Supporting Information:

Visible Light Amination/Smiles Cascade: Access to Phthalazine Derivatives

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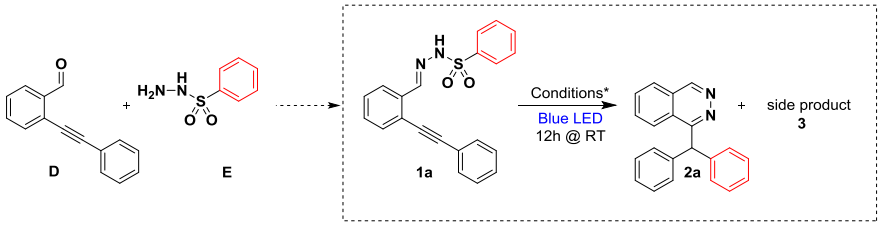
I- General Information

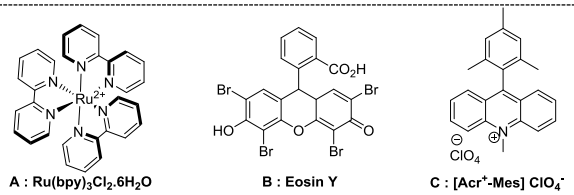
^{1}H NMR spectra were recorded on a Bruker Avance 300 or 400 MHz spectrometer in $CDCl_3$, acetone-d6 or DMSO-d6 solution with internal solvent signal as reference. ^{13}C NMR were recorded on a 100 MHz spectrometer in $CDCl_3$, acetone-d6 or DMSO-d6 solution and referenced to the internal solvent signal. ^{1}H NMR data are reported as follows: chemical shift (ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, quint = quintet, dd = doublet of doublets, ddd = doublet of doublet of doublets, td = triplet of doublets, qd = quartet of doublets, m = multiplet, br. s. = broad singlet), and coupling constants (Hz) and number of protons. All reactions were monitored by thin-layer chromatography using Merck silica gel plates 60 F254; visualization was accomplished with short wavelength UV light (254 nm) and/or staining with appropriate stains (anisaldehyde, ortho-phosphomolybdic acid). Standard flash chromatography was performed using silica gel of particle size 40−63 µm. Ruthenium catalyst was purchased from Sigma Aldrich. All other commercially available reagents and solvents were used without further purification. The blue light irradiation was performed using high-power LEDs Philips LUXEON® Rebel (1W, λ = 450±10 nm, 145 lm @700mA).

II- Optimization of the reaction conditions

We started our investigation on a model substrate, *N*'-(2-(phenylethynyl)benzylidene)benzenesulfonohydrazone **1a**, easily prepared from the corresponding aldehyde **D**[1] and sulfonohydrazide **E**[2] moieties. Although *ortho*-alkynylbenzaldehydes have already been used to prepare phthalazines using hydrazine and triethylamine [3] starting from our preformed hydrazone **1a**, the use of triethylamine without photocatalyst (PC), led only to the degradation of the starting material (entry **1**). Starting from simple conditions: $Ru(bpy)_3Cl_2$ as photocatalyst and NaOH as base in $CHCl_3$, we were pleased to find that the expected phthalazine **2a** was obtained in an encouraging 25% yield (entry **2**, Table 1). The X-ray analysis (**2a**, Table **2**) unambiguously confirmed the structure. However, product **2a** was contaminated by a small amount (5%) of an inseparable side product **3** (see mechanism and NMR spectra of the mixture below). Variation of the base (entries **2-5**), did not improve the reaction yield, as well as the use of polar solvents (DMSO or ACN, entries **6-7**). However, the use of polar protic solvents, such as methanol or ethanol (entries **8-9**), improved the isolated yields to 65 and 75%, respectively, but still accompanied with 5% of the side product **3**. Other photocatalysts **B** and **C** did not promote the reaction under the same conditions (entries **9-11**). Fukuzumi catalyst **C** (entry **11**) led to only 10% conversion[4]; eosin Y, **B**, gave 55% conversion of the starting material in a complex mixture. Interestingly, the presence of 3Å molecular sieves suppressed the formation of the side product **3**, giving **2a** with an excellent 81% yield (entry **12**). Other drying agents, for instance $MgSO_4$ gave a similar result (entry **13**). Water seems to promote the formation of the side product, but addition of water to the reaction media did not enhance significately the formation of product **3** (entry **14**). Moreover, we confirmed that the presence of a photocatalyst, light and a base is crucial for the reaction (entries **15-17**). **Best reaction conditions found were 2.5 mol% of $Ru(bpy)_3Cl_2.6H_2O$, 1.5 equivalents of NaOH and 100 mg of 3Å molecular sieves in EtOH (0.08M) under blue led irradiation (~450 nm).**

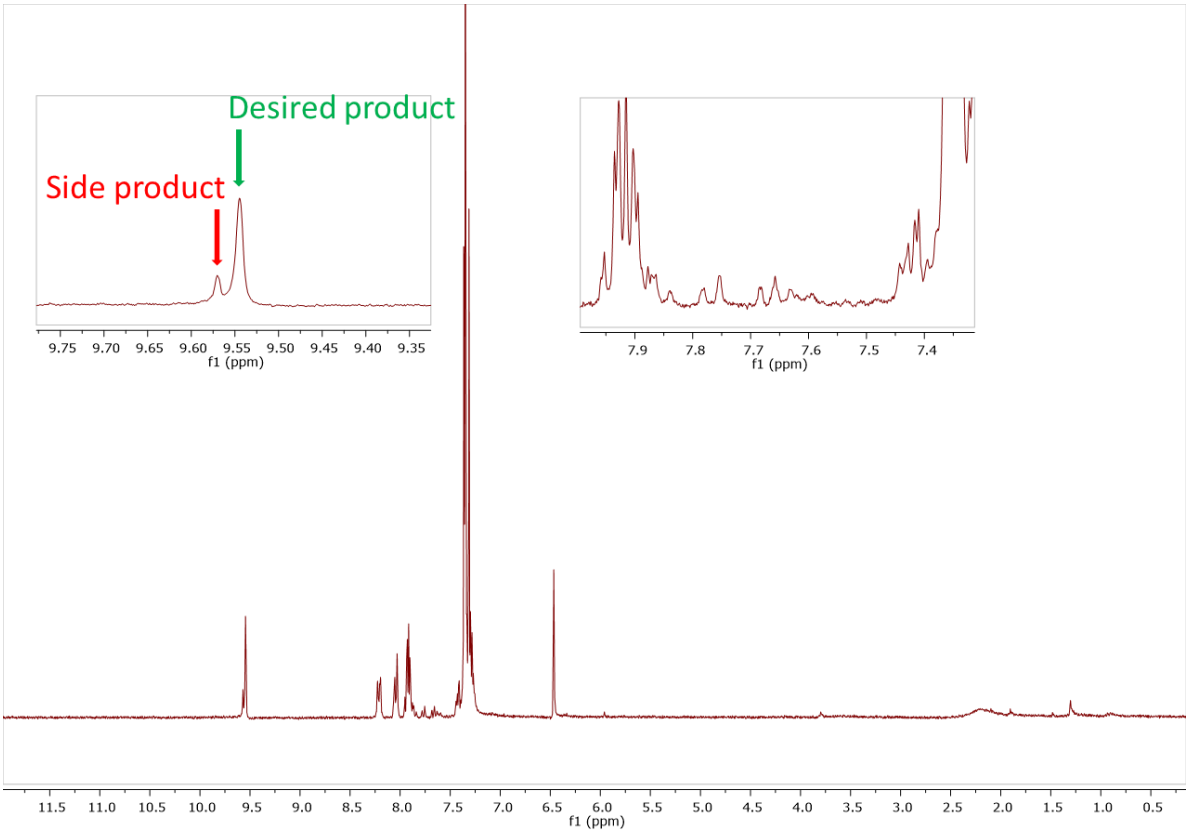
Table 1. Optimization of the reaction conditions.



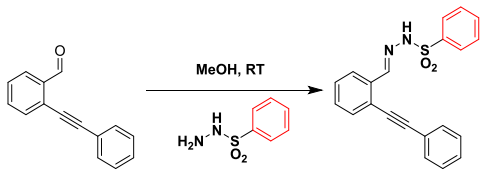


Entry	PC[a]	Base	Additive	Solvent	Conv. [%]	Yield[b] **2a/3**
1	-	Et_3N	-	$CHCl_3$	100	0/0
2	A	**NaOH**	-	$CHCl_3$	100	25/5
3	A	**tBuONa**	-	$CHCl_3$	80	10/0
4	A	**Cs_2CO_3**	-	$CHCl_3$	60	-
5	A	**KOH**	-	$CHCl_3$	100	20/0
6	A	NaOH	-	**DMSO**	45	-
7	A	NaOH	-	**ACN**	95	17/0
8	A	NaOH	-	**MeOH**	100	65/5
9	**A**	NaOH	-	**EtOH**	100	75/5
10	**B**	NaOH	-	EtOH	55	-
11	**C**	NaOH		EtOH	10	-
12	**A**	**NaOH**	**3Å M.S.**	**EtOH**	**100**	**81/0**
13	**A**	**NaOH**	**$MgSO_4$**	**EtOH**	**100**	**81/0**
14	A	NaOH	**H_2O**	EtOH	95	65/7
15	**-**	NaOH	**3Å M.S.**	EtOH	50	0/0
16	A	NaOH	**3Å M.S.**	EtOH	100	0/0[c]
17	A	**-**	**3Å M.S.**	EtOH	0	0/0

Reaction conditions: **1a** (0.15 mmol, 1 eq.), additives (100mg or 500µL in case of water), photocatalyst (PC) (3.5 µmol, 2.5 mol%) and base (0.225 mmol, 1.5 eq.) in dry solvent (0.08M) was irradiated with blue light. [a] 2.5 mol% of photocatalyst (PC). [b] isolated yields; ratio between product **2a** and side product determined by ^{1}H NMR. [c]. Without light.

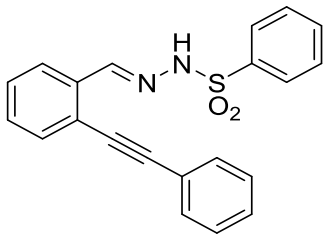


III- General procedure for the synthesis of sulfonohydrazones and characterizations



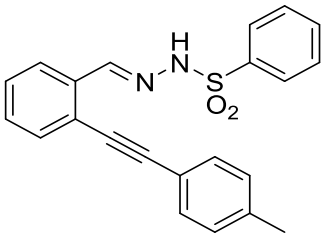
A flame-dried re-sealable tube was charged with benzenesulfonohydrazide (1.1 mmol, 1.1 equiv.) and 2-(phenylethynyl)benzaldehyde (1.0 mmol, 1 equiv.) and 3.5 mL of MeOH. The tube was capped with a rubber septum, evacuated and backfilled with argon; this evacuation/ backfill sequence was repeated one additional time. The mixture was then sonicated at room temperature until precipitation occurs. Then, the precipitate is filtrated and dry under vacuum giving the desired product almost in a quantitative yield in each cases.

Compound 1a: N'-(2-(Phenylethynyl)benzylidene)benzenesulfonohydrazide



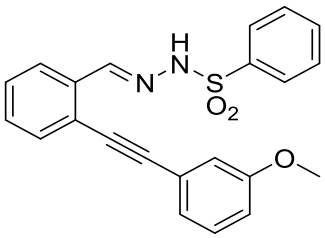
R_f = 0.45 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (300 MHz, acetone-d_6) δ 10.58 (s, 1H), 8.65 (s, 1H), 8.02 (dd, *J* = 7.9, 1.8 Hz, 2H), 7.96 (dd, *J* = 5.8, 3.5 Hz, 1H), 7.58 (ddt, *J* = 16.0, 9.1, 2.7 Hz, 4H), 7.41 (dt, *J* = 6.3, 3.4 Hz, 5H); ^{13}C NMR (75 MHz, acetone) δ 145.69, 140.17, 135.48, 133.83, 133.10, 132.24, 130.70, 129.87, 129.70, 129.60, 129.36, 128.35, 125.58, 123.58, 123.29, 95.63, 86.51; HR-MS (ESI+): m/z calculated for $C_{21}H_{16}N_2O_2NaS$ 383.0830 obtained 383.0816.

Compound 1b: N'-(2-(p-Tolylethynyl)benzylidene)benzenesulfonohydrazide



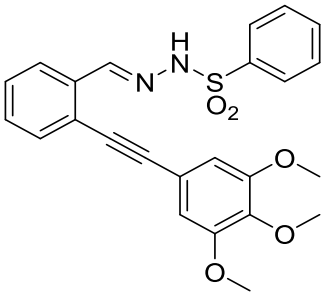
R_f = 0.46 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 10.51 (s, 1H), 8.62 (s, 1H), 7.98 (d, *J* = 7.0 Hz, 2H), 7.96 – 7.91 (m, 1H), 7.67 – 7.63 (m, 1H), 7.60 (dd, *J* = 8.2, 6.4 Hz, 2H), 7.57 – 7.51 (m, 1H), 7.47 (d, *J* = 7.9 Hz, 2H), 7.42 (dd, *J* = 5.9, 3.0 Hz, 2H), 7.25 (d, *J* = 7.9 Hz, 2H), 2.37 (s, 3H); ^{13}C NMR (101 MHz, acetone) δ 145.82, 140.42, 140.09, 135.58, 133.92, 133.16, 132.32, 130.81, 130.16, 129.97, 129.57, 128.49, 125.72, 124.02, 120.46, 95.98, 85.99, 21.47; HR-MS (ESI+ +): m/z calculated for $C_{22}H_{18}N_2O_2NaS$ 397.0987 obtained 397.0992.

Compound 1c: N'-(2-((3-Methoxyphenyl)ethynyl)benzylidene)benzenesulfonohydrazide



R_f = 0.40 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 10.50 (s, 1H), 8.61 (s, 1H), 7.98 (d, *J* = 7.1 Hz, 2H), 7.96 – 7.89 (m, 1H), 7.69 – 7.57 (m, 3H), 7.57 – 7.53 (m, 1H), 7.43 (dd, *J* = 5.9, 3.3 Hz, 2H), 7.34 (t, *J* = 8.0 Hz, 1H), 7.15 (d, *J* = 7.6 Hz, 1H), 7.12 (s, 1H), 7.04 – 6.97 (m, 1H), 3.84 (s, 3H); ^{13}C NMR (101 MHz, acetone) δ 160.60, 145.76, 140.38, 135.71, 133.92, 133.25, 130.81, 130.61, 129.96, 129.77, 128.48, 125.76, 124.74, 124.45, 123.67, 117.56, 115.89, 95.67, 86.35, 55.74; HR-MS (ESI+): m/z calculated for $C_{22}H_{18}N_2O_3NaS$ 413.0936 obtained 413.0941.

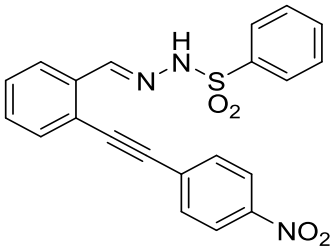
Compound 1d: N'-(2-((3,4,5-Trimethoxyphenyl)ethynyl)benzylidene)benzenesulfonohydrazide



R_f = 0.30 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (300 MHz, chloroform-*d*) δ 8.65 (s, 1H), 8.39 (s, 1H), 8.10 – 7.96 (m, 2H), 7.95 – 7.88 (m, 1H), 7.62 – 7.43 (m, 4H), 7.37 – 7.27 (m, 2H), 6.69 (s, 2H), 3.85 (s, 3H), 3.79 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 153.1, 146.2, 139.3, 138.5, 134.1, 133.4, 132.6,

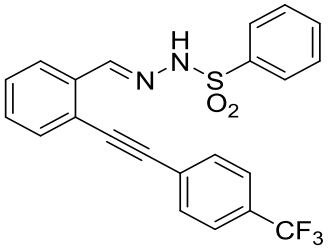
130.07, 129.1, 128.6, 127.9, 125.6, 123.3, 117.6, 108.9, 95.3, 85.1, 61.0, 56.2.; HR-MS (ESI+): m/z calculated for $C_{24}H_{22}N_2O_5NaS$ 473.1147 obtained 473.1163.

Compound 1e: N'-(2-((4-Nitrophenyl)ethynyl)benzylidene)benzenesulfonohydrazide



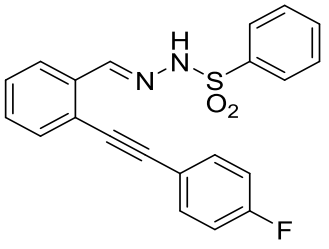
R_f = 0.35 (cyclohexane:EA, 7:3); yellow solid; ^{1}H NMR (300 MHz, DMSO-d_6) δ 11.40 (s, 1H), 7.97 (s, 1H), 7.49 – 7.29 (m, 6H), 7.25 – 7.13 (m, 4H), 7.11 – 6.97 (m, 3H); ^{13}C NMR (75 MHz, DMSO) δ 144.29, 138.92, 134.52, 134.15, 133.13, 132.58, 130.19, 129.81, 129.52, 129.28, 127.09, 126.16, 124.70, 121.20, 119.64, 91.13, 90.33; HR-MS (ESI+): m/z calculated for $C_{21}H_{15}N_3O_4NaS$ 428.0681 obtained 428.0667.

Compound 1f: N'-(2-((4-(Trifluoromethyl)phenyl)ethynyl)benzylidene)benzenesulfonohydrazide



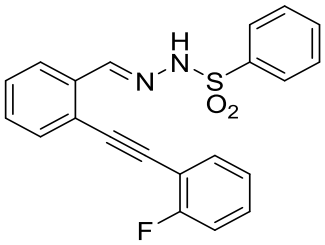
R_f = 0.43 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (300 MHz, chloroform-*d*) δ 8.62 (s, 1H), 8.41 (s, 1H), 8.02 (d, *J* = 7.1 Hz, 2H), 7.95 (dd, *J* = 5.8, 3.5 Hz, 1H), 7.69 – 7.46 (m, 8H), 7.36 (dd, *J* = 5.9, 3.3 Hz, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 145.9, 138.4, 134.3, 133.7, 133.5, 132.6, 131.9, 130.32, 130.2, 129.2, 128.0, 126.4, 125.7, 125.60, 125.56, 125.50, 125.46, 122.7, 122.1, 93.8, 88.3.; HR-MS (ESI++): m/z calculated for $C_{22}H_{15}N_2O_2NaSF_3$ 451.0704 obtained 451.0691.

Compound 1g: N'-(2-((4-Fluorophenyl)ethynyl)benzylidene)benzenesulfonohydrazide



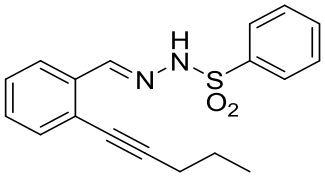
R_f = 0.43 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (300 MHz, DMSO-d_6) δ 11.85 (s, 1H), 8.47 (s, 1H), 7.95 – 7.87 (m, 2H), 7.80 (dd, *J* = 5.9, 3.4 Hz, 1H), 7.73 – 7.52 (m, 6H), 7.43 (dd, *J* = 5.9, 3.4 Hz, 2H), 7.32 (t, *J* = 8.9 Hz, 2H); ^{13}C NMR (75 MHz, DMSO) δ 163.8, 160.6 , 144.4, 138.9, 134.2, 133.8, 133.7, 133.1, 132.1, 130.0, 129.3, 129.1, 127.0, 124.4, 121.8, 118.2, 116.1, 115.8, 93.7, 85.6; HR-MS (ESI+): m/z calculated for $C_{21}H_{15}N_2O_2FNaS$ 401.0736 obtained 401.0734.

Compound 1h: N'-(2-((4-Fluorophenyl)ethynyl)benzylidene)benzenesulfonohydrazide



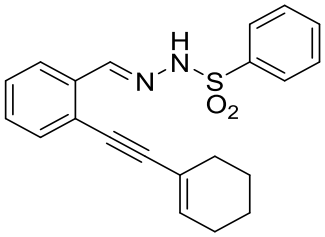
R_f = 0.46 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 10.60 (s, 1H), 8.61 (s, 1H), 8.02 (d, *J* = 7.1 Hz, 2H), 7.99 – 7.93 (m, 1H), 7.70 – 7.53 (m, 5H), 7.49 – 7.39 (m, 3H), 7.25 (t, *J* = 7.8 Hz, 2H); ^{13}C NMR (101 MHz, acetone) δ 164.40, 161.91, 145.56, 140.23, 135.65, 134.28, 133.84, 133.19, 131.93, 131.85, 130.76, 130.02, 129.87, 128.40, 125.71, 125.34, 125.30, 123.11, 116.45, 116.24, 111.81, 111.66, 91.63, 91.60, 88.82; HR-MS (ESI+): m/z calculated for $C_{21}H_{15}N_2O_2FNaS$ 401.0736 obtained 401.0740.

Compound 1i: N'-(2-(Pent-1-yn-1-yl)benzylidene)benzenesulfonohydrazide



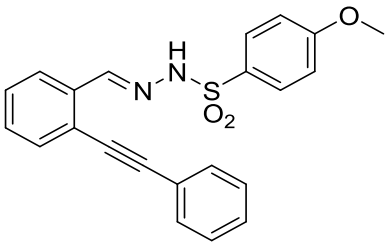
R_f = 0.45 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (300 MHz, Chloroform-d) δ 8.33 (s, 1H), 8.23 (s, 1H), 8.07 – 7.87 (m, 2H), 7.87 – 7.76 (m, 1H), 7.63 – 7.34 (m, 3H), 7.30 – 7.23 (m, 1H), 7.24 – 7.09 (m, 2H), 2.30 (t, J = 7.0 Hz, 2H), 1.52 (h, J = 7.3 Hz, 2H), 0.92 (t, J = 7.4 Hz, 3H).; ^{13}C NMR (75 MHz, CDCl3) δ 146.7, 138.5, 133.9, 133.4, 132.5, 130.0, 129.1, 128.0, 127.8, 125.3, 124.4, 96.8, 77.5, 22.2, 21.6, 13.7; HR-MS (ESI+): m/z calculated for $C_{18}H_{18}N_2O_2NaS$ 349,0987 obtained 349,0972.

Compound 1j: N'-(2-(Cyclohex-1-en-1-ylethynyl)benzylidene)benzenesulfonohydrazide



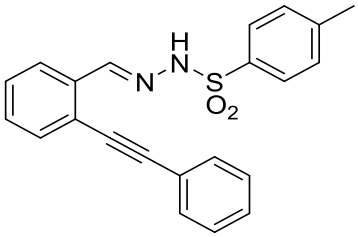
R_f = 0.48 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (300 MHz, acetone-d_6) δ 10.50 (s, 1H), 8.50 (s, 1H), 8.00 (dd, *J* = 7.8, 1.8 Hz, 2H), 7.94 – 7.84 (m, 1H), 7.69 – 7.52 (m, 3H), 7.46 – 7.24 (m, 3H), 6.21 (dt, *J* = 4.1, 2.1 Hz, 1H), 2.37 – 2.04 (m, 4H), 1.60 (dddd, *J* = 11.9, 10.5, 5.8, 2.9 Hz, 4H); ^{13}C NMR (75 MHz, acetone) δ 145.81, 140.19, 136.52, 135.11, 133.79, 132.90, 130.60, 129.84, 129.01, 128.34, 125.47, 124.27, 121.14, 97.72, 84.00, 29.52, 26.19, 22.79, 21.98; HR-MS (ESI+): m/z calculated for $C_{21}H_{20}N_2O_2NaS$ 387.1143 obtained 387.1139.

Compound 1k: 4-Methoxy-N'-(2-(phenylethynyl)benzylidene)benzenesulfonohydrazide



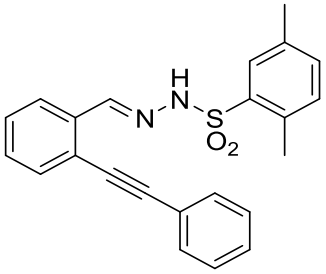
R_f = 0.35 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 10.40 (s, 1H), 8.64 (s, 1H), 7.97 (dd, *J* = 5.6, 3.6 Hz, 1H), 7.93 (d, *J* = 8.9 Hz, 2H), 7.59 (ddd, *J* = 11.9, 6.3, 3.4 Hz, 3H), 7.44 (q, *J* = 5.6, 4.0 Hz, 5H), 7.10 (d, *J* = 8.9 Hz, 2H), 3.87 (s, 3H); ^{13}C NMR (101 MHz, acetone) δ 164.15, 145.38, 135.76, 133.19, 132.34, 131.85, 130.69, 130.66, 129.78, 129.70, 129.46, 125.69, 123.63, 123.44, 115.03, 95.66, 86.62, 56.07; HR-MS (ESI+): m/z calculated for $C_{22}H_{18}N_2O_3NaS$ 413.0936 obtained 413.0954.

Compound 1b': 4-Methyl-N'-(2-(phenylethynyl)benzylidene)benzenesulfonohydrazide



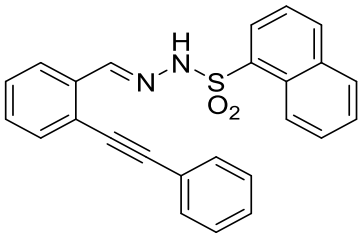
R_f = 0.35 (cyclohexane:EA, 8:2); white solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 10.46 (s, 1H), 8.64 (s, 1H), 7.95 (dd, *J* = 5.8, 3.5 Hz, 1H), 7.87 (d, *J* = 8.4 Hz, 2H), 7.66 – 7.49 (m, 3H), 7.41 (dt, *J* = 5.8, 3.3 Hz, 5H), 7.38 (d, *J* = 8.1 Hz, 2H), 2.36 (s, 3H); ^{13}C NMR (101 MHz, acetone) δ 145.51, 144.71, 137.41, 135.67, 133.17, 132.32, 130.71, 130.41, 129.76, 129.67, 129.43, 128.48, 125.67, 123.63, 123.40, 95.66, 86.59, 21.41; HR-MS (ESI+): m/z calculated for $C_{22}H_{18}N_2O_2NaS$ 397.0987 obtained 397.0979.

Compound 1l: 2,5-Dimethyl-N'-(2-(phenylethynyl)benzylidene)benzenesulfonohydrazide



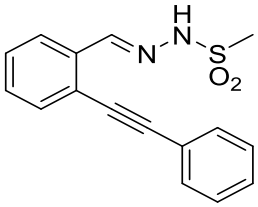
R_f = 0.40 (cyclohexane:EA, 8:2); white solid; ^{1}H NMR (300 MHz, chloroform-*d*) δ 8.40 (s, 1H), 8.30 (brs, 1H), 7.93 (s, 1H), 7.85 (dd, *J* = 7.4, 1.9 Hz, 1H), 7.59 – 7.43 (m, 3H), 7.39 – 7.23 (m, 6H), 7.18 (d, *J* = 7.8 Hz, 1H), 2.70 (s, 3H), 2.35 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 145.29, 136.48, 136.30, 134.99, 134.37, 134.16, 132.68, 132.52, 131.71, 130.86, 130.02, 128.93, 128.62, 125.56, 123.40, 122.70, 95.35, 86.08, 20.92, 20.52; HR-MS (ESI+): m/z calculated for $C_{23}H_{20}N_2O_2NaS$ 411.1143 obtained 411.1149.

Compound 1m: N'-(2-(Phenylethynyl)benzylidene)naphthalene-1-sulfonohydrazide



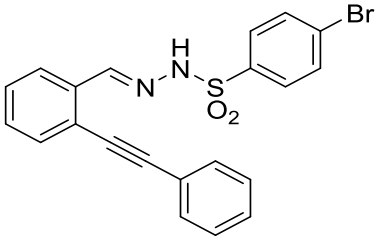
R_f = 0.52 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (300 MHz, DMSO-d6) δ 12.26 (s, 1H), 8.85 (d, J = 8.7 Hz, 1H), 8.48 (s, 1H), 8.37 – 8.23 (m, 2H), 8.08 (dd, J = 8.3, 1.4 Hz, 1H), 7.86 – 7.74 (m, 1H), 7.73 – 7.65 (m, 3H), 7.60 (ddt, J = 7.0, 5.0, 2.8 Hz, 2H), 7.51 (dd, J = 5.8, 3.3 Hz, 1H), 7.47 – 7.44 (m, 3H), 7.37 (dd, J = 5.9, 3.4 Hz, 2H); ^{13}C NMR (75 MHz, DMSO) δ 143.38, 134.59, 134.40, 134.28, 133.74, 132.16, 131.39, 129.90, 129.68, 129.14, 129.01, 128.92, 128.68, 127.94, 127.64, 126.94, 124.77, 124.65, 124.33, 121.85, 121.78, 94.78, 85.82.; HR-MS (ESI+): m/z calculated for $C_{25}H_{18}N_2O_2NaS$ 433.0987 obtained 433.0976.

Compound 1n: N'-(2-(Phenylethynyl)benzylidene)methanesulfonohydrazide



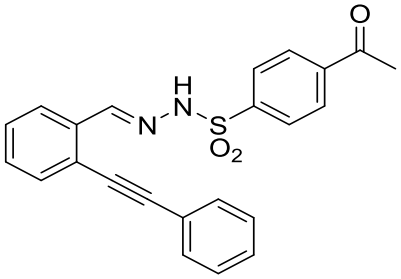
R_f = 0.62 (cyclohexane:EA, 7:3); white yellow solid; ^{1}H NMR (300 MHz, acetone-d_6) δ 10.18 (s, 1H), 8.71 (s, 1H), 8.06 (dd, *J* = 6.0, 3.4 Hz, 1H), 7.68 – 7.55 (m, 3H), 7.51 – 7.40 (m, 5H), 3.15 (s, 3H); ^{13}C NMR (75 MHz, acetone) δ 145.24, 135.69, 133.19, 132.32, 130.71, 129.75, 129.67, 129.42, 125.83, 123.62, 123.41, 95.66, 86.67, 39.11; HR-MS (ESI+): m/z calculated for $C_{16}H_{14}N_2O_2NaS$ 321.0674 obtained 321.0676.

Compound 1o: 4-Bromo-N'-(2-(phenylethynyl)benzylidene)benzenesulfonohydrazide



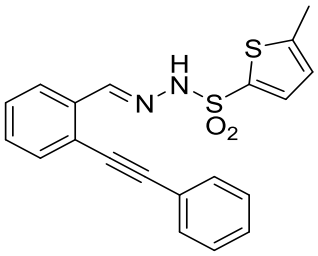
R_f = 0.45 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 10.59 (s, 1H), 8.63 (s, 1H), 7.97 – 7.94 (m, 1H), 7.91 (d, *J* = 8.7 Hz, 2H), 7.80 (d, *J* = 8.6 Hz, 2H), 7.57 (td, *J* = 7.1, 3.7 Hz, 3H), 7.47 – 7.38 (m, 5H); ^{13}C NMR (101 MHz, acetone) δ 146.25, 139.52, 135.50, 133.24, 133.20, 132.35, 130.92, 130.38, 129.82, 129.75, 129.47, 128.23, 125.76, 123.81, 123.42, 95.74, 86.55; HR-MS (ESI+): m/z calculated for $C_{21}H_{15}N_2O_2NaSBr$ 460.9935 obtained 460.9943.

Compound 1p: 4-acetyl-N'-(2-(phenylethynyl)benzylidene)benzenesulfonohydrazide



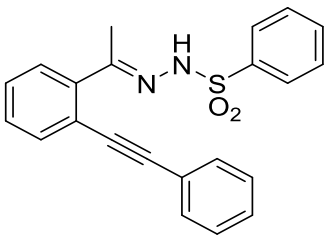
R_f = 0.45 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 10.70 (s, 1H), 8.65 (s, 1H), 8.16 (d, *J* = 8.6 Hz, 2H), 8.10 (d, *J* = 8.5 Hz, 2H), 7.99 – 7.93 (m, 1H), 7.61 – 7.54 (m, 3H), 7.44 – 7.38 (m, 5H), 2.62 (s, 3H); ^{13}C NMR (101 MHz, acetone) δ 197.22, 146.29, 143.77, 141.29, 135.48, 133.24, 132.36, 130.94, 129.82, 129.75, 129.68, 129.47, 128.77, 125.78, 123.80, 123.40, 95.76, 86.53, 26.97; HR-MS (ESI+): m/z calculated for $C_{23}H_{18}N_2O_3NaS$ 425.0936 obtained 425.0929.

Compound 1q: 5-Methyl-N'-(2-(phenylethynyl)benzylidene)thiophene-2-sulfonohydrazide



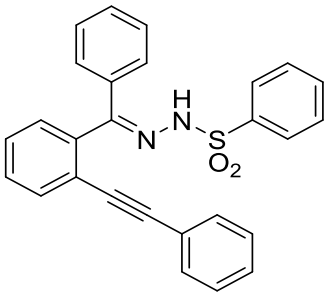
R_f = 0.58 (cyclohexane:EA, 7:3); white-yellow solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 10.53 (s, 1H), 8.69 (s, 1H), 8.19 – 7.93 (m, 1H), 7.68 – 7.50 (m, 4H), 7.50 – 7.33 (m, 5H), 6.87 (d, *J* = 3.7 Hz, 1H), 2.50 (s, 3H); ^{13}C NMR (101 MHz, acetone) δ 149.49, 145.99, 137.41, 135.66, 134.20, 133.22, 132.36, 130.89, 129.81, 129.76, 129.47, 126.90, 125.81, 123.81, 123.43, 95.75, 86.58, 15.37; HR-MS (ESI+): m/z calculated for $C_{20}H_{16}N_2O_2NaS_2$ 403.0551 obtained 403.0539.

Compound 1r: N'-(1-(2-(Phenylethynyl)phenyl)ethylidene)benzenesulfonohydrazide



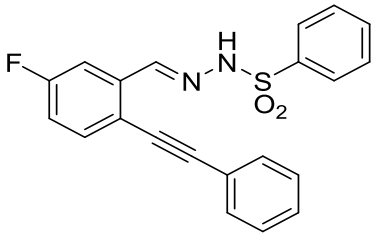
R_f = 0.45 (cyclohexane:EA, 8:2); white solid; ^{1}H NMR (300 MHz, acetone-d_6) δ 9.53 (s, 1H), 7.96 (d, *J* = 7.0 Hz, 2H), 7.59 (dd, *J* = 7.4, 4.7 Hz, 2H), 7.52 – 7.49 (m, 3H), 7.43 (brs, 5H), 7.38 – 7.26 (m, 2H), 2.44 (s, 3H); ^{13}C NMR (75 MHz, acetone) δ 156.27, 142.95, 140.36, 133.66, 133.53, 133.23, 132.32, 132.15, 130.38, 129.63, 129.41, 128.65, 128.42, 123.65, 121.85, 94.64, 88.64, 18.10; HR-MS (ESI+): m/z calculated for $C_{22}H_{18}N_2O_2NaS$ 397.0987 obtained 397.0983.

Compound 1s: N'-(Phenyl(2-(phenylethynyl)phenyl)methylene)benzenesulfonohydrazide



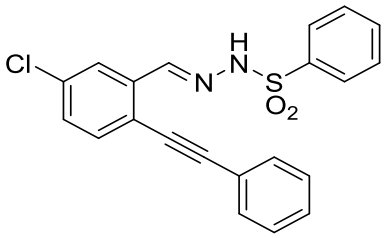
R_f = 0.50 (cyclohexane:EA, 8:2); white solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 9.36 (s, 1H), 8.01 (d, *J* = 5.1 Hz, 2H), 7.79 – 7.61 (m, 1H), 7.57 (d, *J* = 3.4 Hz, 2H), 7.48 (brs, 4H), 7.37 – 7.26 (m, 8H), 7.04 (d, *J* = 7.2 Hz, 2H); ^{13}C NMR (101 MHz, acetone) δ 153.65, 140.52, 137.79, 136.15, 133.60, 133.34, 132.19 (2CH), 130.62, 130.29, 130.02, 129.86, 129.66 (2CH), 129.41, 129.11 (2CH), 129.09 (2CH), 128.47 (2CH), 127.76 (2CH), 123.59, 123.32, 94.29, 87.50; HR-MS (ESI+): m/z calculated for $C_{27}H_{20}N_2O_2NaS$ 459.1143 obtained 459.1134.

Compound 1t: N'-(5-Fluoro-2-(phenylethynyl)benzylidene)benzenesulfonohydrazide



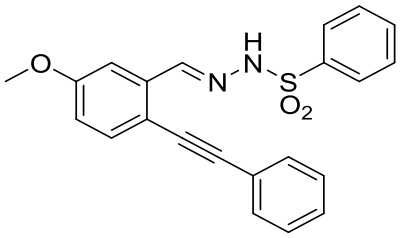
R_f = 0.55 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 10.66 (s, 1H), 8.58 (d, *J* = 2.0 Hz, 1H), 8.00 (d, *J* = 7.0 Hz, 2H), 7.76 – 7.52 (m, 7H), 7.52 – 7.37 (m, 3H), 7.22 (td, *J* = 8.5, 2.7 Hz, 1H); ^{13}C NMR (101 MHz, acetone) δ 163.67, 161.20, 143.58, 143.55, 139.35, 137.35, 137.26, 134.75, 134.67, 133.15, 131.46, 129.16, 128.99, 128.61, 127.61, 122.42, 119.20, 119.17, 117.49, 117.26, 111.06, 110.82, 94.55, 84.69; HR-MS (ESI+): m/z calculated for $C_{21}H_{15}N_2O_2NaSF$ 401.0736 obtained 401.0725.

Compound 1u: N'-(5-Chloro-2-(phenylethynyl)benzylidene)benzenesulfonohydrazide



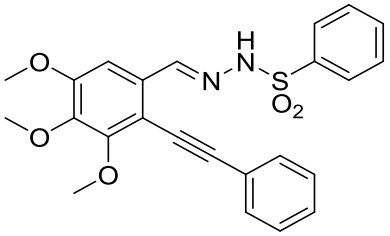
R_f = 0.35 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (300 MHz, acetone-d_6) δ 10.70 (s, 1H), 8.57 (s, 1H), 7.99 (dd, *J* = 8.1, 1.4 Hz, 2H), 7.88 (d, *J* = 2.2 Hz, 1H), 7.69 – 7.54 (m, 6H), 7.48 – 7.41 (m, 4H); ^{13}C NMR (75 MHz, acetone) δ 144.16, 140.24, 137.37, 135.26, 134.83, 134.05, 132.41, 130.74, 130.05, 130.05, 129.51, 128.45, 125.20, 123.11, 122.33, 96.66, 85.53; HR-MS (ESI+): m/z calculated for $C_{21}H_{15}N_2O_2NaSCl$ 417.0440 obtained 417.0428.

Compound 1v: N'-(5-Methoxy-2-(phenylethynyl)benzylidene)benzenesulfonohydrazide



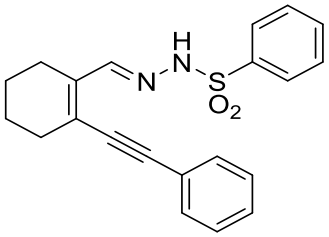
R_f = 0.40 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 10.54 (s, 1H), 8.60 (s, 1H), 8.02 (d, *J* = 7.2 Hz, 2H), 7.65 (dq, *J* = 14.4, 7.0 Hz, 3H), 7.56 (dd, *J* = 6.4, 2.9 Hz, 2H), 7.49 (d, *J* = 8.6 Hz, 1H), 7.45 (d, *J* = 2.6 Hz, 1H), 7.44 – 7.38 (m, 3H), 7.02 (dd, *J* = 8.6, 2.7 Hz, 1H), 3.88 (s, 3H); ^{13}C NMR (101 MHz, acetone) δ 160.80, 145.65, 140.25, 137.11, 134.68, 133.93, 132.14, 129.94, 129.39, 129.39, 128.50, 123.81, 117.72, 116.19, 109.63, 94.23, 86.66, 55.85; HR-MS (ESI+): m/z calculated for $C_{22}H_{18}N_2O_3NaS$ 413.0936 obtained 413.0944.

Compound 1w: N'-(3,4,5-Trimethoxy-2-(phenylethynyl)benzylidene)benzenesulfonohydrazide



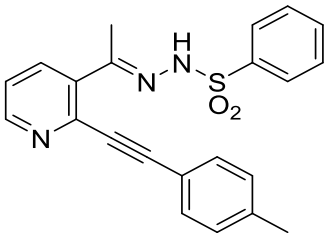
R_f = 0.20 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (300 MHz, chloroform-d) δ 8.75 (s, 1H), 8.33 (s, 1H), 8.16 – 7.93 (m, 2H), 7.76 – 7.53 (m, 1H), 7.53 – 7.43 (m, 4H), 7.33 – 7.27 (m, 3H), 7.21 (s, 1H), 3.95 (s, 3H), 3.89 (s, 3H), 3.88 (s, 3H).; ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.4, 154.08, 146.01, 144.2, 138.5, 133.40, 131.49, 130.3, 129.1, 128.6, 128.5, 127.9, 123.0, 112.0, 103.7, 98.2, 82.0, 61.4, 61.2, 56.2; HR-MS (ESI+): m/z calculated for $C_{24}H_{22}N_2O_5NaS$ 473.1147 obtained 473.1163.

Compound 1x: N'-((2-(Phenylethynyl)cyclohex-1-en-1-yl)methylene)benzenesulfonohydrazide



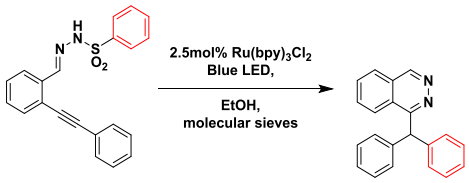
R_f = 0.51 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 10.18 (s, 1H), 8.39 (s, 1H), 7.92 (d, *J* = 6.8 Hz, 2H), 7.66 (t, *J* = 7.3 Hz, 1H), 7.60 (t, *J* = 7.3 Hz, 2H), 7.45 (dd, *J* = 3.7, 1.9 Hz, 2H), 7.42 – 7.35 (m, 3H), 2.47 – 2.25 (m, 4H), 1.65 (brs, 4H); ^{13}C NMR (101 MHz, acetone) δ 148.64, 140.28, 139.84, 133.78, 132.14, 129.83, 129.49, 129.40, 128.44, 126.79, 123.81, 96.69, 88.38, 31.62, 24.54, 22.78, 22.11; HR-MS (ESI+): m/z calculated for $C_{21}H_{20}N_2O_2NaS$ 387.1143 obtained 387.1138.

Compound 1y: N'-(1-(2-(p-Tolylethynyl)pyridin-3-yl)ethylidene)benzenesulfonohydrazide



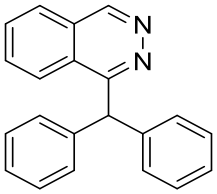
R_f = 0.25 (cyclohexane:EA, 7:3); white solid; ^{1}H NMR (400 MHz, acetone-d_6) δ 8.60 (dd, *J* = 4.8, 1.8 Hz, 1H), 7.93 (d, *J* = 7.2 Hz, 2H), 7.72 (dd, *J* = 7.9, 1.5 Hz, 1H), 7.58 (d, *J* = 7.2 Hz, 2H), 7.52 (t, *J* = 7.4 Hz, 2H), 7.43 (d, *J* = 8.2 Hz, 2H), 7.35 – 7.21 (m, 2H), 2.38 (s, 3H), 2.09 (s, 3H); ^{13}C NMR (101 MHz, acetone) δ 153.38, 149.61, 139.78, 139.40, 138.31, 136.23, 132.90, 131.66, 129.32, 128.82, 127.78, 125.98, 122.80, 118.91, 93.51, 87.13, 20.61, 16.93; HR-MS (ESI+): m/z calculated for $C_{22}H_{19}N_3O_2NaS$ 412.1096 obtained 412.1093.

IV- General procedure for the photocatalyzed reaction and characterizations data.



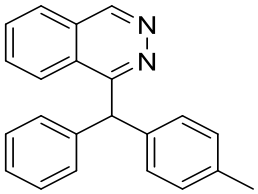
A flame-dried re-sealable tube was charged with sulfonohydrazone (0.15 mmol, 1 equiv.), $Ru(bpy)_3Cl_2.6H_2O$ (0.00375 mmol, 2.5 mol%), NaOH (0.225 mmol, 1.5 equiv.) and molecular sieves 3Å (~100mg). The tube was capped with a rubber septum, evacuated and backfilled with argon; this evacuation/ backfill sequence was repeated one additional time. EtOH (2 mL for 0.15 mmol of sulfonylhydrazone) were added through the septum. The septum was replaced with a teflon screwcap. The Schlenk tube was sealed, and the mixture was stirred at 20°C under 450nm irradiation. After completion of the reaction check by TLC, the resulting suspension was filtered through a pad of celite eluting with ethyl acetate, and the inorganic salts were removed. The filtrate was concentrated and purification of the residue by silica gel column chromatography eluting with a cyclohexane/ethyl acetate mixture gave the desired product.

Compound 2a: 1-Benzhydrylphthalazine



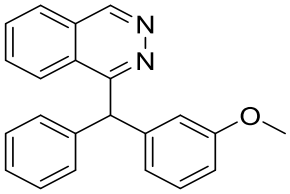
Yield 77% (0.12 mmol, 35.5 mg) , R_f = 0.45 (cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (400 MHz, chloroform-*d*) δ 9.46 (s, 1H), 8.17 (d, *J* = 7.5 Hz, 1H), 7.97 (d, *J* = 7.2 Hz, 1H), 7.85 (p, *J* = 6.5, 5.9 Hz, 2H), 7.42 – 7.11 (m, 10H), 6.44 (s, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.70, 150.62, 141.61, 132.70, 131.96, 129.64, 128.60, 127.25, 127.06, 126.90, 125.95, 124.29, 54.29; HR-MS (ESI+): m/z calculated for $C_{21}H_{16}N_2Na$ 319.1211 obtained 319.1212.

Compound 2b: 1-(Phenyl(p-tolyl)methyl)phthalazine



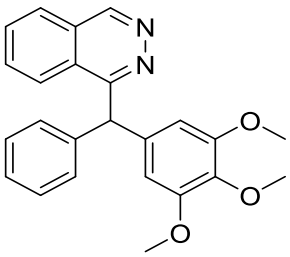
Yield 71% (0.11 mmol, 33.5 mg) , R_f = 0.50 (cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (300 MHz, chloroform-*d*) δ 9.49 (s, 1H), 8.22 – 8.14 (m, 1H), 8.03 – 7.95 (m, 1H), 7.93 – 7.81 (m, 2H), 7.39 – 7.31 (m, 4H), 7.26 (m, 3H), 7.16 (d, *J* = 8.0 Hz, 2H), 6.43 (s, 1H), 2.36 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 160.82, 150.58, 141.82, 138.55, 136.48, 132.67, 131.92, 129.59, 129.48, 129.33, 128.55, 127.22, 127.02, 126.80, 125.93, 124.33, 53.91, 21.16; HR-MS (ESI+): m/z calculated for $C_{22}H_{18}N_2Na$ 333.1368 obtained 333.1365.

Compound 2c: 1-((3-Methoxyphenyl)(phenyl)methyl)phthalazine



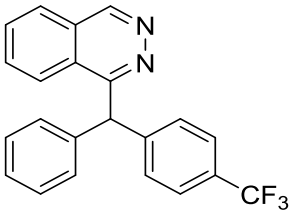
Yield 79% (0.12 mmol, 39 mg), R_f = 0.53 (cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (400 MHz, chloroform-*d*) δ 9.46 (s, 1H), 8.16 (d, *J* = 7.7 Hz, 1H), 7.96 (d, *J* = 7.0 Hz, 1H), 7.84 (p, *J* = 6.8 Hz, 2H), 7.41 – 7.17 (m, 6H), 6.96 – 6.86 (m, 2H), 6.80 (dd, *J* = 8.3, 2.4 Hz, 1H), 6.40 (s, 1H), 3.74 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.52, 159.70, 143.05, 141.28, 132.58, 131.84, 129.54, 129.43, 128.46, 127.12, 126.94, 126.81, 125.86, 124.20, 121.99, 115.58, 112.01, 55.15, 54.21; HR-MS (ESI+): m/z calculated for $C_{22}H_{18}N_2ONa$ 349.1317 obtained 349.1327.

Compound 2d: 1-(Phenyl(3,4,5-trimethoxyphenyl)methyl)phthalazine



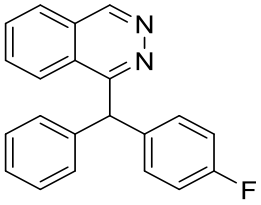
Yield 60% (0.12 mmol, 35 mg), R_f = 0.33 (cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (400 MHz, chloroform-*d*) δ 9.44 (s, 1H), 8.15 (d, *J* = 7.7 Hz, 1H), 7.95 (d, *J* = 6.5 Hz, 1H), 7.85 (q, *J* = 5.4, 3.7 Hz, 2H), 7.41 – 7.12 (m, 5H), 6.53 (s, 2H), 6.33 (s, 1H), 3.81 (s, 3H), 3.72 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 160.67, 153.25, 150.66, 141.46, 137.08, 136.87, 132.78, 132.05, 129.47, 128.59, 128.29, 127.28, 126.98, 125.93, 124.19, 106.88, 60.89, 56.15, 54.34; HR-MS (ESI+): m/z calculated for $C_{24}H_{23}N_2O_3$ 387.1709 obtained 387.1694.

Compound 2f: 1-(Phenyl(4-(trifluoromethyl)phenyl)methyl)phthalazine



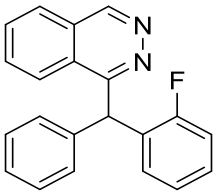
Yield 61% (0.092 mmol, 34 mg), R_f = 0.45 (cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (300 MHz, chloroform-*d*) δ 9.51 (s, 1H), 8.20 – 8.11 (m, 1H), 8.07 – 7.99 (m, 1H), 7.91 (tt, *J* = 7.1, 5.3 Hz, 2H), 7.61 (d, *J* = 8.0 Hz, 2H), 7.47 (d, *J* = 8.1 Hz, 2H), 7.39 – 7.29 (m, 5H), 6.49 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 160.08, 150.78, 145.63, 140.74, 133.04, 132.26, 130.13, 129.74, 129.70, 129.46, 129.27, 129.17, 128.95, 128.85, 128.51, 127.45, 127.40, 127.06, 126.14, 125.84, 125.52, 125.47, 125.42, 125.37, 123.99, 122.53, 118.93, 53.94 ; HR-MS (ESI+): m/z calculated for $C_{22}H_{15}N_2NaF_3$ 387.1085 obtained 387.1096.

Compound 2g: 1-((4-Fluorophenyl)(phenyl)methyl)phthalazine



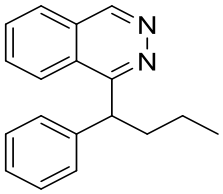
Yield 83% (0.125 mmol, 40 mg), R_f = 0.55 (cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (300 MHz, chloroform-*d*) δ 9.42 (s, 1H), 8.17 – 8.01 (m, 1H), 7.95 – 7.90 (m, 1H), 7.86 – 7.74 (m, 2H), 7.51 – 7.12 (m, 7H), 6.96 (t, *J* = 8.7 Hz, 2H), 6.36 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 161.80 (d, *J* = 245.5 Hz), 160.48, 150.69, 141.52, 137.30 (d, *J* = 3.2 Hz), 132.82, 132.08, 131.26, 131.15, 129.42, 128.75, 127.32, 127.06, 125.81, 124.09, 115.36 (d, *J* = 21.2 Hz), 53.38 ; HR-MS (ESI+): m/z calculated for $C_{21}H_{16}N_2F$ 315.1298 obtained 315.1292.

Compound 2h: 1-((2-Fluorophenyl)(phenyl)methyl)phthalazine



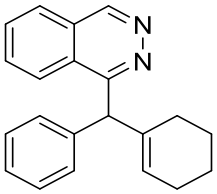
Yield 61% (0.091 mmol, 29 mg), R_f = 0.52 (cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (400 MHz, chloroform-*d*) δ 9.46 (s, 1H), 8.28 – 8.13 (m, 1H), 8.02 – 7.91 (m, 1H), 7.90 – 7.81 (m, 2H), 7.41 – 7.17 (m, 7H), 7.07 (q, *J* = 10.1, 9.0 Hz, 2H), 6.70 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 161.83, 159.83, 158.58, 152.22, 150.69, 139.96, 132.84, 132.00, 131.50, 131.45, 129.62, 129.03, 128.84, 128.74, 128.59, 128.48, 128.25, 127.86, 127.19, 126.91, 126.69, 125.62, 124.13, 124.09, 123.90, 115.20, 114.91, 46.31; HR-MS (ESI+): m/z calculated for $C_{21}H_{15}N_2NaF$ 337.1117 obtained 337.1118.

Compound 2i: 1-(1-Phenylbutyl)phthalazine



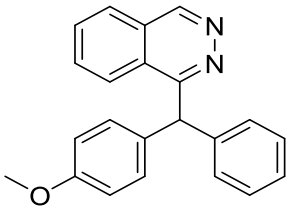
Yield 51% (0.077 mmol, 20 mg), R_f = 0.59(cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (400 MHz, chloroform-*d*) δ 9.42 (s, 1H), 8.23 – 8.08 (m, 1H), 7.90 (d, *J* = 4.1 Hz, 1H), 7.84 – 7.77 (m, 2H), 7.43 (d, *J* = 7.5 Hz, 2H), 7.25 (q, *J* = 7.8, 5.6 Hz, 2H), 7.15 (t, *J* = 7.5 Hz, 1H), 4.82 (t, *J* = 7.5 Hz, 1H), 2.60 (dq, *J* = 14.0, 6.9 Hz, 1H), 2.30 (tt, *J* = 13.6, 7.2 Hz, 1H), 1.48 – 1.31 (m, 2H), 0.96 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.74, 150.58, 143.34, 132.54, 131.76, 128.70, 128.33, 127.24, 126.94, 126.72, 125.96, 124.03, 48.19, 37.80, 21.38, 14.26; HR-MS (ESI+): m/z calculated for $C_{18}H_{18}N_2Na$ 285.1368 obtained 285.1364.

Compound 2j: 1-(Cyclohex-1-en-1-yl(phenyl)methyl)phthalazine



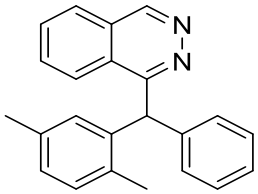
Yield 66% (0.10 mmol, 30 mg), R_f = 0.50(cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (300 MHz, chloroform-*d*) δ 9.43 (s, 1H), 8.19 – 8.04 (m, 1H), 7.98 – 7.89 (m, 1H), 7.89 – 7.75 (m, 2H), 7.50 – 7.11 (m, 5H), 5.51 (s, 1H), 5.38 – 5.27 (m, 1H), 2.03 – 2.10 (m, 2H), 1.74 – 1.50 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.22, 150.33, 140.31, 138.44, 132.44, 131.68, 129.64, 128.30, 127.08, 126.84, 126.66, 126.22, 126.16, 124.28, 55.98, 29.02, 25.48, 23.06, 22.30; HR-MS (ESI+): m/z calculated for $C_{21}H_{20}N_2Na$ 323.1524 obtained 323.1534.

Compound 2k: 1-((4-Methoxyphenyl)(phenyl)methyl)phthalazine



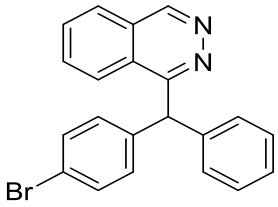
Yield 69% (0.10 mmol, 34 mg), R_f = 0.20 (cyclohexane:EA, 7:3); yellow solid; ^{1}H NMR (300 MHz, chloroform-d) δ 9.43 (s, 1H), 8.18 – 8.04 (m, 1H), 7.98 – 7.87 (m, 1H), 7.82 (dd, J = 6.7, 3.0 Hz, 2H), 7.34 – 7.08 (m, 7H), 6.81 (d, J = 8.7 Hz, 2H), 6.34 (s, 1H), 3.74 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 161.0, 158.5, 150.5, 141.9, 133.6, 132.8, 132.0, 130.6, 129.5, 128.6, 127.3, 127.0, 126.8, 126.0, 124.3, 114.0, 55.3, 53.4; HR-MS (ESI+): m/z calculated for $C_{22}H_{19}N_2O$ 327.1497 obtained 327.1484.

Compound 2l: 1-((2,5-Dimethylphenyl)(phenyl)methyl)phthalazine



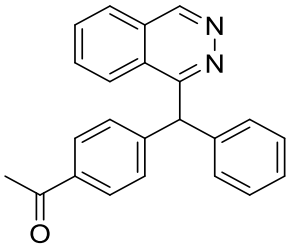
Yield 30% (0.05 mmol, 15 mg), R_f = 0.70 (cyclohexane:EA, 7:3); yellow solid; ^{1}H NMR (400 MHz, chloroform-*d*) δ 9.45 (s, 1H), 8.03 – 7.91 (m, 2H), 7.82 (pd, *J* = 7.1, 1.5 Hz, 2H), 7.40 – 7.15 (m, 5H), 7.09 (d, *J* = 7.6 Hz, 1H), 6.96 (d, *J* = 7.6 Hz, 1H), 6.78 (s, 1H), 6.45 (s, 1H), 2.24 (s, 3H), 2.15 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.90, 150.41, 140.43, 139.77, 135.50, 132.76, 132.62, 131.84, 130.47, 130.11, 129.96, 128.40, 127.69, 127.19, 126.84, 126.70, 125.91, 123.99, 50.99, 21.16, 19.60; HR-MS (ESI+): m/z calculated for $C_{23}H_{20}N_2Na$ 347.1524 obtained 347.1518.

Compound 2o: 1-((4-Bromophenyl)(phenyl)methyl)phthalazine



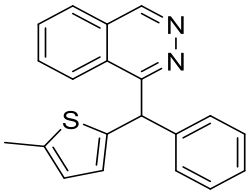
Yield 73% (0.11 mmol, 42 mg), R_f = 0.30 (cyclohexane:EA, 7:3); yellow solid; ^{1}H NMR (300 MHz, chloroform-d) δ 9.54 (s, 1H), 8.62 – 8.11 (m, 1H), 8.10 – 7.99 (m, 1H), 7.99 – 7.82 (m, 2H), 7.47 (d, J = 8.5 Hz, 2H), 7.38 – 7.25 (m, 5H), 7.23 (d, J = 8.4 Hz, 2H), 6.40 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 160.4, 150.5, 140.9, 140.5, 133.2, 132.3, 131.6, 131.4, 129.4, 128.8, 127.6, 127.2, 127.0, 125.9, 124.1, 121.0, 53.6; HR-MS (ESI+): m/z calculated for $C_{21}H_{15}N_2BrNa$ 397.0316 obtained 397.0319.

Compound 2p: 1-(4-(Phenyl(phthalazin-1-yl)methyl)phenyl)ethan-1-one



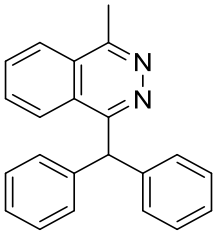
Yield 68% (0.10 mmol, 34 mg), R_f = 0.30(cyclohexane:EA, 6:4); yellow solid; ^{1}H NMR (400 MHz, chloroform-d) δ 9.41 (s, 1H), 8.06 (d, J = 8.0 Hz, 1H), 7.99 – 7.89 (m, 1H), 7.88 – 7.69 (m, 4H), 7.36 (d, J = 8.2 Hz, 2H), 7.31 – 7.14 (m, 5H), 6.39 (s, 1H), 2.52 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 197.9, 160.1, 150.7, 147.1, 140.8, 135.7, 132.9, 132.1, 130.0, 129.5, 128.8, 128.6, 127.39, 127.32, 127.0, 125.8, 124.0, 54.1, 26.7; HR-MS (ESI+): m/z calculated for $C_{23}H_{18}N_2ONa$ 361.1317 obtained 361.1313.

Compound 2q: 1-((5-Methylthiophen-2-yl)(phenyl)methyl)phthalazine



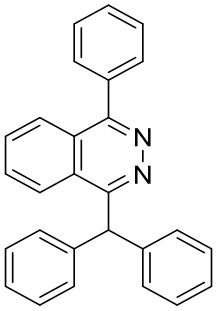
Yield 71% (0.11 mmol, 35 mg), R_f = 0.40(cyclohexane:EA, 6:4); yellow solid; ^{1}H NMR (400 MHz, chloroform-d) δ 9.39 (s, 1H), 8.15 – 8.06 (m, 1H), 7.95 – 7.83 (m, 1H), 7.81 – 7.73 (m, 2H), 7.34 (d, J = 7.5 Hz, 2H), 7.19 (dt, J = 21.2, 7.3 Hz, 3H), 6.58 (d, J = 3.4 Hz, 1H), 6.48 (d, J = 3.4 Hz, 1H), 6.44 (s, 1H), 2.33 (s, 3H).; ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.3, 150.7, 141.9, 141.6, 140.0, 132.8, 132.1, 128.9, 128.7, 127.3, 127.2, 127.1, 126.8, 125.6, 124.6, 124.2, 49.9, 15.4.; HR-MS (ESI+): m/z calculated for $C_{20}H_{16}N_2NaS$ 339.0932 obtained 339.0938.

Compound 2r: 1-Benzhydryl-4-methylphthalazine



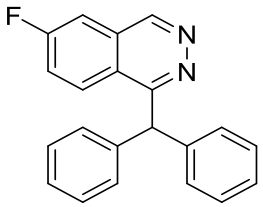
Yield 78% (0.12 mmol, 37 mg), R_f = 0.50 (cyclohexane:EA, 8:2); yellow solid; ^{1}H NMR (400 MHz, chloroform-*d*) δ 8.14 (dd, *J* = 19.2, 8.1 Hz, 2H), 7.84 (dt, *J* = 20.6, 7.4 Hz, 2H), 7.48 – 7.07 (m, 10H), 6.38 (s, 1H), 3.02 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.23, 156.72, 141.48, 132.84, 132.15, 129.62 (4CH), 128.88, 128.60 (4CH), 128.20, 126.93 (2CH), 125.57, 125.02, 54.10, 19.47 ; HR-MS (ESI+): m/z calculated for $C_{22}H_{18}N_2Na$ 333.1368 obtained 333.1375.

Compound 2s: 1-Benzhydryl-4-phenylphthalazine



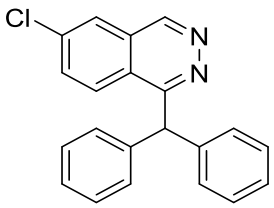
Yield 71% (0.11 mmol, 39.5 mg), R_f = 0.55 (cyclohexane:EA, 7:3); yellow solid; ^{1}H NMR (300 MHz, chloroform-d) δ 8.35 – 8.22 (m, 1H), 8.22 – 8.11 (m, 1H), 7.85 (dq, J = 5.7, 2.7 Hz, 4H), 7.60 (dd, J = 5.1, 2.1 Hz, 3H), 7.49 – 7.23 (m, 10H), 6.49 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.5, 158.9, 141.7, 136.4, 132.1, 131.7, 130.4, 129.7, 129.3, 128.59, 128.52, 127.2, 126.8, 126.3, 124.5, 54.2; HR-MS (ESI+): m/z calculated for $C_{27}H_{20}N_2Na$ 395.1524 obtained 395.1530.

Compound 2t: 1-Benzhydryl-6-fluorophthalazine



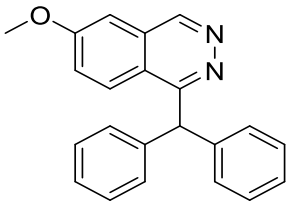
Yield 49% (0.07 mmol, 23 mg), R_f = 0.30 (cyclohexane:EA, 7:3); yellow solid; ^{1}H NMR (400 MHz, chloroform-*d*) δ 9.39 (s, 1H), 8.14 (dd, *J* = 8.9, 5.0 Hz, 1H), 7.59 – 7.46 (m, 2H), 7.41 – 7.11 (m, 10H), 6.34 (s, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.32, 161.92, 160.25, 150.33, 150.27, 141.31, 129.91, 129.58, 128.70, 128.43, 128.03, 127.91, 127.05, 123.11, 123.09, 122.85, 122.53, 111.12, 110.84, 54.56; HR-MS (ESI+): m/z calculated for $C_{21}H_{16}N_2F$ 315.1298 obtained 315.1301.

Compound 2u: 1-Benzhydryl-6-chlorophthalazine



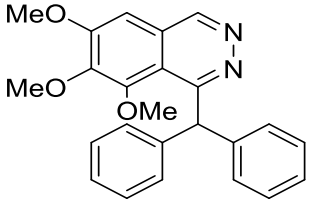
Yield 46% (0.07 mmol, 23 mg), R_f = 0.38(cyclohexane:EA, 7:3); yellow solid; ^{1}H NMR (300 MHz, chloroform-d) δ 9.52 (brs, 1H), 8.14 (d, J = 8.9 Hz, 1H), 8.04 (d, J = 2.1 Hz, 1H), 7.82 (dd, J = 8.9, 2.1 Hz, 1H), 7.50 – 7.21 (m, 10H), 6.42 (s, 1H).; ^{13}C NMR (75 MHz, $CDCl_3$) δ 140.8, 138.4, 134.12, 129.4, 128.6, 128.5, 128.3, 127.9, 127.0, 126.4, 124.40, 124.36, 54.3; HR-MS (ESI+): m/z calculated for $C_{21}H_{15}N_2NaCl$ 353.0821 obtained 353.0828.

Compound 2v: 1-Benzhydryl-6-methoxyphthalazine



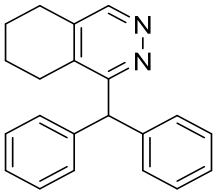
Yield 68% (0.102 mmol, 34 mg), R_f = 0.30(cyclohexane:EA, 7:3); yellow solid; ^{1}H NMR (400 MHz, chloroform-*d*) δ 9.35 (s, 1H), 8.00 (d, *J* = 9.2 Hz, 1H), 7.35 (dd, *J* = 9.1, 2.5 Hz, 1H), 7.30 – 7.09 (m, 11H), 6.32 (s, 1H), 3.92 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.90, 160.13, 150.20, 141.62, 129.60, 129.33, 128.59, 126.87, 126.42, 124.87, 121.45, 105.14, 55.95, 54.33; HR-MS (ESI+): m/z calculated for $C_{22}H_{18}N_2ONa$ 349.1317 obtained 349.1320.

Compound 2w: 1-Benzhydryl-6,7,8-trimethoxyphthalazine



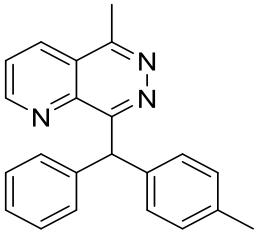
Yield 52% (0.08 mmol, 30 mg), R_f = 0.10 (cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (300 MHz, chloroform-d) δ 9.42 (s, 1H), 7.61 – 7.15 (m, 11H), 7.05 (s, 1H), 4.11 (s, 3H), 4.03 (s, 3H), 3.68 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.50, 149.87, 147.20, 142.64, 129.93, 128.39, 127.97, 127.91, 127.14, 126.67, 118.41, 104.29, 62.03, 61.45, 56.98, 55.26; HR-MS (ESI+): m/z calculated for $C_{24}H_{22}N_2O_3Na$ 409.1528 obtained 409.1517.

Compound 2x: 1-Benzhydryl-5,6,7,8-tetrahydrophthalazine



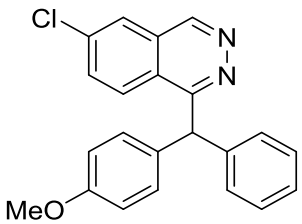
Yield 36% (0.06 mmol, 17 mg), R_f = 0.35 (cyclohexane:EA, 7:3); yellow solid; ^{1}H NMR (300 MHz, chloroform-d) δ 8.67 (s, 1H), 7.1 – 7.24 (m, 10H), 5.68 (s, 1H), 2.62 (dt, J = 16.1, 6.1 Hz, 4H), 1.83 – 1.56 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 150.8, 141.4, 137.3, 136.1, 129.6, 129.0, 128.5, 126.79, 53.3, 26.4, 24.6, 22.1, 21.1.; HR-MS (ESI+): m/z calculated for $C_{21}H_{20}N_2Na$ 323.1524 obtained 323.1519.

Compound 2y: 5-Methyl-8-(phenyl(p-tolyl)methyl)pyrido[2,3-d]pyridazine



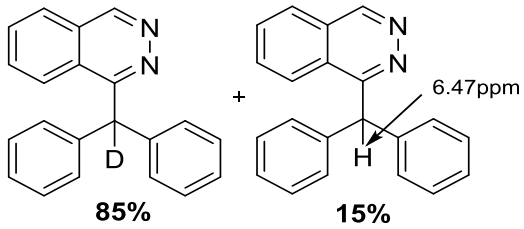
Yield 66% (0.10 mmol, 33 mg), R_f = 0.42 (cyclohexane:EA, 6:4); yellow solid; ^{1}H NMR (300 MHz, chloroform-d) δ 9.29 (dd, J = 4.3, 1.6 Hz, 1H), 8.43 (dd, J = 8.3, 1.7 Hz, 1H), 7.83 (dd, J = 8.4, 4.3 Hz, 1H), 7.53 (d, J = 7.4 Hz, 2H), 7.44 (d, J = 8.0 Hz, 2H), 7.31 (t, J = 7.4 Hz, 2H), 7.26 – 7.18 (m, 2H), 7.13 (d, J = 7.9 Hz, 2H), 3.08 (s, 3H), 2.33 (s, 3H); ^{13}C NMR (75 MHz, chloroform-d) δ 163.1, 156.8, 155.7, 142.2, 140.7, 138.9, 136.1, 133.1, 129.6, 129.5, 129.0, 128.2, 126.9, 126.4, 122.0, 49.3, 21.0, 18.9; HR-MS (ESI+): m/z calculated for $C_{22}H_{19}N_3Na$ 348.1477 obtained 348.1493.

Compound 2z: 6-Chloro-1-((4-methoxyphenyl)(phenyl)methyl)phthalazine



Yield 61% (0.091 mmol, 33 mg), R_f = 0.30 (cyclohexane:EA, 7:3); yellow solid; ^{1}H NMR (400 MHz, chloroform-*d*) δ 9.41 (s, 1H), 8.08 (d, *J* = 8.9 Hz, 1H), 7.95 (s, 1H), 7.74 (d, *J* = 8.8 Hz, 1H), 7.39 – 7.14 (m, 7H), 6.83 (d, *J* = 8.3 Hz, 2H), 6.31 (s, 1H), 3.76 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.98, 158.66, 149.53, 141.54, 138.28, 133.85, 133.21, 130.59 (2CH), 129.46 (2CH), 128.71 (2CH), 128.01, 127.03, 126.54, 126.32, 124.32, 114.17 (2CH), 55.37, 53.73; HR-MS (ESI+): m/z calculated for $C_{22}H_{17}N_2ONaCl$ 383.0927 obtained 383.0934.

Compound 2aa: 1-(Diphenylmethyl-d)phthalazine

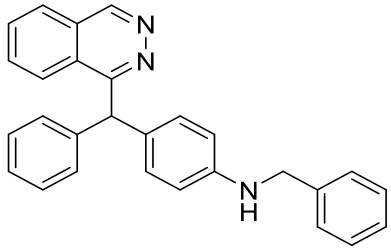


Yield 68% (0.10 mmol, 30 mg), R_f = 0.45 (cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (300 MHz, chloroform-*d*) δ 9.49 (s, 1H), 8.23 – 8.14 (m, 1H), 8.03 – 7.95 (m, 1H), 7.87 (tt, *J* = 7.1, 5.2 Hz, 2H), 7.47 – 7.21 (m, 10H), 6.47 (s, 0.32H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 165.32, 161.92, 160.27, 160.25, 150.33, 150.27, 141.31, 139.56, 129.91, 129.58, 129.01, 128.89, 128.72, 128.70, 128.43, 128.38, 128.02, 127.91, 127.05, 123.12, 123.09, 122.85, 122.52, 111.12, 110.84, 54.56; HR-MS (ESI+): m/z calculated for $C_{21}H_{16}DN_2$ 298.1455 obtained 298.1465.

General procedure for the synthesis of **4**:

A flame-dried resealable Schlenk tube was charged with $Pd(OAc)_2$ (0.0125 mmol, 5 mol%), Xantphos (0.025 mmol, 10 mol%), **2o** (0.25 mmol), benzylamine (0.33 mmol) and Cs_2CO_3 (0.50 mmol). The Schlenk tube was capped with a rubber septum, evacuated and backfilled with argon; this evacuation/backfill sequence was repeated one additional time. The liquid reactant(s) and 1,4-dioxane (4 mL/mmol) were added through the septum. The septum was replaced with a Teflon screw cap. The Schlenk tube was sealed, and the mixture was stirred at 130 °C for 12 hours. The resulting suspension was cooled to room temperature and filtered through a pad of celite eluting with ethyl acetate, and the inorganic salts were removed. The filtrate was concentrated and purification of the residue by silica gel column chromatography gave the desired product.

Compound 4: *N*-Benzyl-4-(phenyl(phthalazin-1-yl)methyl)aniline

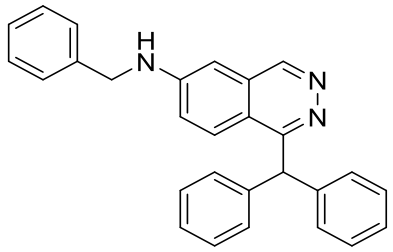


Yield 73% (0.18 mmol, 65 mg), R_f = 0.50(cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (300 MHz, chloroform-d) δ 9.34 (s, 1H), 8.15 – 8.02 (m, 1H), 7.91 – 7.82 (m, 1H), 7.80 – 7.65 (m, 2H), 7.34 – 7.11 (m, 10H), 7.04 (d, J = 8.5 Hz, 2H), 6.50 (d, J = 8.6 Hz, 2H), 6.22 (s, 1H), 4.19 (s, 2H). ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 161.2, 150.4, 146.9, 142.2, 139.3, 132.7, 131.9, 130.5, 130.4, 129.5, 128.7, 128.4, 127.7, 127.3, 127.2, 127.0, 126.6, 126.0, 124.5, 113.1, 53.5, 48.6.; HR-MS (ESI+): m/z calculated for $C_{28}H_{23}N_3Na$ 424.1790 obtained 424.1792.

General procedure for the synthesis of **5**:

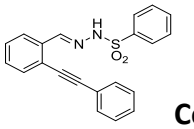
A flame-dried resealable Schlenk tube was charged with Buchwald precatalyst [XPhos palladacycle Gen. 3] (0.005 mmol, 2 mol%), **2u** (0.25 mmol), benzylamine (0.33 mmol) and K_3PO_4 (0.75 mmol). The Schlenk tube was capped with a rubber septum, evacuated and backfilled with argon; this evacuation/backfill sequence was repeated one additional time. The liquid reactant(s) and *t*-BuOH (2 mL/mmol) were added through the septum. The septum was replaced with a Teflon screw cap. The Schlenk tube was sealed, and the mixture was stirred at 110 °C for 12 hours. The resulting suspension was cooled to room temperature and filtered through a pad of celite eluting with ethyl acetate, and the inorganic salts were removed. The filtrate was concentrated and purification of the residue by silica gel column chromatography gave the desired product.

Compound 5: 1-benzhydryl-*N*-benzylphthalazin-6-amine

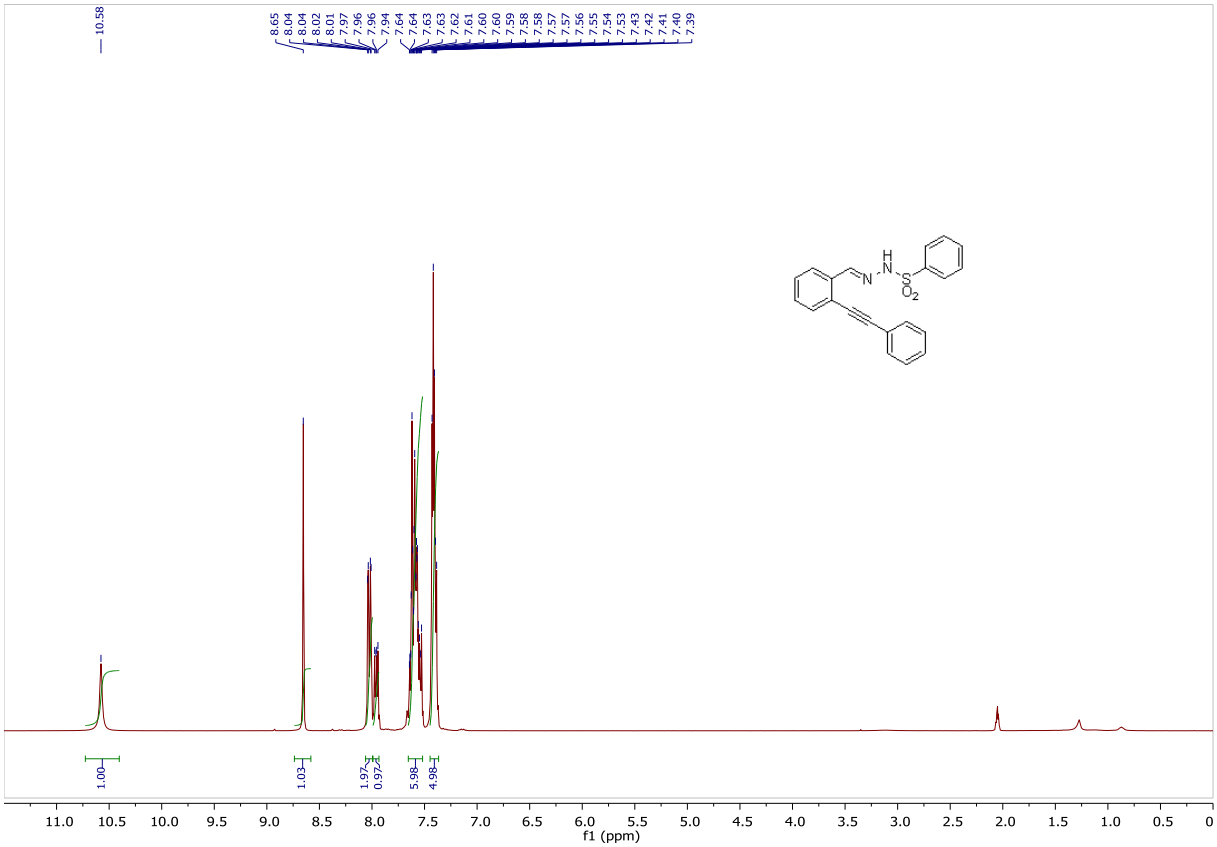


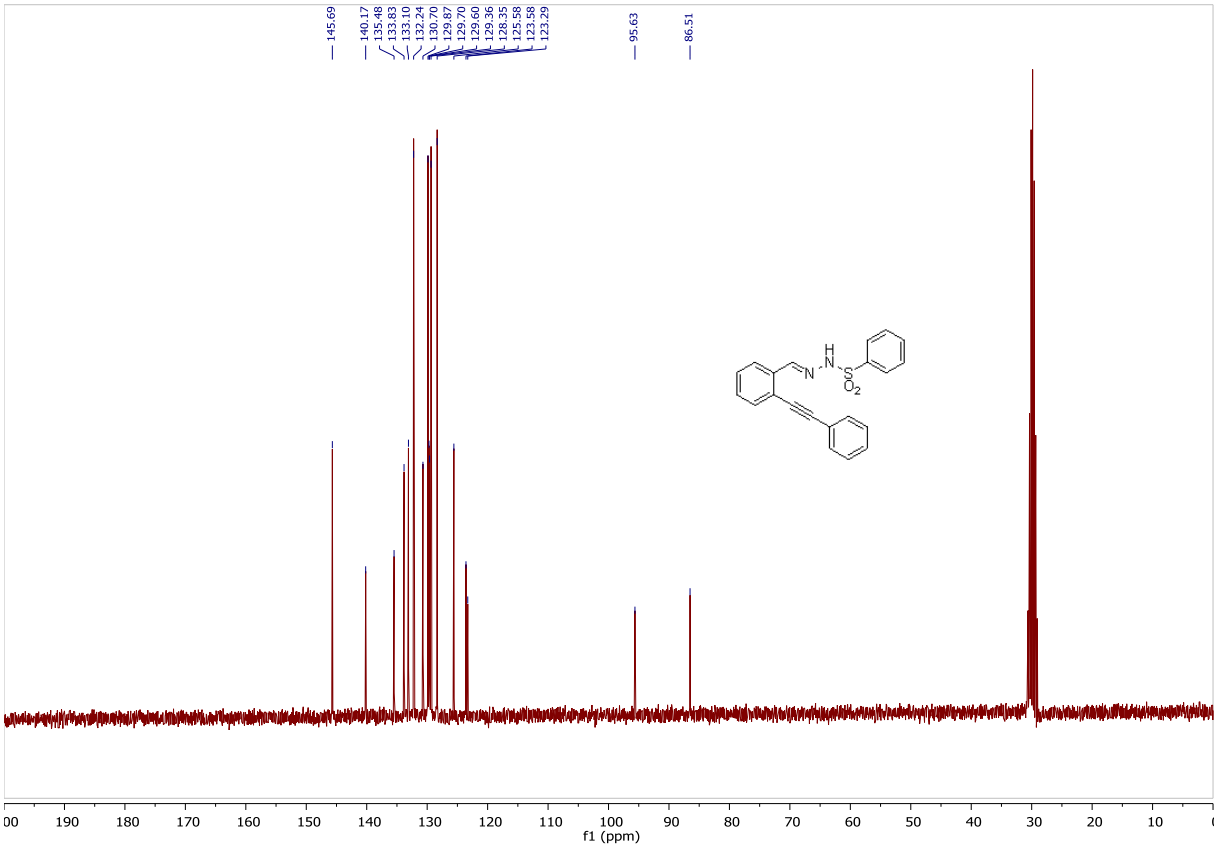
Yield 66% (0.16 mmol, 64 mg), R_f = 0.15 (cyclohexane:EA, 5:5); yellow solid; ^{1}H NMR (300 MHz, Chloroform-*d*) δ 9.10 (s, 1H), 7.87 (d, *J* = 9.1 Hz, 1H), 7.34 (dd, *J* = 29.3, 4.1 Hz, 16H), 6.78 (s, 1H), 6.34 (s, 1H), 5.81 (brs, 1H), 4.49 (s, 2H) ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.63, 151.11, 149.68, 141.43, 137.68, 130.08, 129.56, 128.98, 128.58, 127.78, 127.44, 126.89, 126.12, 123.39, 119.14, 115.08, 102.58, 53.91, 47.63. HR-MS (ESI+): m/z calculated for $C_{28}H_{24}N_3$ 402.1970 obtained 402.1971.

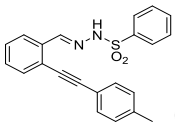
V- Full spectra of each compounds



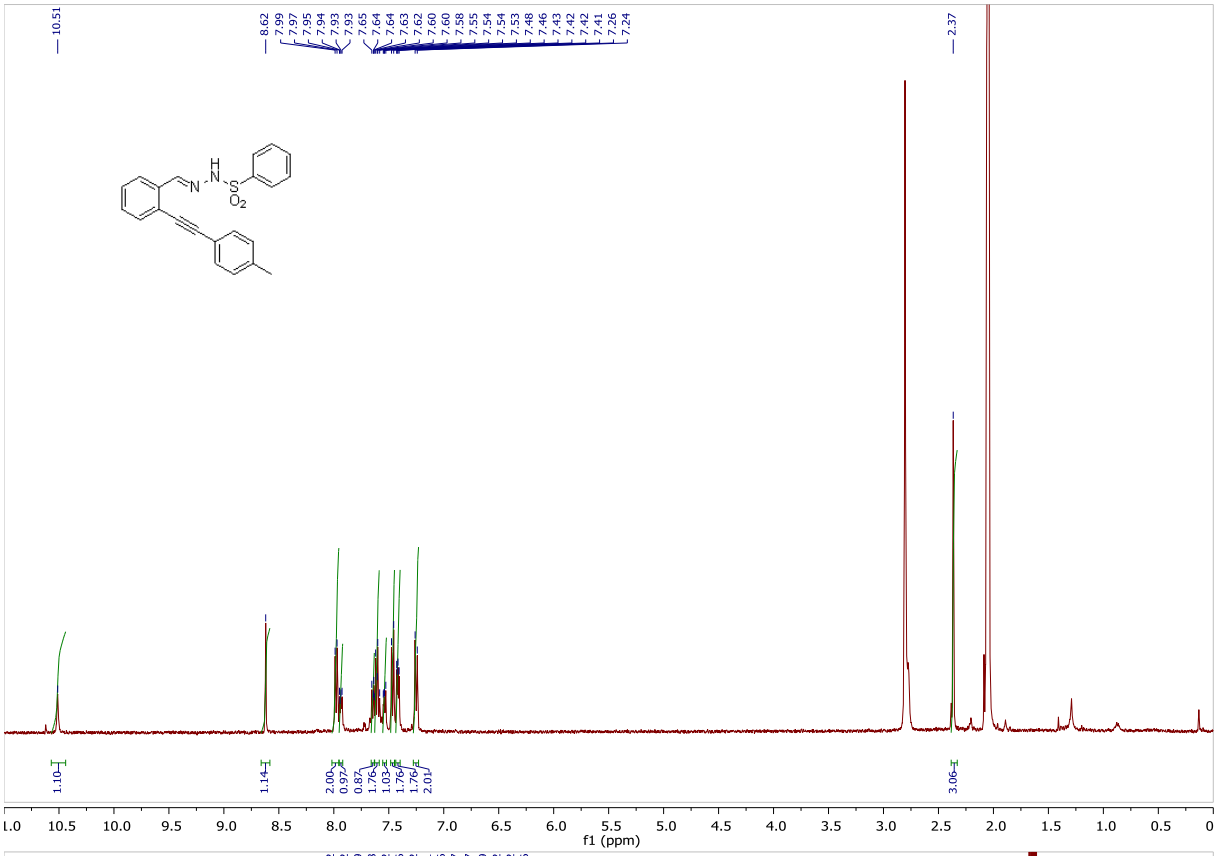
Compound 1a: N'-(2-(phenylethynyl)benzylidene)benzenesulfonohydrazide

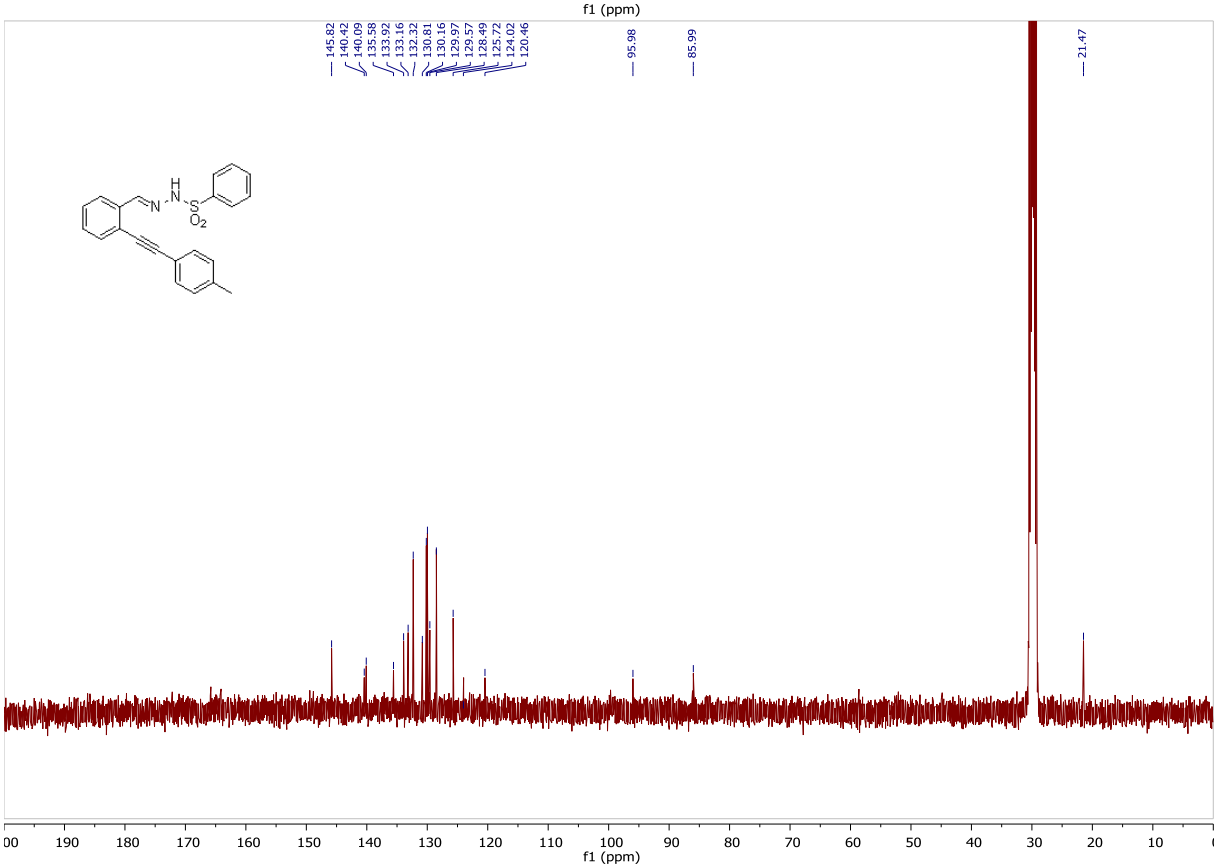


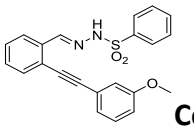




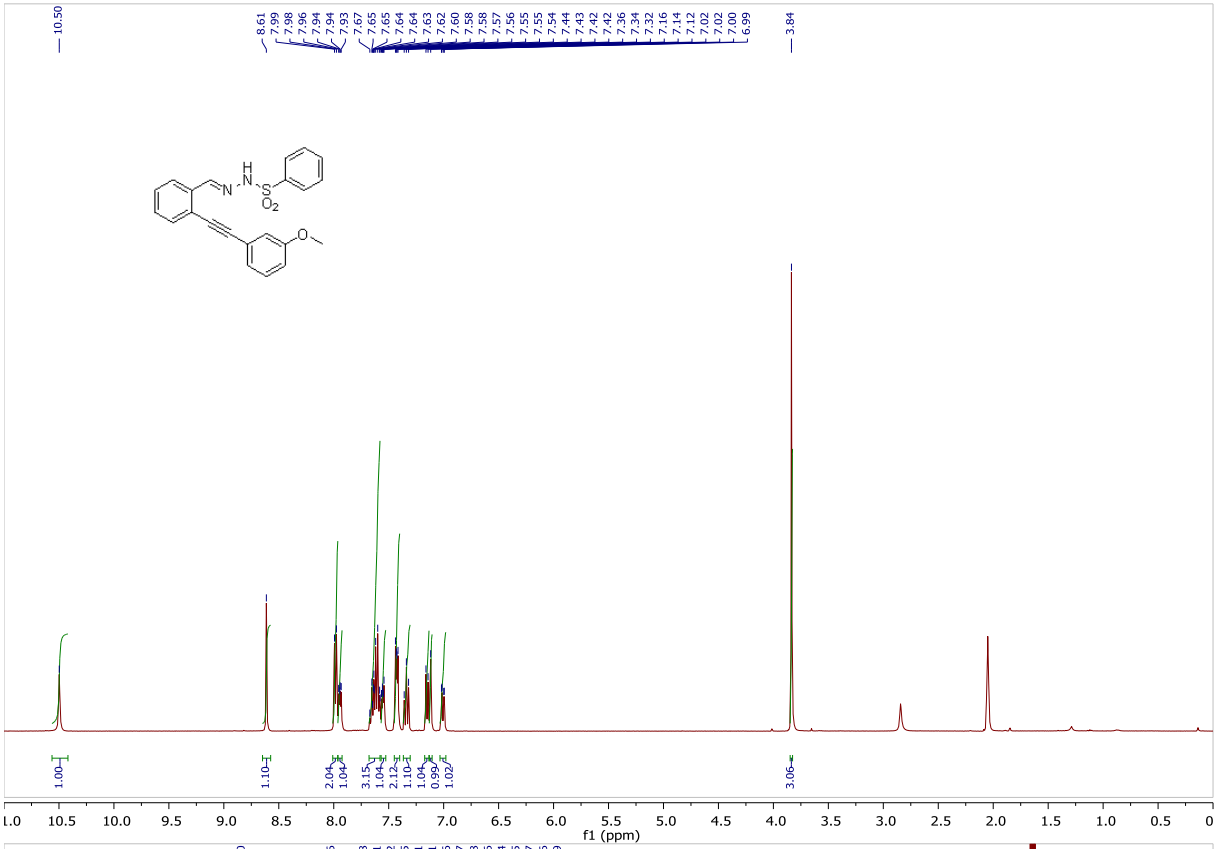
Compound 1b: N'-(2-(p-tolylethynyl)benzylidene)benzenesulfonohydrazide

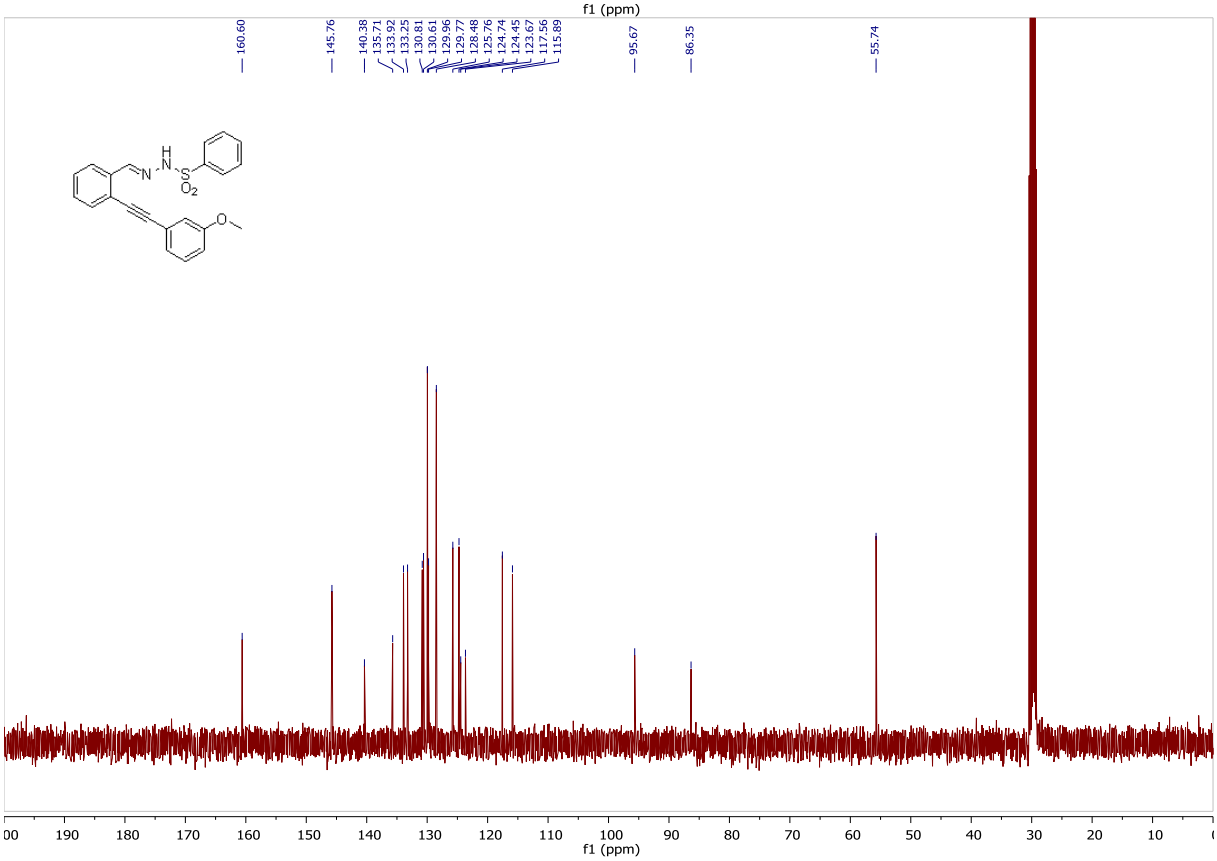


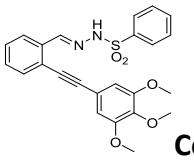




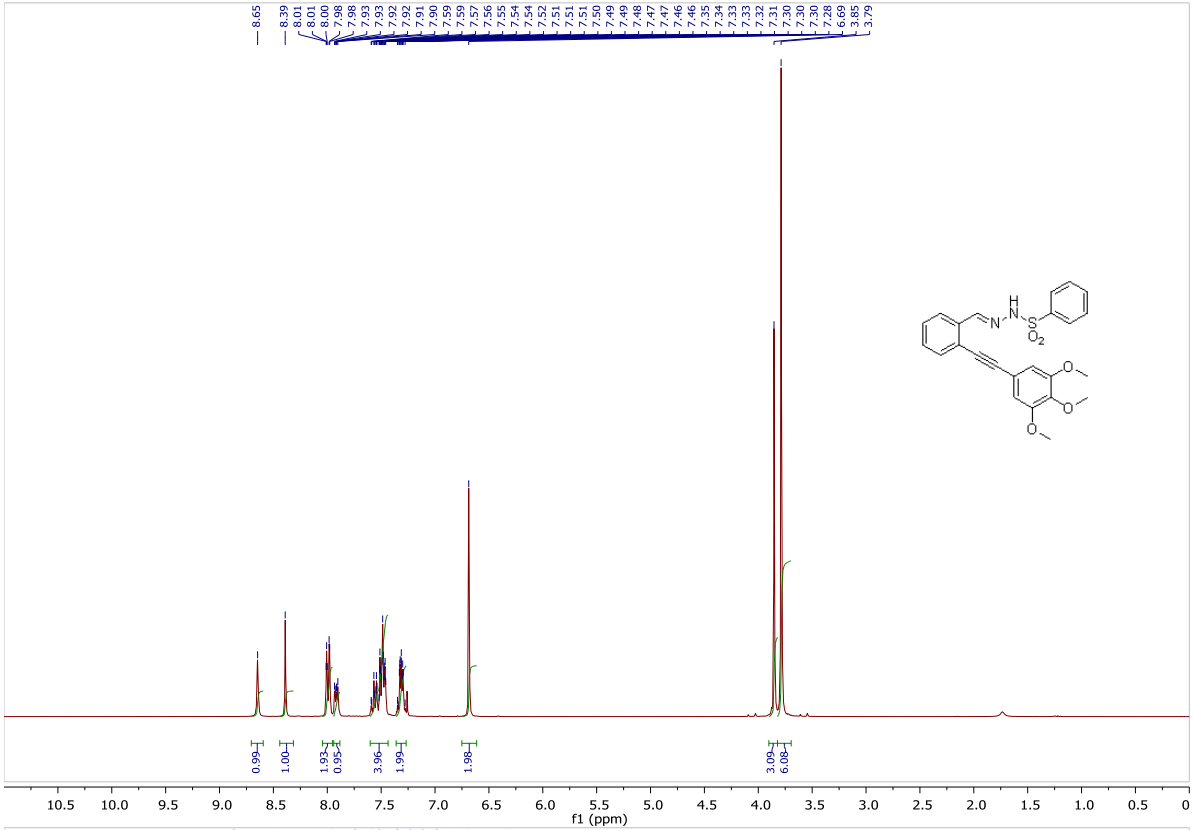
Compound 1c: N'-(2-((3-methoxyphenyl)ethynyl)benzylidene)benzenesulfonohydrazide

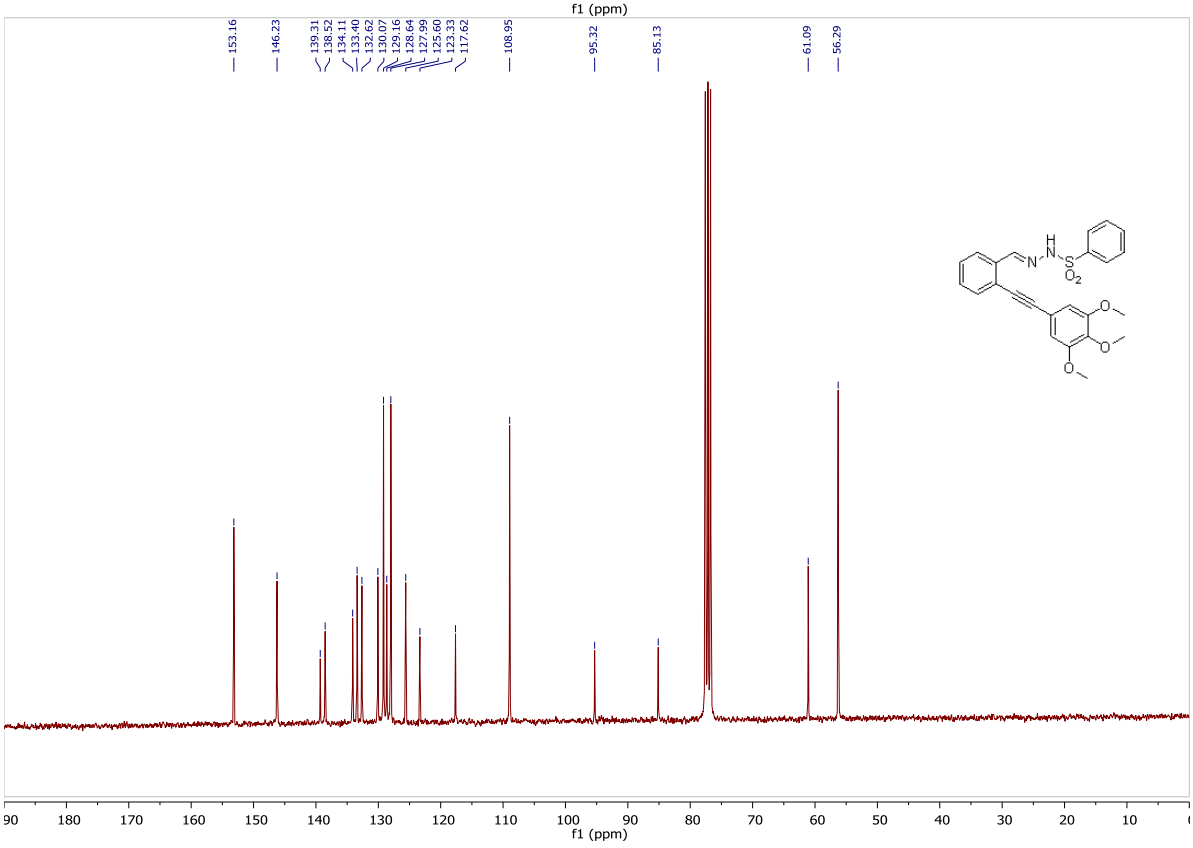


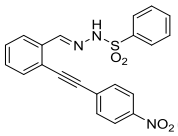




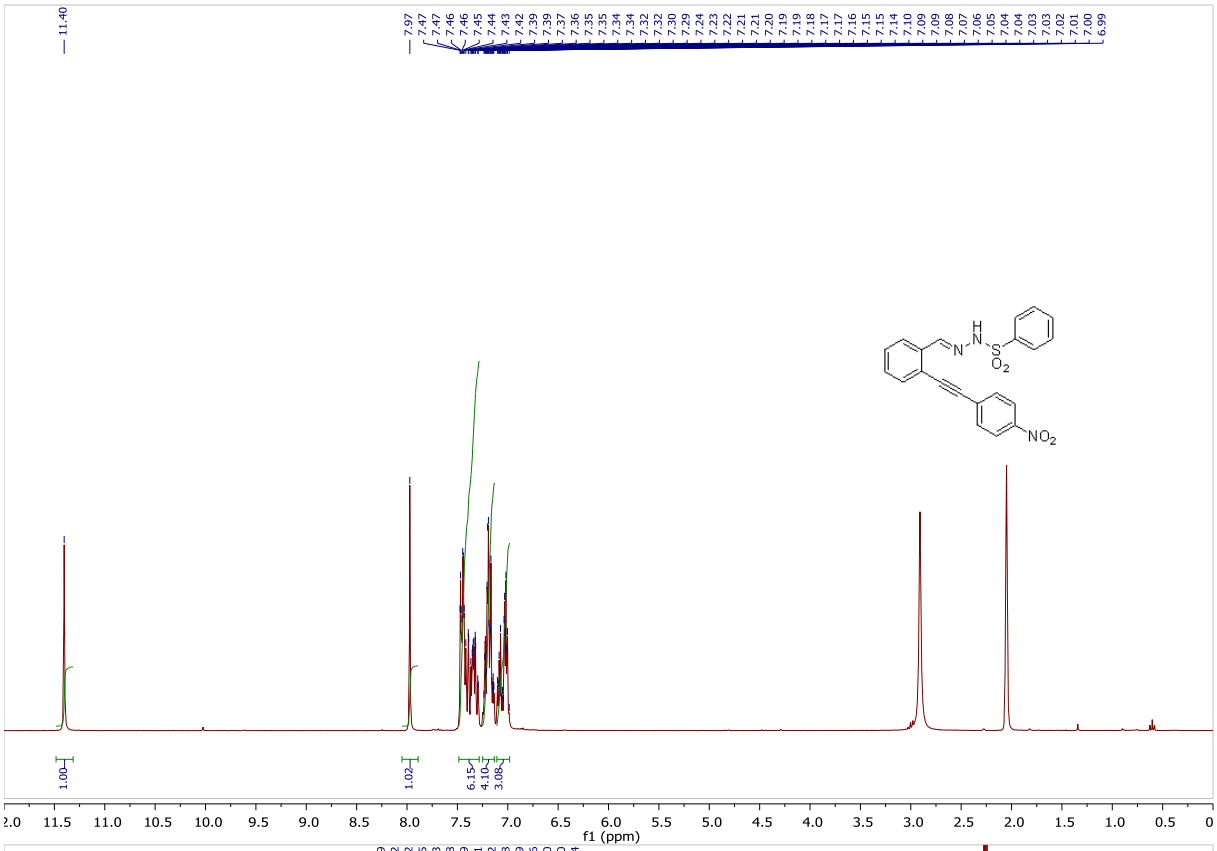
Compound1d:N'-(2-((3,4,5-trimethoxyphenyl)ethynyl)benzylidene)benzenesulfonohydrazide

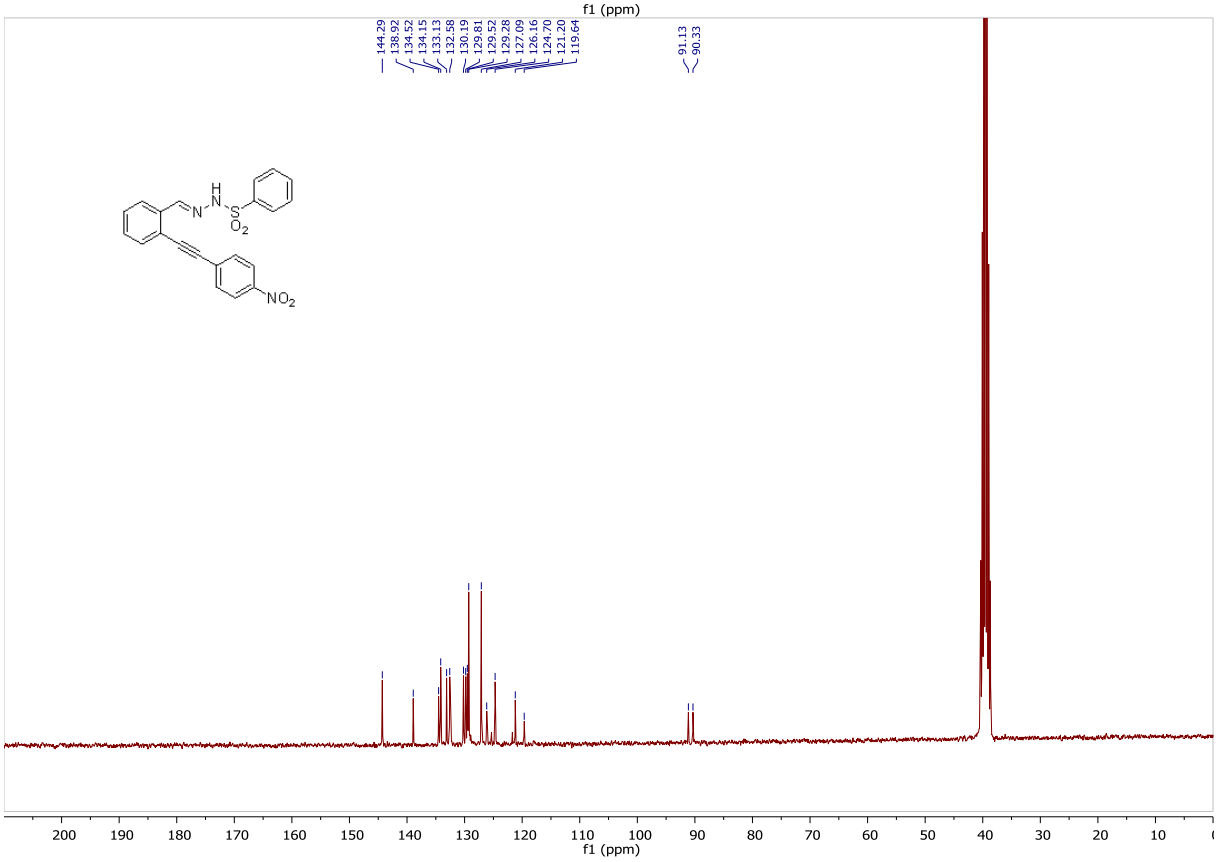


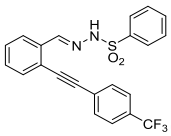




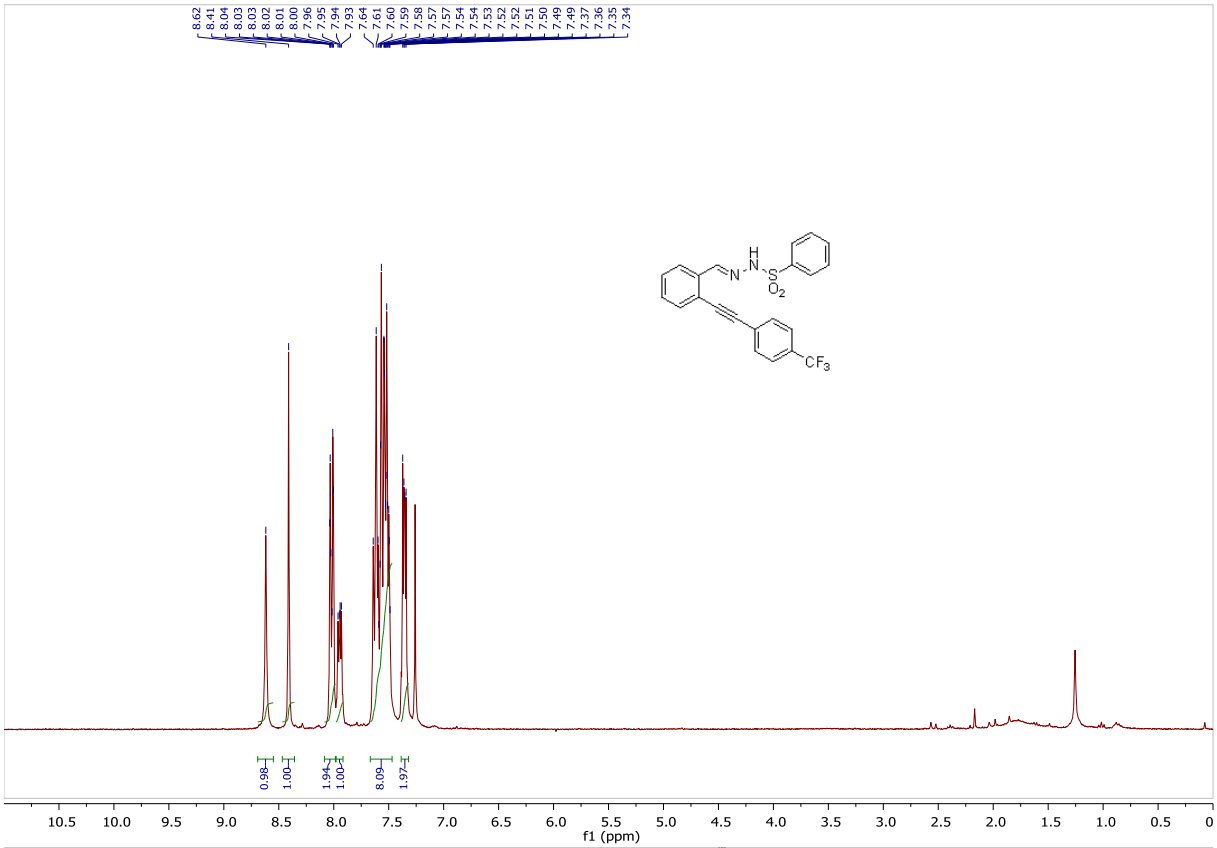
Compound 1e: N'-(2-((4-nitrophenyl)ethynyl)benzylidene)benzenesulfonohydrazide

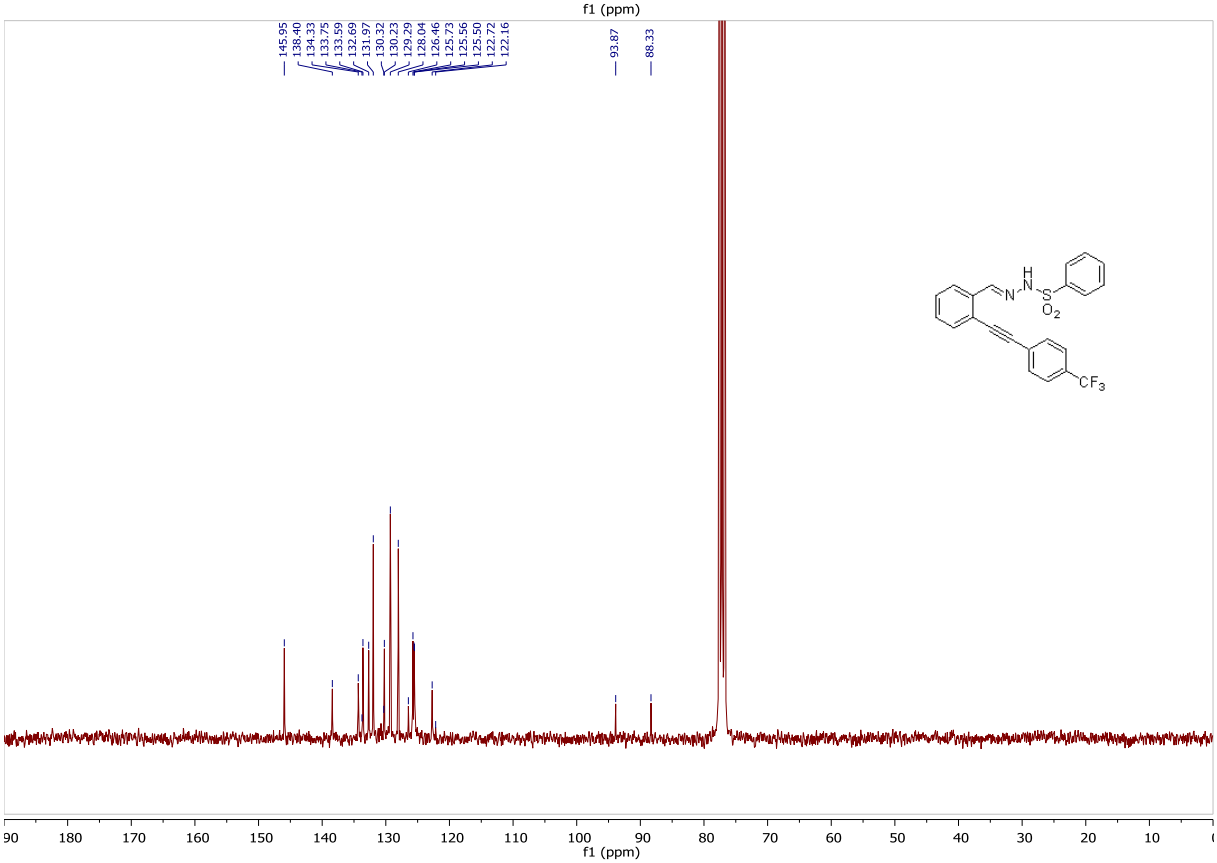


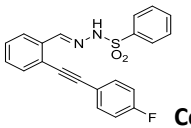




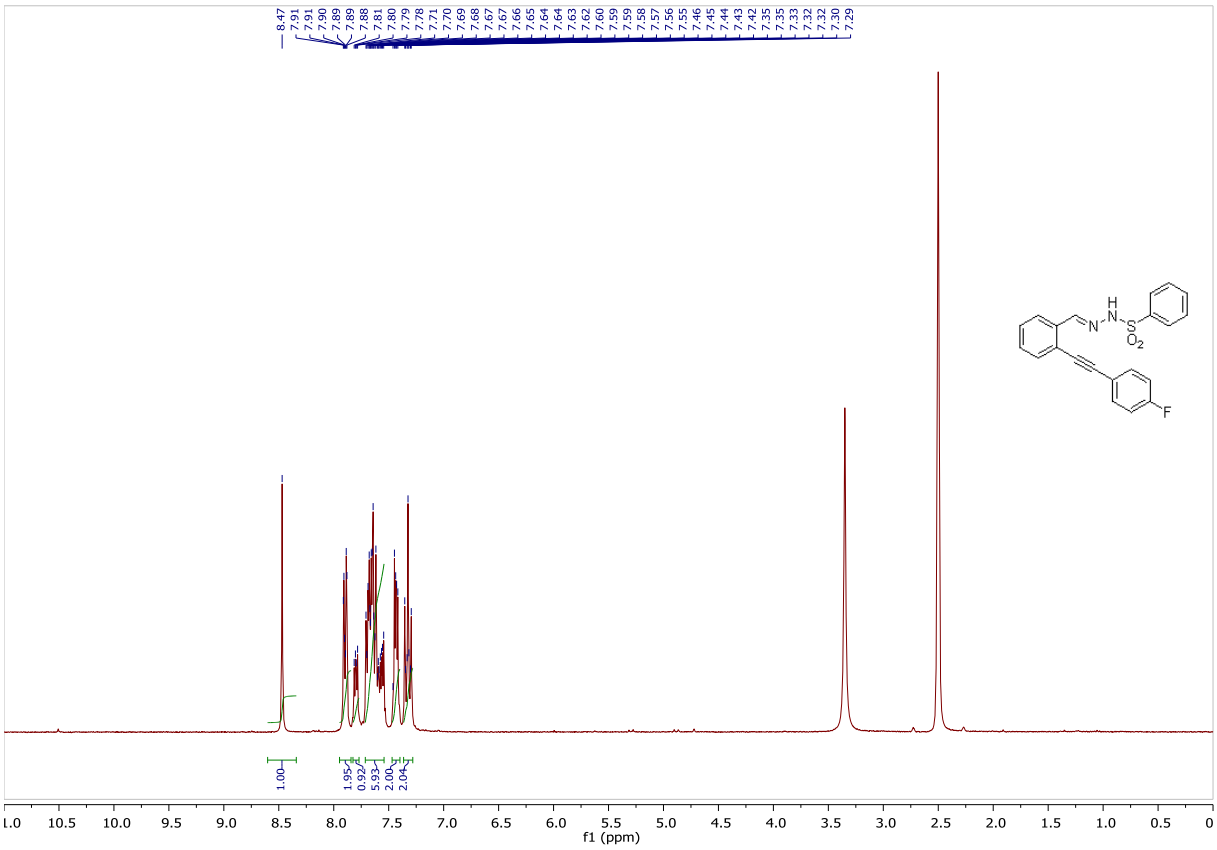
Compound1f: N'-(2-((4-(trifluoromethyl)phenyl)ethynyl)benzylidene)benzenesulfonohydrazide

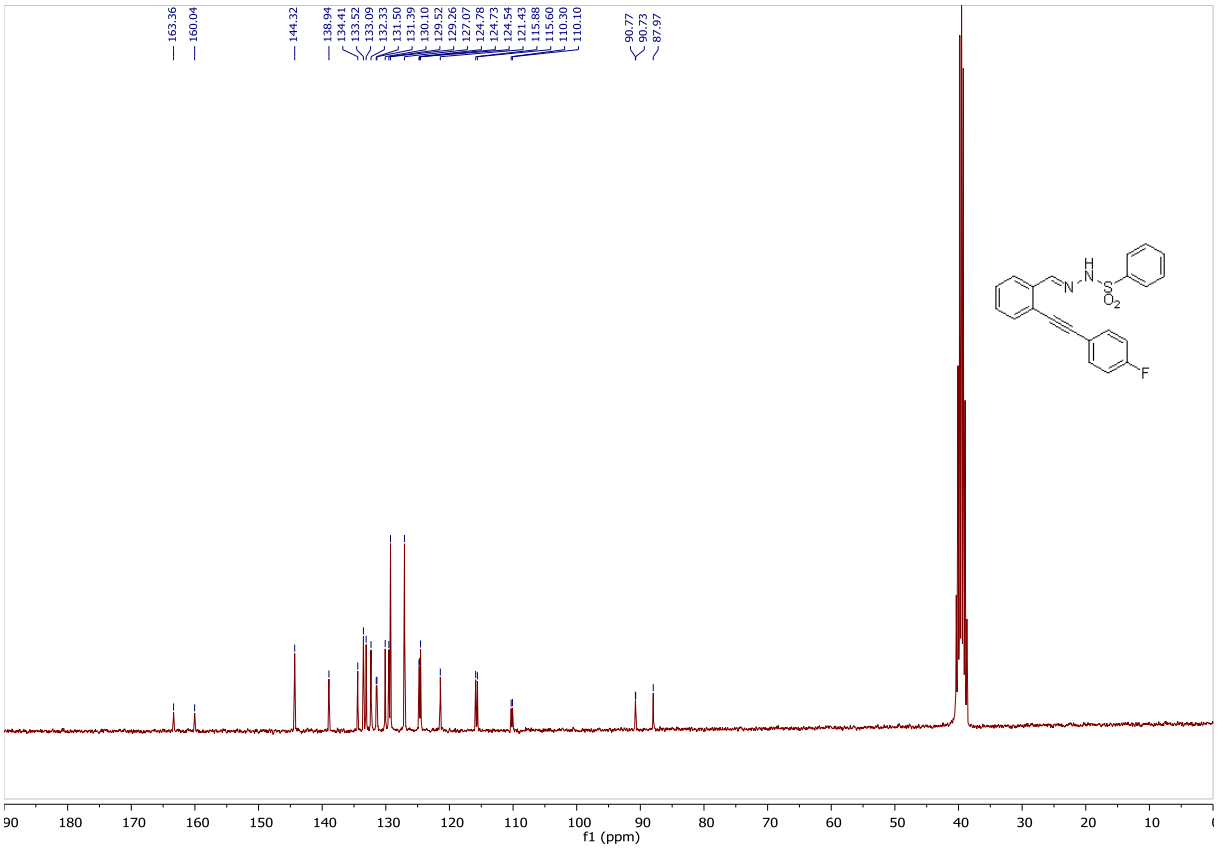


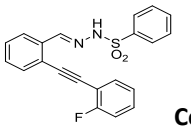




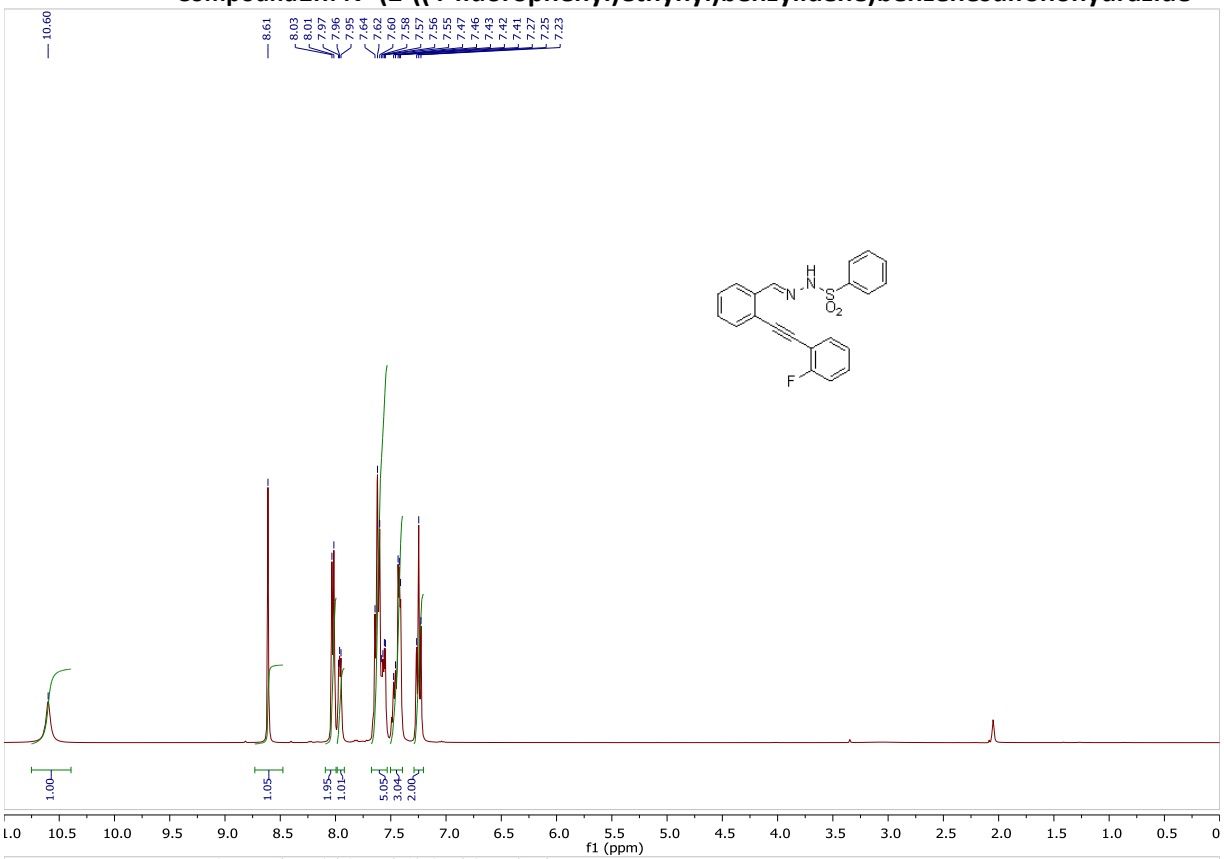
Compound1g: N'-(2-((4-fluorophenyl)ethynyl)benzylidene)benzenesulfonohydrazide

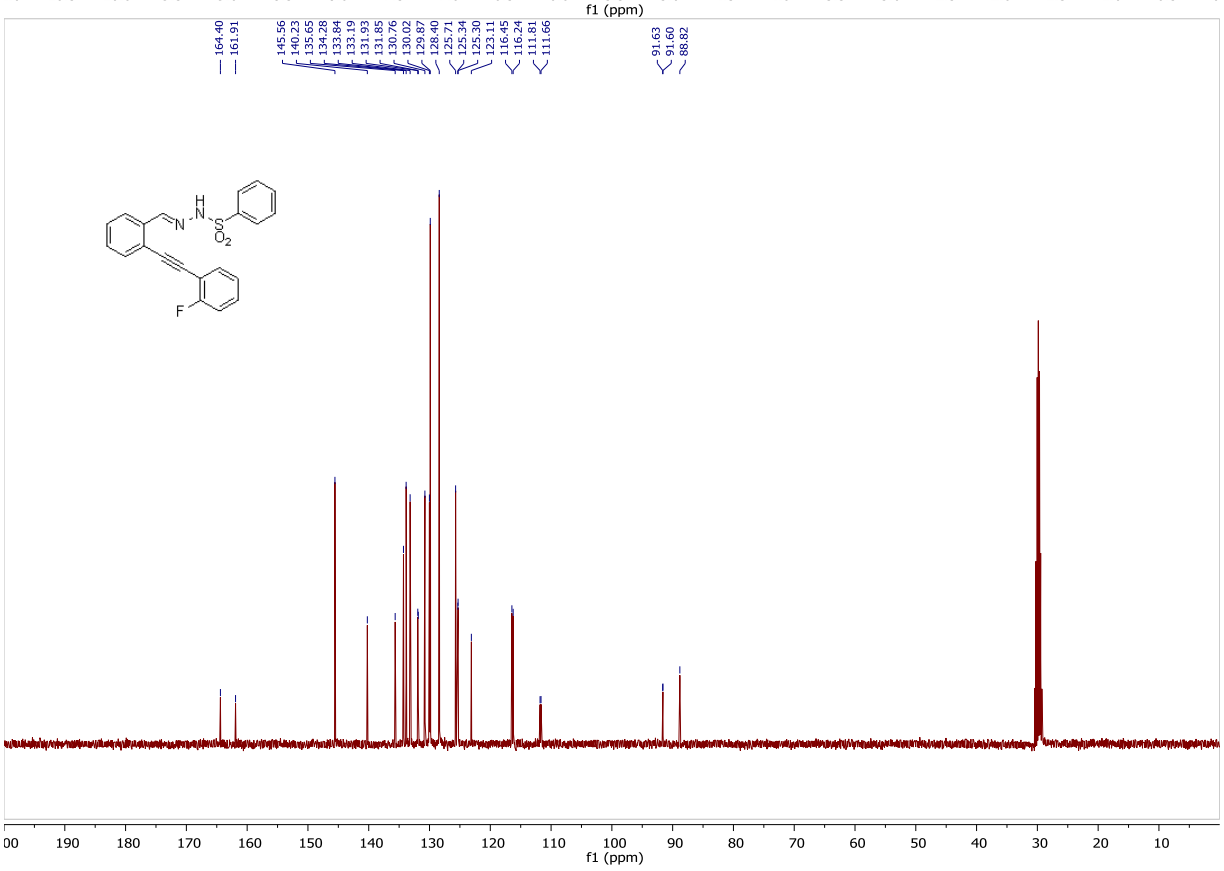


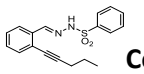




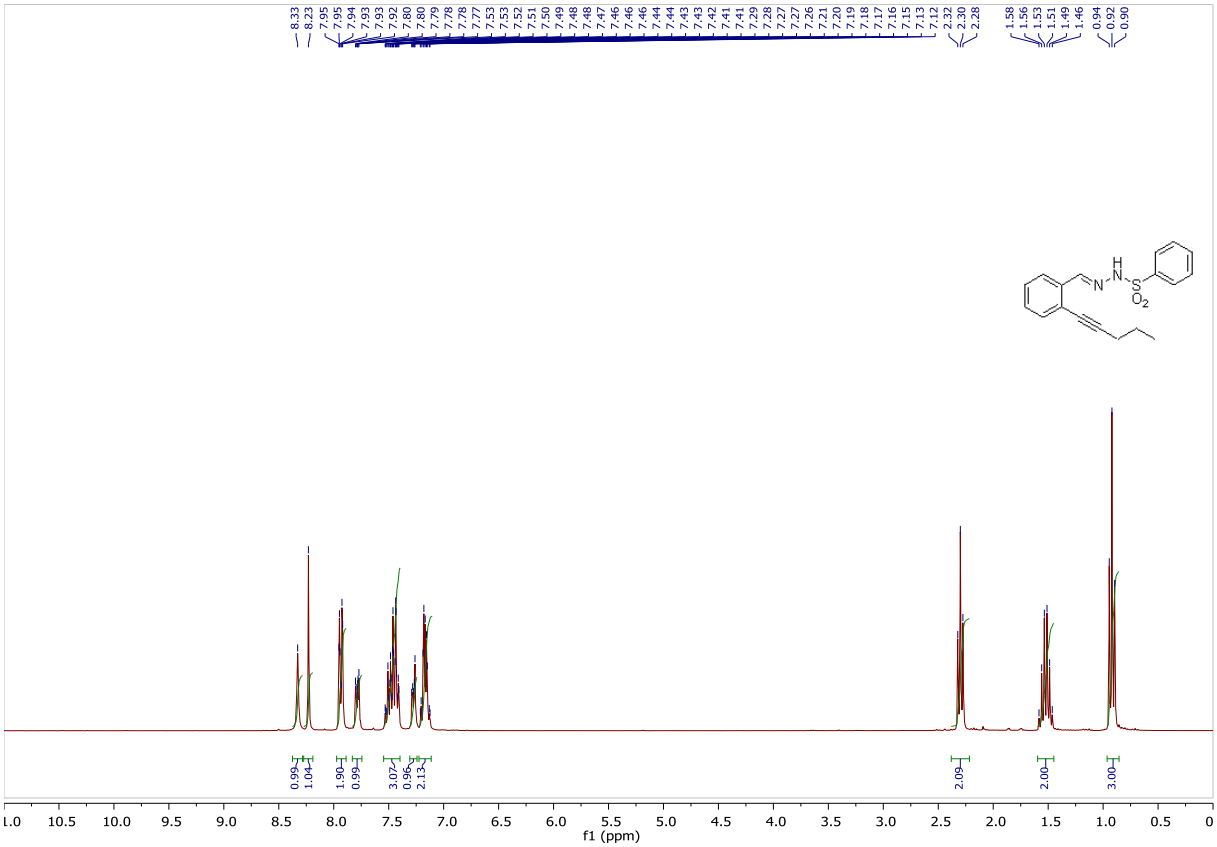
Compound1h: N'-(2-((4-fluorophenyl)ethynyl)benzylidene)benzenesulfonohydrazide

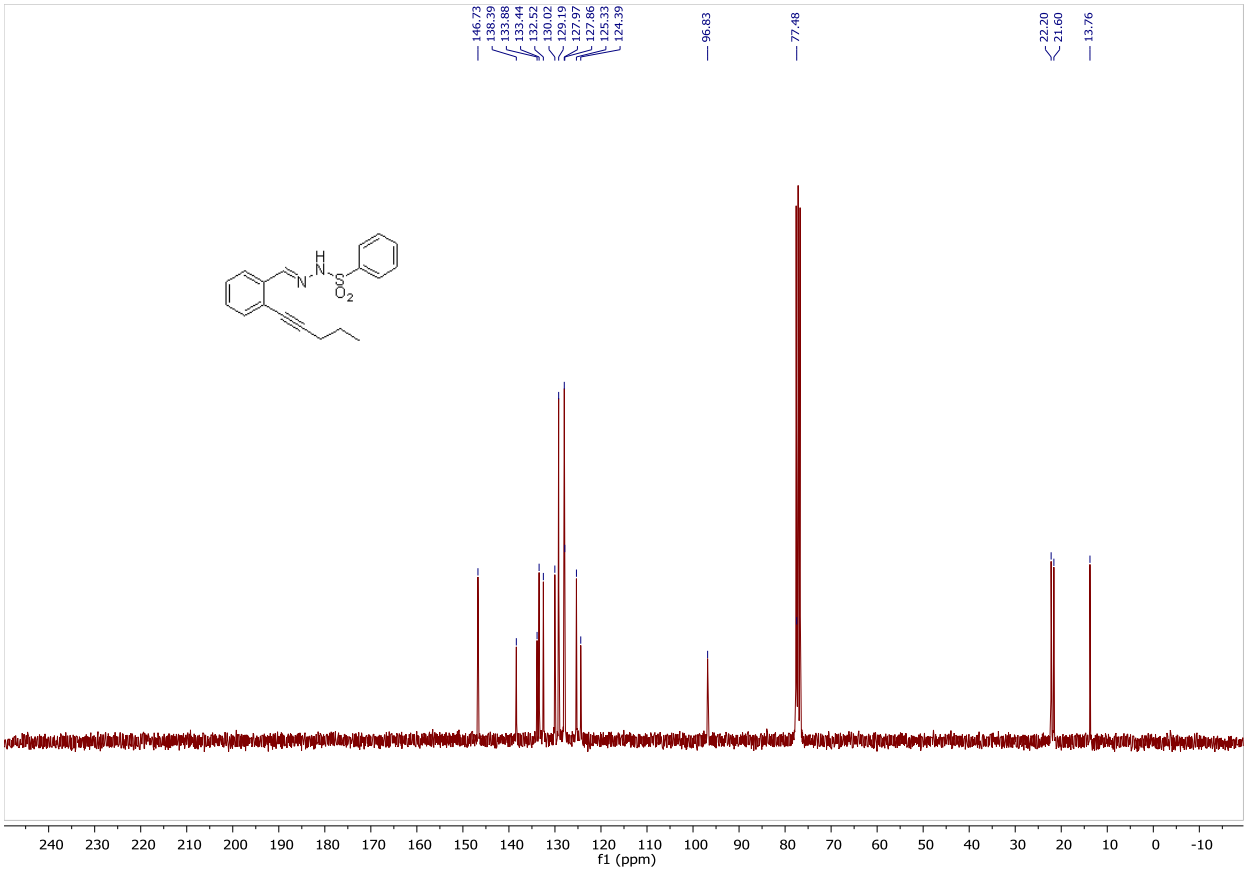


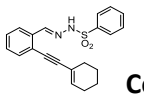




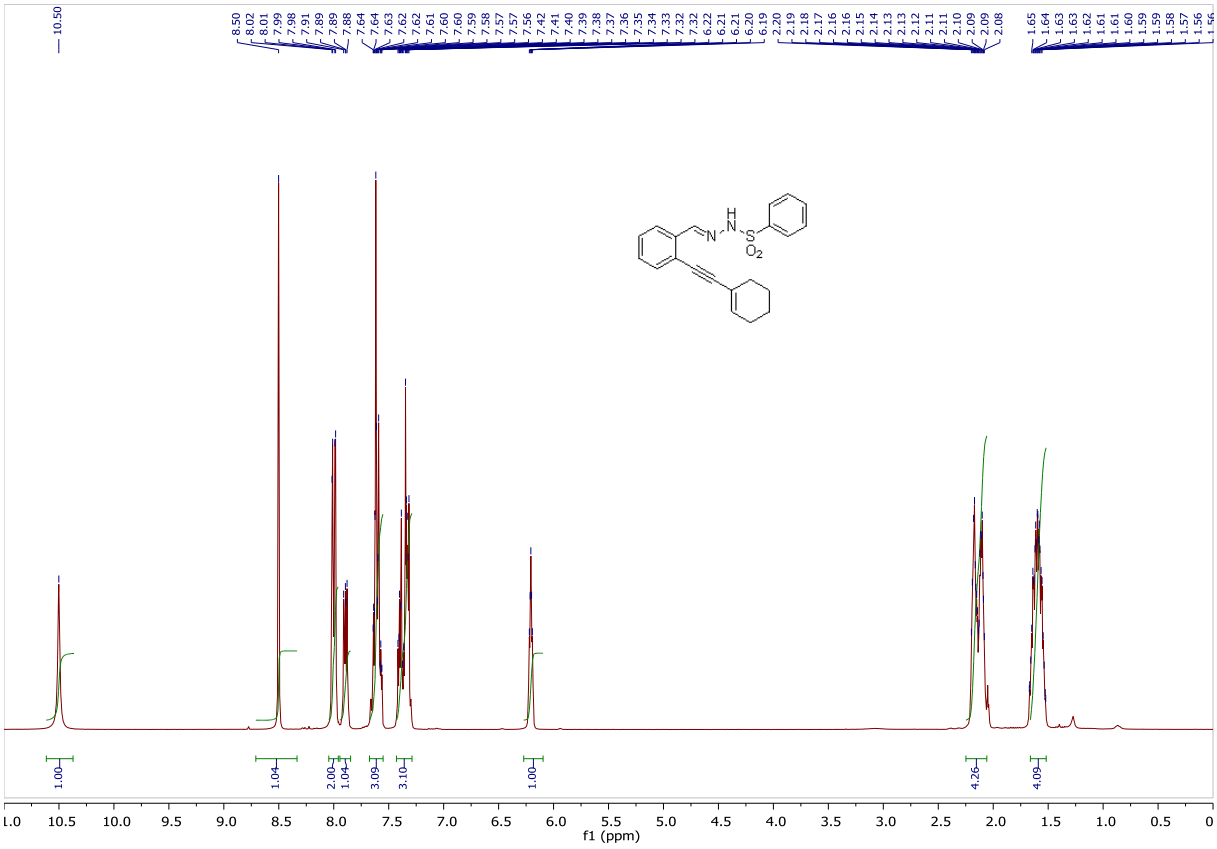
Compound 1i: N'-(2-(pent-1-yn-1-yl)benzylidene)benzenesulfonohydrazide

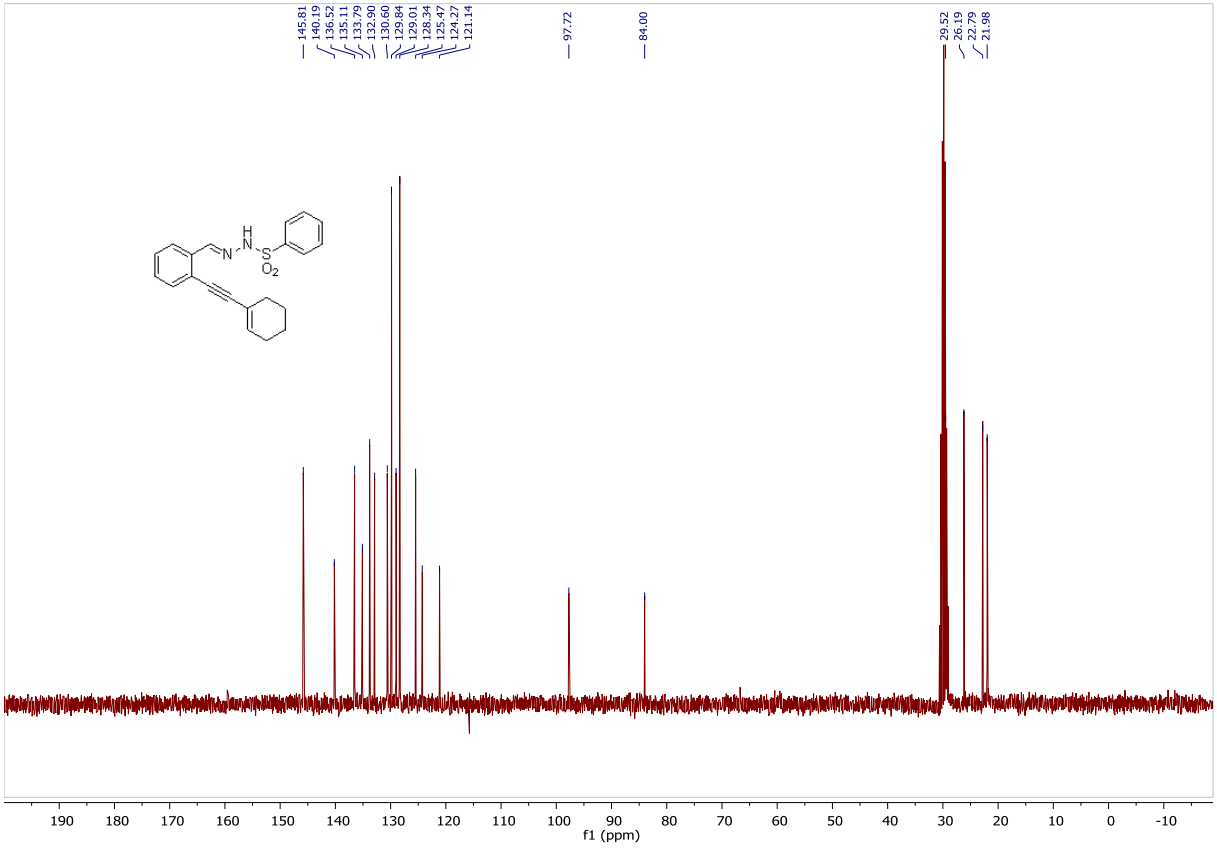


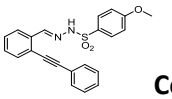




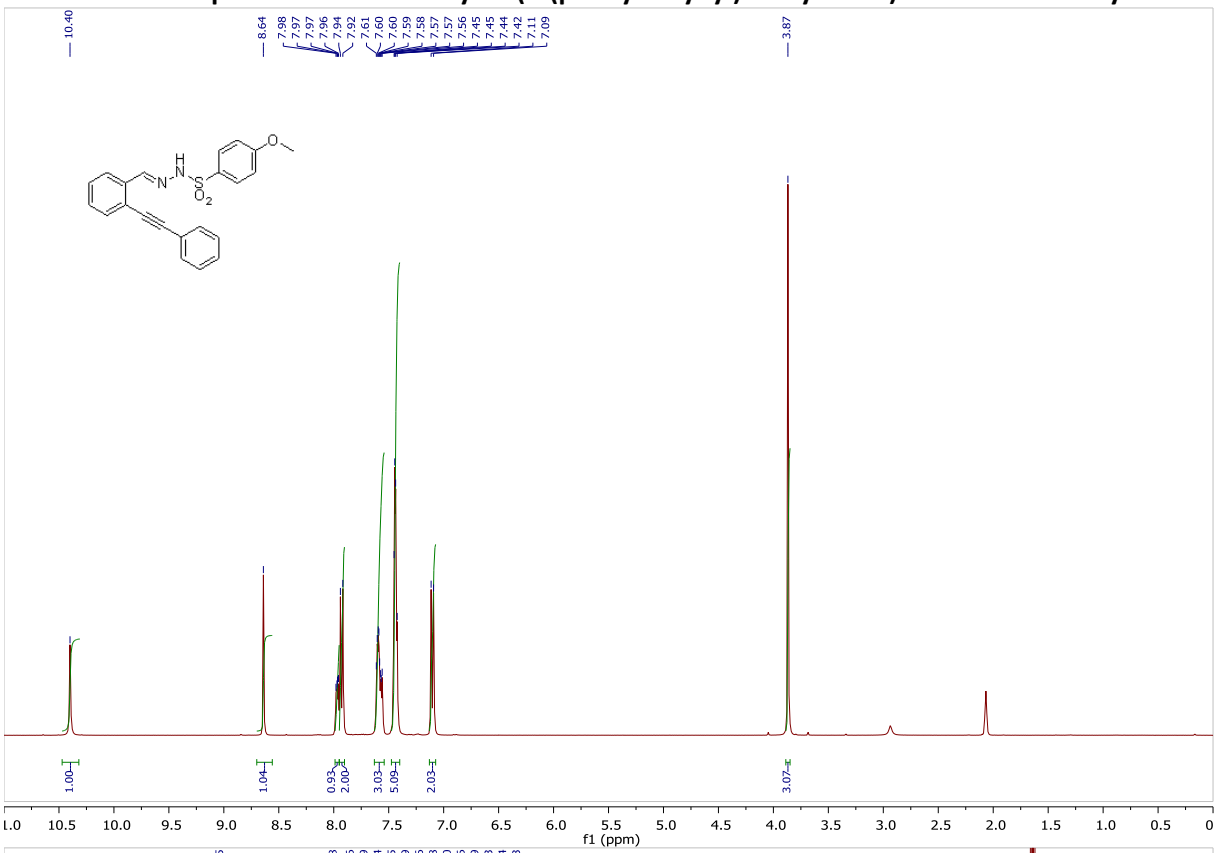
Compound 1j: N'-(2-(cyclohex-1-en-1-ylethynyl)benzylidene)benzenesulfonohydrazide

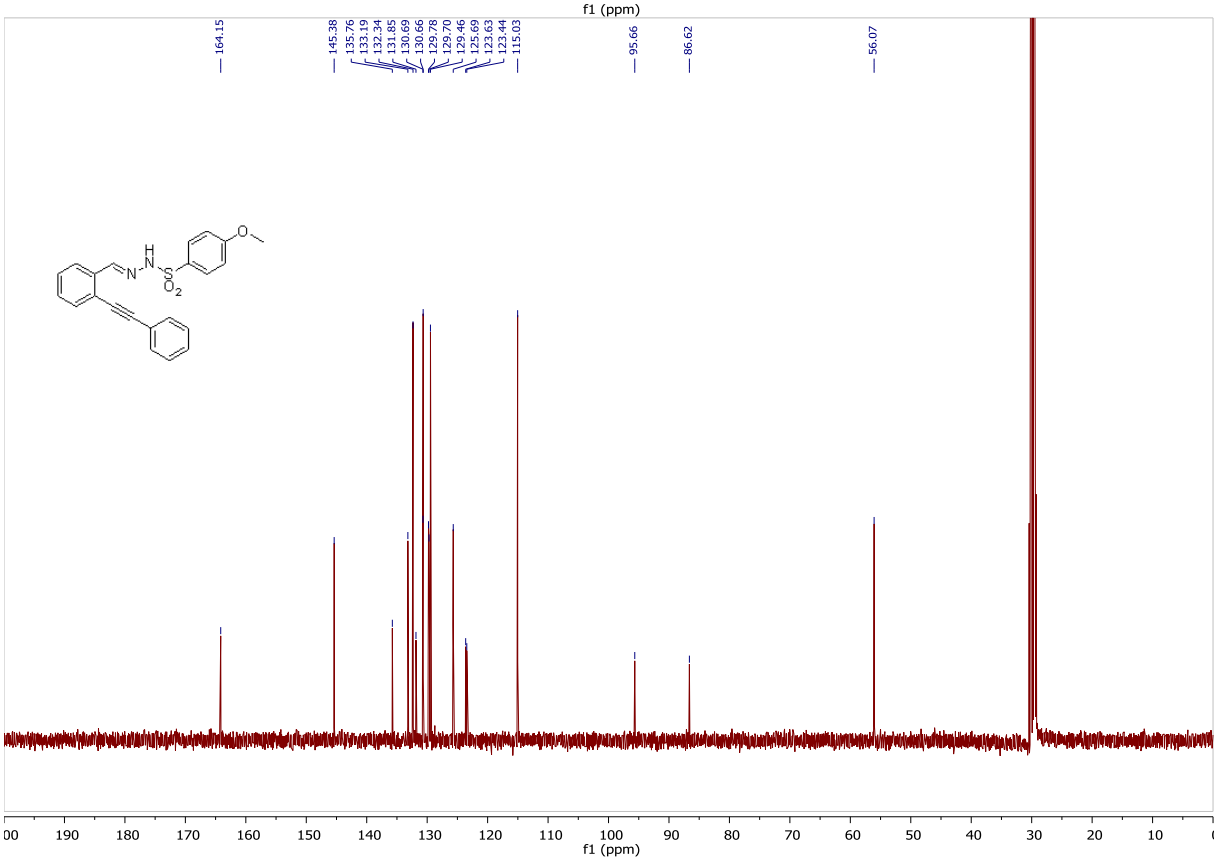


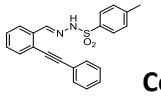




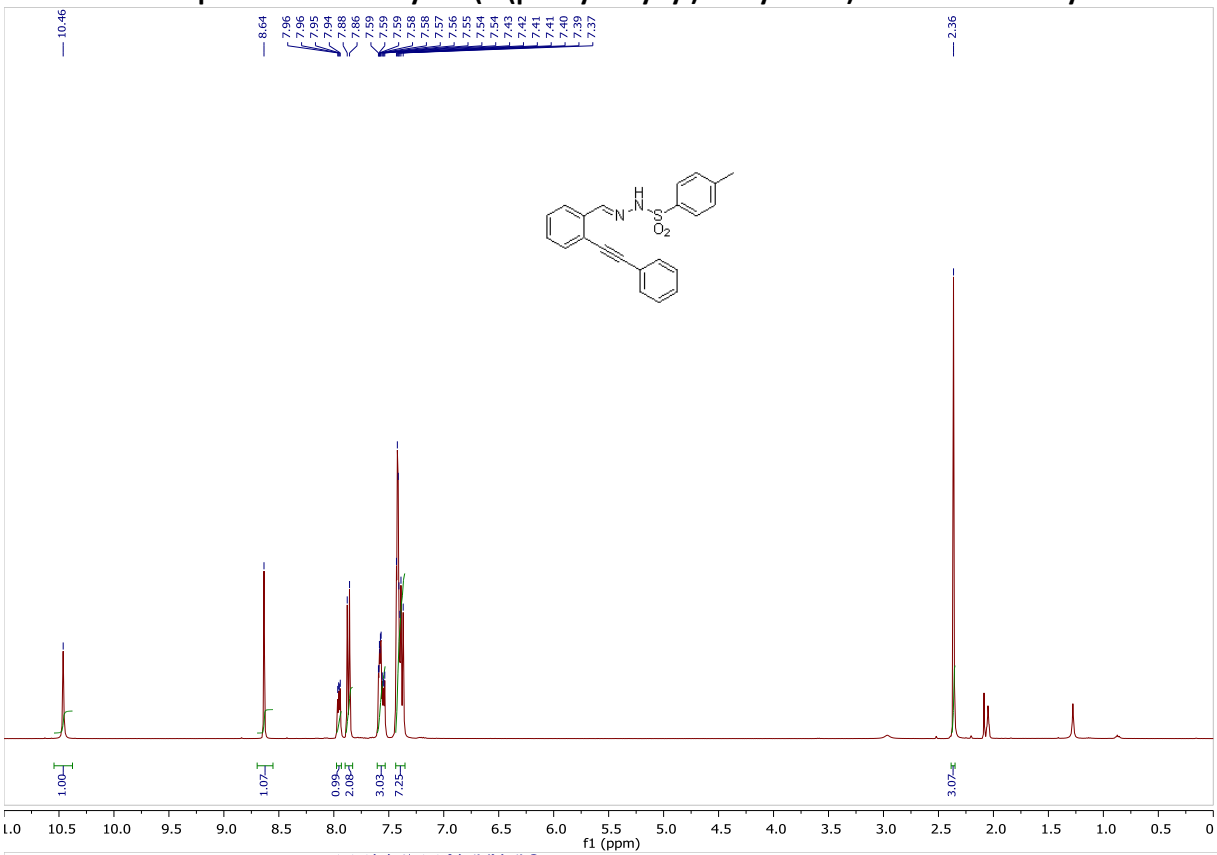
Compound 1k: 4-methoxy-N'-(2-(phenylethynyl)benzylidene)benzenesulfonohydrazide

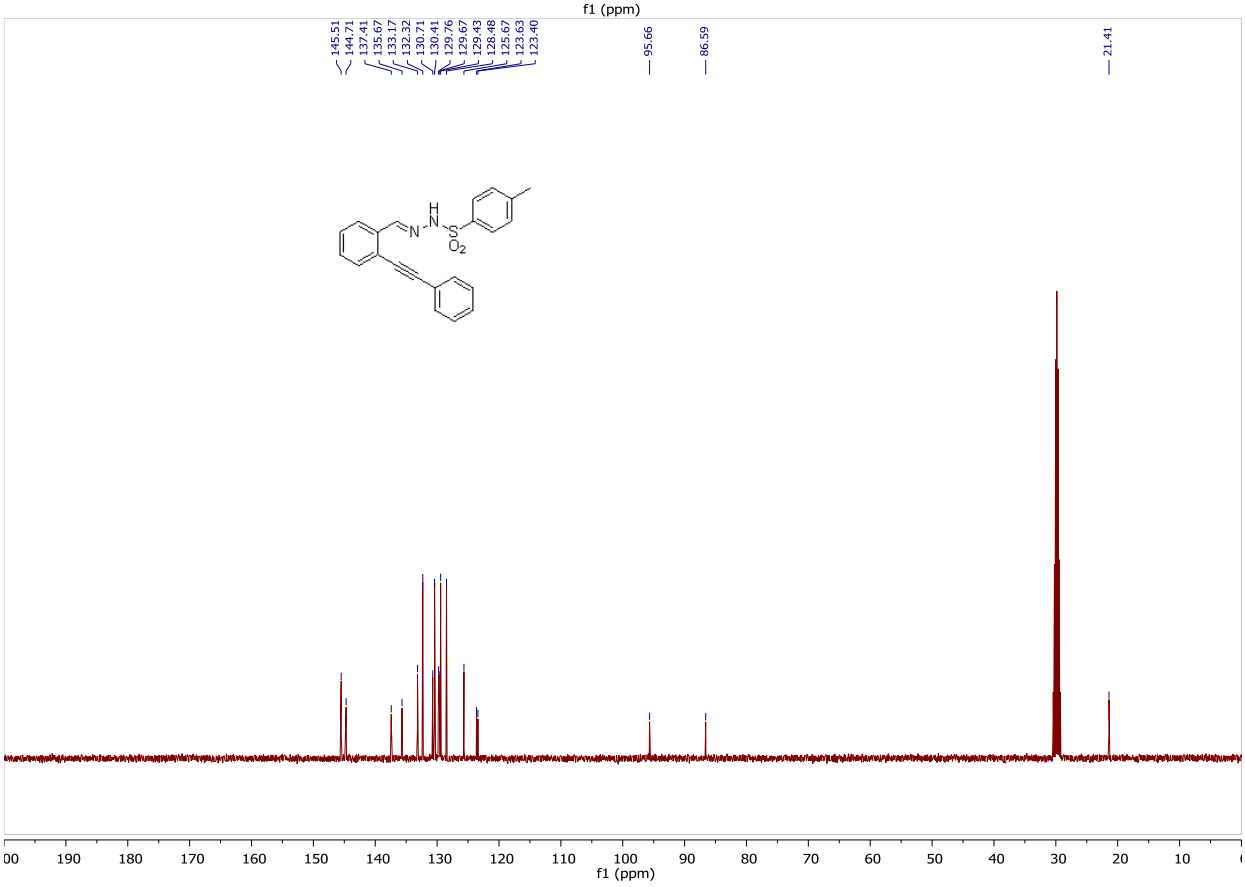


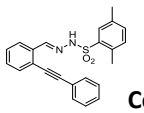




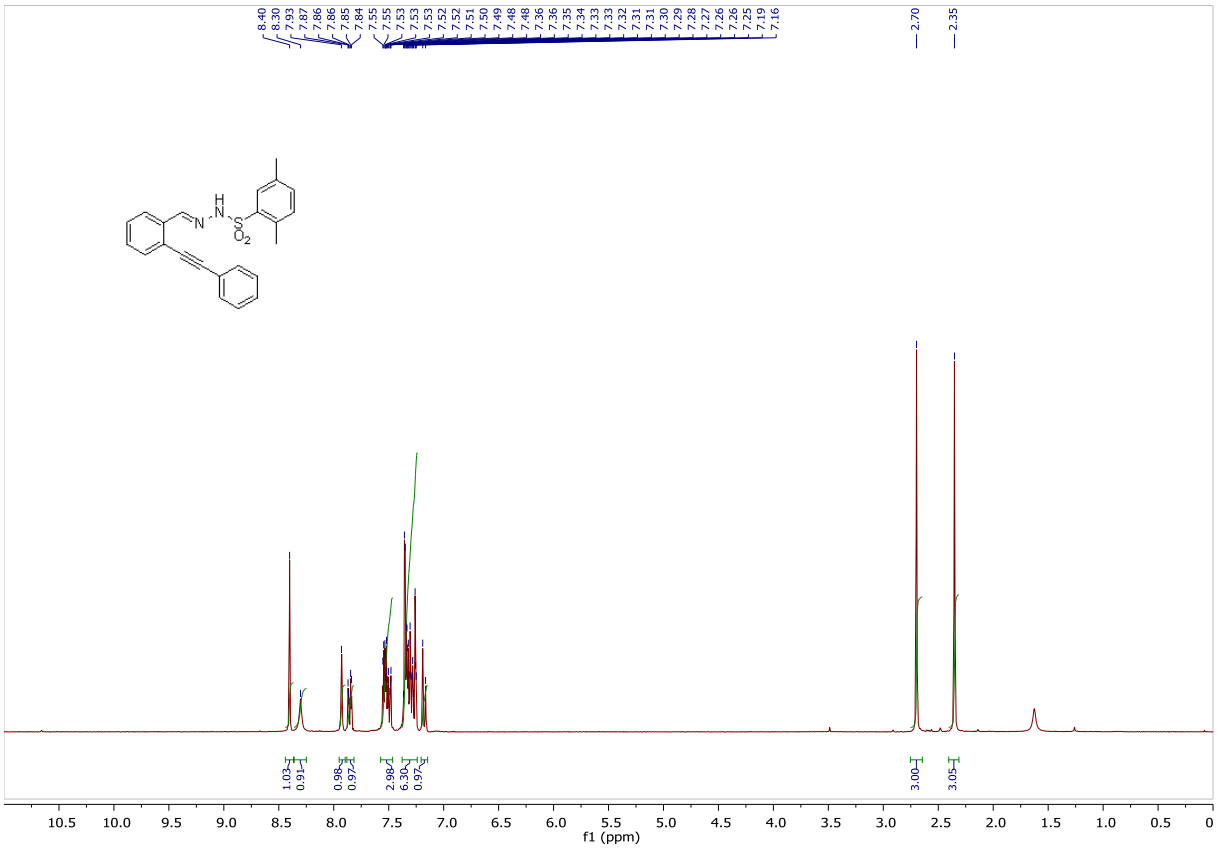
Compound 1l: 4-methyl-N'-(2-(phenylethynyl)benzylidene)benzenesulfonohydrazide

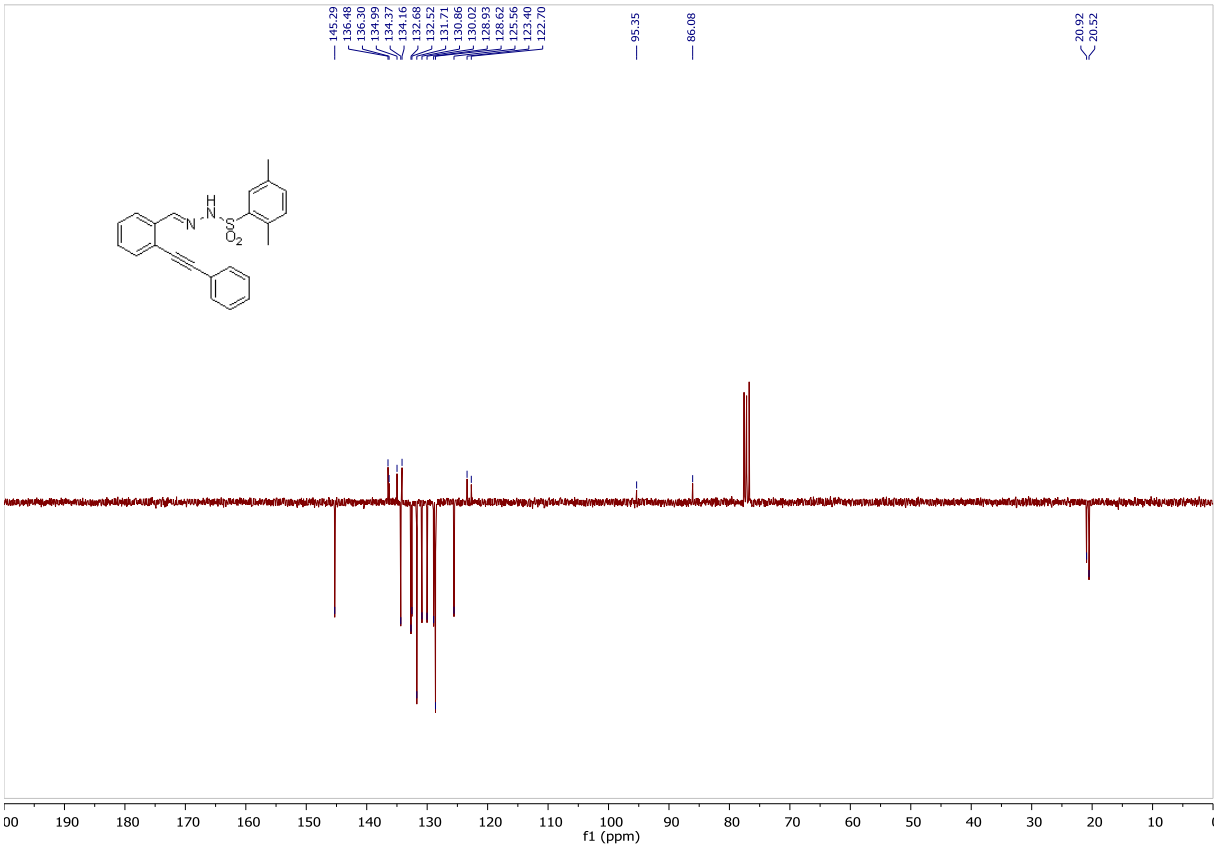


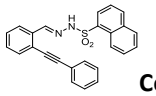




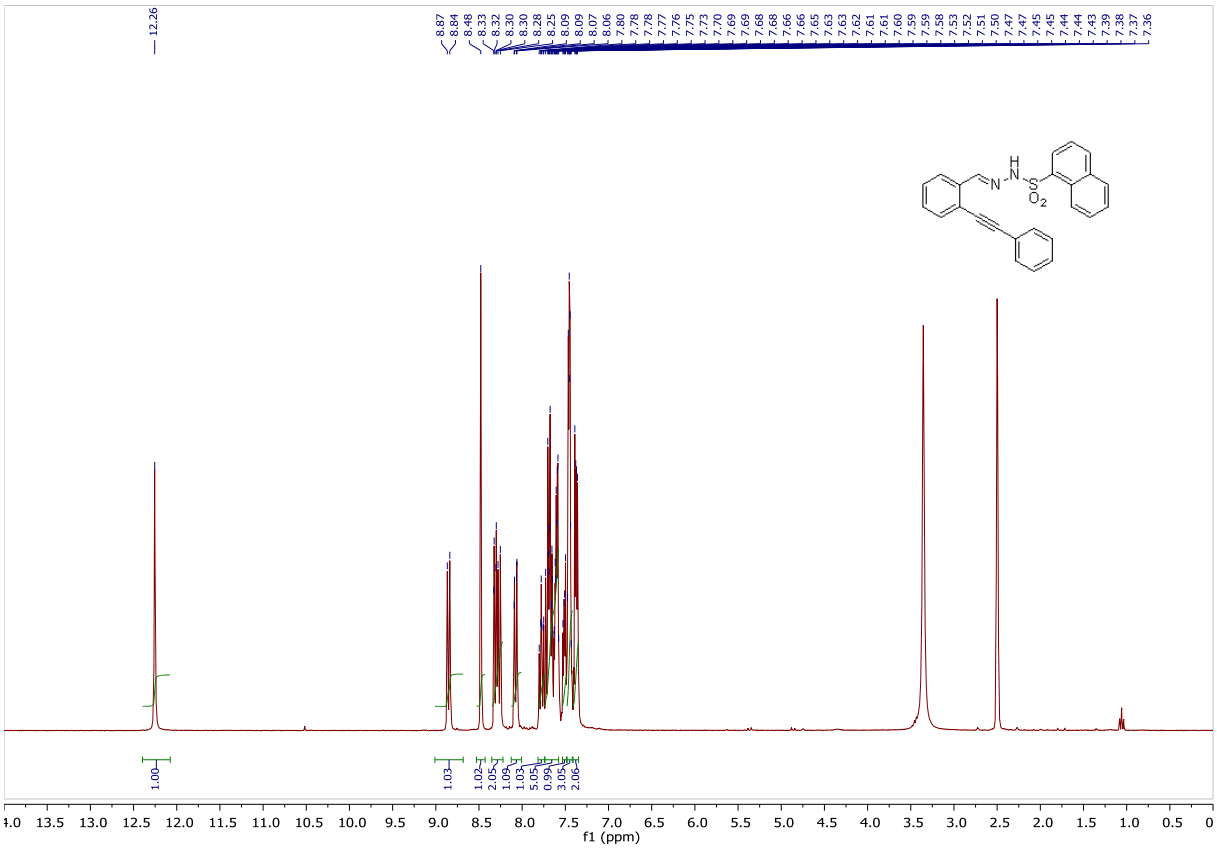
Compound1m: 2,5-dimethyl-N'-(2-(phenylethynyl)benzylidene)benzenesulfonohydrazide

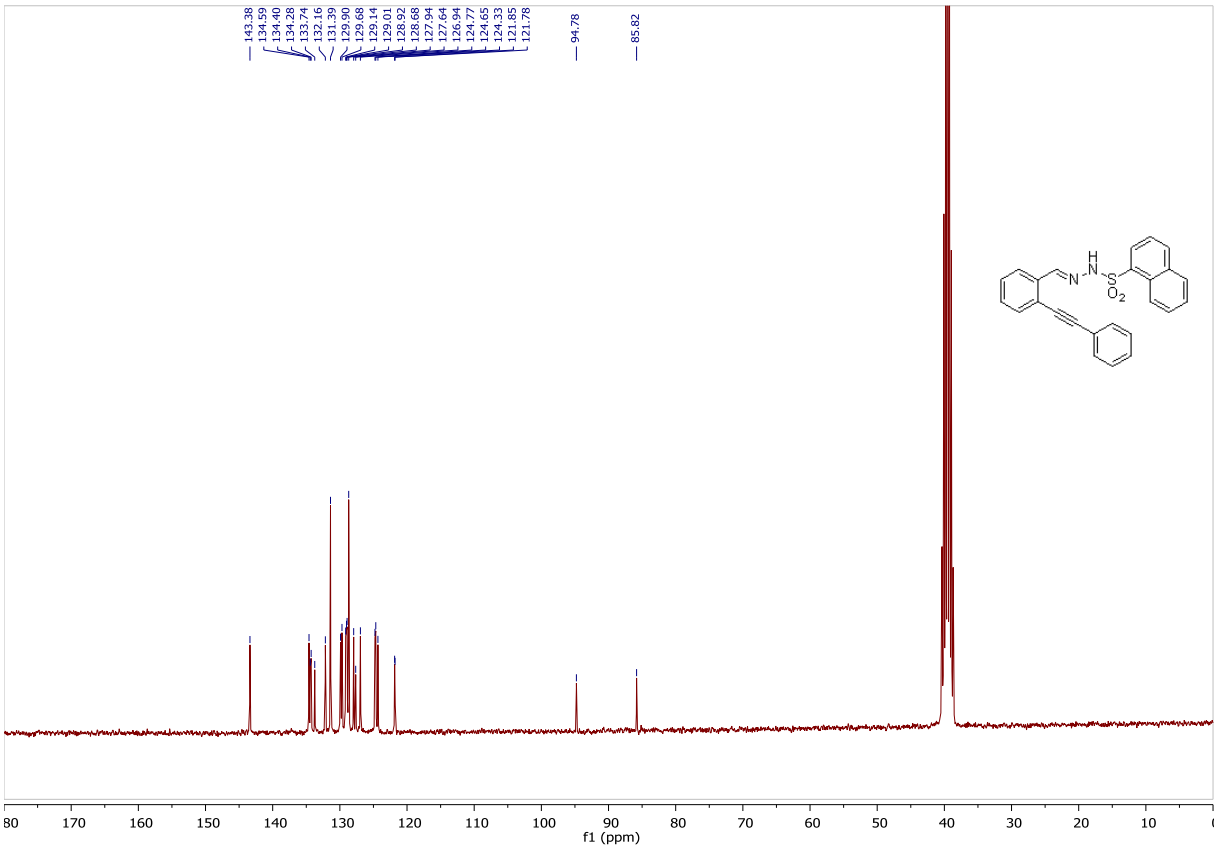


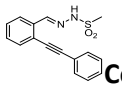




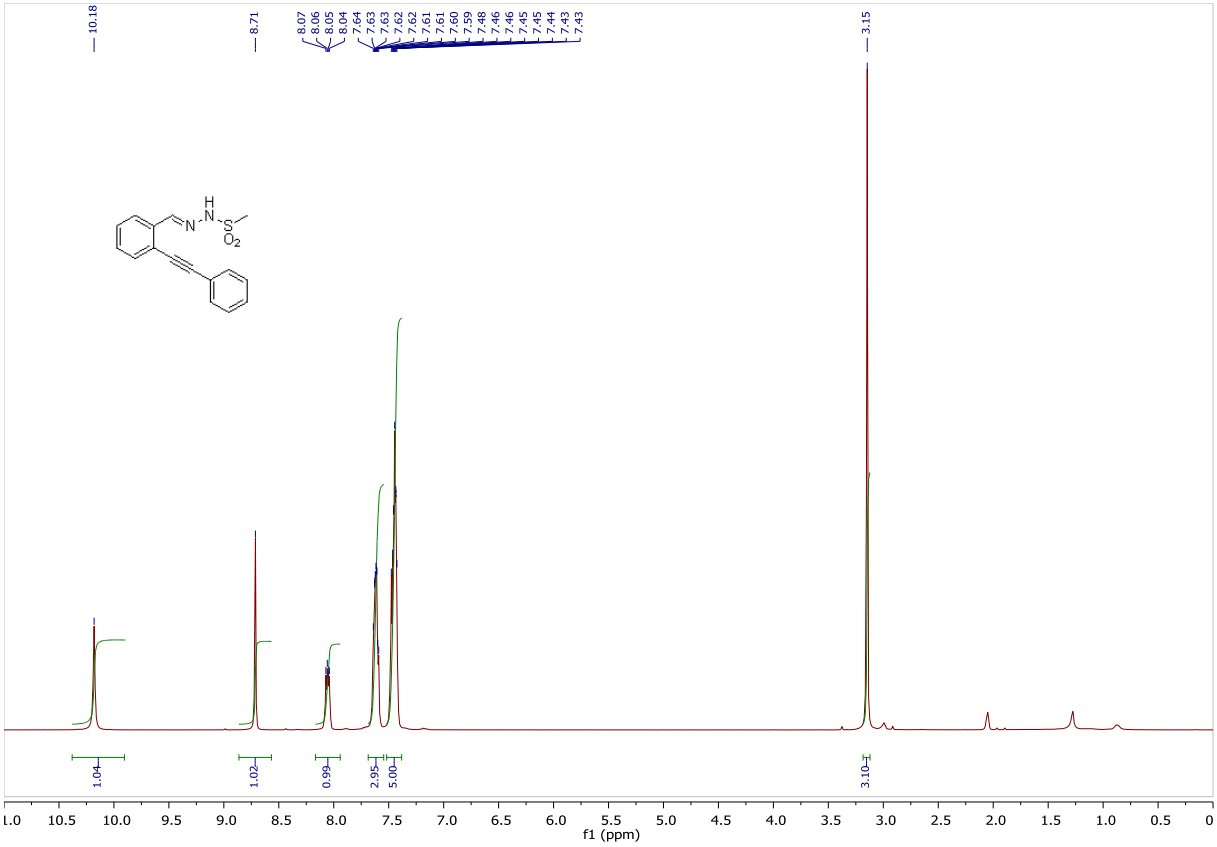
Compound1n: N'-(2-(phenylethynyl)benzylidene)naphthalene-1-sulfonohydrazide

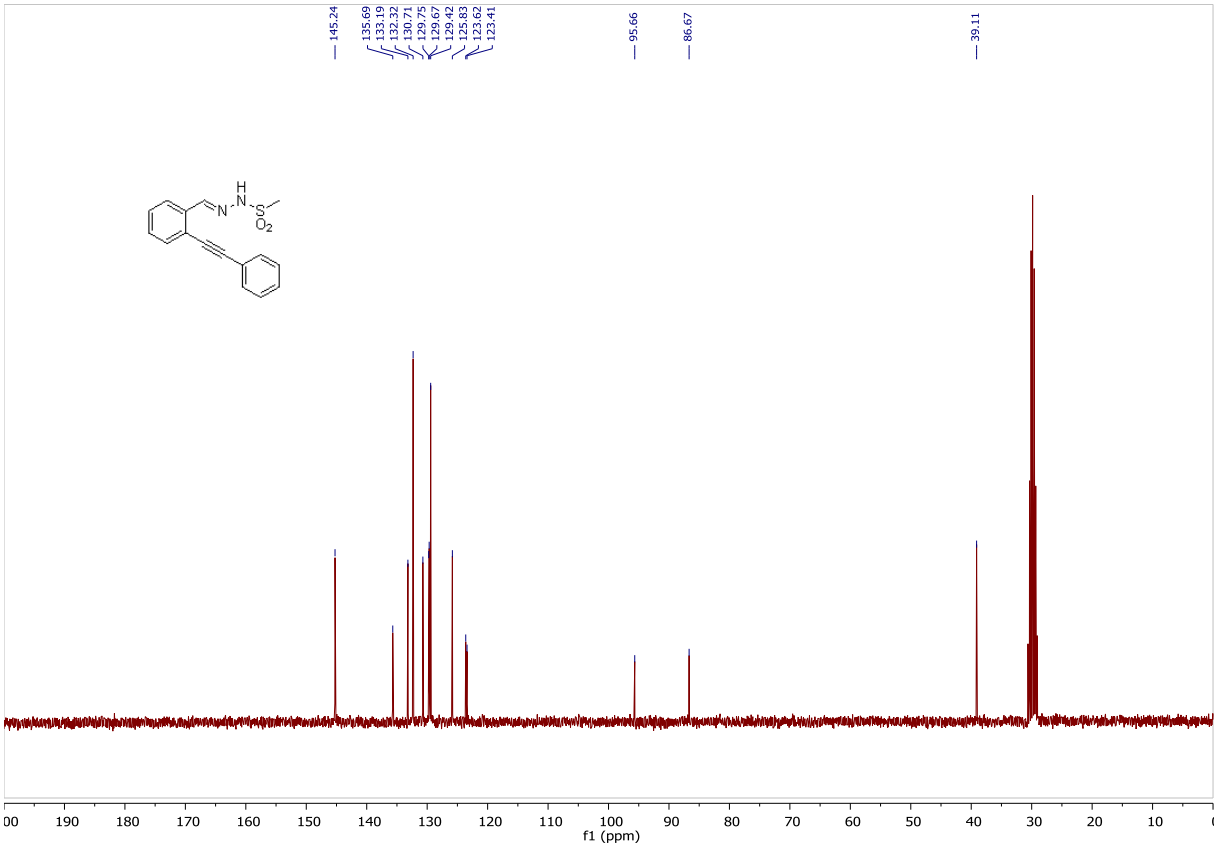


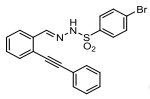




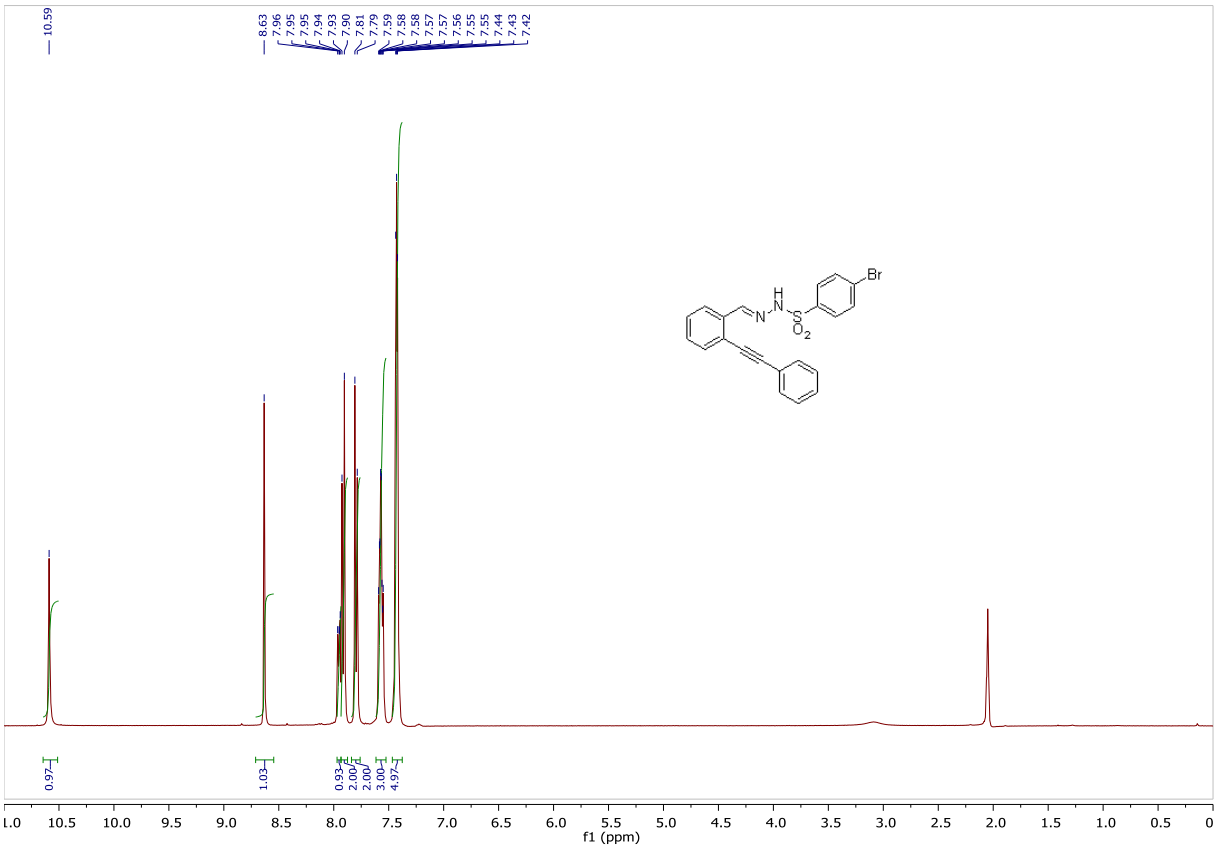
Compound 1o: N'-(2-(phenylethynyl)benzylidene)methanesulfonohydrazide

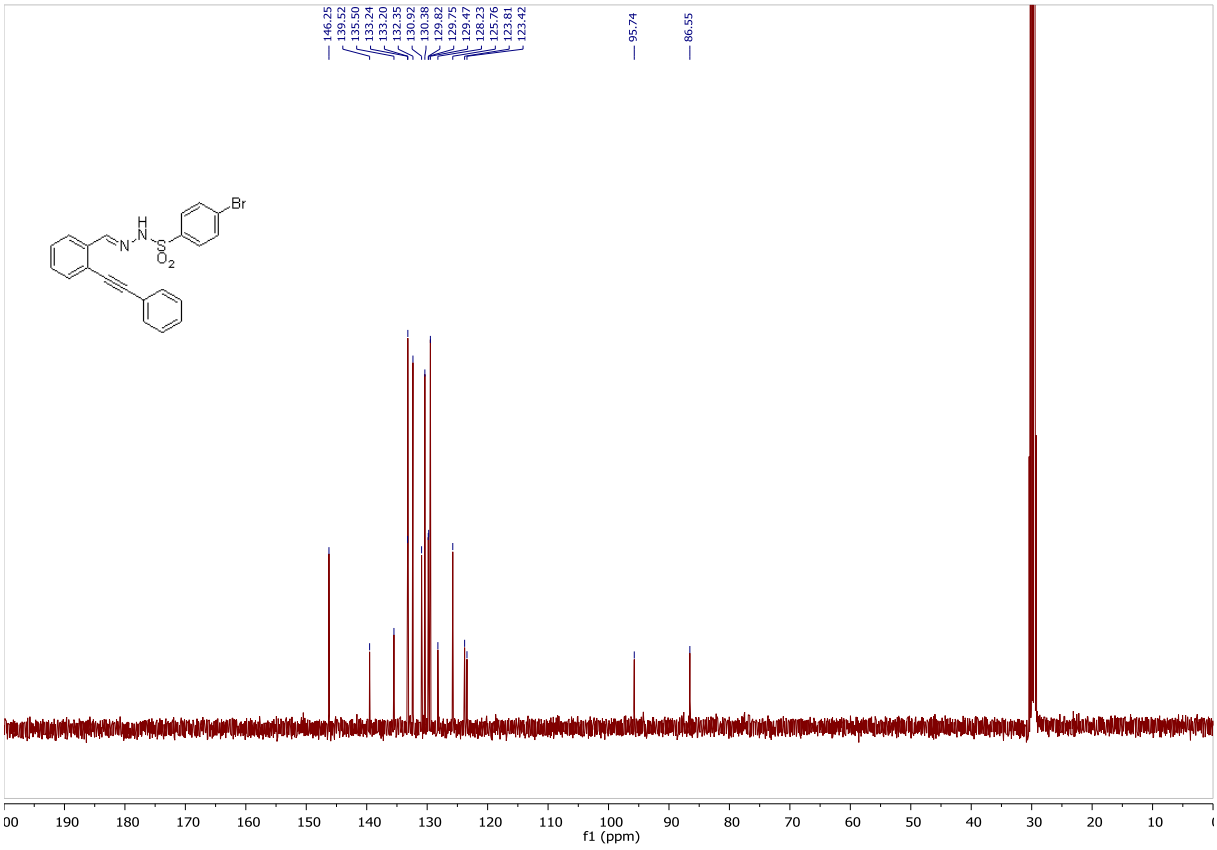


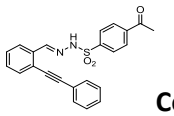




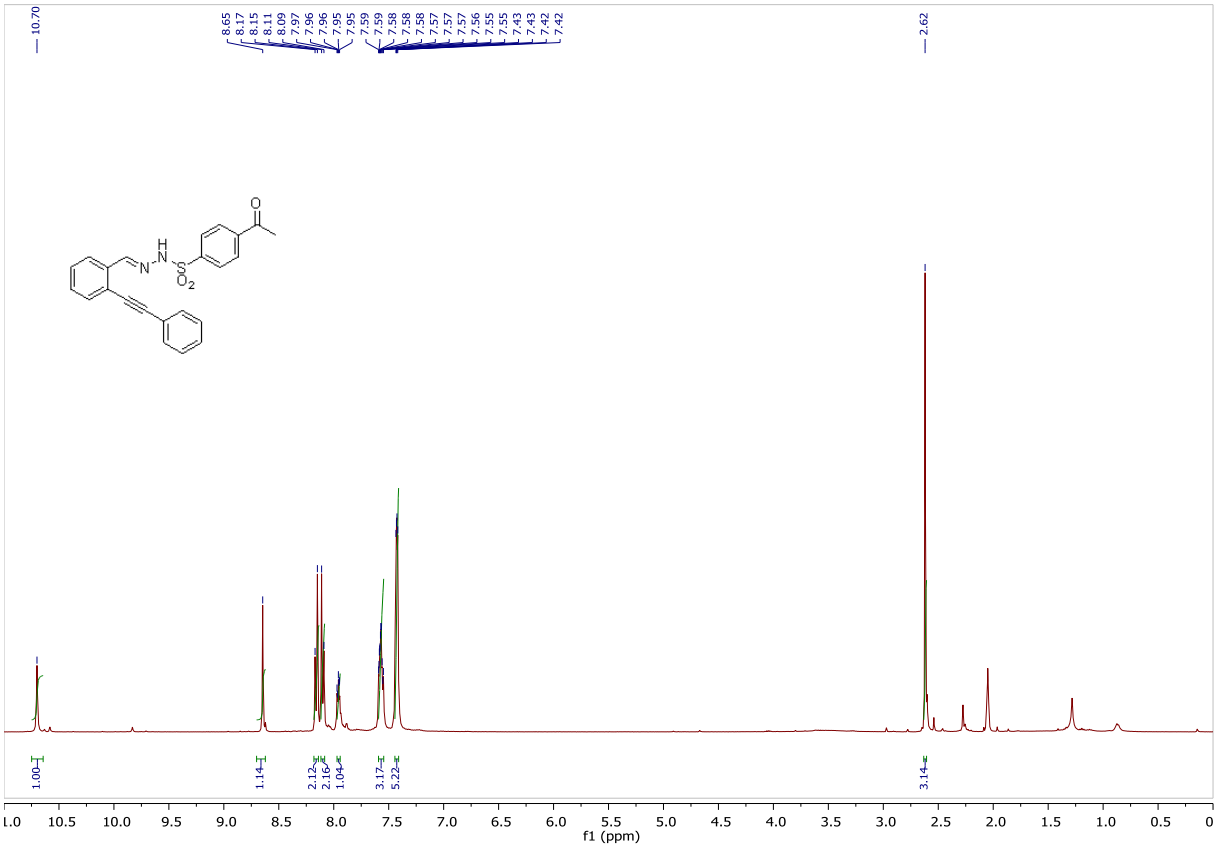
Compound 1p: 4-bromo-N'-(2-(phenylethynyl)benzylidene)benzenesulfonohydrazide

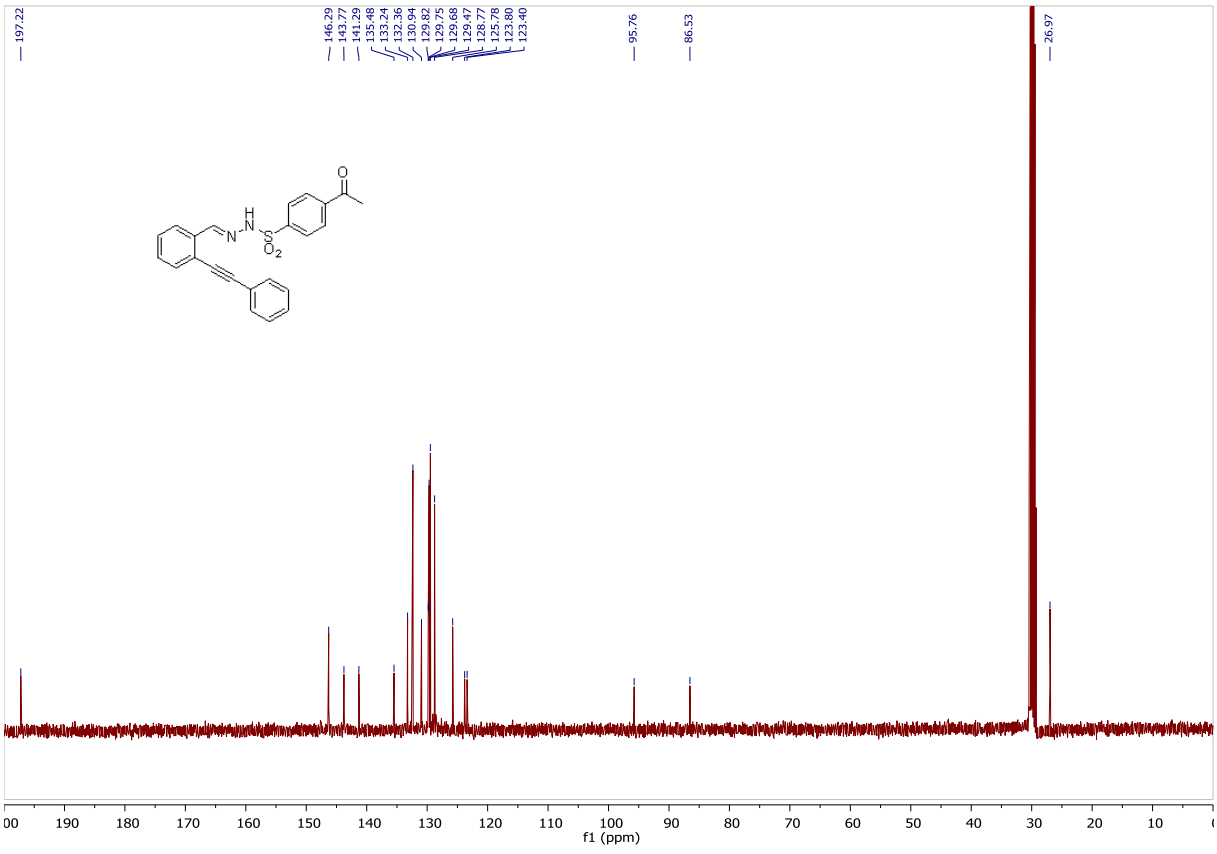


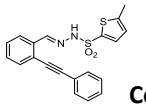




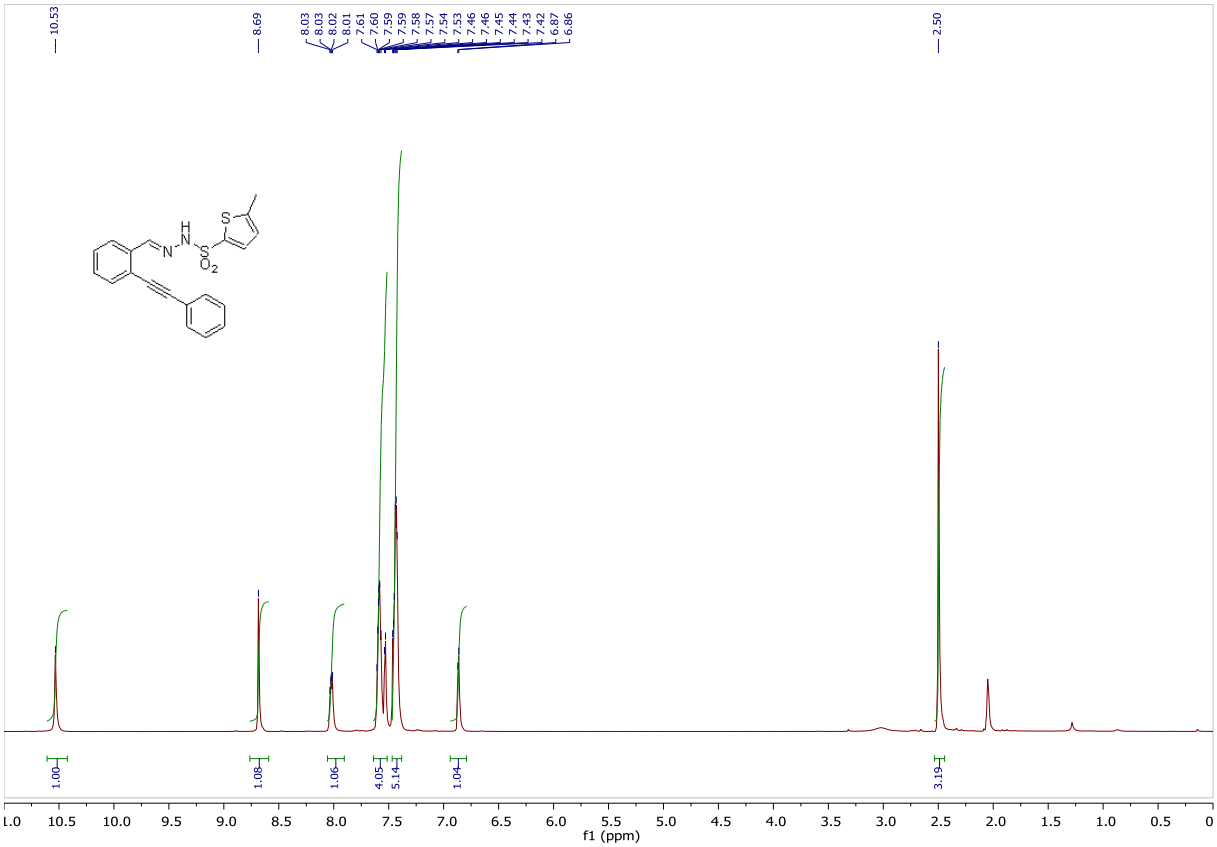
Compound 1q: 4-acetyl-N'-(2-(phenylethynyl)benzylidene)benzenesulfonohydrazide

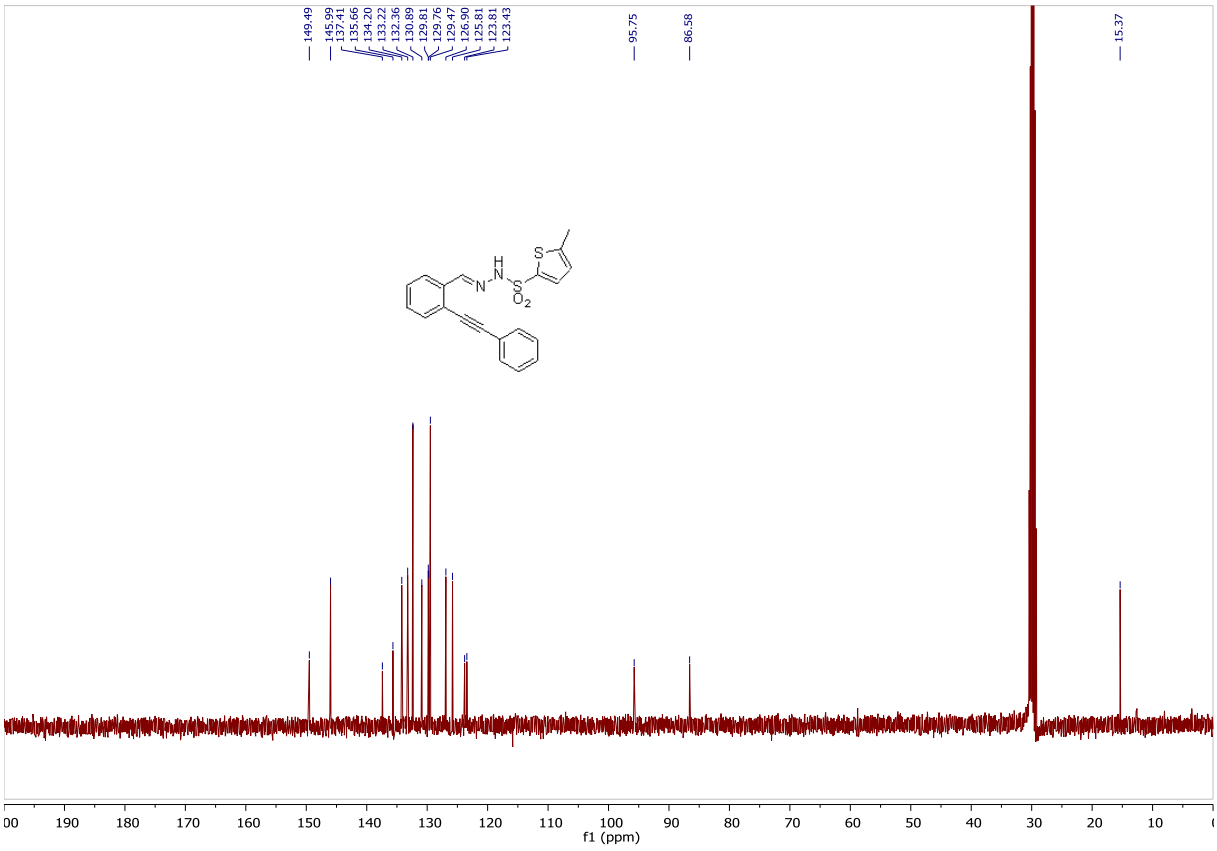


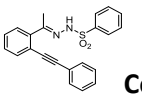




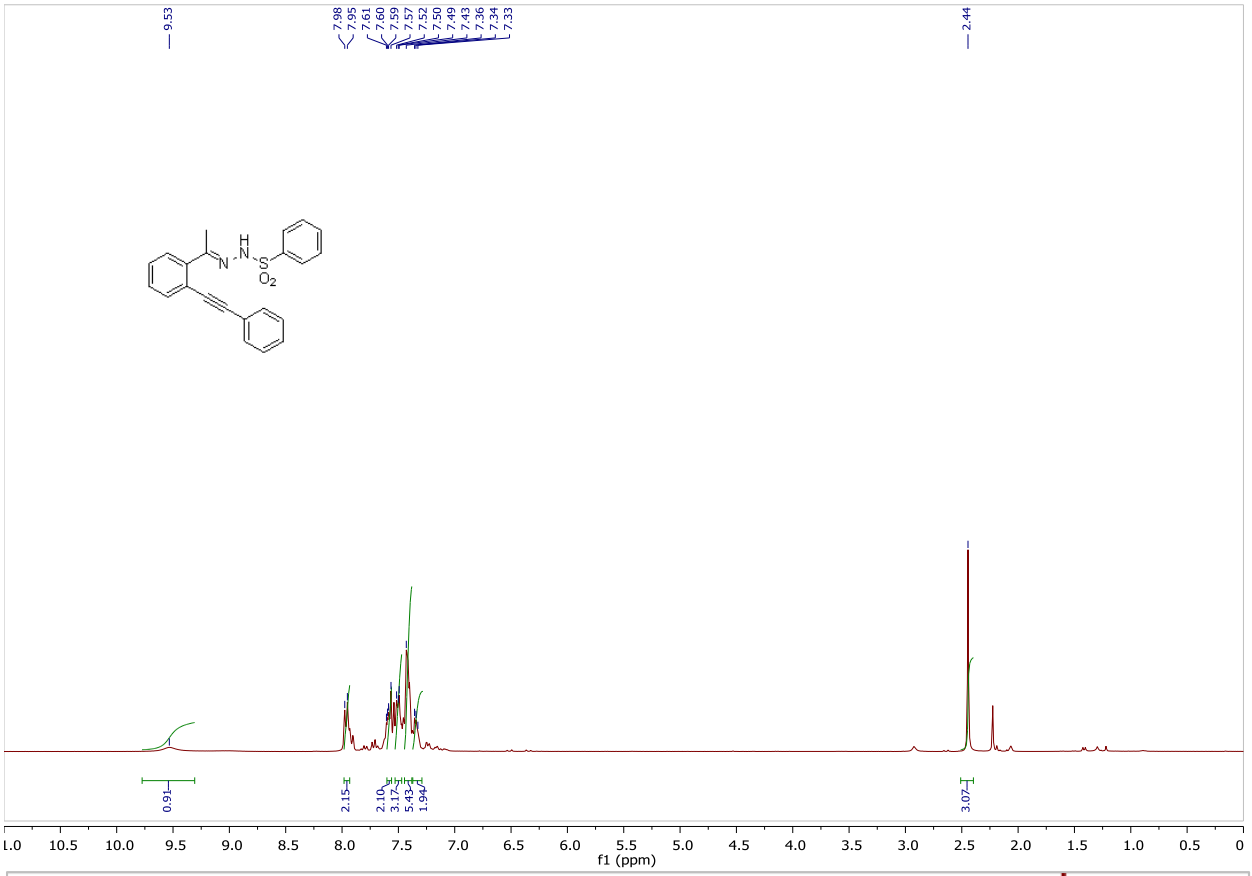
Compound 1r: 5-methyl-N'-(2-(phenylethynyl)benzylidene)thiophene-2-sulfonohydrazide

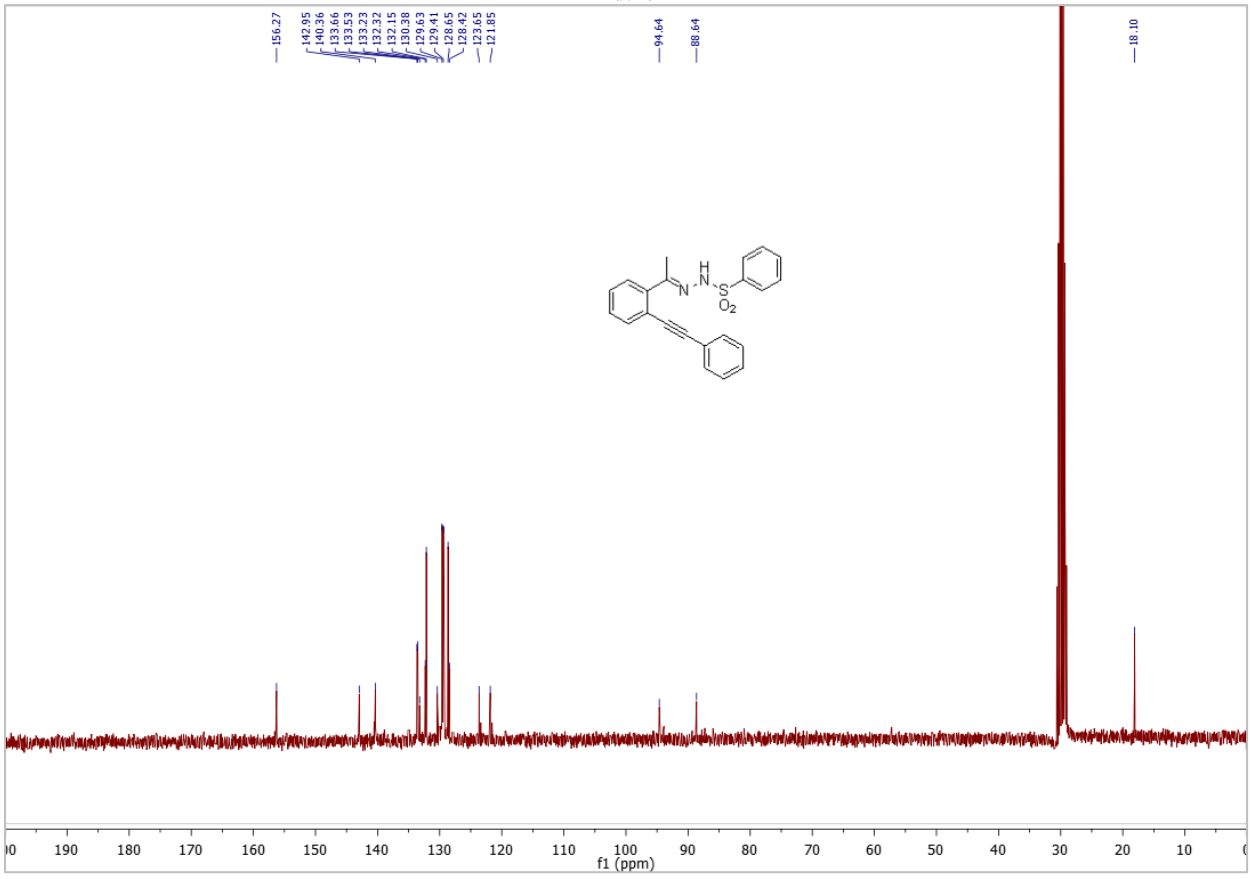


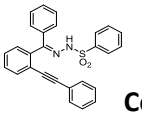




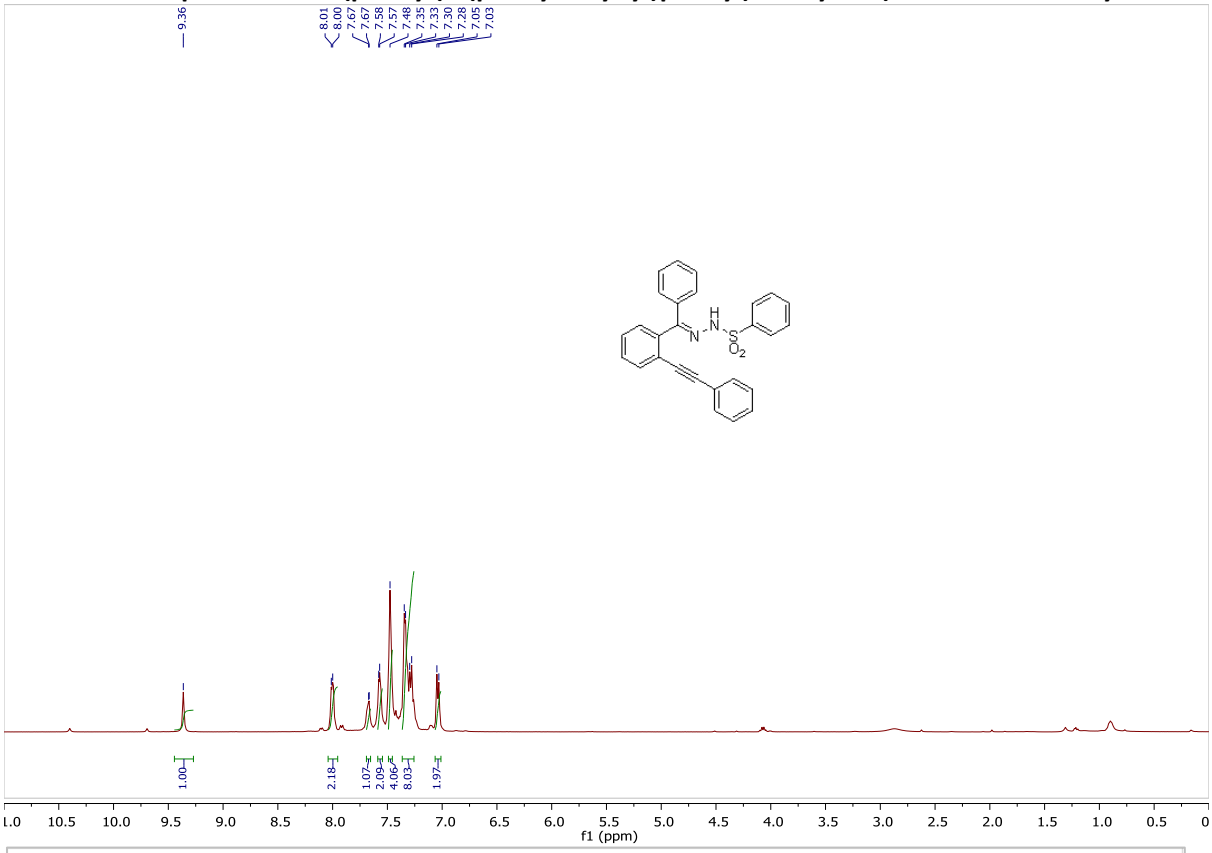
Compound 1s: N'-(1-(2-(phenylethynyl)phenyl)ethylidene)benzenesulfonohydrazide

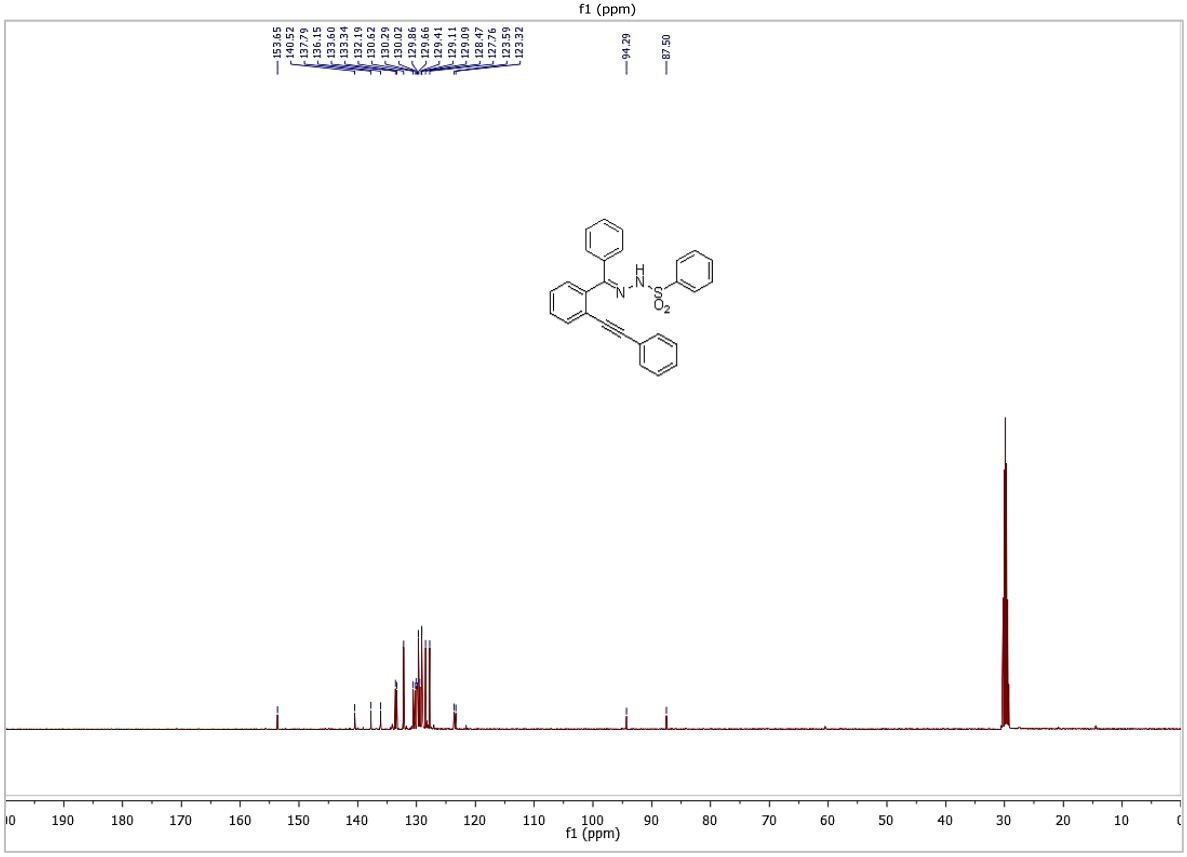


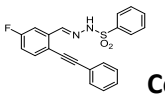




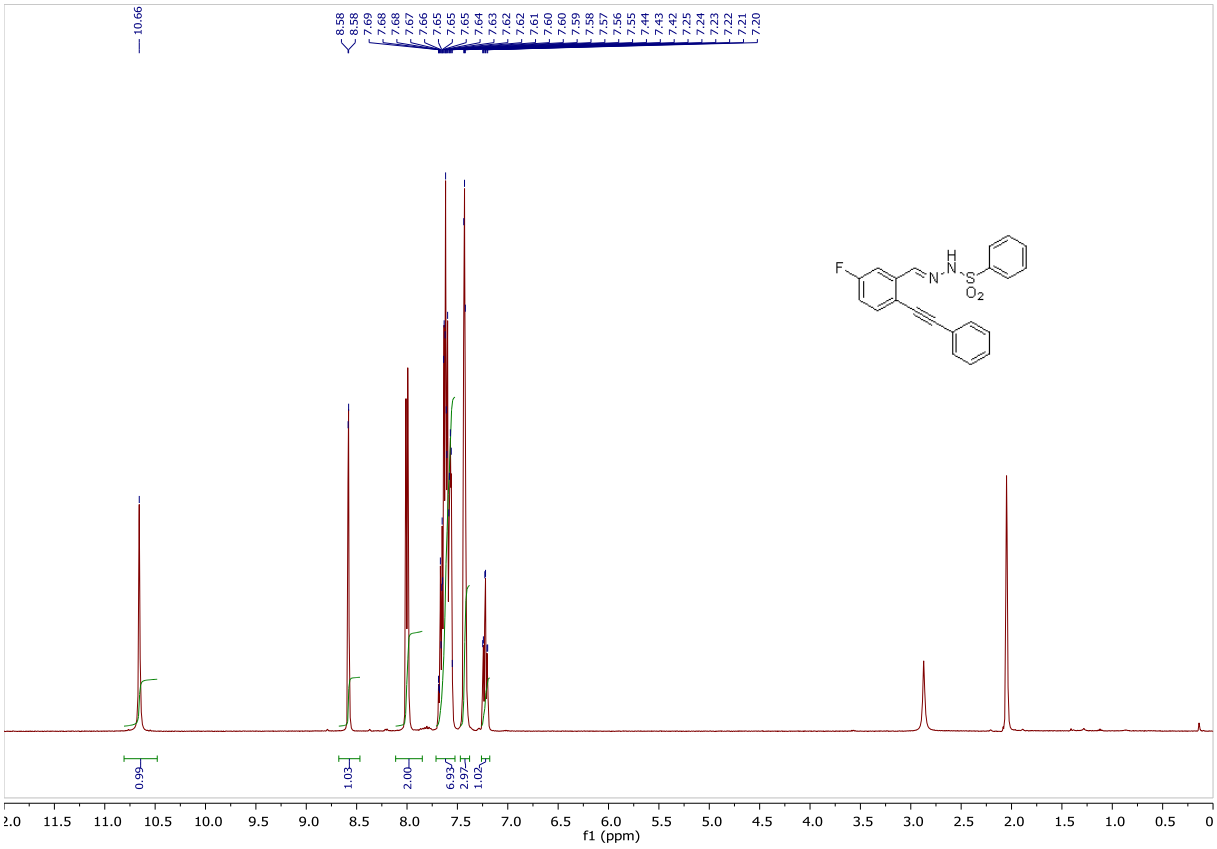
Compound 1t: N'-(phenyl(2-(phenylethynyl)phenyl)methylene)benzenesulfonohydrazide

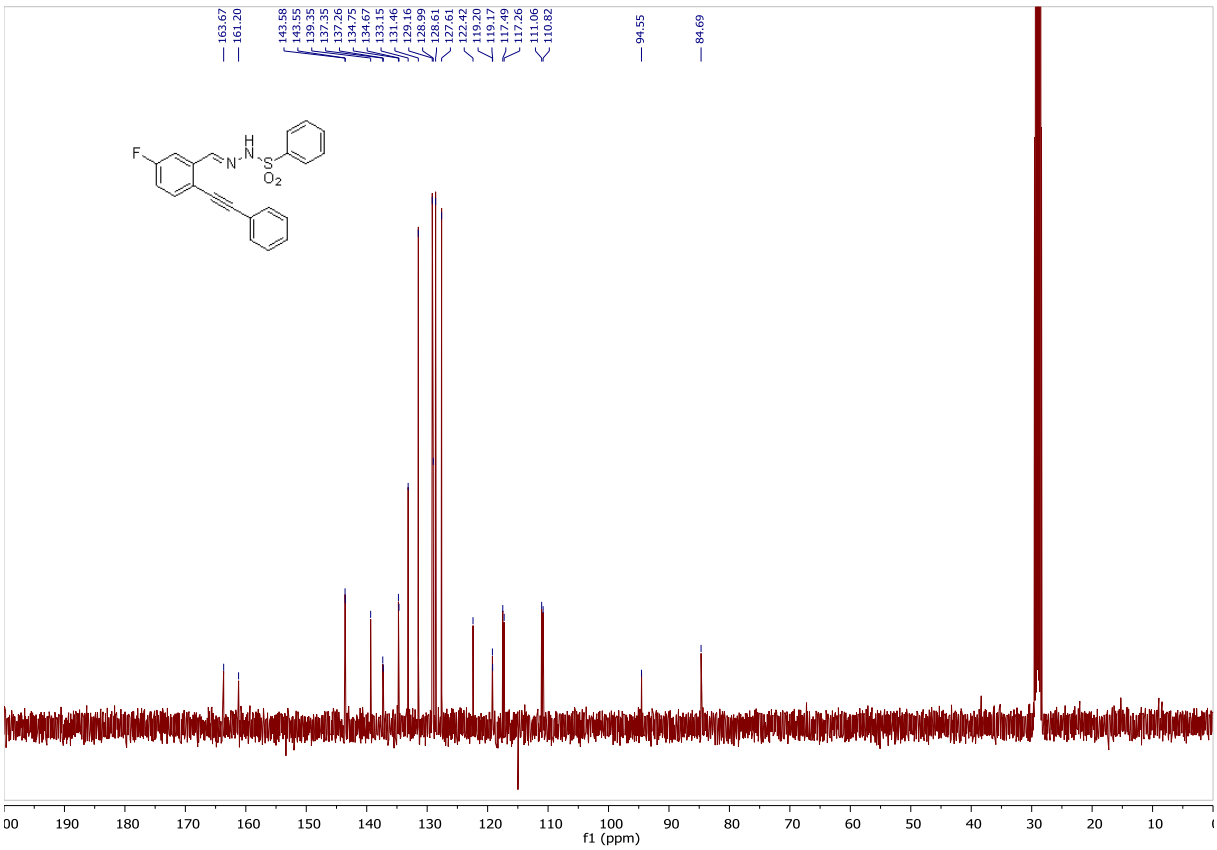


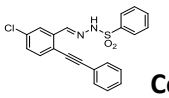




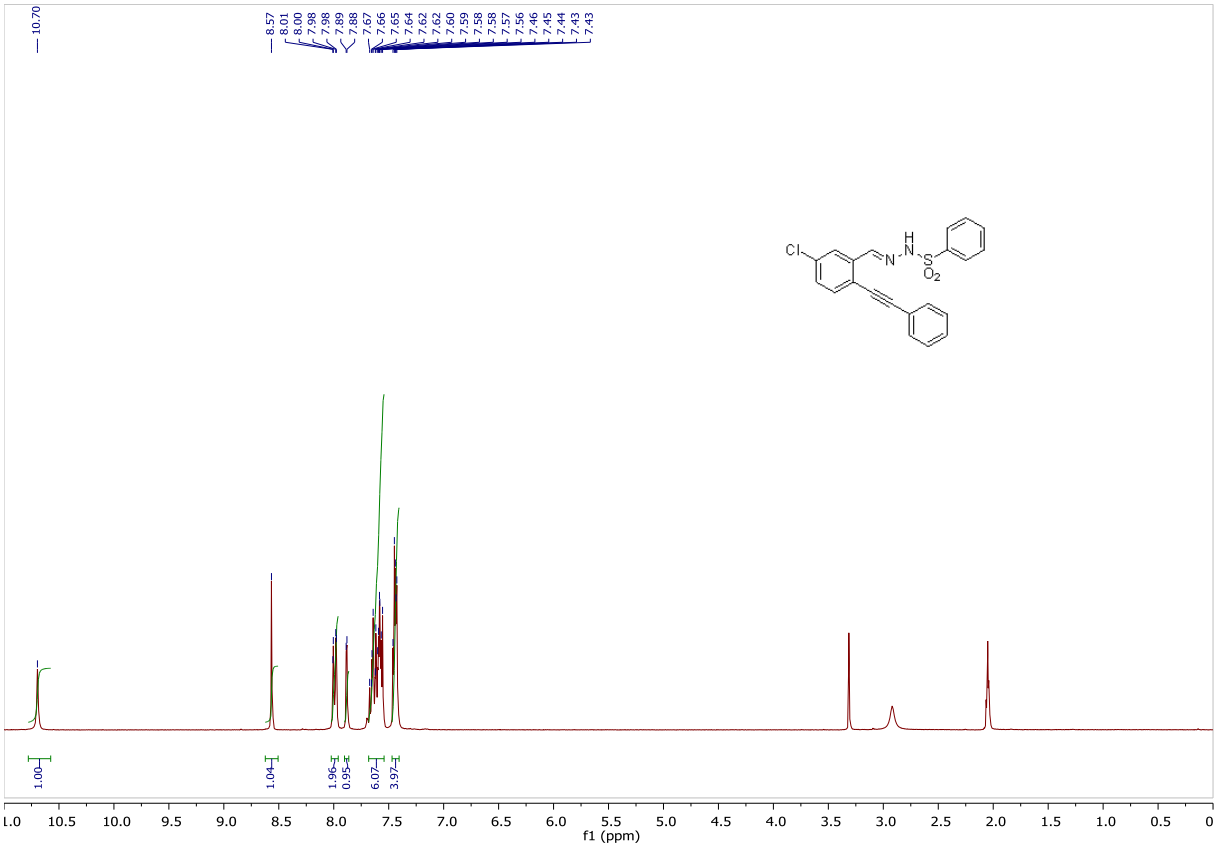
Compound 1u: N'-(5-fluoro-2-(phenylethynyl)benzylidene)benzenesulfonohydrazide

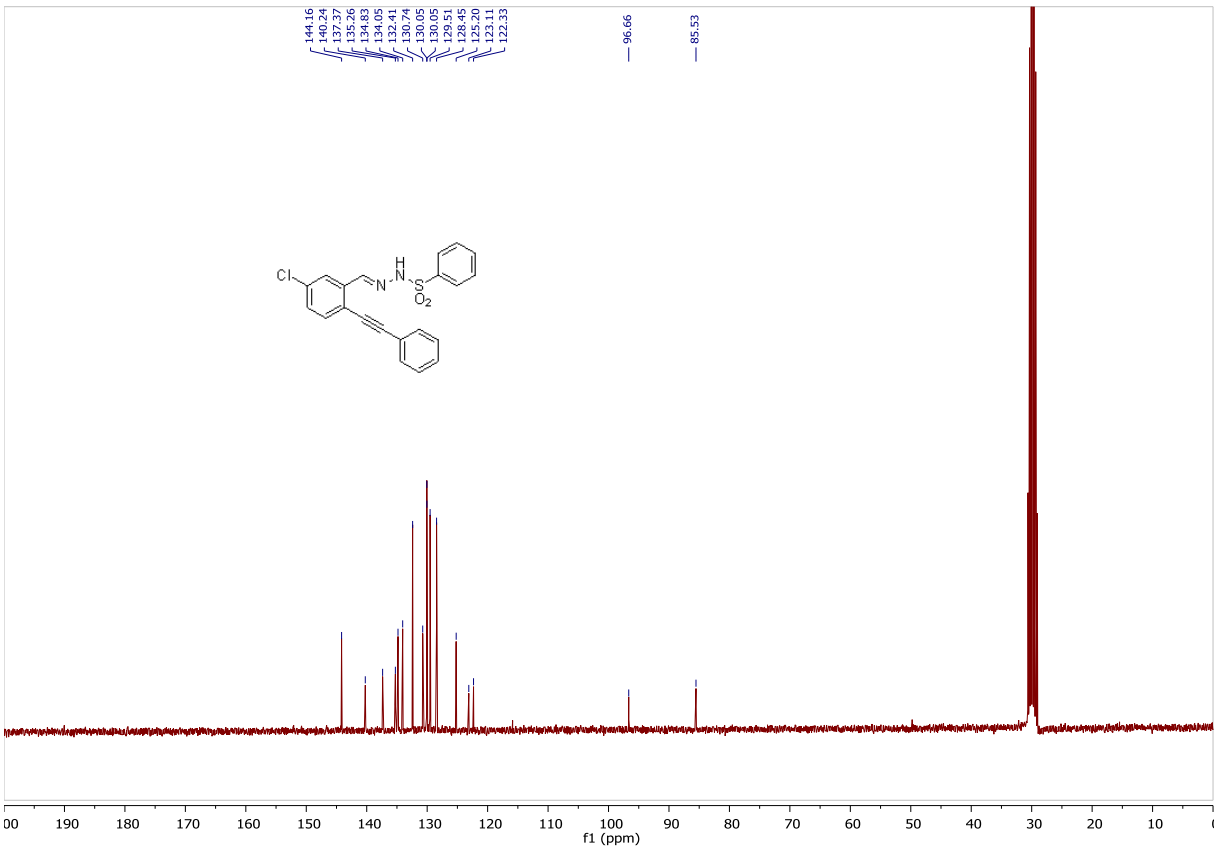


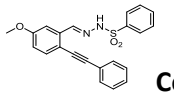




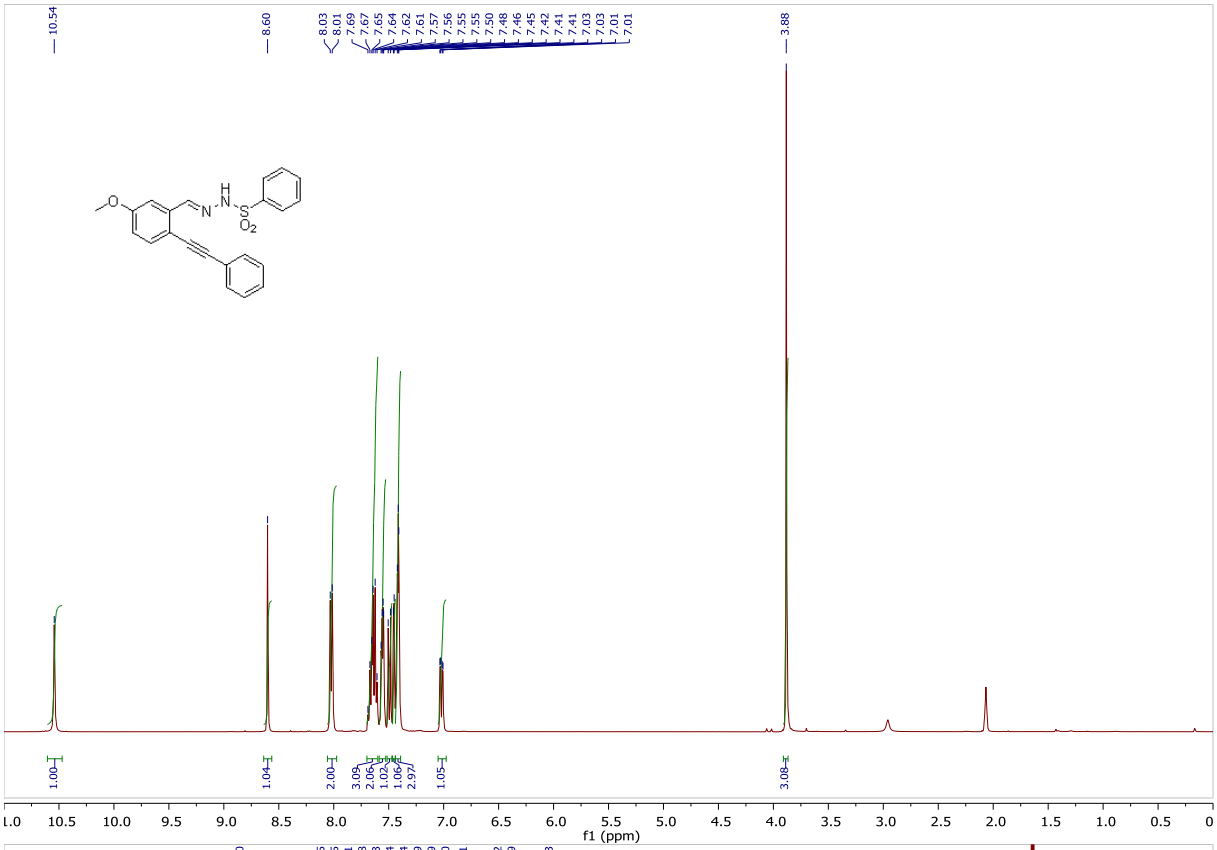
Compound 1v: N'-(5-chloro-2-(phenylethynyl)benzylidene)benzenesulfonohydrazide

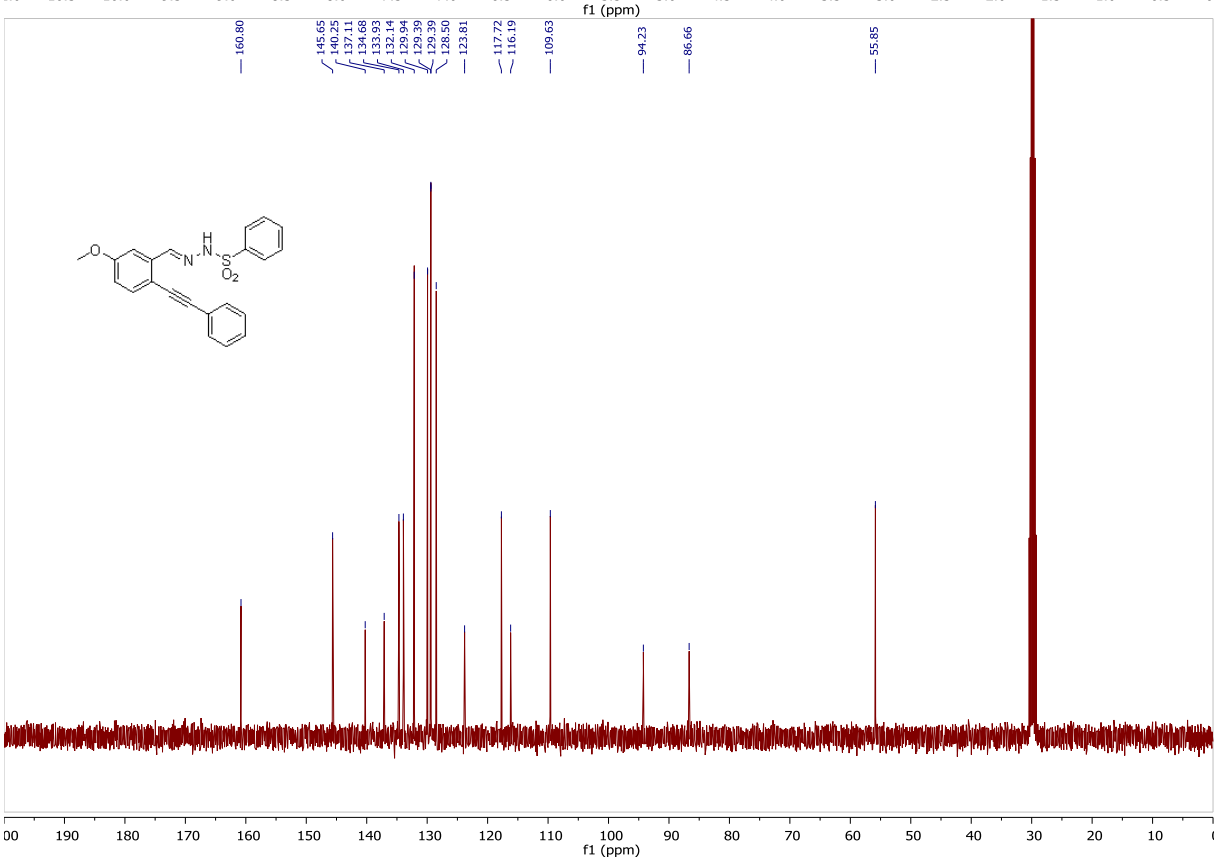


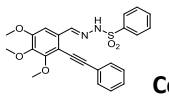




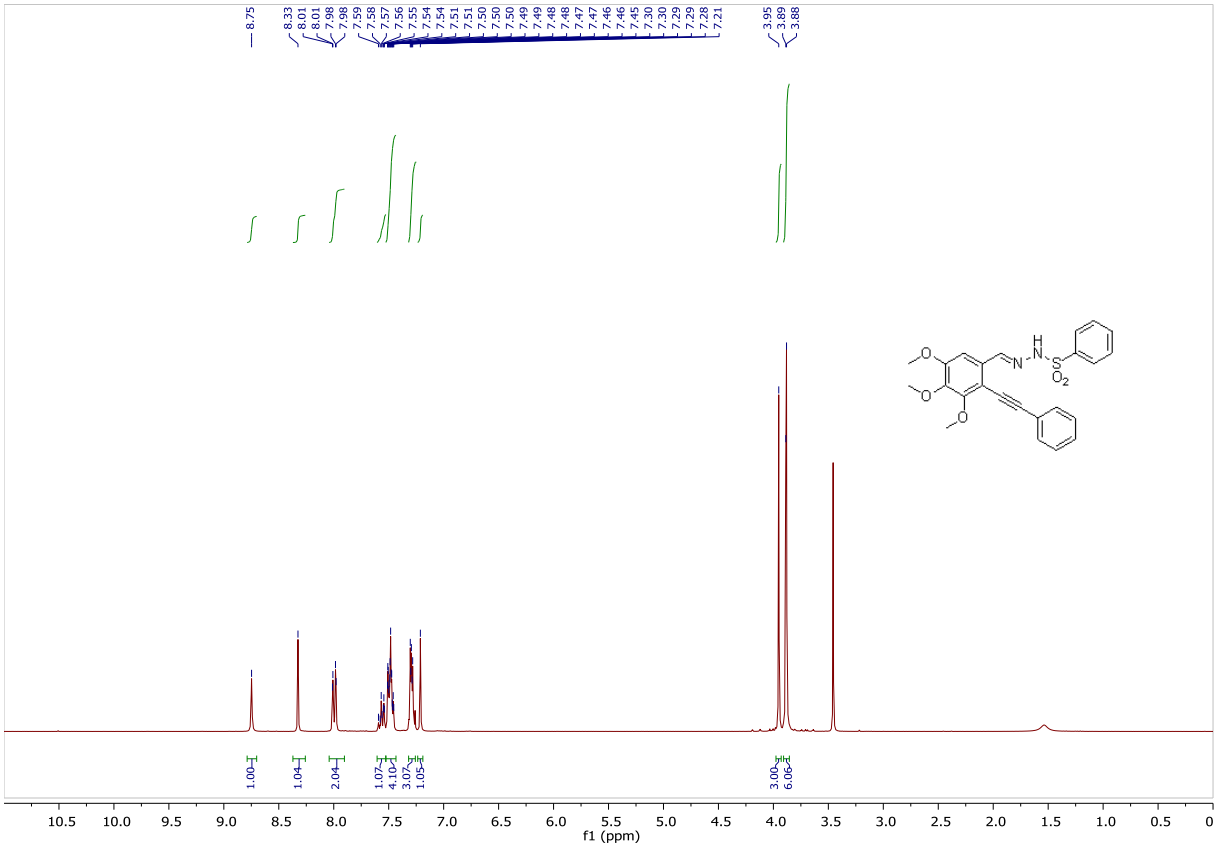
Compound 1w: N'-(5-methoxy-2-(phenylethynyl)benzylidene)benzenesulfonohydrazide

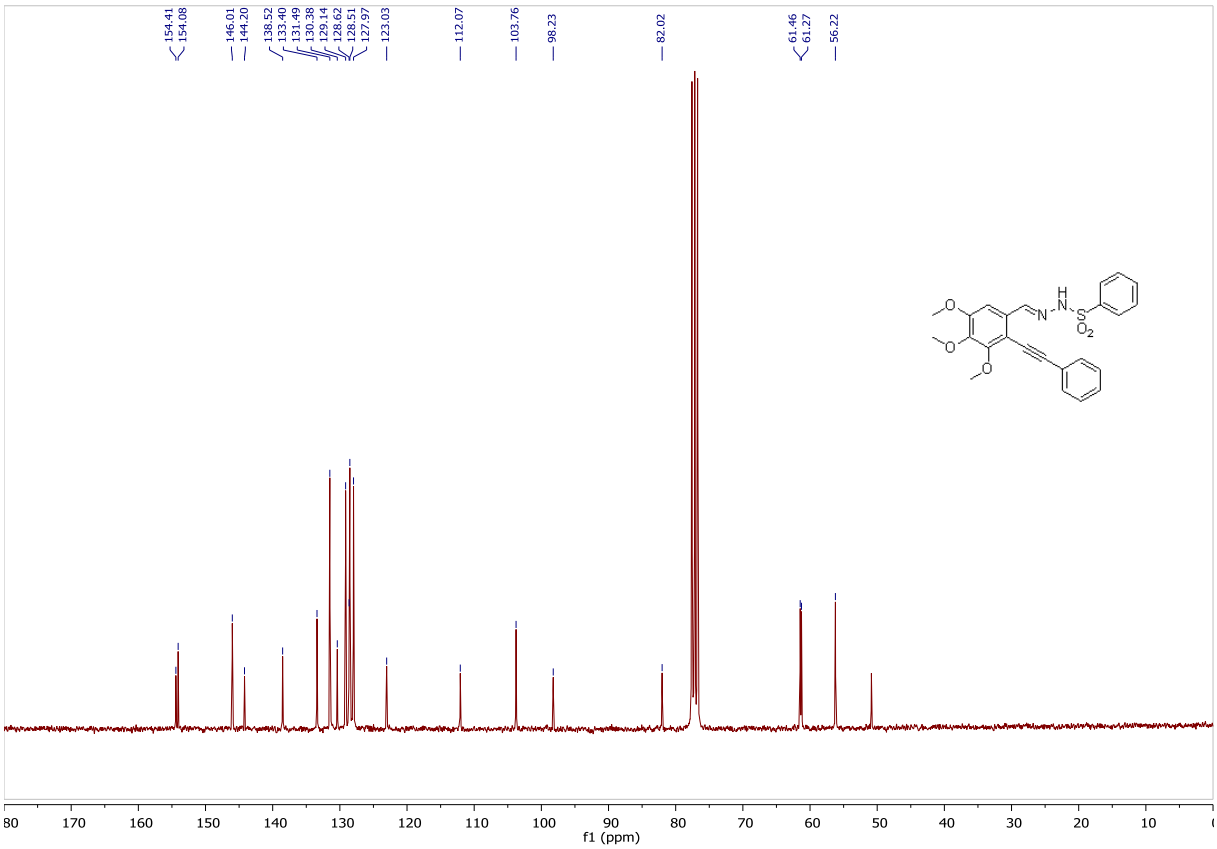


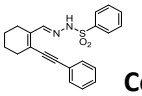




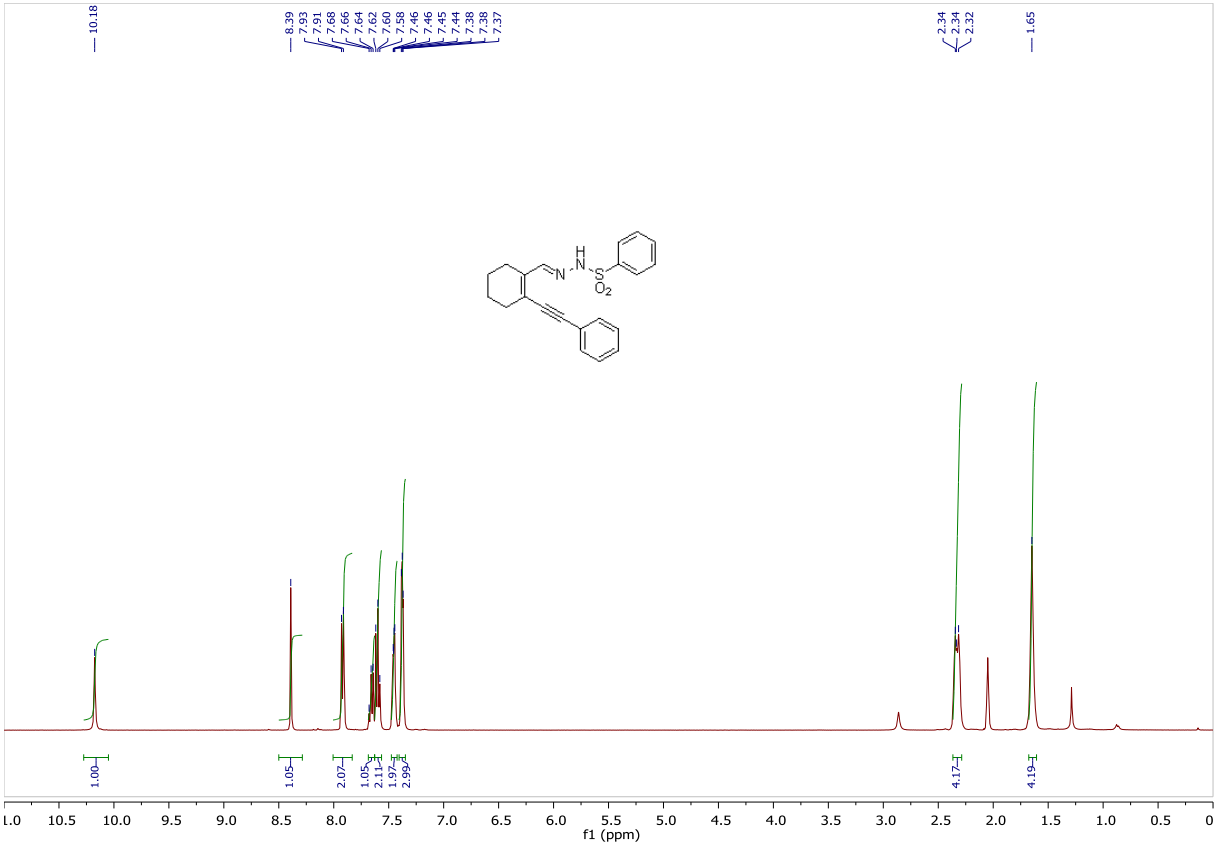
Compound1x: N'-(3,4,5-trimethoxy-2-(phenylethynyl)benzylidene)benzenesulfonohydrazide

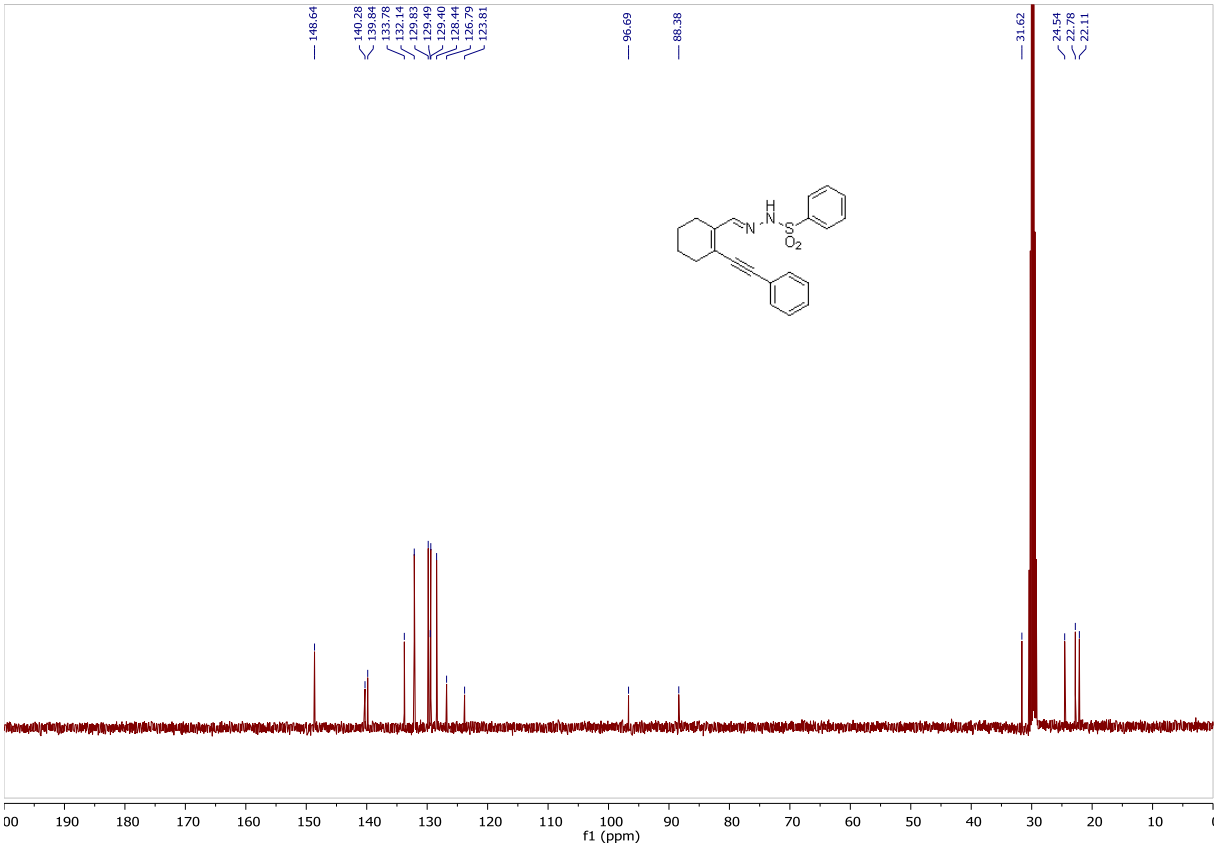


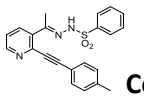




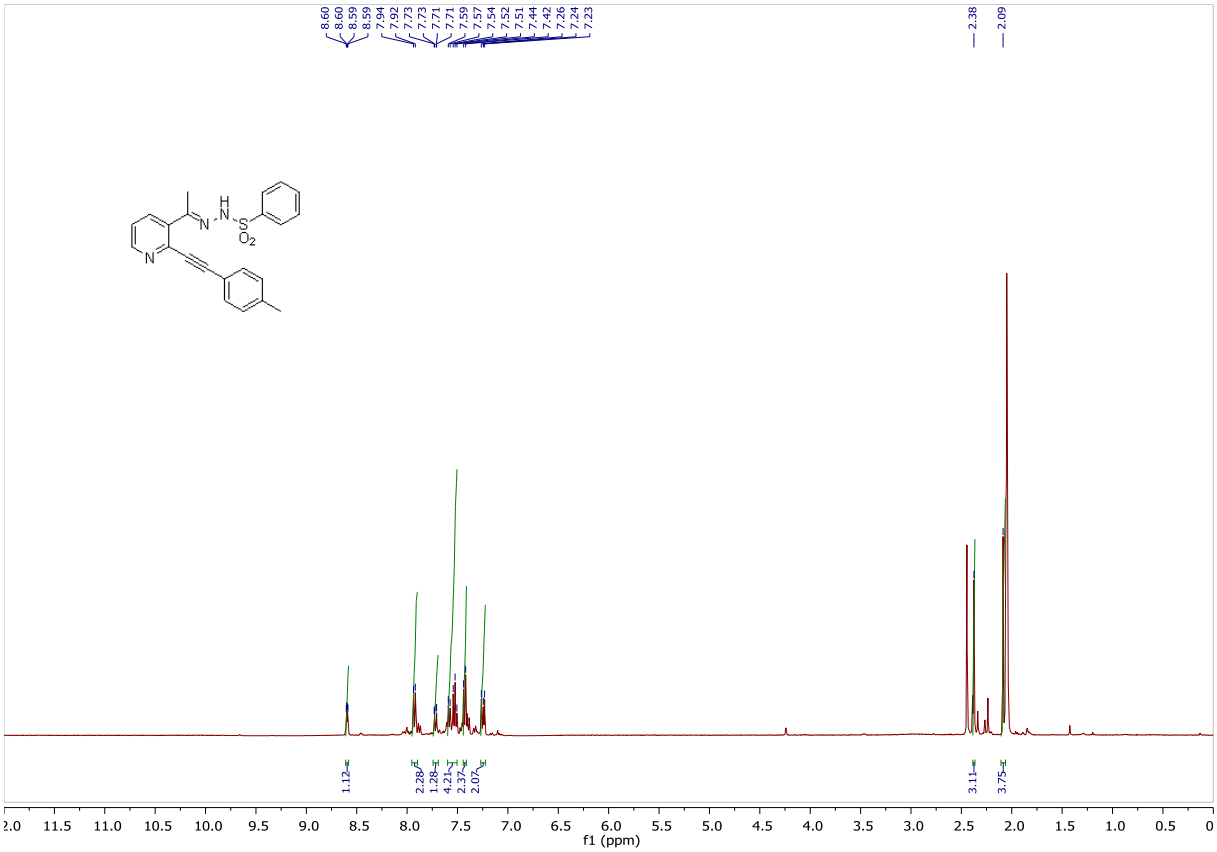
Compound 1y: N'-((2-(phenylethynyl)cyclohex-1-en-1-yl)methylene)benzenesulfonohydrazide

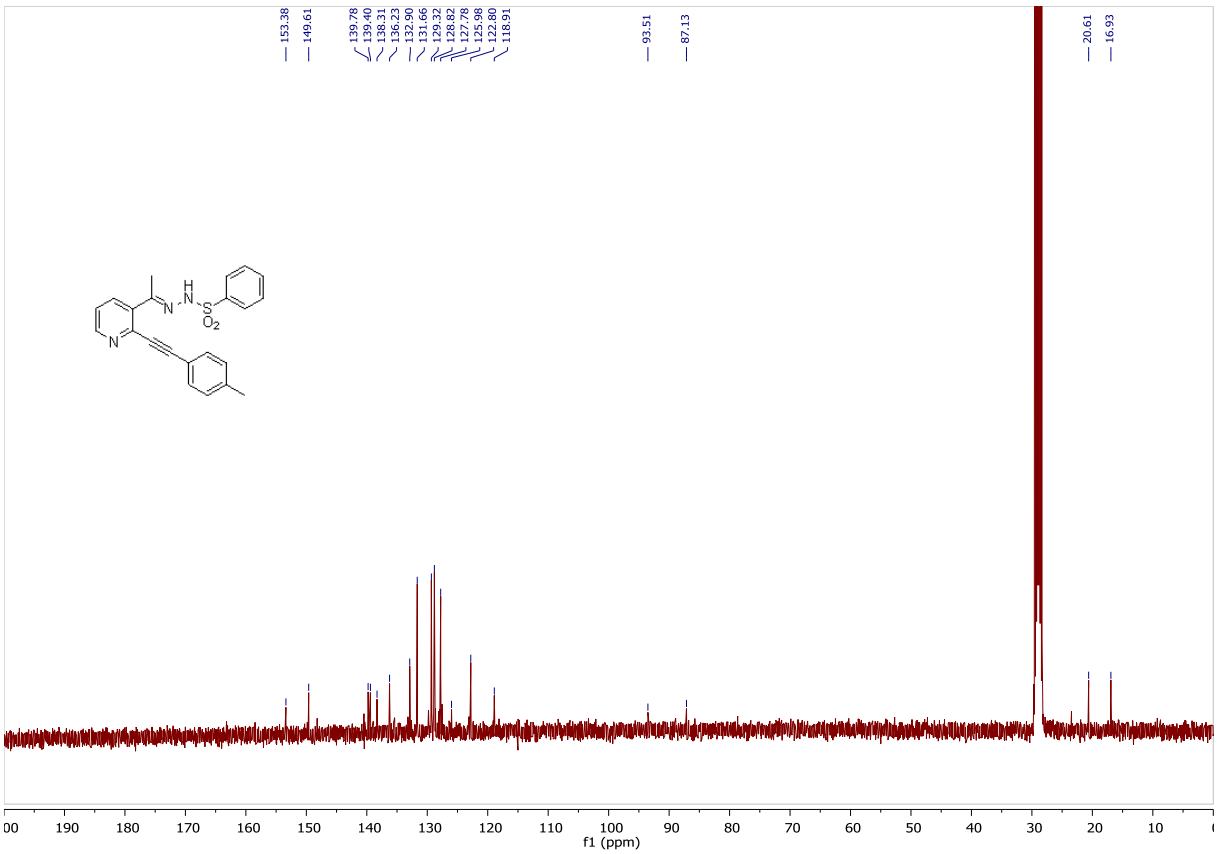


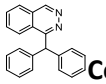




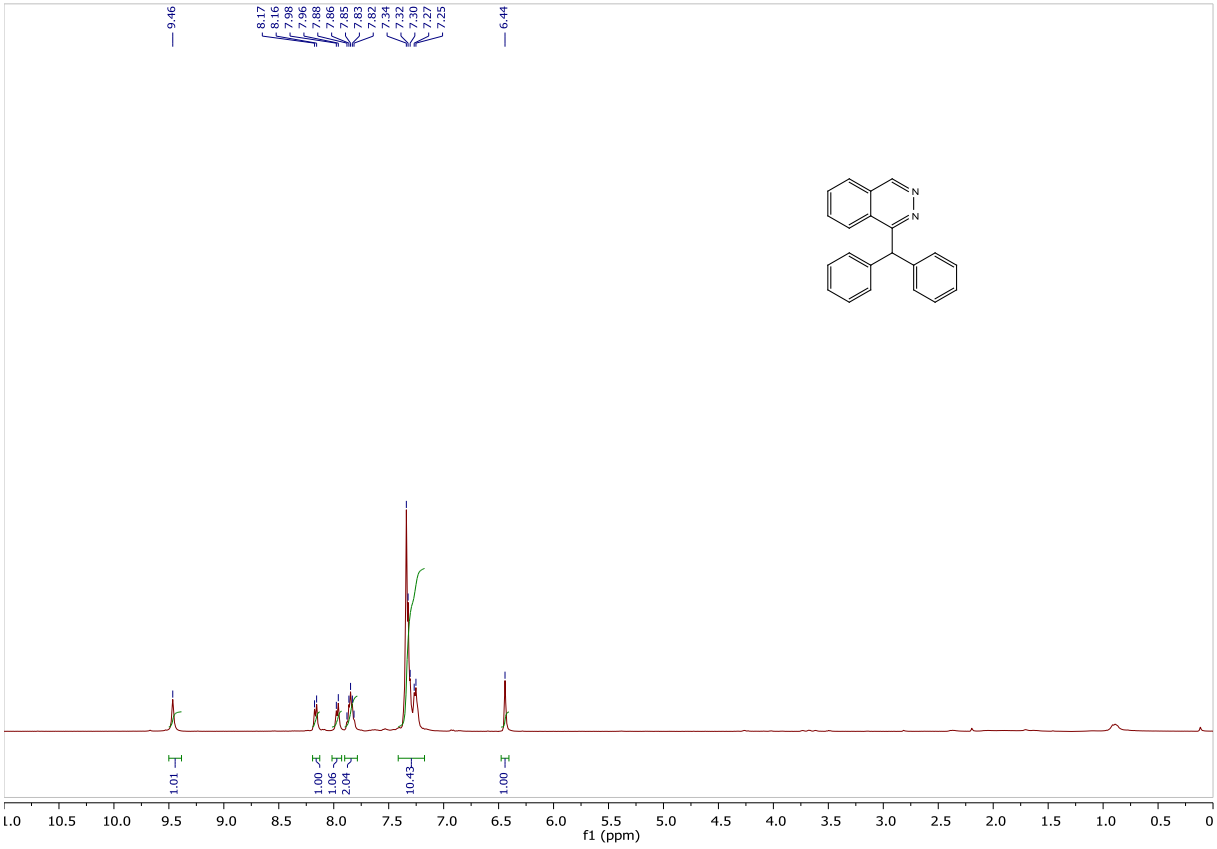
Compound 1z: N'-(1-(2-(p-tolylethynyl)pyridin-3-yl)ethylidene)benzenesulfonohydrazide

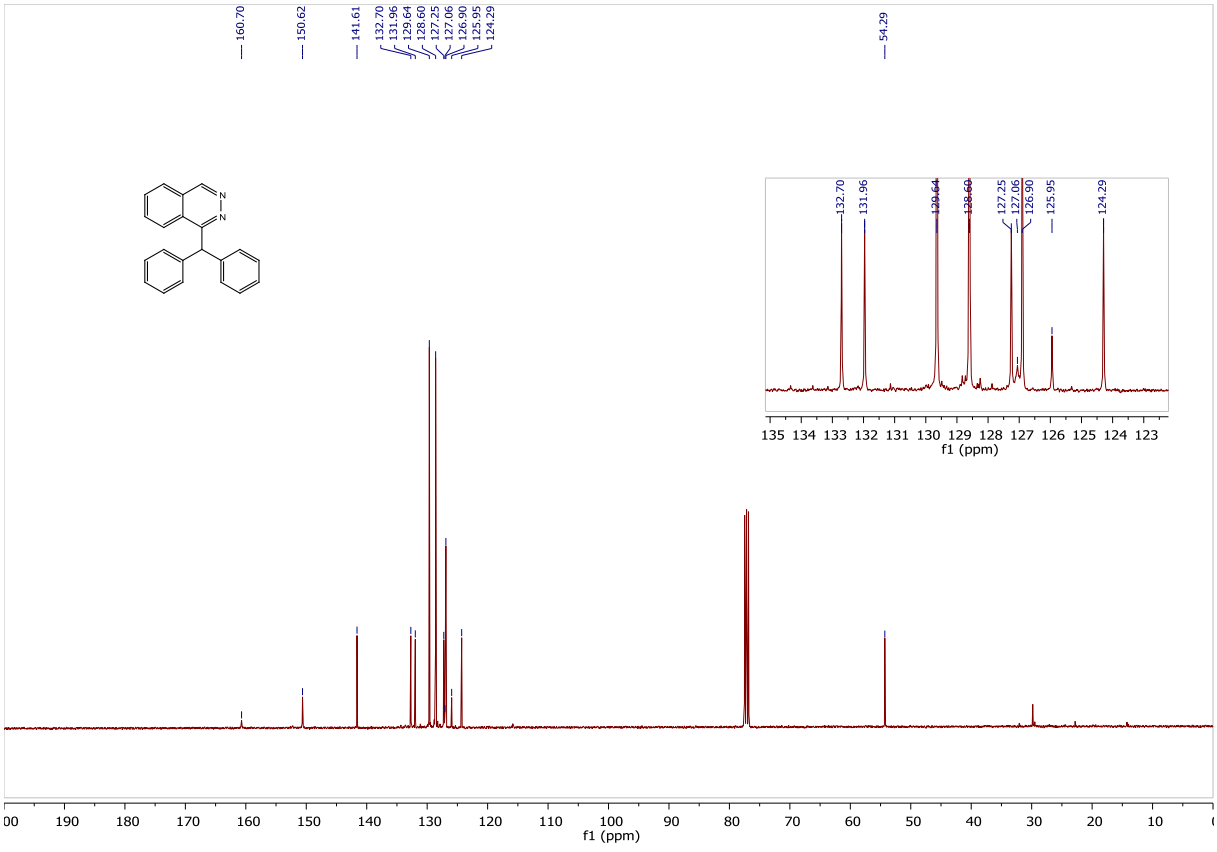


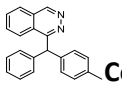




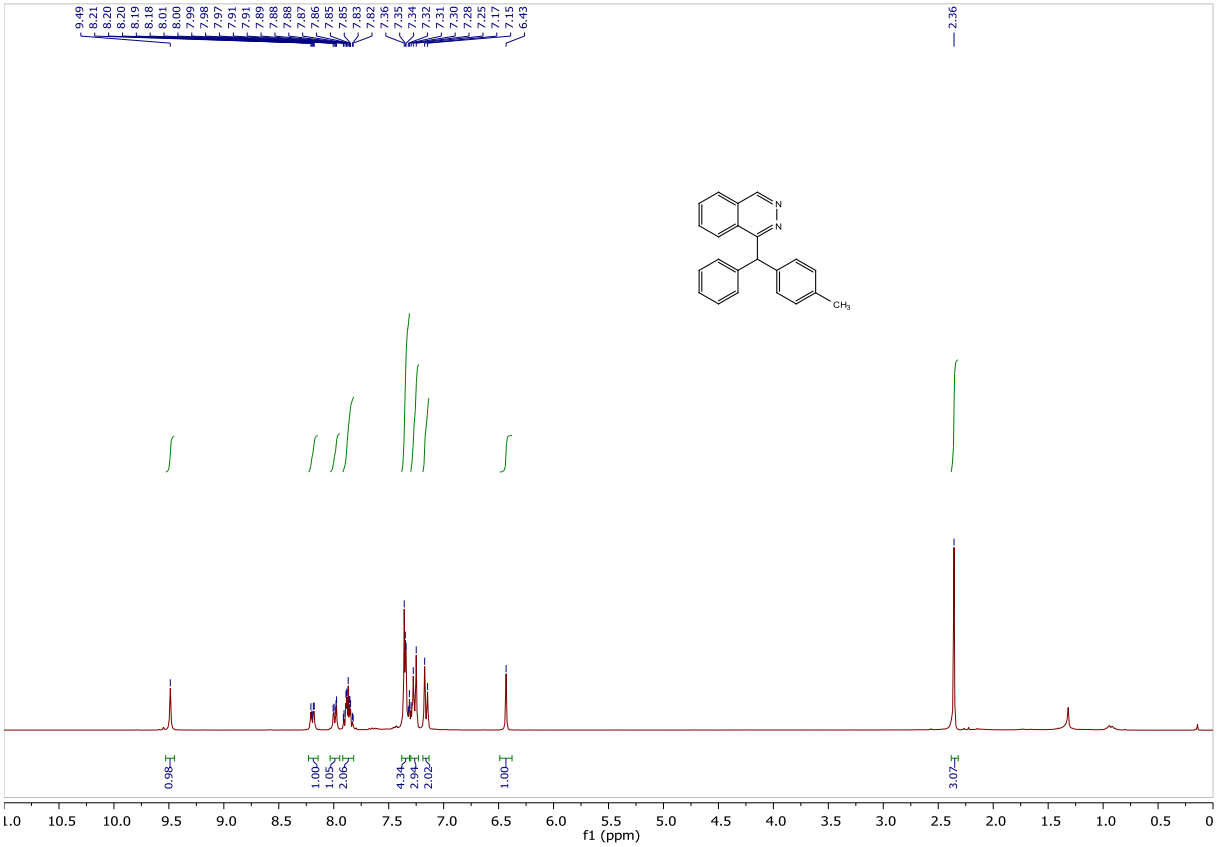
Compound 2a: 1-benzhydrylphthalazine

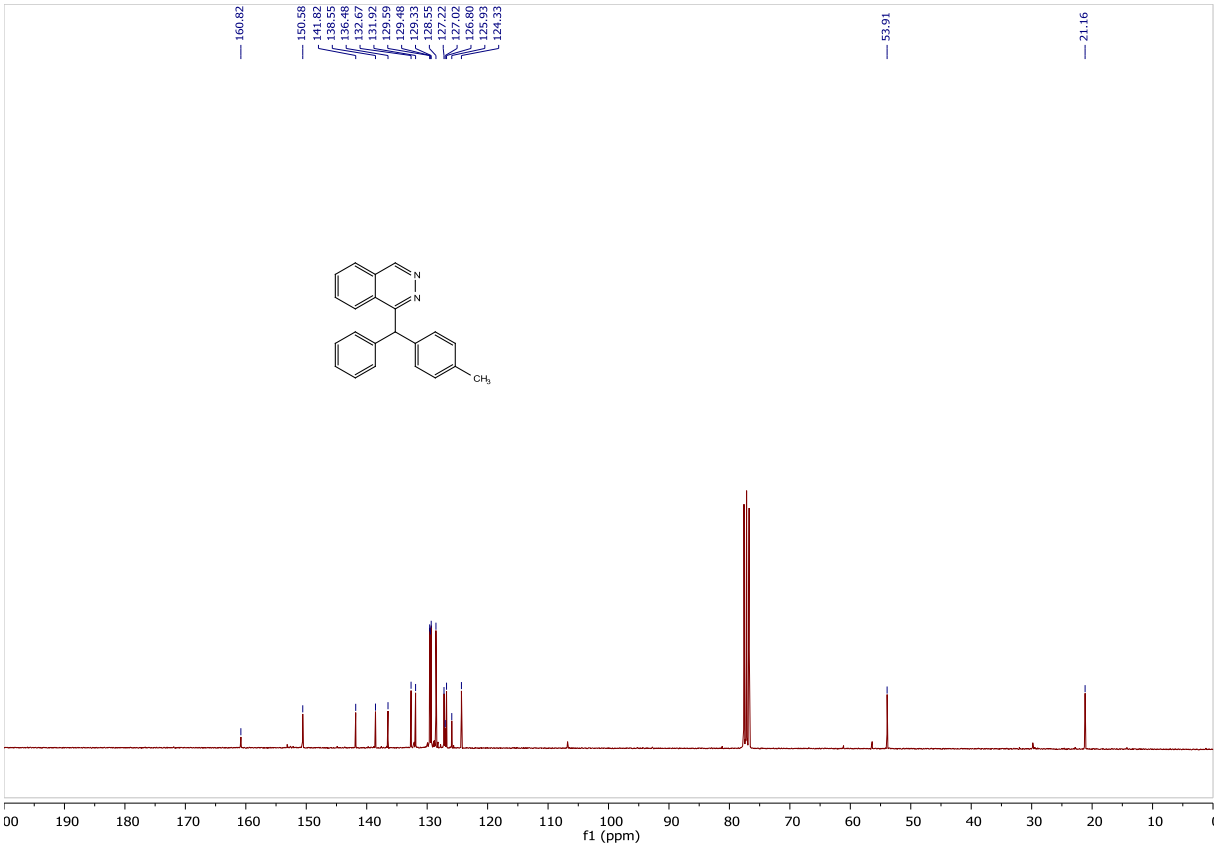


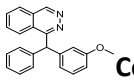




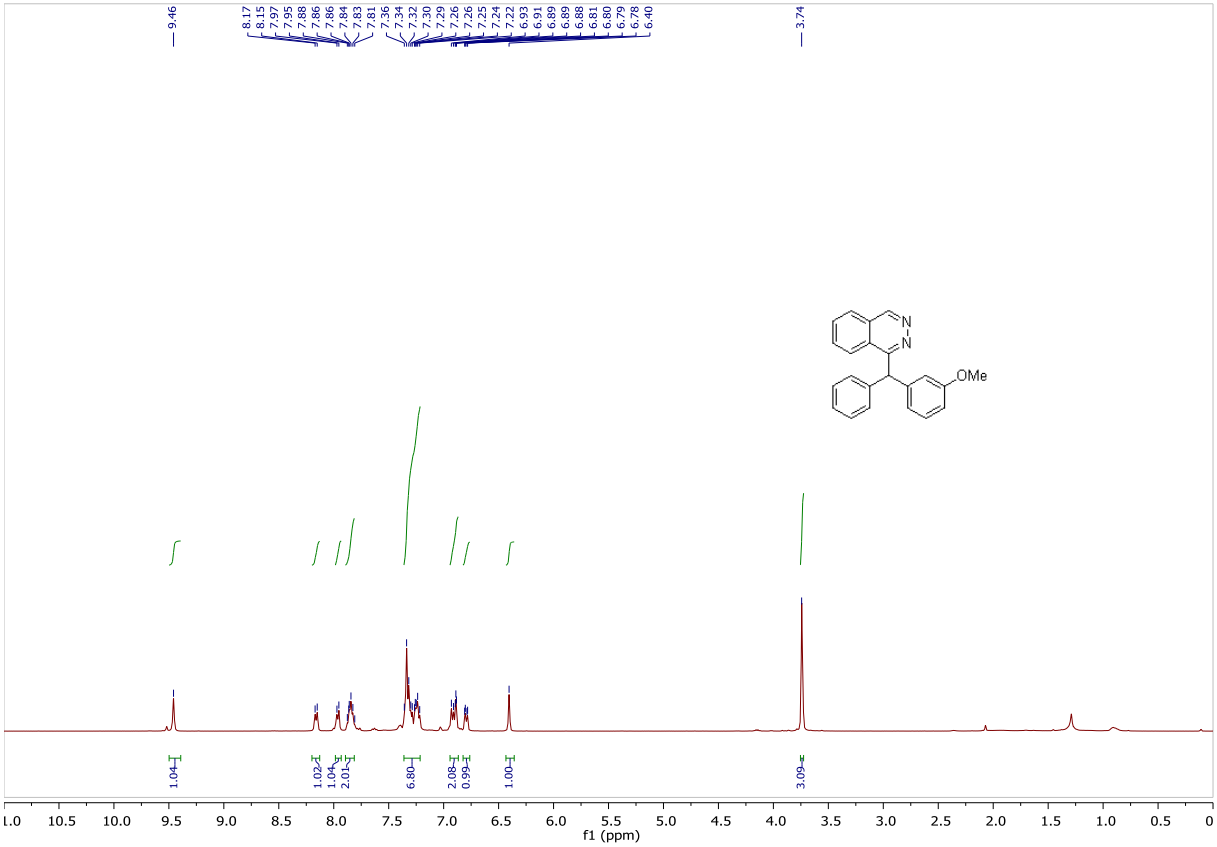
Compound 2b: 1-(phenyl(p-tolyl)methyl)phthalazine

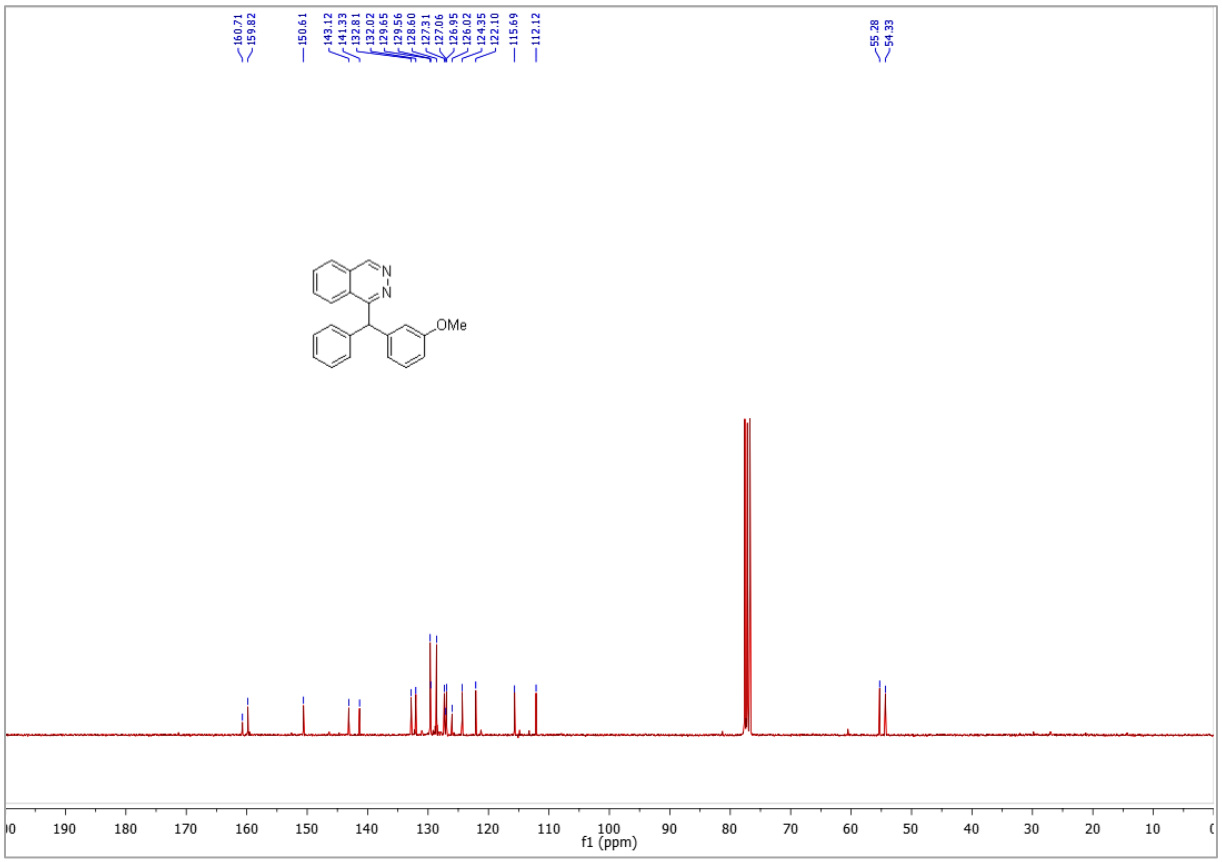


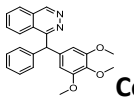




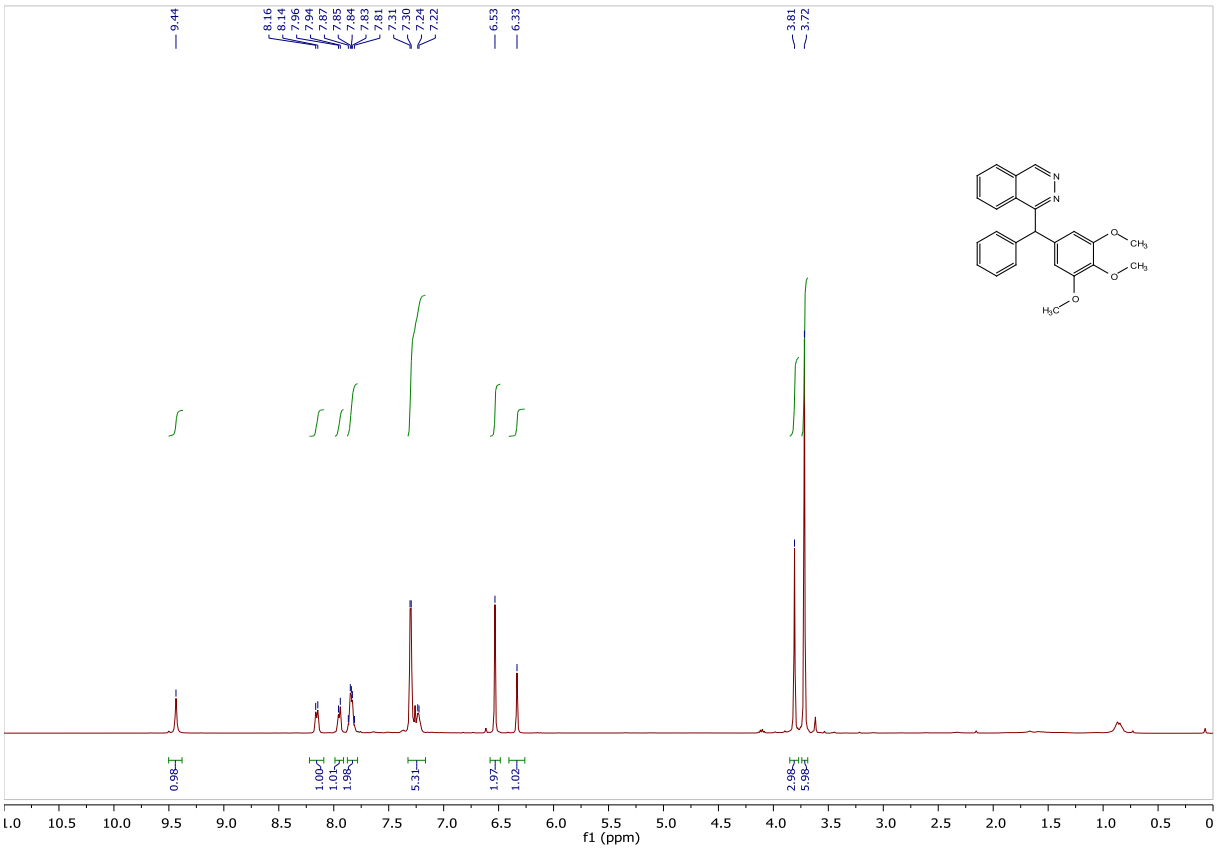
Compound 2c: 1-((3-methoxyphenyl)(phenyl)methyl)phthalazine

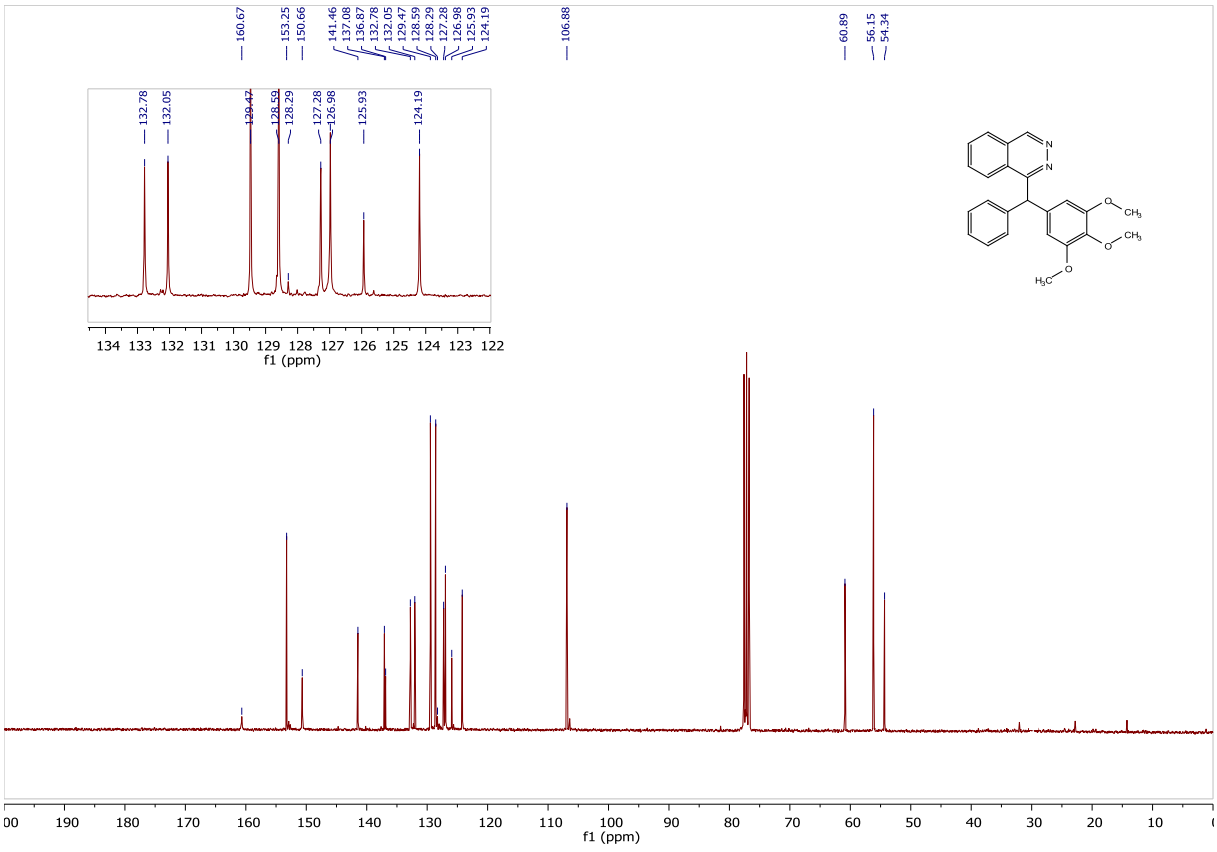


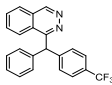




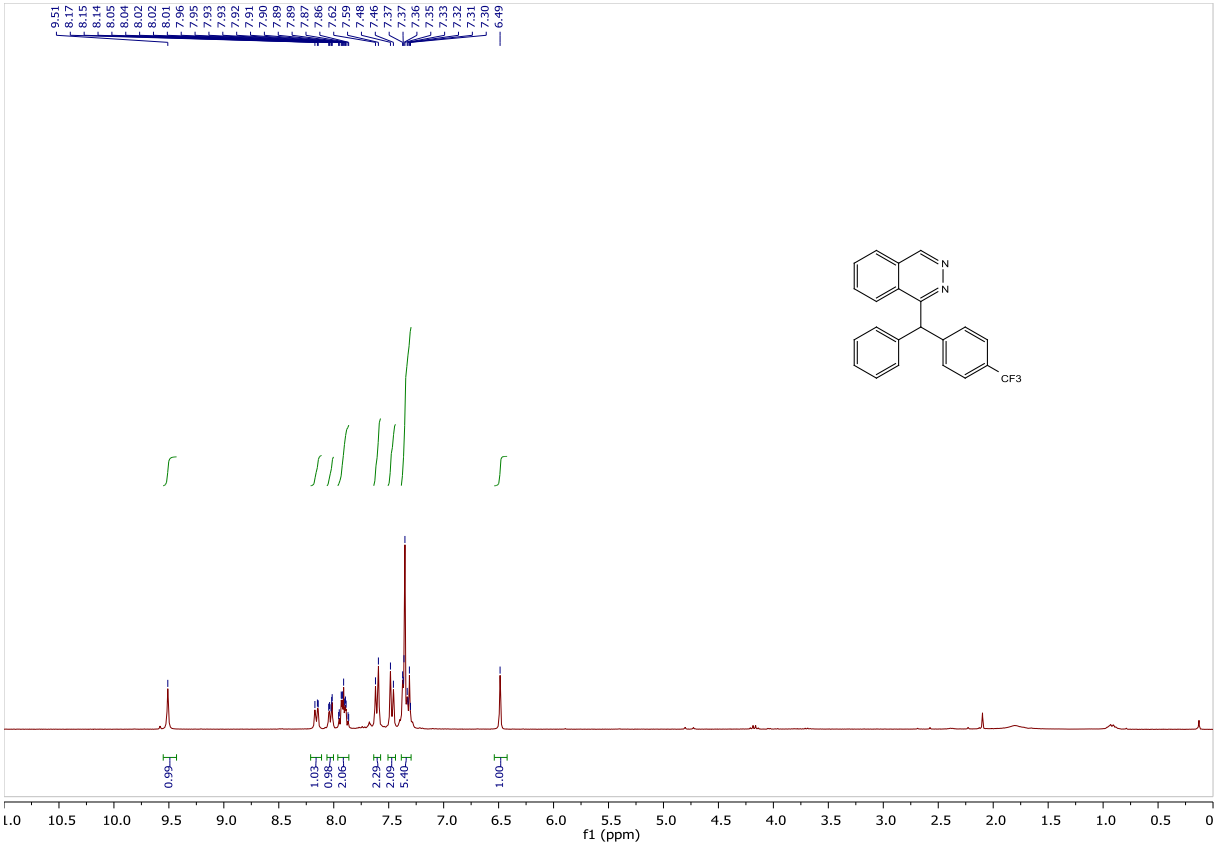
Compound 2d: 1-(phenyl(3,4,5-trimethoxyphenyl)methyl)phthalazine

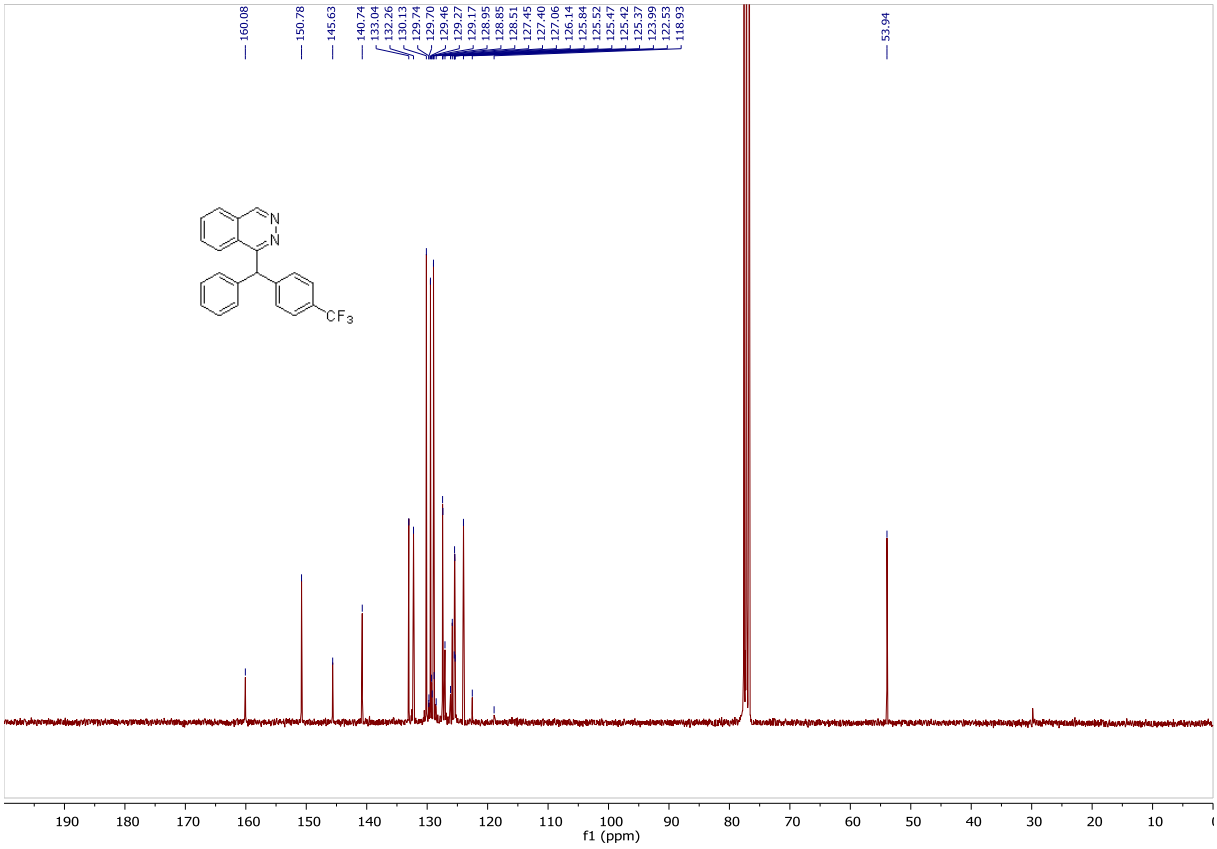


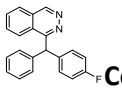




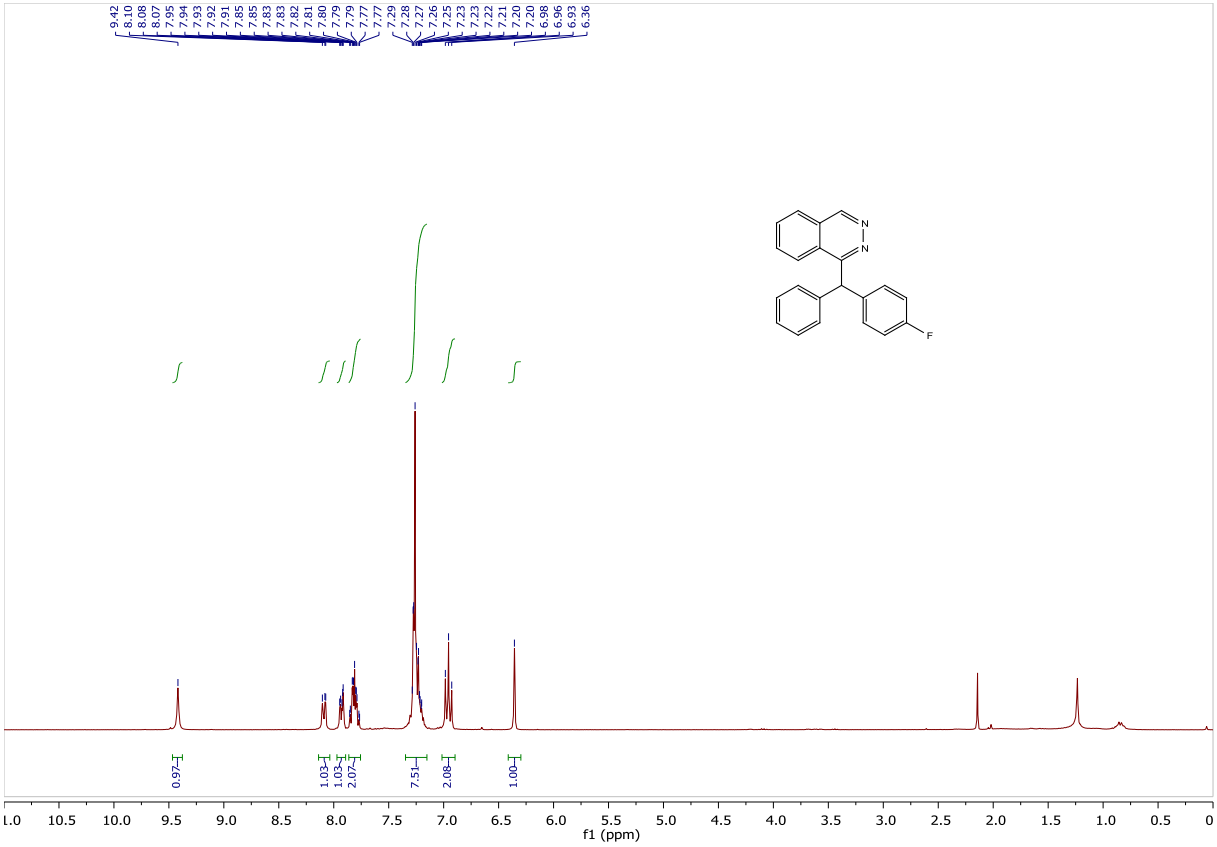
Compound 2f: 1-(phenyl(4-(trifluoromethyl)phenyl)methyl)phthalazine

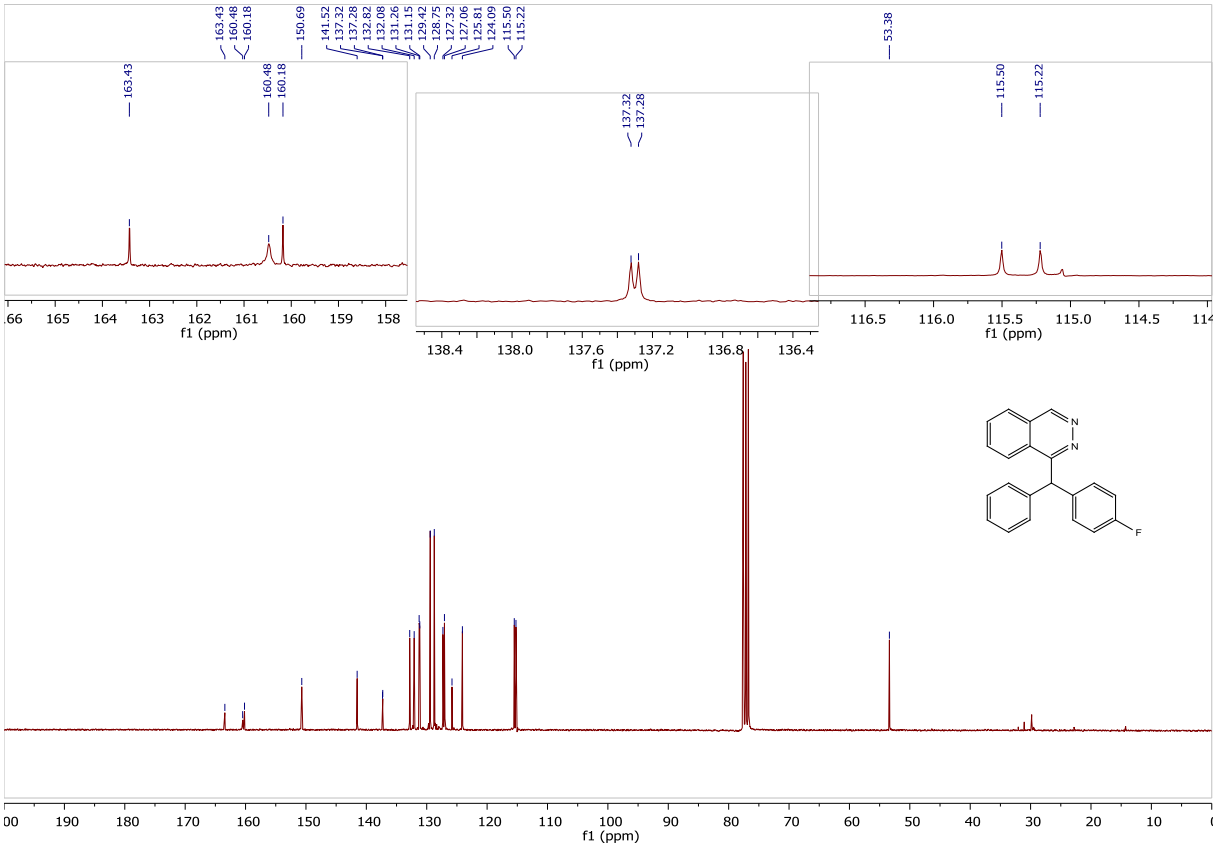


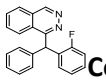




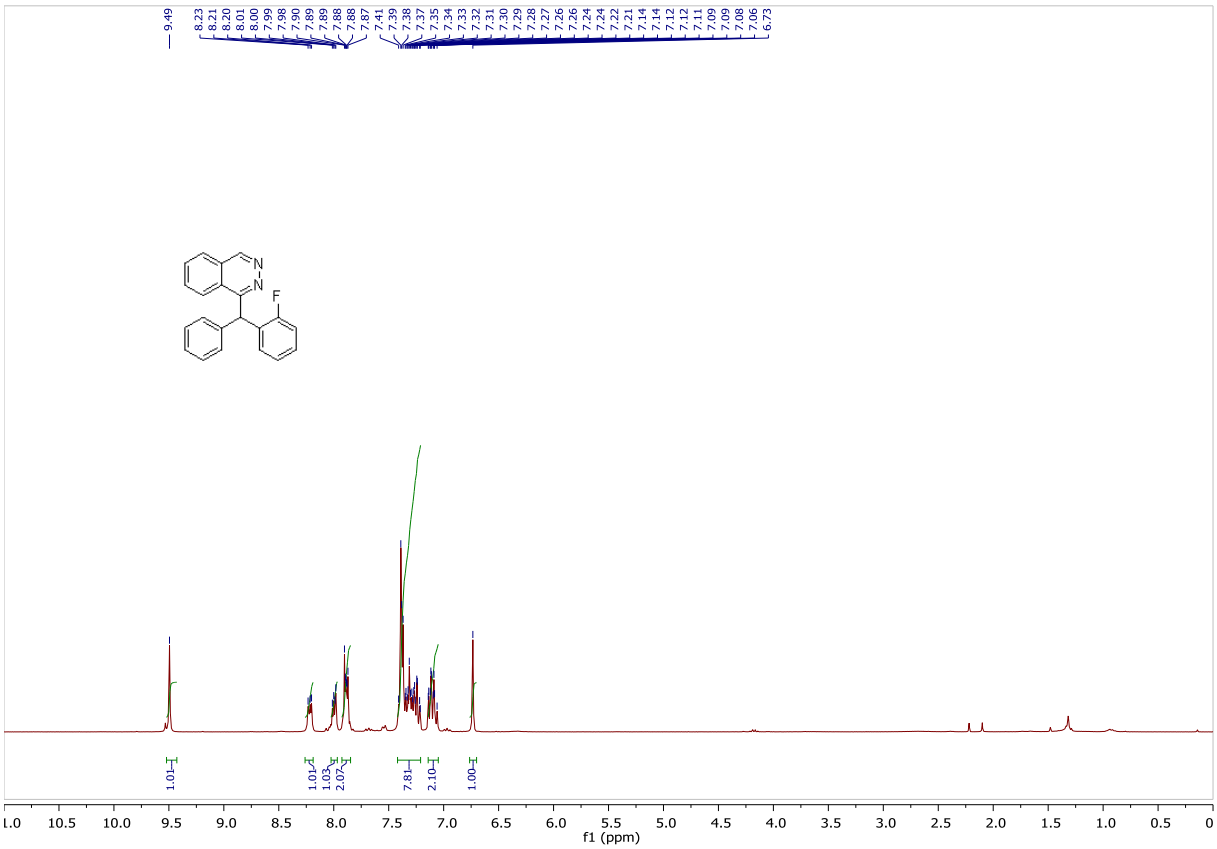
Compound 2g: 1-((4-fluorophenyl)(phenyl)methyl)phthalazine

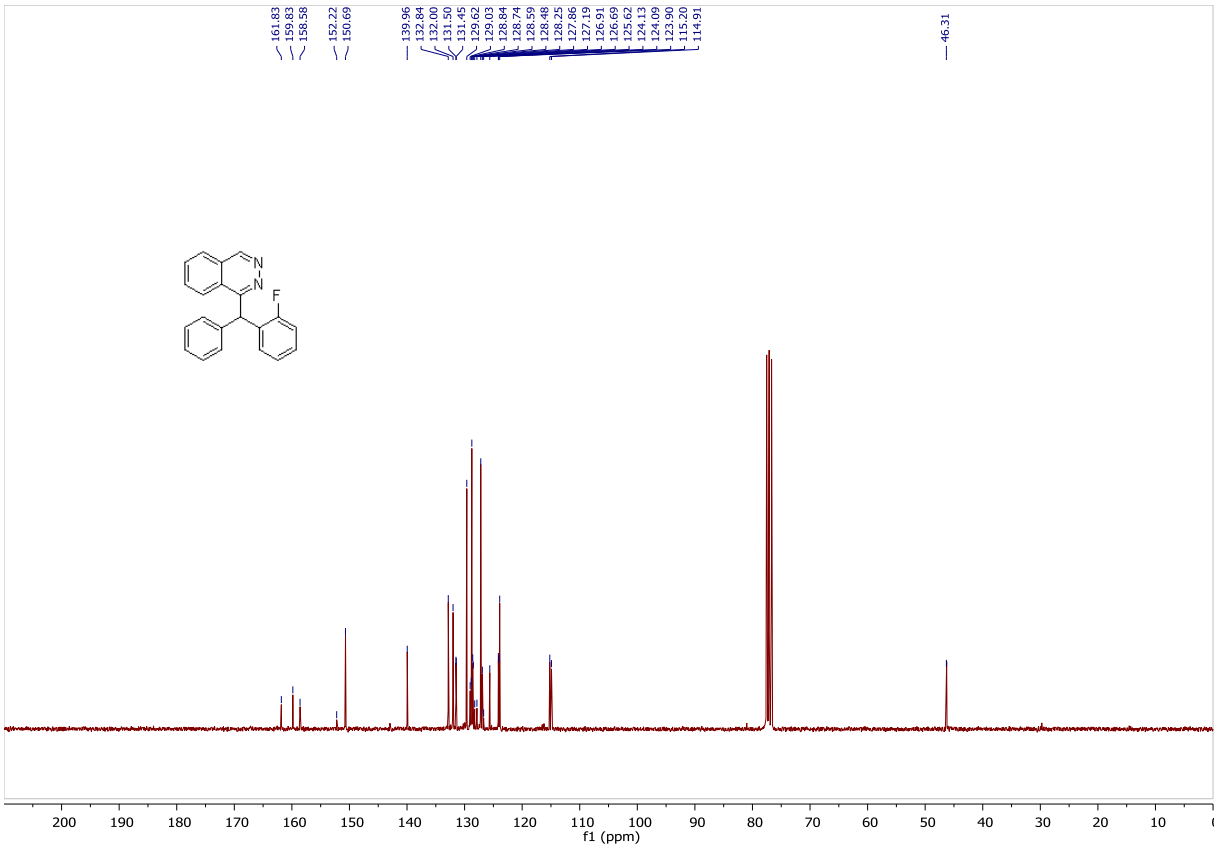


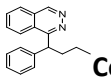




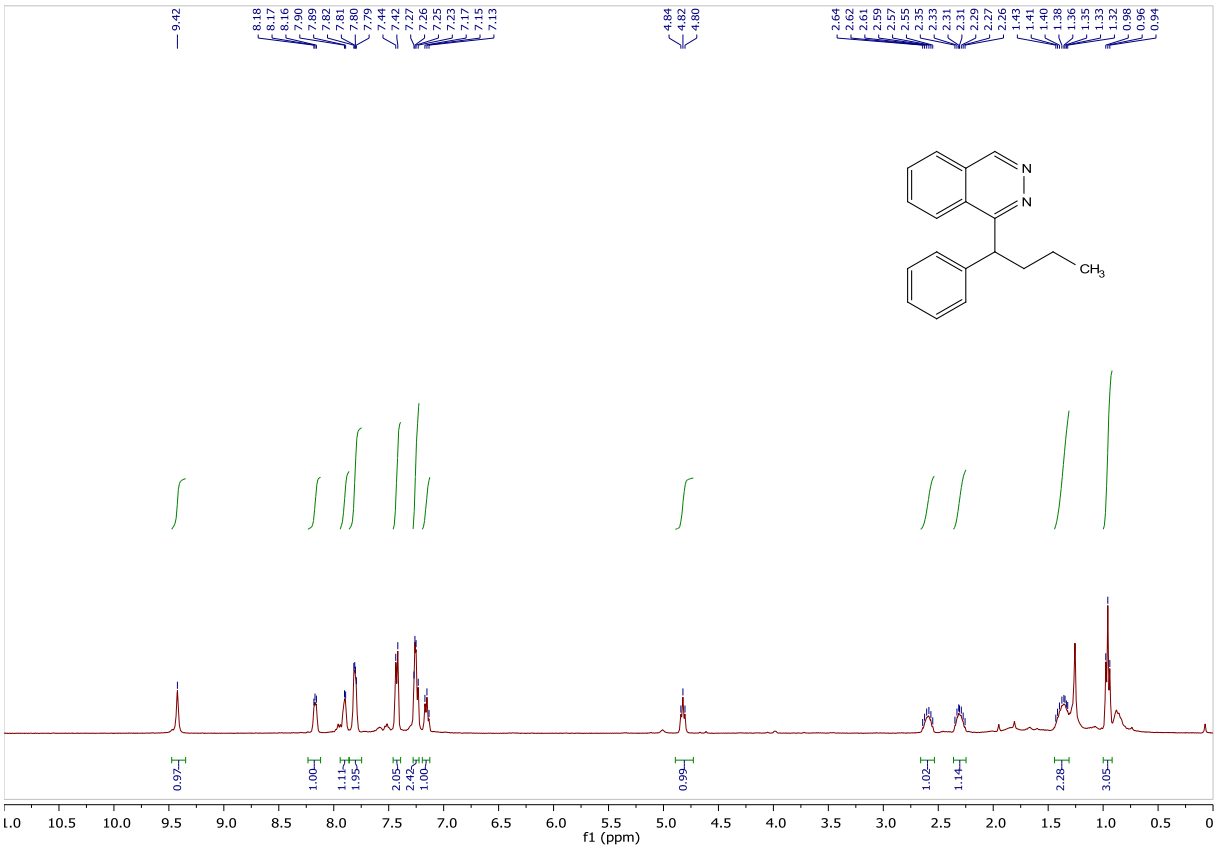
Compound 2h: 1-((2-fluorophenyl)(phenyl)methyl)phthalazine

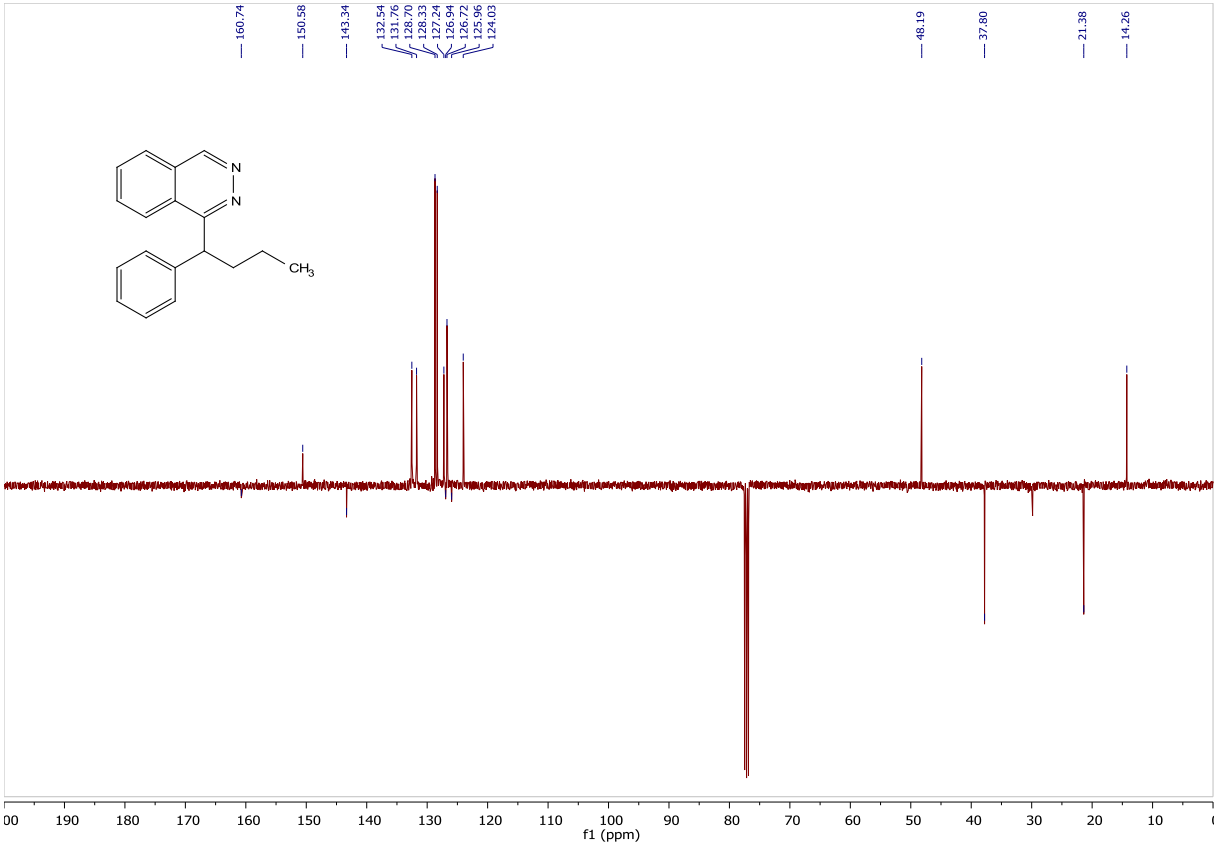


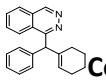




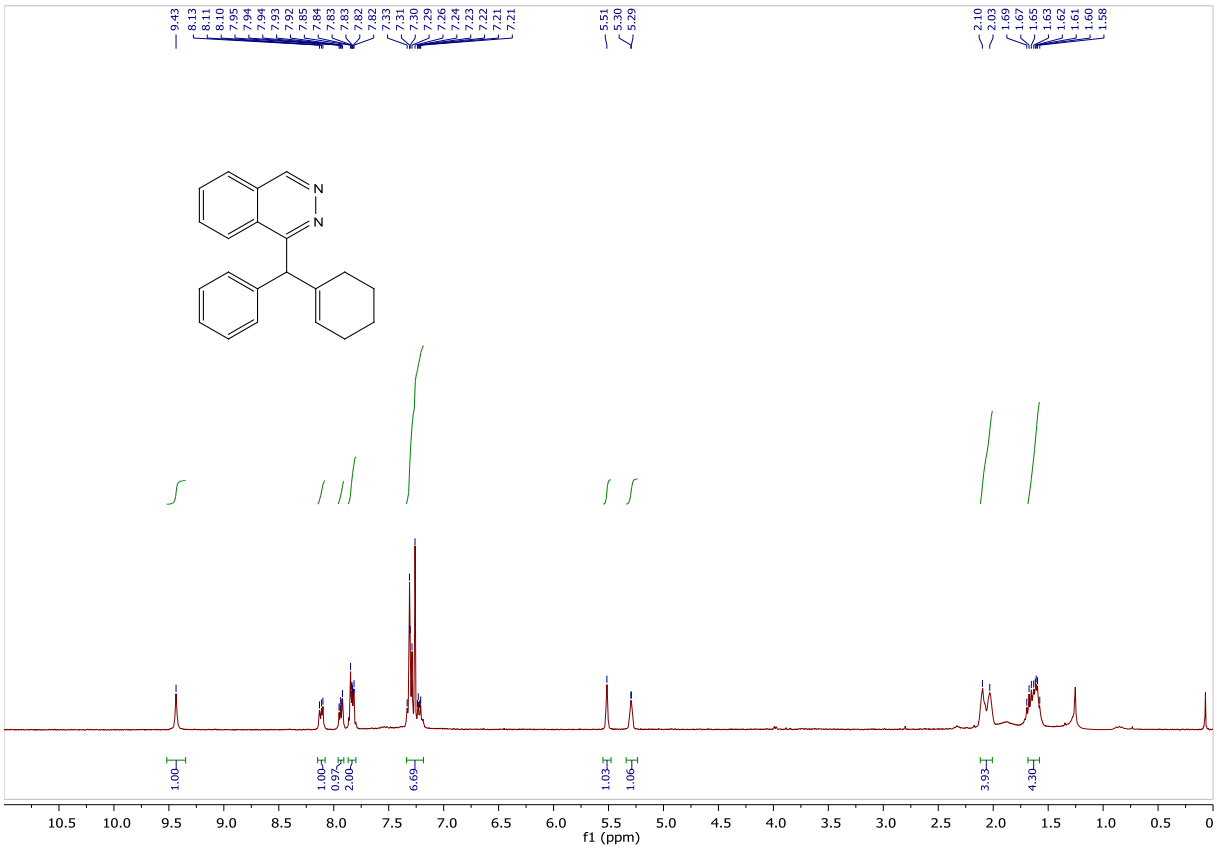
Compound 2i: 1-(1-phenylbutyl)phthalazine

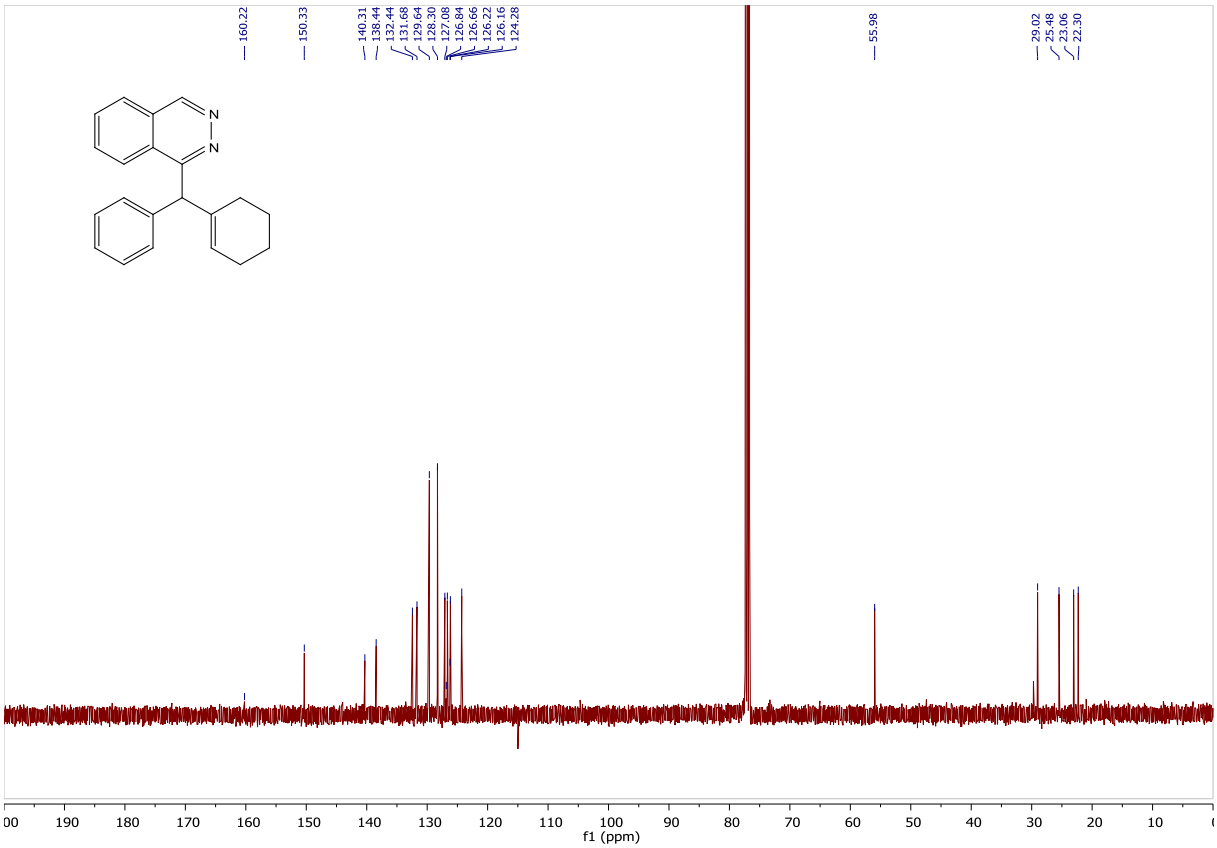


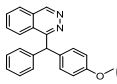




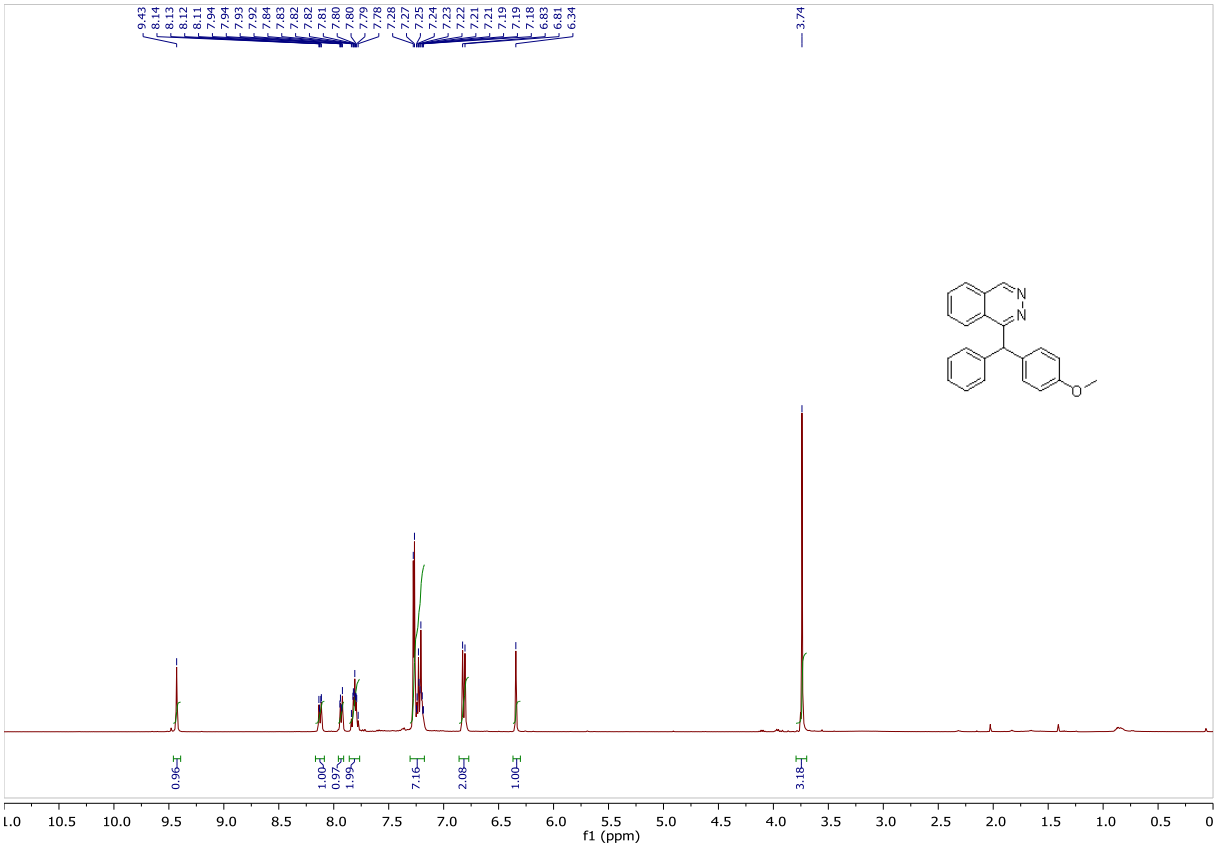
Compound 2j: 1-(cyclohex-1-en-1-yl(phenyl)methyl)phthalazine

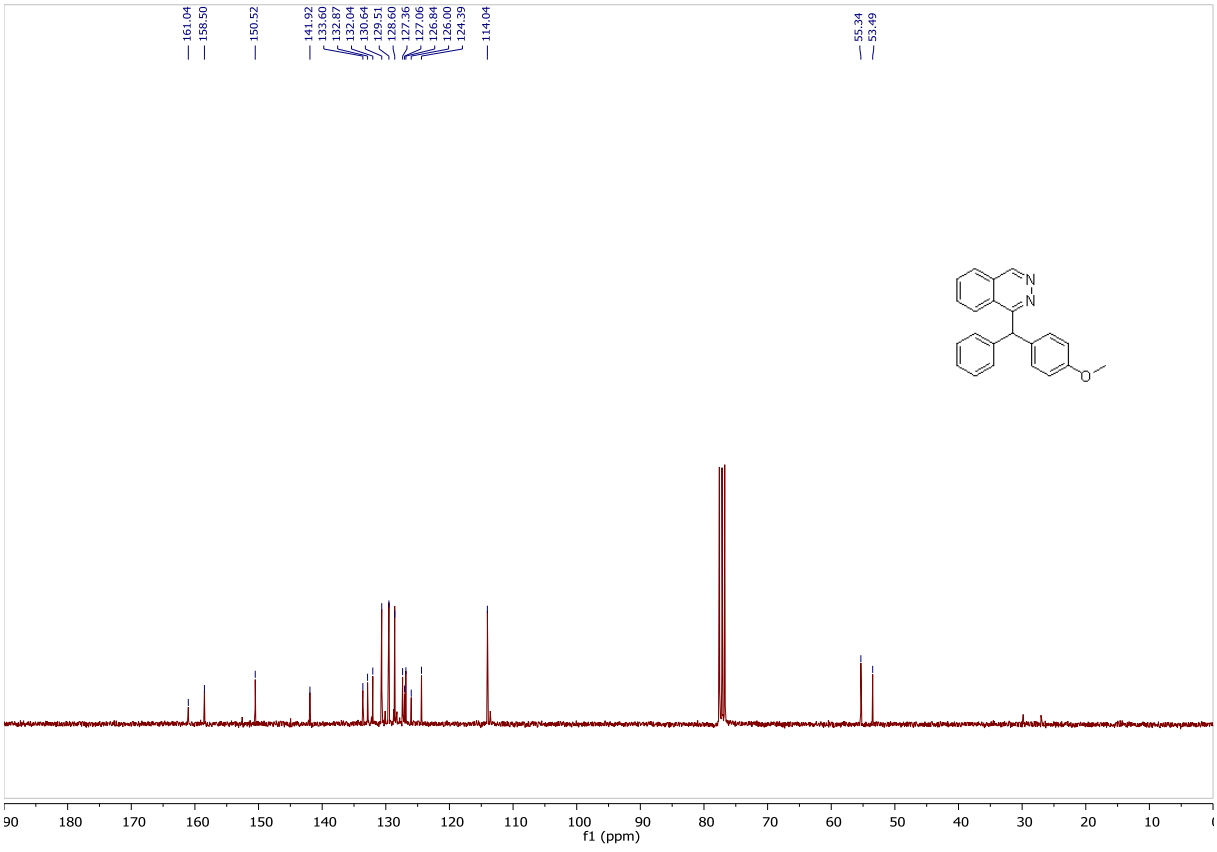


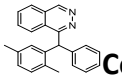




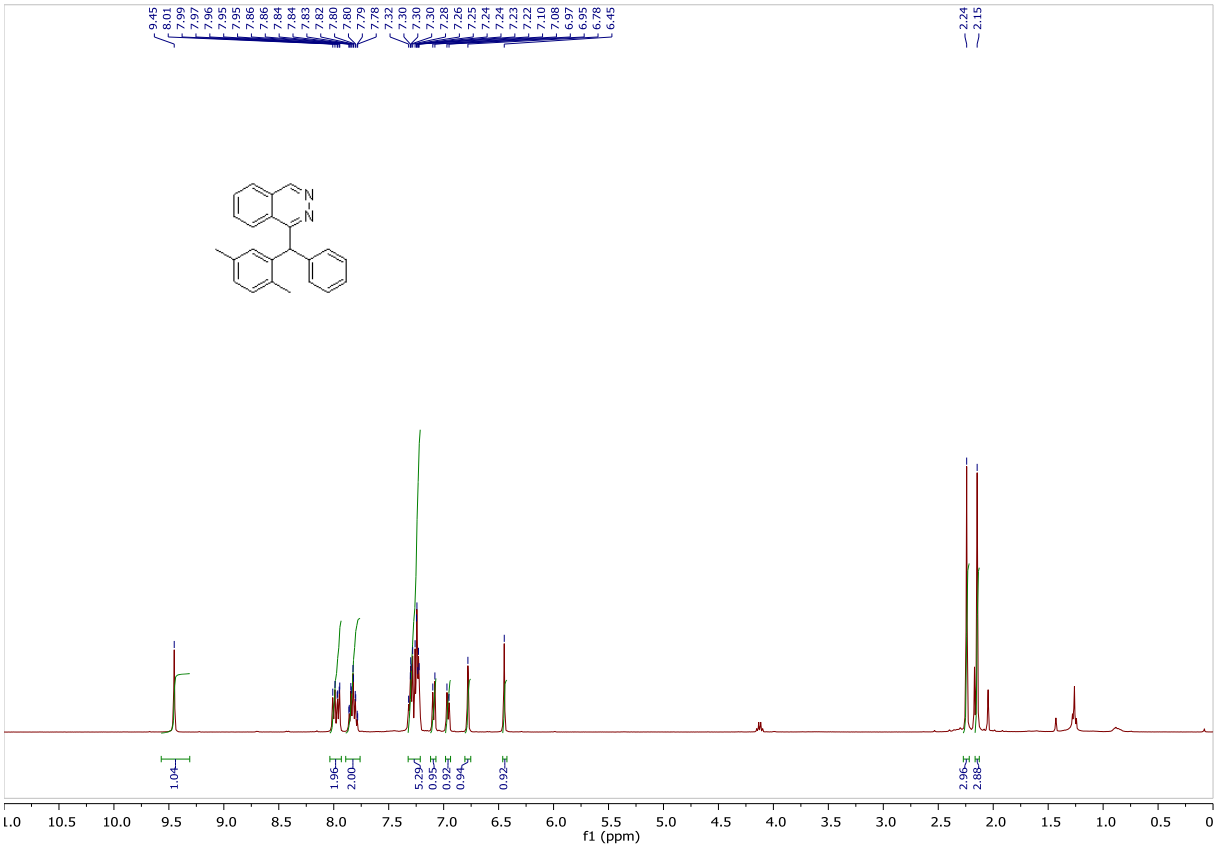
Compound 2k: 1-((4-methoxyphenyl)(phenyl)methyl)phthalazine

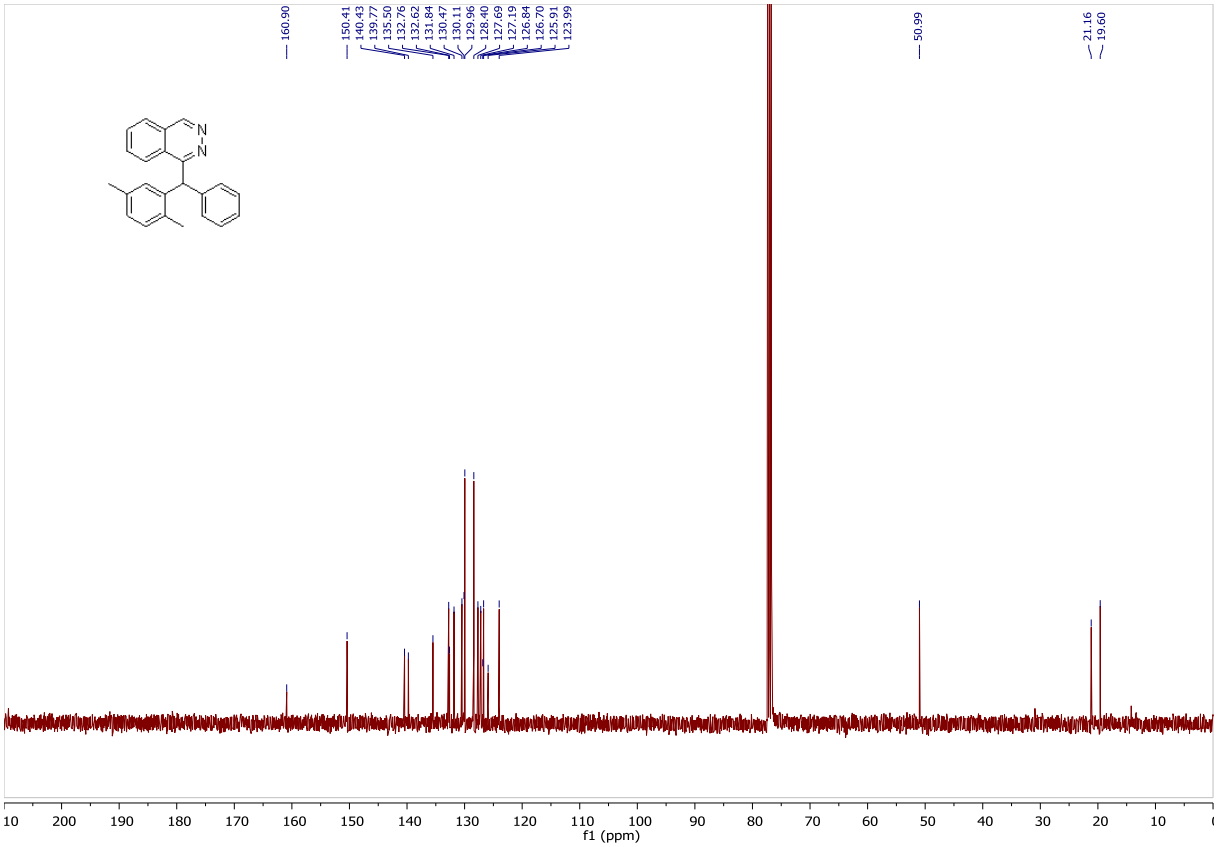


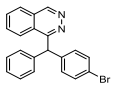




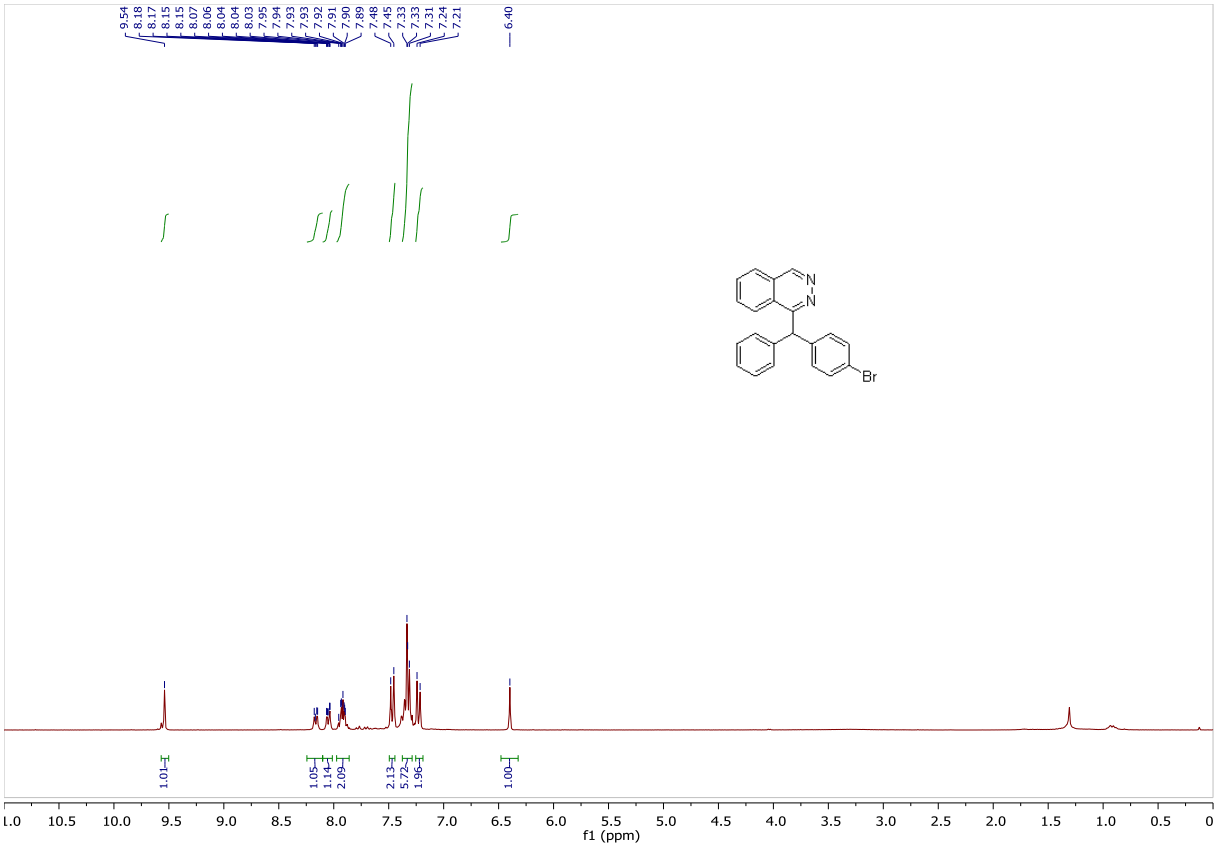
Compound 2l: 1-((2,5-dimethylphenyl)(phenyl)methyl)phthalazine

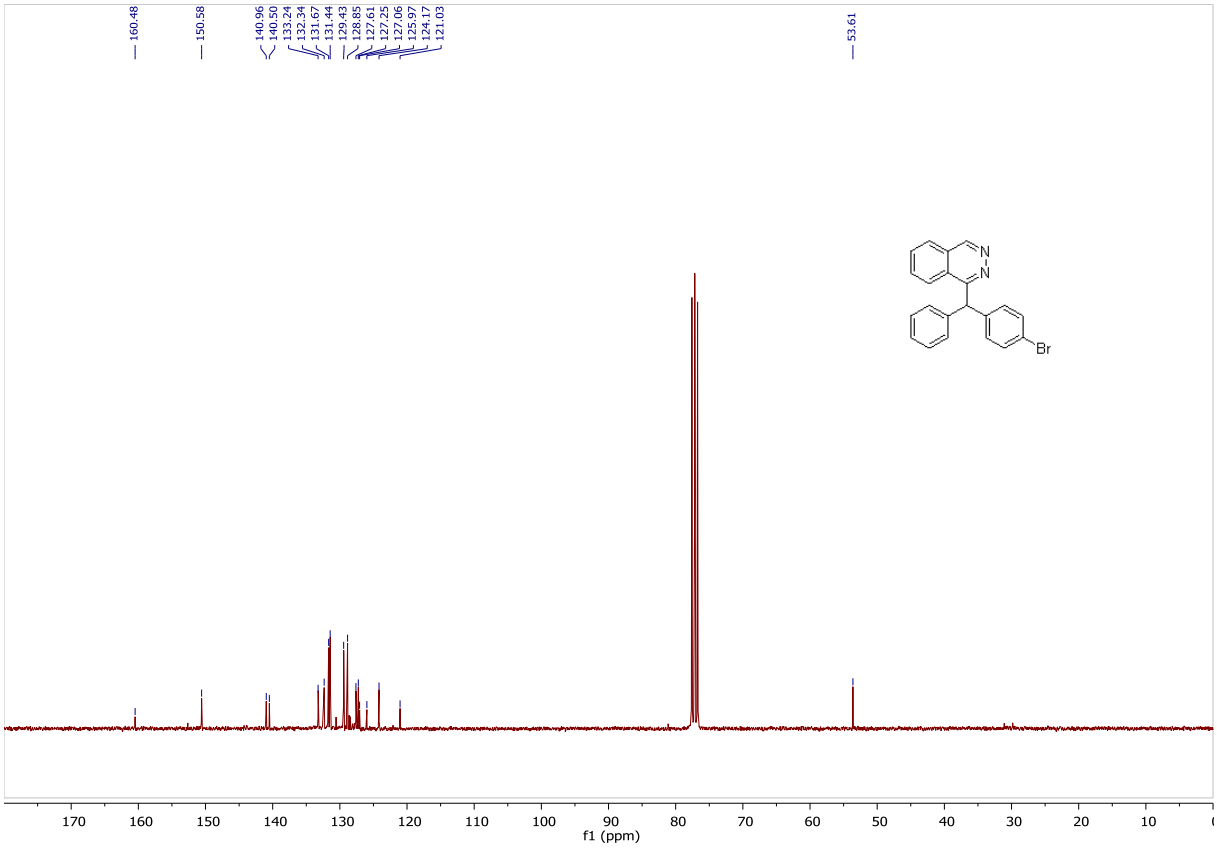


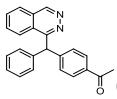




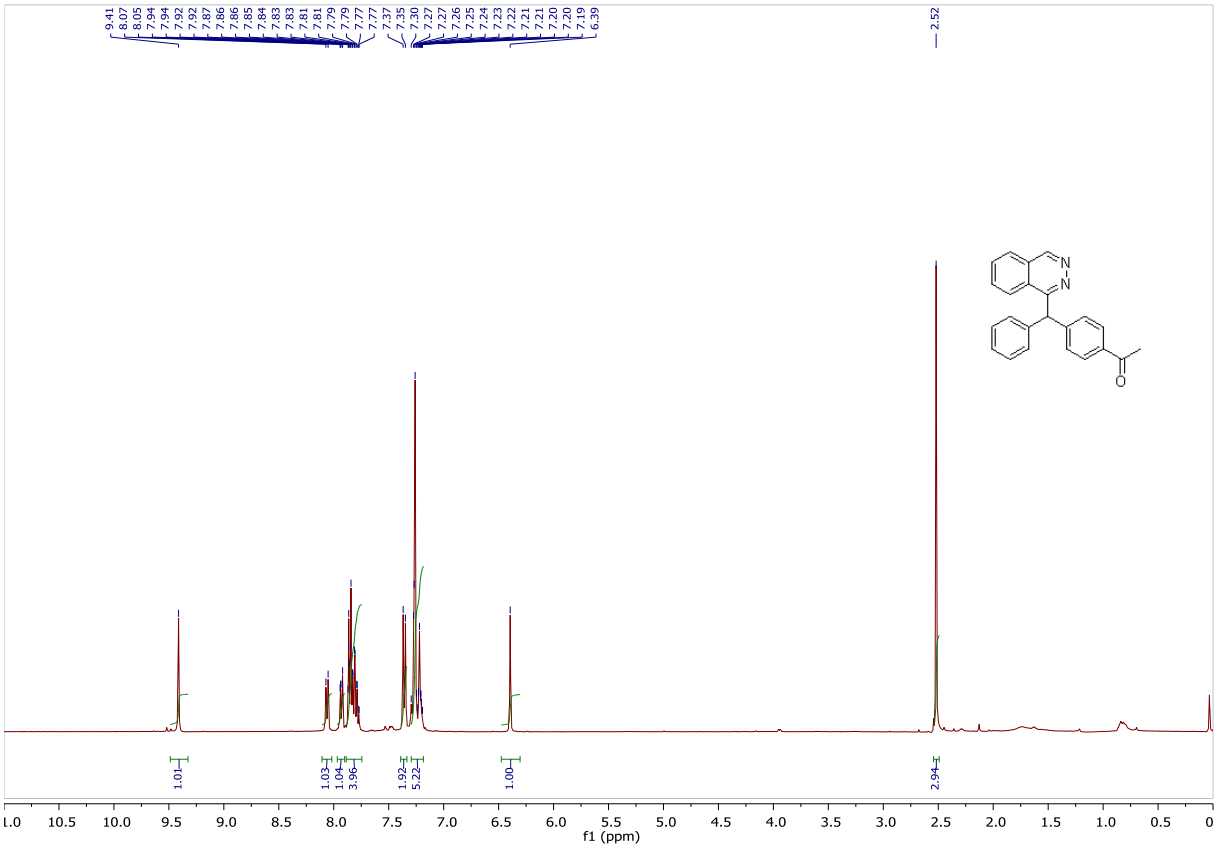
Compound 2o: 1-((4-bromophenyl)(phenyl)methyl)phthalazine

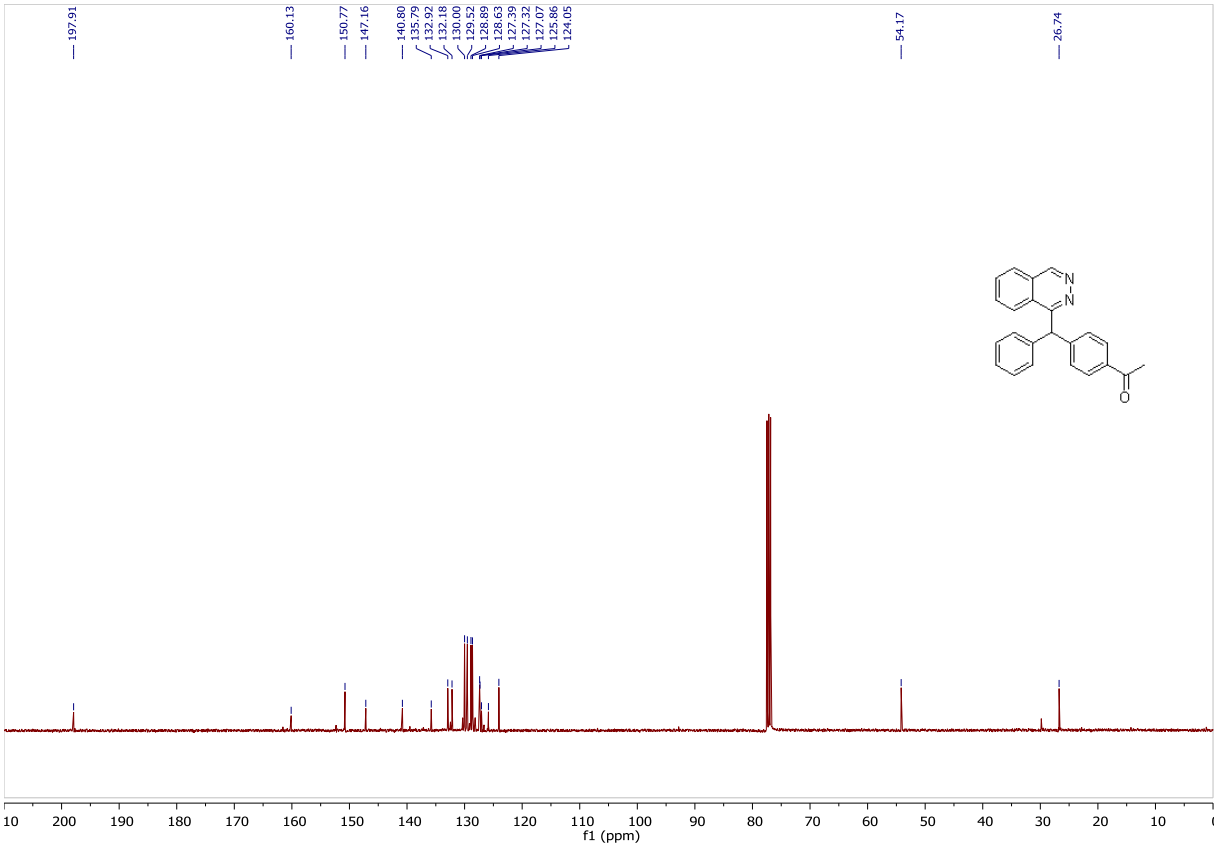


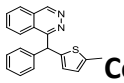




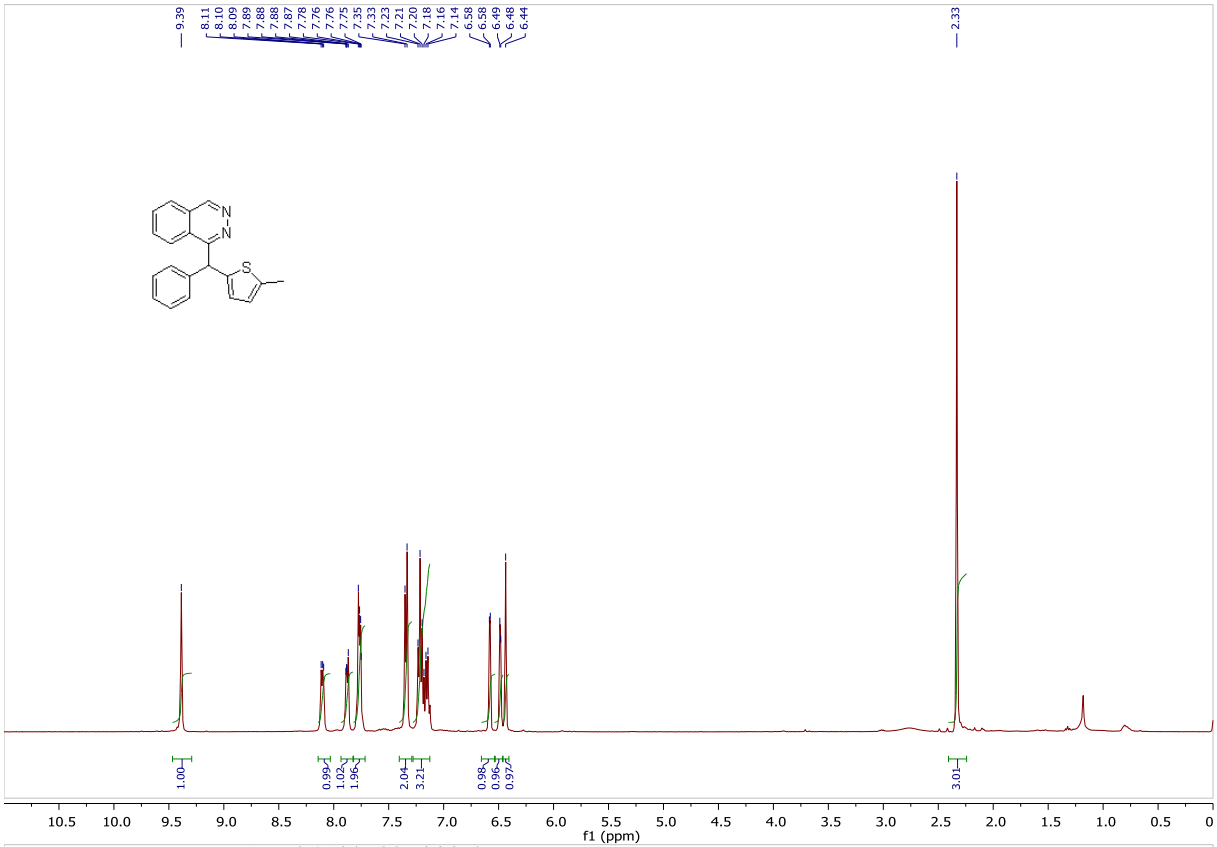
Compound 2p: 1-(4-(phenyl(phthalazin-1-yl)methyl)phenyl)ethan-1-one

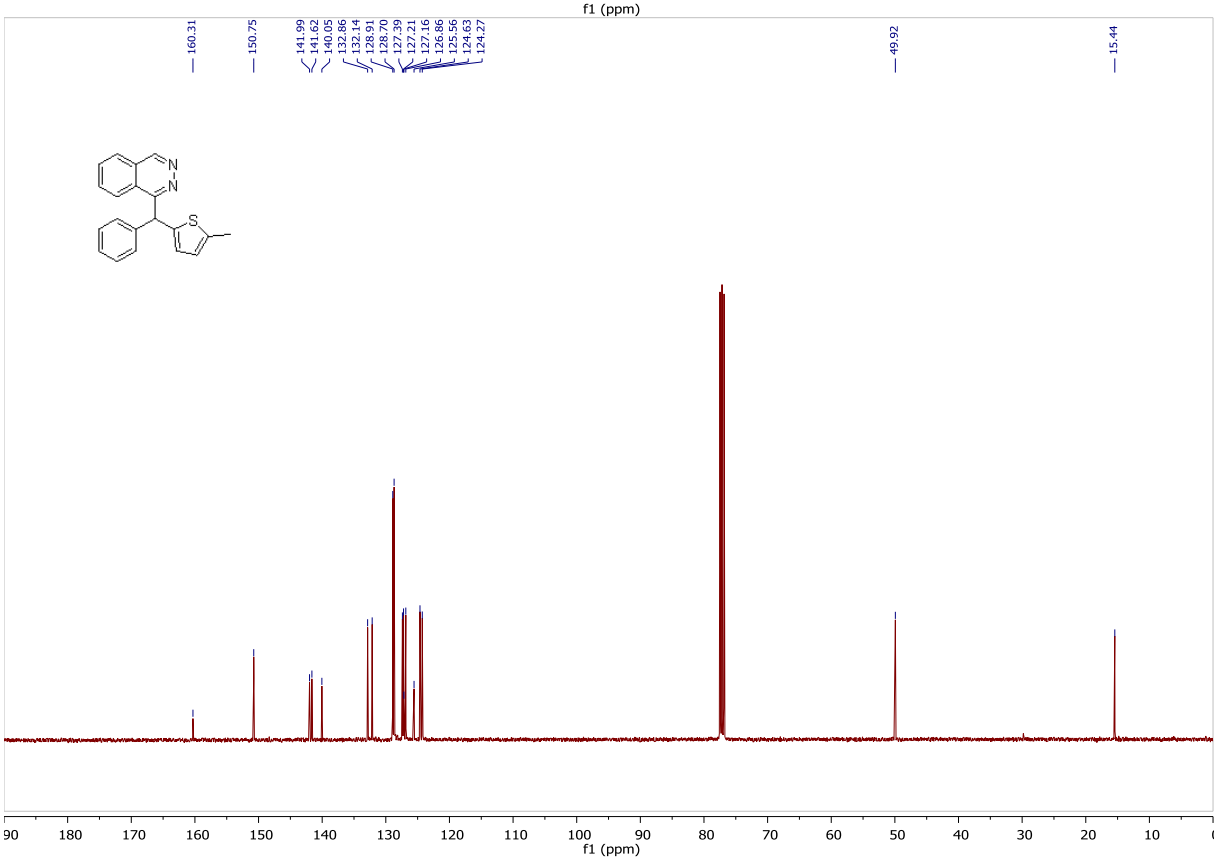


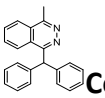




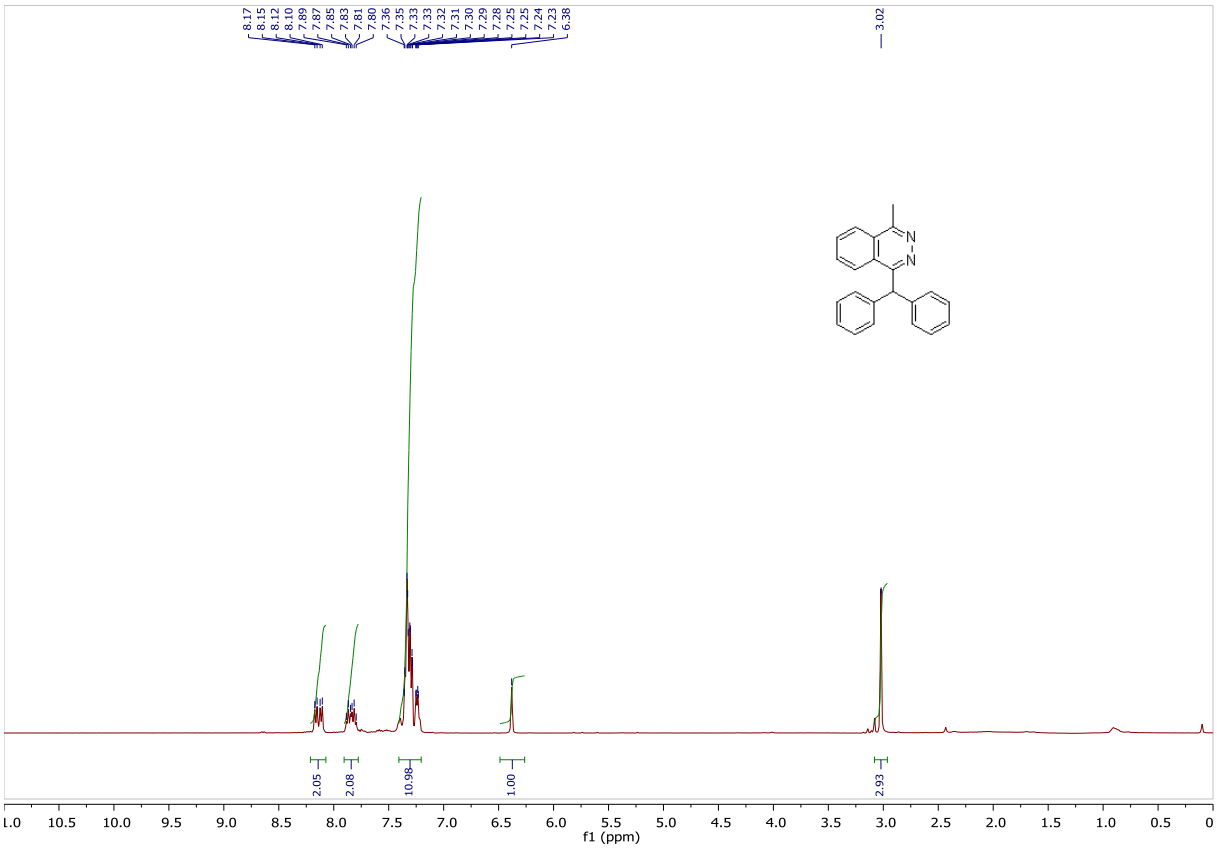
Compound 2q: 1-((5-methylthiophen-2-yl)(phenyl)methyl)phthalazine

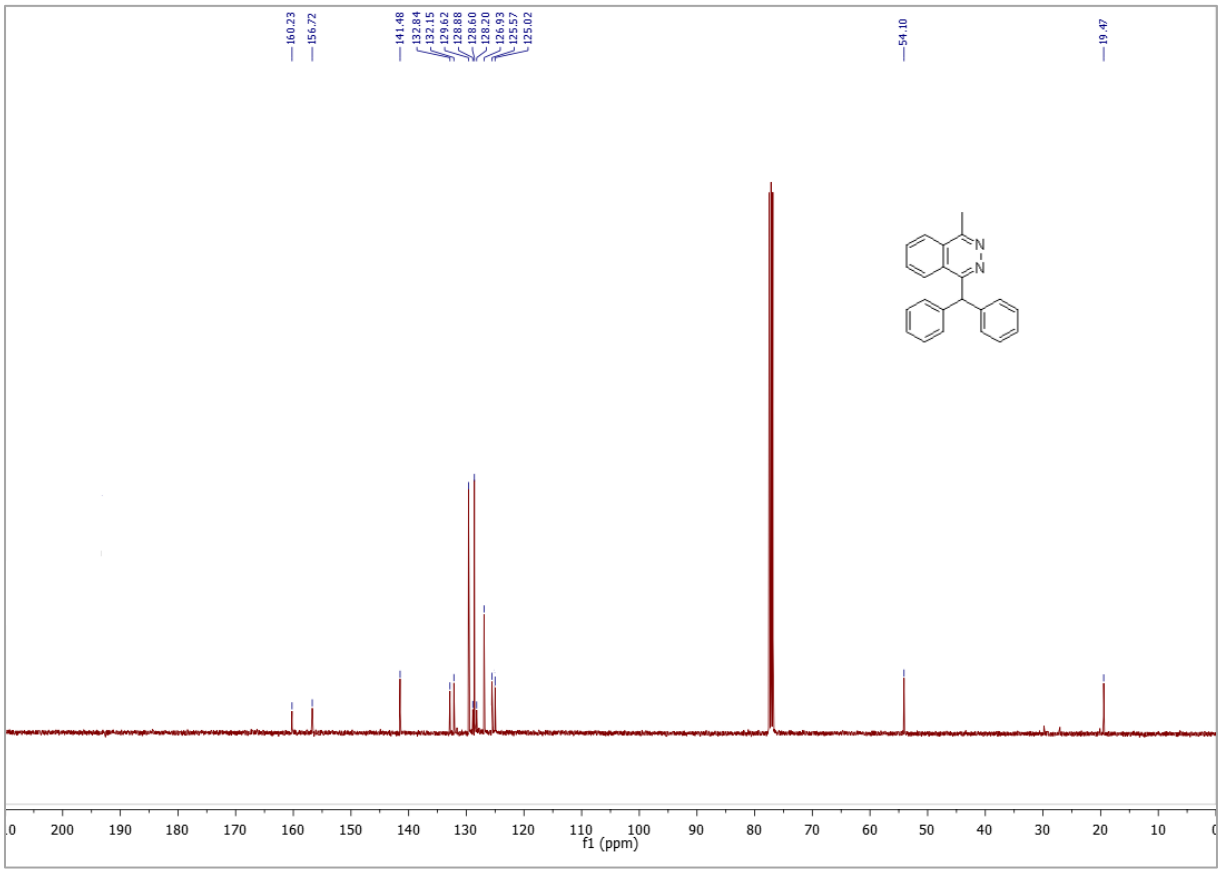


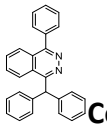




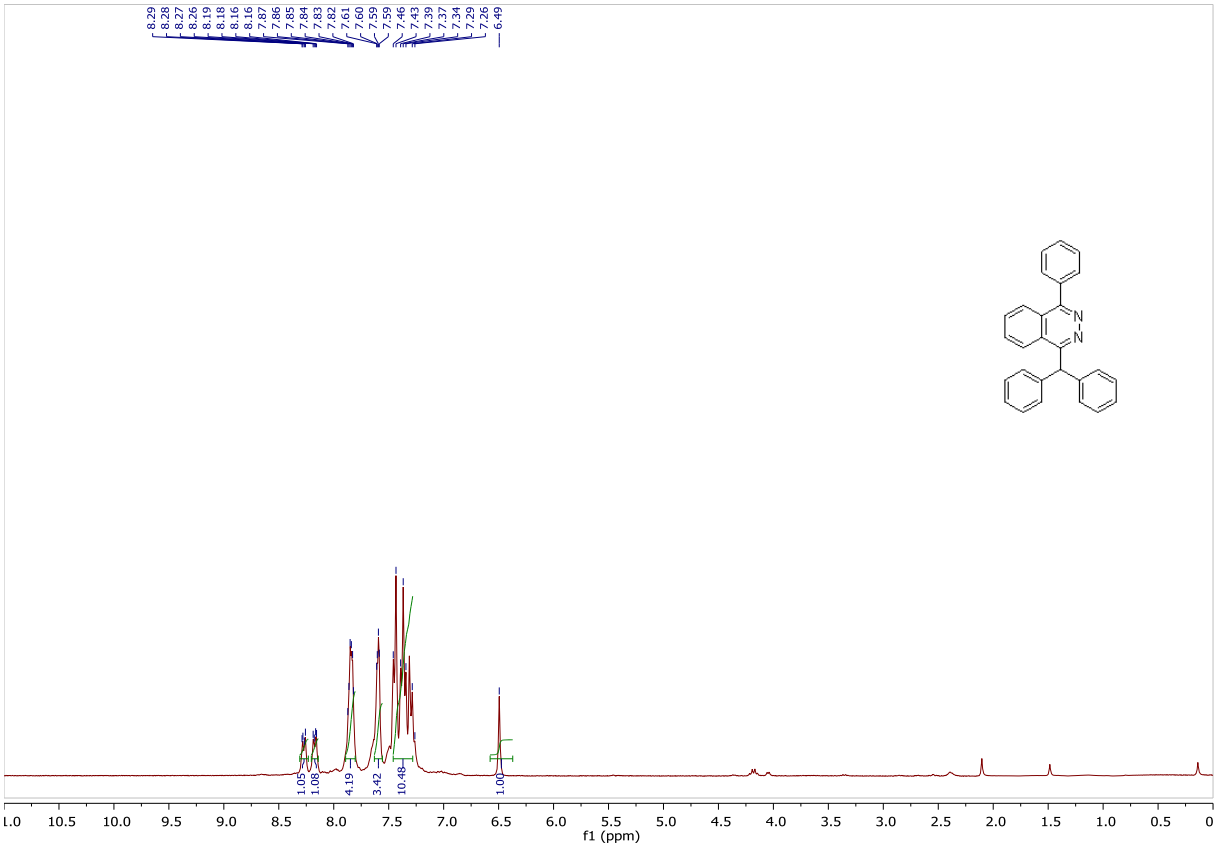
Compound 2r: 1-benzhydryl-4-methylphthalazine

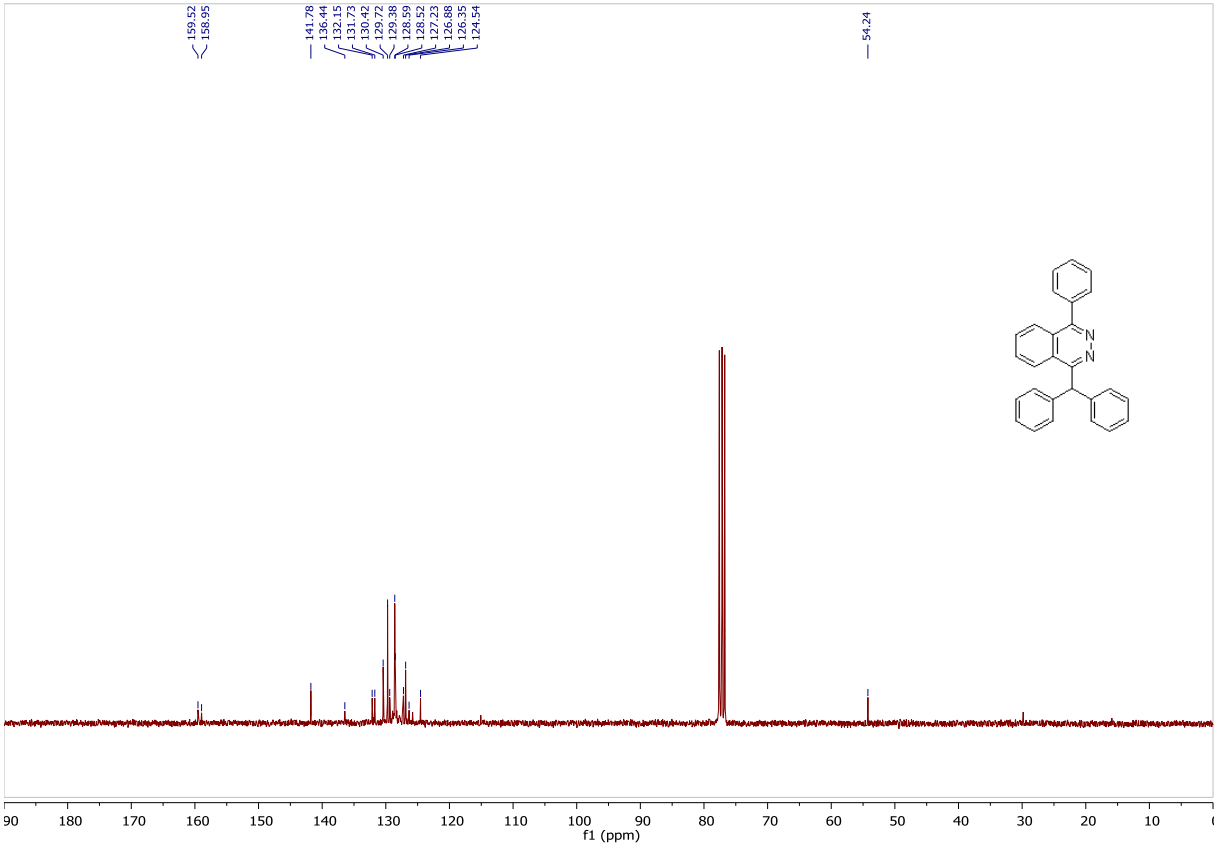


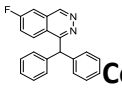




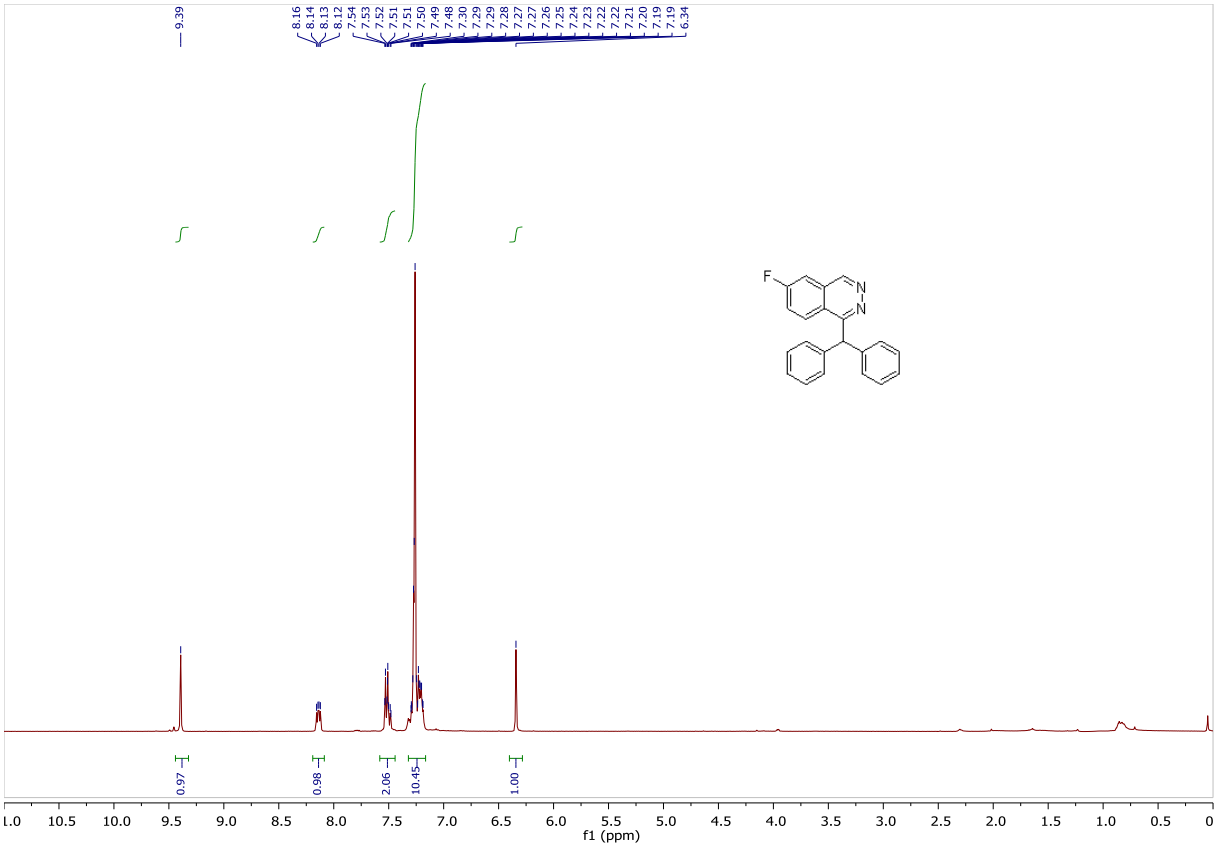
Compound 2s: 1-benzhydryl-4-phenylphthalazine

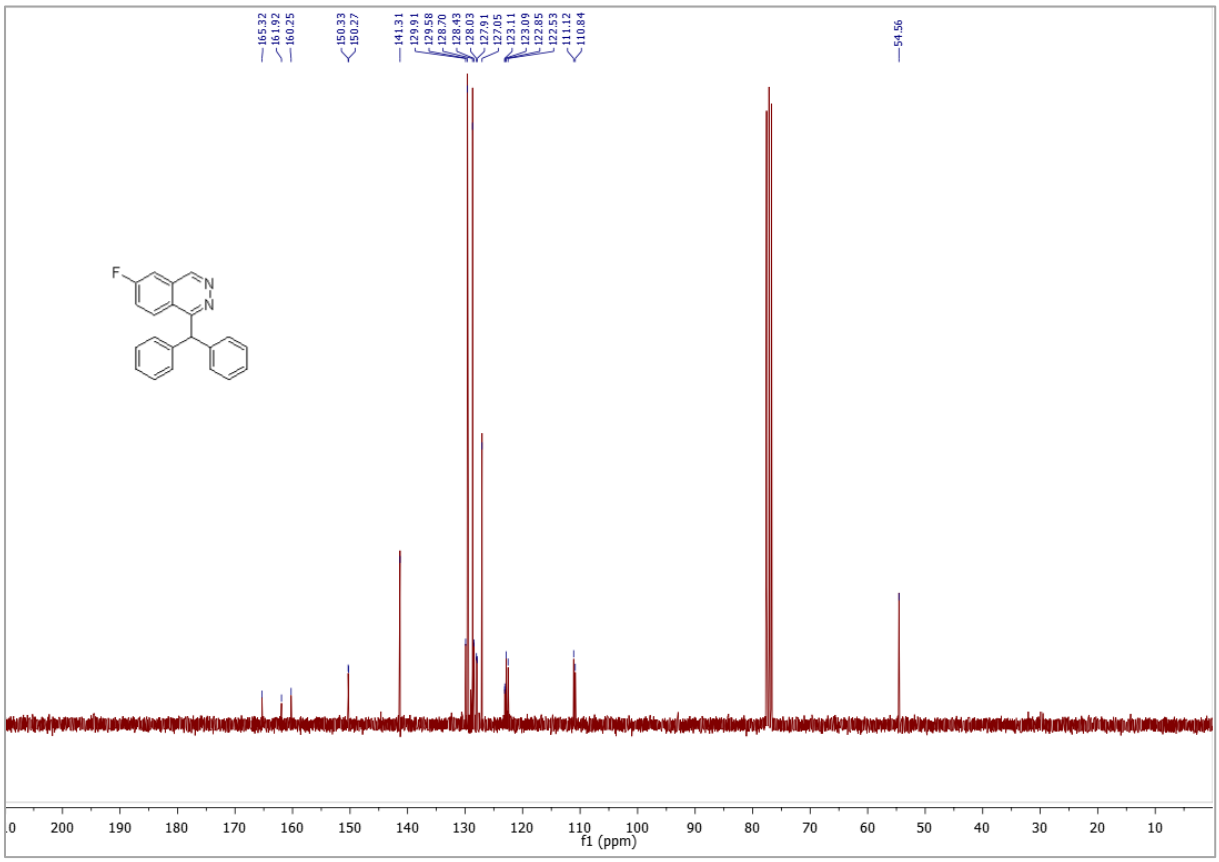


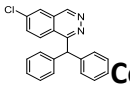




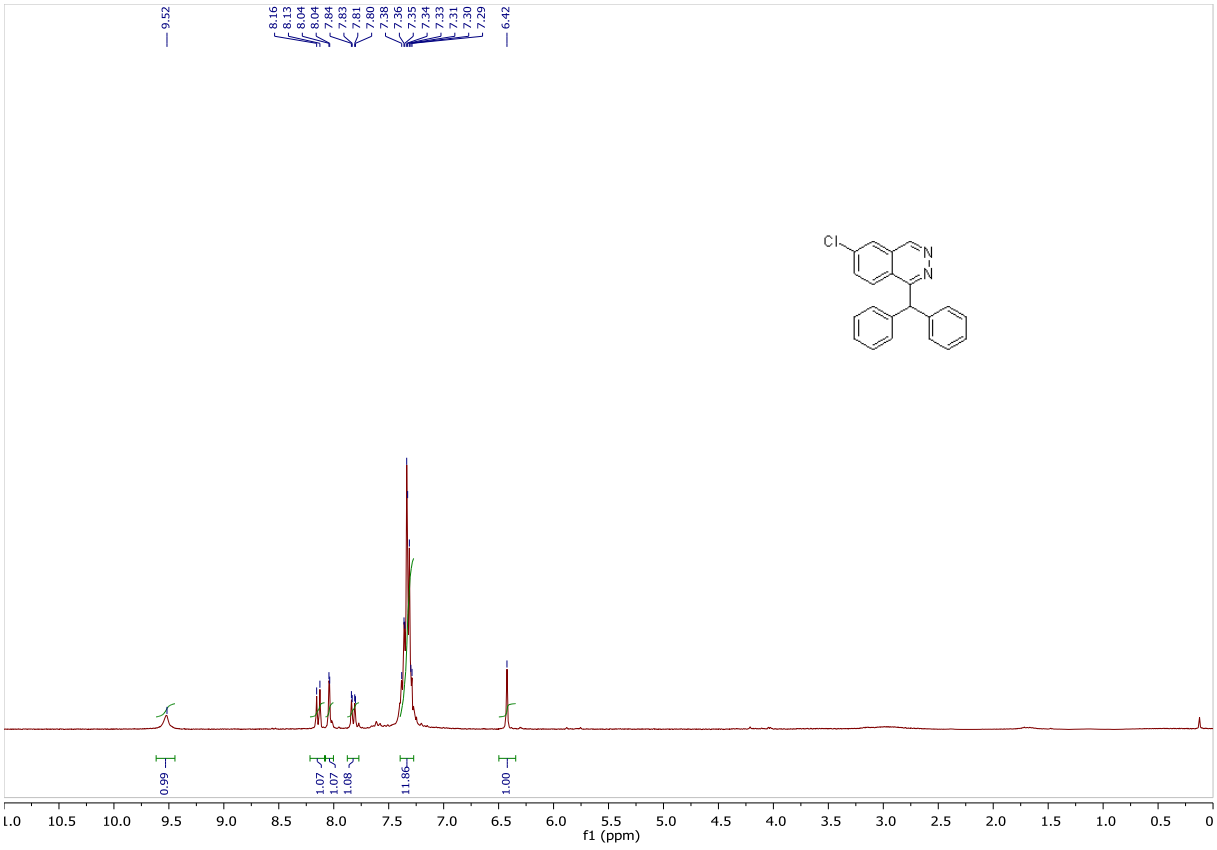
Compound 2t: 1-benzhydryl-6-fluorophthalazine

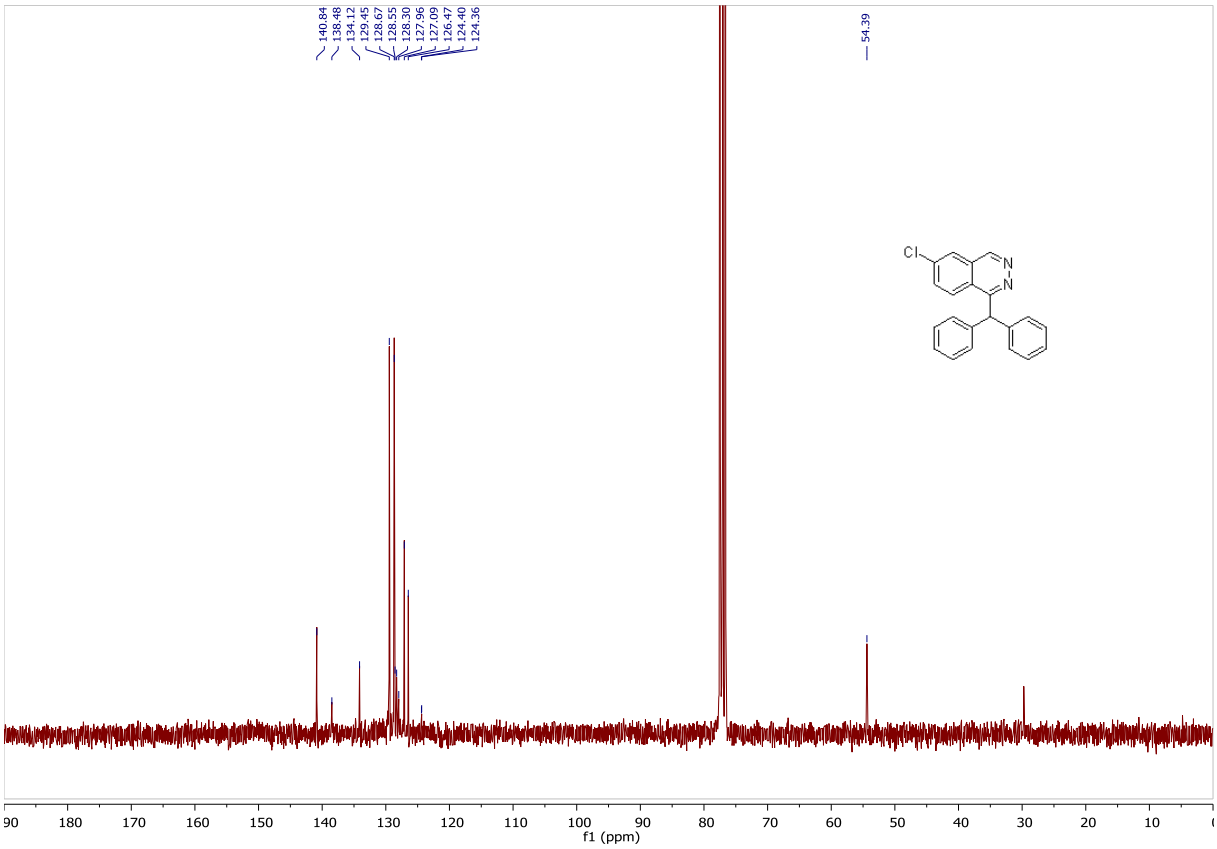


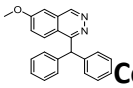




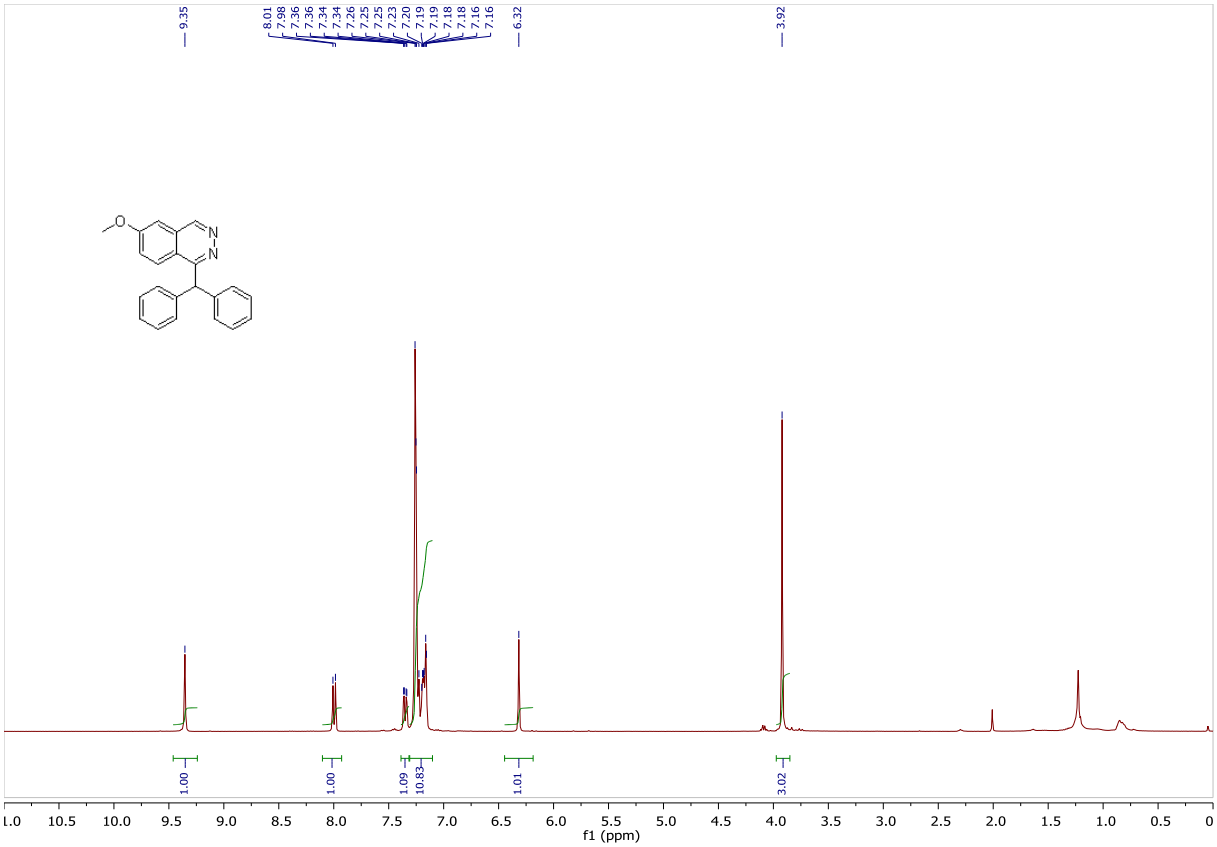
Compound 2u: 1-benzhydryl-6-chlorophthalazine

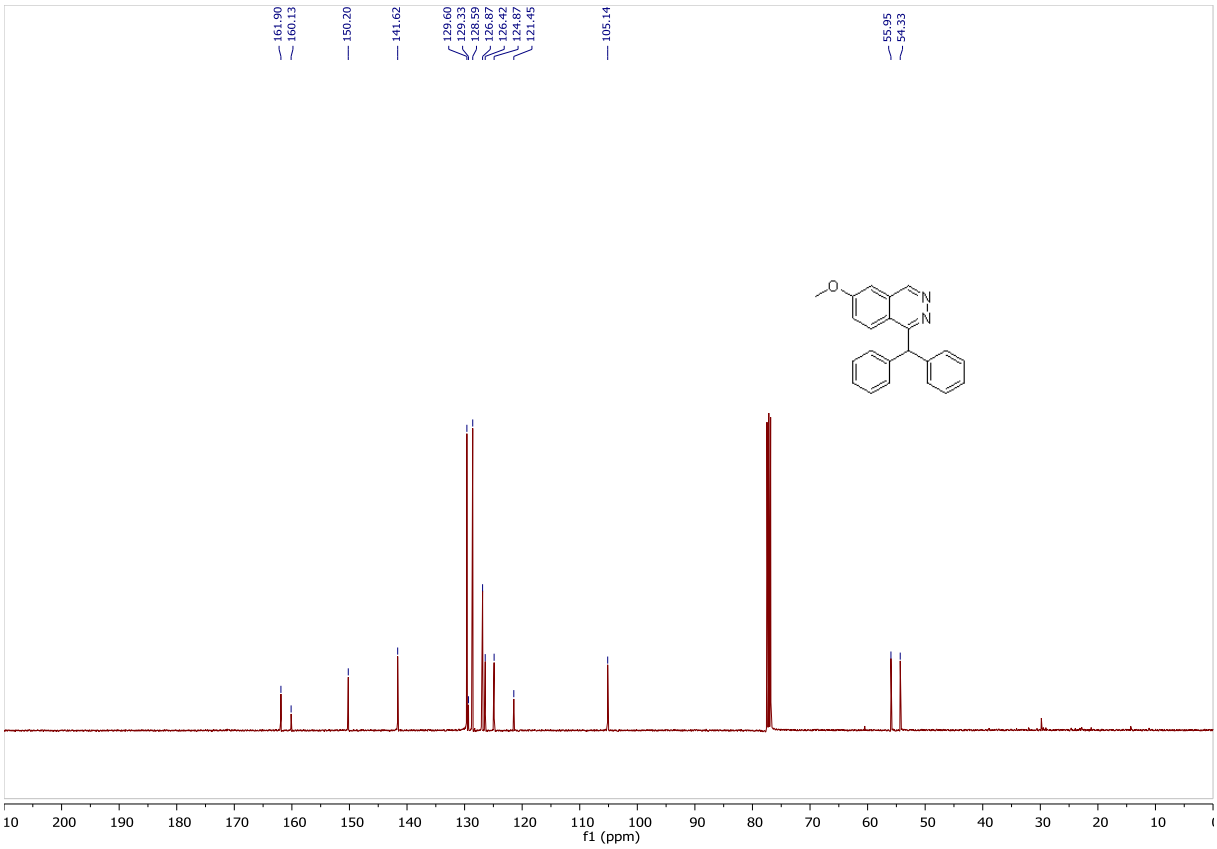


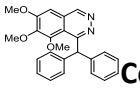




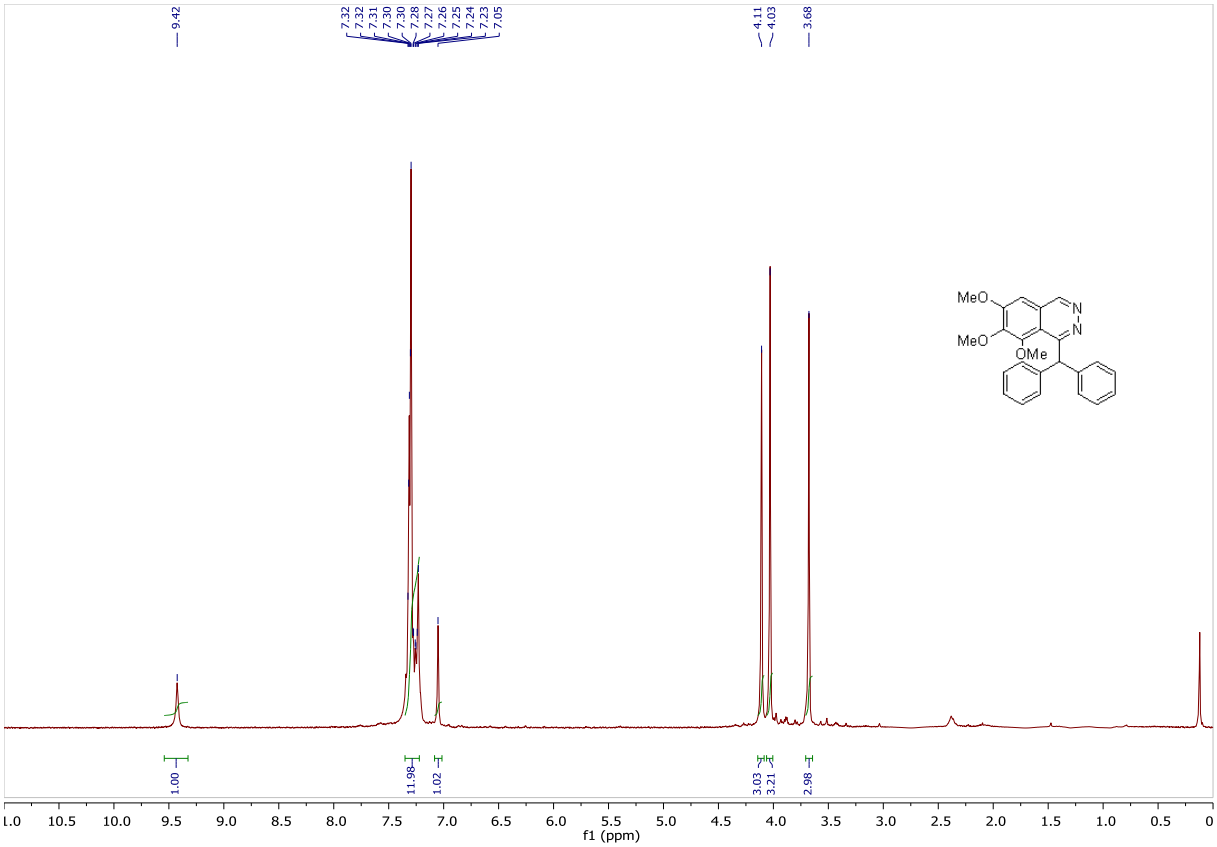
Compound 2v: 1-benzhydryl-6-methoxyphthalazine

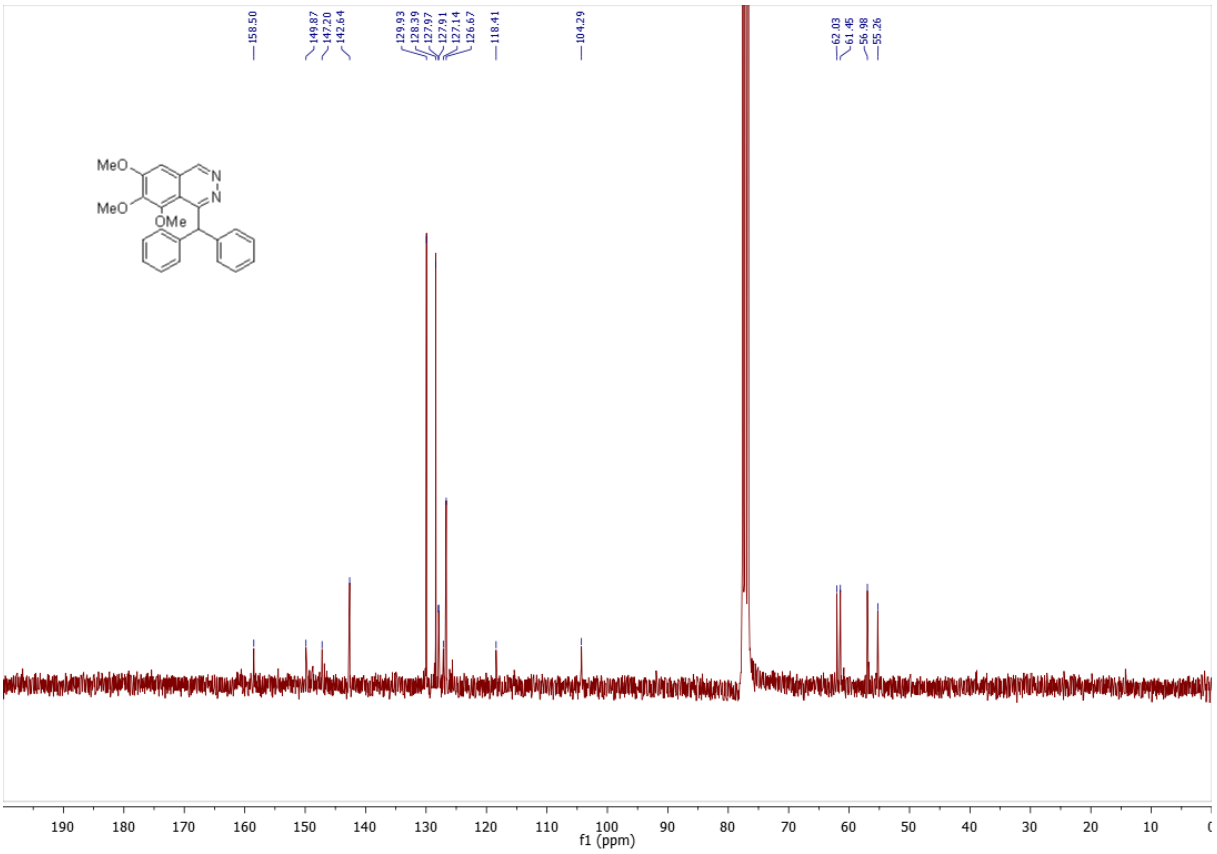


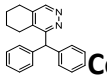




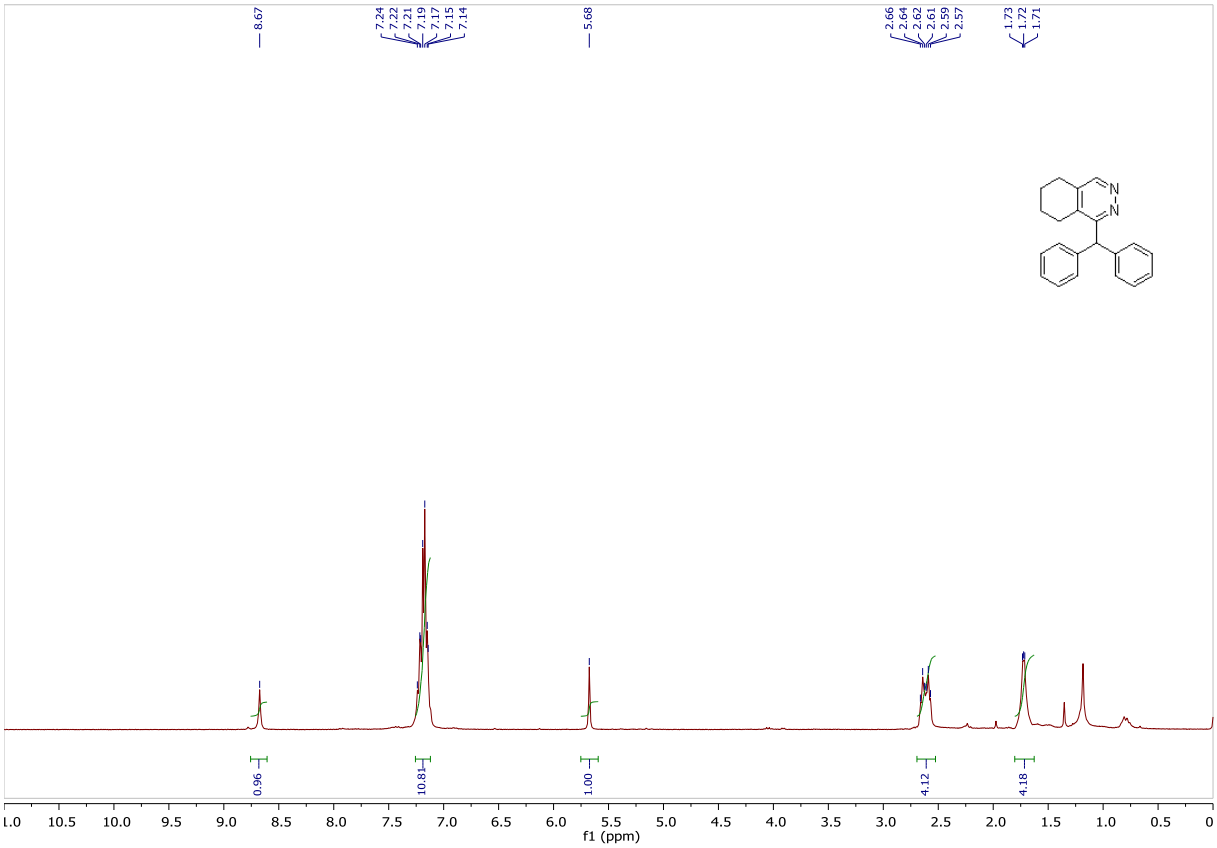
Compound 2w: 1-benzhydryl-6,7,8-trimethoxyphthalazine

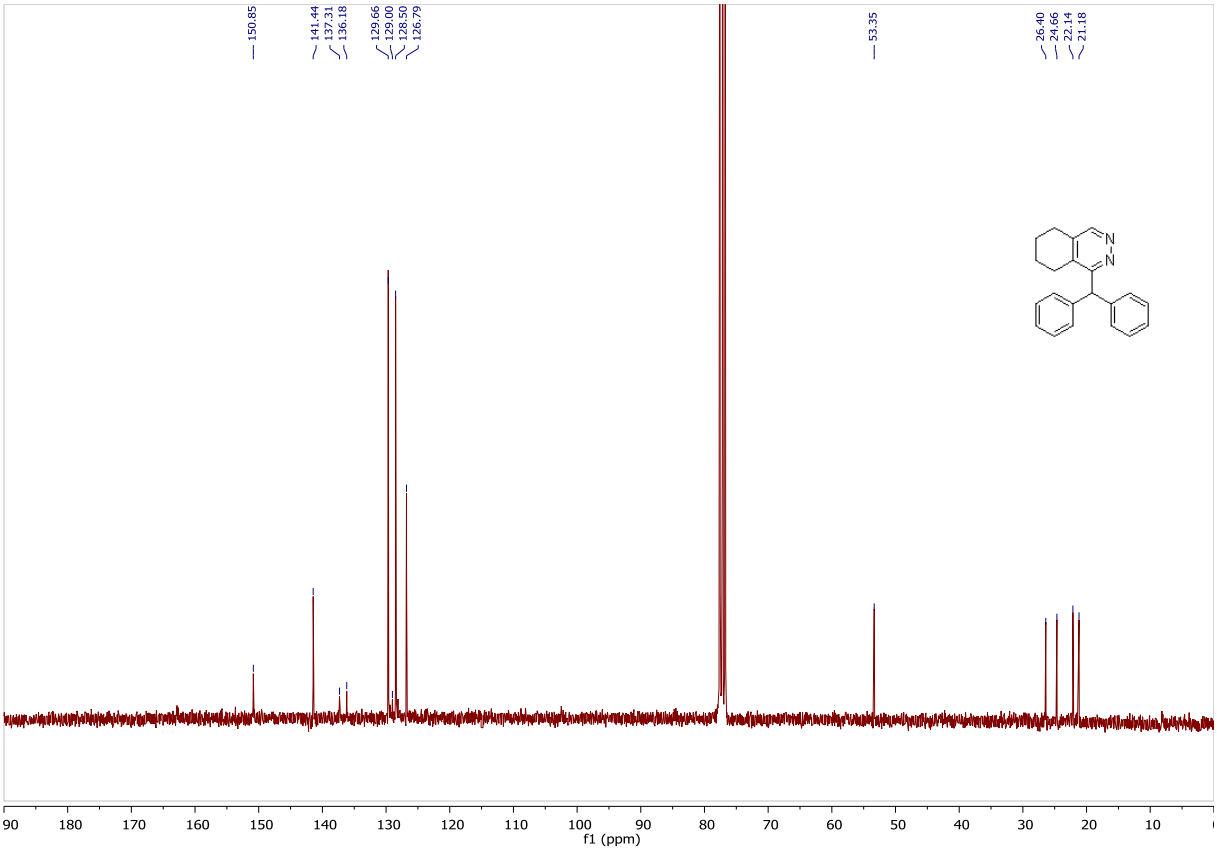


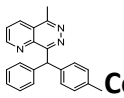




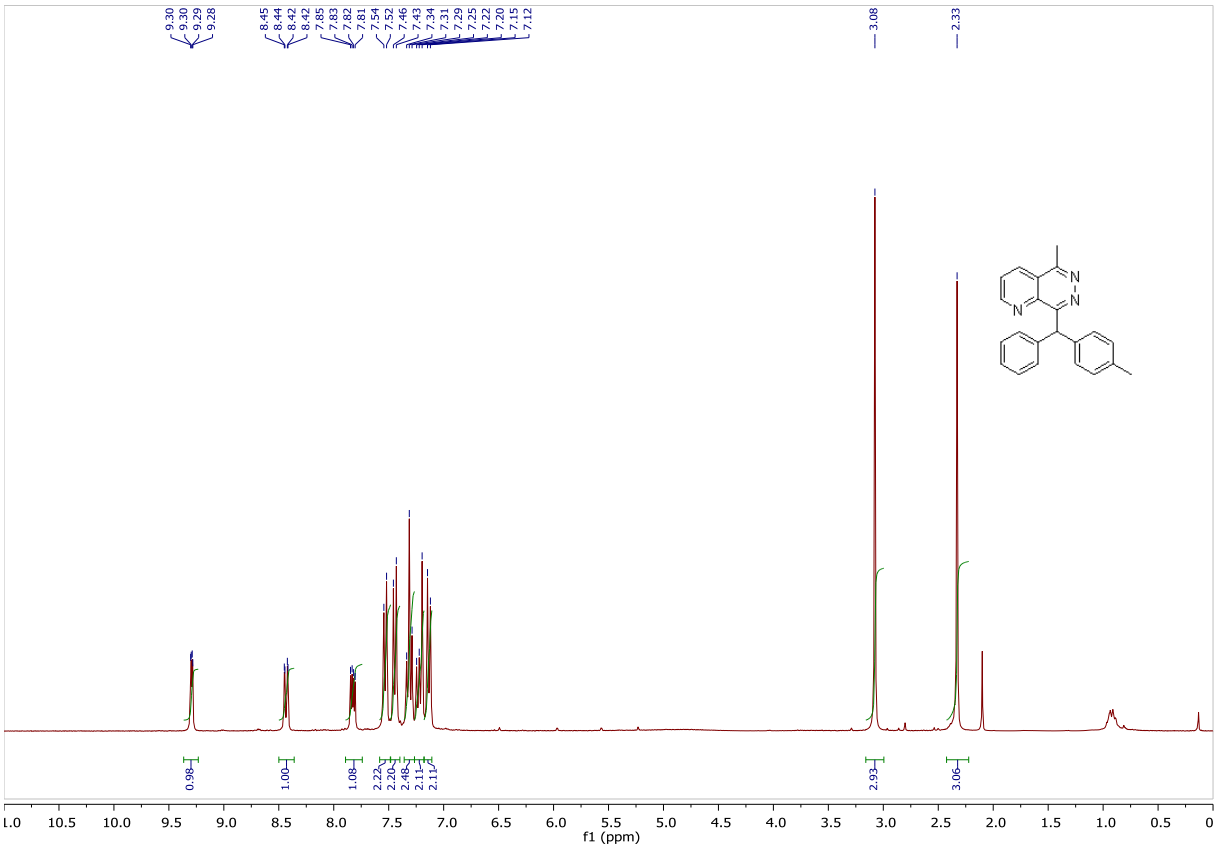
Compound 2x: 1-benzhydryl-5,6,7,8-tetrahydrophthalazine

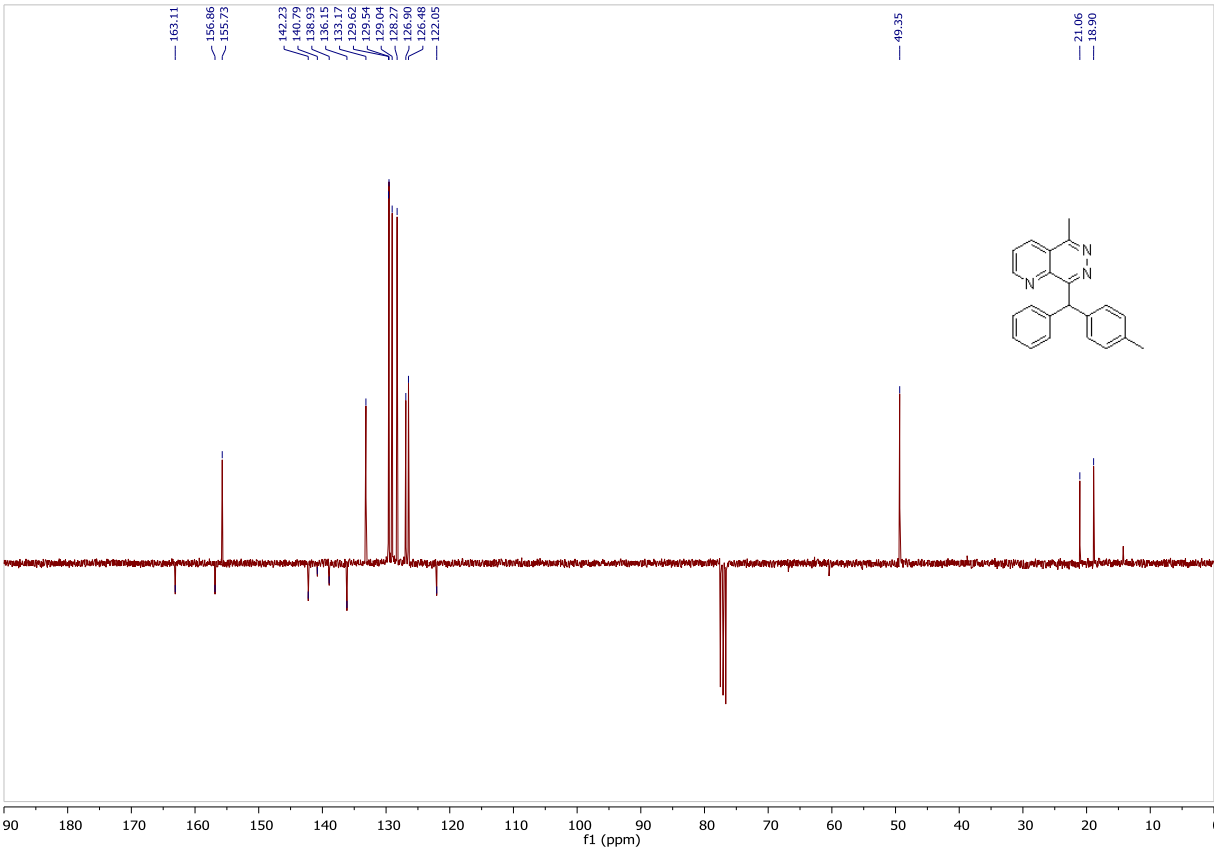


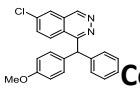




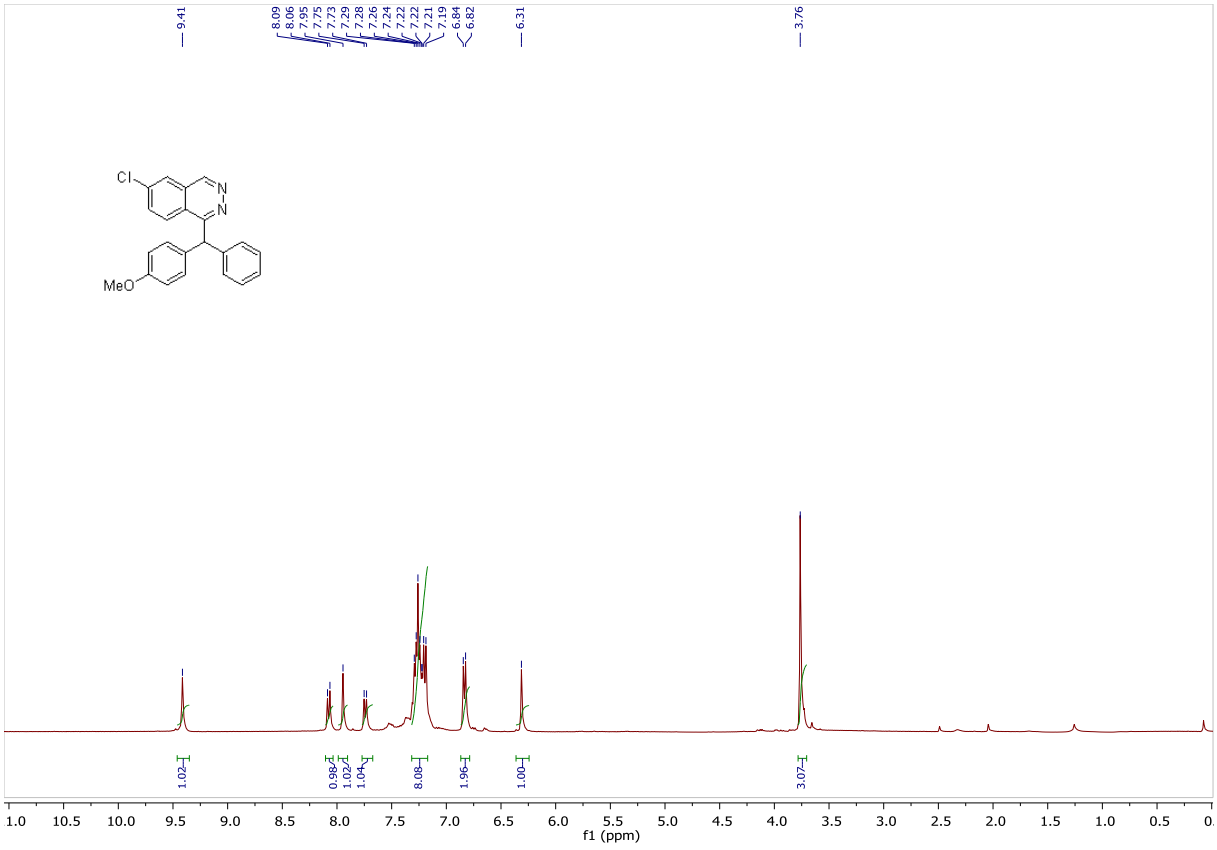
Compound 2y: 5-methyl-8-(phenyl(p-tolyl)methyl)pyrido[2,3-d]pyridazine

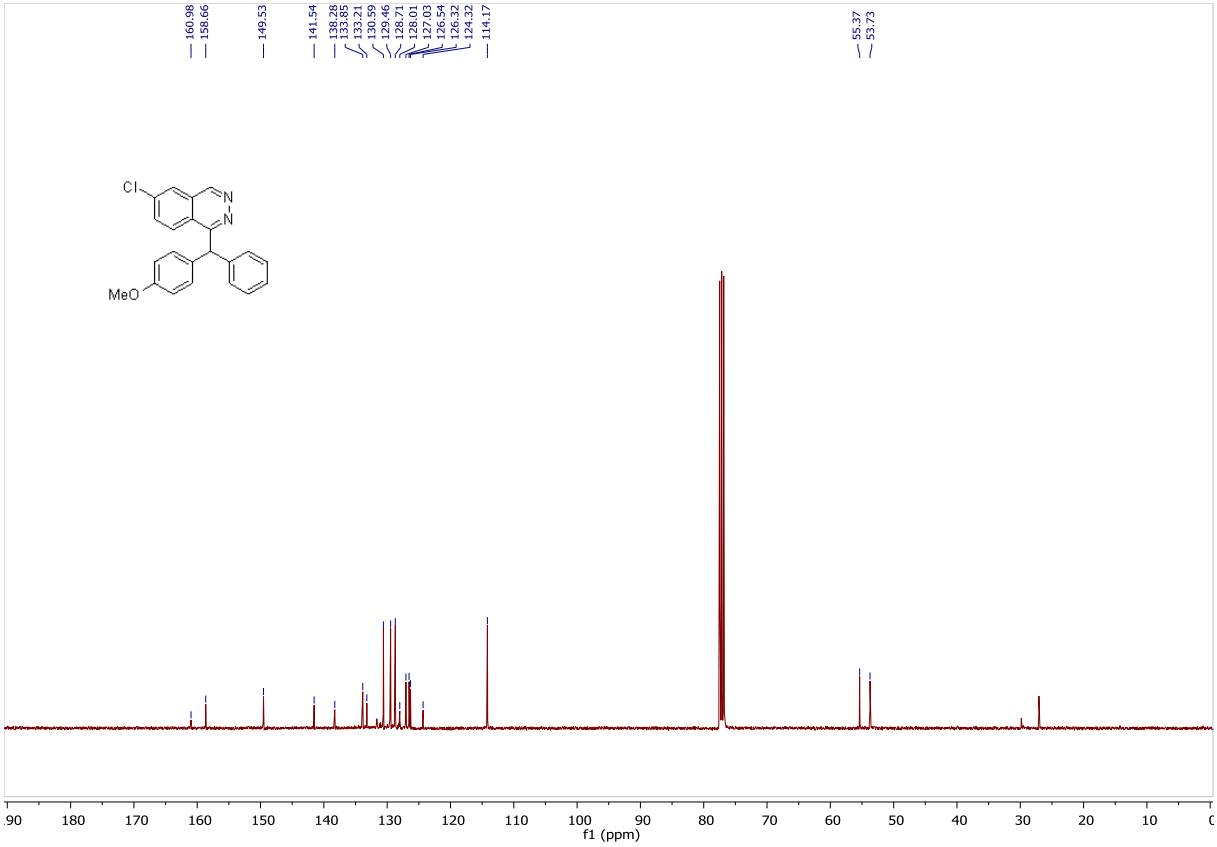


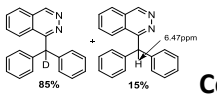




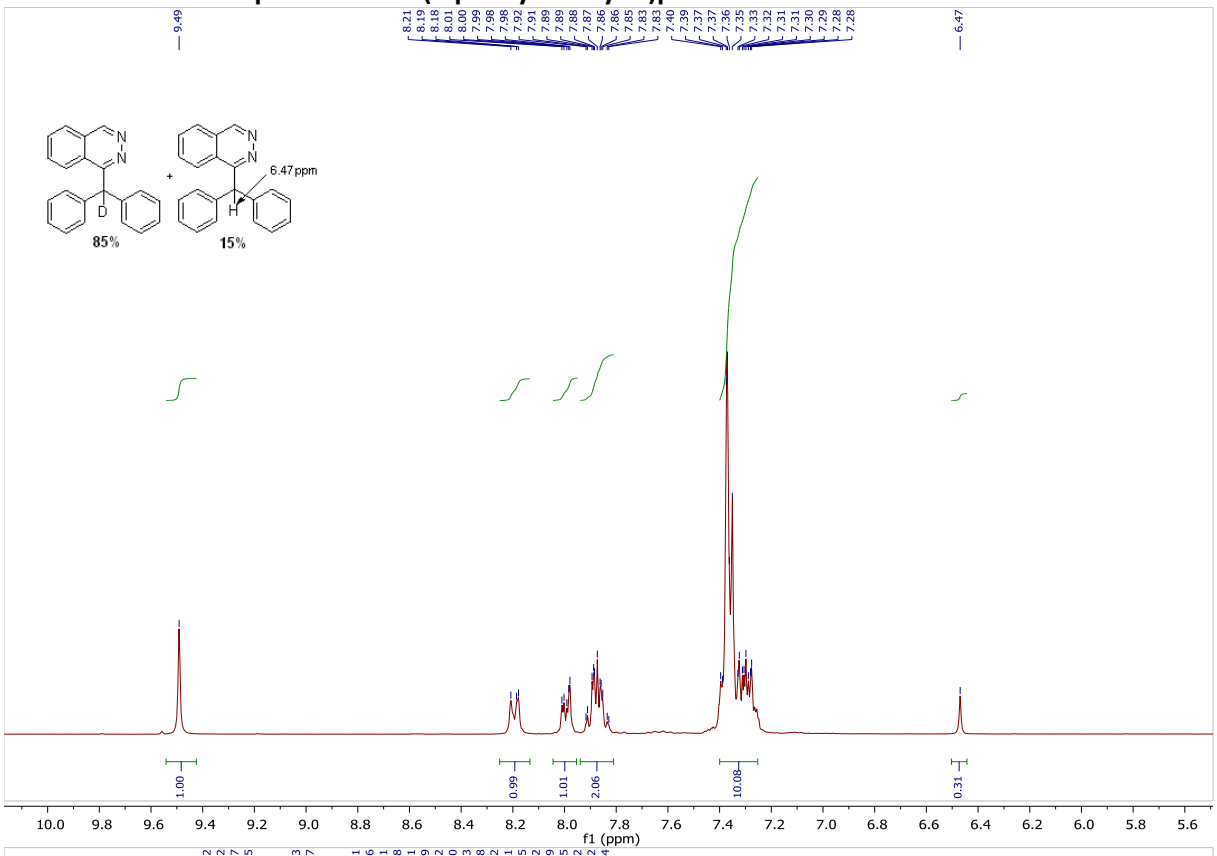
Compound 2z: 6-chloro-1-((4-methoxyphenyl)(phenyl)methyl)phthalazine

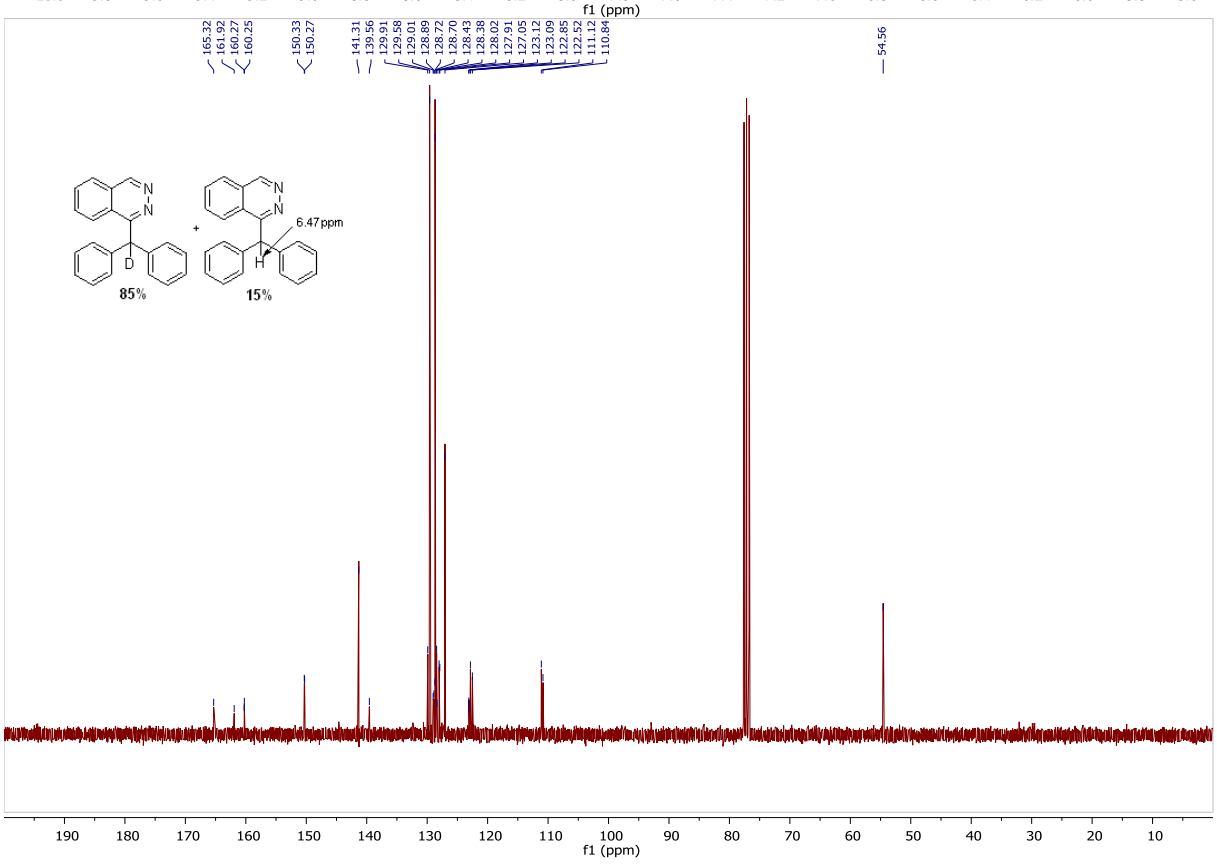


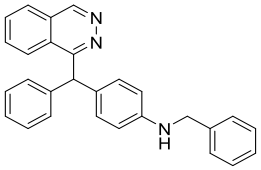




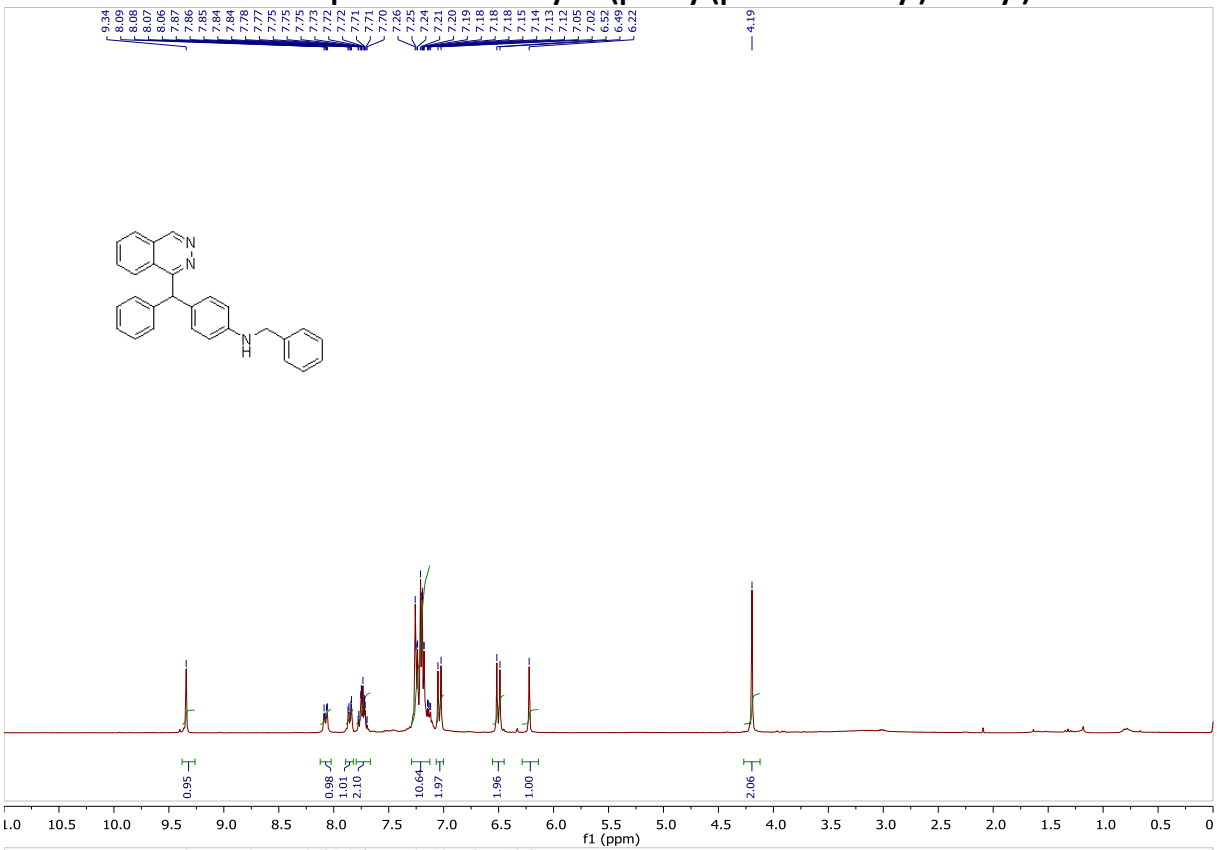
Compound 2aa: 1-(diphenylmethyl-d)phthalazine

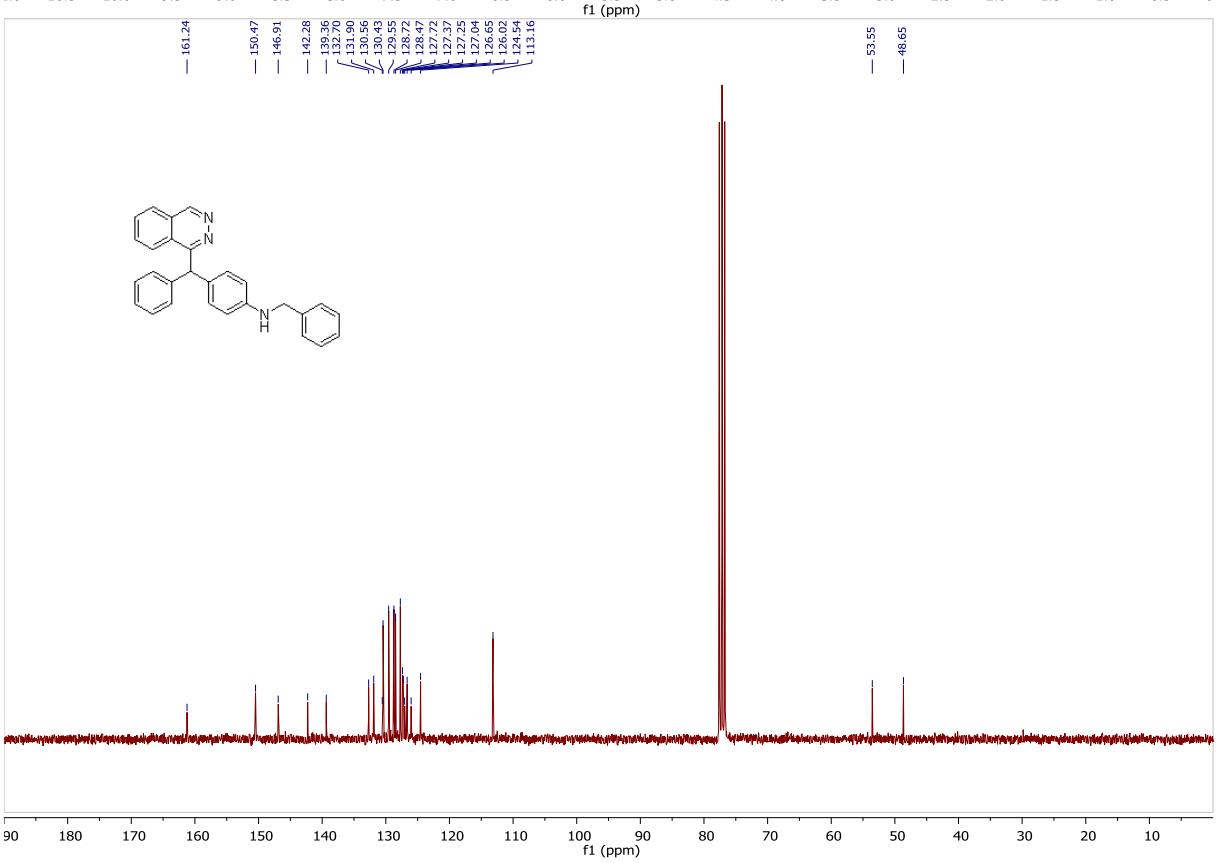


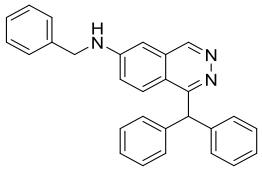




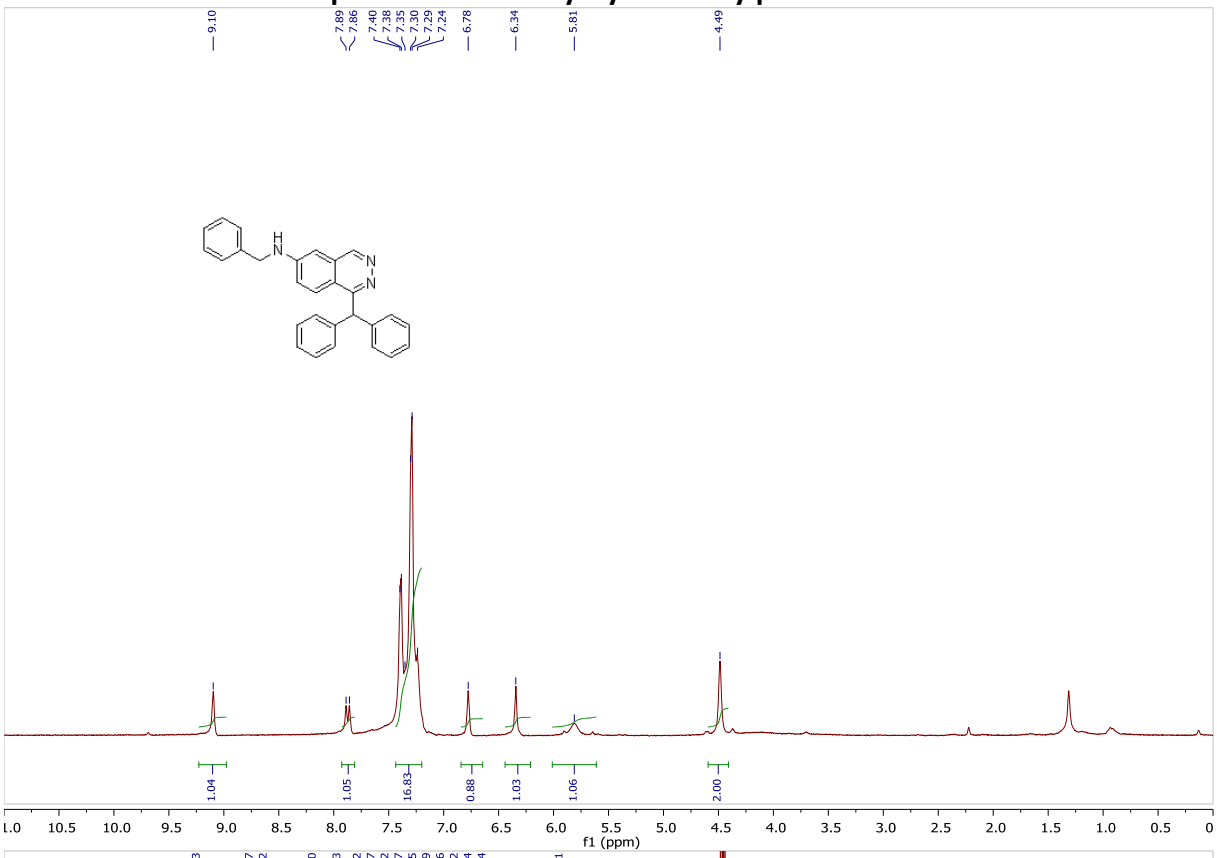
Compound 4: *N*-benzyl-4-(phenyl(phthalazin-1-yl)methyl)aniline

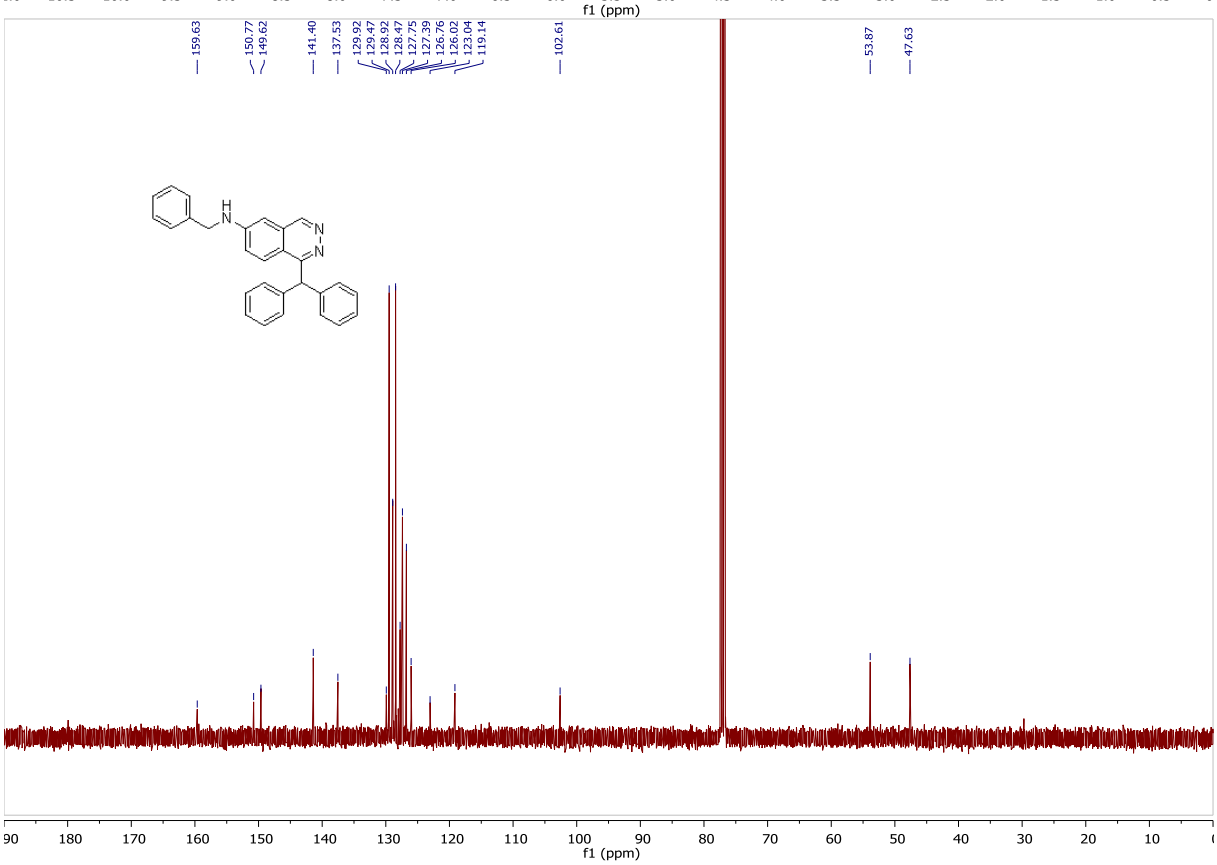






Compound 5: 1-benzhydryl-*N*-benzylphthalazin-6-amine





VI- RX structure of the compound 2a :

CCDC 1450316

Summary of Data CCDC 1450316

Compound Name:
Formula: C21 H16 N2
Unit Cell Parameters: a 8.8549(4) b 18.0318(9) c 10.1285(5) P21/n

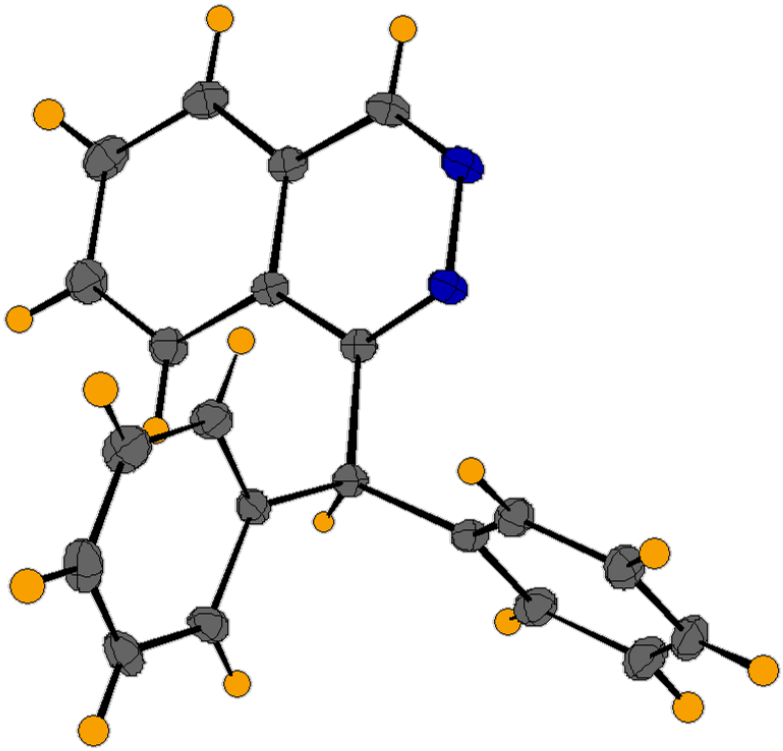
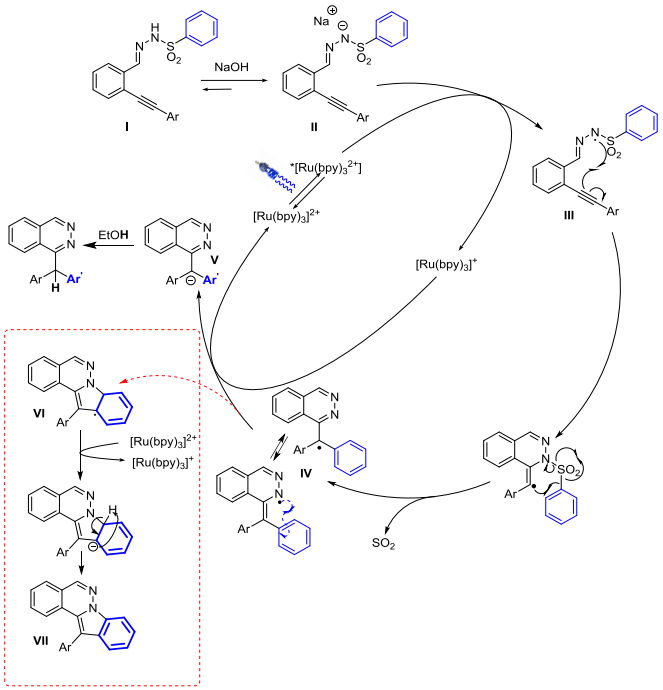


Figure 1: RX structure of 2a

VII- Mechanistic proposal and side product proposal

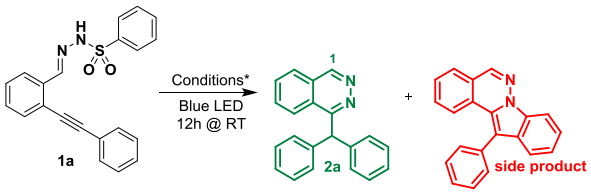
The side product observed during the optimization step may be derived from **IV**. Indeed, radical **IV** could continue in a cascade reaction adding on one of the two phenyl rings (**VI**), and would provide compound **VII** after reduction and rearomatization[5]. This 12-phenylindolo[2,1-*a*]phthalazine seems to be obtained in this reaction based on the HR-MS data, resulting from an additional radical addition as similarly reported in radical cascades.[6] Indeed, this last compound would have a M-2 m/z as found on the HRMS data of purified product during the optimization steps.



Scheme 1 :Proposed mechanism and formation of the side product

<u>Indications on the side product:</u>

During the optimization of the reaction conditions, formation of a side product contaminated the final product **2a**. We were unable to separate compound **2a** from the side product despite the use of column chromatography or HPLC. We propose the following structure for the side product (see the red compound).



As shown below, a small singlet resonance signal at 9.75 ppm close to the proton in C-1 for the compound **2a** (9.55 ppm) seems to indicate that this proton may be conserved in the side product. Some aromatic resonance signals between 7.8 and 7.4 ppm indicate an aromatic moiety (see spectra below).

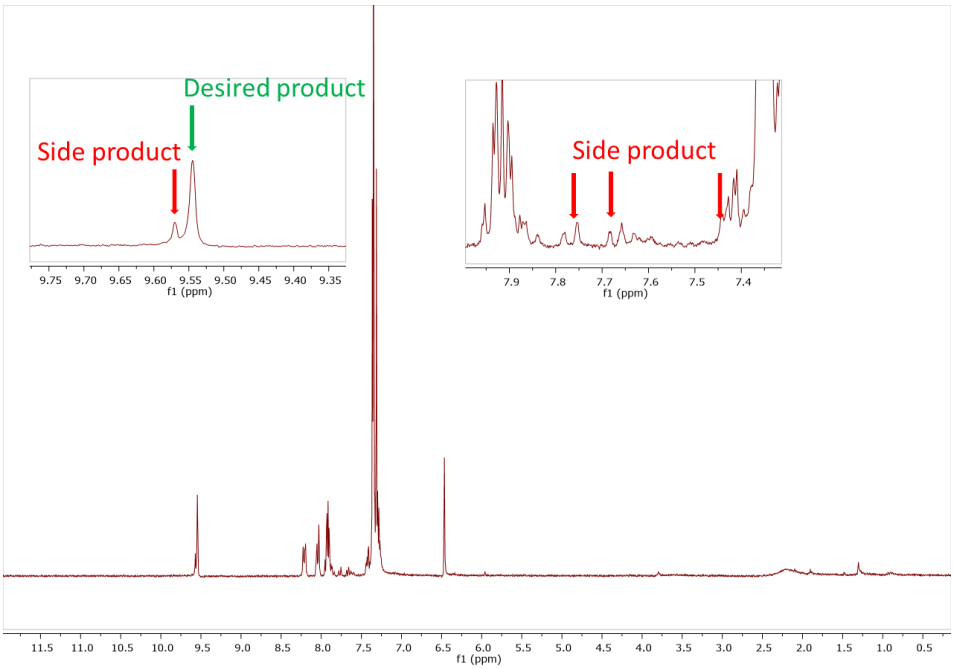


Figure 2: NMR spectra of the model reaction during optimization of the reaction conditions.

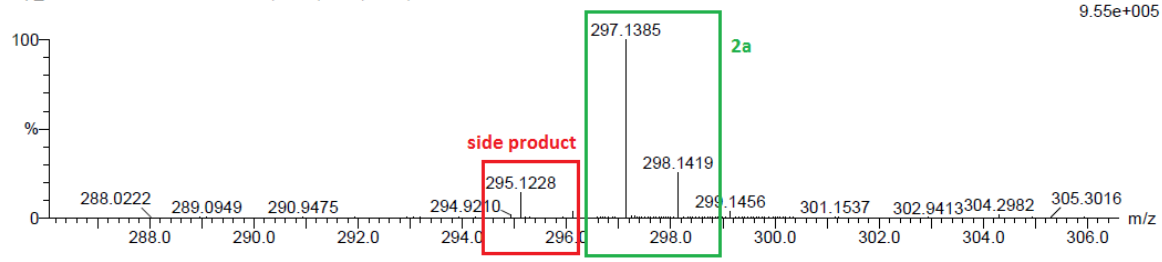
In addition, the HRMS analysis of the mixture with compound **2a** gave the following data. The correct value for the proposed 12-phenylindolo[2,1-*a*]phthalazine structure is observed.

Elemental Composition Report **Page 1**

Single Mass Analysis
Tolerance = 50.0 PPM / DBE: min = -1.5, max = 50.0
Element prediction: Off
Number of isotope peaks used for i-FIT = 3

Monoisotopic Mass, Even Electron Ions
102 formula(e) evaluated with 5 results within limits (up to 50 closest results for each mass)
Elements Used:
C: 15-25 H: 1-20 N: 0-10 Na: 0-1 Mg: 0-1 Br: 0-1

EB 326 /CH3CNCH2Cl2 HCOOH LCT Premier 21-Jan-2016 13:09:30
exp_0077 P B CH3CN CH2Cl2 47 (2.068) Cm (30:47) 1: TOF MS ES+ 9.55e+005



Minimum:				-1.5			
Maximum:		5.0	50.0	50.0			
Mass	Calc. Mass	mDa	PPM	DBE	i-FIT	i-FIT (Norm)	Formula
295.1228	295.1235	-0.7	-2.4	15.5	662.6	0.9	C21 H15 N2

Figure 3 : HRMS spectra of a mixture compound 2a/side product

With these indications we postulate the structure: 12-phenylindolo[2,1-*a*]phthalazine as a side reaction product.

VIII- Quantum yield

Procedure:

In a flamed-dried cuvette containing a stirring bar, sulfonylhydrazone, $Ru(bpy)_3Cl_2.6H_2O$, NaOH, and molecular sieve 3A were dissolved in EtOH (following the general procedure). Then the reaction mixture was irradiated with a blue LED (LD-CQ7P-1U3U) in a Quantum Yield Determination Setup.[7] Aliquots of the reaction mixture were analyzed at different times by NMR. Finally, applying the following equation the Quantum Yield was determined:

Quantum Yield = 0.33

$$Q.Y. = \frac{N_{prod}}{N_{ph,abs}} = \frac{c_{prod} \cdot V \cdot N_A \cdot h \cdot c}{P_{abs} \cdot \Delta t \cdot \lambda}$$

C_{prod} = concentration of final product (determined by NMR)

V = solution volume

Δt = illumination time

P_{abs} = absorbed power ($P_{reference}$ - P_{sample})

λ = LED wavelength

N_A = Avogadro number

h = plank constant

c = speed of light

IX- UV and Fluorescence experiments

Procedure:

UV–Vis and fluorescence measurements were performed with a Varian Cary 50 UV/Vis spectrophotometer and FluoroMax-4 spectrofluorometer, respectively. Electrochemical studies were performed in ethanol (EtOH) containing 0.1 M tetra-*n*-butylammonium tetrafluoroborate using ferrocene/ferrocenium (Fc/Fc+) as an internal reference. A glassy carbon electrode (working electrode), platinum wire counter electrode, and Ag quasi-reference electrode were employed. Spectroelectrochemical studies were carried out in an optically transparent thin layer electrochemical cell (OTTLE).

Fluorescence and phosphorescence experiments, quenching experiments

UV–Vis and fluorescence measurements were performed with a Varian Cary 50 UV/Vis spectrophotometer and FluoroMax-4 spectrofluorometer, respectively.

In literature it is described that the ^{1}(MLCT) of $Ru(bpy)_3Cl_2$ is almost non-fluorescent and that the formation of the ^{3}(MLCT) state is rapid with a quantum yield near the unit.[8] Moreover, the observed emission from the complex is believed to be from the long-lived ^{3}(MLCT), and can be detected either by photoluminescence or by laser technique.

Procedure

A solution of $Ru(bpy)_3Cl_2.6H_2O$ (3 mL of c = 10^{-5} M) was placed in the cuvette. First, we measured the absorption and fluorescence (irradiating at 450 nm) of the Ru catalyst. Then, increasing amounts of a solution of the sulfonylhydrazone + NaOH were added to the initial solution, and the absorption and fluorescence spectra were recorded in each case. As can be seen in the Figure 4, the absorption of the Ru catalyst in the visible light region is not affected by the presence of the hydrazone. However, the fluorescence decreases while increasing the number of equivalents of sulfonylhydrazone + NaOH (Figure 5), thus confirming that the compound is able to quench the ^{3}(MLCT) state of the catalyst.

In Figure 6, the Stern-Volmer plot for the fluorescence quenching is shown. This is a linear relationship between the number of equivalents of sulfonylhydrazone + NaOH and I_0/I_n (where I_0 = Intensity of the signal for the initial Ru solution, and I_n = Intenstity at different concentrations of sulfonylhydrazone + NaOH. Intensity in the maximum of the graph) indicating dynamic emission quenching. The graph also shows that the fluorescence is not quenched by the sulfonylhydrazone alone, or by NaOH.

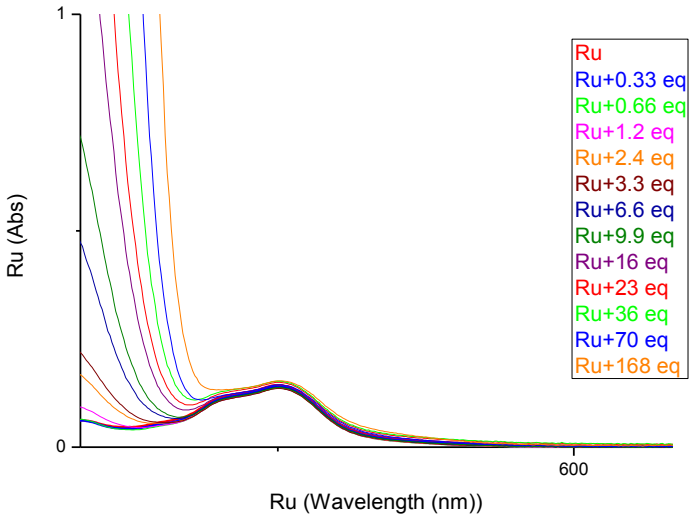


Figure 4: Absorbance of the $Ru(bpy)_3Cl_2.6H_2O$ (C = 10^{-5} M) in the presence of different amounts of sulfonohydrazone + NaOH.

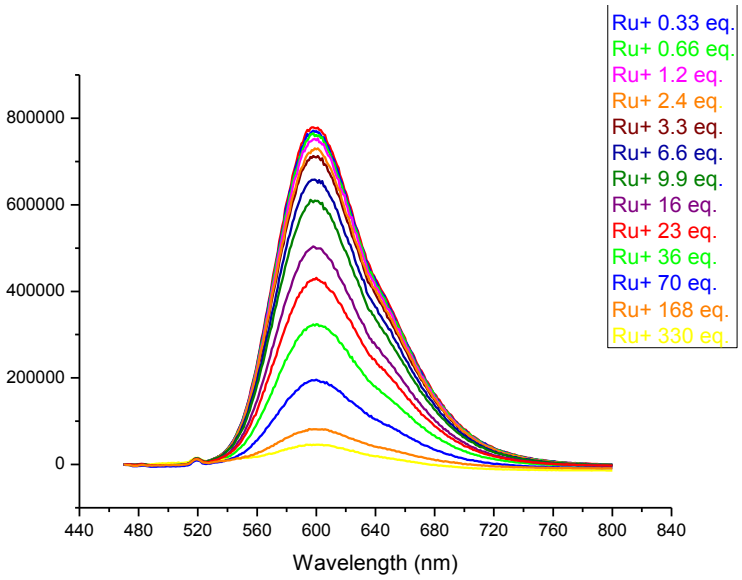


Figure 5: Changes in the fluorescence spectra of the $Ru(bpy)_3Cl_2.6H_2O$ ($C = 10^{-5}$ M) upon successive addition of a mixture of sulfonohydrazone + NaOH

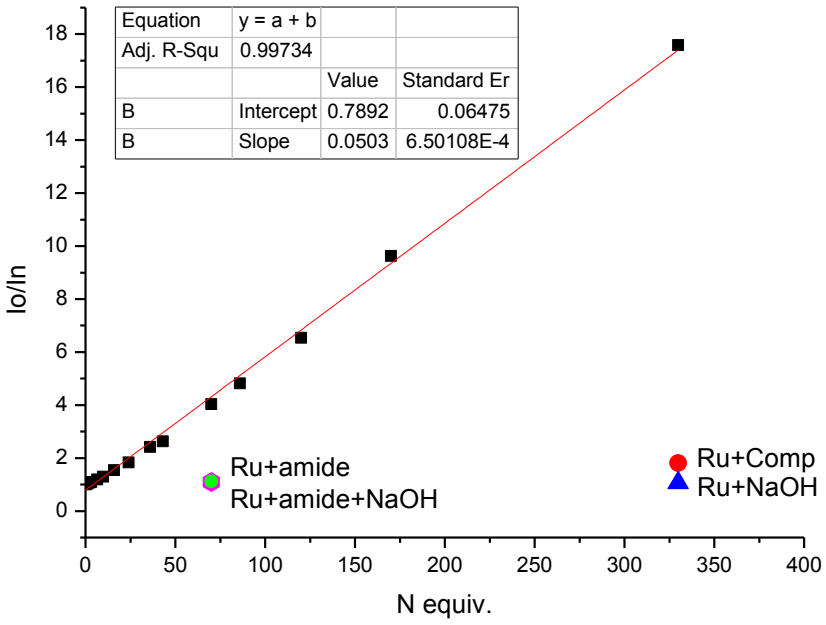
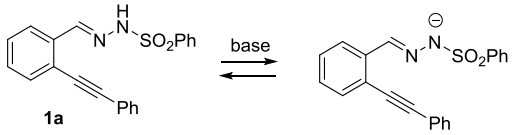


Figure 6: Stern-Volmer plot for the fluorescence quenching.

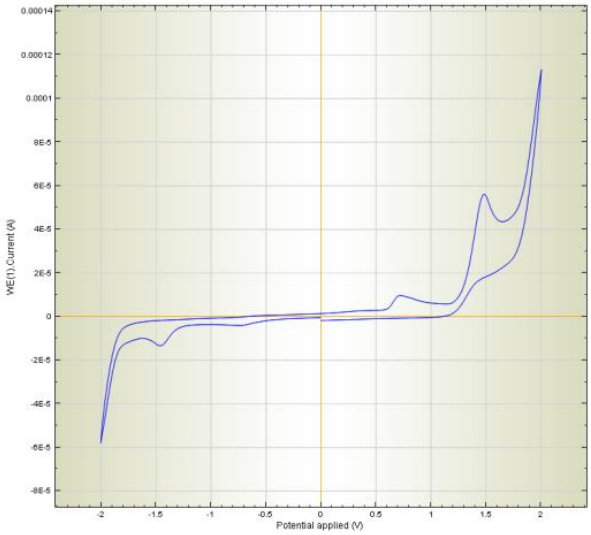
X- Cyclic voltammetry

Electrochemical studies were performed in ethanol (EtOH) containing 0.1 M tetra-*n*-butylammonium tetrafluoroborate using ferrocene/ferrocenium (Fc/Fc+) as an internal reference. A glassy carbon electrode (working electrode), platinum wire counter electrode, and Ag quasi-reference electrode were employed. Spectro-electrochemical studies were carried out in an optically transparent thin layer electrochemical cell (OTTLE).

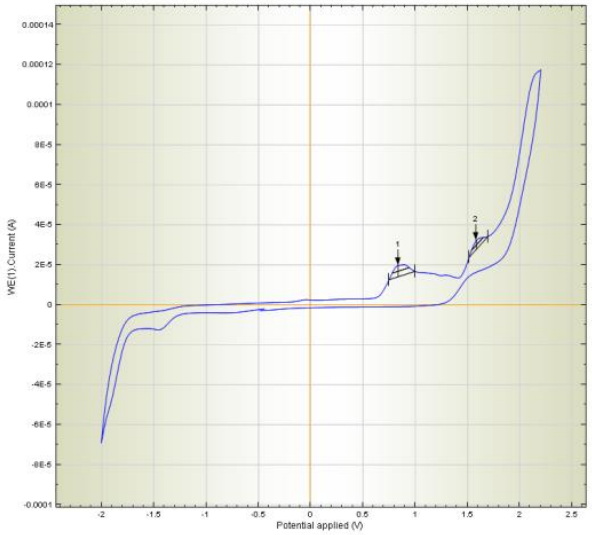
The measurement on the left corresponds to the redox behaviour of the neutral specie **1a**, while the one on the right corresponds to a solution of the sulfonohydrazone + NaOH in the same ratio as in the reaction. Comparing both spectra indicates that the anion is oxidized more easily than the neutral molecule. Moreover, the calculation of the Gibbs free energy for both species, predict the oxidation of the anion by the photocatalyst to be thermodynamically favored, while the oxidation of the neutral species to be disfavored.



1a



Without base



With base

Eox 1 = 0.54 eV vs SCE
Eox 2 = 1.3 eV vs SCE

ΔG_1 = -7.3 Kcal/mol
ΔG_2 = 10.3 Kcal/mol

$\Delta G = 23.06 \times (E_{ox} - E_{red}) - E^*_{(S1 \text{ or } T1)}$

where $E^*_{(S1 \text{ or } T1)}$ = energy of the excited state.

[1] G. Mariaule, G. Newsome, P.Y Toullec, P. Belmont, V. Michelet *Org. Lett.* **2014**, *16*, 4570.
[2] G. L. Backes, B. S. Jursic, D. M. Neumann *Bioorg. Med. Chem.*, **2015**, *23*, 3397.
[3] C. Dong, Z. Liao, X. Xu and H. Zhou *J. Heterocycl. Chem.,* **2014**, *51*, 1282.
[4] S. Fukuzumi, H. Kotani, K. Ohkubo, S. Ogo, N. V. Tkachenko and H. Lemmetyinen, *J. Am. Chem. Soc.*, 2004, **126**, 1600.
[5] This last compound would have a M-2 m/z as found on the HRMS data of the mixture.
[6] Additionnal reactivity of the radical specie has already been observed: M. Pudlo, I. Allart-Simon, B. Tinant, S. Gérard, J. Sapi *Chem. Commun.* **2012**, *48*, 2442.
[7] U. Megerle, R. Lechner, B. König, E. Riedle, *Photochem. Photobiol. Sci*. **2010**, *9*, 1400 .
[8] Demas, J. N.; Adamson, A. W. *J. Am. Chem. Soc*. **1971**, *93*, 1800; b) A. C. Bhasikuttan, M. Suzuki, S. Nakashima, T. Okada, *J. Am. Chem. Soc*. **2002**, *124*, 8398.