Supporting Information

Thiophenol-Catalyzed Visible-Light Photoredox Decarboxylative Couplings of *N*-(Acetoxy)phthalimides

Yunhe Jin, Haijun Yang and Hua Fu*

Key Laboratory of Bioorganic Phosphorus Chemistry and Chemical Biology (Ministry of Education), Department of Chemistry, Tsinghua University, Beijing 100084, P. R. China

*Email: fuhua@mail.tsinghua.edu.cn

Table of Contents

I. General Information

Commercial reagents, thiolphenol catalysts and *N*,*N*-Dimethylformamide (DMF) were purchased from J&K Chemical and Beijing Ouhe Technology, and used directly without further purification. Organic solutions were concentrated under reduced pressure on a Heidolph rotary evaporator using an alcohol-ice bath. Chromatographic purification of products was accomplished by silica gel column chromatography on silica gel (Qingdao Haiyang, 200-300 mesh). Thin layer chromatography (TLC) was performed on Shandong Jiangyou 0.2 mm silica gel plates. Visualization of the developed chromatogram was performed by fluorescence quenching, *p*-anisaldehyde, potassium permanganate, or ceric ammonium molybdate stain. ^{1}H and ^{13}C NMR spectra were recorded on JEOL 300 MHz, 400 MHz (100 MHz) and 600 MHz (150 MHz) instruments, and are internally referenced to TMS and residual protion solvent signals (note: TMS referenced at 0.00 ppm; $CDCl_3$ referenced at 7.26 and 77.0 ppm respectively; DMSO-d_6 referenced at 2.54 and 40.4 ppm respectively; due to the probe for $CDCl_3$ on the 400 MHz instrument was slightly polluted, there was a needless signal at 168.2 ppm in ^{13}C spectra). Data for ^{1}H NMR are reported as follows: chemical shift (δ ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, quint = quintet, sext = sextet, h = heptet, m = multiplet, dd = doublet of doublets, dt = doublet of triplets, br = broad), coupling constant (*J* Hz) and integration. Data for ^{13}C are reported in terms of chemical shift and no special nomenclature is used for equivalent carbons. Melting point was recorded on a Beijing Tech X-4 melting point apparatus. High resolution mass spectra were obtained on LCMS-IT/TOF (SHIMADZU, Japan) with electrospray ionization method.

II. Reaction Setup

a) **b)**

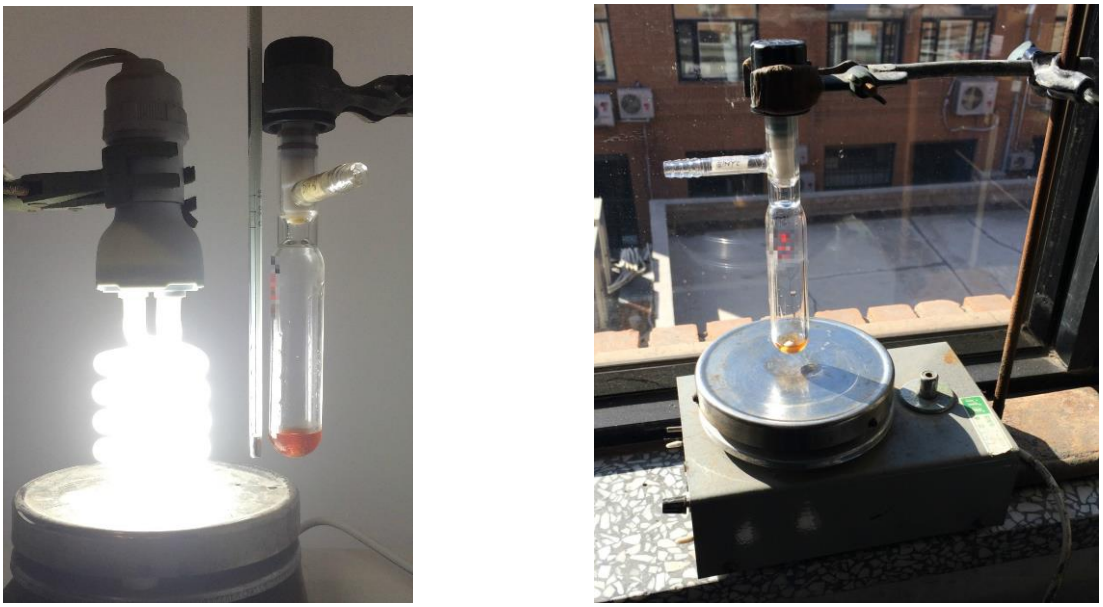


Fig. S1. a) Reaction step with a 40 W compact fluorescent light (CFL), a 25-mL Schlenk tube and a magnetic stirrer. b) Reaction step for Fig. 1c with a 25-mL Schlenk tube and a magnetic stirrer with sunlight on Oct. 9th of 2015 in Beijing.

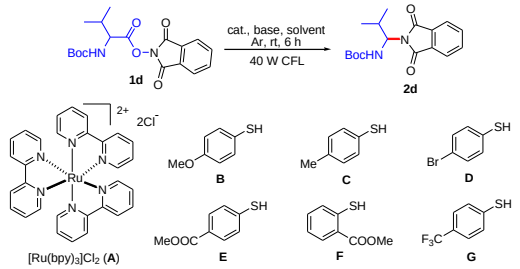
III. Reaction Optimization

Initially, as shown in Table S1, we examined this intramolecular photoredox decarboxylative amination leading to target product **2d** using Boc-Val-OPht (Pht = phthalimide) (**1d**) as a model substrate, and the reaction was performed well in DMF in the presence of 1 mol% common transition-metal photocatalyst, $[Ru(bpy)_3]Cl_2$ (**A**), and Cs_2CO_3 as the base under irradiation with 40 W compact fluorescent light and argon atmosphere (entry 1). Subsequently, we attempted photocatalyst-free visible-light decarboxylative amination of **1d**. Six thiophenols (10 mol%), 4-methoxythiophenol (**B**), 4-methylthiophenol (**C**), 4-bromothiophenol (**D**), methyl 4-sulfanylbenzoate (**E**), methyl 2-sulfanylbenzoate (**F**) and 4-(trifluoromethyl)thiophenol (TFTP) (**G**), were used as the organocatalysts, respectively (entries 2-7). To our happiness, **D**, **E** and **G** containing electron-withdrawing groups at *para*-position of thiol group exhibited higher catalytic activity (entries 4, 5 and 7), and 4-(trifluoromethyl)thiophenol (TFTP) (**G**) gave the highest yield (entry 7). One key factor was that the aryl thiols containing electron-donating groups were of higher nucleophilicity and more easily formed carboxylic acid thiol esters through reaction of *N*-(acetoxy)phthalimide (**1d**) with aryl thiols, which was not favorable for subsequent visible-light photoredox decarboxylative coupling.[1] Only 6% conversion yield was observed in the absence of both photocatalyst and organocatalyst (entry 8). Other bases, Na_2CO_3 and $NaHCO_3$, were attempted, and they also afforded satisfactory yields (entries 9 and 10). When amount of Cs_2CO_3 was reduced to one or 0.5 equivalent, the yields slightly increased (entries 11 and 12). However, the reaction did not work in the absence of base (entry 13). Effect of solvents was investigated, and DMF provided the best result (compare entries 12, 14-16). The reaction did not work under air (entry 17) or in the absence of light (entry 18). In order to confirm whether trace amount of transition metals in the system involve in this reaction, the solvent in the resulting solution of entry 12 was removed by a rotary evaporator, and the residue was determined by ICP mass spectrometry. Co, Cu, Fe, Ir, Mn, Ni, Pd, Rh and Ru almost were not observed (Data determined by ICP mass spectrometry: Co < 0.5 ppb, Cu < 0.05 ppb, Fe < 1 ppb, Ir < 0.05 ppb, Mn = 5 ppb, Ni < 0.05 ppb, Pd = 0.34 ppb, Rh < 0.05 ppb, and Ru < 0.05 ppb). The result shows that the present reaction is a transition metal-free visible-light photoredox process catalyzed by organocatalyst.

Reference

(1) Jin, Y.; Yang, H.; Fu, H. *Chem. Commun*. **2016**, *52*, 12909.

Table S1. Optimization of Conditions for Intramolecular Photoredox Decarboxylative Amination of Boc-Val-OPht (1d)[a]



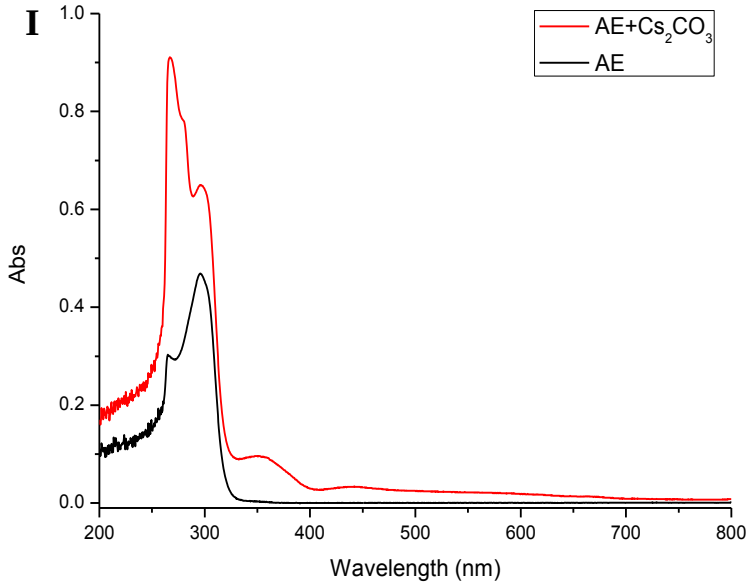
entry	cat.	base (equiv)	solvent	yield (%)[b]
1	**A**	Cs_2CO_3 (1.5)	DMF	62
2	**B**	Cs_2CO_3 (1.5)	DMF	12
3	**C**	Cs_2CO_3 (1.5)	DMF	32
4	**D**	Cs_2CO_3 (1.5)	DMF	64
5	**E**	Cs_2CO_3 (1.5)	DMF	72
6	**F**	Cs_2CO_3 (1.5)	DMF	32
7	**G**	Cs_2CO_3 (1.5)	DMF	90
8[c]	-	Cs_2CO_3 (1.5)	DMF	6
9	**G**	Na_2CO_3 (1.5)	DMF	89
10	**G**	$NaHCO_3$ (1.5)	DMF	86
11	**G**	Cs_2CO_3 (1.0)	DMF	92
12	**G**	**Cs_2CO_3 (0.5)**	**DMF**	**97 (94[d])**
13[e]	**G**	-	DMF	NR
14	**G**	Cs_2CO_3 (0.5)	DMSO	70
15	**G**	Cs_2CO_3 (0.5)	MeCN	7
16	**G**	Cs_2CO_3 (0.5)	DCE	trace
17[f]	**G**	Cs_2CO_3 (0.5)	DMF	NR
18[g]	**G**	Cs_2CO_3 (0.5)	DMF	NR

[a] Reaction conditions: Ar atmosphere and irradiation of visible light, Boc-Val-OPht (**1d**) (0.15 mmol), catalyst (1.5 μmol using **A**; 15 μmol using others), base (0.075-0.225 mmol), solvent (1.5 mL), temperature (rt, ~25 °C), time (6 h) in a sealed Schlenk tube. [b]Conversion yield by ^{1}H NMR determination using trichloroethylene as the internal standard. [c]No addition of catalyst. [d]Isolated yield. [e]No addition of base. [f]Under air. [g]No light. DMF = *N*,*N*-dimethylformamide. DMSO = dimethylsulfoxide. DCE = 1,2-dichloroethane. CFL = compact fluorescent light. NR = no reaction.

IV. Mechanism Investigations

a. The UV-visible absorption spectra of active esters, HE, aryl thiols and disulfides

The UV-visible absorption spectra of cyclohexanecarboxylic acid active ester (AE), Hantzsch Ester (HE), 4-(trifluoromethyl)thiophenol (TFTP) and 1,2-bis(4-(trifluoromethyl)phenyl)disulfane (BTFPD) were determined in the absence or presence of Cs_2CO_3, and no new absorption peak was observed beyond 400 nm except AE (Figure S2-I,II,III,IV), which implied that only carboxylic active acids could be the visible light photosensitizers in the reactions.



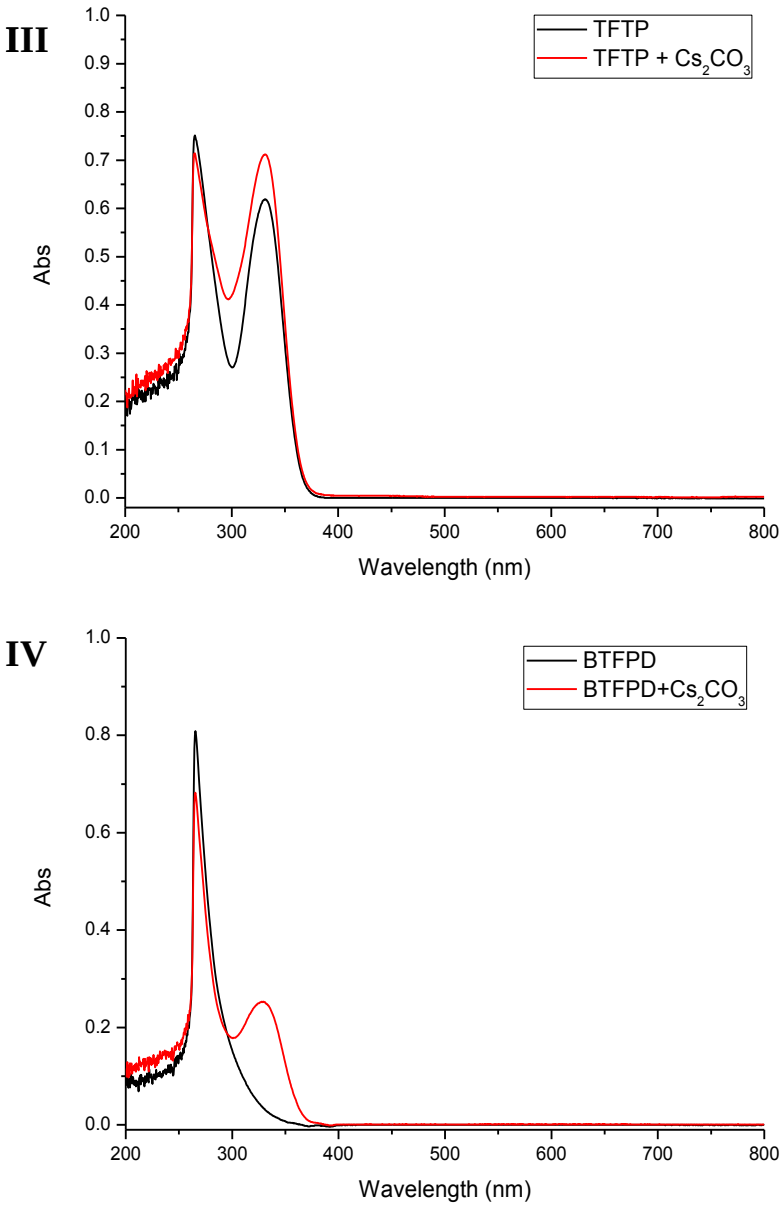


Fig. S2. UV-visible absorption spectra of I) cyclohexanecarboxylic acid active ester (AE), II) Hantzsch ester (HE), III) 4-(trifluoromethyl)thiophenol (TFTP), IV) 1,2-bis(4-(trifluoromethyl)phenyl)disulfane (BTFPD) ($4 * 10^{-4}$ mol/L solution in DMF) in the absence or presence of excess Cs_2CO_3.

b. Stern-Volmer fluorescence quenching experiments

In a typical experiment, 1.0 mL solution of 1.0 mM cyclohexanecarboxylic acid active ester (AE) in DMF in the presence of Cs_2CO_3 was added to the appropriate amount of quencher in a screw-top 1.0 cm quartz cuvette. After degassing by bubbling a stream of nitrogen for 10 minutes, 0.06 M solution of the quencher were added into the cuvette by microliters and the emission of the sample was collected. The solutions were excited at λ= 375 nm (to avoid the effects of UV absorption of TFTP and BTFPD) and the emission intensity at 429 nm (emission maximum of **A'-3** (**A'-3** represents the excited-state of AE-Cs_2CO_3 complex)) was observed (Figure S3-5). Stern–Volmer fluorescence quenching experiments demonstrated that the emission intensity of **A'-3** diminished in the presence of TFTP, presumably signifying an electron transferring from TFTP to **A'-3**.

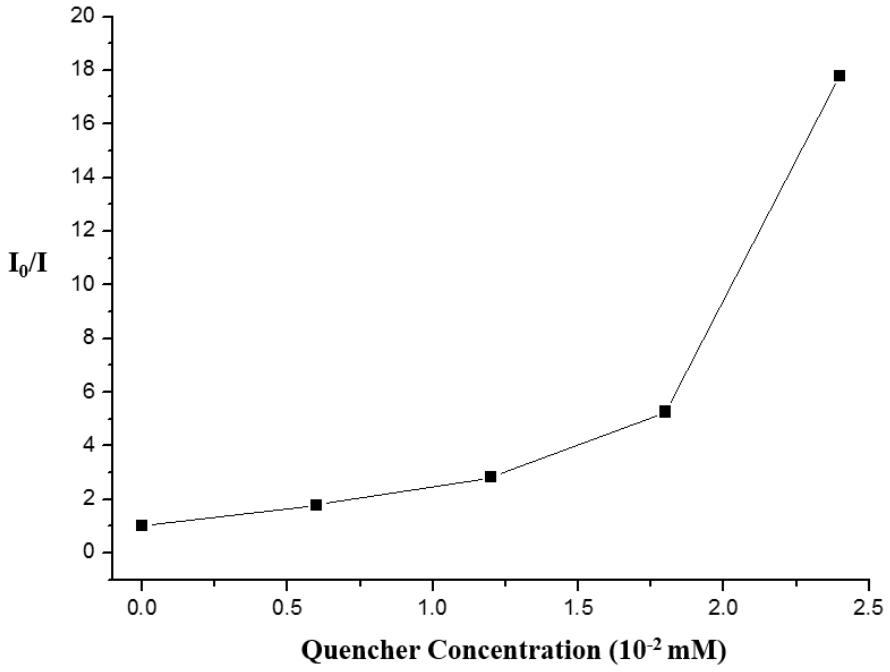


Fig. S3. A'-3 emission quenching by 4-(trifluoromethyl)thiophenol (TFTP). Non-linear quenching is observed.

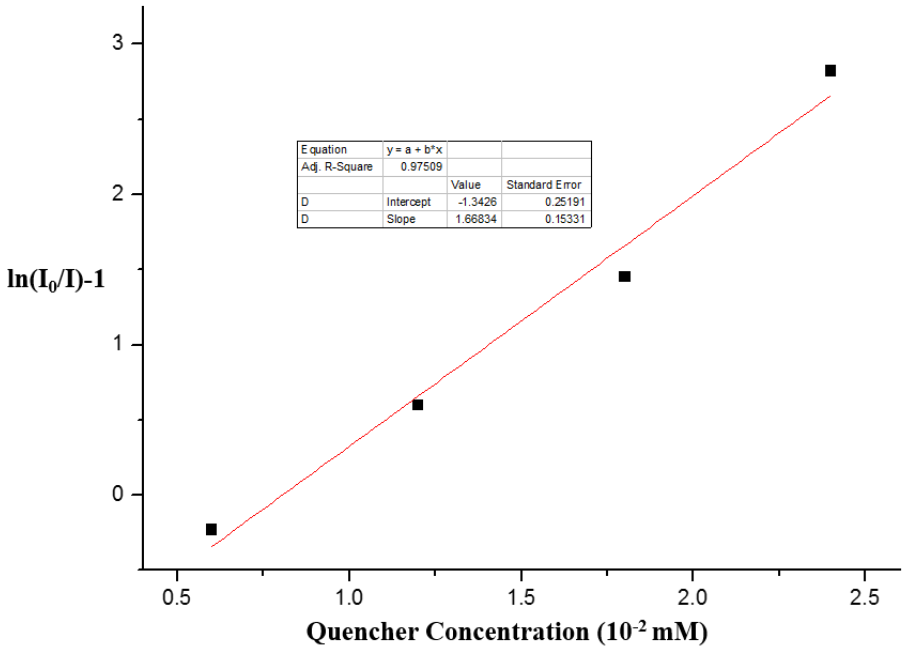


Fig. S4. Log plot of emission quenching of **A'-3** by 4-(trifluoromethyl)thiophenol (TFTP). Linear correlation represents exponential trend in emission quenching.

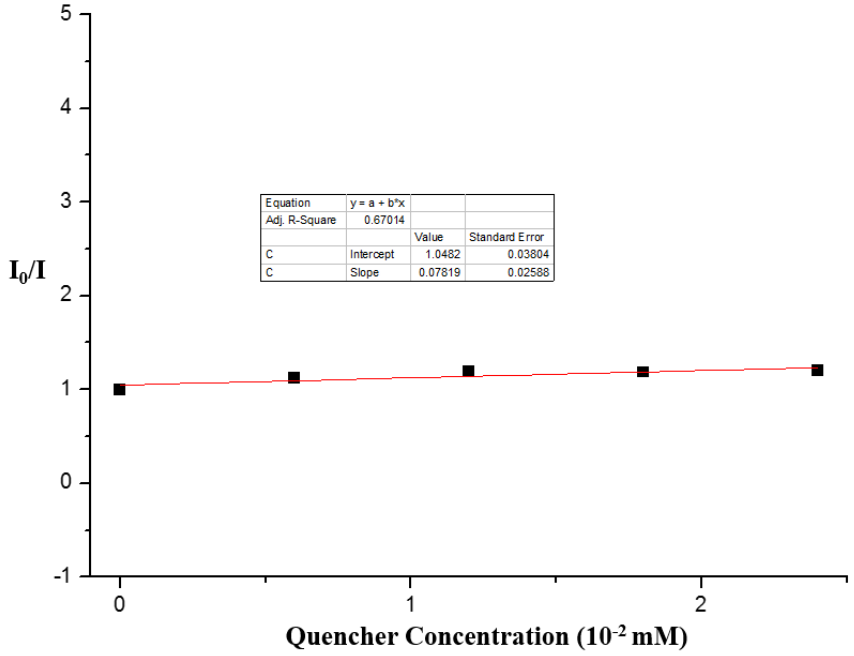


Fig. S5. A'-3 emission quenching in the presence of 1,2-bis(4-(trifluoromethyl)phenyl)disulfane (BTFPD). No quenching was observed.

c. The radical-trapping experiments

Treatment of *Boc*-Pro-COOPht (**1m**) and *N*-phenylacrylamide (**3a**) in the presence of 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO) was investigated, and only trace amount of **4m** was found. HRESI-MS showed that intermediate **B-1** occurred in the former reaction. The results displayed that free-radical intermediates were involved in the reactions (Figure S6, Scheme S1).

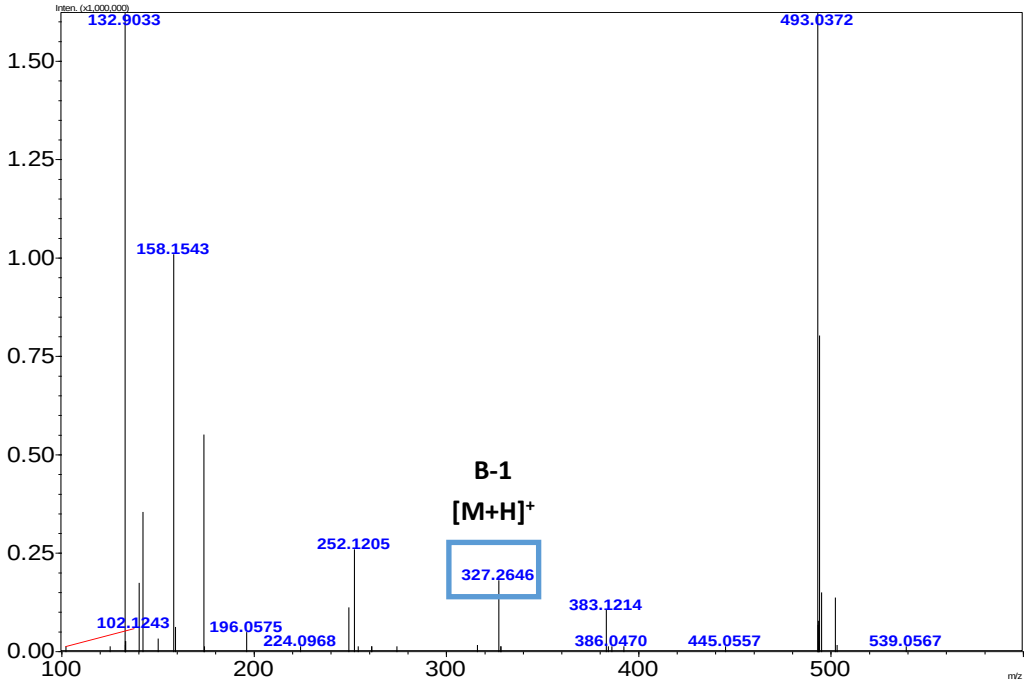
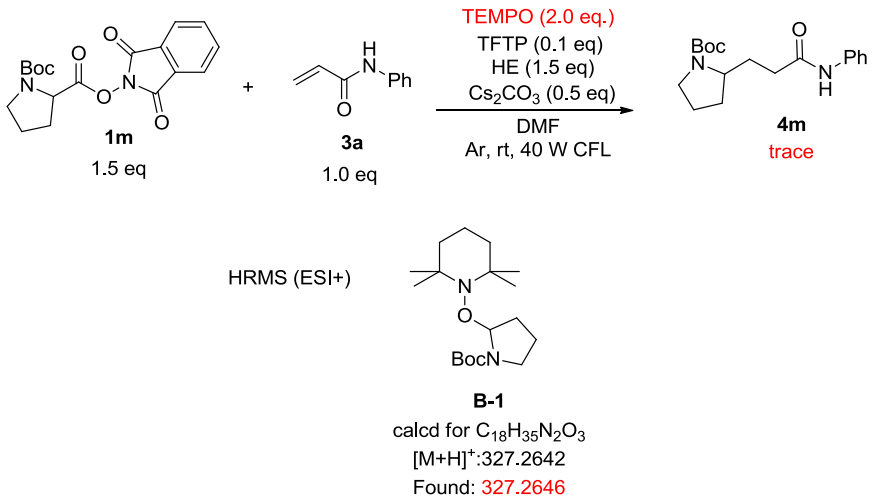
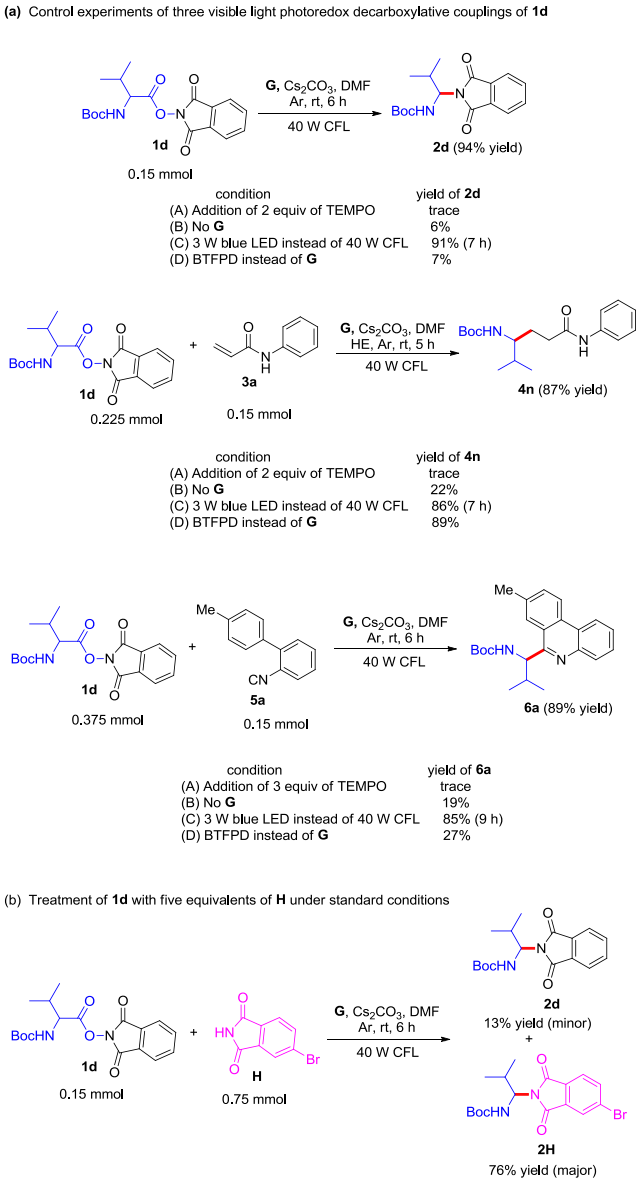


Fig. S6. Positive ion mass spectrum of products from reaction of *Boc*-Pro-COOPht (**1m**), *N*-phenylacrylamide (**3a**) and 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO).



Scheme S1. Treatment of *Boc*-Pro-COOPht (**1m**) and *N*-phenylacrylamide (**3a**) in the presence of 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO).

d. Some Control Experiments



Scheme S2. Treatment of *Boc*-Pro-COOPht (**1m**) and *N*-phenylacrylamide (**3a**) in the presence of 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO).

In 1991, Okada and co-workers reported decarboxylative Michael addition of *N*-(acy1oxy)phthalimides to electron-deficient olefins in the presence of 1-benzyl-l,4-dihydro-nicotinamide (BNAH) under irradiation of light with a shorter wavelength,[2] and they thought that initiation of the reaction was from oxidation of BNAH under assistance of light (λ_{max} = 352 nm for BNAH). In 2015, Overman's groups also observed the similar reaction upon irradiation with low-energy blue LED's in the absence of photocatalyst,[3] and they thought that the transformation was poorly understood at the time. Here, some control experiments were

performed as follows: (i) When a radical-trapping agent, 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO), was added to the three reaction systems of **1d**, **1d** and **3a**, **1d** and **5a**, respectively, only trace amount of products **2d**, **4n** and **6a** were observed (see conditions A in Scheme S2a), which indicates that free-radical intermediates were involved in the reactions. (ii) In the absence of both photocatalyst and organocatalyst, the reactions gave **2d**, **4n** and **6a** in 6%, 22% and 19% yields, respectively (see conditions B in Scheme S2a). (iii) When 3 W blue LED (λ= 465-470 nm) was used instead of the 40 W CFL, the three reactions provided high yields with longer time (see conditions C in Scheme S2a), which were similar to the yields under irradiation of 40 W CFL. *The results exhibited that the three reactions performed well under irradiation of visible light rather than UV light.* (iv) When 1,2-bis(4-(trifluoromethyl)phenyl)disulfane (BTFPD) replaced TFTP as the organocatalyst, only decarboxylative Michael addition of *N*-(acy1oxy)phthalimides to electron-deficient olefins gave similar yield to using TFTP (*A key factor is that BTFPD can be reduced by HE to form TFTP under irradiation of visible light*[4]), but the other two reactions afforded poor results (see conditions D in Scheme S2a). (v) Treatment of **1d** with five equivalents of 4-bromophthalimide (**H**) under the same conditions as those in Table 2 provided major product **2H** together with minor product **2d** (see Scheme S2b).

References

(2) Okada, K.; Okamoto, K.; Morita, N.; Okubo, K.; Oda, M. *J. Am. Chem. Soc*. **1991**, *113*, 9401.

(3) Pratsch, G.; Lackner, G. L.; Overman, L. E. *J. Org. Chem*. **2015**, *80*, 6025.

(4) Huang, W.; Chen, W.; Wang, G.; Li, J.; Cheng, X.; Li, G. *ACS Cat.* **2016**, *11*, 7471.

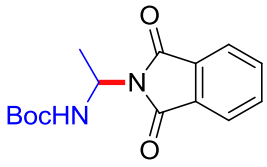
V. Experimental Procedures and Product Characterization

General procedure A for synthesis of compounds 2a-o. 4-(Trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL), *N*-protected amino acid-OPht (**1**) (0.15 mmol) and Cs_2CO_3 (0.075 mmol, 24.4 mg) were added to a 25-mL Schlenk tube with DMF (1.5 mL), and the tube was evacuated and back-filled with argon for three cycles. The tube was sealed, and then irradiated with a 40 W fluorescent lamp (approximately 2 cm away from the light source) at room temperature (~25 °C). After the complete conversion of **1** (monitored by TLC), the reaction mixture was diluted with 20 mL of EtOAc, and the solution was filtered by flash chromatography. The filtrate was evaporated by rotary evaporator, and the residue was purified by silica gel column chromatography to give the

desired product (**2a-o**).

General procedure B for synthesis of compounds 4a-w. 4-(Trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL), R^2CO-OPht (**1**) (0.225 mmol), alkene (**3**) (0.15 mmol), Hantzsch ester (HE) (0.225 mmol, 56.9 mg), and Cs_2CO_3 (0.075 mmol, 24.4 mg) were added to a 25-mL Schlenk tube with DMF (1.5 mL), and the tube was evacuated and back-filled with argon for three cycles. The tube was sealed, and then irradiated with a 40 W fluorescent lamp (approximately 2 cm away from the light source). After the complete conversion of **3** (monitored by TLC), the reaction mixture was diluted with 20 mL of EtOAc, and the solution was filtered by flash chromatography. The filtrate was evaporated by rotary evaporator, and the residue was purified by silica gel column chromatography to give the desired product (**4a-w**).

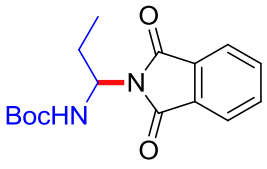
General procedure C for synthesis of compounds 6a-r. 4-(Trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL), R^2CO-OPht (**1**) (0.375 mmol), substituted 2-isocyanobiphenyl (**5**) (0.15 mmol), and Cs_2CO_3 (0.075 mmol, 24.4 mg) were added to a 25-mL Schlenk tube with DMF (1.5 mL), and the tube was evacuated and back-filled with argon for three cycles. The tube was sealed, and then irradiated with a 40 W fluorescent lamp (approximately 2 cm away from the light source). After the complete conversion of **1** (monitored by TLC), the reaction mixture was diluted with 20 mL of EtOAc, and the solution was filtered by flash chromatography. The filtrate was evaporated by rotary evaporator, and the residue was purified by silica gel column chromatography to give the desired product (**6a-r**).



2a

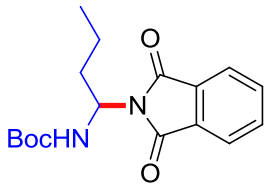
***tert*-Butyl (1-(1,3-dioxoisoindolin-2-yl)ethyl)carbamate (2a):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Ala-OPht (0.15 mmol, 50.1 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 10 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (20.6 mg, 47%

yield). Melting point: 119-121 °C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.88-7.80 (m, 2H), 7.75-7.68 (m, 2H), 6.12-5.95 (m, 1H), 5.81-5.61 (br, 1H), 1.65 (d, *J* = 6.9 Hz, 3H), 1.41 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 167.6, 154.2, 134.2, 132.0, 123.5, 80.3, 54.9, 28.3, 20.1. HRMS (ESI$^+$): Calcd for $C_{15}H_{18}NaN_2O_4$, $[M+Na]^+$ m/z 313.1159. Found 313.1157.



2b

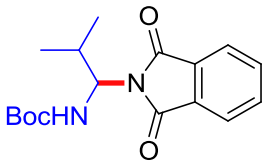
***tert*-Butyl (1-(1,3-dioxoisoindolin-2-yl)propyl)carbamate (2b):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Abu-OPht [1,3-dioxoisoindolin-2-yl 2-((*tert*-butoxycarbonyl)amino)butanoate] (0.15 mmol, 52.2 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 9 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (33.2 mg, 73% yield). Melting point: 101-103 °C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.88-7.81 (m, 2H), 7.77-7.70 (m, 2H), 5.95-5.31 (m, 2H), 2.03 (quint, *J* = 7.6 Hz, 2H), 1.41 (s, 9H), 0.96 (t, *J* = 7.6 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 167.8, 154.4, 134.2, 131.8, 123.5, 80.3, 59.9, 28.3, 26.9, 10.2. HRMS (ESI$^+$): Calcd for $C_{16}H_{20}NaN_2O_4$, $[M+Na]^+$ m/z 327.1315. Found 327.1312.



2c

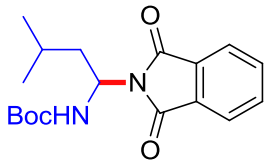
***tert*-Butyl (1-(1,3-dioxoisoindolin-2-yl)butyl)carbamate (2c):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Nva-OPht [1,3-dioxoisoindolin-2-yl 2-((*tert*-butoxycarbonyl)amino)pentanoate] (0.15 mmol, 54.3 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 8 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (40.4 mg, 85% yield). Melting point: 131-133 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.87-7.81 (m, 2H), 7.76-7.69 (m, 2H), 6.00-5.51 (m, 2H), 2.03 (h, *J*

= 7.3 Hz, 2H), 1.45-1.28 (m, 11H), 0.95 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 167.8, 154.4, 134.2, 131.8, 123.5, 80.2, 58.4, 35.5, 28.3, 19.0, 13.5. HRMS (ESI$^+$): Calcd for $C_{17}H_{22}NaN_2O_4$, $[M+Na]^+$ m/z 341.1472. Found 341.1468.



2d

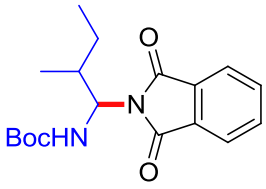
***tert*-Butyl (1-(1,3-dioxoisoindolin-2-yl)-2-methylpropyl)carbamate (2d):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Val-OPht (0.15 mmol, 54.3 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (44.8 mg, 94% yield). Melting point: 126-127 °C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.88-7.81 (m, 2H), 7.77-7.69 (m, 2H), 5.90-5.31 (m, 2H), 2.49-2.31 (m, 1H), 1.41 (s, 9H), 1.10 (d, *J* = 6.9 Hz, 3H), 0.89 (d, *J* = 6.5 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 167.9, 154.7, 134.2, 131.7, 123.5, 80.2, 64.1, 31.8, 28.3, 19.2, 18.9. HRMS (ESI$^+$): Calcd for $C_{17}H_{22}NaN_2O_4$, $[M+Na]^+$ m/z 341.1472. Found 341.1473.



2e

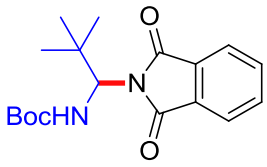
***tert*-Butyl (1-(1,3-dioxoisoindolin-2-yl)-3-methylbutyl)carbamate (2e):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Leu-OPht (0.15 mmol, 56.4 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 8 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (40.7 mg, 82% yield). Melting point: 110-112 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.87-7.81 (m, 2H), 7.75-7.69 (m, 2H), 6.05-5.90 (m, 1H), 5.81-5.22 (br, 1H), 1.99-1.78 (m, 2H), 1.64-1.52 (m, 1H), 1.41 (s, 9H), 0.99 (d, *J* = 6.9 Hz, 3H), 0.95 (d, *J* = 6.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 167.7, 154.3, 134.2, 131.9, 123.5, 80.3, 57.2, 42.3, 28.3, 25.0, 22.5, 22.3. HRMS (ESI$^+$): Calcd for

$C_{18}H_{24}NaN_2O_4$, $[M+Na]^+$ m/z 355.1628. Found 355.1622.



2f

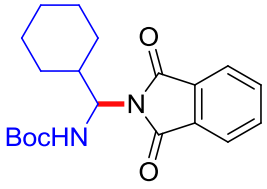
***tert*-Butyl (1-(1,3-dioxoisoindolin-2-yl)-2-methylbutyl)carbamate (2f):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Ile-OPht (0.15 mmol, 56.4 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (45.5 mg, 91% yield). Melting point: 113-115 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.88-7.81 (m, 2H), 7.76-7.70 (m, 2H), 5.83-5.32 (m, 2H), 2.28-2.12 (m, 1H), 1.41 (s, 9H), 1.37-1.08 (m, 2H), 1.07-0.81 (m, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 167.9, 154.7, 134.2, 131.8, 123.5, 80.2, 62.9, 37.7, 28.3, 25.5, 25.3, 15.3, 15.1, 10.8. HRMS (ESI^+): Calcd for $C_{18}H_{24}NaN_2O_4$, $[M+Na]^+$ m/z 355.1628. Found 355.1622.



2g

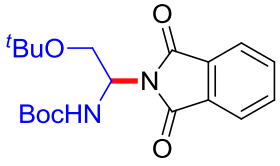
***tert*-Butyl (1-(1,3-dioxoisoindolin-2-yl)-2,2-dimethylpropyl)carbamate (2g):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Tle-OPht [1,3-dioxoisoindolin-2-yl 2-((tert-butoxycarbonyl)amino)-3,3-dimethylbutanoate] (0.15 mmol, 56.4 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 4 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (47.4 mg, 95% yield). Melting point: 133-135 °C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.91-7.77 (m, 2H), 7.76-7.64 (m, 2H), 6.22-5.92 (m, 1H), 5.87-5.61 (m, 1H), 1.41 (s, 9H), 1.04 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 169.2, 167.8, 154.8, 134.2, 132.0, 131.4, 123.7, 123.2 (*Note: The C-N bond (marked in red color) in **2g** can not rotate because of big steric hindrance of tert-butyl which leads to difference of chemical shifts on*

carbons of benzene ring), 80.2, 66.8, 37.5, 28.3, 26.5. HRMS (ESI$^+$): Calcd for $C_{18}H_{24}NaN_2O_4$, $[M+Na]^+$ m/z 355.1628. Found 355.1624.



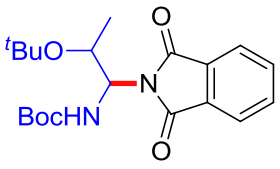
2h

***tert*-Butyl (cyclohexyl(1,3-dioxoisoindolin-2-yl)methyl)carbamate (2h):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Chg-OPht [1,3-dioxoisoindolin-2-yl 2-((tert-butoxycarbonyl)amino)-2-cyclohexylacetate] (0.15 mmol, 60.3 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 5 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (49.6 mg, 92% yield). Melting point: 154-155 °C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.90-7.79 (m, 2H), 7.78-7.65 (m, 2H), 5.87-5.28 (m, 2H), 2.19-1.88 (m, 2H), 1.87-1.53 (m, 3H), 1.41 (s, 9H), 1.29-0.88 (m, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 167.9, 154.7, 134.2, 131.7, 123.5, 80.1, 63.0, 40.4, 29.6, 29.0, 28.3, 26.0, 25.5. HRMS (ESI$^+$): Calcd for $C_{18}H_{24}NaN_2O_4$, $[M+Na]^+$ m/z 381.1785. Found 381.1786.



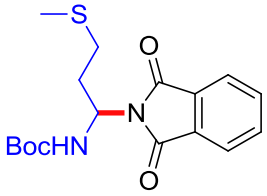
2i

***tert*-Butyl (2-(*tert*-butoxy)-1-(1,3-dioxoisoindolin-2-yl)ethyl)carbamate (2i):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Ser(^{t}Bu)-OPht (0.15 mmol, 60.9 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 8 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (45.2 mg, 83% yield). Melting point: 111-112 °C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.91-7.79 (m, 2H), 7.78-7.68 (m, 2H), 6.17-5.36 (m, 2H), 3.81-3.59 (m, 2H), 1.42 (s, 9H), 1.11 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 167.8, 154.4, 134.1, 131.9, 123.5, 80.4, 73.8, 61.3, 58.6, 28.3, 27.4. HRMS (ESI$^+$): Calcd for $C_{19}H_{26}NaN_2O_5$, $[M+Na]^+$ m/z 385.1734. Found 385.1738.



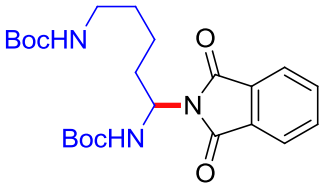
2j

***tert*-Butyl (2-(*tert*-butoxy)-1-(1,3-dioxoisoindolin-2-yl)propyl)carbamate (2j):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Thr(^{t}Bu)-OPht (0.15 mmol, 63.0 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (53.4 mg, 95% yield). Melting point: 138-140 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.88-7.81 (m, 2H), 7.77-7.70 (m, 2H), 6.07-5.49 (m, 2H), 4.11-4.00 (m, 1H), 1.42 (s, 9H), 1.28 (d, *J* = 6.0 Hz, 3H), 1.03 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 168.0, 154.5, 134.2, 131.9, 123.4, 80.2, 74.2, 67.9, 62.8, 28.5, 28.3, 20.0. HRMS (ESI$^+$): Calcd for $C_{20}H_{28}NaN_2O_5$, $[M+Na]^+$ m/z 399.1890. Found 399.1891.



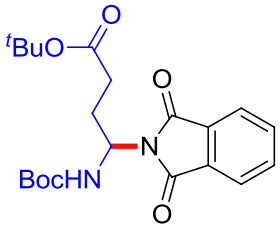
2k

***tert*-Butyl (1-(1,3-dioxoisoindolin-2-yl)-3-(methylthio)propyl)carbamate (2k):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Met-OPht (0.15 mmol, 59.1 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 9 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (37.4 mg, 71% yield). Melting point: 91-93 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.88-7.82 (m, 2H), 7.77-7.70 (m, 2H), 6.08-5.95 (m, 1H), 5.89-5.44 (br, 1H), 2.62-2.43 (m, 2H), 2.38-2.21 (m, 2H), 2.09 (s, 3H), 1.41 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 167.6, 154.3, 134.3, 131.8, 123.6, 80.5, 57.9, 33.2, 30.0, 28.3, 15.7. HRMS (ESI$^+$): Calcd for $C_{17}H_{22}NaN_2O_4S$, $[M+Na]^+$ m/z 373.1192. Found 373.1197.



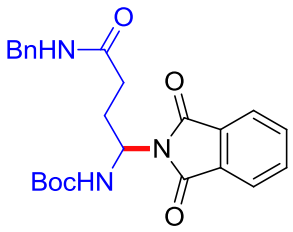
2l

Di-*tert*-butyl (1-(1,3-dioxoisoindolin-2-yl)pentane-1,5-diyl)dicarbamate (2l): According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Lys(Boc)-OPht (0.15 mmol, 73.6 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (63.2 mg, 94% yield). Melting point: 176-177 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.87-7.81 (m, 2H), 7.77-7.70 (m, 2H), 5.98-5.59 (m, 2H), 4.77-4.47 (m, 1H), 3.15-3.02 (m, 2H), 2.10-1.98 (m, 2H), 1.59-1.22 (m, 22H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 167.7, 156.0, 154.4, 134.2, 131.8, 123.5, 80.3, 79.0, 58.3, 40.2, 33.2, 29.4, 28.4, 28.3, 22.8. HRMS (ESI$^+$): Calcd for $C_{23}H_{33}NaN_3O_6$, $[M+Na]^+$ m/z 470.2262. Found 470.2265.



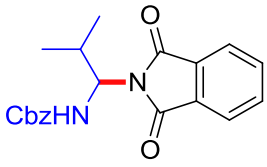
2m

***tert*-Butyl 4-((*tert*-butoxycarbonyl)amino)-4-(1,3-dioxoisoindolin-2-yl)butanoate (2m):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Glu(O^{t}Bu)-OPht (0.15 mmol, 67.2 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 9 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (40.8 mg, 67% yield). Melting point: 138-139 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.88-7.82 (m, 2H), 7.77-7.70 (m, 2H), 6.01-5.42 (m, 2H), 2.40-2.20 (m, 4H), 1.41 (s, 9H) , 1.40 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 171.5, 167.6, 154.3, 134.2, 131.8, 123.6, 80.9, 80.4, 58.2, 31.8, 28.7, 28.3, 28.1. HRMS (ESI$^+$): Calcd for $C_{21}H_{29}N_2O_6$, $[M+H]^+$ m/z 405.2020. Found 405.2027.



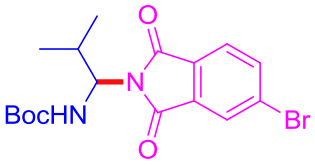
2n

***tert*-Butyl (4-(benzylamino)-1-(1,3-dioxoisoindolin-2-yl)-4-oxobutyl)carbamate (2n):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Gln(Bn)-OPht (0.15 mmol, 72.2 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 10 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 1:1) to provide the title compound as a white solid (34.2 mg, 52% yield). Melting point: 197-199 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.86-7.80 (m, 2H), 7.75-7.69 (m, 2H), 7.35-7.28 (m, 2H), 7.26-7.21 (m, 3H), 6.13-5.72 (m, 3H), 4.40-4.24 (m, 2H), 2.46-2.19 (m, 4H), 1.39 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 171.1, 167.7, 154.5, 138.1, 134.3, 131.8, 128.8, 127.9, 127.6, 123.6, 80.6, 58.4, 43.8, 32.7, 29.5, 28.3. HRMS (ESI$^+$): Calcd for $C_{24}H_{27}NaN_3O_5$, $[M+Na]^+$ m/z 460.1843. Found 460.1840.



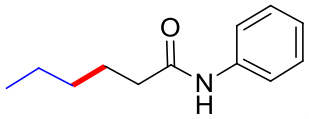
2o

Benzyl (1-(1,3-dioxoisoindolin-2-yl)-2-methylpropyl)carbamate (2o): According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Cbz-Val-OPht (0.15 mmol, 59.4 mg, 1.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (49.0 mg, 93% yield). Melting point: 105-106 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.87-7.78 (m, 2H), 7.76-7.68 (m, 2H), 7.30 (s, 5H), 6.15-5.90 (m, 1H), 5.71-5.47 (m, 1H), 5.19-4.97 (m, 2H), 2.50-2.38 (m, 1H), 1.10 (d, J = 6.9 Hz, 3H), 0.90 (d, J = 6.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 167.8, 155.5, 136.1, 134.3, 131.7, 128.6, 128.3, 123.6, 67.2, 64.5, 31.7, 19.3, 18.9. HRMS (ESI$^+$): Calcd for $C_{20}H_{20}NaN_2O_4$, $[M+Na]^+$ m/z 375.1315. Found 375.1309.



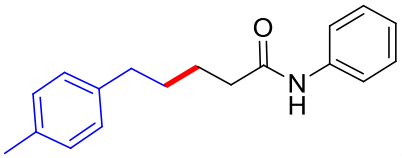
2H

***tert*-Butyl (1-(5-bromo-1,3-dioxoisoindolin-2-yl)-2-methylpropyl)carbamate (2H):** According to the general procedure A, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Val-OPht (0.15 mmol, 54.3 mg, 1.0 equiv.), 5-bromoisoindoline-1,3-dione (0.75 mmol, 169.5 mg, 5.0 equiv.), Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.), and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (45.3 mg, 76% yield). Melting point: 96-98 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.98 (s, 1H), 7.87 (d, *J* = 7.9 Hz, 1H), 7.71 (d, *J* = 7.9 Hz, 1H), 5.73-5.31 (m, 2H), 2.45-2.31 (m, 1H), 1.41 (s, 9H), 1.10 (d, *J* = 6.5 Hz, 3H), 0.88 (d, *J* = 6.5 Hz, 3H). ^{13}C NMR ($CDCl_3$, 150 MHz) δ 167.1, 166.6, 154.7, 137.2, 133.4, 130.2, 129.2, 126.9, 125.0, 80.3, 64.3, 31.6, 28.3, 19.2, 18.9. HRMS (ESI$^+$): Calcd for $C_{17}H_{21}NaN_2O_4Br$, $[M+Na]^+$ m/z 419.0577. Found 419.0570.



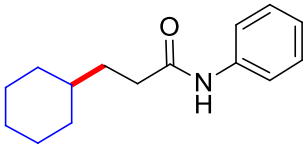
4a

***N*-Phenylhexanamide (4a):** According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), butyric acid active ester (0.225 mmol, 52.4 mg, 1.5 equiv.), *N*-phenylacrylamide (0.15 mmol, 22.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (18.7 mg, 65% yield). Melting point: 94-95 °C (lit. 95-95.5 °C, Puterbaugh, W. H. & Newman, M. S. *J. Am. Chem. Soc*. **79**, 3469-3471 (1957)). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.52 (d, *J* = 8.2 Hz, 2H), 7.37 (br, 1H), 7.30 (t, *J* = 7.8 Hz, 2H), 7.09 (t, *J* = 7.3 Hz, 1H), 2.34 (t, *J* = 7.3 Hz, 2H), 1.78-1.66 (m, 2H), 1.41-1.27 (m, 4H), 0.90 (t, *J* = 6.9 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 171.6, 138.1, 129.0, 124.2, 119.9, 37.9, 31.5, 25.4, 22.5, 14.0. HRMS (ESI$^+$): Calcd for $C_{12}H_{18}NO$, $[M+H]^+$ m/z 192.1383. Found 192.1376.



4b

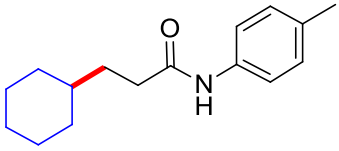
***N*-Phenyl-5-(p-tolyl)pentanamide (4b):** According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), 3-(*p*-tolyl)propanoic acid active ester (0.225 mmol, 69.5 mg, 1.5 equiv.), *N*-phenylacrylamide (0.15 mmol, 22.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (22.7 mg, 57% yield). Melting point: 92-93 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.49 (d, *J* = 7.8 Hz, 2H), 7.34 (br, 1H), 7.29 (t, *J* = 7.8 Hz, 2H), 7.11-7.02 (m, 5H), 2.59 (t, *J* = 7.6 Hz, 2H), 2.37-2.28 (m, 5H), 1.80-1.61 (m, 4H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 171.4, 139.1, 138.0, 135.3, 129.1, 129.0, 128.4, 124.3, 119.9, 37.7, 35.3, 31.2, 25.4, 21.1. HRMS (ESI$^+$): Calcd for $C_{18}H_{22}NO$, $[M+H]^+$ m/z 268.1696. Found 268.1698.



4c

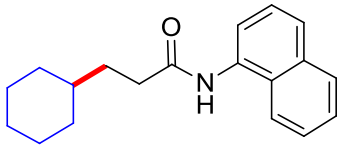
3-Cyclohexyl-*N*-phenylpropanamide (4c): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), cyclohexanecarboxylic acid active ester (0.225 mmol, 61.4 mg, 1.5 equiv.), *N*-phenylacrylamide (0.15 mmol, 22.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 4 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (28.8 mg, 83% yield). Melting point: 96-97 °C (lit. 97.5-98 °C, Metayer, M. *Ann. Chim.* **4**, 196-257 (1949)). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.51 (d, *J* = 8.2 Hz, 2H), 7.41 (br, 1H), 7.30 (t, *J* = 7.8 Hz, 2H), 7.08 (t, *J* = 7.3 Hz, 1H), 2.35 (t, *J* = 7.8 Hz, 2H), 1.81-1.54 (m, 7H), 1.34-1.08 (m, 4H), 0.98-0.84 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 171.9, 138.1, 129.0, 124.2, 119.9, 37.4, 35.4, 33.2, 33.1, 26.6, 26.3. HRMS (ESI$^+$): Calcd for $C_{15}H_{22}NO$, $[M+H]^+$ m/z 232.1696. Found

232.1694.



4d

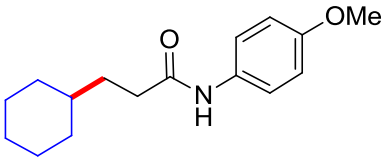
3-Cyclohexyl-*N*-(p-tolyl)propanamide (4d): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), cyclohexanecarboxylic acid active ester (0.225 mmol, 61.4 mg, 1.5 equiv.), *N*-(p-tolyl)acrylamide (0.15 mmol, 24.2 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 4 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (31.4 mg, 85% yield). Melting point: 105-107 °C (lit. 107 °C, Metayer, M. *Ann. Chim.* **4**, 196-257 (1949)). ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.48-7.37 (m, 3H), 7.09 (d, *J* = 7.9 Hz, 2H), 2.39-2.27 (m, 5H), 1.77-1.56 (m, 7H), 1.31-1.09 (m, 4H), 0.95-0.85 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 171.9, 135.6, 133.8, 129.5, 120.0, 37.4, 35.3, 33.2, 26.6, 26.3, 20.9. HRMS (ESI$^+$): Calcd for $C_{16}H_{24}NO$, $[M+H]^+$ m/z 246.1852. Found 246.1856.



4e

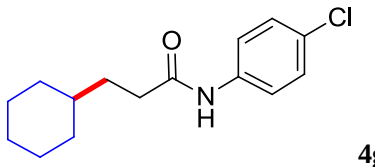
3-Cyclohexyl-*N*-(naphthalen-1-yl)propanamide (4e): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), cyclohexanecarboxylic acid active ester (0.225 mmol, 61.4 mg, 1.5 equiv.), *N*-(naphthalen-1-yl)acrylamide (0.15 mmol, 29.6 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 4 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (30.0 mg, 71% yield). Melting point: 130-131 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.88-7.77 (m, 3H), 7.76-7.61 (m, 2H), 7.52-7.38 (m, 3H), 2.55-2.37 (m, 2H), 1.81-1.61 (m, 7H), 1.35-1.11 (m, 4H), 0.98-0.86 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 172.5, 134.2, 132.4, 128.8, 127.4, 126.3, 126.0, 125.9, 125.8, 121.3, 120.8, 37.5, 35.2, 33.3, 33.2, 26.6, 26.3. HRMS (ESI$^+$):

Calcd for $C_{19}H_{23}NaNO$, $[M+Na]^+$ m/z 304.1672. Found 304.1670.



4f

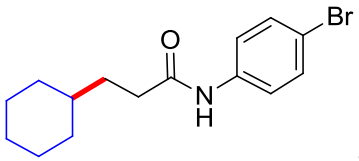
3-Cyclohexyl-*N*-(4-methoxyphenyl)propanamide (4f): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), cyclohexanecarboxylic acid active ester (0.225 mmol, 61.4 mg, 1.5 equiv.), *N*-(4-methoxyphenyl)acrylamide (0.15 mmol, 26.6 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 3 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 3:1) to provide the title compound as a white solid (34.7 mg, 89% yield). Melting point: 127-128 °C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.49-7.32 (m, 3H), 6.83 (d, *J* = 8.9 Hz, 2H), 3.78 (s, 3H), 2.33 (t, *J* = 7.9 Hz, 2H), 1.78-1.52 (m, 7H), 1.34-1.02 (m, 4H), 1.01-0.80 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 171.8, 156.3, 131.3, 121.9, 114.1, 55.6, 37.4, 35.2, 33.2, 26.6, 26.3. HRMS (ESI^+): Calcd for $C_{16}H_{23}NaNO_2$, $[M+Na]^+$ m/z 284.1621. Found 284.1619.



4g

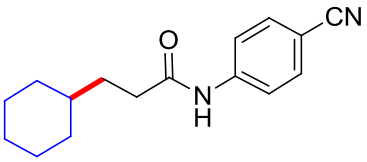
***N*-(4-Chlorophenyl)-3-cyclohexylpropanamide (4g):** According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), cyclohexanecarboxylic acid active ester (0.225 mmol, 61.4 mg, 1.5 equiv.), *N*-(4-chlorophenyl)acrylamide (0.15 mmol, 27.2 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 4 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (27.8 mg, 72% yield). Melting point: 128-129 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.61-7.42 (m, 3H), 7.25 (d, *J* = 8.6 Hz, 2H), 2.35 (t, *J* = 7.9 Hz, 2H), 1.79-1.55 (m, 7H), 1.30-1.08 (m, 4H), 0.95-0.84 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 172.1, 136.7, 129.2, 129.0, 121.2,

37.4, 35.3, 33.1, 33.0, 26.6, 26.3. HRMS (ESI$^+$): Calcd for $C_{15}H_{21}NOCl$, $[M+H]^+$ m/z 266.1306. Found 266.1307.



4h

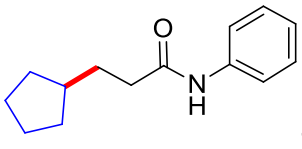
***N*-(4-Bromophenyl)-3-cyclohexylpropanamide (4h):** According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), cyclohexanecarboxylic acid active ester (0.225 mmol, 61.4 mg, 1.5 equiv.), *N*-(4-bromophenyl)acrylamide (0.15 mmol, 33.9 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 4 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (35.5 mg, 76% yield). Melting point: 139-140 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.50 (br, 1H), 7.46-7.34 (m, 4H), 2.35 (t, *J* = 7.9 Hz, 2H), 1.77-1.54 (m, 7H), 1.30-1.09 (m, 4H), 0.95-0.85 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 172.0, 137.2, 132.0, 121.5, 116.8, 37.4, 35.3, 33.1, 33.0, 26.6, 26.3. HRMS (ESI$^+$): Calcd for $C_{15}H_{21}BrNO$, $[M+H]^+$ m/z 310.0801. Found 310.0796.



4i

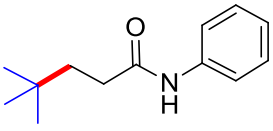
***N*-(4-Cyanophenyl)-3-cyclohexylpropanamide (4h):** According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), cyclohexanecarboxylic acid active ester (0.225 mmol, 61.4 mg, 1.5 equiv.), *N*-(4-cyanophenyl)acrylamide (0.15 mmol, 25.8 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 7 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (28.5 mg, 74% yield). Melting point: 129-131 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.03-7.82 (m, 1H), 7.73-7.67 (m, 2H), 7.62-7.56 (m, 2H), 2.41 (t, *J* = 8.0 Hz, 2H), 1.90-1.56 (m,

7H), 1.33-1.07 (m, 4H), 0.97-0.83 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 172.6, 142.5, 133.3, 119.6, 119.1, 106.7, 37.3, 35.4, 33.1, 32.8, 26.5, 26.2. HRMS (ESI^+): Calcd for $C_{16}H_{19}N_2O$, $[M-H]^-$ m/z 255.1503. Found 255.1508.



4j

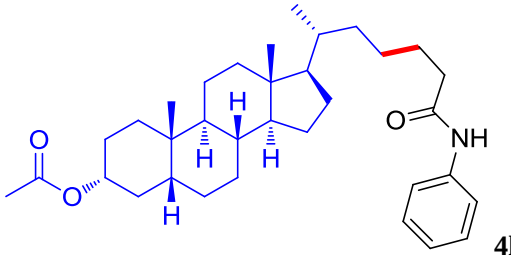
3-Cyclopentyl-*N*-phenylpropanamide (4j): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), cyclopentanecarboxylic acid active ester (0.225 mmol, 58.3 mg, 1.5 equiv.), *N*-phenylacrylamide (0.15 mmol, 22.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 4 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (25.2 mg, 77% yield). Melting point: 108-109 °C (lit. 110 °C, Barrett, J. W., Cook, A. H. & Linstead, R. P. *J. Chem. Soc.* 1065-1069 (1935)). ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.62 (br, 1H), 7.53 (d, *J* = 7.2 Hz, 2H), 7.29 (t, *J* = 6.7 Hz, 2H), 7.09 (t, *J* = 6.9 Hz, 1H), 2.36 (t, *J* = 6.5 Hz, 2H), 1.91-1.46 (m, 9H), 1.16-1.05 (m, 2H). ^{13}C NMR ($CDCl_3$, 150 MHz) δ 172.0, 138.2, 129.0, 124.2, 120.0, 39.8, 37.2, 32.6, 32.0, 25.2. HRMS (ESI^+): Calcd for $C_{14}H_{20}NO$, $[M+H]^+$ m/z 218.1539. Found 218.1530.



4k

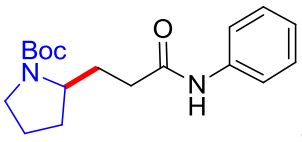
4,4-Dimethyl-*N*-phenylpentanamide (4k): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), pivalic acid active ester (0.225 mmol, 55.6 mg, 1.5 equiv.), *N*-phenylacrylamide (0.15 mmol, 22.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 3 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (27.6 mg, 90% yield). Melting point: 138-139 °C (lit. 138-139 °C, Scott, R. B., Jr. & Gordon,

M. J. *J. Org. Chem.* **21**, 385-387 (1956)). ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.76-7.64 (br, 1H), 7.52 (d, *J* = 8.2 Hz, 2H), 7.28 (t, *J* = 7.7 Hz, 2H), 7.08 (t, *J* = 7.4 Hz, 1H), 2.35-2.28 (m, 2H), 1.67-1.60 (m, 2H), 0.90 (s, 9H). ^{13}C NMR ($CDCl_3$, 150 MHz) δ 172.4, 138.2, 129.0, 124.2, 120.0, 39.4, 33.5, 30.3, 29.2. HRMS (ESI$^+$): Calcd for $C_{13}H_{20}NO$, $[M+H]^+$ m/z 206.1539. Found 206.1532.



4l

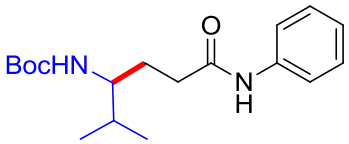
(3*R*,5*R*,8*R*,9*S*,10*S*,13*R*,14*S*,17*R*)-10,13-Dimethyl-17-((*R*)-7-oxo-7-(phenylamino)heptan-2-yl)hexadecahydro-1*H*-cyclopenta[*a*]phenanthren-3-yl acetate (4l): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), acetylated lithocholic acid active ester (0.225 mmol, 126.8 mg, 1.5 equiv.), *N*-phenylacrylamide (0.15 mmol, 22.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 8 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (dichloromethane) to provide the title compound as a white solid (48.6 mg, 62% yield). Melting point: 136-137 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.52 (d, *J* = 7.9 Hz, 2H), 7.35-7.28 (m, 3H), 7.10 (t, *J* = 7.4 Hz, 1H), 4.75-4.68 (m, 1H), 2.41-2.30 (m, 2H), 2.03 (s, 3H), 1.99-1.93 (m, 1H), 1.88-1.78 (m, 4H), 1.77-1.61 (m, 3H), 1.58-1.51 (m, 2H), 1.47-1.32 (m, 9H), 1.30-1.18 (m, 4H), 1.17-0.97 (m, 7H), 0.92 (s, 3H), 0.90 (d, *J* = 6.5 Hz, 3H), 0.63 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 171.5, 170.8, 138.1, 129.1, 124.2, 119.8, 74.5, 56.6, 56.4, 42.8, 42.0, 40.5, 40.2, 38.0, 35.9, 35.7, 35.1, 34.7, 32.3, 28.4, 27.1, 26.7, 26.4, 26.2, 25.9, 24.3, 23.4, 21.6, 20.9, 18.7, 12.1. HRMS (ESI$^+$): Calcd for $C_{34}H_{51}NaNO_3$, $[M+Na]^+$ m/z 544.3761. Found 544.3753.



4m

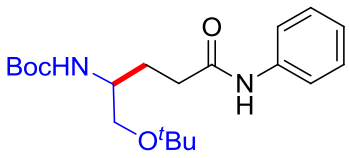
***tert*-Butyl 2-(3-oxo-3-(phenylamino)propyl)pyrrolidine-1-carboxylate (4m):** According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.),

Boc-Pro-OPht (0.225 mmol, 81.0 mg, 1.5 equiv.), *N*-phenylacrylamide (0.15 mmol, 22.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 4 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 2:1) to provide the title compound as colorless oil (43.6 mg, 91% yield). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 9.92 (br, 1H), 7.72-7.52 (m, 2H), 7.33-7.24 (m, 2H), 7.05 (t, *J* = 7.3 Hz, 1H), 4.07-3.77 (m, 1H), 3.46-3.23 (m, 2H), 2.54-2.27 (m, 2H), 2.08-1.55 (m, 6H), 1.50 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 171.8, 156.2, 139.0, 128.8, 123.6, 119.7, 80.0, 56.2, 46.6, 35.1, 31.9, 31.1, 28.6, 23.6. HRMS (ESI$^+$): Calcd for $C_{18}H_{27}N_2O_3$, $[M+H]^+$ m/z 319.2016. Found 319.2018.



4n

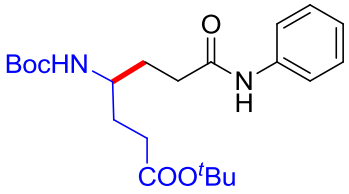
***tert*-Butyl (2-methyl-6-oxo-6-(phenylamino)hexan-3-yl)carbamate (4n):** According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Val-OPht (0.225 mmol, 81.4 mg, 1.5 equiv.), *N*-phenylacrylamide (0.15 mmol, 22.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 5 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 3:1) to provide the title compound as a white solid (41.7 mg, 87% yield). Melting point: 130-131 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 8.96 (br, 1H), 7.63 (d, *J* = 7.9 Hz, 2H), 7.30 (t, *J* = 7.4 Hz, 2H), 7.07 (t, *J* = 7.4 Hz, 1H), 4.56 (d, *J* = 9.6 Hz, 1H), 3.53-3.45 (m, 1H), 2.43-2.33 (m, 2H), 1.94-1.87 (m, 1H), 1.73-1.62 (m, 2H), 1.44 (s, 9H), 0.93-0.85 (m, 6H). ^{13}C NMR ($CDCl_3$, 150 MHz) δ 171.8, 157.4, 138.7, 128.9, 123.9, 119.8, 79.8, 55.3, 35.0, 32.7, 29.8, 28.4, 19.4, 17.8. HRMS (ESI$^+$): Calcd for $C_{18}H_{28}NaN_2O_3$, $[M+Na]^+$ m/z 343.1992. Found 343.1990.



4o

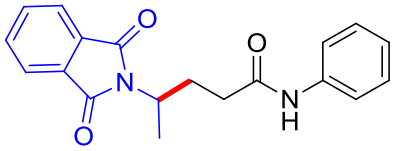
***tert*-Butyl (1-(*tert*-butoxy)-5-oxo-5-(phenylamino)pentan-2-yl)carbamate (4o):** According to

the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Ser(O^{t}Bu)-OPht (0.225 mmol, 91.4 mg, 1.5 equiv.), *N*-phenylacrylamide (0.15 mmol, 22.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 5 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 3:1) to provide the title compound as a white solid (42.2 mg, 77% yield). Melting point: 130-132 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 9.30 (br, 1H), 7.65 (d, *J* = 7.9 Hz, 2H), 7.31 (t, *J* = 7.6 Hz, 2H), 7.07 (t, *J* = 7.2 Hz, 1H), 5.11 (d, *J* = 8.6 Hz, 1H), 3.81-3.73 (m, 1H), 3.44-3.27 (m, 2H), 2.43-2.29 (m, 2H), 2.00-1.81 (m, 2H), 1.48 (s, 9H), 1.15 (s, 9H). ^{13}C NMR ($CDCl_3$, 150 MHz) δ 171.9, 157.2, 138.8, 128.9, 123.8, 119.7, 80.0, 73.1, 64.1, 49.8, 34.8, 30.3, 28.5, 27.5. HRMS (ESI$^+$): Calcd for $C_{20}H_{33}N_2O_4$, $[M+H]^+$ m/z 365.2435. Found 365.2438.



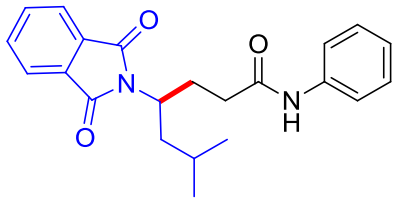
4p

***tert*-Butyl 4-((*tert*-butoxycarbonyl)amino)-7-oxo-7-(phenylamino)heptanoate (4p):** According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Glu(O^{t}Bu)-OPht (0.225 mmol, 100.9 mg, 1.5 equiv.), *N*-phenylacrylamide (0.15 mmol, 22.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 5 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 2:1) to provide the title compound as a white solid (45.0 mg, 74% yield). Melting point: 98-100 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 9.12 (br, 1H), 7.63 (d, *J* = 7.2 Hz, 2H), 7.30 (t, *J* = 7.0 Hz, 2H), 7.07 (t, *J* = 7.0 Hz, 1H), 4.83-4.54 (m, 1H), 3.71-3.47 (m, 1H), 2.45-2.35 (m, 2H), 2.34-2.24 (m, 2H), 1.97-1.88 (m, 1H), 1.82-1.73 (m, 1H), 1.72-1.62 (m, 2H), 1.44 (s, 9H), 1.42 (s, 9H). ^{13}C NMR ($CDCl_3$, 150 MHz) δ 172.9, 171.6, 157.2, 138.7, 128.9, 123.9, 119.8, 80.7, 79.9, 50.3, 34.7, 33.3, 32.4, 30.4, 28.4, 28.1. HRMS (ESI$^+$): Calcd for $C_{22}H_{34}NaN_2O_5$, $[M+Na]^+$ m/z 429.2360. Found 429.2352.



4q

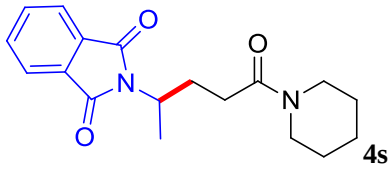
4-(1,3-Dioxoisoindolin-2-yl)-N-phenylpentanamide (4q): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), (*S*)-2-(1,3-dioxoisoindolin-2-yl)propanoic acid active ester (0.225 mmol, 81.9 mg, 1.5 equiv.), *N*-phenylacrylamide (0.15 mmol, 22.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 5 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 3:1) to provide the title compound as colorless oil (40.5 mg, 84% yield). ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.79-7.63 (m, 5H), 7.46 (d, *J* = 8.2 Hz, 2H), 7.24 (t, *J* = 7.9 Hz, 2H), 7.04 (t, *J* = 7.4 Hz, 1H), 4.47-4.38 (m, 1H), 2.57-2.48 (m, 1H), 2.31 (t, *J* = 7.2 Hz, 2H), 2.16-2.07 (m, 1H), 1.53 (d, *J* = 6.9 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 170.4, 168.8, 138.0, 134.1, 131.8, 128.9, 124.2, 123.2, 119.8, 47.3, 35.1, 29.8, 18.9. HRMS (ESI$^+$): Calcd for $C_{19}H_{19}N_2O_3$, $[M+H]^+$ m/z 323.1390. Found 323.1389.



4r

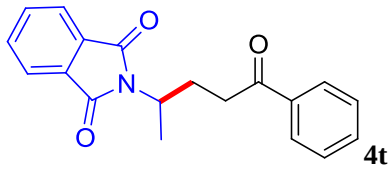
4-(1,3-Dioxoisoindolin-2-yl)-6-methyl-N-phenylheptanamide (4r): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), (*S*)-2-(1,3-dioxoisoindolin-2-yl)-4-methylpentanoic acid active ester (0.225 mmol, 91.4 mg, 1.5 equiv.), *N*-phenylacrylamide (0.15 mmol, 22.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 5 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (42.7 mg, 78% yield). Melting point: 105-107 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.80-7.74 (m, 2H), 7.70-7.64 (m, 2H), 7.56 (br, 1H), 7.44 (d, *J* = 7.8 Hz, 2H), 7.24 (t, *J* = 8.0 Hz, 2H), 7.05 (t, *J* = 7.3 Hz, 1H), 4.43-4.32 (m, 1H), 2.58-2.45 (m, 1H), 2.31 (t, *J* = 7.1 Hz, 2H), 2.28-2.18 (m, 1H), 2.14-2.03 (m, 1H), 1.54-1.38 (m,

2H), 0.94-0.82 (m, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 170.4, 169.1, 138.0, 134.1, 131.7, 128.9, 124.2, 123.3, 119.8, 50.1, 41.2, 35.1, 28.9, 25.3, 23.2, 21.8. HRMS (ESI$^+$): Calcd for $C_{22}H_{24}NaN_2O_3$, $[M+Na]^+$ m/z 387.1679. Found 387.1682.



4s

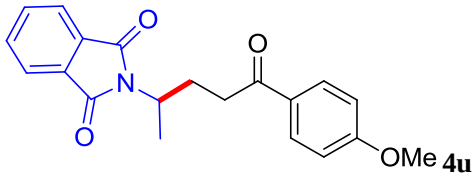
2-(5-Oxo-5-(piperidin-1-yl)pentan-2-yl)isoindoline-1,3-dione (4s): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), (*S*)-2-(1,3-dioxoisoindolin-2-yl)propanoic acid active ester (0.225 mmol, 81.9 mg, 1.5 equiv.), 1-(piperidin-1-yl)prop-2-en-1-one (0.15 mmol, 20.9 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 9 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 1:1) to provide the title compound as a white solid (28.6 mg, 61% yield). Melting point: 70-71 °C (lit. 68-70 °C, Crook, L. R., Jansen, A. B. A., Spencer, K. E. V. & Watson, D. H. GB 1036694 (1966)). ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.87-7.80 (m, 2H), 7.76-7.67 (m, 2H), 4.47-4.35 (m, 1H), 3.56-3.39 (m, 2H), 3.35-3.23 (m, 2H), 2.47-2.38 (m, 1H), 2.34-2.22 (m, 2H), 2.15-2.07 (m, 1H), 1.68-1.41 (m, 9H). ^{13}C NMR ($CDCl_3$, 150 MHz) δ 170.0, 168.6, 134.0, 132.0, 123.2, 47.4, 46.6, 42.7, 30.5, 29.3, 26.4, 25.5, 24.6, 18.9. HRMS (ESI$^+$): Calcd for $C_{18}H_{23}N_2O_3$, $[M+H]^+$ m/z 315.1703. Found 315.1704.



4t

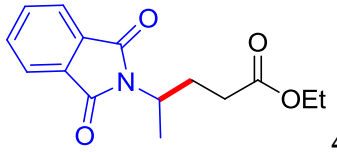
2-(5-Oxo-5-phenylpentan-2-yl)isoindoline-1,3-dione (4t): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), (*S*)-2-(1,3-dioxoisoindolin-2-yl)propanoic acid active ester (0.225 mmol, 81.9 mg, 1.5 equiv.), 1-phenylprop-2-en-1-one (0.15 mmol, 19.8 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 3 hours, the reaction mixture was subjected to the workup procedure outlined in the

general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (34.7 mg, 75% yield). Melting point: 125-126 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.88 (d, *J* = 8.2 Hz, 2H), 7.84-7.79 (m, 2H), 7.73-7.68 (m, 2H), 7.52 (t, *J* = 7.4 Hz, 1H), 7.41 (t, *J* = 7.7 Hz, 2H), 4.52-4.43 (m, 1H), 3.03-2.91 (m, 2H), 2.59-2.50 (m, 1H), 2.26-2.18 (m, 1H), 1.55 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 199.0, 168.6, 136.8, 134.0, 133.1, 132.0, 128.6, 128.1, 123.2, 47.2, 35.7, 28.3, 18.9. HRMS (ESI$^+$): Calcd for $C_{19}H_{18}NO_3$, $[M+H]^+$ m/z 308.1281. Found 308.1278.



4u

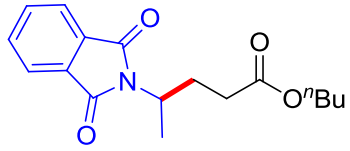
2-(5-(4-Methoxyphenyl)-5-oxopentan-2-yl)isoindoline-1,3-dione (4u): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), (*S*)-2-(1,3-dioxoisoindolin-2-yl)propanoic acid active ester (0.225 mmol, 81.9 mg, 1.5 equiv.), 1-(4-methoxyphenyl)prop-2-en-1-one (0.15 mmol, 24.3 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 3 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 4:1) to provide the title compound as a white solid (44.6 mg, 88% yield). Melting point: 94-95 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.88-7.83 (m, 2H), 7.83-7.78 (m, 2H), 7.74-7.68 (m, 2H), 6.89-6.84 (m, 2H), 4.51-4.42 (m, 1H), 3.84 (s, 3H), 2.97-2.84 (m, 2H), 2.57-2.48 (m, 1H), 2.24-2.15 (m, 1H), 1.55 (d, *J* = 6.9 Hz, 3H). ^{13}C NMR ($CDCl_3$, 150 MHz) δ 197.6, 168.6, 163.4, 134.0, 132.0, 130.3, 129.8, 123.2, 113.7, 55.5, 47.3, 35.4, 28.4, 18.9. HRMS (ESI$^+$): Calcd for $C_{20}H_{19}NaNO_4$, $[M+Na]^+$ m/z 360.1206. Found 360.1207.



4v

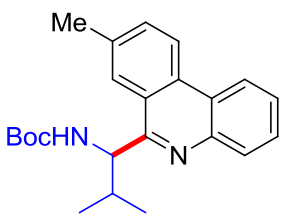
Ethyl 4-(1,3-dioxoisoindolin-2-yl)pentanoate (4v): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), (*S*)-2-(1,3-dioxoisoindolin-2-yl)propanoic acid active ester (0.225 mmol, 81.9 mg, 1.5 equiv.), ethyl acrylate (0.15 mmol, 15.0 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5

equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 4 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (38.1 mg, 92% yield). Melting point: 48-49 °C (lit. 50 °C, Crook, L. R., Jansen, A. B. A., Spencer, K. E. V. & Watson, D. H. GB 1036694 (1966)). ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.85-7.81 (m, 2H), 7.75-7.70 (m, 2H), 4.44-4.36 (m, 1H), 4.12-4.02 (m, 2H), 2.47-2.38 (m, 1H), 2.35-2.23 (m, 2H), 2.14-2.06 (m, 1H), 1.51 (d, *J* = 6.9 Hz, 3H), 1.21 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 172.7, 168.4, 134.0, 132.0, 123.2, 60.6, 46.8, 31.7, 28.9, 18.7, 14.2. HRMS (ESI$^+$): Calcd for $C_{15}H_{17}NaNO_4$, $[M+Na]^+$ m/z 298.1050. Found 298.1053.



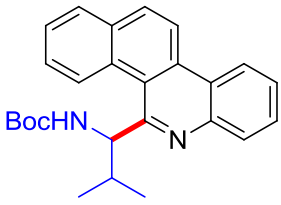
4w

Butyl 4-(1,3-dioxoisoindolin-2-yl)pentanoate (4w): According to the general procedure B, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), (*S*)-2-(1,3-dioxoisoindolin-2-yl)propanoic acid active ester (0.225 mmol, 81.9 mg, 1.5 equiv.), butyl acrylate (0.15 mmol, 19.2 mg, 1.0 equiv.), Hantzsch ester (HE) (0.225 mmol, 56.9 mg, 1.5 equiv.), and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 4 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as colorless oil (41.0 mg, 90% yield). ^{1}H NMR ($CDCl_3$, 600 MHz) δ 7.85-7.81 (m, 2H), 7.74-7.70 (m, 2H), 4.43-4.36 (m, 1H), 4.05-3.97 (m, 2H), 2.46-2.38 (m, 1H), 2.35-2.24 (m, 2H), 2.14-2.06 (m, 1H), 1.56 (quint, *J* = 7.6 Hz, 2H), 1.51 (d, *J* = 6.9 Hz, 3H), 1.33 (sext, *J* = 7.6 Hz, 2H), 0.91 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 172.8, 168.4, 134.0, 132.0, 123.2, 64.5, 46.9, 31.6, 30.6, 28.9, 19.2, 18.7, 13.8. HRMS (ESI$^+$): Calcd for $C_{17}H_{21}NaNO_4$, $[M+Na]^+$ m/z 326.1363. Found 326.1358.



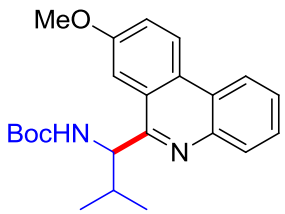
6a

***tert*-Butyl-(2-methyl-1-(8-methylphenanthridin-6-yl)propyl)carbamate (6a):** According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Val-OPht (0.375 mmol, 135.8 mg, 2.5 equiv.), 2-isocyano-4'-methyl-1,1'-biphenyl (0.15 mmol, 29.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 20:1) to provide the title compound as a white solid (48.8 mg, 89% yield). Melting point: 177-179 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.48 (t, *J* = 7.3 Hz, 2H), 8.10 (d, *J* = 8.2 Hz, 1H), 8.06 (s, 1H), 7.69-7.56 (m, 3H), 6.38 (d, *J* = 8.7 Hz, 1H), 5.63 (dd, J_1 = 8.7 Hz, J_2 = 5.0 Hz, 1H), 2.58 (s, 3H), 2.34-2.24 (m, 1H), 1.48 (s, 9H), 1.07 (d, *J* = 6.9 Hz, 3H), 0.86 (d, *J* = 6.9 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 159.6, 156.2, 142.5, 137.3, 132.2, 130.7, 129.7, 128.0, 126.6, 125.1, 124.3, 123.7, 122.3, 121.7, 79.0, 55.3, 34.5, 28.4, 21.8, 20.6, 17.0. HRMS (ESI$^+$): Calcd for $C_{23}H_{29}N_2O_2$, $[M+H]^+$ m/z 365.2224. Found 365.2220.



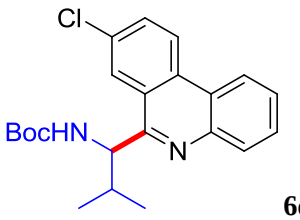
6b

***tert*-Butyl (1-(benzo[i]phenanthridin-5-yl)-2-methylpropyl)carbamate (6b):** According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Val-OPht (0.375 mmol, 135.8 mg, 2.5 equiv.), 2-(2-isocyanophenyl)naphthalene (0.15 mmol, 34.4 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 20:1) to provide the title compound as a white solid (51.2 mg, 85% yield). Melting point: 196-198 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.97 (d, *J* = 8.7 Hz, 1H), 8.60-8.54 (m, 2H), 8.19-8.09 (m, 2H), 7.99 (d, *J* = 7.8 Hz, 1H), 7.80-7.73 (m, 2H), 7.69-7.62 (m, 2H), 6.50 (d, *J* = 9.2 Hz, 1H), 6.20 (dd, J_1 = 9.2 Hz, J_2 = 5.5 Hz, 1H), 2.28-2.16 (m, 1H), 1.52 (s, 9H), 0.82 (d, *J* = 6.9 Hz, 3H), 0.73 (d, *J* = 6.9 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 159.2, 156.4, 143.4, 133.8, 133.3, 132.2, 129.9, 129.4, 129.0, 128.9, 127.6, 127.4, 126.8, 126.7, 123.5, 122.7, 121.6, 120.2, 79.2, 59.2, 35.0, 28.6, 20.2, 17.2. HRMS (ESI$^+$): Calcd for $C_{26}H_{29}N_2O_2$, $[M+H]^+$ m/z 401.2224. Found 401.2222.



6c

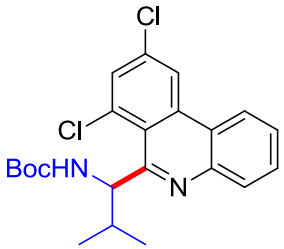
***tert*-Butyl (1-(8-methoxyphenanthridin-6-yl)-2-methylpropyl)carbamate (6c):** According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Val-OPht (0.375 mmol, 135.8 mg, 2.5 equiv.), 2-isocyano-4'-methoxy-1,1'-biphenyl (0.15 mmol, 31.4 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 5 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 10:1) to provide the title compound as a white solid (53.5 mg, 94% yield). Melting point: 155-157 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.51 (d, J = 8.7 Hz, 1H), 8.43 (d, J = 8.2 Hz, 1H), 8.10 (d, J = 7.8 Hz, 1H), 7.67-7.55 (m, 3H), 7.44 (dd, J_1 = 9.2 Hz, J_2 = 2.7 Hz, 1H), 6.29 (d, J = 8.7 Hz, 1H), 5.55 (dd, J_1 = 9.2 Hz, J_2 = 5.0 Hz, 1H), 3.99 (s, 3H), 2.43-2.30 (m, 1H), 1.48 (s, 9H), 1.08 (d, J = 6.9 Hz, 3H), 0.89 (d, J = 6.9 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 159.0, 158.8, 156.3, 142.2, 129.9, 127.6, 127.4, 126.9, 125.7, 124.2, 123.9, 121.5, 121.4, 105.7, 79.2, 55.8, 55.6, 34.1, 28.6, 20.8, 17.3. HRMS (ESI$^+$): Calcd for $C_{23}H_{29}N_2O_3$, $[M+H]^+$ m/z 381.2173. Found 381.2173.



6d

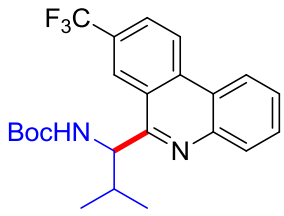
***tert*-Butyl (1-(8-chlorophenanthridin-6-yl)-2-methylpropyl)carbamate (6d):** According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Val-OPht (0.375 mmol, 135.8 mg, 2.5 equiv.), 4'-chloro-2-isocyano-1,1'-biphenyl (0.15 mmol, 32.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 20:1) to provide the title compound as a white solid (53.0 mg, 92% yield). Melting point: 169-171 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.48 (d, J = 8.7 Hz, 1H), 8.40 (d, J = 8.2 Hz, 1H), 8.22

(s, 1H), 8.09 (d, J = 8.2 Hz, 1H), 7.77-7.64 (m, 2H), 7.61 (t, J = 7.6 Hz, 1H), 6.29 (d, J = 8.7 Hz, 1H), 5.54 (dd, J_1 = 8.7 Hz, J_2 = 5.0 Hz, 1H), 2.36-2.09 (m, 1H), 1.50 (s, 9H), 1.06 (d, J = 6.9 Hz, 3H), 0.86 (d, J = 6.9 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 159.0, 156.3, 142.9, 133.6, 131.3, 131.1, 130.1, 128.9, 127.2, 125.2, 125.1, 124.3, 123.1, 121.9, 79.3, 55.6, 34.6, 28.6, 20.7, 17.1. HRMS (ESI$^+$): Calcd for $C_{22}H_{26}N_2O_2Cl$, $[M+H]^+$ m/z 385.1677. Found 385.1681.



6e

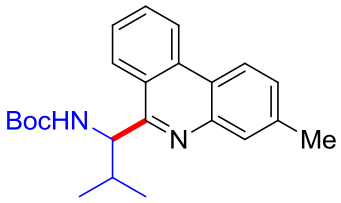
***tert*-Butyl (1-(7,9-dichlorophenanthridin-6-yl)-2-methylpropyl)carbamate (6e):** According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Val-OPht (0.375 mmol, 135.8 mg, 2.5 equiv.), 3',5'-dichloro-2-isocyano-1,1'-biphenyl (0.15 mmol, 37.2 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 8 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 20:1) to provide the title compound as a white solid (40.4 mg, 64% yield). Melting point: 176.178 ºC. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.50 (s, 1H), 8.34 (d, J = 8.2 Hz, 1H), 8.08 (d, J = 8.2 Hz, 1H), 7.80-7.58 (m, 3H), 6.74-6.24 (m, 2H), 2.31-2.10 (m, 1H), 1.51 (s, 9H), 1.14 (d, J = 6.9 Hz, 3H), 0.64 (d, J = 6.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 158.2, 156.4, 142.1, 137.1, 135.9, 133.4, 131.3, 129.9, 129.8, 127.6, 122.2, 122.0, 121.7, 120.5, 79.1, 57.0, 34.7, 28.6, 20.8, 15.2. HRMS (ESI$^+$): Calcd for $C_{22}H_{25}N_2O_2Cl_2$, $[M+H]^+$ m/z 419.1288. Found 419.1288.



6f

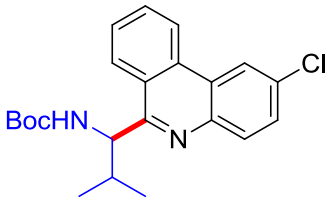
***tert*-Butyl (2-methyl-1-(8-(trifluoromethyl)phenanthridin-6-yl)propyl)carbamate (6f):** According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Val-OPht (0.375 mmol, 135.8 mg, 2.5 equiv.), 2-isocyano-4'-(trifluoromethyl)-1,1'-biphenyl (0.15 mmol, 37.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075

mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 20:1) to provide the title compound as a white solid (57.3 mg, 91% yield). Melting point: 125-127 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 8.69 (d, *J* = 8.6 Hz, 1H), 8.58-8.44 (m, 2H), 8.14 (d, *J* = 7.9 Hz, 1H), 8.00 (d, *J* = 8.6 Hz, 1H), 7.76 (t, *J* = 7.6 Hz, 1H), 7.65 (t, *J* = 7.6 Hz, 1H), 6.33 (d, *J* = 8.9 Hz, 1H), 5.64 (dd, J_1 = 8.9 Hz, J_2 = 4.8 Hz, 1H), 2.36-2.23 (m, 1H), 1.51 (s, 9H), 1.08 (d, *J* = 6.5 Hz, 3H), 0.86 (d, *J* = 6.9 Hz, 3H). ^{13}C NMR ($CDCl_3$, 150 MHz) δ 159.8, 156.2, 143.5, 135.2, 130.2, 129.9, 129.2 (q, *J* = 33.2 Hz), 127.4, 126.4, 124.0 (q, *J* = 271.6 Hz), 123.7, 123.6, 123.2, 122.8, 122.3, 79.5, 55.7, 34.7, 28.6, 20.6, 17.1. HRMS (ESI$^+$): Calcd for $C_{23}H_{25}NaN_2O_2F_3$, $[M+Na]^+$ m/z 441.1760. Found 441.1763.



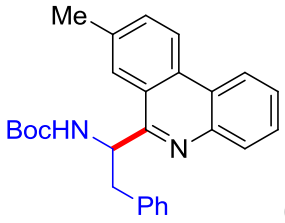
6g

***tert*-Butyl (2-methyl-1-(3-methylphenanthridin-6-yl)propyl)carbamate (6g):** According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Val-OPht (0.375 mmol, 135.8 mg, 2.5 equiv.), 2-isocyano-4-methyl-1,1'-biphenyl (0.15 mmol, 29.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 20:1) to provide the title compound as a white solid (46.0 mg, 84% yield). Melting point: 122-124 °C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.59 (d, *J* = 8.3 Hz, 1H), 8.42 (d, *J* = 8.3 Hz, 1H), 8.28 (d, *J* = 8.3 Hz, 1H), 7.94 (s, 1H), 7.81 (t, *J* = 7.6 Hz, 1H), 7.67 (t, *J* = 7.6 Hz, 1H), 7.46 (d, *J* = 8.3 Hz, 1H), 6.36 (d, *J* = 8.9 Hz, 1H), 5.62 (dd, J_1 = 8.6 Hz, J_2 = 4.8 Hz, 1H), 2.59 (s, 3H), 2.38-2.20 (m, 1H), 1.47 (s, 9H), 1.06 (d, *J* = 6.9 Hz, 3H), 0.85 (d, *J* = 6.5 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 160.0, 156.3, 143.1, 138.8, 133.1, 130.5, 129.5, 128.6, 127.0, 125.8, 124.0, 122.4, 121.8, 121.5, 79.1, 55.6, 34.7, 28.6, 21.6, 20.7, 17.1. HRMS (ESI$^+$): Calcd for $C_{23}H_{29}N_2O_2$, $[M+H]^+$ m/z 365.2224. Found 365.2226.



6h

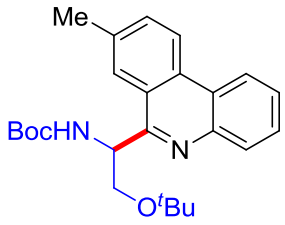
***tert*-Butyl (1-(2-chlorophenanthridin-6-yl)-2-methylpropyl)carbamate (6h):** According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Val-OPht (0.375 mmol, 135.8 mg, 2.5 equiv.), 5-chloro-2-isocyano-1,1'-biphenyl (0.15 mmol, 32.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 20:1) to provide the title compound as a white solid (52.1 mg, 90% yield). Melting point: 123-125 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.47 (d, *J* = 8.2 Hz, 1H), 8.40 (s, 1H), 8.28 (d, *J* = 8.2 Hz, 1H), 8.02 (d, *J* = 8.7 Hz, 1H), 7.82 (t, *J* = 7.6 Hz, 1H), 7.72 (t, *J* = 7.6 Hz, 1H), 7.60 (d, *J* = 8.7 Hz, 1H), 6.30 (d, *J* = 9.2 Hz, 1H), 5.62 (dd, J_1 = 8.7 Hz, J_2 = 5.0 Hz, 1H), 2.33-2.21 (m, 1H), 1.49 (s, 9H), 1.05 (d, *J* = 6.9 Hz, 3H), 0.85 (d, *J* = 6.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 160.4, 156.3, 141.3, 132.6, 132.0, 131.4, 130.8, 129.1, 128.2, 125.8, 124.8, 124.4, 122.5, 121.6, 79.3, 55.6, 34.6, 28.6, 20.7, 17.1. HRMS (ESI$^+$): Calcd for $C_{22}H_{26}N_2O_2Cl$, $[M+H]^+$ m/z 385.1677. Found 385.1678.



6i

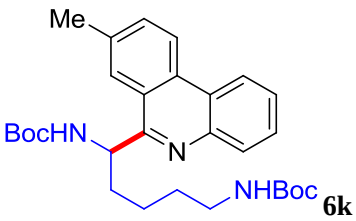
***tert*-Butyl (1-(8-methylphenanthridin-6-yl)-2-phenylethyl)carbamate (6i):** According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Phe-OPht (0.375 mmol, 153.8 mg, 2.5 equiv.), 2-isocyano-4'-methyl-1,1'-biphenyl (0.15 mmol, 29.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 8 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 20:1) to provide the title compound as a white solid (50.3 mg, 81% yield). Melting point: 116-118 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 8.45 (t, *J* = 9.9 Hz, 2H), 8.05 (d, *J* = 7.9 Hz, 1H), 7.80

(s, 1H), 7.69-7.53 (m, 3H), 7.22-6.93 (m, 5H), 6.43 (d, J = 7.9 Hz, 1H), 5.93 (q, J = 7.2 Hz, 1H), 3.33 (dd, J_1 = 6.9 Hz, J_2 = 13.4 Hz, 1H), 3.26 (dd, J_1 = 5.8 Hz, J_2 = 13.4 Hz, 1H), 2.46 (s, 3H), 1.46 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 158.9, 155.5, 142.7, 137.6, 137.3, 132.3, 130.8, 129.9, 129.8, 128.2, 128.0, 126.9, 126.4, 125.2, 124.2, 124.0, 122.3, 121.9, 79.4, 52.5, 43.1, 28.6, 21.8. HRMS (ESI$^+$): Calcd for $C_{27}H_{29}N_2O_2$, $[M+H]^+$ m/z 413.2224. Found 413.2231.



6j

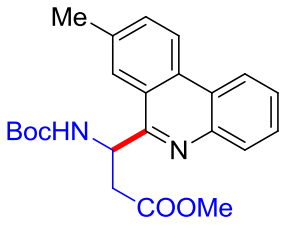
***tert*-Butyl (2-(*tert*-butoxy)-1-(8-methylphenanthridin-6-yl)ethyl)carbamate (6j):** According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Ser(O^{t}Bu)-OPht (0.375 mmol, 152.2 mg, 2.5 equiv.), 2-isocyano-4'-methyl-1,1'-biphenyl (0.15 mmol, 29.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 5 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 15:1) to provide the title compound as a white solid (27.1 mg, 44% yield). Melting point: 195-197 ^{o}C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 8.51 (d, J = 7.9 Hz, 2H), 8.23 (s, 1H), 8.12 (d, J = 7.9 Hz, 1H), 7.71-7.59 (m, 3H), 6.43 (d, J = 7.6 Hz, 1H), 5.81 (q, J = 6.5 Hz, 1H), 3.88-3.77 (m, 1H), 3.71-3.64 (m, 1H), 2.59 (s, 3H), 1.49 (s, 9H), 0.98 (s, 9H). ^{13}C NMR ($CDCl_3$, 150 MHz) δ 158.7, 155.7, 142.9, 137.0, 132.3, 130.7, 129.8, 128.1, 126.8, 126.5, 125.0, 124.1, 122.0, 121.9, 79.3, 73.3, 66.1, 51.8, 28.6, 27.3, 21.9. HRMS (ESI$^+$): Calcd for $C_{25}H_{33}N_2O_3$, $[M+H]^+$ m/z 409.2486. Found 409.2488.



6k

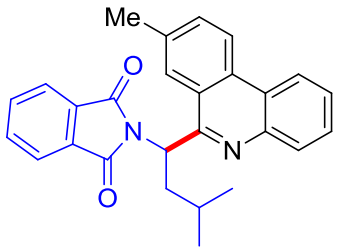
Di-*tert*-butyl (1-(8-methylphenanthridin-6-yl)pentane-1,5-diyl)dicarbamate (6k): According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Lys(Boc)-OPht (0.375 mmol, 184.1 mg, 2.5 equiv.), 2-isocyano-4'-methyl-1,1'-biphenyl (0.15 mmol, 29.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol,

24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (55.1 mg, 74% yield). Melting point: 146-148 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 8.48 (t, *J* = 9.1 Hz, 2H), 8.10 (d, *J* = 7.9 Hz, 1H), 7.98 (s, 1H), 7.70-7.55 (m, 3H), 6.59 (d, *J* = 7.6 Hz, 1H), 5.76-5.66 (m, 1H), 4.76 (br, 1H), 3.16-2.96 (m, 2H), 2.58 (s, 3H), 2.10-1.96 (m, 1H), 1.84-1.73 (m, 1H), 1.68-1.23 (m, 22H). ^{13}C NMR ($CDCl_3$, 150 MHz) δ 159.4, 156.1, 142.6, 137.6, 132.5, 131.0, 129.8, 128.3, 126.8, 124.8, 124.0, 123.7, 122.6, 121.9, 79.4, 78.9, 50.7, 40.6, 36.9, 29.5, 28.6, 28.5, 22.8, 22.0. HRMS (ESI$^+$): Calcd for $C_{29}H_{40}N_3O_4$, $[M+H]^+$ m/z 494.3013. Found 494.3013.



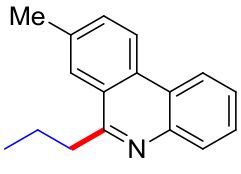
6l

Methyl 3-((*tert*-butoxycarbonyl)amino)-3-(8-methylphenanthridin-6-yl)propanoate (6l): According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Asp(OMe)-OPht (0.375 mmol, 147.1 mg, 2.5 equiv.), 2-isocyano-4'-methyl-1,1'-biphenyl (0.15 mmol, 29.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 6 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5:1) to provide the title compound as a white solid (50.5 mg, 85% yield). Melting point: 162-164 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 8.47 (t, *J* = 8.9 Hz, 2H), 8.18 (s, 1H), 8.08 (d, *J* = 7.9 Hz, 1H), 7.69-7.58 (m, 3H), 6.25 (d, *J* = 8.6 Hz, 1H), 6.16-6.08 (m, 1H), 3.66 (s, 3H), 3.10 (dd, J_1 = 5.5 Hz, J_2 = 14.4 Hz, 1H), 2.91 (dd, J_1 = 6.9 Hz, J_2 = 14.4 Hz, 1H), 2.59 (s, 3H), 1.49 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 172.0, 157.8, 155.3, 142.6, 137.8, 132.6, 131.1, 129.9, 128.3, 127.1, 125.0, 124.2, 123.8, 122.5, 121.9, 79.8, 51.9, 49.0, 40.7, 28.5, 22.0. HRMS (ESI$^+$): Calcd for $C_{23}H_{27}N_2O_4$, $[M+H]^+$ m/z 395.1965. Found 395.1965.



6m

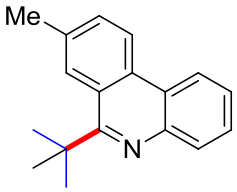
2-(3-Methyl-1-(8-methylphenanthridin-6-yl)butyl)isoindoline-1,3-dione (6m): According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), (*S*)-2-(1,3-dioxoisoindolin-2-yl)-4-methylpentanoic acid active ester (0.375 mmol, 152.2 mg, 2.5 equiv.), 2-isocyano-4'-methyl-1,1'-biphenyl (0.15 mmol, 29.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 5 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 20:1) to provide the title compound as a white solid (34.4 mg, 56% yield). Melting point: 140-142 °C. ^{1}H NMR ($CDCl_3$, 600 MHz) δ 8.52-8.42 (m, 2H), 8.05-7.99 (m, 2H), 7.87-7.82 (m, 2H), 7.72-7.67 (m, 2H), 7.63-7.54 (m, 3H), 6.39 (dd, J_1 = 3.8 Hz, J_2 = 11.3 Hz, 1H), 2.99-2.91 (m, 1H), 2.58 (s, 3H), 2.27-2.20 (m, 1H), 1.90-1.80 (m, 1H), 1.21 (d, J = 6.5 Hz, 3H), 1.04 (d, J = 6.5 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 169.0, 156.5, 142.9, 137.4, 133.9, 132.3, 132.0, 131.3, 130.7, 128.1, 127.0, 124.6, 124.1, 123.3, 122.8, 121.7, 52.6, 39.4, 26.0, 23.5, 22.1, 21.8. HRMS (ESI$^+$): Calcd for $C_{27}H_{25}N_2O_2$, $[M+H]^+$ m/z 409.1911. Found 409.1908.



6n

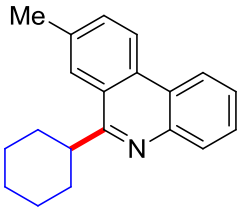
8-Methyl-6-propylphenanthridine (6n): According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), butyric acid active ester (0.375 mmol, 87.4 mg, 2.5 equiv.), 2-isocyano-4'-methyl-1,1'-biphenyl (0.15 mmol, 29.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 5 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (Petroleum ether/ethyl acetate = 25:1) to provide the title compound as a white solid (24.2 mg, 69% yield). Melting point: 44-46 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.48 (t, J = 7.8 Hz, 2H), 8.10 (d, J = 8.2 Hz, 1H), 7.99 (s, 1H),

7.69-7.54 (m, 3H), 3.32 (t, *J* = 7.8 Hz, 2H), 2.59 (s, 3H), 1.96 (sext, *J* = 7.8 Hz, 2H), 1.12 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 162.0, 143.5, 137.1, 132.0, 130.8, 129.5, 128.2, 126.2, 125.9, 125.5, 123.8, 122.4, 121.8, 38.4, 23.0, 22.0, 14.5. HRMS (ESI$^+$): Calcd for $C_{17}H_{18}N$, $[M+H]^+$ m/z 236.1434. Found 236.1431.



6o

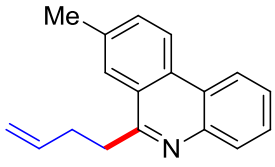
6-(*tert*-Butyl)-8-methylphenanthridine (6o): According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), pivalic acid active ester (0.375 mmol, 92.6 mg, 2.5 equiv.), 2-isocyano-4'-methyl-1,1'-biphenyl (0.15 mmol, 29.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 4 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 100:1) to provide the title compound as colorless oil (32.6 mg, 87% yield). ^{1}H NMR ($CDCl_3$, 600 MHz) δ 8.58 (d, *J* = 8.6 Hz, 1H), 8.50 (d, *J* = 8.2 Hz, 1H), 8.43 (s, 1H), 8.15 (d, *J* = 7.9 Hz, 1H), 7.69 (t, *J* = 7.6 Hz, 1H), 7.64-7.58 (m, 2H), 2.64 (s, 3H), 1.77 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 166.4, 142.8, 135.7, 131.9, 131.0, 130.3, 128.0, 127.9, 126.5, 124.6, 123.6, 123.0, 121.5, 40.3, 31.3, 22.3. HRMS (ESI$^+$): Calcd for $C_{18}H_{20}N$, $[M+H]^+$ m/z 250.1590. Found 250.1587.



6p

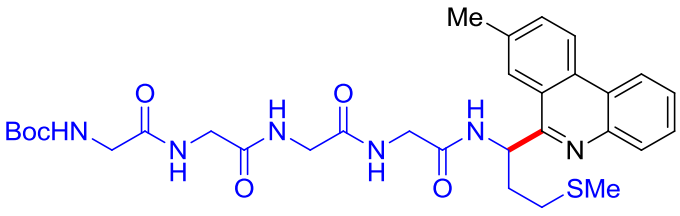
6-Cyclohexyl-8-methylphenanthridine (6p): According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), cyclohexanecarboxylic acid active ester (0.375 mmol, 102.4 mg, 2.5 equiv.), 2-isocyano-4'-methyl-1,1'-biphenyl (0.15 mmol, 29.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 4 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 100:1) to provide the title compound as a white solid (34.2 mg, 83% yield). Melting

point: 119-121 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 8.54-8.44 (m, 2H), 8.10 (d, *J* = 8.2 Hz, 1H), 8.05 (s, 1H), 7.68-7.52 (m, 3H), 3.63-3.53 (m, 1H), 2.60 (s, 3H), 2.11-1.80 (m, 7H), 1.64-1.51 (m, 2H), 1.49-1.37 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 165.1, 143.6, 137.0, 131.7, 130.9, 129.9, 128.0, 126.1, 125.1, 125.0, 123.5, 122.6, 121.7, 41.9, 32.4, 27.0, 26.4, 22.1. HRMS (ESI$^+$): Calcd for $C_{20}H_{22}N$, $[M+H]^+$ m/z 276.1747. Found 276.1747.



6q

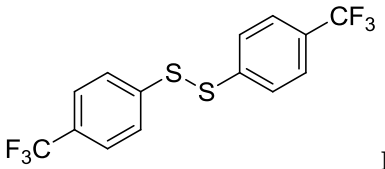
6-(But-3-en-1-yl)-8-methylphenanthridine (6q): According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), pent-4-enoic acid active ester (0.375 mmol, 91.9 mg, 2.5 equiv.), 2-isocyano-4'-methyl-1,1'-biphenyl (0.15 mmol, 29.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol, 24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 5 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (petroleum ether/ethyl acetate = 50:1) to provide the title compound as colorless oil (15.7 mg, 42% yield). ^{1}H NMR ($CDCl_3$, 600 MHz) δ 8.55-8.46 (m, 2H), 8.11 (d, *J* = 7.9 Hz, 1H), 8.00 (s, 1H), 7.71-7.62 (m, 2H), 7.60 (t, *J* = 7.6 Hz, 1H), 6.10-6.01 (m, 1H), 5.17 (dd, J_1 = 1.7 Hz, J_2 = 17.2 Hz, 1H), 5.05 (d, *J* = 10.3 Hz, 1H), 3.44 (t, *J* = 8.1 Hz, 2H), 2.71 (q, *J* = 7.6 Hz, 2H), 2.60 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 161.1, 143.4, 138.2, 137.3, 132.2, 130.8, 129.6, 128.2, 126.4, 125.7, 125.4, 123.8, 122.5, 121.8, 115.1, 35.4, 33.2, 22.0. HRMS (ESI$^+$): Calcd for $C_{18}H_{18}N$, $[M+H]^+$ m/z 248.1434. Found 248.1428.



6r

***tert*-Butyl (5-(8-methylphenanthridin-6-yl)-7,10,13,16-tetraoxo-2-thia-6,9,12,15-tetraazaheptadecan-17-yl)carbamate (6r):** According to the general procedure C, 4-(trifluoromethyl)thiophenol (TFTP) (**G**) (15 μmol, 2.1 μL, 0.1 equiv.), Boc-Gly-Gly-Gly-Gly-Met-OPht (0.375 mmol, 233.6 mg, 2.5 equiv.), 2-isocyano-4'-methyl-1,1'-biphenyl (0.15 mmol, 29.0 mg, 1.0 equiv.) and Cs_2CO_3 (0.075 mmol,

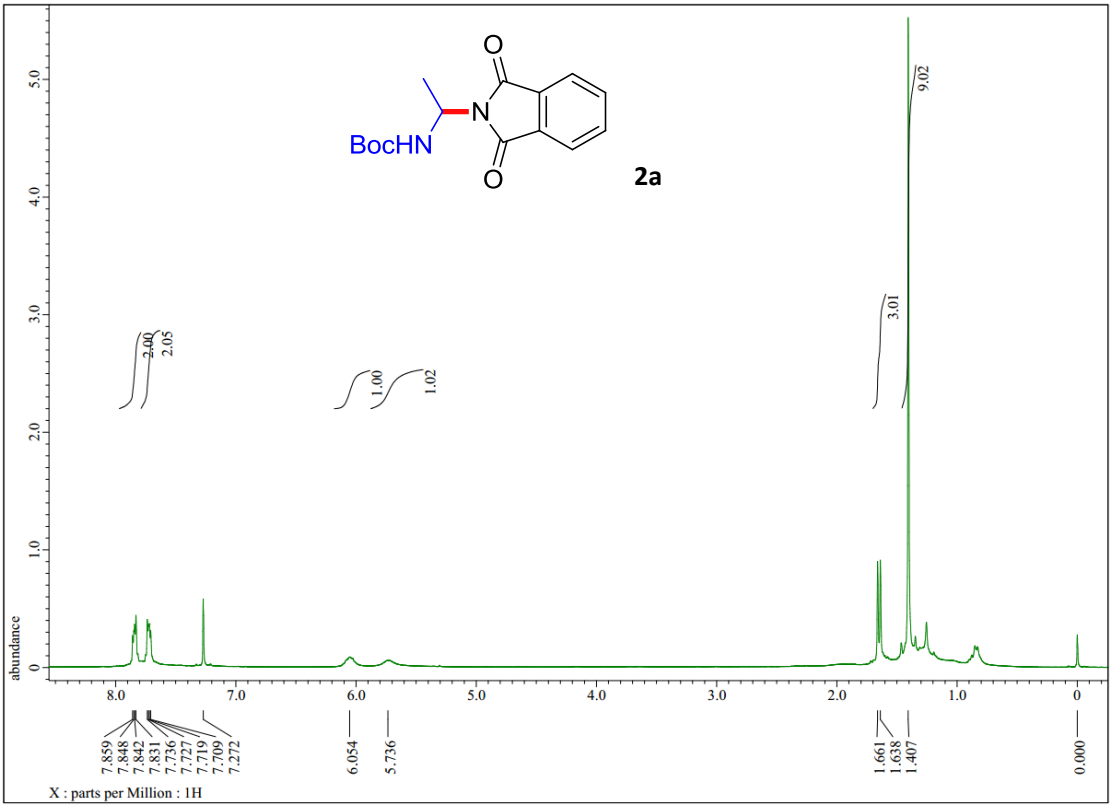
24.4 mg, 0.5 equiv.) and 1.5 mL of DMF were used. After 8 hours, the reaction mixture was subjected to the workup procedure outlined in the general procedure and purified by silica gel column chromatography (dichloromethane/methanol = 10:1) to provide the title compound as a white solid (54.6 mg, 58% yield). Melting point: 125-127 °C. ^{1}H NMR (DMSO-*d*6, 600 MHz) δ 8.76-8.66 (m, 2H), 8.46 (d, *J* = 8.6 Hz, 1H), 8.23 (s, 1H), 8.20-8.12 (m, 2H), 8.07-7.98 (m, 2H), 7.77-7.68 (m, 2H), 7.65 (t, *J* = 7.6 Hz, 1H), 7.00 (t, *J* = 5.8 Hz, 1H), 6.03-5.96 (m, 1H), 3.83-3.68 (m, 6H), 3.55 (d, *J* = 5.8 Hz, 2H), 2.62-2.48 (m, 5H), 2.32-2.24 (m, 1H), 2.15-2.06 (m, 1H), 2.02 (s, 3H), 1.32 (s, 9H). ^{13}C NMR (DMSO-*d*6, 100 MHz) δ 170.7, 170.1, 170.0, 169.3, 160.2, 156.7, 143.1, 138.5, 133.5, 131.3, 130.3, 129.3, 128.0, 125.7, 124.7, 124.5, 123.8, 123.3, 79.0, 49.8, 44.2, 43.0, 34.8, 31.1, 29.1, 22.3, 15.6. HRMS (ESI^{+}): Calcd for $C_{31}H_{40}NaN_6O_6S$, $[M+Na]^{+}$ m/z 647.2622. Found 647.2614.

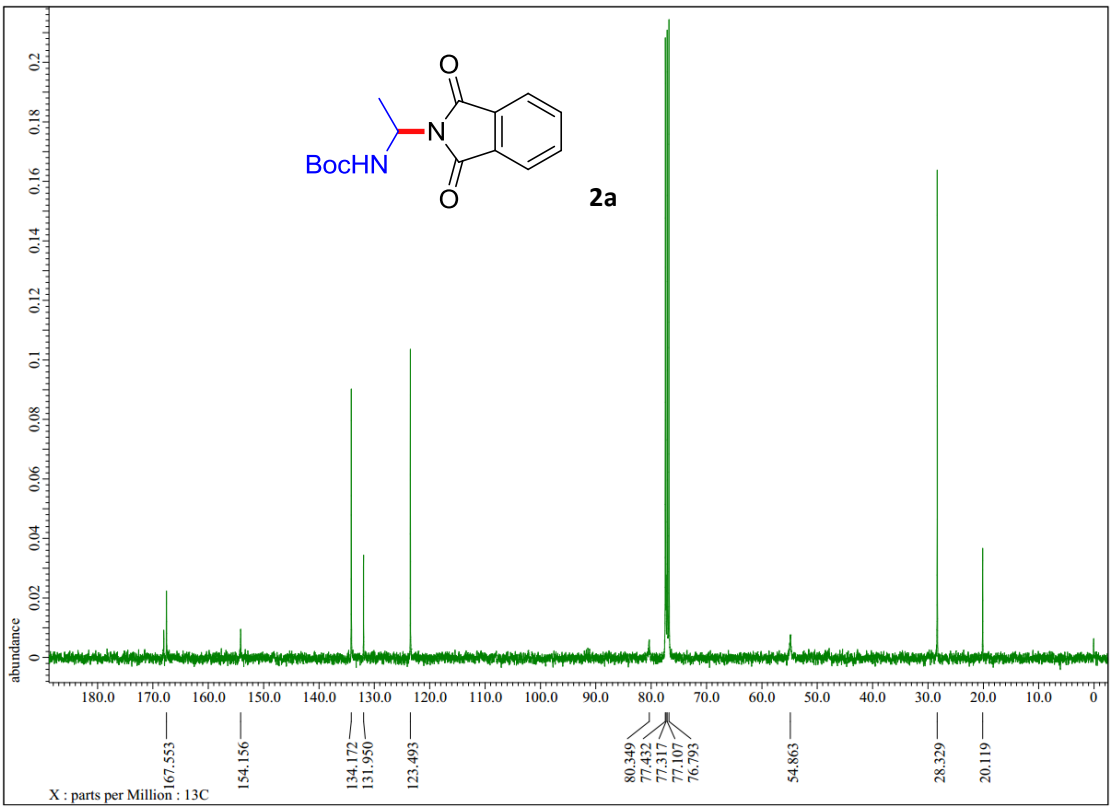


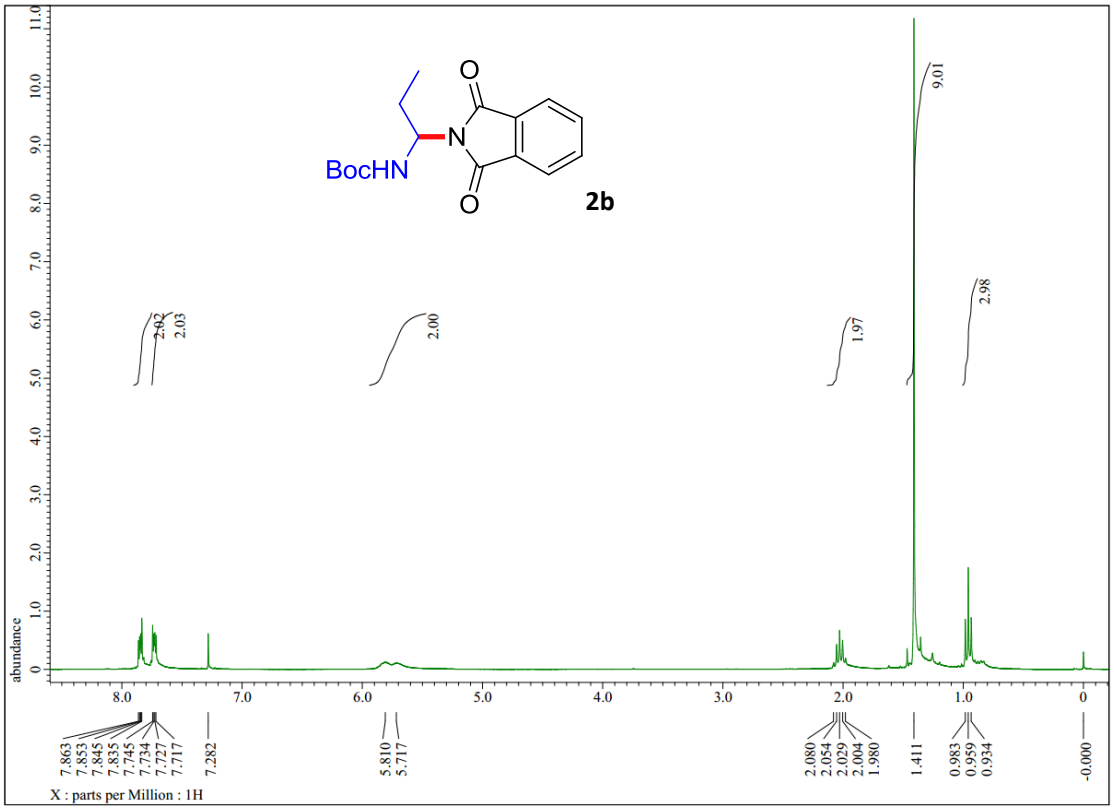
BTFPD

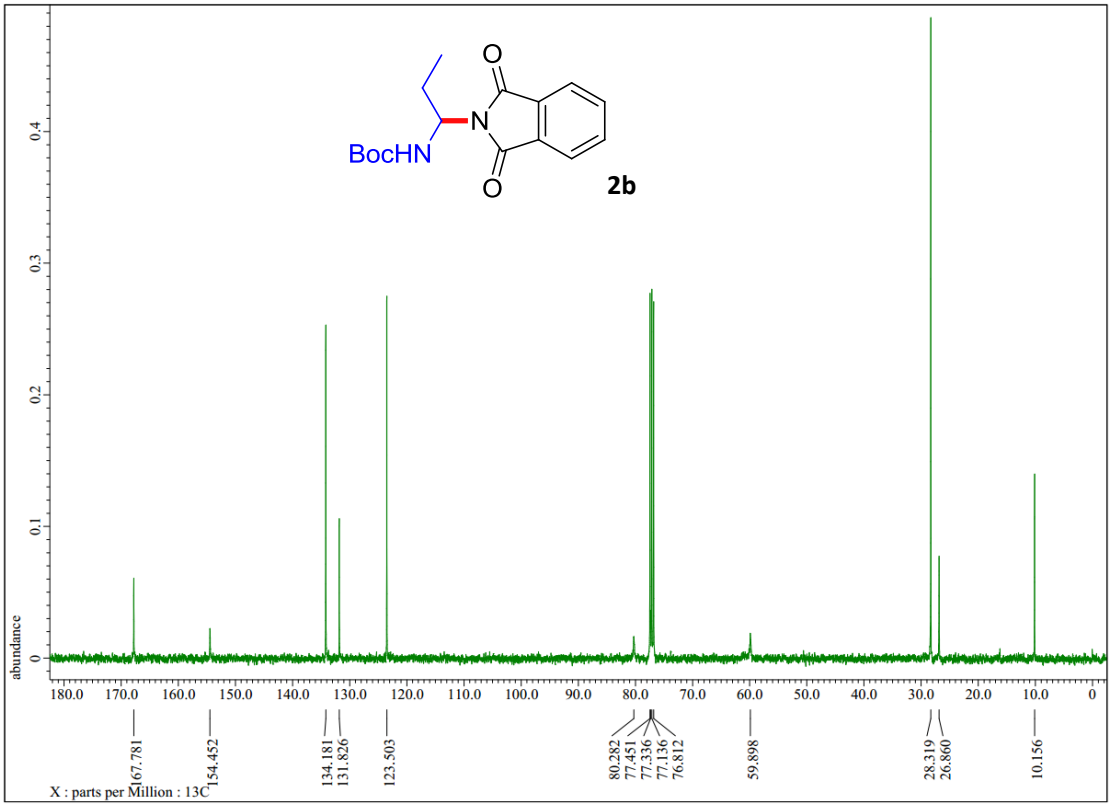
1,2-bis(4-(trifluoromethyl)phenyl)disulfane (BTFPD): white solid. Melting point: 120-122 °C. ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.57 (s, 4H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 140.9, 129.5 (q, *J* = 33.6 Hz), 126.6, 126.2 (q, *J* = 3.8 Hz), 123.9 (q, *J* = 272.2 Hz). HRMS (ESI^{+}): Calcd for $C_{14}H_9F_6S_2$, $[M+H]^{+}$ m/z 355.0052. Found 355.0057.

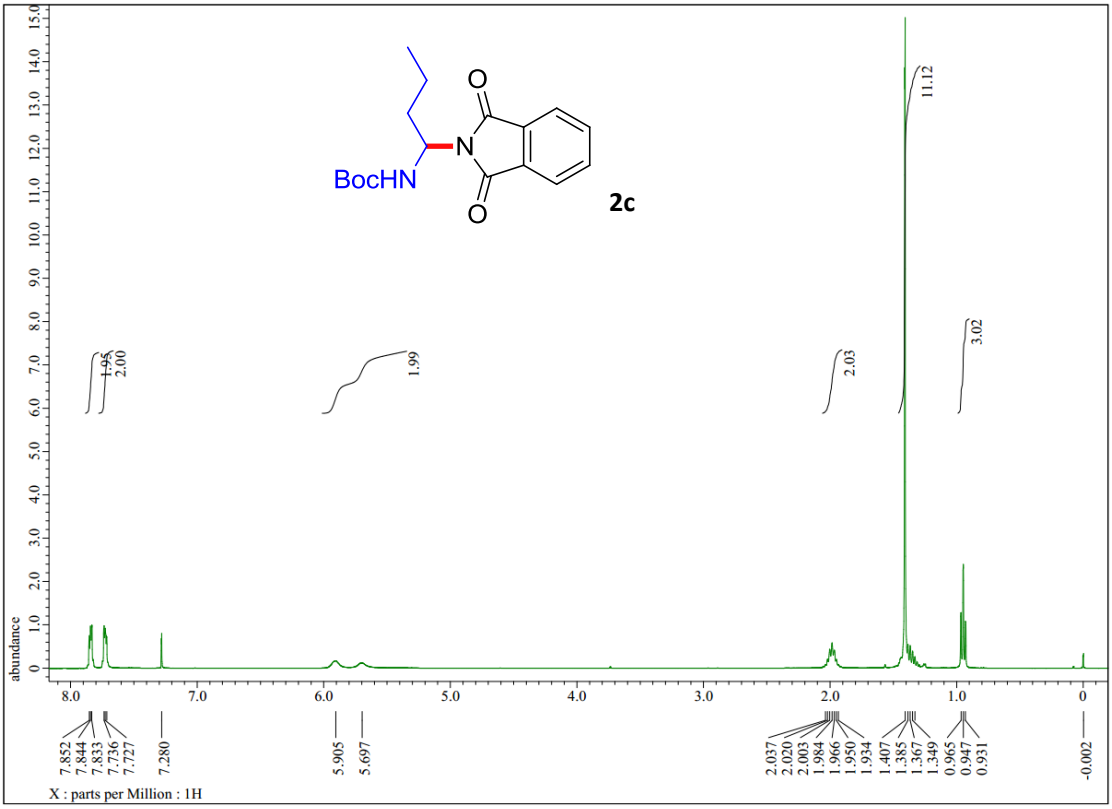
VI. NMR Spectra

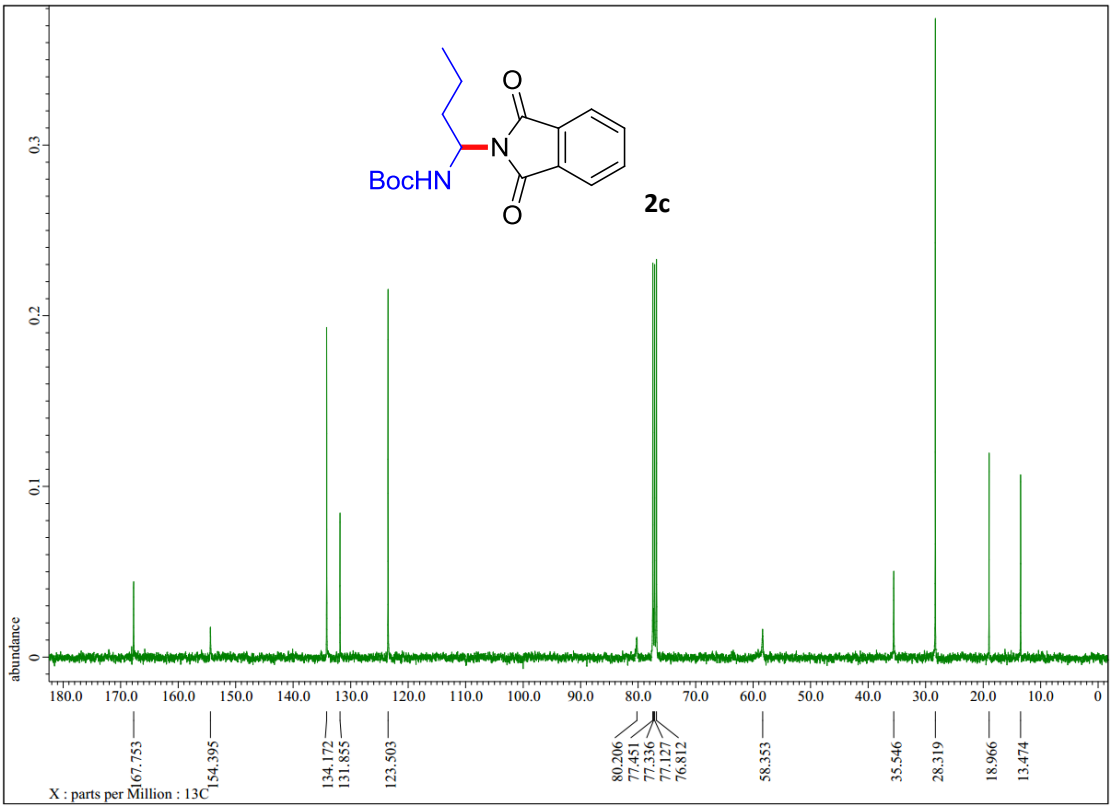


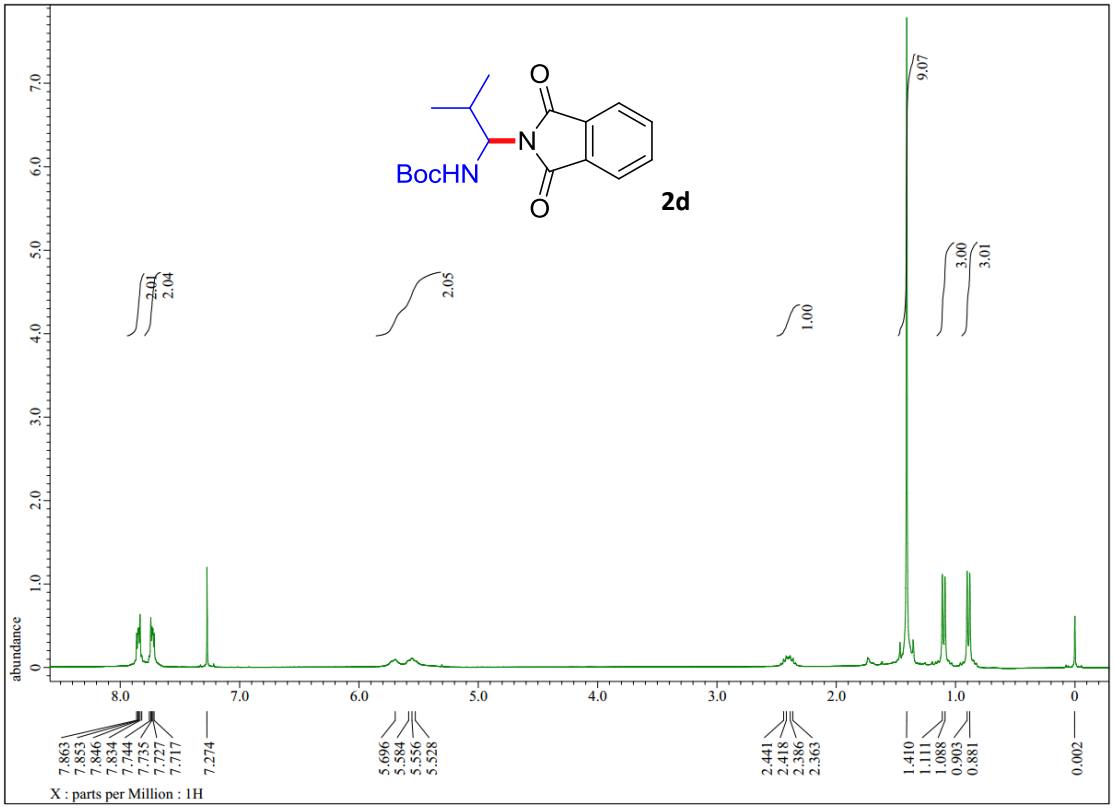


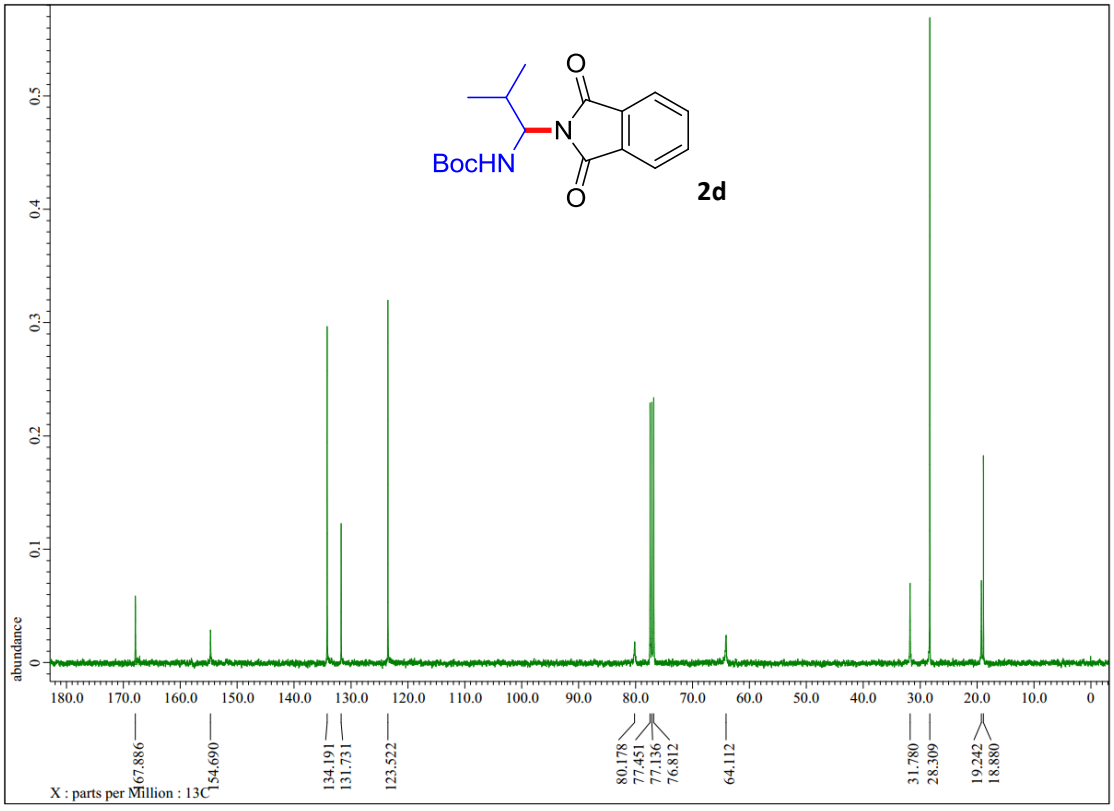

BocHN
O
N
O
2b
abundance
X : parts per Million : 1H

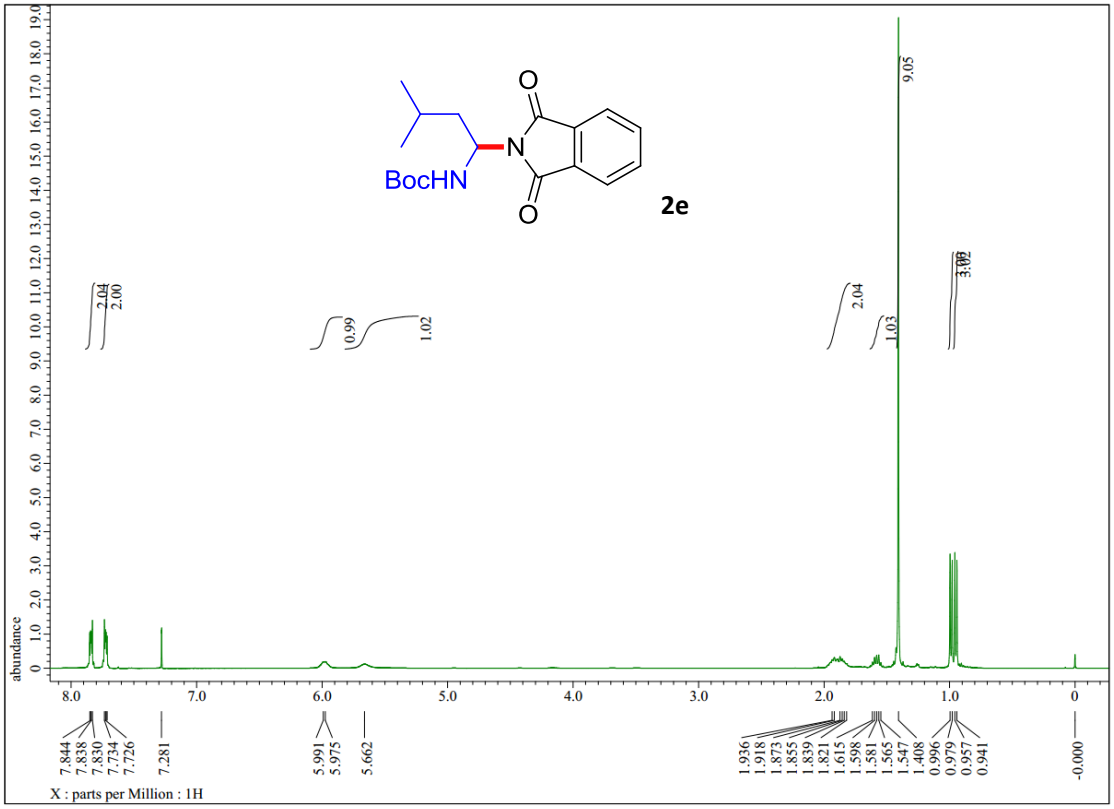

BocHN
O
N
O
2b
abundance
X : parts per Million : 13C

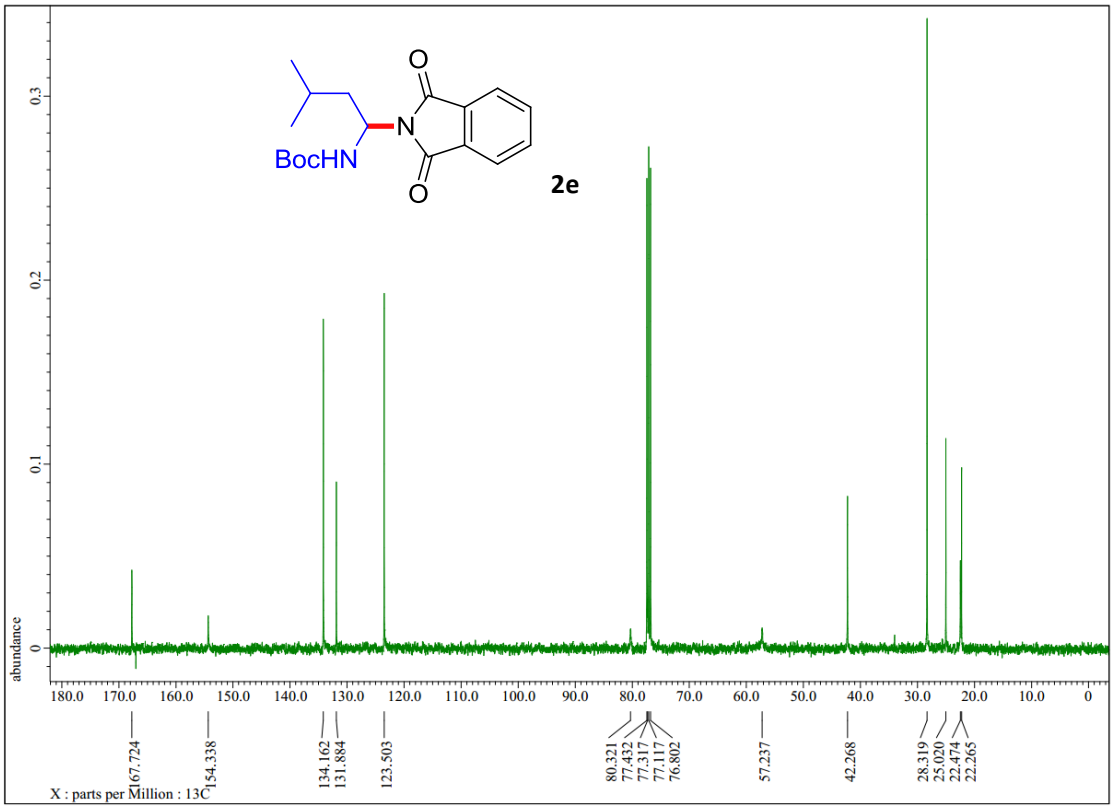

BocHN
O
N
O
2c
11.12
3.02
2.03
1.99
1.95
2.00
abundance
X : parts per Million : 1H
7.852
7.844
7.833
7.736
7.727
7.280
5.905
5.697
2.037
2.020
2.003
1.984
1.966
1.950
1.934
1.407
1.385
1.367
1.349
0.965
0.947
0.931
-0.002

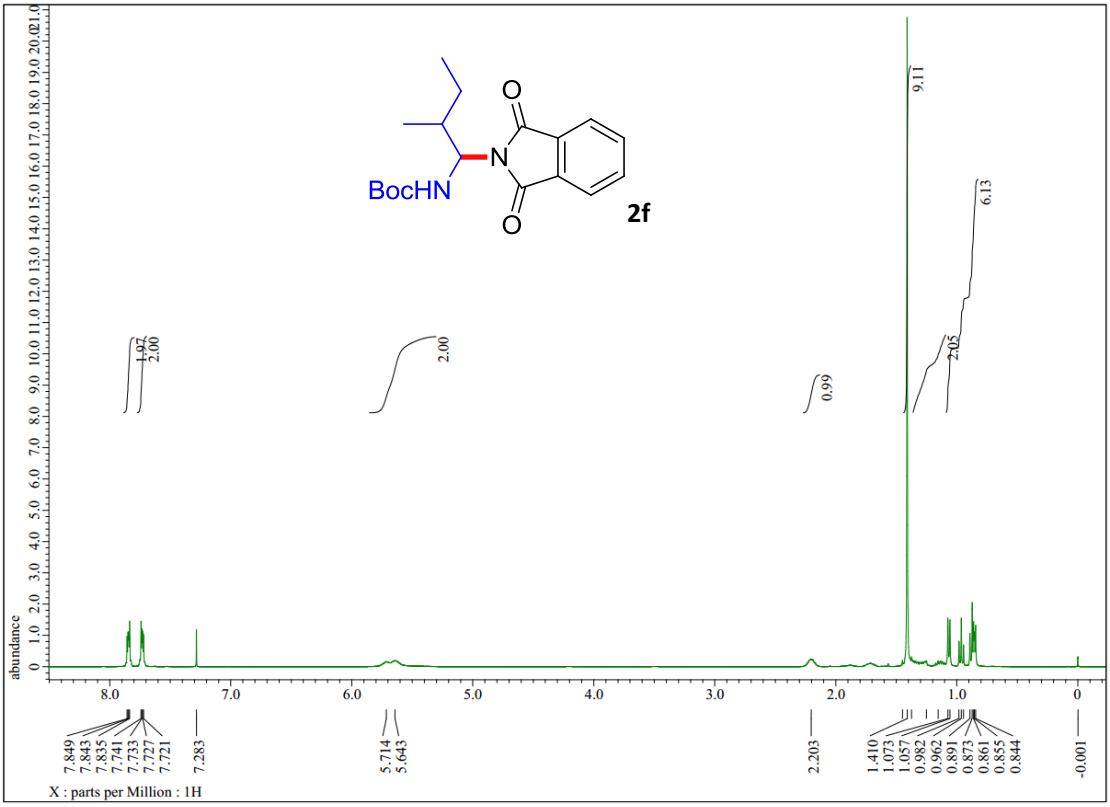

BocHN
O
N
O
2c
abundance
X : parts per Million : 13C
167.753
154.395
134.172
131.855
123.503
80.206
77.451
77.336
77.127
76.812
58.353
35.546
28.319
18.966
13.474

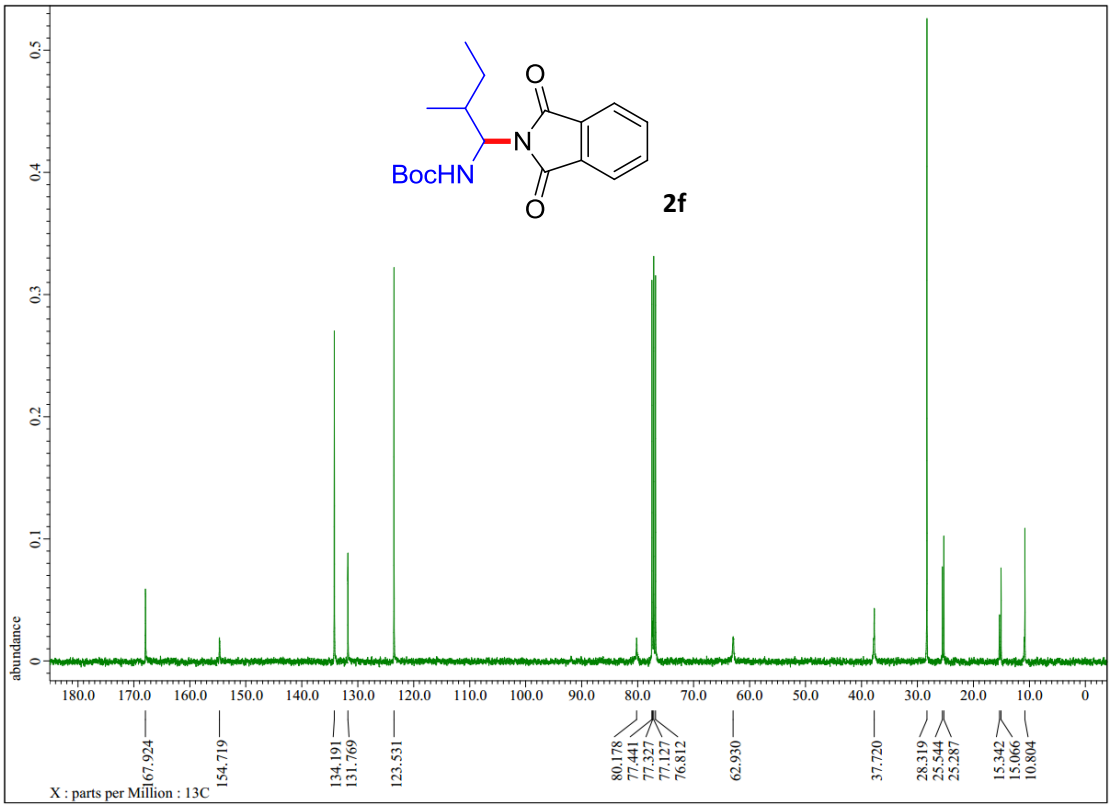

BocHN
2d
abundance
X : parts per Million : 1H

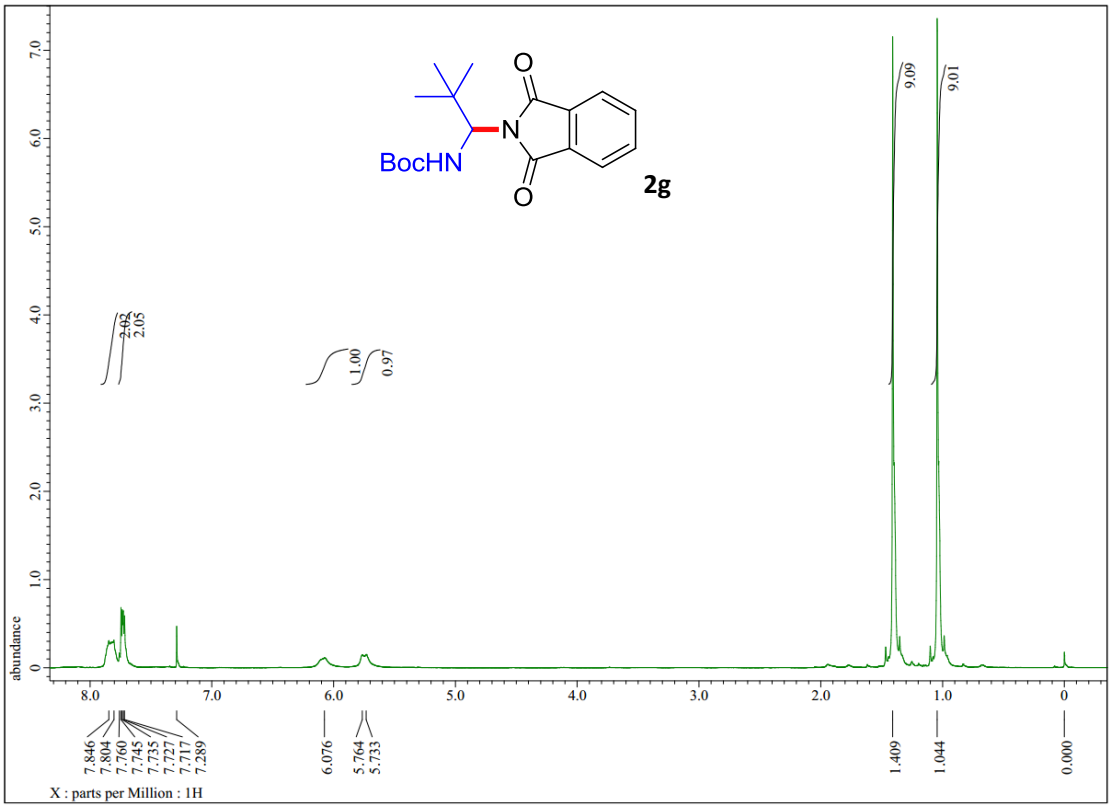

BocHN
2d
abundance
X : parts per Million : 13C

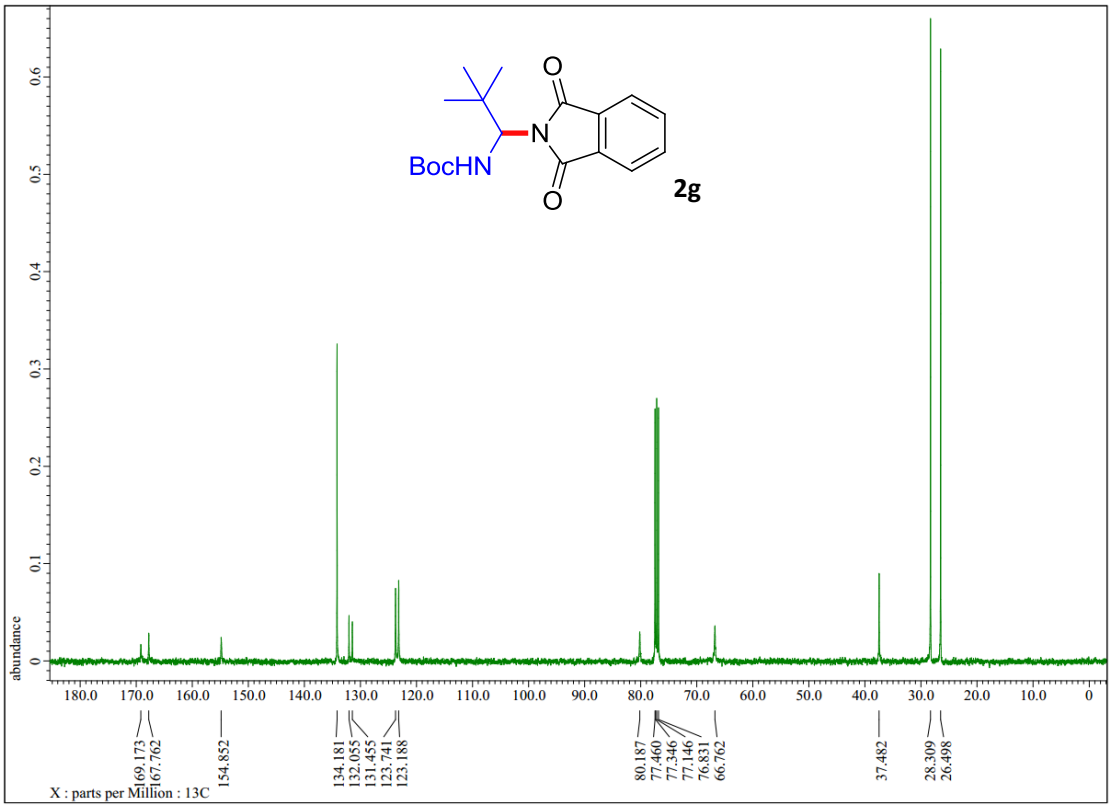

BocHN
O
N
O
2e
abundance
X : parts per Million : 1H

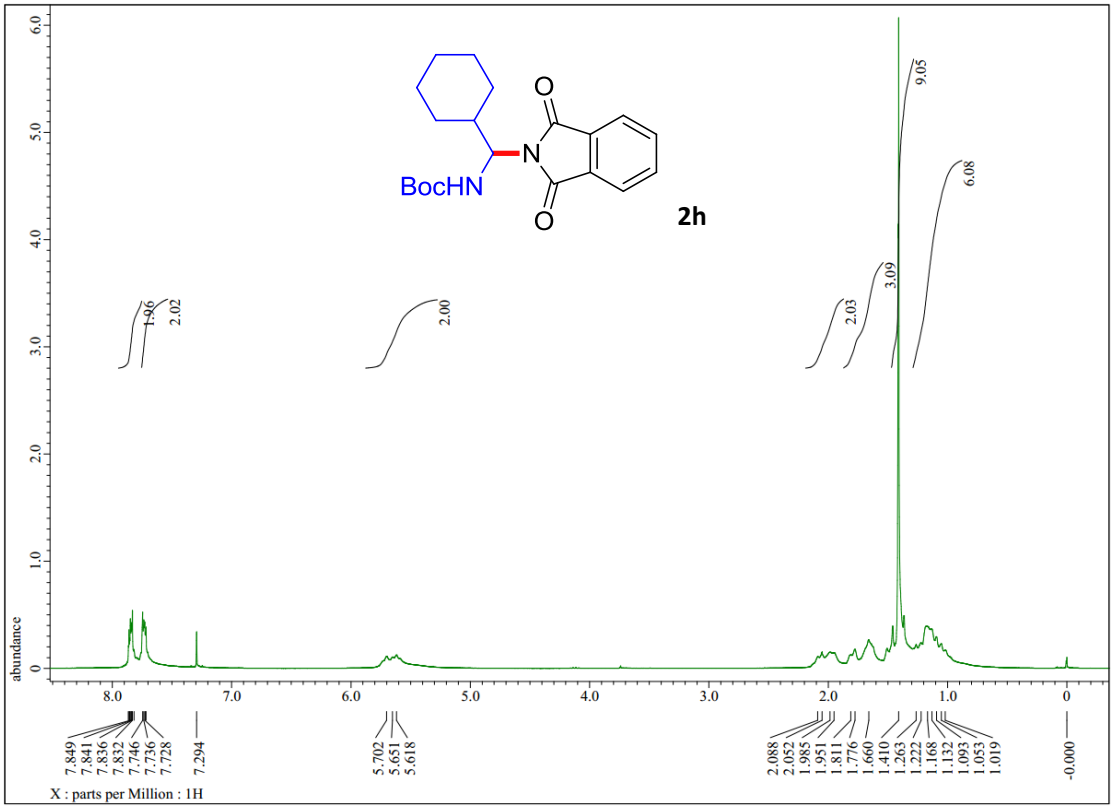

BocHN
O
N
O
2e
abundance
X : parts per Million : 13C

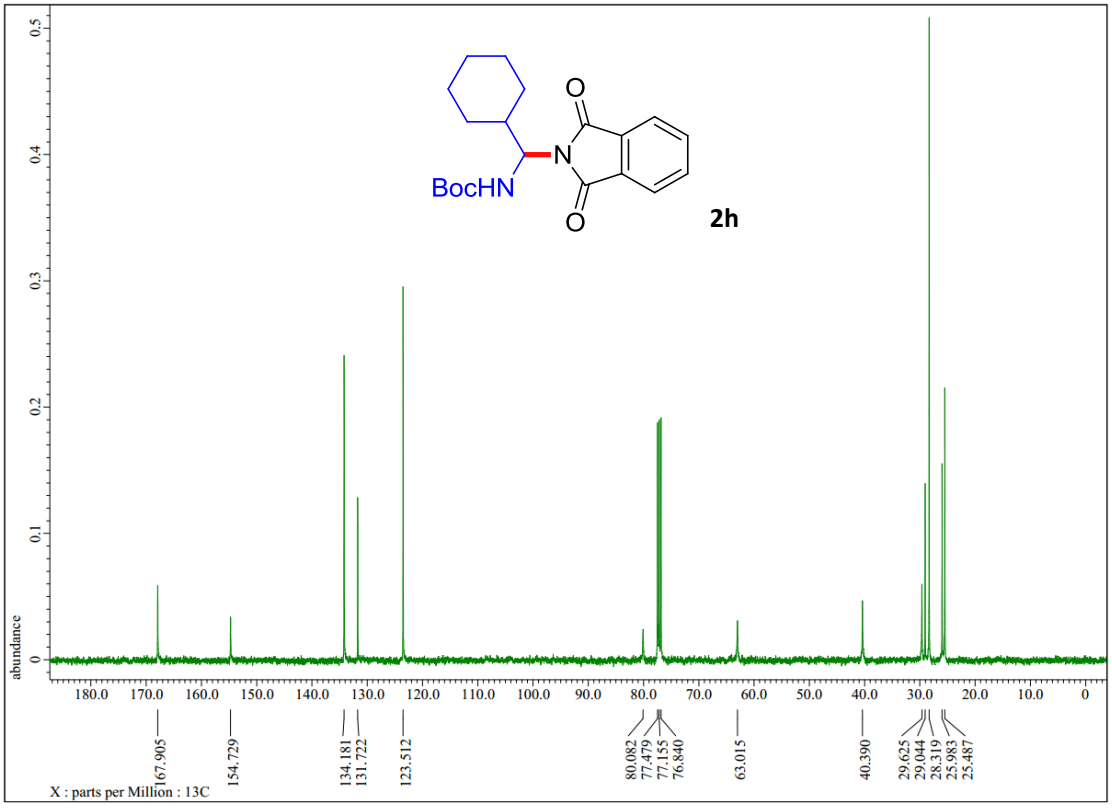

BocHN
O
N
O
2f
abundance
X : parts per Million : 1H
7.849
7.843
7.835
7.741
7.733
7.727
7.721
7.283
5.714
5.643
2.203
1.410
1.073
1.057
0.982
0.962
0.891
0.873
0.861
0.855
0.844
-0.001

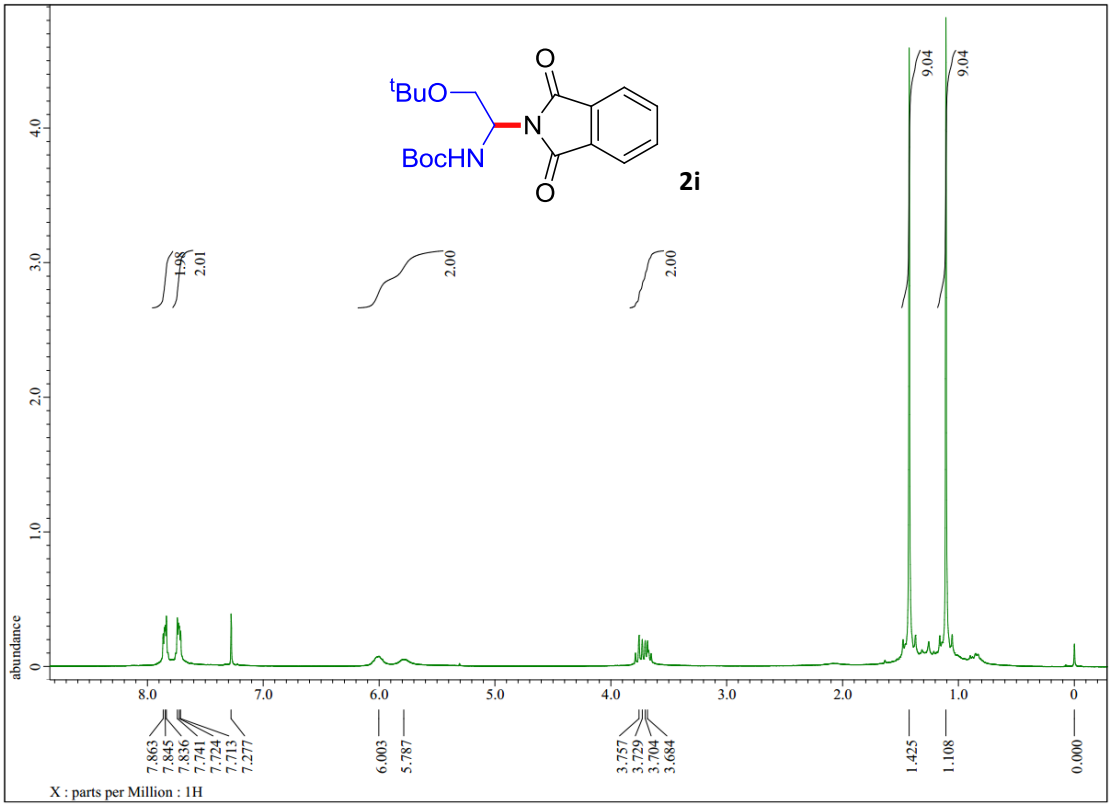

BocHN
O
N
O
2f
abundance
X : parts per Million : 13C
167.924
154.719
134.191
131.769
123.531
80.178
77.441
77.327
77.127
76.812
62.930
37.720
28.319
25.544
25.287
15.342
15.066
10.804

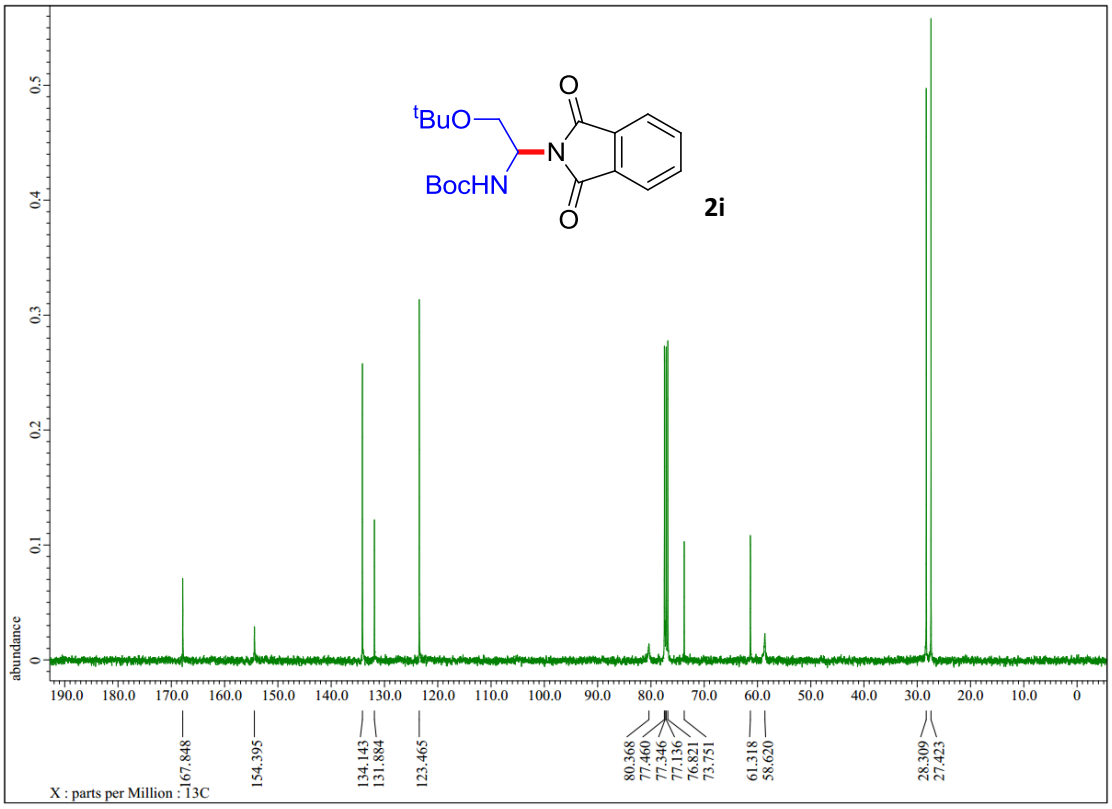

BocHN
2g
abundance
X : parts per Million : 1H

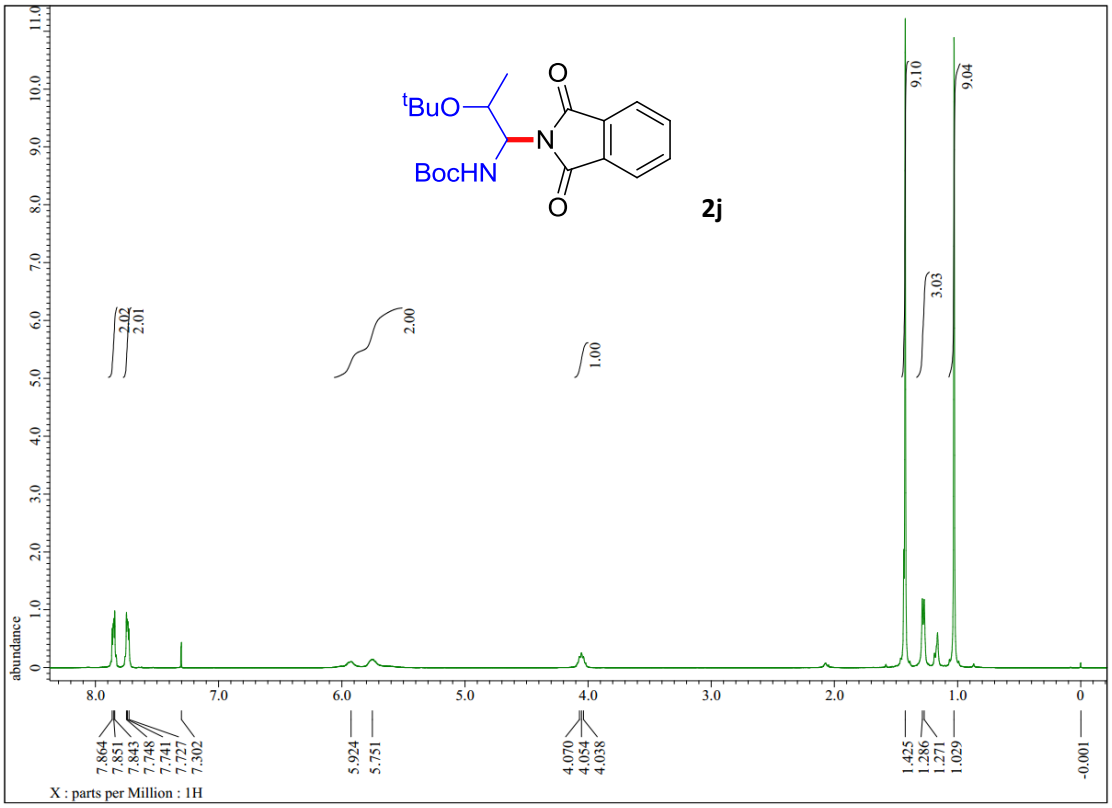

BocHN
2g
abundance
X : parts per Million : 13C

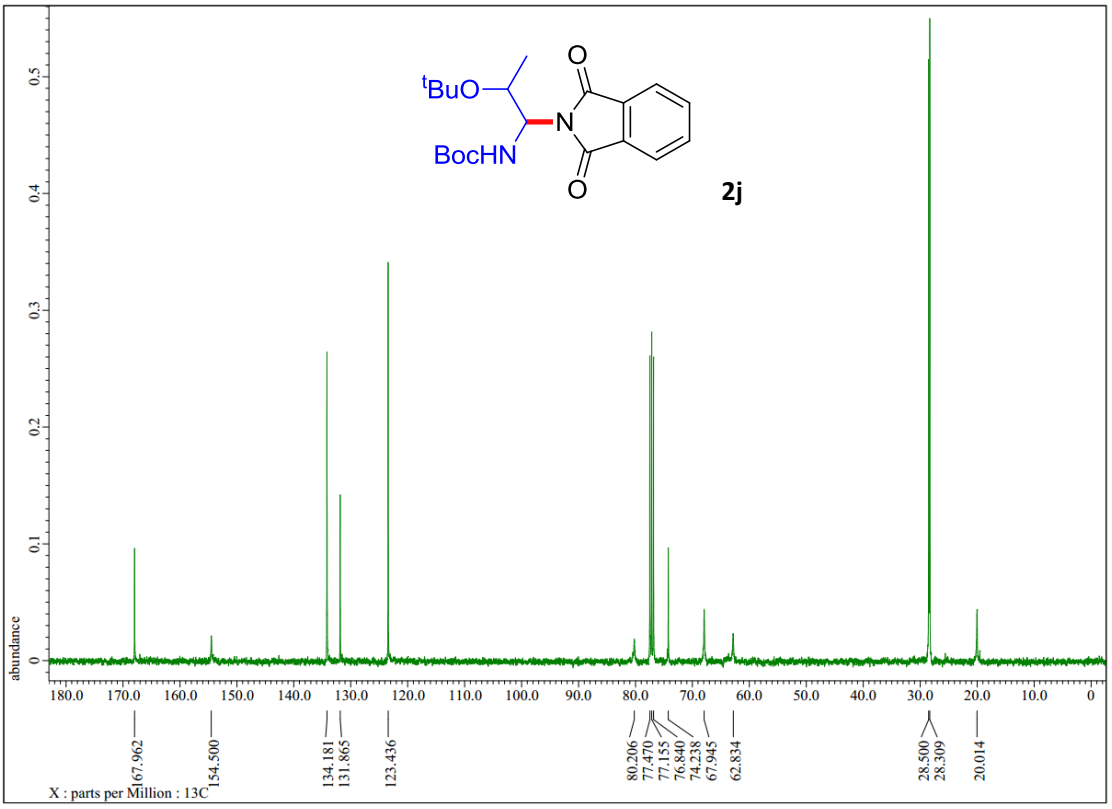

BocHN
O
N
O
2h
abundance
X : parts per Million : 1H
7.849
7.841
7.836
7.832
7.746
7.736
7.728
7.294
5.702
5.651
5.618
2.088
2.052
1.985
1.951
1.811
1.776
1.660
1.410
1.263
1.222
1.168
1.132
1.093
1.053
1.019
-0.000

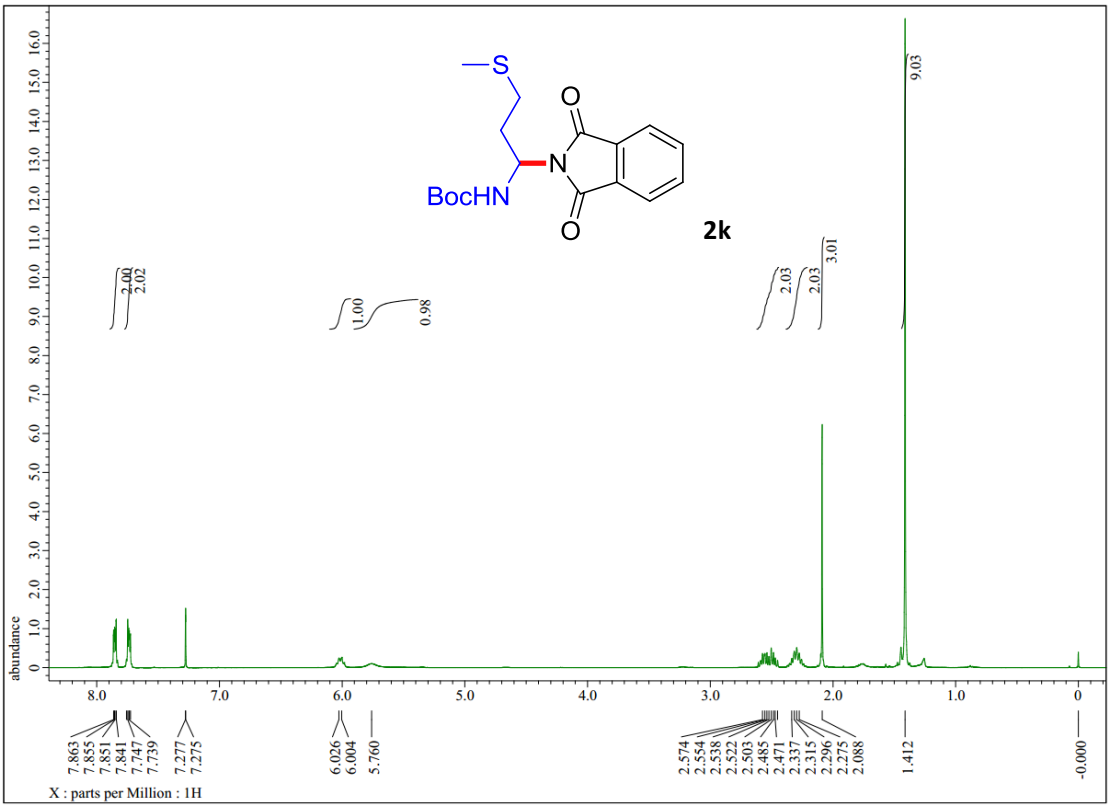

BocHN
O
N
O
2h
abundance
X : parts per Million : 13C
167.905
154.729
134.181
131.722
123.512
80.082
77.479
77.155
76.840
63.015
40.390
29.625
29.044
28.319
25.983
25.487

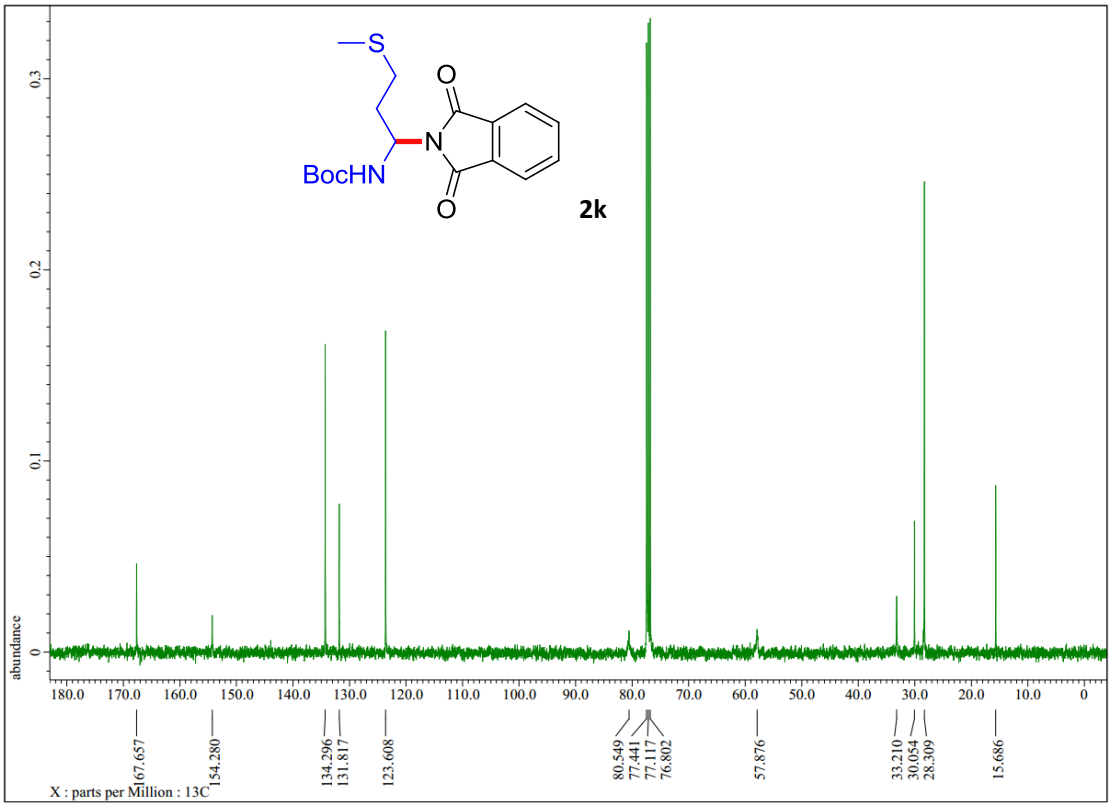

tBuO
BocHN
O
N
O
2i
9.04
9.04
1.98
2.01
2.00
2.00
abundance
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.863
7.845
7.836
7.741
7.724
7.713
7.277
6.003
5.787
3.757
3.729
3.704
3.684
1.425
1.108
0.000
X : parts per Million : 1H

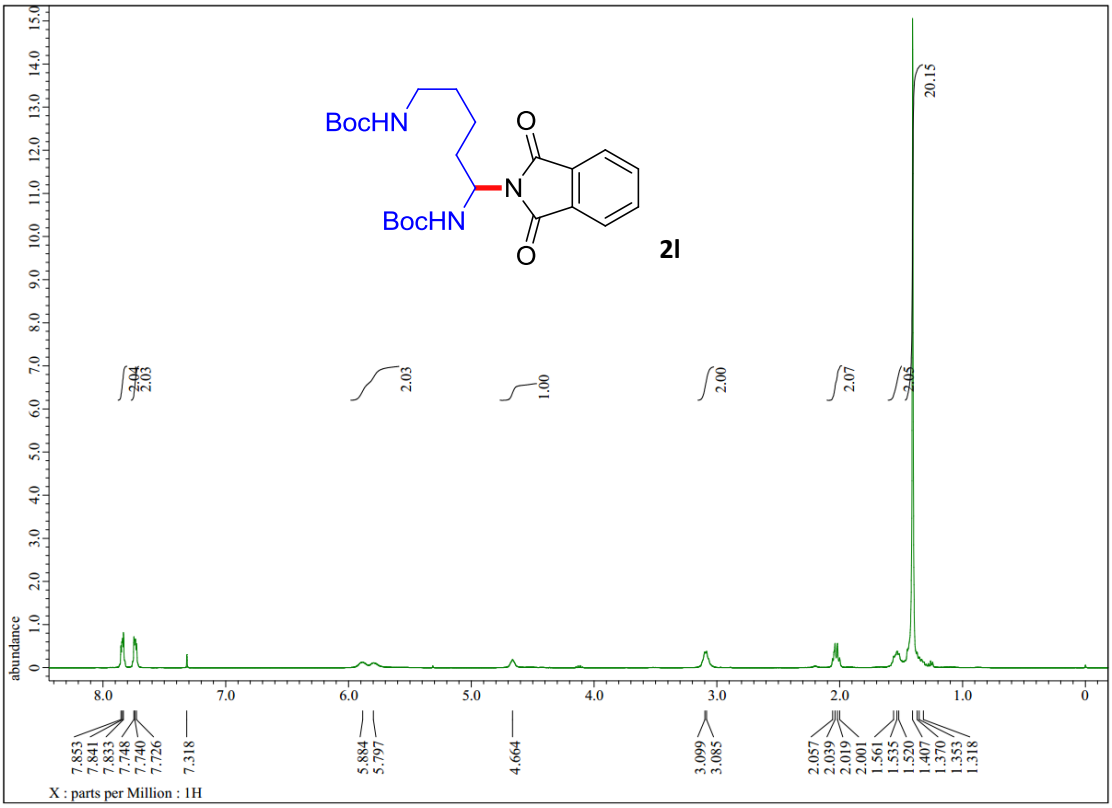

tBuO
BocHN
O
N
O
2i
abundance
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
167.848
154.395
134.143
131.884
123.465
80.368
77.460
77.346
77.136
76.821
73.751
61.318
58.620
28.309
27.423
X : parts per Million : 13C

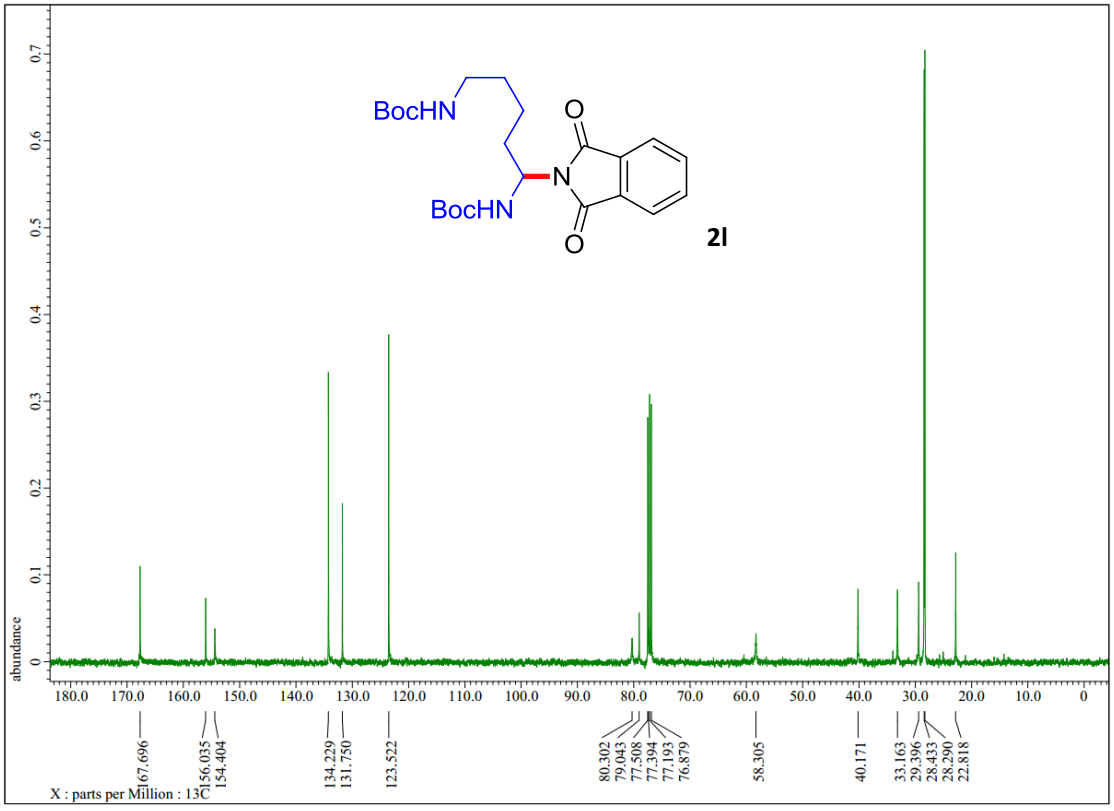

tBuO
BocHN
O
N
O
2j
abundance
X : parts per Million : 1H
2.02
2.01
2.00
1.00
3.03
9.10
9.04
7.864
7.851
7.843
7.748
7.741
7.727
7.302
5.924
5.751
4.070
4.054
4.038
1.425
1.286
1.271
1.029
-0.001

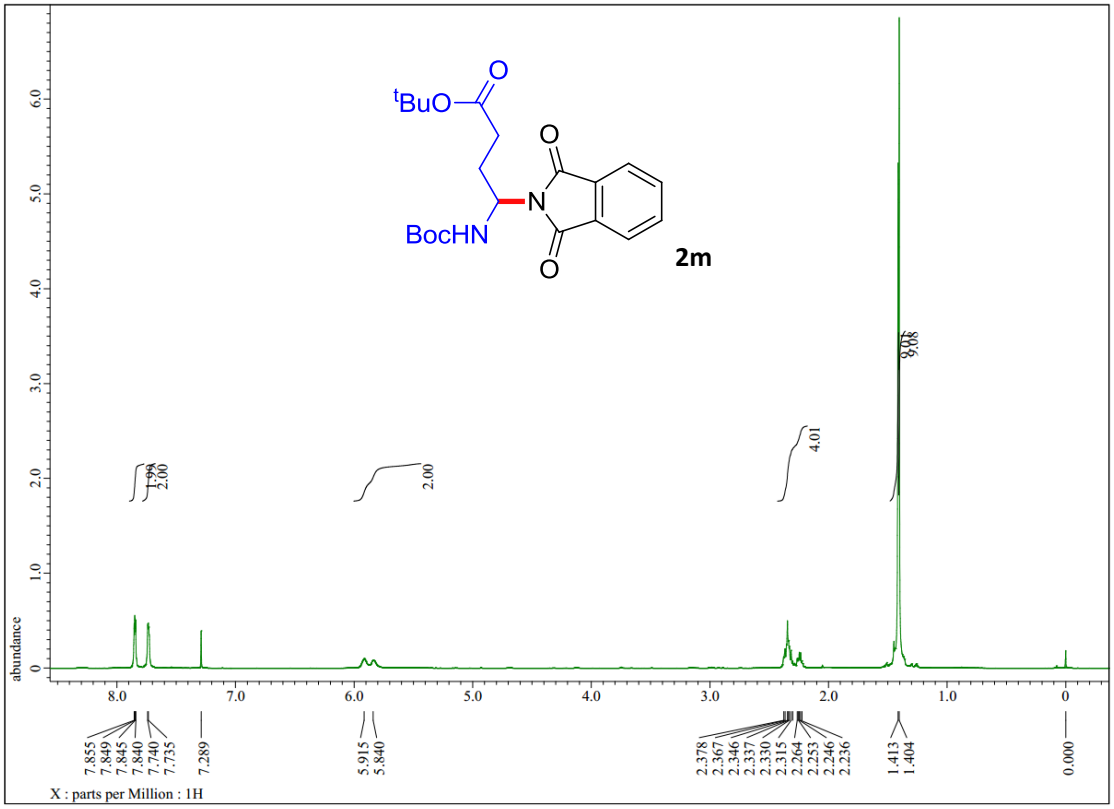

tBuO
BocHN
O
N
O
2j
abundance
X : parts per Million : 13C
167.962
154.500
134.181
131.865
123.436
80.206
77.470
77.155
76.840
74.238
67.945
62.834
28.500
28.309
20.014

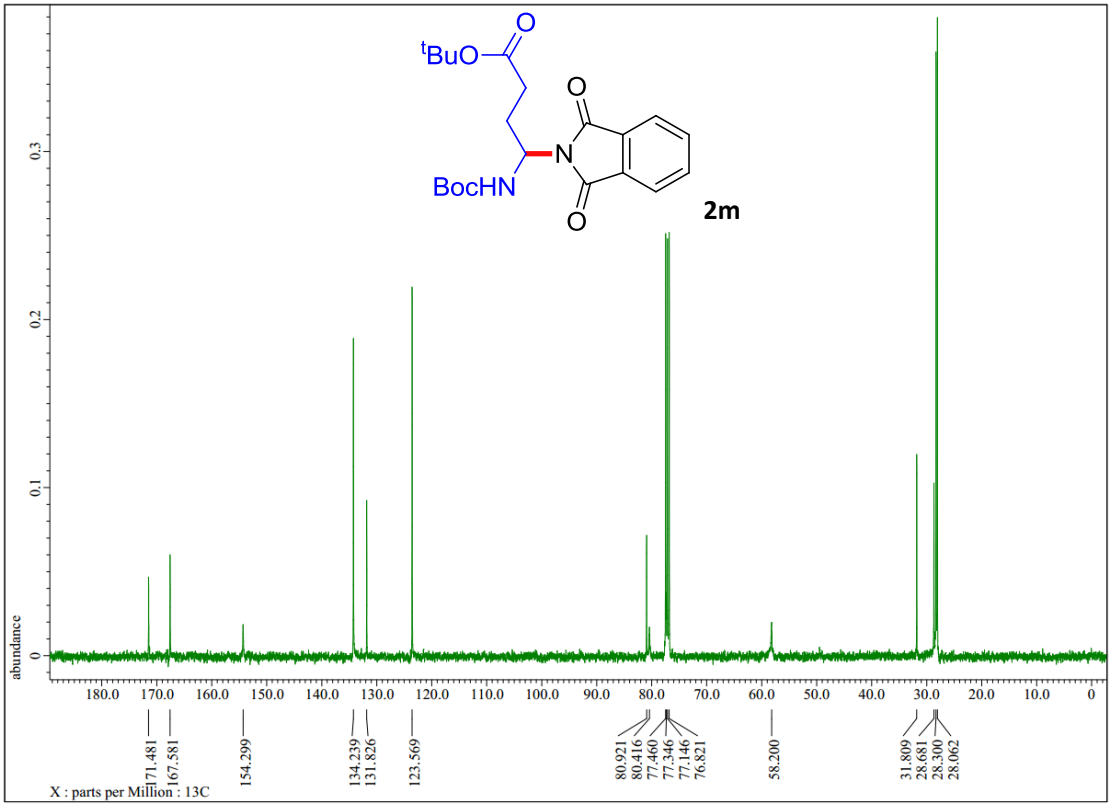

BocHN
2k
abundance
X : parts per Million : 1H

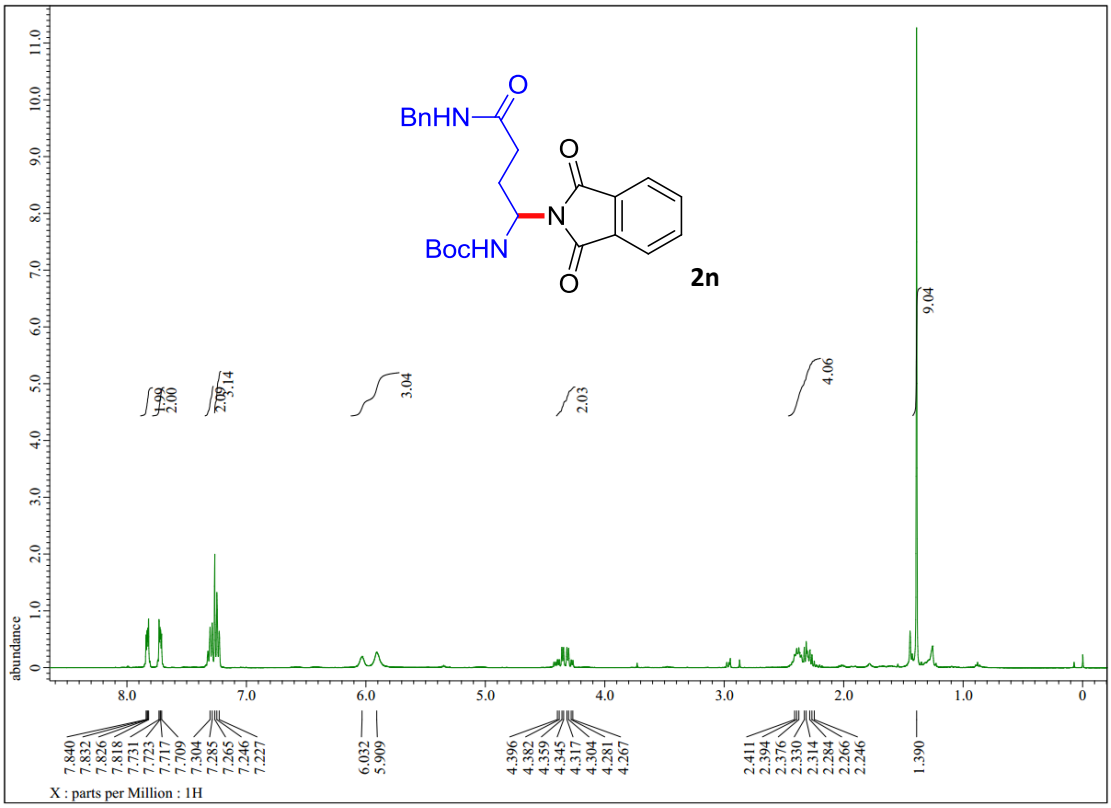

BocHN
2k
abundance
X : parts per Million : 13C

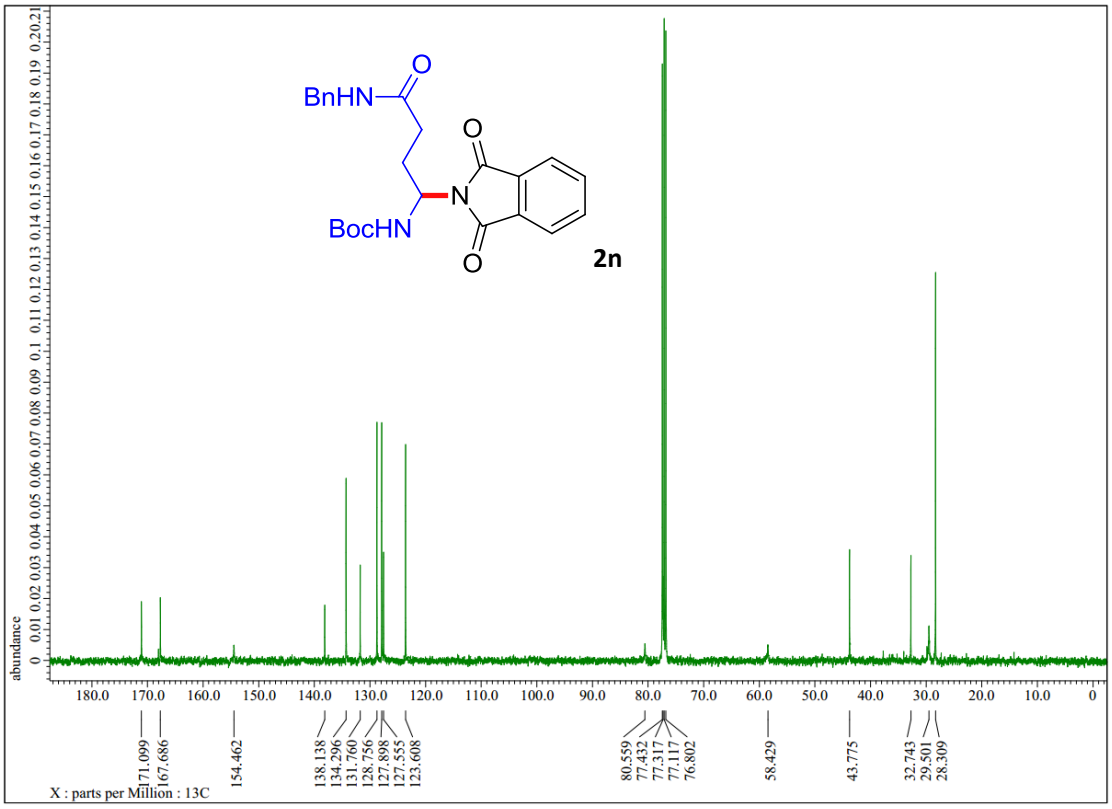

BocHN
BocHN
O
N
O
2l
20.15
2.04
2.03
2.03
1.00
2.00
2.07
2.05
abundance
7.853
7.841
7.833
7.748
7.740
7.726
7.318
5.884
5.797
4.664
3.099
3.085
2.057
2.039
2.019
2.001
1.561
1.535
1.520
1.407
1.370
1.353
1.318
X : parts per Million : 1H

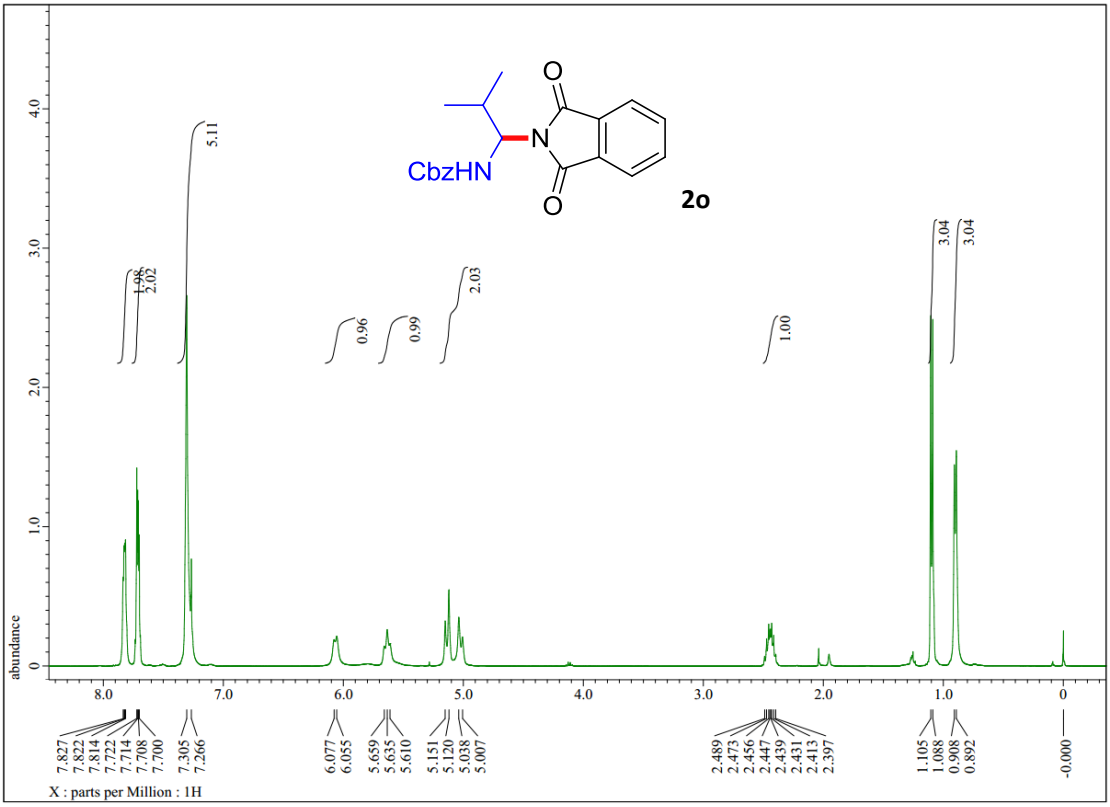

BocHN
BocHN
O
N
O
2l
abundance
67.696
156.035
154.404
134.229
131.750
123.522
80.302
79.043
77.508
77.394
77.193
76.879
58.305
40.171
33.163
29.396
28.433
28.290
22.818
X : parts per Million : 13C

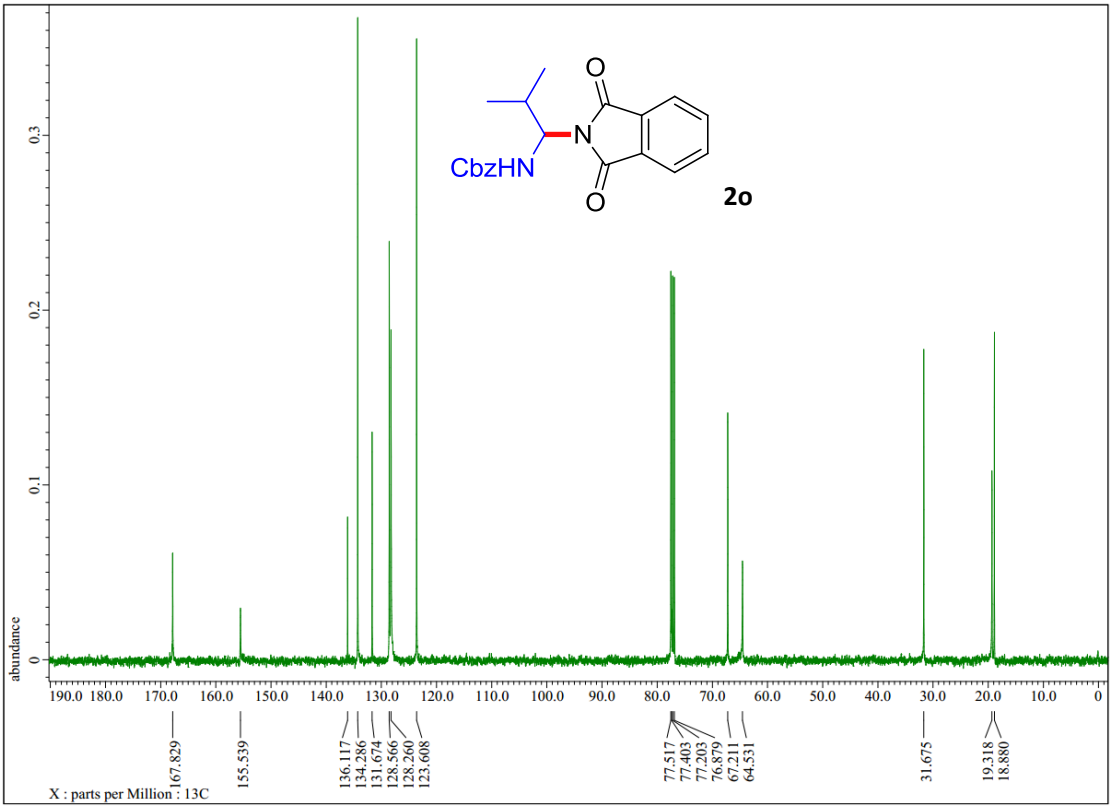

tBuO
O
O
N
BocHN
O
2m
abundance
X : parts per Million : 1H
7.855
7.849
7.845
7.840
7.740
7.735
7.289
5.915
5.840
2.378
2.367
2.346
2.337
2.330
2.315
2.264
2.253
2.246
2.236
1.413
1.404
0.000
1.99
2.00
2.00
4.01
9.00

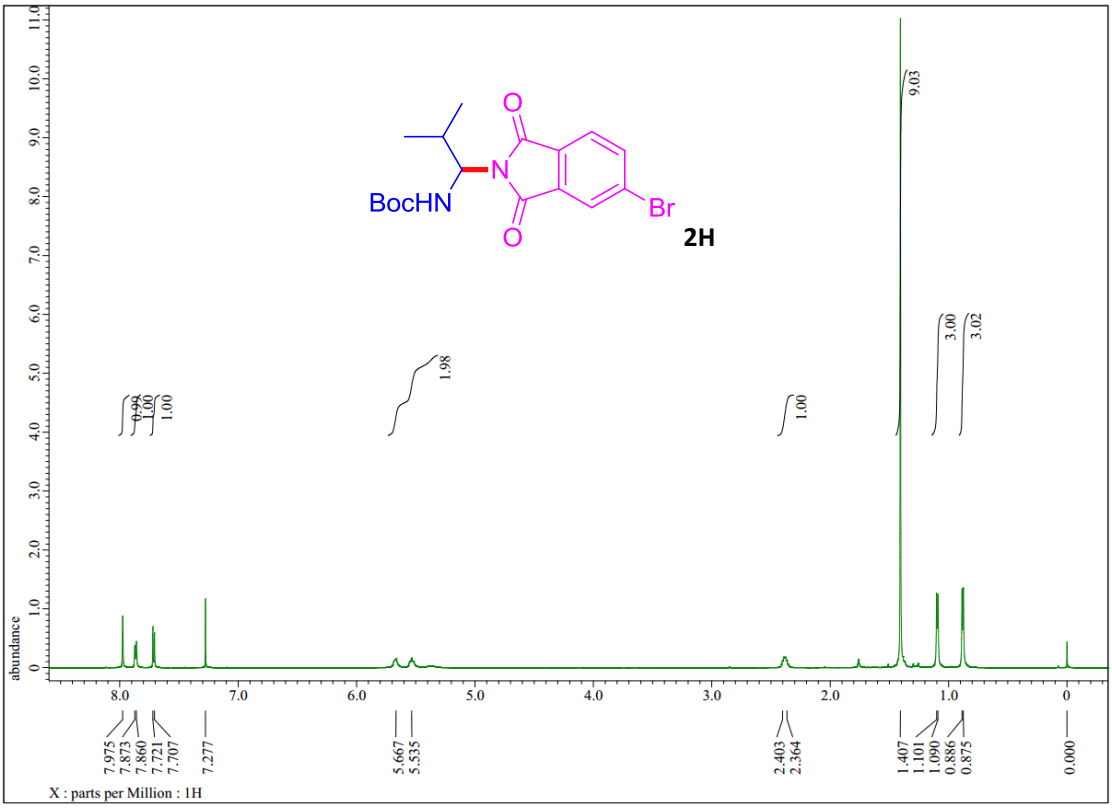

tBuO
O
O
N
BocHN
O
2m
abundance
X : parts per Million : 13C
171.481
167.581
154.299
134.239
131.826
123.569
80.921
80.416
77.460
77.346
77.146
76.821
58.200
31.809
28.681
28.300
28.062

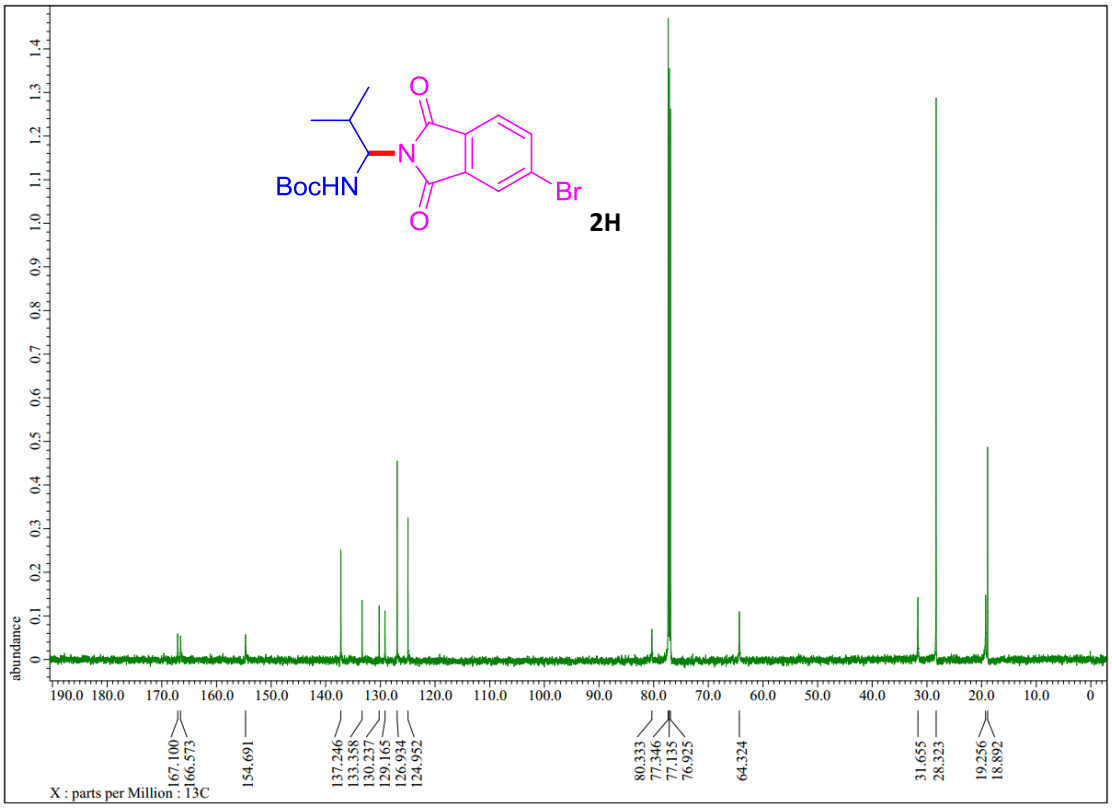

BnHN
O
O
N
BocHN
O
O
2n
abundance
9.04
4.06
3.04
2.03
3.14
2.09
1.99
2.00
7.840
7.832
7.826
7.818
7.731
7.723
7.717
7.709
7.304
7.285
7.265
7.246
7.227
6.032
5.909
4.396
4.382
4.359
4.345
4.317
4.304
4.281
4.267
2.411
2.394
2.376
2.330
2.314
2.284
2.266
2.246
1.390
X : parts per Million : 1H

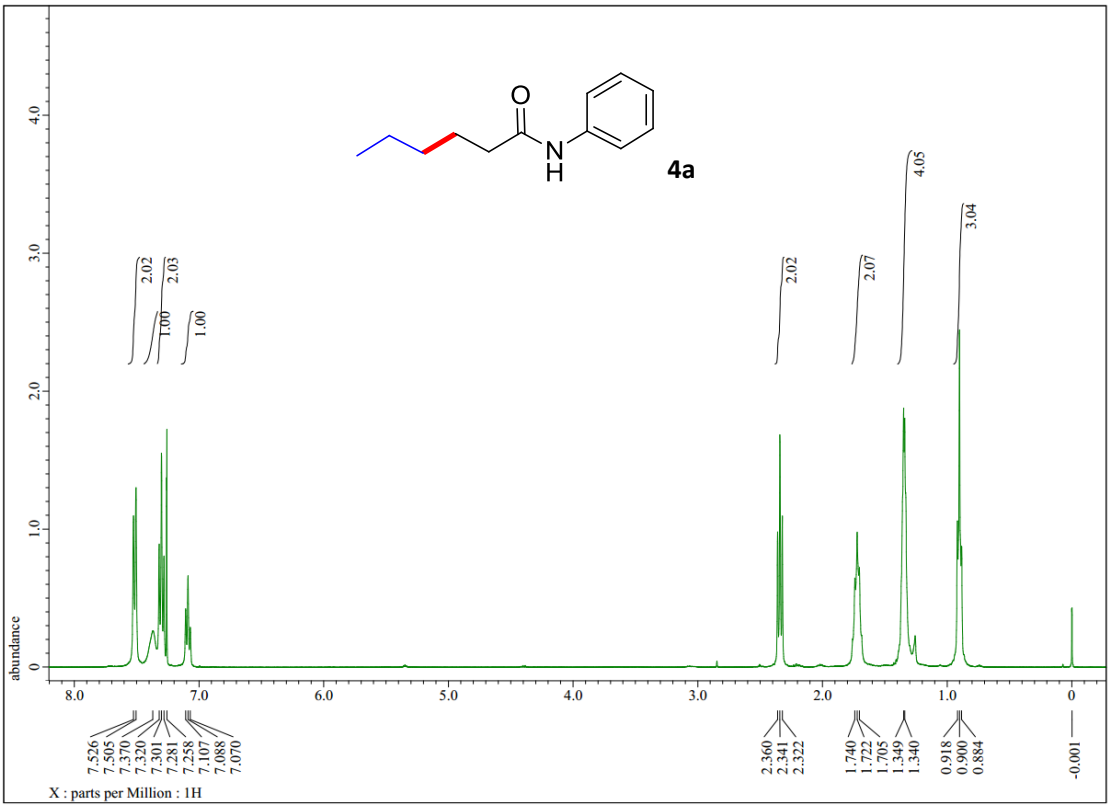

BnHN
O
O
N
BocHN
O
2n
abundance
171.099
167.686
154.462
138.138
134.296
131.760
128.756
127.898
127.555
123.608
80.559
77.432
77.317
77.117
76.802
58.429
43.775
32.743
29.501
28.309
X : parts per Million : 13C

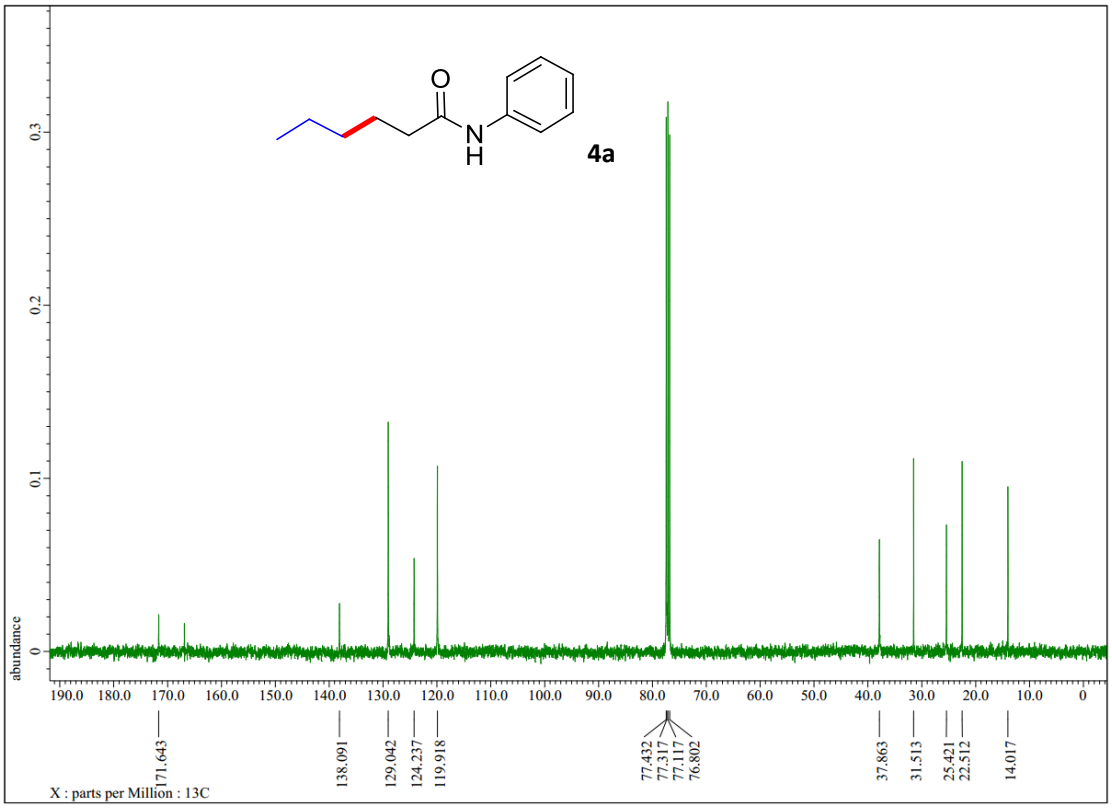

CbzHN
O
N
O
2o
abundance
X : parts per Million : 1H

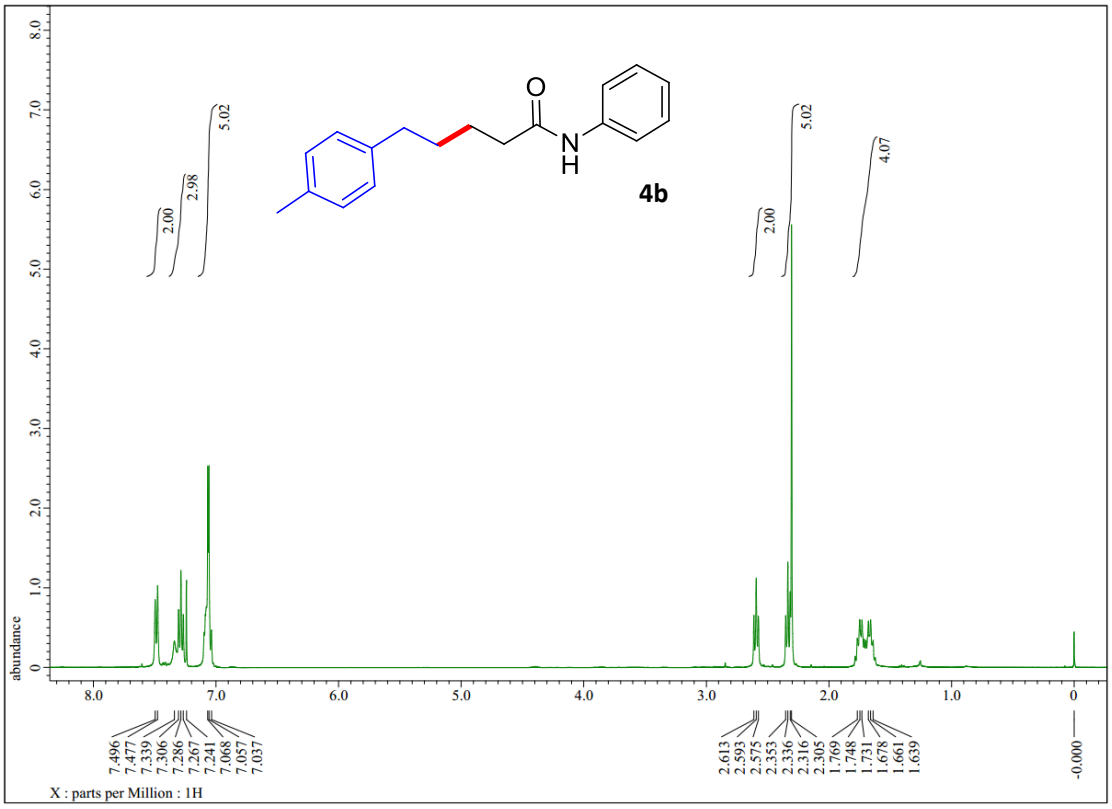

CbzHN
O
N
O
2o
abundance
X : parts per Million : 13C

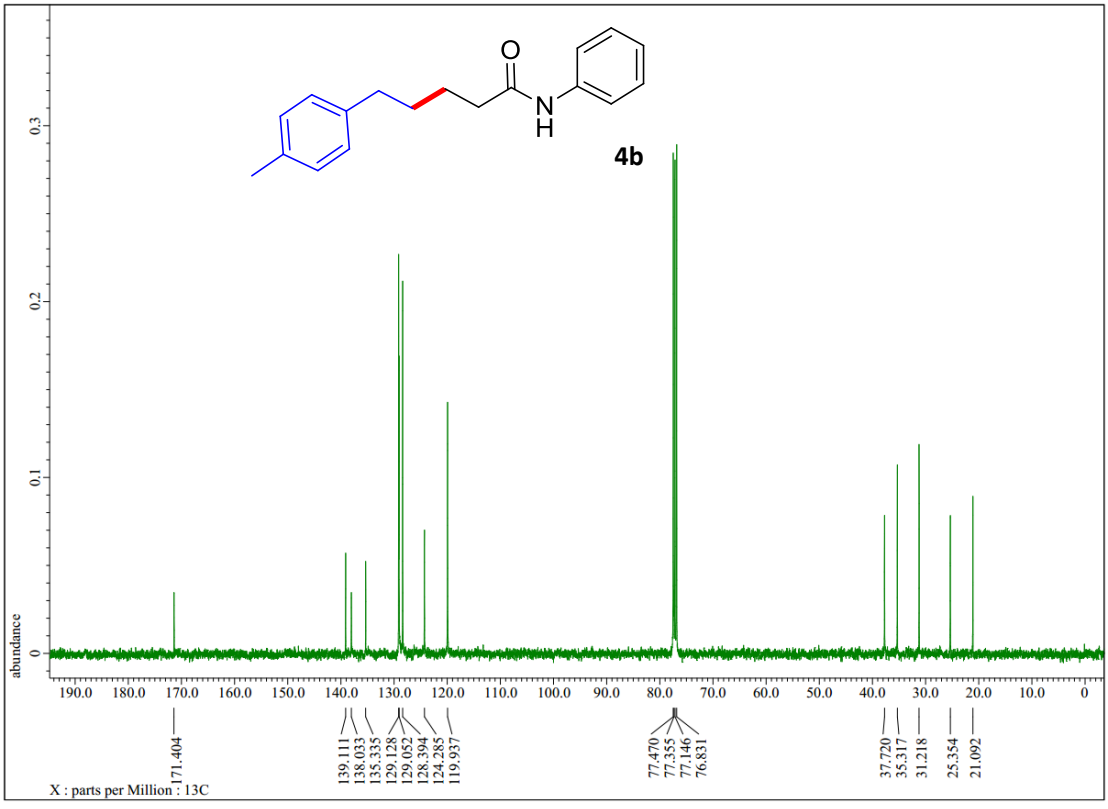

BocHN
N
O
O
Br
2H
9.03
3.00
3.02
1.98
1.00
1.00
0.99
1.00
1.00
abundance
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.975
7.873
7.860
7.721
7.707
7.277
5.667
5.535
2.403
2.364
1.407
1.101
1.090
0.886
0.875
0.000
X : parts per Million : 1H

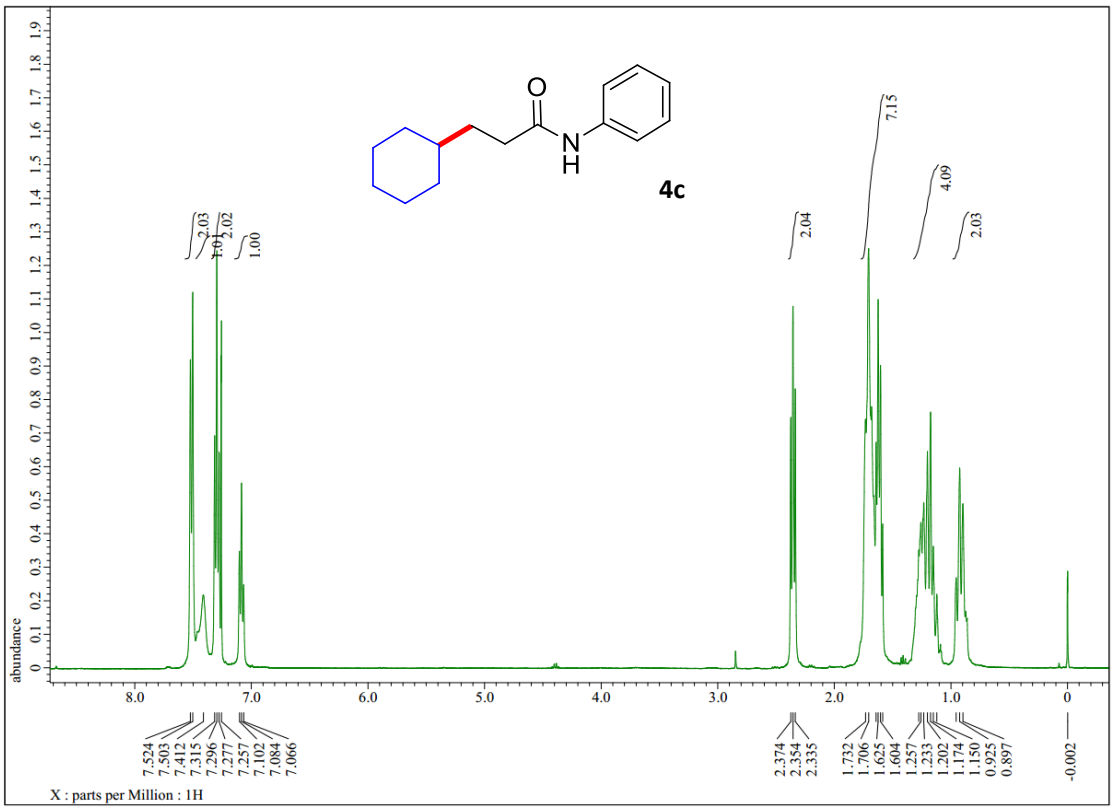

BocHN
N
O
O
Br
2H
abundance
190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
167.100
166.573
154.691
137.246
133.358
130.237
129.165
126.934
124.952
80.333
77.346
77.135
76.925
64.324
31.655
28.323
19.256
18.892
X : parts per Million : 13C

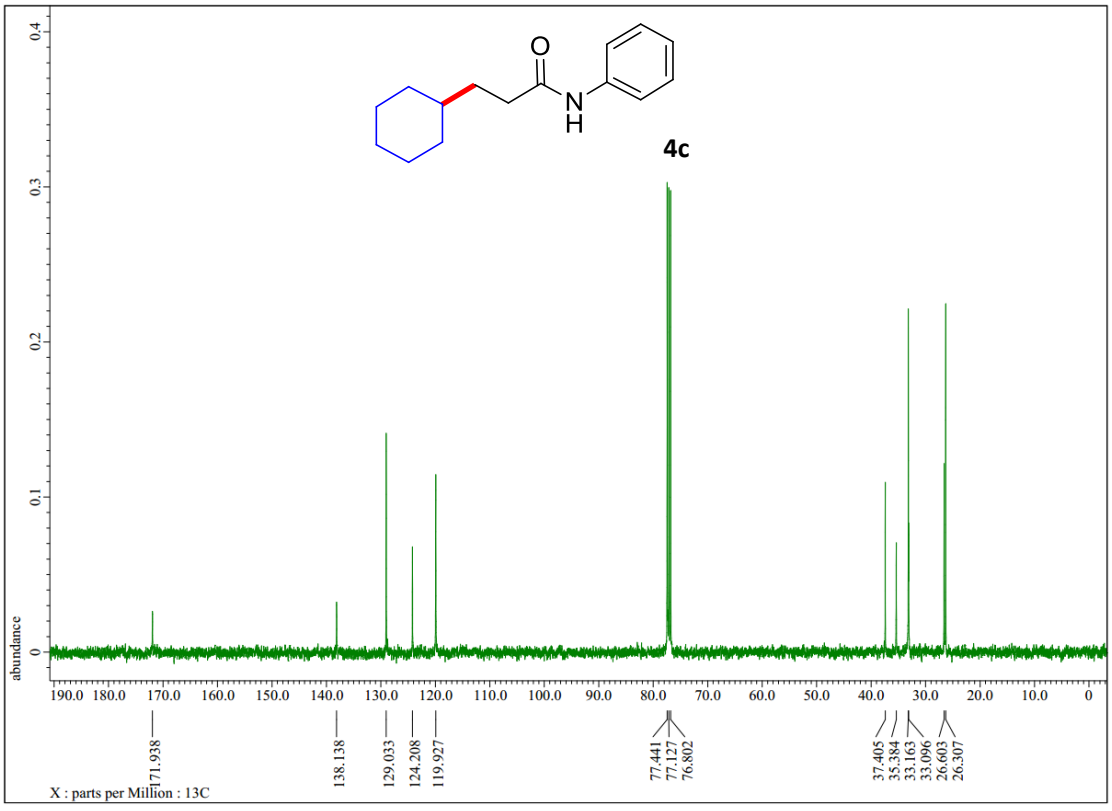

4a
abundance
X : parts per Million : 1H

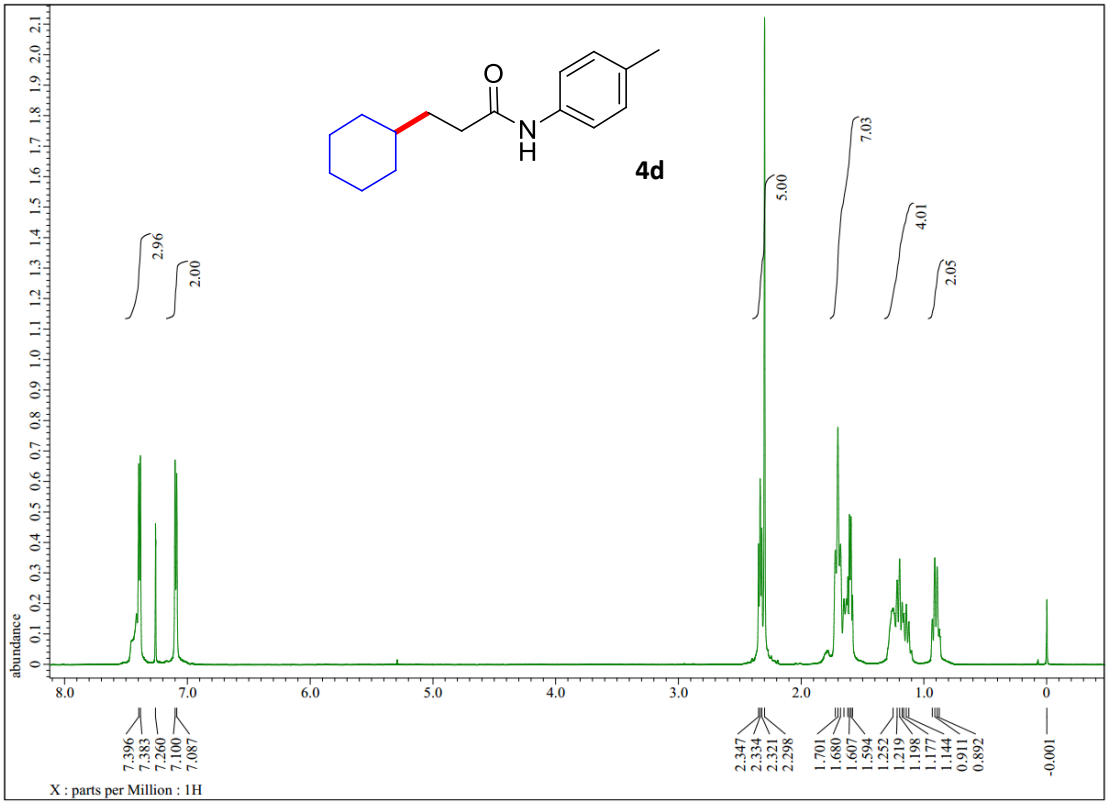

4a
abundance
X : parts per Million : 13C

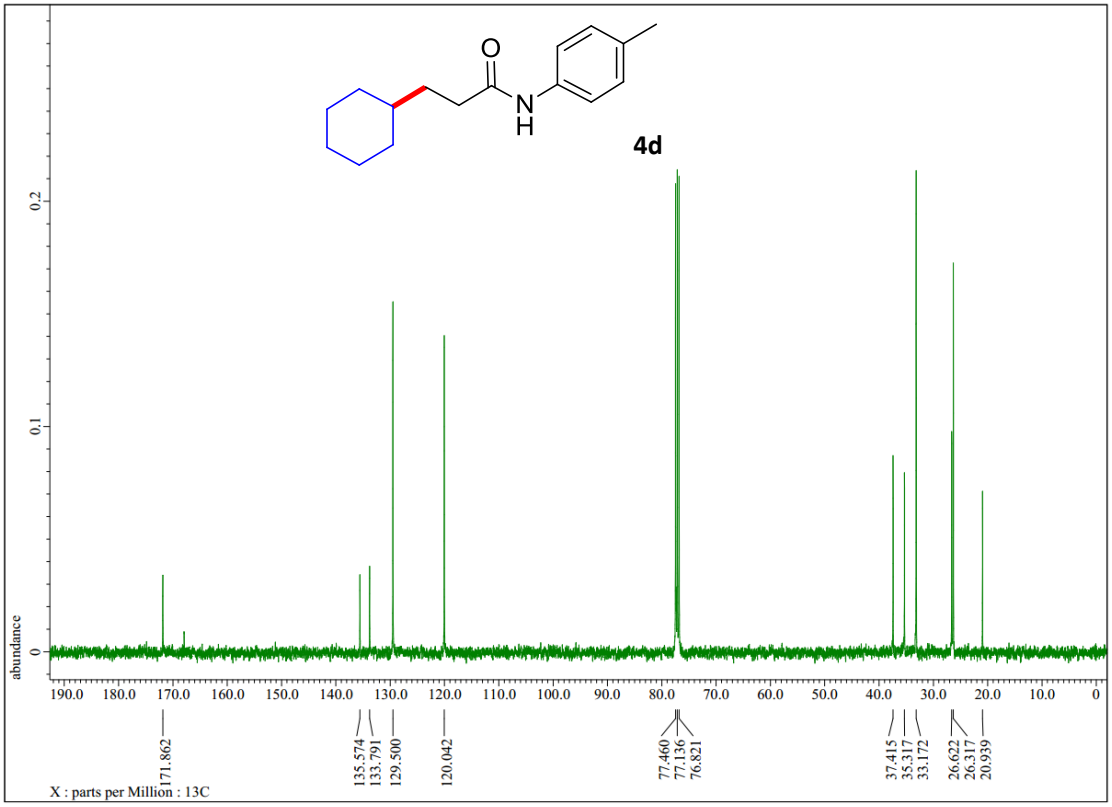

4b
abundance
X : parts per Million : 1H

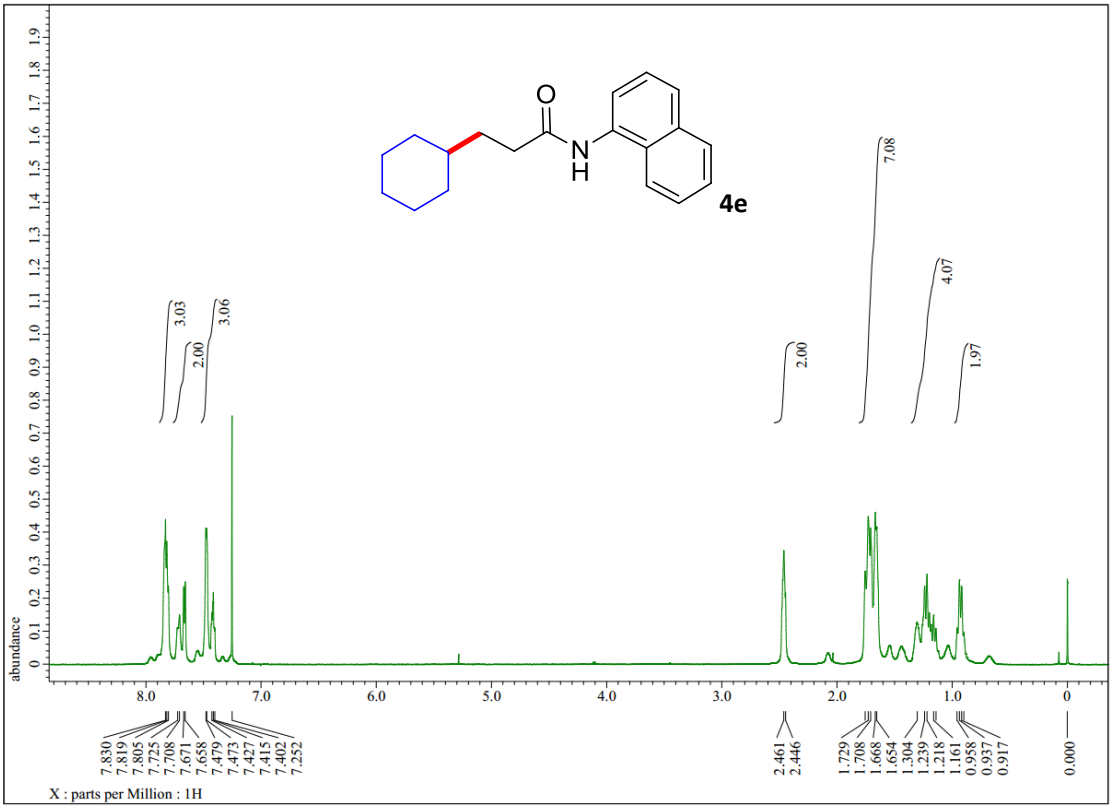

4b
abundance
X : parts per Million : 13C

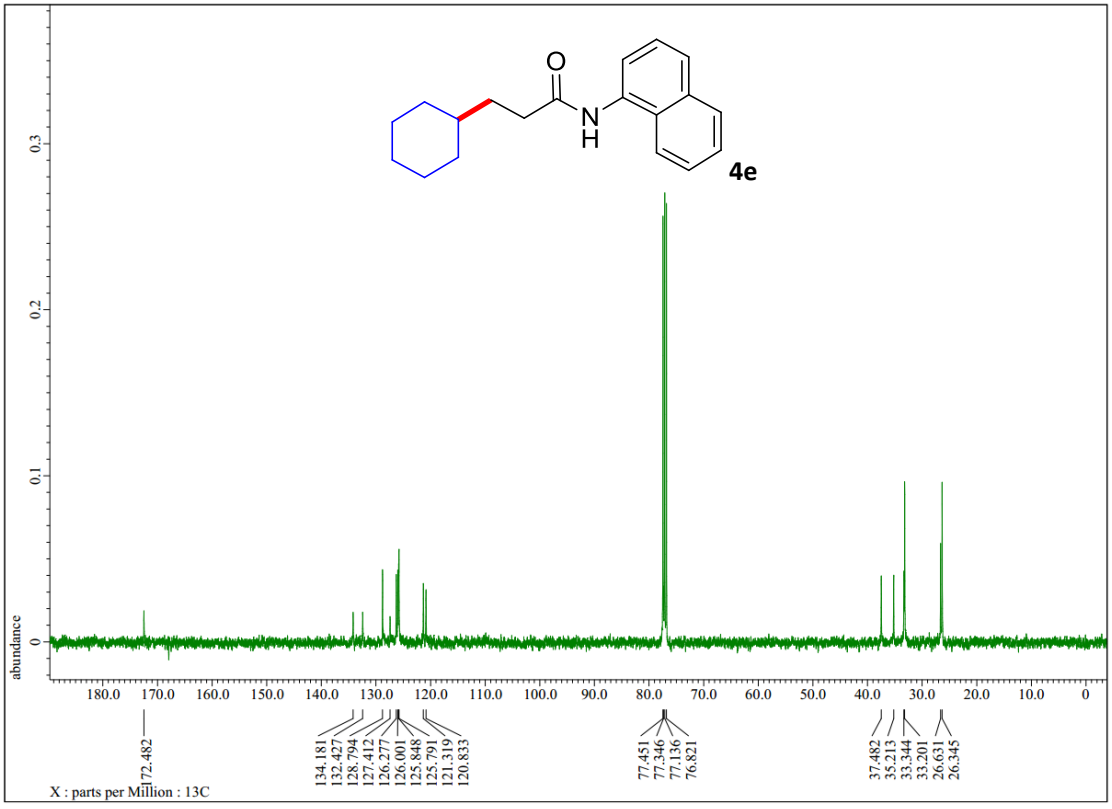

4c
abundance
X : parts per Million : 1H

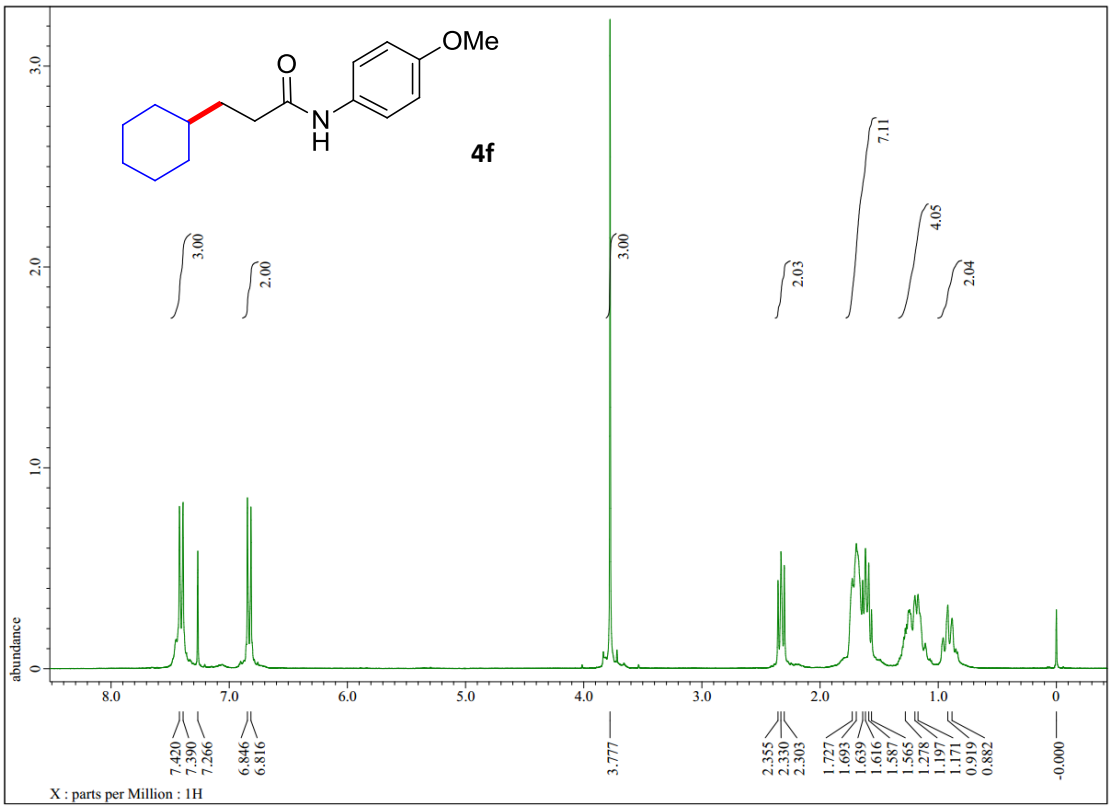

4c
abundance
X : parts per Million : 13C

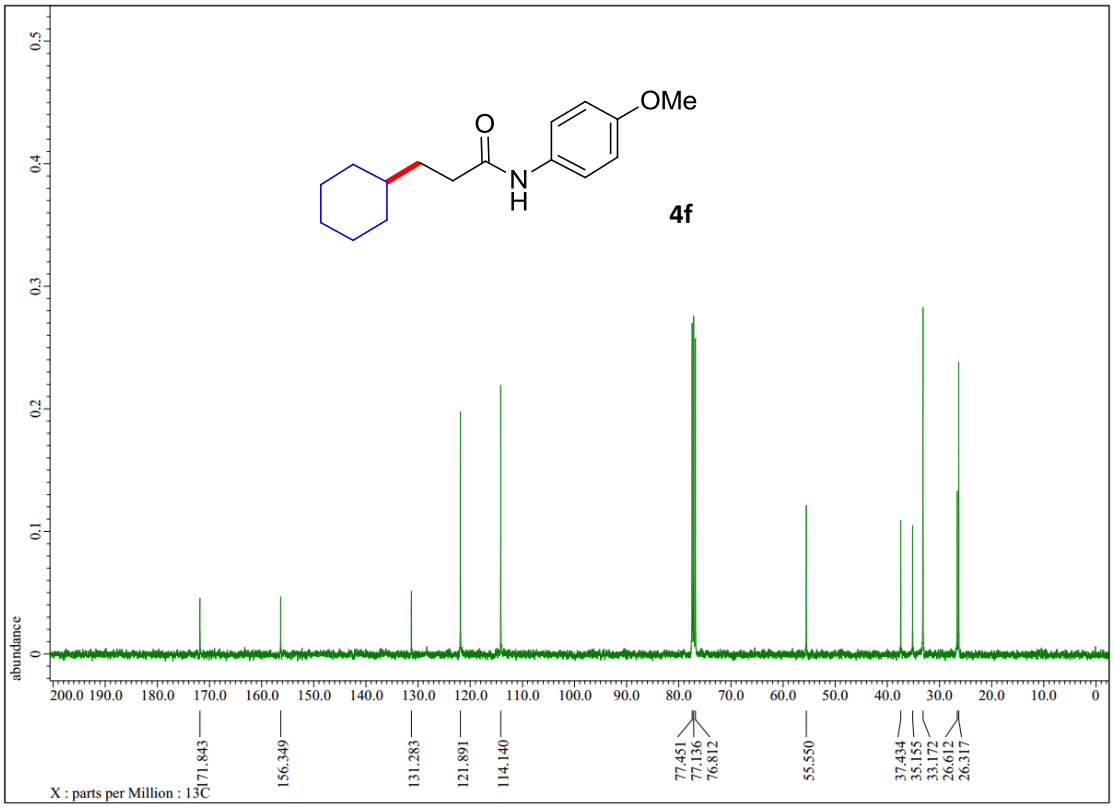

4d
2.96
2.00
5.00
7.03
4.01
2.05
abundance
X : parts per Million : 1H
7.396
7.383
7.260
7.100
7.087
2.347
2.334
2.321
2.298
1.701
1.680
1.607
1.594
1.252
1.219
1.198
1.177
1.144
0.911
0.892
-0.001

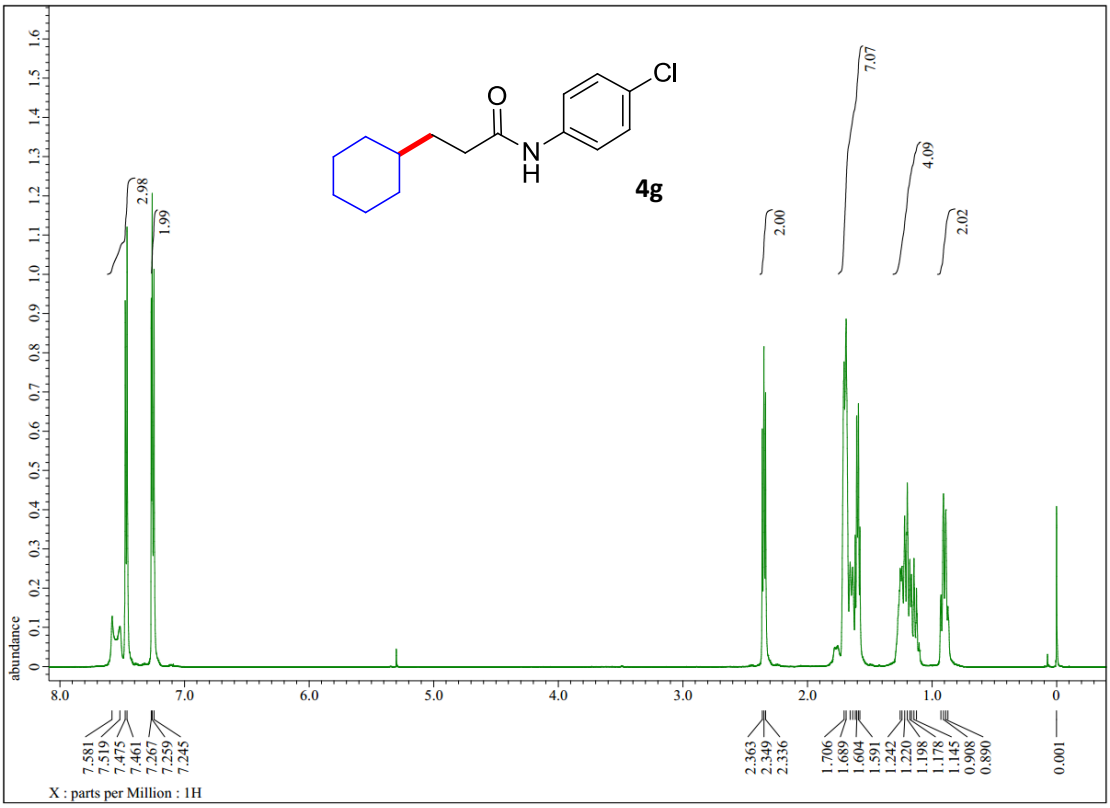

4d
abundance
X : parts per Million : 13C
171.862
135.574
133.791
129.500
120.042
77.460
77.136
76.821
37.415
35.317
33.172
26.622
26.317
20.939

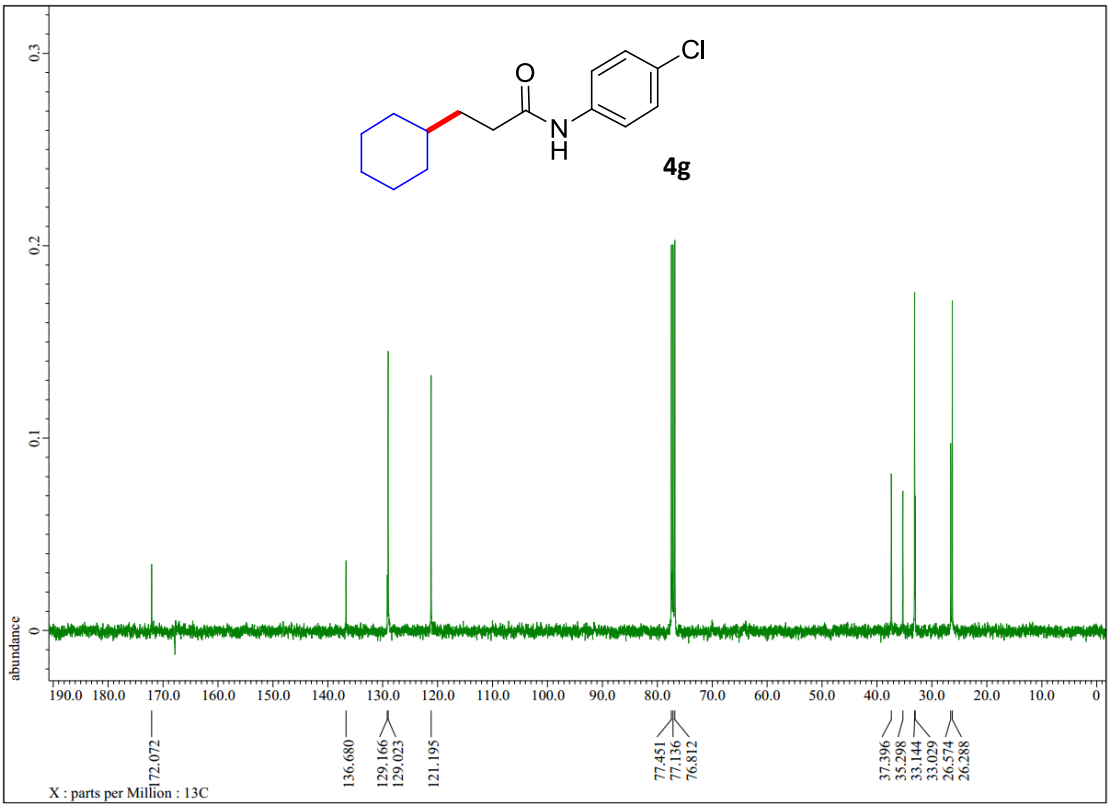

4e
abundance
X : parts per Million : 1H

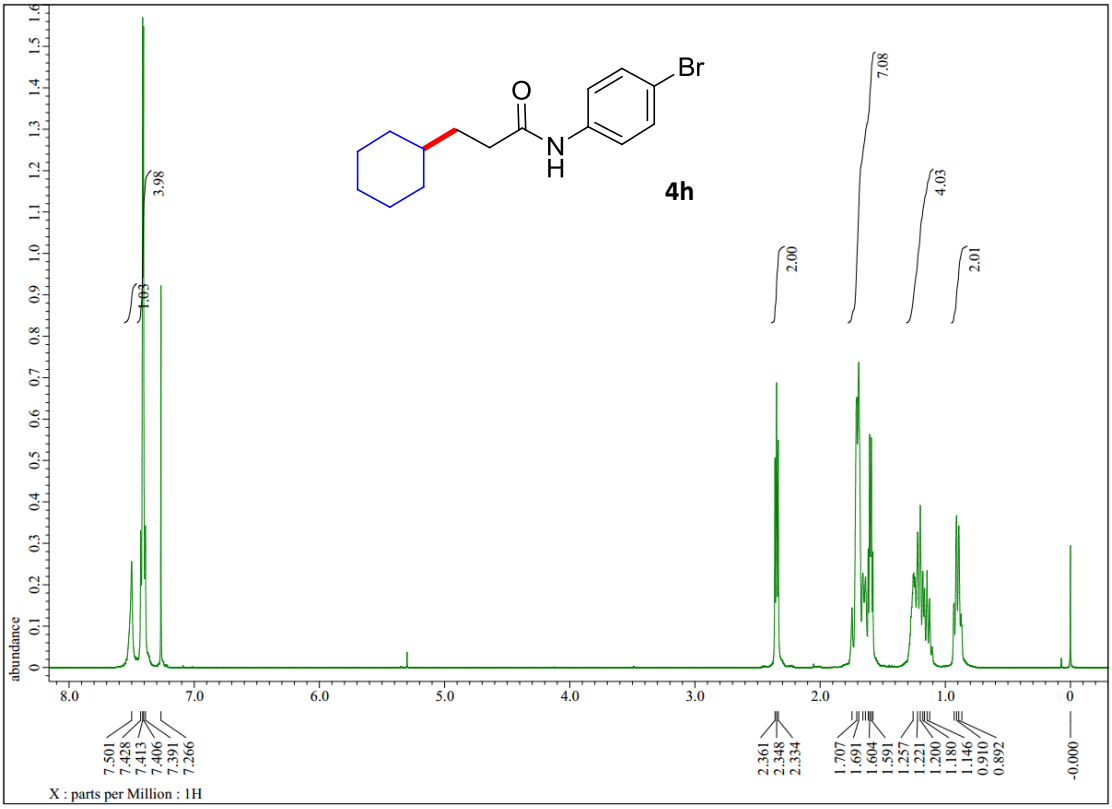

4e
abundance
X : parts per Million : 13C

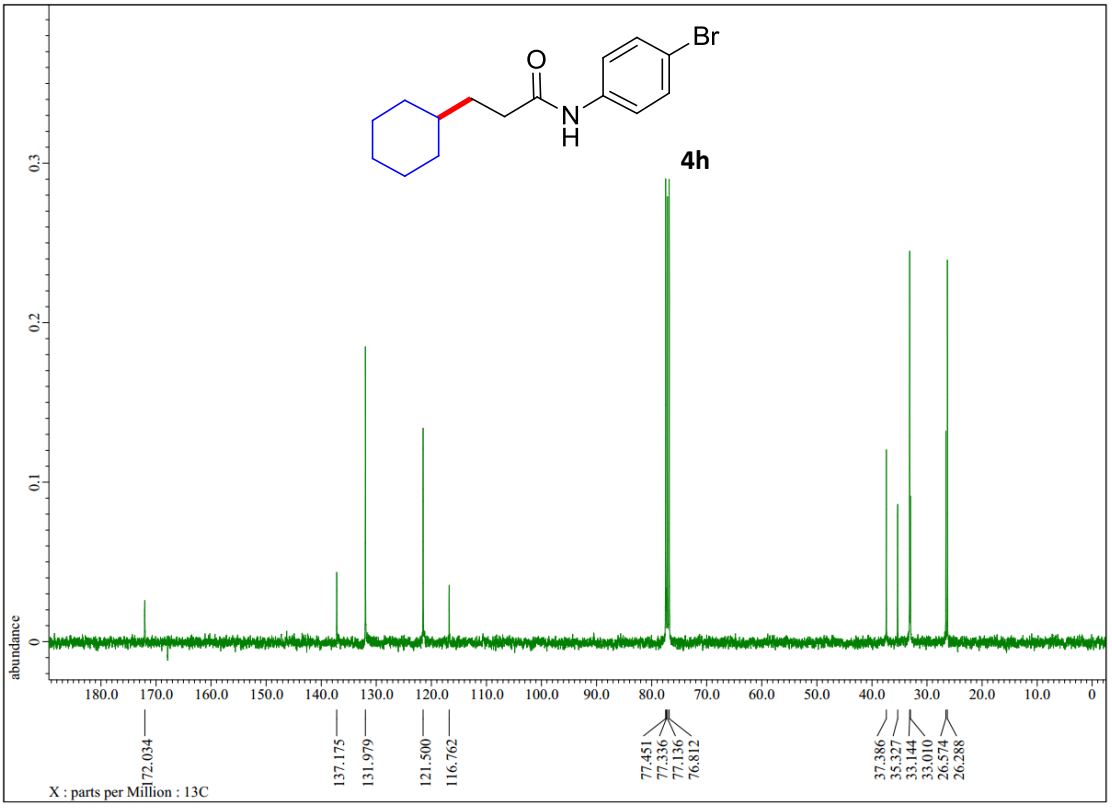

OMe
O
N
H
4f
3.00
2.00
3.00
2.03
7.11
4.05
2.04
abundance
7.420
7.390
7.266
6.846
6.816
3.777
2.355
2.330
2.303
1.727
1.693
1.639
1.616
1.587
1.565
1.278
1.197
1.171
0.919
0.882
-0.000
X : parts per Million : 1H

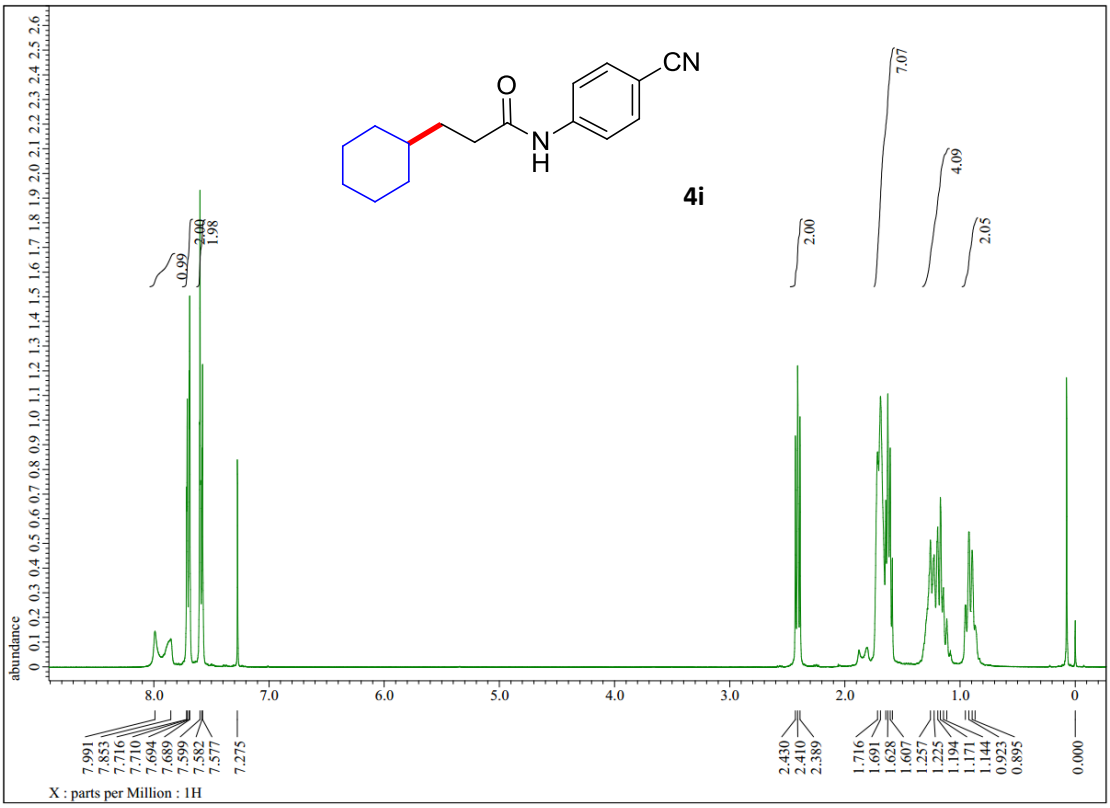

OMe
O
N
H
4f
abundance
171.843
156.349
131.283
121.891
114.140
77.451
77.136
76.812
55.550
37.434
35.155
33.172
26.612
26.317
X : parts per Million : 13C

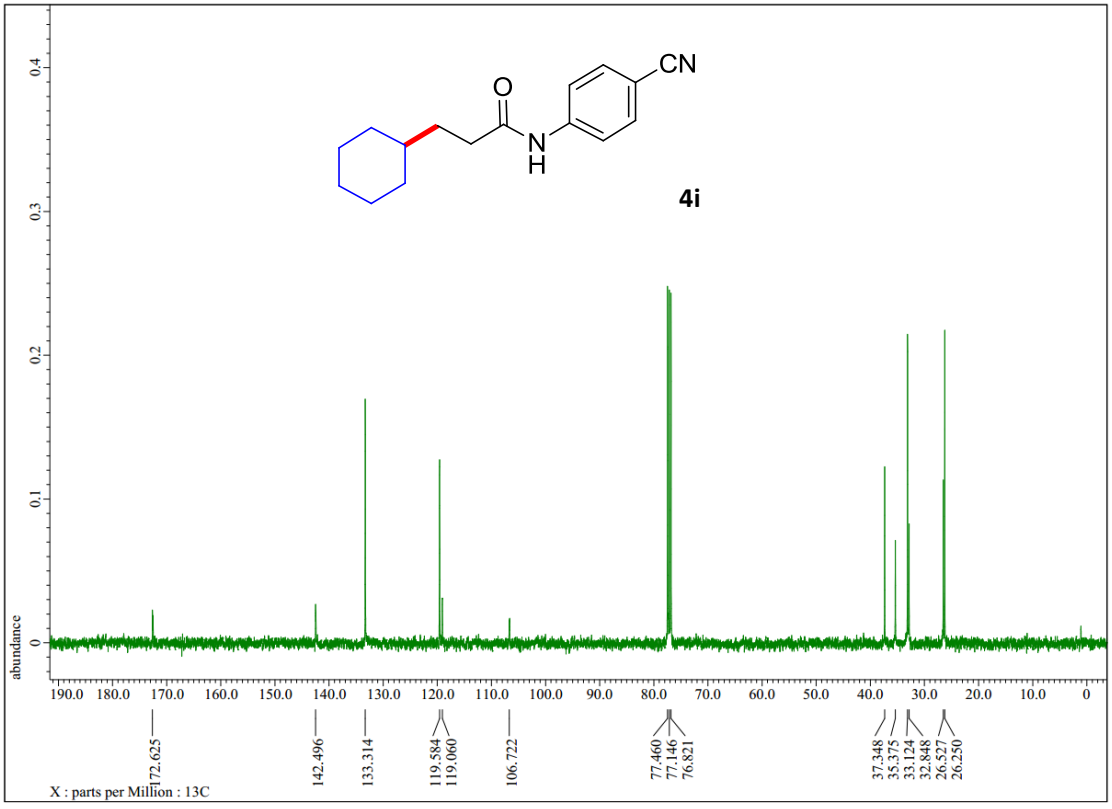

Cl
O
N
H
4g
2.98
1.99
2.00
7.07
4.09
2.02
abundance
7.581
7.519
7.475
7.461
7.267
7.259
7.245
2.363
2.349
2.336
1.706
1.689
1.604
1.591
1.242
1.220
1.198
1.178
1.145
0.908
0.890
0.001
X : parts per Million : 1H

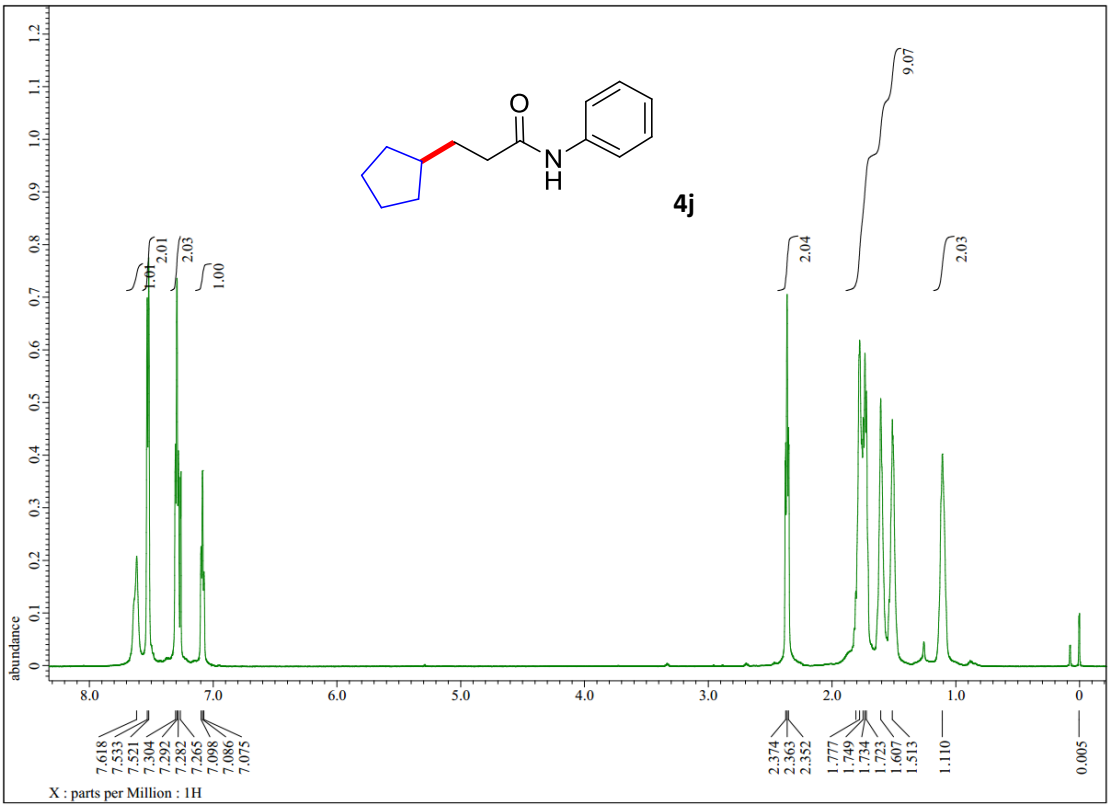

Cl
O
N
H
4g
abundance
172.072
136.680
129.166
129.023
121.195
77.451
77.136
76.812
37.396
35.298
33.144
33.029
26.574
26.288
X : parts per Million : 13C

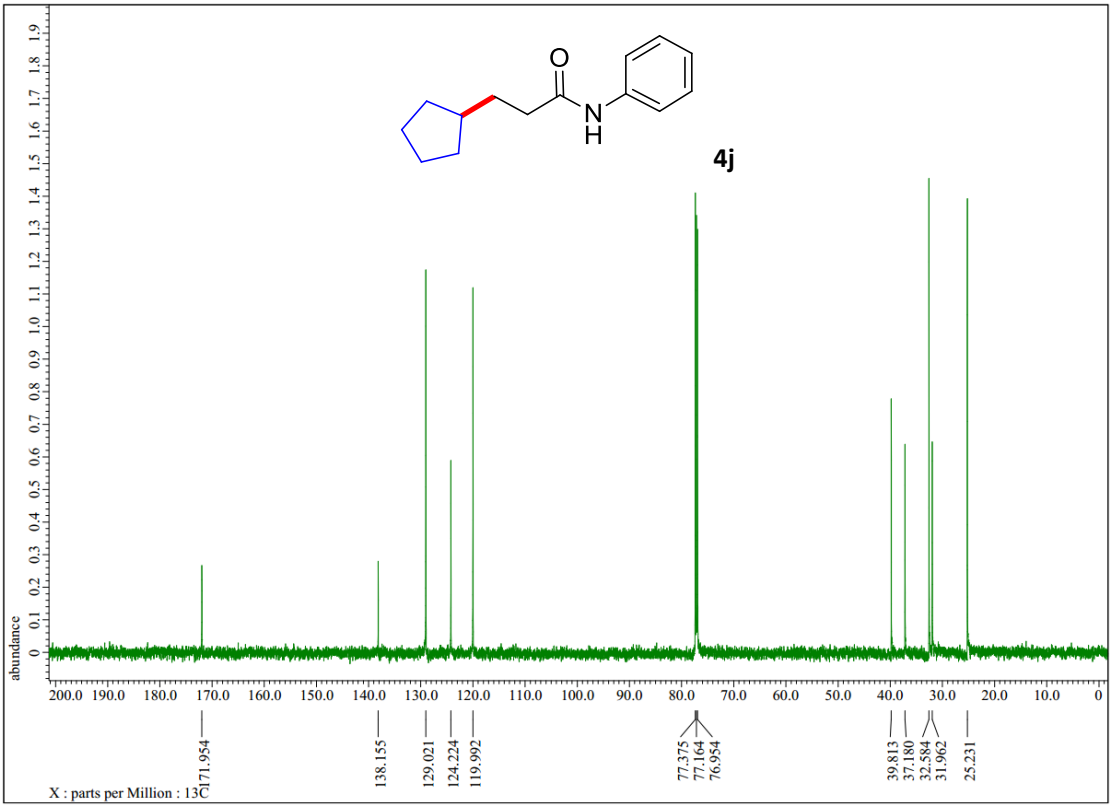

Br
O
N
H
4h
7.08
4.03
3.98
2.00
2.01
1.03
abundance
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.501
7.428
7.413
7.406
7.391
7.266
2.361
2.348
2.334
1.707
1.691
1.604
1.591
1.257
1.221
1.200
1.180
1.146
0.910
0.892
-0.000
X : parts per Million : 1H

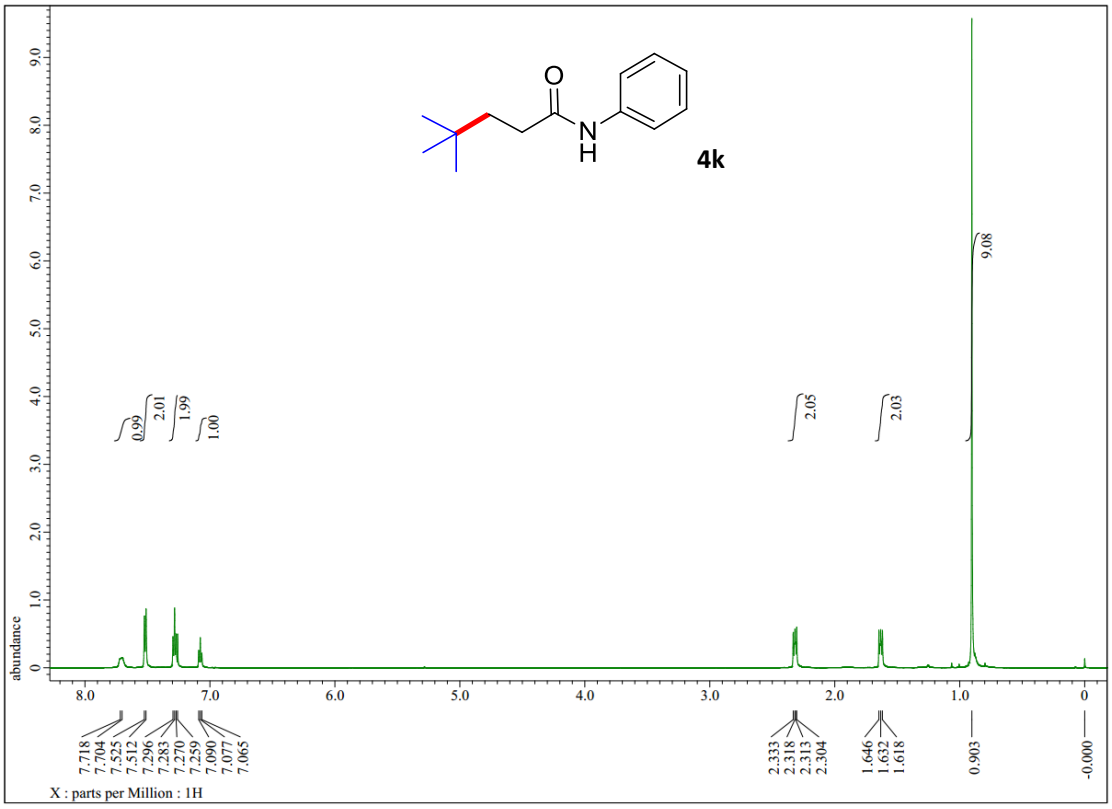

Br
O
N
H
4h
abundance
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
172.034
137.175
131.979
121.500
116.762
77.451
77.336
77.136
76.812
37.386
35.327
33.144
33.010
26.574
26.288
X : parts per Million : 13C

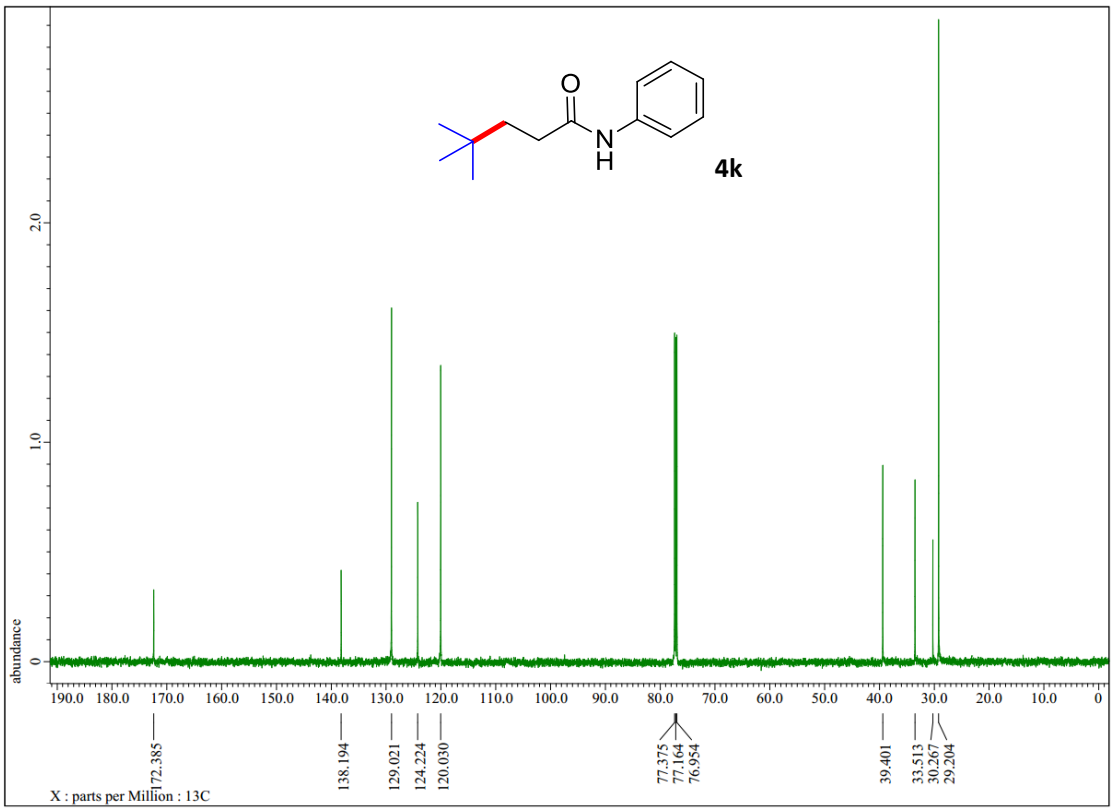

CN
O
N
H
4i
abundance
X : parts per Million : 1H

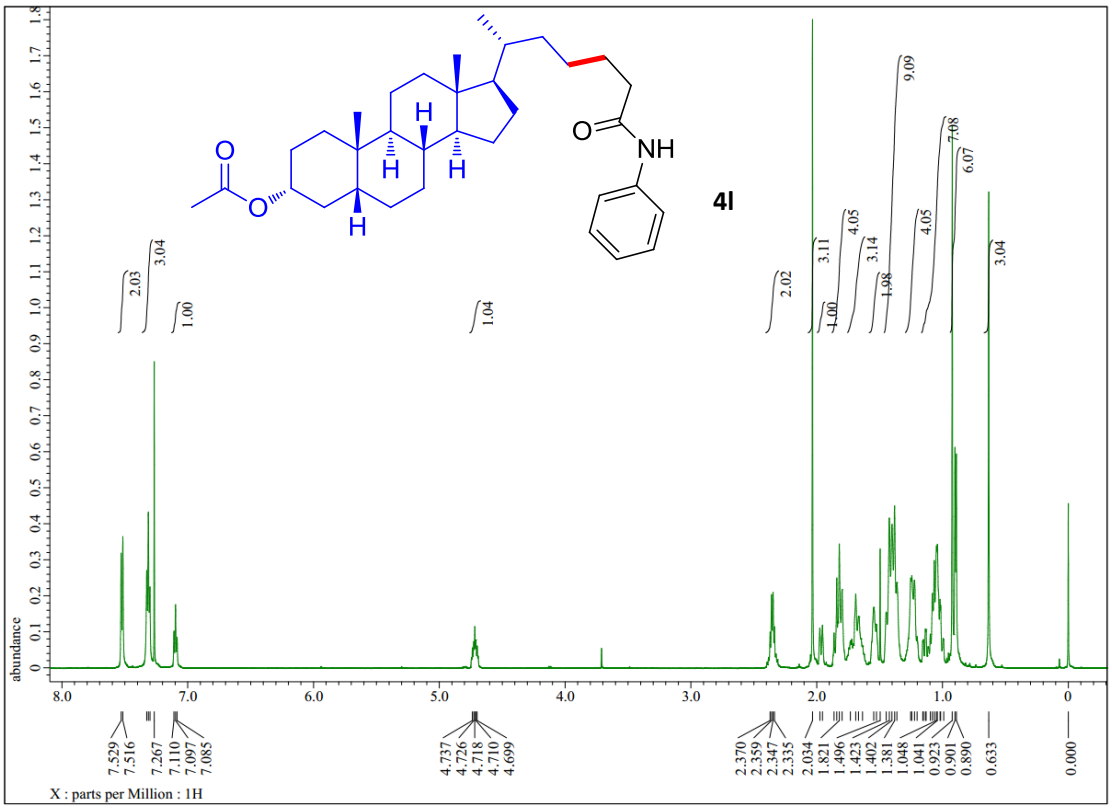

CN
O
N
H
4i
abundance
X : parts per Million : 13C

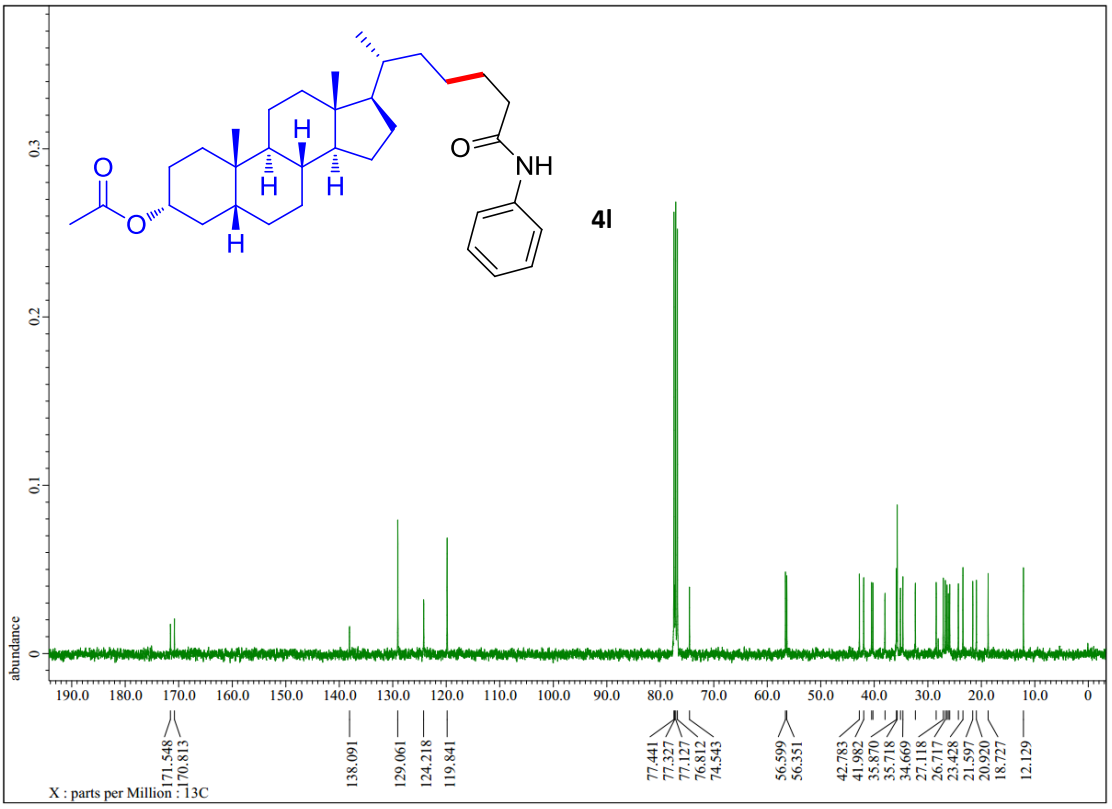

4j
abundance
X : parts per Million : 1H

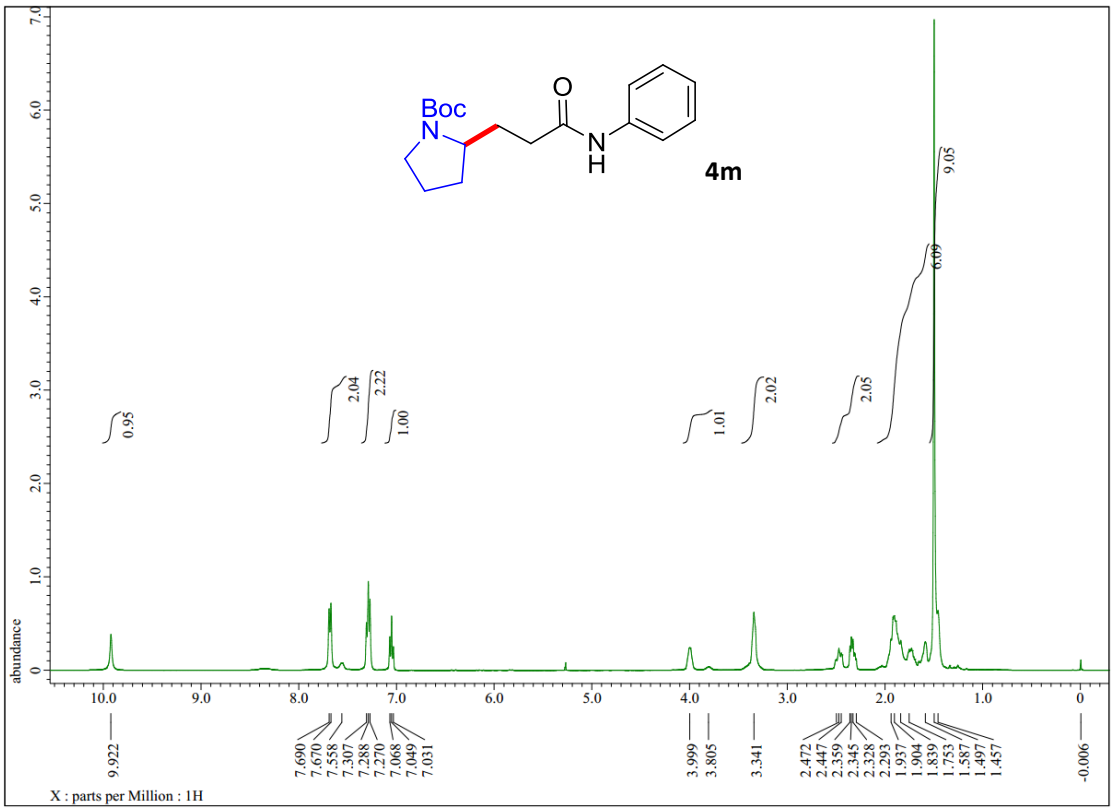

4j
abundance
X : parts per Million : 13C

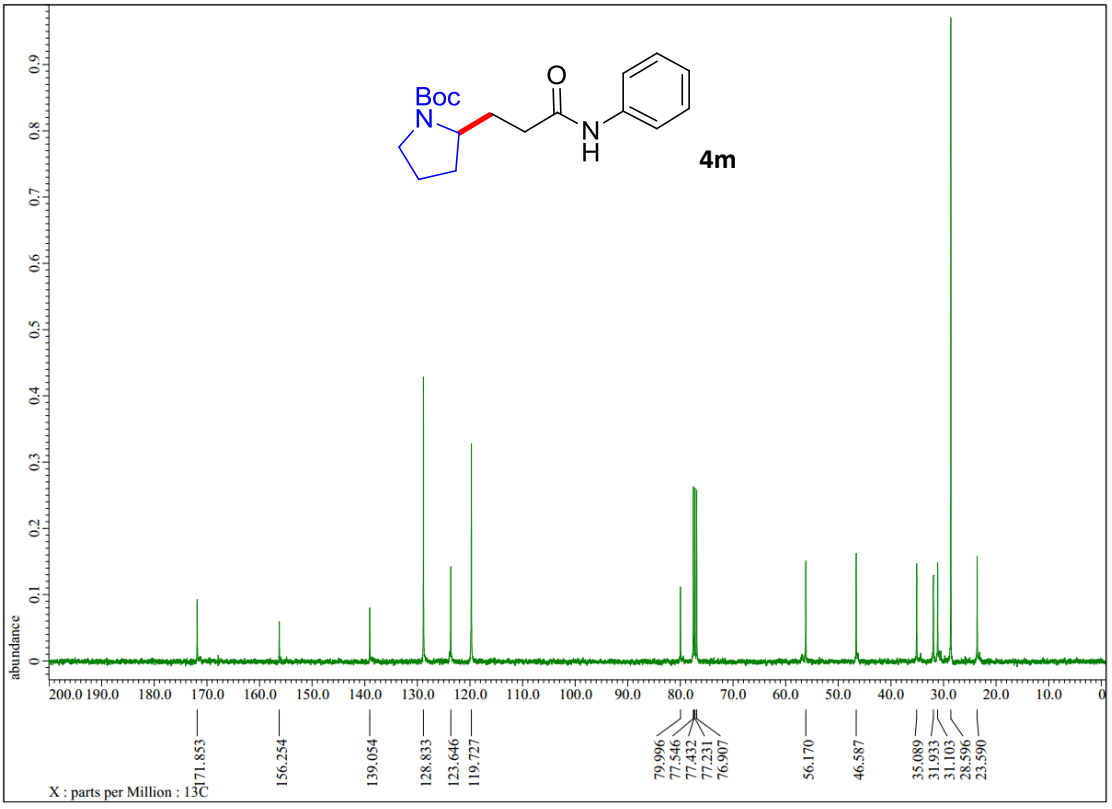

4k
abundance
0.99
2.01
1.99
1.00
2.05
2.03
9.08
7.718
7.704
7.525
7.512
7.296
7.283
7.270
7.259
7.090
7.077
7.065
2.333
2.318
2.313
2.304
1.646
1.632
1.618
0.903
-0.000
X : parts per Million : 1H

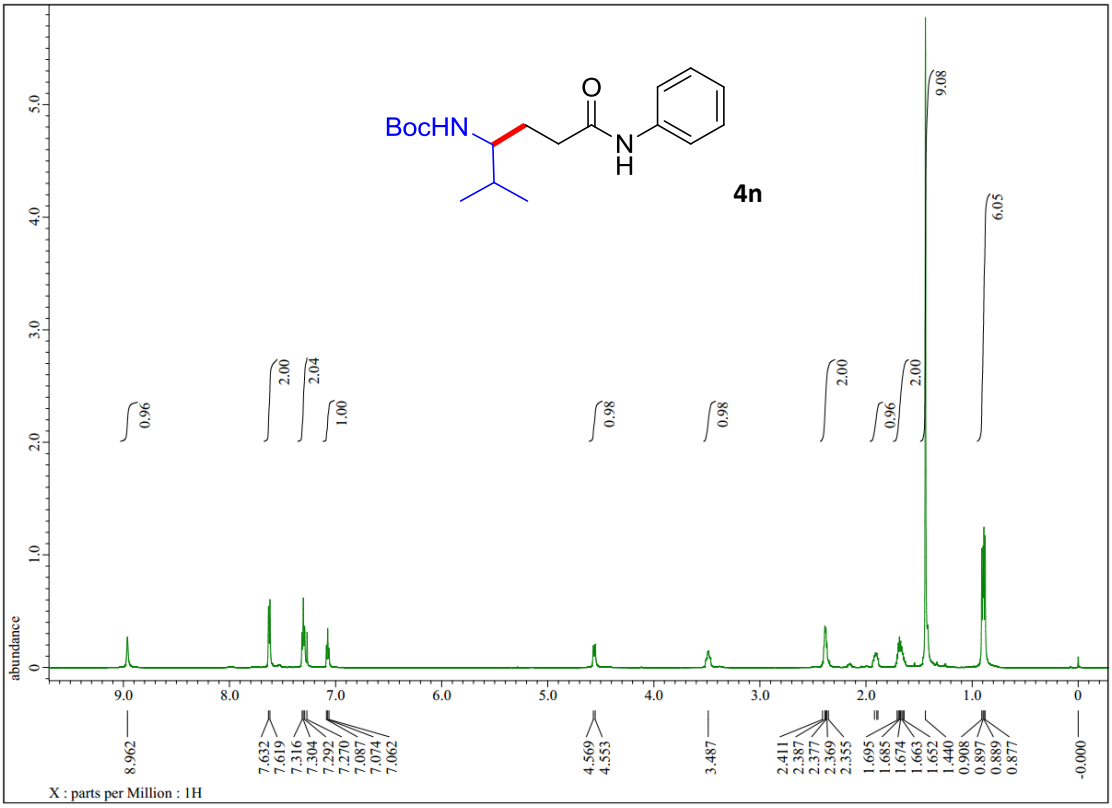

4k
abundance
172.385
138.194
129.021
124.224
120.030
77.375
77.164
76.954
39.401
33.513
30.267
29.204
X : parts per Million : 13C

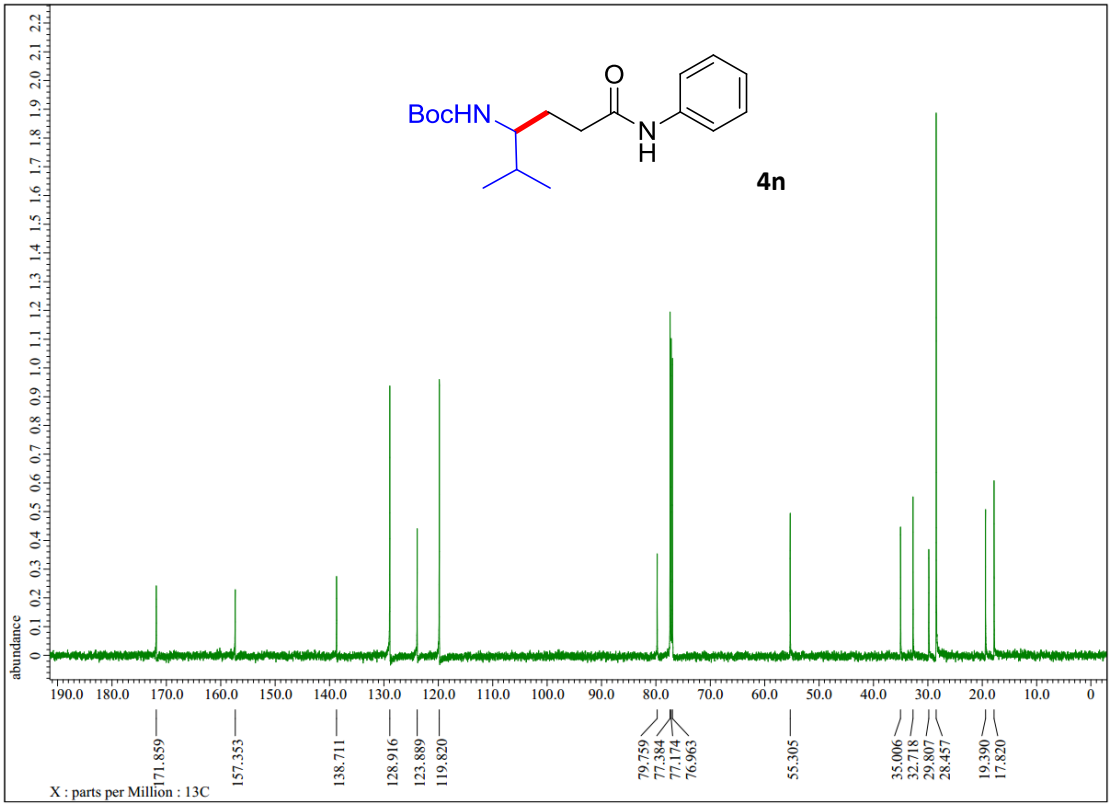

4l
abundance
X : parts per Million : 1H

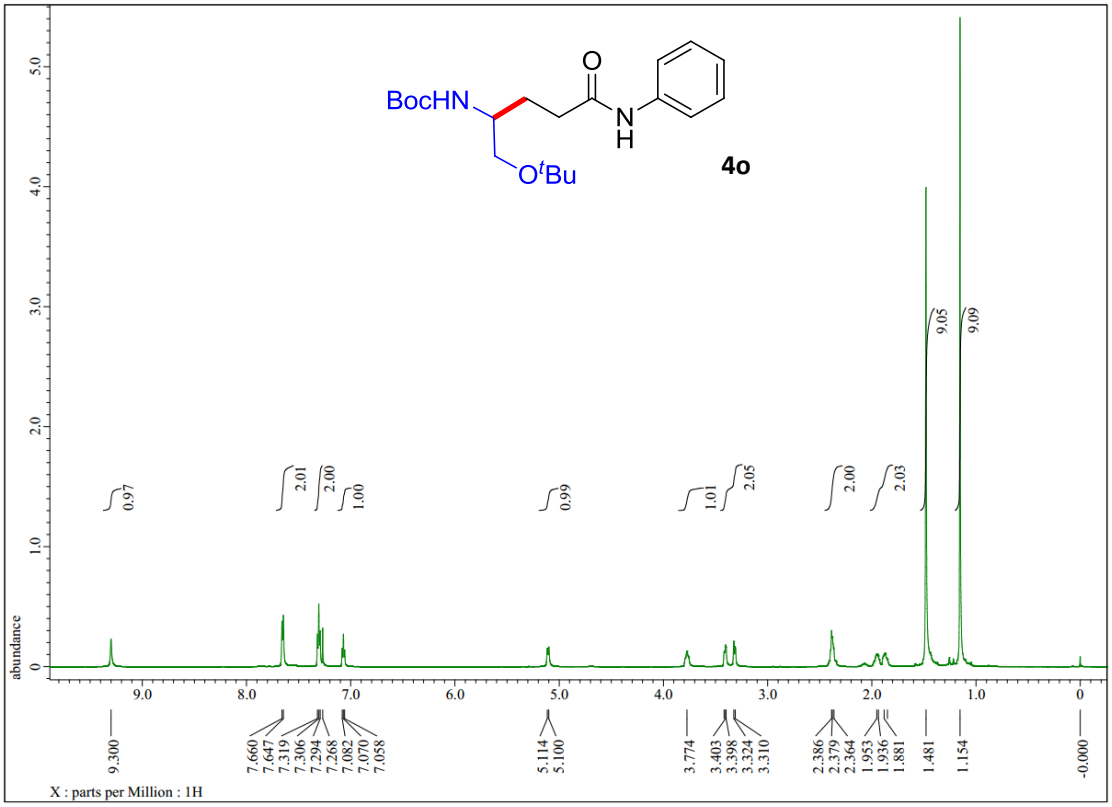

4l
abundance
X : parts per Million : 13C

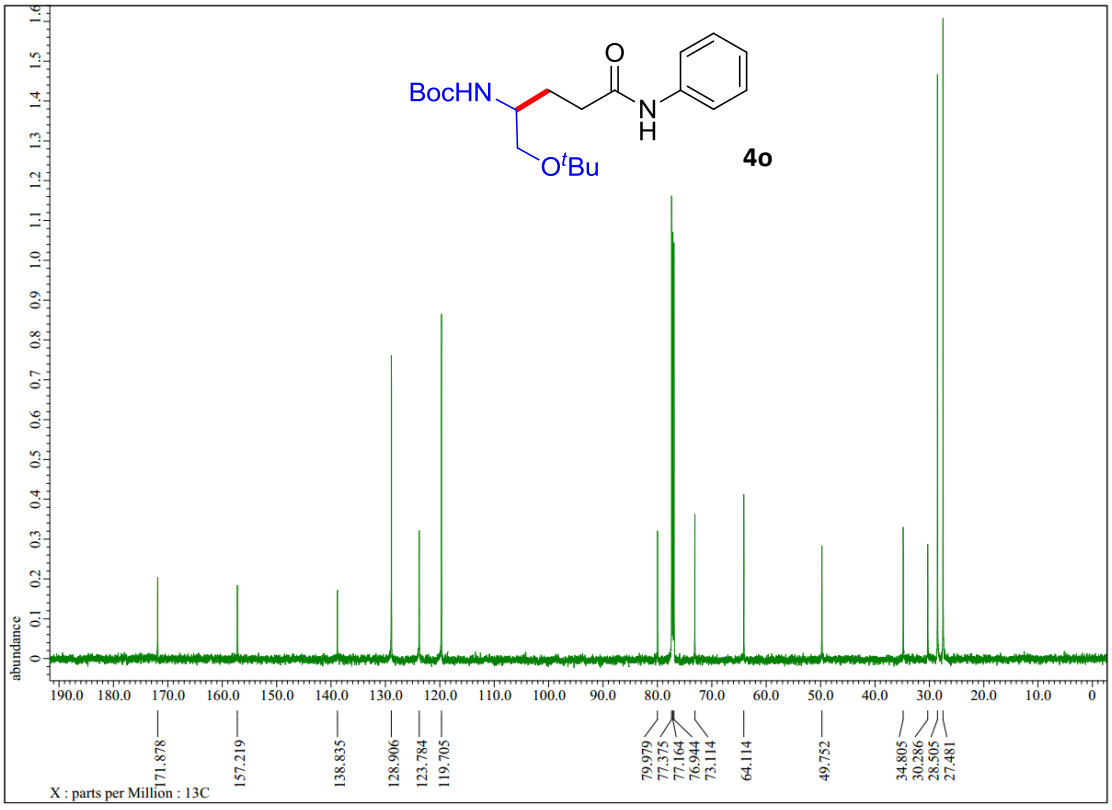

Boc
N
O
N
H
4m
abundance
X : parts per Million : 1H
9.922
7.690
7.670
7.558
7.307
7.288
7.270
7.068
7.049
7.031
3.999
3.805
3.341
2.472
2.447
2.359
2.345
2.328
2.293
1.937
1.904
1.839
1.753
1.587
1.497
1.457
-0.006

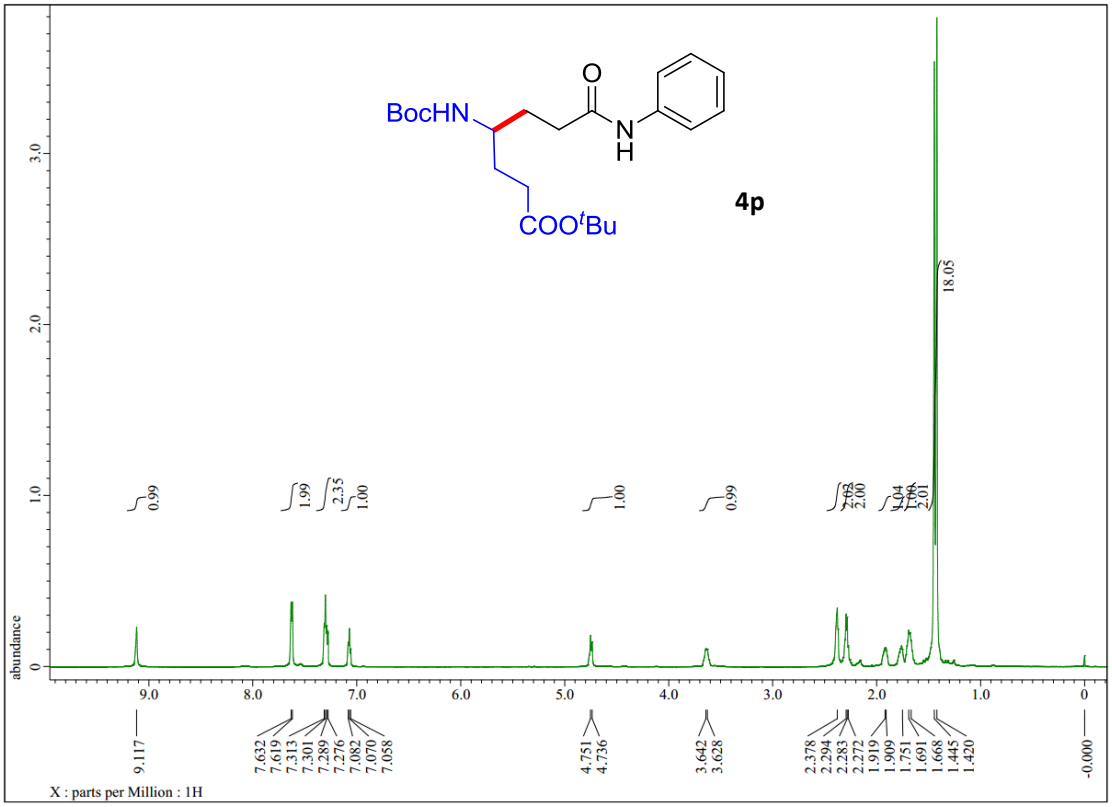

Boc
N
O
N
H
4m
abundance
X : parts per Million : 13C
171.853
156.254
139.054
128.833
123.646
119.727
79.996
77.546
77.432
77.231
76.907
56.170
46.587
35.089
31.933
31.103
28.596
23.590

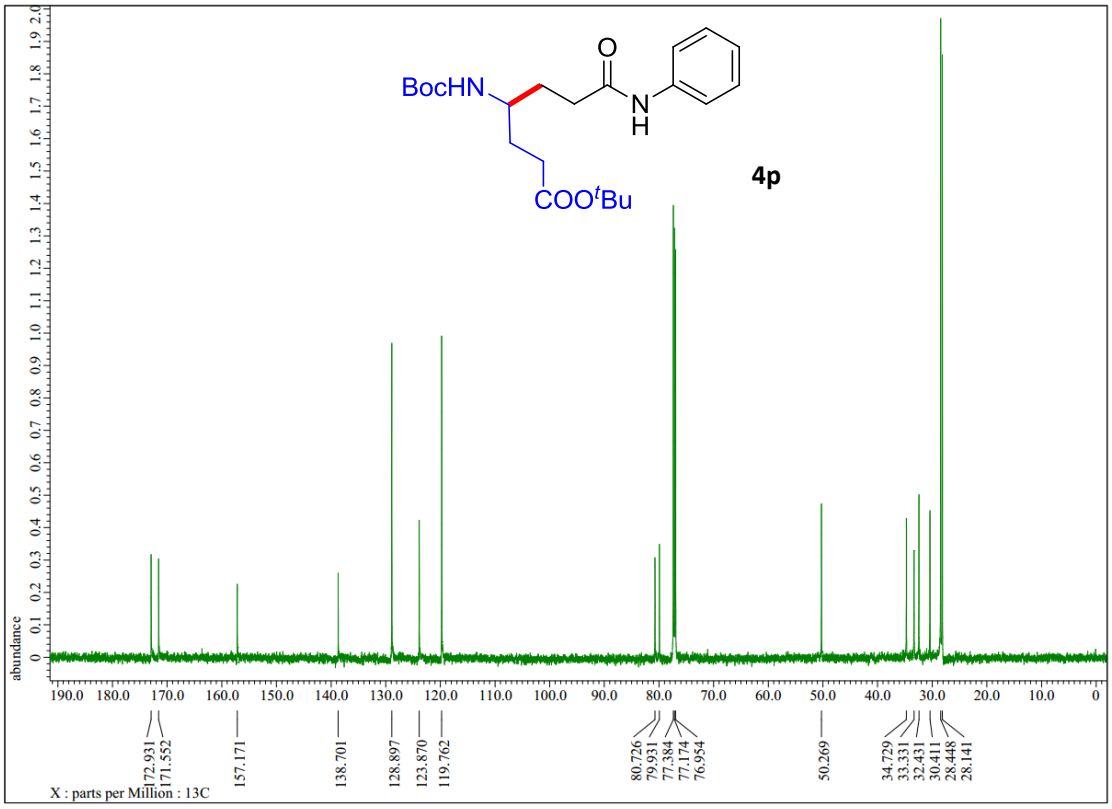

BocHN
O
N
H
4n
abundance
X : parts per Million : 1H

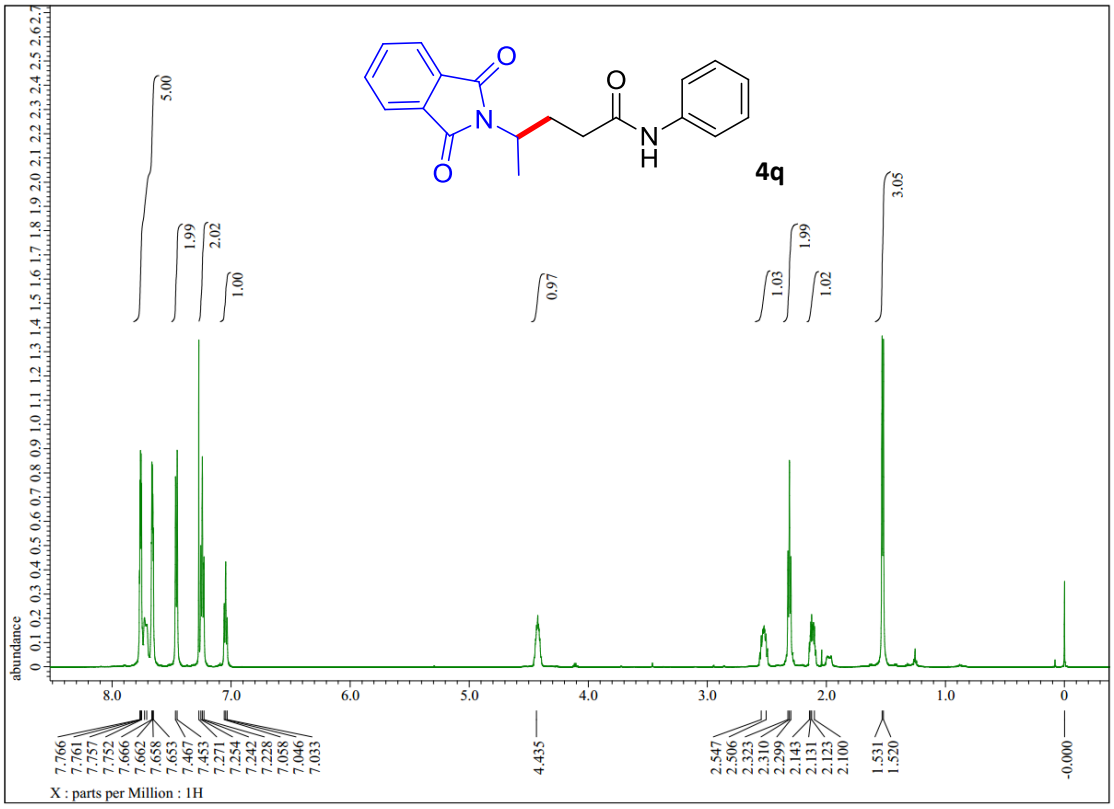

BocHN
O
N
H
4n
abundance
X : parts per Million : 13C

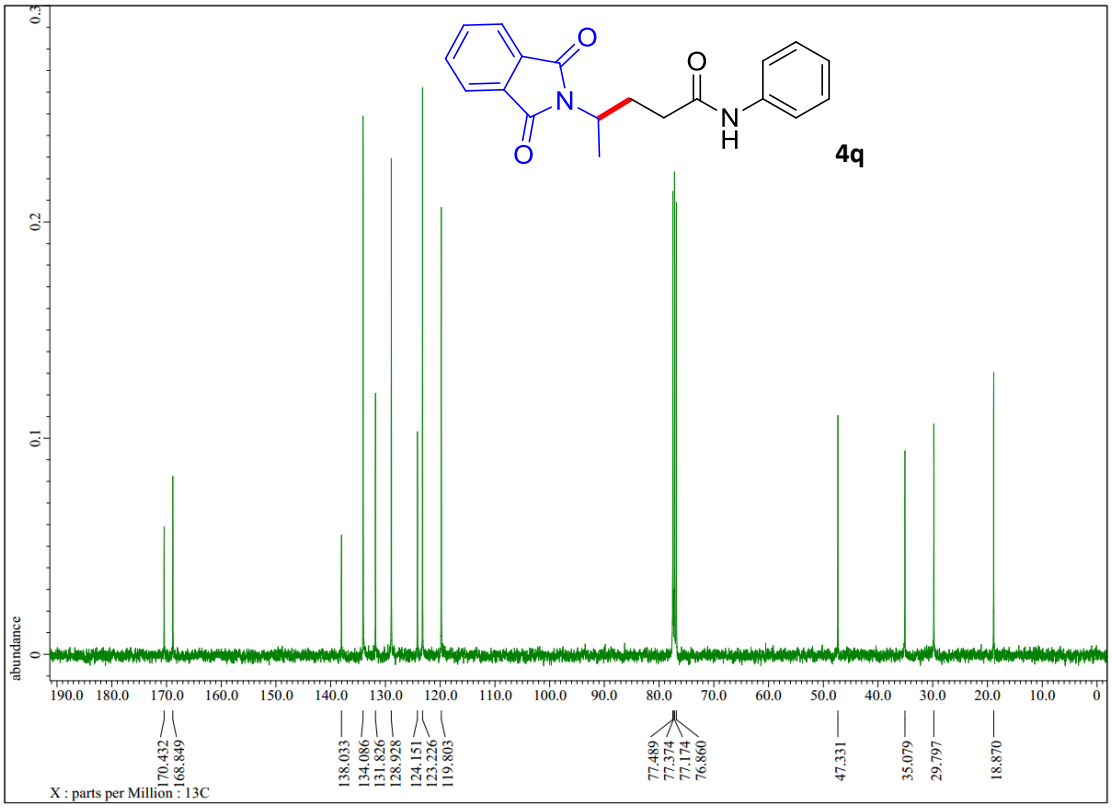

BocHN
O
N
H
O^{t}Bu
4o
abundance
X : parts per Million : 1H

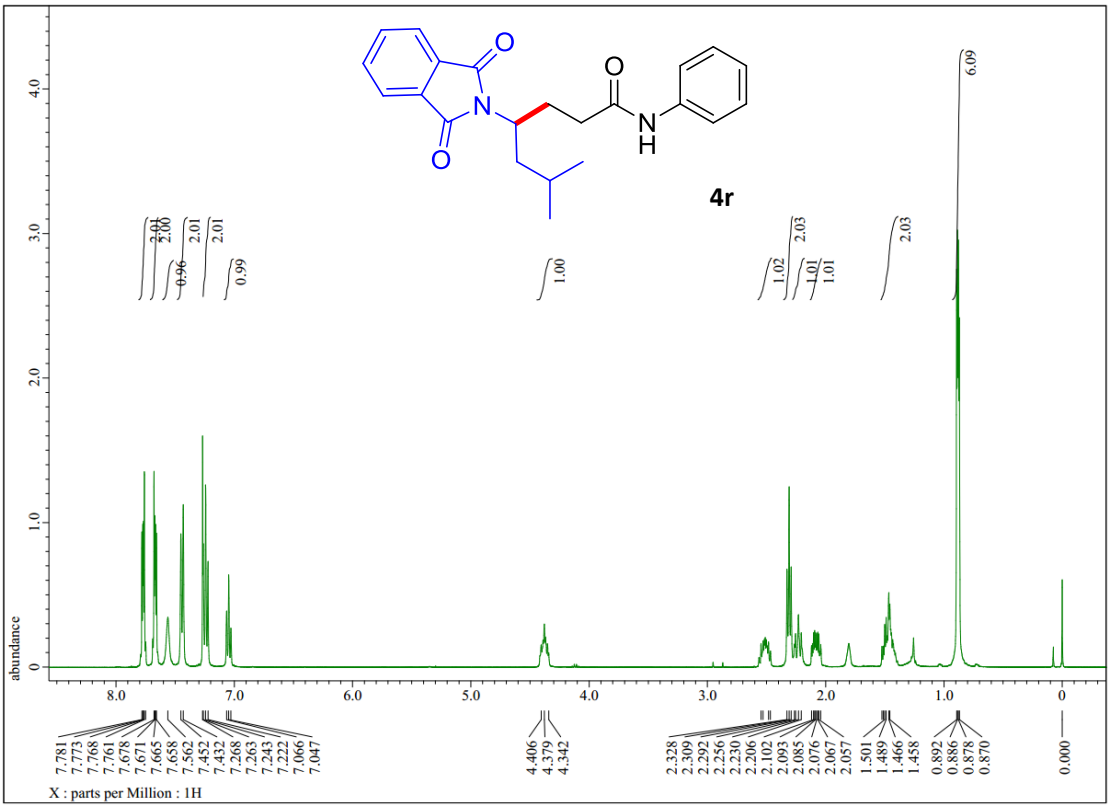

BocHN
O
N
H
O^{t}Bu
4o
abundance
X : parts per Million : 13C

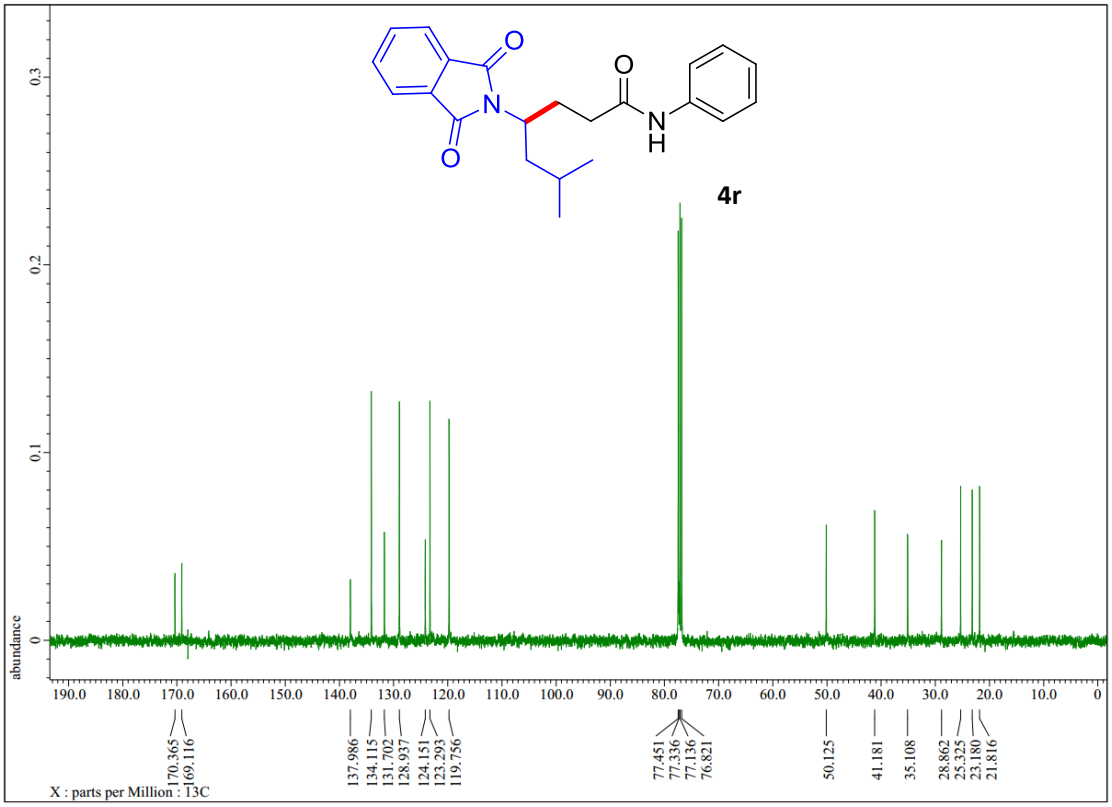

BocHN
O
N
H
COO^{t}Bu
4p
abundance
X : parts per Million : 1H

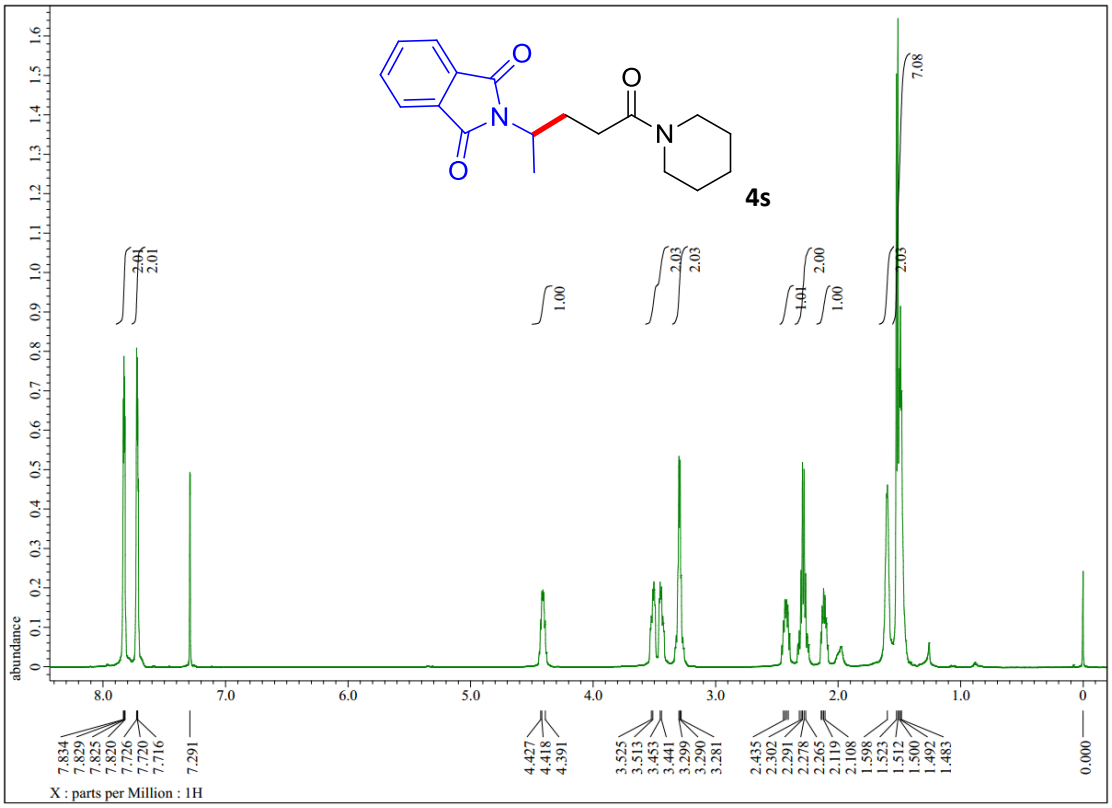

BocHN
O
N
H
COO^{t}Bu
4p
abundance
X : parts per Million : 13C

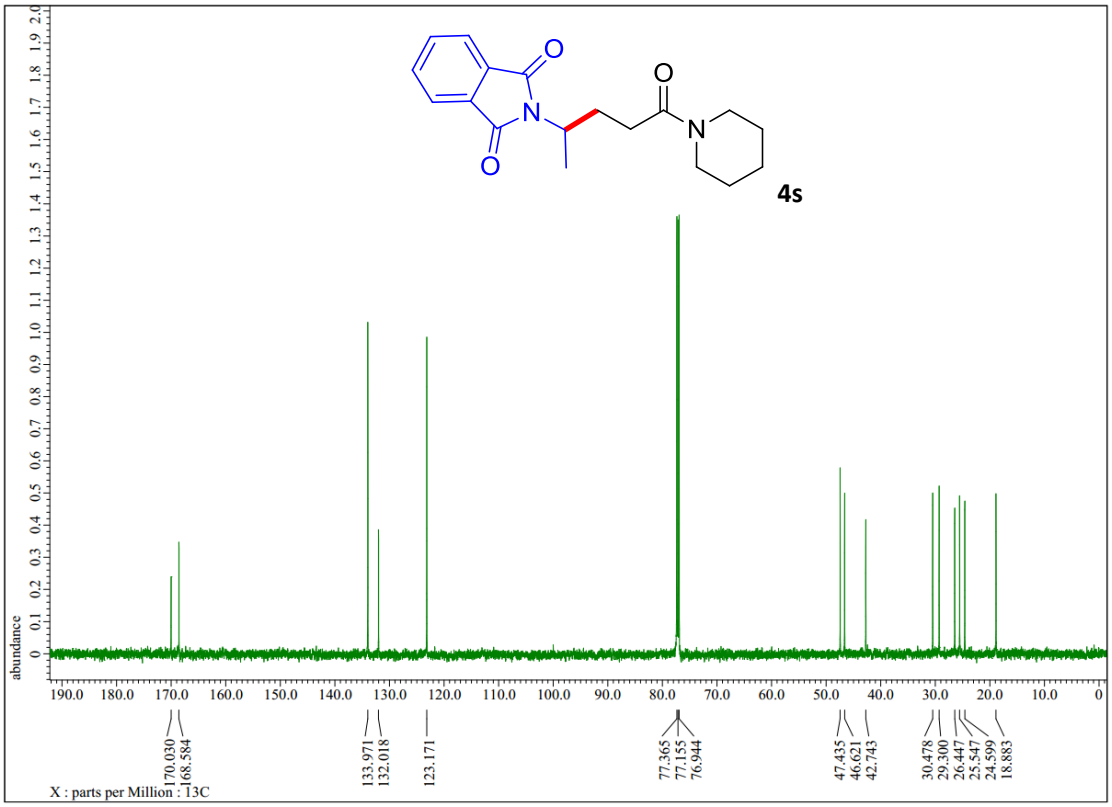

4q
5.00
1.99
2.02
1.00
0.97
1.03
1.99
1.02
3.05
abundance
X : parts per Million : 1H

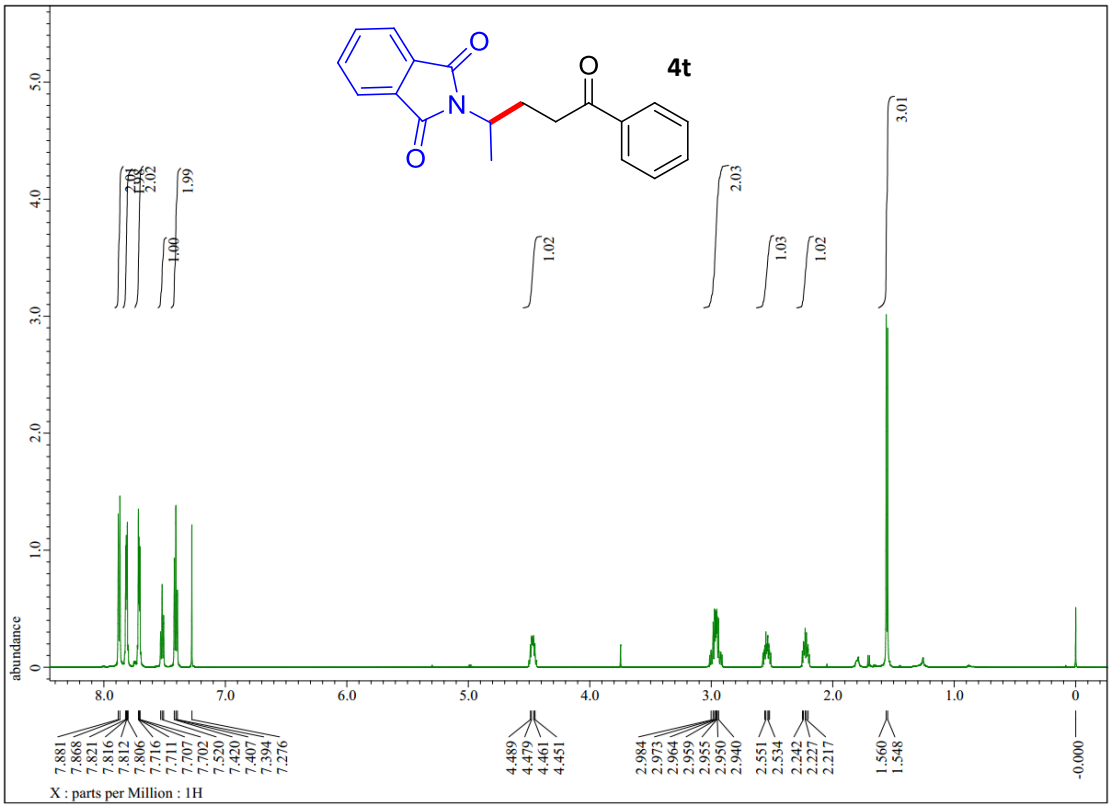

4q
abundance
X : parts per Million : 13C

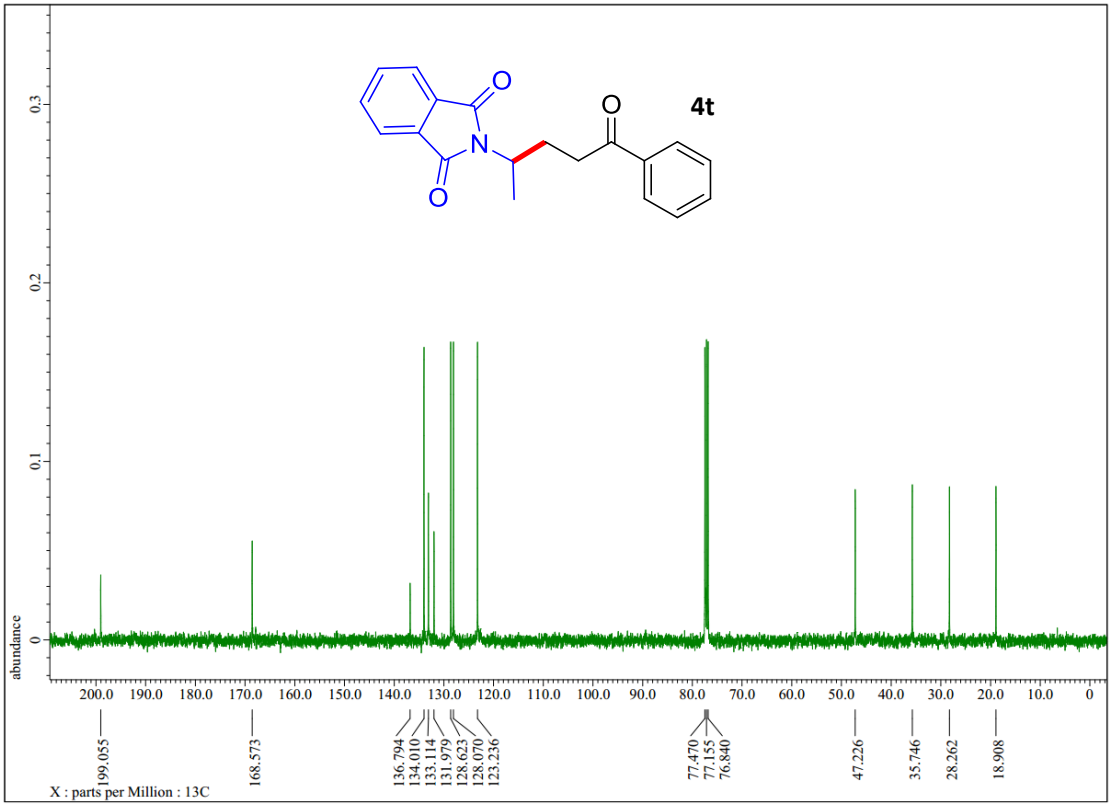

4r
abundance
X : parts per Million : 1H

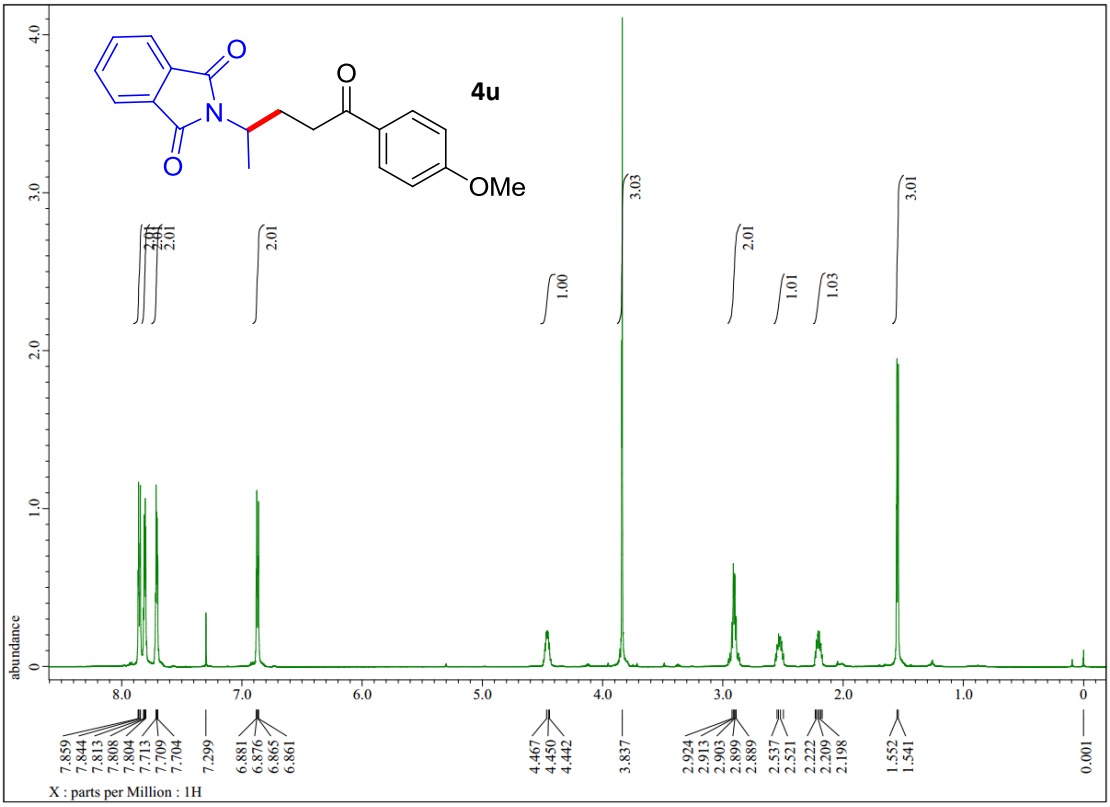

4r
abundance
X : parts per Million : 13C

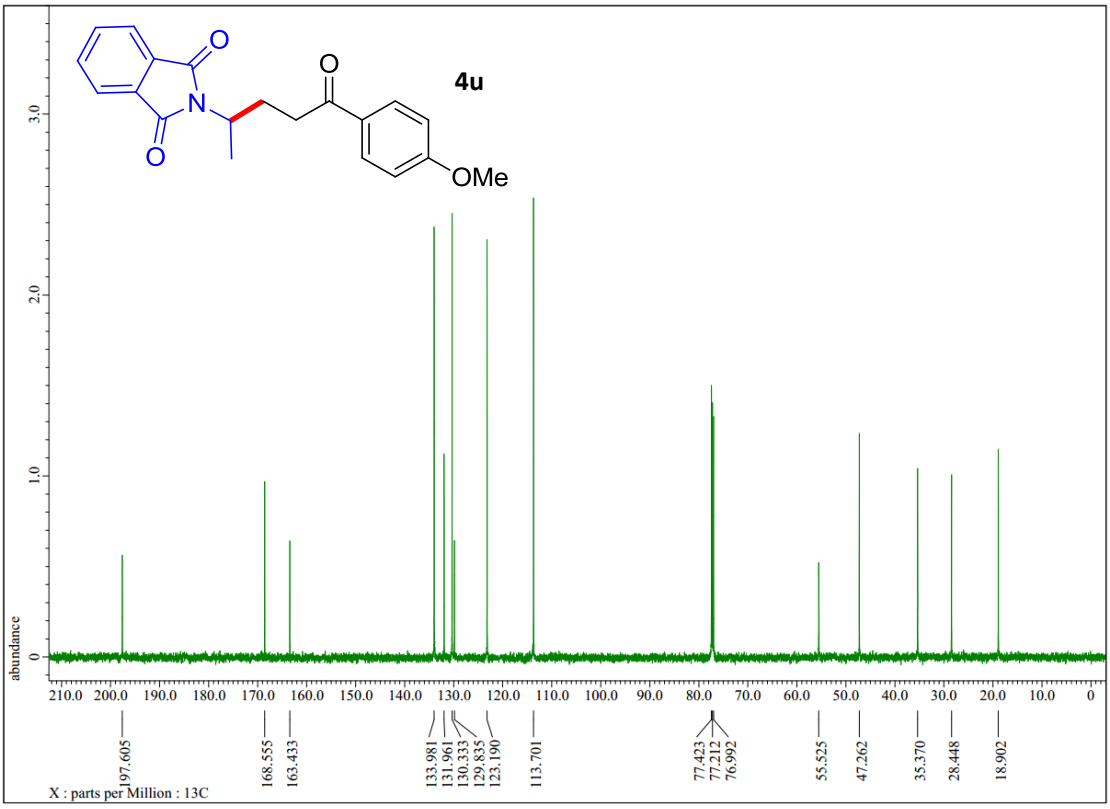

4s
abundance
X : parts per Million : 1H

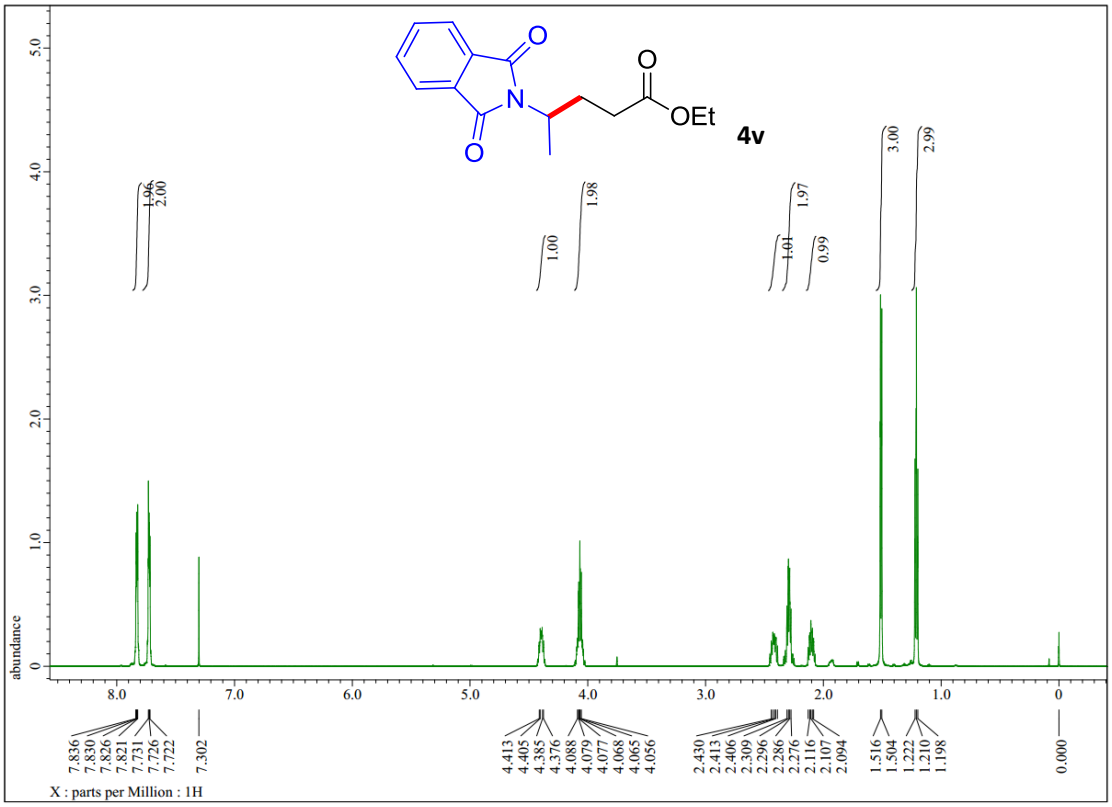

4s
abundance
X : parts per Million : 13C

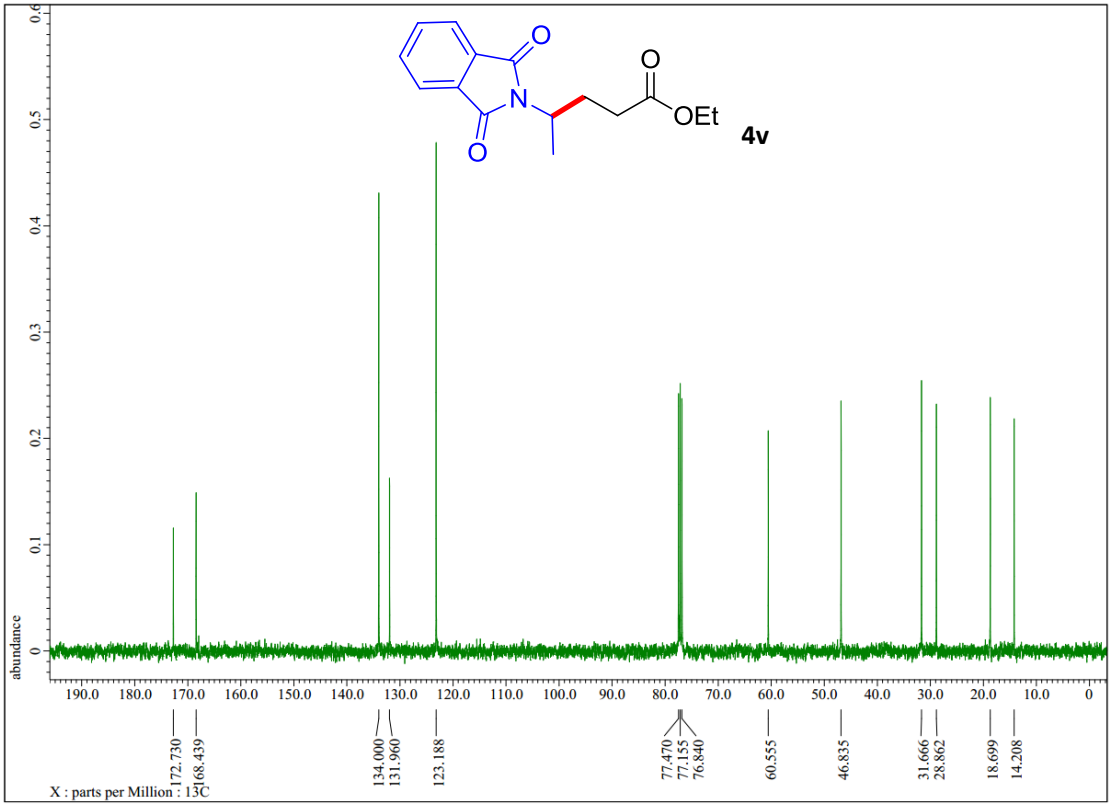

4t
abundance
X : parts per Million : 1H

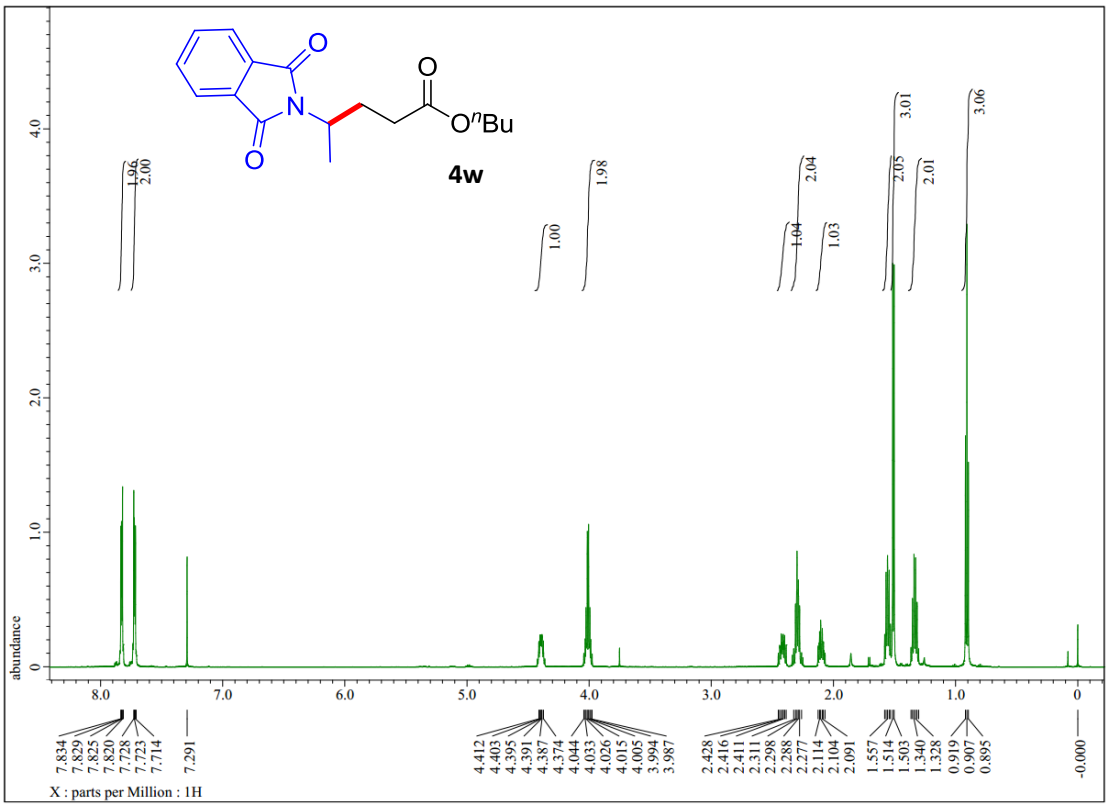

4t
abundance
X : parts per Million : 13C

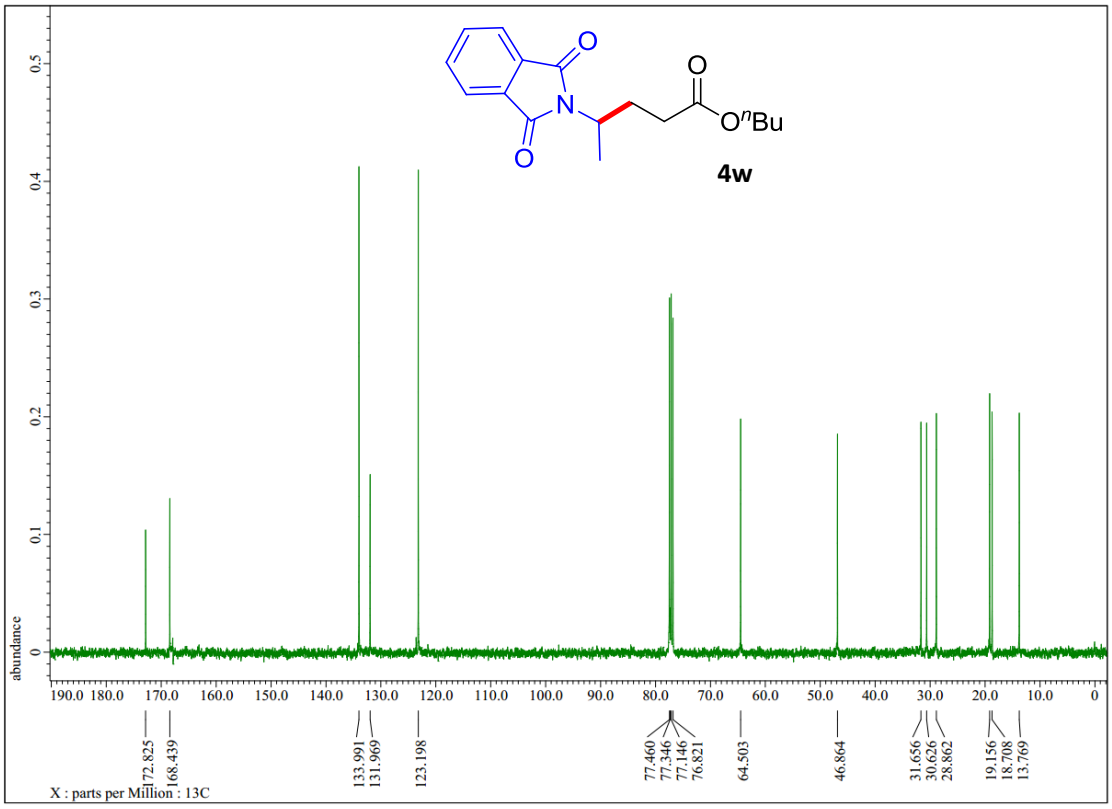

4u
OMe
abundance
X : parts per Million : 1H

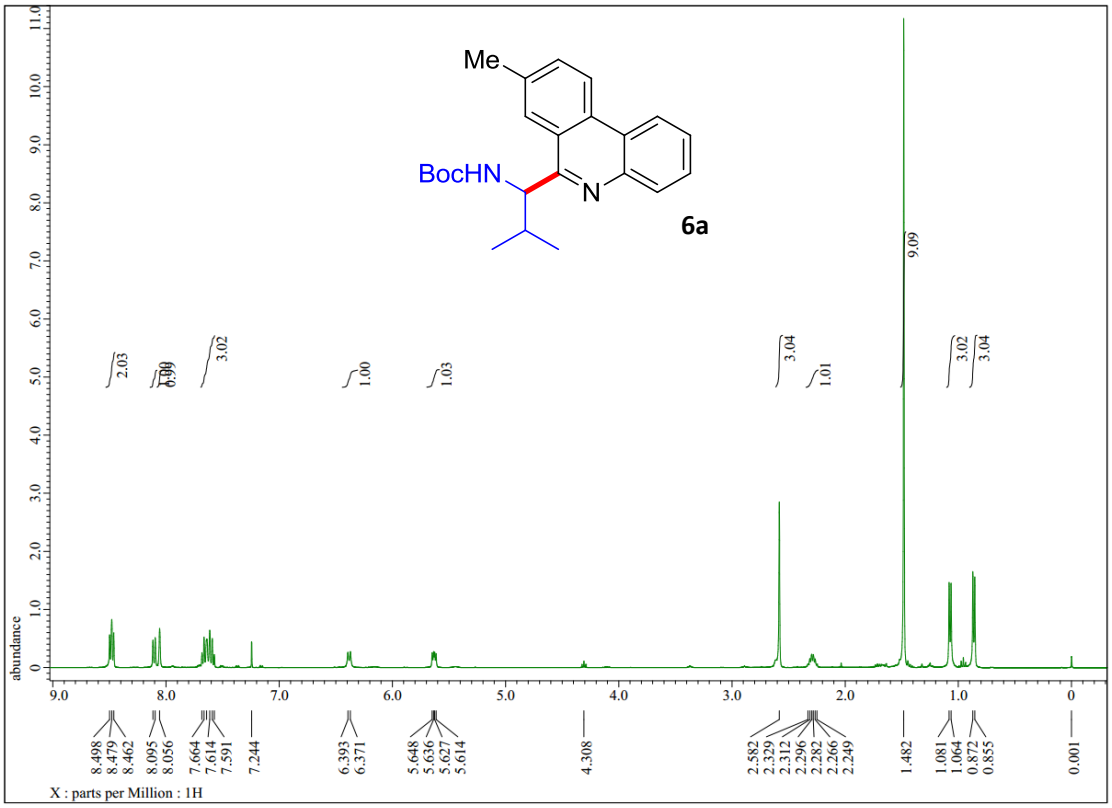

4u
OMe
abundance
X : parts per Million : 13C

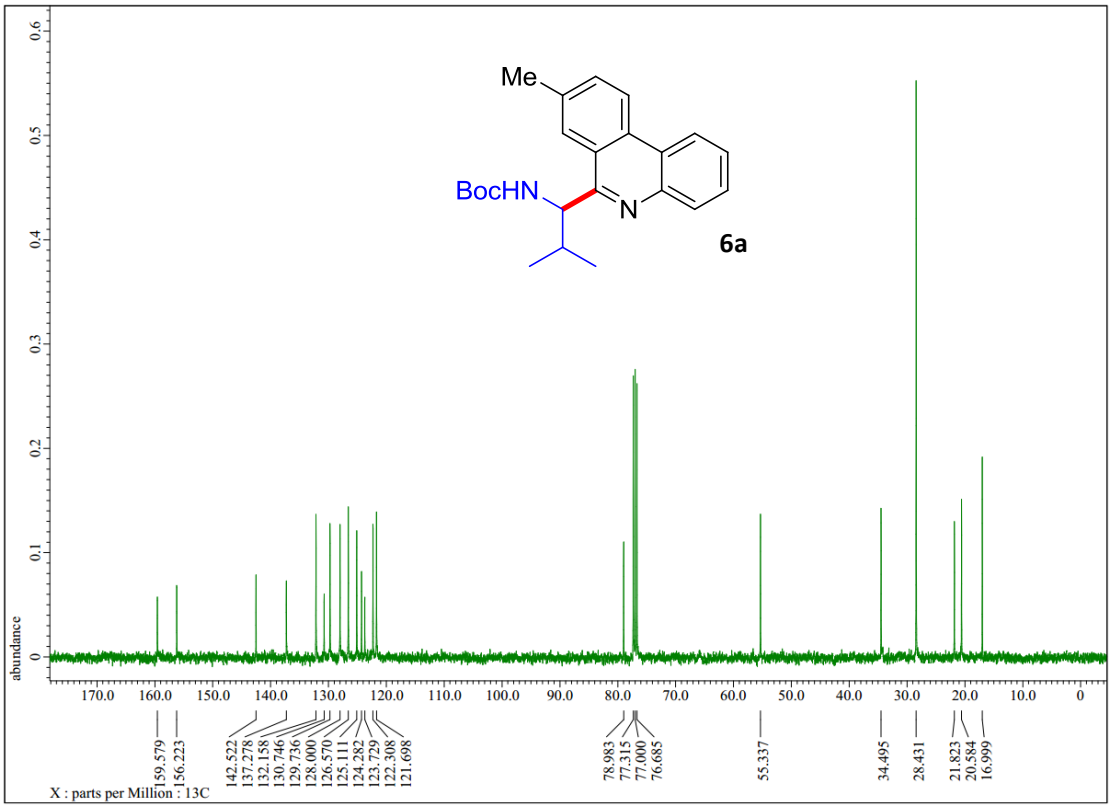

4v
abundance
X : parts per Million : 1H

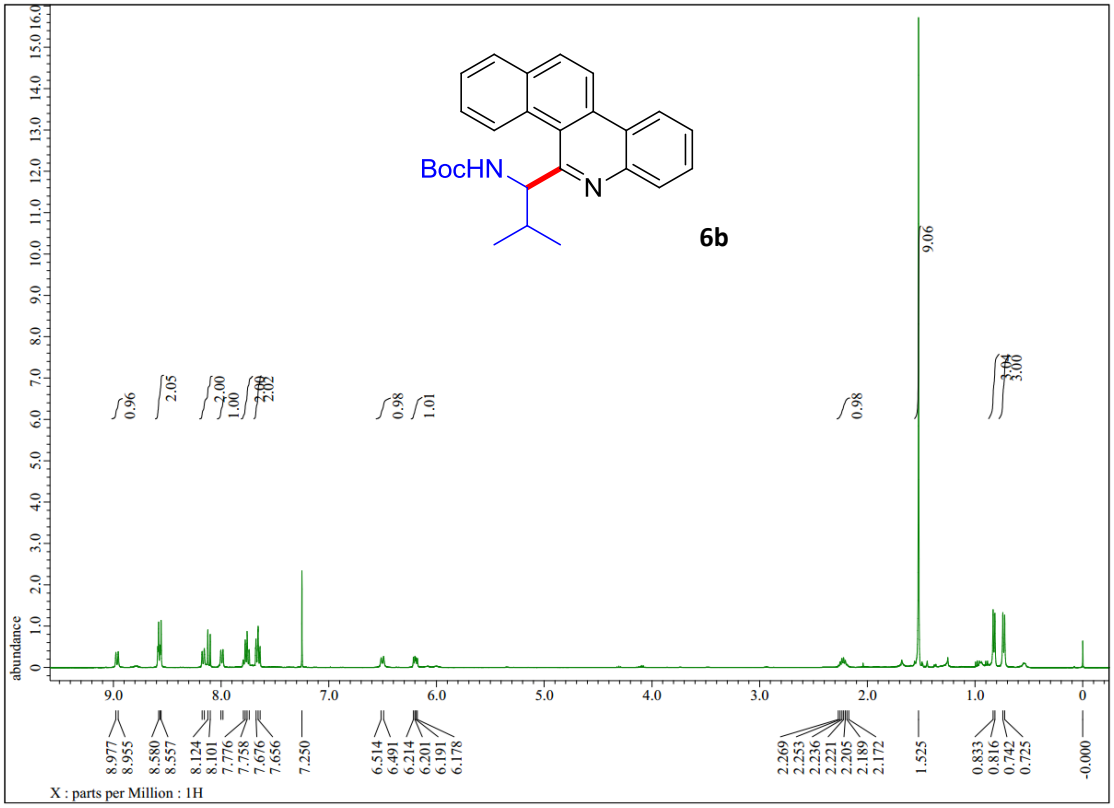

4v
abundance
X : parts per Million : 13C

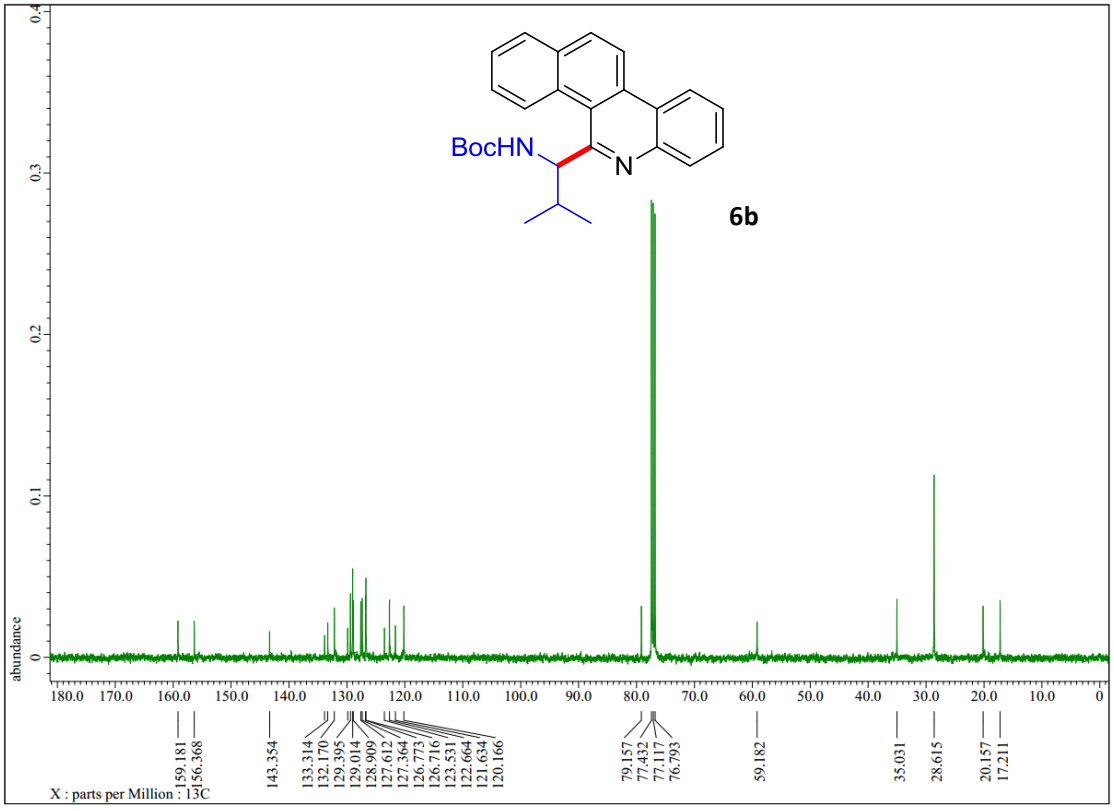

4w
abundance
X : parts per Million : 1H

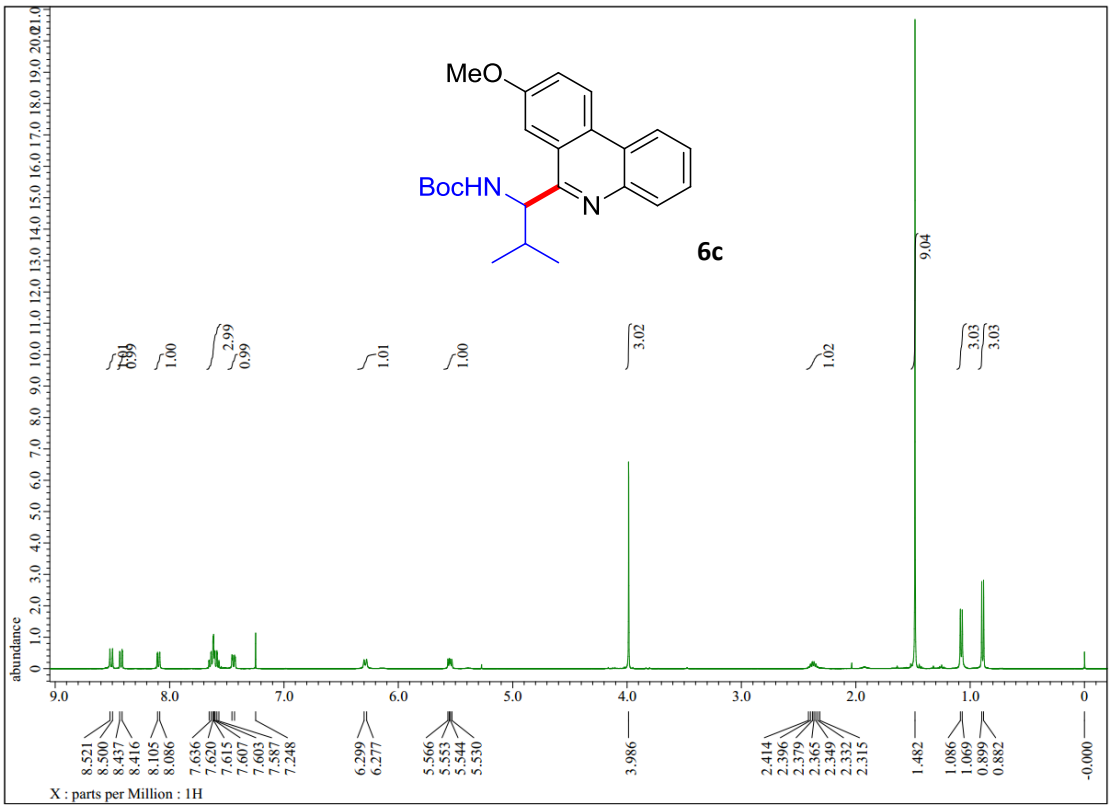

4w
abundance
X : parts per Million : 13C

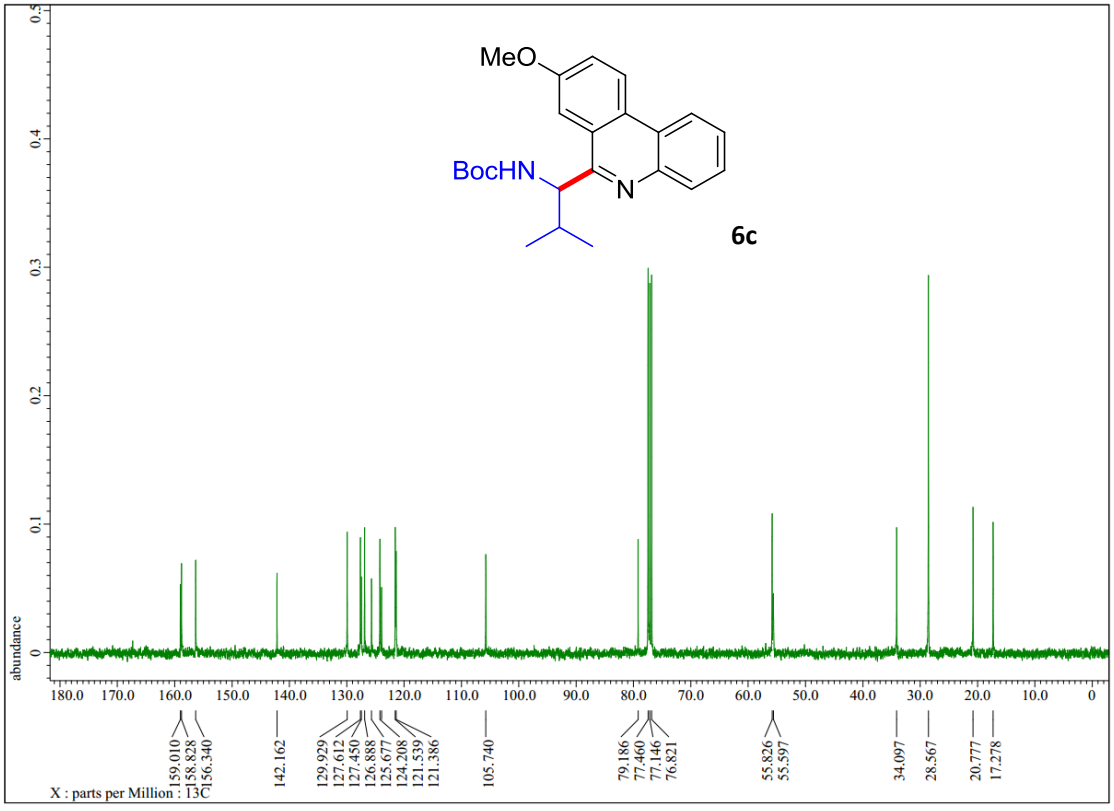

Me
BocHN
N
6a
abundance
X : parts per Million : 1H

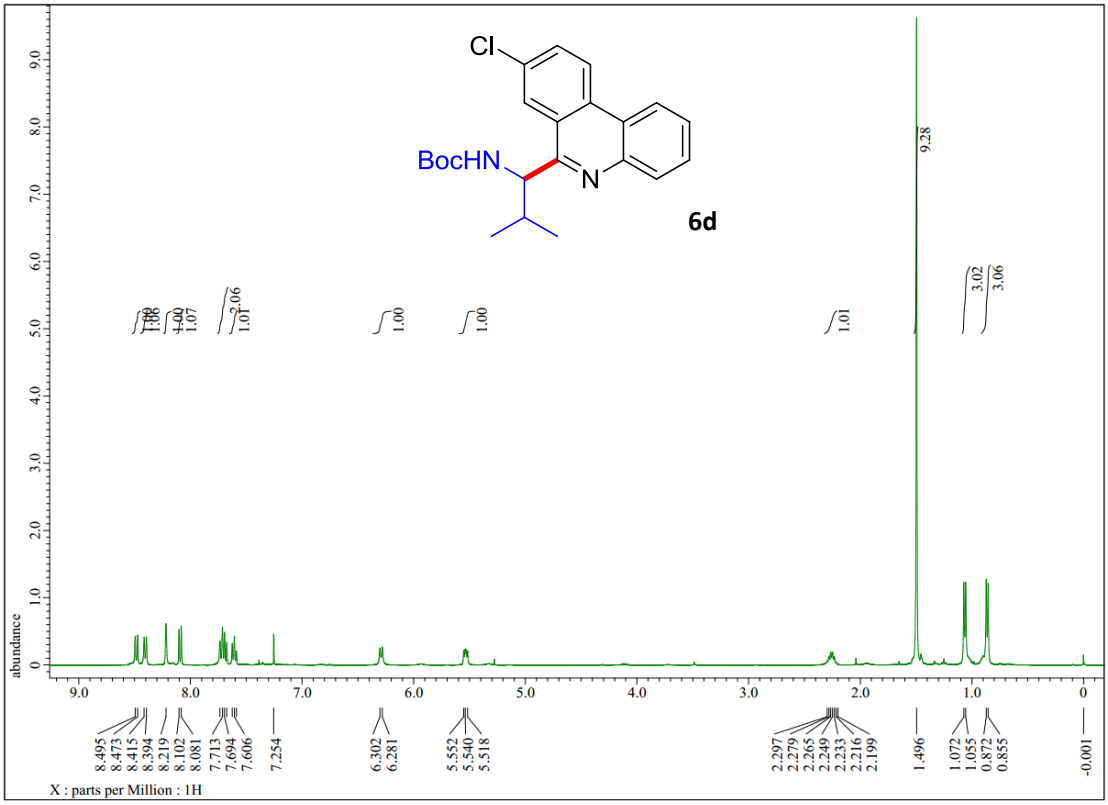

Me
BocHN
N
6a
abundance
X : parts per Million : 13C

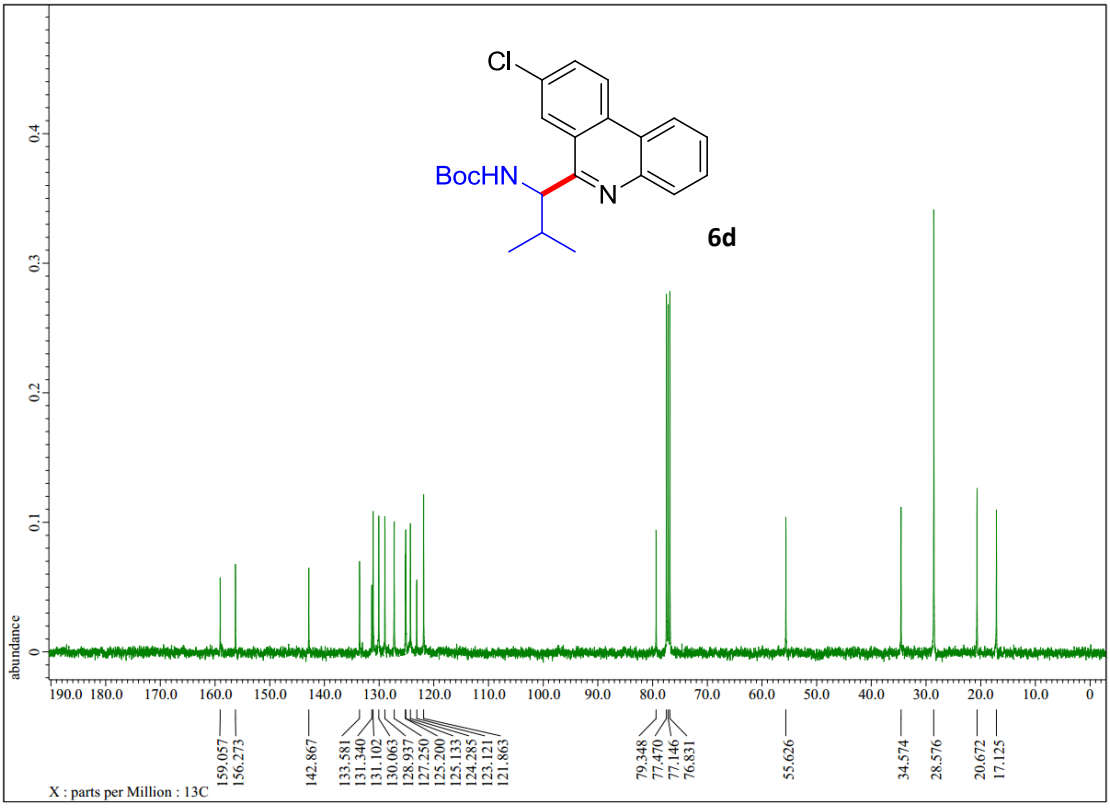

BocHN
N
6b
abundance
X : parts per Million : 1H

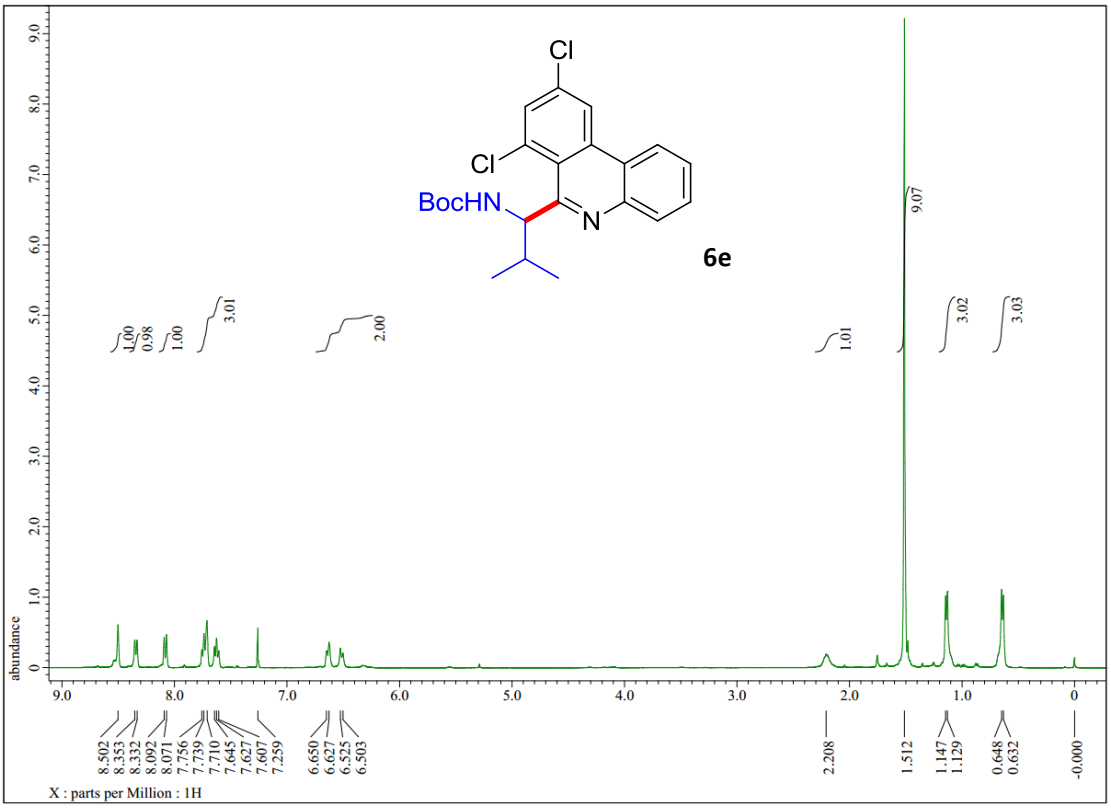

BocHN
N
6b
abundance
X : parts per Million : 13C

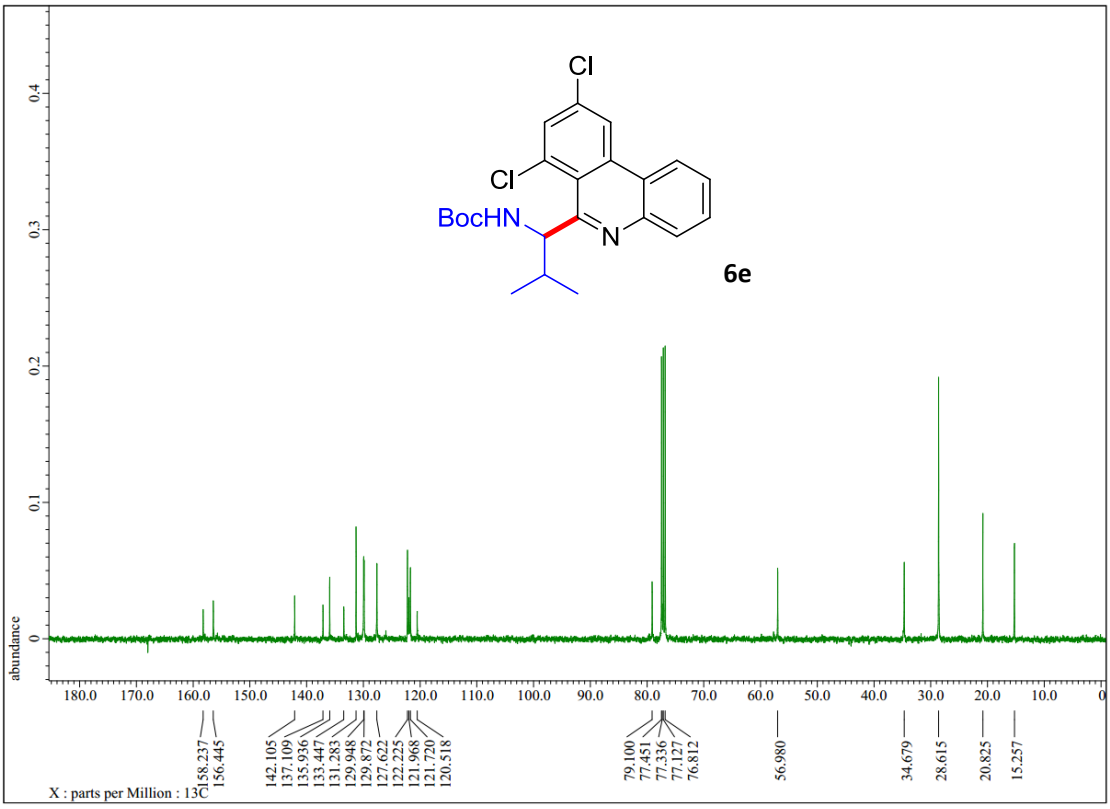

MeO
BocHN
N
6c
abundance
X : parts per Million : 1H

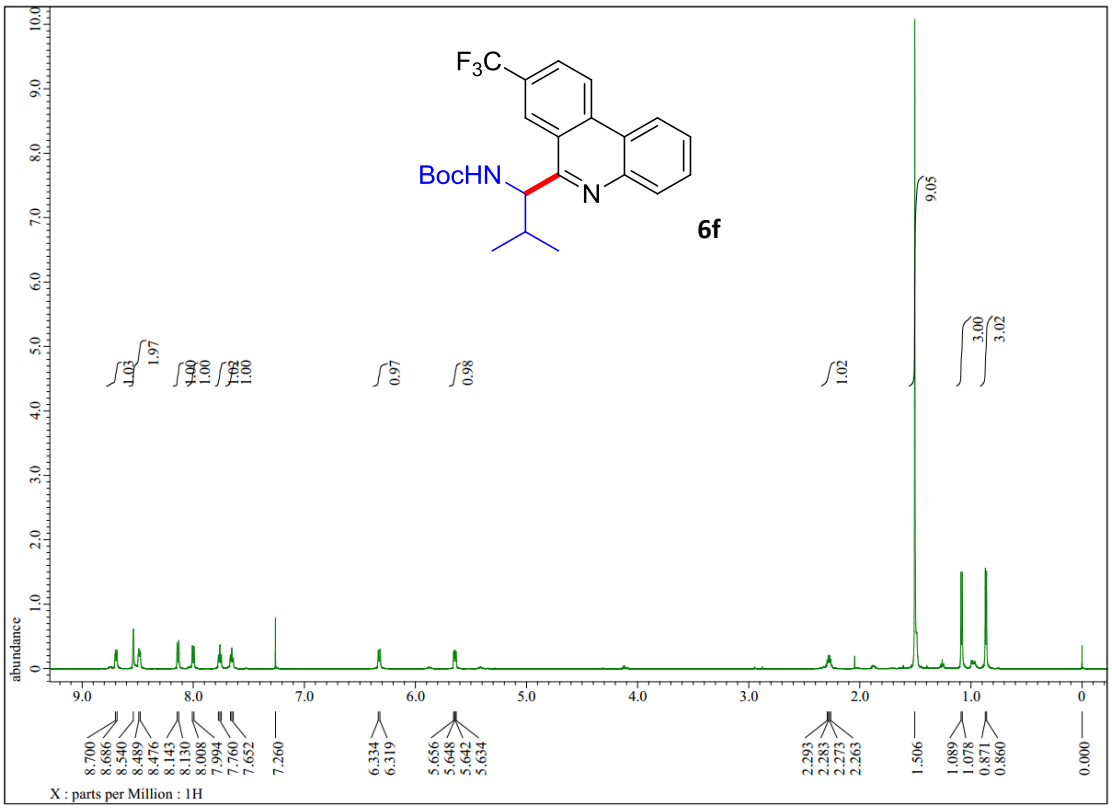

MeO
BocHN
N
6c
abundance
X : parts per Million : 13C

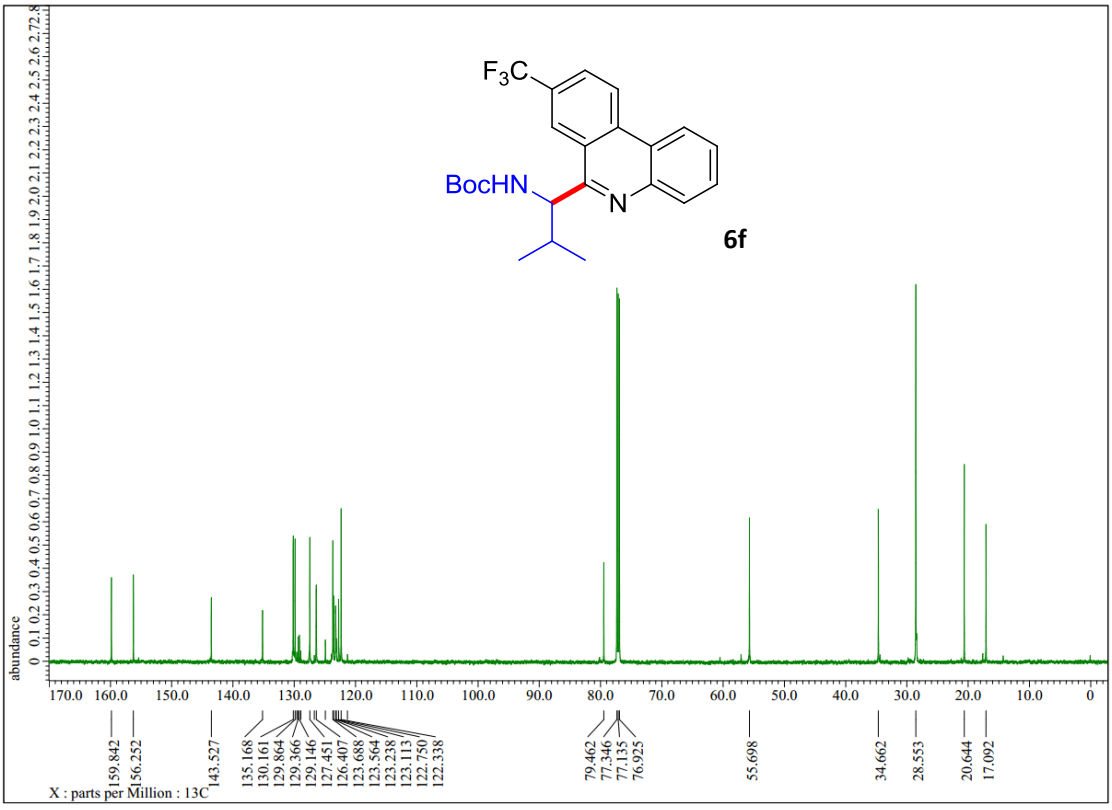

Cl
BocHN
N
6d
abundance
X : parts per Million : 1H

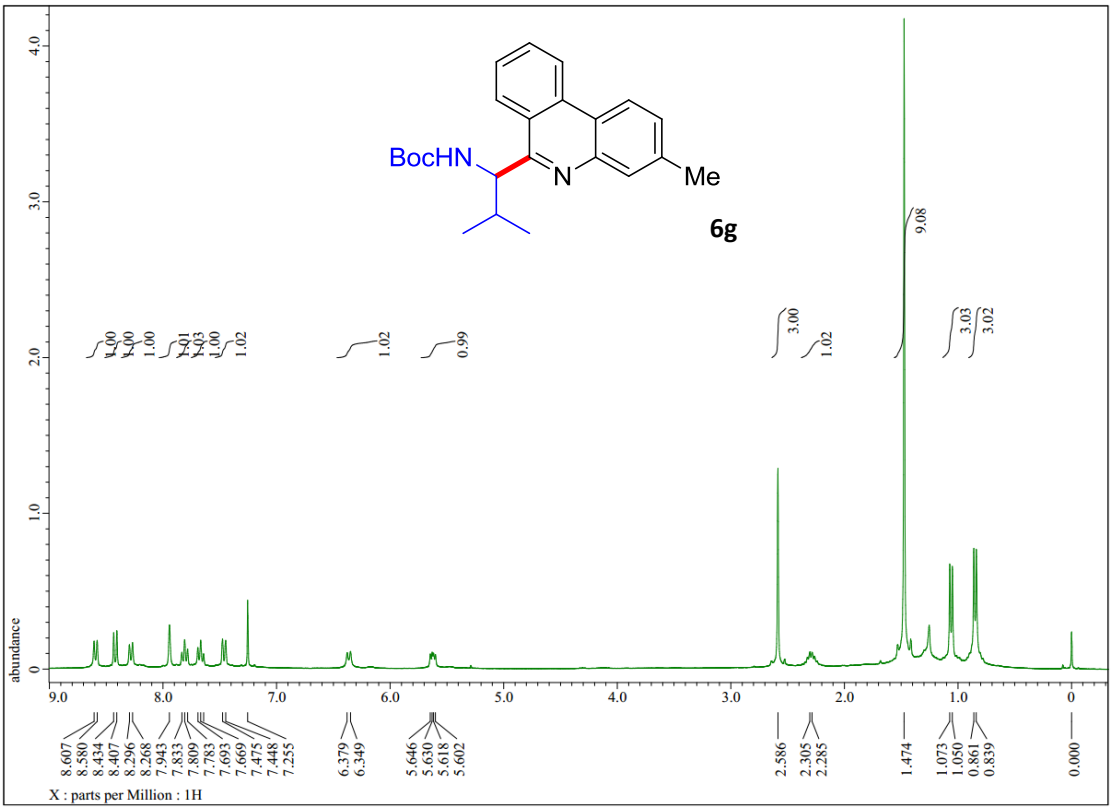

Cl
BocHN
N
6d
abundance
X : parts per Million : 13C

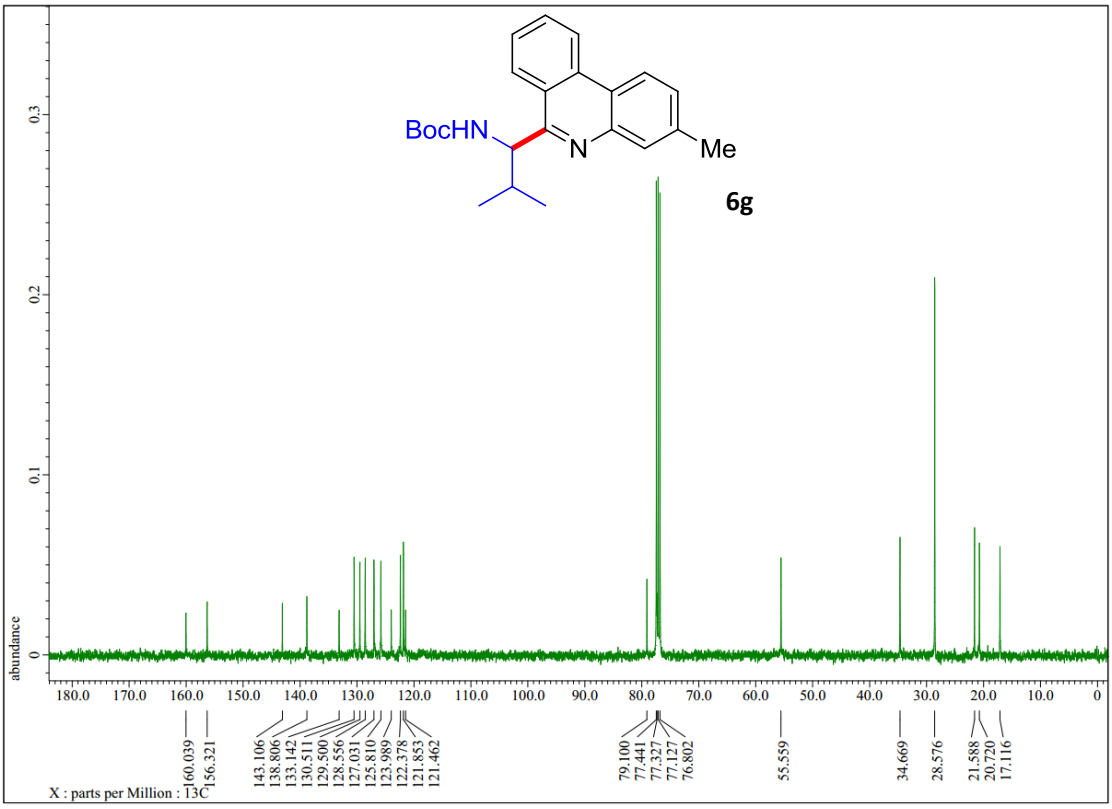

Cl
Cl
BocHN
N
6e
abundance
X : parts per Million : 1H
8.502
8.353
8.332
8.092
8.071
7.756
7.739
7.710
7.645
7.627
7.607
7.259
6.650
6.627
6.525
6.503
2.208
1.512
1.147
1.129
0.648
0.632
-0.000

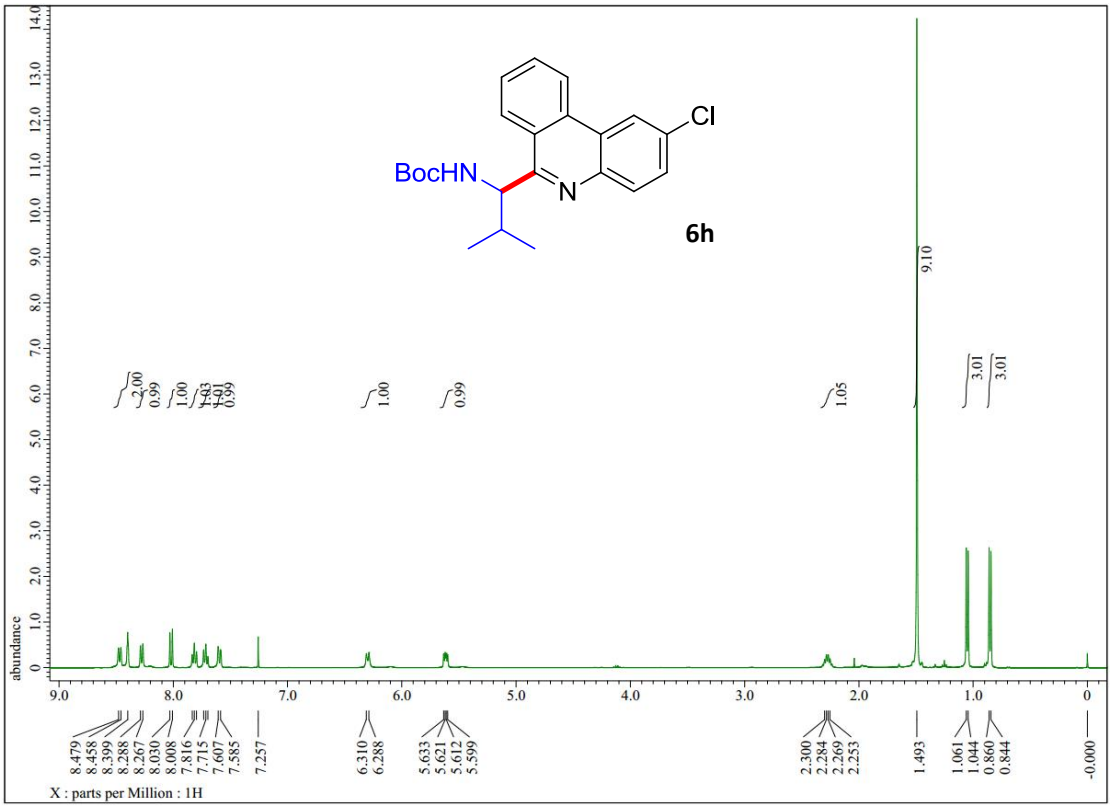

Cl
Cl
BocHN
N
6e
abundance
X : parts per Million : 13C
158.237
156.445
142.105
137.109
135.936
133.447
131.283
129.948
129.872
127.622
122.225
121.968
121.720
120.518
79.100
77.451
77.336
77.127
76.812
56.980
34.679
28.615
20.825
15.257

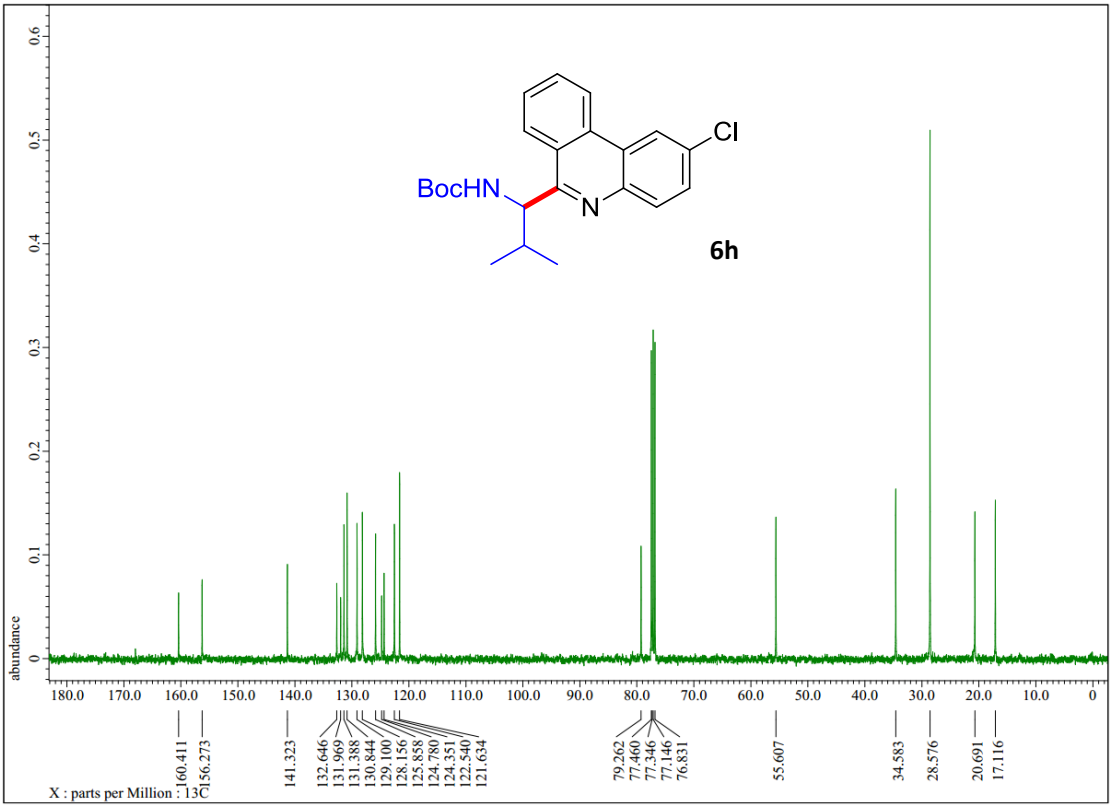

F3C
BocHN
N
6f
abundance
X : parts per Million : 1H

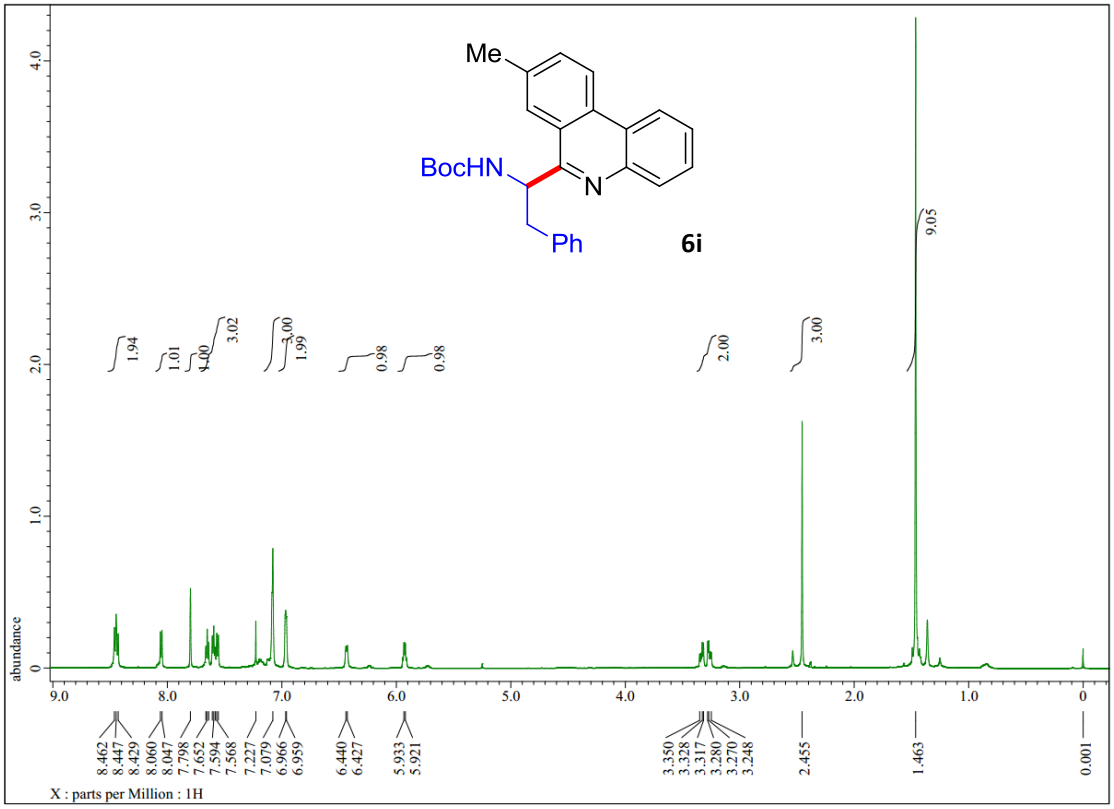

F3C
BocHN
N
6f
abundance
X : parts per Million : 13C

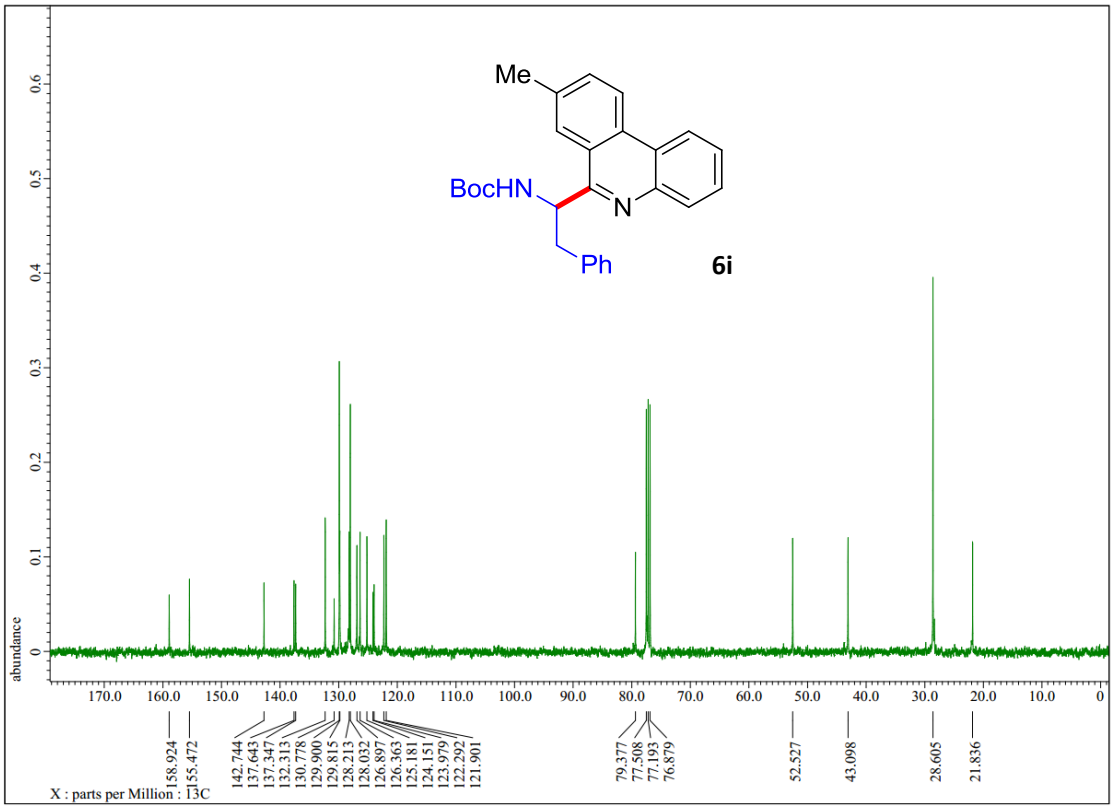

BocHN
N
Me
6g
abundance
X : parts per Million : 1H

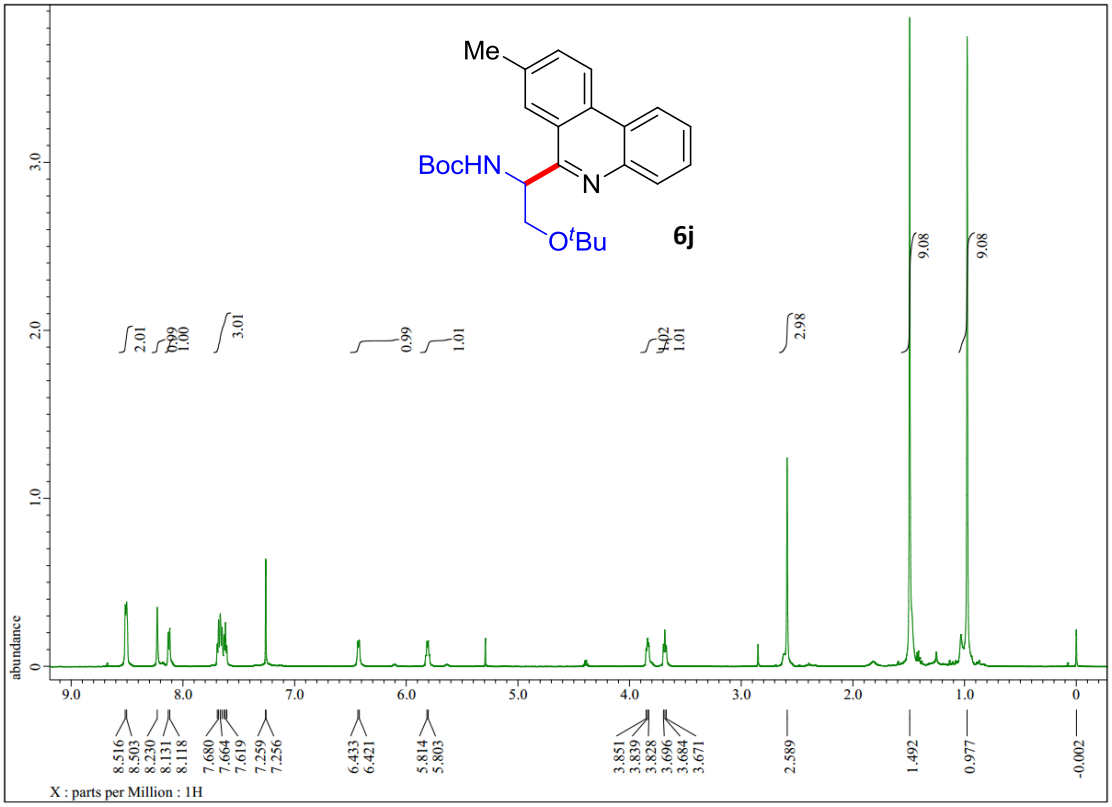

BocHN
N
Me
6g
abundance
X : parts per Million : 13C

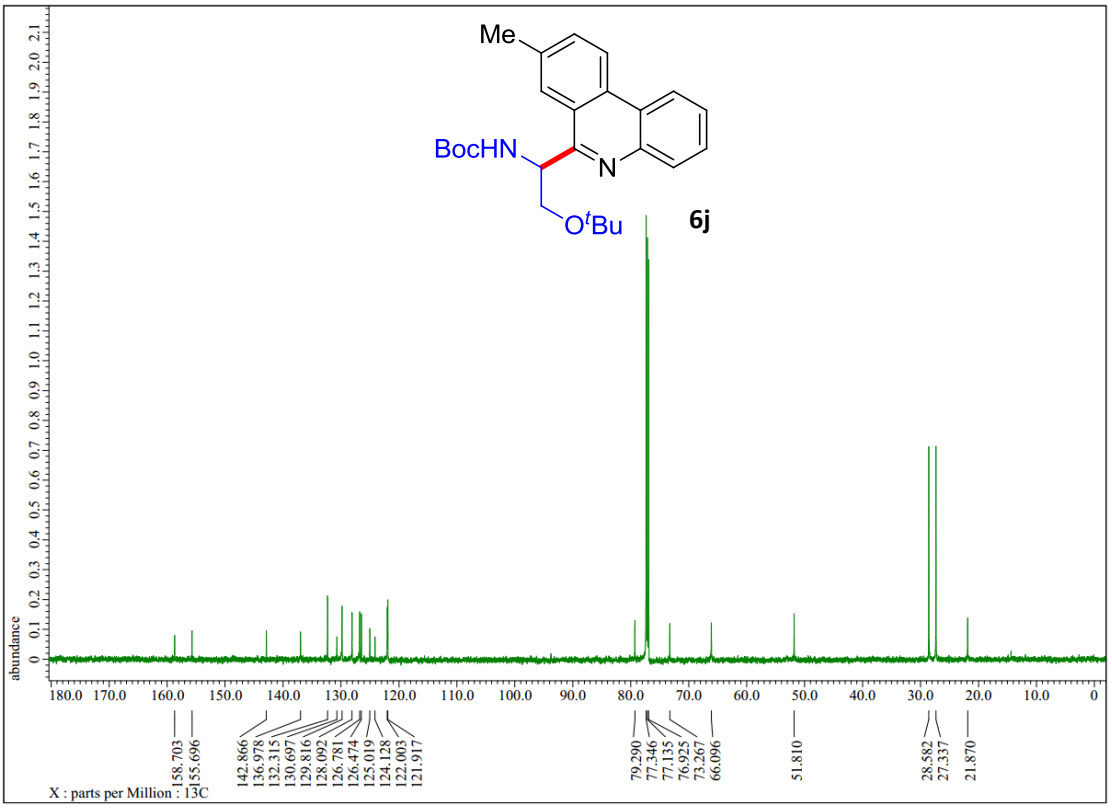

BocHN
Cl
N
6h
abundance
X : parts per Million : 1H

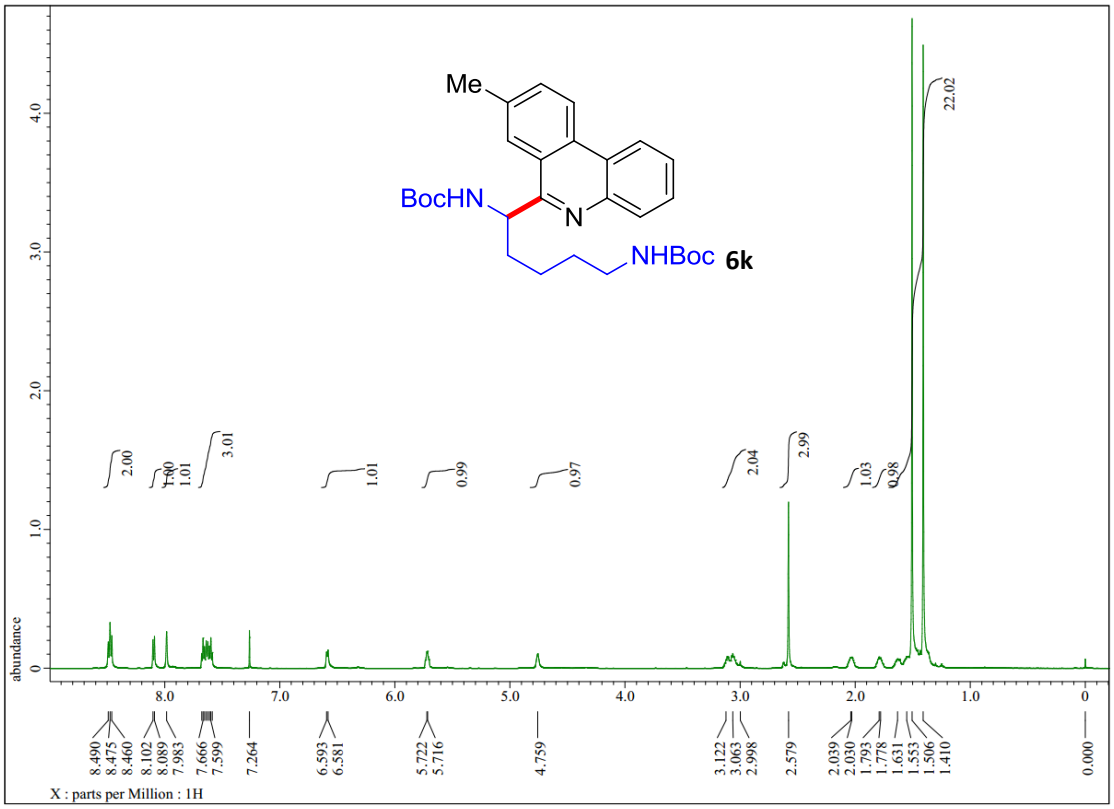

BocHN
Cl
N
6h
abundance
X : parts per Million : 13C

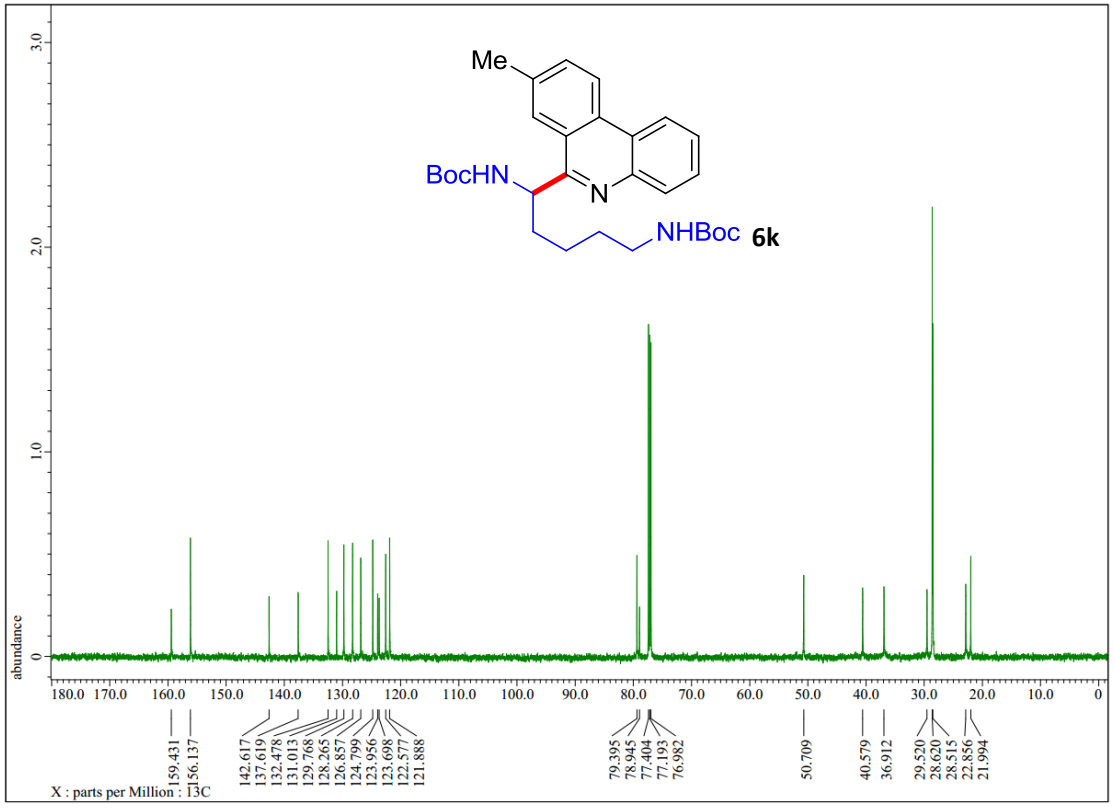

Me
BocHN
N
Ph
6i
abundance
X : parts per Million : 1H

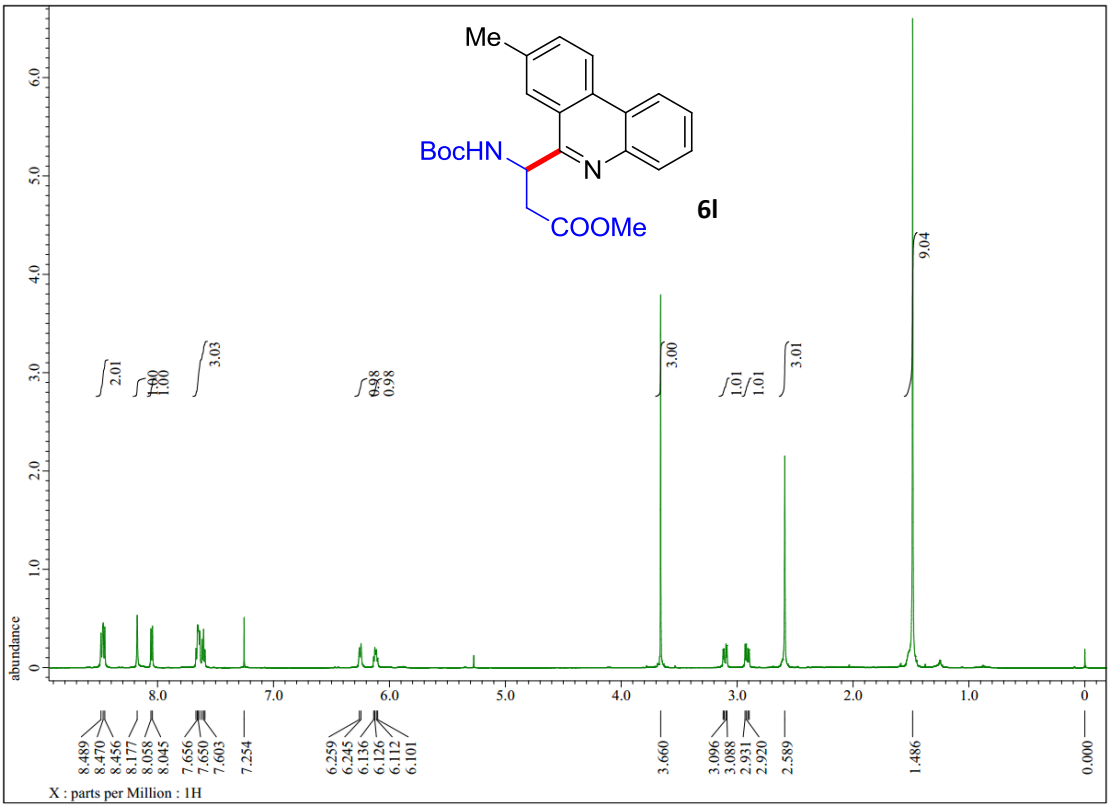

Me
BocHN
N
Ph
6i
abundance
X : parts per Million : 13C

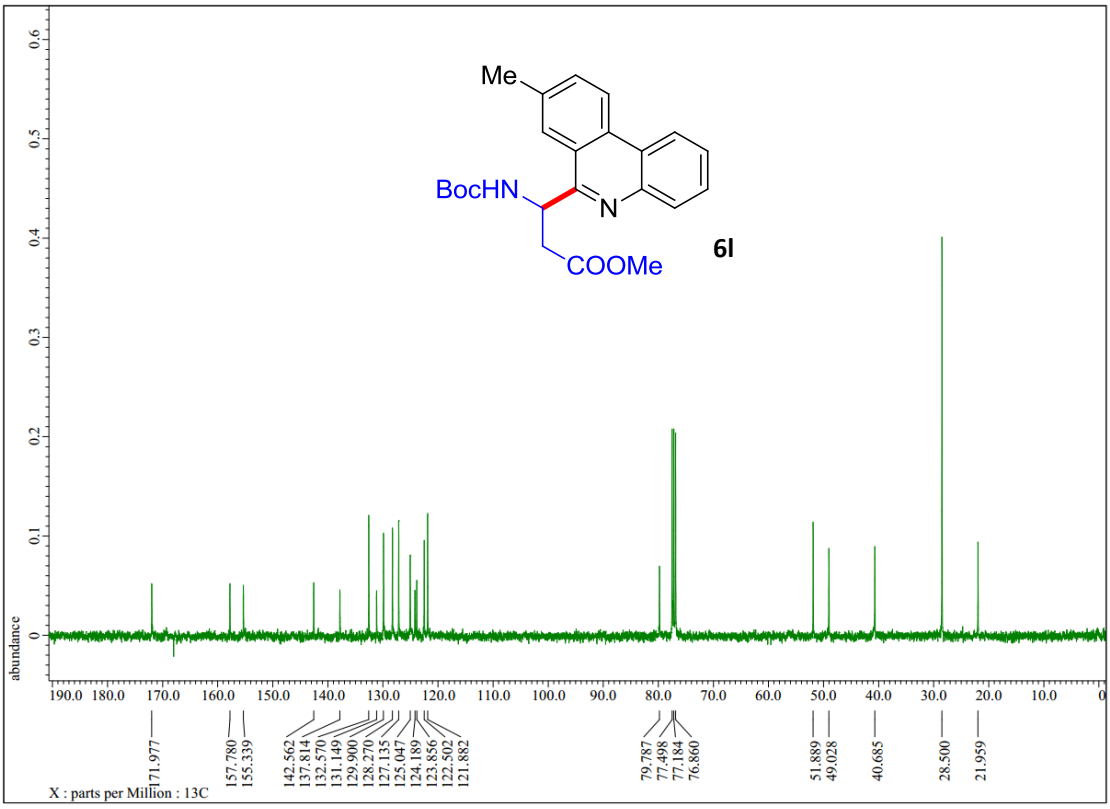

Me
BocHN
N
O^{t}Bu
6j
abundance
X : parts per Million : 1H

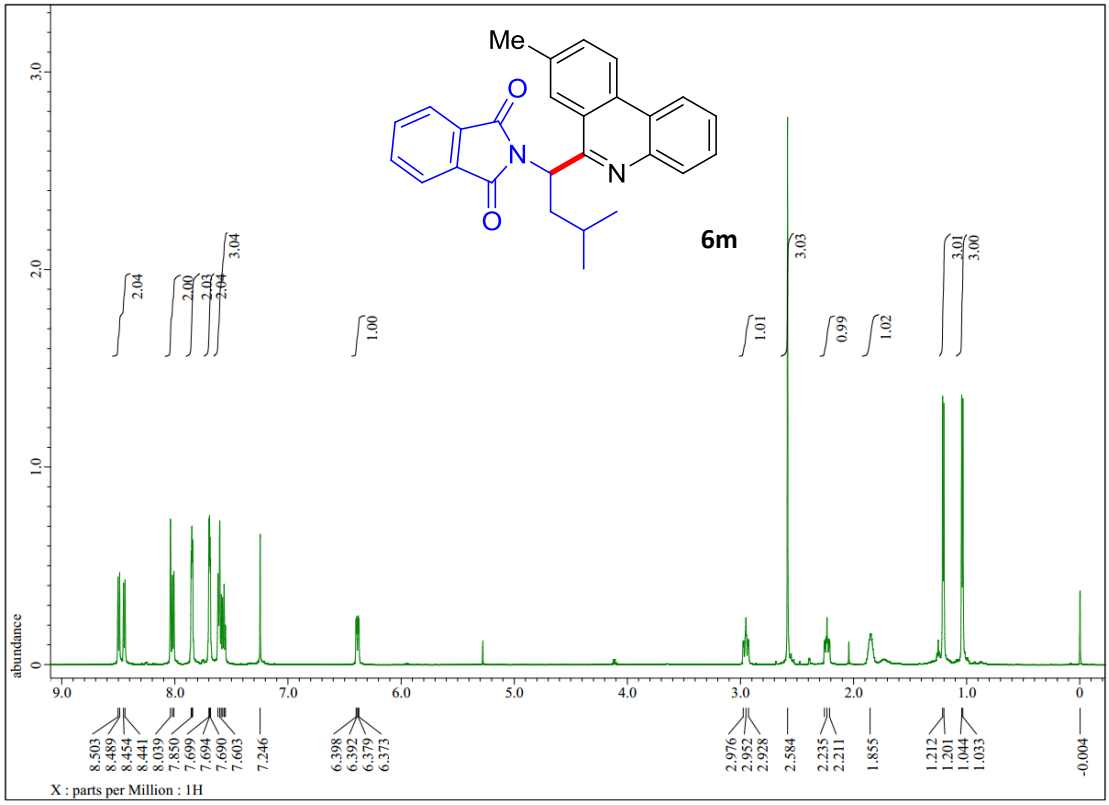

Me
BocHN
N
O^{t}Bu
6j
abundance
X : parts per Million : 13C

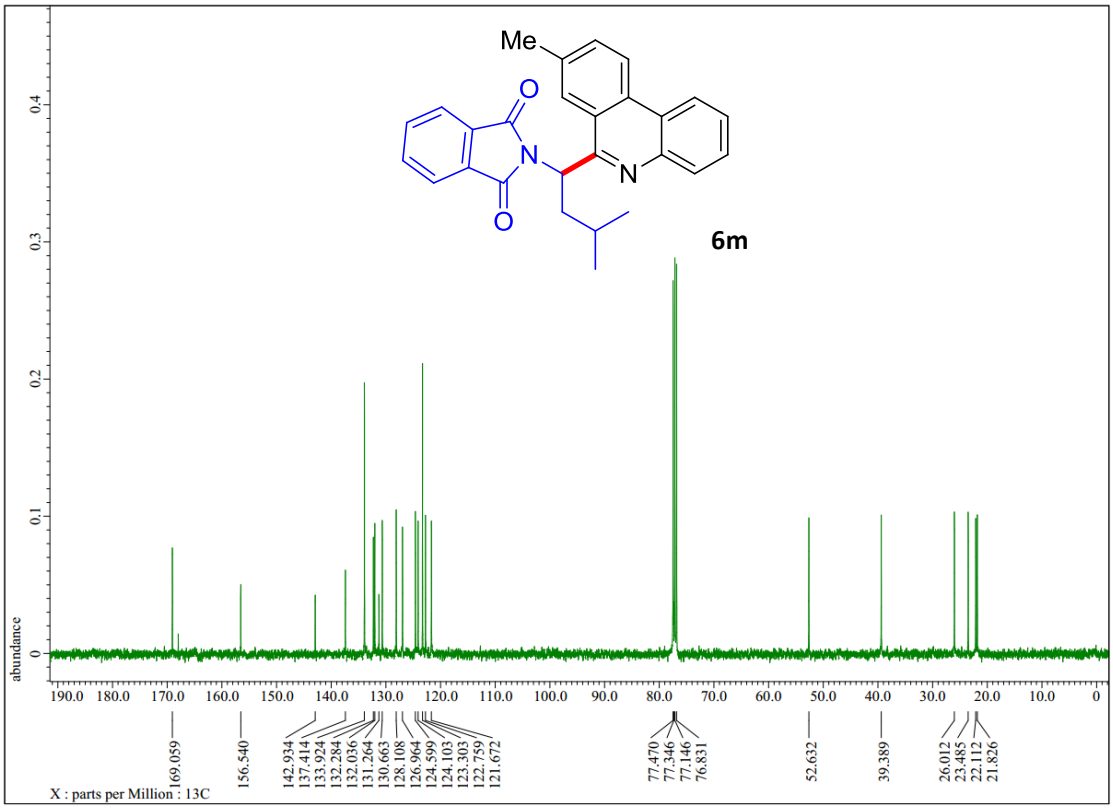

Me
BocHN
N
NHBoc
6k
abundance
X : parts per Million : 1H

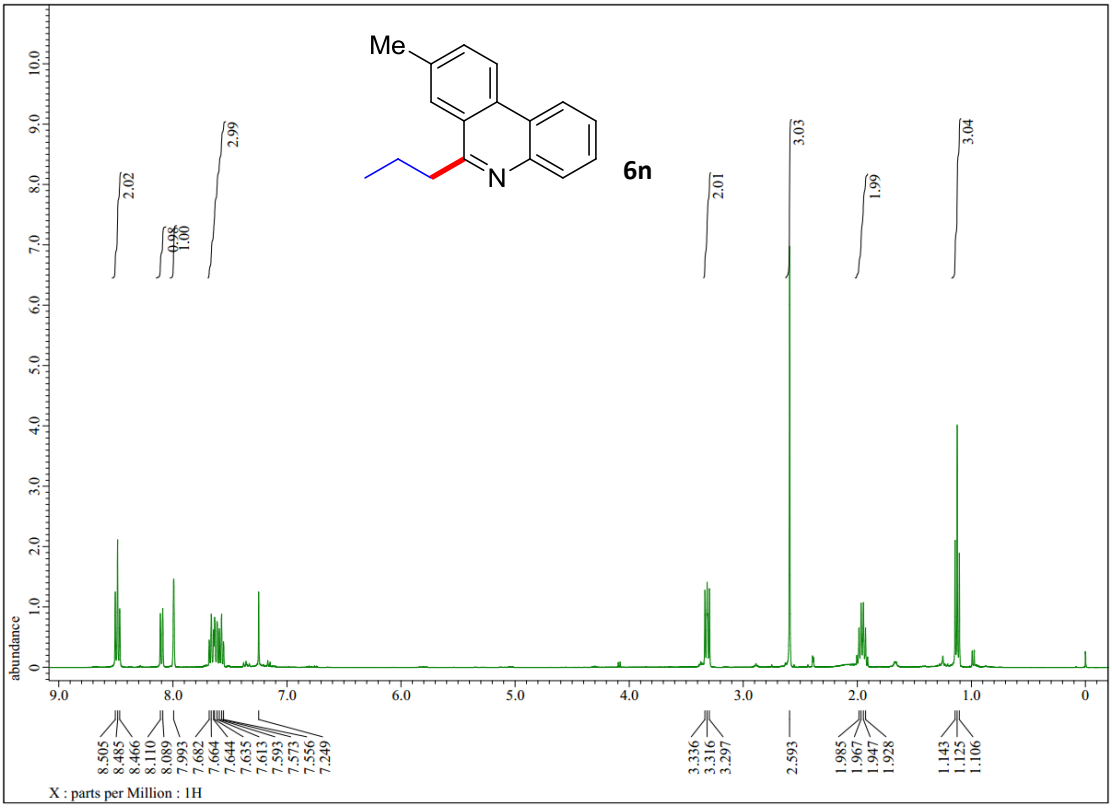

Me
BocHN
N
NHBoc
6k
abundance
X : parts per Million : 13C

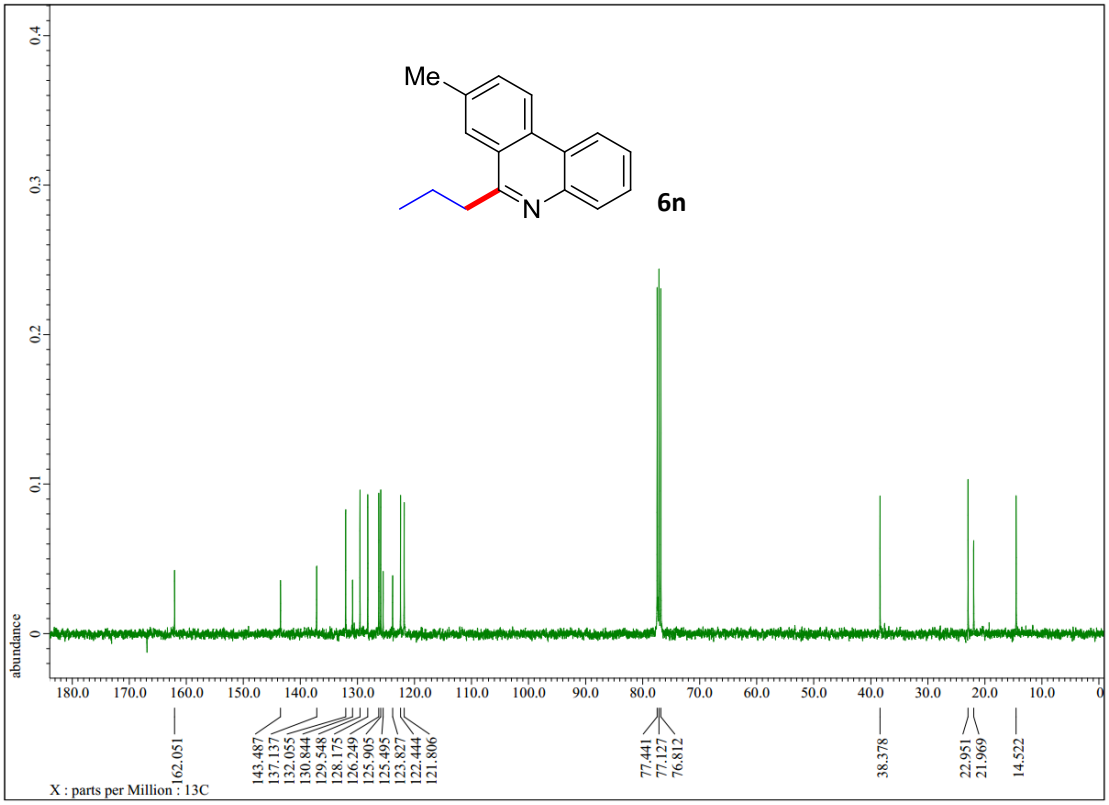

Me
BocHN
N
COOMe
6l
abundance
X : parts per Million : 1H

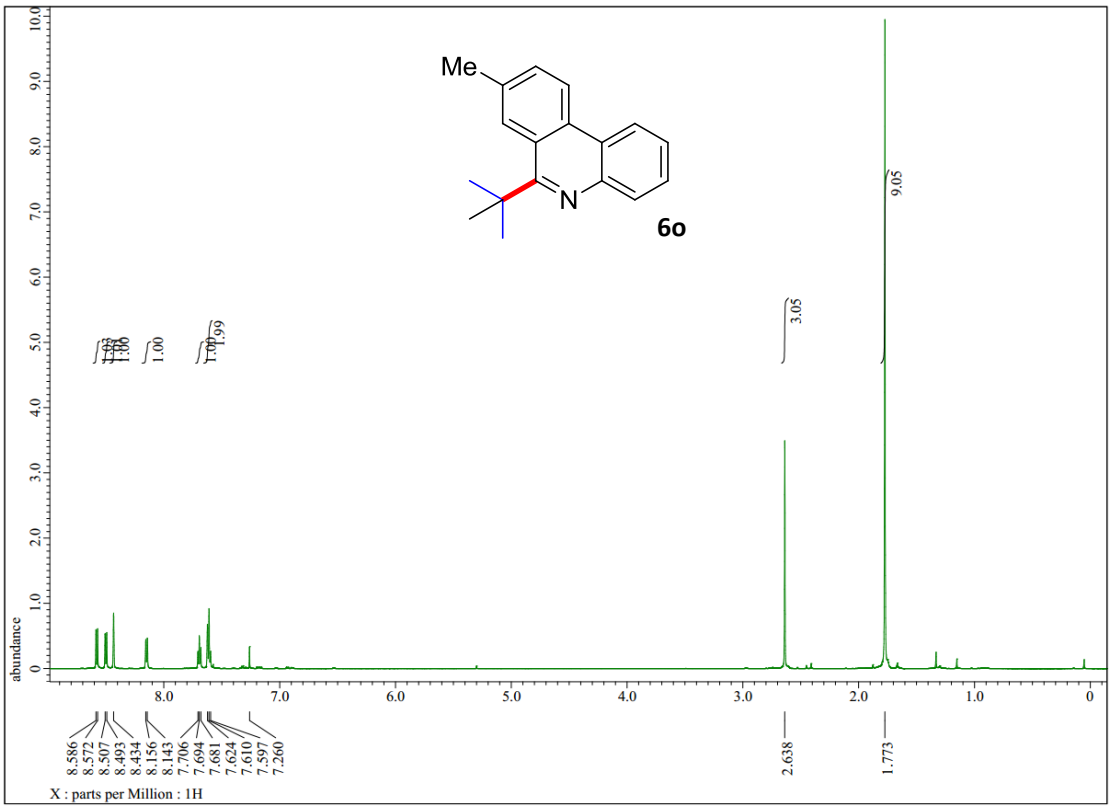

Me
BocHN
N
COOMe
6l
abundance
X : parts per Million : 13C

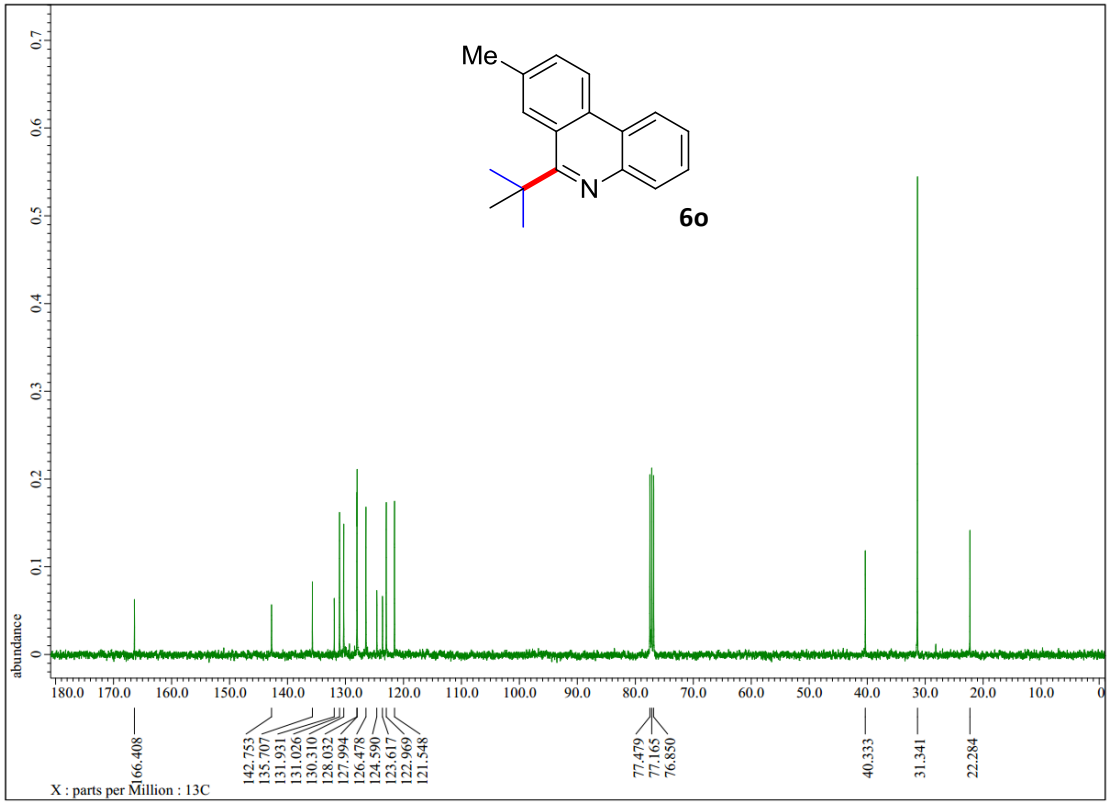

Me
O
N
O
N
6m
2.04
2.00
2.03
2.04
3.04
1.00
1.01
3.03
0.99
1.02
3.01
3.00
abundance
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
8.503
8.489
8.454
8.441
8.039
7.850
7.699
7.694
7.690
7.603
7.246
6.398
6.392
6.379
6.373
2.976
2.952
2.928
2.584
2.235
2.211
1.855
1.212
1.201
1.044
1.033
-0.004
X : parts per Million : 1H

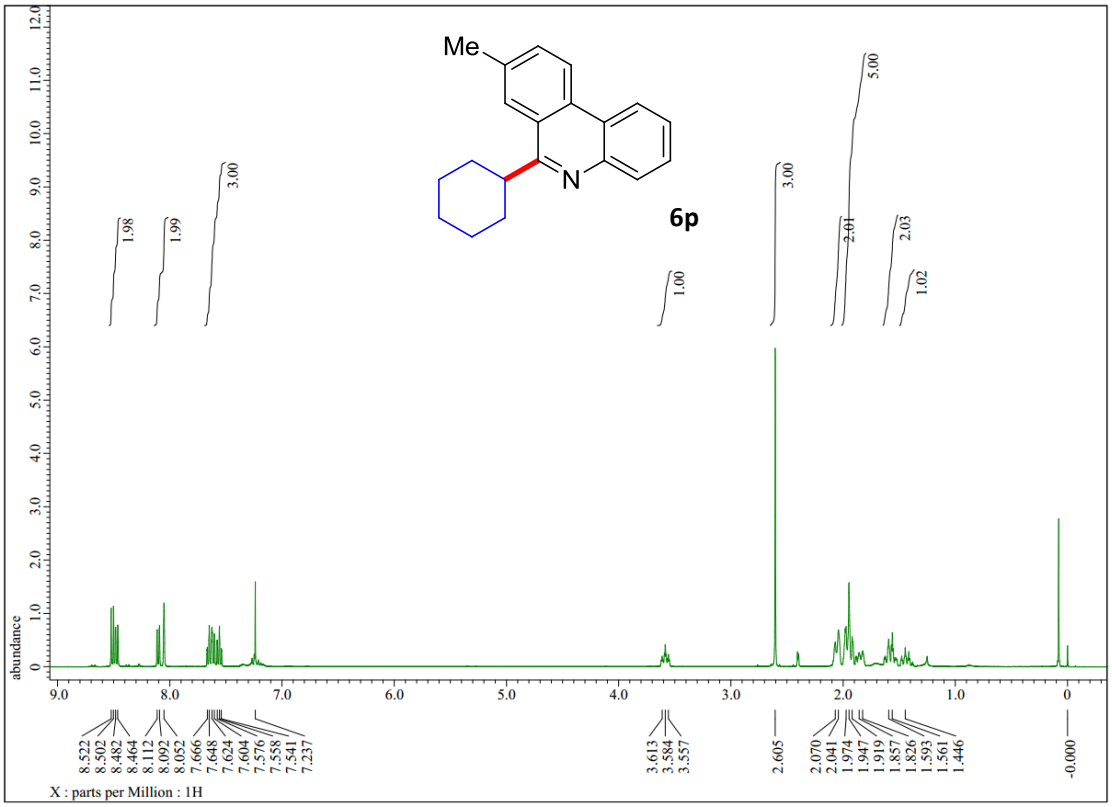

Me
O
N
O
N
6m
abundance
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
169.059
156.540
142.934
137.414
133.924
132.284
132.036
131.264
130.663
128.108
126.964
124.599
124.103
123.303
122.759
121.672
77.470
77.346
77.146
76.831
52.632
39.389
26.012
23.485
22.112
21.826
X : parts per Million : 13C

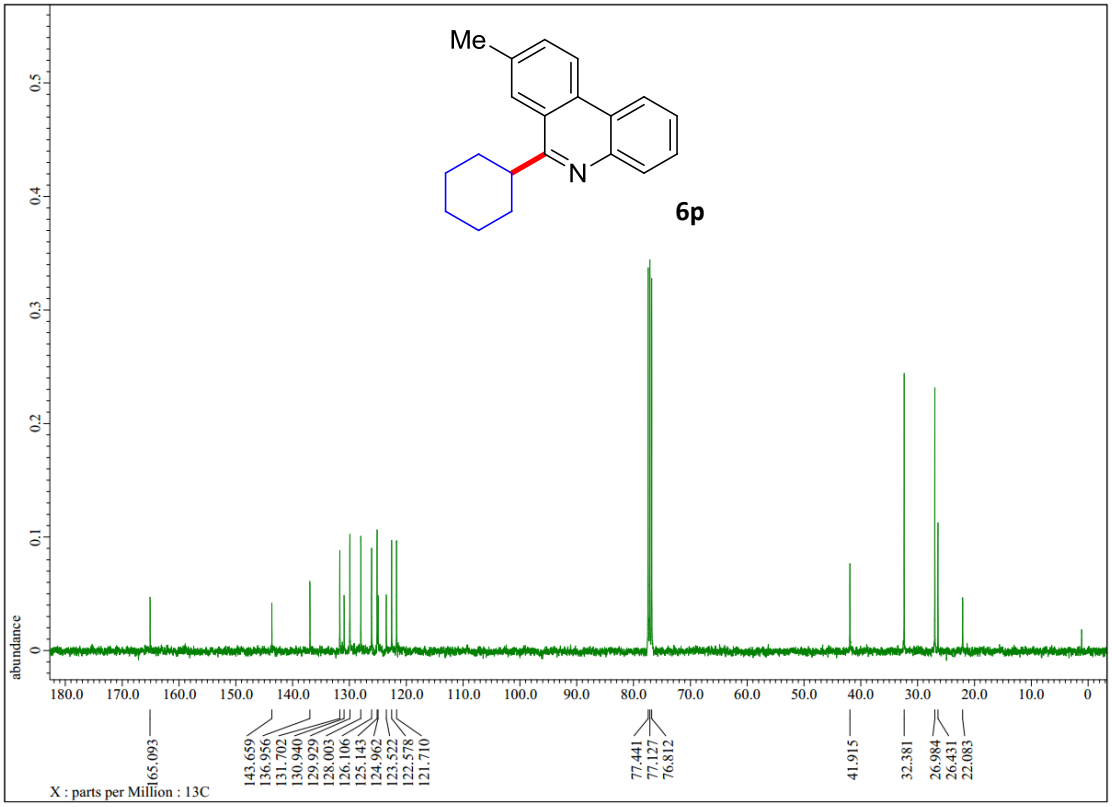

Me
N
6n
2.02
0.98
1.00
2.99
2.01
3.03
1.99
3.04
abundance
8.505
8.485
8.466
8.110
8.089
7.993
7.682
7.664
7.644
7.635
7.613
7.593
7.573
7.556
7.249
3.336
3.316
3.297
2.593
1.985
1.967
1.947
1.928
1.143
1.125
1.106
X : parts per Million : 1H

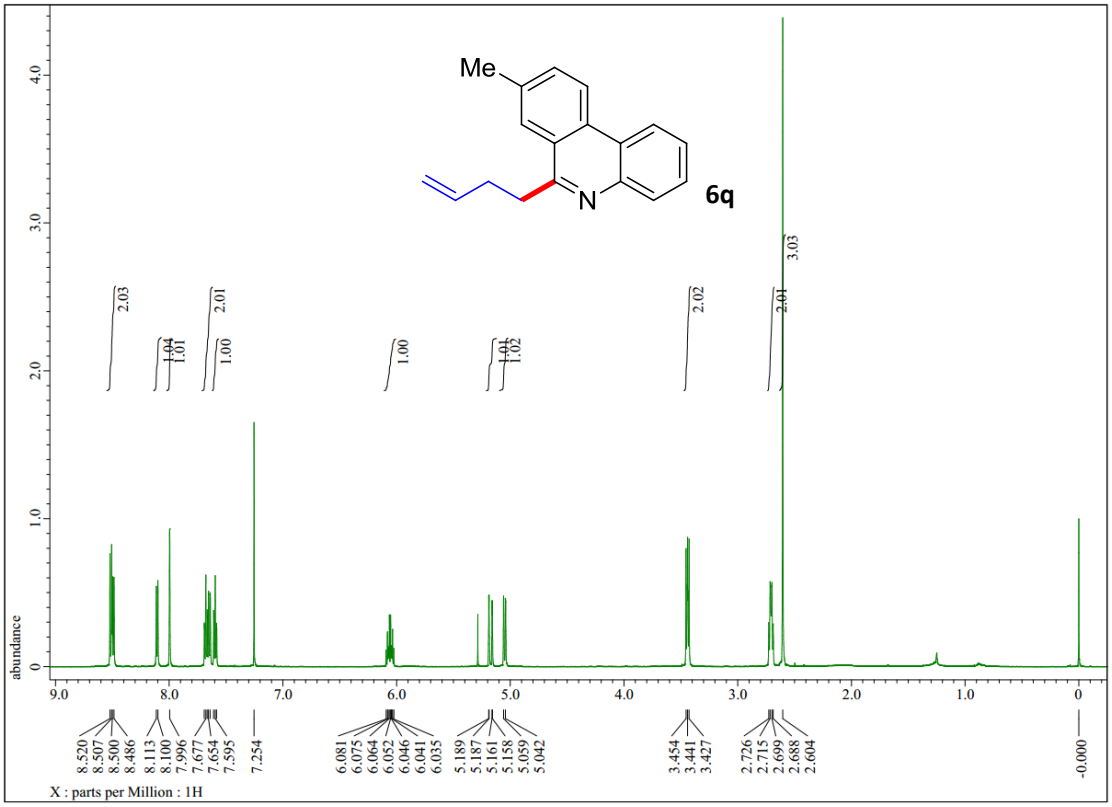

Me
N
6n
abundance
162.051
143.487
137.137
132.055
130.844
129.548
128.175
126.249
125.905
125.495
123.827
122.444
121.806
77.441
77.127
76.812
38.378
22.951
21.969
14.522
X : parts per Million : 13C

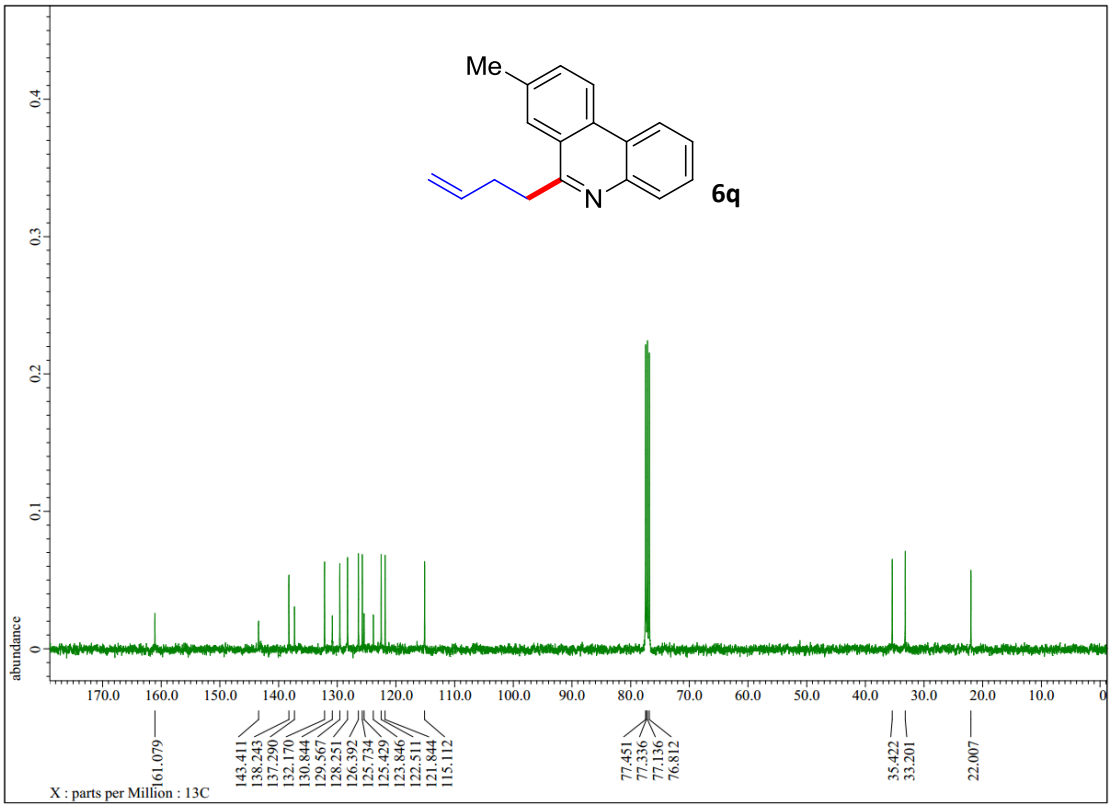

Me
N
6o
9.05
3.05
1.00
1.99
abundance
8.586
8.572
8.507
8.493
8.434
8.156
8.143
7.706
7.694
7.681
7.624
7.610
7.597
7.260
2.638
1.773
X : parts per Million : 1H

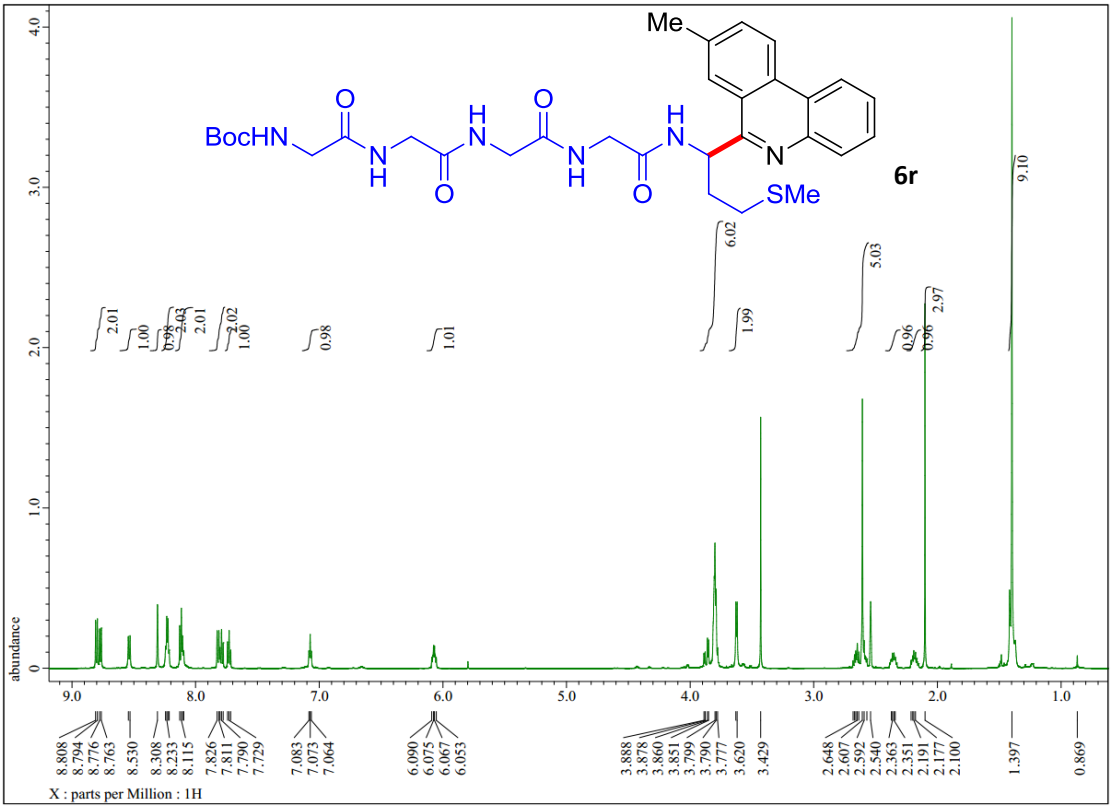

Me
N
6o
abundance
166.408
142.753
135.707
131.931
131.026
130.310
128.032
127.994
126.478
124.590
123.617
122.969
121.548
77.479
77.165
76.850
40.333
31.341
22.284
X : parts per Million : 13C

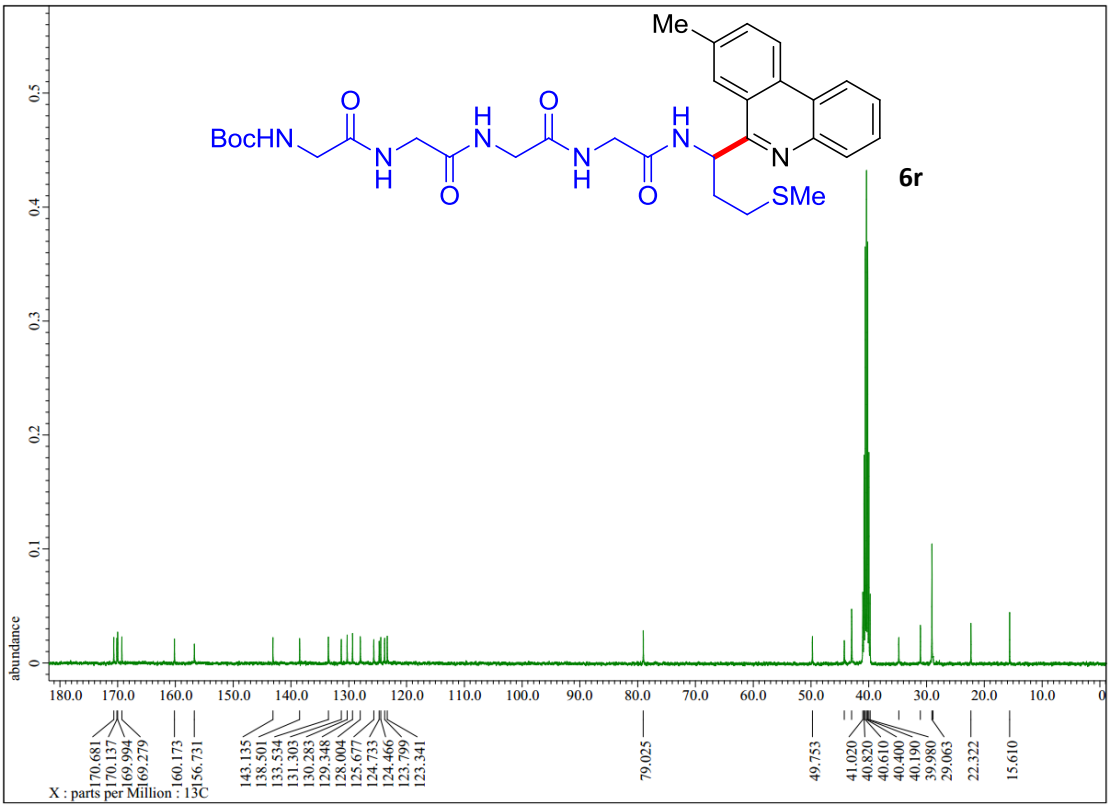

Me
N
6p
1.98
1.99
3.00
1.00
3.00
2.01
5.00
2.03
1.02
abundance
8.522
8.502
8.482
8.464
8.112
8.092
8.052
7.666
7.648
7.624
7.604
7.576
7.558
7.541
7.237
3.613
3.584
3.557
2.605
2.070
2.041
1.974
1.947
1.919
1.857
1.826
1.593
1.561
1.446
-0.000
X : parts per Million : 1H

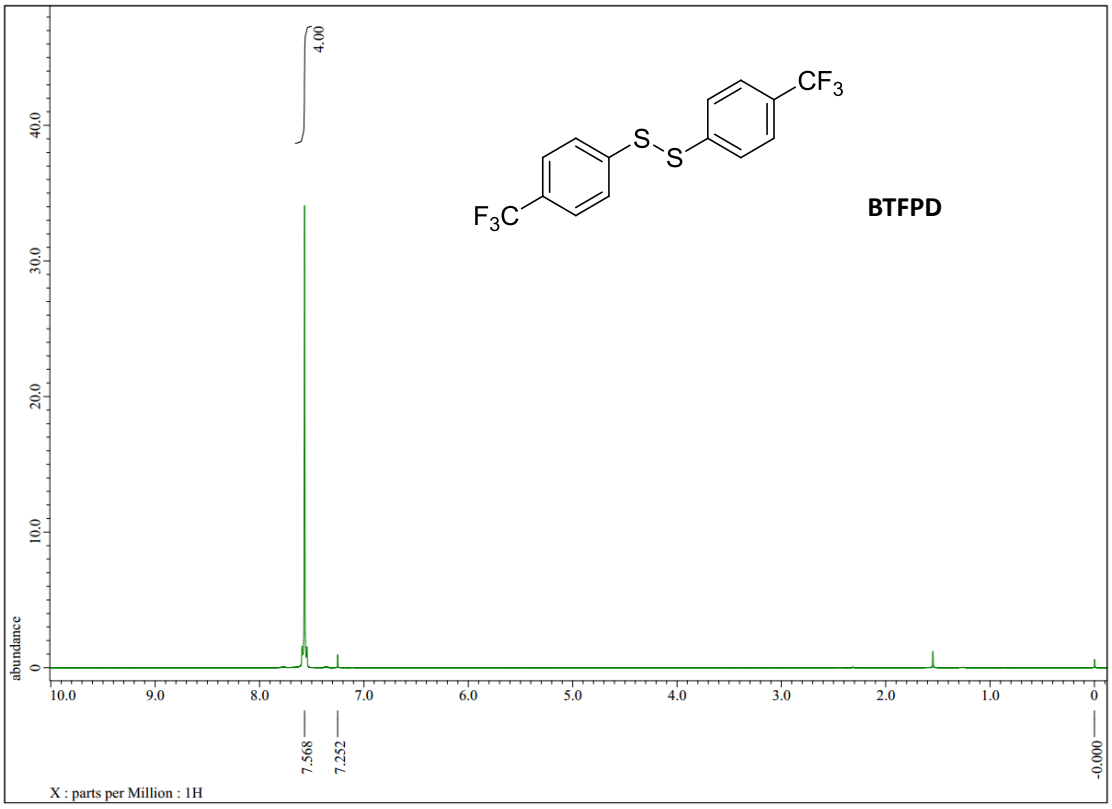

Me
N
6p
abundance
165.093
143.659
136.956
131.702
130.940
129.929
128.003
126.106
125.143
124.962
123.522
122.578
121.710
77.441
77.127
76.812
41.915
32.381
26.984
26.431
22.083
X : parts per Million : 13C

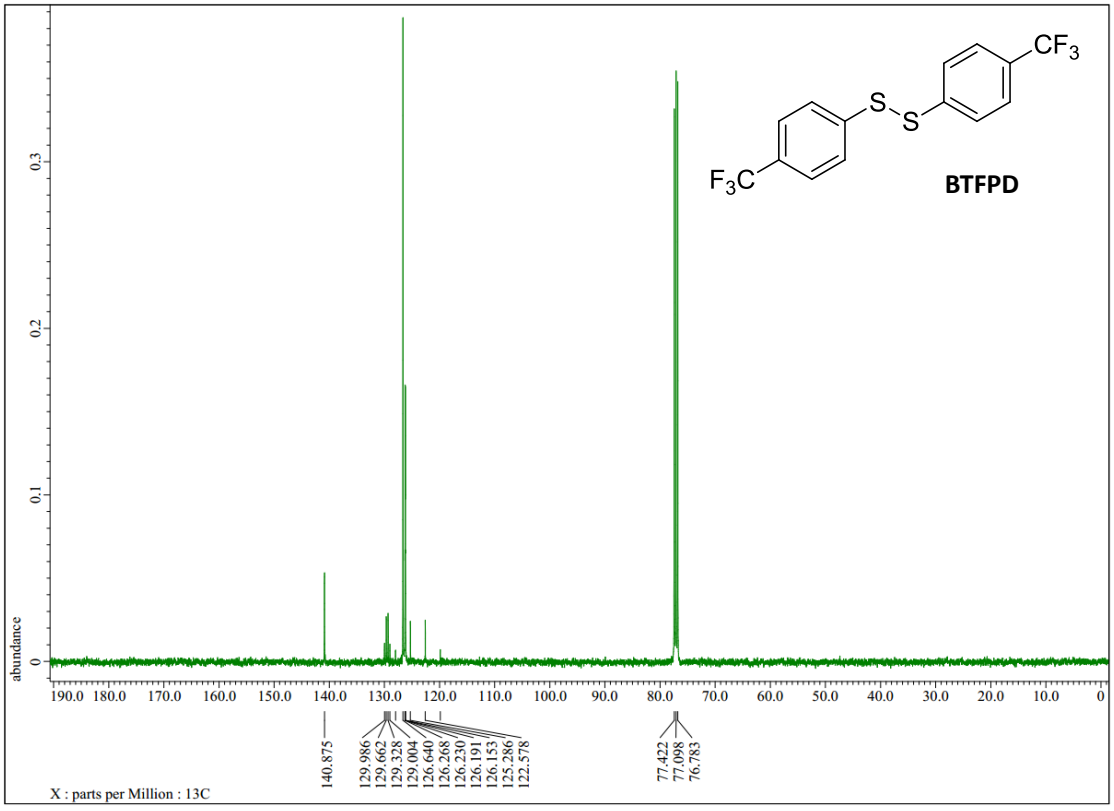

Me
N
6q
abundance
X : parts per Million : 1H


Me
N
6q
abundance
X : parts per Million : 13C


Me
BocHN
O
N
H
O
H
N
O
H
N
O
N
SMe
6r
6.02
5.03
9.10
2.97
1.99
2.01
1.00
1.00
2.03
2.01
2.02
1.00
0.98
1.01
0.96
0.96
abundance
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
8.808
8.794
8.776
8.763
8.530
8.308
8.233
8.115
7.826
7.811
7.790
7.729
7.083
7.073
7.064
6.090
6.075
6.067
6.053
3.888
3.878
3.860
3.851
3.799
3.790
3.777
3.620
3.429
2.648
2.607
2.592
2.540
2.363
2.351
2.191
2.177
2.100
1.397
0.869
X : parts per Million : 1H


Me
BocHN
O
N
H
O
H
N
O
H
N
O
N
SMe
6r
abundance
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
170.681
170.137
169.994
169.279
160.173
156.731
143.135
138.501
133.534
131.303
130.283
129.348
128.004
125.677
124.733
124.466
123.799
123.341
79.025
49.753
41.020
40.820
40.610
40.400
40.190
39.980
29.063
22.322
15.610
X : parts per Million : 13C


4.00
40.0
30.0
20.0
10.0
0
abundance
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.568
7.252
-0.000
X : parts per Million : 1H
CF3
S
S
F3C
BTFPD


0.3
0.2
0.1
0
abundance
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
140.875
129.986
129.662
129.328
129.004
126.640
126.268
126.230
126.191
126.153
125.286
122.578
77.422
77.098
76.783
X : parts per Million : 13C
CF3
S
S
F3C
BTFPD