Supporting Information

Visible Light Initiated Amino Group *Ortho*-Directed Copper (I)-Catalysed Aerobic Oxidative C(*sp*)-S Coupling Reaction: Synthesis of 2-phenylbenzothiazoles *via* Thia-Wolff rearrangement

1.General experimental details:

The ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ on Bruker spectrometers 300, 400 and 500 MHz NMR spectrometer (300, 400 and 500 MHz for ^{1}H NMR and 75, 100 and 125 MHz for ^{13}C NMR) respectively with TMS as an internal standard. Mass spectra were recorded on Xevo G2S Q-TOF spectrometer. TLC was performed on using Merck pre-coated TLC plates (Merck 60 F_{254}) and detected under UV light. Column chromatography was carried out with silica gel (100-200 mesh). Reagents and solvents were purified as per standard procedures. Absorption spectra were recorded using Shimadzu UV-1601 UV-VIS spectrophotometer in ACN solvent. Steady-state fluorescence spectra were recorded on Perkin Elmer LS 45 Fluorescence spectrometer by excitation at 420 nm.

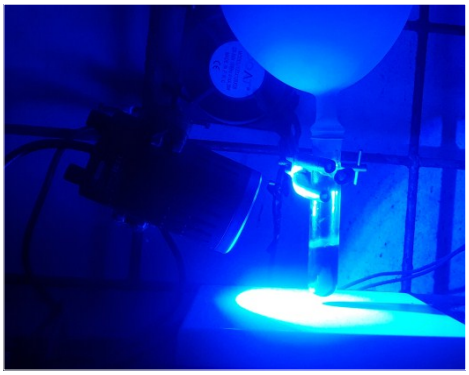


Figure I. Reaction setup for S-alkynylation reactions.

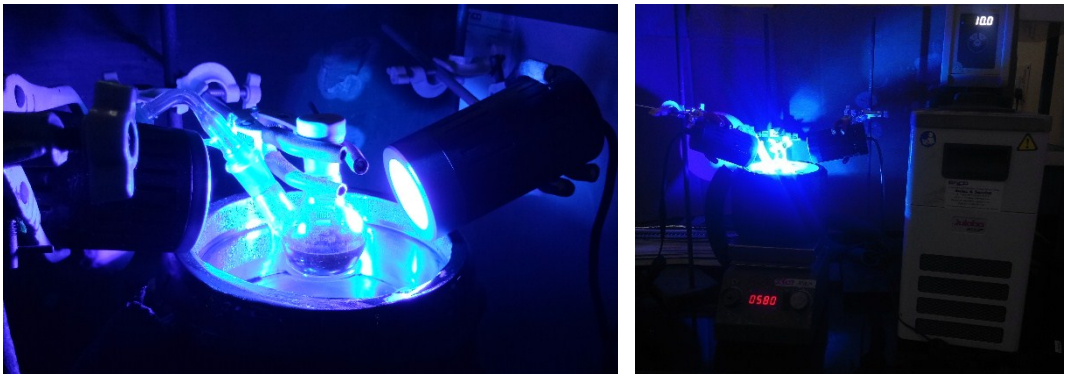


Figure 2. Reaction setup for synthesis of 2-phenylbenzothiazoles.

2. X-ray crystallographic studies of compound 3ai

Figure 3. ORTEP structure of compound **3ai** (CCDC 1951215).

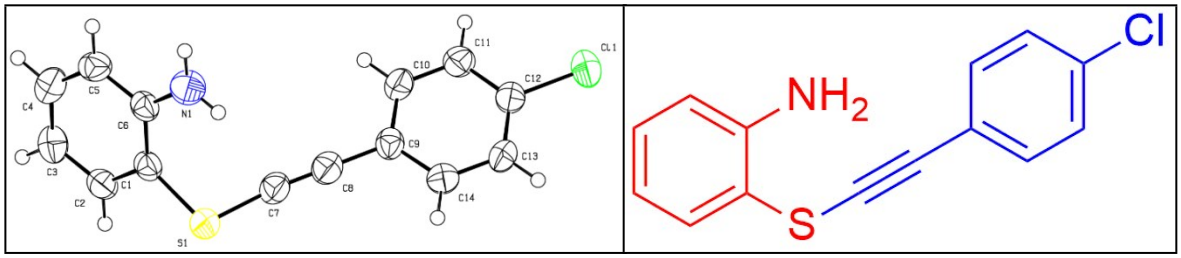


Table 1. Crystal data and structure refinement for Compound **3ai**.

Identification code Compound	**3ai**
Empirical formula	C_{14} H_{10} Cl N S
Formula weight	259.74
Temperature	293 (2) K
Wavelength	0.71073 Å
Crystal system	Monoclinic
Space group	P 21/n
Unit cell dimensions	a = 7.9940(9) Å α= 90 ° b = 5.8548(6) Å β= 92.333 (10)° c = 25.946(2) Å γ = 90 (3)°
Volume	1213.4(2) $Å^3$
Z	4
Density (calculated)	1.422 g/cm^3
Absorption coefficient	0.460 mm^{-1}
F(000)	536.0
Crystal size	0.280x 0.210 x 0.170 mm^3

Theta range for data collection	1.571 to 31.224°.
Index ranges	-11<=h<=11, -8<=k<=7, -37<=l<=37
Reflections collected	16223
Independent reflections	3648 [R(int) = 0.0763]
Completeness to theta 25.242°	100 %
Absorption correction	Multi-scan
Max. and min. transmission	0.925 and 0.891
Refinement method	Full-matrix least-squares on F2
Data / restraints / parameters	3648 / 0 / 154
Goodness-of-fit on F2	1.050
Final R indices [I>2sigma(I)]	R1 = 0.0675, wR2 = 0.1397
R indices (all data)	R1 = 0.1275, wR2 = 0.1724

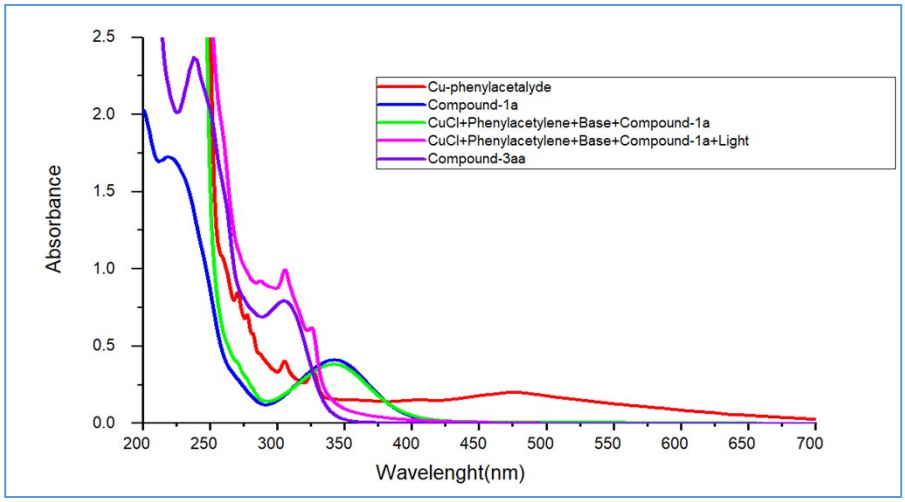


Figure 4. UV-visible absorption spectra of copper phenylacetylide(red), substrate **1a**(blue), phenylacetylene with CuCl before (green) and after irradiation in ACN solvent(purple).

a) b)

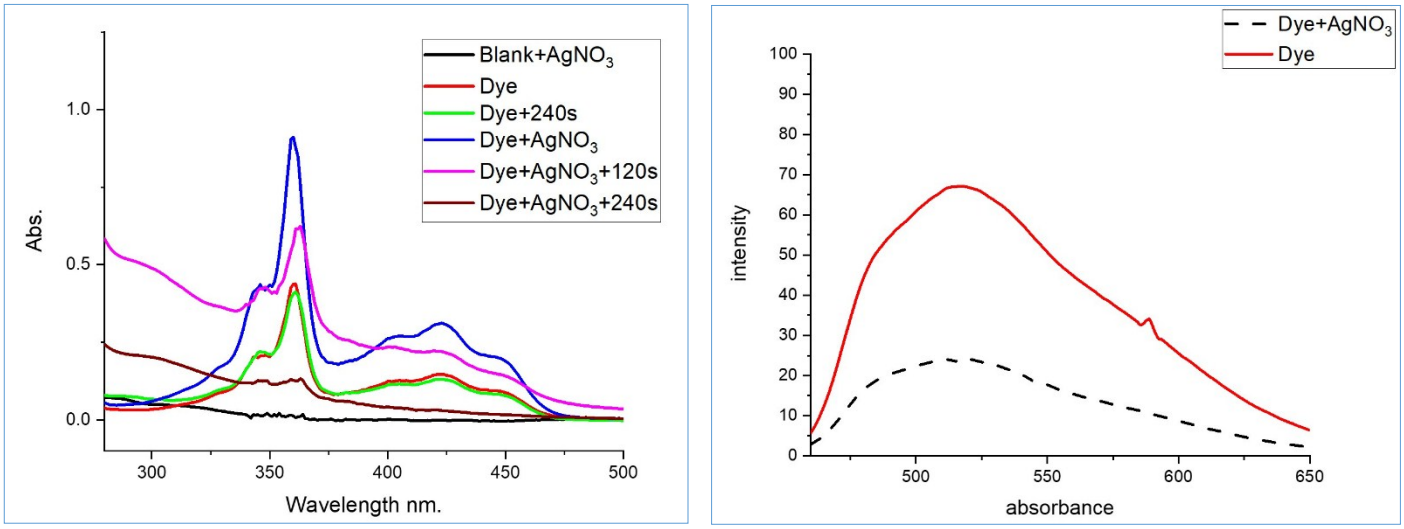


Figure 5. Spectra of the reduced catalyst $Acr^{\bullet}$-Mes formed upon irradiation in the presence of $AgNO_3$ under inert atmosphere after 120s (purple) and 240s (wine).**b)** Quenching of the fluorescence of excited Acr^{+}-Mes by $AgNO_3$ (50 equiv.).

HRMS DST-FIST Funded, Department of Chemistry, IIT Madras

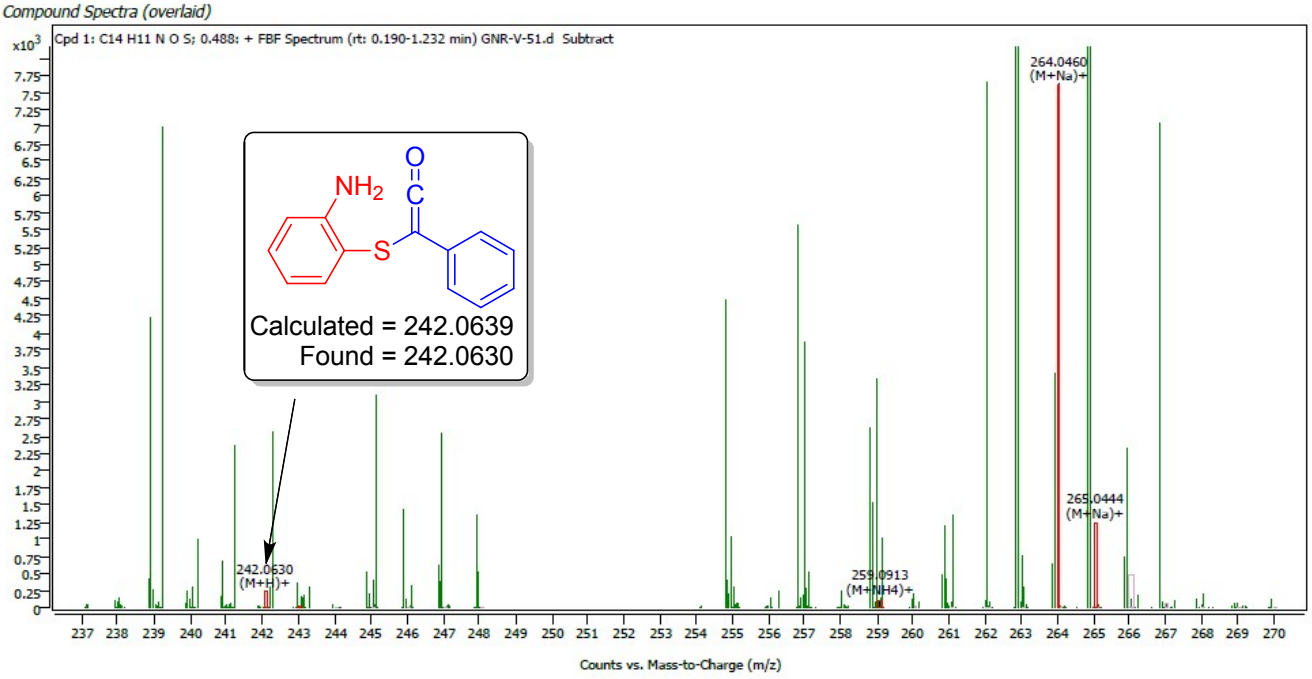
ESI Mass Report

Name	19022020-46-GSK	**Data File Path**	D:\MassHunter\Data\2020\FEB-2020\GSK\GNR-V-51.d
Sample ID		**Acq. Time (Local)**	19-02-2020 17:38:18 (UTC+05:30)
Instrument	Instrument 1	**Method Path (Acq)**	D:\MassHunter\Methods\Direct Infusion_HPLC.m
MS Type	QTOF	**Version (Acq SW)**	6200 series TOF/6500 series Q-TOF 10.1 (48.0)
Inj. Vol. (ul)	2	**IRM Status**	Success
Position	P2-D5	**Method Path (DA)**	D:\MassHunter\Methods\10.0\Default.m
Plate Pos.		**Target Source Path**	
Operator		**Result Summary**	1 qualified (1 targets)

Compound Details

Cpd. 1: C14 H11 N O S

Compound Spectra (overlaid)

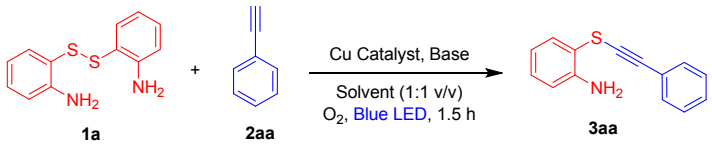


Compound ID Table

Cpd	Formula	Mass (Tgt)	Calc. Mass	Mass	Species	Diff(Tgt.ppm)	mDa
1	C14 H11 N O S	241.0561	241.0563	242.0630 259.0913 264.0460	(M+H)+ (M+NH4)+ (M+Na)+	0.75	0.18

HRMS spectrum of compound of ketene intermediate **14** (Mass recorded after irradiation of 1.5 h)

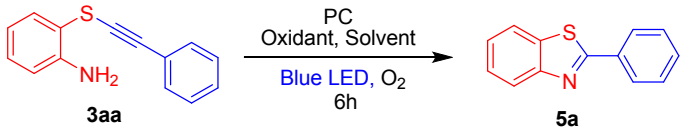
Table S1: Optimization table for alkynylsulfide**3aa** from 2-aminothiophenol dimer **1a** and phenylacetylene **2aa**[a]



Entry	Cat. (mol %)	Base	Solvent	Yield (%)[b]
1	CuCl (5)	K_2CO_3	MeOH	88
2	CuCl (5)	K_2CO_3	ACN	85
3	CuCl (5)	K_2CO_3	DMSO	55
4	CuCl (5)	K_2CO_3	ACN:MeOH	92
5	CuCl (10)	K_2CO_3	ACN:MeOH	85
6	CuCl(5)	Cs_2CO_3	ACN:MeOH	90
7	CuCl(5)	Na_2CO_3	ACN:MeOH	81
8	CuCl(5)	K(OAC)	ACN:MeOH	75
9	CuI(5)	K_2CO_3	ACN:MeOH	91
10	CuBr(5)	K_2CO_3	ACN:MeOH	90
11	Cu(OAc) (5)	K_2CO_3	ACN:MeOH	78
12	$CuCl_2$ (5)	K_2CO_3	ACN:MeOH	40
13	$CuSO_4$ (5)	K_2CO_3	ACN:MeOH	15
14	CuCl (5)	K_2CO_3	H_2O:MeOH	n.r[e]
15	-	K_2CO_3	ACN:MeOH	n.r[e]
16	CuCl(5)	-	ACN:MeOH	n.r[e]
17[c]	CuCl(5)	K_2CO_3	ACN:MeOH	n.r[e]
18[d]	CuCl(5)	K_2CO_3	ACN:MeOH	trace

[a]Reaction conditions: **1a** (0.2 mmol), **2aa** (0.42 mmol), base (0.43 mmol.) and CuCl (5mol%) in solvent (1:1, 8 mL). [b]Yields were determined after purification.[c]In the presence of N_2. [d]In the absence of light. [e]nr = No reaction.

Table S2: Optimization table for 2-phenylbenzothiazoles **5a** from alkynyl sulfide **3aa**[a]



3aa **5a**

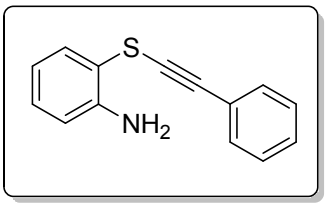
Entry	PC	Oxidant	Temp.	Solvent	Condition (light/thermal)	Yield[b] (%)
1	-	$AgNO_3$	rt	ACN	thermal	nr[d]
2	-	AgOAc	rt	ACN	thermal	nr[d]
3	-	$AgNO_3$	rt	ACN	light	10
4	-	AgOAc	rt	ACN	light	nr[d]
5	Acr^+–Mes	$AgNO_3$	rt	ACN	light	50[c]
6	Acr^+–Mes	AgOAc	rt	ACN	light	nr[d]
7	Acr^+–Mes	$AgNO_3$	10 °C	ACN	light	66
8	Acr^+–Mes	$AgNO_3$	0 °C	ACN	light	46
9	Acr^+–Mes	$AgNO_3$	10 °C	DMSO	light	40
10	Acr^+–Mes	$AgNO_3$	10 °C	MeOH	light	22
11	Acr^+–Mes	$AgNO_3$	10 °C	DCE	light	30
12	Rose Bengal	$AgNO_3$	10 °C	ACN	light	31
13	Eosin Y	$AgNO_3$	10 °C	ACN	light	15
14	Benzophenone	$AgNO_3$	10 °C	ACN	light	10

[a]Reaction conditions: **3aa** (0.22 mmol), 2 equiv. of oxidant and 5 mol% of Acr^+–Mes used in blue LED and 8 mL of solvent. [b]Yields were determined after column purification.[c]No reaction was observed under thermal condition. [d]nr = No reaction.

General procedure for the synthesis of S-alkynylated compounds

Reaction tube was charged with Dimer (0.2 mmol), Acetylene (0.42 mmol), K_2CO_3 (0.21 mmol)and CuCl (5 mol%) in ACN: MeOH (1:1) 8 mL. The reaction mixture was stirred under bluelight for 1.5 hour. After the reaction completion, mixture was passed through celite and solventwas evaporated under reduced pressure. The crude was purified by column chromatographyusing EtOAc/Hexane (5: 95) as eluent to furnish the afforded S-alkynylated compounds.

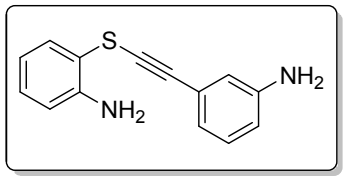
2-((phenylethynyl)thio)aniline 3aa



Yield 92%, yellow liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.20 (br s, 2H), 6.66-6.71 (m, 2H), 7.09 (dt, *J*= 3Hz, *J*= 6Hz, 1H), 7.18-7.23 (m, 3H), 7.33-7.36 (m, 2H), 7.43 (dd, *J*= 3Hz, *J*= 6Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C93.5, 114.5, 115.9, 119.0, 123.2, 128.1, 129.9, 131.5,132.8, 146.5;HRMS: $(M+H)^+$ calculated for $C_{14}H_{12}NS$: 226.0690, Found: 226.0688.

2-(((4-methoxyphenyl)ethynyl)thio)aniline 3ab

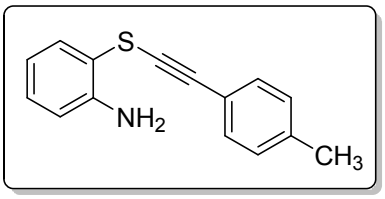


Yield 65%, brown solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 3.66 (br s, 4H), 6.57 (dd, *J*= 2.4Hz, *J*=5.7 Hz, 1H), 6.69-6.75 (m, 3H), 6.80 (d, *J*= 6.2Hz, 1H), 7.03 (t, *J*= 7.8Hz, 1H), 7.12 (dt, *J*= 1.2Hz, *J*= 6.6Hz, 1H), 7.48 (dd, *J*= 1.5Hz,

J= 6.3Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C75.9, 93.9, 114.4, 115.4, 115.9, 117.8, 119.0, 122.0, 123.7, 129.2, 130.0, 132.7, 146.3, 146.5.

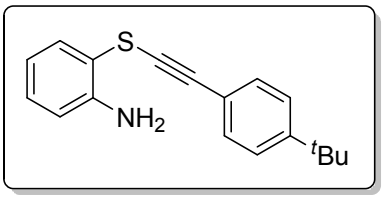
2-((p-tolylethynyl)thio)aniline 3ac



Yield 91%, yellow solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 2.26 (s, 3H), 4.19 (br s, 2H), 6.68 (t, *J*= 7.8Hz, 2H), 7.01-7.10 (m, 3H), 7.24 (d, *J*= 9Hz, 2H), 7.43 (d, *J*= 9Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C 21.5, 75.5, 93.6, 114.4, 115.9, 119.0, 119.8, 129.0, 130.0, 131.7, 132.8, 138.7, 146.4; **HRMS:** $(M+H)^+$ calculated for $C_{15}H_{14}NS$: 240.0846, Found: 240.0894.

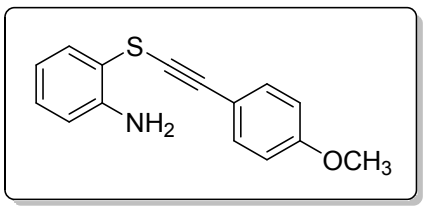
2-((p-tolylethynyl)thio)aniline 3ad



Yield 90%, yellow oily liquid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H 1.21 (s, 9H), 4.17 (br s, 2H), 6.64-6.69 (m, 2H), 7.01-7.09 (m, 1H), 7.22-7.24 (m, 2H), 7.27-7.30 (m, 2H), 7.41 (dd, *J*=1.6Hz, *J*= 6.4Hz, 1H); ^{13}C NMR (100MHz, $CDCl_3$): δ_C 30.1, 33.7, 74.5, 92.7, 113.4, 114.8, 118.0, 118.8, 124.2, 128.9, 130.5, 131.6, 145.3, 150.8.

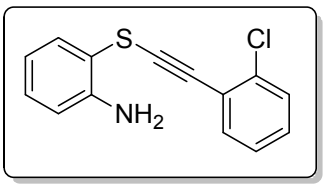
2-(((4-methoxyphenyl)ethynyl)thio)aniline 3ae



Yield 75%, yellow crystalline solid.

^{1}H NMR (500 MHz, $CDCl_3$): δ_H 3.71 (s, 3H), 4.18 (br s, 2H), 6.64-6.69 (m, 2H), 6.72-6.74 (m, 2H), 7.06 (dt, *J*= 1Hz, *J*= 3Hz, 1H), 7.29-7.31 (m, 2H), 7.42 (dd, *J*= 1Hz, *J*= 3Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ_C 55.3, 74.6, 93.5, 113.9, 114.6, 115.0, 115.9, 119.0, 130.0, 132.7, 133.6, 146.4, 159.8.

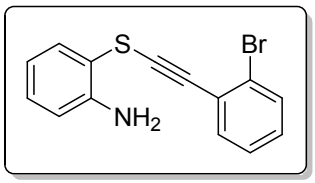
2-(((2-chlorophenyl)ethynyl)thio)aniline 3af



Yield 86%, yellow oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.22 (br s, 2H), 6.68 (t, *J*=9Hz, 2H), 7.07-7.17 (m, 3H), 7.28 (d, *J*=9Hz, 1H), 7.35 (dd, *J*= 2Hz, *J*= 6Hz, 1H), 7.46 (d, *J*= 9Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C 82.5, 90.3, 115.9, 119.0, 123.2, 126.2, 129.0, 129.18, 130.0, 132.9, 133.0, 135.9, 146.6.

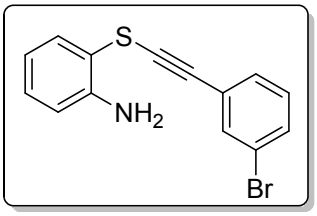
2-(((2-bromophenyl)ethynyl)thio)aniline 3ag



Yield 75%, yellow liquid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H 4.21 (br s, 2H), 6.63-6.69 (m, 2H), 7.01-7.19 (m, 3H), 7.31-7.33 (m, 1H), 7.44-7.48 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C82.0, 92.1, 116.0, 119.1, 125.3, 127.0, 127.6, 128.9, 129.4, 130.3, 132.3, 133.0, 133.3, 146.6.

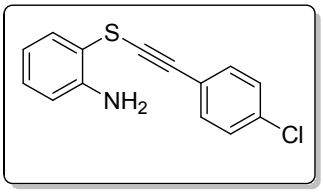
2-(((2-chlorophenyl)ethynyl)thio)aniline 3ah



Yield 85%, yellow oil.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.19 (br s, 2H), 6.68 (t, *J*= 9Hz, 2H), 7.03-7.12 (m, 2H), 7.24 (d, *J*= 9Hz, 1H), 7.34 (d,*J*= 9Hz, 1H), 7.42 (dd, *J*= 1.5Hz, *J*= 6Hz, 1H), 7.47 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C78.8, 91.5, 113.5, 115.9, 119.1, 122.0, 124.9, 129.7, 130.0, 130.4, 131.4, 133.2, 134.2, 146.7.

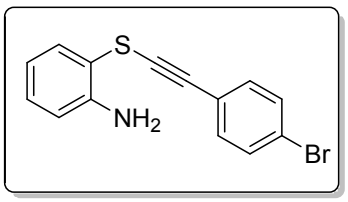
2-(((4-chlorophenyl)ethynyl)thio)aniline 3ai



Yield 89%, White solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.20 (br s, 2H), 6.68 (t, *J*= 9Hz, 2H), 7.11 (dt, *J*= 1.5Hz, *J*= 6Hz, 1H), 7.17-7.19 (m, 2H), 7.25-7.28 (m, 2H), 7.42 (dd, *J*= 1.5Hz, *J*= 6Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C 78.3, 92.1, 115.9,116.5, 119.1, 121.7, 128.5, 130.1, 132.7, 133.0, 134.4, 146.6.

2-(((4-bromophenyl)ethynyl)thio)aniline 3aj

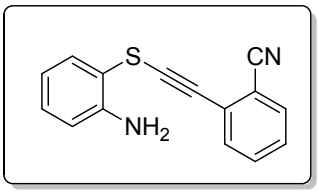


Yield 88%, yellow solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.19 (br s, 2H), 6.67 (t, *J*= 9Hz, 2H), 7.08 (t, *J*= 9Hz, 1H), 7.18

(d,*J*= 6Hz, 2H), 7.33 (d, *J*= 6Hz, 2H), 7.41 (d, *J*= 9Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C 78.6, 92.2, 114.0, 115.9, 119.1, 122.1, 122.5, 130.1, 130.8, 131.5, 132.8, 146.6.

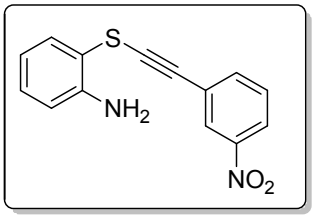
2-(((2-aminophenyl)thio)ethynyl)benzonitrile 3ak



Yield 65%, Red liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.28 (br s, 2H), 6.69 (d, *J*= 9Hz, 2H), 7.05-7.13 (m, 1H), 7.18-7.19 (m, 1H), 7.25-7.31 (m, 1H), 7.41-7.47 (m, 2H), 7.46 (d, *J*= 9Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C 85.1, 89.1,112.5, 114.9, 116.1, 117.5, 119.0, 126.9, 128.2, 130.8, 132.2, 132.3, 132.6, 133.5, 147.0.

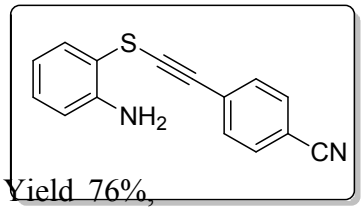
2-(((3-nitrophenyl)ethynyl)thio)aniline 3al



Yield 75%, yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ_H 4.24 (br s, 2H), 6.69 (dt, *J*=0.6, *J*=3Hz, 2H), 7.12 (dt, *J*= 0.9Hz, *J*= 3Hz, 1H), 7.11-7.14 (m, 1H), 7.37 (t, *J*= 6Hz, 1H), 7.42 (dd, *J*= 0.9Hz, *J*= 3Hz, 1H), 7.59-7.61 (m, 1H), 8.03 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ_C 80.9, 90.4, 112.7, 116.0, 119.1, 122.8, 124.8, 126.1, 129.33, 130.85, 133.6, 136.9, 146.9, 148.0.

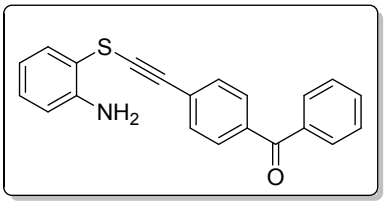
2-(((4-bromophenyl)ethynyl)thio)aniline 3am



Yield 76%, yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H 4.21 (br s, 2H), 6.67-6.7 (m, 2H), 7.12 (dt, *J*= 1.6Hz,*J*= 5.6Hz, 1H), 7.35-7.36 (m, 2H), 7.41 (dd, *J*= 1.2Hz, *J*= 1.6Hz, 1H), 7.47-7.49 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C83.1, 91.5, 111.2, 112.8, 116.0, 118.4, 119.1, 127.9, 130.8, 131.5, 131.9, 133.5, 146.8.

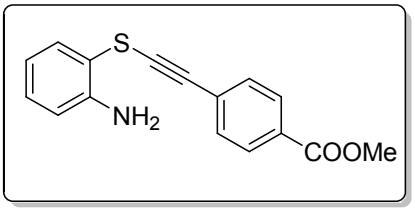
(4-(((2-aminophenyl)thio)ethynyl)phenyl)(phenyl)methanone 3an



Yield 83%, yellow solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.23 (br s, 2H), 6.69 (t, *J*= 6Hz, 2H), 7.10 (t, *J*= 6Hz, 1H), 7.40 (q, *J*= 6Hz, *J*= 9Hz, 5H), 7.50 (t, *J*= 6Hz, 1H), 7.66 (t, *J*= 9Hz, 4H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C 81.1, 92.6, 113.3, 116.0, 119.1, 127.2, 128.3, 129.9, 130.0, 130.5, 131.0, 132.5, 133.3, 136.6, 137.3, 146.8, 195.8.

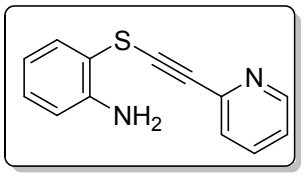
2-(((4-bromophenyl)ethynyl)thio)aniline 3ao



Yield 78%, white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H3.82 (s, 3H), 4.21 (br s, 2H), 6.67-6.70 (m, 2H), 7.10 (dt, *J*= 1.2Hz, *J*= 5.6Hz, 1H), 7.34-7.37 (m, 2H), 7.42 (dd, *J*= 1.6Hz, *J*= 6.4Hz,1H), 7.85-7.88 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C52.2, 80.8, 92.5, 113.3, 115.9, 119.1, 127.6, 129.3, 129.4, 130.5, 131.1, 133.3, 146.7, 166.4.

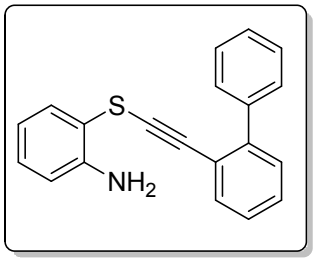
2-((pyridin-2-ylethynyl)thio)aniline 3ap



Yield 67%, brown liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.26 (br s, 2H), 6.63-6.67 (m, 2H), 7.04-7.10 (m, 2H), 7.27 (d, *J*= 8.1Hz, 1H), 7.42 (dd, *J*= 1.2Hz, *J*= 6.6Hz, 1H), 7.47-7.53 (m, 1H), 8.42 (d, *J*= 4.2Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C 78.7, 92.4, 112.6, 115.9, 119.0, 1226, 126.8, 130.6, 133.6, 136.1, 143.0, 147.0, 149.9.

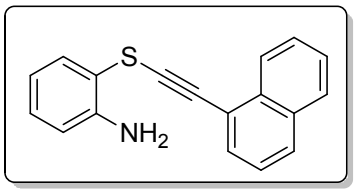
2-(([1,1'-biphenyl]-2-ylethynyl)thio)aniline 3aq



Yield 86%, yellow liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 3.87 (br s, 2H), 6.60 (t, *J*= 9Hz, 2H), 7.05 (dt, *J*= 1.2Hz, *J*= 6.4Hz, 1H), 7.17-7.28 (m, 7H), 7.41-7.44 (m, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C79.2, 93.3, 113.7, 115.9, 118.9, 121.4, 127.0, 127.3, 128.0, 128.4, 129.1, 129.4, 130.0, 132.7, 132.9, 140.4, 143.8, 146.5.

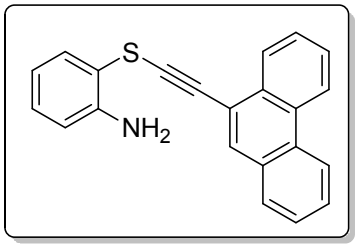
2-((naphthalen-1-ylethynyl)thio)aniline 3ar



Yield 88%, yellow liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.22 (br s, 2H), 6.64-6.70 (m, 2H), 7.07 (dt, *J*= 1.2Hz,*J*= 6.2Hz, 1H), 7.27 (t, *J*= 6.1Hz, 1H), 7.36-7.45 (m, 2H), 7.49 (dd, *J*=1.2Hz, *J*= 6Hz, 1H), 7.54 (d, *J*=10.8Hz, 1H), 7.67-7.72 (m, 2H), 8.16 (d, *J*= 10.2Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C81.5, 91.7, 114.3, 115.9, 119.1, 120.6, 125.1, 126.1, 126.4, 126.8, 128.8, 128.8, 130.2, 130.5, 132.9, 133.1, 133.4, 146.5.

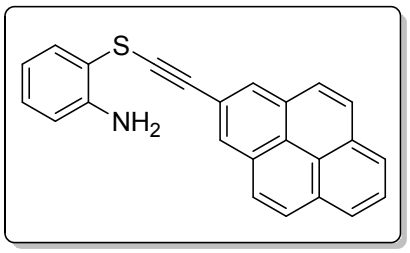
2-((phenanthren-9-ylethynyl)thio)aniline 3as



Yield 85%, white solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.29 (br s, 2H), 6.71 (t, *J*= 9Hz, 2H), 7.11 (t, *J*= 7.5Hz, 1H), 7.45-7.55 (m, 5H), 7.72 (d,*J*= 7.8Hz, 1H), 7.91 (s, 1H), 8.27 (d, *J*= 7.5Hz, 1H), 8.54 (t, *J*= 9Hz, 2H);^{13}C NMR (75 MHz, $CDCl_3$): δ_C 81.2, 91.8, 114.2, 116.0, 119.1, 119.4, 122.6, 122.7, 126.8, 126.9, 127.1, 127.5, 128.5, 130.0, 130.2, 130.3, 131.1, 132.0, 133.1, 146.6.

2-((pyren-2-ylethynyl)thio)aniline 3at

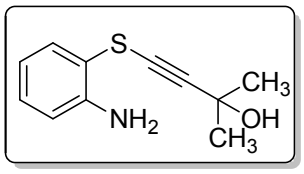


Yield 75%, yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H 4.31 (br s, 2H), 6.70-6.75 (m, 2H), 7.10-7.15 (m, 1H), 7.57 (d,*J*= 6.4Hz, 1H), 7.84-8.02 (m, 6H), 8.08 (t, *J*= 9.2Hz, 2H), 8.38 (d, *J*= 9.2Hz, 1H);^{13}C NMR (100 MHz,

$CDCl_3$): δ_C82.1, 92.7, 114.4, 116.0, 117.4, 119.2, 124.2, 124.4, 125.4, 125.6, 126.2, 127.1, 128.2, 128.4, 129.6, 130.3, 131.0, 131.2, 131.3, 132.1, 133.0, 146.6.

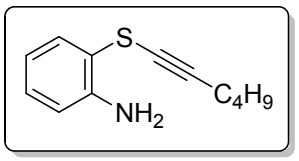
4-((2-aminophenyl)thio)-2-methylbut-3-yn-2-ol 3au



Yield 63%, yellow liquid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H 1.43 (s, 6H), 6.64-6.69 (m, 2H), 7.07 (dt, *J*= 1.2Hz, *J*= 6Hz, 1H), 7.35 (dd, *J*= 0.9Hz, *J*= 6Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C 31.2, 65.8, 69.7, 98.6, 114.1, 116.0, 119.1, 130.1, 132.8, 146.4.

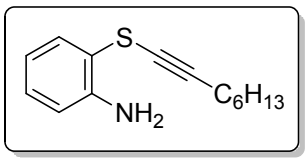
2-(hex-1-yn-1-ylthio)aniline 3av



Yield 83%, yellow liquid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H 0.80 (t, *J*= 7.2Hz, 3H), 1.28-1.34 (m, 2H), 1.39-1.44 (m, 2H), 2.24 (t, *J*= 6Hz, 2H), 4.11 (br s, 2H), 6.61-6.65 (m, 2H), 7.04-7.05 (m, 1H), 7.35-7.37 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C13.5, 19.8, 21.9, 30.7, 65.5, 95.5, 115.1, 115.7, 118.9, 129.6, 132.3, 146.2.

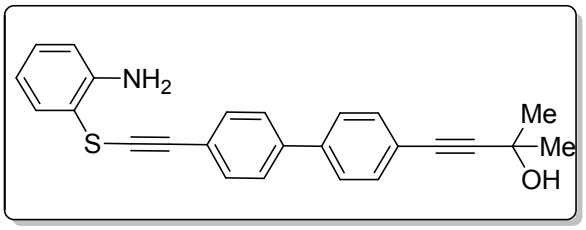
2-(oct-1-yn-1-ylthio)aniline 3aw



Yield 85%, yellow liquid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H 0.80 (t, *J*= 7.2Hz, 3H), 1.17-1.29 (m, 6H), 1.42-1.45 (m, 2H), 2.22-2.25 (t, *J*= 1.2Hz, 2H), 4.10 (br s, 2H), 6.62-6.67 (m, 2H), 7.02-7.06 (m, 1H), 7.36-7.38 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C 14.0, 20.1, 22.5, 28.5, 28.6, 31.3, 65.6, 95.6, 115.2, 115.7, 118.9, 129.6, 132.3, 146.1.

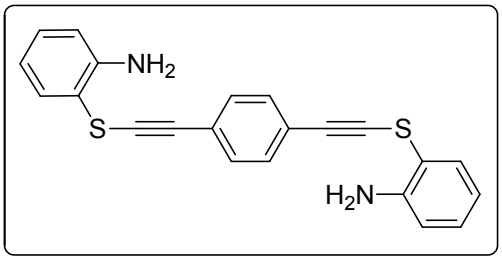
4-(4'-(((2-aminophenyl)thio)ethynyl)-[1,1'-biphenyl]-4-yl)-2-methylbut-3-yn-2-ol 3ax



Yield 73%, brown solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 1.55 (s, 6H), 2.0 (br s, 1H), 4.22 (br s, 2H), 6.69 (t, *J*= 7.8Hz, 2H), 7.10-7.12 (m, 1H), 7.38-7.46 (m, 9H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C31.5, 65.6, 77.8, 81.9, 93.2, 94.8, 114.0, 116.0, 119.1, 122.1, 122.2, 126.7, 126.8, 130.2, 132.1, 133.0, 139.9, 140.0, 146.5.

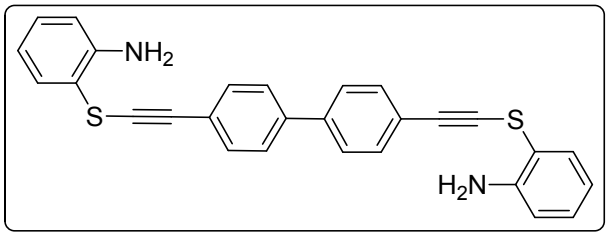
2,2'-((1,4-phenylenebis(ethyne-2,1-diyl))bis(sulfanediyl))dianiline 3ba



Yield 82%, brown solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.20 (br s, 4H), 6.65-6.70 (m, 4H), 7.06-7.11 (m, 2H), 7.23 (s, 4H), 7.41 (dd, *J*= 1.2Hz, *J*= 6.4Hz, 2H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C79.2, 92.9, 113.7, 115.9, 119.1, 122.8, 130.4, 131.3, 133.1, 146.6; **HRMS:** $(M+H)^+$ calculated for $C_{22}H_{17}N_2S_2$: 373.0833, Found: 373.0851.

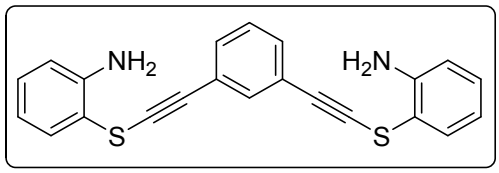
2,2'-(([1,1'-biphenyl]-4,4'-diylbis(ethyne-2,1-diyl))bis(sulfanediyl))dianiline 3bb



Yield 83%, brown solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H4.20 (br s, 4H), 6.66-6.72 (m, 4H), 7.06-7.12 (m, 2H), 7.37-7.45(m, 10H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C77.8, 93.1, 113.9, 115.8, 119.0, 122.2, 126.7, 130.1, 132.0, 132.9, 139.9, 146.5.

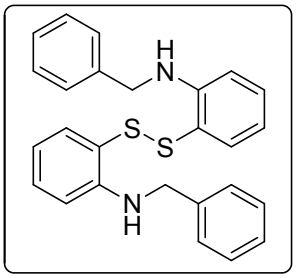
2,2'-((1,3-phenylenebis(ethyne-2,1-diyl))bis(sulfanediyl))dianiline 3bc



Yield 75%, brown liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.22 (br s, 4H), 6.70-6.76 (m, 4H), 7.11-7.17 (m, 3H), 7.20-7.31 (m, 2H), 7.44-7.48 (m, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C 78.0, 92.3, 113.9, 115.9, 119.1, 123.4, 128.3, 130.2, 131.2, 133.1, 134.4, 146.6.

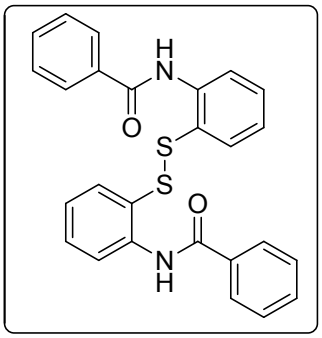
2,2'-disulfanediylbis(N-benzylaniline) 1b:



Yield 40%, yellow liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H4.20 (s, 4H), 5.30 (br s, 2H), 6.43-6.46 (m, 4H), 7.10-7.30 (m, 14H; ^{13}C NMR (75 MHz, $CDCl_3$): δ_C47.6, 110.7, 116.6, 118.4, 127.1, 127.2, 128.6, 131.9, 137.1, 138.9, 149.1.

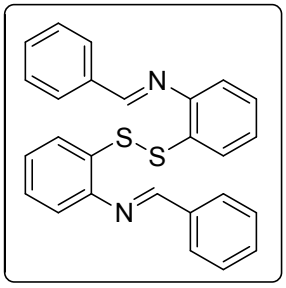
N,N'-(disulfanediylbis(2,1-phenylene))dibenzamide 1c[1]:



Yield 91%, White solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 6.93-6.98 (m, 2H), 7.31 (dt, *J*= 1.2Hz, *J*= 6.4Hz, 2H), 7.42-7.49 (m, 6H), 7.54-7.59 (m, 2H), 7.70 (d, *J*= 7.5Hz, 4H), 8.50 (d, *J*= 8.1Hz, 2H), 8.95 (br s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C120.6, 123.5, 124.3, 127.0, 128.8, 132.0, 132.3, 134.3, 136.6, 139.9, 164.9.

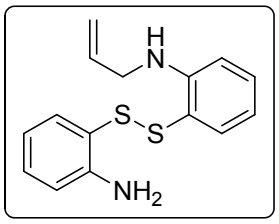
(NE,N'E)-2,2'-disulfanediylbis(N-benzylideneaniline) 1d[2]:



Yield 88%, White solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H7.16-7.19 (m, 2H), 7.22-7.28 (m, 4H), 7.51-7.54 (m, 6H), 7.71-7.74 (m, 2H), 8.01-8.05 (m, 4H), 8.52 (s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C117.2, 126.0, 126.9, 128.8, 129.2, 131.7, 132.1, 136.0, 148.9, 160.0.

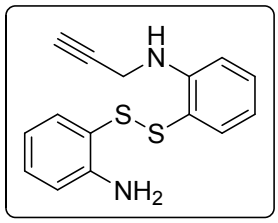
N-allyl-2-((2-aminophenyl)disulfanyl)aniline 1i:



Yield 35%, yellow liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 3.72 (d, *J*= 4.5Hz, 2H), 4.26 (br s, 2H), 5.06 (br s, 1H), 5.12 (dd, *J*= 1.2Hz, *J*= 9Hz, 1H), 5.25 (dd, *J*= 1.2Hz, *J*= 15Hz, 1H), 5.78-5.90 (m, 1H), 6.48-6.68 (m, 4H), 7.09-7.21 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C46.0, 110.6, 115.1, 116.0, 116.5, 118.2, 118.6, 119.0, 131.4, 131.8, 134.8, 136.7, 137.0, 148.6, 149.2.

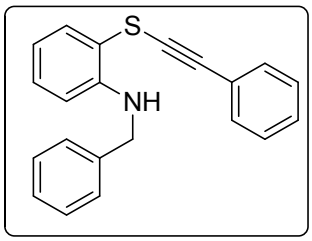
2-((2-aminophenyl)disulfanyl)-N-(prop-2-yn-1-yl)aniline1j:



Yield 33%, yellow liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H2.19 (t, *J*= 2.4Hz, 1H), 3.88 (s,2H), 4.31 (br s, 2H), 5.13 (br s, 1H), 6.56-6.62 (m, 2H), 6.67-6.73 (m, 2H), 7.11-7.30 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C33.2, 71.2, 80.5, 111.0, 115.2, 117.6, 118.3, 118.7, 119.4, 131.6, 131.9, 136.8, 137.1, 148.2, 148.6.

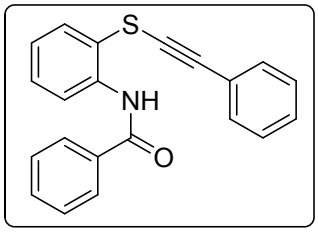
N-benzyl-2-((phenylethynyl)thio)aniline 4b:



Yield 60%, yellow liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 4.36 (s, 2H), 5.07 (br s, 1H), 6.53-6.62 (m, 2H), 7.08-7.19 (m, 7H), 7.24-7.29 (m, 4H) 7.45 (dd, *J*= 1.2Hz, *J*= 6.6Hz, 1H) ; ^{13}C NMR (75 MHz, $CDCl_3$): δ_C47.8, 77.5, 92.9, 111.2, 113.0, 117.4, 123.0, 127.2, 127.3, 128.3, 128.4, 128.7, 130.8, 131.7, 133.7, 138.8, 147.5.

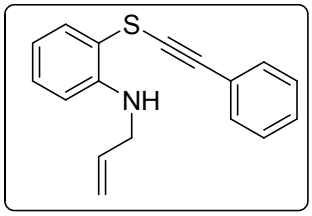
N-(2-((phenylethynyl)thio)phenyl)benzamide 4c:



Yield 75%, White solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H7.20 (dt, *J*= 1.2Hz, *J*= 6.3Hz, 1H), 7.27-7.34 (m, 3H), 7.36-7.39 (m, 2H), 7.44-7.51 (m, 3H), 7.55-7.60 (m, 1H), 8.01-8.04 (m, 2H), 8.44 (dd, *J*= 0.6Hz, *J*= 7.5Hz, 1H), 8.84 (br s, 2H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C75.6, 94.6, 120.9, 122.2, 122.6, 125.1, 127.2, 128.4, 128.9, 129.0, 130.3, 131.8, 132.1, 132.5, 134.5, 137.9, 165.4.

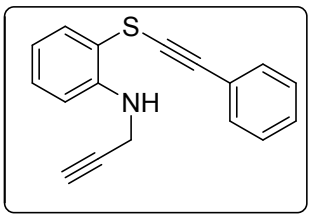
N-allyl-2-((phenylethynyl)thio)aniline 4i:



Yield 35%, yellow liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 3.90 (d, *J*= 4.8Hz, 2H), 4.86 (br s, 1H), 5.18 (dd, *J*= 1.2Hz, *J*= 9Hz, 1H), 5.33 (dd, *J*= 1.2Hz, *J*= 15Hz, 1H), 5.91-6.02 (m, 1H), 6.64-6.71 (m, 2H), 7.21-7.28 (m, 4H), 7.36-7.54 (m, 2H), 7.52 (d, *J*= 1.2Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C46.1, 77.4, 92.8, 111.2, 113.4, 116.2, 117.3, 123.0, 128.2, 128.3, 130.6, 131.6, 133.5, 134.6, 147.4.

2-((phenylethynyl)thio)-N-(prop-2-yn-1-yl)aniline 4j:



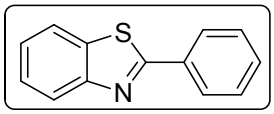
Yield 37%, yellow liquid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H2.13 (t, *J*= 2.1Hz, 1H), 3.94 (d, *J*= 2.7Hz, 2H), 4.76 (br s, 1H), 6.66-6.71 (m, 2H), 7.15-7.22 (m, 4H), 7.31-7.34 (m, 2H), 7.46-7.49 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C33.5, 71.4, 77.4, 80.4, 93.4, 111.9, 115.1, 118.6, 123.0, 128.2, 128.3, 130.3, 131.6, 133.2, 146.4.

General procedure for synthesis of 2-phenylbenzothiazoles:

Reaction tube was charged with S-alkynylated compound (0.2 mmol), $AgNO_3$(0.4 mmol), and 9-mesityl-10-methylacridinium tetrafluoroborate (5 mol%) in ACN 8 mL. The reaction mixture was stirred under blue light in presence of O_2 atmosphere at 10 °C for 6 hour. After the reaction completion, mixture was passed through celite and solvent was evaporated under reduced preassure. The crude was purified by column chromatography using EtOAc/Hexane (2: 98) as eluent to furnish the afforded 2-phenylbenzothiazoles

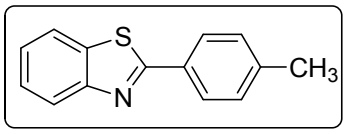
2-phenylbenzo[d]thiazole 5a[3]:



Yield 66%, half white solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H7.29 (t, *J* = 6.9 Hz, 1H), 7.40-7.43 (m, 4H),7.80 (d, *J* = 7.8 Hz, 1H), 7.99-8.04 (m, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C121.4, 123.3, 125.0, 126.1, 127.5, 128.8, 130.7, 133.9, 135.2, 154.4, 167.8;**HRMS:** $(M+H)^+$ calculated for $C_{13}H_{10}NS$: 212.0533, Found: 212.0543.

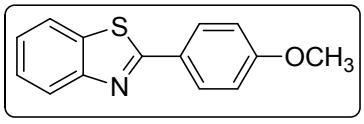
2-(p-tolyl)benzo[d]thiazole5b[3]:



Yield 68%, pale yellow solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H2.35 (s, 3H), 7.26 (d, *J* = 8.1 Hz, 2H), 7.30 (t, *J* = 7.8 Hz, 1H),7.38-7.43 (m, 1H), 7.82 (d, *J* = 7.8 Hz, 1H), 7.91 (d, *J* = 8.1 Hz, 2H),7.99 (d, *J* = 8.1 Hz, 1H),; ^{13}C NMR (75 MHz, $CDCl_3$): δ_C20.4, 120.5, 122.0, 123.9, 125.2, 126.4, 128.6, 129.9, 133.8, 140.4, 153.1, 167.2.

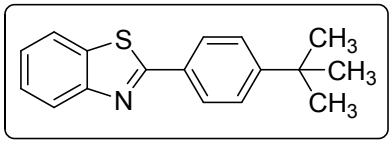
2-(4-methoxyphenyl)benzo[d]thiazole 5c[3]:



Yield 70%, pale yellow solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H 3.86 (s, 3H), 7.24 (d, J = 8.2 Hz, 2H), 7.29-731 (m, 1H), 7.40-7.43 (m, 1H), 7.82 (d, J = 7.8 Hz, 1H), 7.98-7.81 (m, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C55.5, 114.3, 120.0, 121.5, 122.7, 124.9, 126.2, 129.2, 134.6, 154.1, 162.0, 167.3.

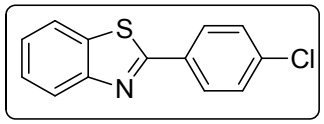
2-(4-(tert-butyl)phenyl)benzo[d]thiazole 5d[4]:



Yield 68%, pale yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H1.31 (s, 9H), 7.29-7.32 (m, 1H), 7.40-7.45 (m, 2H),7.81-7.83 (m, 1H), 7.93-7.96 (m, 3H), 7.98-7.80 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C30.1, 33.9, 120.5, 122.0, 123.9, 124.9, 125.1, 126.3, 128.5, 132.1, 133.9, 153.5, 167.4.

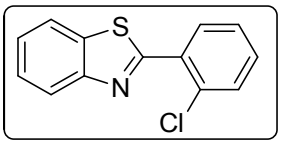
2-(4-chlorophenyl)benzo[d]thiazole 5e[3]:



Yield 64%, half white solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H7.33 (t, J = 7.5 Hz, 1H), 7.38-7.45 (m, 3H),7.83 (d, J = 8.1 Hz, 1H), 8.94-8.02 (m, 3H); ^{13}C NMR (125 MHz, $CDCl_3$): δ_C121.6, 123.0, 125.4, 126.5, 128.7, 129.2, 1321, 135.0, 137.0, 154.0, 166.6.

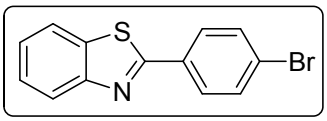
2-(2-chlorophenyl)benzo[d]thiazole 5f[3]:



Yield 55%, white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H7.33-7.38 (m, 3H), 7.44-7.48 (m, 2H),7.97-7.90 (m, 1H), 8.05-8.08 (m, 1H), 8.13-8.15 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C120.3, 122.4, 124.4, 125.2, 126.0, 129.7, 130.1, 130.7, 131.2, 131.7, 135.0, 151.4, 163.1.

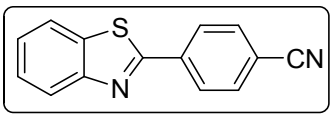
2-(4-bromophenyl)benzo[d]thiazole 5g[3]:



Yield 65%, pale yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H7.33 (t, *J* = 7.5 Hz, 1H), 7.40-7.45 (m, 1H),7.51-7.57 (m, 2H), 7.82-8.7.94 (m, 3H), 8.01 (d, *J*= 8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C121.6, 123.3. 125.4, 126.5, 128.9, 131.4, 132.2, 133.3, 135.0, 154.0, 166.7.

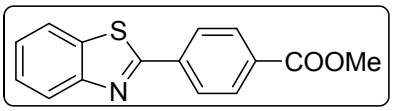
4-(benzo[d]thiazol-2-yl)benzonitrile 5h[5]:



Yield 58%, pale yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H7.36-7.40 (m, 1H), 7.45-7.49 (m, 1H),7.72 (d, *J* = 6.5 Hz, 2H), 7.86-7.88 (m, 1H), 8.03-8.05 (m, 1H), 8.14 (d, *J* = 6.5 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C114.1, 118.2, 121.8, 123.8, 126.0, 126.8, 127.9, 132.7, 135.3, 137.5, 154.0, 165.3.

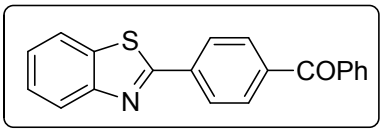
Methyl 4-(benzo[d]thiazol-2-yl)benzoate 5i[4]:



Yield 61%, white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H 3.89 (s, 3H), 7.33-7.37 (m, 1H), 7.43-7.47 (m, 1H), 7.85-7.87 (m, 1H), 8.02-8.04 (m, 1H), 8.09 (s, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C52.3, 121.7, 123.6, 125.7, 126.6, 127.4, 130.2, 132.0, 135.2, 137.4, 154.1, 166.4, 166.6.

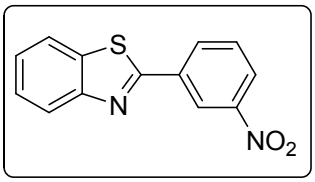
(4-(benzo[d]thiazol-2-yl)phenyl)(phenyl)methanone 5j:



Yield 56%, pale yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H7.34-7.38 (m, 1H), 7.42-7.48 (m, 3H),7.53-7.57 (m, 1H), 7.75-7.78 (m, 2H), 7.85-7.88 (m, 3H), 8.05 (d, *J*= 8.1Hz, 1H), 8.13-8.15 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C121.7, 123.6, 125.7, 126.6, 127.3, 128.4, 130.0, 130.7, 132.7, 135.3, 136.9, 137.2, 139.3, 154.1, 166.5, 195.9, **HRMS:** $(M+H)^+$ calculated for $C_{20}H_{14}NOS$: 316.0796, Found: 316.0843.

2-(3-nitrophenyl)benzo[d]thiazole 5k[5]:

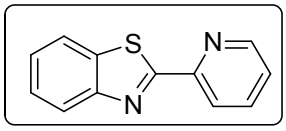


Yield 64%, yellow solid.

^{1}H NMR (500 MHz, $CDCl_3$): δ_H7.38 (t, *J* = 7.5 Hz, 1H), 7.47 (t, *J* = 8.0 Hz, 1H), 7.62 (t, *J* = 8.0Hz, 1H), 7.88 (d, *J* = 8.0 Hz, 1H),8.05 (d, *J* = 8.0 Hz, 1H), 8.26 (d, *J* = 7.5 Hz, 1H), 8.35 (d, *J* = 8 Hz, 1H),

8.86 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ_C120.8, 121.3, 122.7, 124.1, 125.0, 125.8, 129.0, 131.9, 134.1, 134.2, 147.7, 152.9, 163.8.

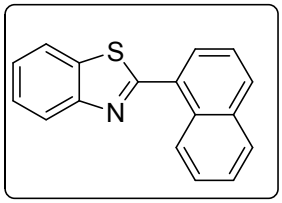
2-(pyridin-2-yl)benzo[d]thiazole 5l[6]:



Yield 59%, brown solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H7.29-7.36 (m, 2H), 7.41-7.45 (m, 1H),7.75-7.80 (m, 1H), 7.88-7.90 (m, 1H), 8.01-8.03 (m, 1H),8.29-8.31 (m, 1H), 8.60-8.62 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C120.8, 122.0, 123.5, 125.2, 125.6, 126.2, 136.1, 137.0, 149.6, 151.4, 154.2, 169.4.

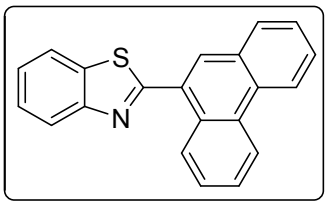
2-(naphthalen-1-yl)benzo[d]thiazole 5m[3]:



Yield 76%, half white solid.

^{1}H NMR (300 MHz, $CDCl_3$): δ_H7.43 (t, *J*= 3.3 Hz, 1H), 7.45-7.65 (m, 4H),7.86-8.01 (m, 4H), 8.20 (d, *J*= 8.1Hz, 1H), 8.92 (d, *J*= 8.1Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$): δ_C121.4, 123.5, 125.0, 125.3, 125.9, 126.2, 126.5, 127.6, 128.4, 129.4, 130.6, 130.8, 131.0, 134.0, 135.4, 154.1, 167.6.

2-(phenanthren-9-yl)benzo[d]thiazole 5n[6]:



Yield 79%, white solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ_H7.38-7.42 (m, 1H), 7.48-7.52 (m, 1H),7.58-7.69 (m, 4H), 7.89-7.93 (m, 2H), 8.13-8.15 (m, 2H), 8.65-8.73 (m, 2H), 8.82-8.85 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ_C121.4, 122.7, 122.9, 123.6, 125.4, 126.3, 126.7, 1271, 127.2, 127.4, 128.1, 129.2, 129.4, 129.8, 130.7, 130.8, 131.0, 131.2, 135.4, 154.1, 167.5; **HRMS:** $(M+H)^+$ calculated for $C_{21}H_{14}NS$: 312.0846, Found: 312.0857.

References:

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2. J. Srogl, J. Hyvl, A. Revesz and D. Schroder, *Chem. Commun.*, 2009, **23**, 3463.
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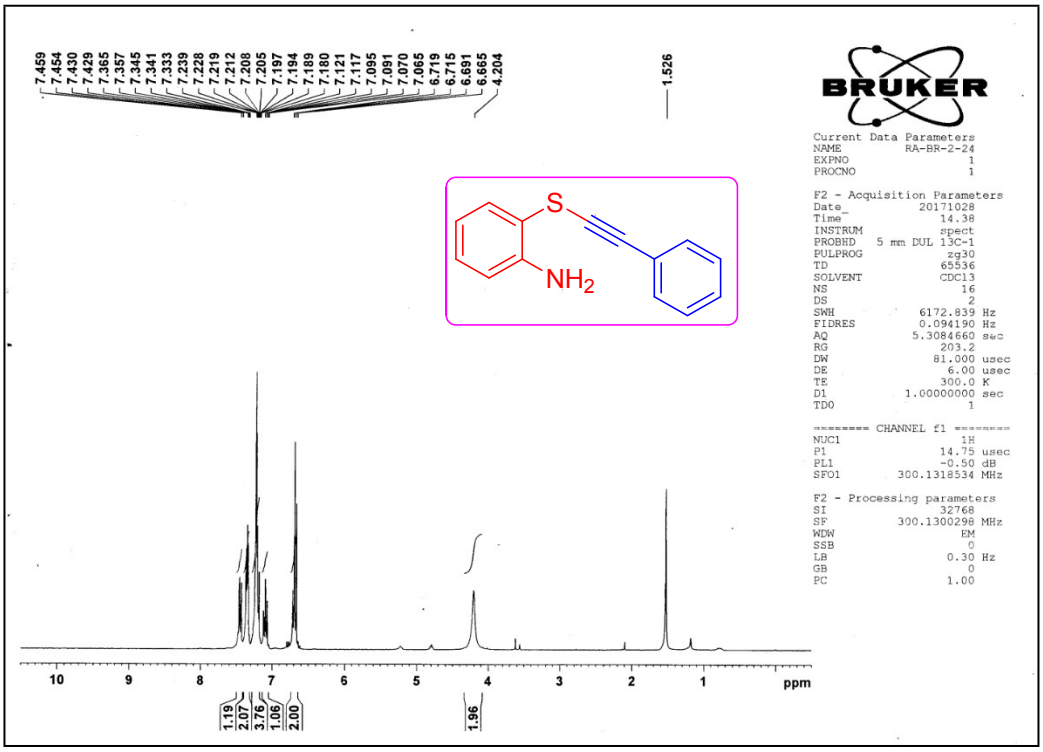
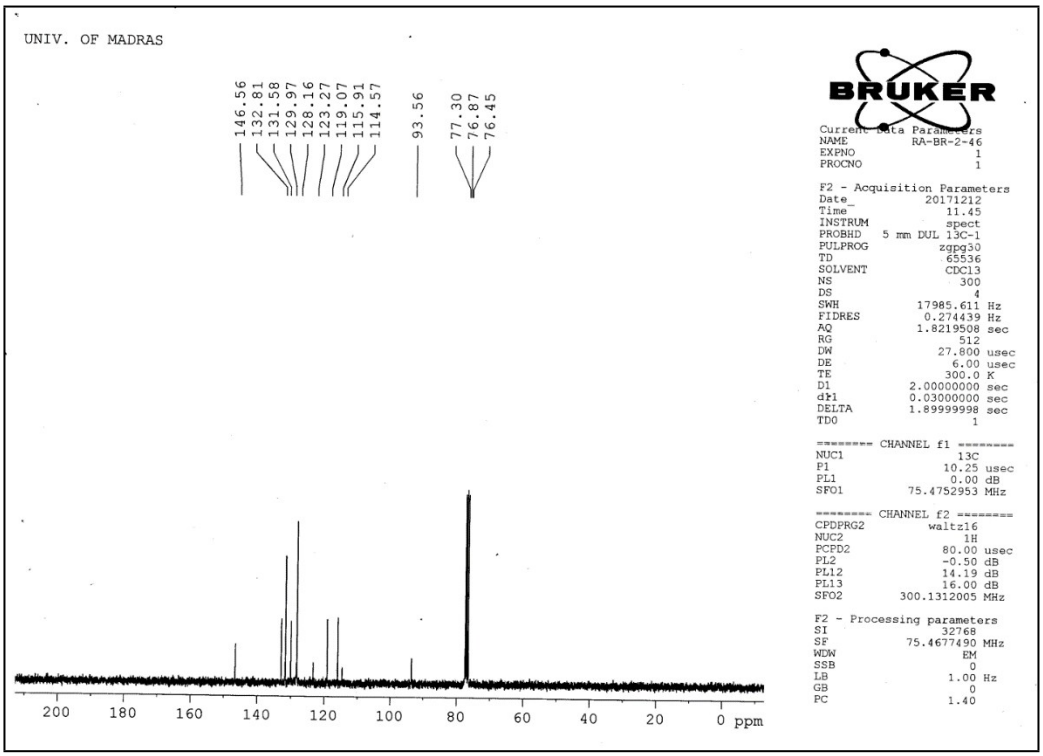
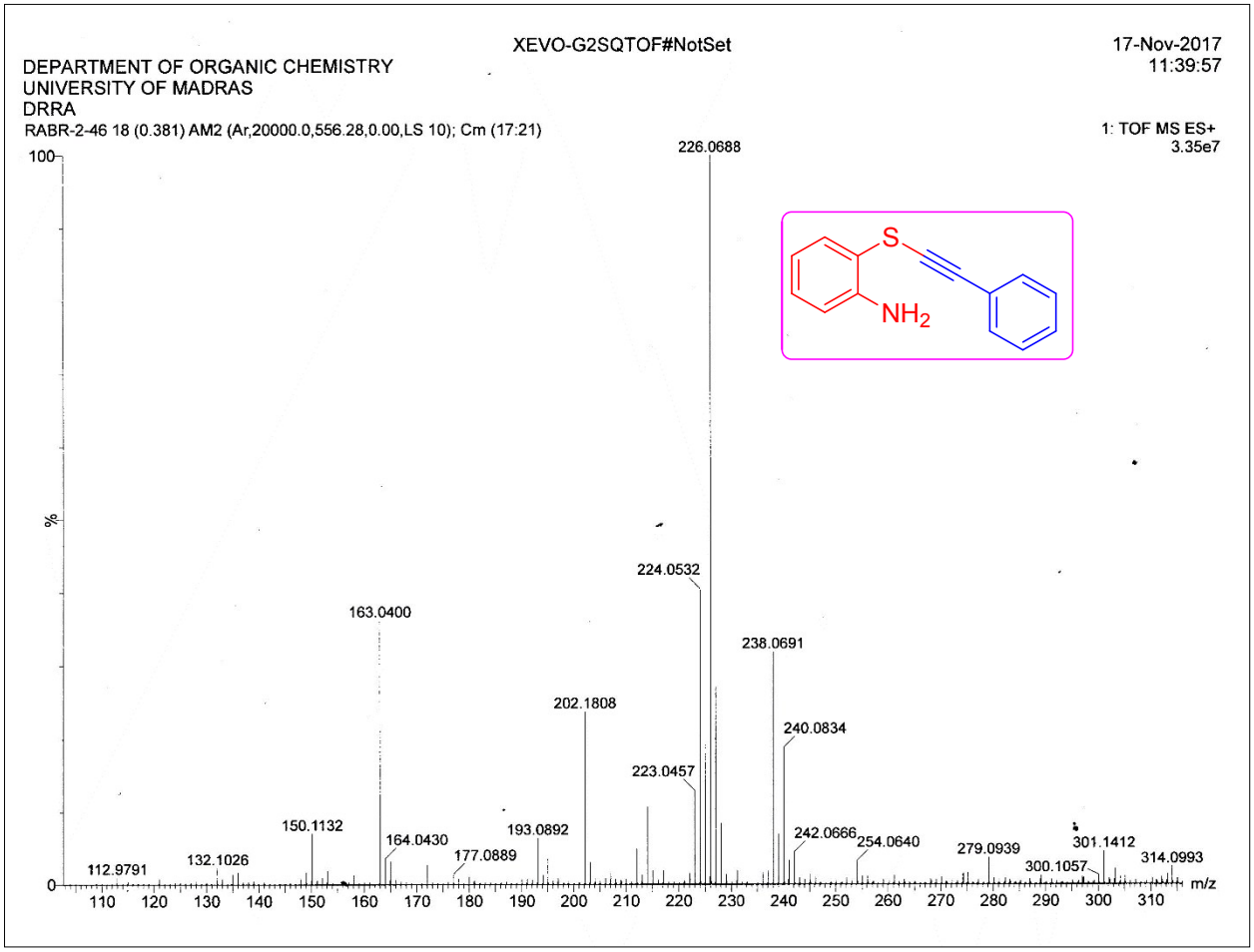
5. A. A. Weekes, J. Frydrych, and A. D. Westwell, *Synth. Comm.*, 2013, **43**, 2656.
6. T. Yamamoto, K. Muto, M. Komiyama, J. Canivet, J. Yamaguchi and K. Itami, *Chem. Eur. J.*, 2011, **17**, 10113.

Spectral Data:

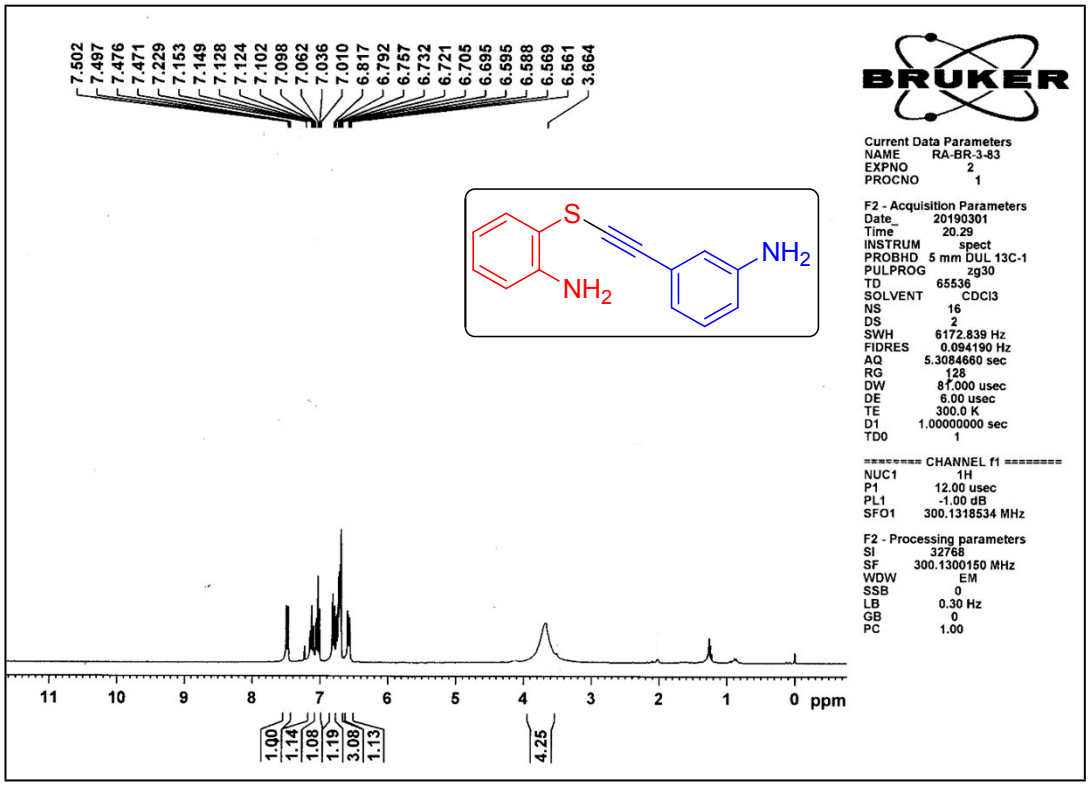


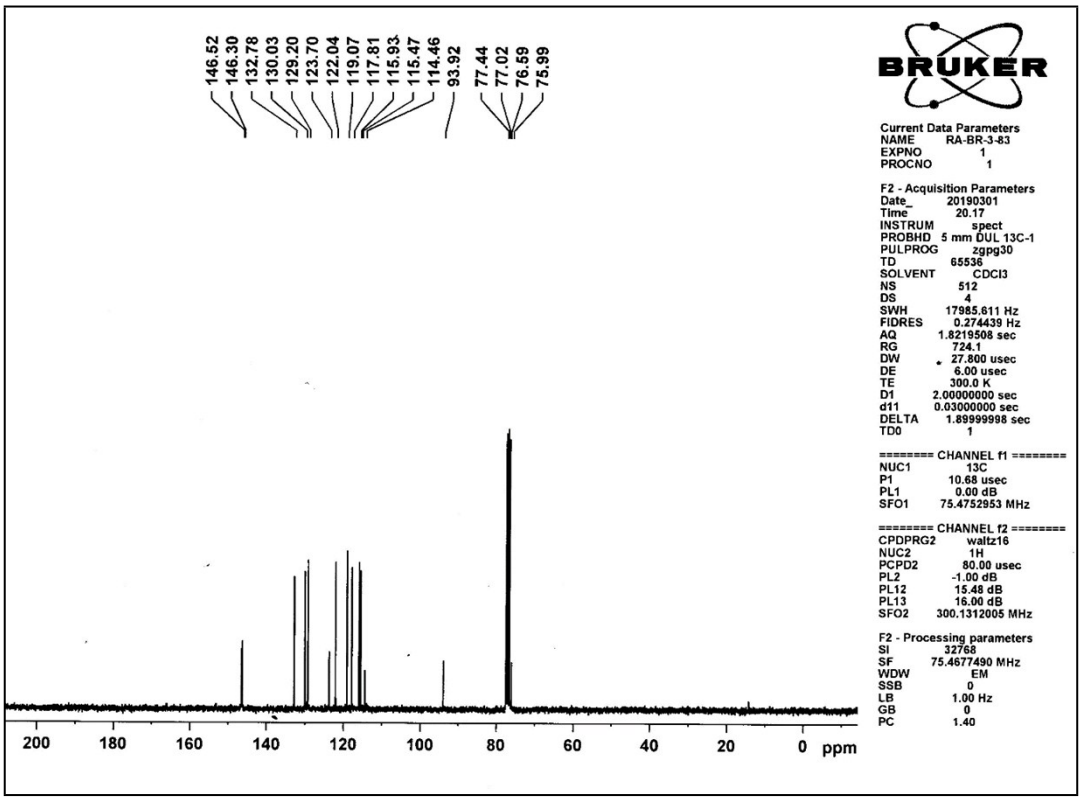


^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3aa

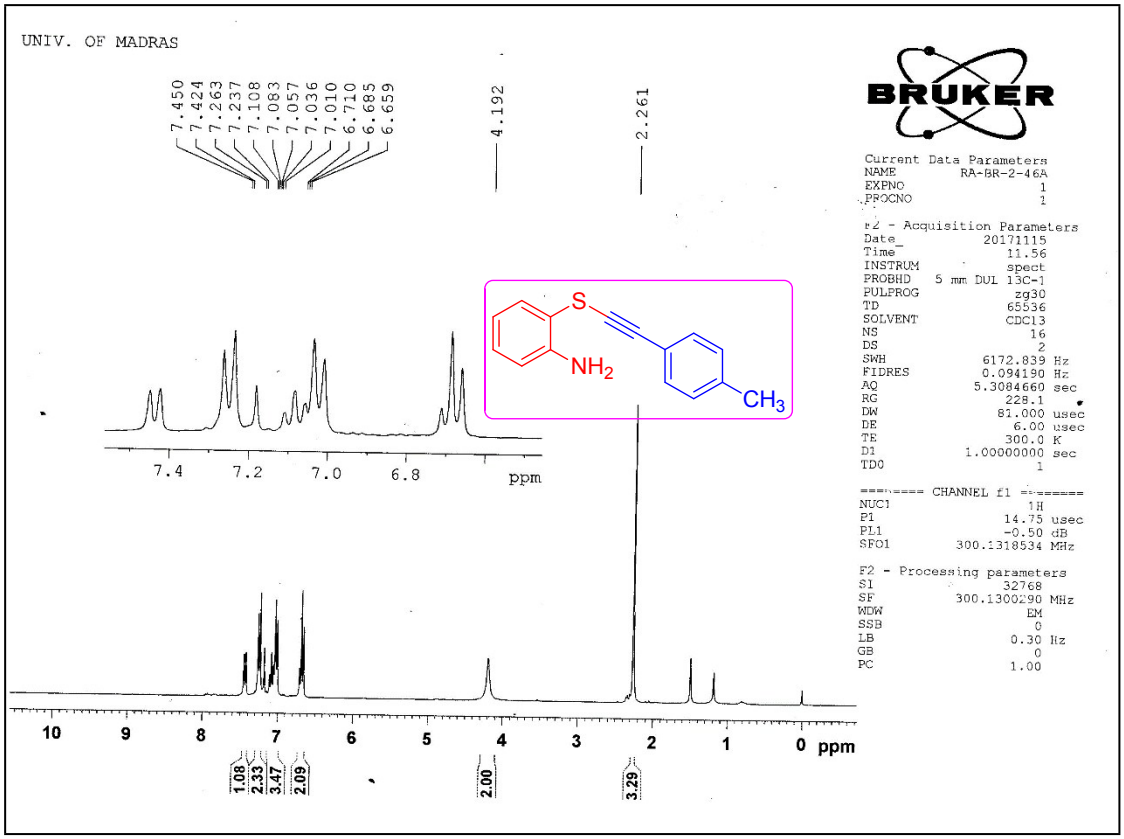


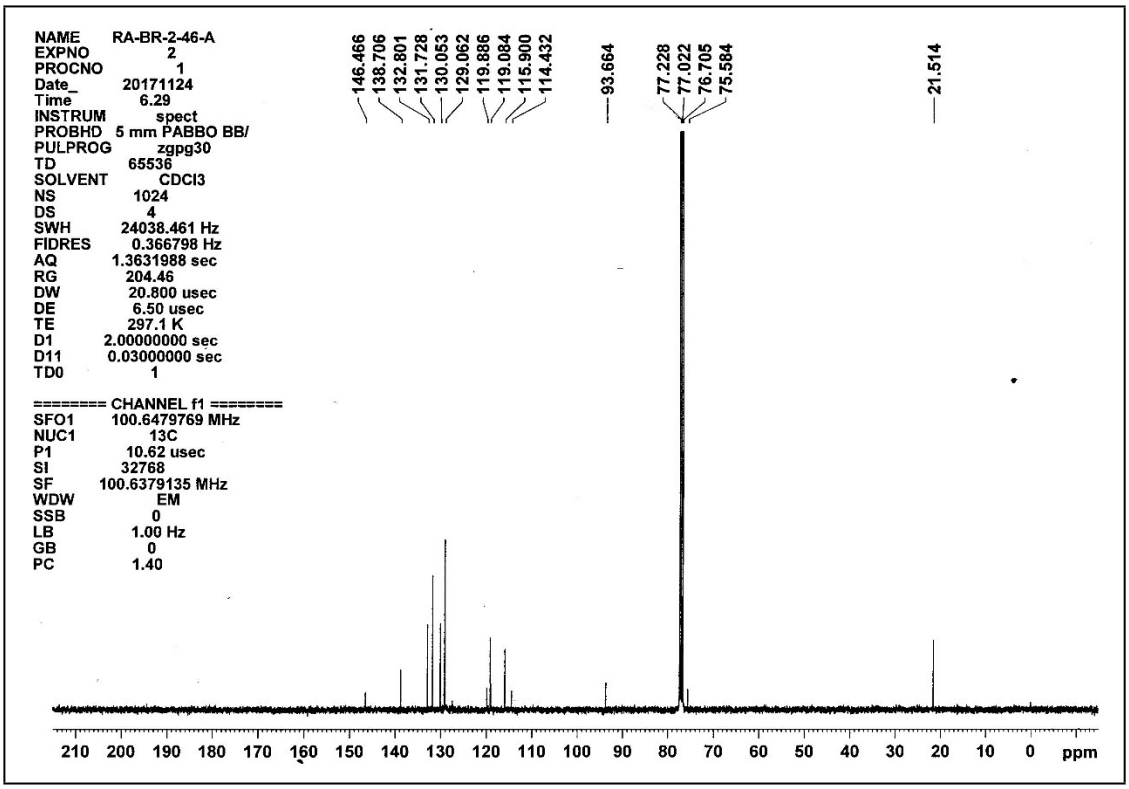
HRMS spectrum of compound 3aa



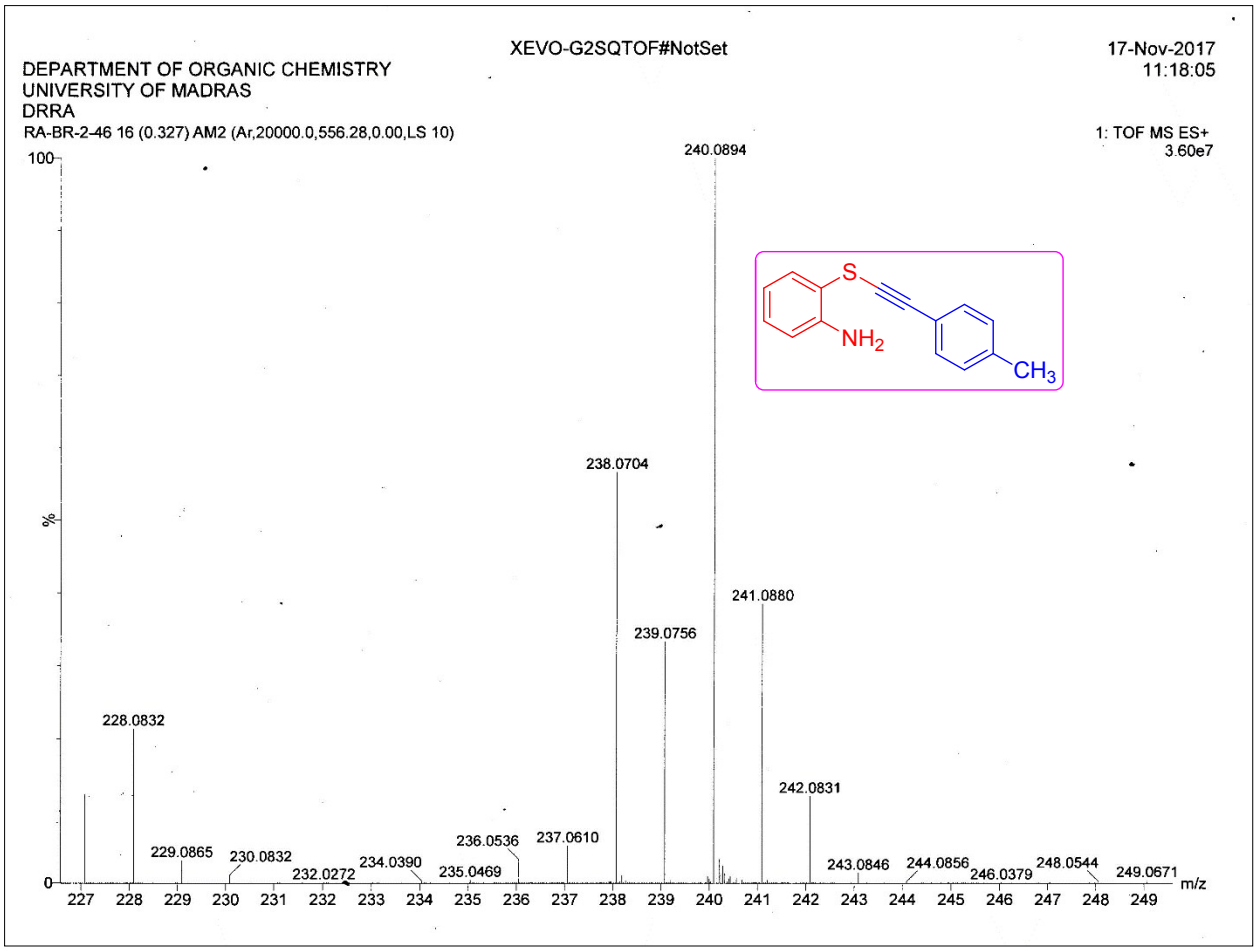


^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ab

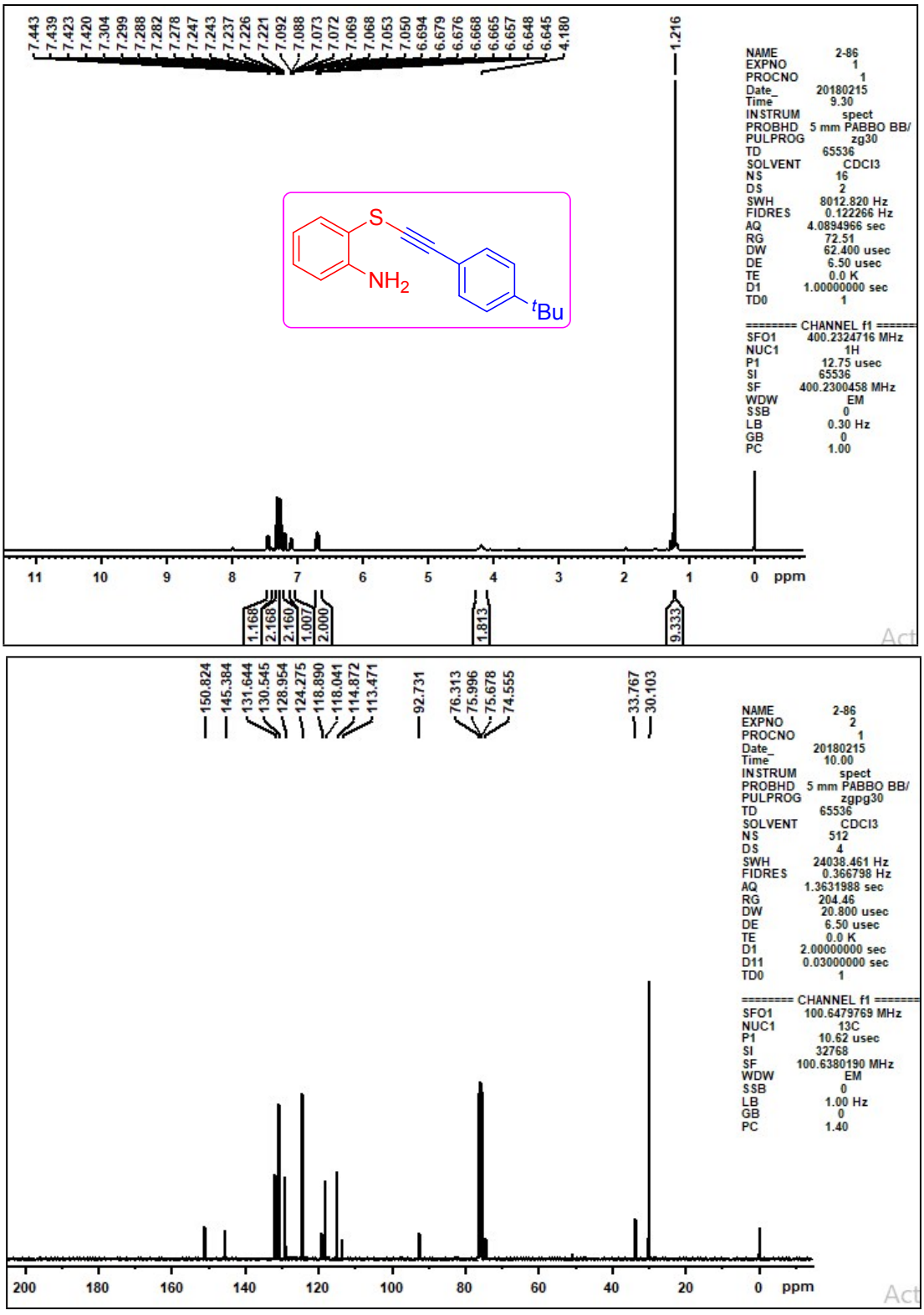




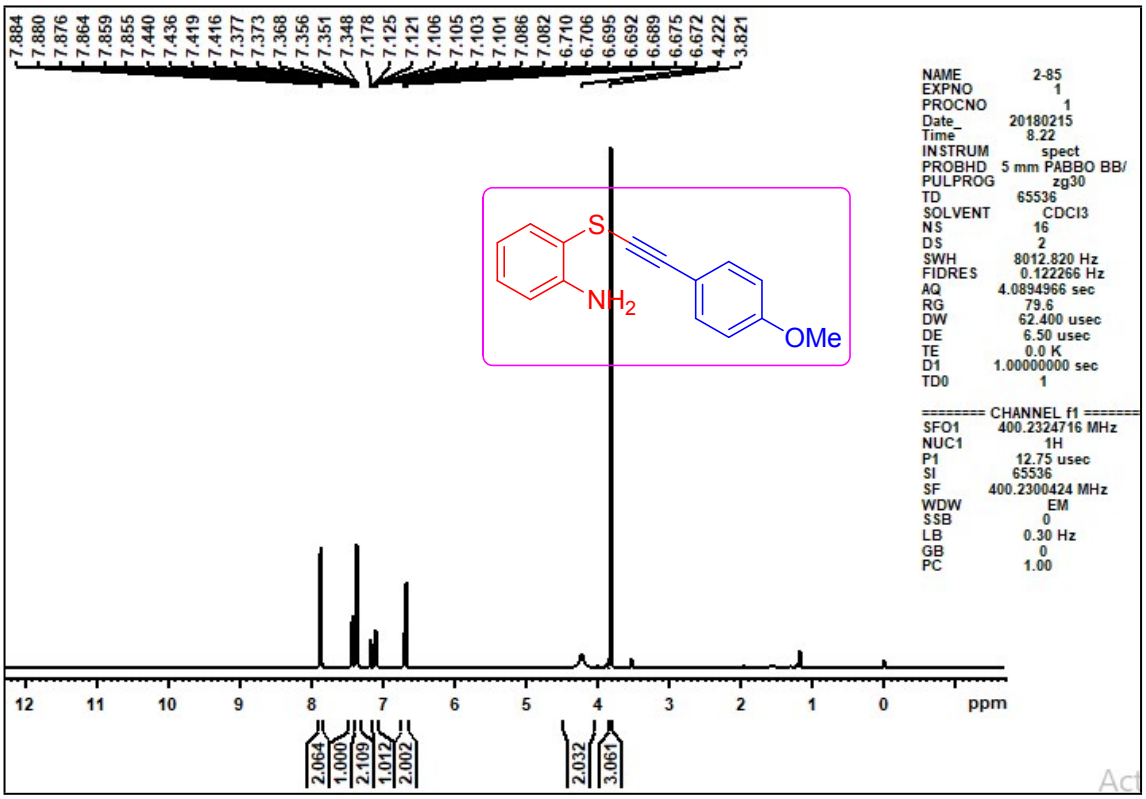
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ac

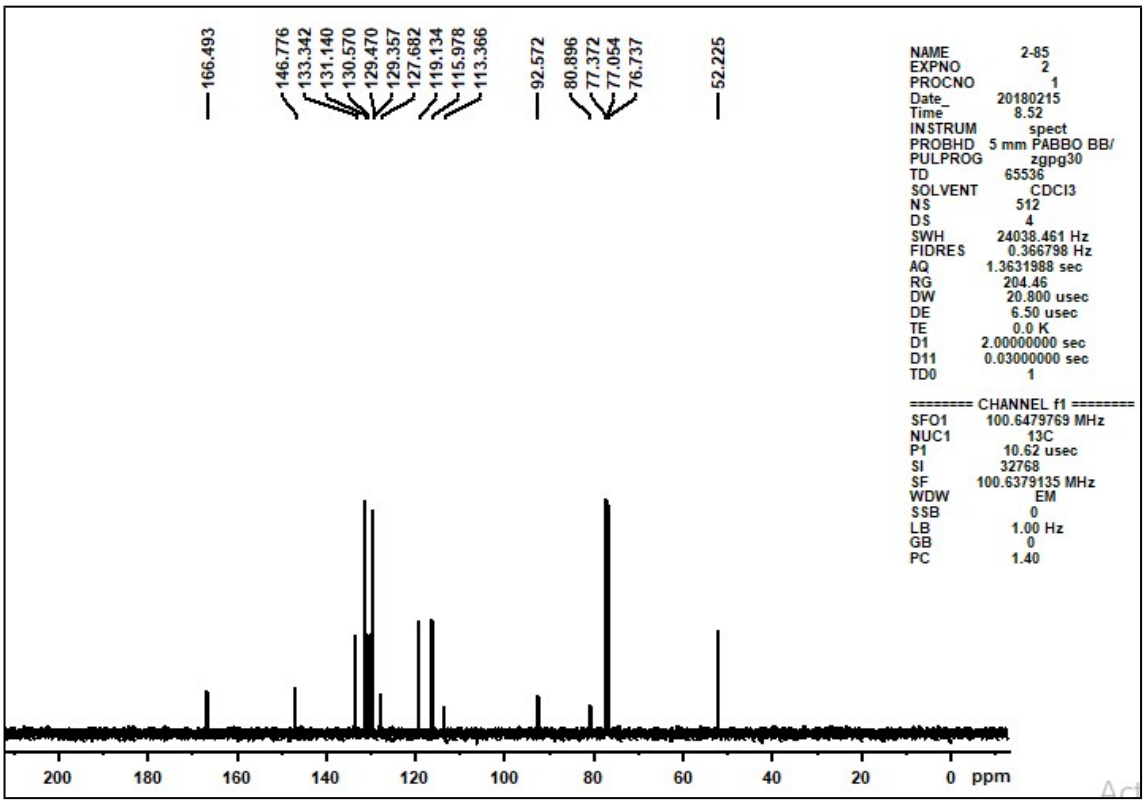


HRMS spectrum of compound 3ac

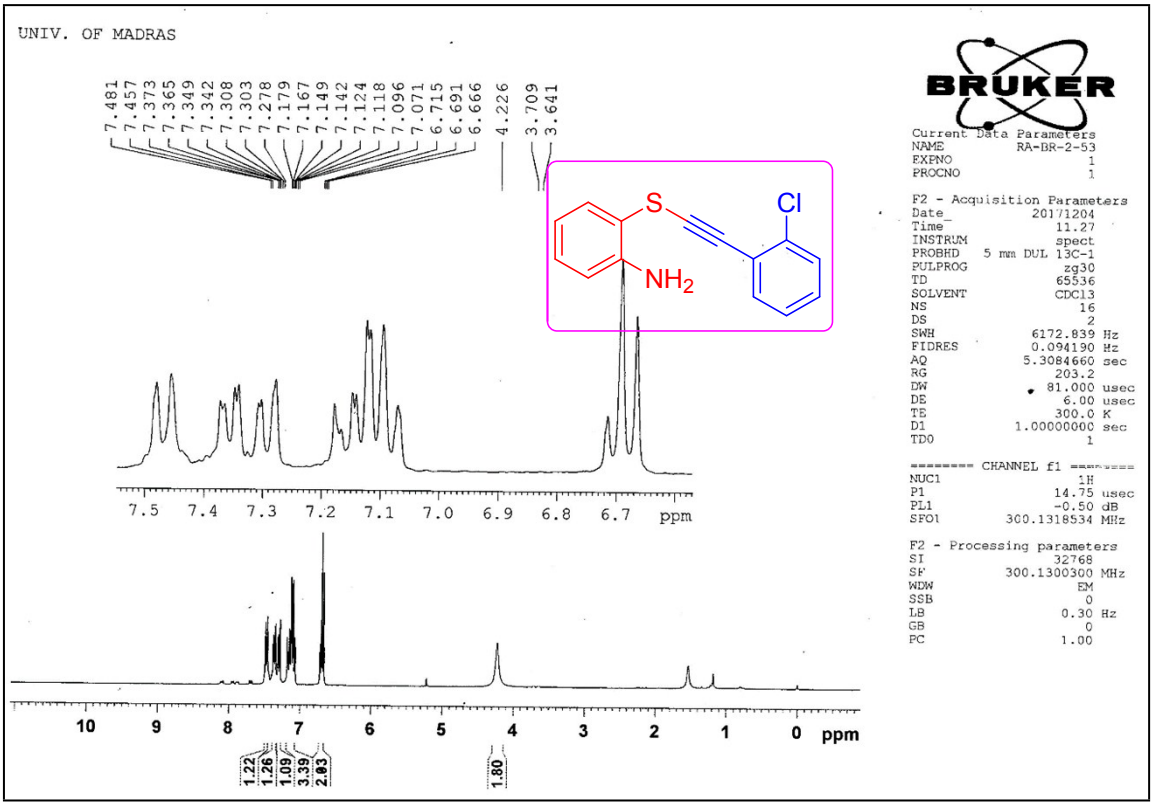


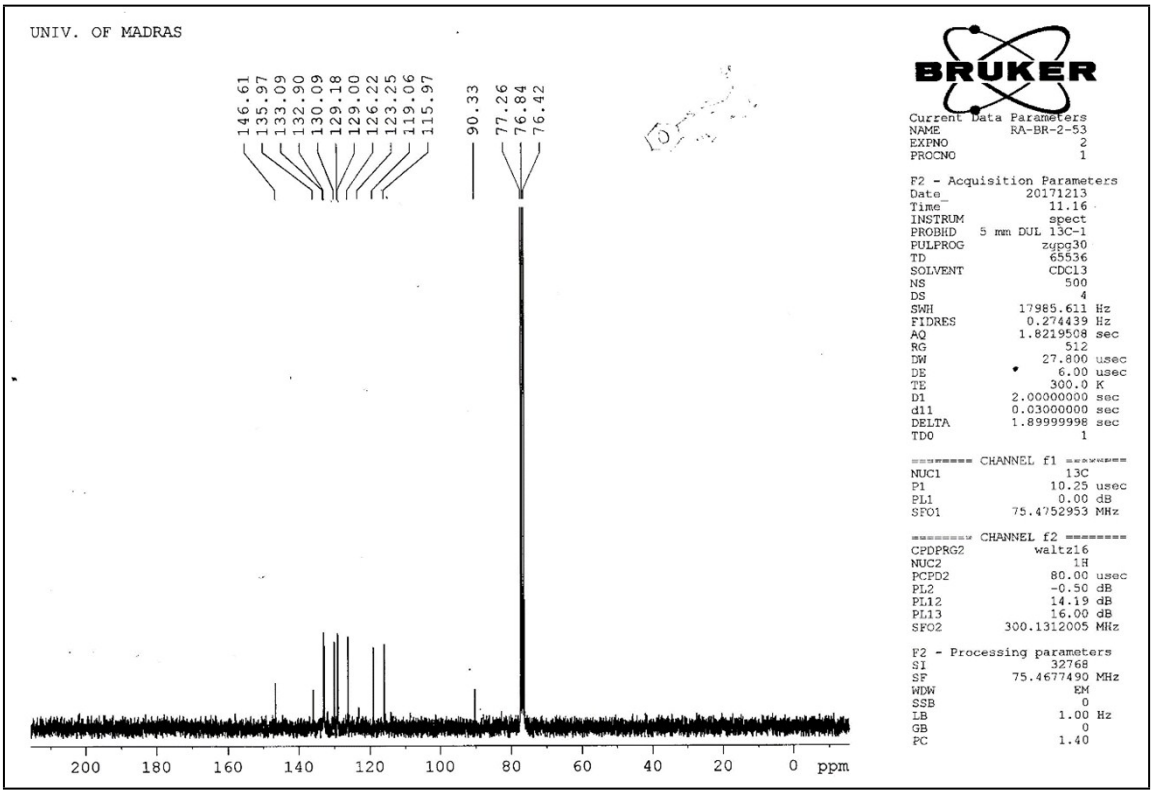
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ad



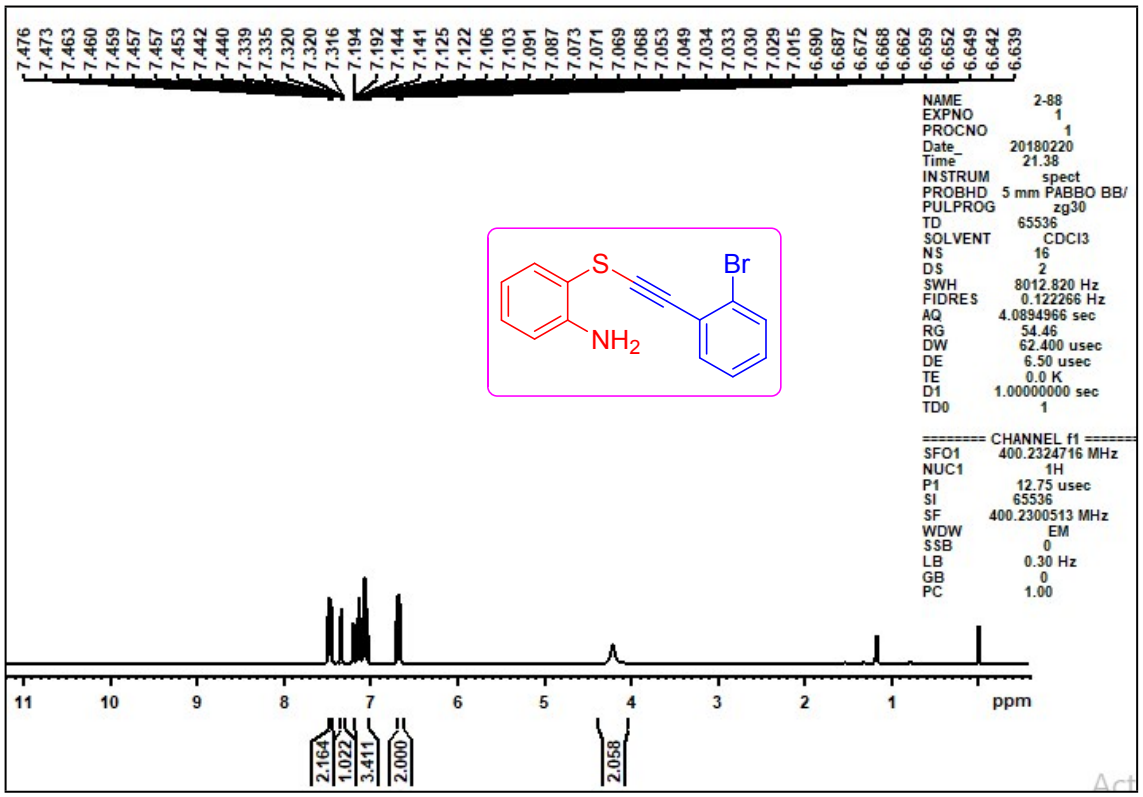


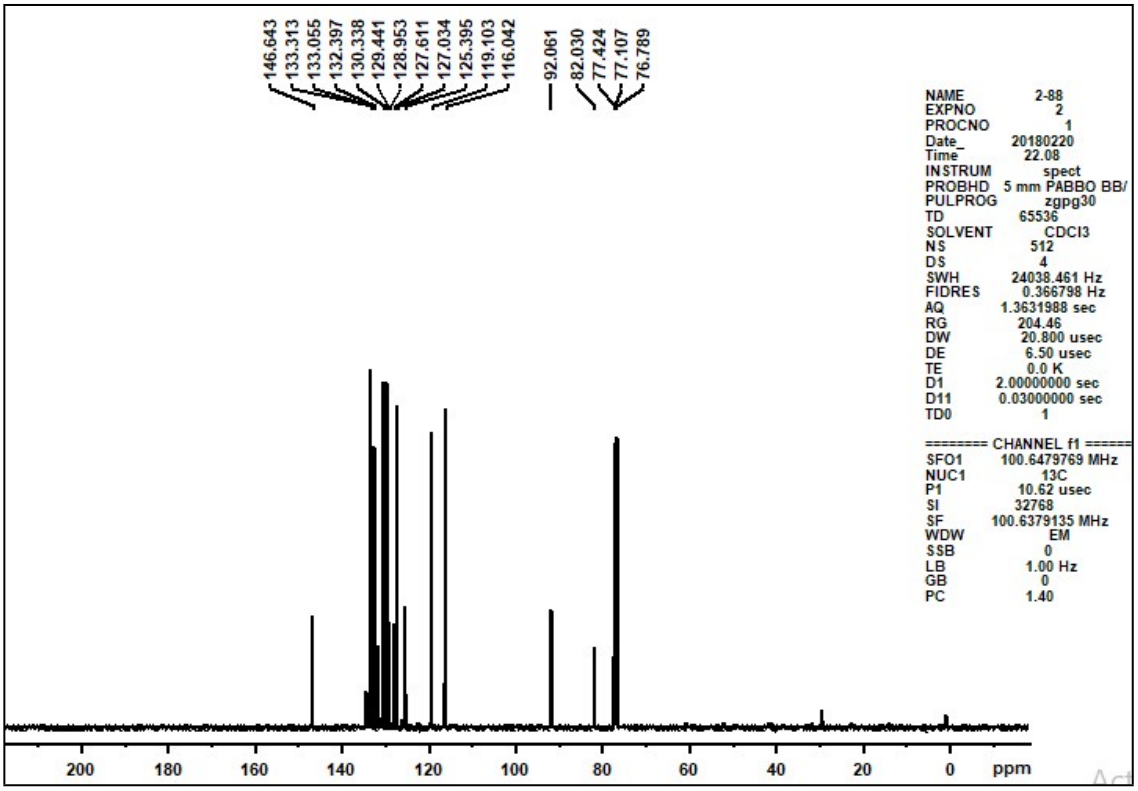
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ae



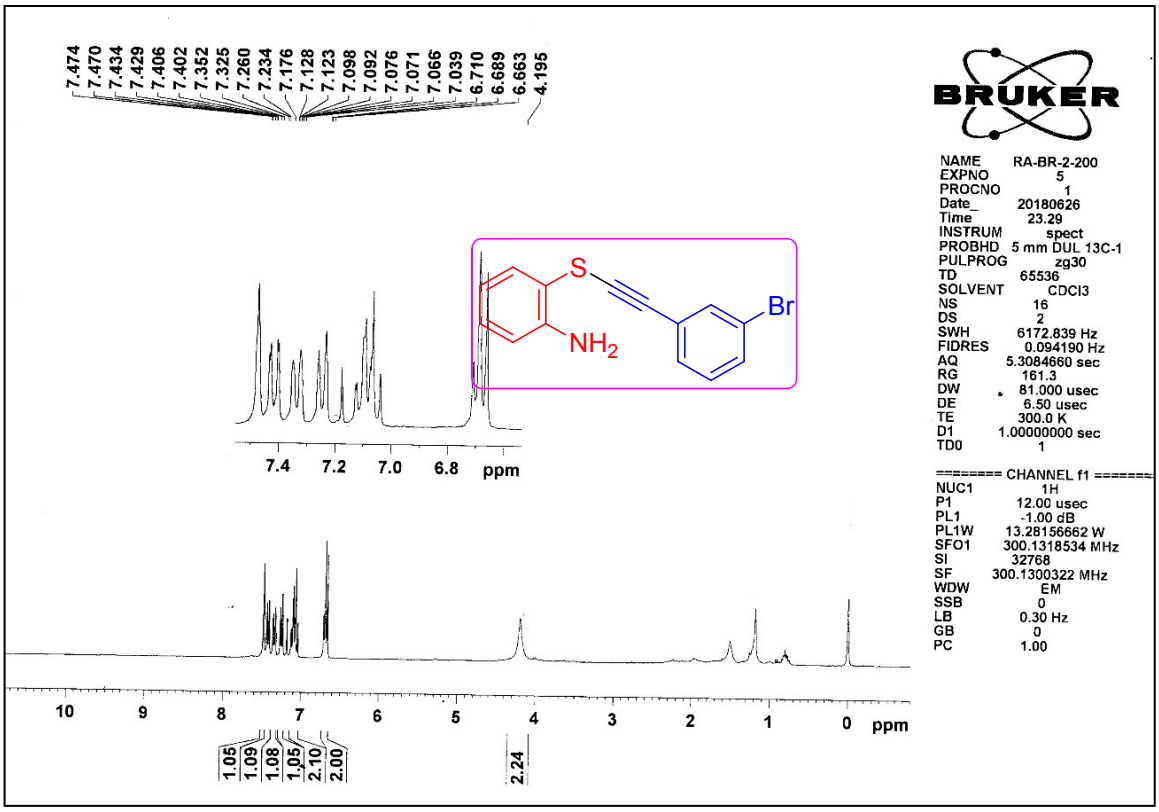


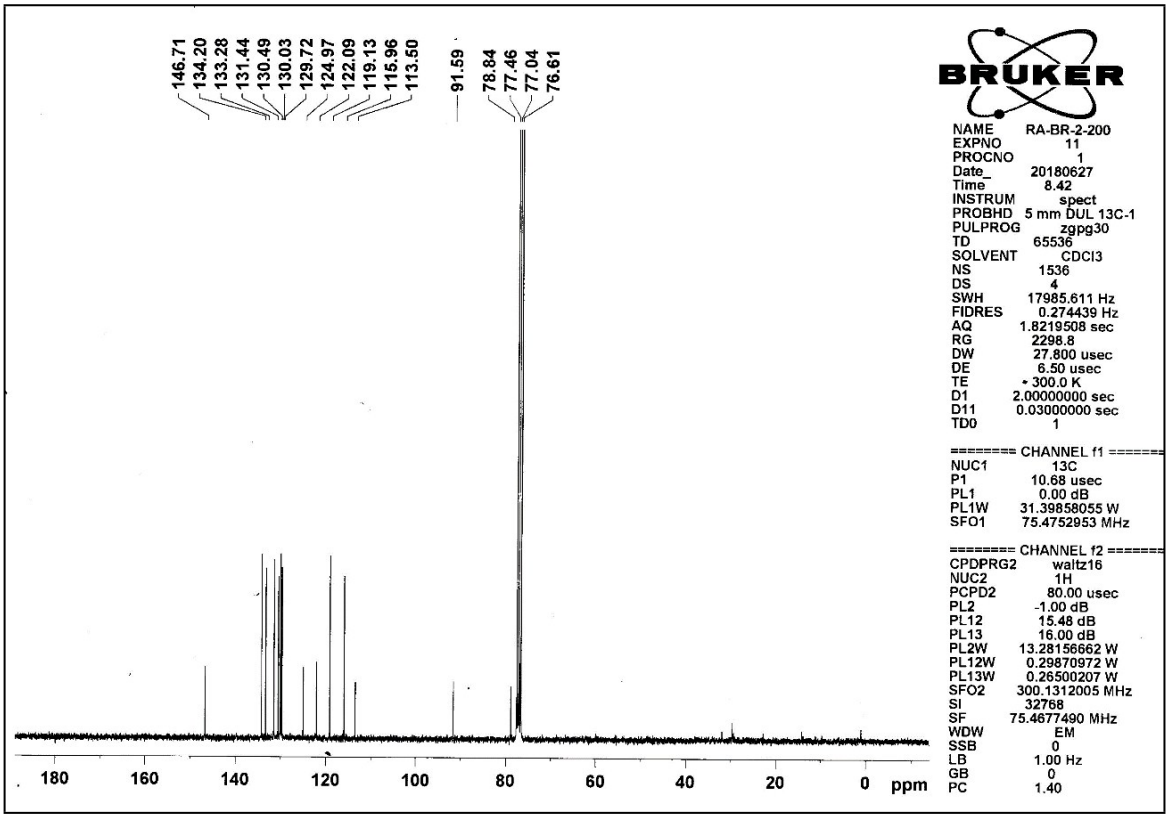
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3af



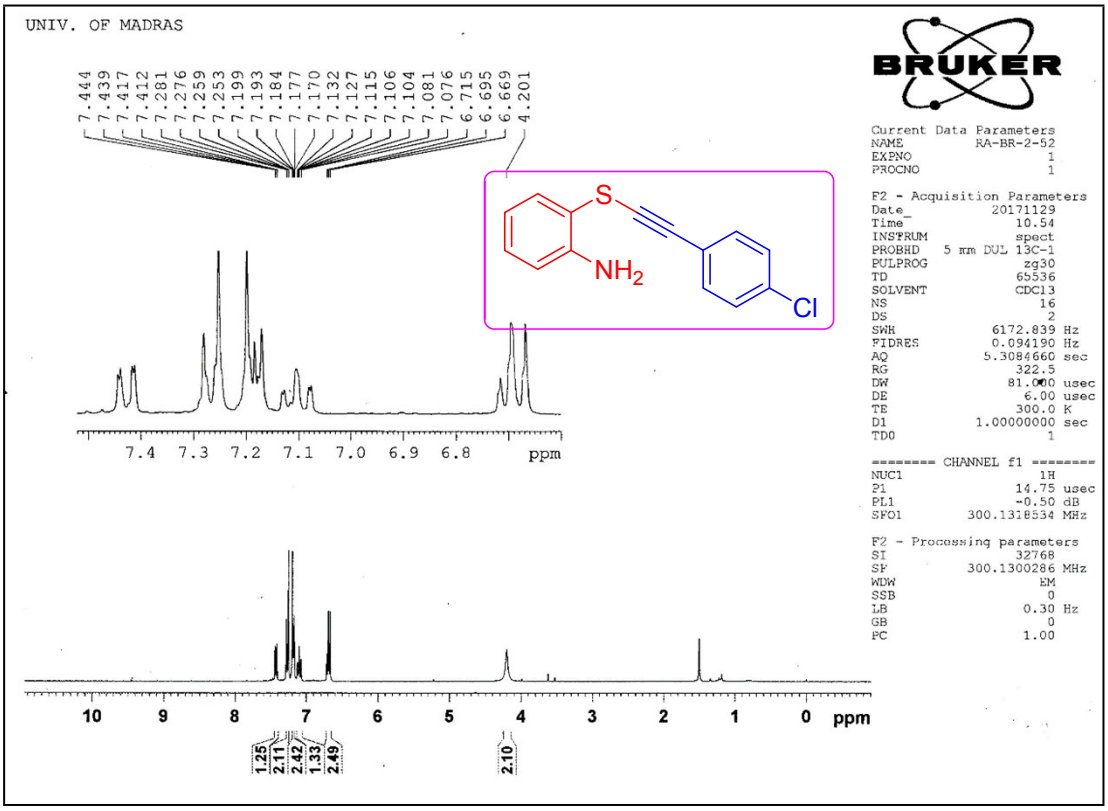


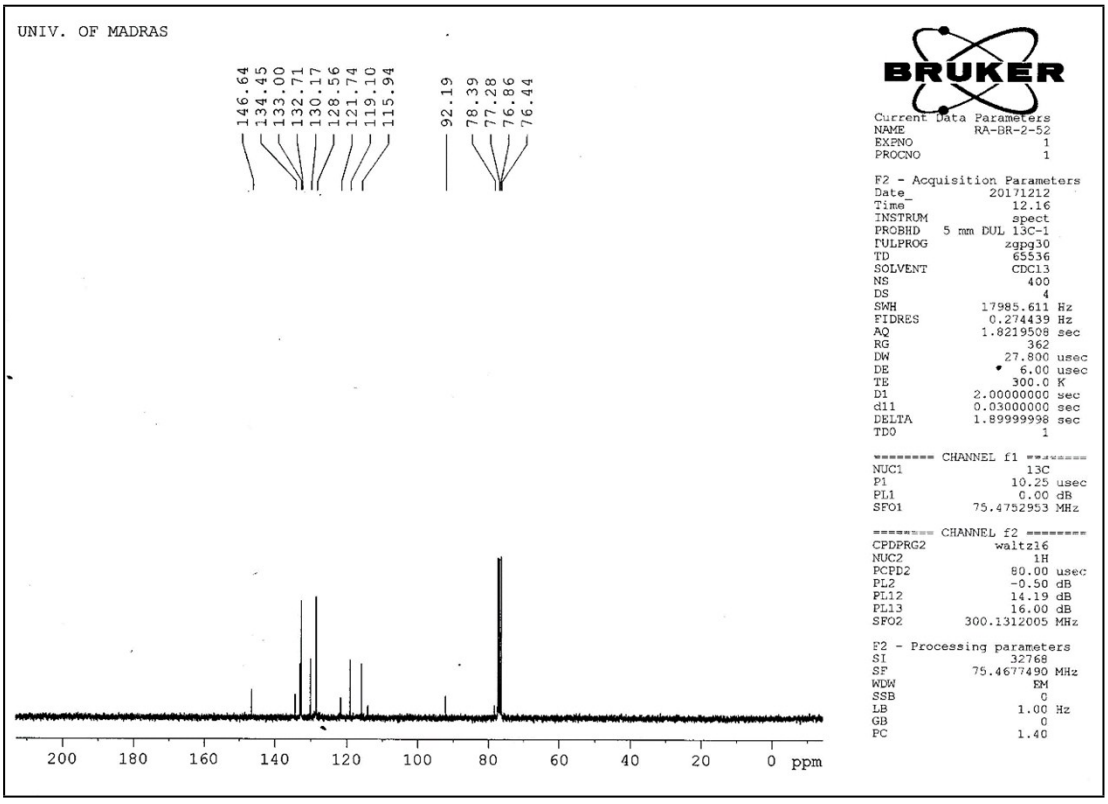
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ag



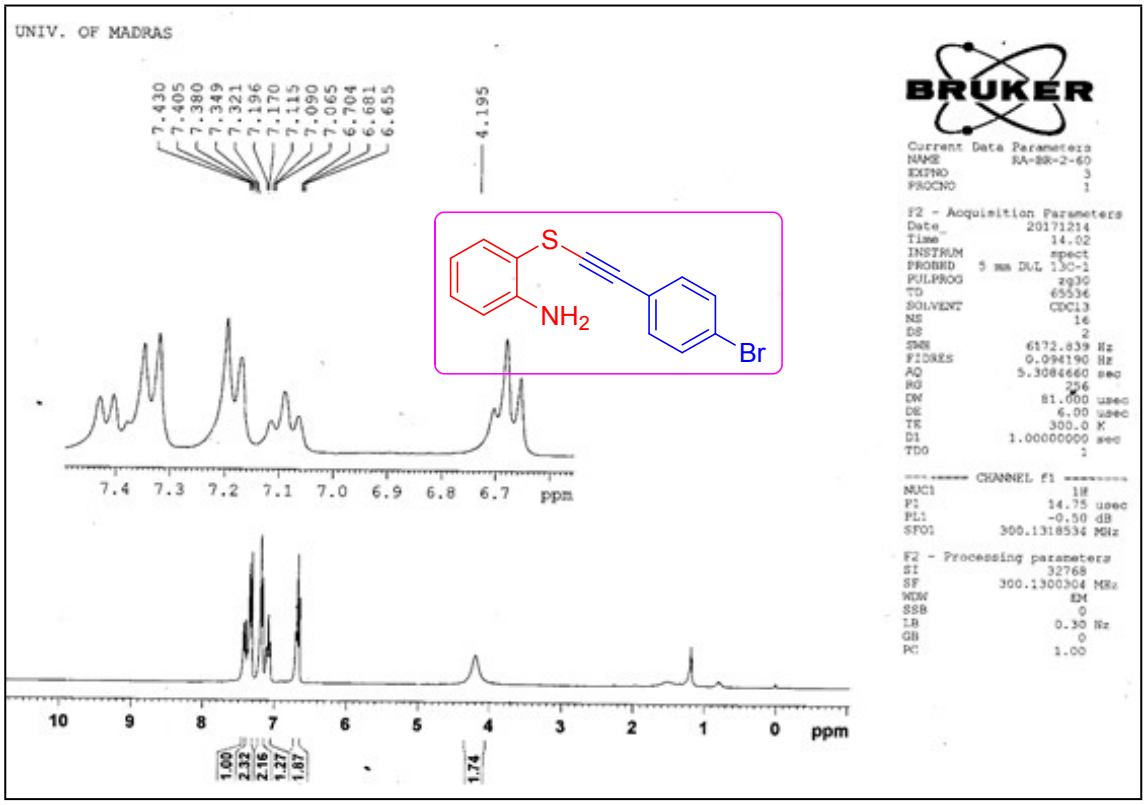


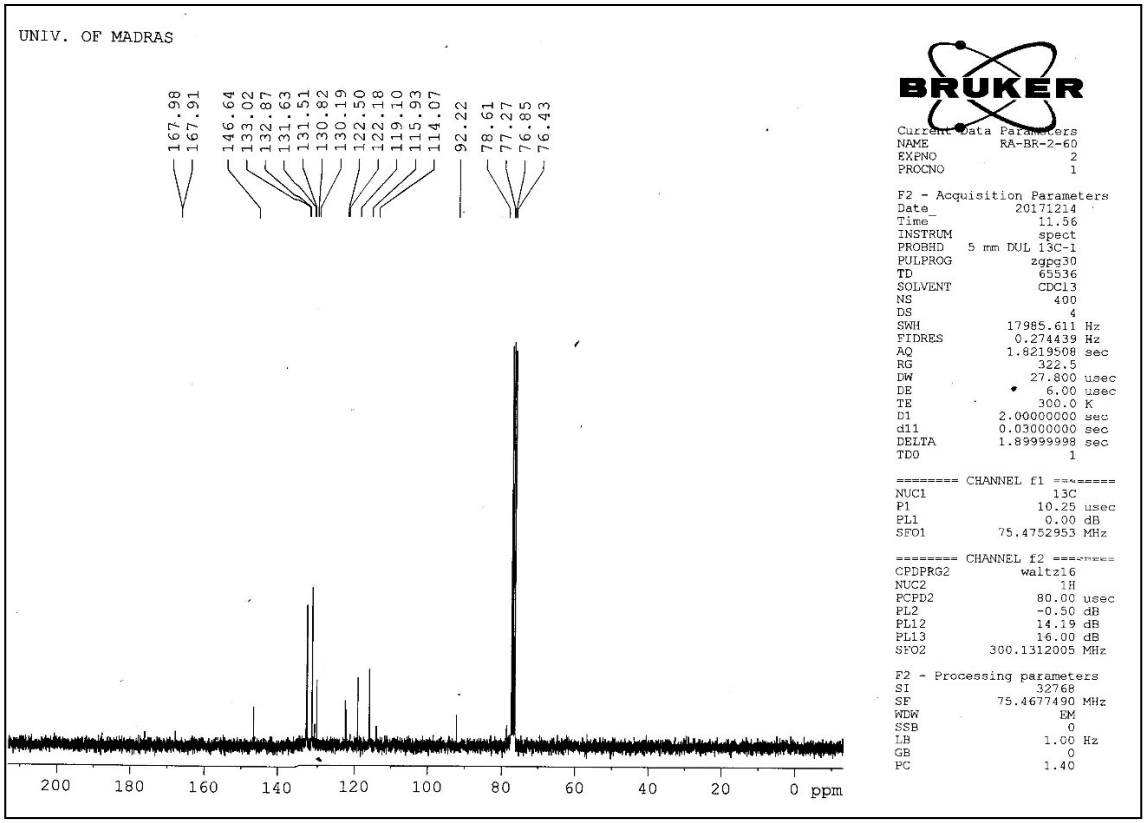
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ah



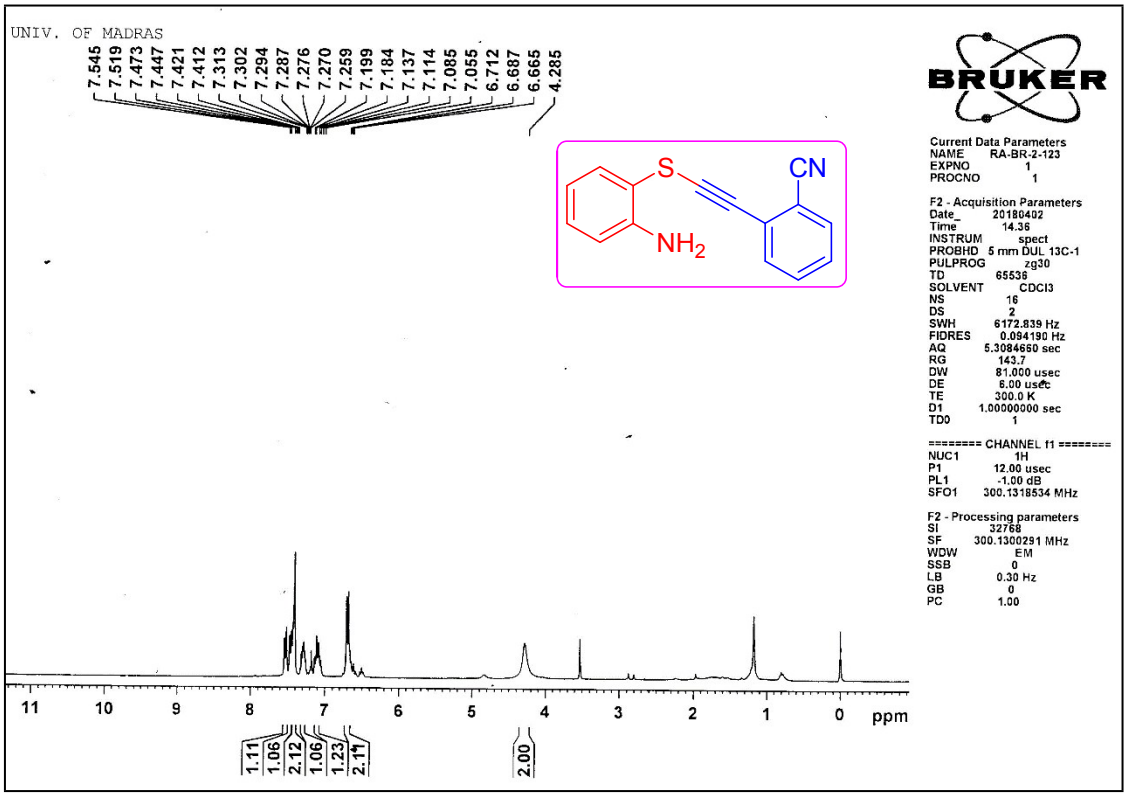


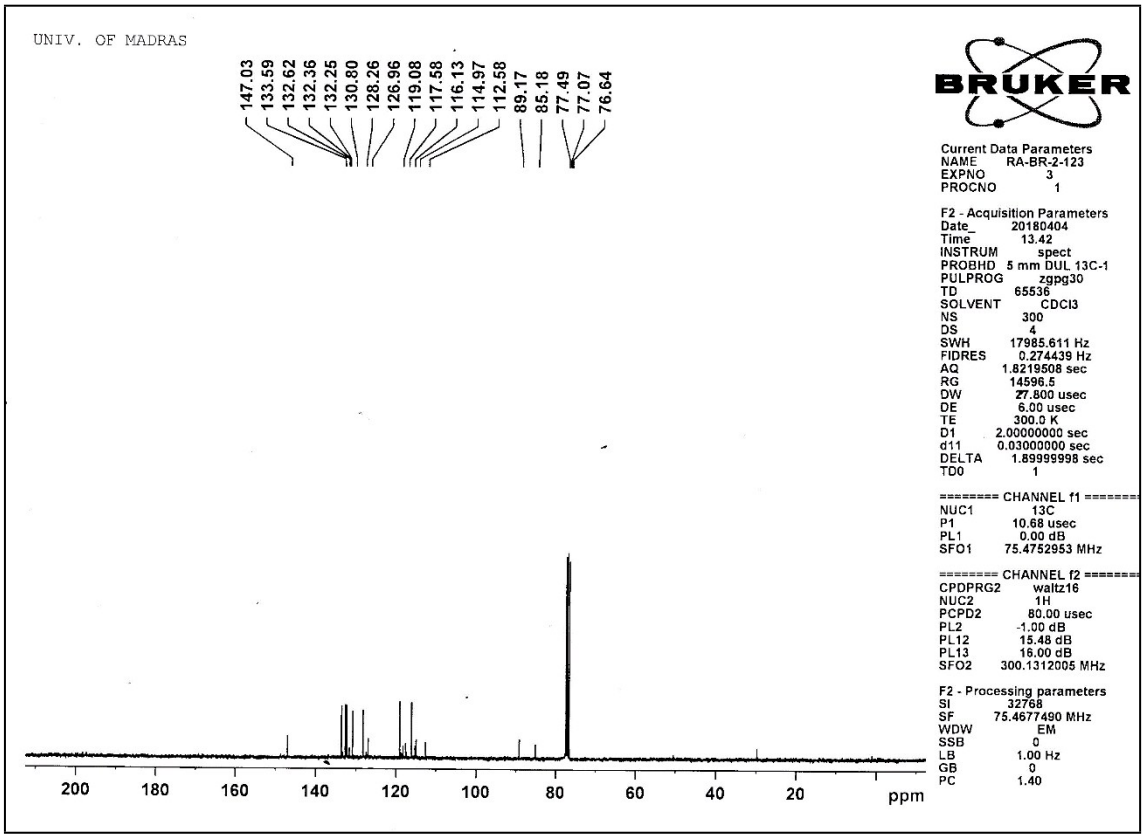
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ai



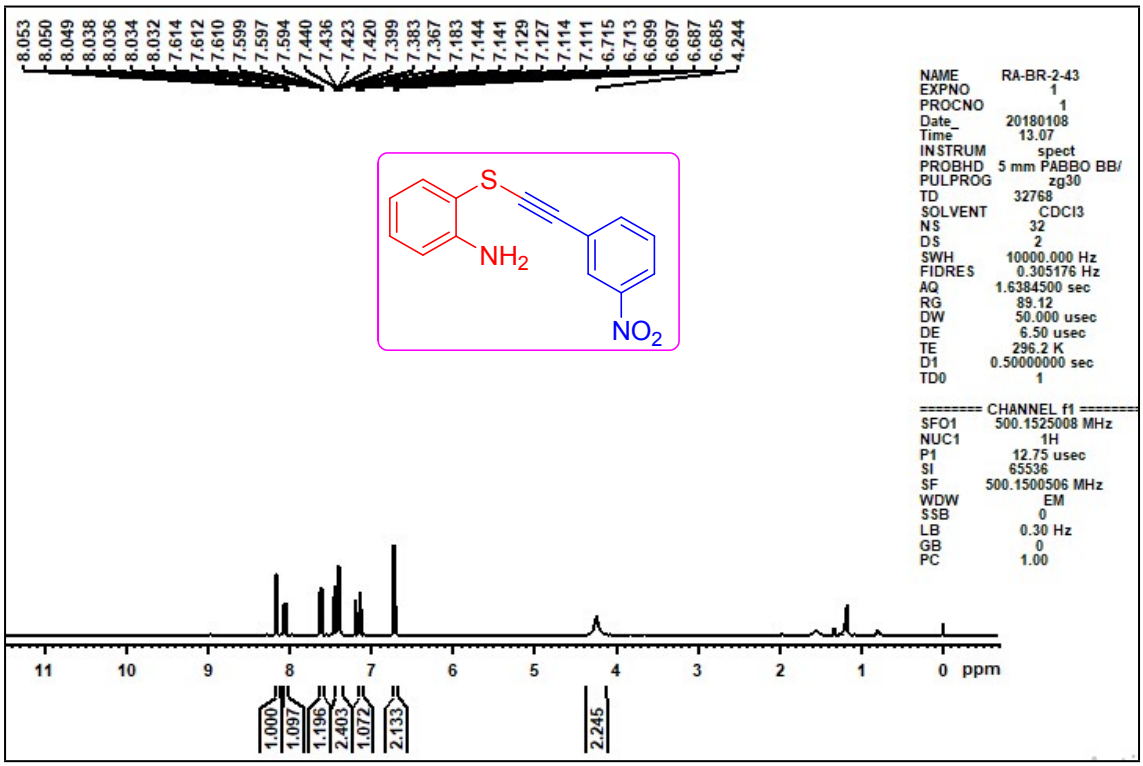


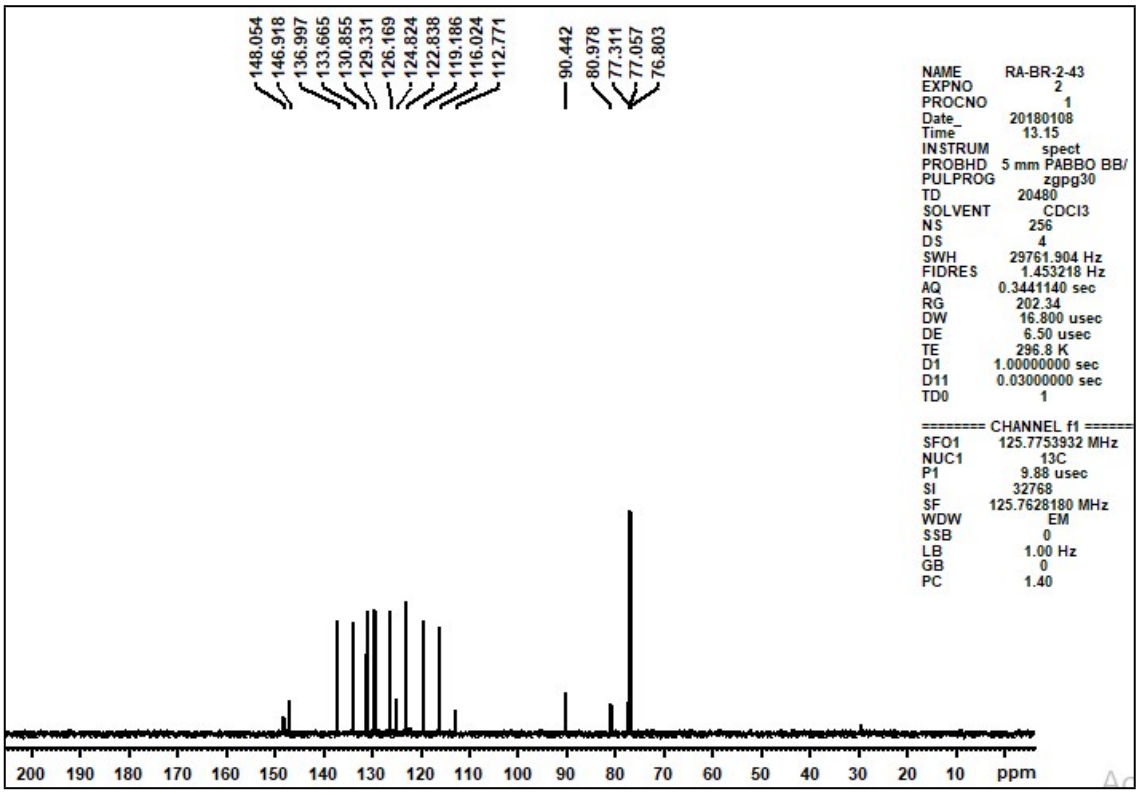
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3aj



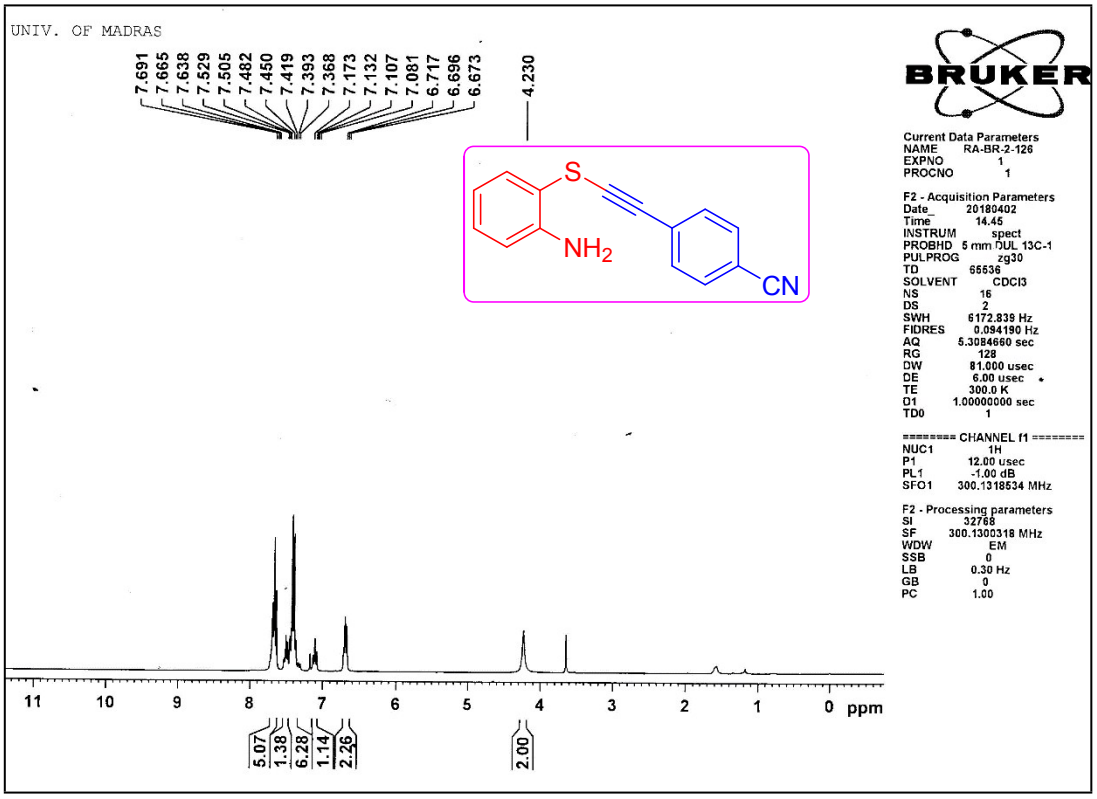


^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ak





^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3al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D1 1.00000000 sec
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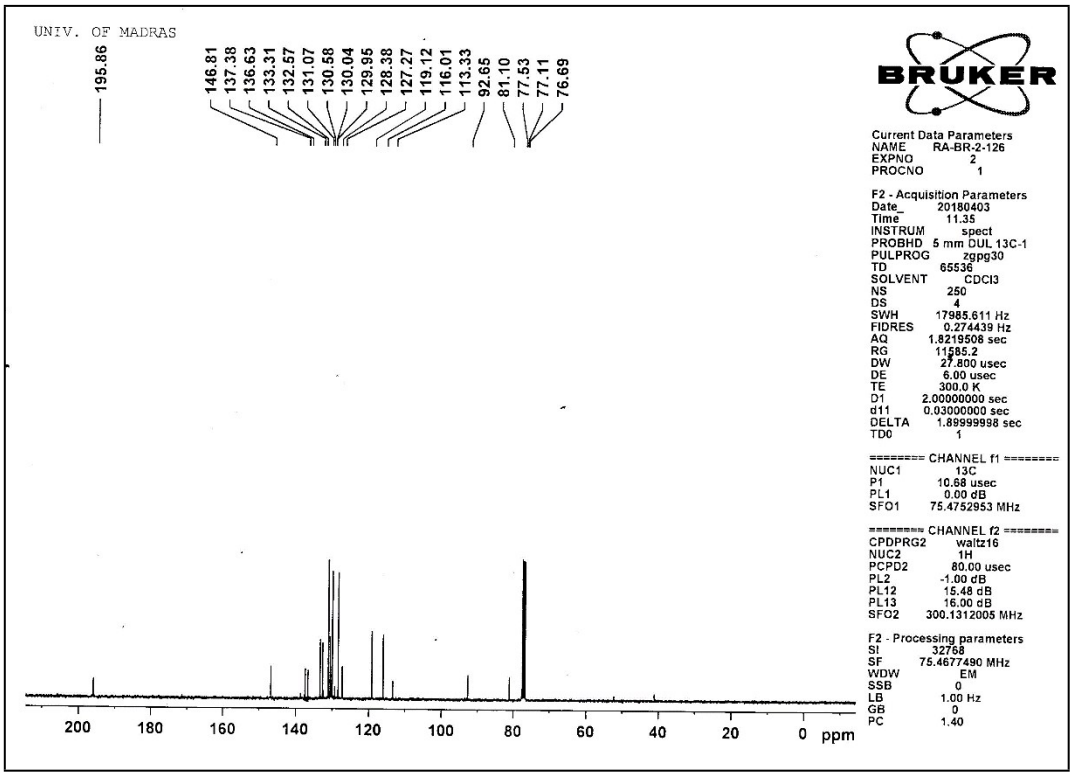
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PL13 16.00 dB
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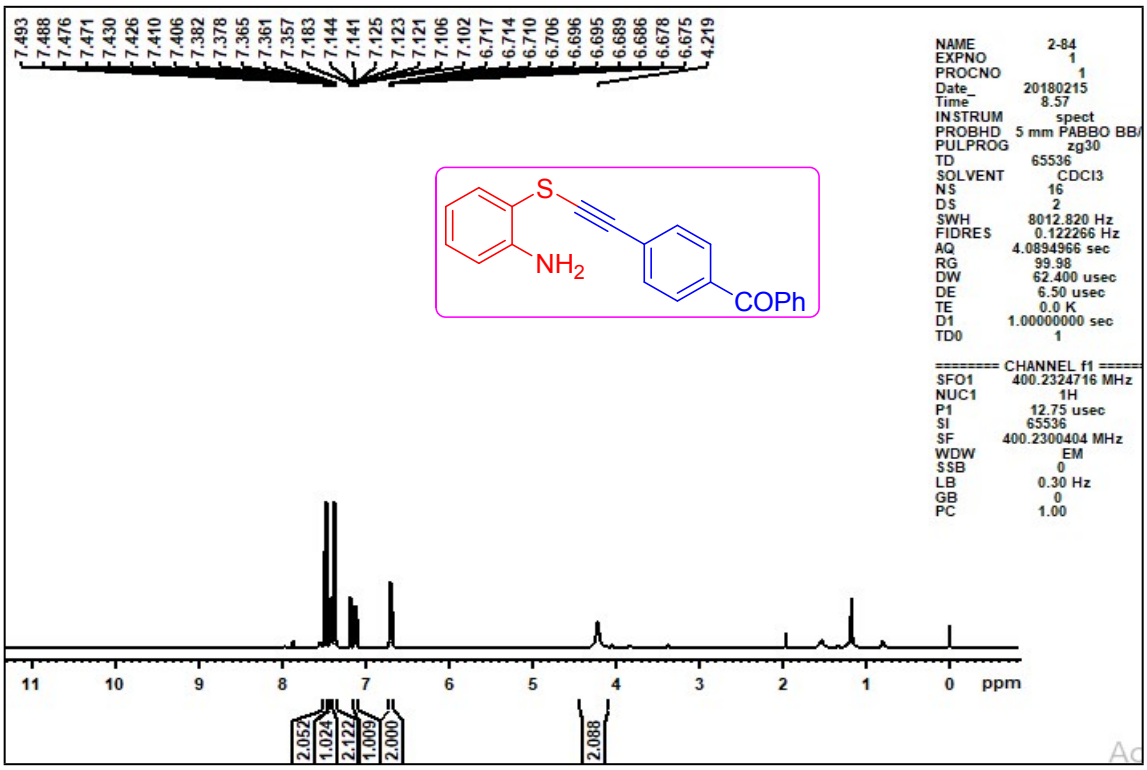
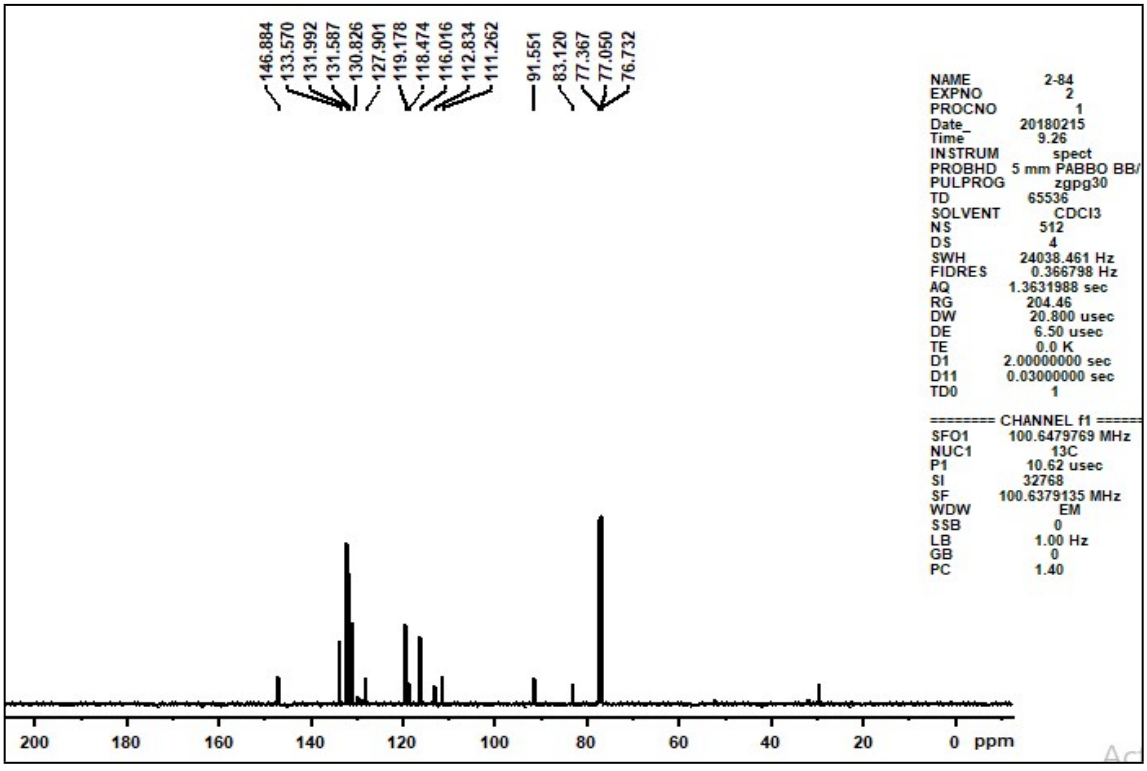
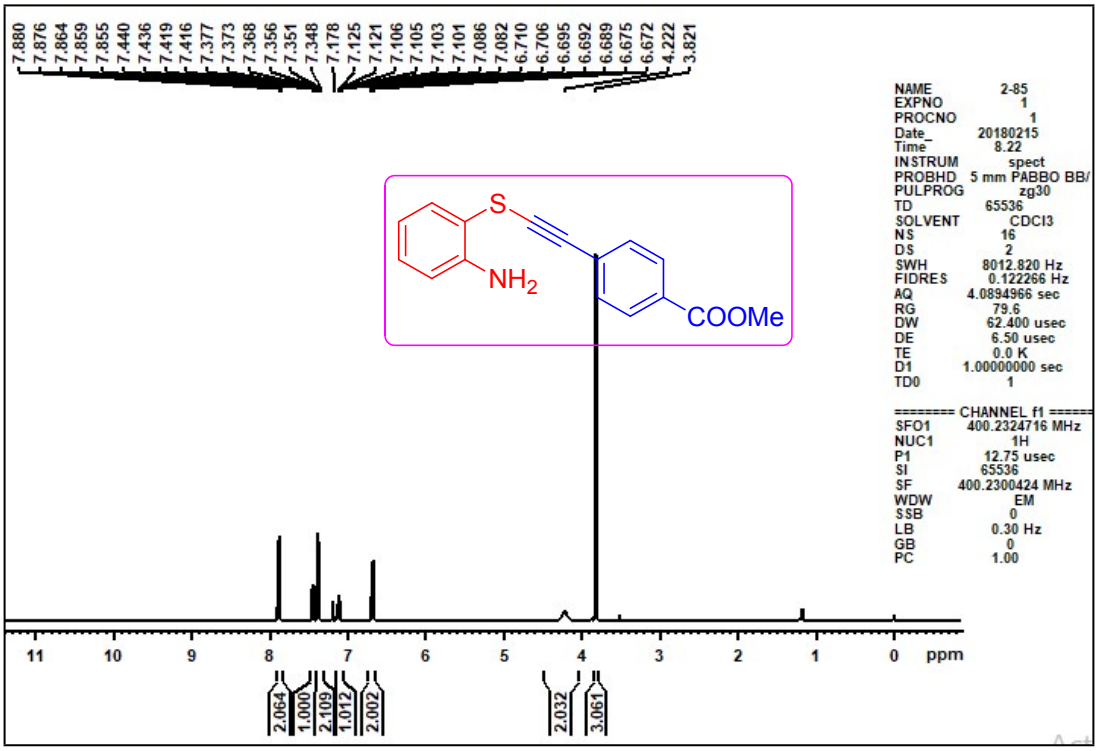
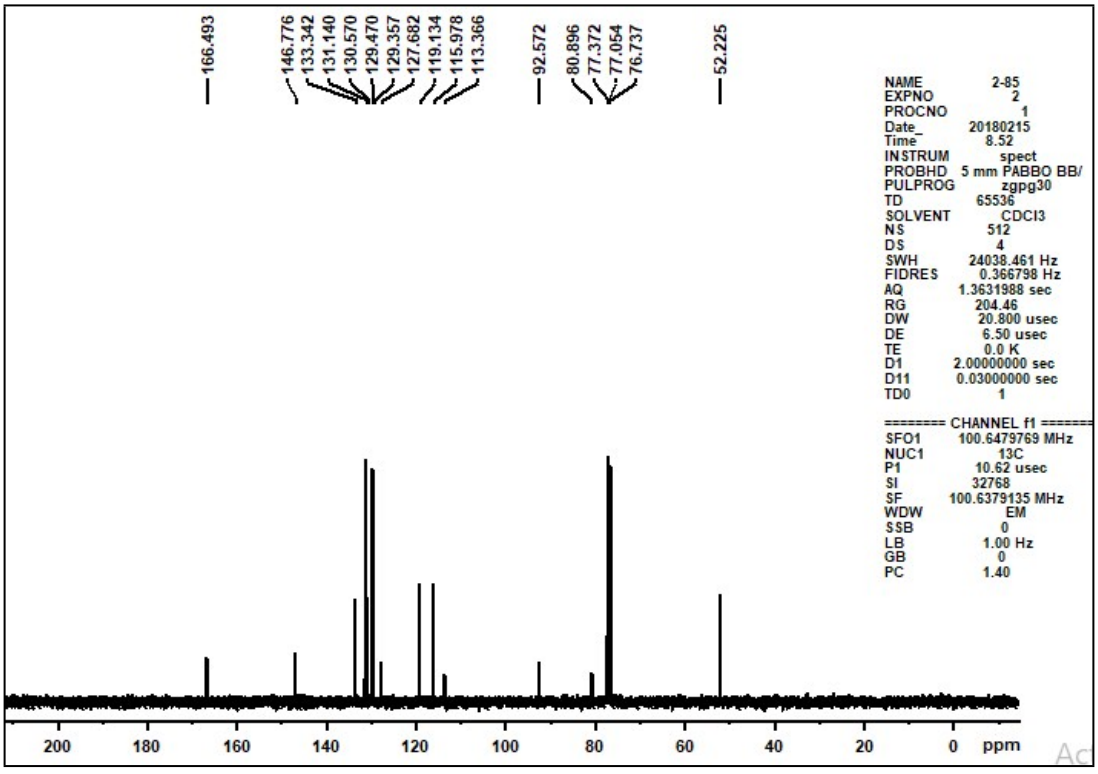
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3am



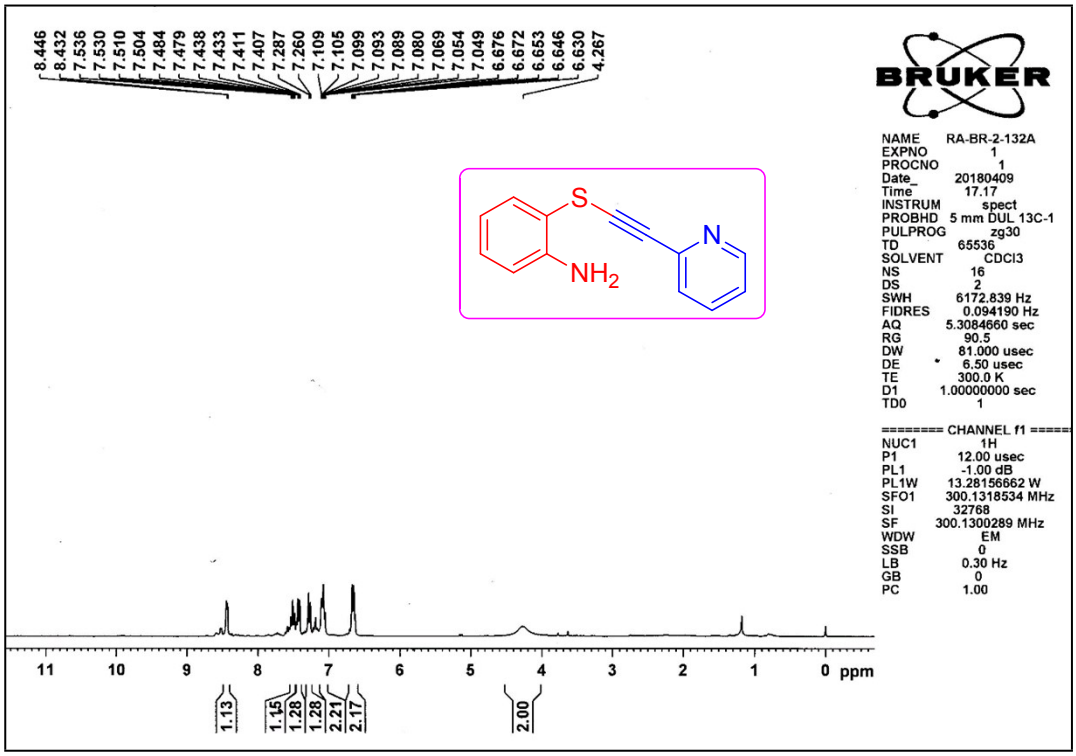


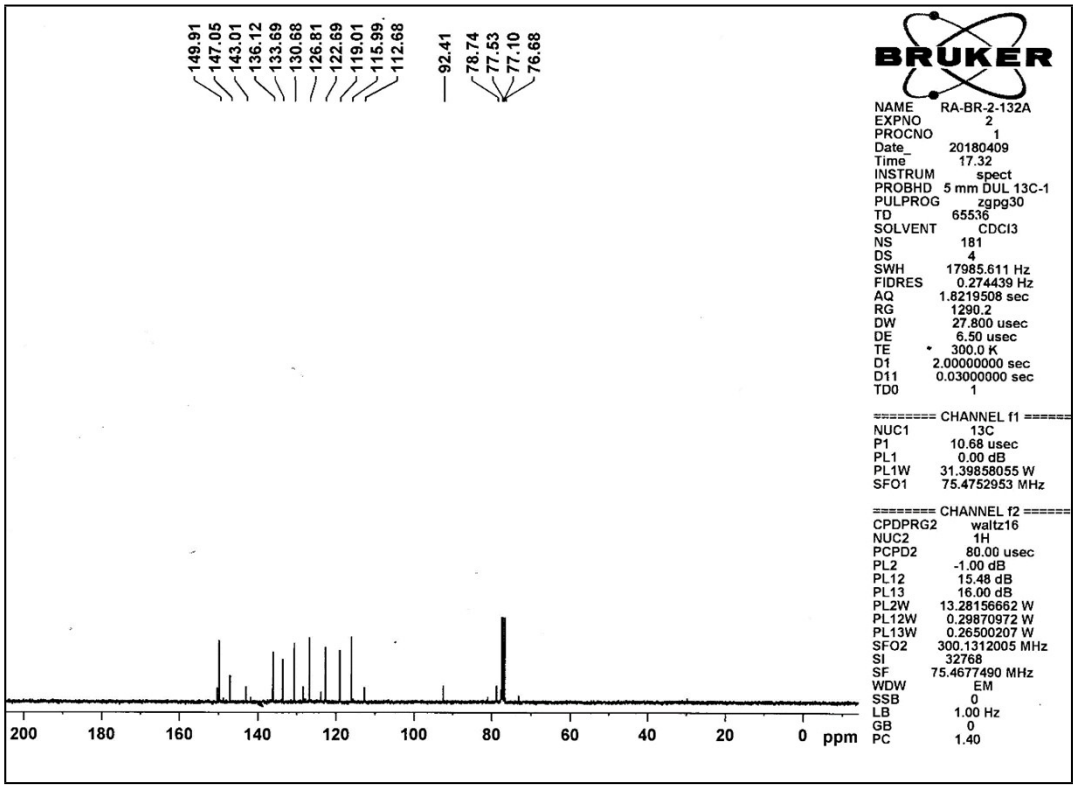
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3an



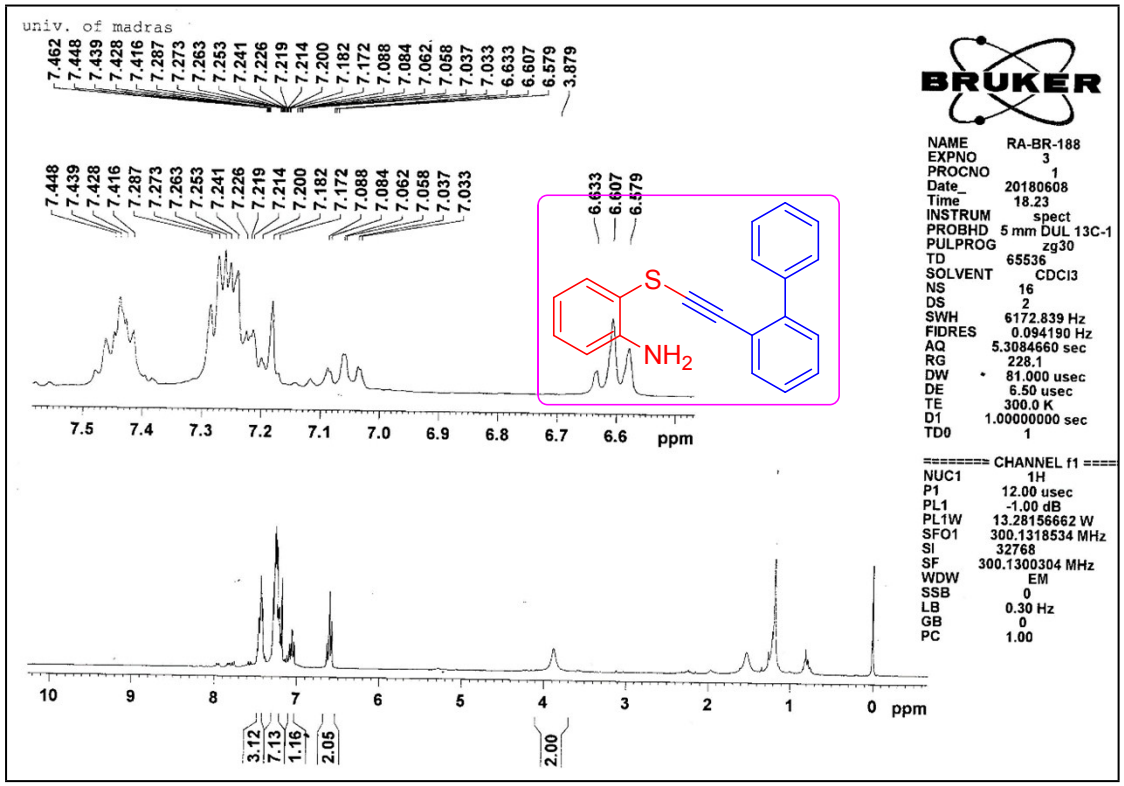


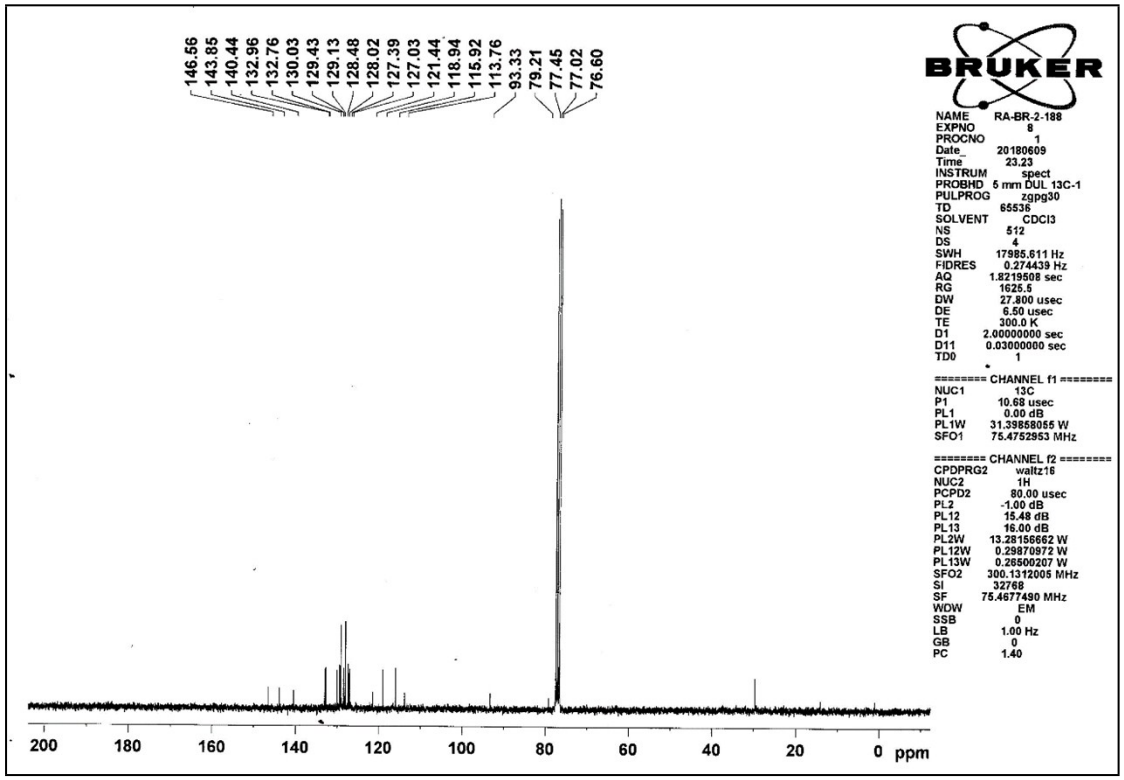
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ao



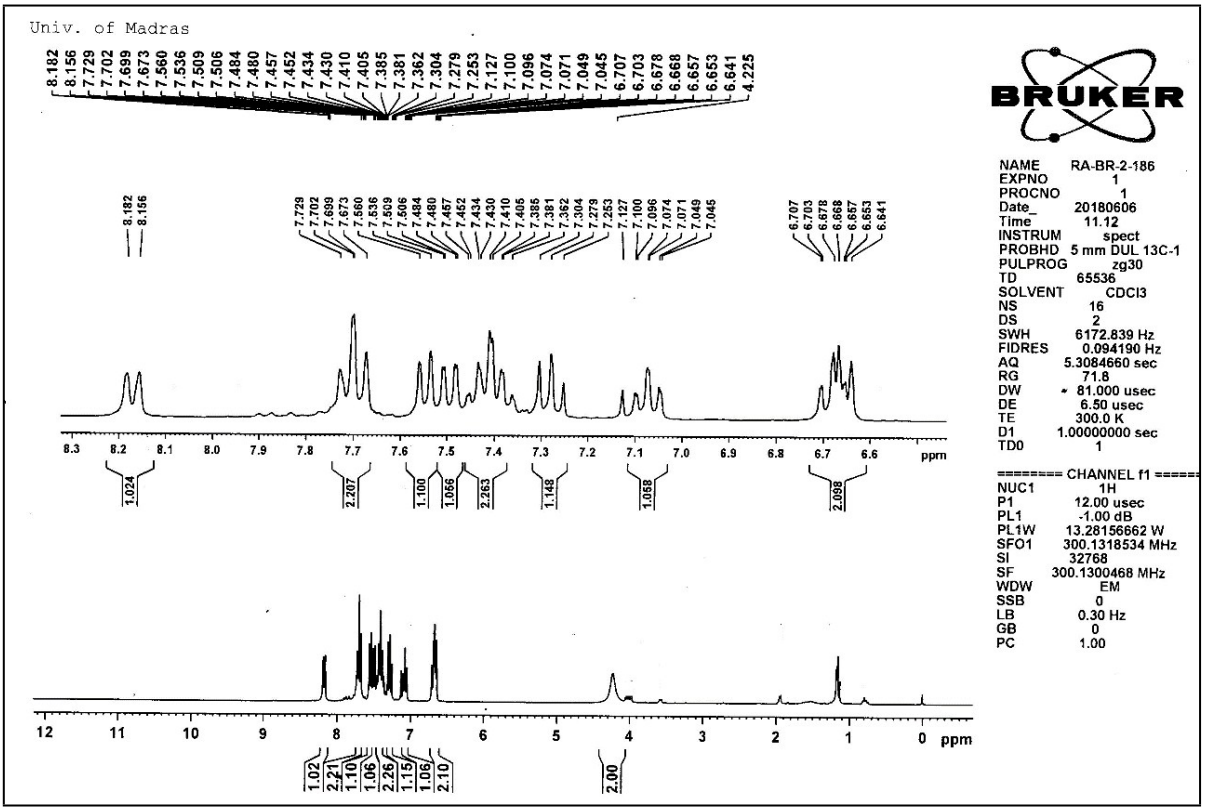


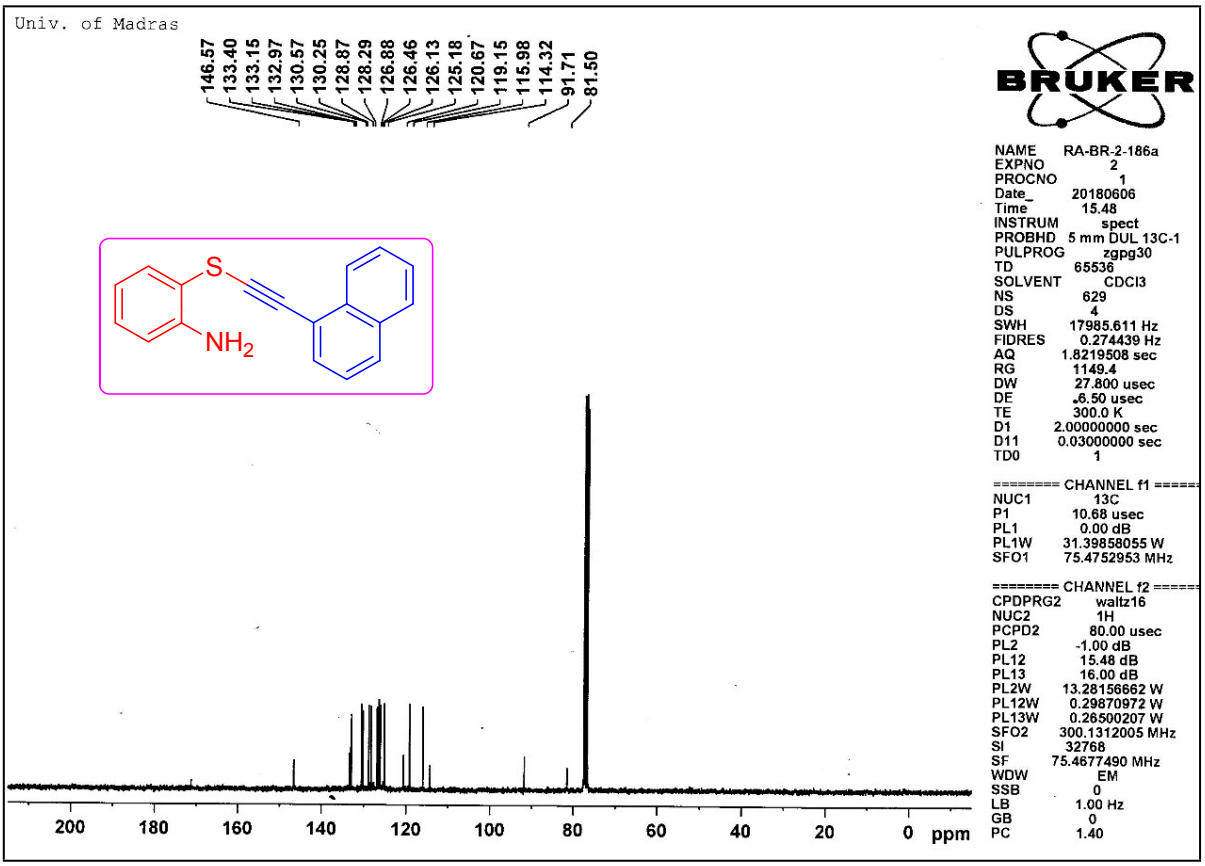
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ap



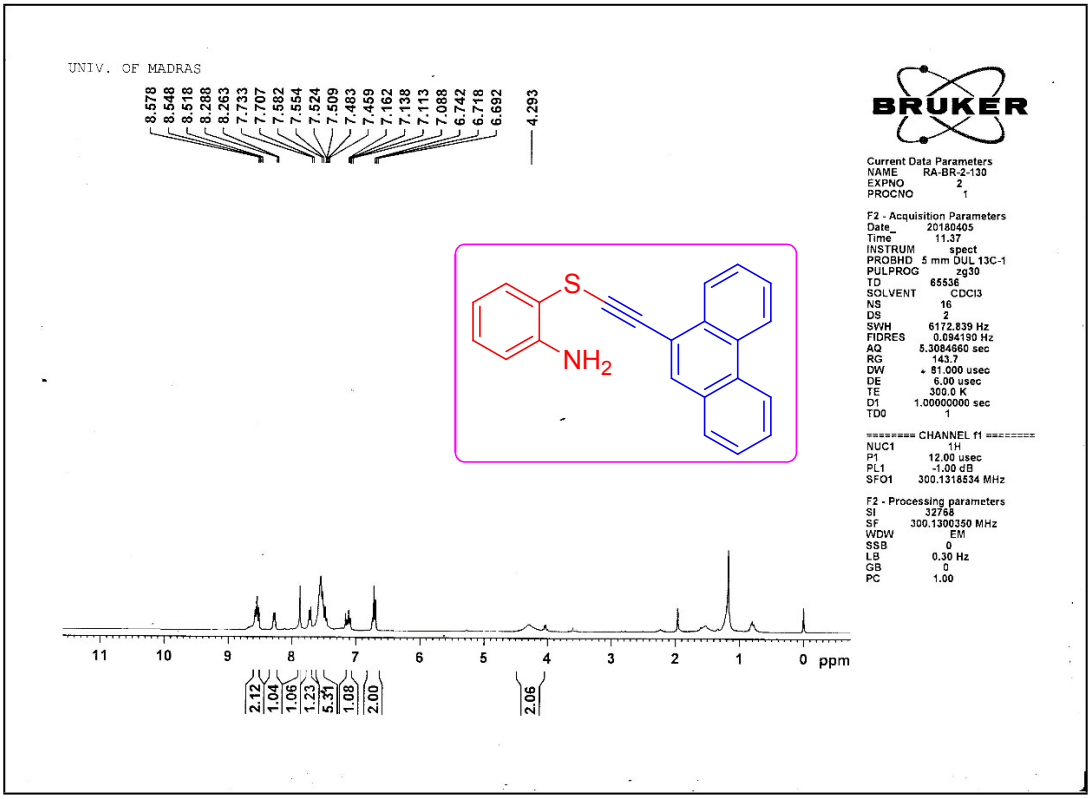


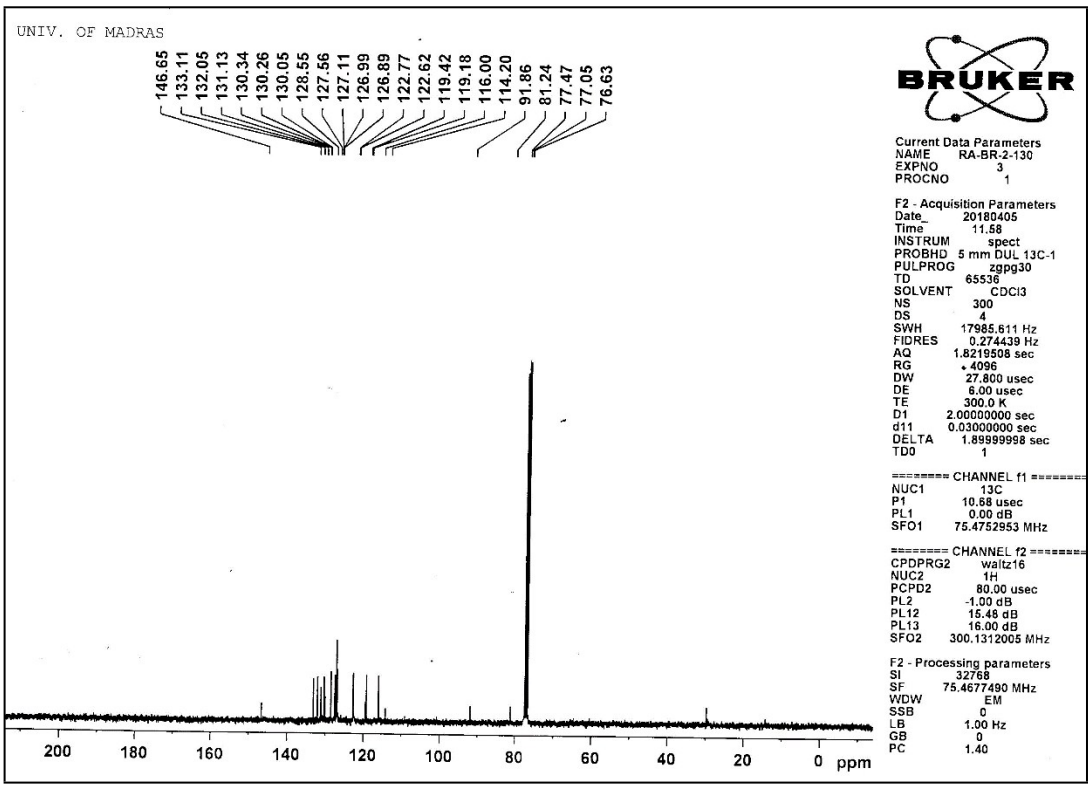
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3aq



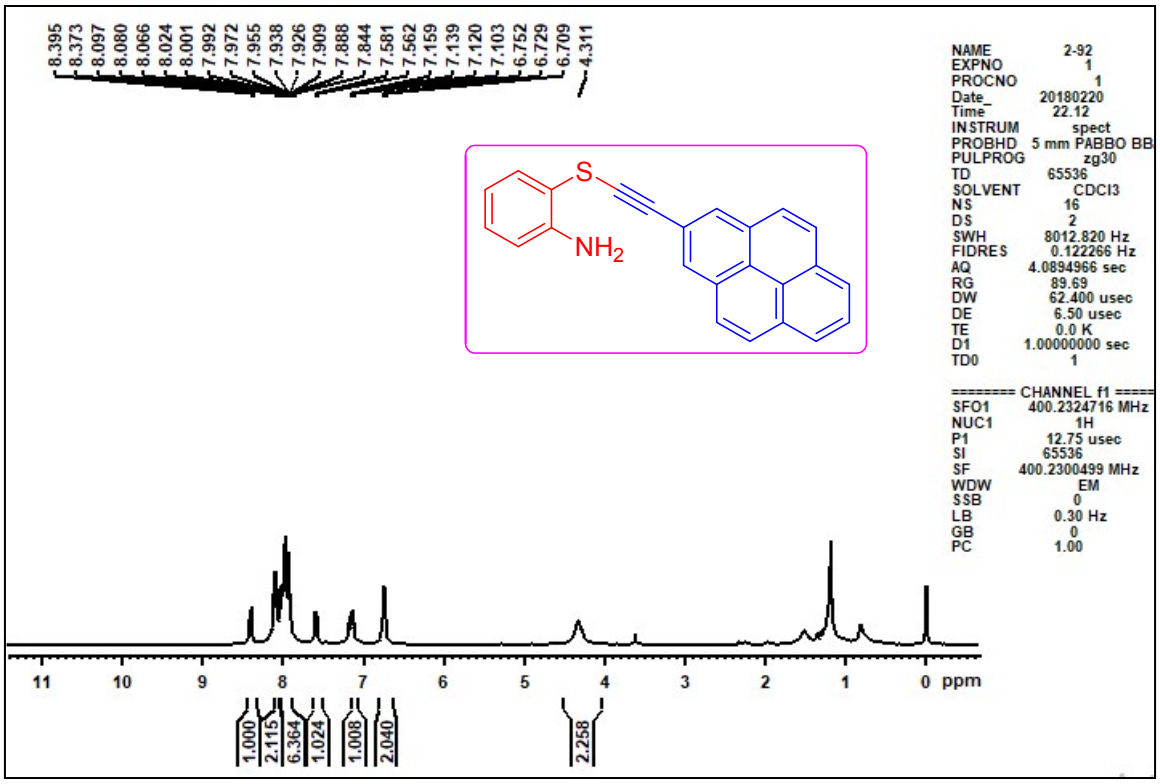


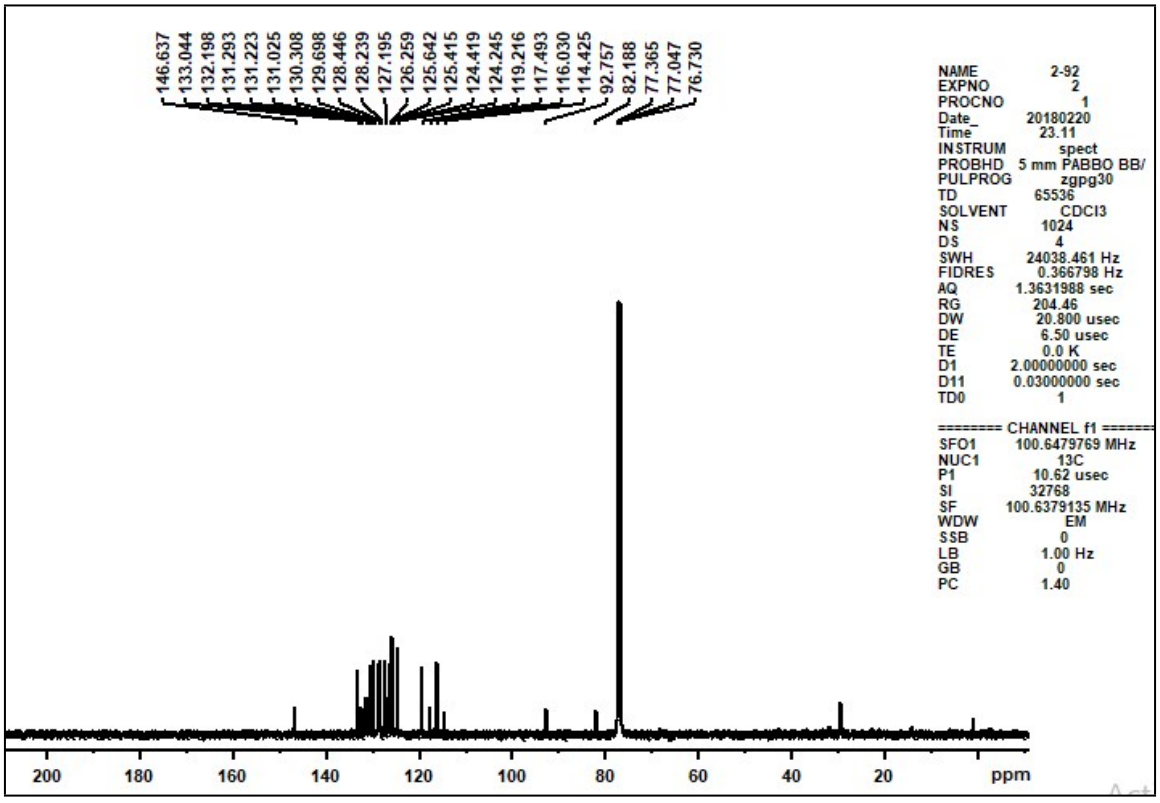
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ar



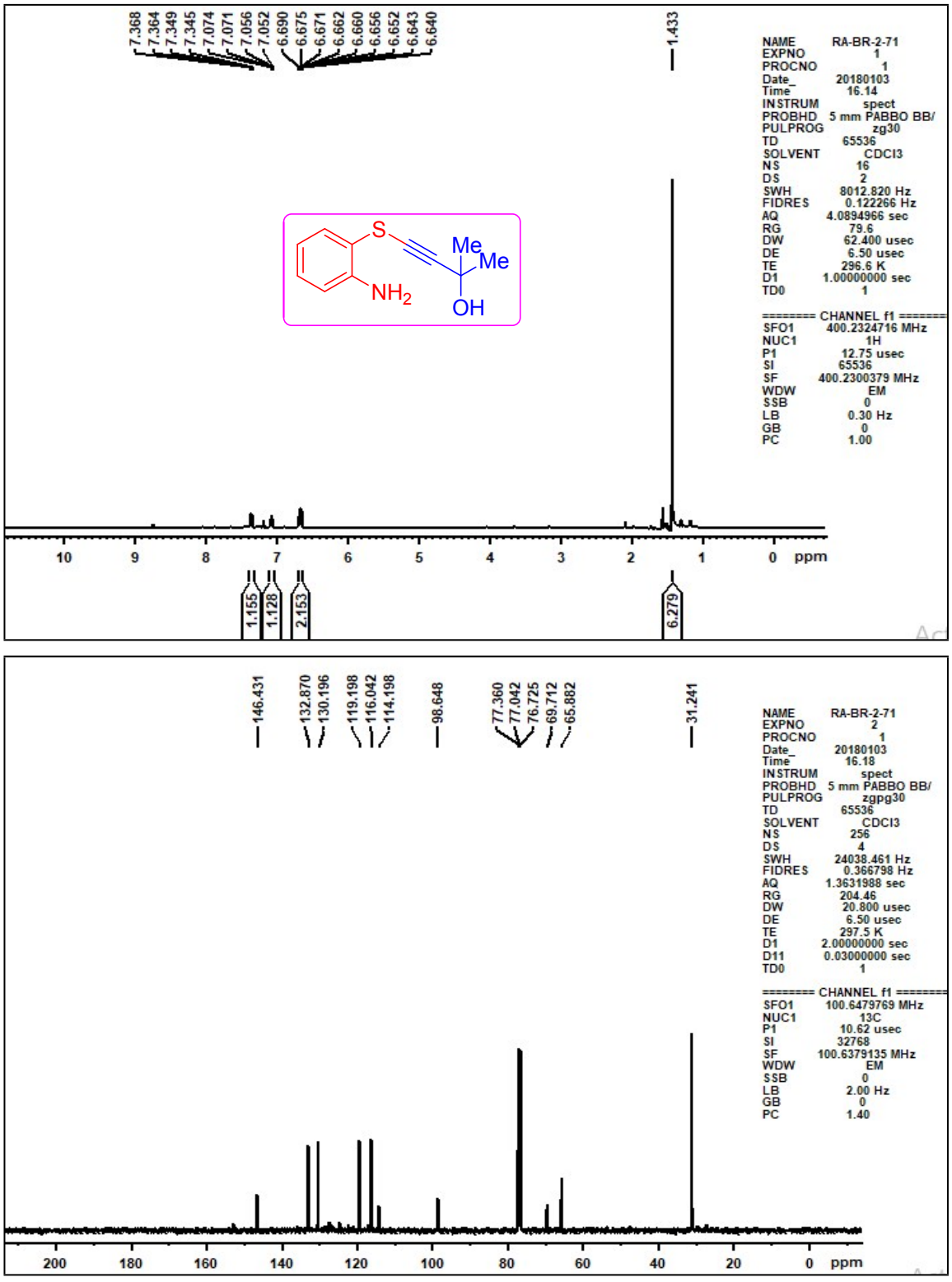


^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3as

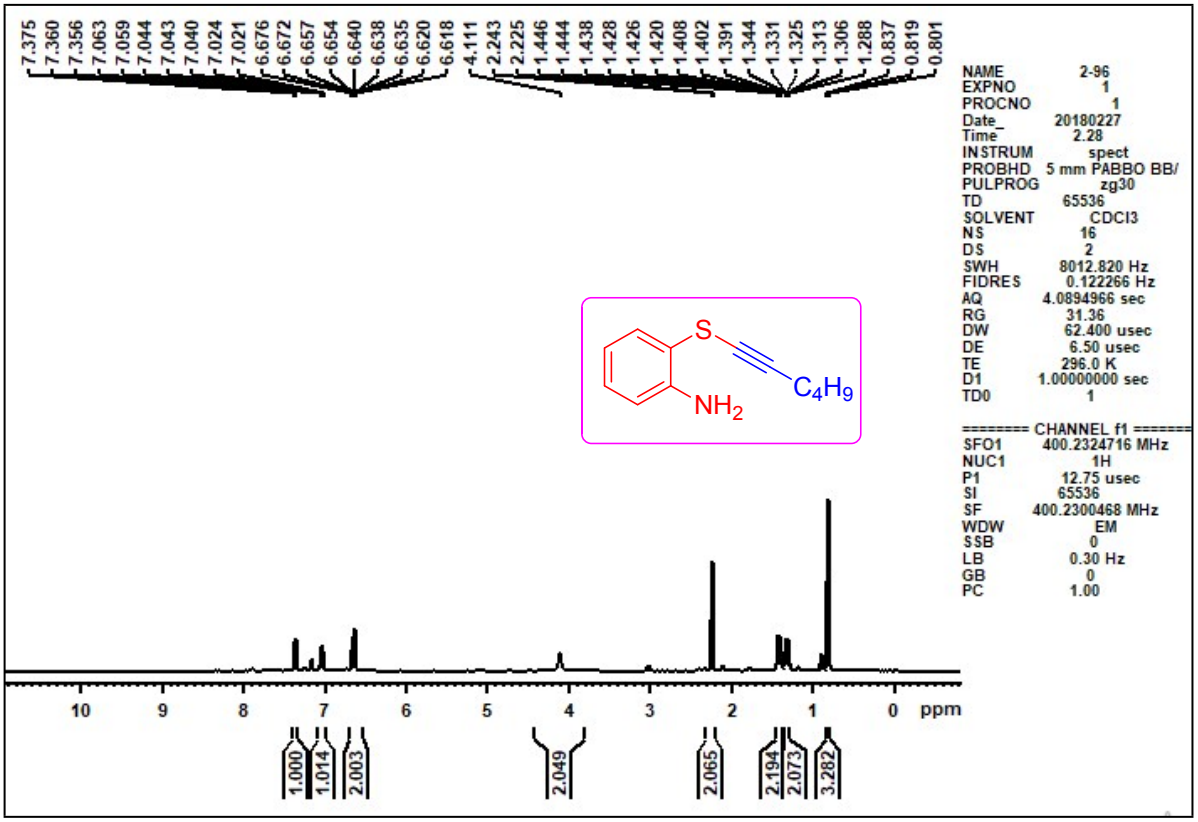


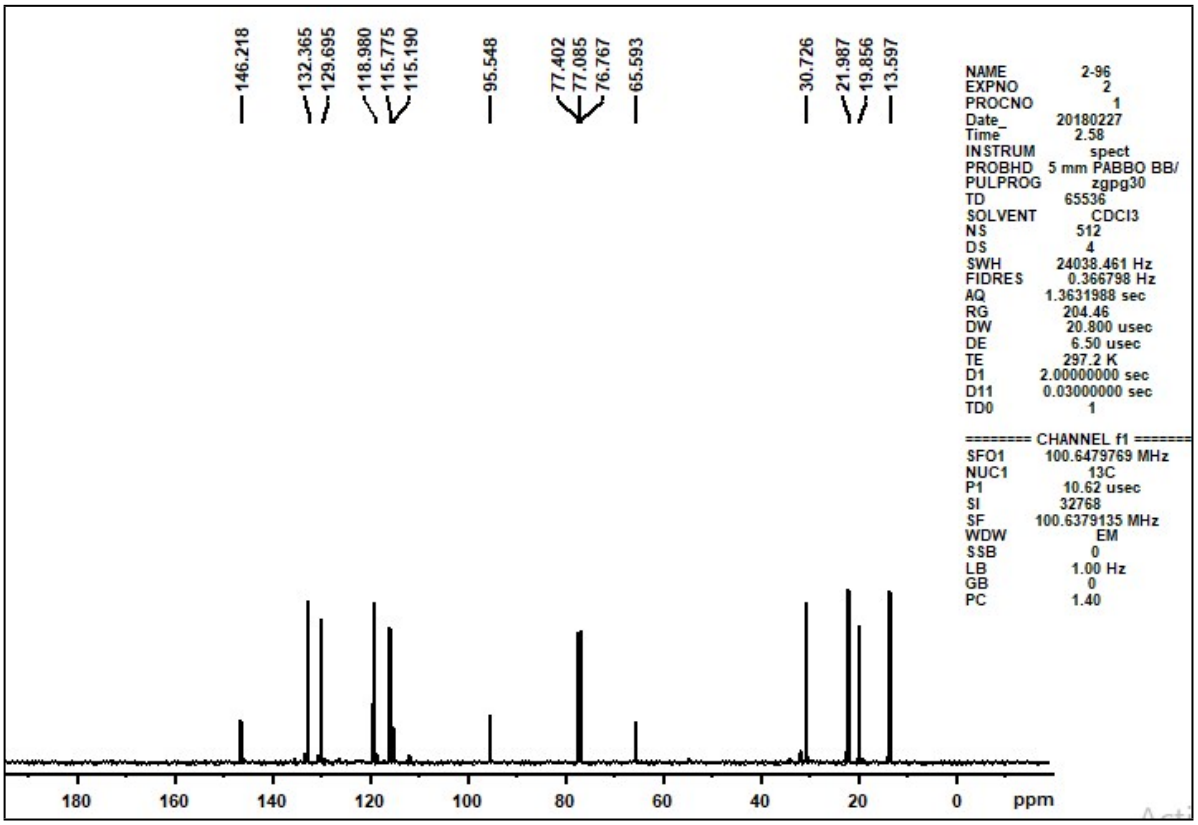


^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3at

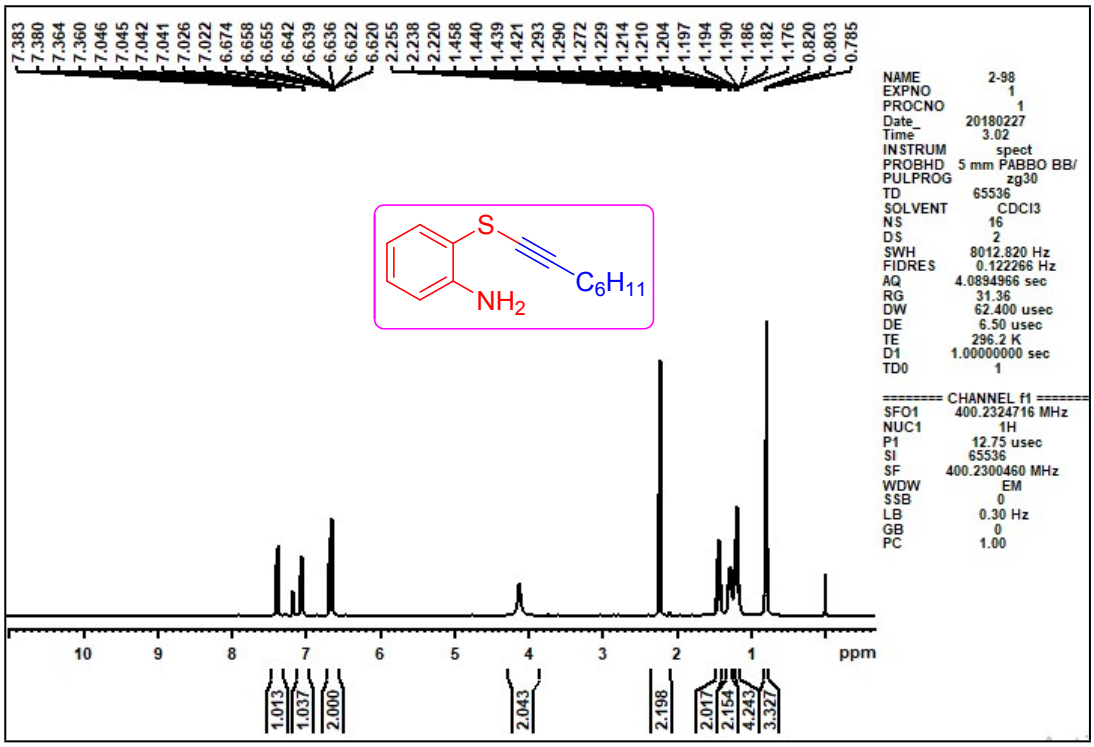


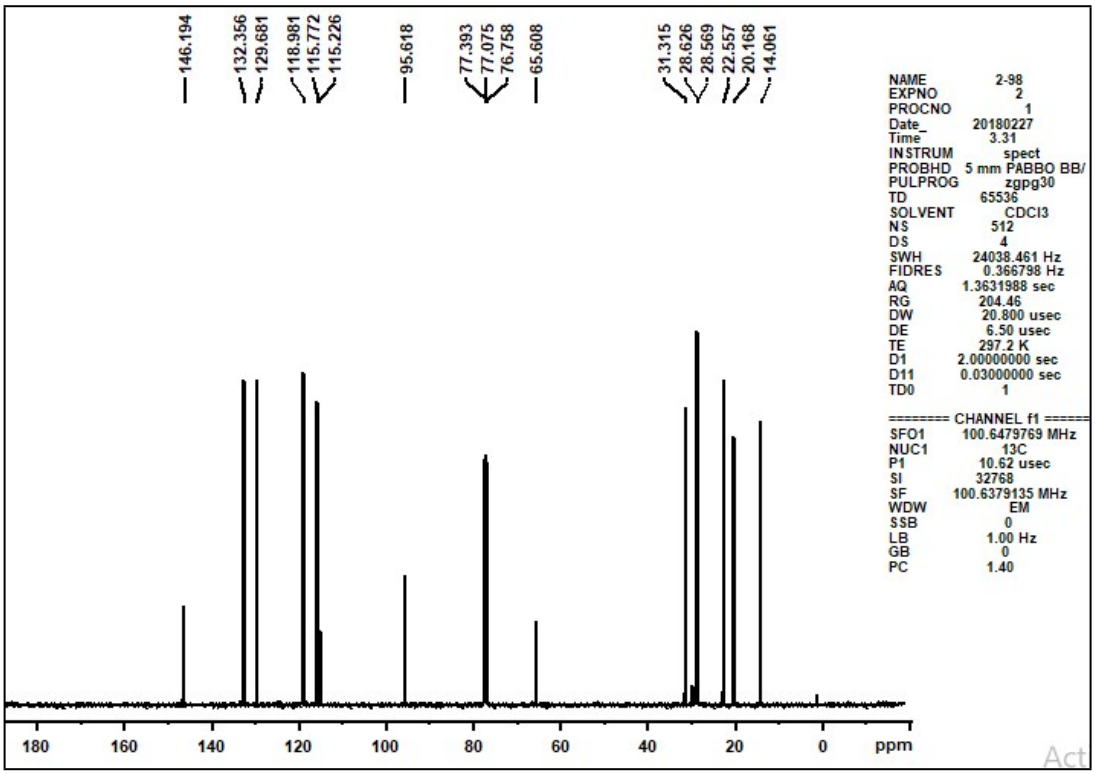
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3au



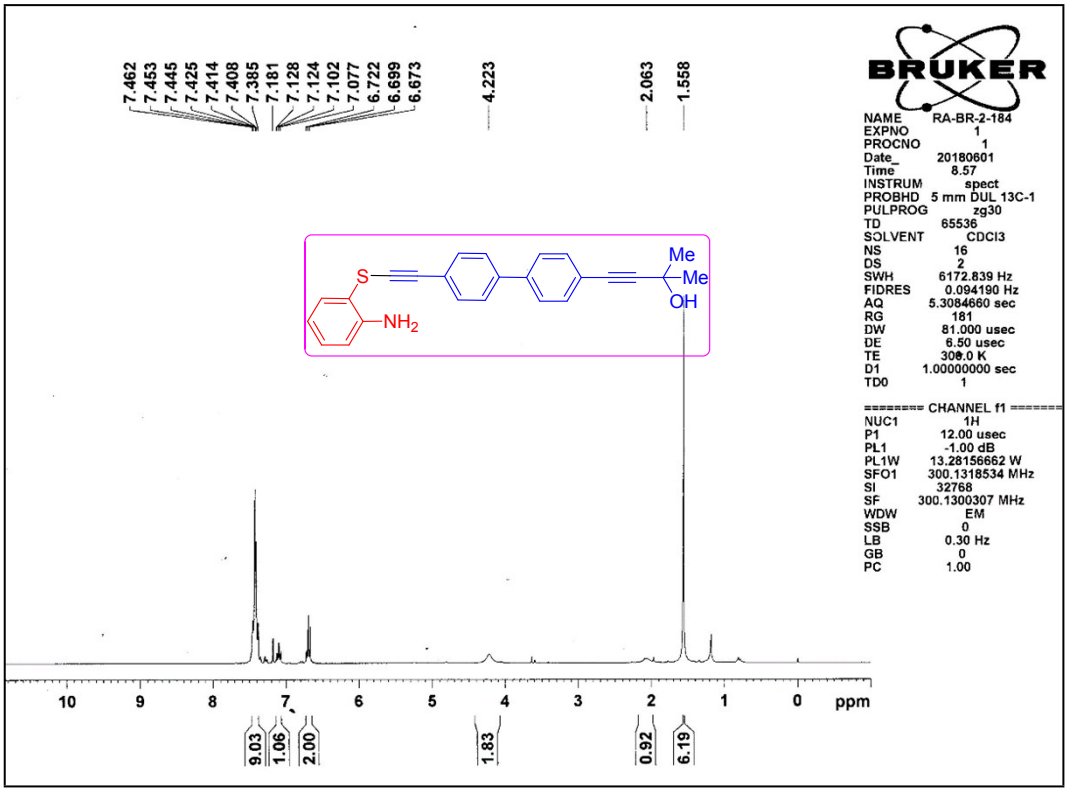


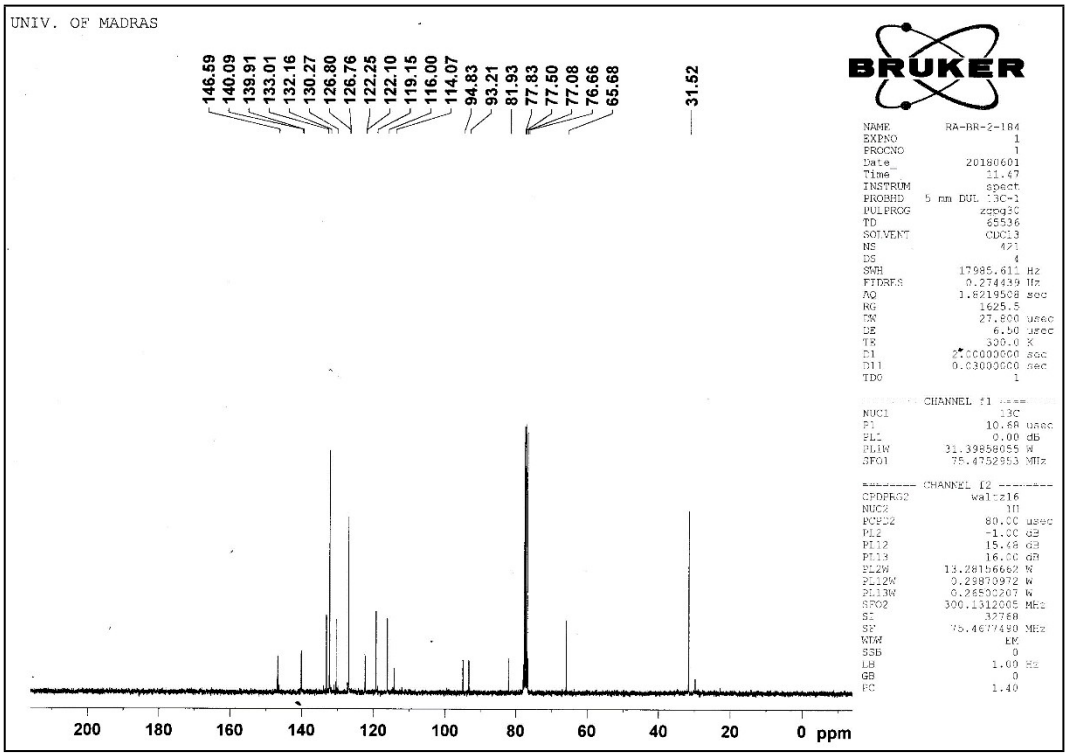
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3av



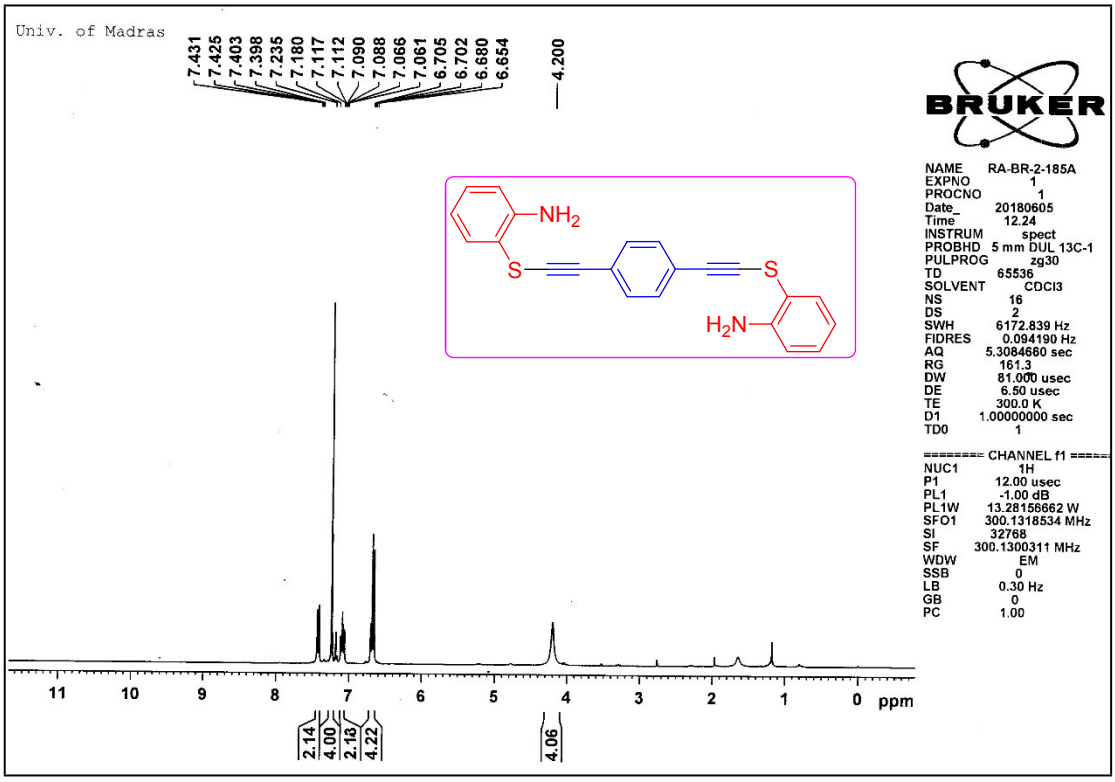


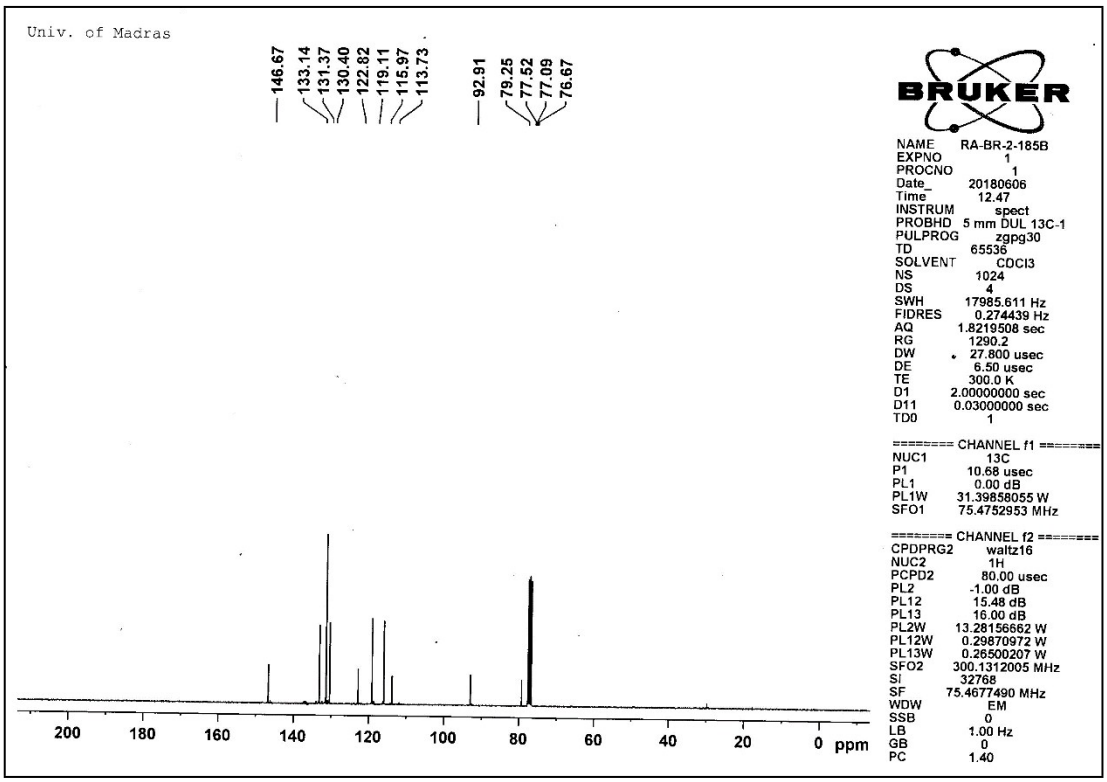
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3aw



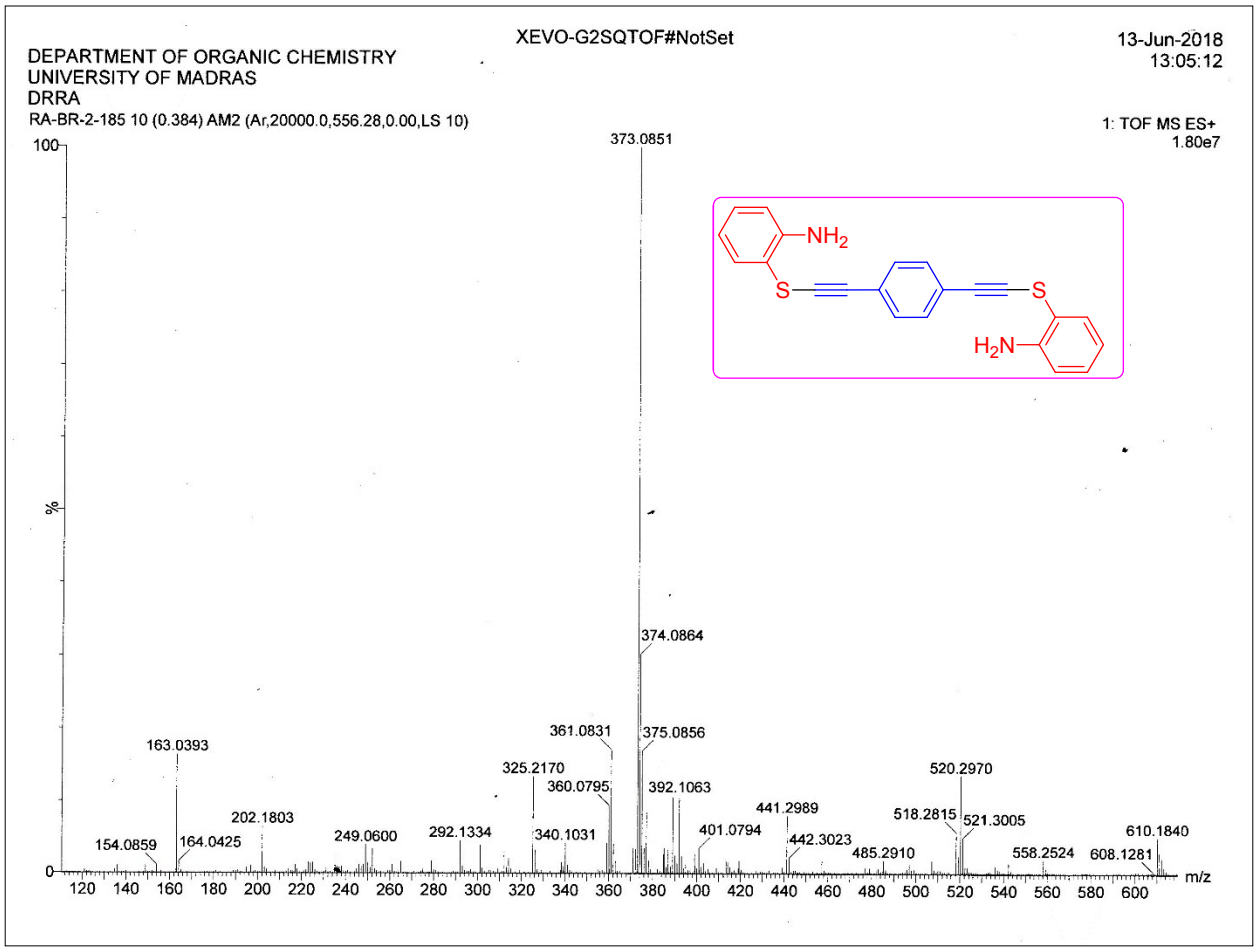


^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ax

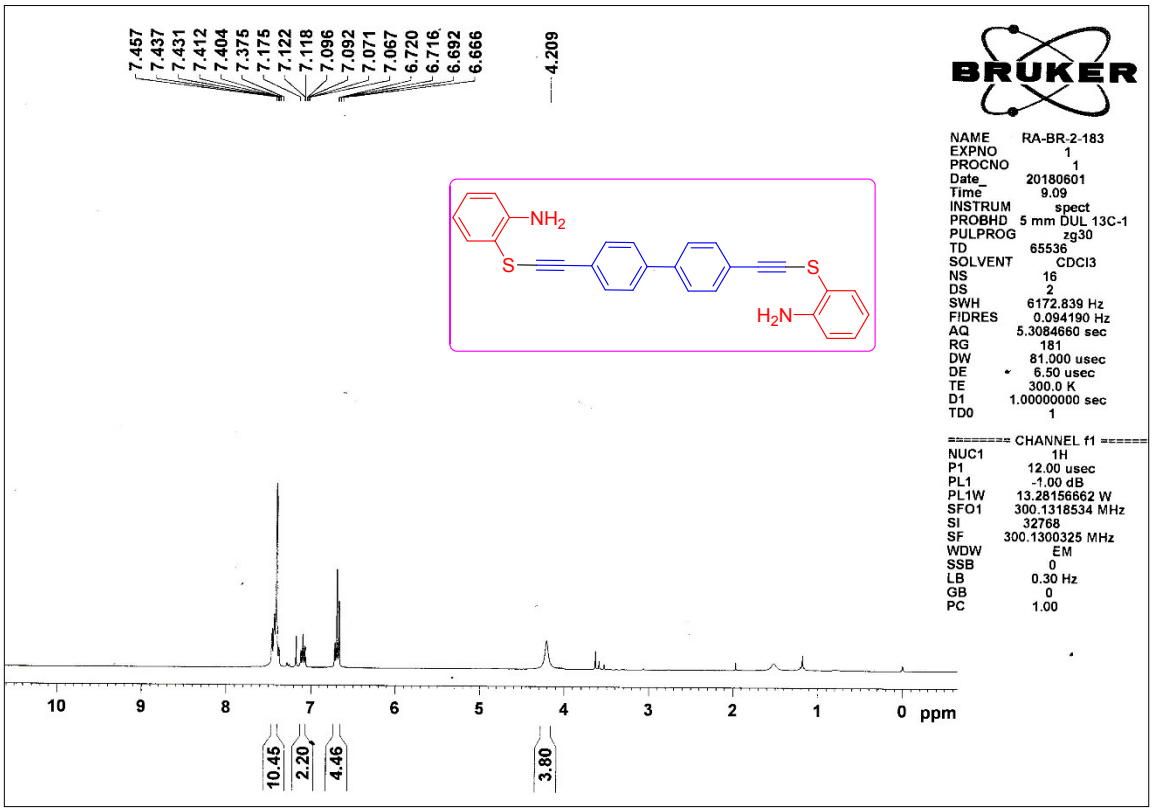


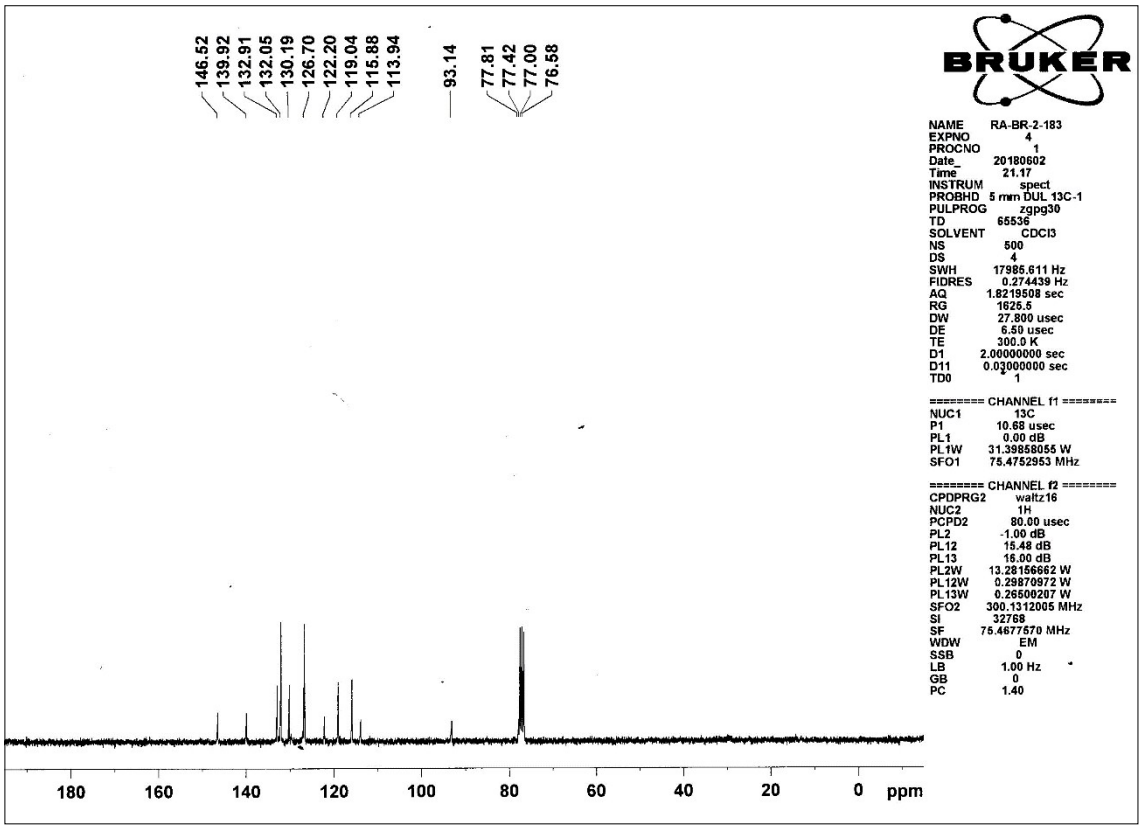


^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3ba

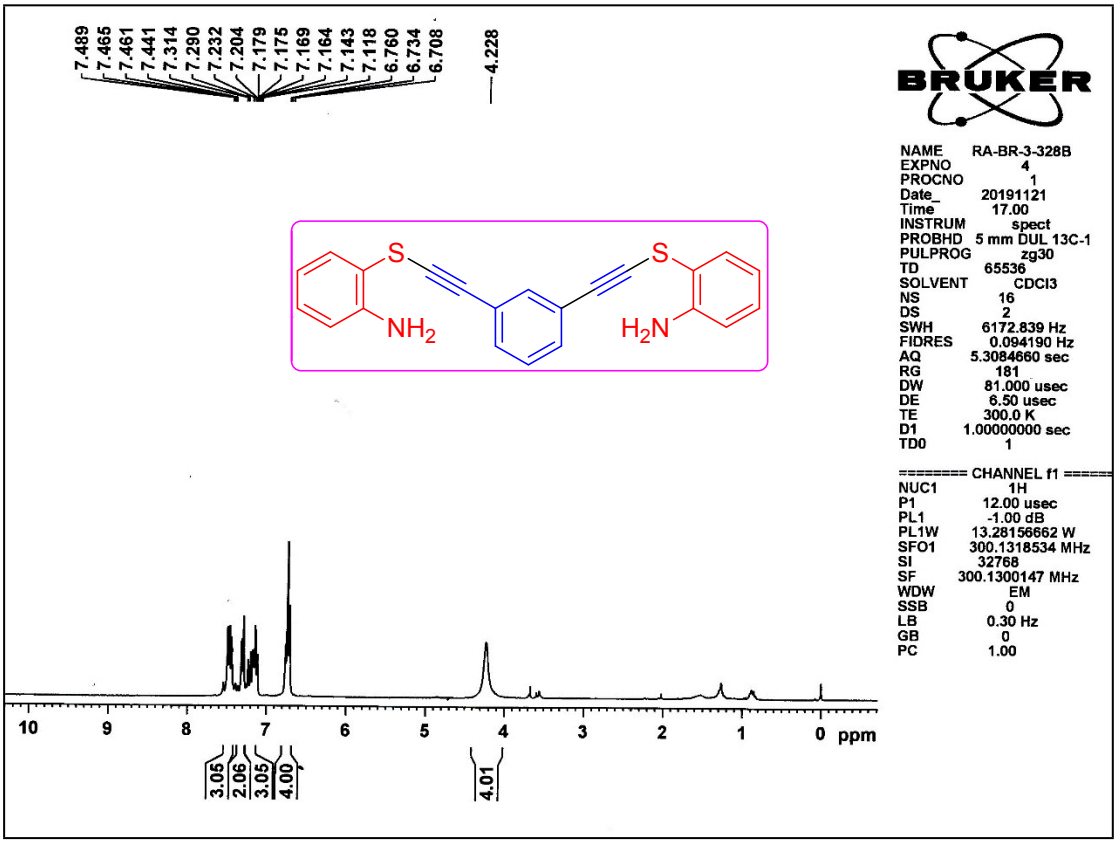


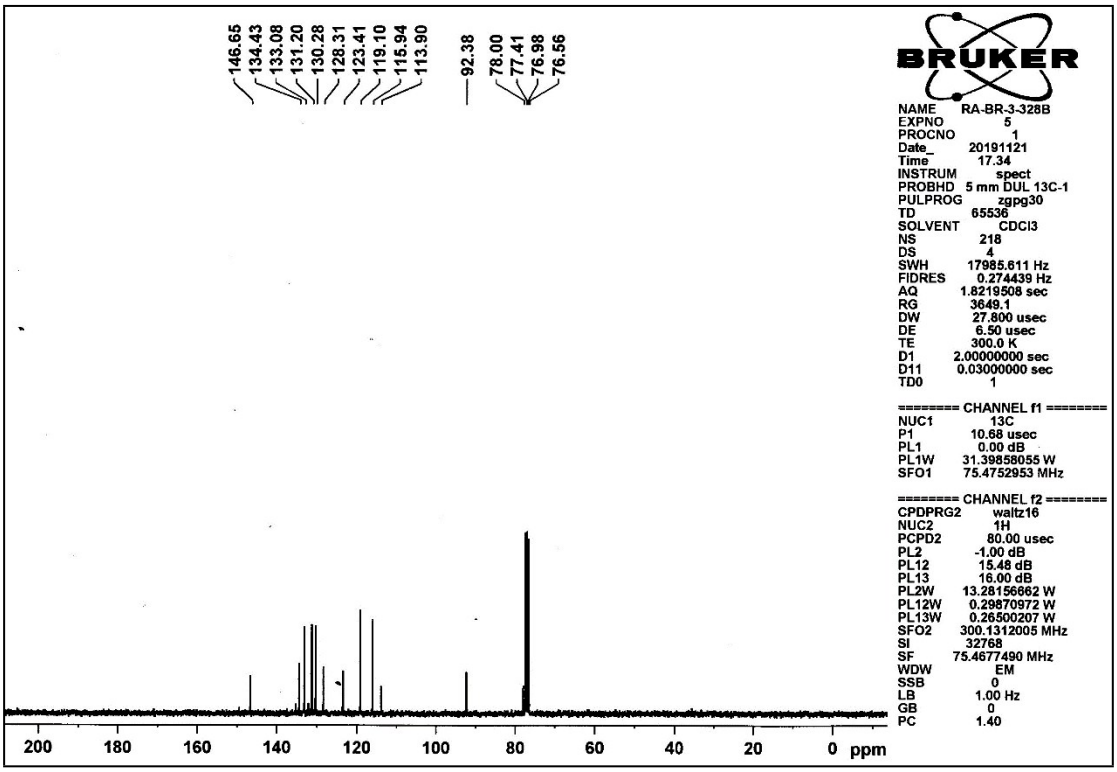
HRMS spectrum of compound 3ba



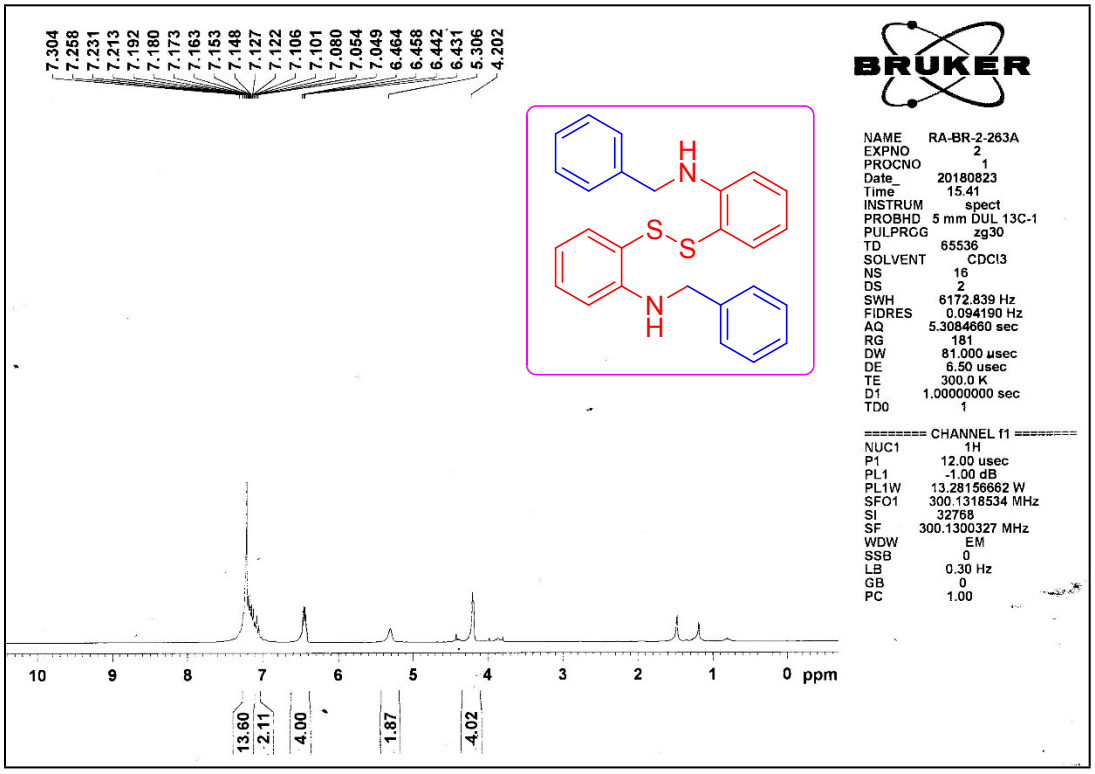


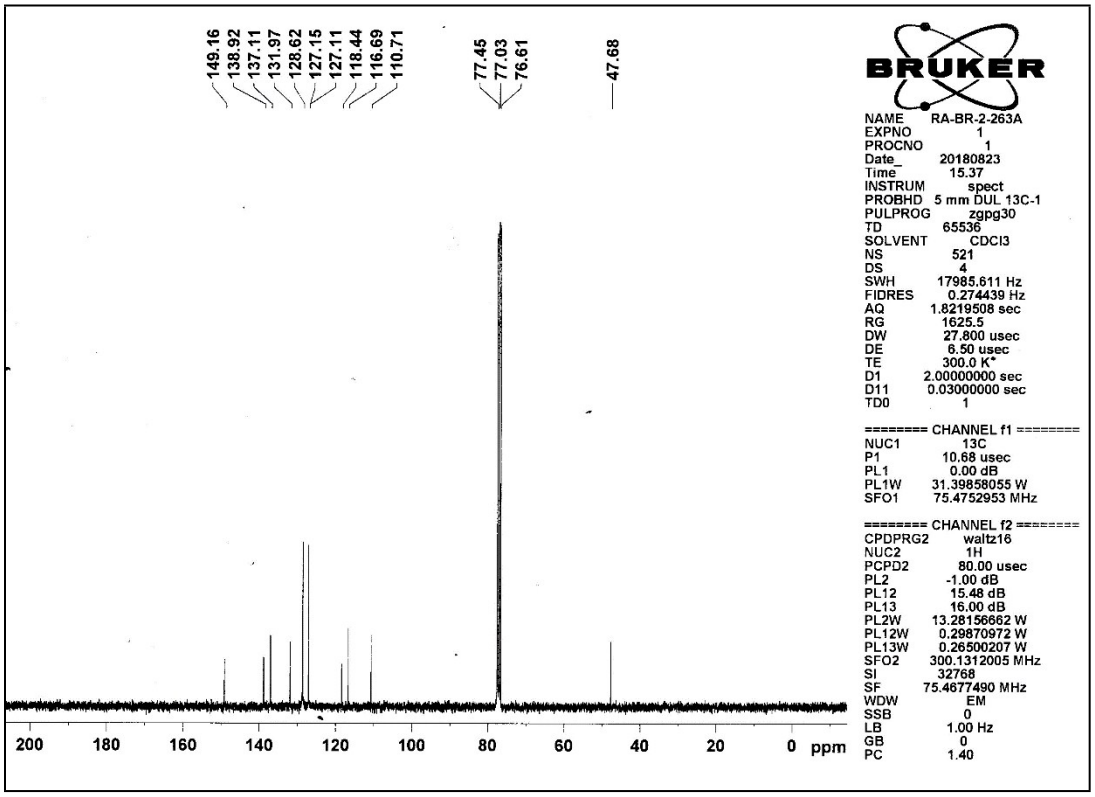
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3bb



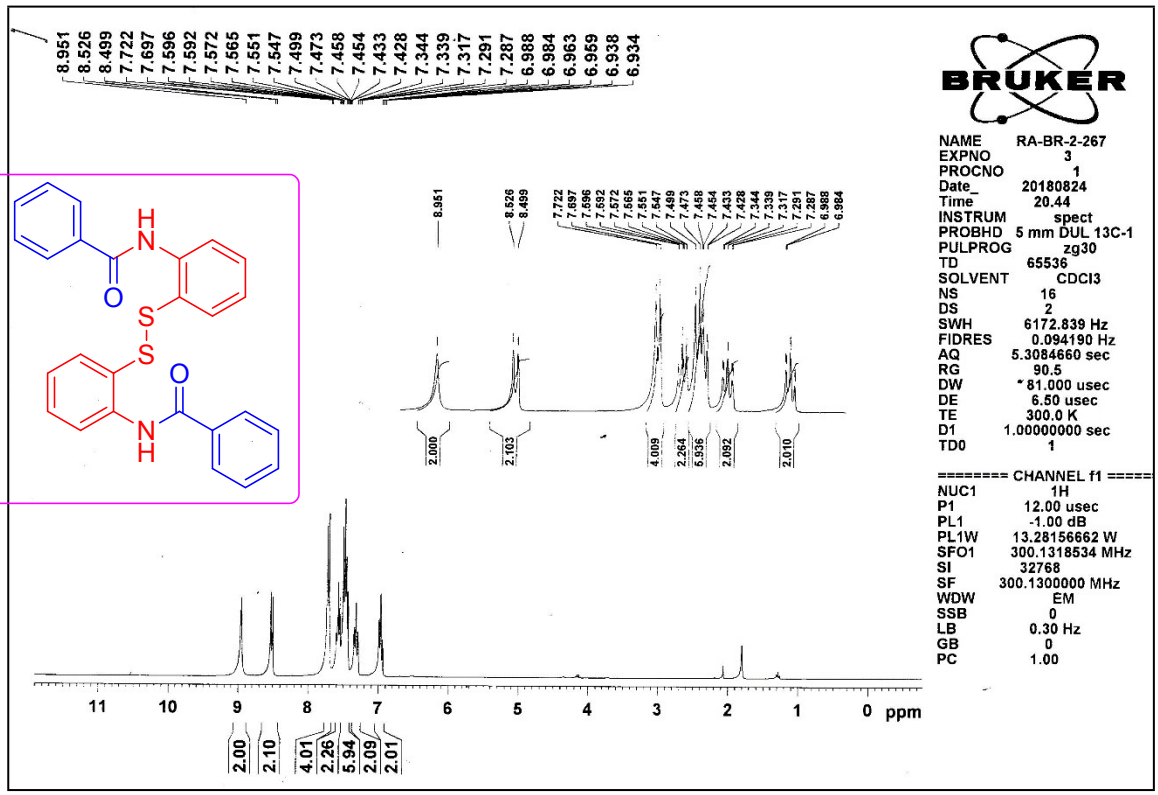


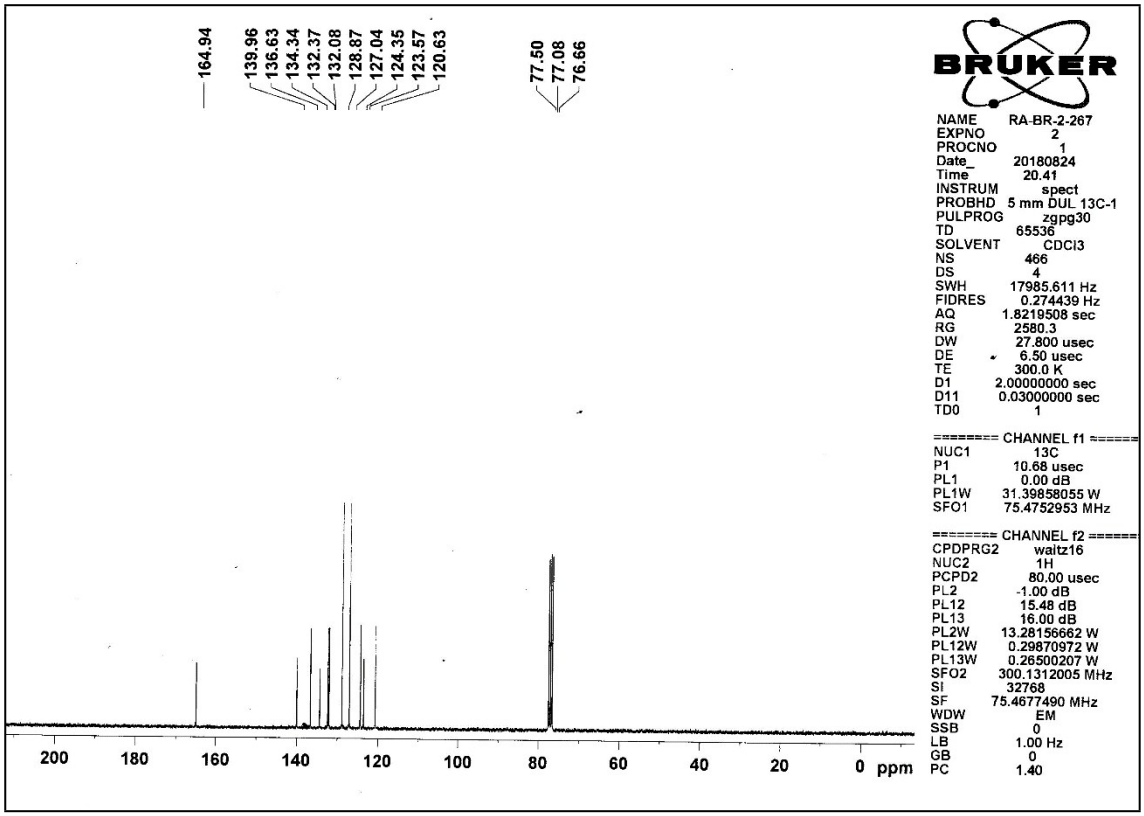
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 3bc



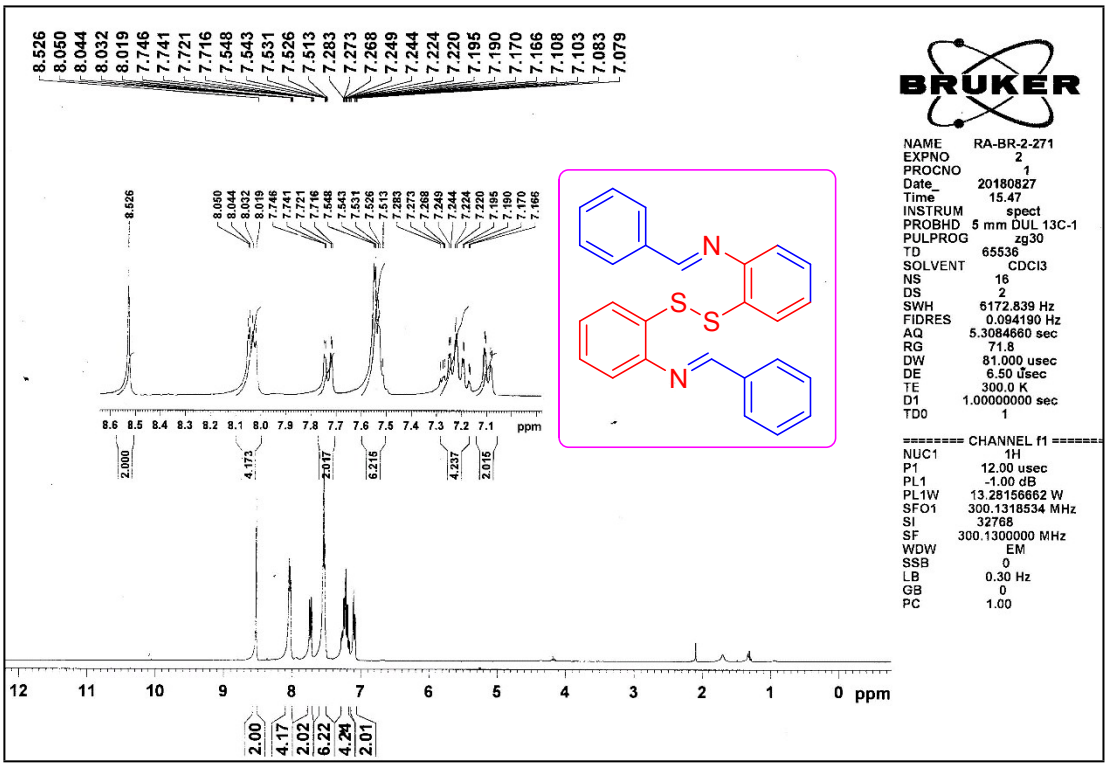


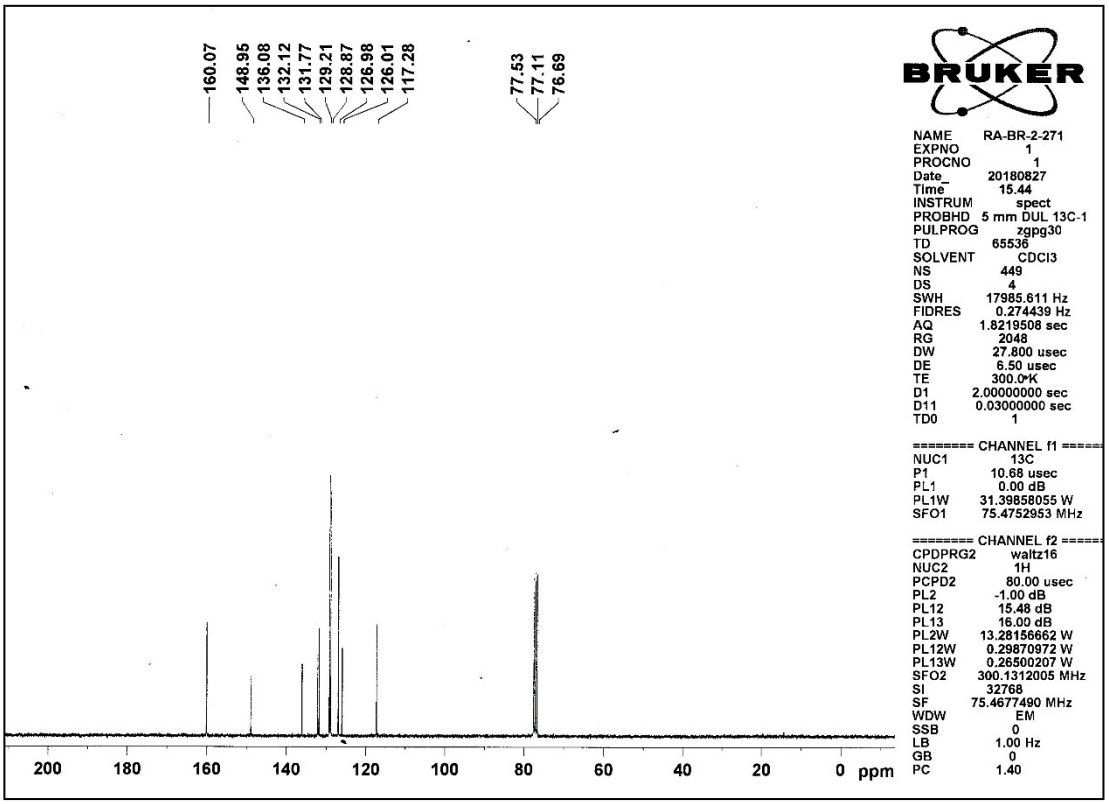
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 1b



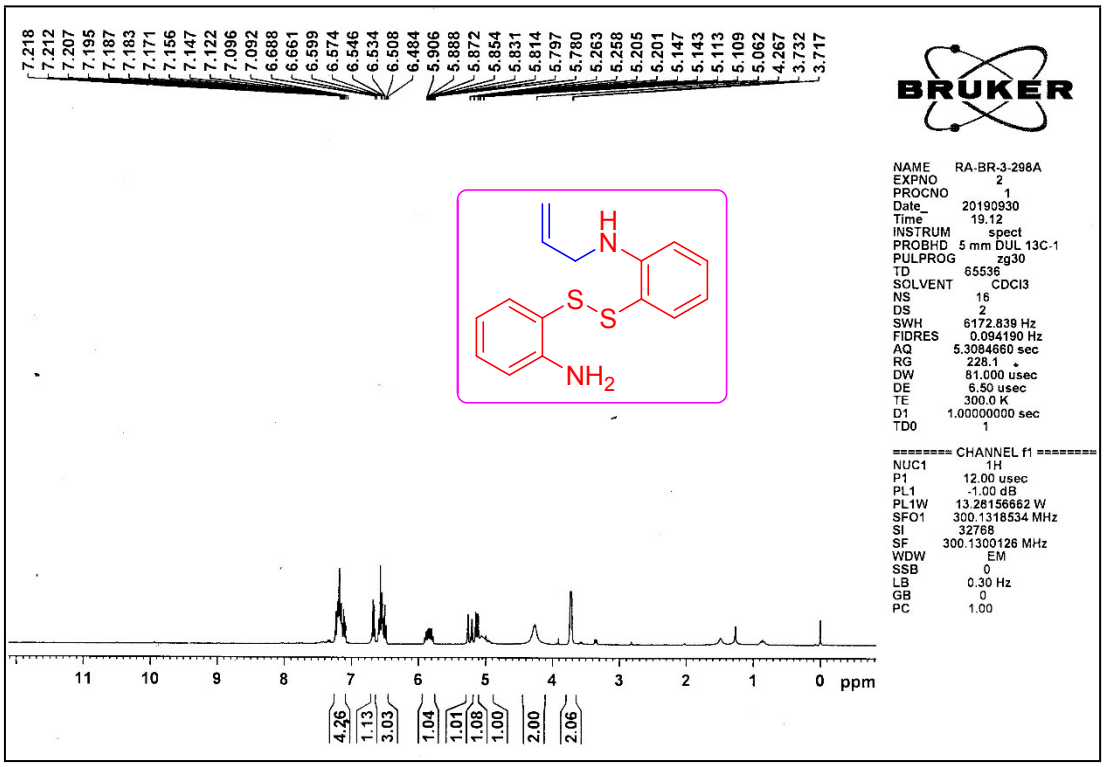


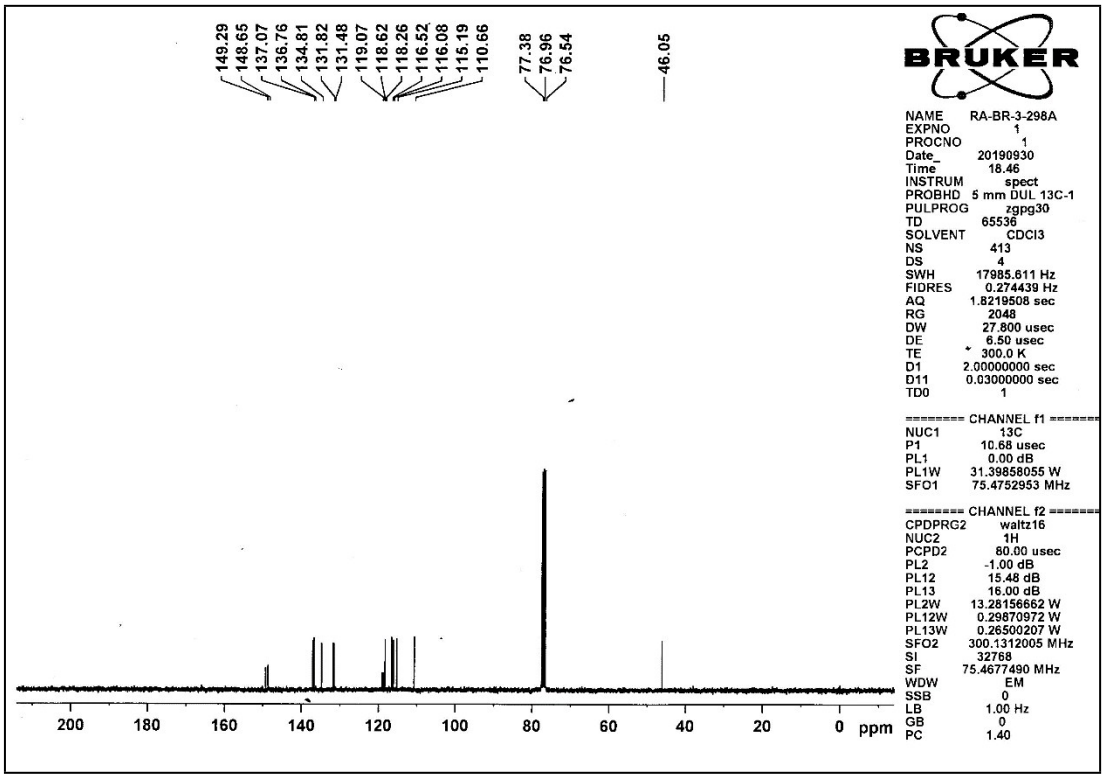
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 1c



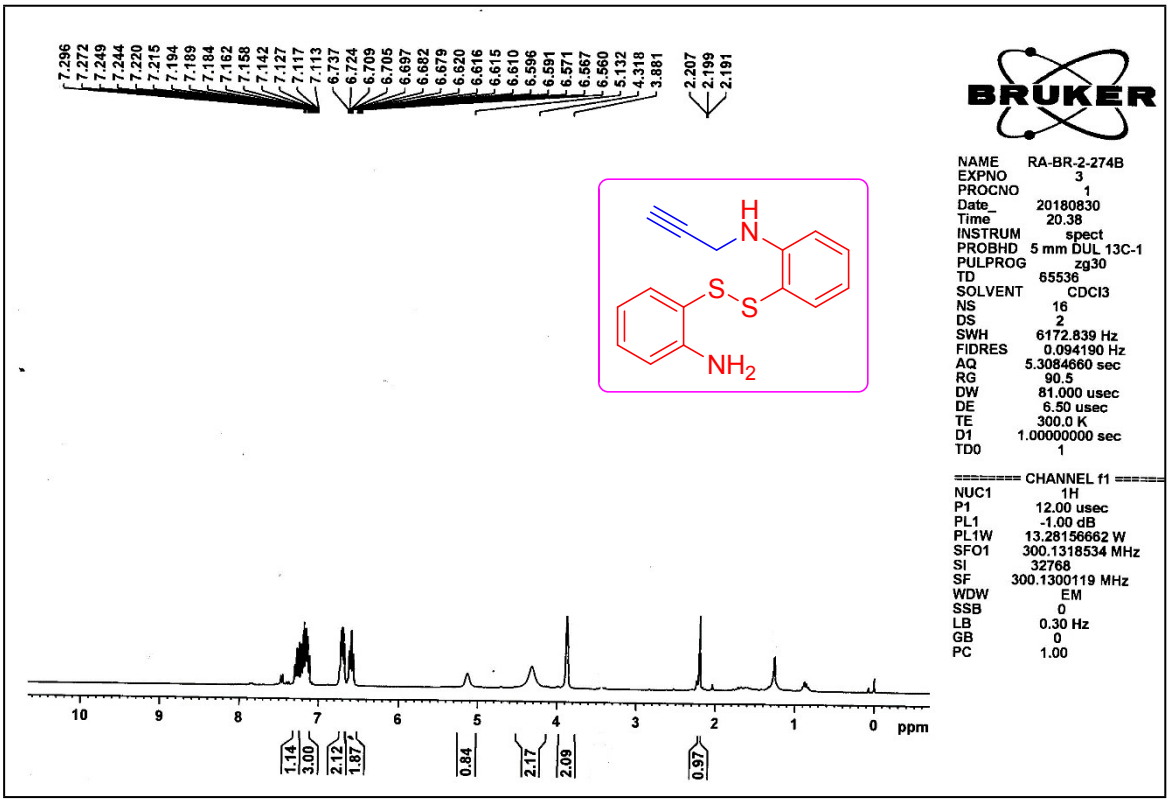


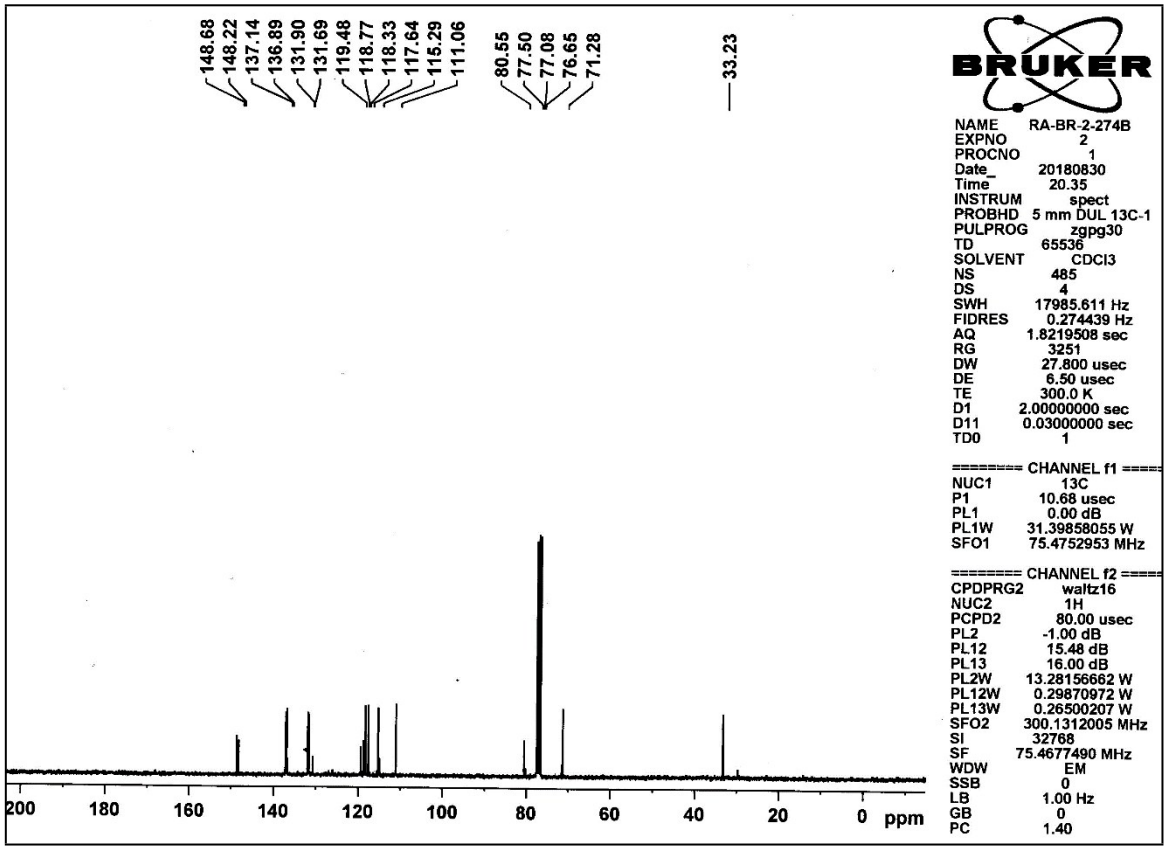
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 1d



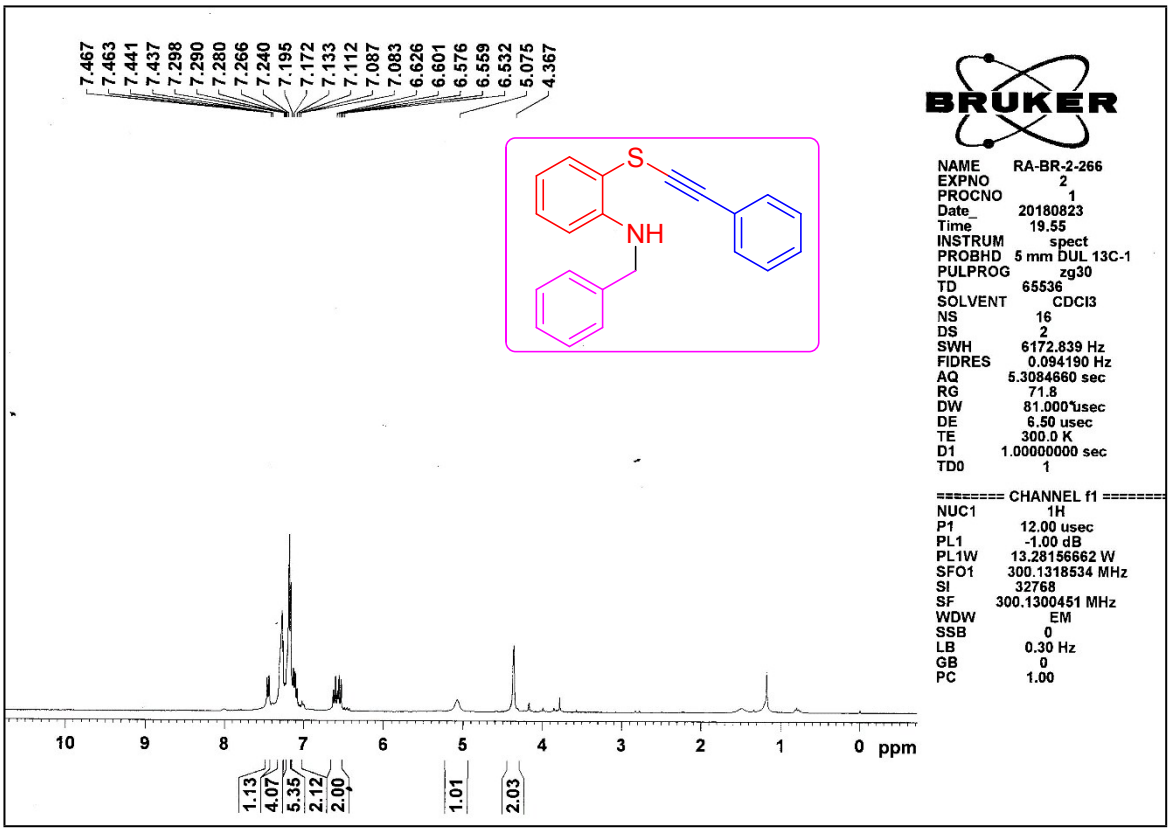


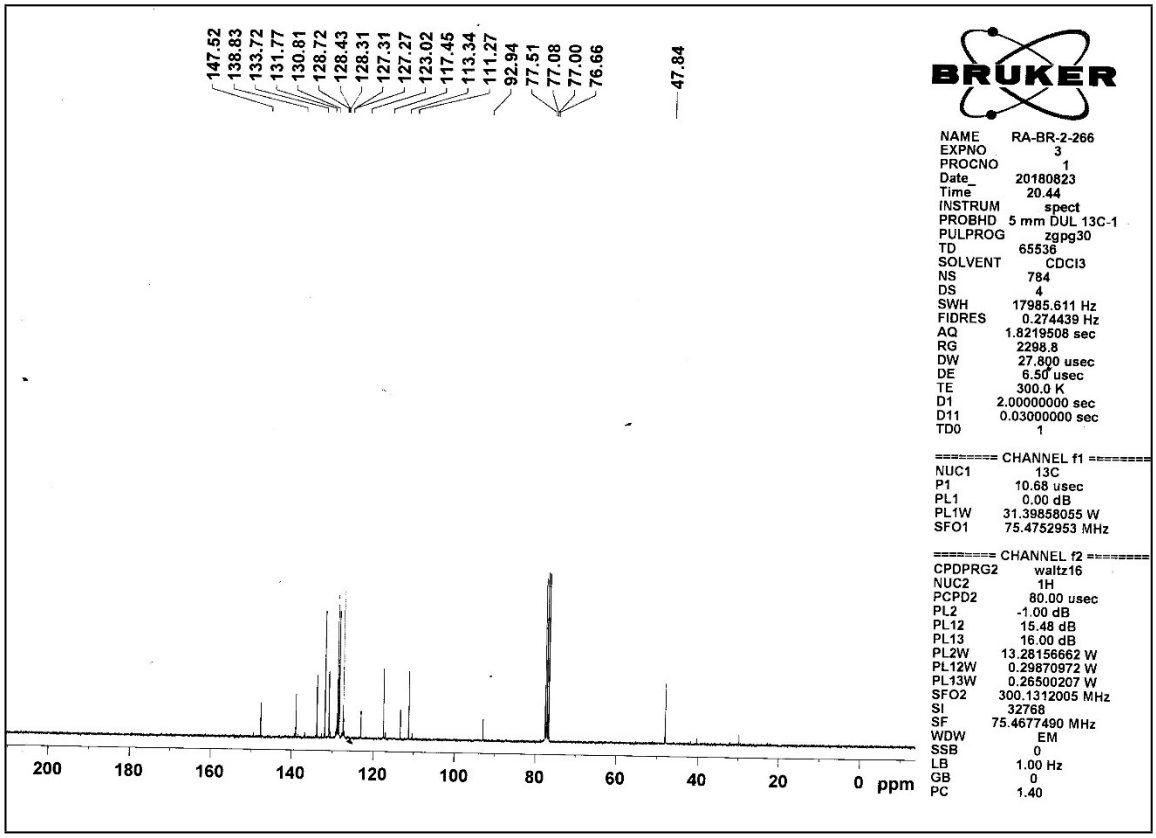
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 1i



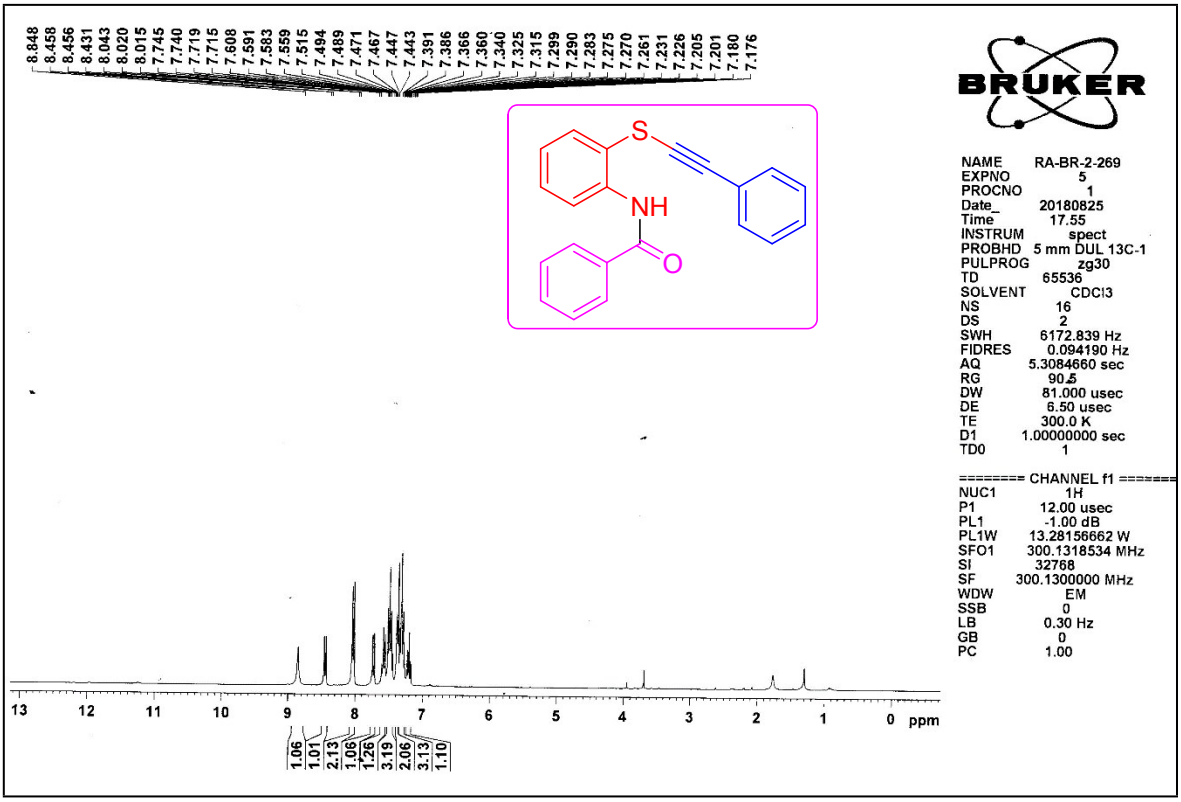


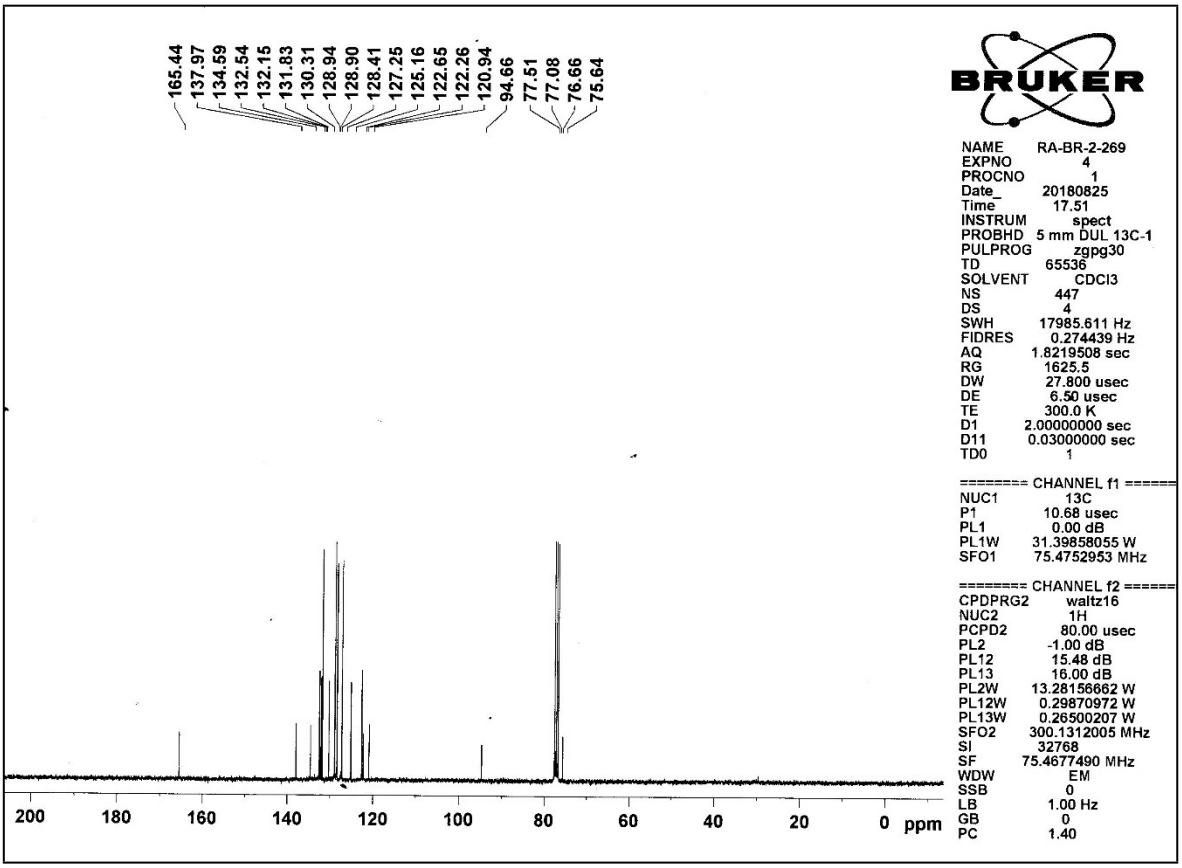
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 1j



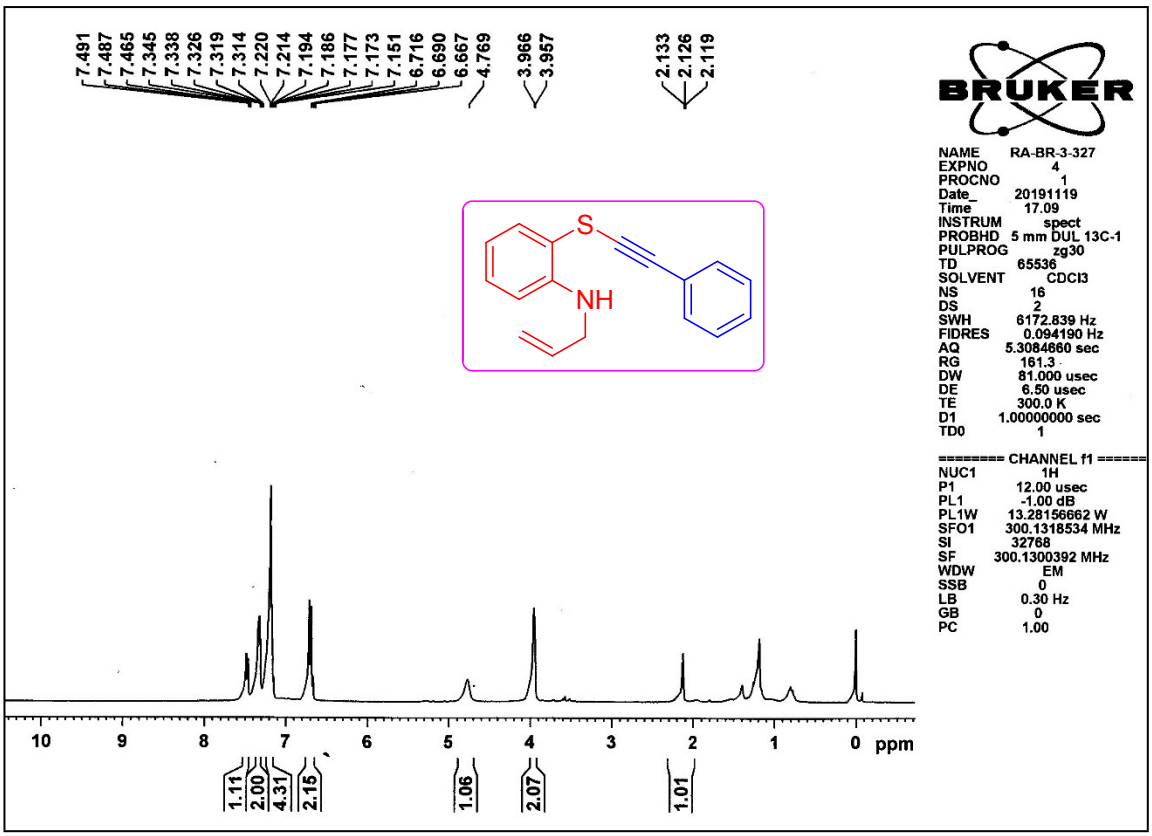


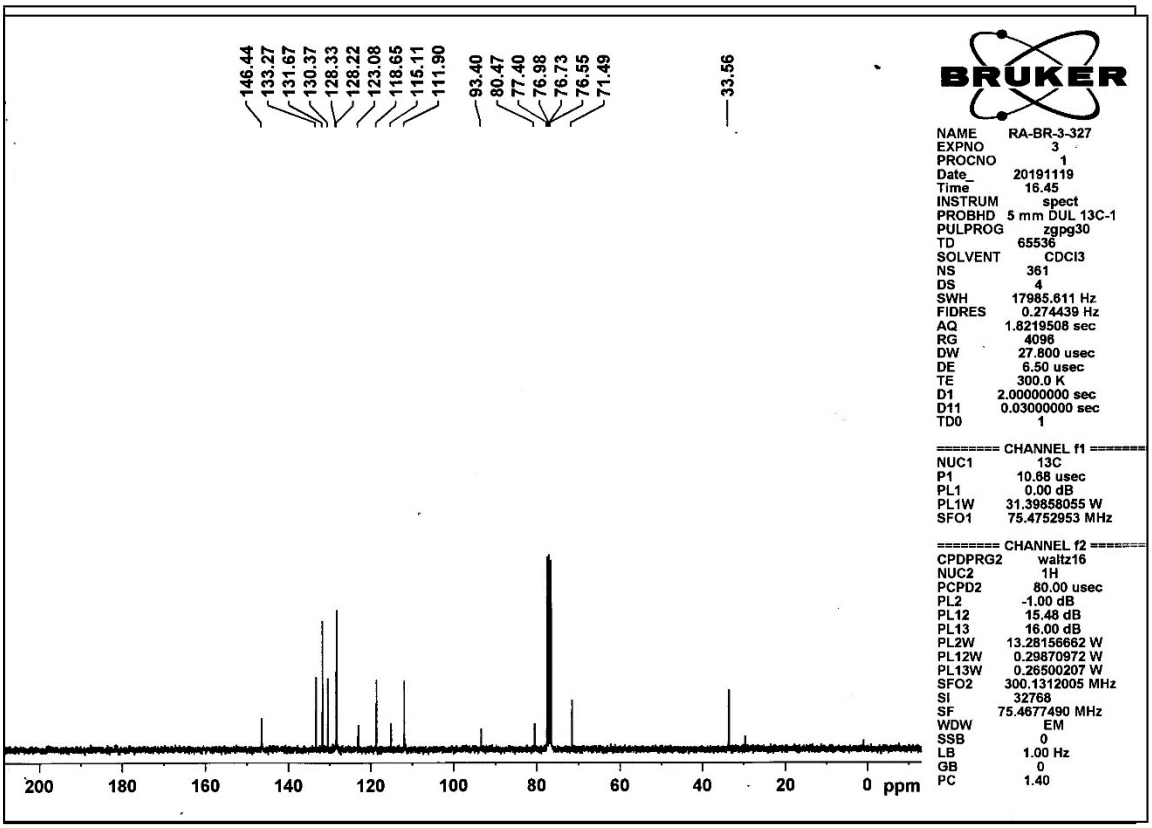
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 4b



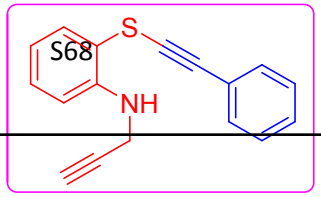


^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 4c

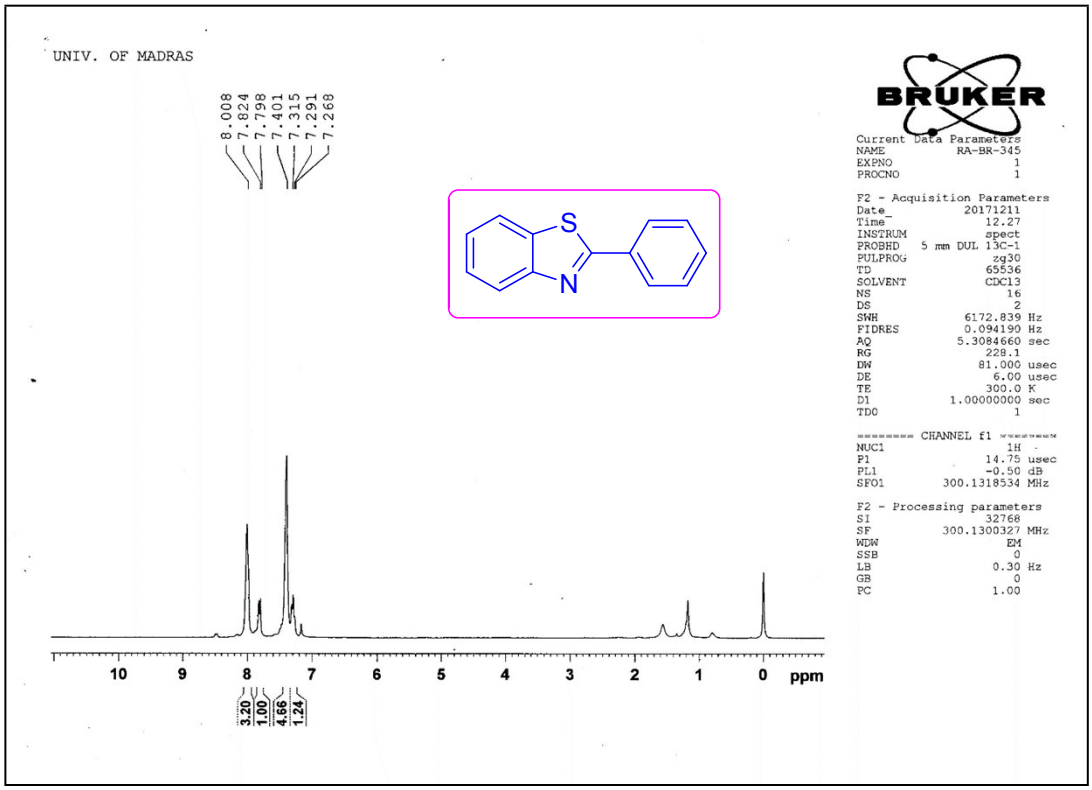


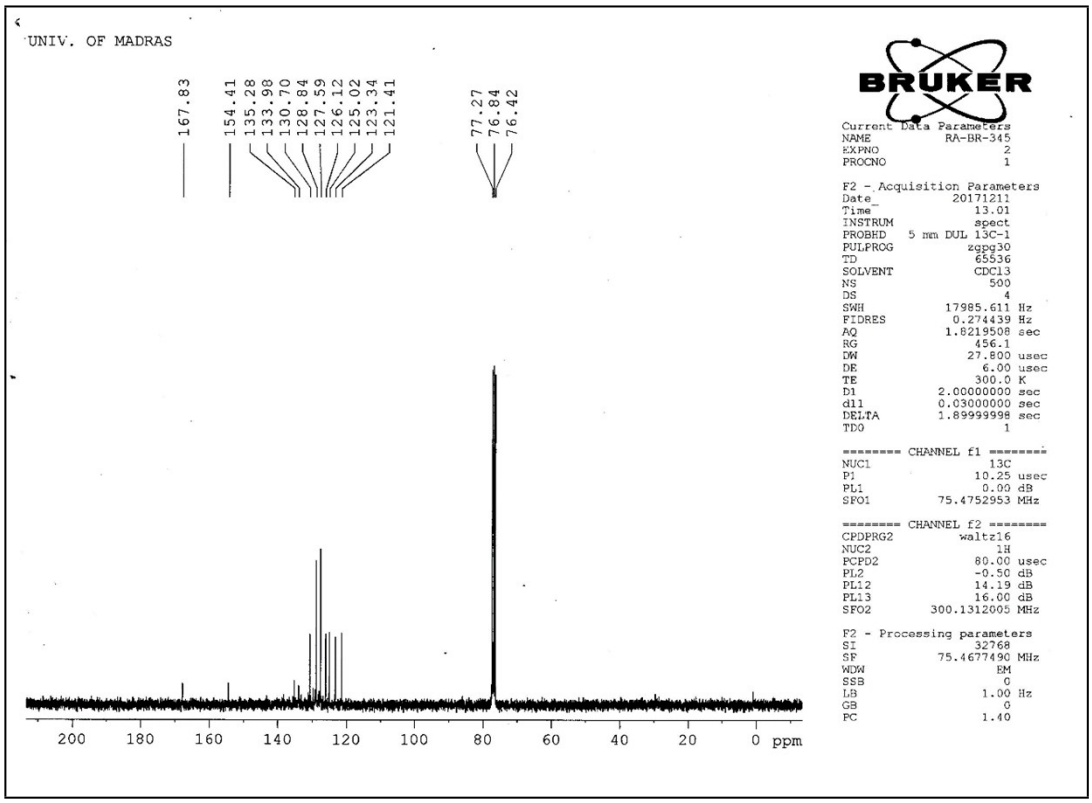


^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 4i

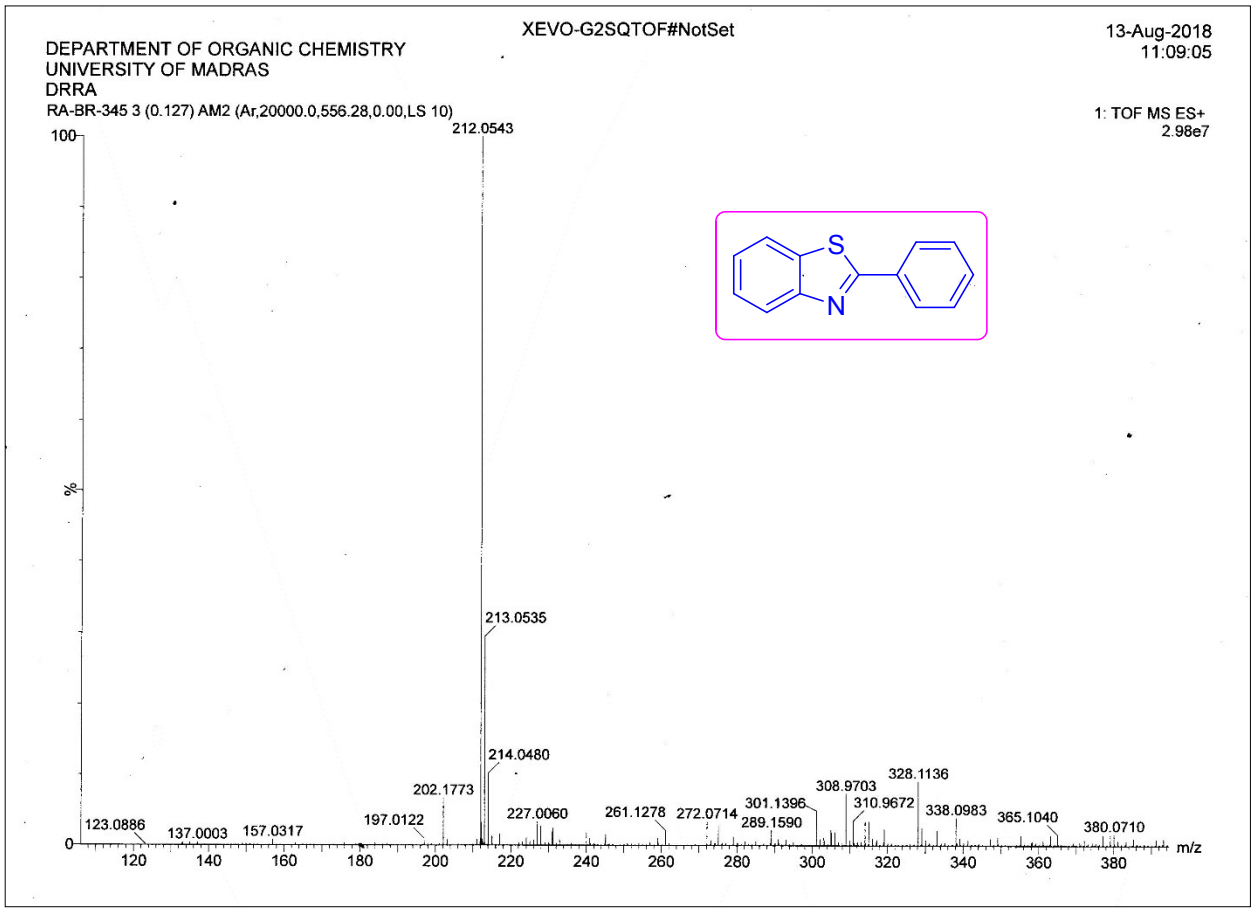


^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 4j

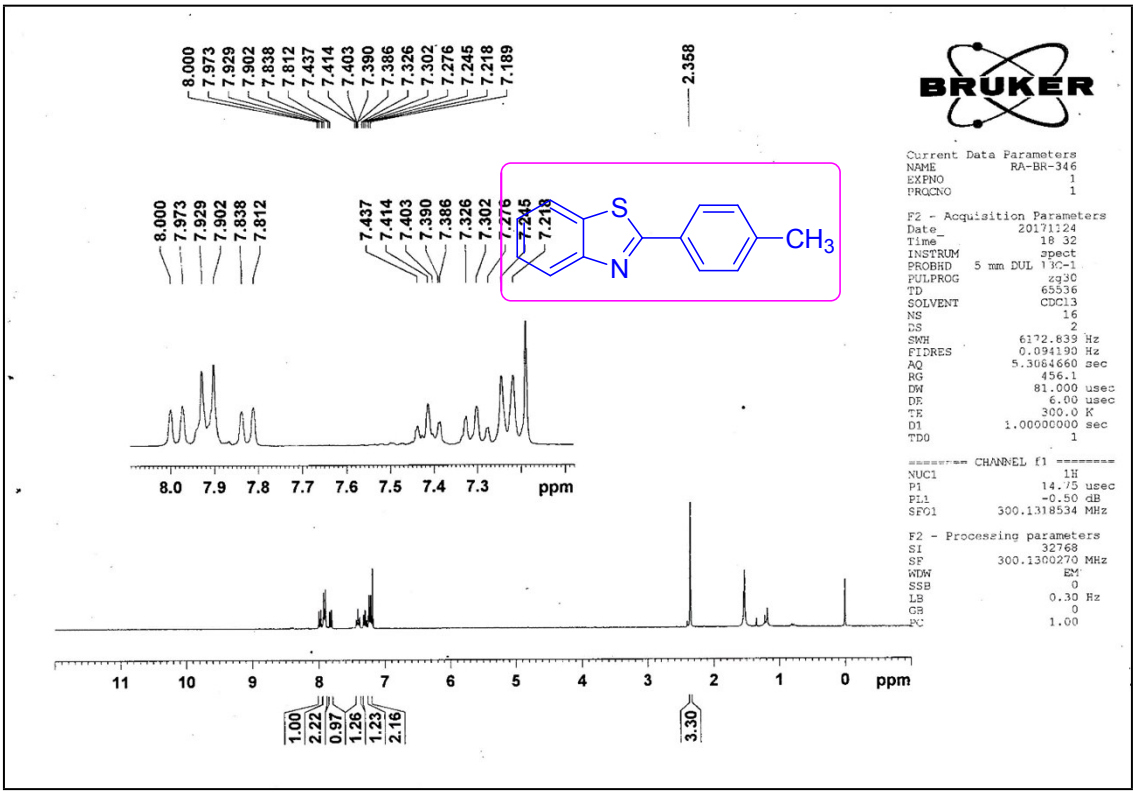


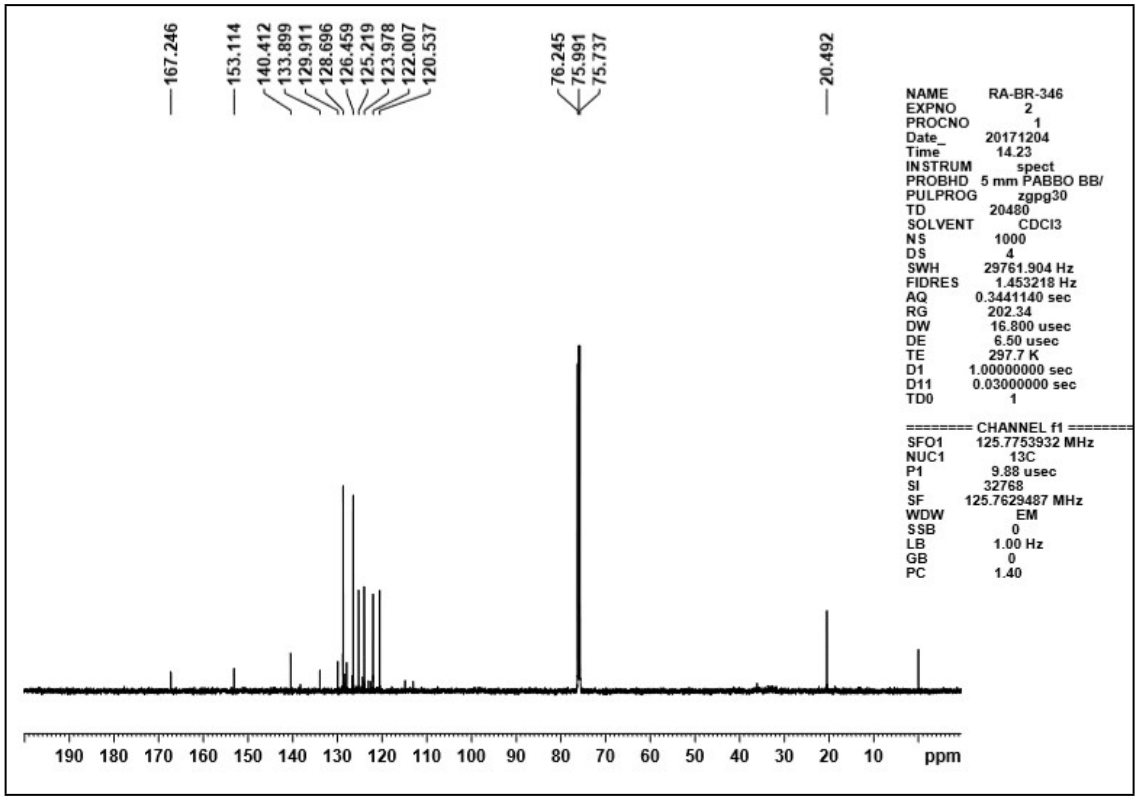


^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 5a

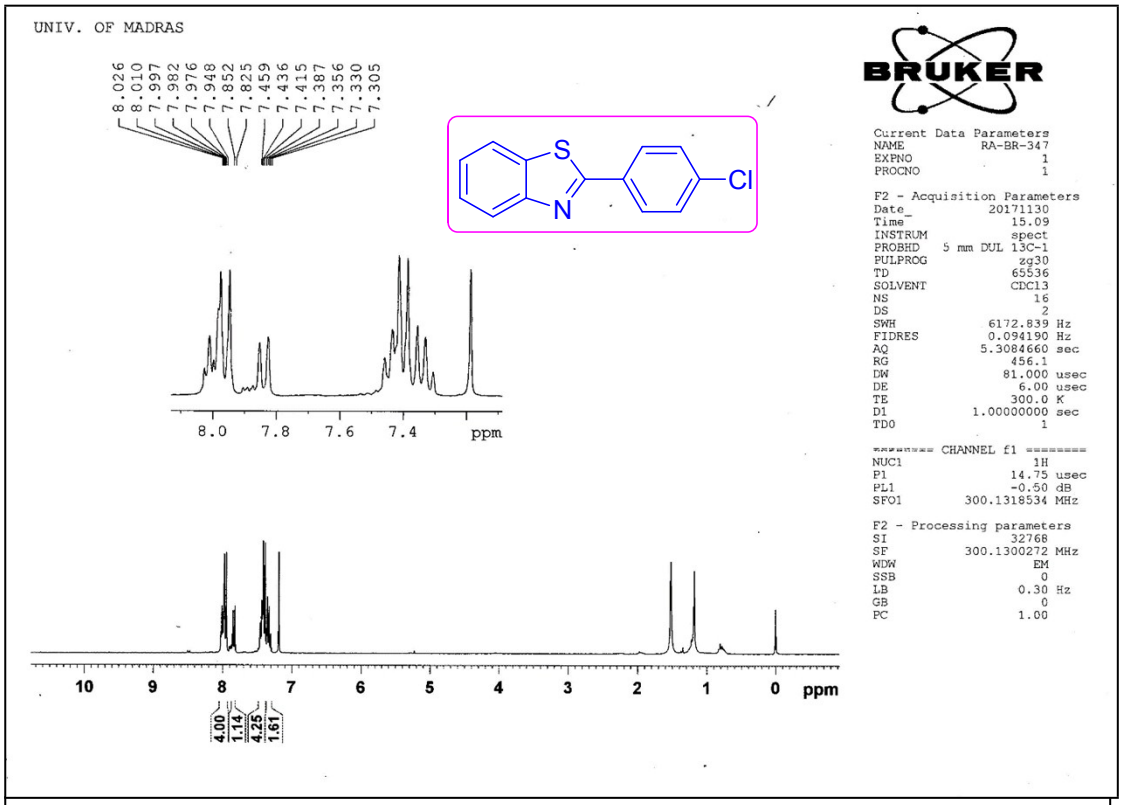


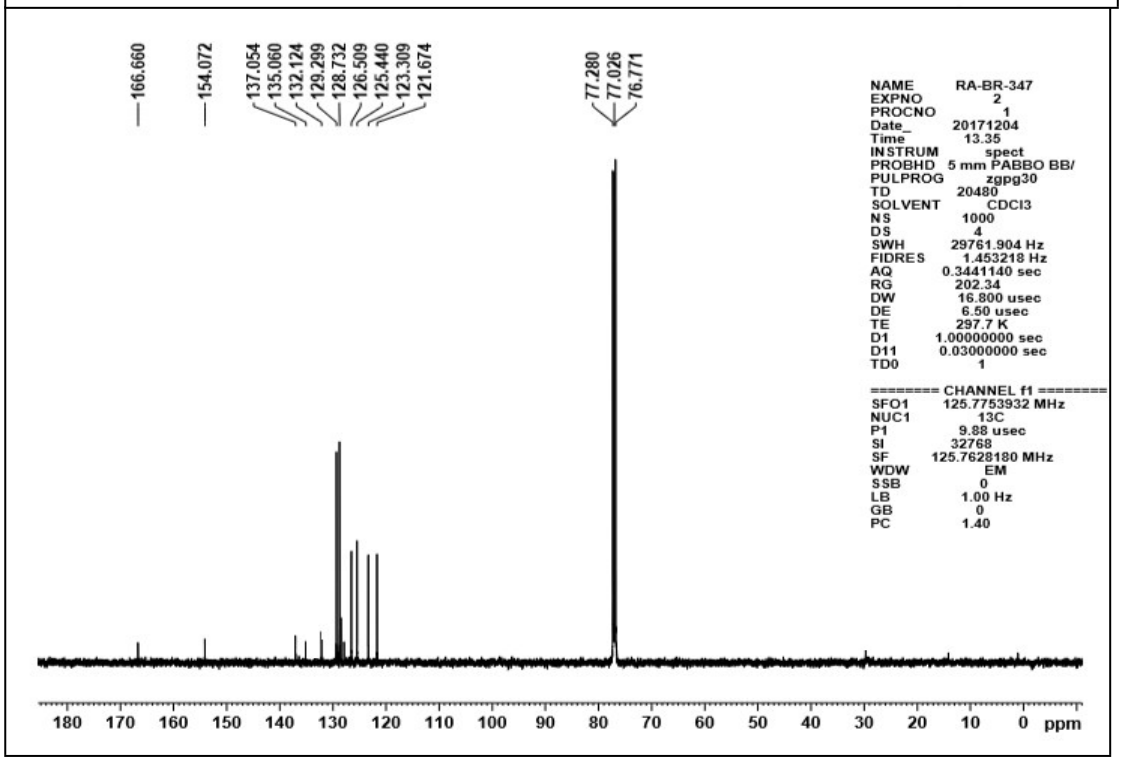
HRMS spectrum of compound 5a



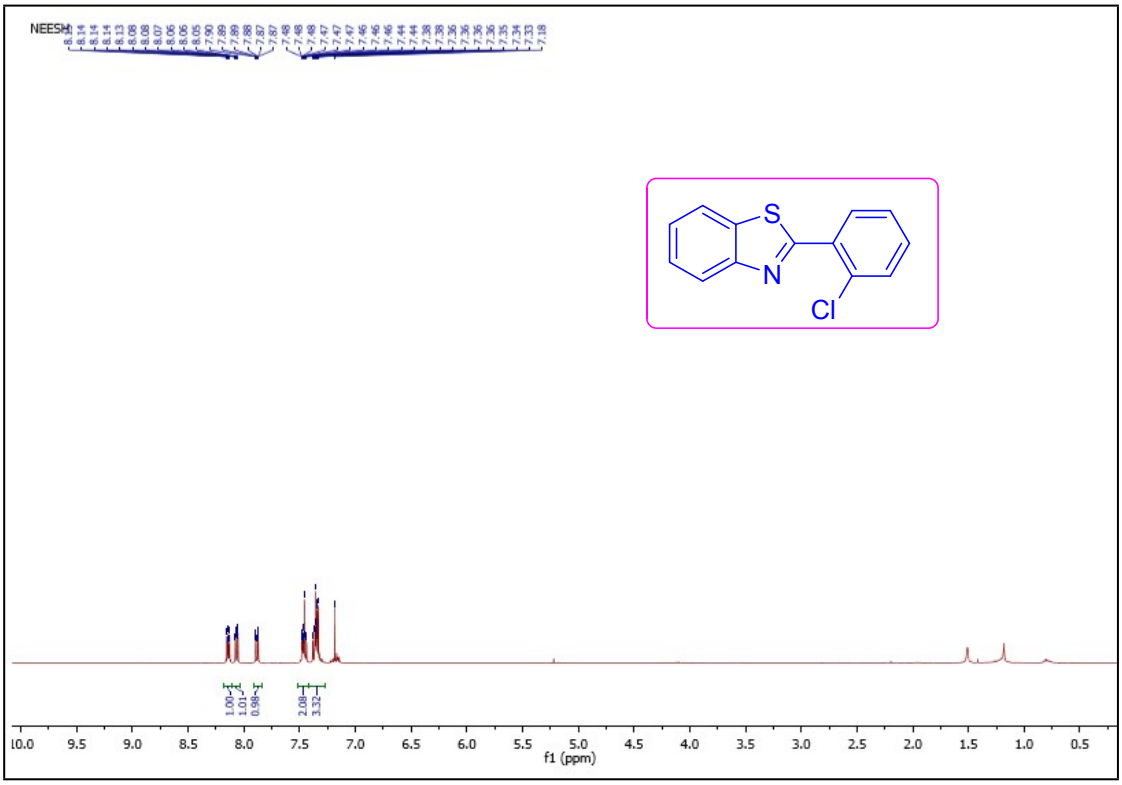


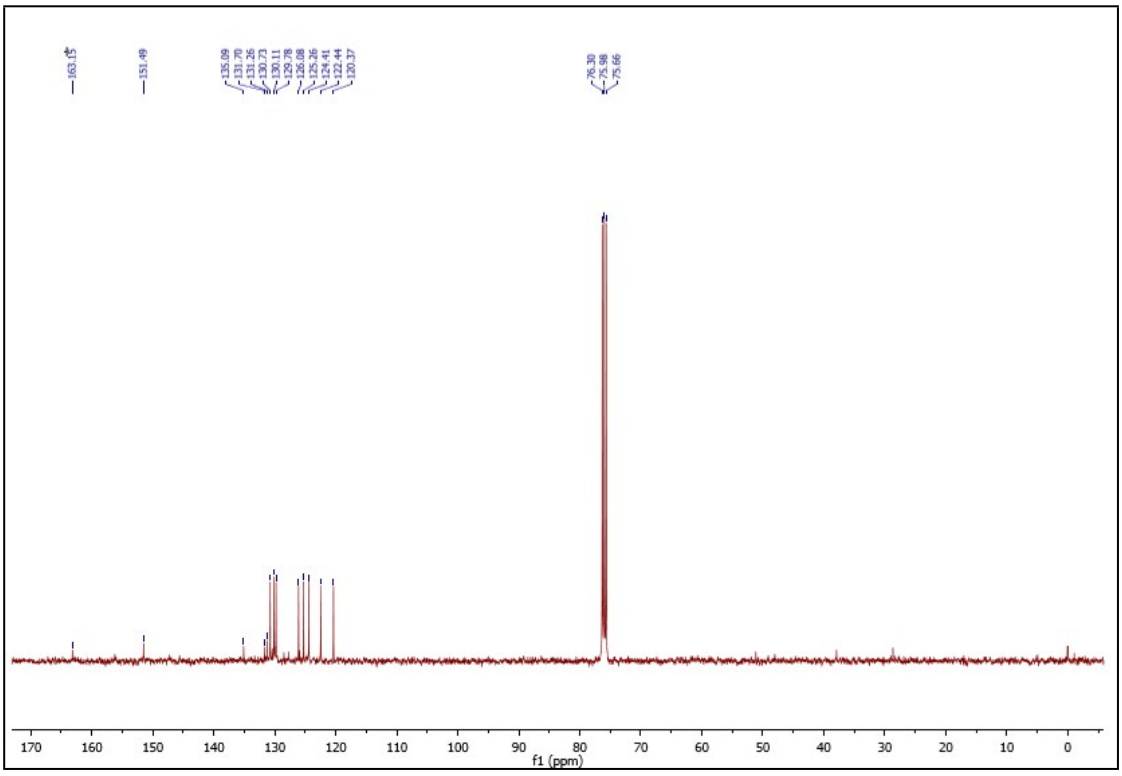
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 5b



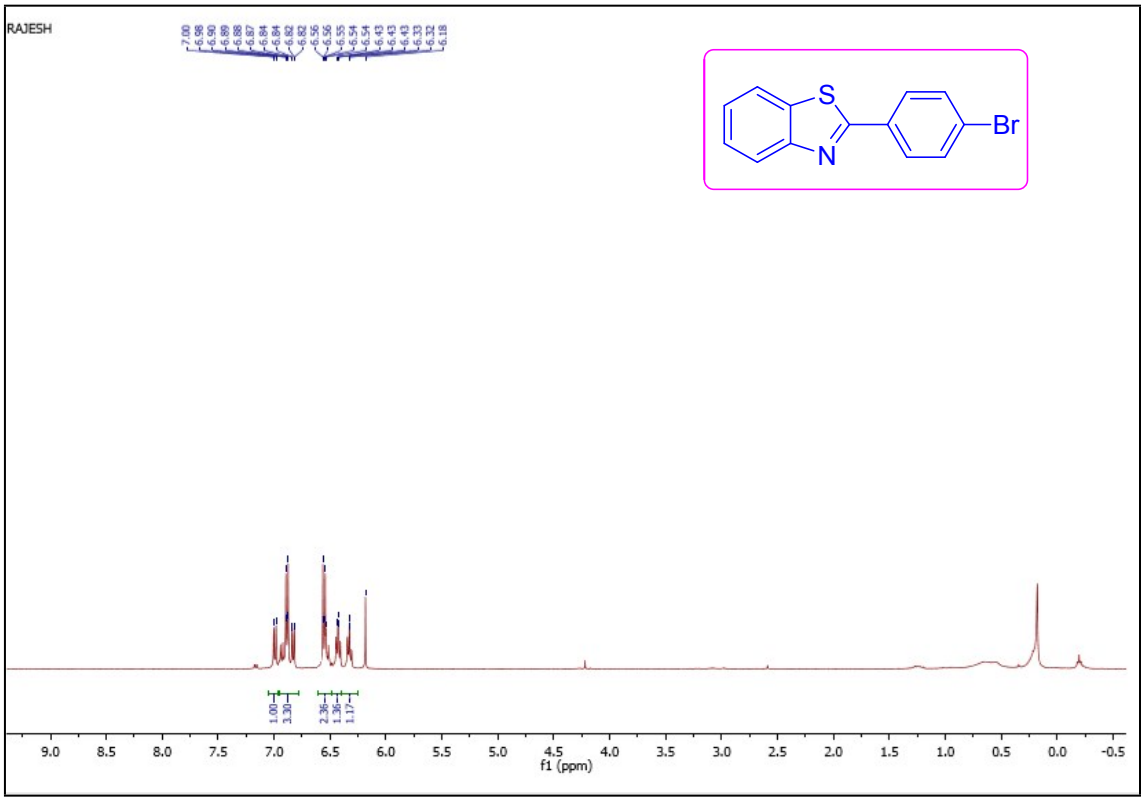


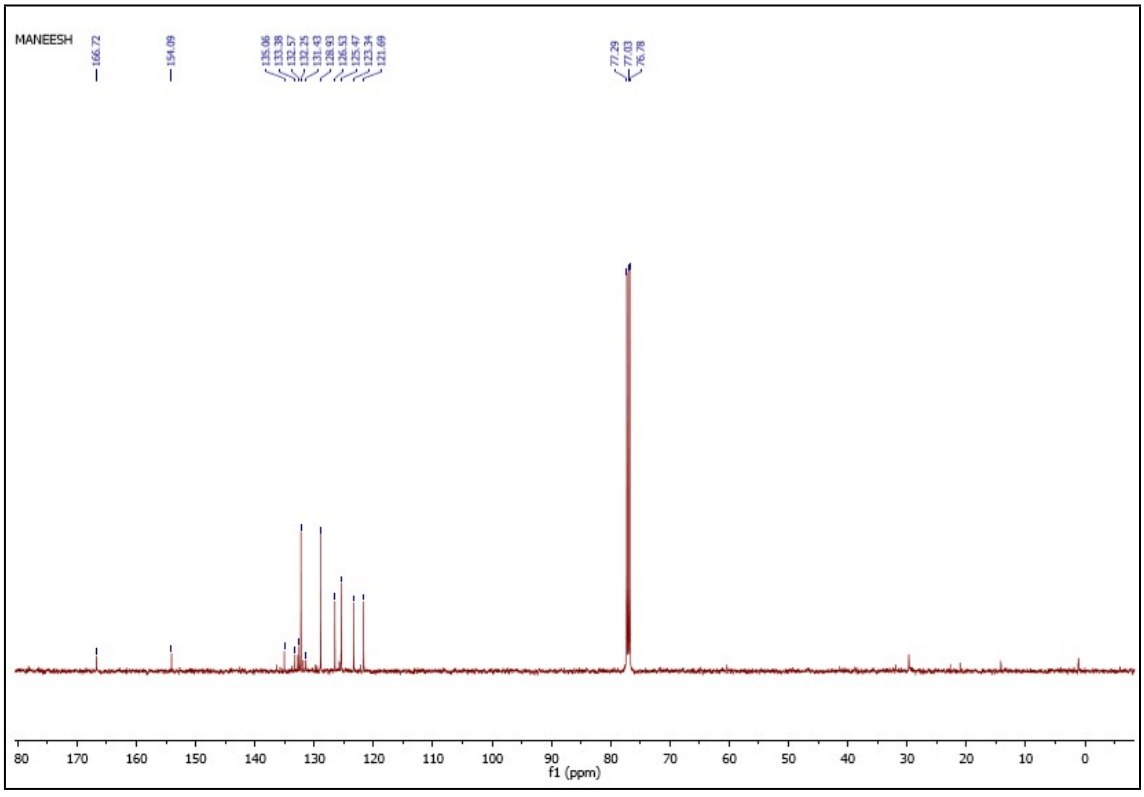
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 5e



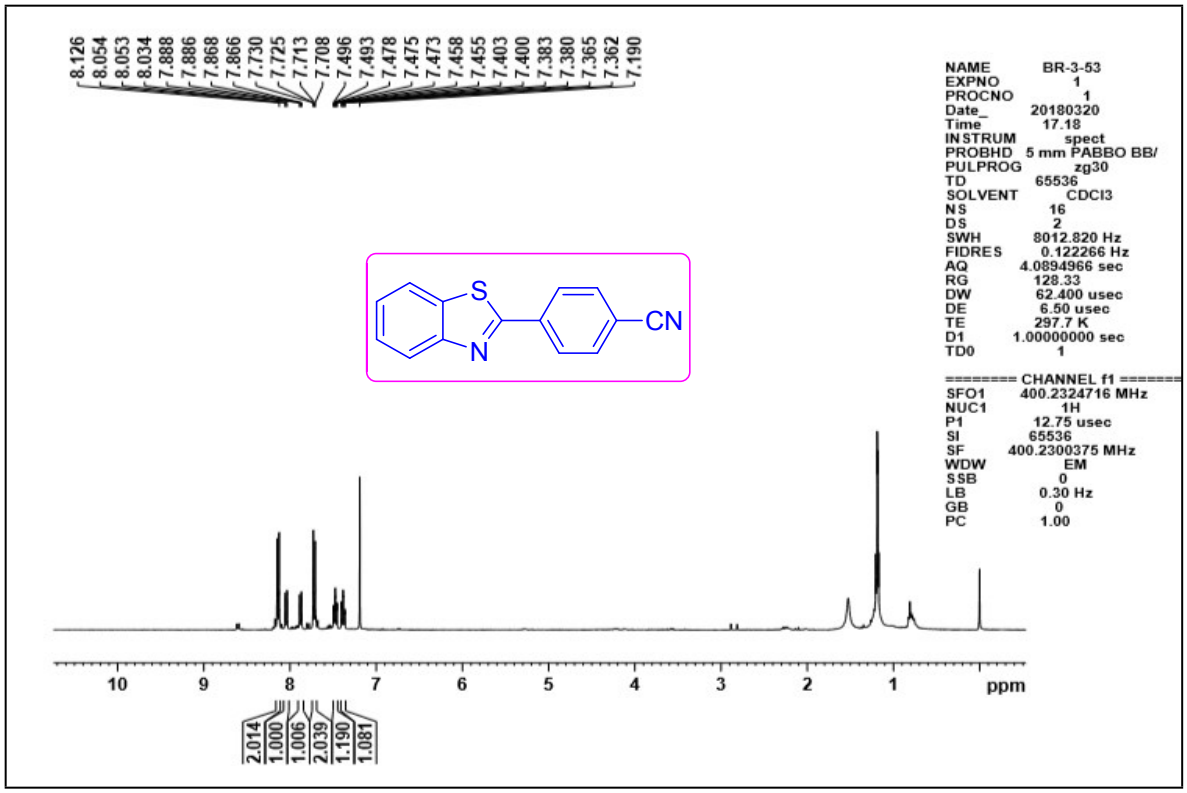


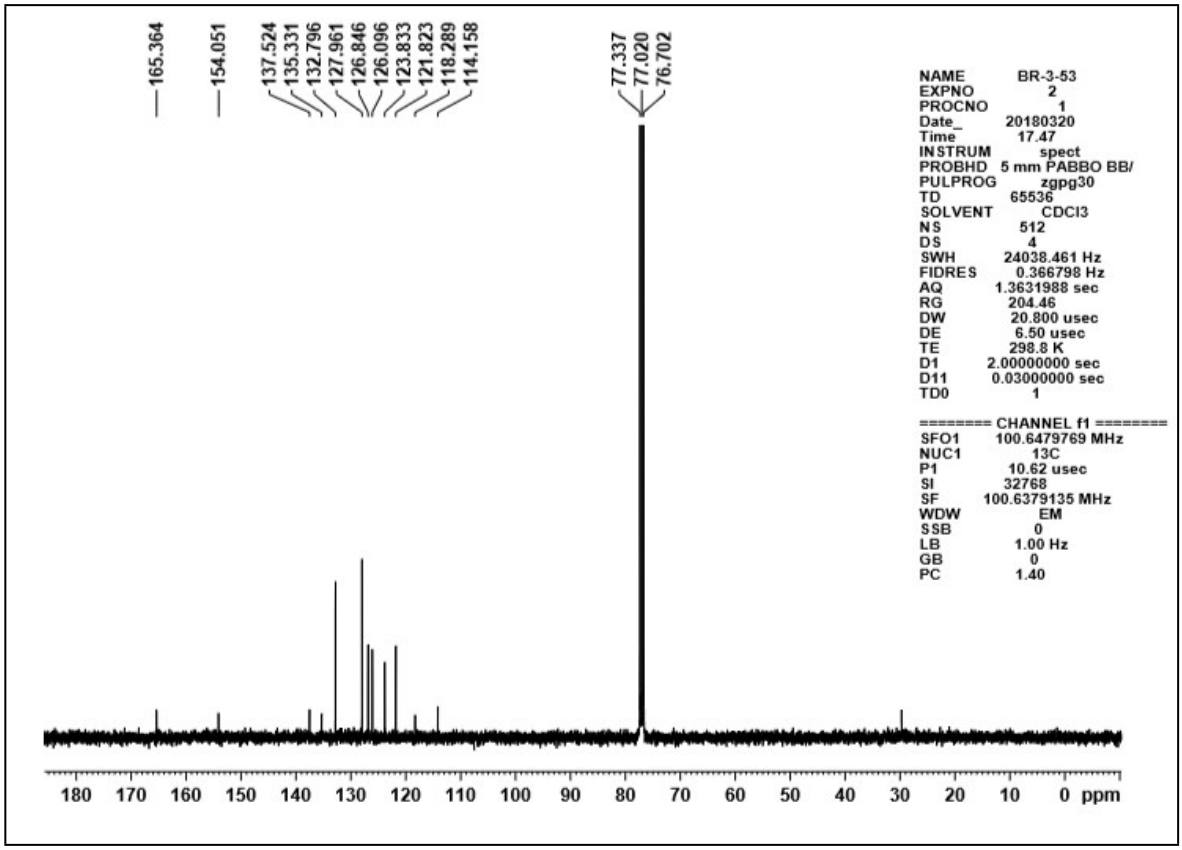
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 5f



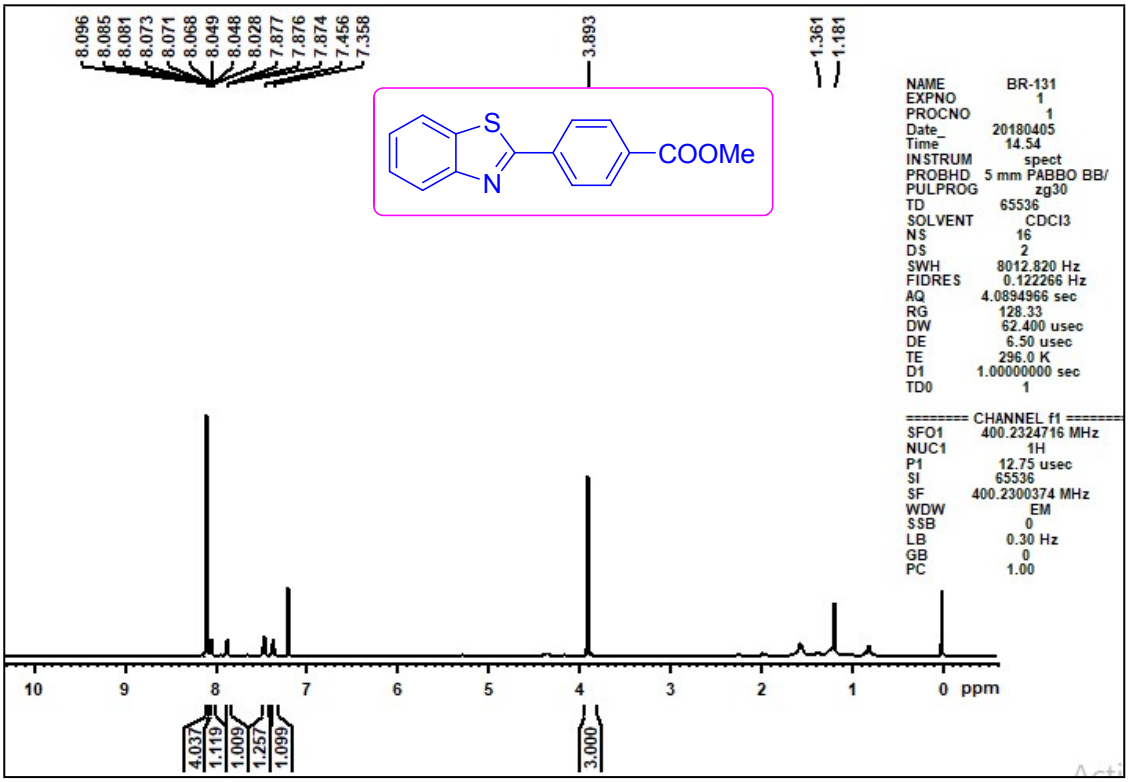


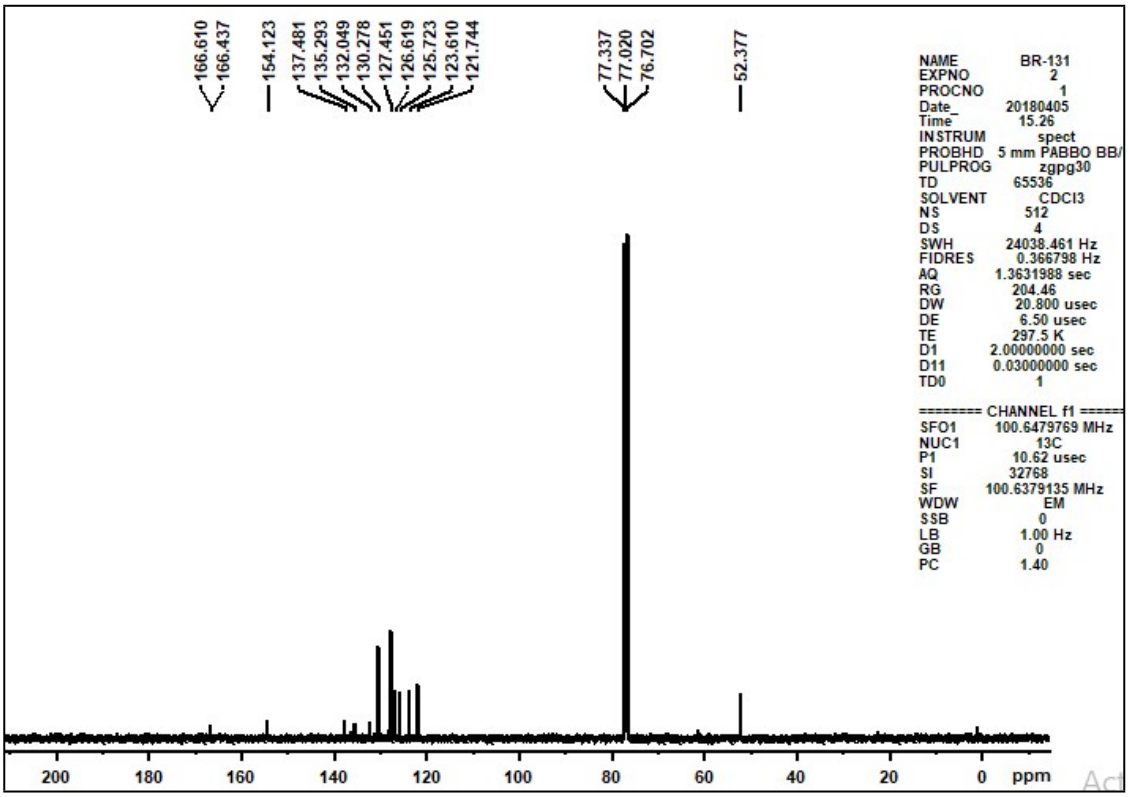
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 5g





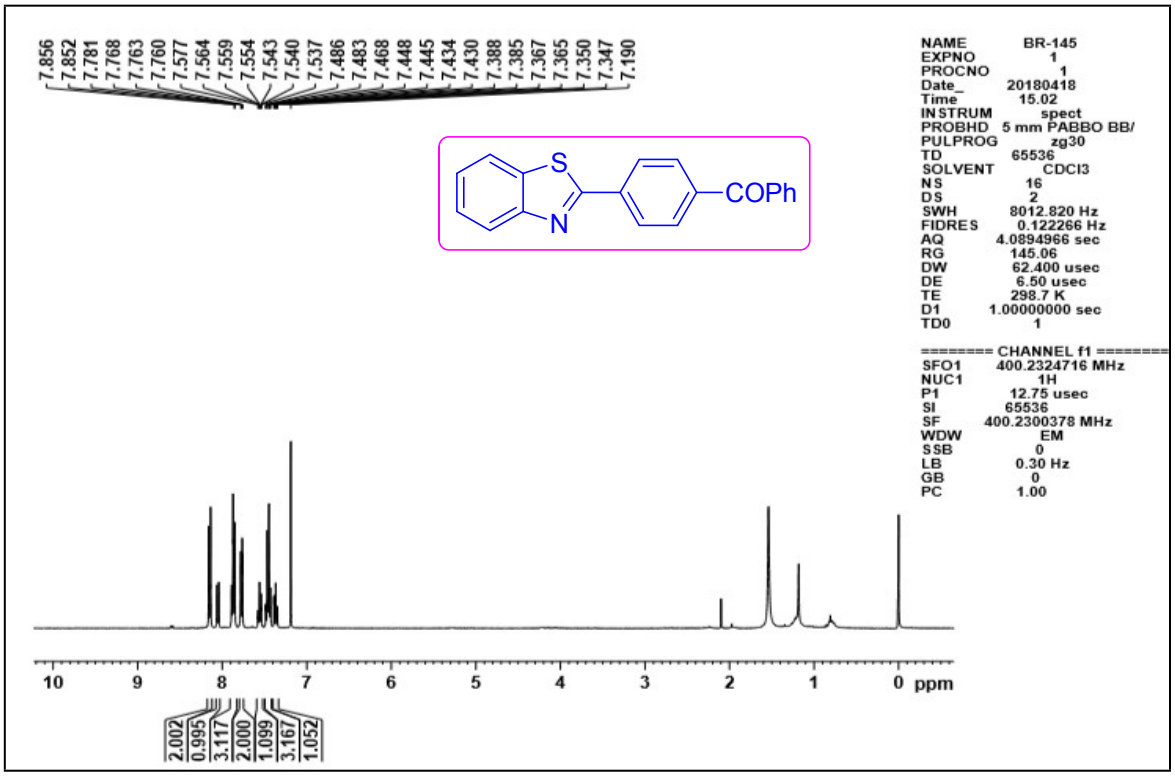
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 5h

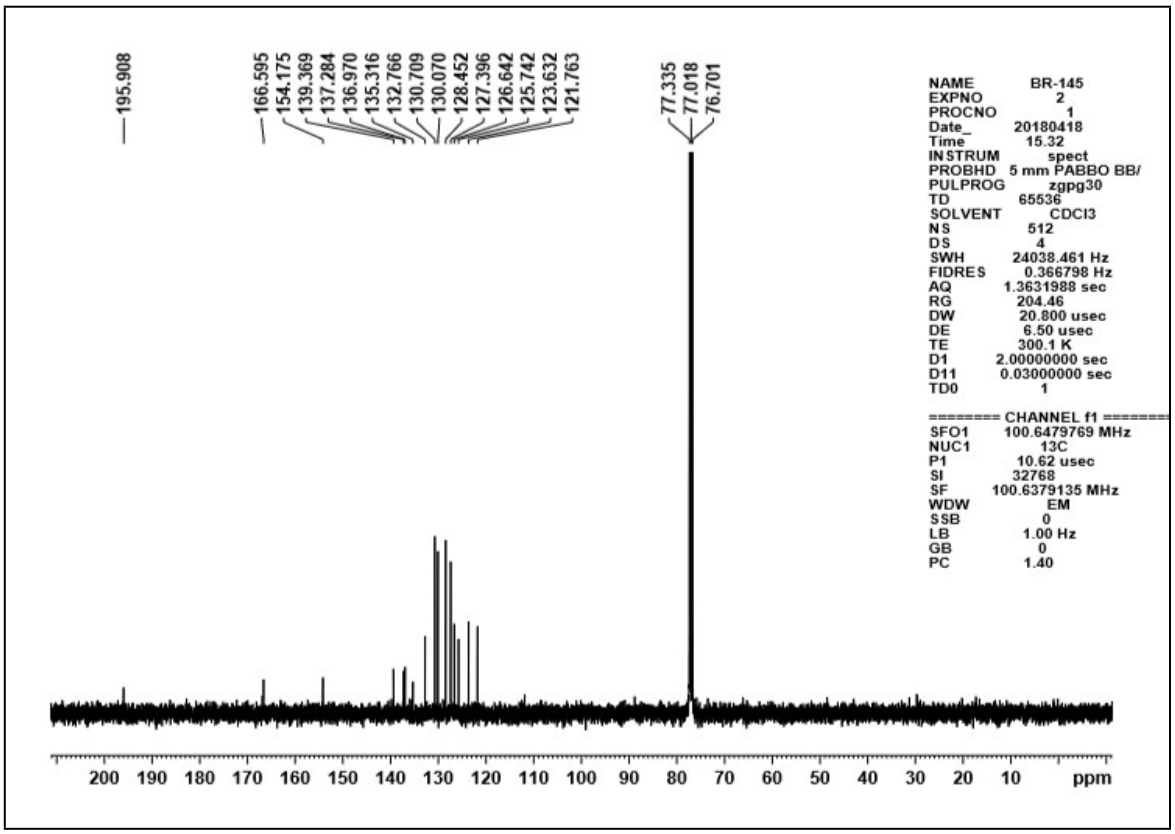




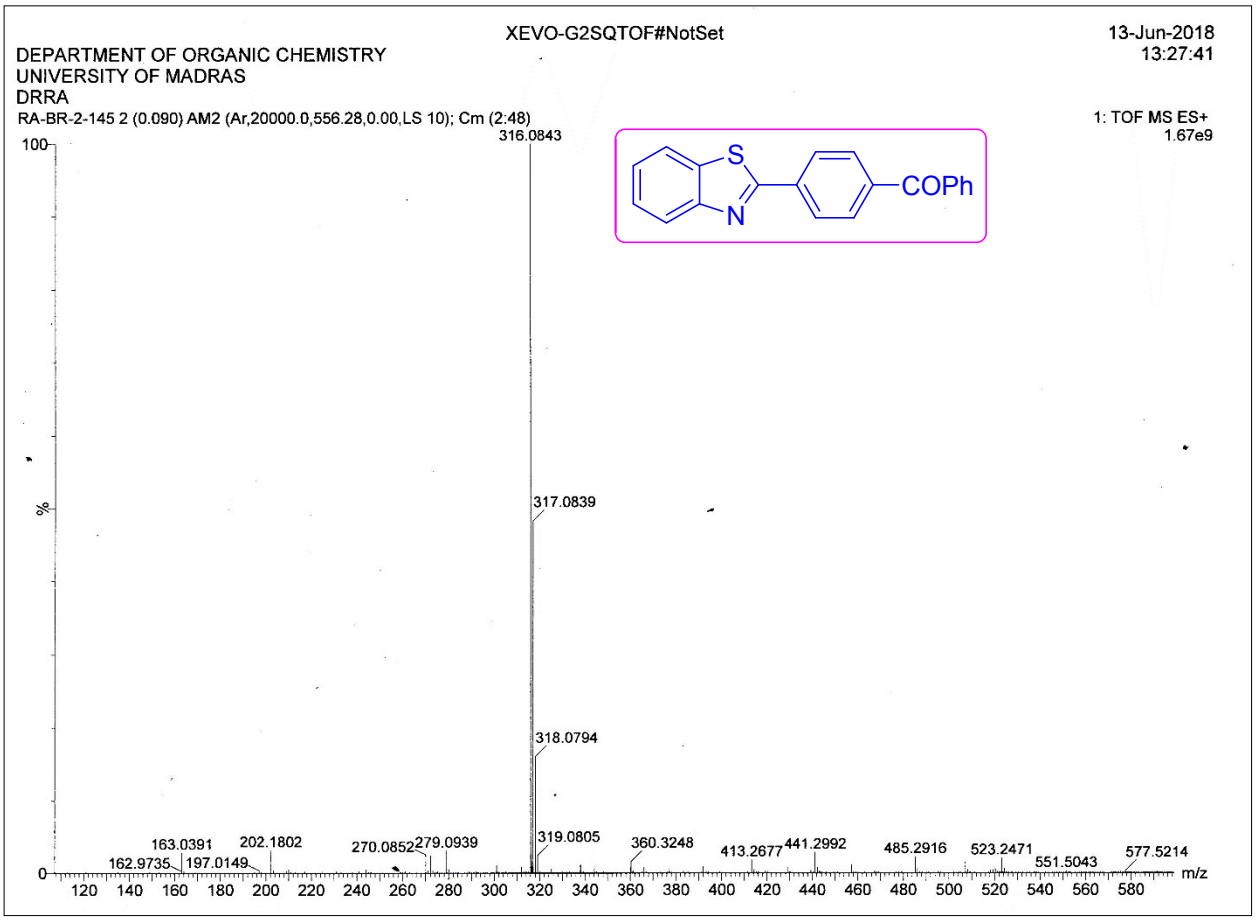
^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 5i

^{1}H

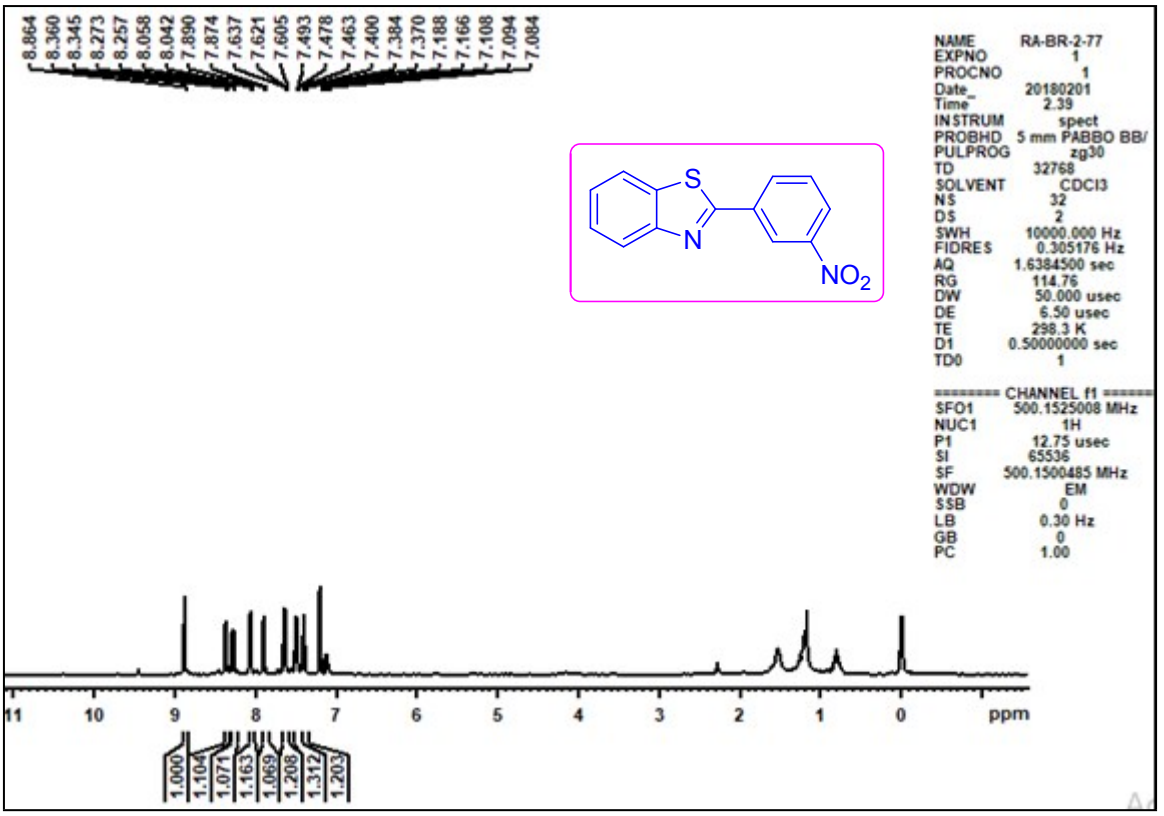


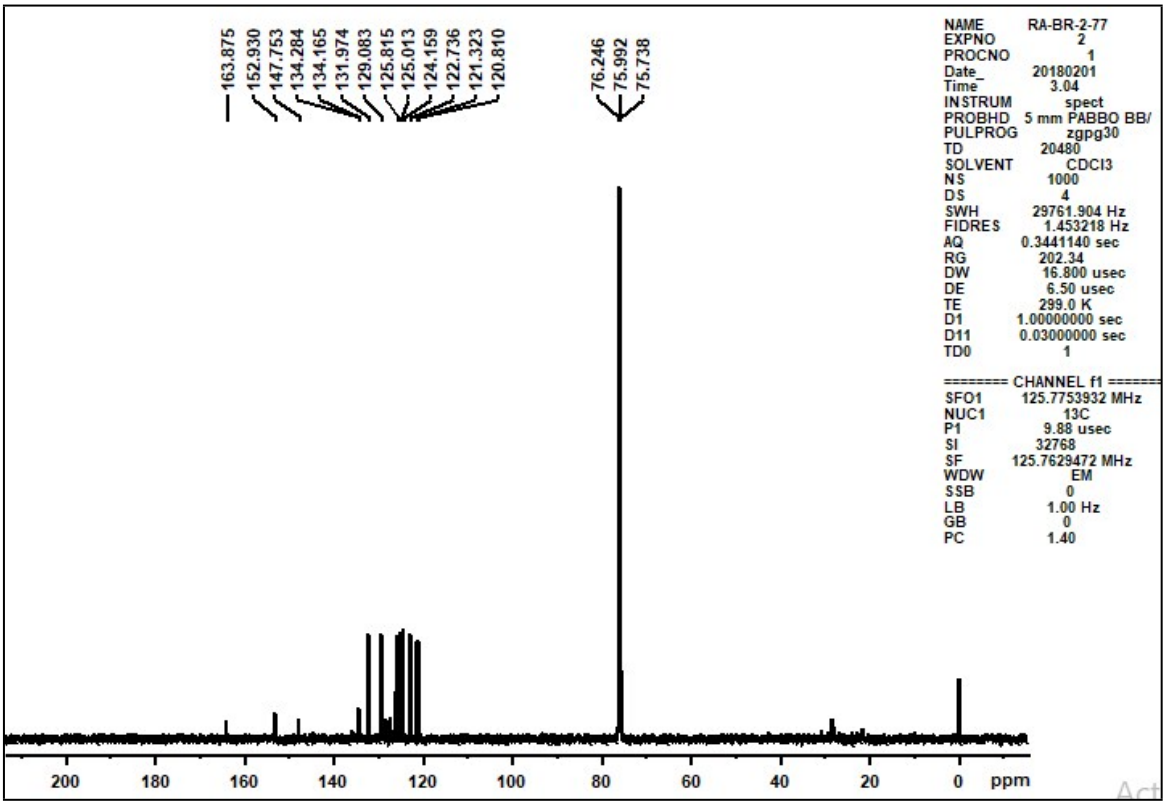


&^{13}C NMR ($CDCl_3$) spectra of compound 5j

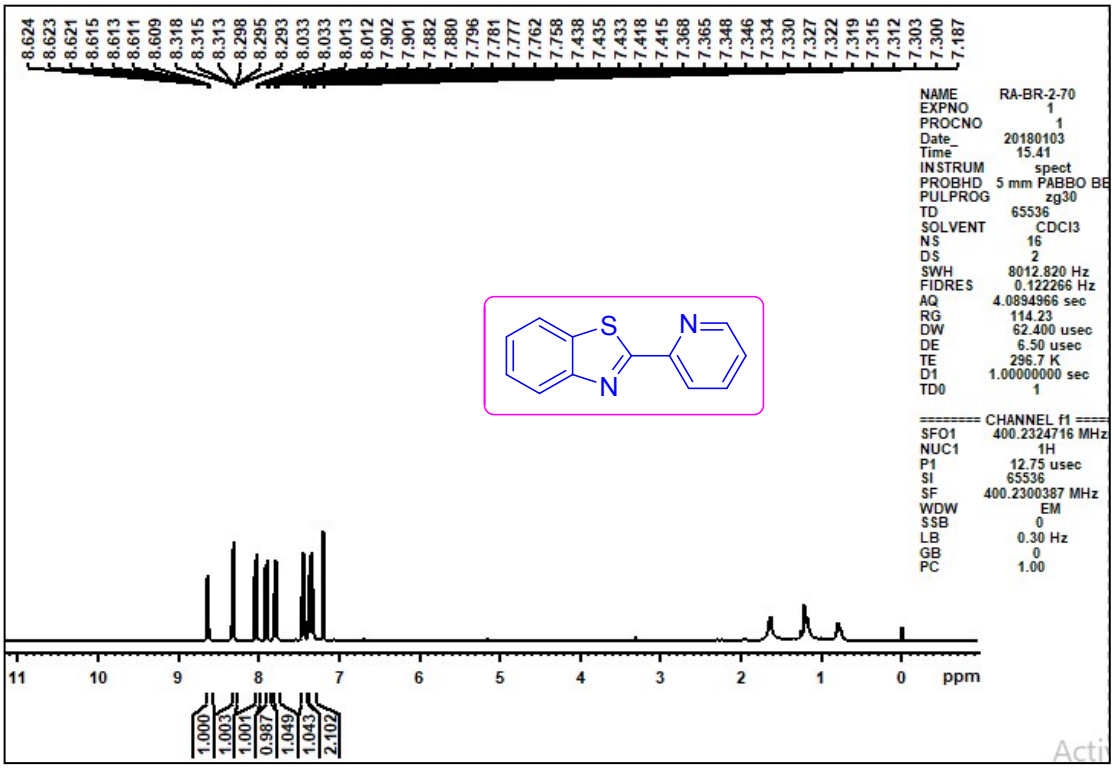


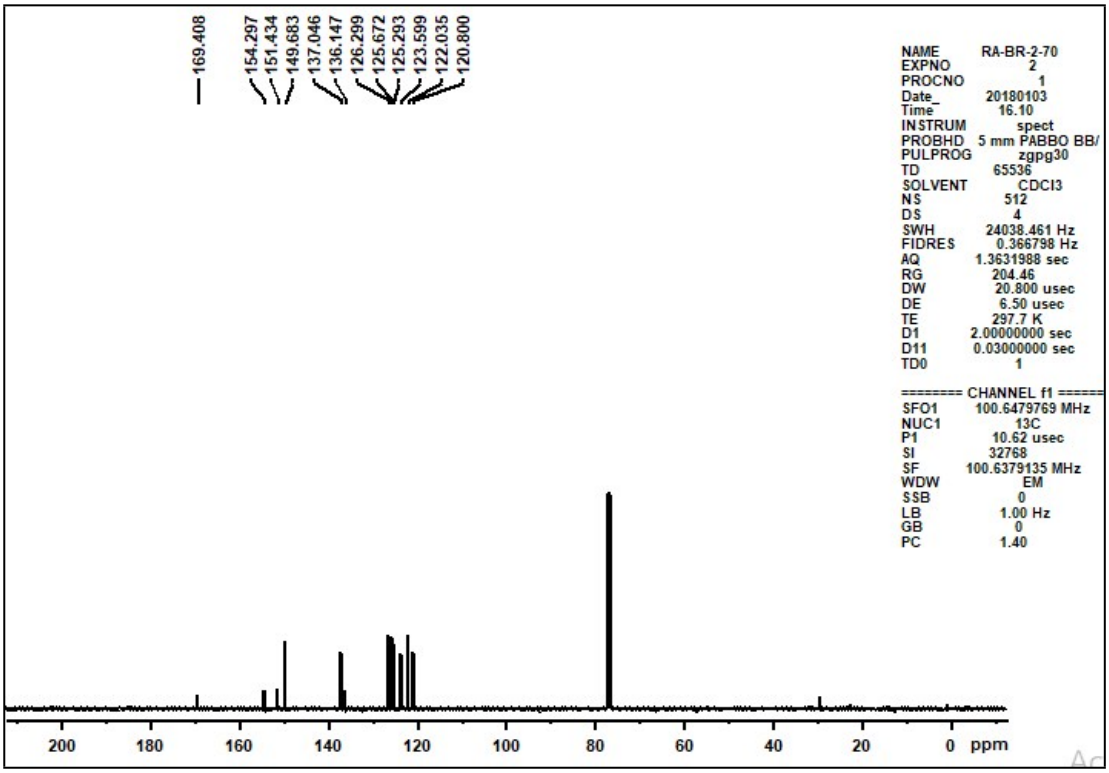
HRMS spectrum of compound 5j



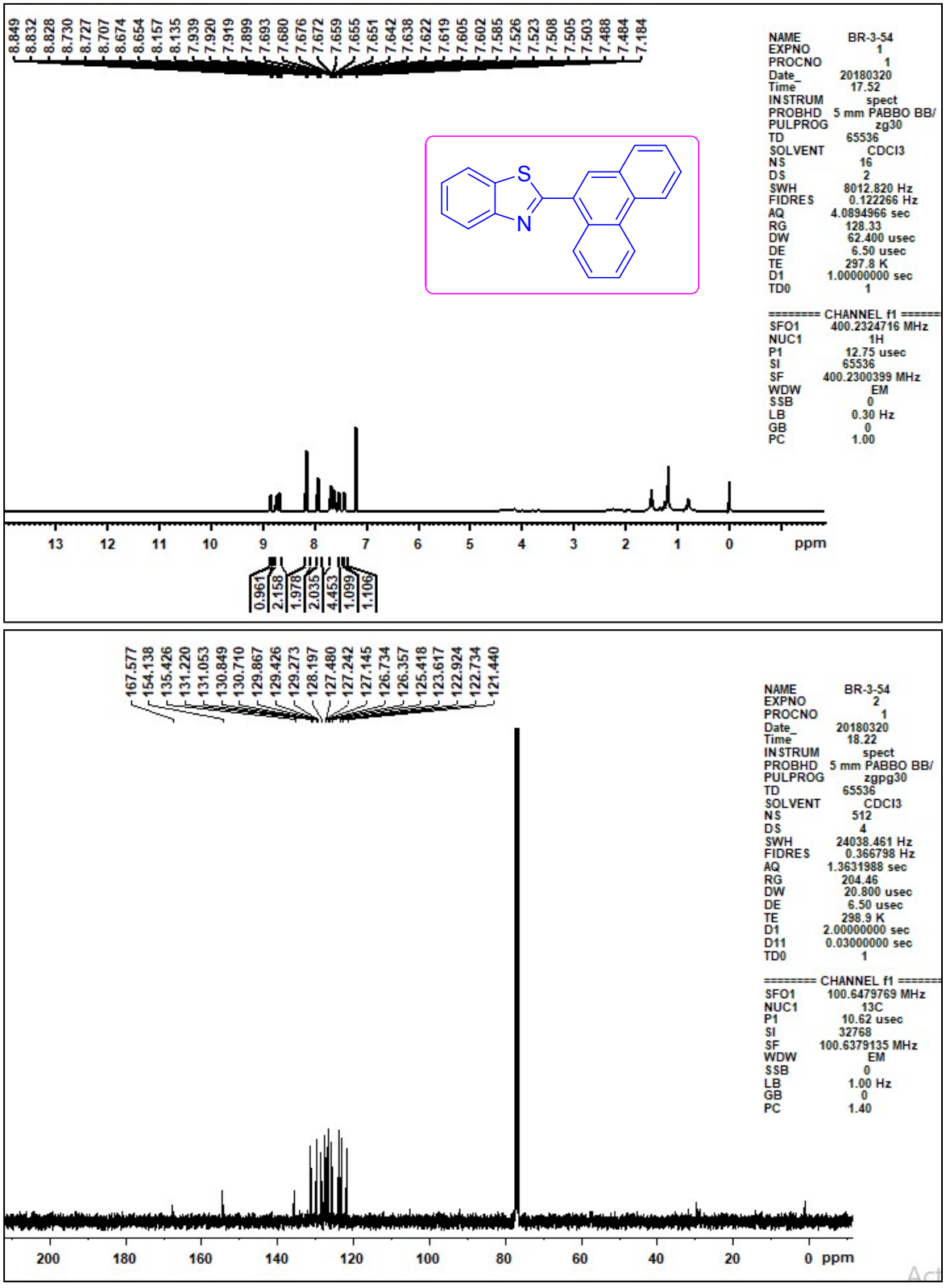


^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 5k

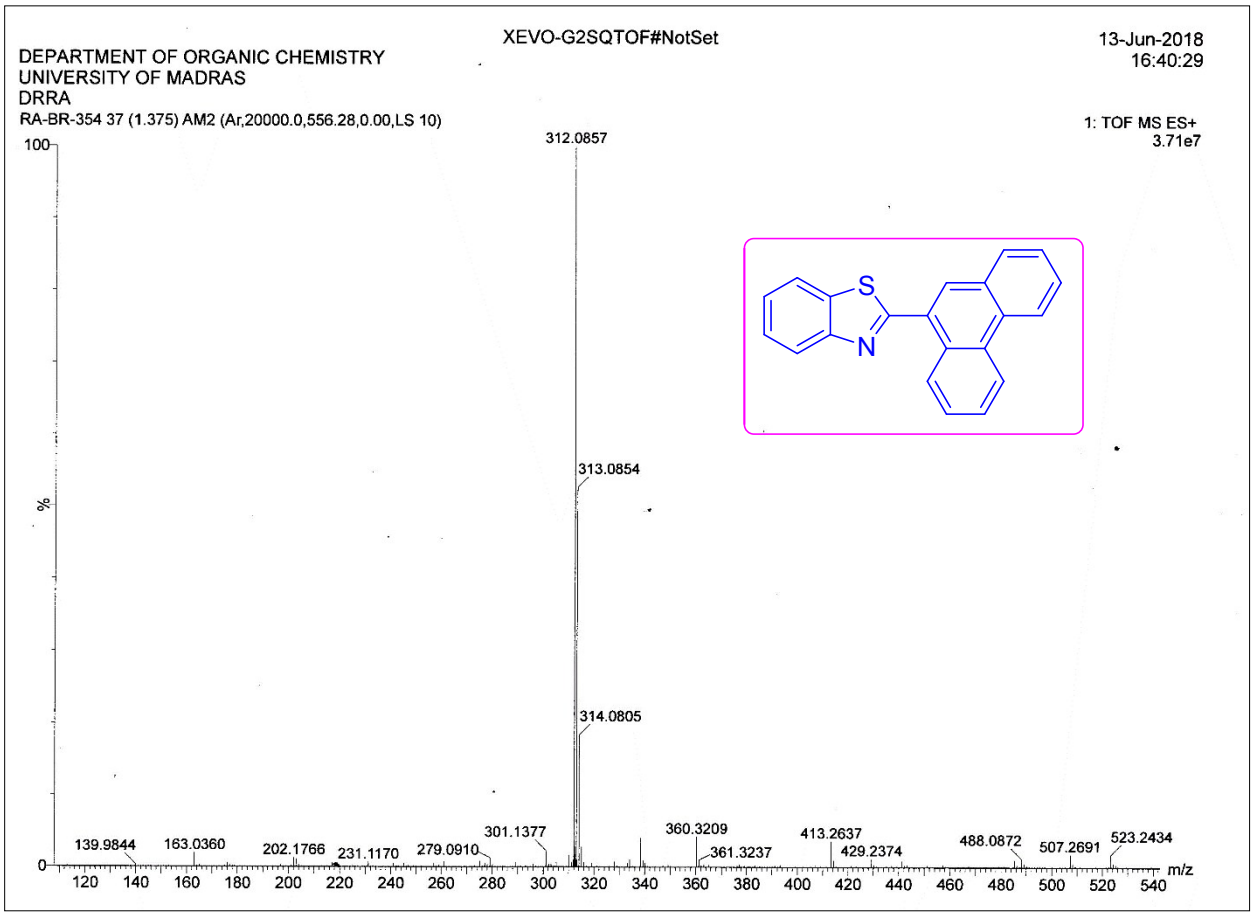




^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 5l



^{1}H &^{13}C NMR ($CDCl_3$) spectra of compound 5n



HRMS spectrum of compound 5n