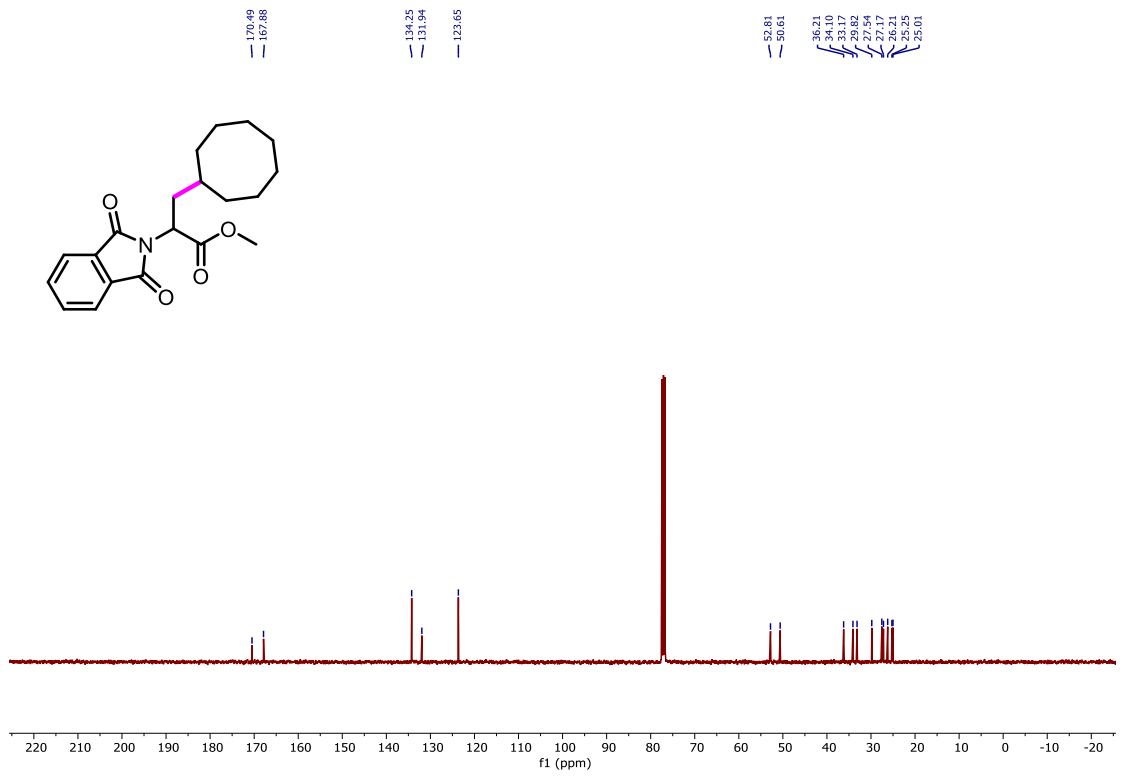
^{13}C NMR in $CDCl_3$ (4c)



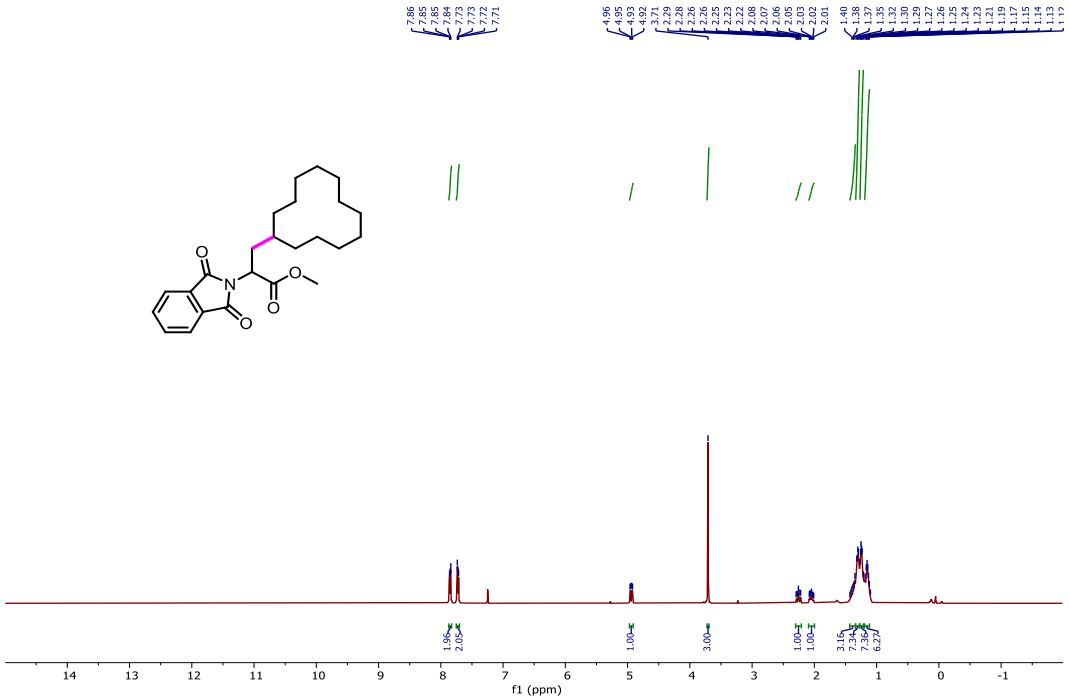
^{1}H NMR in $CDCl_3$ (4d)



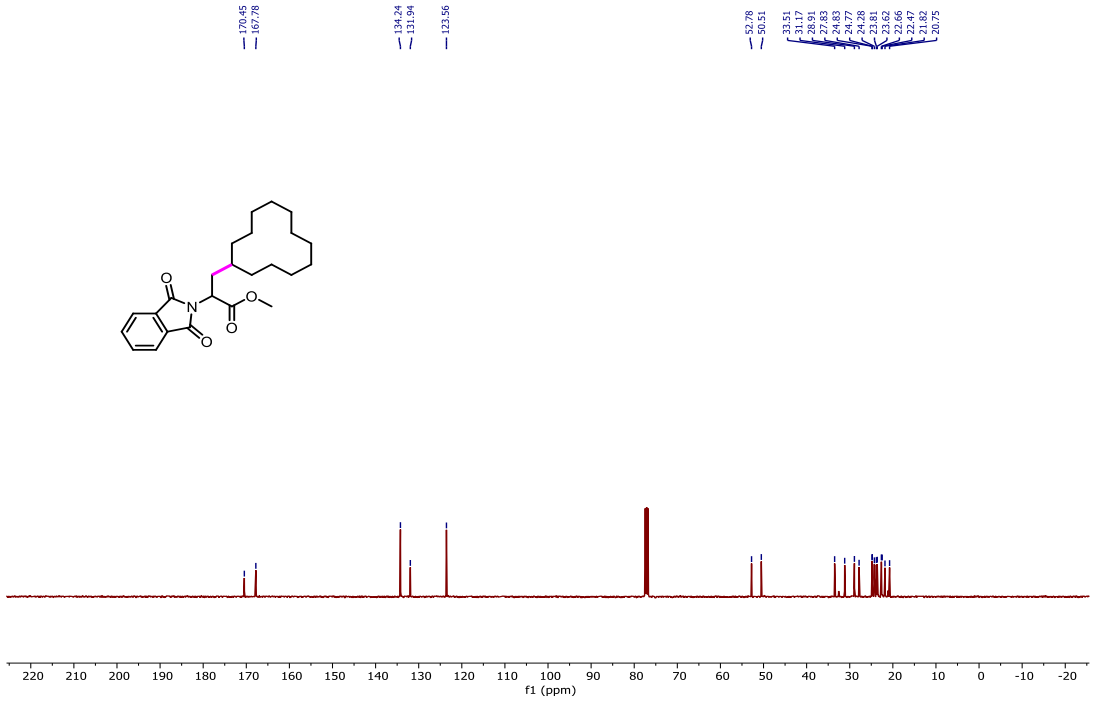
^{13}C NMR in $CDCl_3$ (4d)



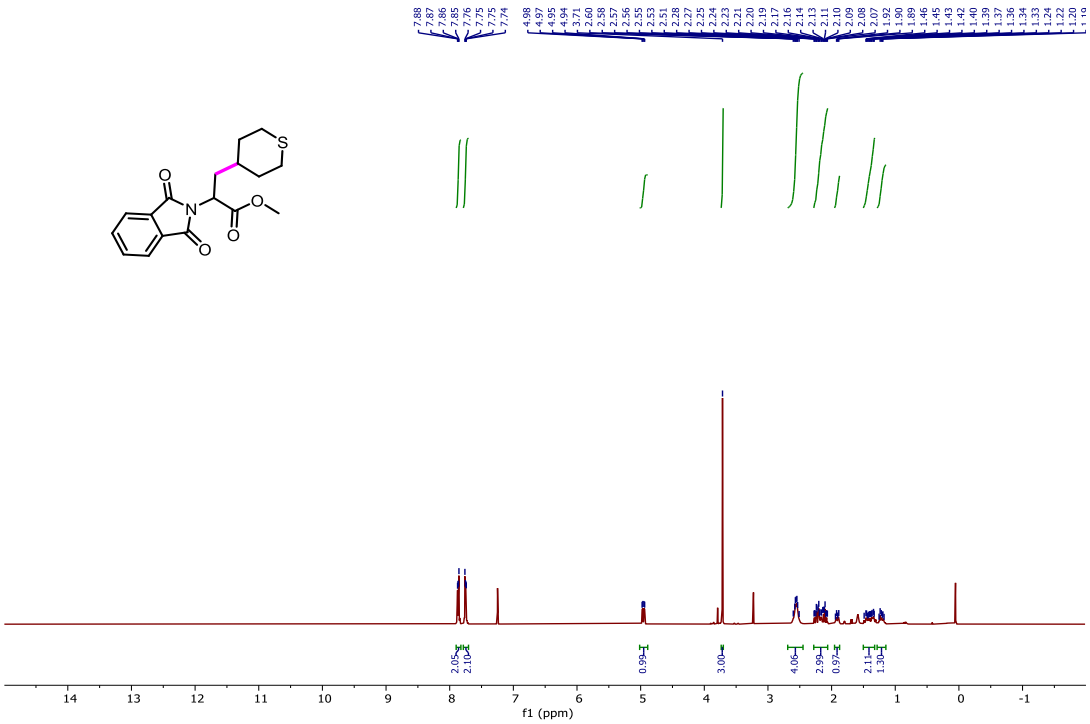
^{1}H NMR in $CDCl_3$ (4e)



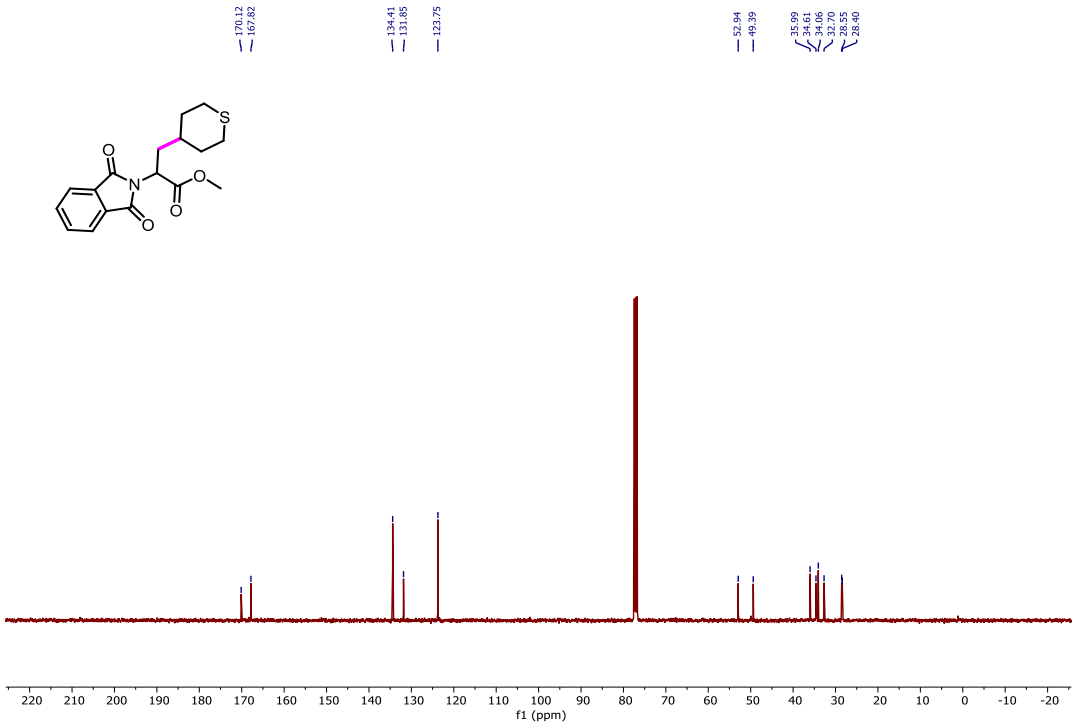
^{13}C NMR in $CDCl_3$ (4e)



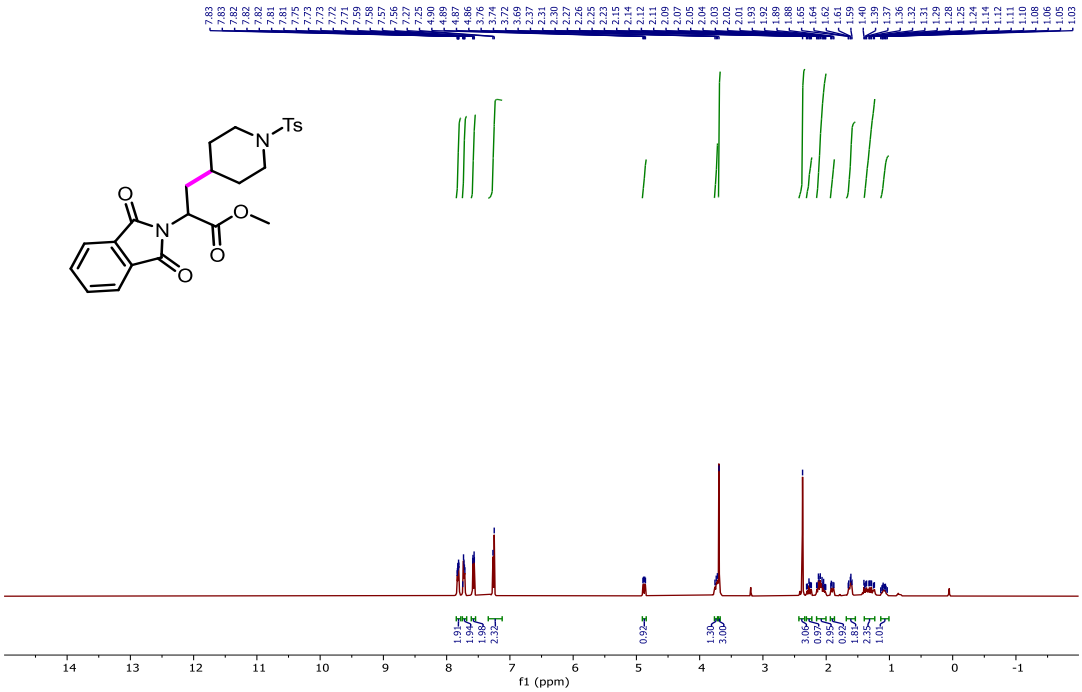
^{1}H NMR in $CDCl_3$ (4f)



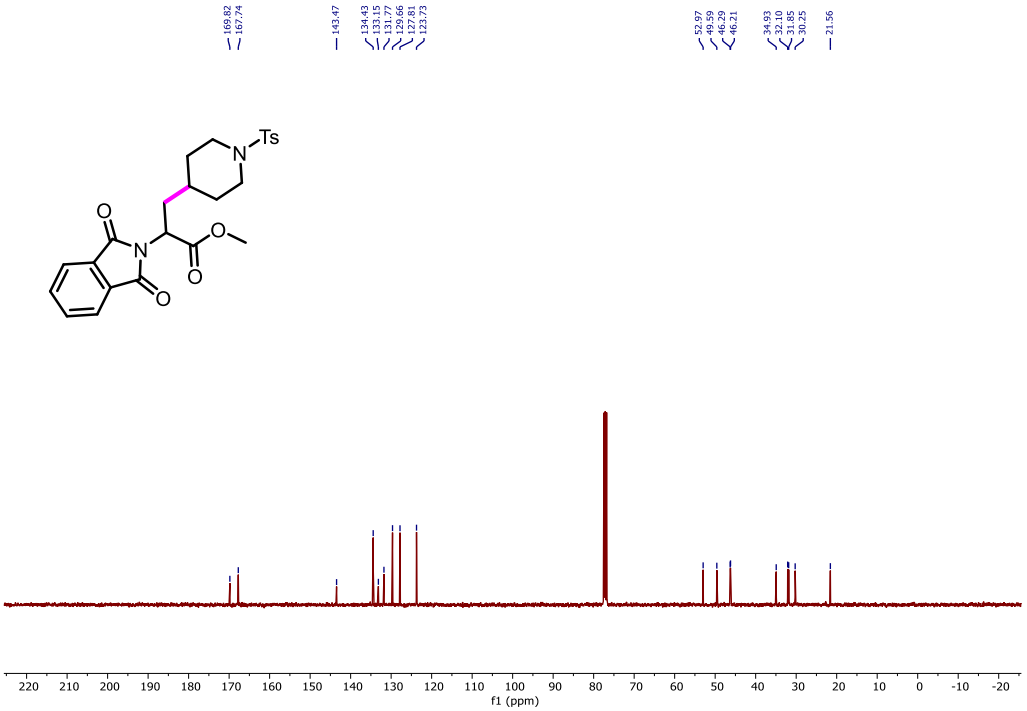
^{13}C NMR in $CDCl_3$ (4f)



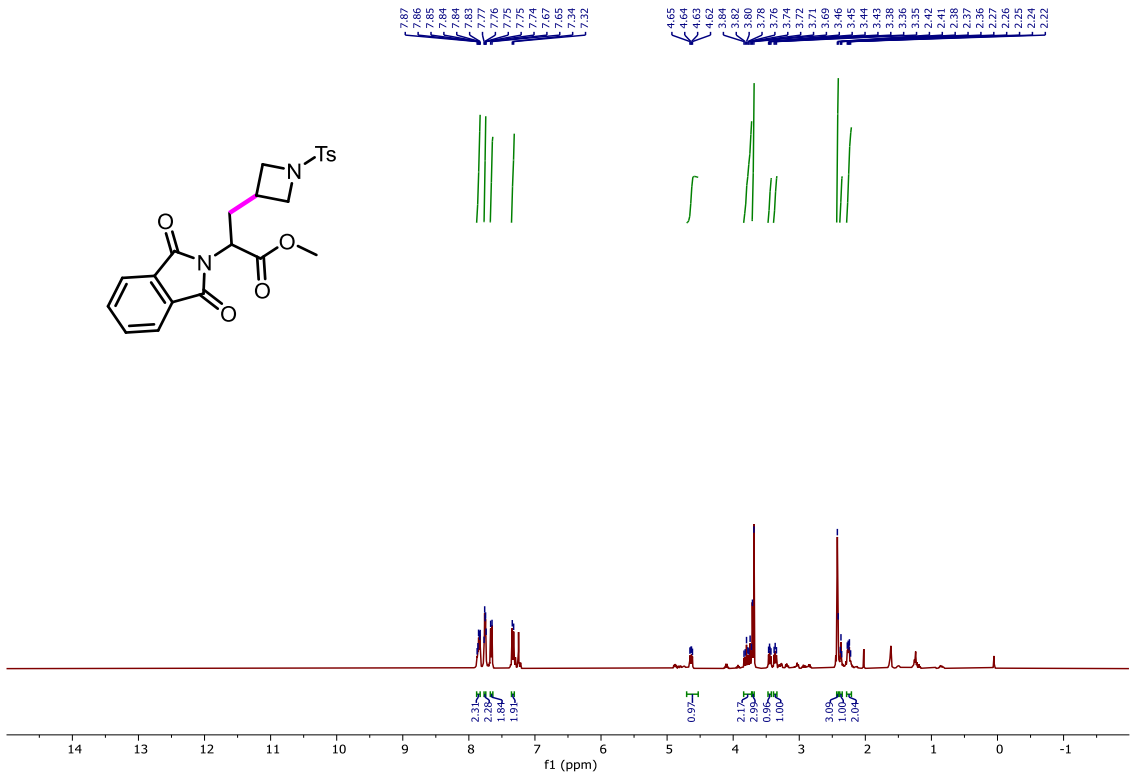
^{1}H NMR in $CDCl_3$ (4g)



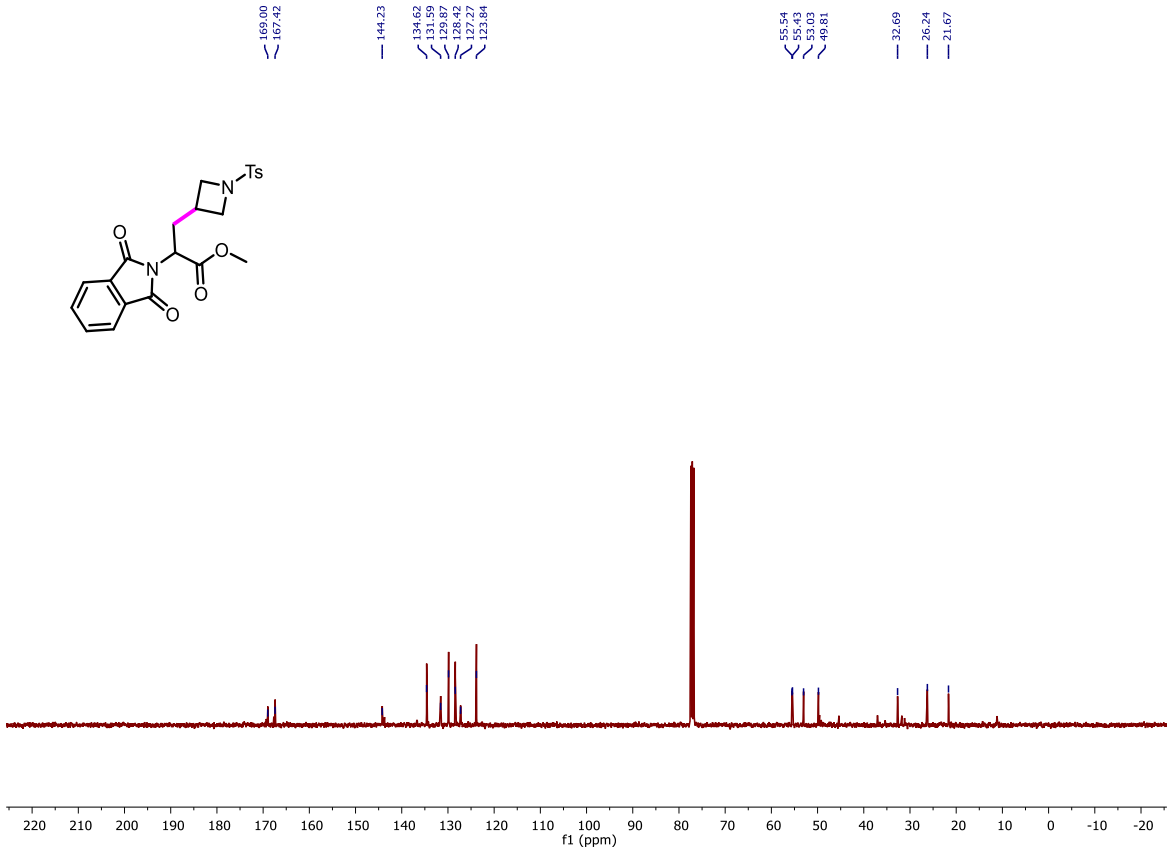
^{13}C NMR in $CDCl_3$ (4g)



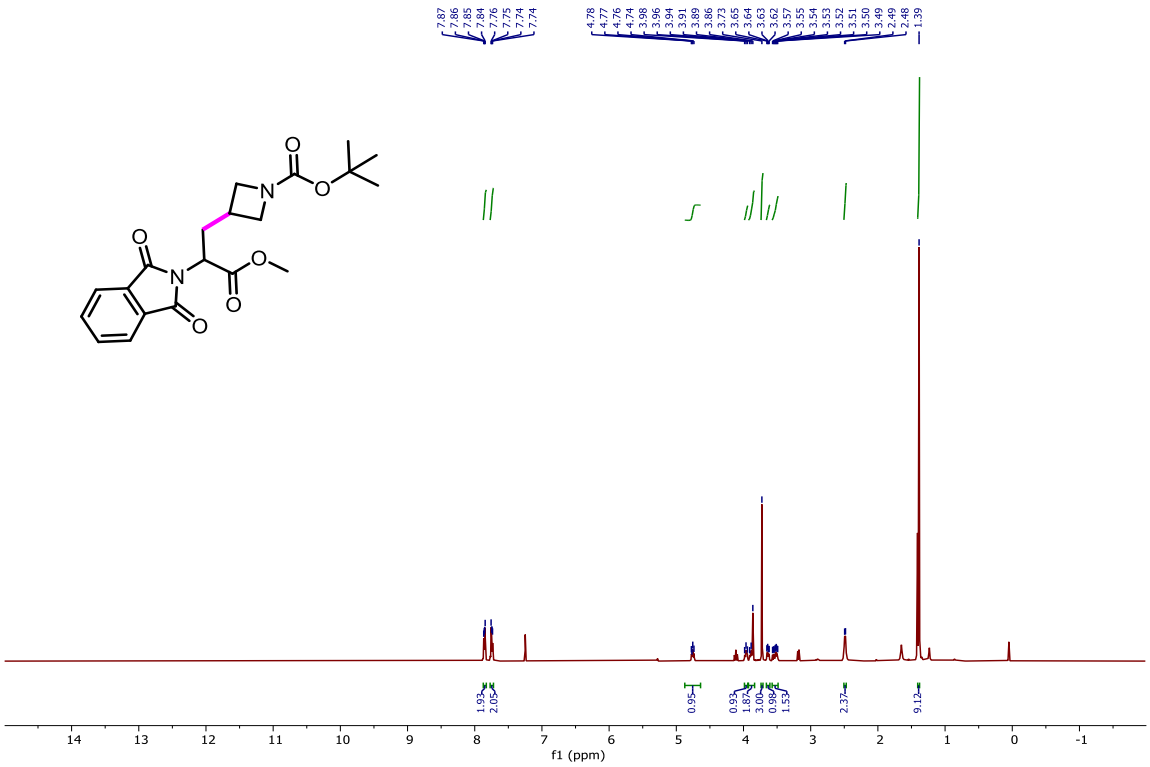
^{1}H NMR in $CDCl_3$ (4h)



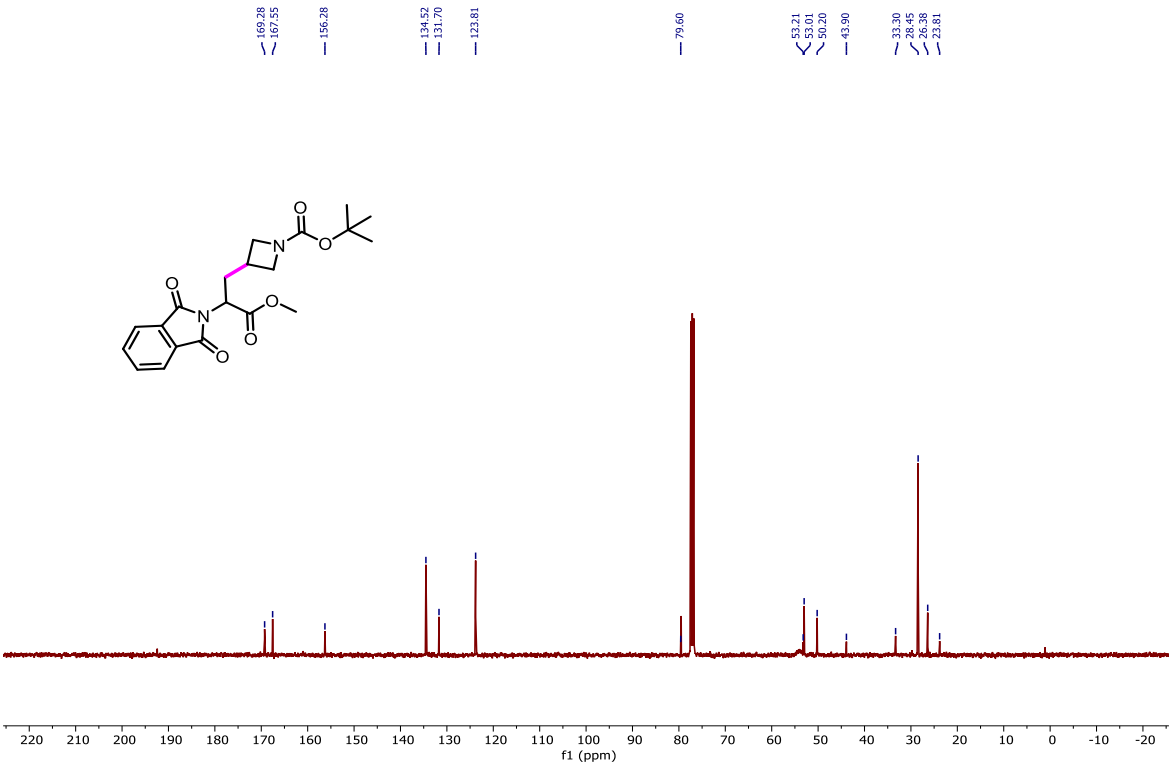
^{13}C NMR in $CDCl_3$ (4h)



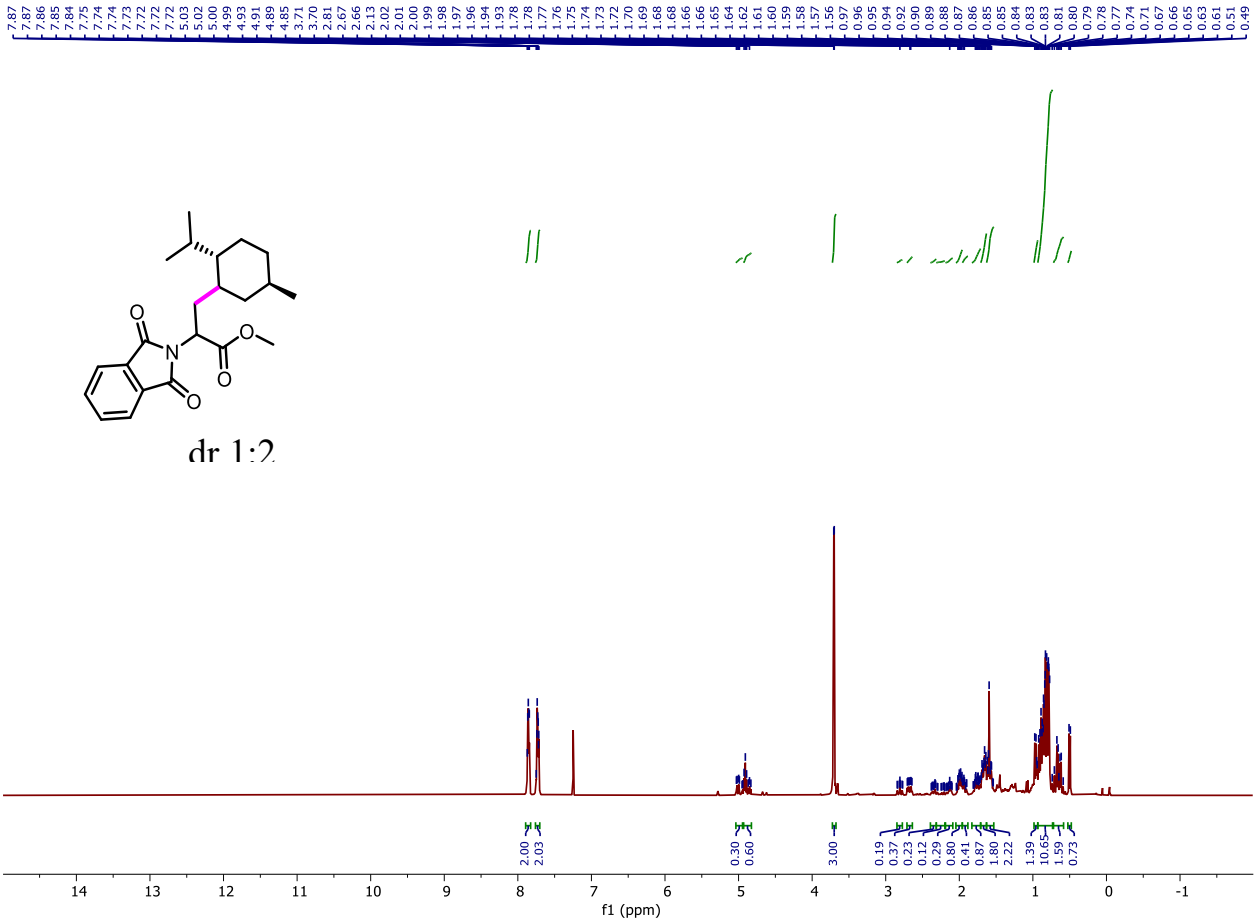
^{1}H NMR in $CDCl_3$ (4i)



^{13}C NMR in $CDCl_3$ (4i)

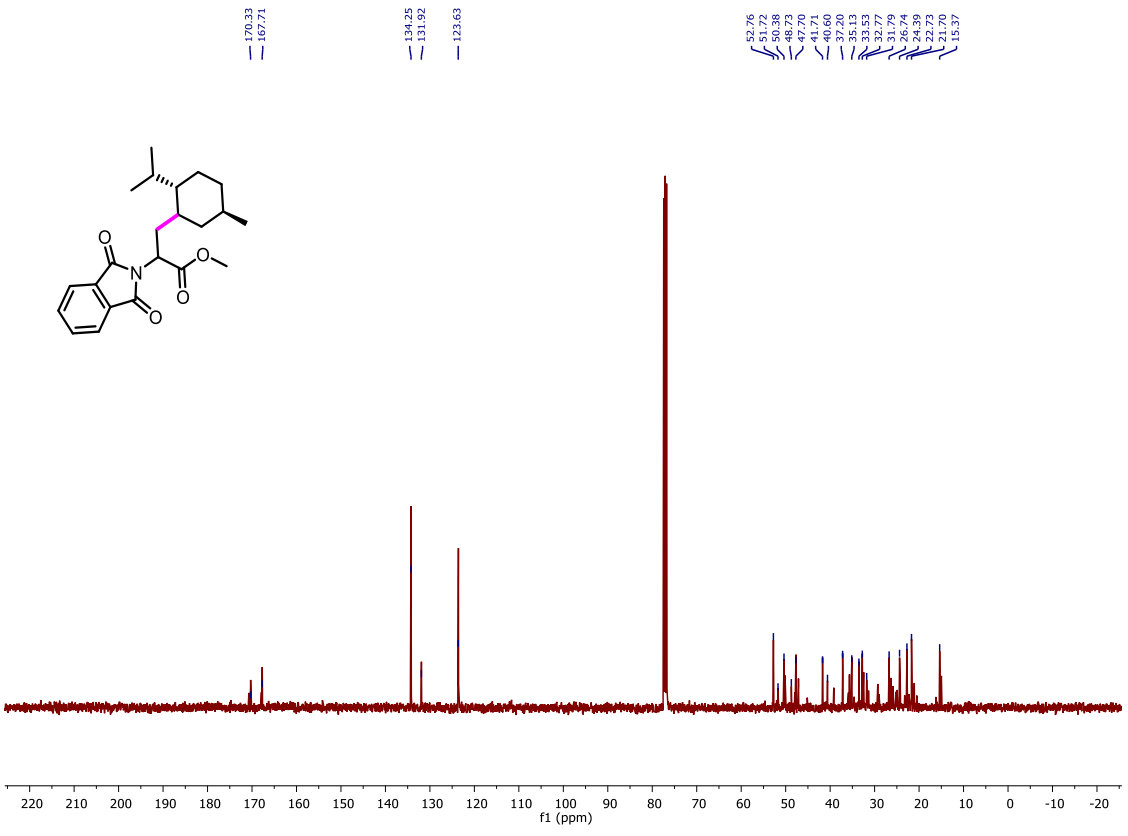


^{1}H NMR in $CDCl_3$ (4j)

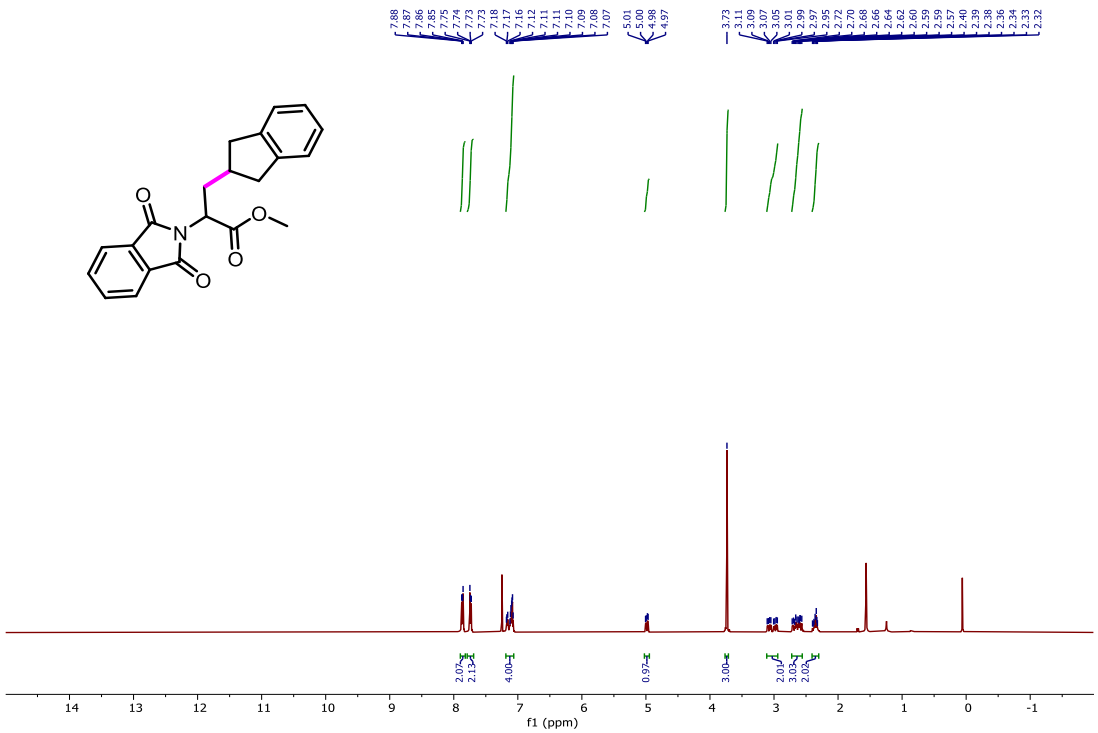


dr 1:2

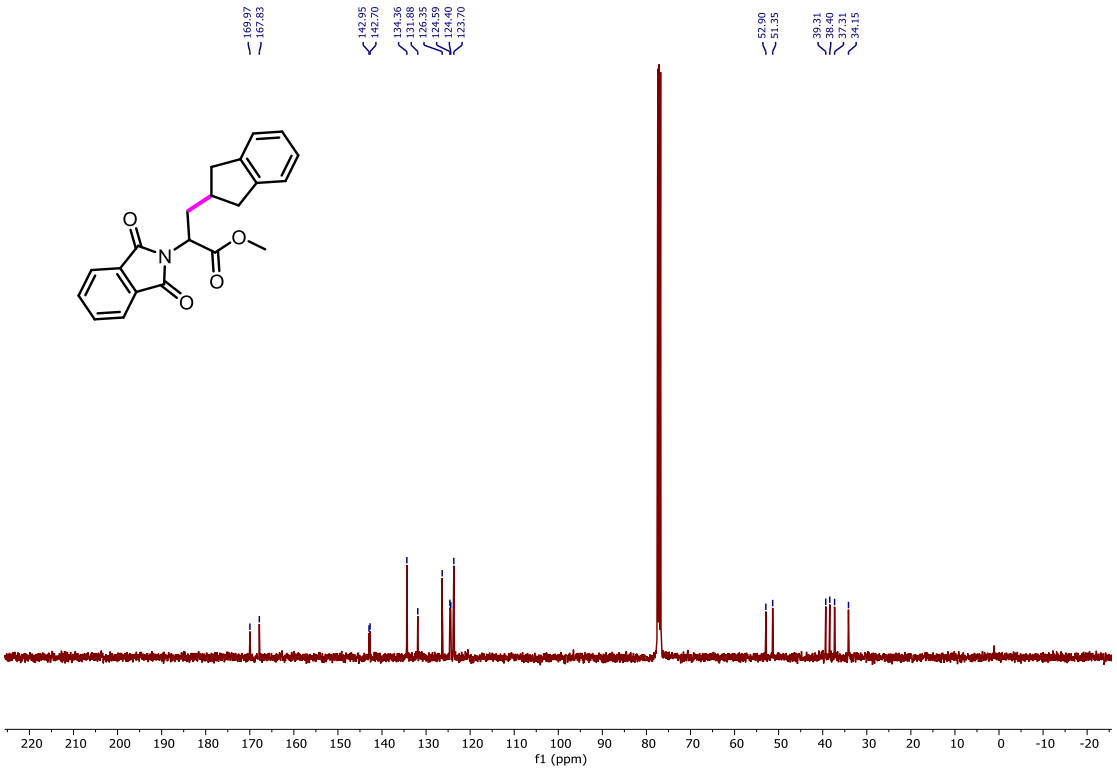
^{13}C NMR in $CDCl_3$ (4j)



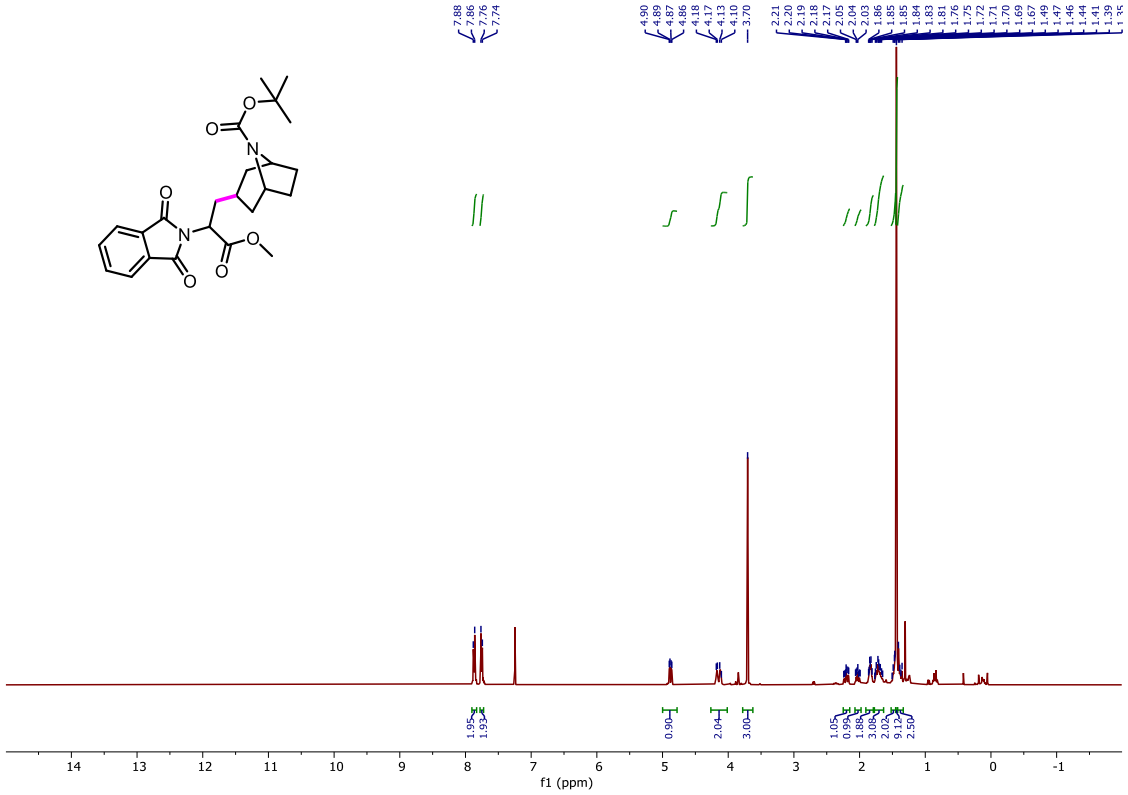
^{1}H NMR in $CDCl_3$ (4k)



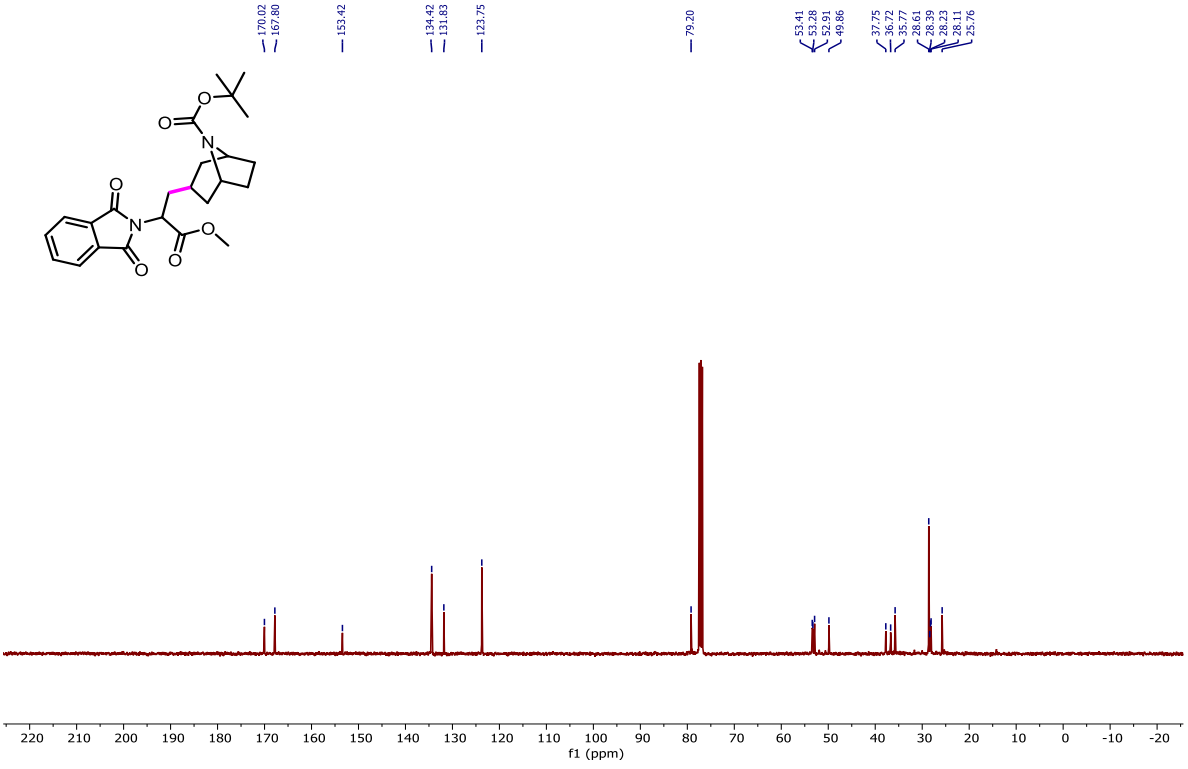
^{13}C NMR in $CDCl_3$ (4k)



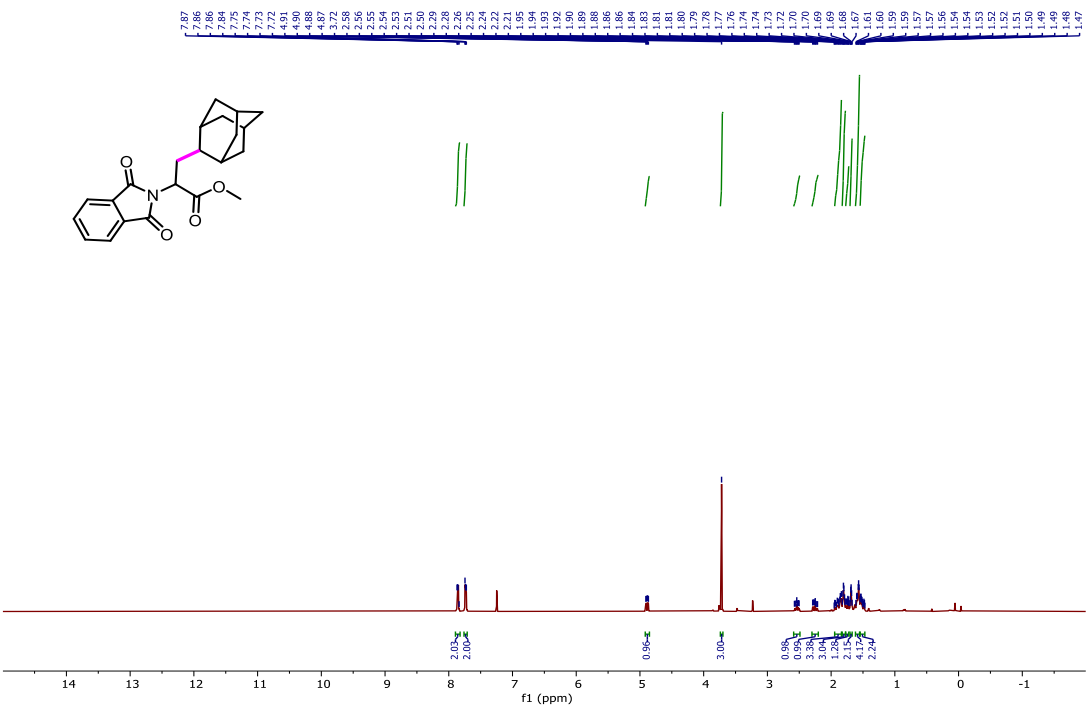
^{1}H NMR in $CDCl_3$ (4l)



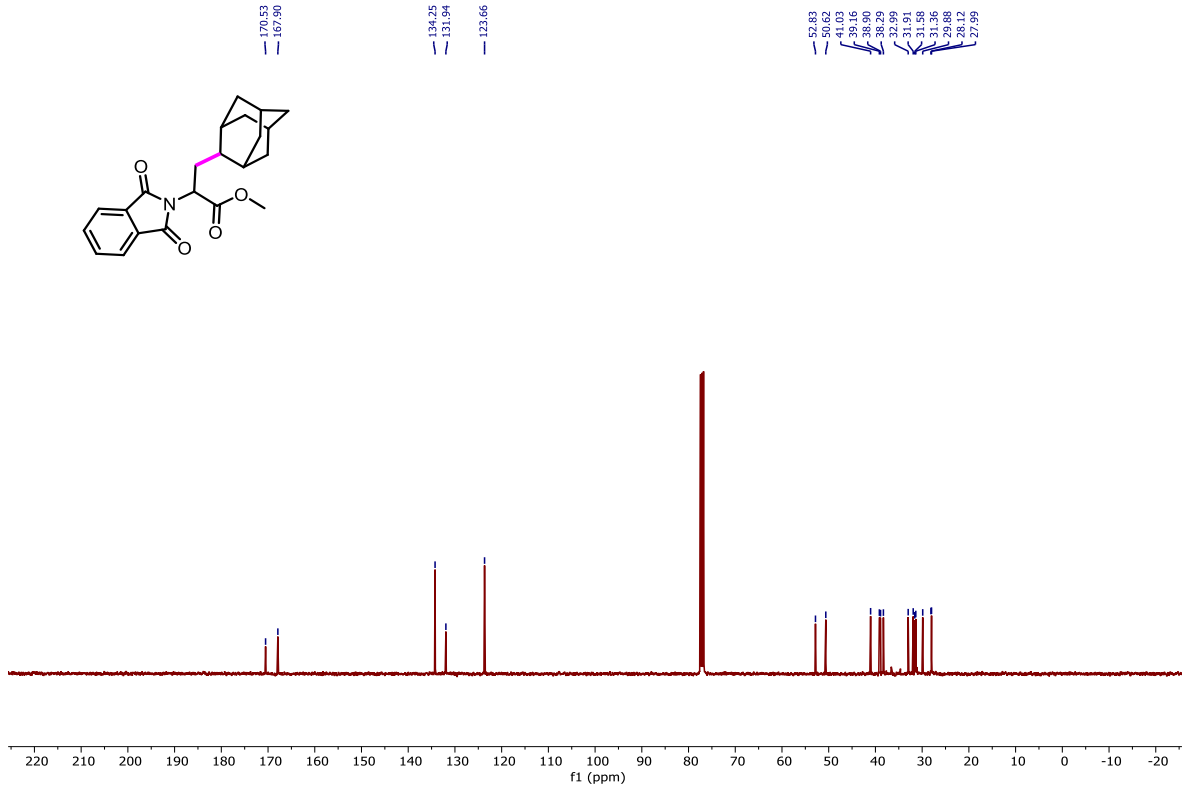
^{13}C NMR in $CDCl_3$ (4l)



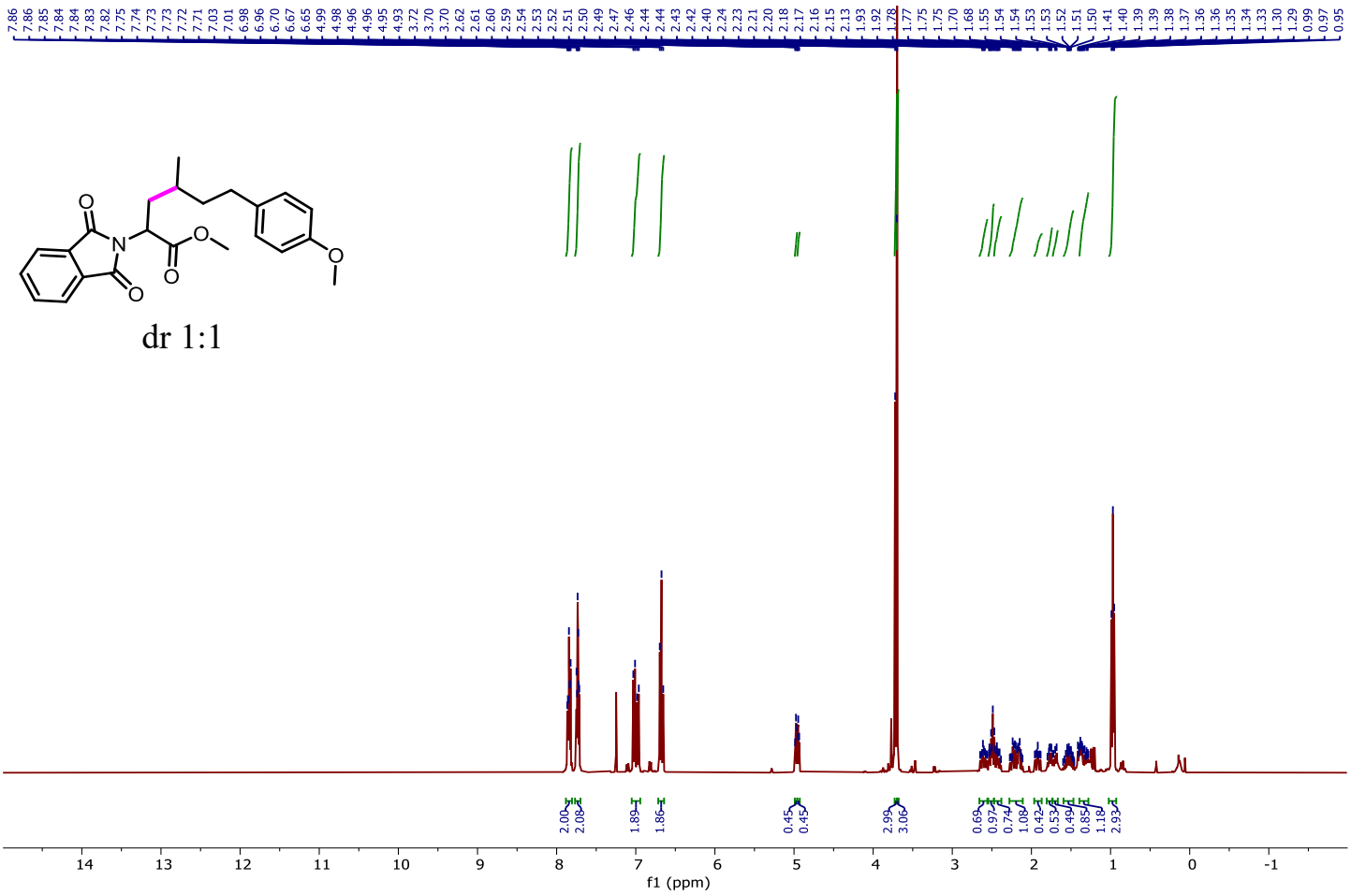
^{1}H NMR in $CDCl_3$ (4m)



^{13}C NMR in $CDCl_3$ (4m)

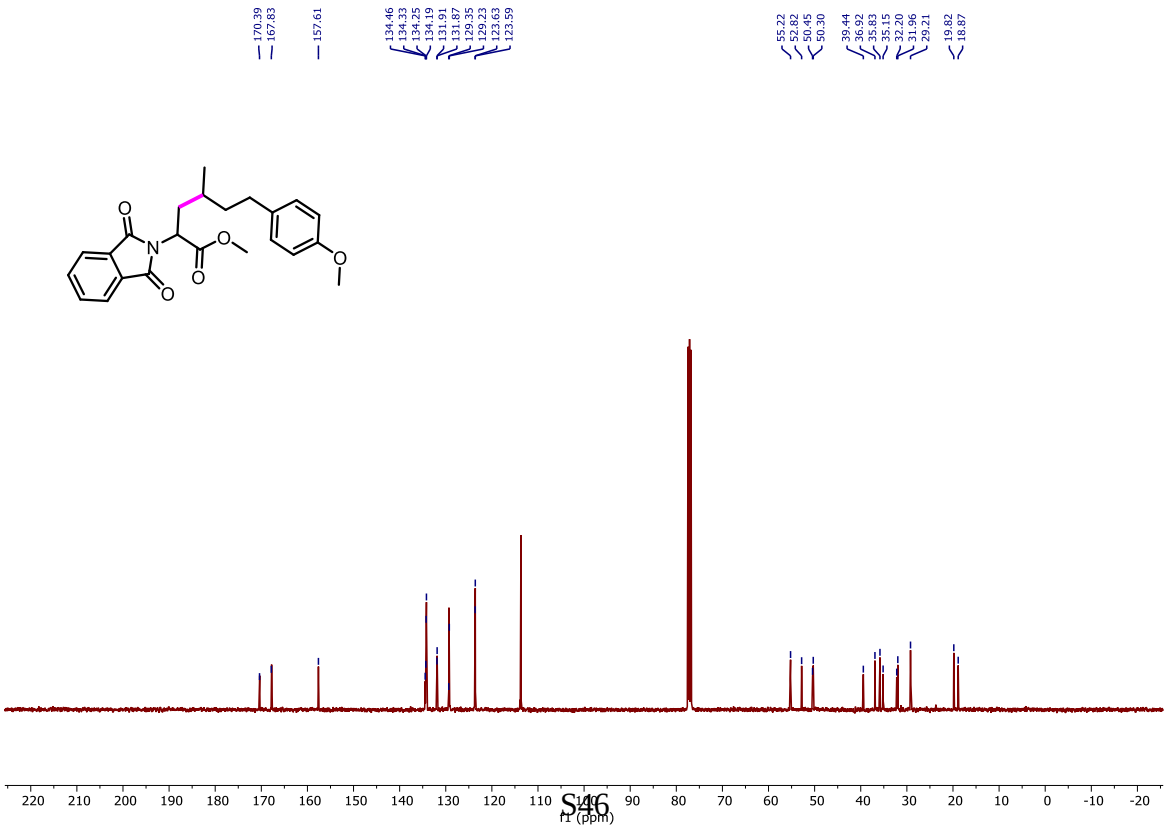


^{1}H NMR in $CDCl_3$ (4n)

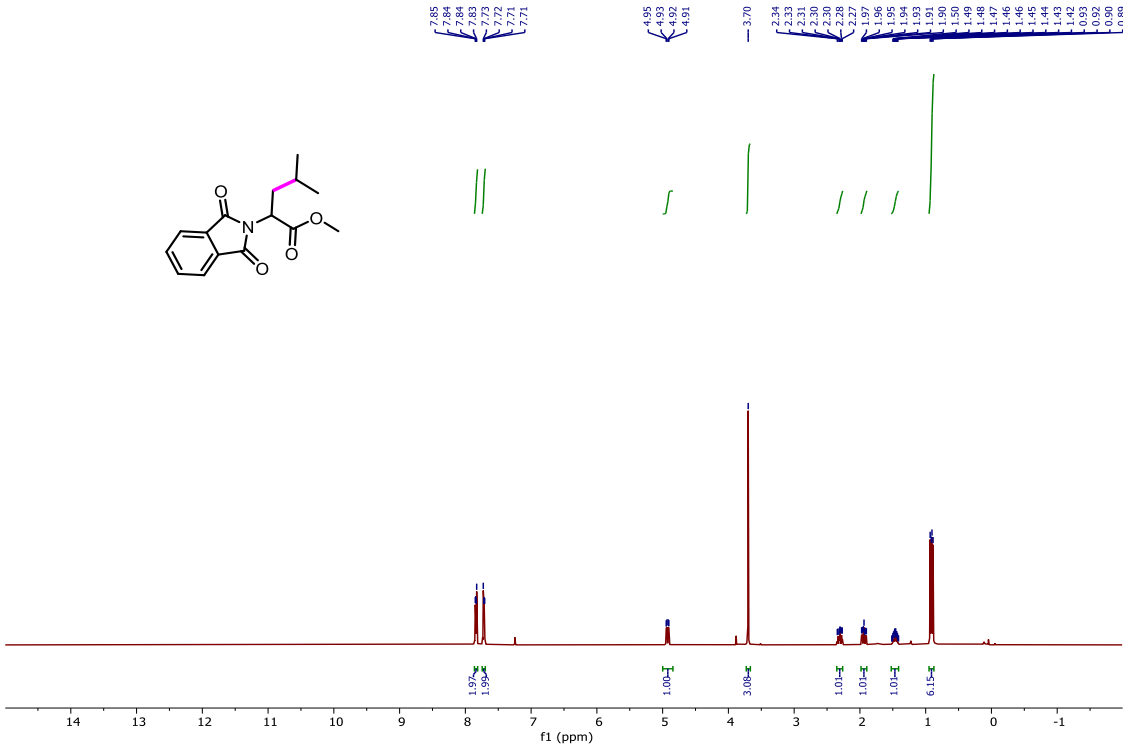


dr 1:1

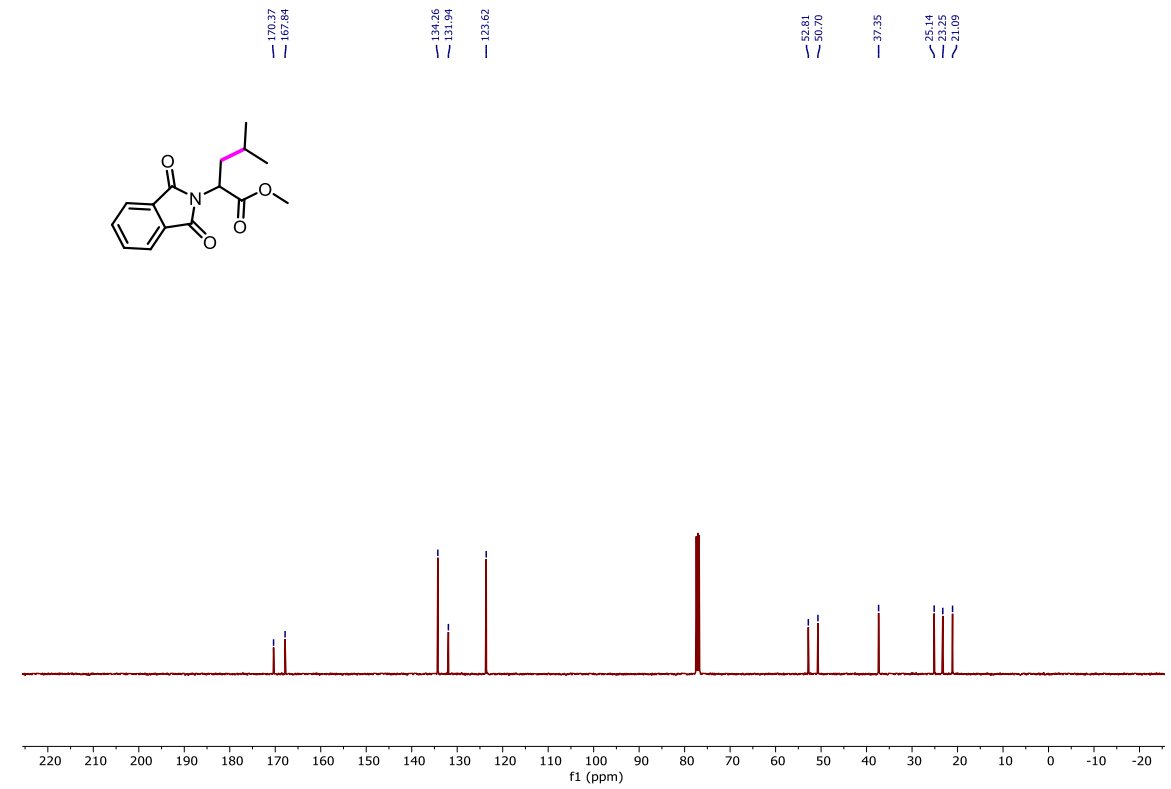
^{13}C NMR in $CDCl_3$ (4n)



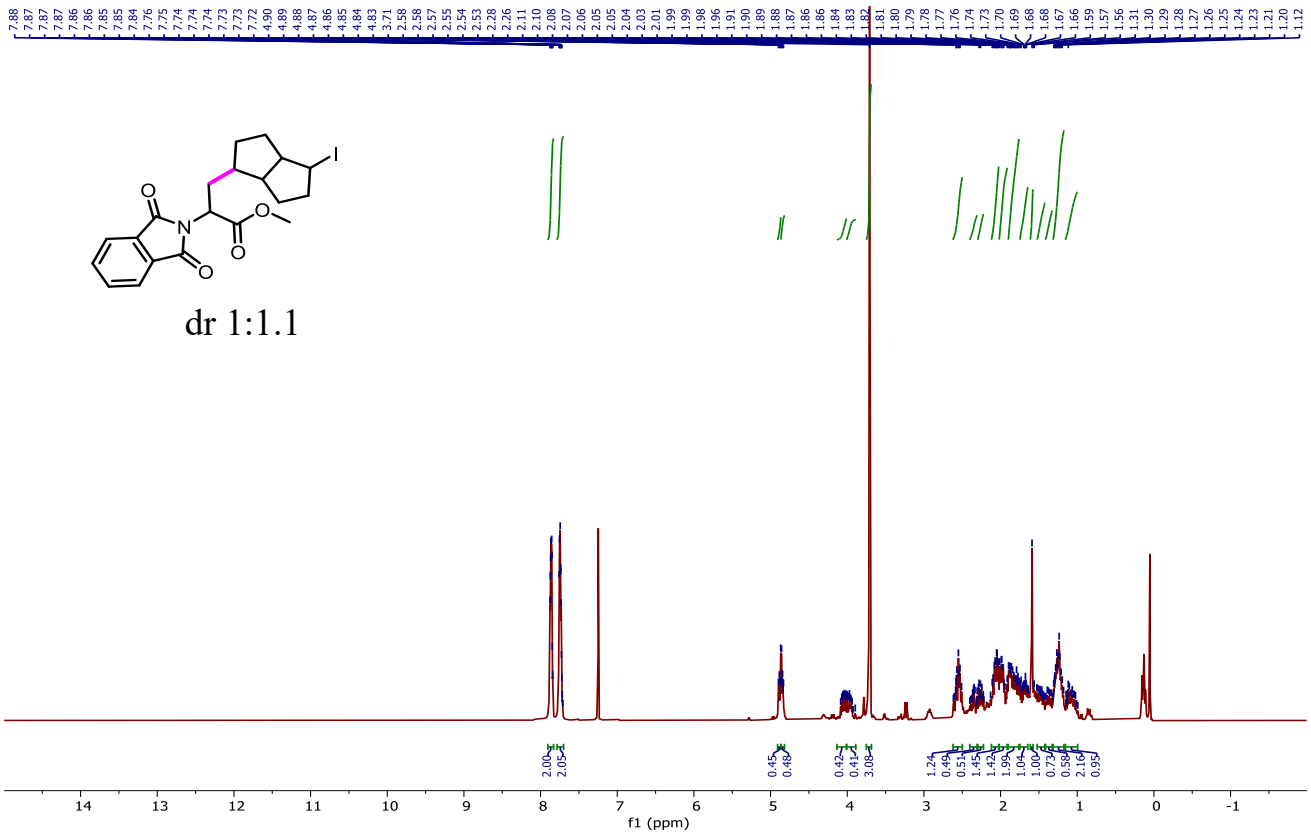
^{1}H NMR in $CDCl_3$ (4o)



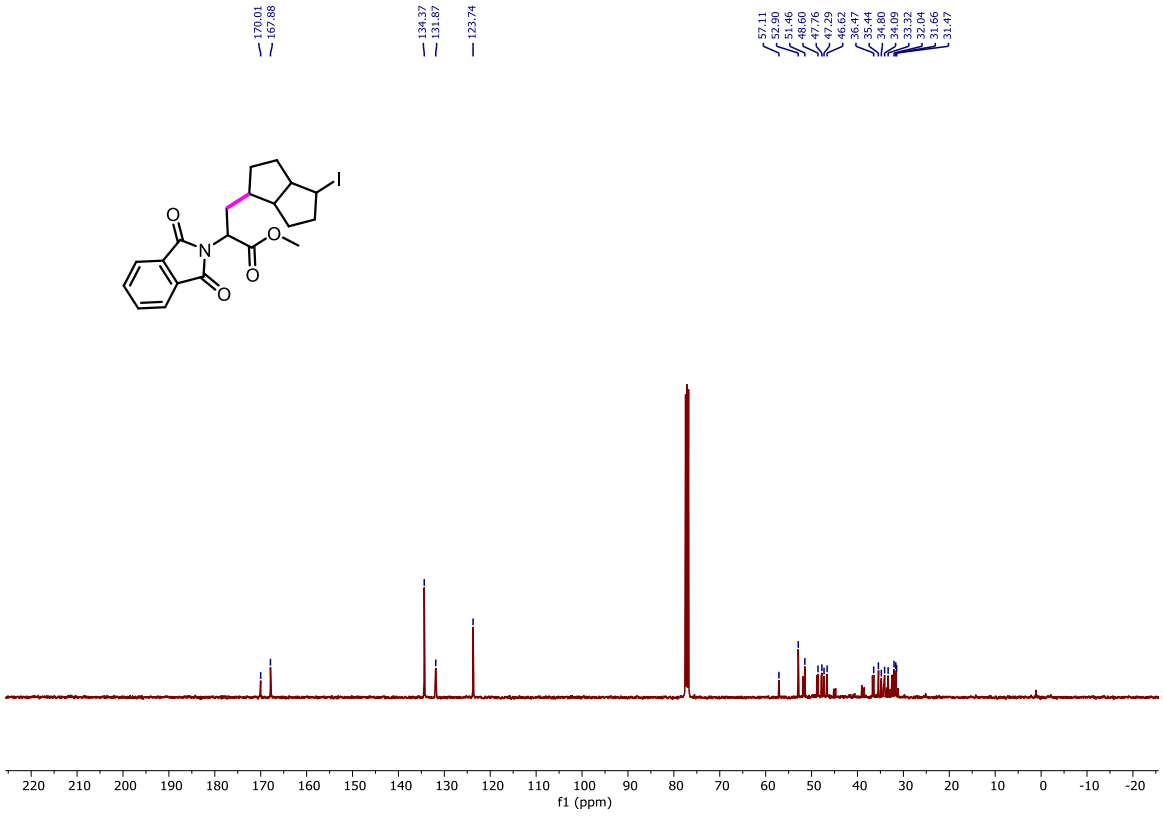
^{13}C NMR in $CDCl_3$ (4o)



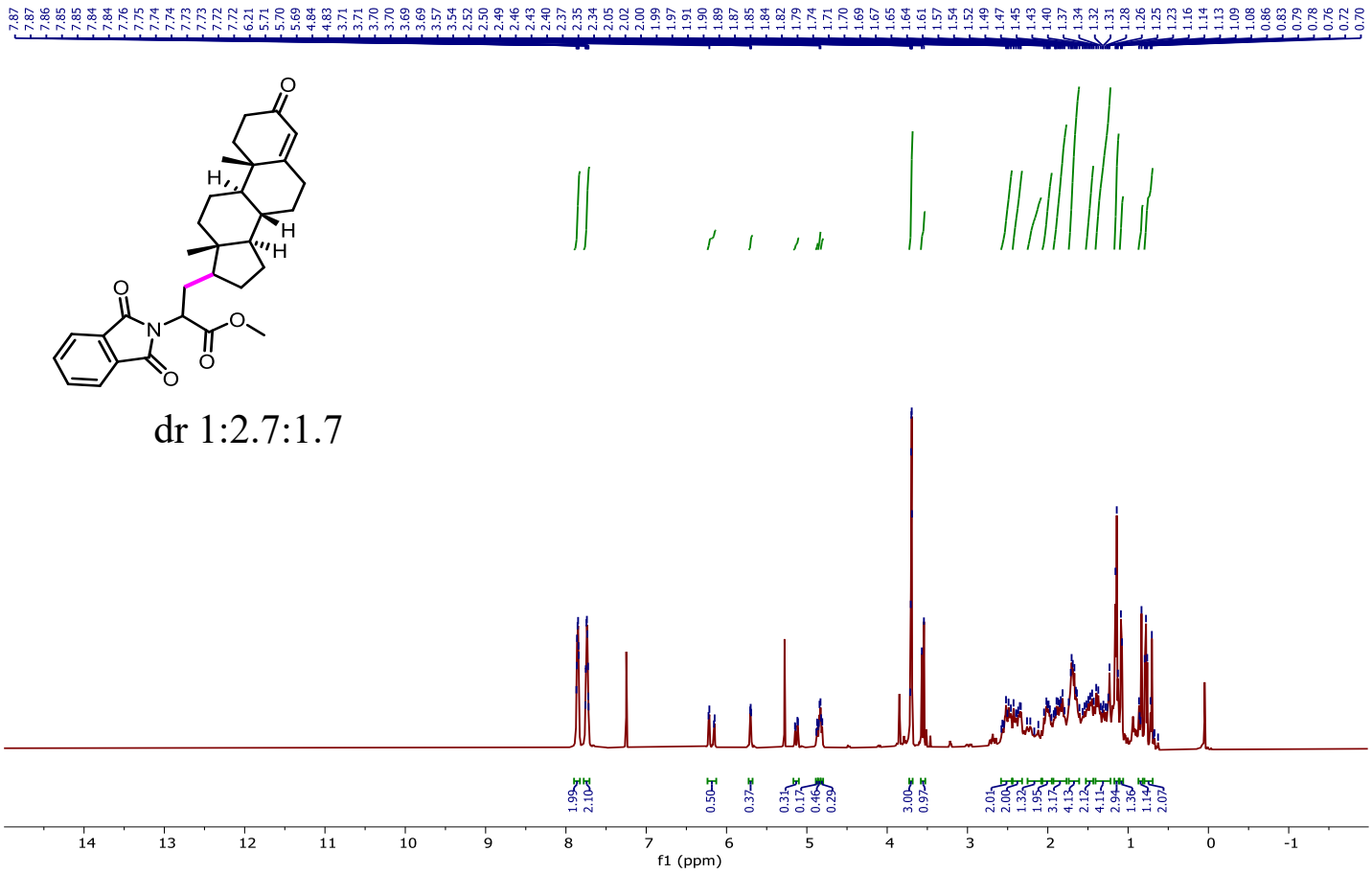
^{1}H NMR in $CDCl_3$ (4p)



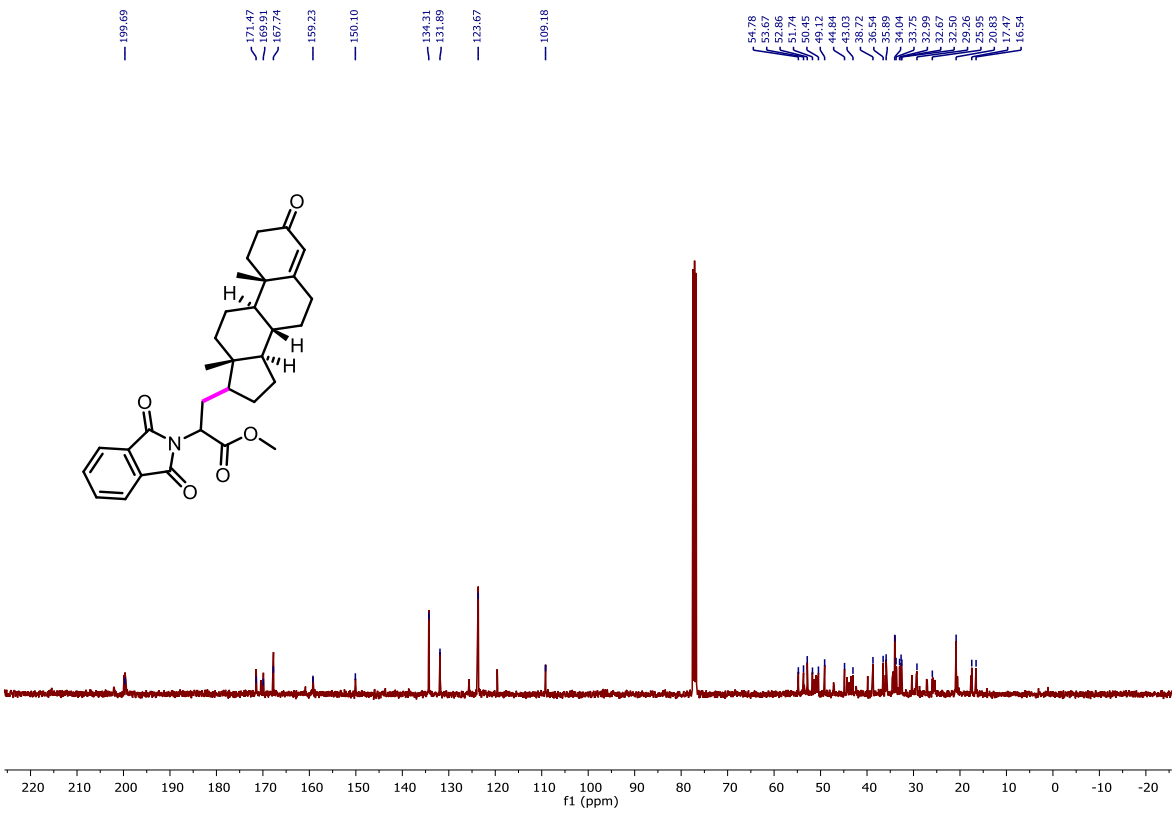
^{13}C NMR in $CDCl_3$ (4p)



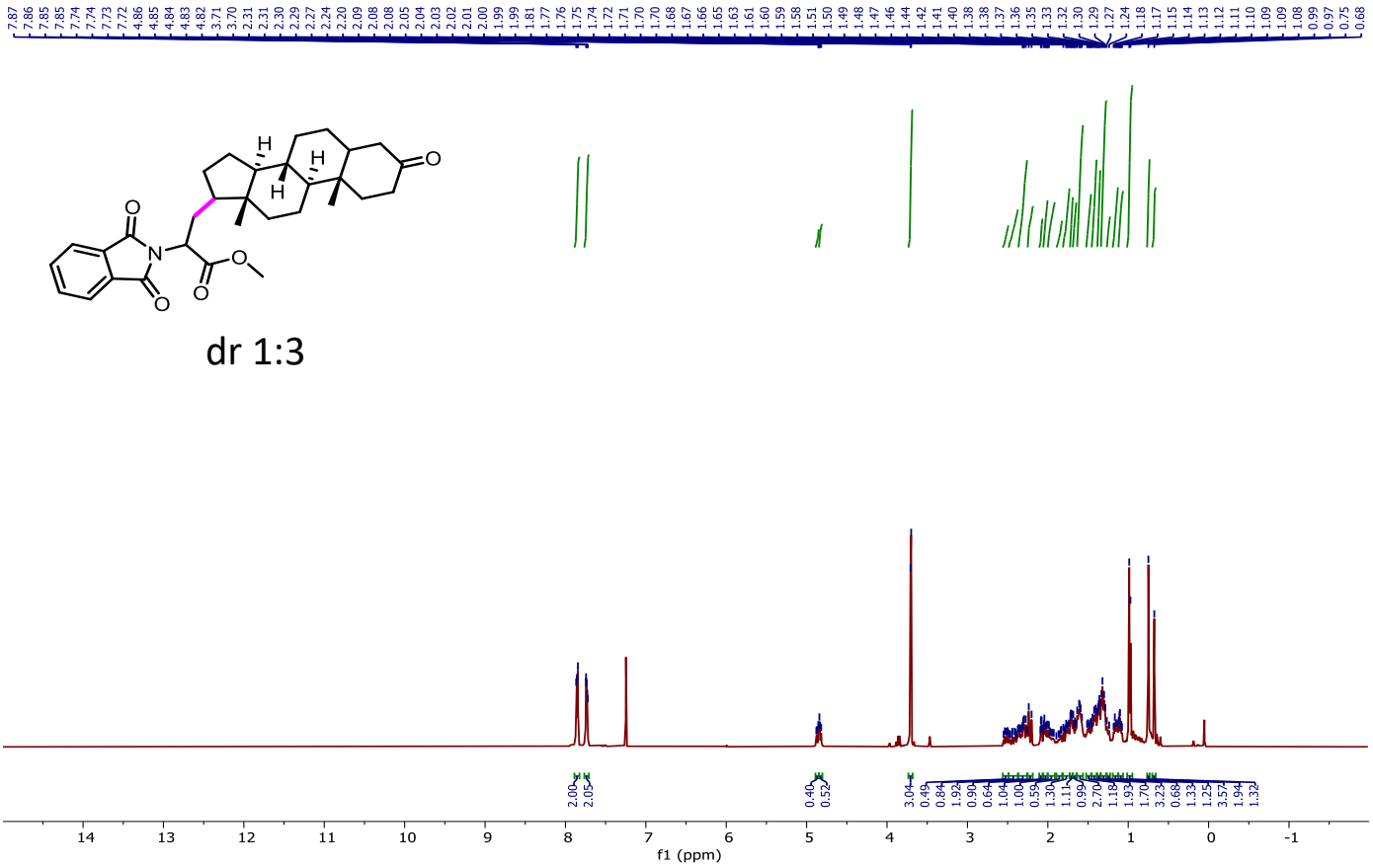
^{1}H NMR in $CDCl_3$ (4q)



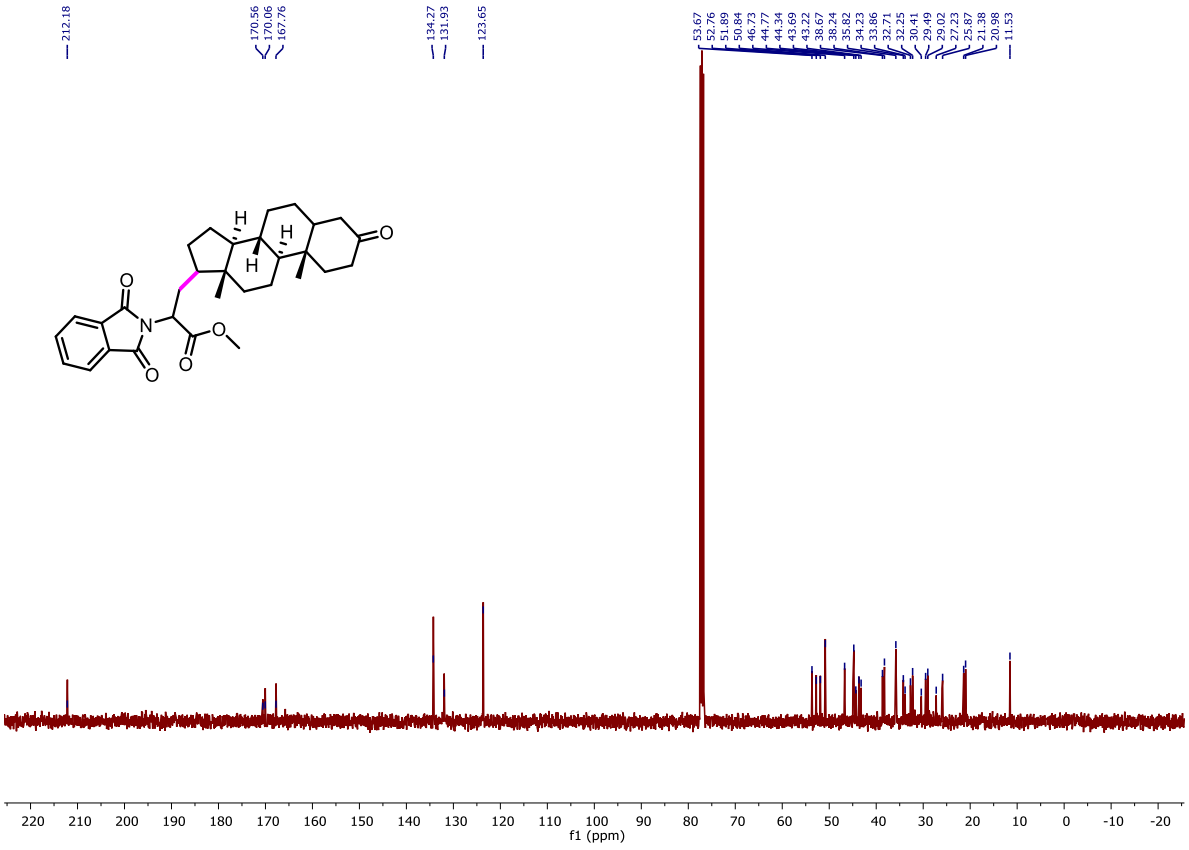
^{13}C NMR in $CDCl_3$ (4q)



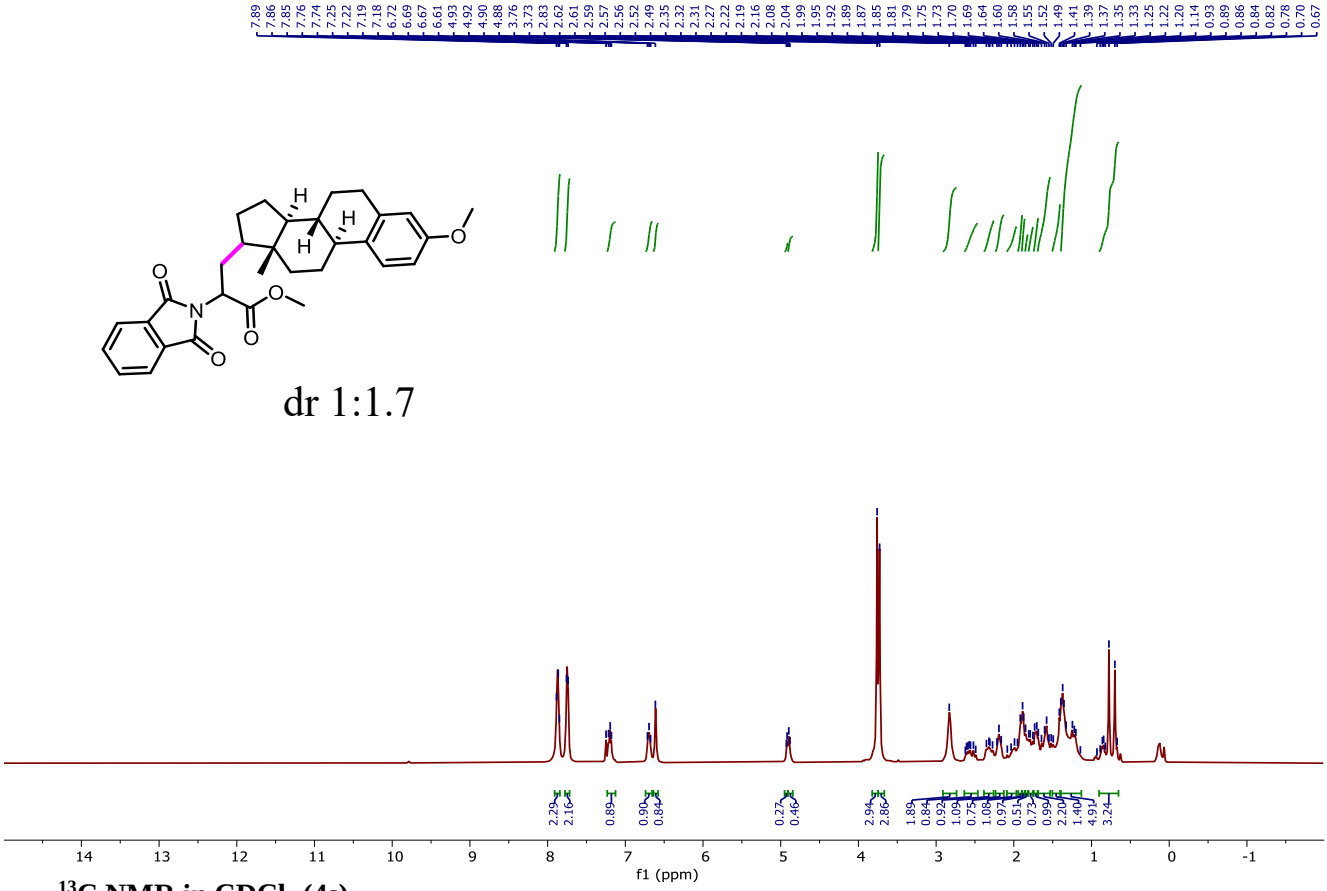
^{1}H NMR in $CDCl_3$ (4r)



^{13}C NMR in $CDCl_3$ (4r)

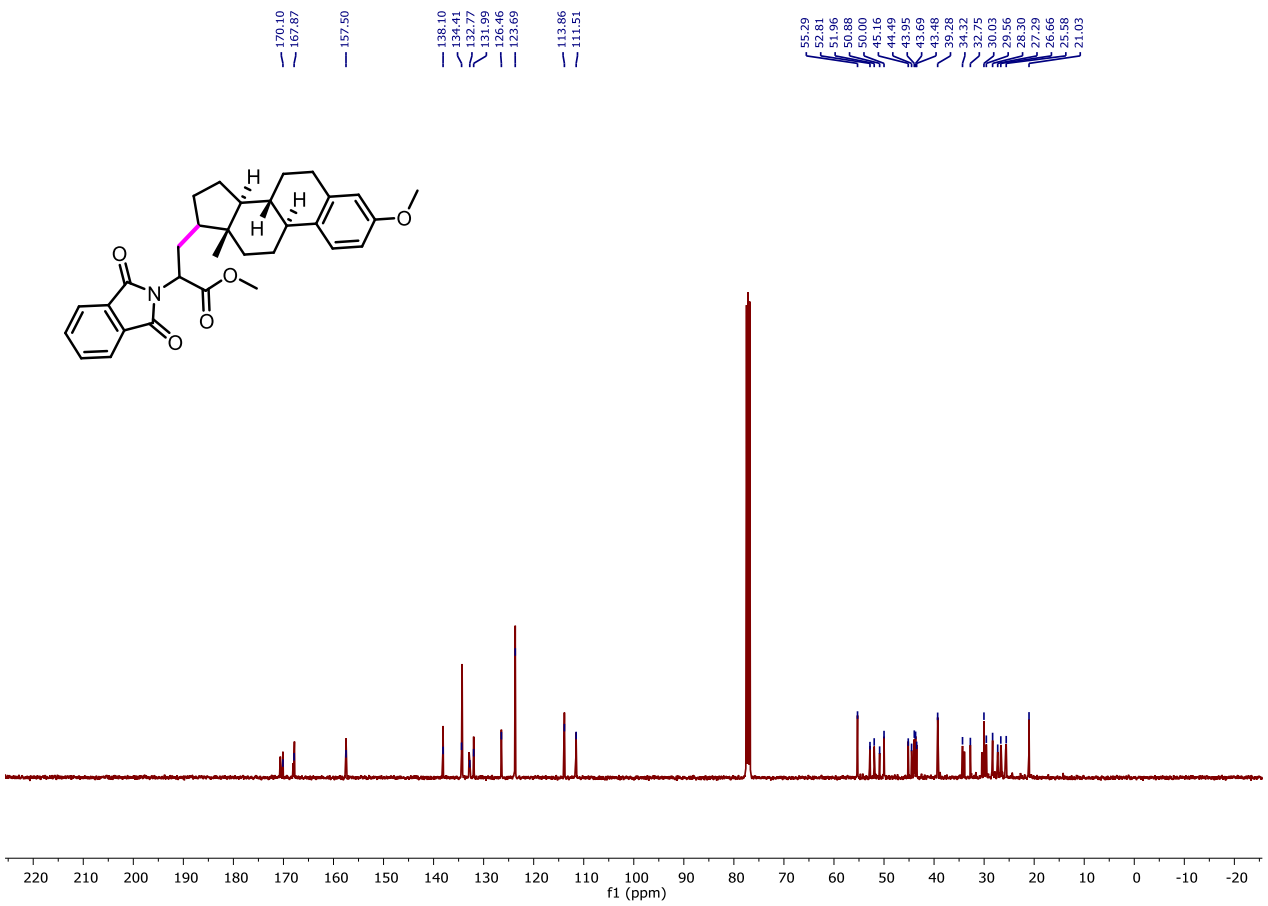


^{1}H NMR in $CDCl_3$ (4s)

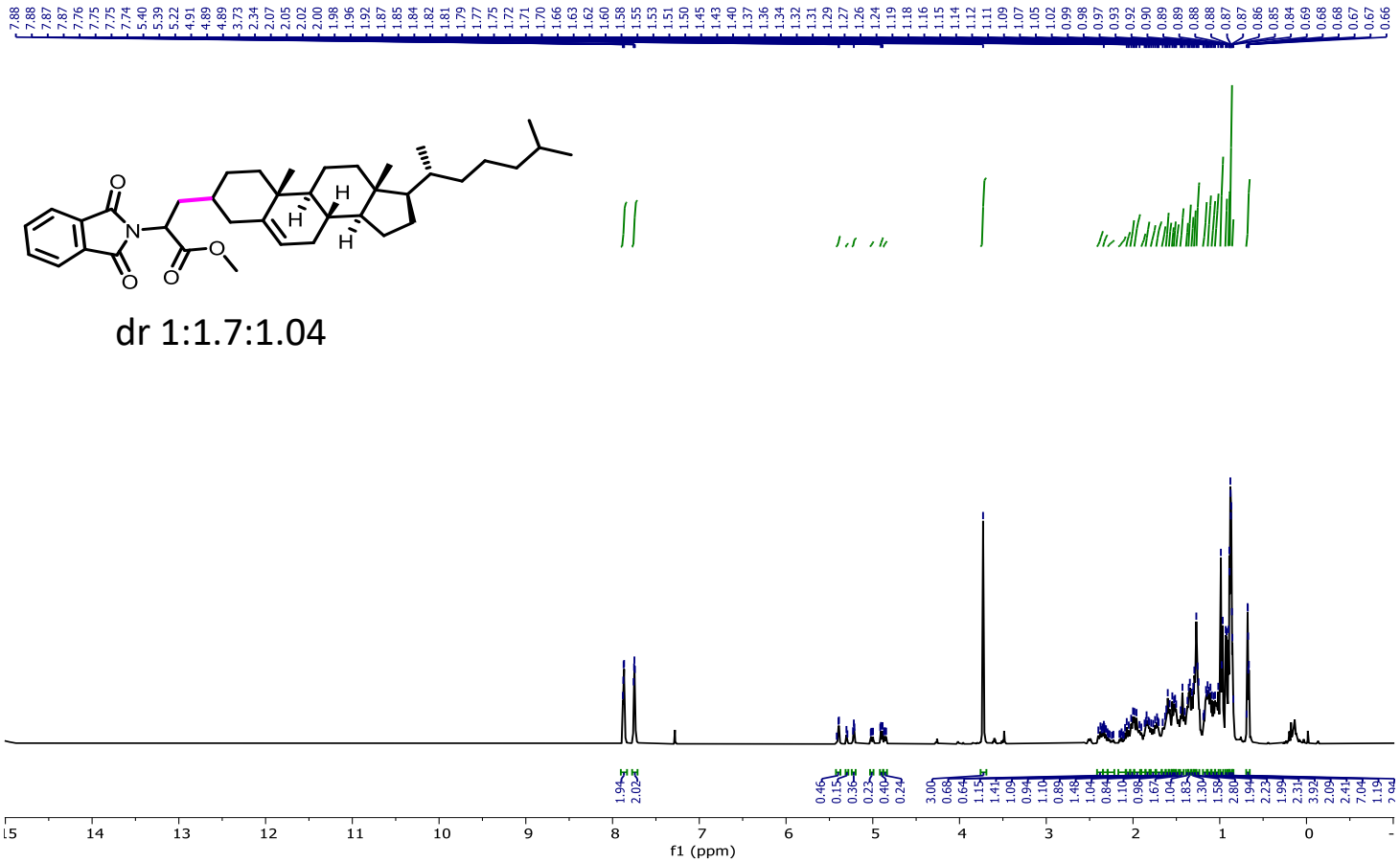


dr 1:1.7

^{13}C NMR in $CDCl_3$ (4s)

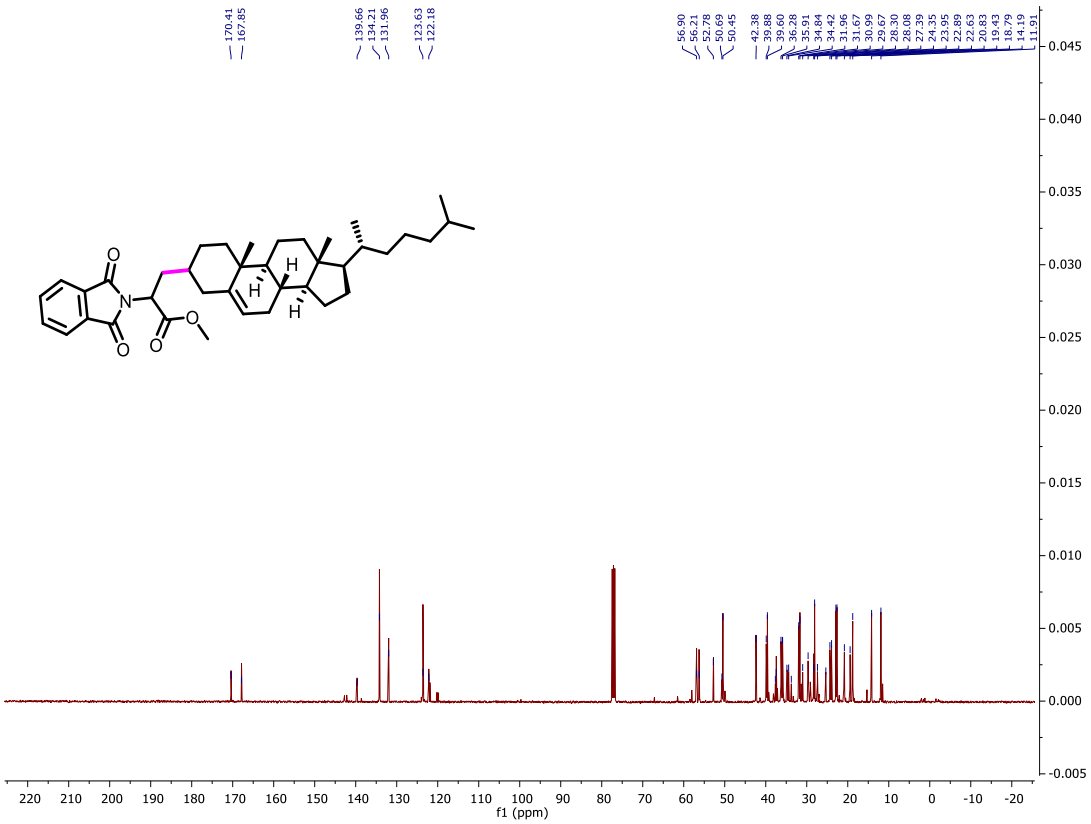


^{1}H NMR in $CDCl_3$ (4t)

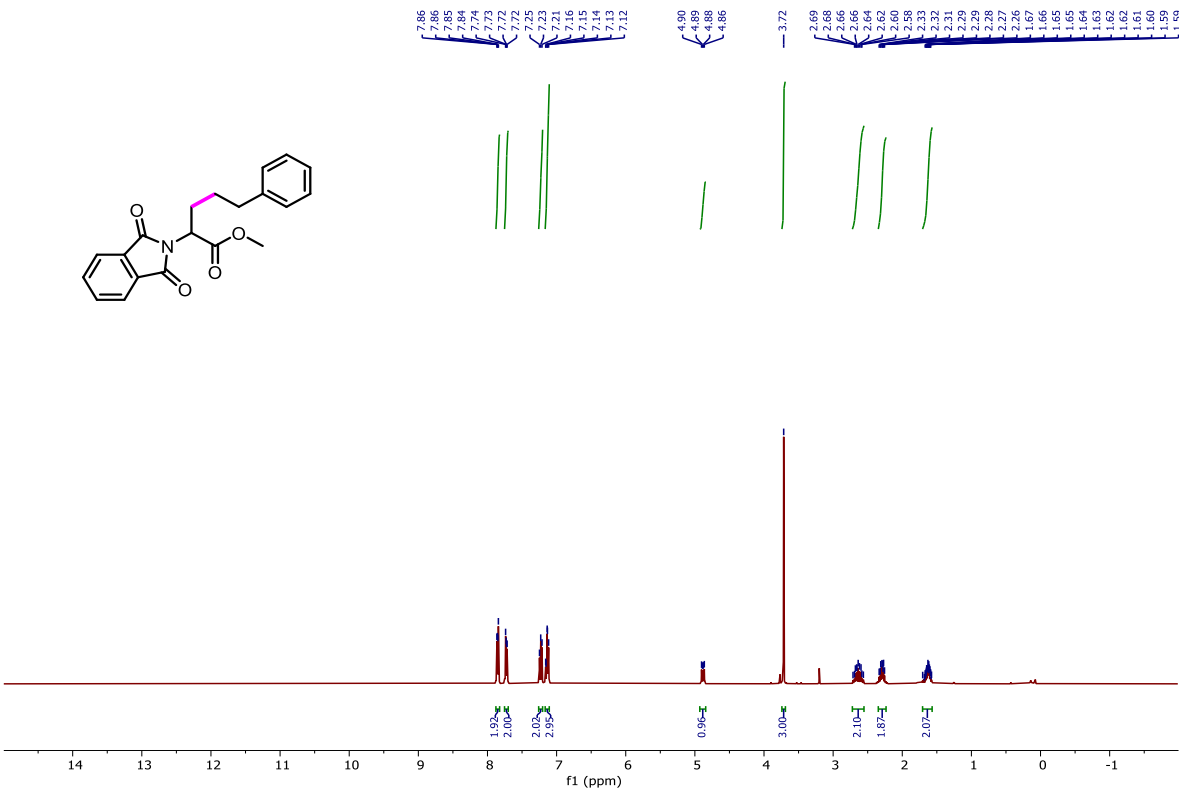


dr 1:1.7:1.04

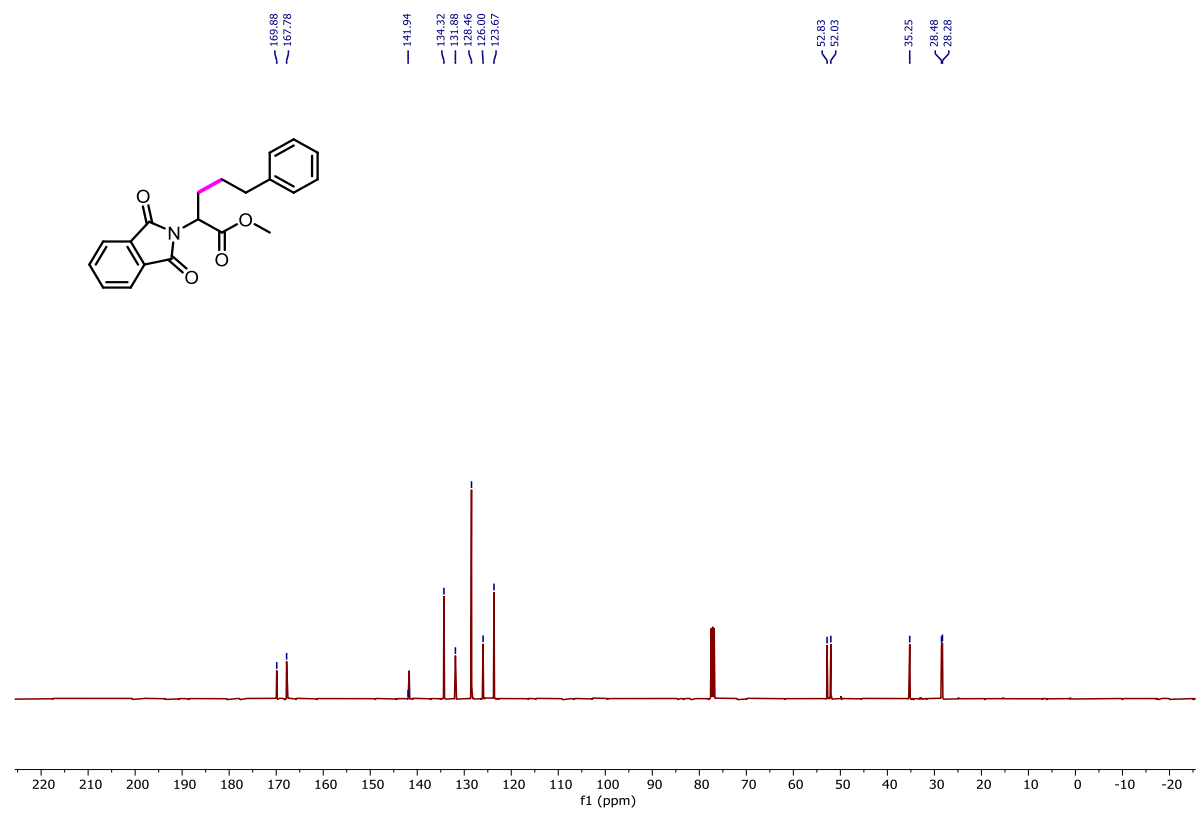
^{13}C NMR in $CDCl_3$ (4t)



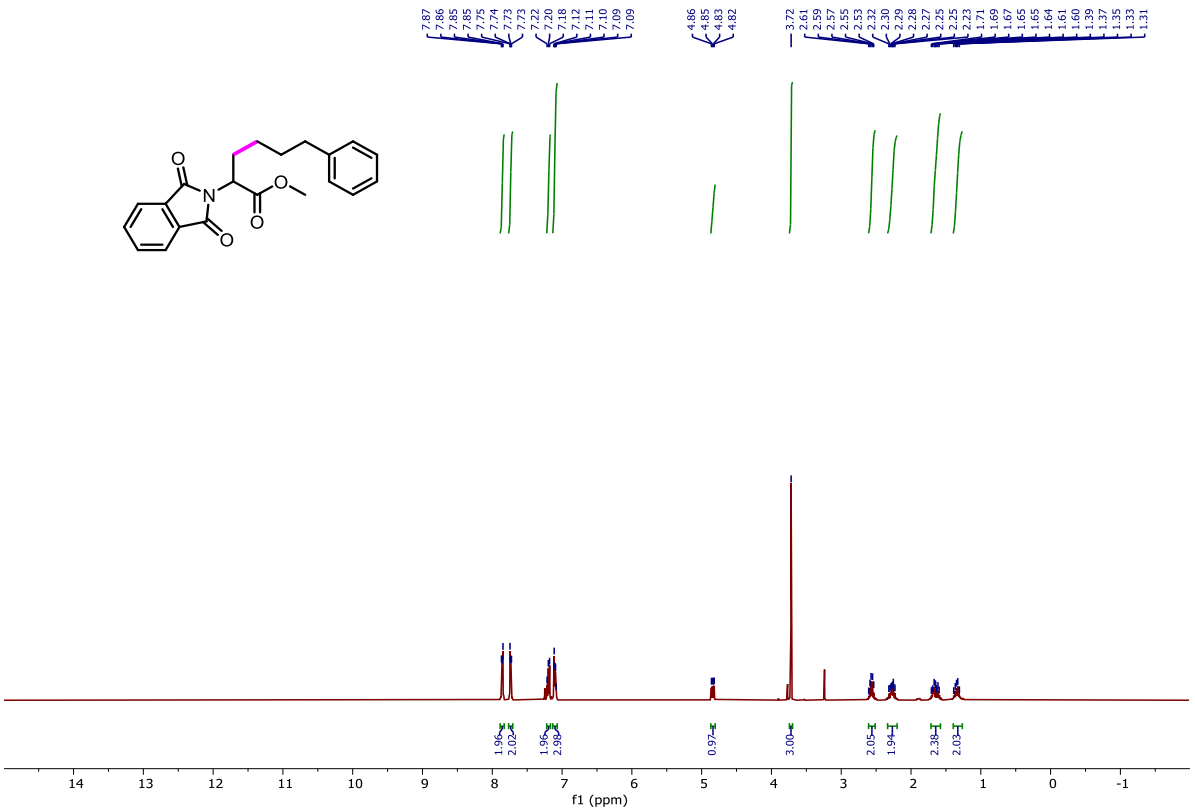
^{1}H NMR in $CDCl_3$ (4u)



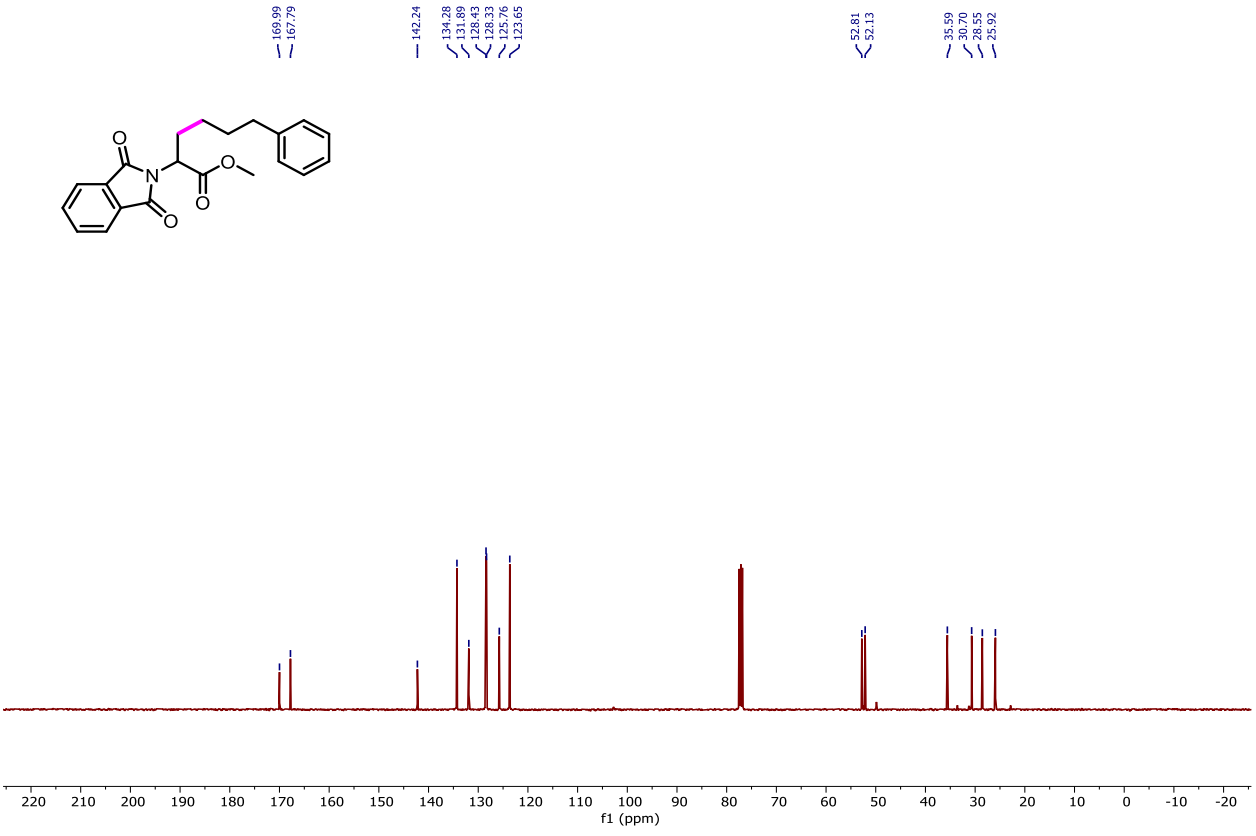
^{13}C NMR in $CDCl_3$ (4u)



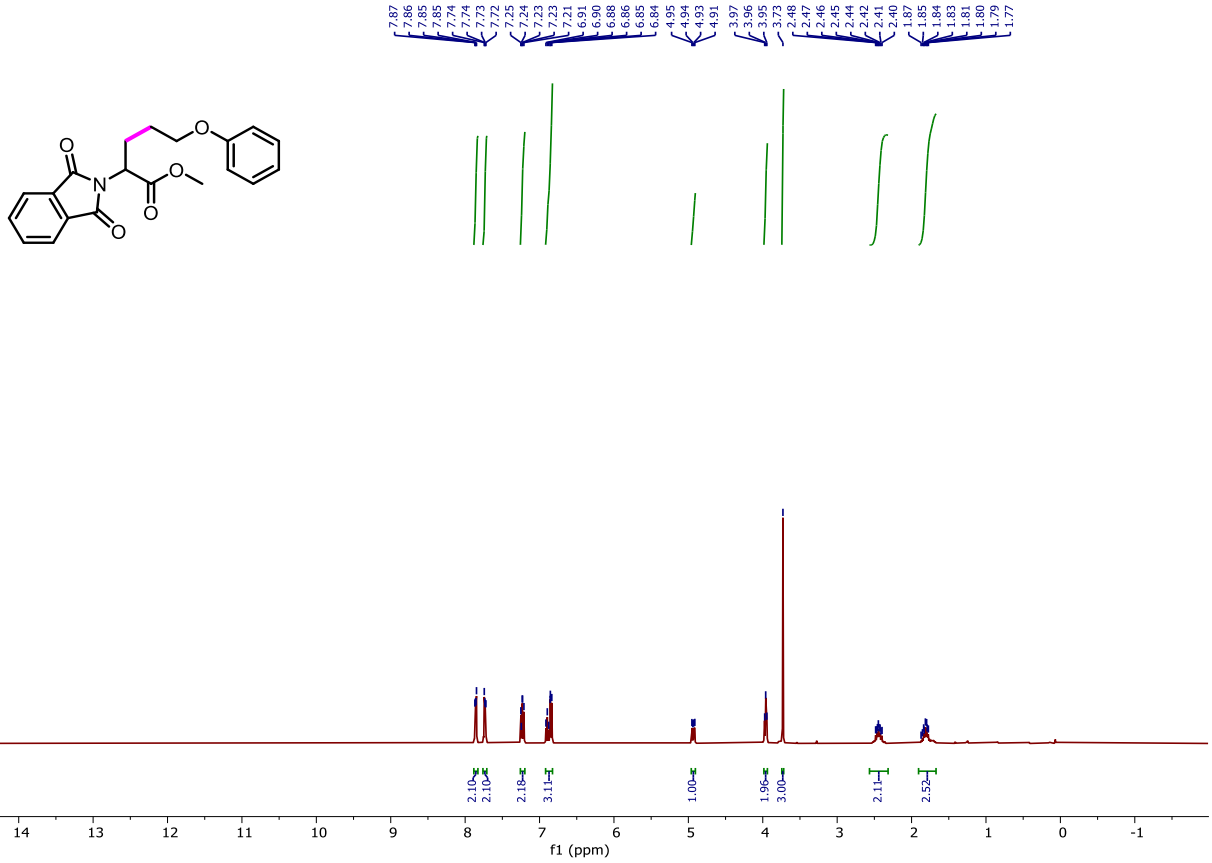
^{1}H NMR in $CDCl_3$ (4v)



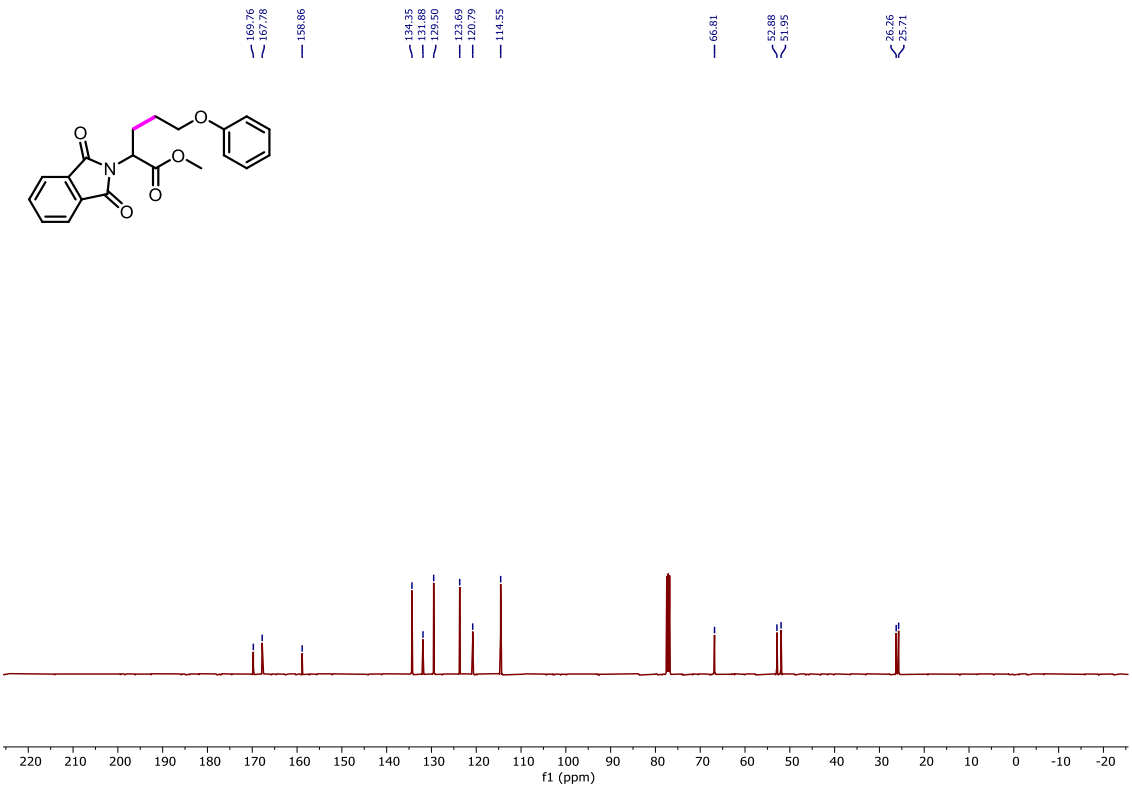
^{13}C NMR in $CDCl_3$ (4v)



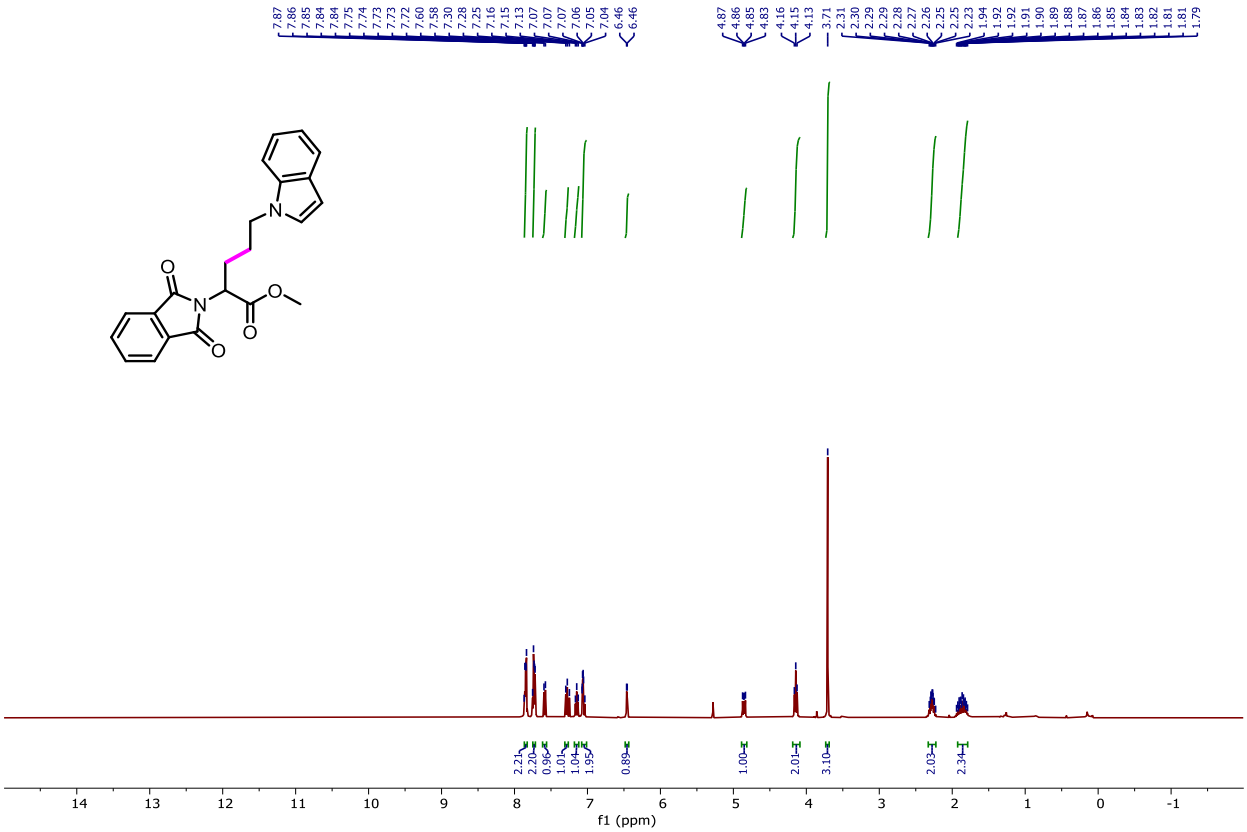
^{1}H NMR in $CDCl_3$ (4w)



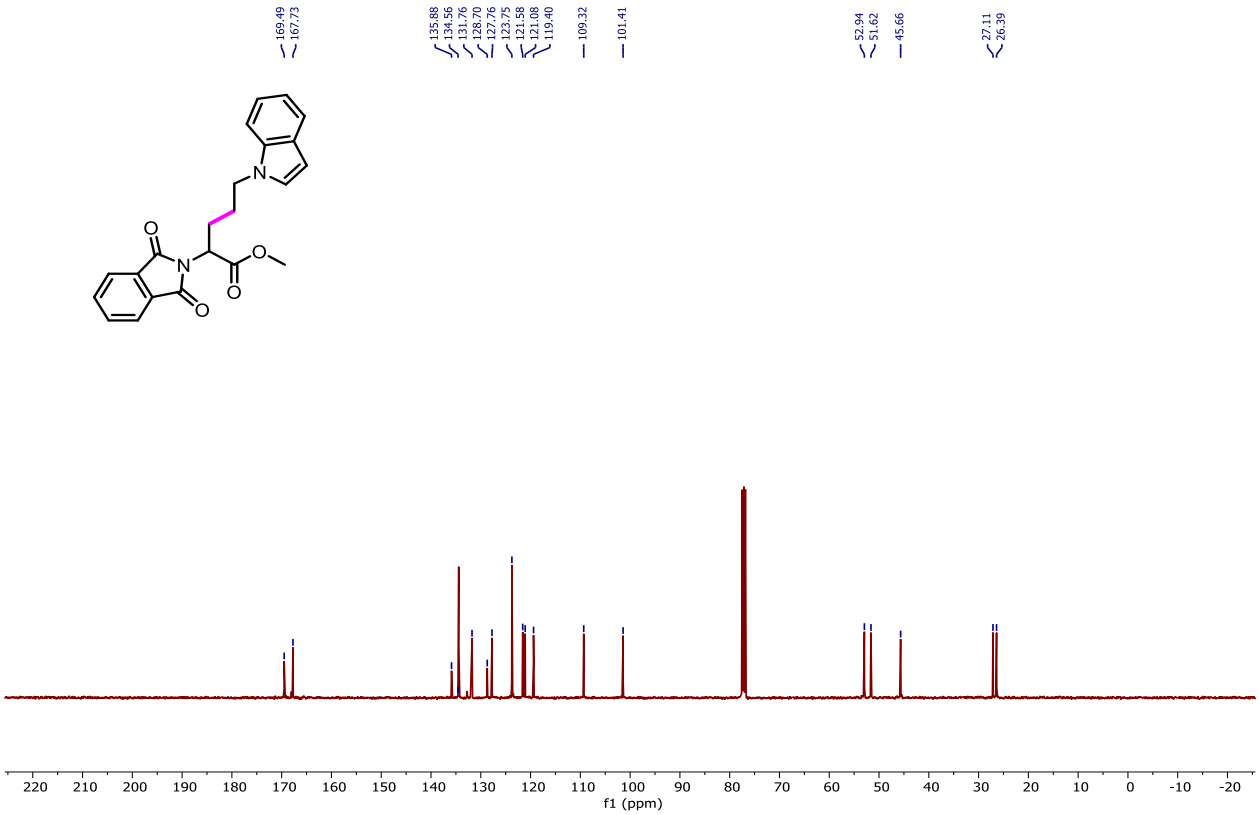
^{13}C NMR in $CDCl_3$ (4w)



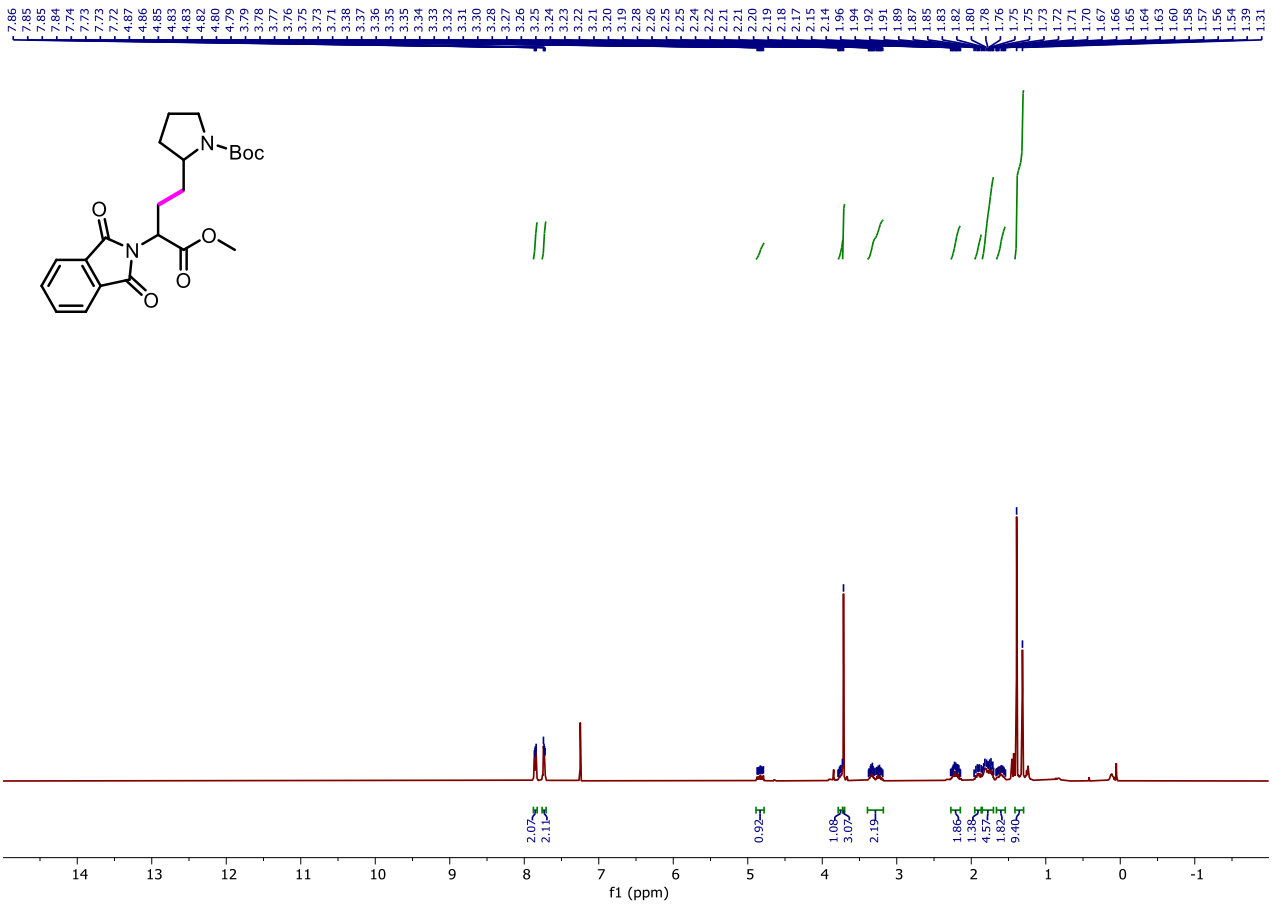
^{1}H NMR in $CDCl_3$ (4x)



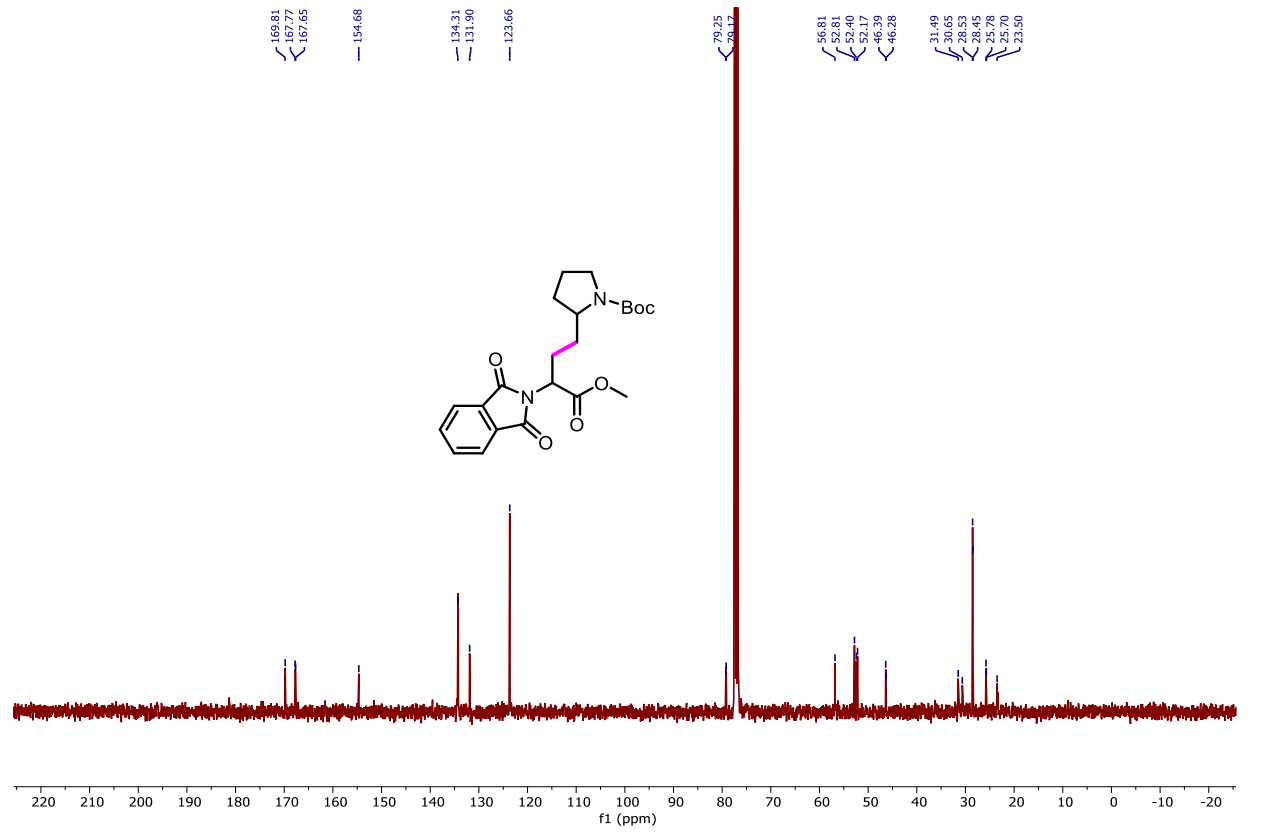
^{13}C NMR in $CDCl_3$ (4x)



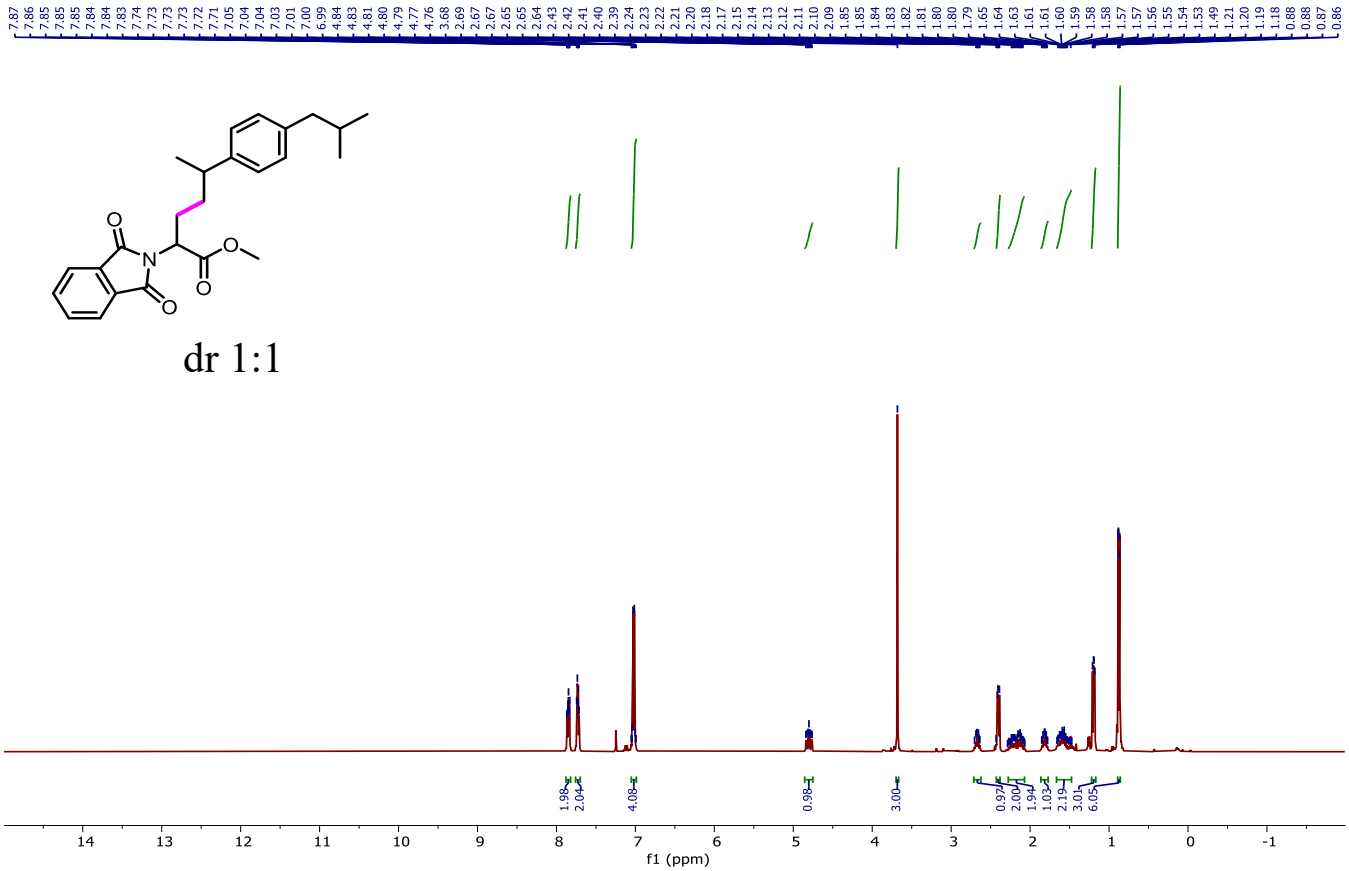
^{1}H NMR in $CDCl_3$ (4y)



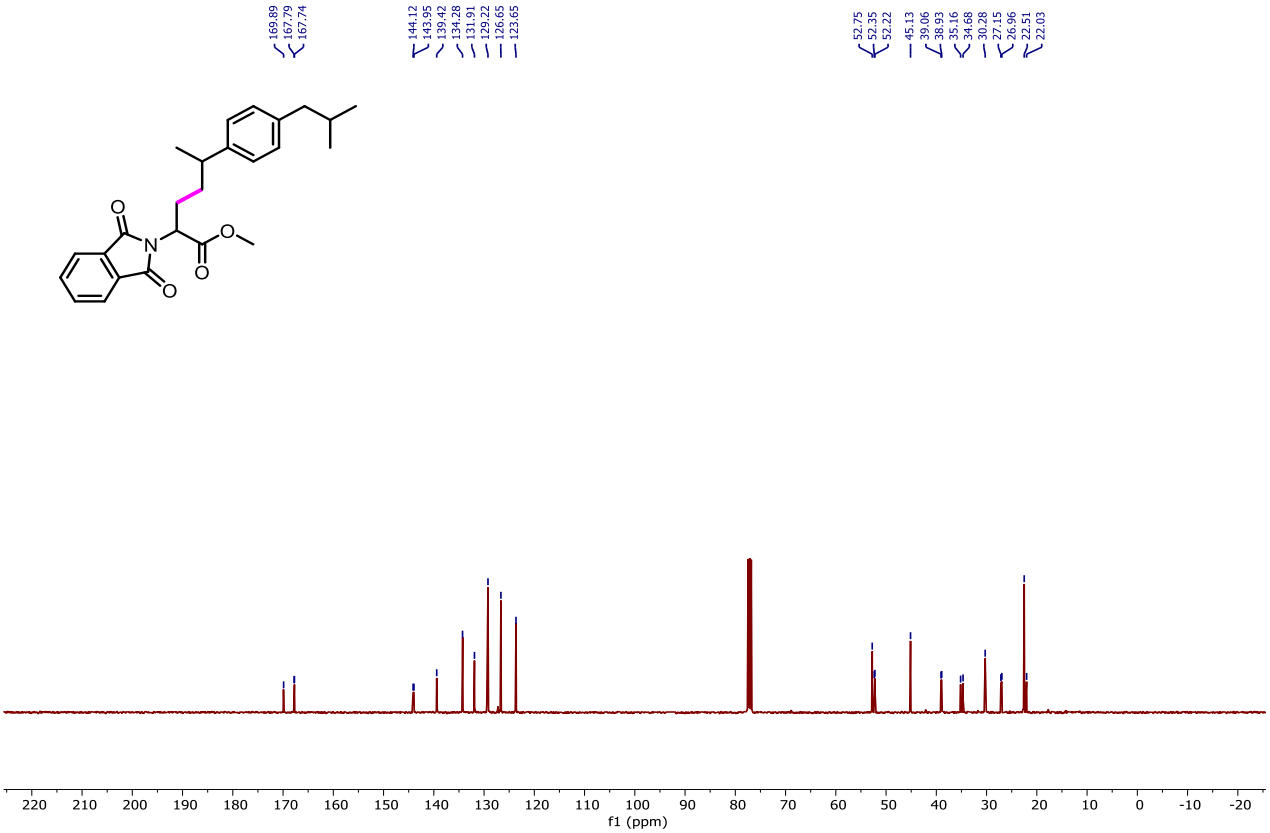
^{13}C NMR in $CDCl_3$ (4y)



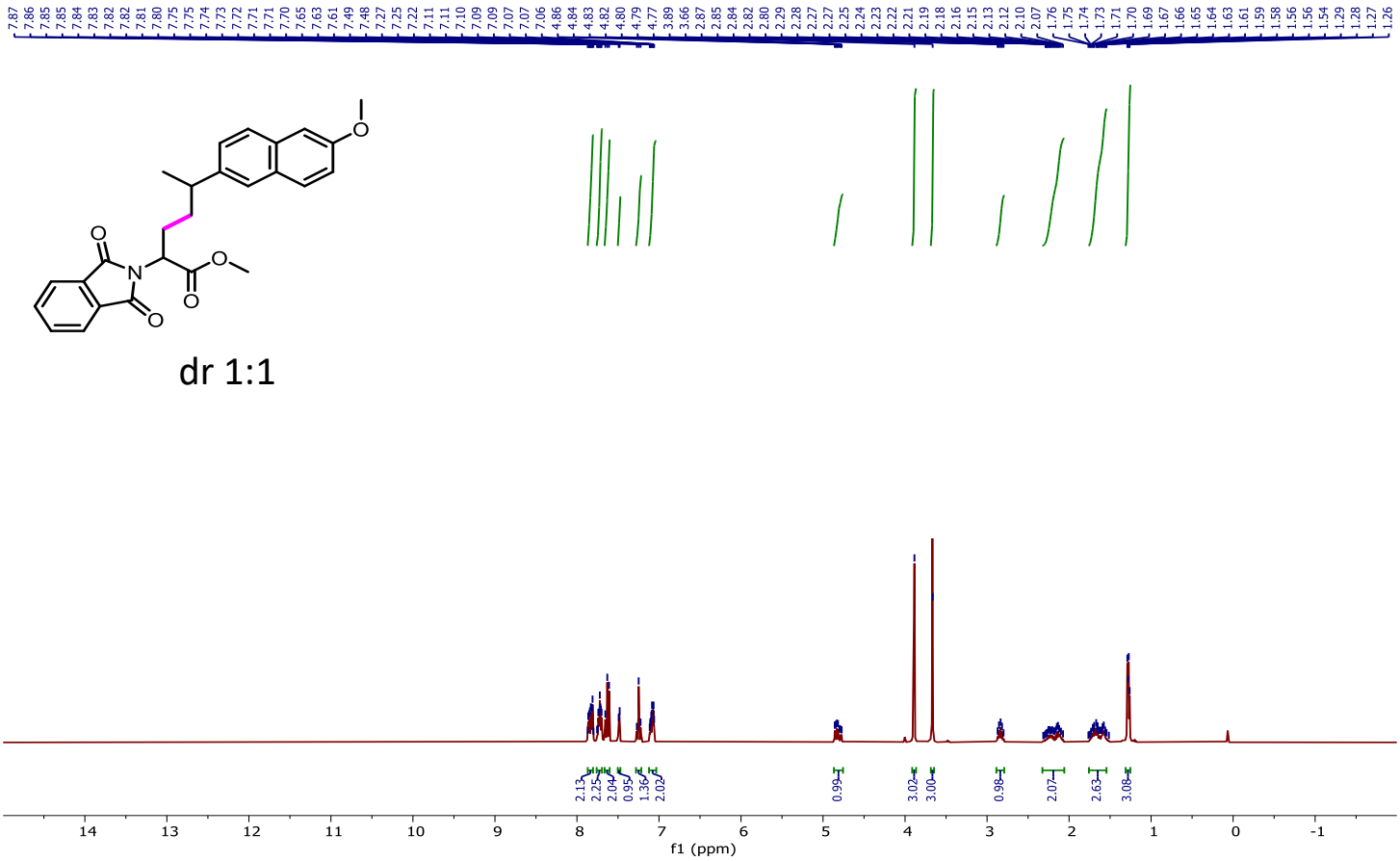
^{1}H NMR in $CDCl_3$ (4z)



^{13}C NMR in $CDCl_3$ (4z)

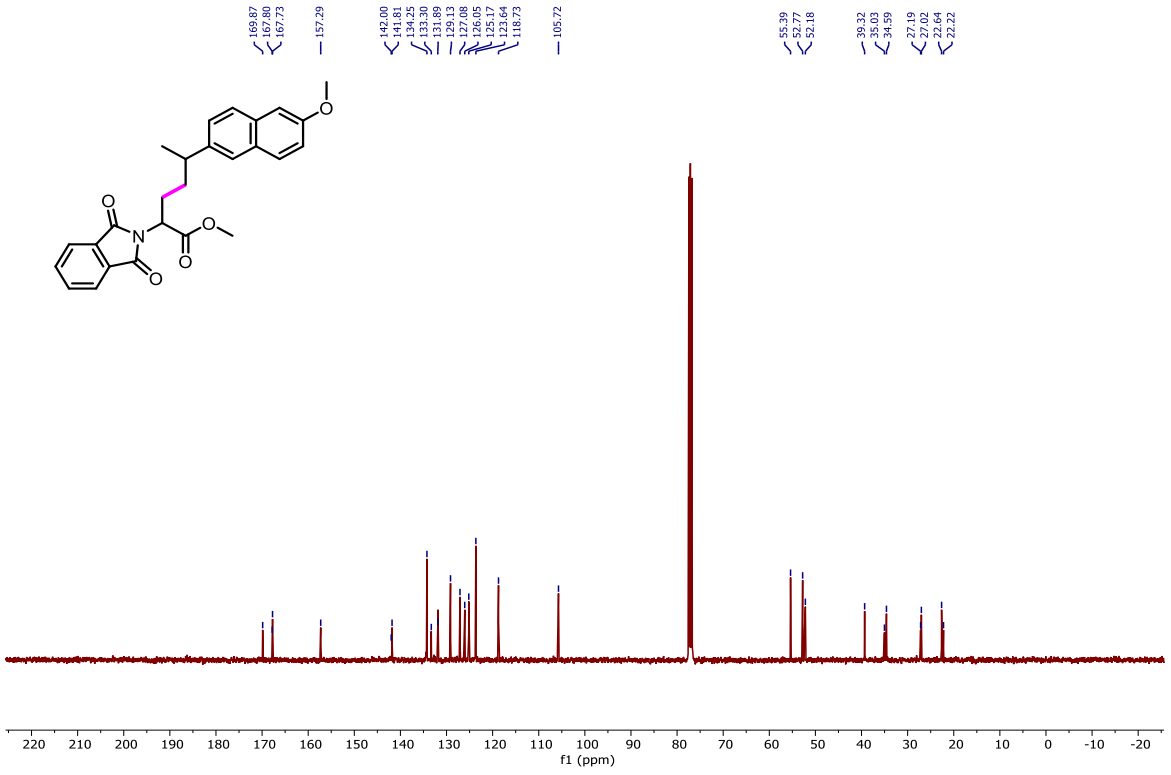


^{1}H NMR in $CDCl_3$ (4aa)

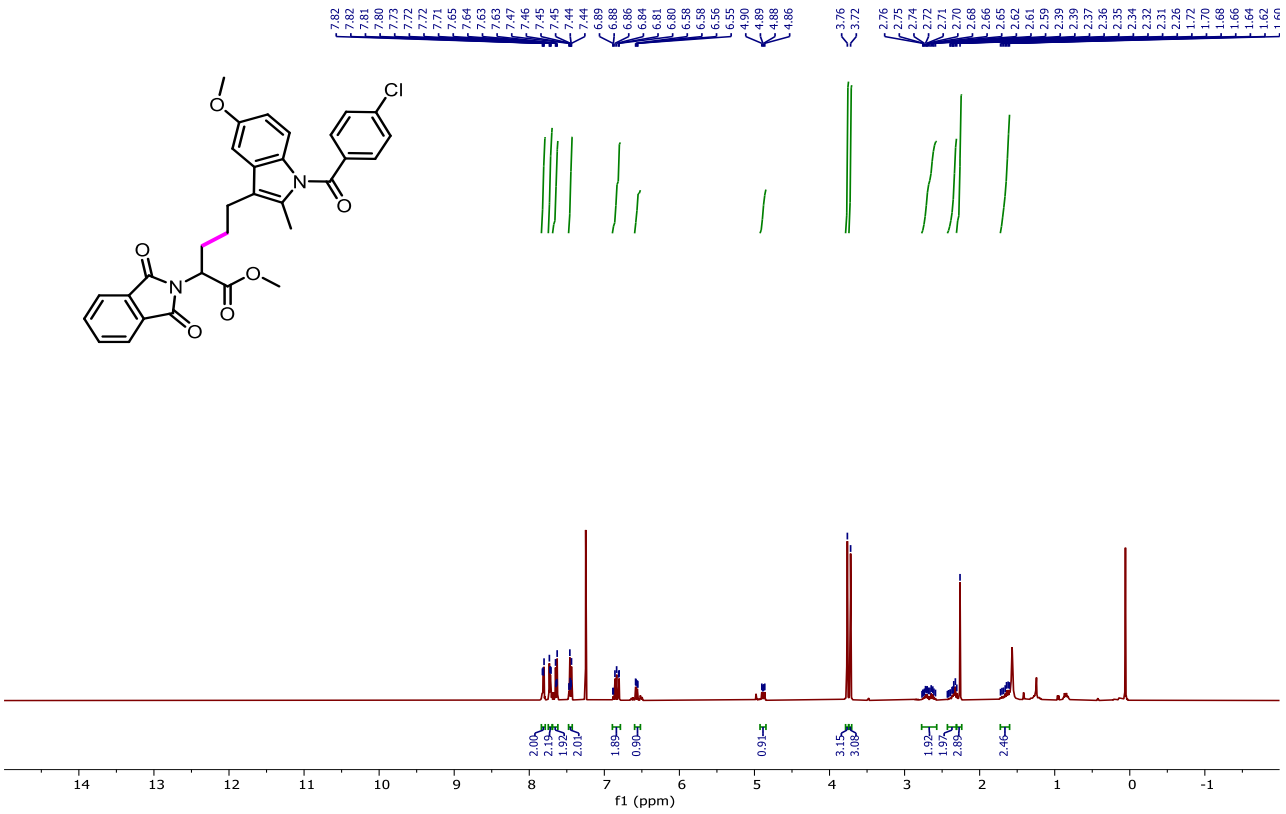


dr 1:1

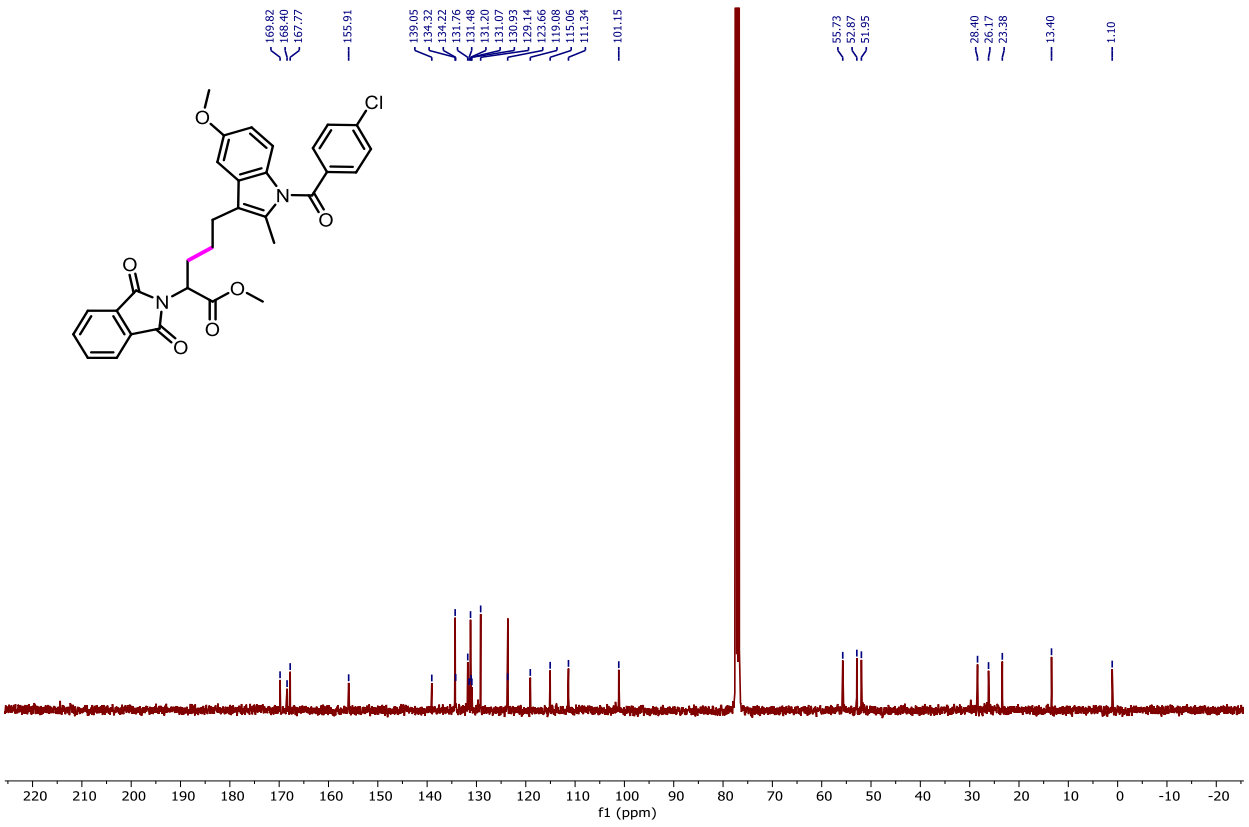
^{13}C NMR in $CDCl_3$ (4aa)



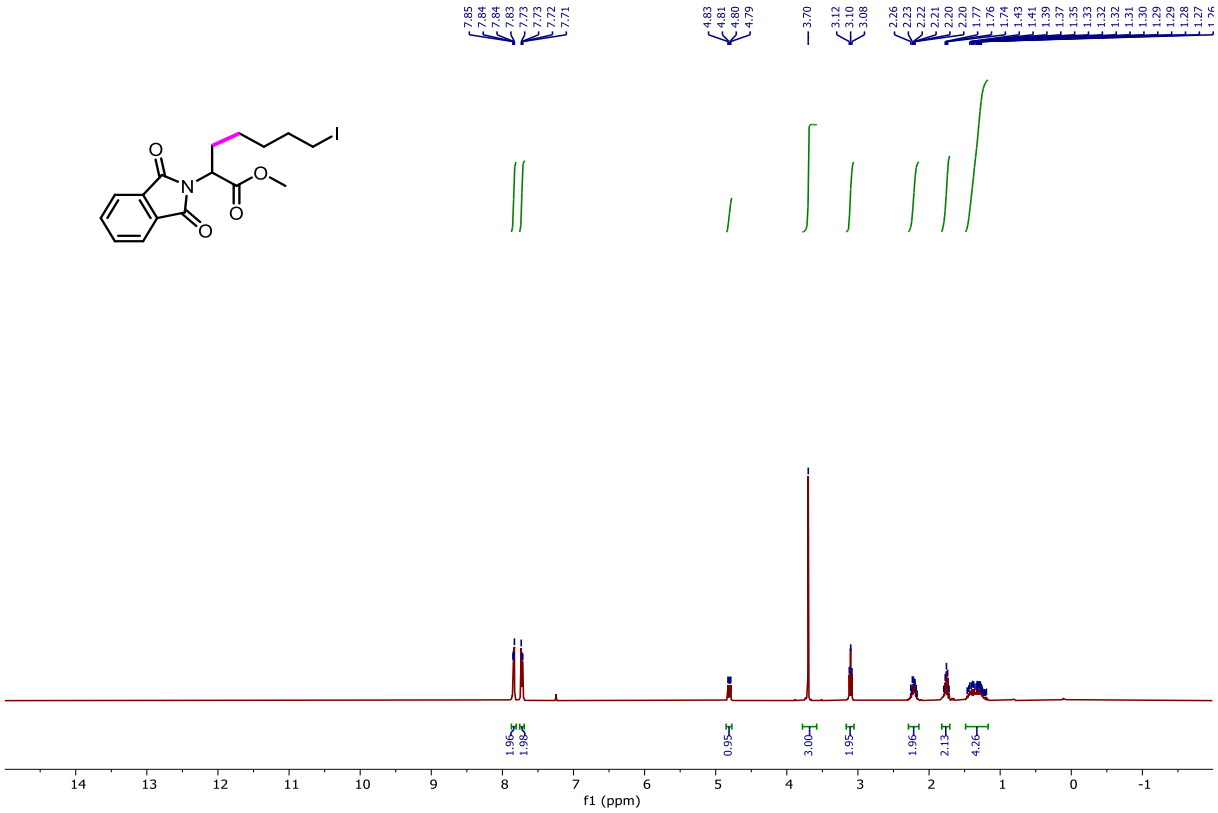
^{1}H NMR in $CDCl_3$ (4ab)



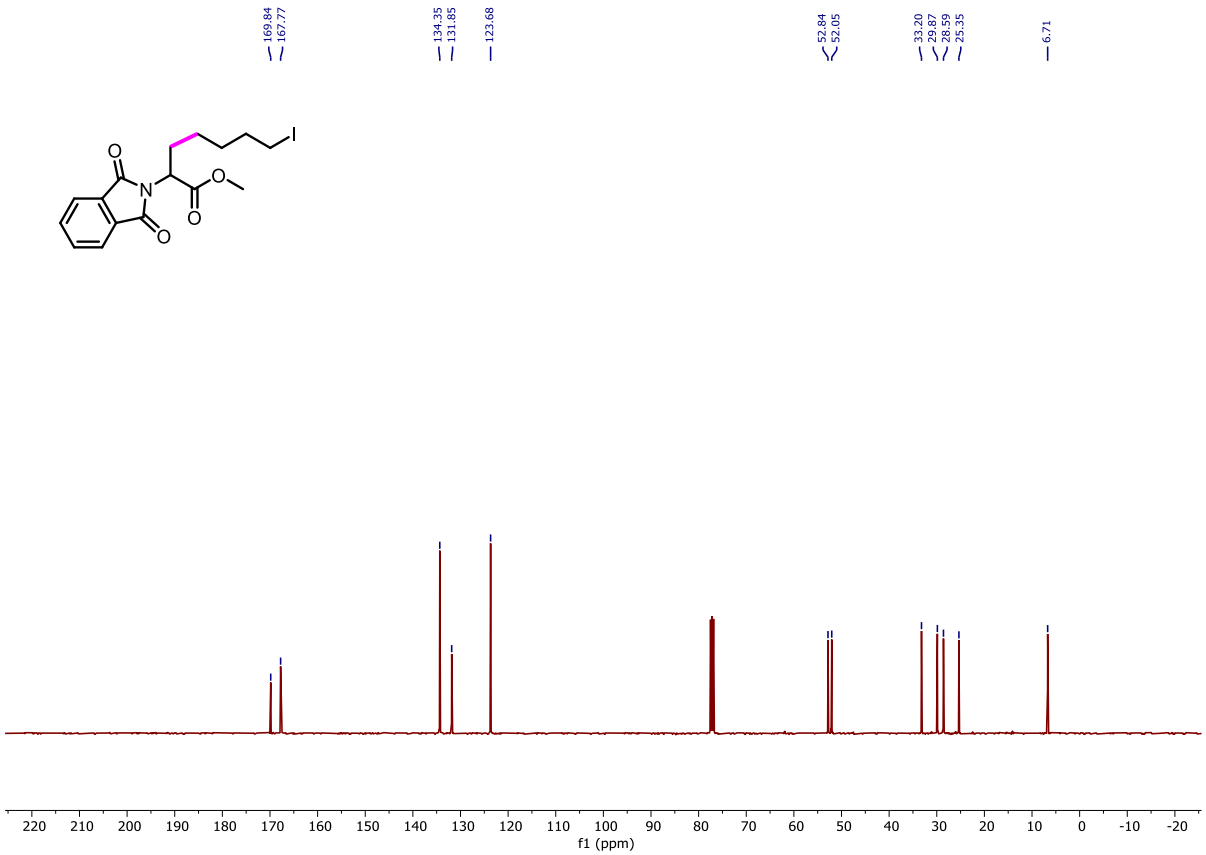
^{13}C NMR in $CDCl_3$ (4ab)



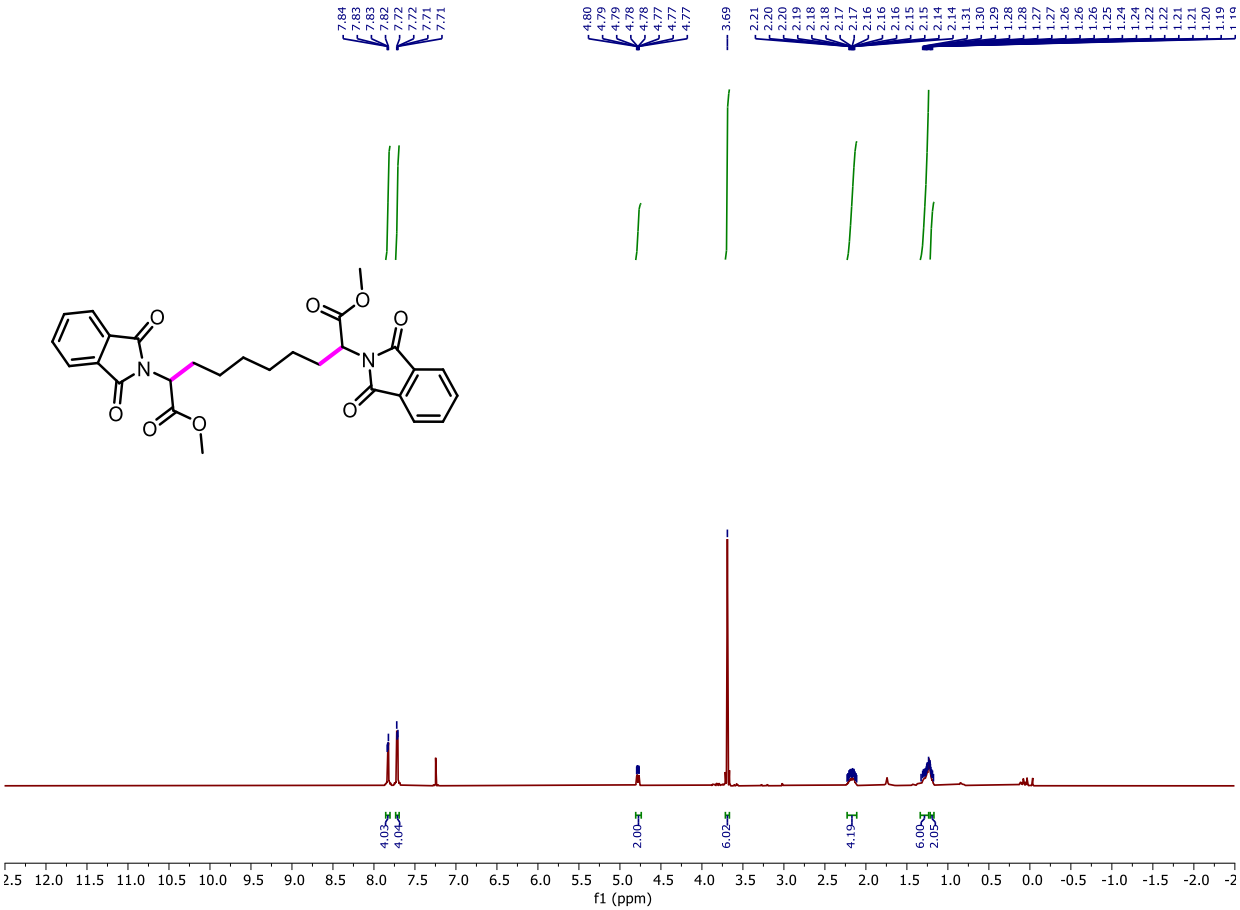
^{1}H NMR in $CDCl_3$ (4ac)



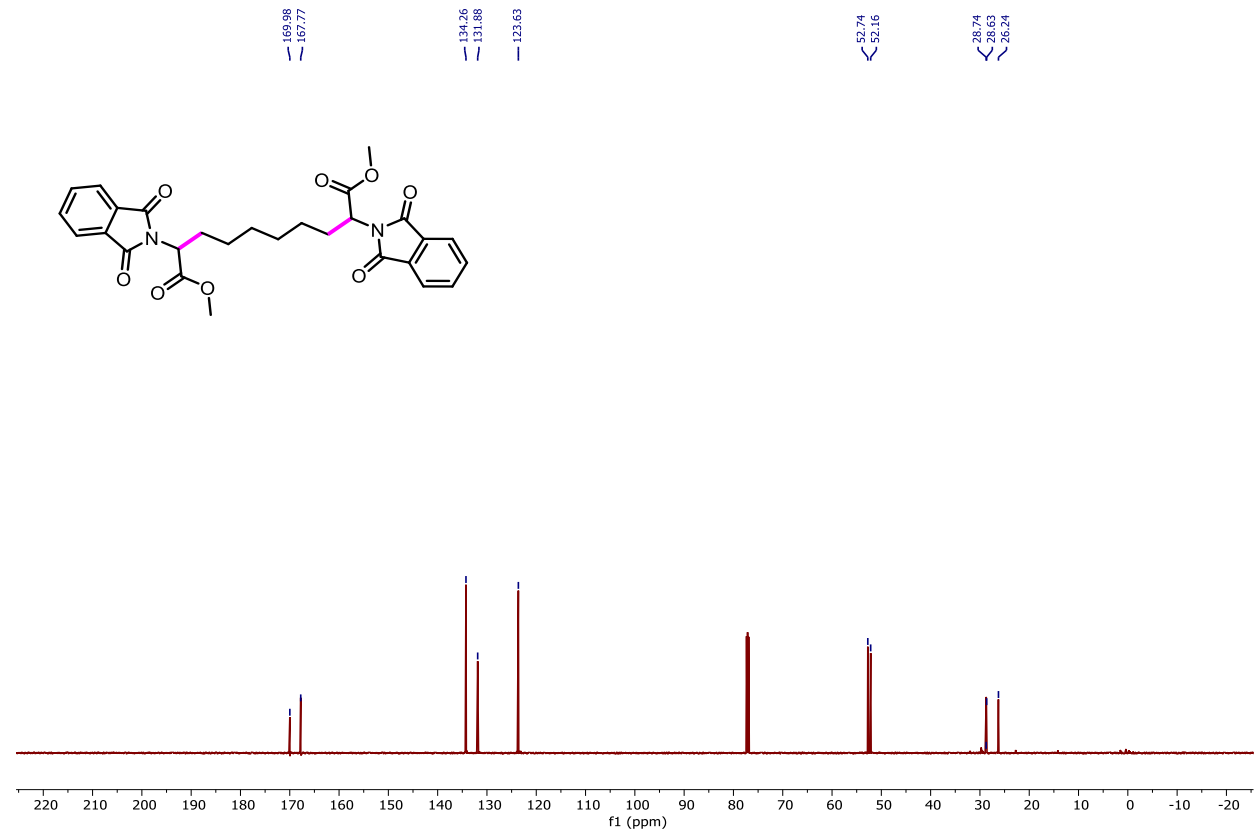
^{13}C NMR in $CDCl_3$ (4ac)



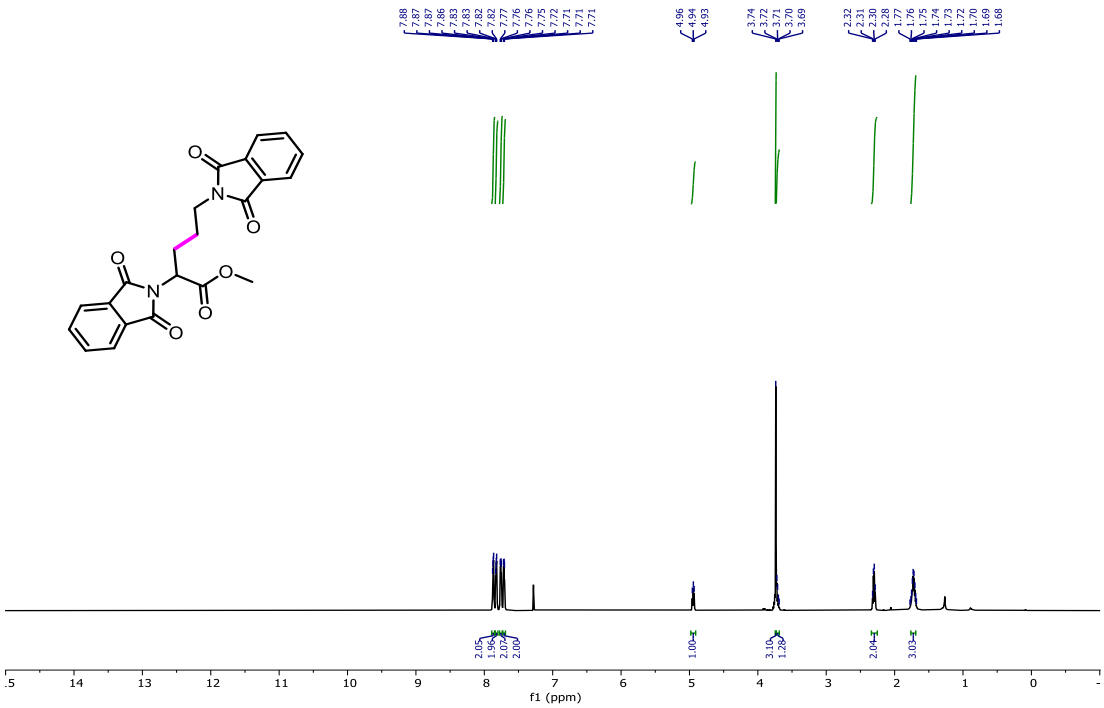
^{1}H NMR in $CDCl_3$ (4ac′)



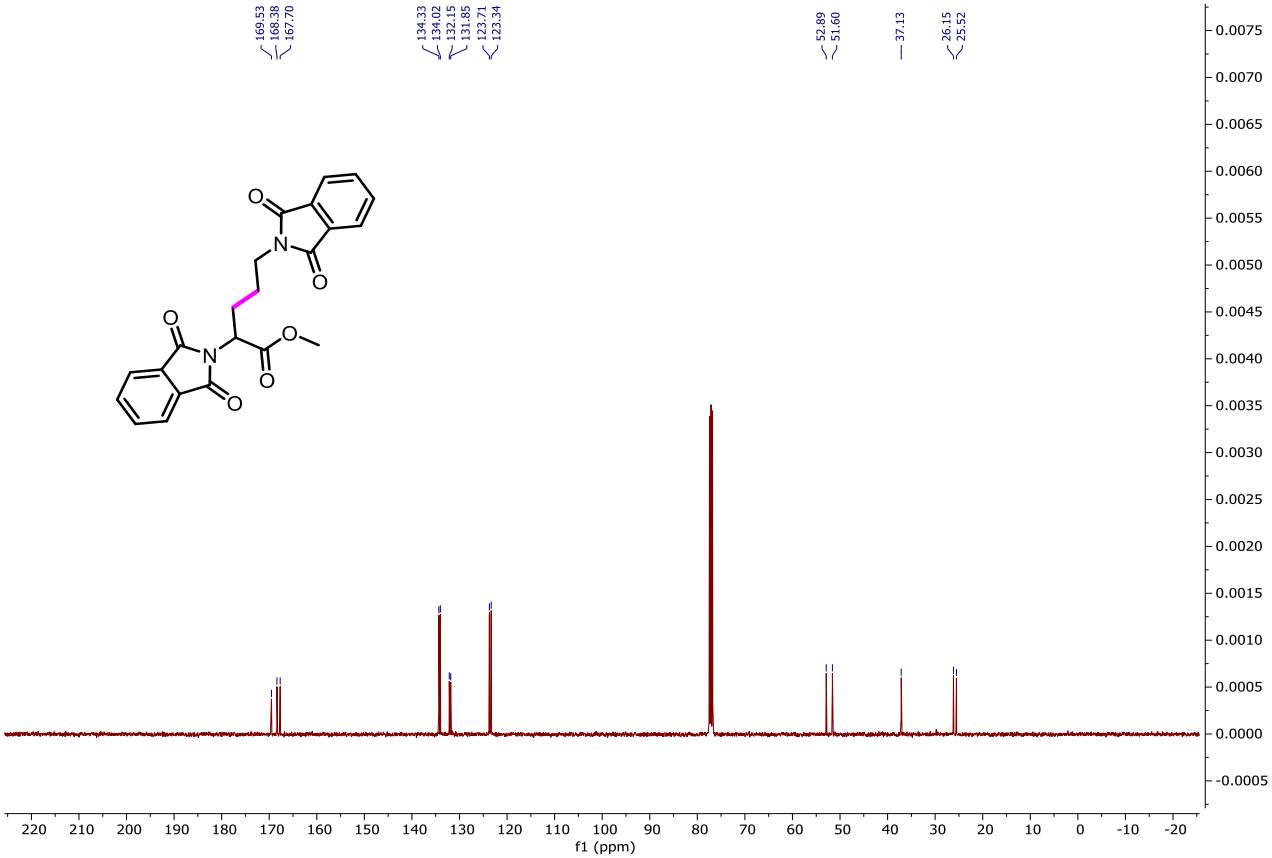
^{13}C NMR in $CDCl_3$ (4ac′)



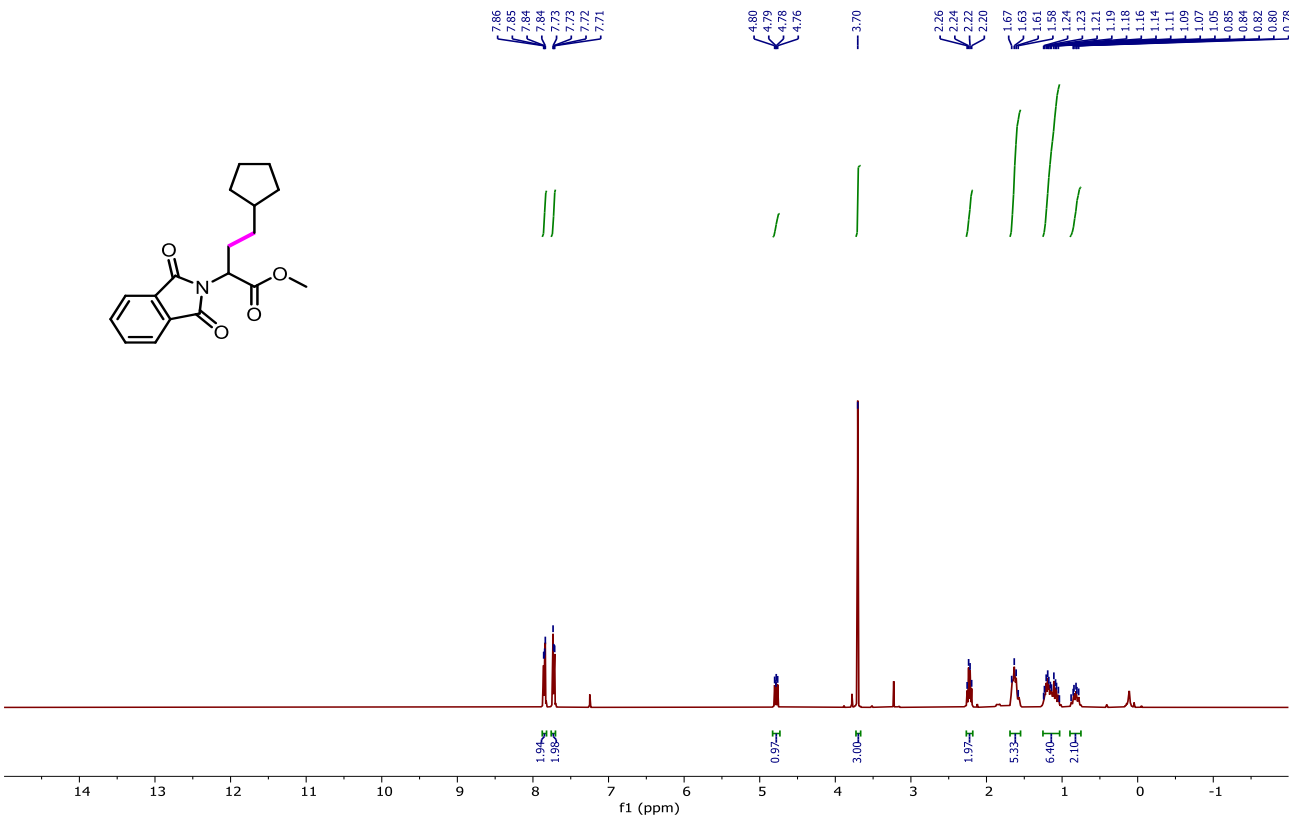
^{1}H NMR in $CDCl_3$ (4ad)



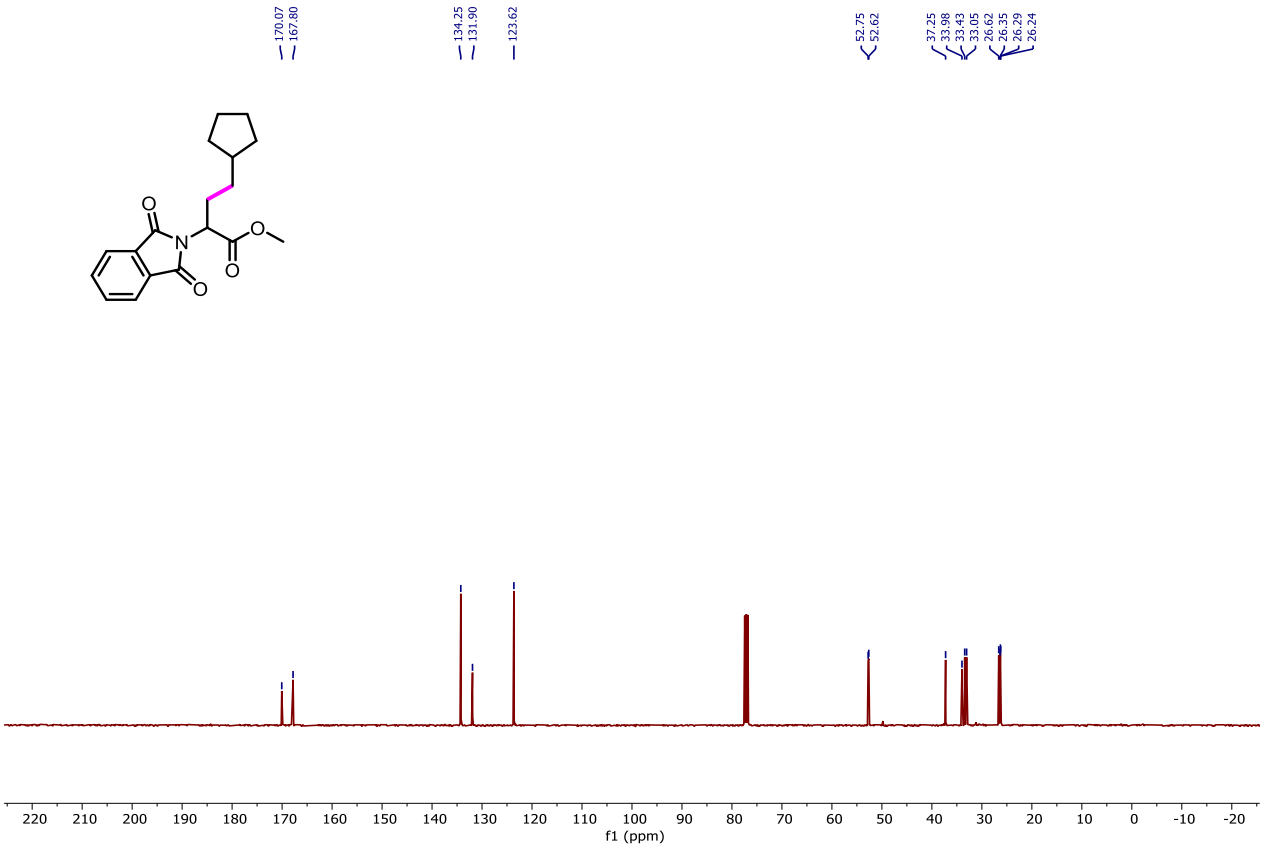
^{13}C NMR in $CDCl_3$ (4ad)



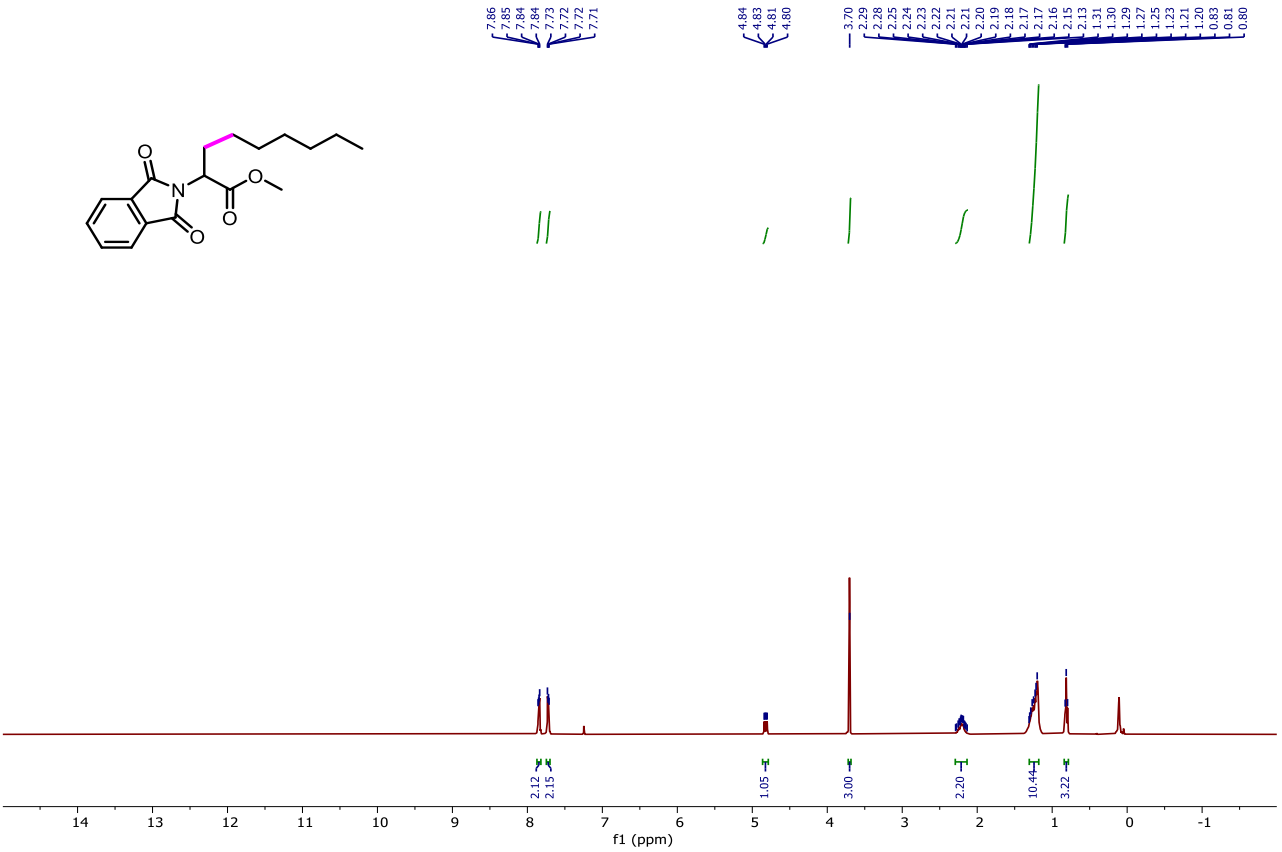
^{1}H NMR in $CDCl_3$ (4ae)



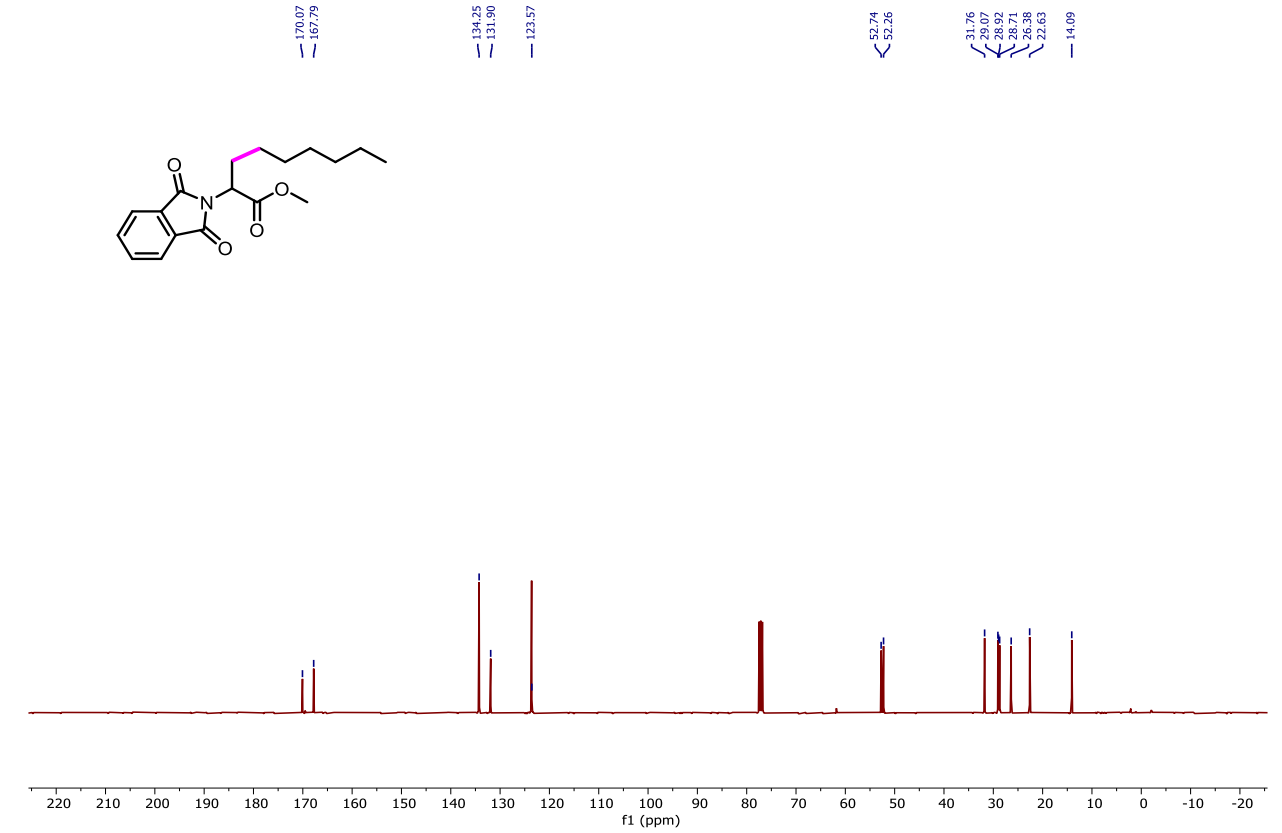
^{13}C NMR in $CDCl_3$ (4ae)



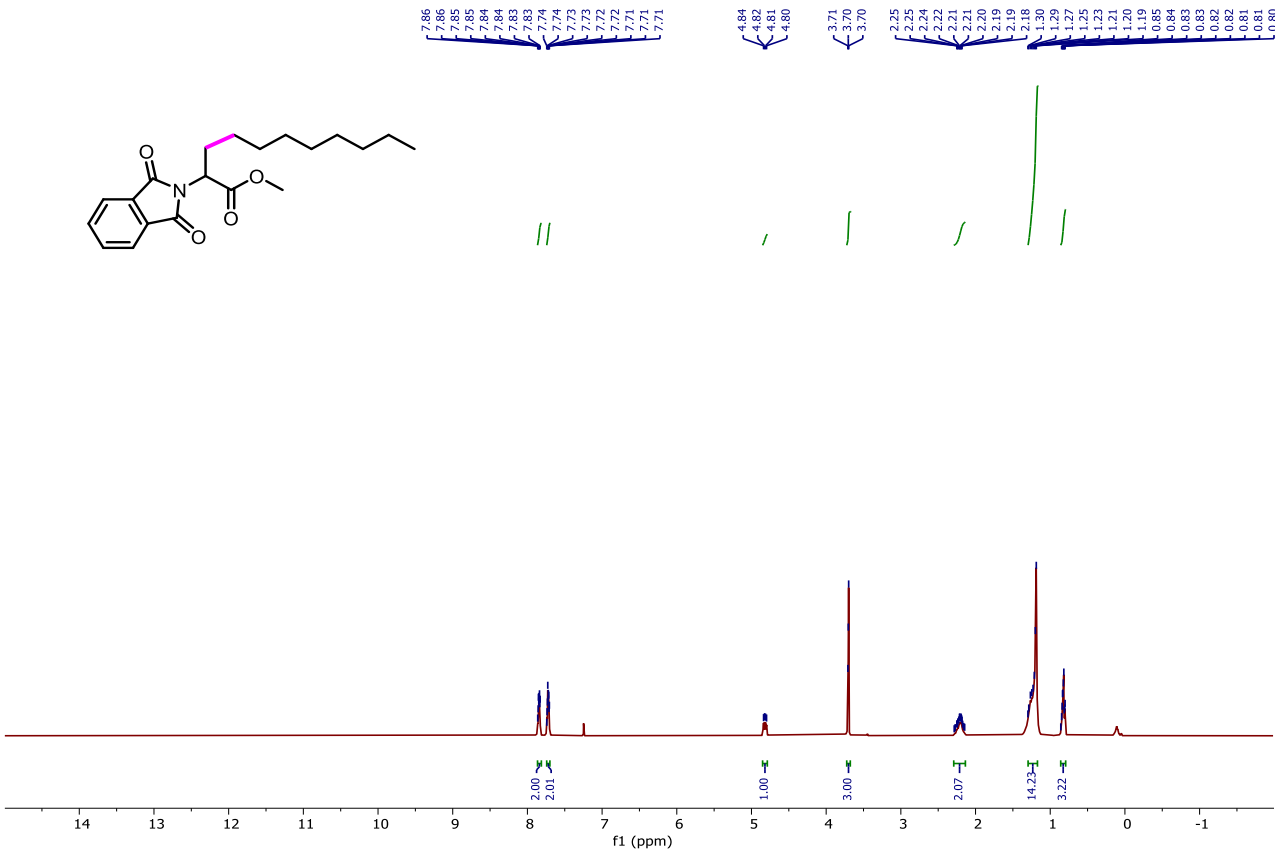
^{1}H NMR in $CDCl_3$ (4af)



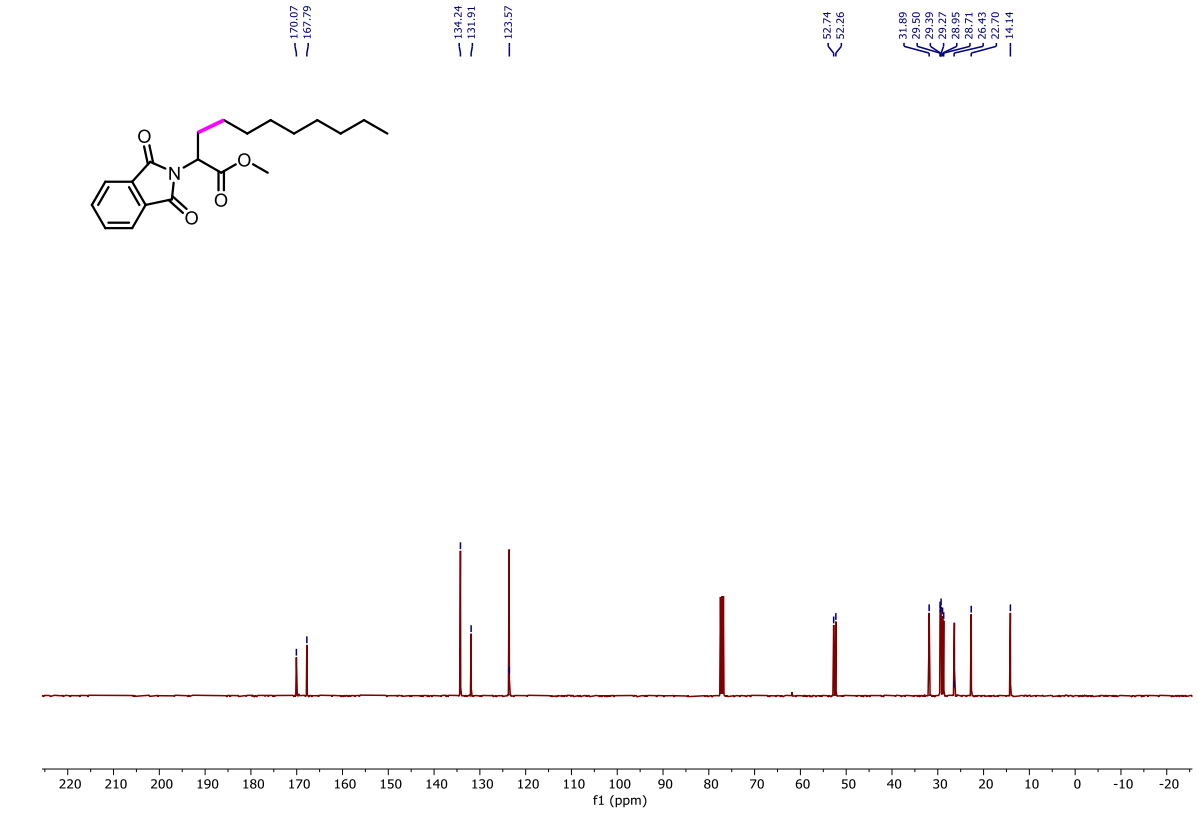
^{13}C NMR in $CDCl_3$ (4af)



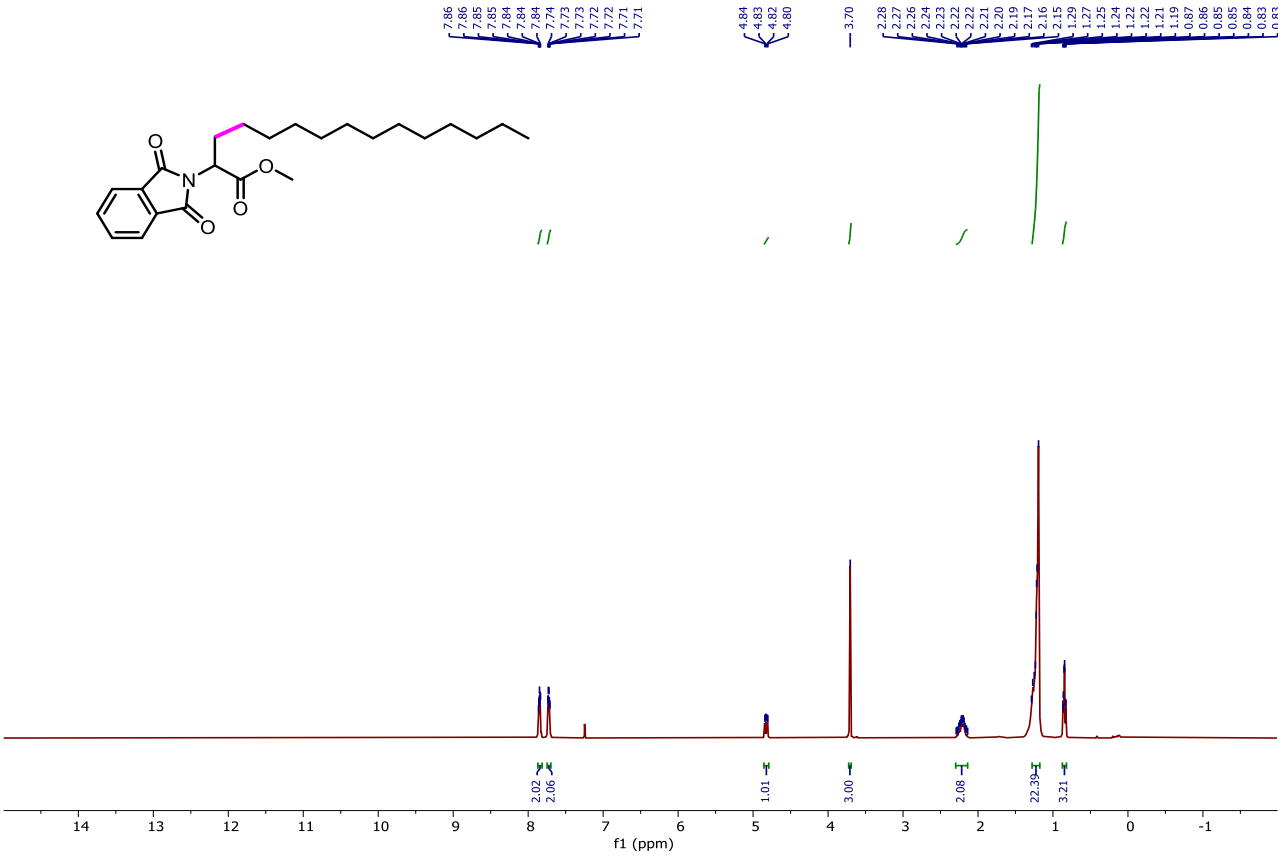
^{1}H NMR in $CDCl_3$ (4ag)



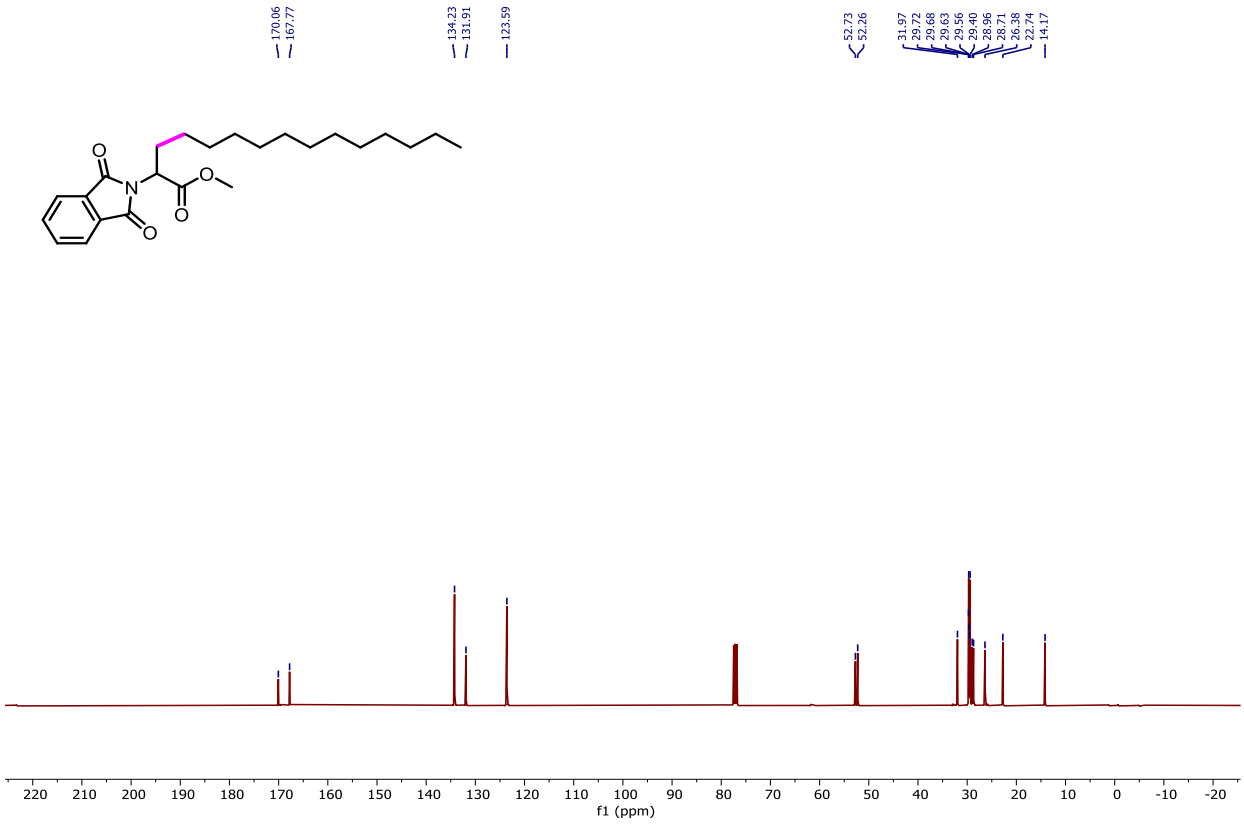
^{13}C NMR in $CDCl_3$ (4ag)



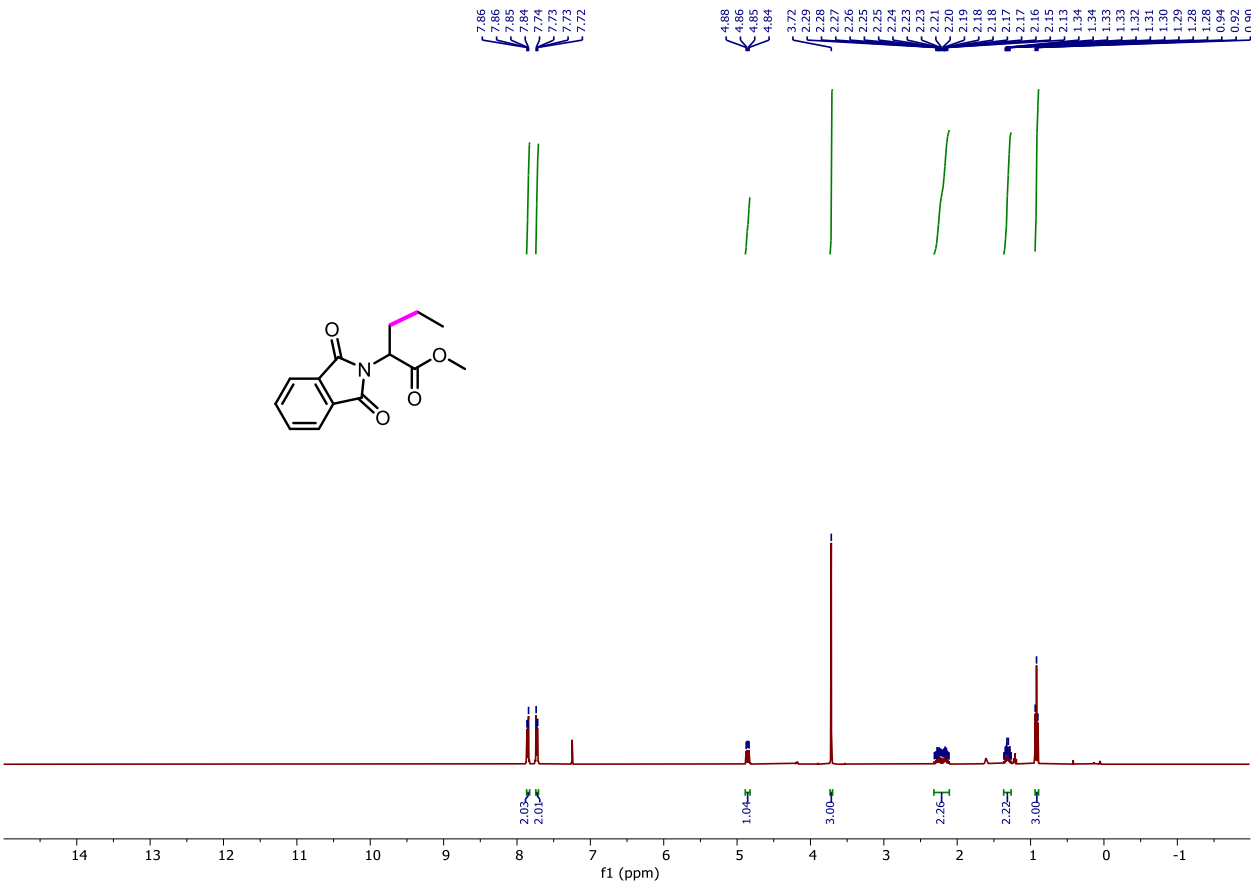
^{1}H NMR in $CDCl_3$ (4ah)



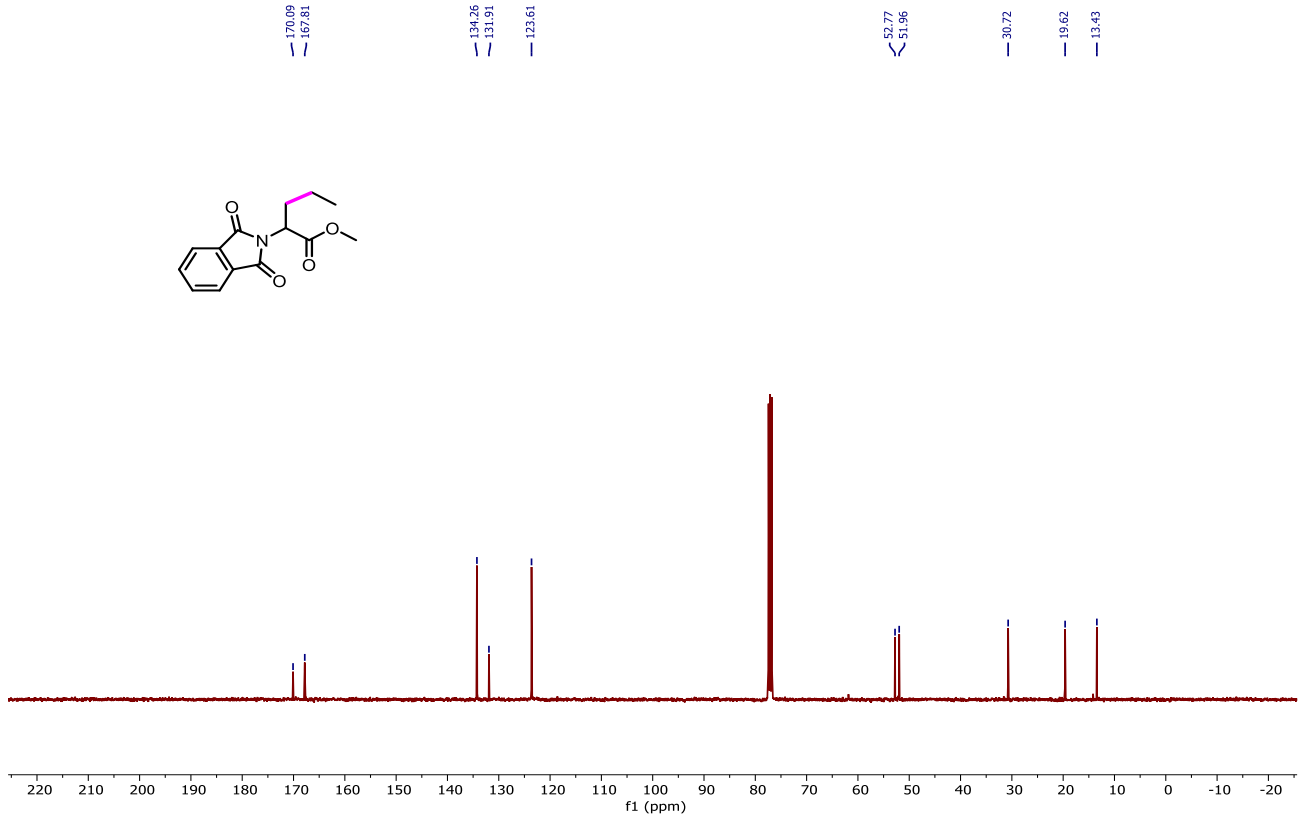
^{13}C NMR in $CDCl_3$ (4ah)



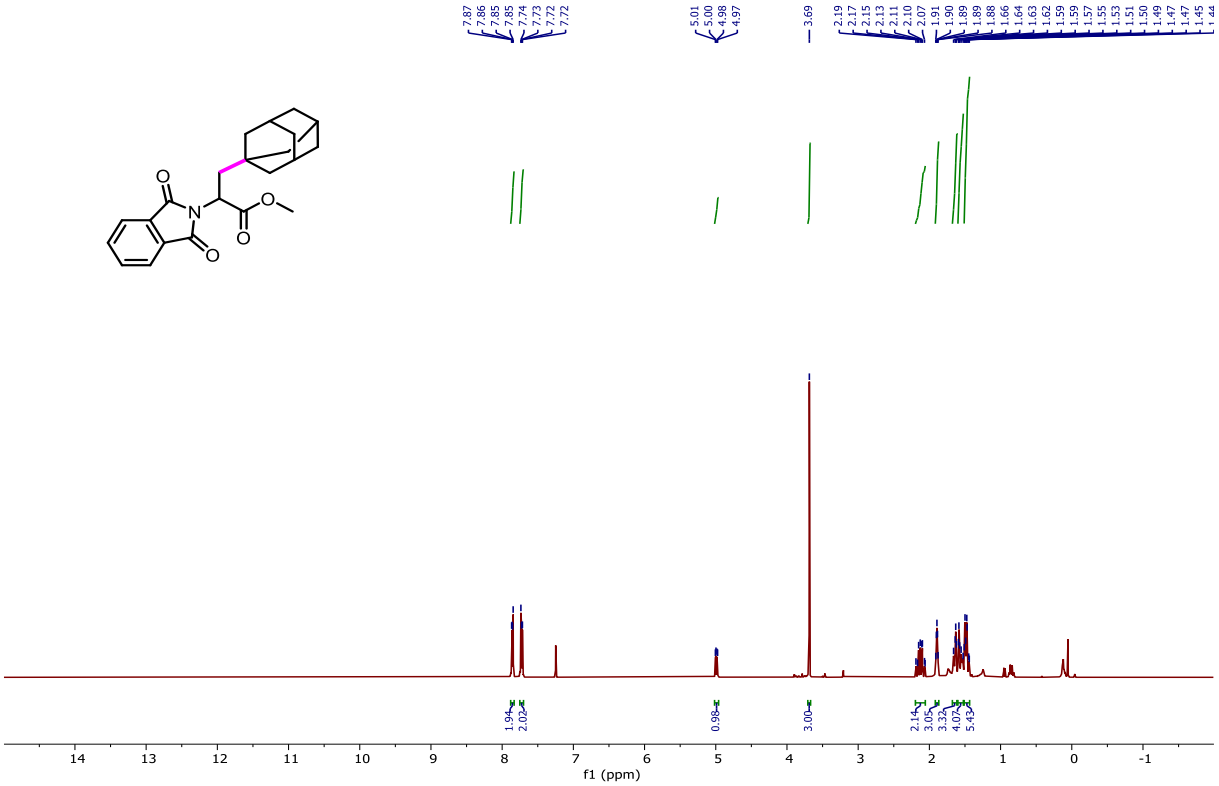
^{1}H NMR in $CDCl_3$ (4ai)



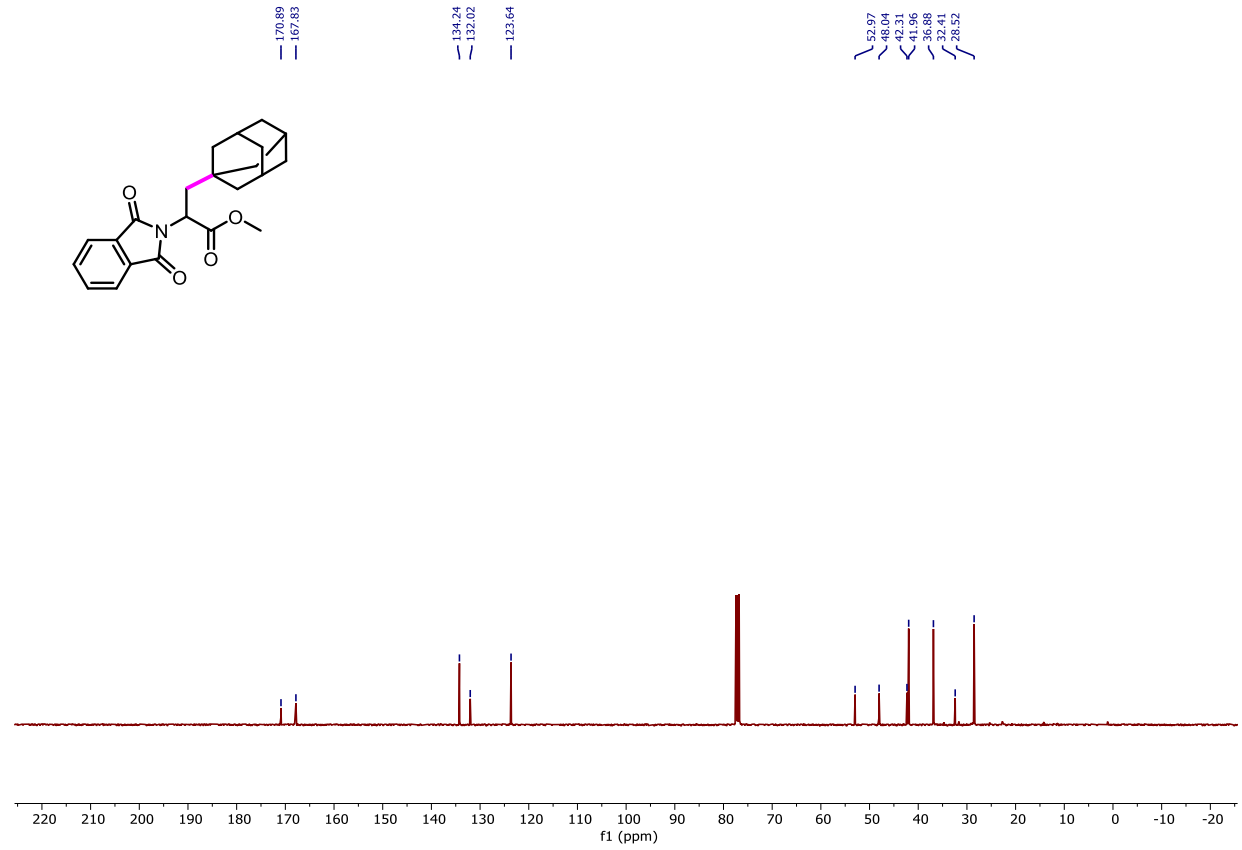
^{13}C NMR in $CDCl_3$ (4ai)



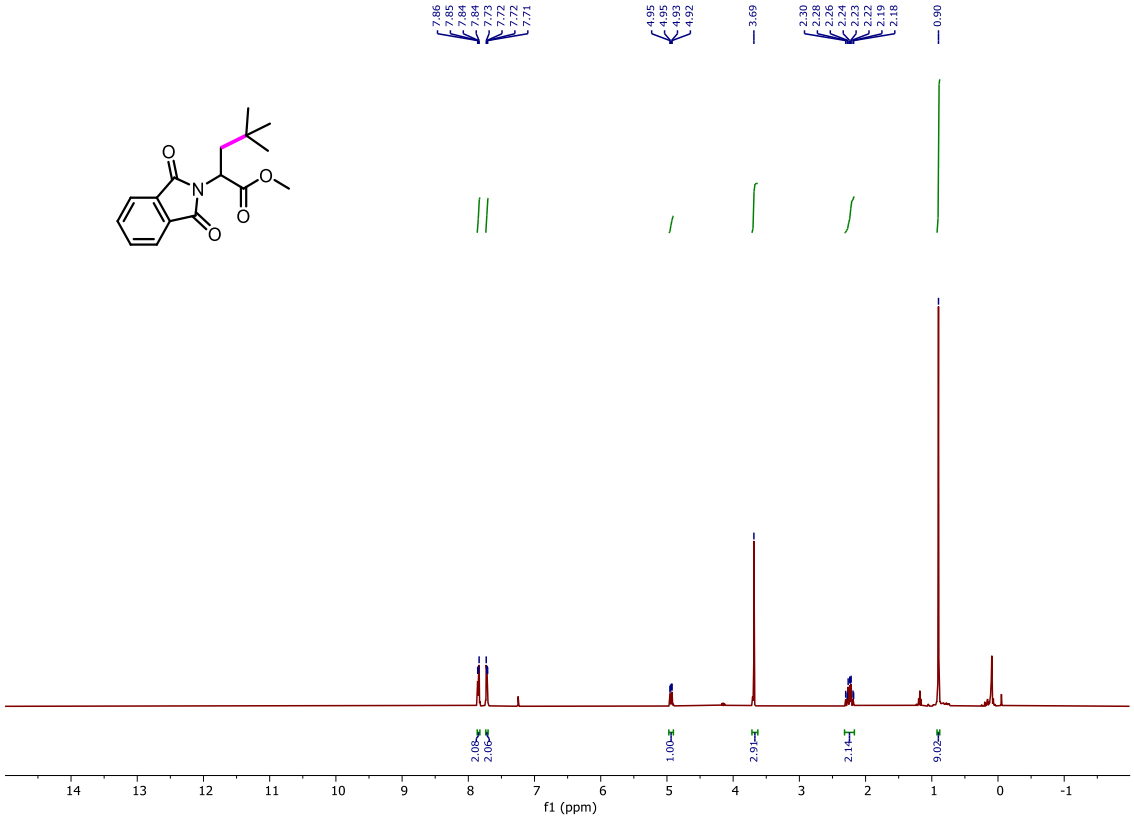
^{1}H NMR in $CDCl_3$ (4aj)



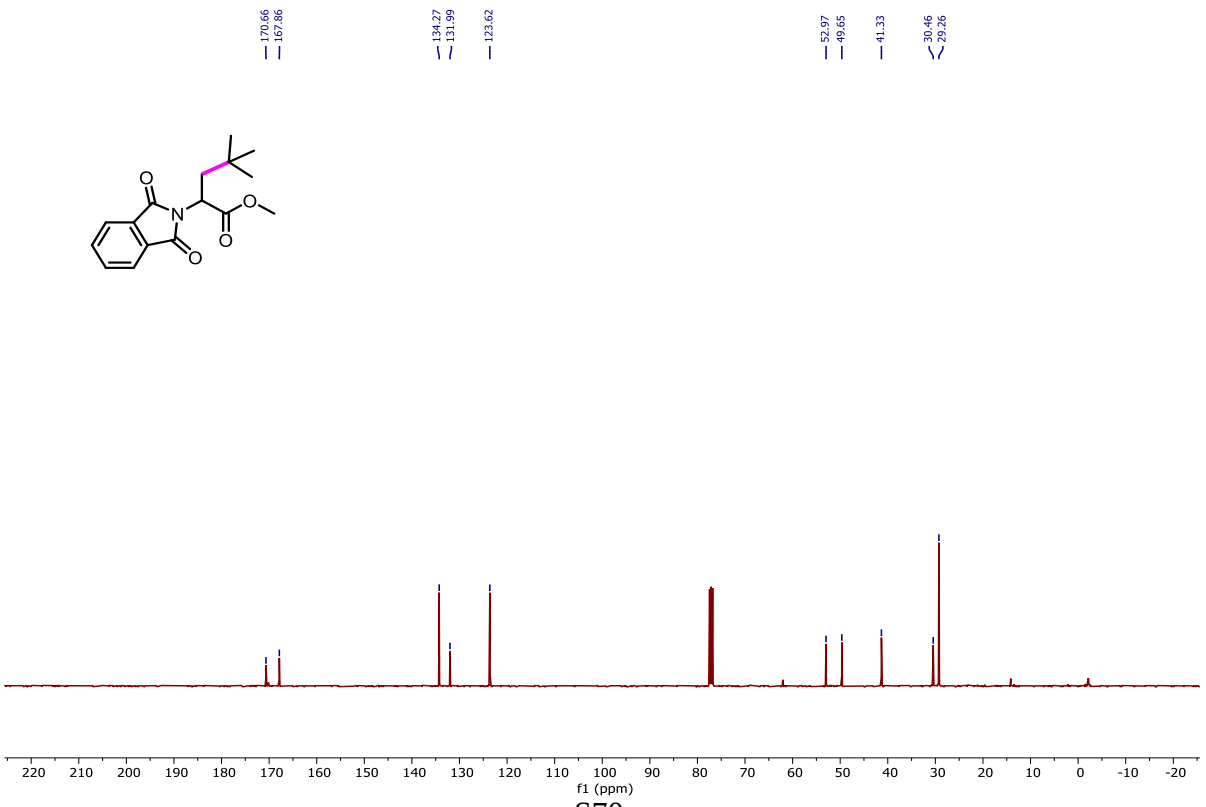
^{13}C NMR in $CDCl_3$ (4aj)



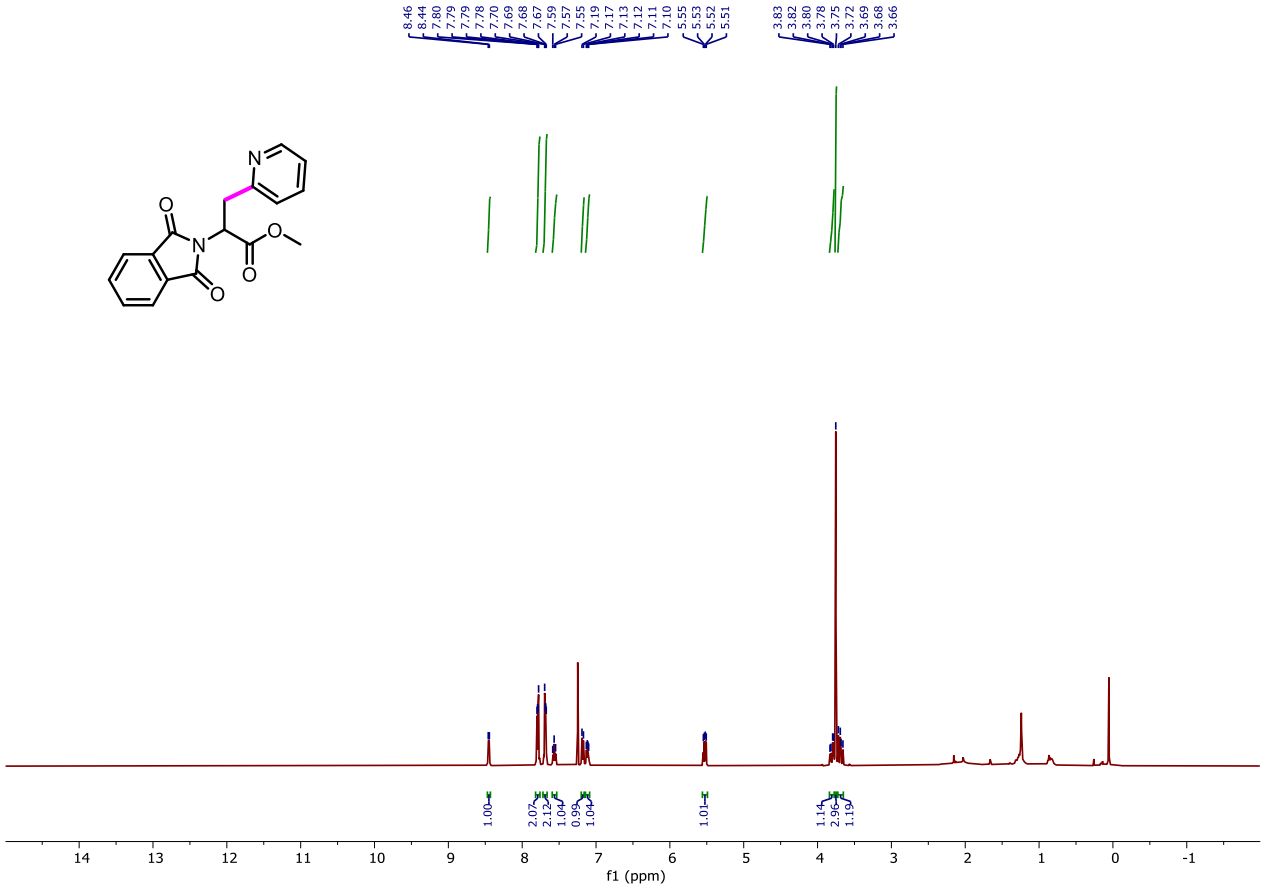
^{1}H NMR in $CDCl_3$ (4ak)



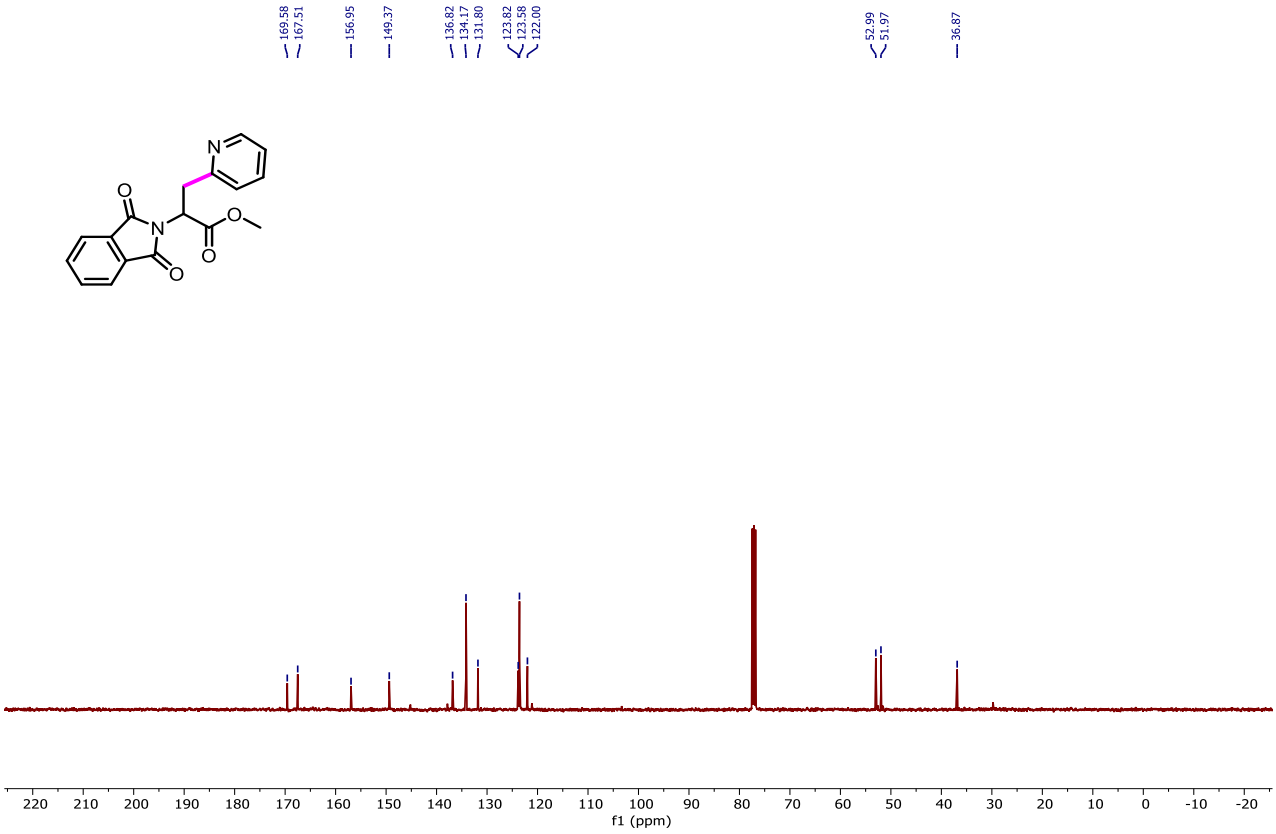
^{13}C NMR in $CDCl_3$ (4ak)



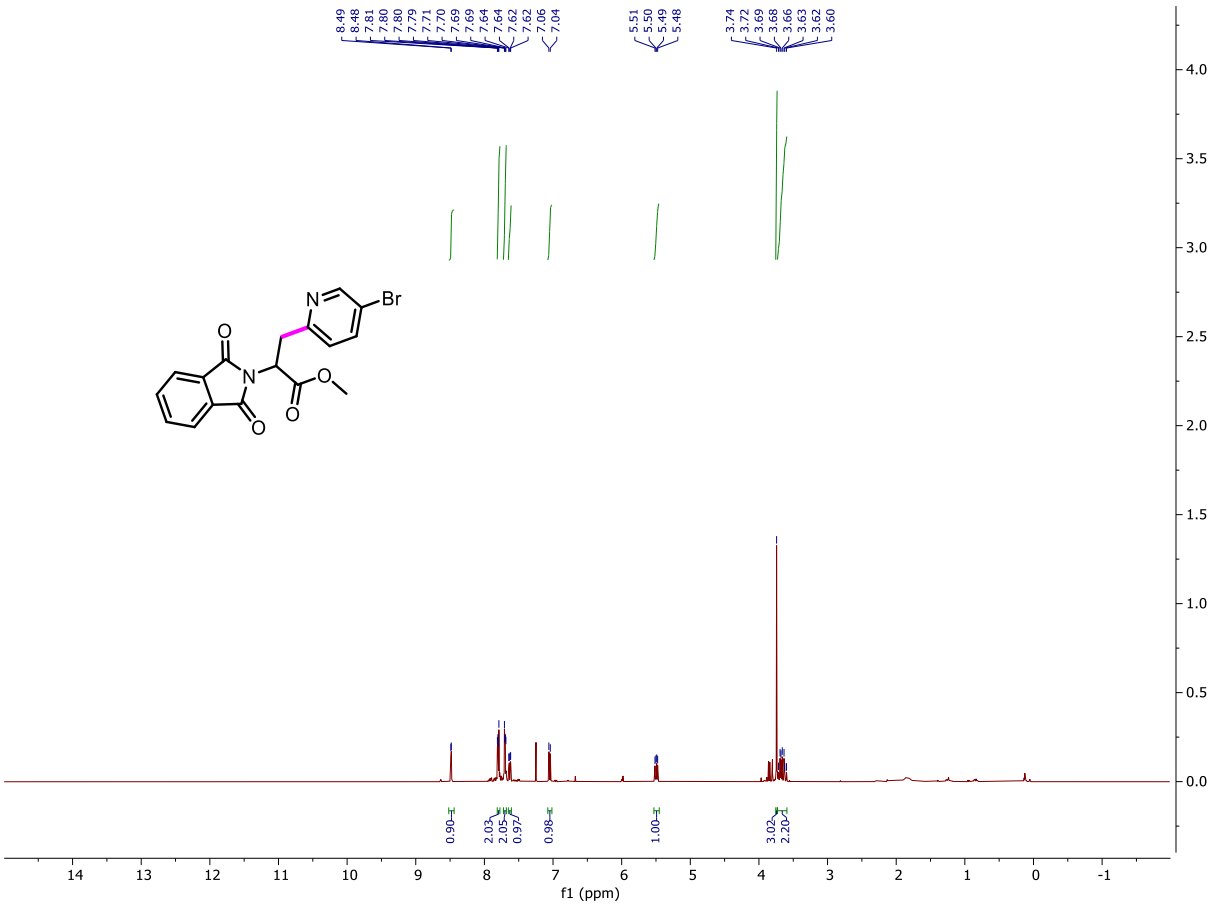
^{1}H NMR in $CDCl_3$ (4al)



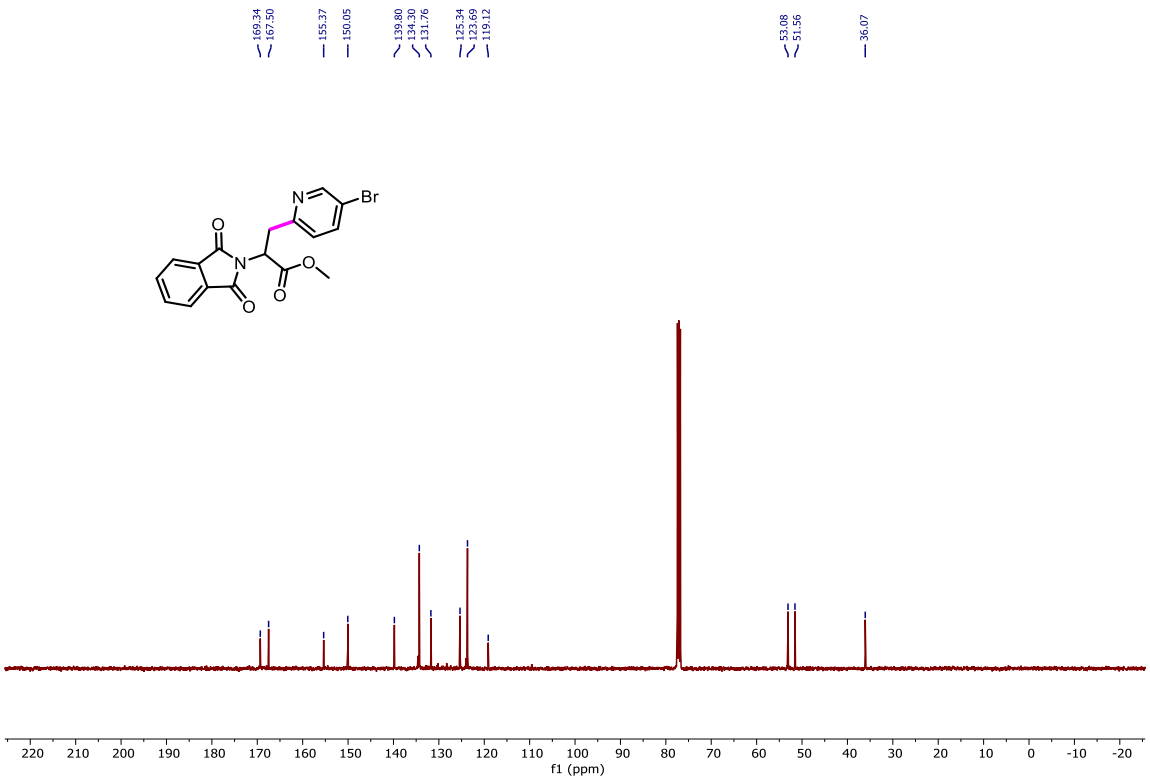
^{13}C NMR in $CDCl_3$ (4al)



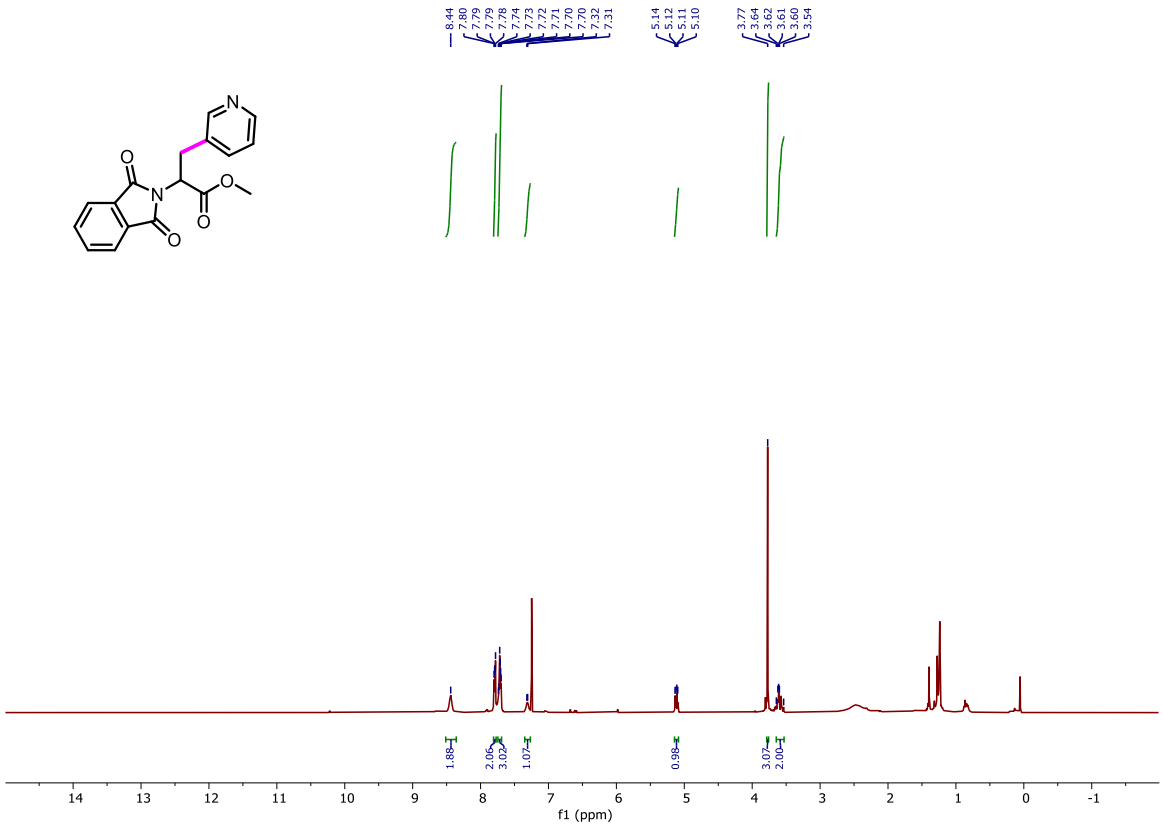
^{1}H NMR in $CDCl_3$ (4am)



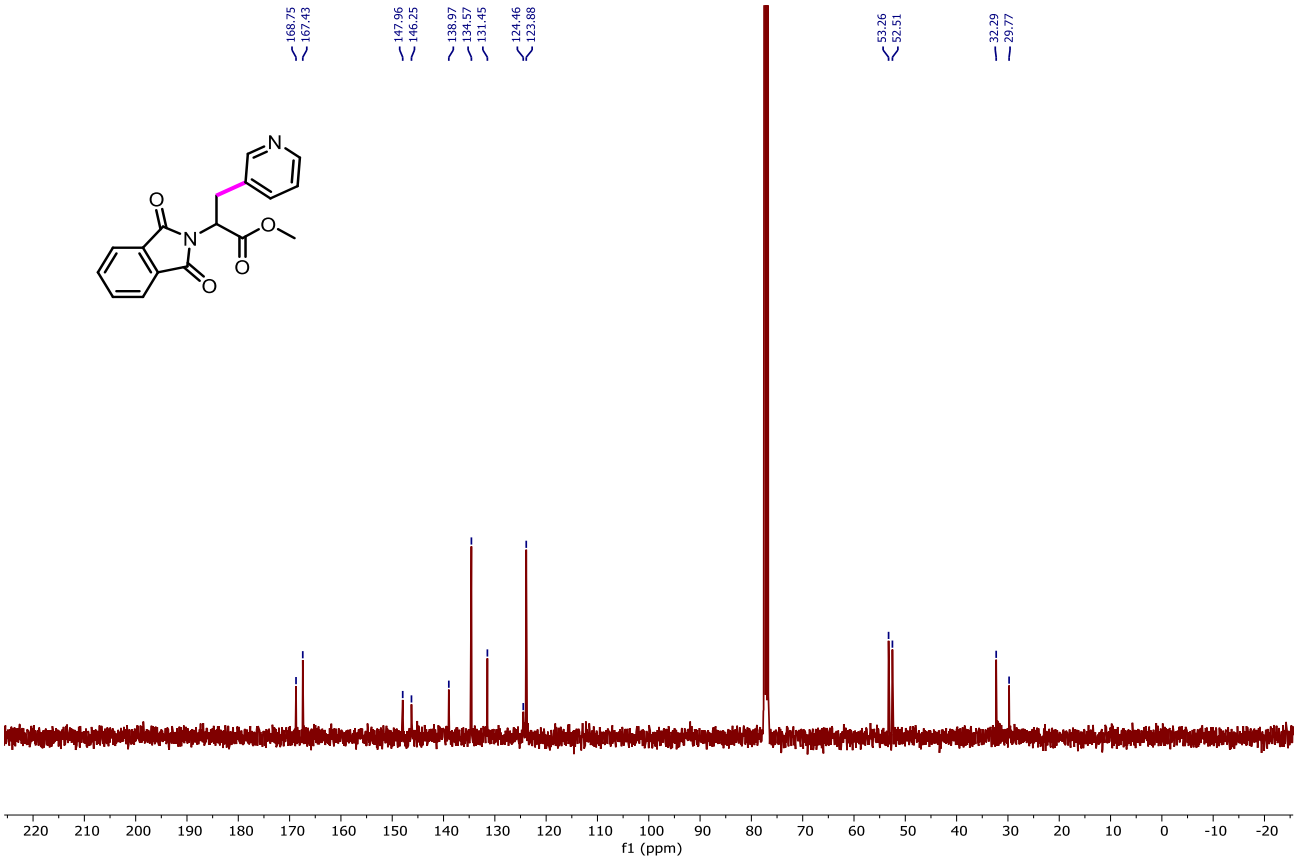
^{13}C NMR in $CDCl_3$ (4am)



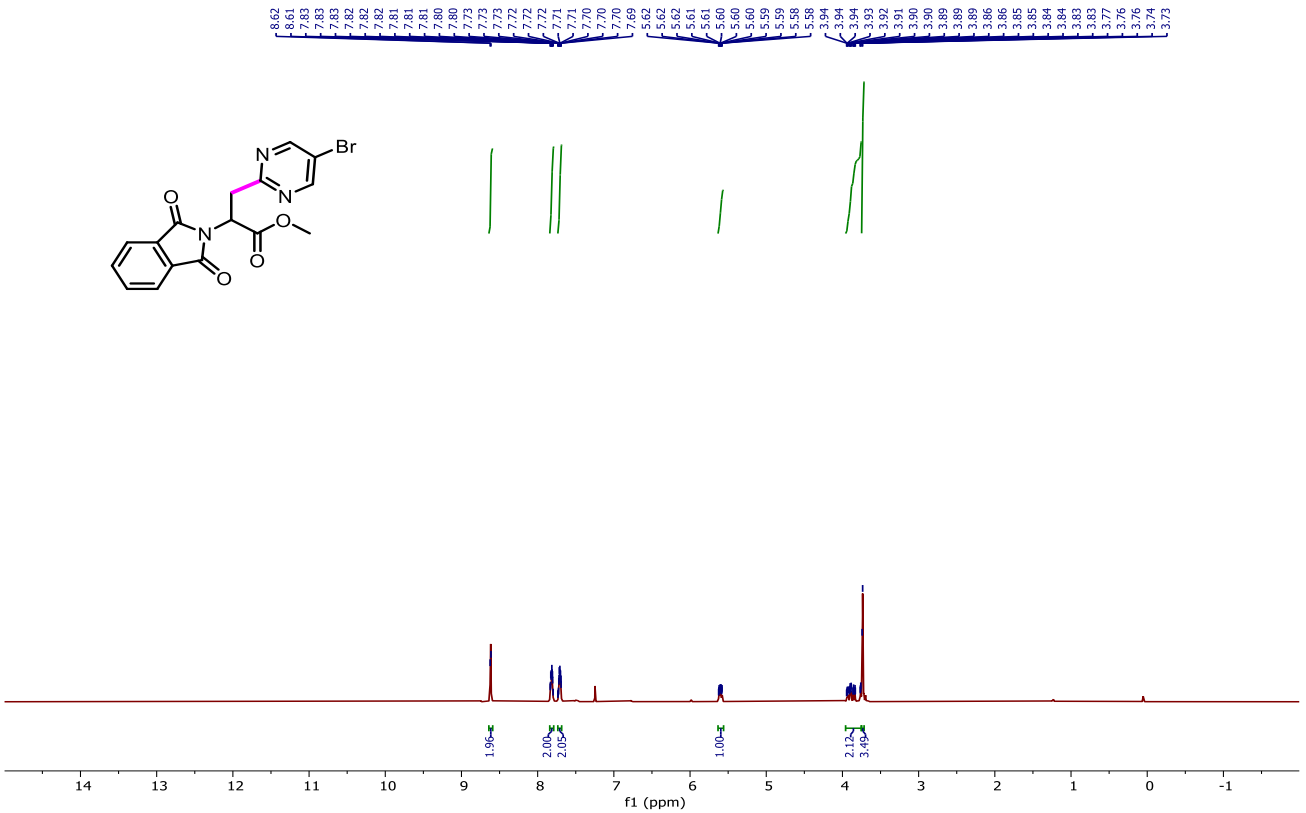
^{1}H NMR in $CDCl_3$ (4an)



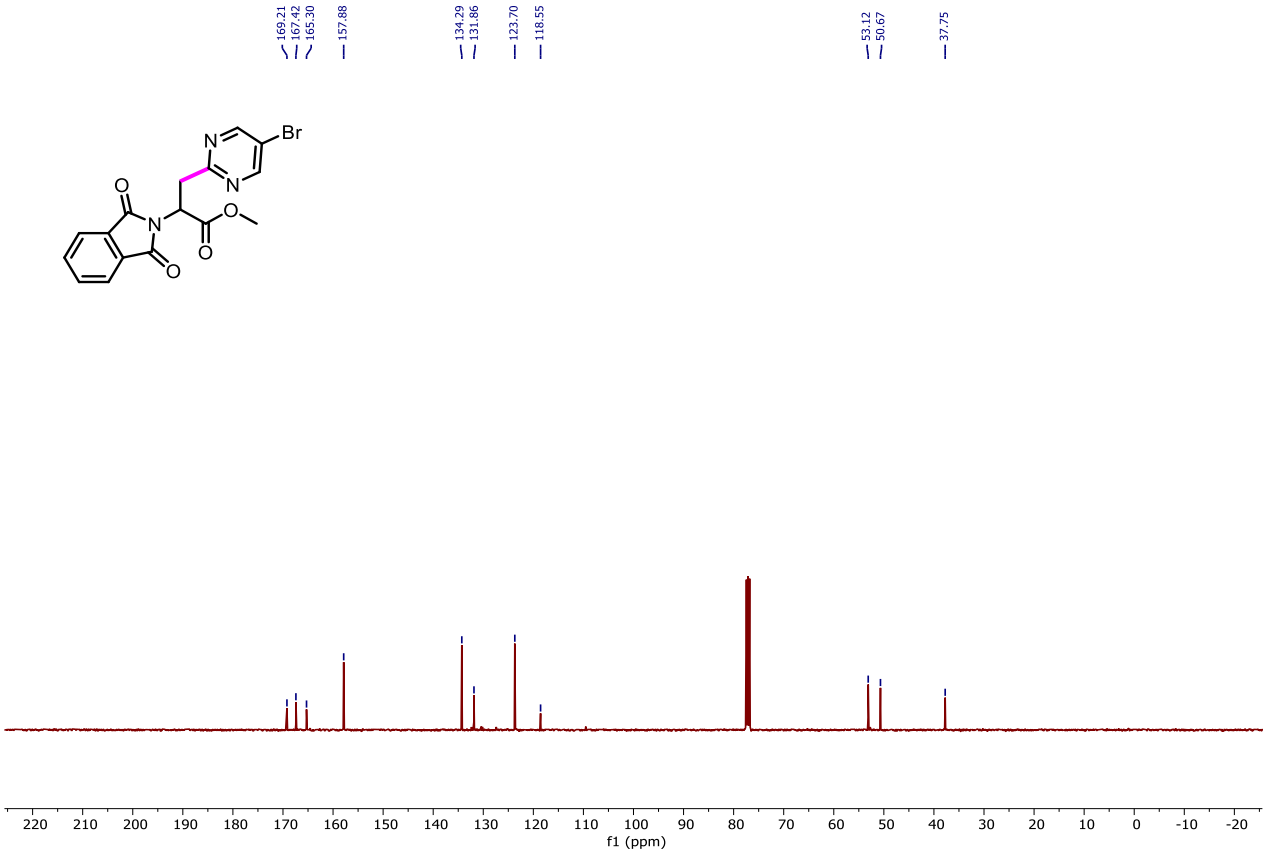
^{13}C NMR in $CDCl_3$ (4an)



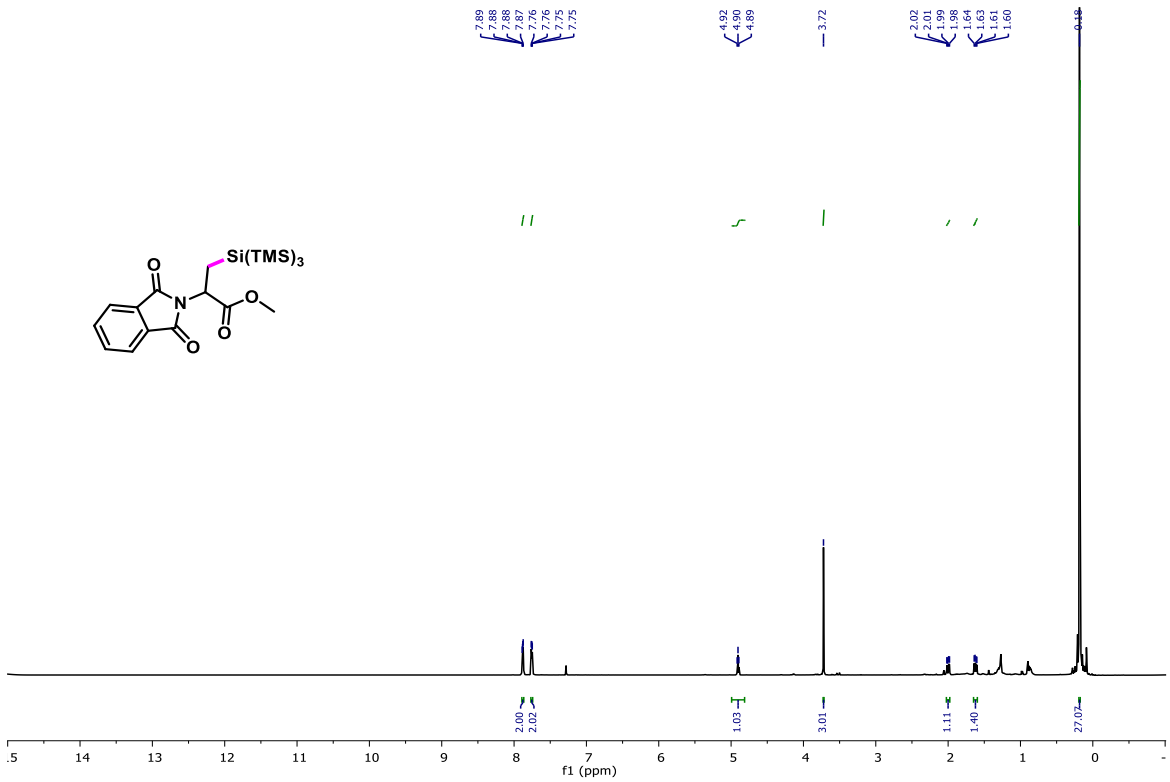
^{1}H NMR in $CDCl_3$ (4ao)



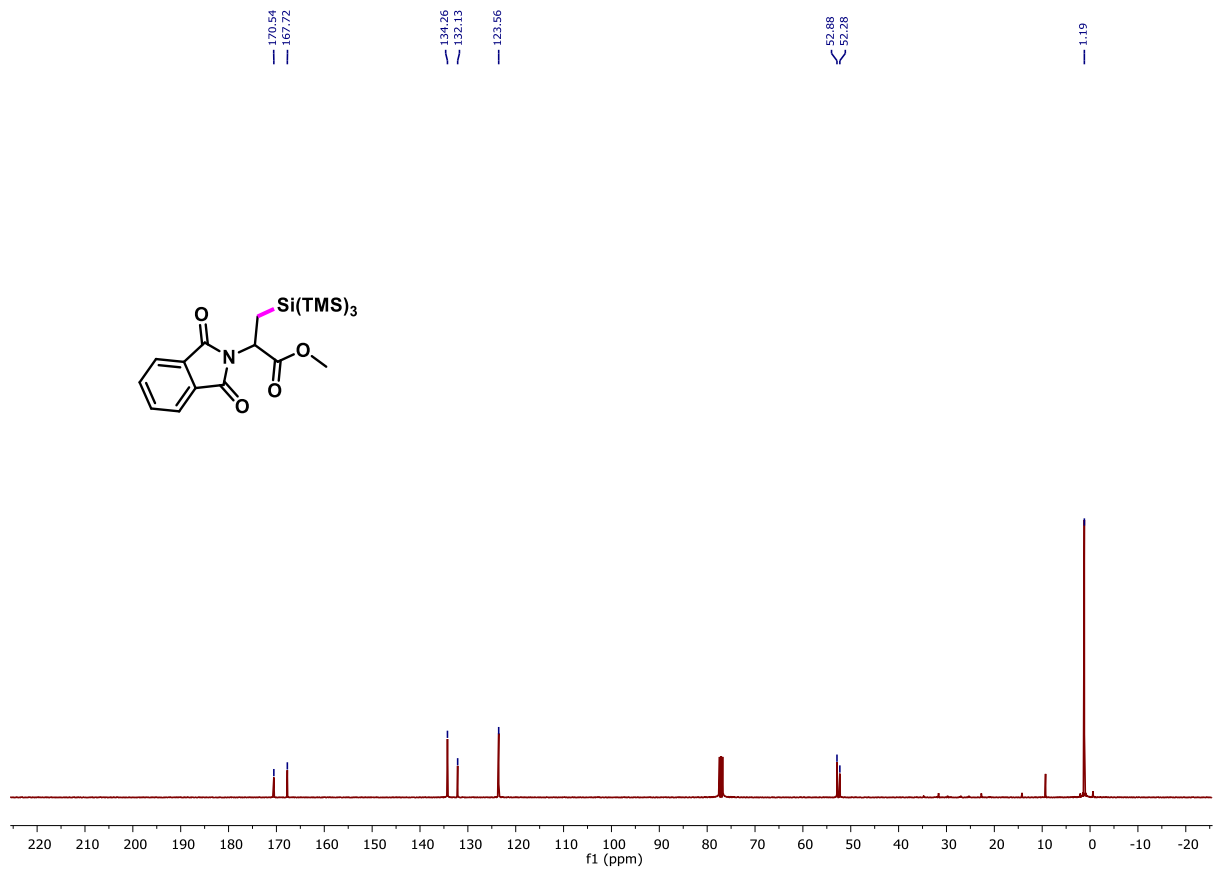
^{13}C NMR in $CDCl_3$ (4ao)



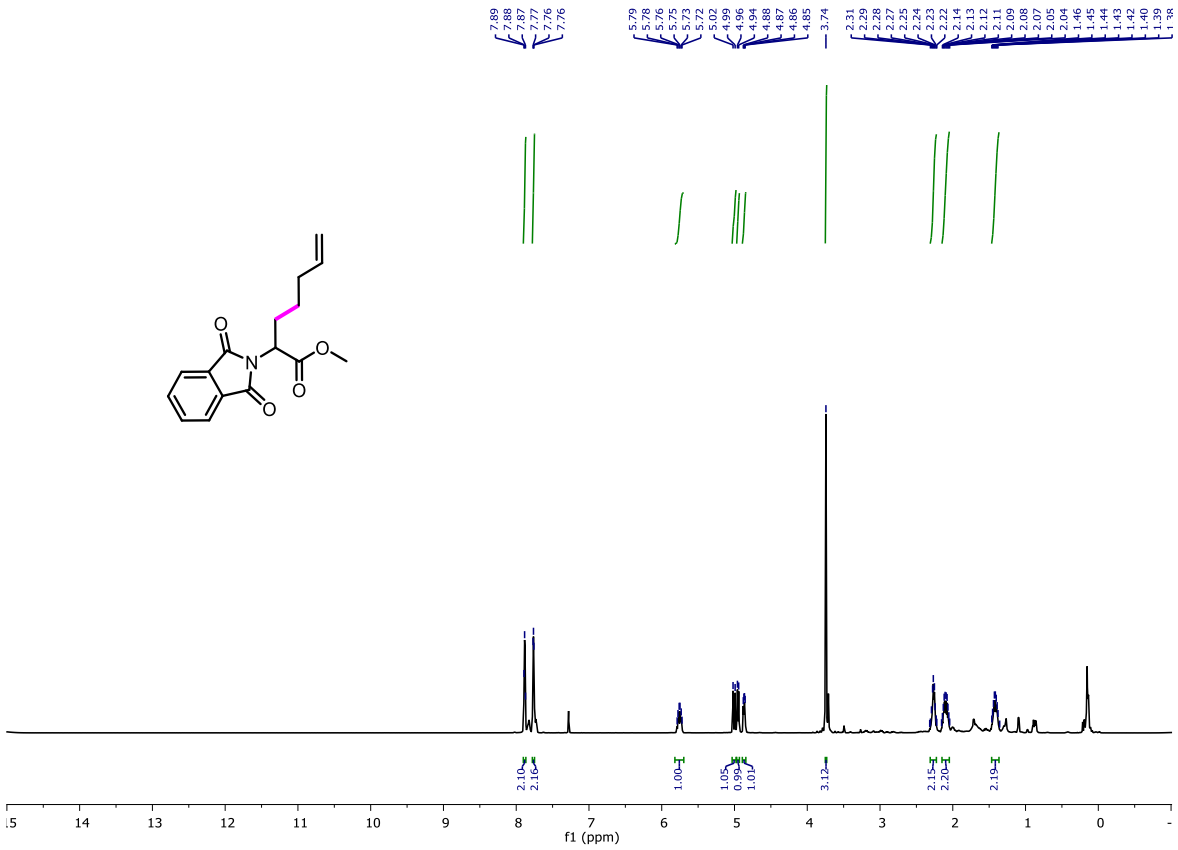
^{1}H NMR in $CDCl_3$ (5a)



^{13}C NMR in $CDCl_3$ (5a)



^{1}H NMR in $CDCl_3$ (6a)



^{13}C NMR in $CDCl_3$ (6a)