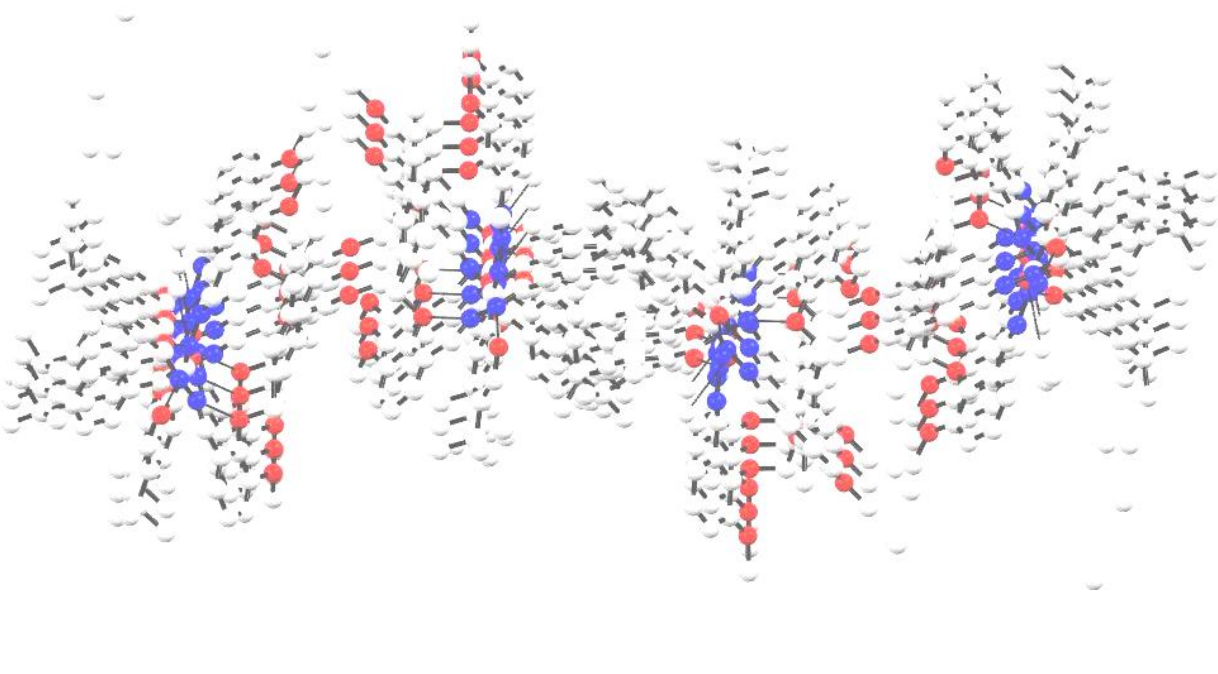
CHAPTER III

Synthesis and characterization of 1,3,5-tris[(5-aryl-1,3,4-oxadiazol-2-yl)-aryloxymethyl]-2,4,6-tri-methylbenzenes

Part A

Synthesis of 1,3,5-tris[(5-aryl-1,3,4-oxadiazol-2-yl)-phenyl-oxy-methyl-2,4,6-trimethyl benzenes



3.1 INTRODUCTION

This chapter is presented in two parts based on the methodology of synthesis of the heterocyclic tripodal C_3 symmetric compounds.

PART - A

In continuation with the work on the synthesis of new C_3 symmetric compounds having heterocyclic moiety as a part of podand groups, in this chapter several new compounds containing 1,3,4-oxadiazole heterocycle have been prepared. It also involves the synthesis of new acylhydrazones with diverse applicability.

1,3,4-Oxadiazole is a five member heterocycle containing an oxygen atom and two consecutive nitrogen atoms, each one separated by a carbon atom from the oxygen, thus resulting in a symmetric heterocyclic structure. The substituents if present at the carbon atoms at the positions 2 and 5 contribute to various properties of oxadiazoles.

1,3,4-Oxadiazoles can be prepared from different acyclic substrates by using a variety of reagents.[1] Acylhydrazones **1** can be oxidatively cyclized to oxadiazoles **1'** by using different oxidants (Figure 1) such as potassium permanganate,[2] cerric ammonium nitrate,[3] lead(IV) oxide,[4] hypervalent iodine reagents such as 2–iodobenzenediacetate (IBD)**,**[5] bis-(trifluoroacetoxy)-iodobenzene[6] and Dess Martin periodinane (DMP),[7] iodosobenzene $(PhIO)_n$,[8] molecular iodine (I_2),[9] trichloroisocyanuric acid (TCICA),[10] Oxone®,[11] *N*-chlorosuccinimide/1,8-diazabicyclo[5.4.0]undec-7-ene (NCS-DBU)[12] and chloramine T.[13]

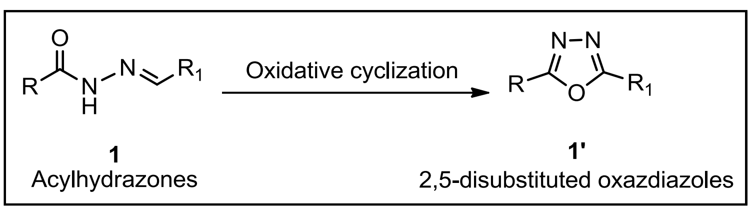


Figure 1 ***Oxadiazoles from acylhydrazones***

Diacylhydrazines **2** or acylsemicarbazides **3** can be cyclocondensed to oxadiazoles **1'** (Figure 2) by using thionyl chloride,[14] phosphorous oxycholride,[15] sulfuric acid,[16] phosphorous pentoxide,[17] polyphosporic acid[18] or zirconium(IV) chloride.[19]

Acylthiosemicarbazides **4** can undergo oxidative cyclodesulfurization to 1,3,4-oxadiazoles **4’** (Figure 2) by using reagents such as lead(IV) oxide,[4] mercury oxide,[20] carbodiimides[21] or 2-iodoxybenzoic acid.[22]

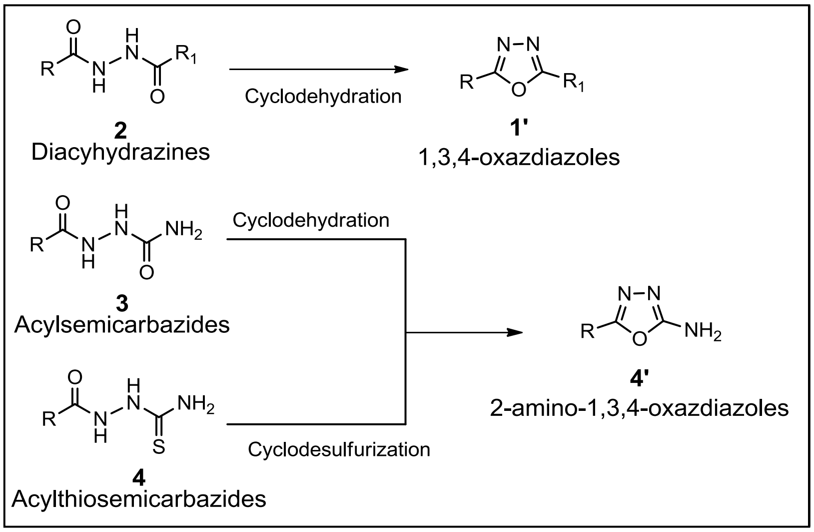


Figure 2 ***Acylhydrazine derivatives to 1,3,4-oxadiazoles***

Synthesis of 1,3,4-oxadiazoles has attracted much attention not only due to the chemistry involved in their synthesis but also due to diverse biological activities they posses. 1,3,4-Oxadiazoles are reported to have a wide spectrum of biological activities[23] such as antimicrobial,[24] anticancer,[25] antituberculosis,[26] anti-inflammatory,[27] antiviral,[28] anti-HIV[29] and antifungal[30] bioactivities. Some significant molecules possessing 1,3,4-oxadiazole as a core unit **9** are used as fluorescent compound in the Liquid Scintillator Neutrino Detector (LSND) (Figure 3).

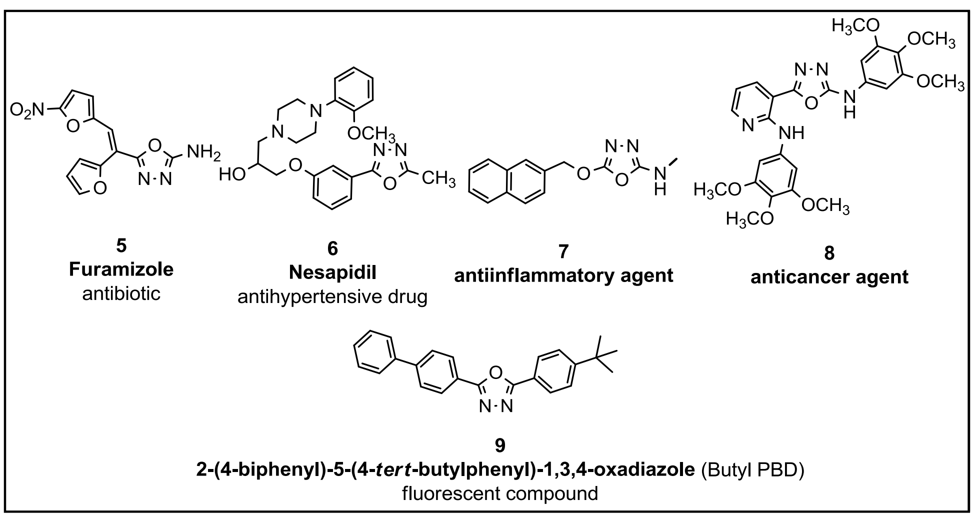


Figure 3 ***1,3,4-oxadiazoles with useful properties***

Acylhydrazones **1** have been widely employed for the synthesis of 1,3,4-oxadiazoles derivatives by oxidative cyclization as described earlier. Acylhydrazones can be prepared by condensation reaction of acylhydrazines with aldehydes or ketones (Figure 4).

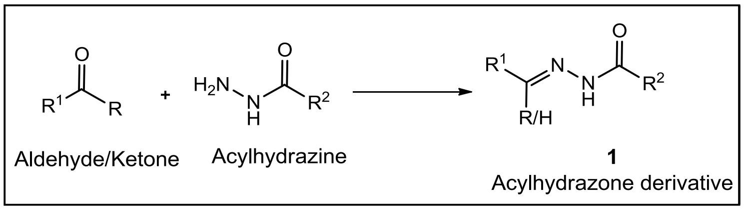


Figure 4 ***Preparation of hydrazones***

Hydrazones are biologically important compounds as they posses –C=N– linkage which is prone to undergo attack by a nucleophile and due to that it may also undergo hydrolysis back to starting compounds. Hyrazones can also be cyclized to give 4–thiazolidinone[31] or 2–azitidinone derivatives[32] or can be reduced to give hydrazine compounds (Figure 5).

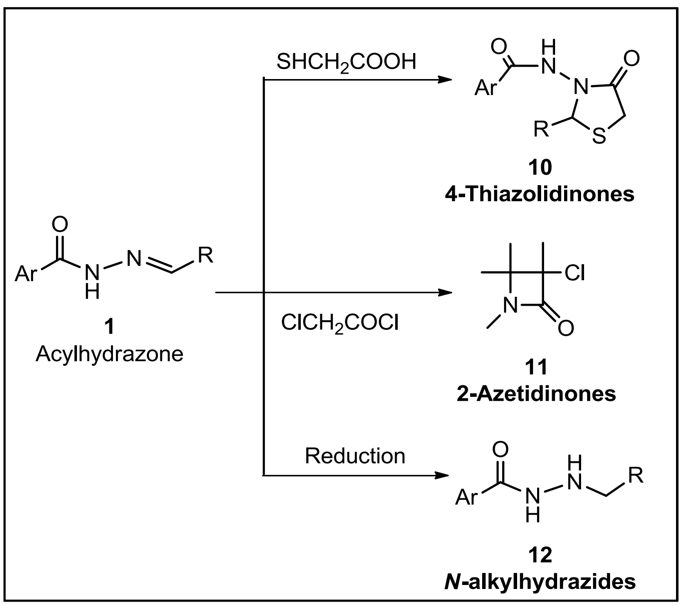


Figure 5 ***Synthesis from acylhydrazones***

Hydrazones show a diverse biological activities not only because of hydrazone linkage but also due to various heterocyclic moieties brought together either from a hydrazine, a hydrazide or from a carbonyl compound. Acylhydrazones have been studied widely for a variety of bioactivities[33] such as animycobacterial,[34] antimalarial,[35] antibacterial,[36] antidepressant,[37] anticonvulsant,[38] anti-inflammatory,[39] antianalgesic[40] and antitumor[41] activities (Figure 6).

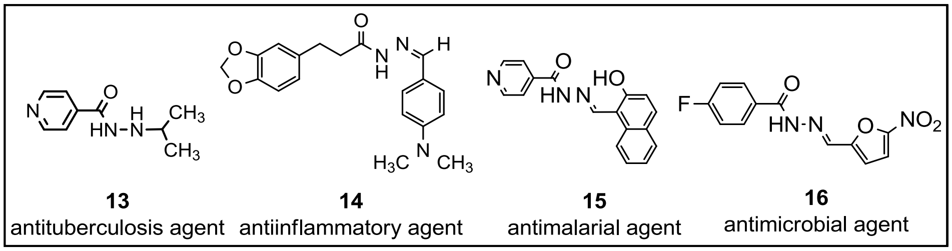


Figure 6 ***Representative bioactive compounds with hydrazone linkage***

3.1.2 Hydrazones in supramolecular chemistry & materials science

Acylhydrazones are good chelating agents for transition metal ions[42] and can also be used as chemical sensors due to their binding abilities.

Several C_3-Symmetric hydrazones and acylhydrazones have been reported and studied. Novel tri-arm star shaped 1,3,5-triazine acylhydrazones **17** were reported recently and were studied for their biological activities.[43]

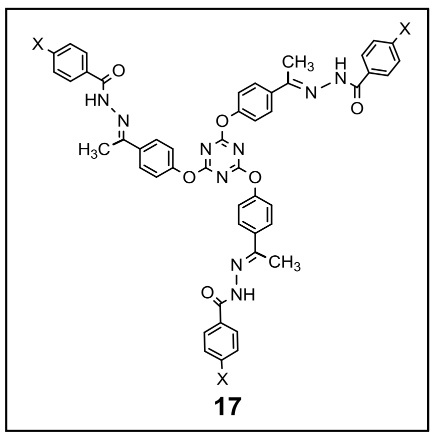


Figure 7 ***Star shape acylhydrazone derived from 1,3,5-triazine***

Discotic liquid crystalline property was observed in C_3-Symmetric hydrazones **18** having long alkoxy chains attached to the peripheral aromatic rings[44] (Figure 8).

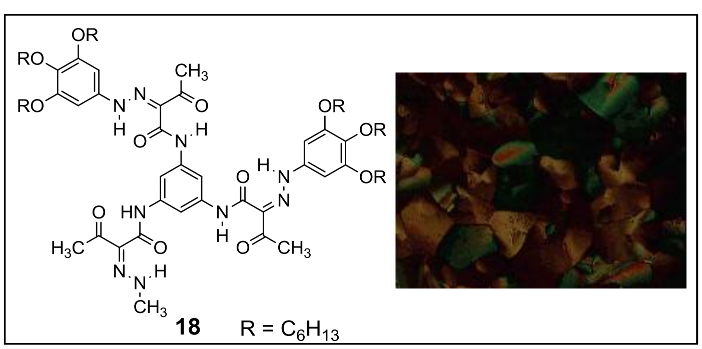


Figure 8 ***Tripodal tris-hydrazone derivative with discotic LC property***

Tripodal compound **19** with triethylamine core having acylhydrazone linkage in the outer circle were reported as novel hydrazone based tripodal sensors for acetate anions in aqueous medium[45] (Figure 9).

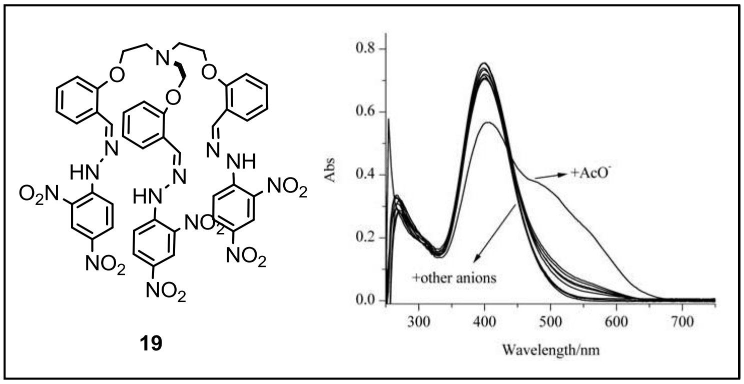


Figure 9 ***Tripodal host with hydrazone binding sites as a colorimetric chemosensor***

Tris-aromatic acylhydrazone **20** having adjacent hydroxy/alkoxy groups undergo self assembly leading to definite shapes due to stacking and forming flower shaped aggregates [46] (Figure 10).

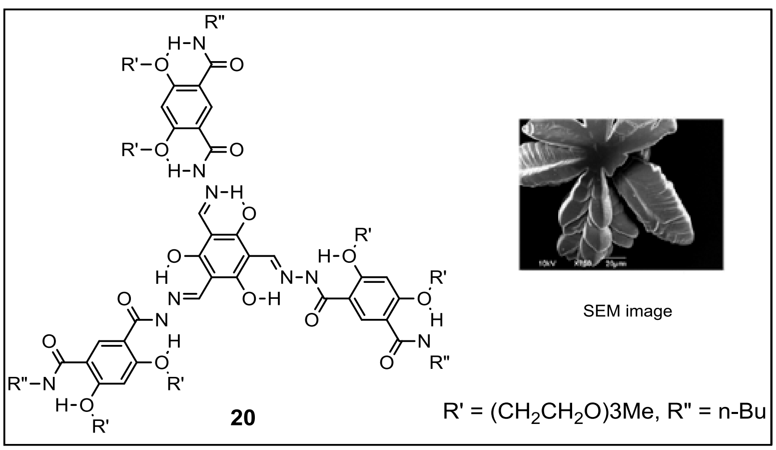


Figure 10 ***Hydrogen bonded self-assembled tris-aromatic acylhydrazones***

A very few C_3 symmetric compounds substituted with 1,3,4-oxadiazoles are found in literature. One such compound with 2-phenyl-1,3,4-oxadiazole directly attached to the central phenyl ring via position 5 **21** was found to posses liquid crystalline property[47] (Figure 11).

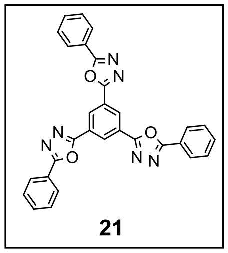


Figure 11 ***C_3 Symmetric oxadiazole compound with LC property***

When alkoxy group was introduced at para position of the phenyl rings in **21** it resulted into luminescent liquid crystalline materials **22** and showed a dendritic growth of crystals on cooling for the formation of hexagonal columnar phase[48] (Figure 12).

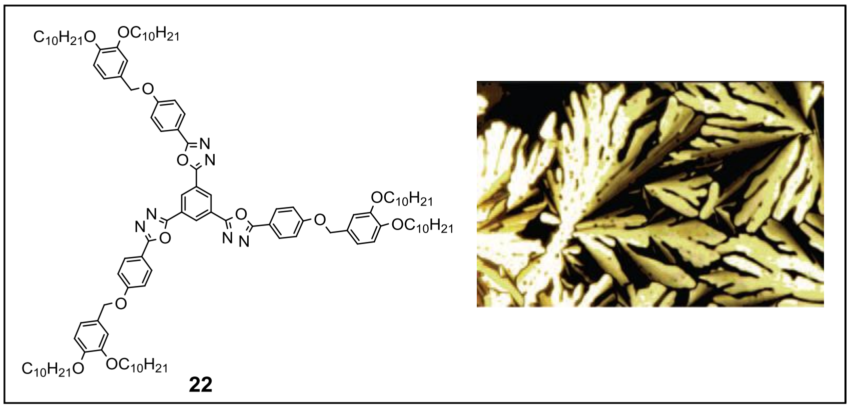


Figure 12 ***Fluorescent liquid crystalline tripodal 1,3,4-oxadiazole***

With more such alkoxy chains attached to aromatic ring, in turn attached to 1,3,4-oxadiazole as a part of star shaped C_3 symmetric molecule, the resulting molecule **23** undergo aggregation leading to Langmuir Blodgett-film due to conformation change at the surface interface due to supramolecular interactions[49] (Figure 13).

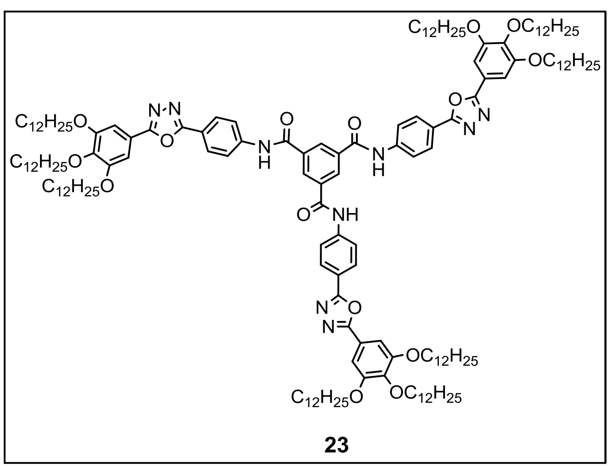


Figure 13 ***Surface active C_3 symmetric tripodal 1,3,4-oxadiazoles***

C_3 symmetric tris-4-pyridyl oxadiazoles **24** were prepared by the reaction of 5-(4-pyridyl)tetrazole and the tris-acylchloride. The tripodal compounds on complexation with Pd(II) gave self-assembled nano-sized ball which was found to catalyze the Suzuki-Miyaura cross coupling reaction[50] (Figure 14).

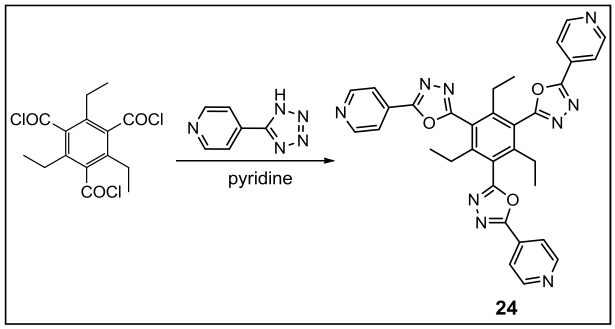


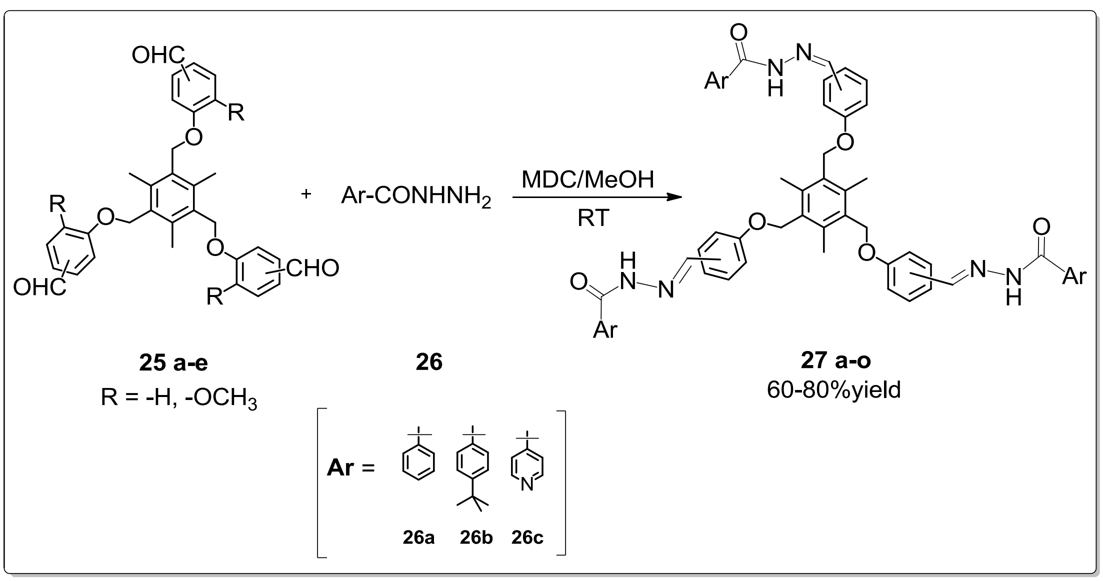
Figure 14 ***Synthesis of tripodal oxadiazole ligand***

3.3 RESULTS AND DISCUSSION

In this part of the chapter fifteen new acylhydrazones **27** have been prepared by using five C_3 symmetric tris-aldehydes **25** and three different acylhydrazides **26** namely benzhydrazide, isonicotinic acid hydrazide and *p*-*tert*-butyl benzhydrazide. Tris C_3 symmetric acylhydrazones were prepared for their potential application as host molecules with the additional binding sites they offer and for their application in the synthesis of C_3 symmetric heterocyclic supramolecular scaffolds.

The newly synthesized acylhydrazones **27** were employed for the construction of C_3 symmetric tris-1,3,4-oxadiazoles on the oxidative cyclization resulting in the fifteen new tripodal compounds containing oxadiazole heterocycles.

The reactions of tris-aldehydes **25** with the respective hydrazides **26** were carried out by dissolving them in dichloromethane (DCM) and methanol respectively and mixing together to allow them to react under reflux conditions with stirring for 1-2 hours time until completion of the reaction as observed on TLC. The resulting products were obtained after removal of the solvents under reduced pressure and treating the residue with alcohol and DCM to remove unreacted materials (Scheme 3.1).



Scheme 3.1

All the newly synthesized tris-acylhydrazones were characterized by spectro-analytical techniques.

The typical bands observed in IR spectra of the compounds **27a–o** have $\nu_{N–H}$ between 3200–3290 cm^{-1}, a strong band of $\nu_{C=O}$ between 1650–1660 cm^{-1} and $\nu_{C=N}$ are observed as a strong to medium intensity band between 1554–1560 cm^{-1} flanked by the bands at 1500 and 1600 cm^{-1} for aromatic $\nu_{C=C}$. In the compounds with –OCH_3 group attached, show $\nu_{C–O}$ at about 1260 cm^{-1} and 1070 cm^{-1}. The compounds with tert-butylphenylhydrazones **27f–j** show strong bands at 2961 cm^{-1} due to $\nu_{C–H}$ and a typical band around 1363 cm^{-1} due to bending vibrations of *tert*-butyl group.

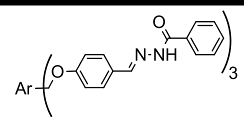
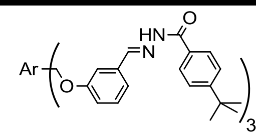
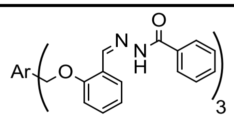
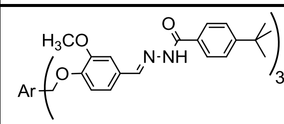
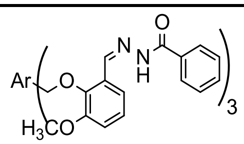
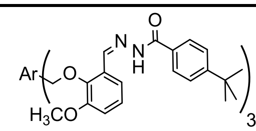
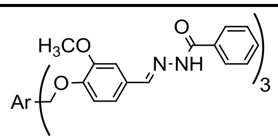
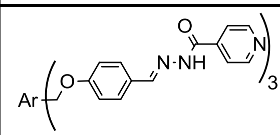
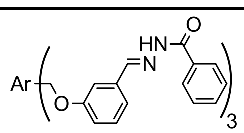
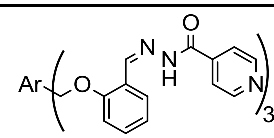
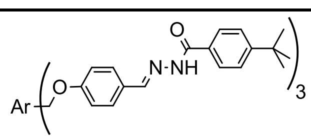
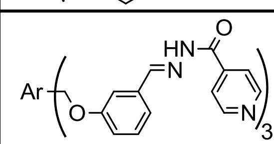
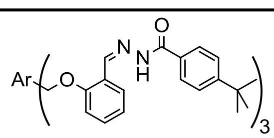
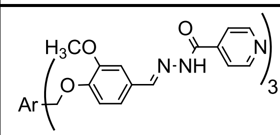
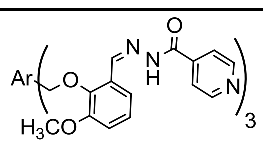
The hydrazones **27a–o** show characteristic ^{1}H NMR signals with distinct chemical shifts for different kinds of protons. The methyl group protons are observed at δ 2.4 while oxygen attached methylene group protons (–OCH_2) are observed at δ 5.2. The methyne proton of imine linkage (–N═CH–) is observed as singlet between δ 8.4 to 8.8 and N–H proton of the hydrazine group is observed most downfield between δ 11.7 to 12.1 as a singlet. The compounds with methoxy group (–OCH_3) in their structure show a singlet for three protons at δ 3.8. The *tert*-butyl group protons of compounds **27f–j** are observed as a singlet for nine protons at about δ 1.2–1.3. The protons on aromatic rings are observed between δ 7.0 to 8.0 as per the substitution patterns.

The ^{13}C–NMR spectra of the tris-acylhydrazones show central ring methyl carbon (–CH_3) signal at δ 16.0 and methylene carbon (–OCH_2) signal at δ 65.0. The signal around δ 161 to 163 is observed for carbonyl group (–C═O) and position of the imine carbon (–C═N) varies from δ 153.0 to 161.0. The methoxy group if present is observed at δ 56 while *tert*-butyl carbon signals are observed as downfield as at δ 31.0 and 35.0 for primary and quaternary carbons respectively. The aromatic carbons are observed from δ 108 to 155. The aromatic tertiary and quaternary carbon signals observed are in accordance with the proposed structures of the respective tris-acylhydrazone compounds.

All the tripodal tris-acylhydrazones were characterized with the help of mass spectrometer having Q-TOF analyzer by using ESI technique. The molecular ion peaks of all the compounds were observed as $(M+H)^+$ including $(M+Na)^+$ in accordance with their proposed structures.

Yields and melting points of the newly synthesized tris-hydrazones are summarized in the following table (Table 3.1.0)

Table 3.1.0 ***Yields and melting points of newly synthesized tris-acylhydrazones***

ID	Attachment of aryl-hydrazone group	Yield [%]	mp [°C]	ID	Attachment of aryl-hydrazone group	Yield [%]	mp [°C]
27a		78	256	**27h**		77	258
27b		63	223	**27i**		65	268
27c		81	262	**27j**		59	261
27d		63	260	**27k**		81	225
27e		65	247	**27l**		67	190
27f		73	284	**27m**		62	180
27g		67	279	**27n**		77	247
27o		69	234				

One of the newly synthesized tris-acylhydrazone **27j** was characterized by single crystal X-ray diffraction technique. Crystals suitable for the analysis were obtained by slow evaporation of dichloromethane and *iso*-propylalcohol solvent mixture.

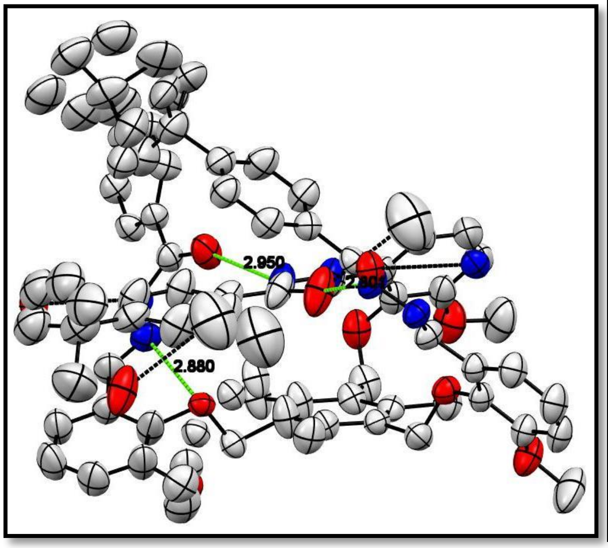


Figure 15 ***ORTEP diagram of 27j***

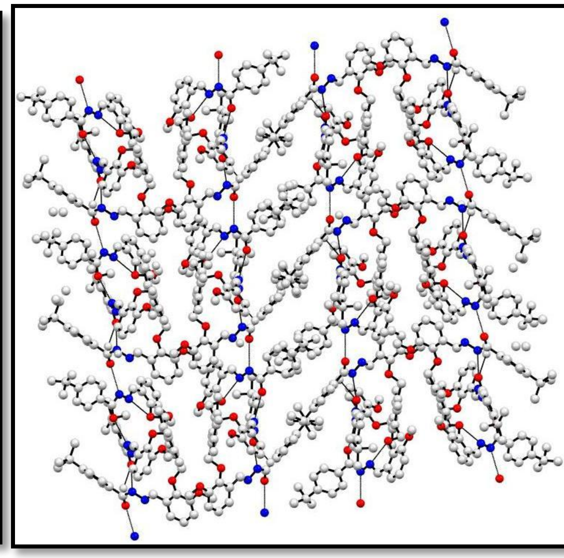


Figure 16 ***Crystal packing pattern of 27j***

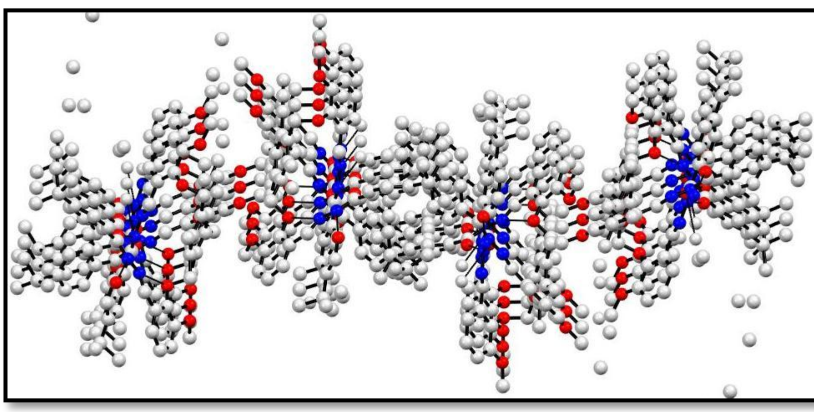


Figure 17 ***Crystal packing pattern of 27j***

Due to intramolecular hydrogen bonding between the carbonyl oxygen of one arm and hydrogen bonded to nitrogen of the hydrazone functionality of another arm, the molecule exhibits the example of the flexible tri-arm tripod leading to all arms in *syn* conformation as shown in figure 15. Crystal packing of the tris-hydrazones results in to different molecular designs due to inter- and intra- molecular hydrogen bonding (Figure 16- 17).

Crystal data of 27j: CCDC: 1427887**;** $C_{69}H_{78}N_6O_9$ (*M* =1134.5830): monoclinic, space group $P2_1/c$, a = 13.6770(7) Å, b = 40.846(2) Å, c = 12.6330(7) Å, α = 90°, β =

115.113(1)°, γ = 90°, V = 6390.3(6) Å3, Z = 4, T = 294 K, μ(MoKα) = 0.08 mm-1, $Dcalc$ = 1.199 g/mm^3, 11250 reflections measured (3.2 ≤ 2Θ ≤ 56.1), 7089 unique reflections which were used in all calculations. The final R_1 was 0.0724 (>2σ(I)) and wR_2 was 0.2123 (all data).

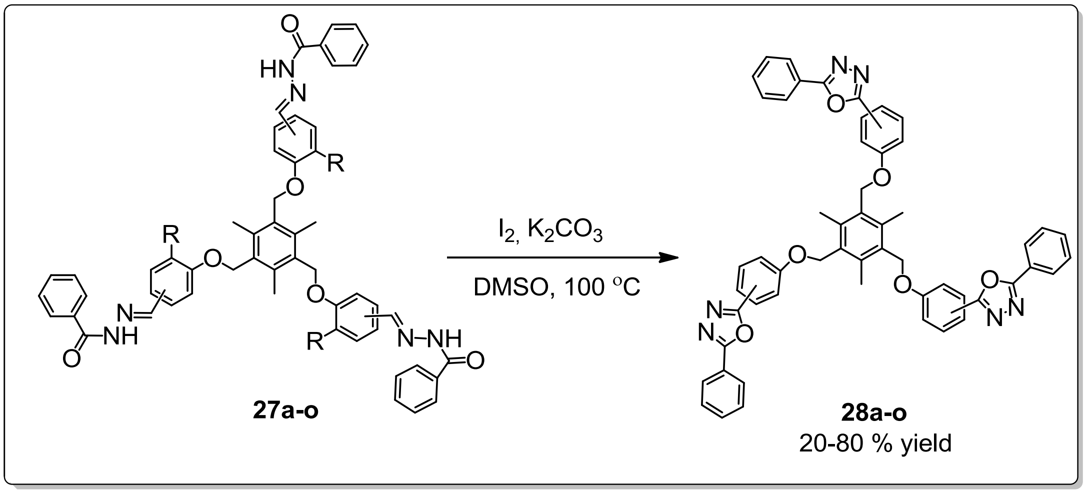
These newly synthesized C_3 symmetric tris-hydrazones **27** have potential for number of applications such as they can be studied for their binding ability with appropriate guest ions or larger organic molecules with complementary functionalities. They can be studied for their biological activities because hydrazides and hydrazones are reported to have diverse biological activities as stated earlier. They can be employed for the synthesis of heterocyclic compounds by cyclocondensation with the other regents and they themselves can be oxidatively cyclized to form new C_3 symmetric 1,3,4-oxadiazoles containing host molecules. In the present study they have been utilized for one of the many potential applications that is for the synthesis of tris-1,3,4-oxadiazole carrying tripodal compounds.

3.3.2 Oxidative heterocyclization of acylhydrazones to tris-1,3,4-oxadiazoles

There are a number of oxidizing reagents and reaction conditions reported for the heterocyclization of acylhydrazones to 1,3,4-oxadiazoles. For the threefold heterocyclization in the present study, several of these reagents were attempted which include $KMnO_4$ in DMF under reflux condition, CAN in DCM, NCS-DBU in DCM, IBD in $CHCl_3$ or DMSO and TCICA in ethanol. All these conditions failed to give the desired reaction. Without getting disappointed further, attempts were continued to achieve the targeted synthesis.

The attempts to affect the threefold heterocyclization met with success when molecular iodine was used as oxidizative reagent under basic condition (excess of K_2CO_3) in DMSO and heating at 100 °C for a short period of time.[9b]

Progress of the reaction was monitored by TLC. The desired products were obtained after aqueous work up and chromatographic separation giving poor to good yields depending on the substrates used (Scheme 3.2).



Scheme 3.2

The structure and the symmetry present in the 1,3,4-oxadiazole tripodal compounds were reflected in their spectral characteristics.

The infrarred spectra of final heterocyclic compounds **28** were characterized by disappearance of the typical IR bands for ν_{N-H} and $\nu_{C=O}$ frequencies present in their hydrazones. But the strong bands for $\nu_{C=N}$ and $\nu_{C=C}$ were clearly observed between 1600 to 1450 cm^{-1}. The IR bands for the respective substituents in the compounds continued to appear marking their presence similar as in the case of tris-acylhydrazones.

In the ^{1}H NMR spectra of tripodal 1,3,4-oxadiazoles **28,** the methyl groups ($-CH_3$) on the central ring appeared at δ 2.5 with exceptions when DMSO was used in one case (δ 1.99) and when tris-oxadiazole compound **28j** with *tert*-butylphenyl ring and methoxy group ($-OCH_3$) were situated at *ortho* positions with respect to aryloxy linkage (δ 2.19) in the other case. The position of the methylene protons attached to oxygen atom ($-OCH_2$) was found in between from δ 4.9 to 5.2 and at δ 4.8 (in DMSO). The –NH and –CH=N– proton signals of hydrazone functionality are disappeared while aromatic protons signals are observed with the new chemical shifts ranging between δ 7.1 to 8.9. The *tert*-butyl and methoxy group protons were observed as singlets at their respective positions.

The typical signals in ^{13}C-NMR spectra of tris-1,3,4-oxadiazoles include signals for, two oxadiazole ring carbons appearing near δ 164. The central ring $-CH_3$ carbon signal is observed between δ 16.0 to 16.3 and $-OCH_2$ carbon signal between δ 65.0 to 65.6. The methyl group (–CH_3) carbon signal shifts upfield and methylene group (–OCH_2) carbon signal shifts downfield from their regular chemical shift in case of tripodal compounds having both methoxy group and oxadiazole moiety at *ortho* to the ether linkage. The *tert*-butyl and the methoxy group carbon signals were observed at their respective positions. The carbon signals of the carbon next to nitrogen in the pyridyl ring of compounds **28k-o** are observed at δ 150.4 or 150.9 consistently in all of them. The aromatic carbons are observed between δ 110 to 161.7.

All the final tripodal 2,5-disubstituted-1,3,4-oxadiazole compounds were characterized with the help of high resolution mass spectrometer having Q-TOF analyzer by using electron spray ionization (ESI) technique. The molecular ion peaks were observed as mass peaks corresponding to $(M+H)^+$ and $(M+Na)^+$.

Yields and melting points of the compounds **28a-28o** are included in the following table (Table 3.1.1).

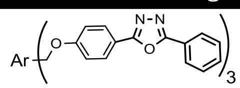
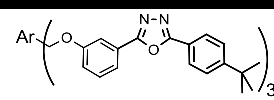
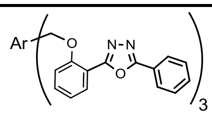
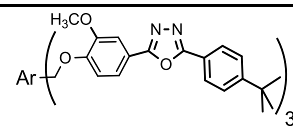
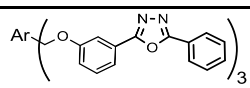
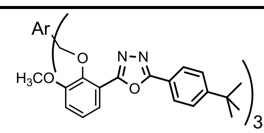
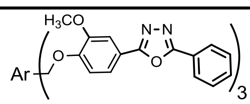
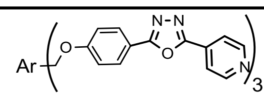
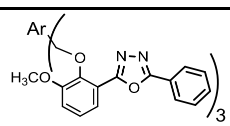
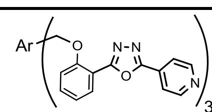
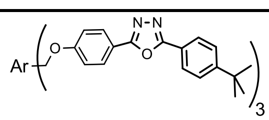
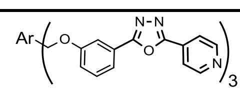
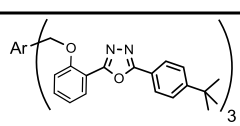
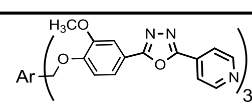
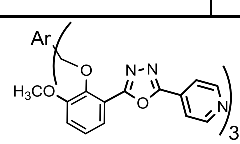
Table 3.1.1 ***Yields and Melting points of newly synthesized tris-1,3,4-oxadiazoles***

ID	Yield [%]	M.P [°C]	ID	Yield [%]	M.P [°C]	ID	Yield [%]	M.P [°C]
28a	61	215	**28f**	76	175	**28k**	32	245
28b	49	200	**28g**	72	150	**28l**	21	255
28c	40	230	**28h**	32	190	**28m**	54	250
28d	58	215	**28i**	61	140	**28n**	45	225
28e	22	140	**28j**	41	160	**28o**	15	230

The tripodal oxadiazole compounds were subjected to preliminary bioactivity screening against two types of bacteria namely *S. aureus* representing gram-positive and *E. coli* representing gram-negative bacteria. The testing method employed was REMA plate method same as described in the previous chapter. Most of the compounds showed poor activity or no activity for both the bacterial type. While two compounds with para heteroaryl substitution having 4-*tert*-butylphenyl and 4-pyridyl attachments (**28f** and **28k**) showed noticeable activity against both the bacteria with minimum inhibition concentration of 62.5 μg/ml against *S. aureus* while 31.25 and 12.5 μg/ml respectively for *E.coli*. The other two compounds with MIC of 62.5 μg/ml against *E.coli* were having phenyl end group attached to oxadiazole ring and having methoxy group attached to the linker ring (**28e**) and *ortho* heteroaryl substitution having 4-pyridyl ring attached (**28l**). Further bioactivity study against other bacteria was not carried out due to moderate activity found in few compounds during this screening study.

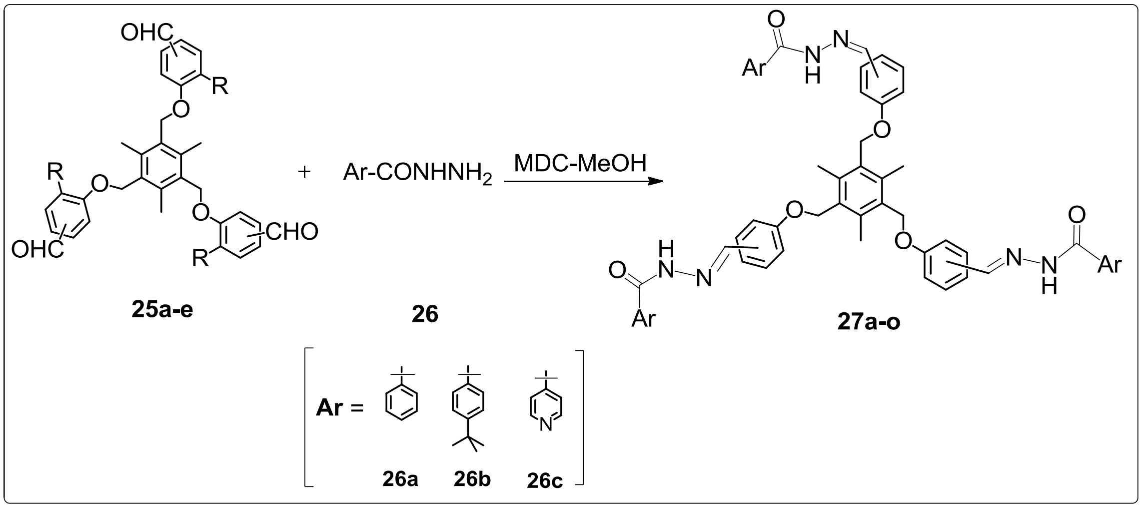
The biological screening data of the compounds **28a- 28o** are summarized in the table (Table 3.1.2).

Table 3.1.2 ***MIC values of newly synthesized tris-1,3,4-oxadiazoles***

ID	Position of Oxadiazole ring	MIC µg/ml *S. aureus*	*E. coli*	ID	Position of Oxadiazole ring	MIC µg/ml *S. aureus*	*E. coli*
28a		>125	>125	**28h**		>125	>125
28b		>125	>125	**28i**		>125	>125
28c		125	125	**28j**		>125	>125
28d		>125	>125	**28k**		**62.5**	**12.5**
28e		125	**62.5**	**28l**		125	**62.5**
28f		**62.5**	**31.25**	**28m**		>125	>125
28g		125	–	**28n**		>125	>125
28o		>125	>125				
Standard drug Ciprofloxacin 0.5 0.5							

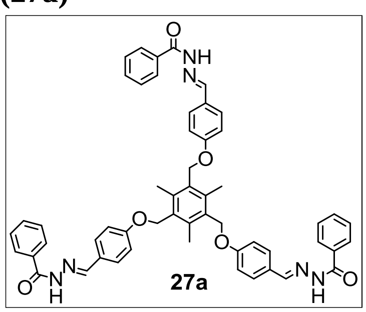
3.4 EXPERIMENTAL

3.4.1 1,3,5-Tris[n-(aroylhydrazonomethyl)-phenyloxymethyl]-2,4,6-trimethyl-benzene 27



To a solution of **26** in MeOH was added dropwise a MDC solution of appropriate trialdehyde **25** at room temperature with stirring. After complete addition, the reaction mixture was heated to reflux for 1-2 hours until the completion of reaction (TLC). The product separated on cooling was crystallized from (EtOH+MeOH) to get the desired tris-acylhydrazones **27**.

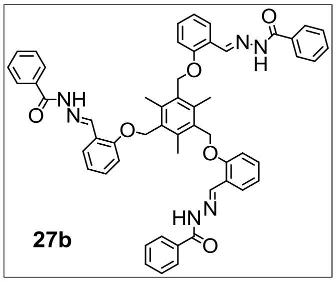
1,3,5–Tris[4–(benzoylhydrazonomethyl)–phenyloxymethyl]–2,4,6–trimethylbenzene (27a)



27a was prepared from **25a** (0.5 g, 0.95 mmol) and benzhydrazide **26a** (0.42 g, 3.06 mmol) following the general procedure described above as a white solid. Yield: 0.65 g, 78%; mp: 256 °C.

IR (KBr) : 3206, 1654, 1603, 1559, 1506, 1366, 1233 cm^{-1}; ^{1}**H NMR (DMSO-*d6*) :** δ (ppm) 2.40 (9H, s, $–CH_3$), 5.21 (6H, s, $–OCH_2–$), 7.18-7.20 (6H, d, *J* = 8.4 Hz), 7.51-7.54 (6H, d, *J* = 8.8 Hz), 7.57-7.59 (3H, d, *J* = 7.6 Hz), 7.71-7.37 (6H, d, *J* = 8.8 Hz), 7.90-7.92 (6H, d, 7.2 Hz), 8.43 (3H, s, –HC═N–), 11.72 (3H, s, –N–NH); ^{13}**C NMR (DMSO-*d6*) :** δ (ppm) 16.0 ($–CH_3$), 65.5 ($–OCH_2–$), 115.5, 127.6, 128.0, 128.9, 129.2, 131.7, 132.0, 134.0, 139.5, 148.1 (–HC=N–), 160.9 (Ar-O), 163.4 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{54}H_{48}N_6O_6$: 876.3635, found: (*m/z*) 877.3135 ($(M+H)^+$, 90%), 899.2945 and 899.6812 ($(M+Na)^+$, 100%, 50%).

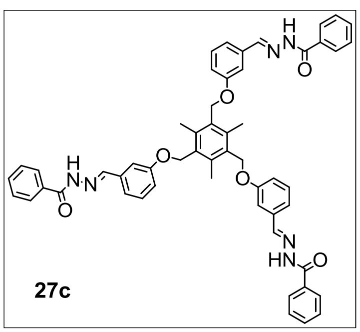
1,3,5–Tris[2–(benzoylhydrazonomethyl)–phenyloxymethyl]–2,4,6–trimethylbenzene (27b)



27b was prepared from **25b** (0.5 g, 0.95 mmol) and benzhydrazide **26a** (0.42 g, 3.06 mmol) following the general procedure as a white solid. Yield: 0.53 g, 63%; mp: 223 °C.

IR (KBr) : 3215, 1651, 1601, 1481, 1356, 1287, 1238 cm^{-1}; **^{1}H NMR (DMSO-*d6*) :** δ (ppm) 2.50 (9H, s, –CH_3), 5.25 (6H, s, –OCH_2–), 7.07 (3H, t, *J* = 7.4 Hz), 7.40-7.55 (15H, m), 7.82-7.91 (9H, dd, J_{ortho} = 28.4 Hz), 8.66 (3H, s, –HC═N–), 11.85 (3H, s, –N–NH–); **^{13}C NMR (DMSO-*d6*) :** δ (ppm) 16.2 (–CH_3), 65.9 (–OCH_2–), 113.4, 121.5, 123.1, 126.3, 128.0, 128.8, 131.8, 132.0, 132.1, 133.8, 140.1, 143.5 (–HC=N–), 157.7, 163.5 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{54}H_{48}N_6O_6$: 876.3635, found: (*m/z*) 877.3135 ($(M+H)^+$, 80%), 899.2945 and 899.6812 ($(M+Na)^+$, 100%, 50%).

1,3,5–Tris[3–(benzoylhydrazonomethyl)–phenyloxymethyl]–2,4,6–trimethylbenzene (27c)

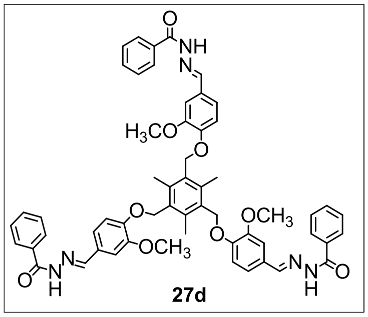


27c was prepared from **25c** (0.5 g, 0.95 mmol) and benzhydrazide **26a** (0.42 g, 3.06 mmol) following the general procedure as a white solid. Yield: 0.68 g, 81%; mp: 262 °C.

IR (KBr) : 3222, 1653, 1559, 1484, 1367 cm^{-1}; **^{1}H NMR (DMSO-*d6*) :** δ (ppm) 2.42 (9H, s, –CH_3), 5.20 (6H, s, –OCH_2–), 7.15-7.17 (3H, d, *J* = 7.2 Hz), 7.34-7.44 (9H, m), 7.51-7.60 (9H, m), 7.91-7.93 (6H, d, 7.6 Hz), 8.46 (3H, s, –HC═N–), 11.92 (3H, s, –N–NH–) ; **^{13}C NMR (DMSO-*d6*) :** δ (ppm) 16.0 (–CH_3), 65.3 (–OCH_2–), 112.6, 117.3, 120.6, 128.1, 128.9, 130.5, 131.8, 132.2, 133.8, 136.3, 139.4, 148.1 (–HC=N–), 159.6

(Ar-O), 163.6 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{54}H_{48}N_6O_6$: 876.3635 found: (*m/z*) 877.3862 ($(M+H)^+$, 100%), 899.3681 $(M+Na)^+$.

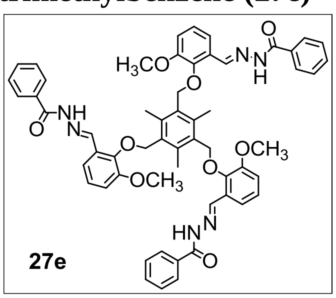
1,3,5–Tris[2–methoxy–{4–(benzoylhydrazonomethyl)}–phenyloxymethyl]–2,4,6–trimethylbenzene (27d)



27d was prepared from **25d** (0.5 g, 0.81 mmol) and benzhydrazide **26a** (0.36 g, 2.61 mmol) following the general procedure as a white solid. mp: Yield: 0.5 g, 63%; 260 °C.

IR (KBr) : 3229, 1659, 1600, 1508, 1420, 1267 cm^{-1}; **^{1}H NMR (DMSO-*d6*) :** δ (ppm) 2.40 (9H, s, $–CH_3$), 3.82 (9H, s, $–OCH_3$), 5.18 (6H, s, $–OCH_2–$), 7.26-7.63 (18H, m), 7.90-7.92 (6H, d, *J* = 7.2 Hz), 8.41 (3H, s, –HC═N–), 11.74 (3H, s, –N–NH–); **^{13}C NMR (DMSO-*d6*) :** δ (ppm) 15.9 ($–CH_3$), 55.9 ($–OCH_3$), 66.0 ($–OCH_2–$), 108.9, 113.5, 122.2, 128.0, 128.9, 131.7, 132.0, 134.0, 139.7, 148.4 (–HC=N–), 149.9, 150.6 (Ar-O), 163.4 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{57}H_{54}N_6O_9$: 966.3952, found: (*m/z*) 967.4166 ($(M+H)^+$, 20%), 989.4039 ($(M+Na)^+$, 20%), 871.3472 (100%).

1,3,5–Tris[6–methoxy–{2–(benzoylhydrazonomethyl)}–phenyloxymethyl]–2,4,6–trimethylbenzene (27e)

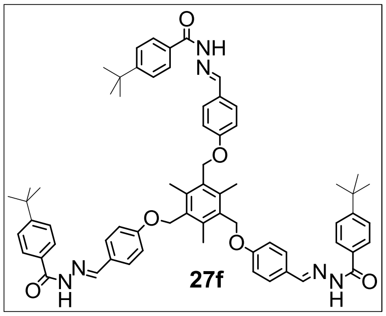


27e was prepared from **25e** (0.5 g, 0.81 mmol) and benzhydrazide **26a** (0.36 g, 2.61 mmol) following the general procedure as a white solid. Yield: 0.52 g, 65%; mp: 247 °C.

IR (KBr) : 3228, 1650, 1535, 1358, 1265, 1066 cm^{-1}; **^{1}H NMR (DMSO-*d6*) :** δ (ppm) 2.35 (9H, s, $–CH_3$), 3.78 (9H, s, $–OCH_3$), 5.10 (6H, s, $–OCH_2–$), 7.09-7.11 (6H, s), 7.34-7.43 (6H, m), 7.53 (6H, t, *J* = 7.2 Hz), 7.80-7.82 (6H, d, 7.6 Hz), 8.45 (3H, s, –HC═N–), 11.81 (3H, s, –N–NH–); **^{13}C NMR (DMSO-*d6*) :** δ (ppm)16.0 ($–CH_3$), 56.2 ($–OCH_3$), 70.2 ($–OCH_2–$), 114.6, 124.7, 1127.9, 128.6, 128.8, 132.1, 133.7, 139.9, 144.5 (–HC=N), 147.3, 153.1 (Ar-O), 163.7 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for

$C_{57}H_{54}N_6O_9$: 966.3952, found: (*m/z*) 967.4166 ($(M+H)^+$, 100%), 989.3974 ($(M+Na)^+$, 40%).

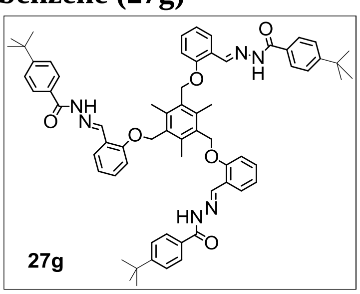
1,3,5–Tris[4–(*tert*–butylbenzoylhydrazonomethyl)–phenyloxymethyl]-2,4,6-trimethyl benzene (27f)



27f was prepared from **25a** (0.5 g, 0.95 mmol) and *p*-*tert*butylbenzhydrazide **26b** (0.58 g, 3.06 mmol) following the general procedure as a white solid. Yield: 0.073 g, 73%; mp: 284 °C.

IR (KBr) : 3207, 2961, 1654, 1604, 1503, 1363, 1232 cm^{-1}; **^{1}H NMR (DMSO-*d6*) :** δ (ppm)1.32 (27H, s, –$C(CH_3)_3$, 2.39 (9H, s, –CH_3), 5.20 (6H, s, –OCH_2–), 7.17-7.19 (6H, d, *J* = 8.4 Hz), 7.53-7.55 (6H, d, *J* = 8.4 Hz), 7.70-7.72 (6H, d, *J* = 8.4 Hz), 7.83-7.86 (6H, d, *J* ═ 8.4 Hz), 8.41 (3H, s, –HC═N–), 11.67 (3H, s, –N–NH–); **^{13}C NMR (DMSO-*d6*) :** δ (ppm) 16.0 (–CH_3), 31.3 (–C(<u>**C**</u>$H_3)_3$), 35.1 (–<u>**C**</u>$(CH_3)_3$), 65.7 (–OCH_2–), 115.4, 125.7, 127.7, 127.9, 129.1, 131.2, 131.7, 139.5, 147.8 (–HC=N–), 154.9, 160.8 (Ar-O), 163.3 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{66}H_{72}N_6O_6$: 1044.5513, found: (*m/z*) 1045.4893 ($(M+H)^+$, 100%), 1067.4722 ($(M+Na)^+$, 80%), 1068.4686 ($(M+Na+H)^+$, 70%).

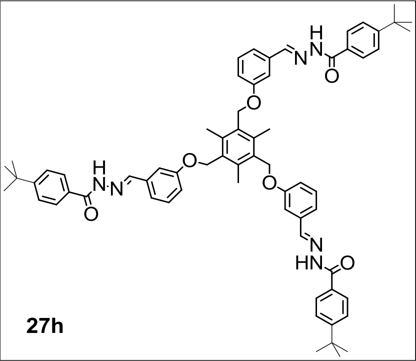
1,3,5–Tris[2–(*tert*–butylbenzoylhydrazonomethyl)–phenyloxymethyl]-2,4,6-trimethyl benzene (27g)



27g was prepared from **25b** (0.5 g, 0.95 mmol) and *p*-*tert*butylbenzhydrazide **26b** (0.58 g, 3.06 mmol) following the general procedure as a white solid. Yield: 0.67 g, 67%; mp: 279 °C.

IR (KBr) : 3234, 3068, 2961, 1652, 1603, 1551, 1451, 1362 cm^{-1}; **^{1}H NMR (DMSO-*d6*) :** δ (ppm) 1.21 (27H, s, –$C(CH_3)_3$, 2.45 (9H, s, –CH_3), 5.25 (6H, s, –OCH_2–), 7.07 (3H, t, *J* = 7.2 Hz), 7.40-7.47 (12H, m), 7.76-7.78 (6H, d, *J* = 8.4 Hz), 7.89-7.91 (3H, d, *J* ═ 7.2 Hz), 8.64 (3H, s, –HC═N–), 11.81 (3H, s, –N–NH); **^{13}C NMR (DMSO-*d6*) :** δ (ppm) 16.2 (–CH_3), 31.2 (–C(<u>**C**</u>$H_3)_3$), 35.0 (–<u>**C**</u>$(CH_3)_3$), 65.9 (–OCH_2–), 113.5, 121.5, 123.3, 125.5, 126.2, 127.9, 131.1, 131.8, 140.1, 143.0 (–HC=N–), 154.9, 157.7 (Ar-O), 163.5 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{66}H_{72}N_6O_6$: 1044.5513, found: (*m/z*) 1045.4893 ($(M+H)^+$, 100%), 1067.4722 ($(M+Na)^+$, 80%), 1068.4753 ($(M+Na+H)^+$, 40%).

1,3,5–Tris[3–(*tert*–butylbenzoylhydrazonomethyl)–phenyloxymethyl]-2,4,6-trimethyl benzene (27h)

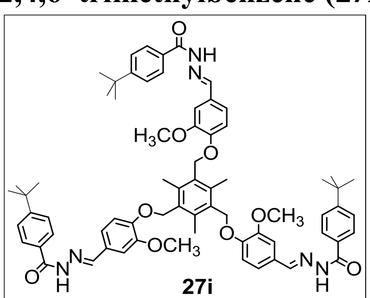


27h

27h was prepared from **25c** (0.5 g, 0.95 mmol) and *p-tert*butylbenzhydrazide **26b** (0.58 g, 3.06 mmol) following the general procedure as a white solid. Yield: 0.77 g, 77%; mp: 258 °C.

IR (KBr) : 3198, 2961, 1652, 1602, 1551, 1486, 1363, 1140 cm^{-1}; **^{1}H NMR (DMSO-*d6*) :** δ (ppm) 1.31 (27H, s, $–C(CH_3)_3$, 2.42 (9H, s, $–CH_3$), 5.20 (6H, s, $–OCH_2–$), 7.14-7.16 (3H, d, J = 7.6 Hz), 7.33-7.43 (9H, m), 7.53-7.55 (6H, d, J = 8.0 Hz), 7.85-7.87 (6H, d, J = 8.0 Hz), 8.45 (3H, s, –HC=N–), 11.84 (3H, s, –N–NH–); **^{13}C NMR (DMSO-*d6*) :** δ (ppm) 16.0 ($–CH_3$), 31.3 ($–C(\underline{\mathbf{C}}H_3)_3$), 35.1 ($–\underline{\mathbf{C}}(CH_3)_3$), 65.3 ($–OCH_2$), 112.5, 117.2, 120.5, 125.7, 127.9, 130.5, 131.0, 131.8, 136.3, 139.4, 147.8 (–HC=N–), 155.1, 159.6 (Ar-O), 163.5 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{66}H_{72}N_6O_6$: 1044.5513, found: (*m/z*) 1045.5752 ($(M+H)^+$, 100%), 1046.5747 ($(M+2H)^+$, 50%), 1067.5591 $(M+Na)^+$, 1068.5555 $(M+Na+H)^+$.

1,3,5–Tris[2–methoxy–{4–(*tert*–butylbenzoylhydrazonomethyl)}–phenyloxymethyl]–2,4,6–trimethylbenzene (27i)

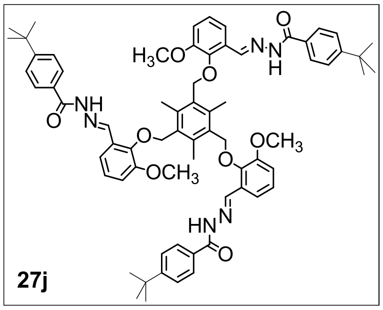


27i

27i was prepared from **25d** (0.5 g, 0.81 mmol) and *p-tert*butylbenzhydrazide **26b** (0.5 g, 2.61 mmol) following the general procedure as a white solid. 0.6 g, 65%; mp: 268 °C.

IR (KBr) : 3233, 2961, 1657, 1604, 1505, 1270 cm^{-1}; **^{1}H NMR (DMSO-*d6*) :** δ (ppm) 1.34 (27H, s, $–C(CH_3)_3$, 2.39 (9H, s, $–CH_3$), 3.81 (9H, s, $–OCH_3$), 5.18 (6H, s, $–OCH_2–$), 7.25-7.37 (9H, m), 7.53-7.55 (6H, d, *J* = 8.0 Hz), 7.83-7.85 (3H, d, *J* = 8.4 Hz), 8.40 (3H, s, –HC═N–), 11.68 (3H, s, –N–NH–); **^{13}C NMR (DMSO-*d6*) :** δ (ppm) 15.9 ($–CH_3$), 31.3 ($–C(\underline{\mathbf{C}}H_3)_3$), 35.1 ($–\underline{\mathbf{C}}(CH_3)_3$), 55.9 ($–OCH_3$), 70.1 ($–OCH_2$), 108.9, 125.6, 127.9, 128.0, 131.3, 131.7, 139.7, 148.2 (–HC═N–), 149.9 (Ar-O), 163.3 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{69}H_{78}N_6O_9$: 1134.5830, found: (*m/z*) 1135.6139 ($(M+H)^+$, 100%), 1157.5868 ($(M+Na)^+$, 75%), 1158.5966 ($(M+Na+H)^+$, 50%).

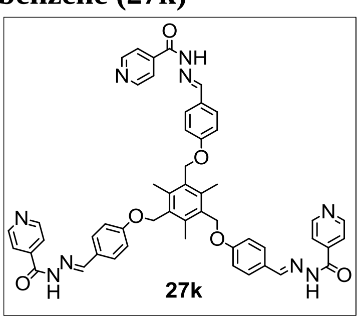
1,3,5–Tris[6–methoxy–{2–(*tert*–butylbenzoylhydrazonomethyl)}–phenyloxymethyl]–2,4,6–trimethylbenzene (27j)



27j (0.55 g, 59%) was prepared from **25e** (0.5 g, 0.81 mmol) and *p-tert*butylbenzhydrazide **26b** (0.5 g, 2.61 mmol) following the general procedure as a white solid. mp: 261 °C.

IR (KBr) : 3216, 2961, 1656, 1609, 1554, 1472, 1359, 1268 cm^{-1}; **^{1}H NMR (DMSO-*d6*) :** δ (ppm) 1.23 (27H, s, $–C(CH_3)_3$, 2.34 (9H, s, $–CH_3$), 3.77 (9H, s, $–OCH_3$), 5.11 (6H, s, $–OCH_2–$), 7.08 (6H, s), 7.36-7.38 (9H, d, *J* = 7.6 Hz), 7.70-7.72 (6H, d, *J* = 8.0 Hz), 8.44 (3H, s, –HC═N–), 11.70 (3H, s, –N–NH–); **^{13}C NMR (DMSO-*d6*) :** δ (ppm) 16.0 ($–CH_3$), 31.3 ($–C(\underline{\mathbf{C}}H_3)_3$), 35.0 ($–\underline{\mathbf{C}}(CH_3)_3$), 56.2 ($–OCH_3$), 70.1 ($–OCH_2$), 114.5, 117.8, 124.6, 125.5, 127.7, 128.8, 131.0, 132.1, 139.9, 144.4 (–HC=N–), 147.2, 153.1, 154.9 (Ar-O), 163.8 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{69}H_{78}N_6O_9$: 1134.5830 *m/z*, found: (*m/z*) 1135.6001 ($(M+H)^+$, 100%), 1136.6072 ($(M+2H)^+$, 50%), 1157.5868 ($(M+Na)^+$, 20%).

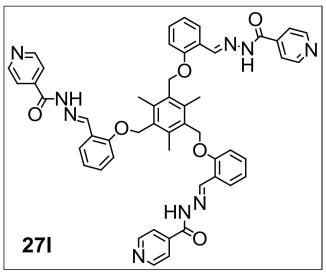
1,3,5–Tris[4–(isonicotinoylhydrazonomethyl)–phenyloxymethyl]–2,4,6–trimethylbenzene (27k)



27k was prepared from **25a** (0.5 g, 0.95 mmol) and **26c** INH (0.42 g, 3.06 mmol) following the general procedure as a yellow solid. Yield: 0.68 g, 81%; mp: 225 °C.

IR (KBr) : 3244, 1658, 1604, 1510, 1298, 1244 cm^{-1}; **^{1}H NMR (DMSO-*d6*) :** δ (ppm) 2.39 (9H, s, $–CH_3$), 5.21 (6H, s, $–OCH_2–$), 7.18-7.20 (6H, d, *J* = 8.4 Hz), 7.73-7.75 (6H, d, *J* = 8.4 Hz), 7.81–7.83 (6H, d, *J* = 6.0 Hz), 8.43 (3H, s, –HC═N–), 8.78 (6H, s), 11.98 (3H, s, –N–NH–); **^{13}C NMR (DMSO-*d6*) :** δ (ppm) 16.0 ($–CH_3$), 65.5 ($–OCH_2–$), 115.5, 121.9, 127.3, 129.4, 131.7, 139.5, 141.0, 145.0, 149.3 (–HC=N–), 150.7 (–C=N–), 161.1 (Ar-O), 161.8 (–C=O);**Mass (TOF MS ES+):** *m/z* calculated for $C_{51}H_{49}N_9O_6$: 879.3493, found: (*m/z*) 880.2 (M+H), 902.0 $(M+Na)^+$,

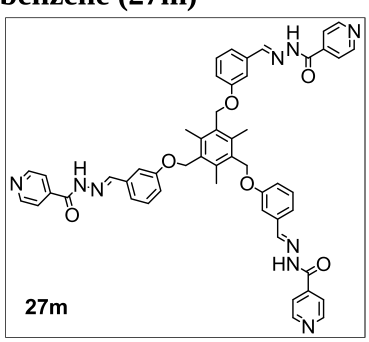
1,3,5–Tris[2–(isonicotinoylhydrazono–methyl)–phenyloxy–methyl]–2,4,6–trimethyl-benzene (27l)



27l was prepared from **25b** (0.5 g, 0.95 mmol) and **26c** INH (0.42 g, 3.06 mmol) following the general procedure as a yellow solid. Yield: 0.56 g, 67%; mp: 190 °C.

IR (KBr) : 3250, 1660, 1554, 1240 cm^{-1}; **^{1}H NMR (DMSO-*d6*):** δ (ppm) 2.39 (9H, s, $–CH_3$), 5.21 (6H, s, $–OCH_2–$), 7.18-7.20 (6H, d, *J* = 8.4 Hz), 7.73-7.75 (6H, d, *J* = 8.4 Hz), 7.81-7.83 (6H, d, *J* = 6.0 Hz), 8.43 (3H, s, –HC═N–), 8.78-8.79 (6H, d, *J* ═ 6.0 Hz), 11.98 (3H, s, –N–NH–); **^{13}C NMR (DMSO-*d6*) :** δ (ppm) 16.2 ($–CH_3$), 65.9 ($–OCH_2–$), 113.5, 121.5, 121.9, 122.9, 126.4, 131.8, 132.3, 140.1, 140.9, 144.7 (–HC=N–), 150.6 (–C=N–), 157.9 (Ar-O), 162.0 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{51}H_{49}N_9O_6$: 879.3493, found: (*m/z*) 880.6 ($(M+H)^+$, 80%) 902.1 $(M+Na)^+$, 50%), 543.1 (100%).

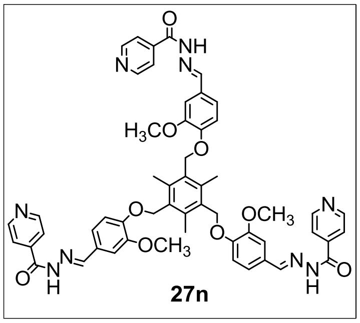
1,3,5–Tris[3–(isonicotinoylhydrazonomethyl)–phenyloxymethyl]–2,4,6–trimethyl-benzene (27m)



27m was prepared from **25c** (0.5 g, 0.95 mmol), **26c** INH (0.42 g, 3.06 mmol) following the general procedure as a yellow solid. Yield: 0.53 g, 62%; mp: 180 °C.

IR (KBr) : 3200, 1672, 1558, 1301, 1263 cm^{-1}; **^{1}H NMR (DMSO-*d6*):** δ (ppm) 2.43 (9H, s, –CH_3), 5.21 (6H, s, –OCH_2–), 7.17-7.19 (3H, d, *J* = 4.0 Hz), 7.36-7.45 (9H, m), 7.82-7.83 (6H, d, *J* = 4.8 Hz), 8.46 (3H, s, –HC═N–), 8.79 (6H, s), 12.11 (3H, s, –N–NH–); **^{13}C NMR (DMSO-*d6*):** δ (ppm) 16.1 (–CH_3), 65.4 (–OCH_2–), 112.8, 117.6, 120.8, 122.0, 130.5, 131.8, 135.9, 139.4, 140.9, 149.3 (–HC=N–), 150.8 (–C=N–), 159.6 (Ar-O), 162.1 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{51}H_{49}N_9O_6$: 879.3493, found: (*m/z*) 880.1 $(M+H)^+$, 70%), 902.3 $(M+Na)^+$, 749.3 (100%).

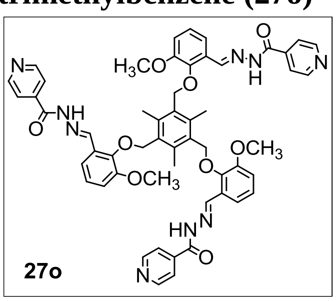
1,3,5–Tris[2–methoxy–{4–(isonicotinoylhydrazonomethyl)}–phenyloxymethyl]-2,4,6-trimethylbenzene (27n)



27n was prepared from **25d** (0.5 g, 0.81 mmol), **26c** INH (0.35 g, 2.61 mmol) following the general procedure as a yellow solid. Yield: 1.22 g, 77%; mp: 247 °C.

IR (KBr) : 3204, 1660, 1600, 1508, 1417, 1270 cm^{-1}; **^{1}H NMR (DMSO-*d6*) :** δ (ppm) 2.38 (9H, s, –CH_3), 3.81 (9H, s, –OCH_3), 5.18 (6H, s, –OCH_2–), 7.28-7.38 (9H, m), 7.81-7.83 (6H, d, *J* = 6.0 Hz), 8.41 (3H, s, –HC═N–), 8.78-8.79 (6H, d, *J* ═ 6.0 Hz), 12.0 (3H, s, –N–NH–); **^{13}C NMR (DMSO-*d6*) :** δ (ppm) 15.9 (–CH_3), 55.9 (–OCH_3), 66.0 (–OCH_2), 108.9, 113.4, 122.0, 122.5, 127.5, 131.7, 139.7, 141.1, 149.6, 149.9 (–HC=N–), 150.7 (–C=N–), 150.9 (Ar-O), 161.9 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{54}H_{51}N_9O_9$: 969.3810, found: (*m/z*) 970.3212 ($(M+H)^+$, 100%) 992.3090 ($(M+Na)^+$, 90%).

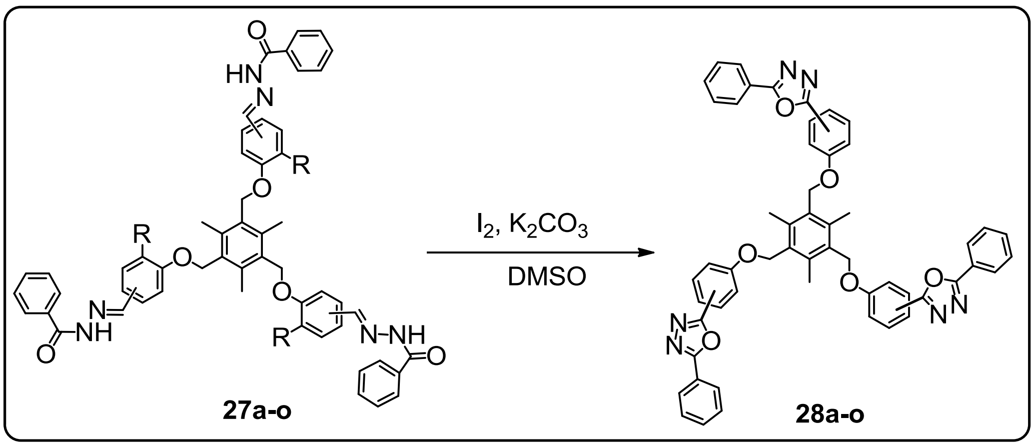
1,3,5–Tris[2–methoxy–{6–(isonicotinoylhydrazonomethyl)}–phenyloxymethyl]-2,4,6-trimethylbenzene (27o)



27o was prepared from **25e** (0.5 g, 0.81 mmol), **26c** INH (0.350 g, 2.61 mmol) following the general procedure as a yellow solid. Yield: 1.1 g, 69%; mp: 234 °C.

IR (KBr) : 3224, 2916, 2847, 1655, 1601, 1552, 1475, 1358 cm^{-1}; **^{1}H NMR (DMSO-*d6*):** δ (ppm) 2.38 (9H, s, $-CH_3$), 3.80 (9H, s, $-OCH_3$), 5.12 (6H, s, $-OCH_2-$), 7.13-7.37 (6H, m), 7.69-7.70 (3H, d, J = 5.6 Hz), 8.49 (3H, s, –HC=N–), 8.66-8.67 (6H, d, J = 5.2 Hz), 11.97 (–N–NH–); **^{13}C NMR (DMSO-*d6*) :** δ (ppm) 16.0 ($-CH_3$), 56.2 ($-OCH_3$), 70.2 ($-OCH_2-$), 115.0, 117.8, 121.7, 124.8, 128.3, 132.1, 140.0, 140.7, 145.8 (–HC=N–), 147.4, 150.6 (–C=N–), 153.4 (Ar-O), 162.3 (–C=O); **Mass (TOF MS ES+):** *m/z* calculated for $C_{54}H_{51}N_9O_9$: 969.3810, found: (*m/z*) 970.3212 $(M+H)^+$, 50%) 992.3090 ($(M+Na)^+$, 100%).

3.4.2 1,3,5-Tris[(5-aryl-1,3,4-oxadiazol-2-yl)-phenyloxymethyl-2,4,6-trimethyl-benzenes 28

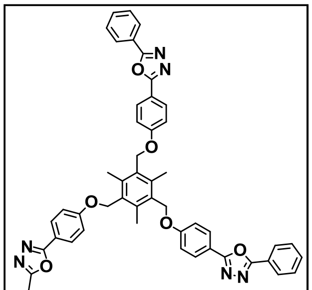


In a dry round bottom flask (50 ml) were place tris-acylhydrazone **27** (0.1 to 0.5 g, 1.0 equiv) in DMSO solvent followed by the addition of potassium carbonate (K_2CO_3, 9.0 equiv) and molecular iodine (I_2, 3.6 equiv). The reaction mixture was heated to 100 °C with stirring till completion of the reaction (TLC, 1–2 hours). The reaction mixture was allowed to attain room temperature, and was treated with 5% sodium thiosulfate ($Na_2S_2O_3$) followed by extraction with dichloromethane (3x10ml). The combined organic layers were washed with brine, dried over anhydrous sodium sulfate and concentrated. The residue was purified on silica gel column giving the corresponding 1,3,4-oxadiazole **28** in good to moderate yields as white or pale yellow solids.

Compounds **28a–28e** were purified through silica gel column chromatography, eluting with EtOAc/ Petroleum ether = 3:7 → 5:5 mixture giving the corresponding 1,3,4-

oxadiazoles as white or yellow solids. Compounds **28f–28j** were eluted with EtOAc/ Petroleum ether ═ 3:7 → 4:6 mixture giving the corresponding 1,3,4-oxadiazoles as white or yellow solids. Compounds **28k–28o** were eluted with MeOH/DCM ═ 1:99 to 5:95 mixture giving the corresponding 1,3,4-oxadiazoles as yellow solids.

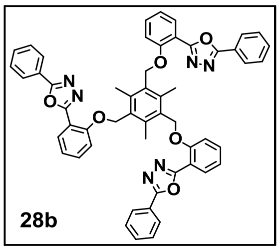
1,3,5–Tris[4–(5–phenyl–1,3,4–oxadiazol–2–yl)–phenyloxymethyl]–2,4,6–trimethyl-benzene (28a)


28a

28a was prepared from **27a** (0.1 g, 0.11 mmol), K_2CO_3 (0.14 g, 1.02 mmol) and I_2 (0.1 g, 0.41 mmol) following the general procedure described above as a white solid. Yield: 0.24 g, 61%; mp: 215 °C.

IR (KBr) : 1609, 1559, 1491, 1244, 1175 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 2.61 (9H, s, –CH_3), 5.19 (6H, s, –OCH_2–), 7.14-7.17 (6H, d, J_{ortho} = 8.8 Hz), 7.51-7.52 (9H, m), 8.09-8.12 (12H, d, J_{ortho} = 8.8 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 16.0 (–CH_3), 65.1 (–OCH_2), 115.1, 116.7, 123.9, 126.8, 128.8, 129.0, 131.3, 131.6, 139.6, 161.7 (Ar-O), 164.1 and 164.4 (–C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{54}H_{42}N_6O_6$: 870.3166, found: (*m/z*) 871.3236 $(M+H)^+$, 893.3066 $(M+Na)^+$.

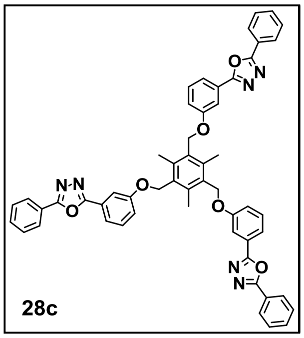
1,3,5–Tris[2–(5–phenyl–1,3,4–oxadiazol–2–yl)–phenyloxymethyl]–2,4,6–trimethyl-benzene (28b)


28b

28b was prepared from **27b** (0.1 g, 0.11 mmol), K_2CO_3 (0.14 g, 1.02 mmol) and I_2 (0.1 g, 0.41 mmol) following the general procedure as a white solid. Yield: 0.05 g, 49%; mp: 200 °C.

IR (KBr) : 1602, 1553, 1469, 1261, 1239 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 2.56 (9H, s, –CH_3), 5.24 (6H, s, –OCH_2–), 7.12-7.28 (15H, m), 7.47-7.59 (9H, m), 8.11-8.14 (12H, dd, J_{ortho} = 8.0 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 16.2 (–CH_3), 65.6 (–OCH_2–), 112.9, 113.5m 121.3, 123.7, 126.3, 128.4, 130.8, 131.1, 131.6, 133.1, 139.4, 156.9 (Ar-O), 163.2 and 164.2 (–C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{54}H_{42}N_6O_6$: 870.3166, found: (*m/z*) 871.3227 $(M+H)^+$, 888.3502 $(M+NH_4)^+$.

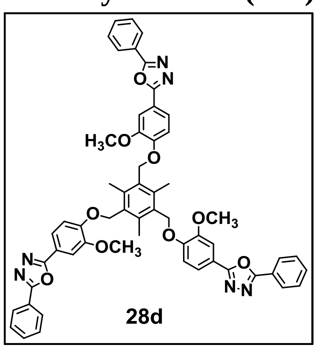
1,3,5–Tris[3–(5–phenyl–1,3,4–oxadiazol–2–yl)–phenyloxymethyl]–2,4,6–trimethyl-benzene (28c)



28c was prepared from **27c** (0.1 g, 0.11 mmol), K_2CO_3 (0.14 g, 1.02 mmol) and I_2 (0.1 g, 0.41 mmol) following the general procedure as a white solid. Yield: 0.04 g, 40%; mp: 230 °C.

IR (KBr) : 1598, 1548, 1491, 1272, 1211 cm^{-1}; ^{1}**H NMR (CDCl$_3$) :** δ (ppm) 2.54 (9H, s, –CH_3), 5.27 (6H, s, –OCH_2–), 7.22-7.25 (3H, dd, J_{ortho} = 14.8 Hz), 7.49-7.57 (12H, m), 7.78-7.80 (3H, d, J = 7.6 Hz), 7.86 (3H, s), 8.16-8.18 (6H, d, J = 7.4 Hz); ^{13}**C NMR (CDCl$_3$) :** δ (ppm) 16.0 (–CH_3), 65.3 (–OCH_2–), 112.1, 118.9, 119.6, 123.9, 125.1, 126.9, 129.1, 130.3, 131.5, 131.7, 139.6, 159.4 (Ar-O), 164.5 and 164.6 (–C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{54}H_{42}N_6O_6$: 870.3166, found: (*m/z*) 871.3232 $(M+H)^+$, 893.3057 $(M+Na)^+$.

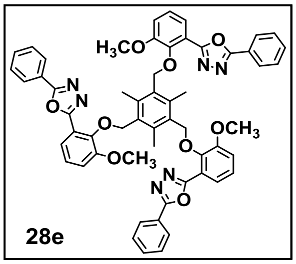
1,3,5–Tris[2–methoxy–4–(5–phenyl–1,3,4–oxadiazol–2–yl)–phenyloxymethyl]-2,4,6-trimethylbenzene (28d)



28d was prepared from **27d** (0.1 g, 0.10 mmol), K_2CO_3 (0.13 g, 0.93 mmol) and I_2 (0.1 g, 0.37 mmol) following the general procedure described as a white solid. Yield: 0.058 g, 58%; mp: 215 °C.

IR (KBr) : 2930, 1607, 1497, 1273, 1218, 1143 cm^{-1}; ^{1}**H NMR (CDCl$_3$) :** δ (ppm) 2.53 (9H, s, –CH_3), 3.96 (9H, s, –OCH_3), 5.23 (6H, s, –OCH_2–), 7.20-7.22 (3H, d, J = 8.4 Hz), 7.56-7.58 (9H, m), 7.70-7.76 (6H, m), 8.15-8.18 (6H, m); ^{13}**C NMR (CDCl$_3$) :** δ (ppm) 16.1 (–CH_3), 56.1 (–OCH_3), 66.4 (–OCH_2–), 110.0, 113.5, 117.0, 120.2, 124.0, 126.8, 129.0, 131.1, 131.6, 140.0, 150.3, 151.7 (Ar-O), 164.3 and 164.6 (–C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{57}H_{48}N_6O_9$: 960.3483, found: (*m/z*) 995.3989 $(M+Na)^+$, 979.4230 $(M+NH_4)^+$.

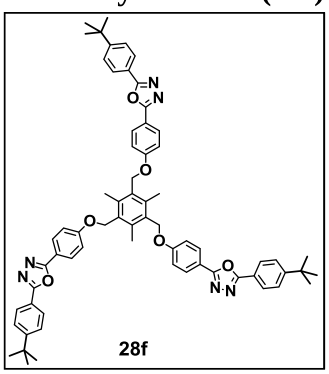
1,3,5–Tris[6–methoxy–2–(5–phenyl–1,3,4–oxadiazol–2–yl)–phenyloxymethyl]–2,4,6–trimethylbenzene (28e)



28e was prepared from **27e** (0.1 g, 0.10 mmol), K_2CO_3 (0.13 g, 0.93 mmol) and I_2 (0.1 g, 0.37 mmol) following the general procedure as a white solid. Yield: 0.021 g, 22%; mp: 140 °C.

IR (KBr) : 2933, 1606, 1581, 1550, 1485, 1263, 1049 cm^{-1}; **^{1}H NMR (DMSO-*d6*) : δ** (ppm) 1.99 (9H, s, $–CH_3$), 3.83 (9H, s, $–OCH_3$), 4.79 (9H, s, $–OCH_2–$), 7.26 (3H, t, J = 8.0 Hz), 7.31-7.41 (15H, m), 7.46-7.50 (3H, t, J = 8.0 Hz), 7.61-7.63 (6H, d, 7.8 Hz); **^{13}C NMR (DMSO-*d6*) : δ** (ppm) 15.3 ($–CH_3$), 56.4 ($–OCH_3$), 69.9 ($–OCH_2–$), 116.7, 118.7, 121.8, 123.5, 125.1, 126.7, 129.4, 132.0, 139.3, 146.6, 153.7 (Ar-O), 162.8 and 164 (–C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{57}H_{48}N_6O_9$: 960.3483, found: (*m/z*) 961.3561 $(M+H)^+$, 978.3791 $(M+NH_4)^+$.

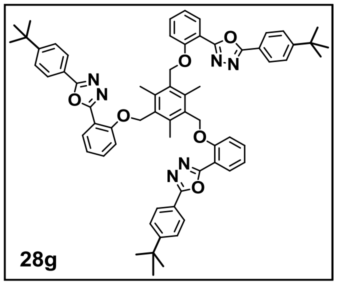
1,3,5–Tris[4–{(5–*tert*–butylbenzene)–1,3,4–oxadiazol–2–yl}–phenyloxymethyl]–2,4,6-–trimethylbenzene (28f)



28f was prepared from **27f** (0.1 g, 0.09 mmol), K_2CO_3 (0.12 g, 0.86 mmol) and I_2 (0.1 g, 0.34 mmol) following the general procedure as a white solid. Yield: 0.075 g, 76%; mp: 175 °C.

IR (KBr) : 2963, 1611, 1493, 1245, 1173 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 1.39 (27H, s, $–C(CH_3)_3$, 2.52 (9H, s, $Ar–CH_3$), 5.24 (6H, s, $–OCH_2–$), 7.18-7.20 (6H, d, J = 8.0 Hz), 7.55-7.58 (6H, d, J = 8.8 Hz), 8.06-8.08 (6H, dd, J_{ortho} = 6.8 Hz), 8.13-8.15 (6H, d, J ═ 9.2 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 16.1 ($–CH_3$) , 31.1 (–C(**C**H$_3$)$_3$), 35.1 (–**C**(CH$_3$)$_3$), 65.1 ($–OCH_2$), 115.1, 116.9, 121.2, 126.0, 128.7, 131.4, 139.7, 155.2, 161.6 (Ar-O), 164.2 and 164.3 (–C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{66}H_{66}N_6O_6$: 1038.5044, found: (*m/z*) 1039.5097 $(M+H)^+$, 1061.4916 $(M+Na)^+$.

1,3,5–Tris[2–{(5–*tert*–butylbenzene)–1,3,4–oxadiazol–2–yl}–phenyloxymethyl]-2,4,6-trimethylbenzene (28g)

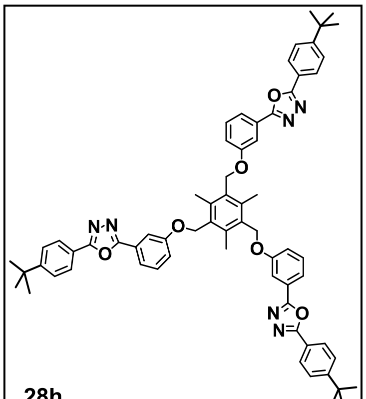


28g

28g was prepared from **27g** (0.1 g, 0.09 mmol), K_2CO_3 (0.12 g, 0.86 mmol) and I_2 (0.1 g, 0.34 mmol) following the general procedure as a yellow solid. Yield: 0.071 g, 72%; mp: 150 °C.

IR (KBr) : 2958, 1604, 1494, 1263, 1116 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 1.25 (27H, s, –C(CH_3)$_3$, 2.57 (9H, s, Ar–CH_3), 5.27 (6H, s, –OCH_2–), 7.11-7.15 (3H, dt, J_{ortho} = 7.6 Hz), 7.17-7.19 (3H, d, J = 8.4 Hz), 7.24-7.26 (6H, dd, J_{ortho} = 8.8 Hz), 7.51-7.54 (9H, d, J = 6.8 Hz) 8.09-8.11 (3H, dd, J = 7.4 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 16.3 (–CH_3), 31.0 (–C(**<u>C</u>**H_3)$_3$), 34.8 (–**<u>C</u>**(CH_3)$_3$), 66.1 (–OCH_2), 113.5, 113.9, 121.0, 121.4, 125.5, 126.4, 130.7, 131.7, 132.9, 139.3, 154.7, 156.9 (Ar-O), 163.0 and 164.4 (–C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{66}H_{66}N_6O_6$ 1038.5044, found: (*m/z*) 1039.5121 $(M+H)^+$, 1056.5383 $(M+NH_4)^+$, 1061.4927 $(M+Na)^+$.

1,3,5-Tris[3-{(5-*tert*-butylbenzene)-1,3,4-oxadiazol-2-yl}-phenyloxymethyl]-2,4,6-trimethylbenzene (28h)

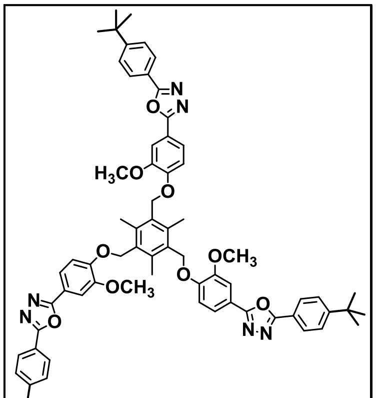


28h

28h was prepared from **27h** (0.1 g, 0.09 mmol), K_2CO_3 (0.12 g, 0.86 mmol) and I_2 (0.1 g, 0.34 mmol) following the general procedure described as a white solid. Yield: 0.031 g, 32%; mp: 190 °C.

IR (KBr) : 2962, 1596, 1547, 1495, 1273, 1223, 1006 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 1.39 (27H, s, –C(CH_3)$_3$, 2.54 (9H, s, Ar–CH_3), 5.27 (6H, s, –OCH_2–), 7.22-7.24 (3H, dd, J_{ortho} = 7.2 Hz), 7.49-7.53 (3H, t, J = 8.0 Hz), 7.56-7.59 (6H, dd, J_{ortho} = 8.8 Hz), 7.77-7.79 (3H, d, J = 8.0 Hz), 7.85-7.86 (3H, t, J = 2.0 Hz), 8.08-8.10 (6H, dd, J = 6.8 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 16.0 (–CH_3), 31.1 (–C(**<u>C</u>**H_3)$_3$), 35.1 (–**<u>C</u>**(CH_3)$_3$), 65.2 (–OCH_2), 96.1, 112.0, 118.8, 119.6, 121.0, 125.2, 126.1, 126.8, 130.3, 131.5, 139.6, 155.4, 159.4 (Ar-O), 164.3 and 164.7 (–C=N–) ; **Mass (TOF MS ES+):** *m/z* calculated for $C_{66}H_{66}N_6O_6$: 1038.5044, found: (*m/z*) 1039.5153 $(M+H)^+$, 1061.4970 $(M+Na)^+$.

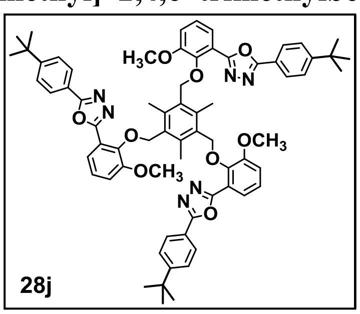
1,3,5–Tris[2–methoxy–4–{(5–*tert*–butylbenzene)–1,3,4–oxadiazol–2–yl}–phenyloxy-methyl]–2,4,6–trimethylbenzene (28i)


28i

28i was prepared from **27i** (0.1 g, 0.09 mmol), K_2CO_3 (0.1 g, 0.81 mmol) and I_2 (0.08 g, 0.32 mmol) following the general procedure described as a white solid. Yield: 0.062 g, 61%; mp: 140 °C.

IR (KBr) : 2960, 1596, 1608, 1507, 1273, 1115 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 1.39 (27H, s, $–C(CH_3)_3$, 2.52 (9H, s, $Ar–CH_3$), 3.96 (9H, s, $–OCH_3$), 5.23 (6H, s, $–OCH_2–$), 7.20-7.22 (3H, d, *J* = 8.8 Hz), 7.56-7.58 (6H, d, *J* = 8.4 Hz), 7.69 (1H, s), 7.73-7.75 (6H, d, *J* = 8.0 Hz), 8.07-8.09 (6H, d, 8.4 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 16.1 ($–CH_3$), 31.1 (–C(<u>**C**</u>H$_3$)$_3$), 35.1 (–<u>**C**</u>(CH$_3$)$_3$), 56.1 ($–OCH_3$), 66.4 ($–OCH_2$), 96.1, 110.0, 113.5, 117.1, 120.2, 121.2, 126.0, 126.7, 131.1, 140.0, 150.2, 151.6, 155.2 (Ar-O), 164.3 (–C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{69}H_{72}N_6O_9$: 1128.5361, found: (*m/z*) 1129.5407 $(M+H)^+$.

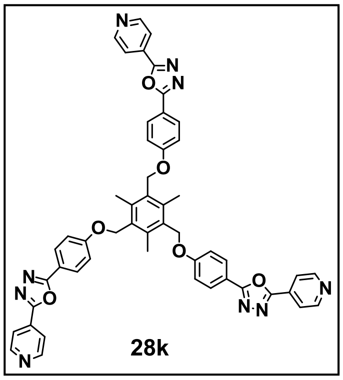
1,3,5–Tris[6–methoxy–2–{(5–*tert*–butylbenzene)–1,3,4–oxadiazol–2–yl}–phenyloxy-methyl]–2,4,6–trimethylbenzene (28j)


28j

28j was prepared from **27j** (0.1 g, 0.09 mmol), K_2CO_3 (0.1 g, 0.81 mmol) and I_2 (0.08 g, 0.32 mmol) following the general procedure as a yellow solid. Yield: 0.068 g, 41%; mp: 160 °C.

IR (KBr) : 2959, 1615, 1533, 1477, 1362, 1266, 1049 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 1.22 (27H, s, $–C(CH_3)_3$, 2.18 (9H, s, $Ar–CH_3$), 3.83 (9H, s, $–OCH_3$), 4.95 (6H, s, –OCH$_2$–), 7.05-7.07 (3H, dd, *J* = 8.0 Hz), 7.16 (3H, t, *J* = 8.0 Hz), 7.26-7.28 (6H, d, *J* = 7.4 Hz), 7.55-7.59 (9H, m); **^{13}C NMR (CDCl$_3$) :** δ (ppm)15.6 ($–CH_3$), 30.9 (–C(<u>**C**</u>H$_3$)$_3$), 34.8 (–**C**(CH$_3$)$_3$), 55.8 (–OCH$_3$), 70.3 (–OCH$_2$), 115.2, 119.0, 120.8, 121.8, 124.2, 125.6, 126.5, 132.2, 139.4, 147.0, 153.6, 154.7 (Ar-O), 163.0 and 164.9 (–C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{69}H_{72}N_6O_9$: 1128.5361, found: (*m/z*) 1129.5439 $(M+H)^+$, 1151.5262 $(M+Na)^+$.

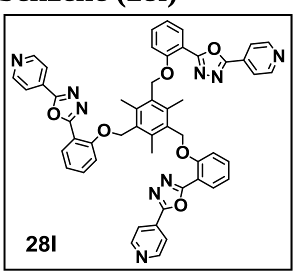
1,3,5–Tris[4–(5–pyridyl–1,3,4–oxadiazol–2–yl)–phenyloxymethyl]–2,4,6–trimethyl-benzene (28k)



28k was prepared from **27k** (0.1 g, 0.11 mmol), K_2CO_3 (0.14 g, 1.02 mmol) and I_2 (0.1 g, 0.40 mmol) following the general procedure as a yellow solid. Yield: 0.031 g, 32%; mp: 245 °C.

IR (KBr) : 1608, 1491, 1249, 1174 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 2.52 (9H, s, –CH$_3$), 5.25 (6H, s, –OCH$_2$–), 7.20-7.22 (6H, d, *J* = 9.2 Hz), 8.00-8.01 (6H, dd, *J* = 4.4 Hz), 8.15-8.18 (6H, dd, J_{ortho} = 7.4 Hz), 8.85-8.87 (6H, dd, *J* = 4.6 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 16.1 (–CH$_3$), 65.2 (–OCH$_2$), 115.2, 116.2, 120.2, 129.1, 131.3, 139.7, 150.9 (pyridyl ring –C=N–), 162.1 and 162.4 (–C=N–), 165.3; **Mass (TOF MS ES+):** *m/z* calculated for $C_{51}H_{39}N_9O_6$: 873.3023, found: (*m/z*) 874.3046 *m/z* $(M+H)^+$.

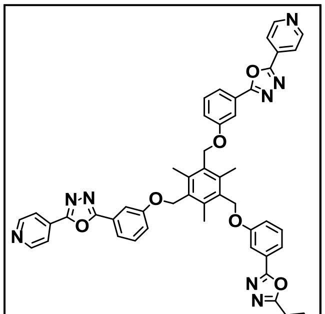
1,3,5–Tris[2–(5–pyridyl–1,3,4–oxadiazol–2–yl)–phenyloxymethyl]–2,4,6–trimethyl-benzene (28l)



28l was prepared from **27l** (0.1 g, 0.11 mmol), K_2CO_3 (0.14 g, 1.02 mmol) and I_2 (0.1 g, 0.40 mmol) following the general procedure described as a yellow solid. Yield: 0.021 g, 21%; mp: 255 °C.

IR (KBr) : 1602, 1535, 1491, 1470, 1221 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 2.61 (9H, s, –CH$_3$), 5.31 (6H, s, –OCH$_2$–), 7.18 (3H, t, *J* = 7.6 Hz), 7.24-7.26 (3H, d, *J* = 8.4 Hz), 7.38-7.40 (6H, dd, J_{ortho} = 6.0 Hz), 7.58-7.62 (3H, dt, *J* = 8.0 Hz), 8.10-8.12 (3H, dd, 8.0 Hz), 8.50-8.51 (6H, d, 6.0 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 16.3 (–CH$_3$), 65.6 (–OCH$_2$), 112.9, 112.9, 119.8, 121.5, 130.9, 130.9, 131.7, 133.7, 139.5, 150.4 (pyridyl ring carbons ortho to N), 157.0, 162.2 and 164.1 (oxadiazole carbons: –C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{51}H_{39}N_9O_6$: 873.3023, found: (*m/z*) 874.3046 $(M+H)^+$, 896.2892 $(M+Na)^+$.

1,3,5–Tris[3–(5–pyridyl–1,3,4–oxadiazol–2–yl)–phenyloxymethyl]–2,4,6–trimethyl-benzene (28m)

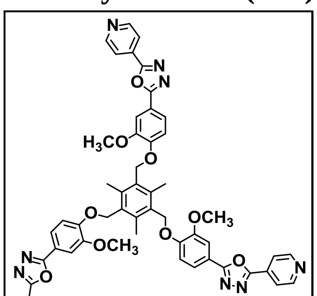


28m

28m was prepared from **27m** (0.1 g, 0.11 mmol), K_2CO_3 (0.14 g, 1.02 mmol) and I_2 (0.1 g, 0.40 mmol) following the general procedure as a yellow solid. Yield: 0.1 g, 54%; mp: 250 °C.

IR (KBr) : 1604, 1546, 1488, 1412, 1323, 1276, 1212 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 2.54 (9H, s, $–CH_3$), 5.27 (6H, s, $–OCH_2–$), 7.26-7.26 (3H, d, *J* = 2.0 Hz), 7.53 (3H, t, *J* = 8.0 Hz), 7.78-7.80 (3H, d, *J* = 7.6 Hz), 7.87 (3H, s), 8.01-8.03 (6H, dd, 4.8 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 16.1 ($–CH_3$), 65.3 ($–OCH_2$), 112.2, 119.5, 119.9, 120.3, 124.5, 130.5, 130.9, 131.4, 139.6, 150.9 (pyridyl ring carbons ortho to N), 159.5, 162.8 and 165.4 (oxadiazole carbons: –C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{51}H_{39}N_9O_6$: 873.3023, found: (*m/z*) 874.3073 $(M+H)^+$, 896.2914 $(M+Na)^+$.

1,3,5–Tris[2–methoxy–4–(5–pyridyl–1,3,4–oxadiazol–2–yl)–phenyloxymethyl]-2,4,6-trimethylbenzene (28n)



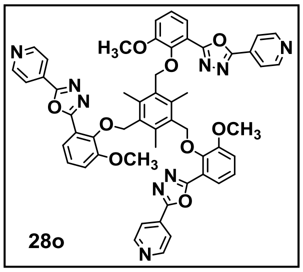
28n

28n was prepared from **27n** (0.1 g, 0.10 mmol), K_2CO_3 (0.13 g, 0.92 mmol) and I_2 (0.09 g, 0.37 mmol) following the general procedure described as a yellow solid. Yield: 0.041 g, 45%; mp: 225 °C.

IR (KBr) : 2913, 1606, 1494, 1275, 1248, 1139 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 2.53 (9H, s, $–CH_3$), 3.97 (9H, s, $–OCH_3$), 5.25 (6H, s, $–OCH_2–$), 7.22-7.24 (3H, d, *J* = 8.4 Hz), 7.70-7.71 (3H, d, *J* = 2.0 Hz), 7.75-7.78 (3H, dd, J_{ortho} = 8.4 Hz), 8.02 (6H, d, *J* = 3.2 Hz), 8.88 (6H, s); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 16.1 ($–CH_3$), 56.1 ($–OCH_3$), 66.4

(–OCH_2), 110.0, 113.3, 116.3, 120.6, 131.0, 140.1, 150.3, 150.9 (pyridyl ring carbons ortho to N), 152.1, 162.4 and 165.5 (oxadiazole carbons: –C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{54}H_{45}N_9O_9$: 963.3340, found: (*m/z*) 964.3409 $(M+H)^+$.

1,3,5-Tris[6-methoxy-2-(6-pyridyl-1,3,4-oxadiazol-2-yl)-phenyloxymethyl]-2,4,6-trimethylbenzene (28o)



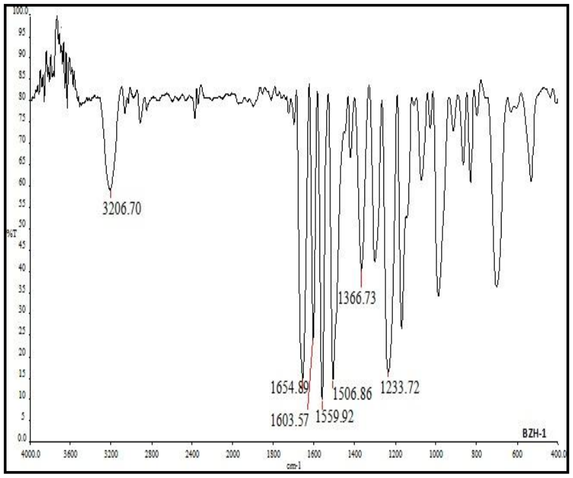
28o was prepared from **27o** (0.1 g, 0.10 mmol), K_2CO_3 (0.13 g, 0.92 mmol) and I_2 (0.1 g, 0.37 mmol) following the general procedure described as a yellow solid. Yield: 0.054 g, 15%; mp: 230 °C (decomposition).

IR (KBr) : 3003, 1608, 1532, 1481, 1440, 1266, 1053 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 2.16 (9H, s, –CH_3), 3.89 (9H, s, –OCH_3), 4.99 (6H, s, –OCH_2–), 7.11-7.13 (3H, dd, *J* = 8.2 Hz), 7.20 (3H, t, *J* = 8.0 Hz), 7.52-7.55 (6H, m), 7.56-7.57 (3H, d, *J* = 1.6 Hz), 8.55-8.57 (6H, dd, *J* = 4.4Hz), 8.10-8.12 (3H, dd, 8.0 Hz), 8.50-8.51 (6H, d, 6.0 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 15.5 (–CH_3), 55.9 (–OCH_3), 69.9 (–OCH_2), 115.7, 118.3, 120.1, 121.9, 124.5, 130.8, 132.3, 139.3, 146.9, 150.4 (pyridyl ring carbons ortho to N), 153.5, 162.9 and 164.1 (oxadiazole carbons: –C=N–); **Mass (TOF MS ES+):** *m/z* calculated for $C_{54}H_{45}N_9O_9$: 963.3340, found: (*m/z*) 964.3414 $(M+H)^+$, 986.3236 $(M+Na)^+$.

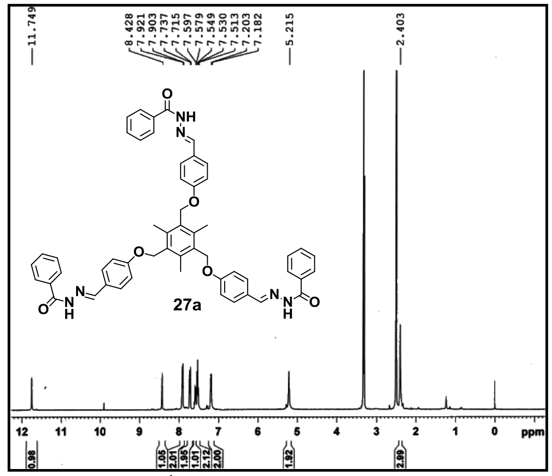
3.5 SPECTRAL DATA

Compound 27a

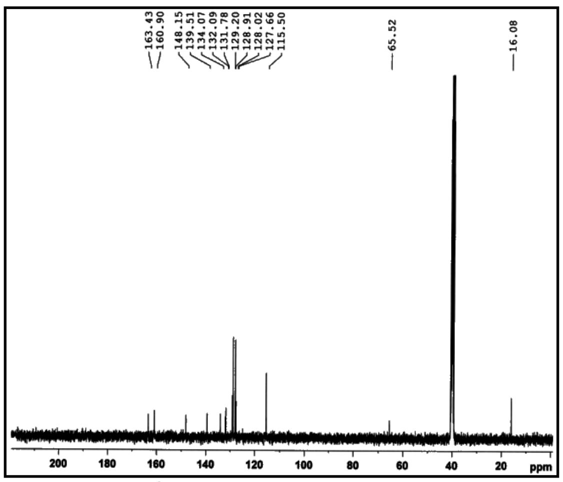
3.5.1 Acyhydrazones



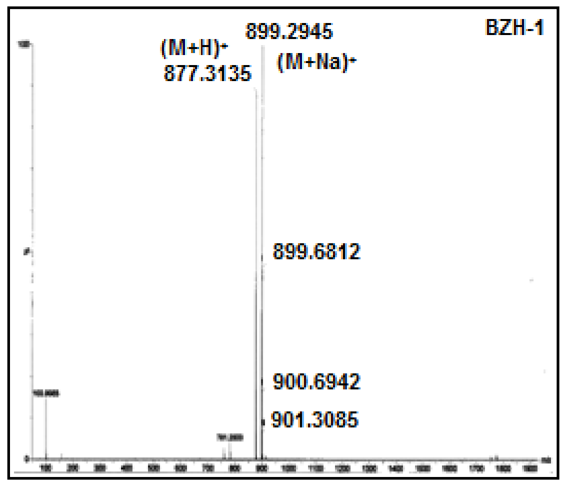
Spectrum 1. IR of 27a



Spectrum 2. ^{1}H NMR of 27a

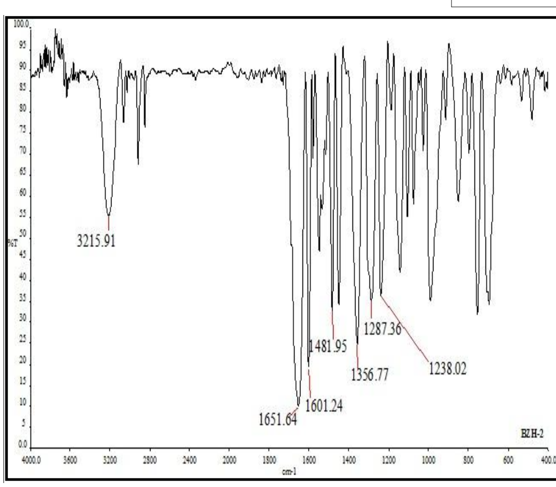


Spectrum 3. ^{13}C NMR of 27a

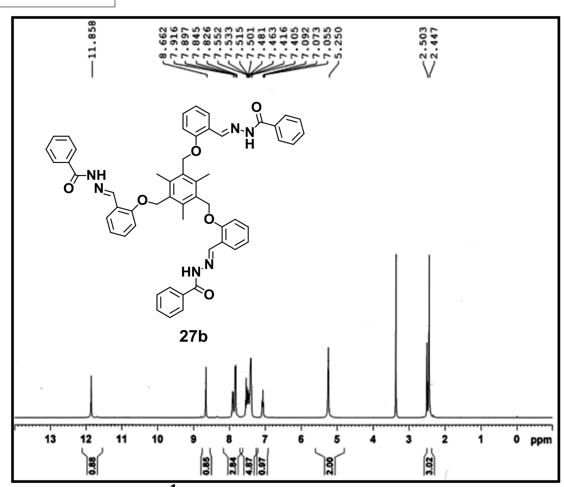


Spectrum 4. Mass of 27a

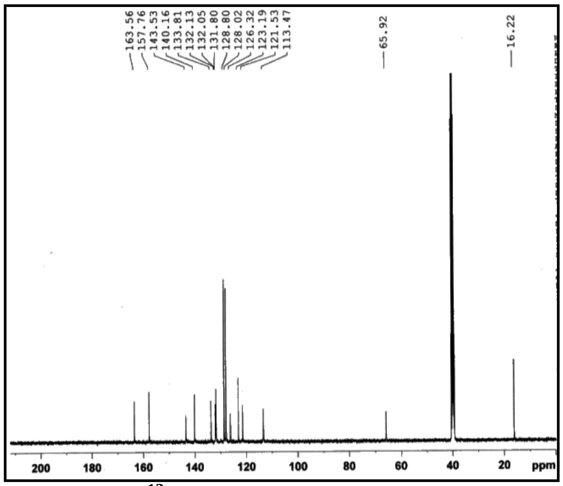
Compound 27b



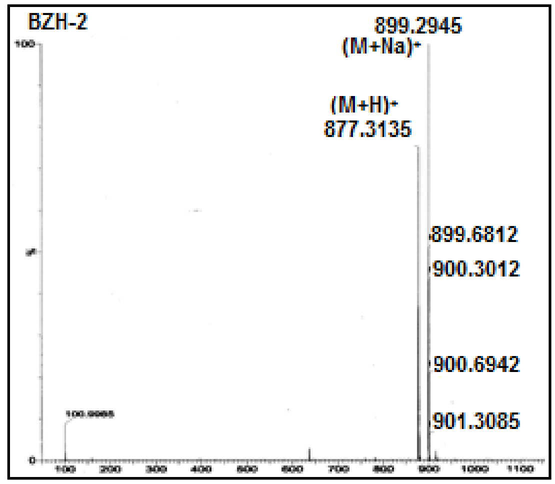
Spectrum 5. IR of 27b



Spectrum 6. ^{1}H NMR of 27b

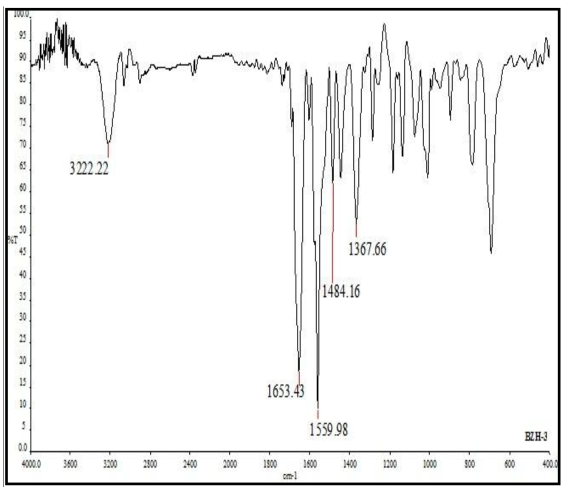


Spectrum 7. ^{13}C NMR of 27b

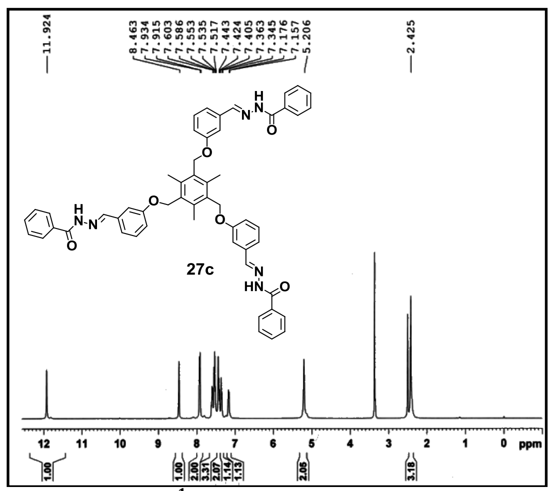


Spectrum 8. Mass of 27b

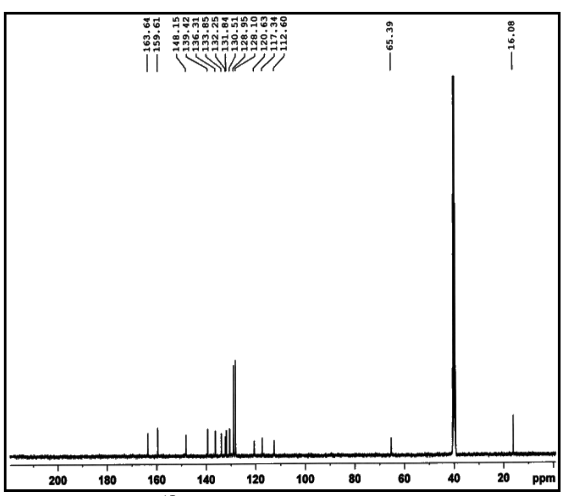
Compound 27c



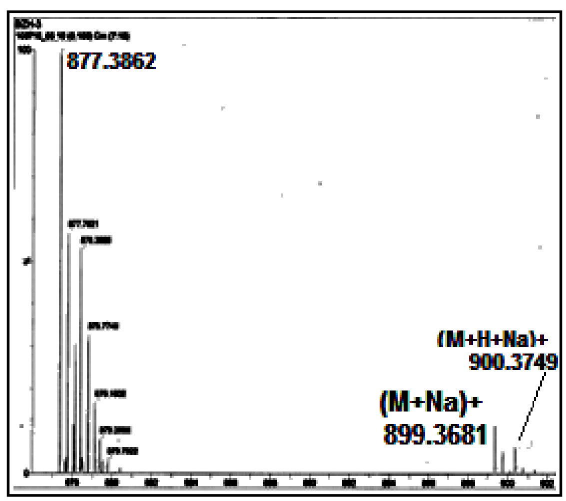
Spectrum 9. IR of 27c



Spectrum 10. ^{1}H NMR of 27c

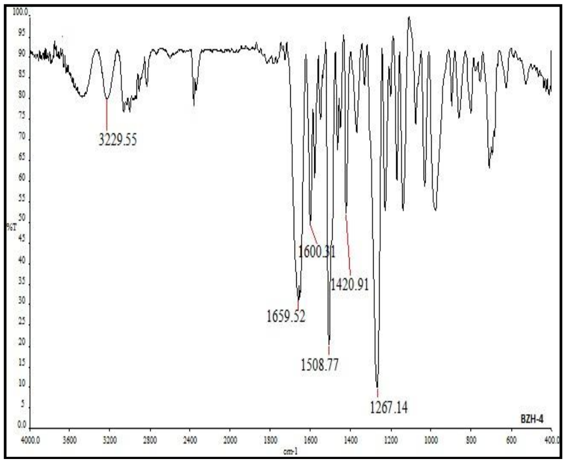


Spectrum 11. ^{13}C NMR of 27c

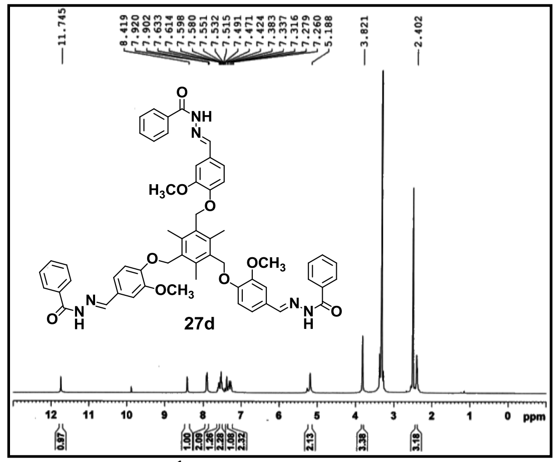


Spectrum 12. Mass of 27c

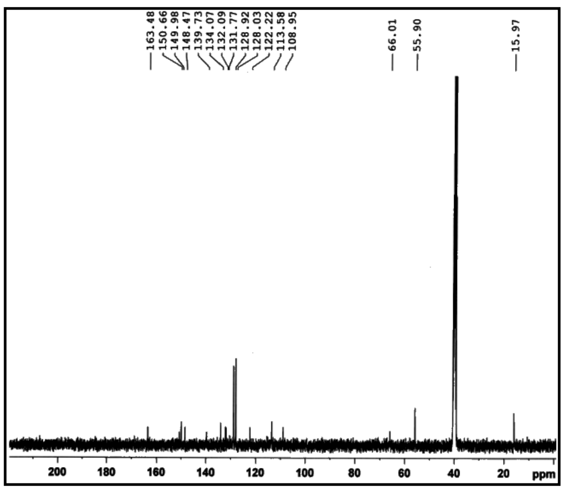
Compound 27d



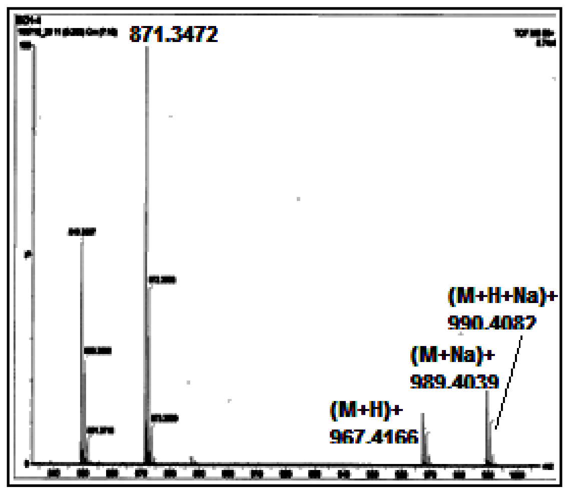
Spectrum 13. IR of 27d



Spectrum 14. ^{1}H NMR of 27d

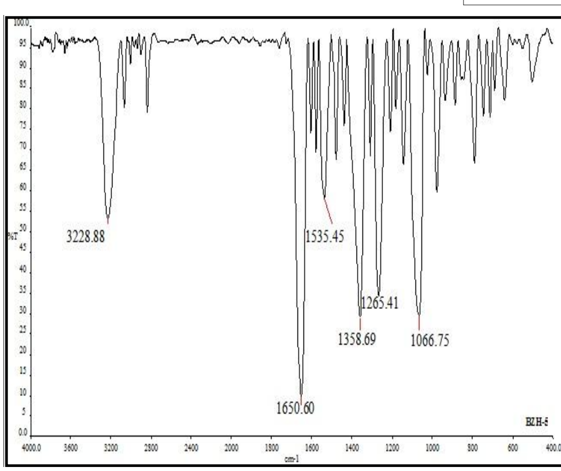


Spectrum 15. ^{13}C NMR of 27d

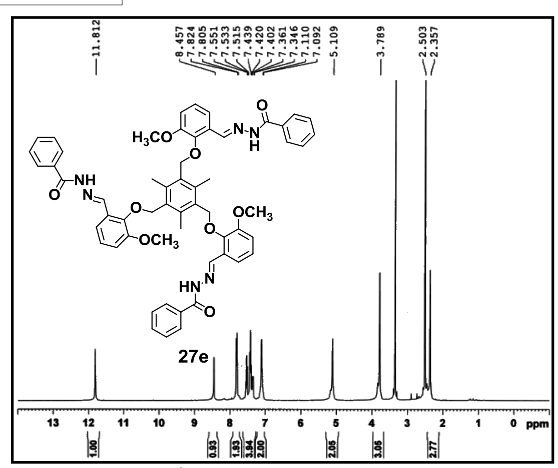


Spectrum 16. Mass of 27d

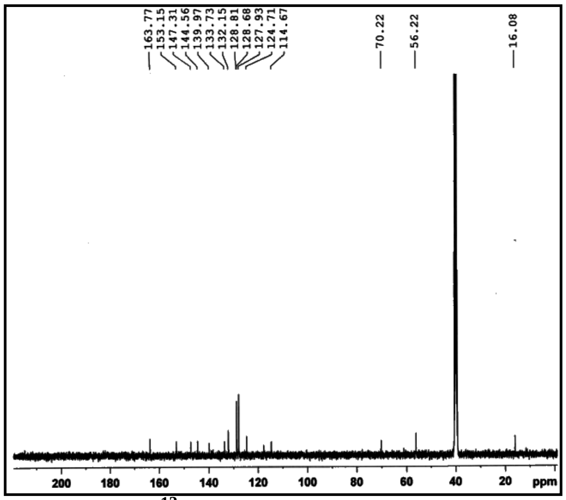
Compound 27e



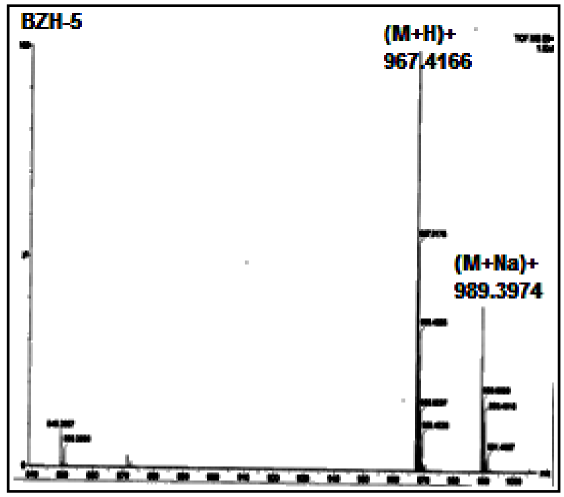
Spectrum 17. IR of 27e



Spectrum 18. ^{1}H NMR of 27e

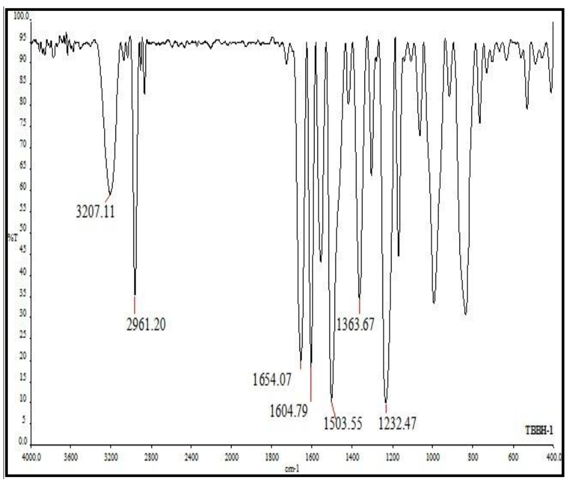


Spectrum 19. ^{13}C NMR of 27e

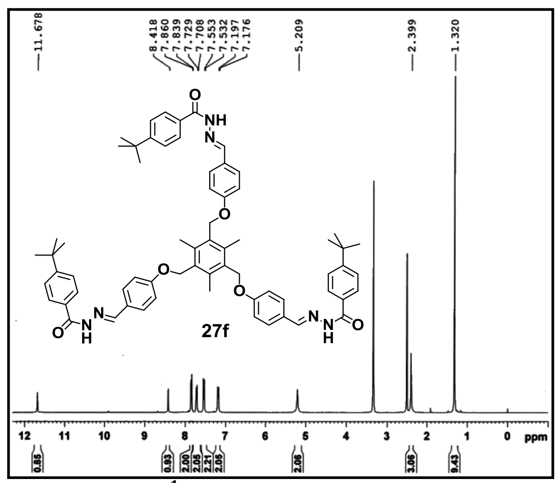


Spectrum 20. Mass of 27e

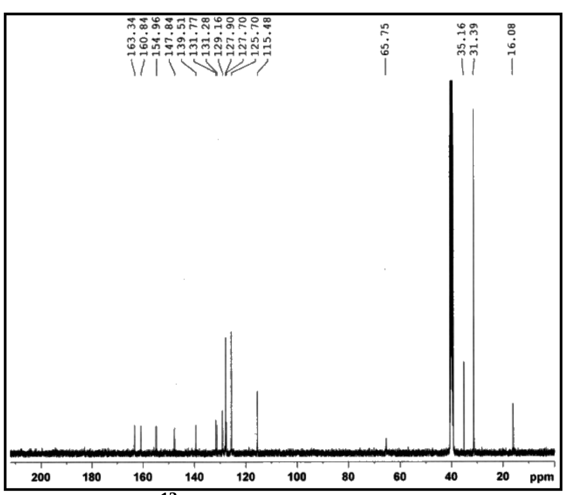
Compound 27f



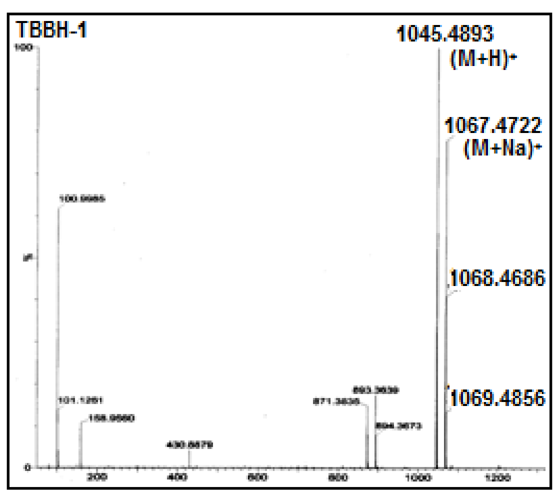
Spectrum 21. IR of 27f



Spectrum 22. ^{1}H NMR of 27f

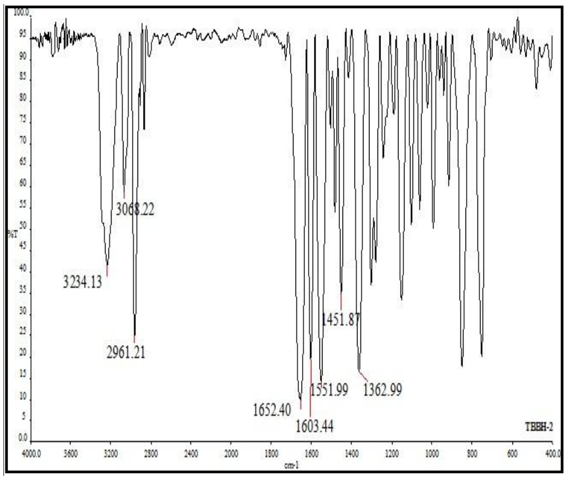


Spectrum 23. ^{13}C NMR of 27f

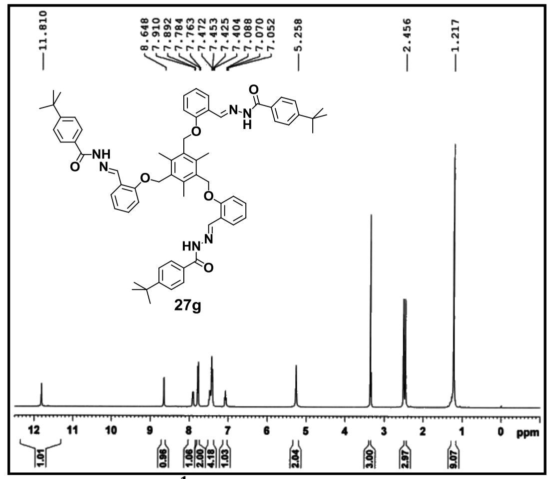


Spectrum 24. Mass of 27f

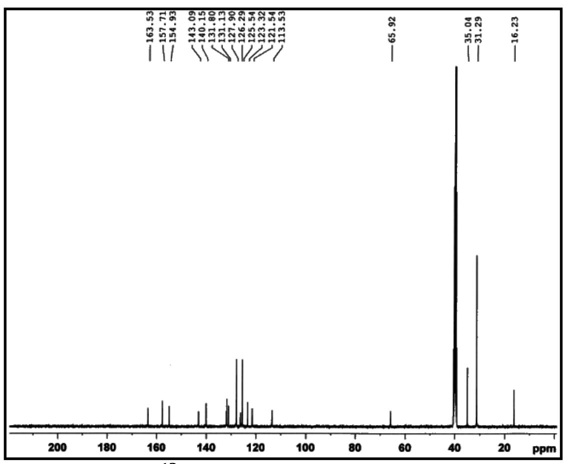
Compound 27g



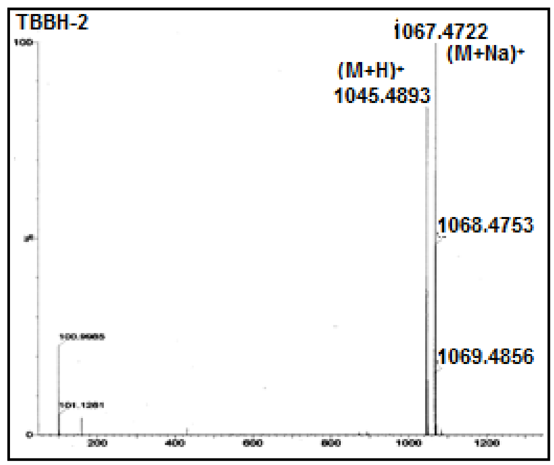
Spectrum 25. IR of 27g



Spectrum 26. ^{1}H NMR of 27g

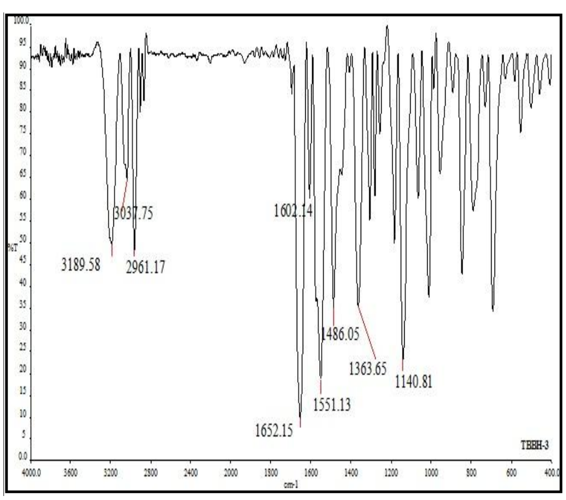


Spectrum 27. ^{13}C NMR of 27g

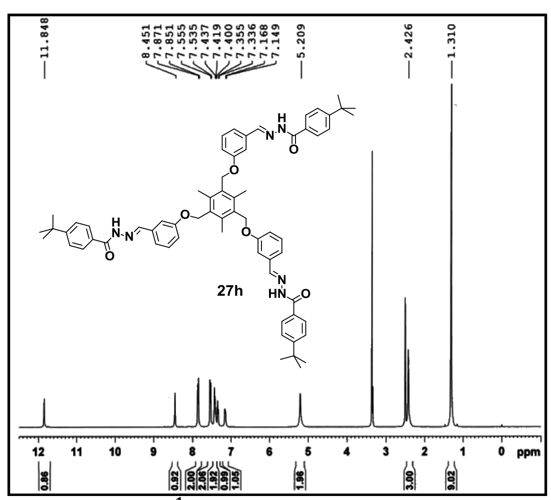


Spectrum 28. Mass of 27g

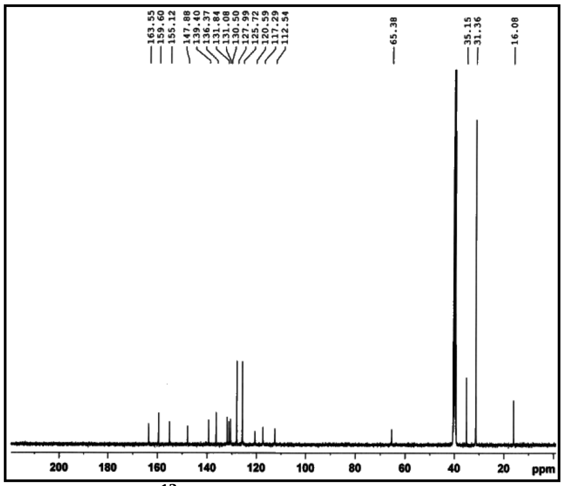
Compound 27h



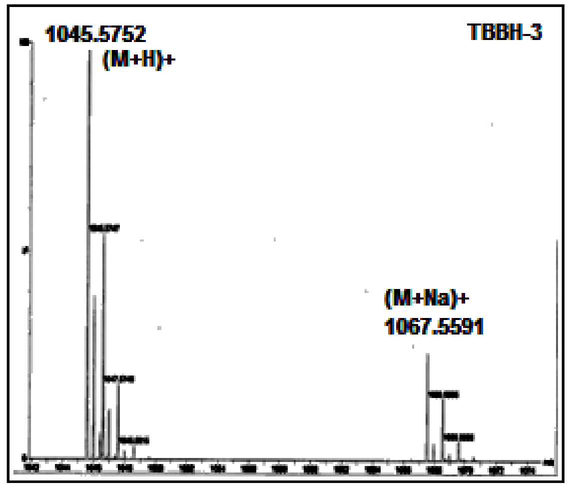
Spectrum 29. IR of 27h



Spectrum 30. ^{1}H NMR of 27h

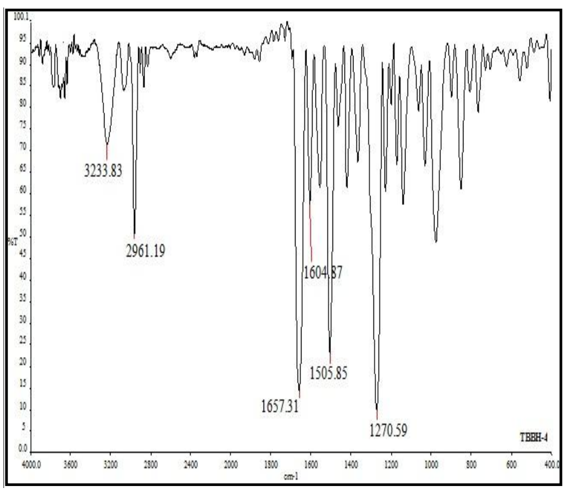


Spectrum 31. ^{13}C NMR of 27h

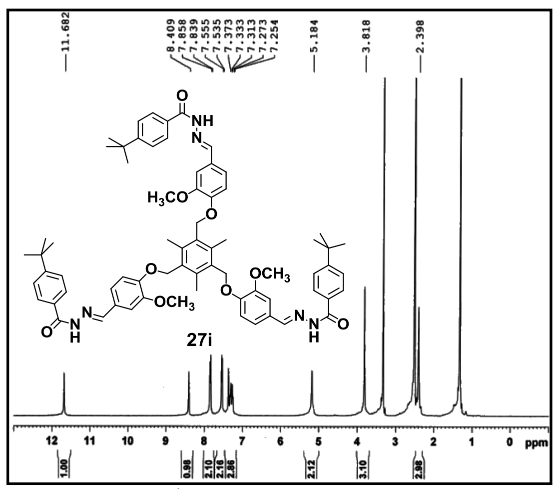


Spectrum 32. Mass of 27h

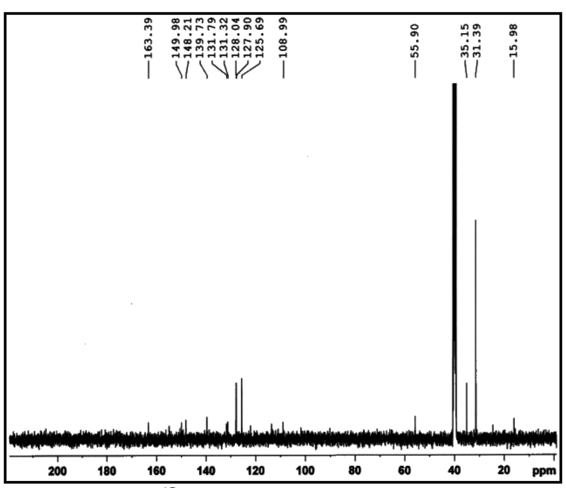
Compound 27i



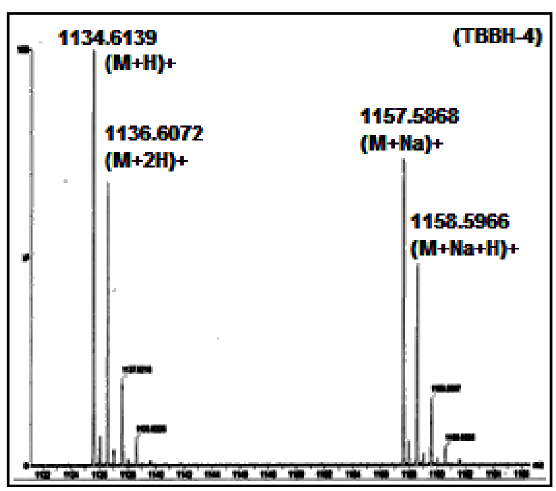
Spectrum 33. IR of 27i



Spectrum 34. ^{1}H NMR of 27i

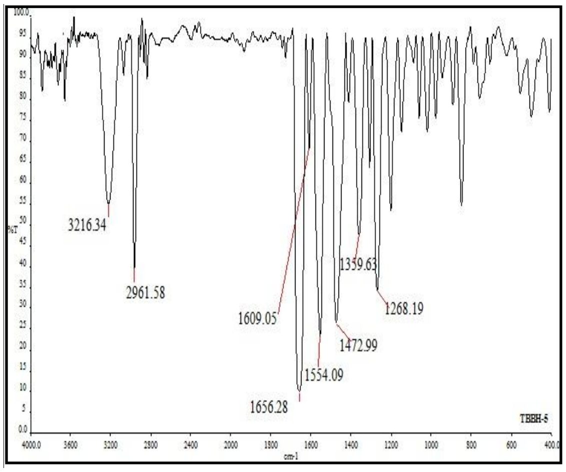


Spectrum 35. ^{13}C NMR of 27i

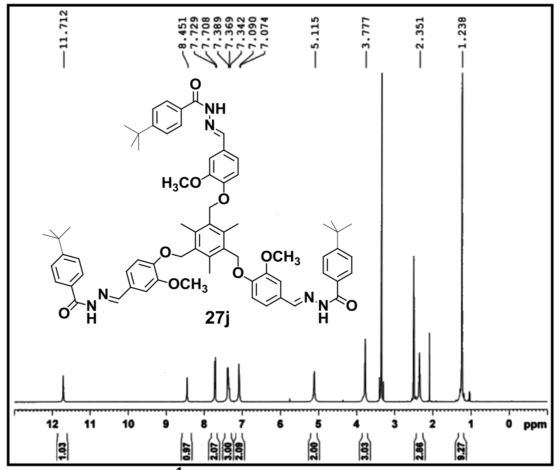


Spectrum 36. Mass of 27i

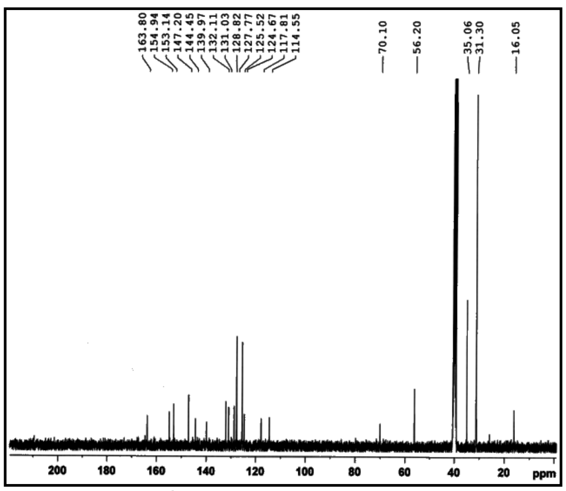
Compound 27j



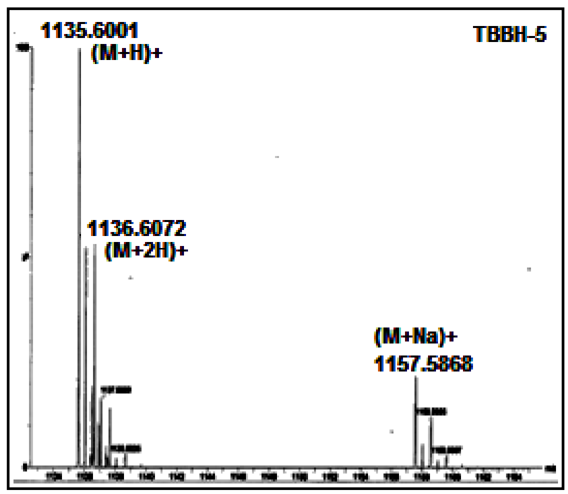
Spectrum 37. IR of 27j



Spectrum 38. [1]H NMR of 27j

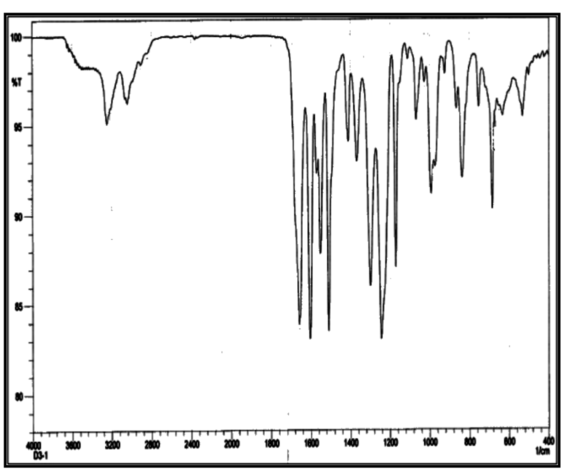


Spectrum 39. [13]C NMR of 27j

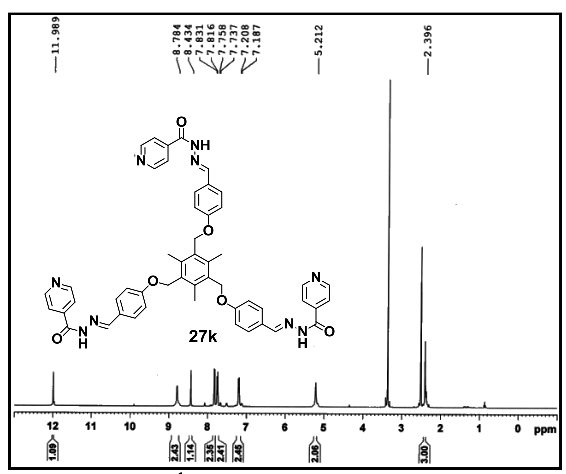


Spectrum 40. Mass of 27j

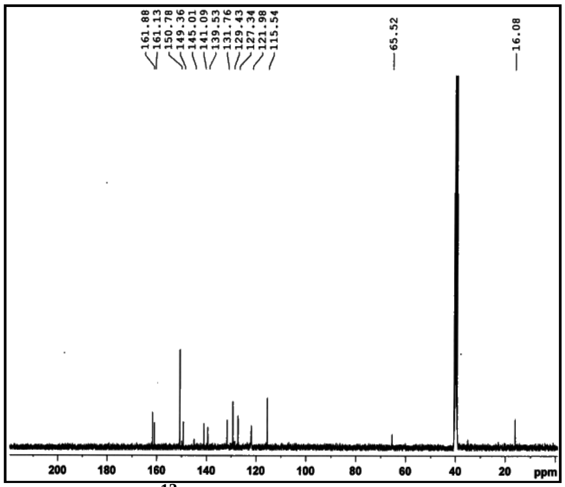
Compound 27k



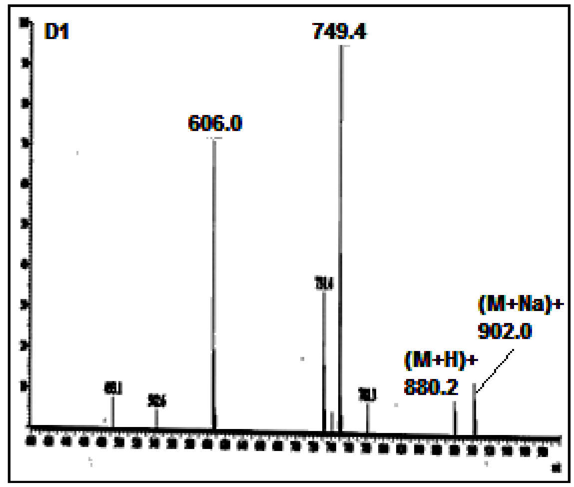
Spectrum 41. IR of 27k



Spectrum 42. [1]H NMR of 27k

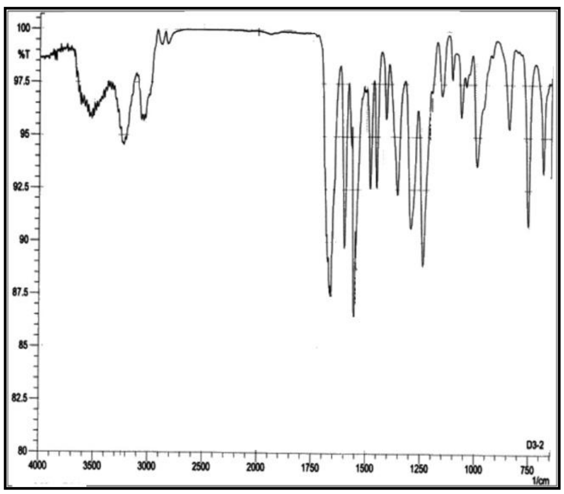


Spectrum 43. ^{13}C NMR of 27k

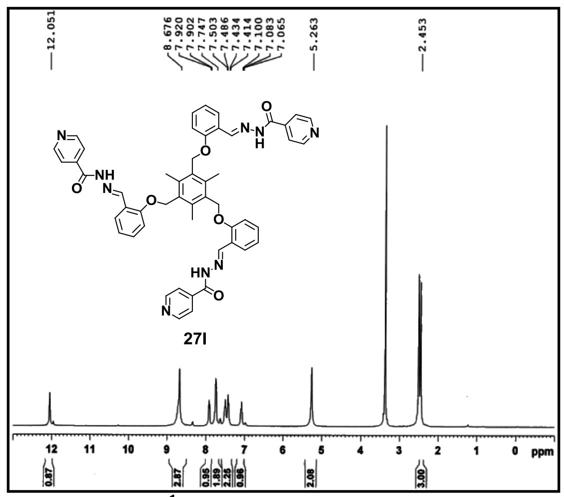


Spectrum 44. Mass of 27k

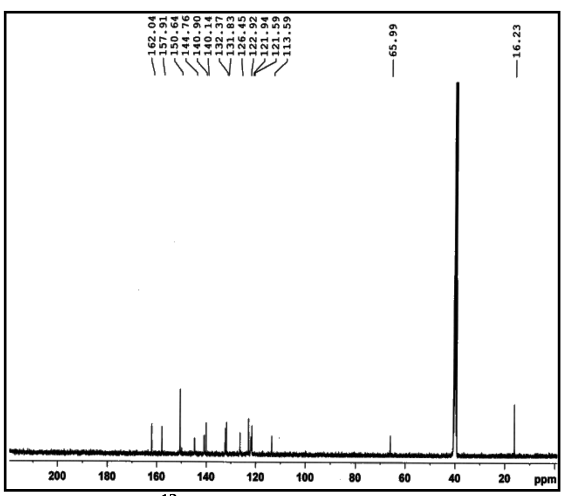
Compound 27l



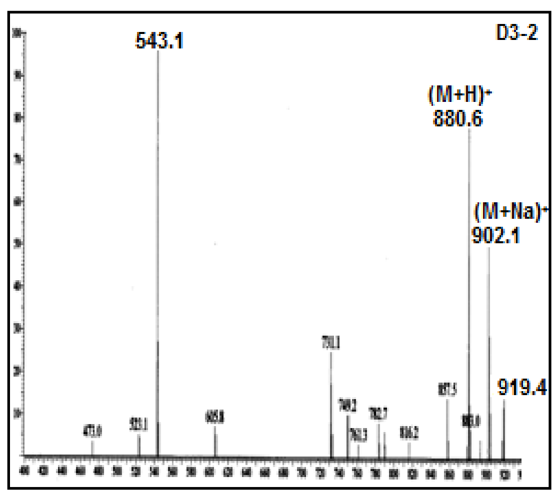
Spectrum 45. IR of 27l



Spectrum 46. ^{1}H NMR of 27l

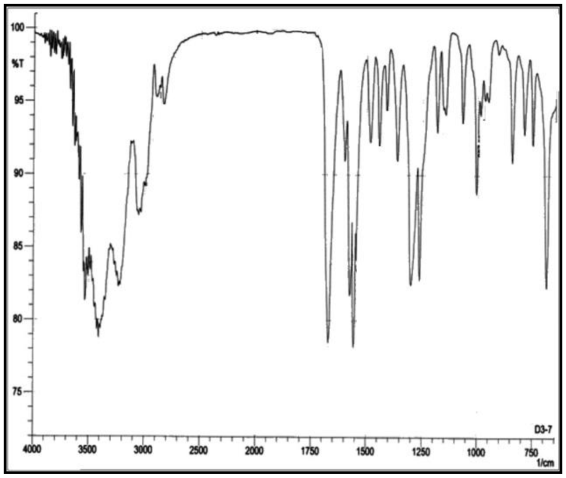


Spectrum 47. ^{13}C NMR of 27l

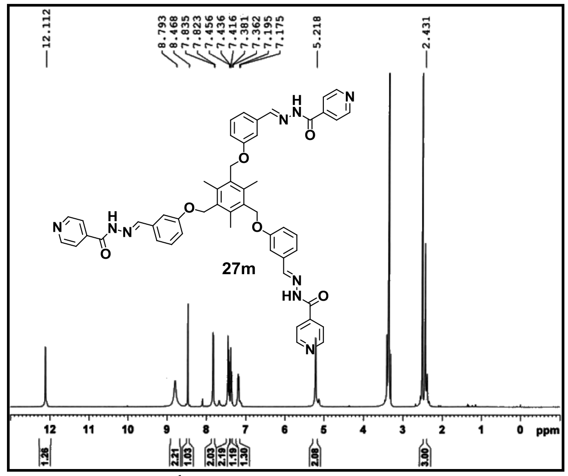


Spectrum 48. Mass of 27l

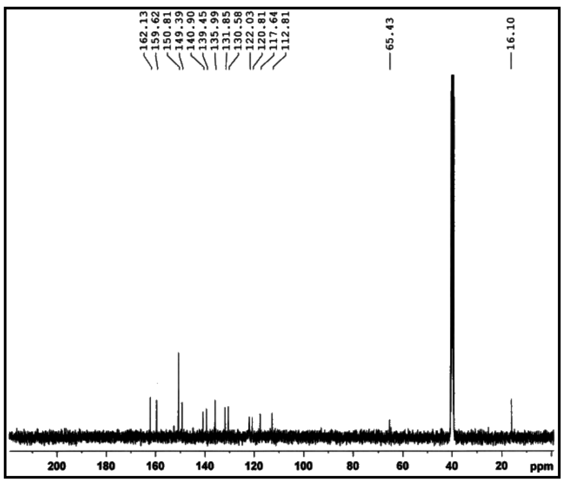
Compound 27m



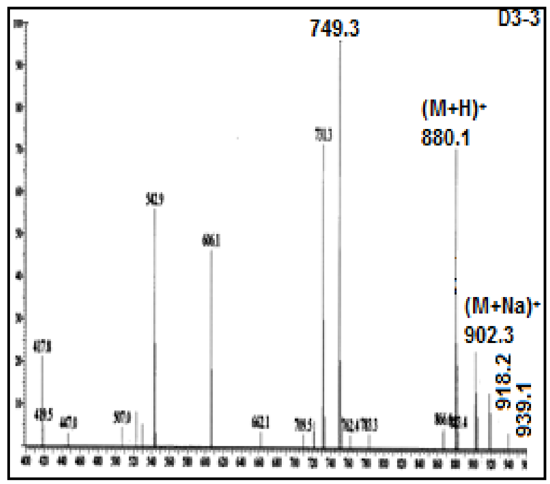
Spectrum 49. IR of 27m



Spectrum 50. ^{1}H NMR of 27m

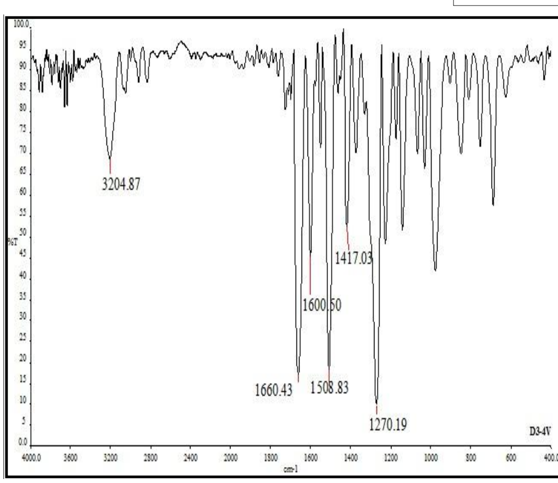


Spectrum 51. ^{13}C NMR of 27m

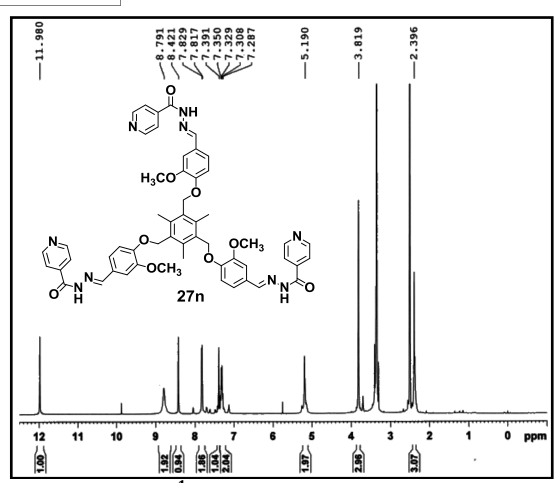


Spectrum 52. Mass of 27m

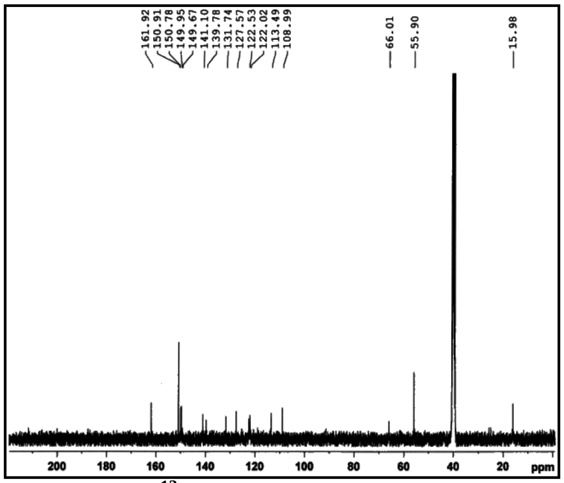
Compound 27n



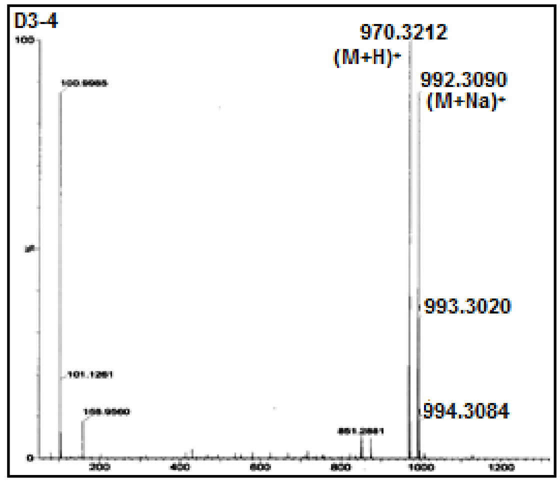
Spectrum 53. IR of 27n



Spectrum 54. ^{1}H NMR of 27n

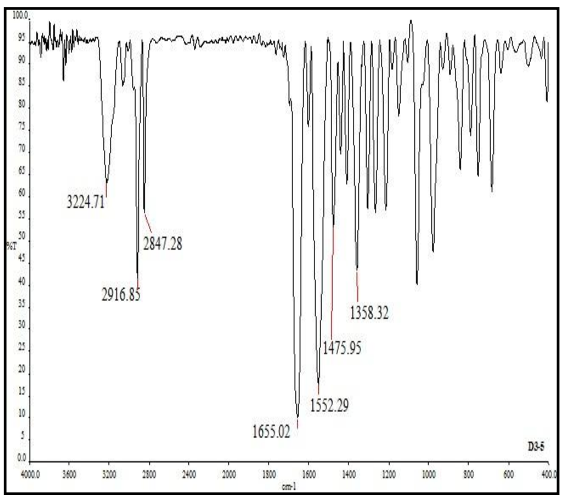


Spectrum 55. ^{13}C NMR of 27n

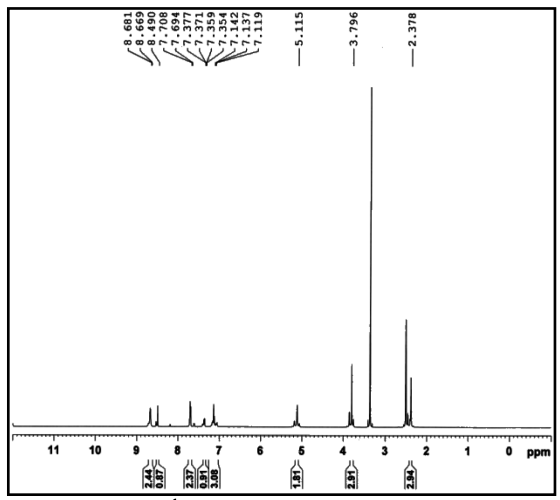


Spectrum 56. Mass of 27n

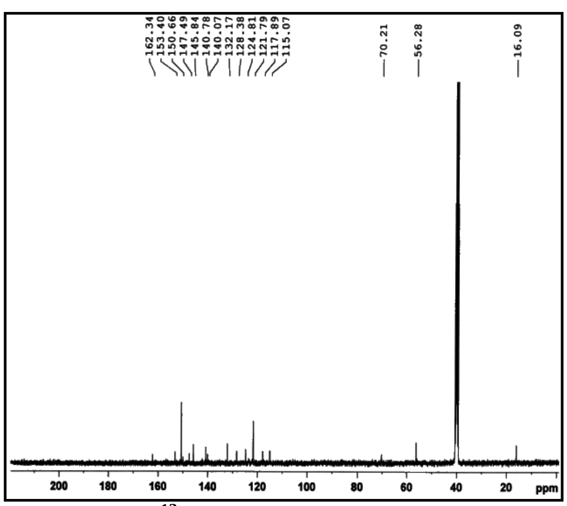
Compound 27o



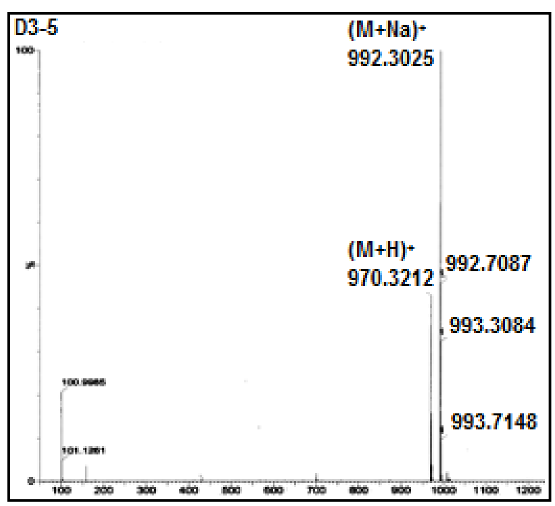
Spectrum 57. IR of 27o



Spectrum 58. ^{1}H NMR of 27o



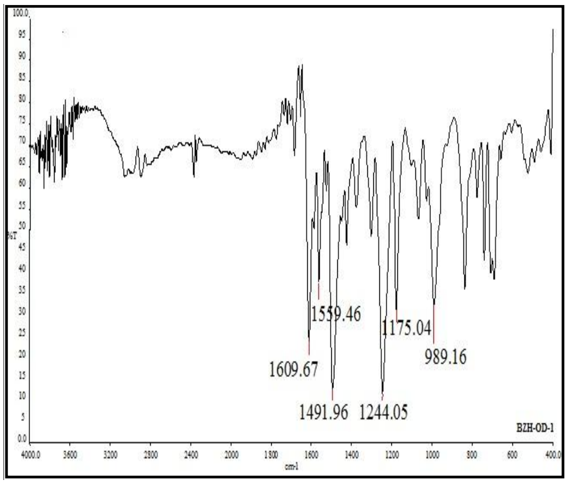
Spectrum 59. ^{13}C NMR of 27o



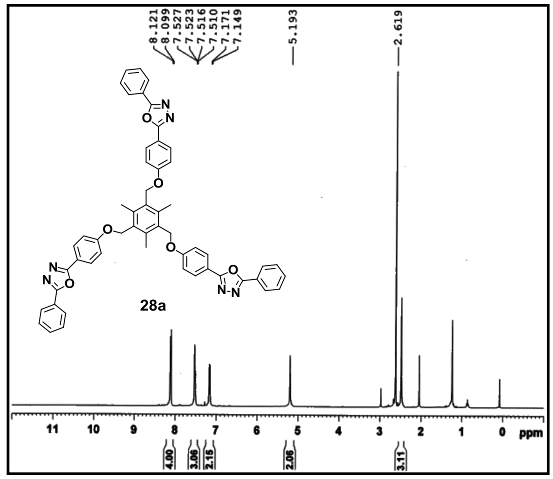
Spectrum 60. Mass of 27o

3.5.2 Tris-1,3,4-oxadiazoles

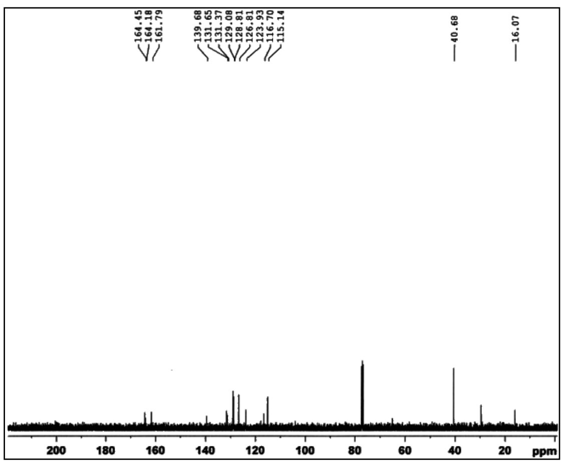
Compound 28a



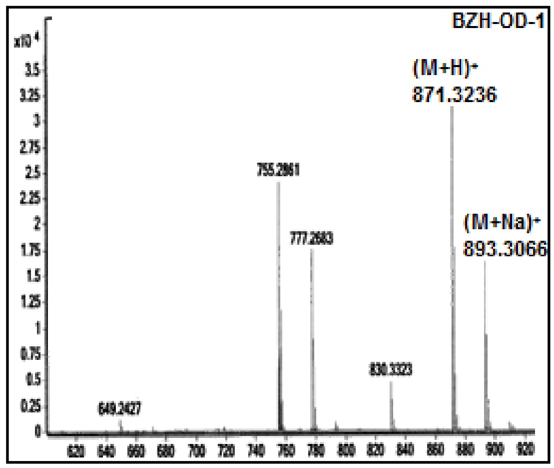
Spectrum 61. IR of 28a



Spectrum 62. [1]H NMR of 28a

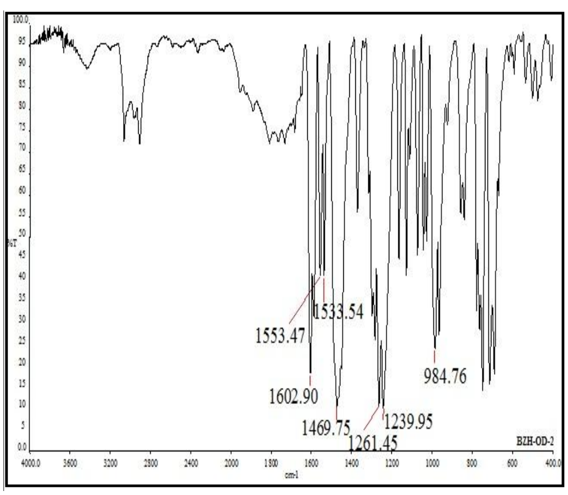


Spectrum 63. [13]C NMR of 28a

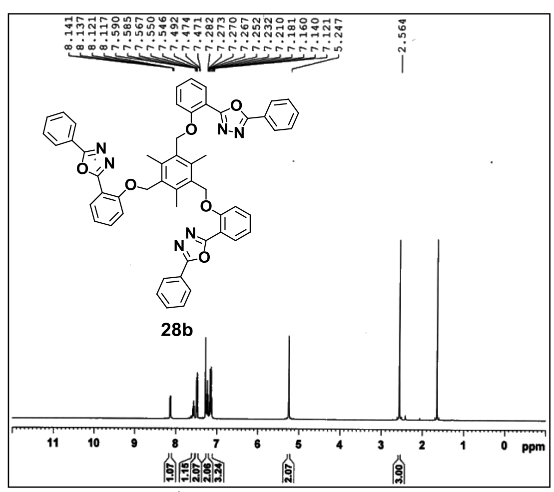


Spectrum 64. Mass of 28a

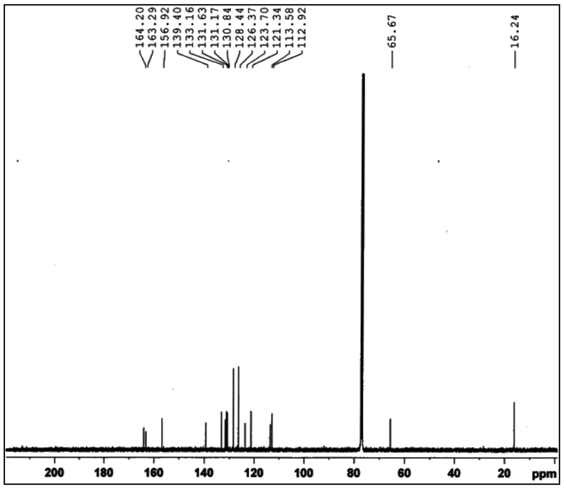
Compound 28b



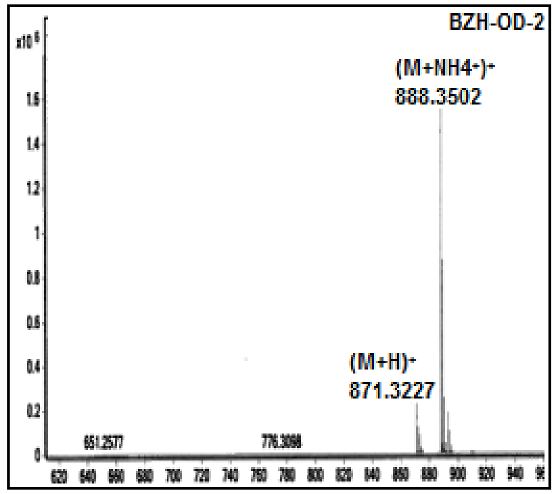
Spectrum 65. IR of 28b



Spectrum 66. [1]H NMR of 28b

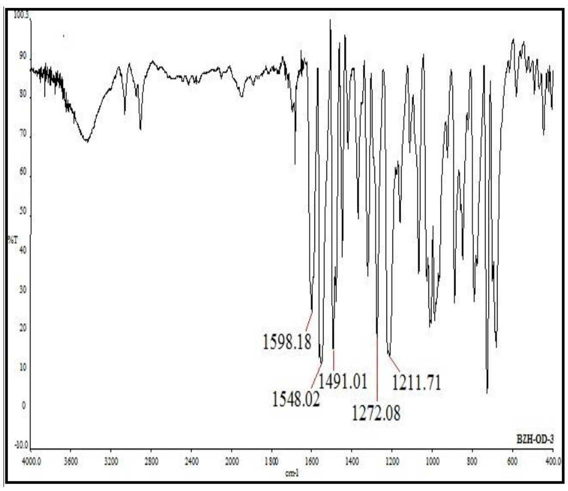


Spectrum 67. ^{13}C NMR of 28b

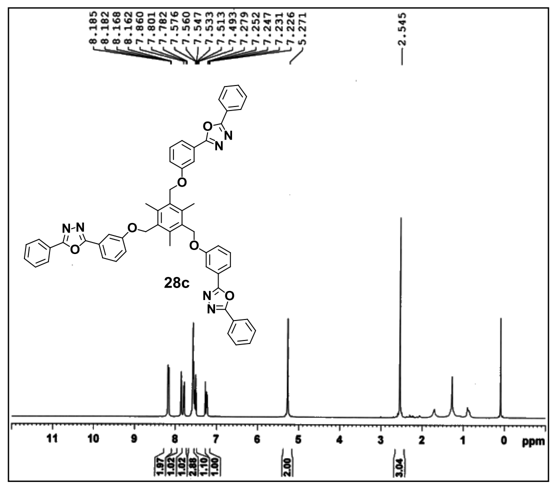


Spectrum 68. Mass of 28b

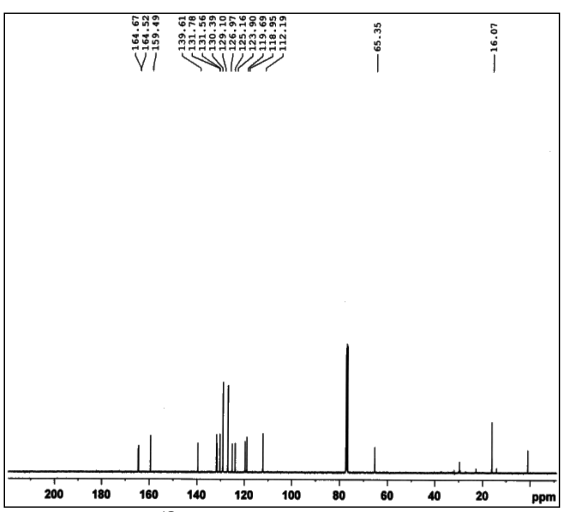
Compound 28c



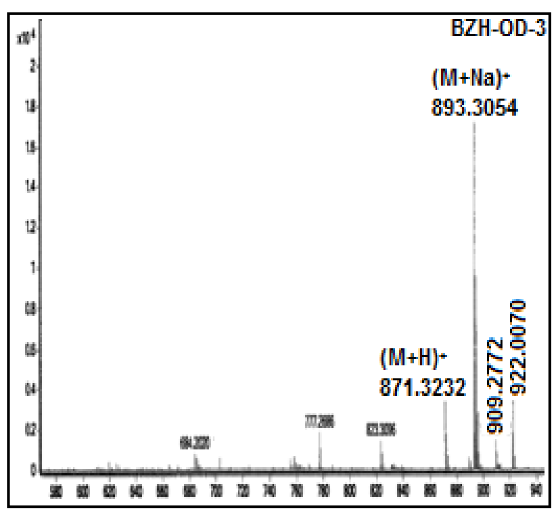
Spectrum 69. IR of 28c



Spectrum 70. ^{1}H NMR of 28c

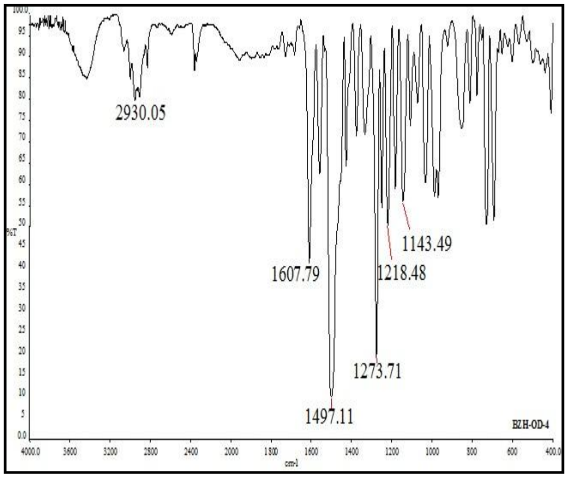


Spectrum 71. ^{13}C NMR of 28c

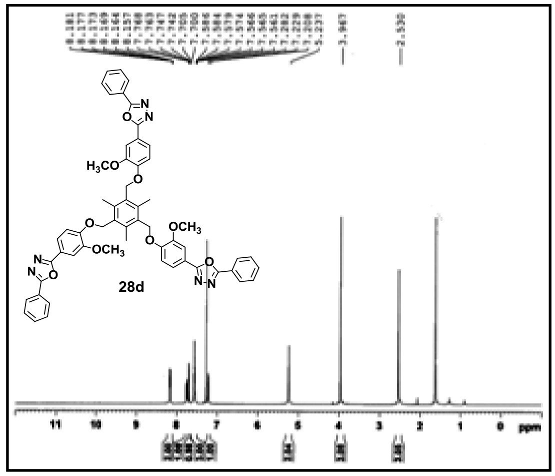


Spectrum 72. Mass of 28c

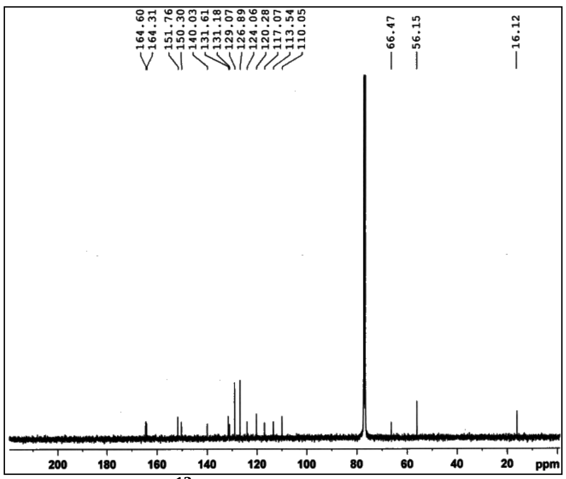
Compound 28d



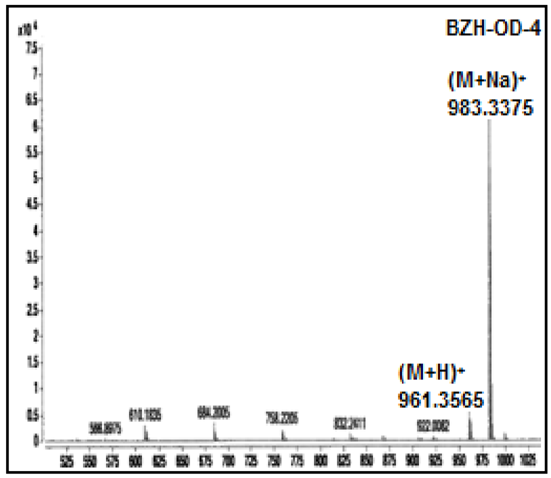
Spectrum 74. IR of 28d



Spectrum 75. ^{1}H NMR of 28d

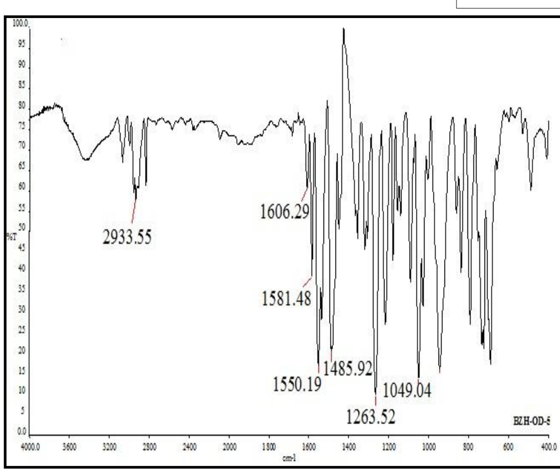


Spectrum 76. ^{13}C NMR of 28d

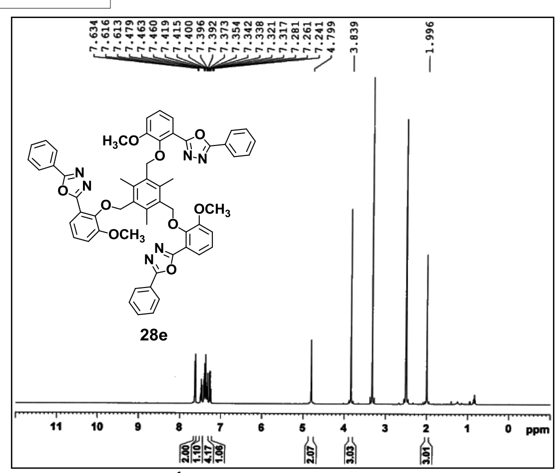


Spectrum 77. Mass of 28d

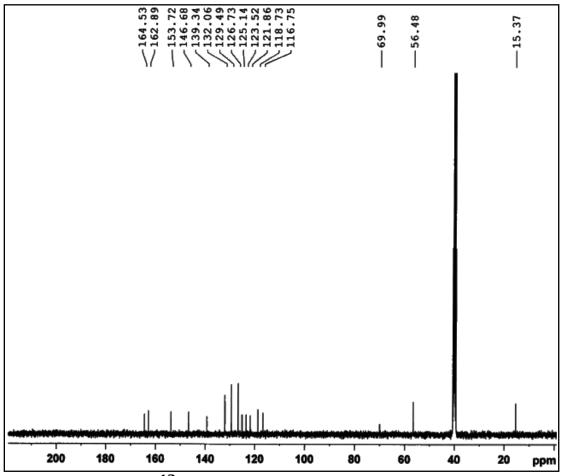
Compound 28e



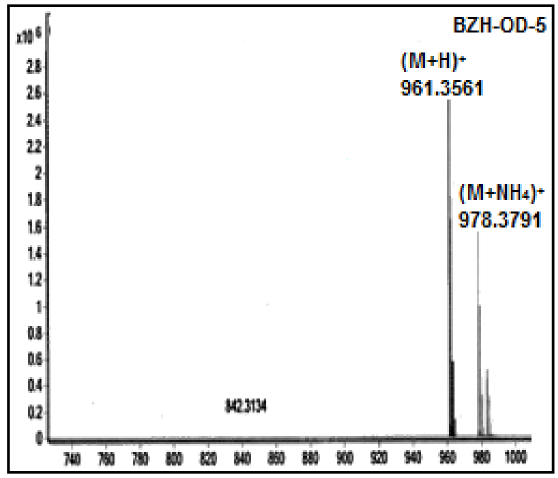
Spectrum 78. IR of 28e



Spectrum 79. ^{1}H NMR of 28e

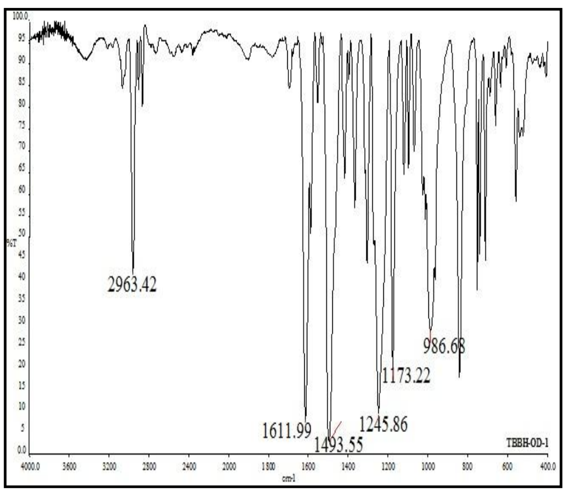


Spectrum 80. ^{13}C NMR of 28e

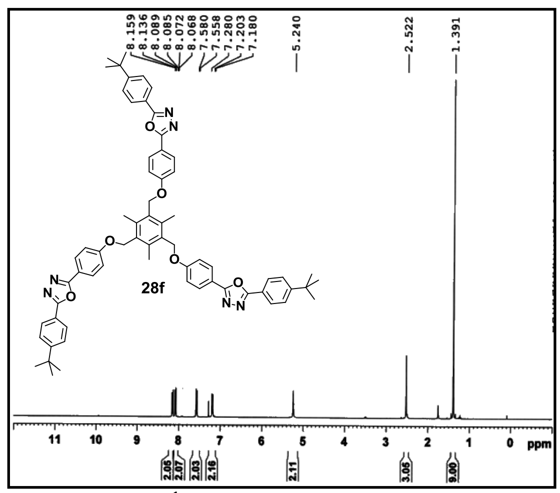


Spectrum 81. Mass of 28e

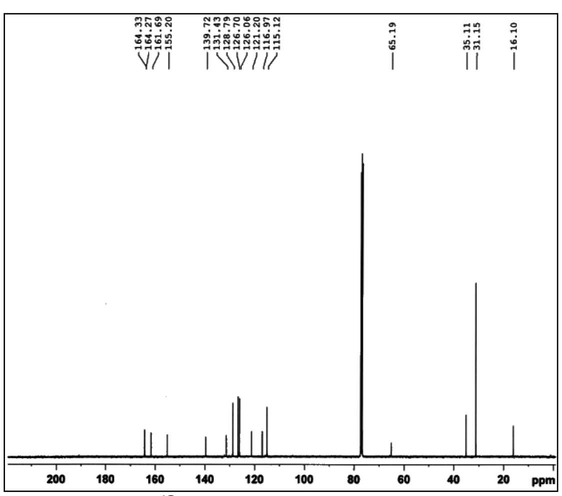
Compound 28f



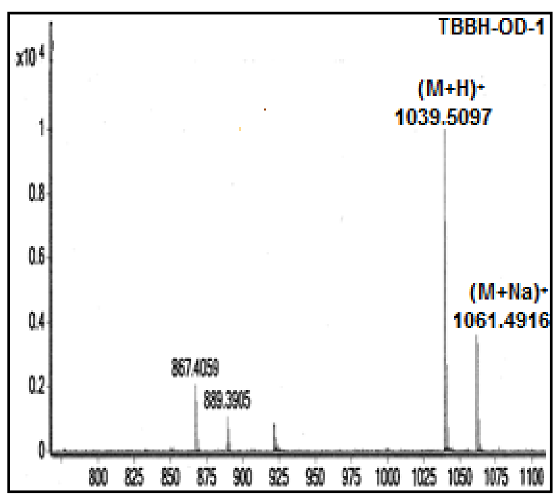
Spectrum 82. IR of 28f



Spectrum 83. ^{1}H NMR of 28f

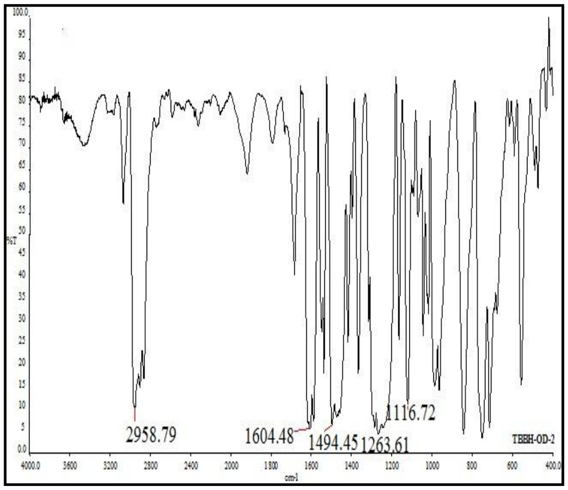


Spectrum 84. ^{13}C NMR of 28f

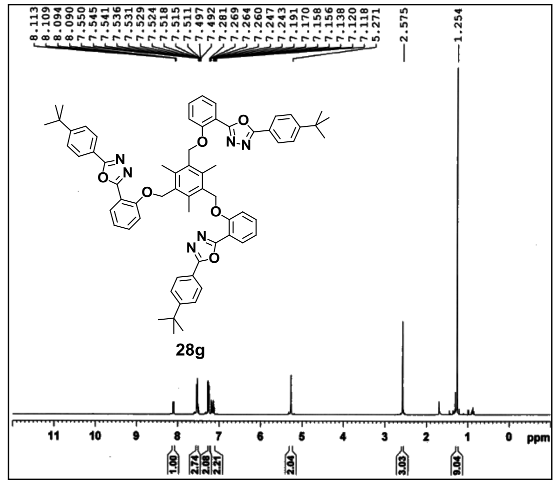


Spectrum 85. Mass of 28f

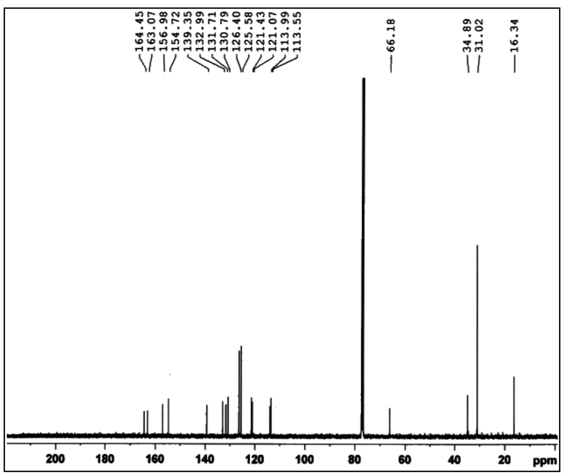
Compound 28g



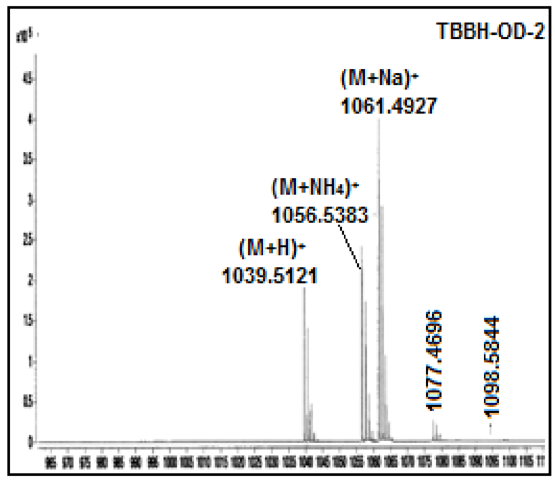
Spectrum 86. IR of 28g



Spectrum 87. ^{1}H NMR of 28g

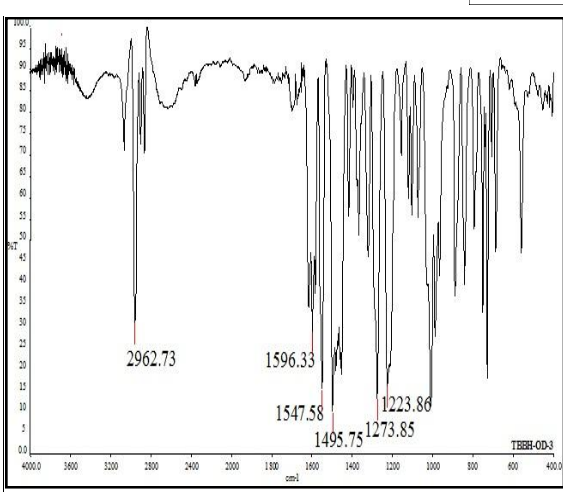


Spectrum 88. ^{13}C NMR of 28g

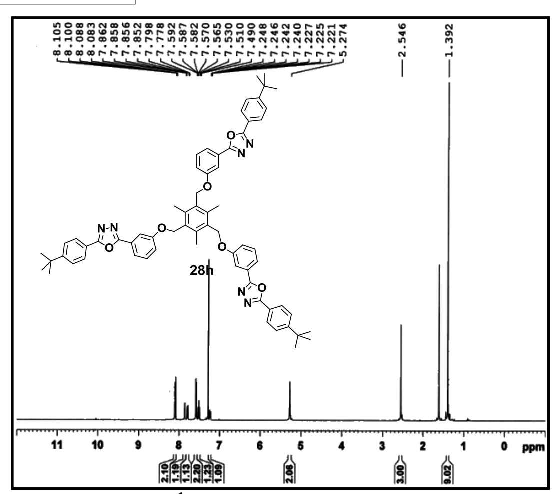


Spectrum 89. Mass of 28g

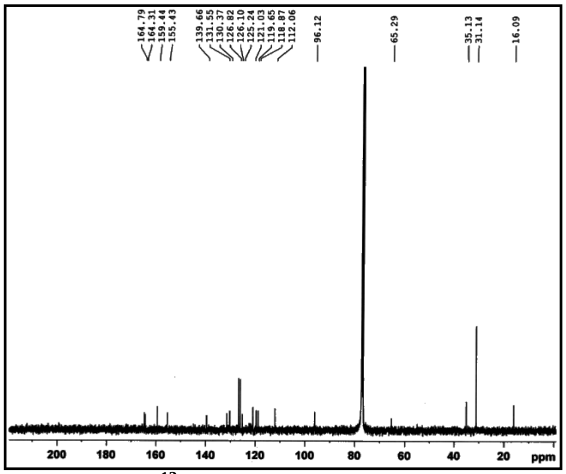
Compound 28h



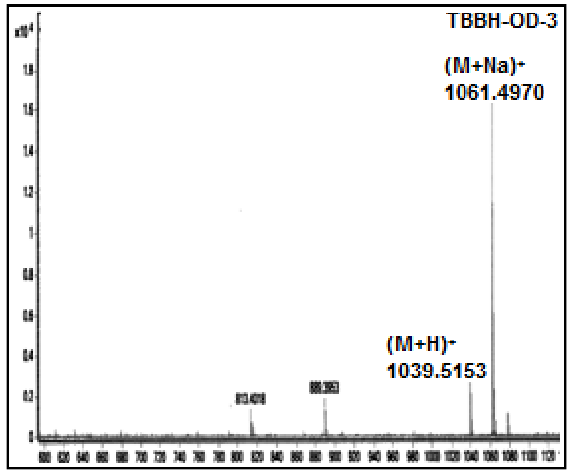
Spectrum 90. IR of 28h



Spectrum 91. ^{1}H NMR of 28h

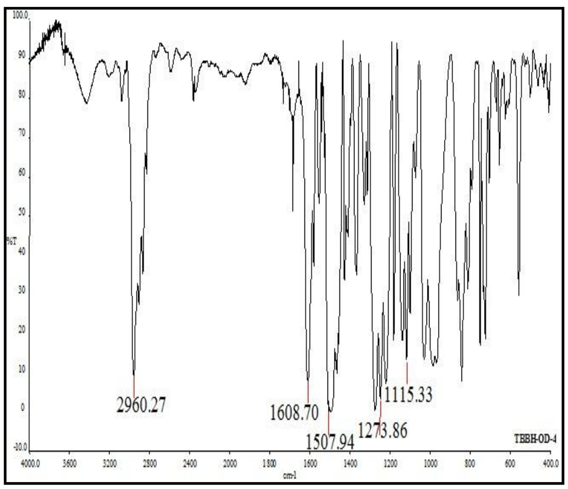


Spectrum 92. ^{13}C NMR of 28h

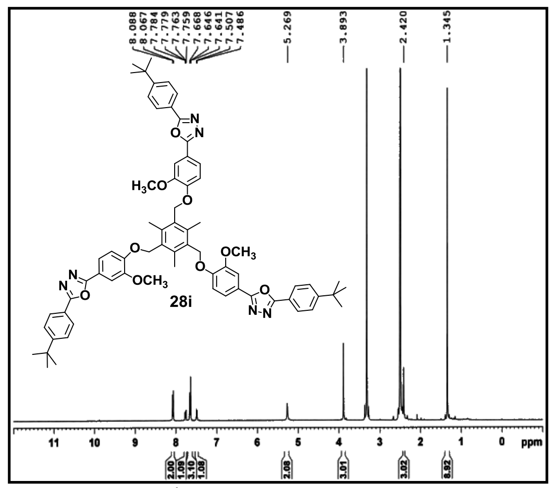


Spectrum 93. Mass of 28h

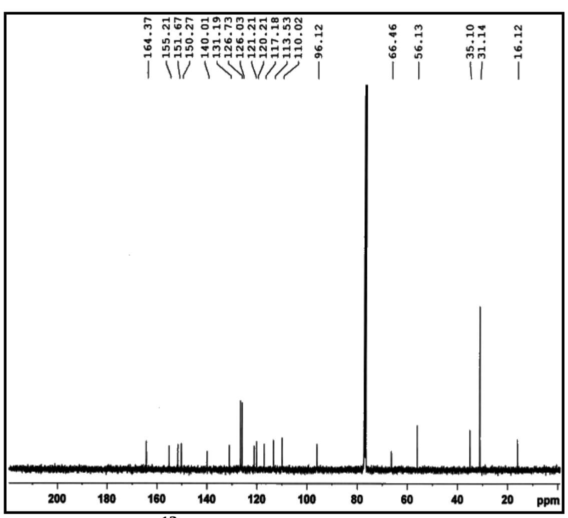
Compound 28i



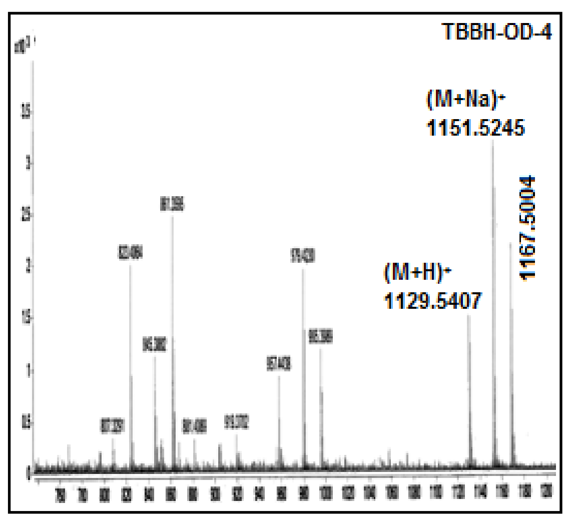
Spectrum 94. IR of 28i



Spectrum 95. ^{1}H NMR of 28i

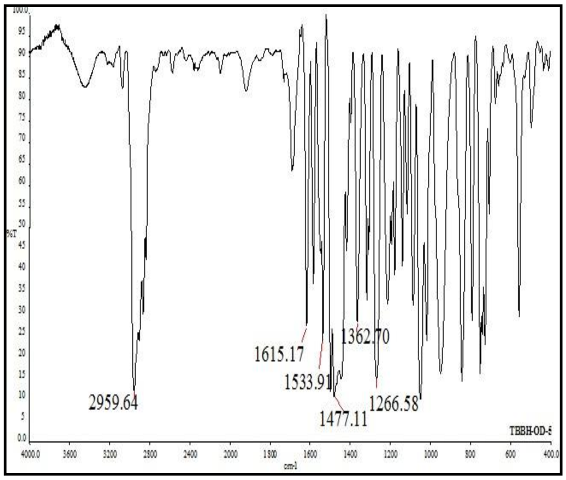


Spectrum 96. ^{13}C NMR of 28i

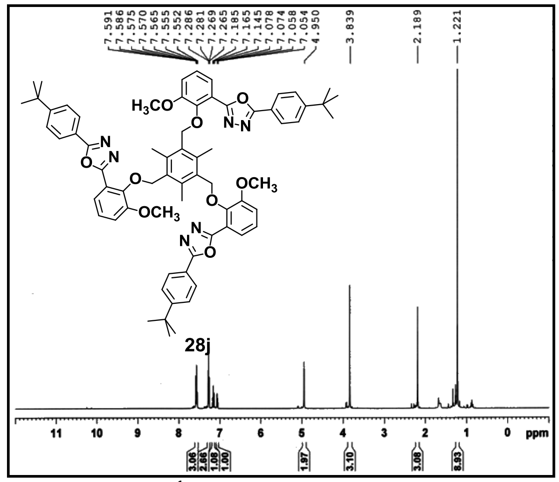


Spectrum 97. Mass of 28i

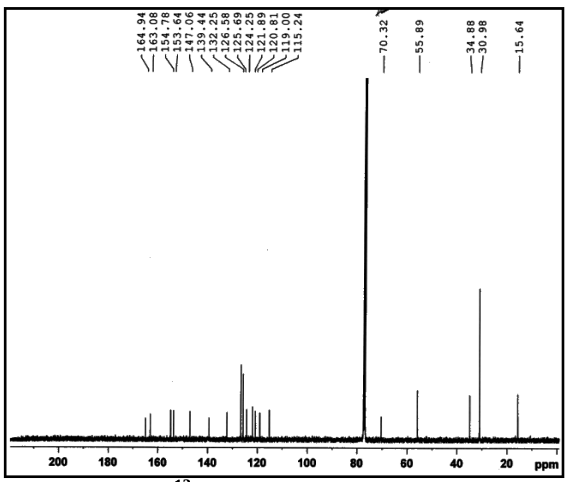
Compound 28j



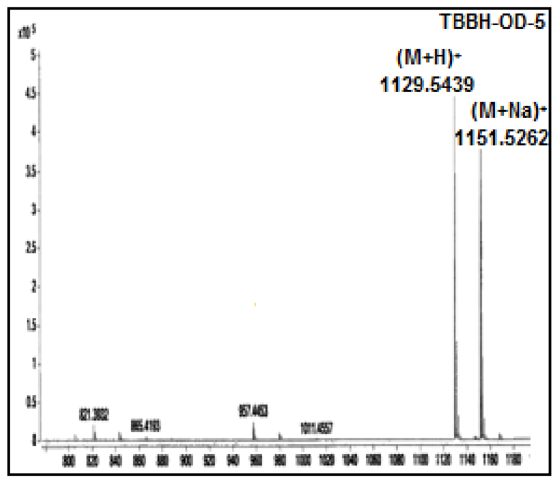
Spectrum 98. IR of 28j



Spectrum 99. ^{1}H NMR of 28j

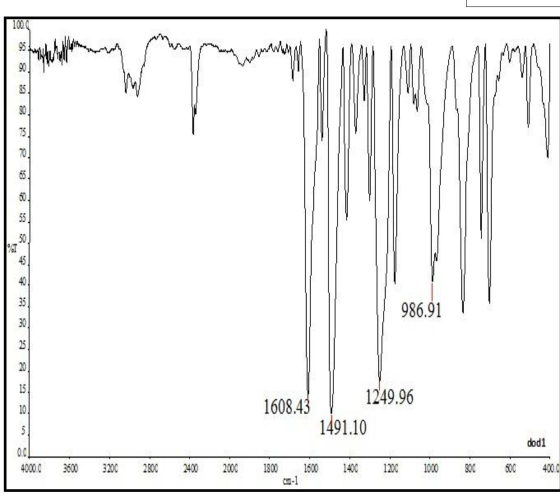


Spectrum 100. ^{13}C NMR of 28j

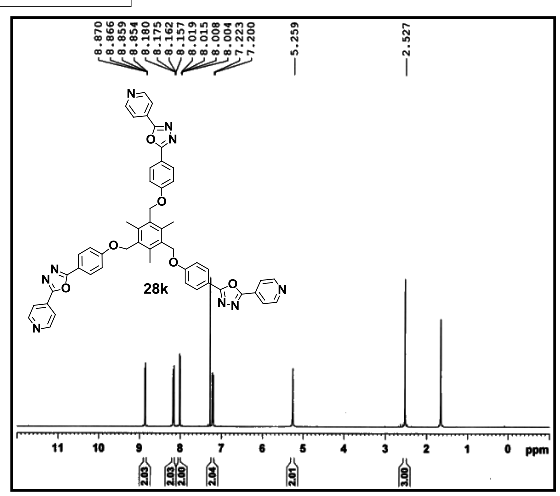


Spectrum 101. Mass of 28j

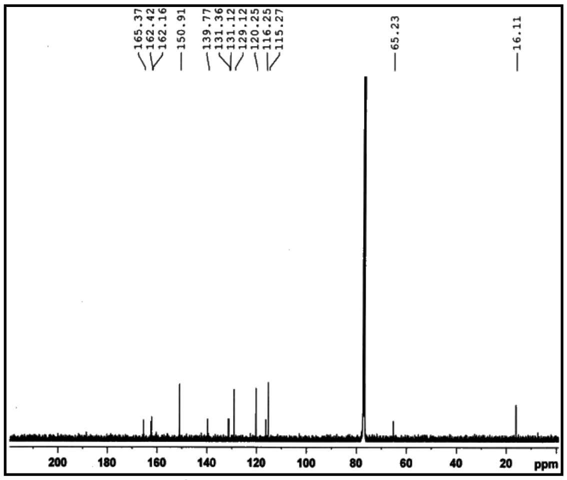
Compound 28k



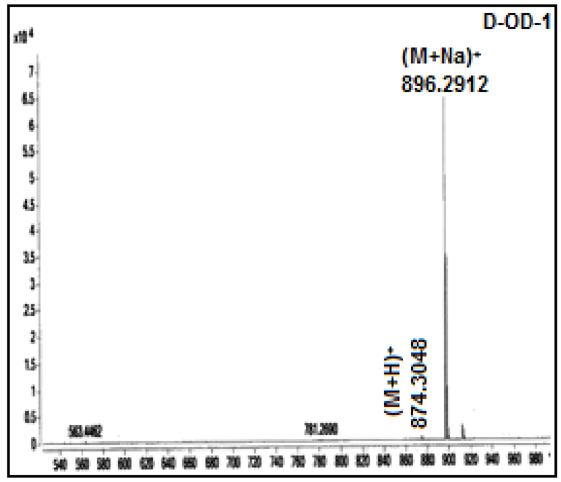
Spectrum 102. IR of 7k



Spectrum 103. ^{1}H NMR of 7k

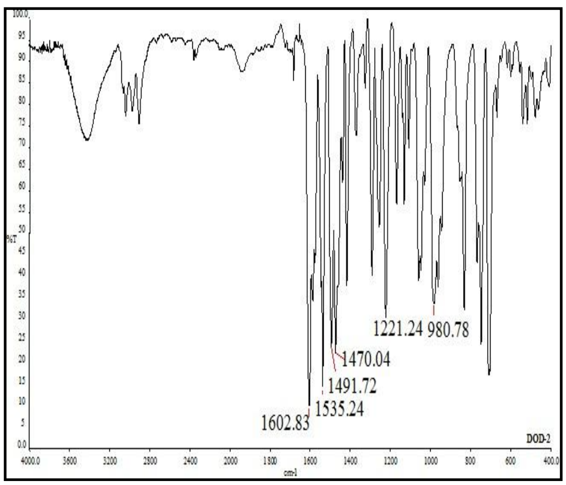


Spectrum 104. ^{13}C NMR of 28k

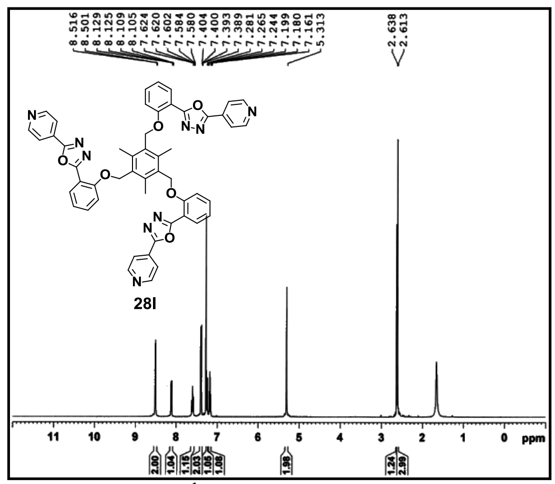


Spectrum 105. Mass of 28k

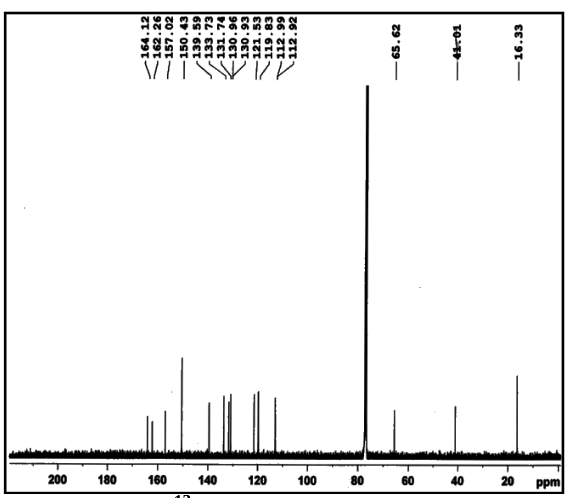
Compound 28l



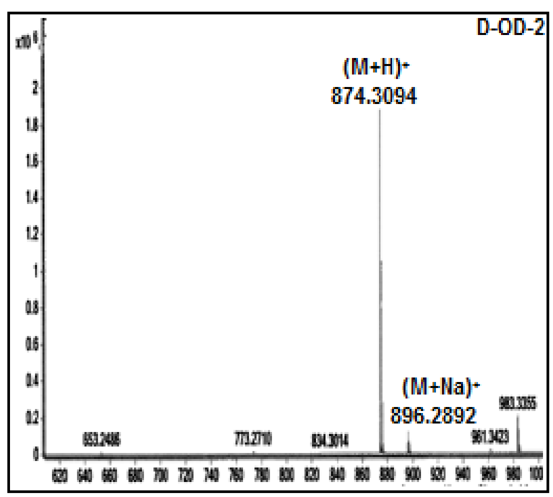
Spectrum 106. IR of 28l



Spectrum 107. ^{1}H NMR of 28l

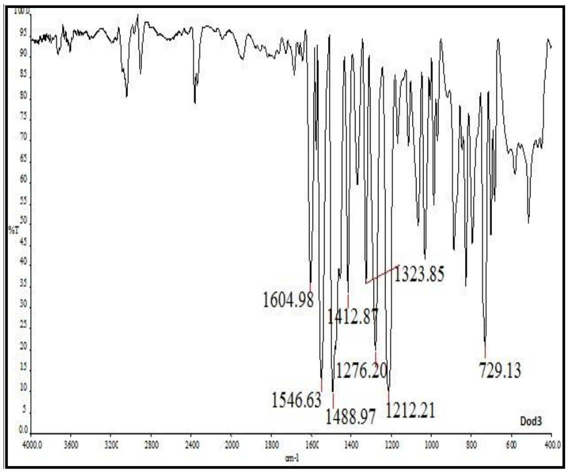


Spectrum 108. ^{13}C NMR of 28l

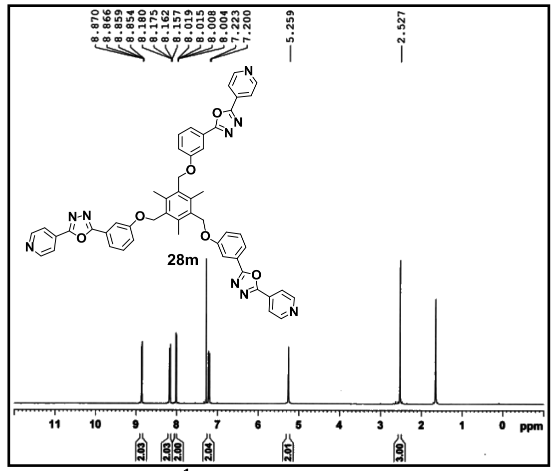


Spectrum 109. Mass of 28l

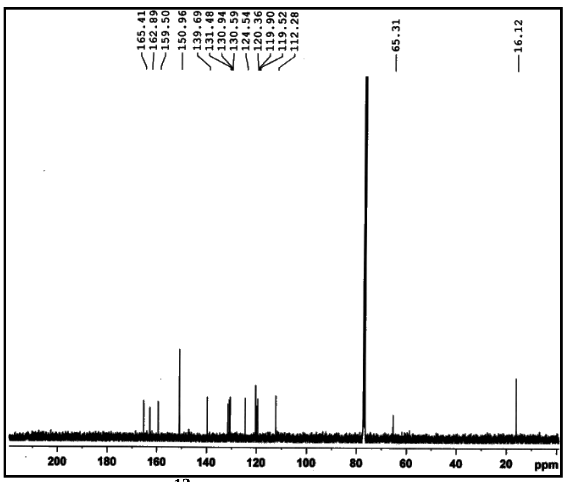
Compound 28m



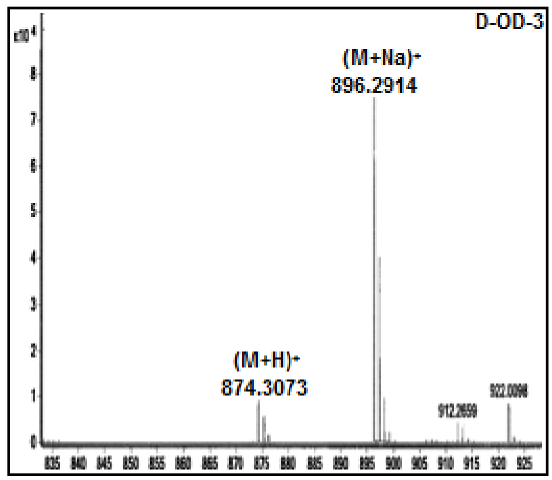
Spectrum 110. IR of 28m



Spectrum 111. [1]H NMR of 28m

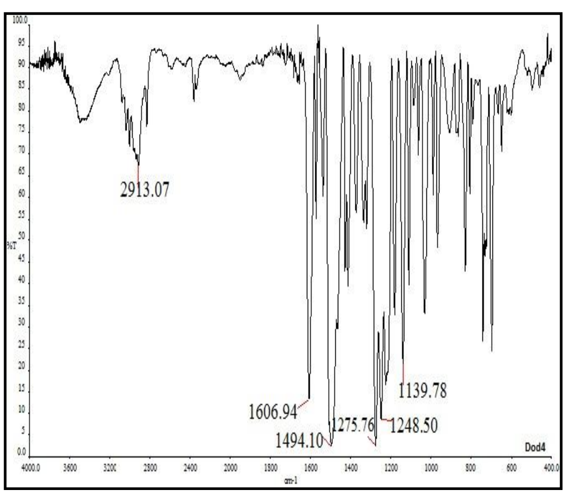


Spectrum 112. [13]C NMR of 28m

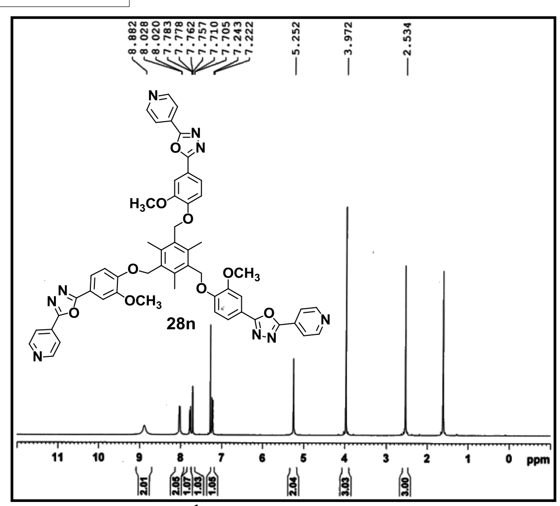


Spectrum 113. Mass of 28m

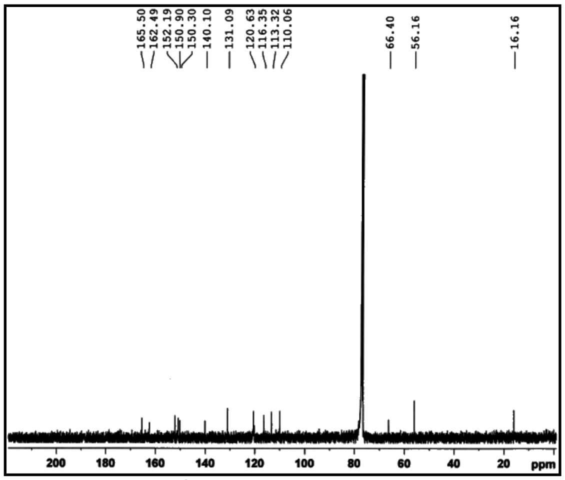
Compound 28n



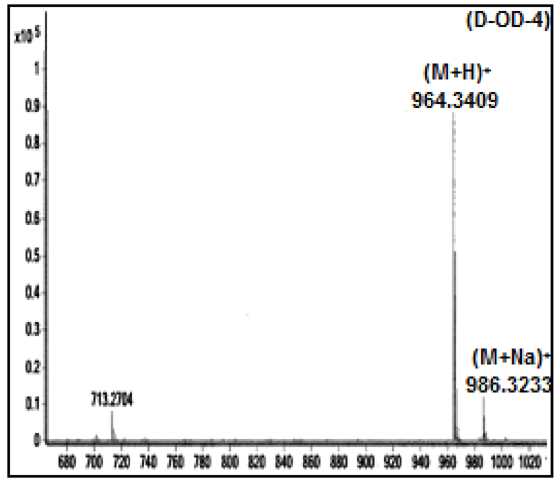
Spectrum 114. IR of 28n



Spectrum 115. [1]H NMR of 28n

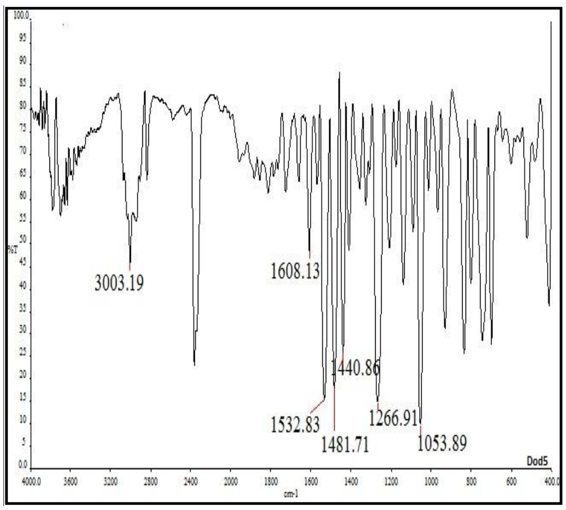


Spectrum 116. ^{13}C NMR of 28n

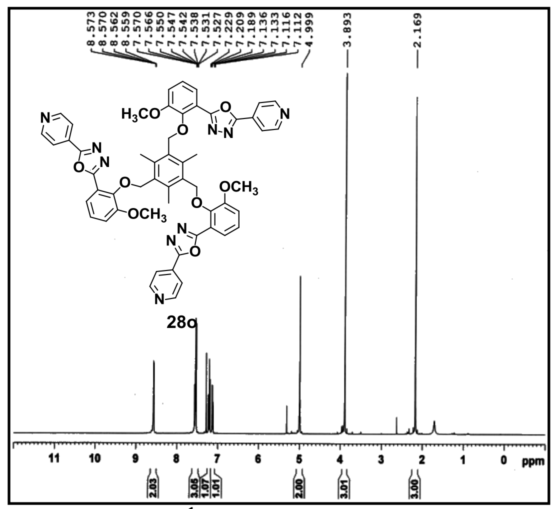


Spectrum 117. Mass of 28n

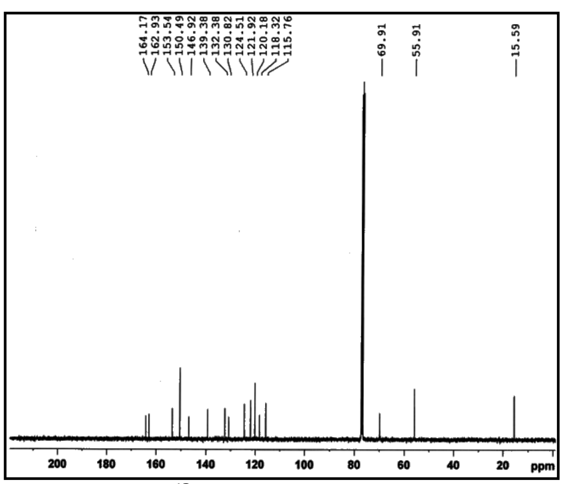
Compound 28o



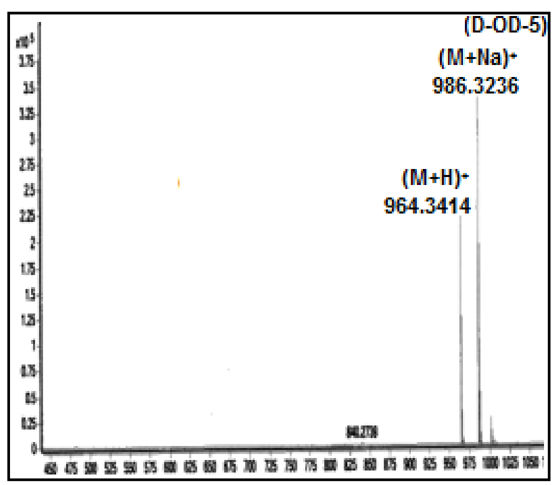
Spectrum 118. IR of 28o



Spectrum 119. ^{1}H NMR of 28o



Spectrum 120. ^{13}C NMR of 28o



Spectrum 121. Mass of 28o

Part B

Convergent synthesis of 1,3,5-tris[4-{5-(4-alkyloxy-phenyl)-1,3,4-oxadiazol -2-yl}-phenyloxy-methyl]-2,4,6-trimethylbenzenes

PART B

3.6 INTRODUCTION

In this part of the chapter tripodal compounds containing tris-1,3,4-oxadiazoles have been synthesized using a different approach from the earlier one wherein the tris-acylhydrazones were oxidatively cyclized to be transformed to tripodal compounds containing tris-1,3,4-oxadiazoles. In the present approach, 2,5-diaryl-1,3,4-oxadiazoles were separately prepared from diaroylhydrazines under dehydrative reaction conditions. The disubstituted 1,3,4-oxadiazoles thus prepared were coupled with 1,3,5-trisbromomethyl-2,4,-6-trimethylbenzene. As a result, this approach can be considered as a convergent approach with respect to the linear synthesis approach employed in **Part A**. The tripodal oxadiazoles prepared here carried a long alkoxy chains with different chain lengths as hydrophobic end groups.

Diacylhydrazines are biologically active compounds. They have been mainly studied for their insecticidal[51] and antifungal[52] bioactivities. Some commercially used insecticidal agents are shown below (Figure 18).

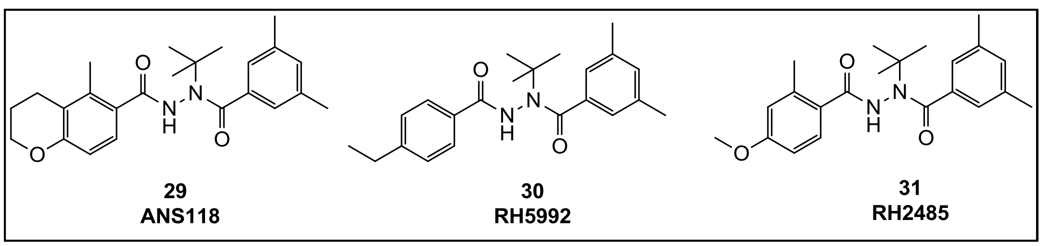
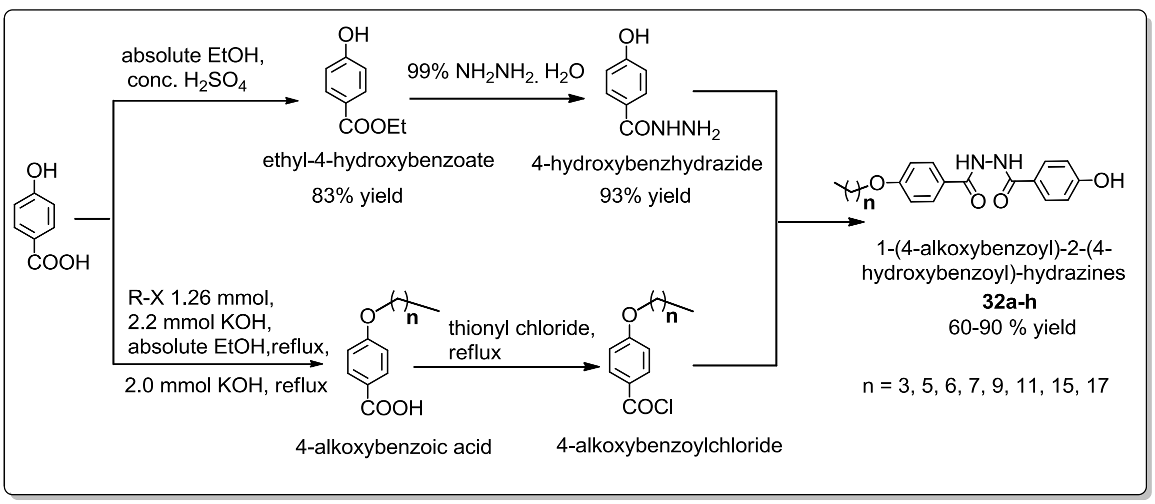


Figure 18 ***Diacyhydrazine insecticides***

3.7 RESULTS AND DISCUSSION

3.7.1 Synthesis and characterization of diacylhydrazines

For the present study the diacylhydrazines were prepared by the reaction of arylacylhydrazine with arylacyl chlorides. Both components were prepared from common starting material, that is *p*-hydroxybenzoic acid. On one hand *p*-hydroxybenzoic acid was converted to ethyl-*p*-hydroxybenzoate[53] which was then converted to *p*-hydroxybenzhydrazide[54] while on the other hand it was converted to 4-alkoxybenzoic acids by reacting with alkyl halides having different chain lengths of C-4 to C-18 carbons.[55] 4-Alkoxybenzoic acids thus prepared were then converted to the corresponding 4-alkoxybenzoylchlorides by treating with thionyl chloride under reflux condition. The resulting 4-alkoxybenzoylchlorides were reacted with 4-hydroxybenzhydrazide to give the corresponding diacylhydrazines[56] namely 1-(4-alkoxybenzoyl)-2-(4-hydroxybenzoyl)-hydrazines **32**. Total eight such diacyhydrazines have been prepared with varying alkyl chain lengths and are being reported here for the first time (Scheme 3.3).



Scheme 3.3 ***Preparation of diacylhydrazines***

In the infrared spectra, diacylhydrazines showed a broad band due to $\nu_{O–H}$ and $\nu_{N–H}$ from 3550 to 3000 cm^{-1} and in one of them two bands were separately observed at 3509 and 3347 cm^{-1}. A strong $\nu_{C–H}$ were observed between 2952 to 2875 cm^{-1} due to the presence of alkyl chains. Bands for two different carbonyl groups are observed as separate absorption bands between 1688 to 1640 cm^{-1}, sometimes overlapping with nearby strong bands near 1600 cm^{-1}. The other important bands for aromatic ring $\nu_{C=C}$ are observed between 1600 to1540 cm^{-1}. ν_{C-O} for ether linkage are observed at 1250 and 1175 cm^{-1}.

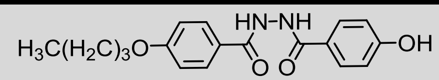
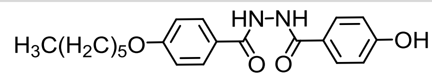
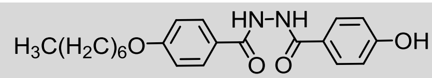
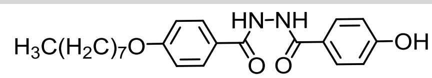
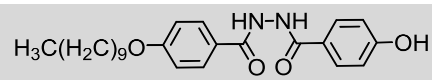
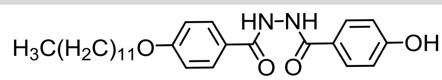
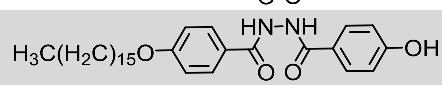
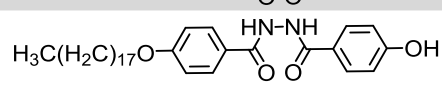
The unsymmetrical diacylhydrazines having monoalkoxy substitution have typical ^{1}H NMR signals with a triplet for the methyl group (–CH_3) present in the alkyl chain giving signal between δ 0.8 to 0.92 and oxygen attached methylene group (–OCH_2) showing a quartet at δ 4.0. The methylene protons present between these two carbons are observed between δ 1.2 to 1.8 as a triplet for two protons towards lower field while the other protons are observed at higher field with varying intensity depending on the number of protons present in the alkyl chain length. The aromatic protons are observed as four sets of doublets between δ 6.8 to 7.9. In general three singlets are observed for N–H and O–H protons present in the diacylhydrazine derivatives.

In ^{13}C-NMR the carbonyl carbons are observed as two close signals at δ 166.0 and 165.8. The oxygen attached aromatic carbons are also observed downfield near δ 162 and 161. The other aromatic carbons are also observed as sets of two close signals between δ 114 to 130. In aliphatic region, most downfield carbon is oxygen attached methylene carbon (–OCH_2–) near δ 68. The other aliphatic chain carbon signals are observed between δ 14 to 32.

The 1–(4–alkoxybenzoyl)–2–(4–hydroxybenzoyl)–hydrazines were characterized with the help of mass spectrometer having Q-TOF analyzer by using electron spray ionization (ESI) technique. The molecular ion peaks were observed as $(M+H)^+$ and $(M+Na)^+$ in all the cases. A peak corresponding to *p*-alkoxybenzoyl fragment $(M-151.0355)^+$ was observed in all the cases due to removal of *p*-hydroxybenzhydrazide ($C_7H_7N_2O_2$) except for compounds having C-16 and C-18 chain lengths.

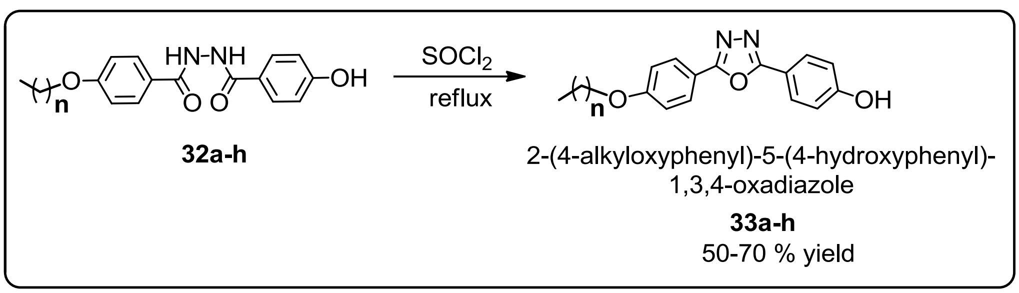
The melting points and yields of the tri-acylhydrazones **32** are summarized in Table 3.1.3. The melting point drops as chain length of the alkoxy group increases (Figure 19).

Table 3.1.3 ***Yields and melting points of newly synthesized diacyhydrazines***

Compound ID	1–(4–alkoxybenzoyl)–2–(4–hydroxybenzoyl)–hydrazines	Yield [%]	M.P. [°C]
32a		80	213
32b		88	205
32c		69	196
32d		71	184
32e		71	175
32f		71	160
32g		80	153
32h		76	141

3.7.2 Synthesis and characterization of 2,5-disubstituted unsymmetrical oxadiazoles

The monoalkoxy diacylhydrazines were subjected to dehydrative heterocyclization by refluxing them with thionyl chloride for 10-12 hours in good yields.[57] The resulting crude products obtained after removal of thionyl chloride were chromatographically purified giving the corresponding 2,5-disubstituted unsymmetrical oxadiazoles (Scheme 3.4).



Scheme 3.4 ***Synthesis of 1,3,4-oxadiazoles from diacylhydrazines***

For most of the oxadiazoles, free ν_{O-H} group was observed as a broad band at ~ 3110 cm^{-1}. The aromatic $\nu_{C=C}$ and $\nu_{C=N}$ were observed as two strong bands at 1610 and 1495 cm^{-1} having clearly visible strong shoulders. The aryl alkyl ether ν_{C-O} were observed as strong bands in general at 1255 and 1172 cm^{-1}. The other bands are due to $\nu_{C–H}$ and $\delta_{C–H}$ vibrations which intensify with increase in the alkyl chain length.

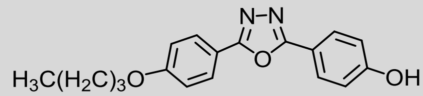
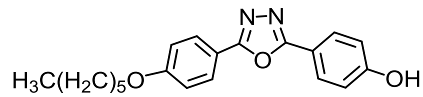
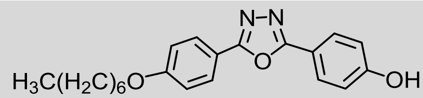
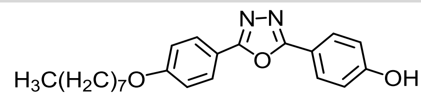
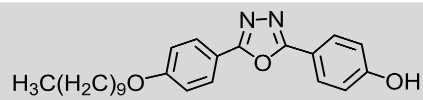
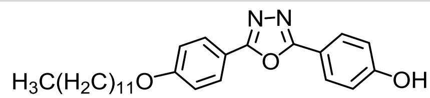
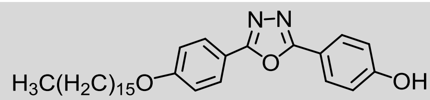
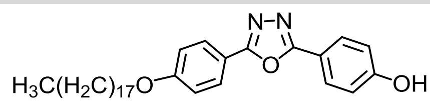
In ^{1}H NMR 2–(4–alkoxyphenyl)–5–(4–hydroxyphenyl)–1,3,4-oxadiazoles have the proton signals in aliphatic region more or less unaffected from their positions in diacylhydrazines coming due to the alkyl chains. The aromatic protons are shifted slightly downfield compared to that observed for their starting materials (diacylhydrazines). Only one most downfield signal observed is due to hydroxyl proton (–OH) at δ 10.29 except when spectra were recorded in $CDCl_3$ (C-16 C-18 chains) where –OH proton may be getting exchanged with moisture present in $CDCl_3$.

In ^{13}C-NMR, the heteroaromatic carbons are the most downfield carbons observed at δ 164 and 163. The oxygen attached aromatic carbons retain their positions at δ 162 and 161. The signals for the other quaternary aromatic carbons attached to oxadiazole ring are shifted upfield near to the unsubstituted aromatic carbons observed in the same region. The aliphatic carbon signals are observed with nearly same chemical shifts observed for the aliphatic chains in their starting materials. There is a slight change in the chemical shifts of the carbons present in C-16 and C-18 alkoxy oxadiazoles because they were recorded in $CDCl_3$.

The 2–(4–alkoxyphenyl)–5–(4–hydroxyphenyl)–1,3,4-oxadiazoles were also characterized with the help of mass spectrometer having Q-TOF analyzer by using ESI technique. All the compounds exhibited molecular ion peaks corresponding to $(M+H)^+$.

Isolated yields and melting points of the synthesized oxadiazoles have been summarized in Table 3.1.4. The same behavior was observed in melting point as in case of diacyhydrazines, as the carbon chain length increase there was depression in melting point of oxadiazoles (Figure 19).

Table 3.1.4 ***Yields and melting points of 1,3,4-oxadiazoles***

Compound ID	1–(4–alkoxybenzoyl)–2–(4–hydroxybenzoyl)–hydrazines	Yield [%]	M.P. [°C]
33a		67	203
33b		64	197
33c		74	189
33d		60	166
33e		70	160
33f		58	135
33g		52	128
33h		62	126

A graphical presentation on effect of carbon chain length on melting point is as shown in figure 19.

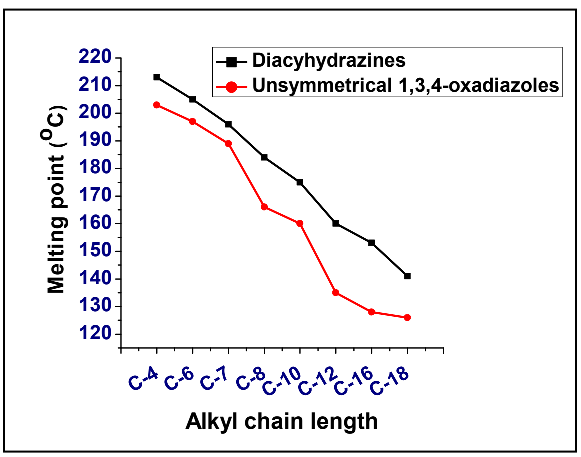
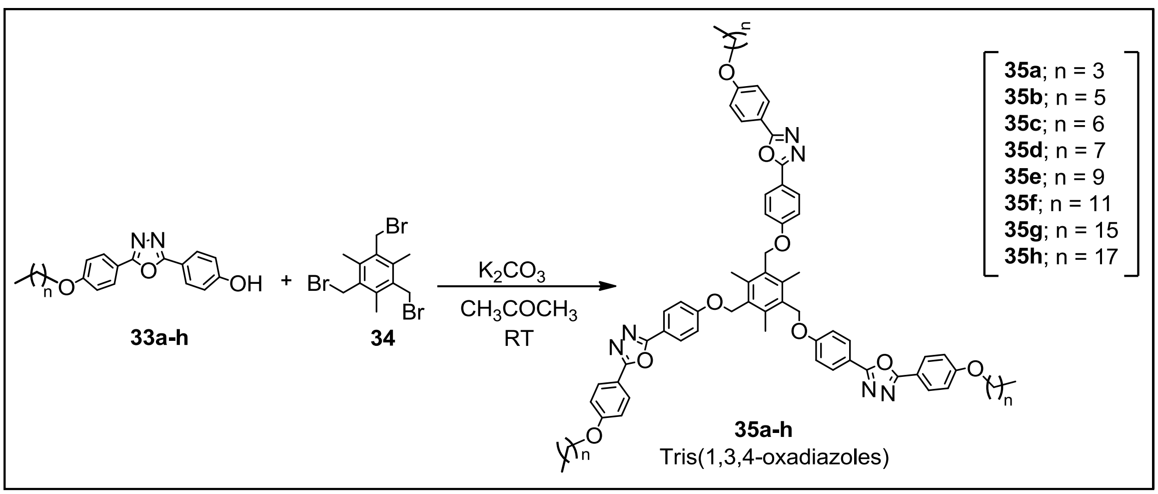


Figure 19 ***Effect of chain length on melting point***

3.7.3 Threefold coupling of 2,5-disubstituted unsymmetrical oxadiazoles with 1,3,5-trisbromomethyl-2,4,6-trimethylbenzene

The eight new unsymmetrical oxadiazoles, namely 2–(4–alkoxyphenyl)–5–(4–hydroxyphenyl)–1,3,4–oxadiazoles having alkyl groups having different chain lengths from C-4 to C-18 were prepared and characterized to be the podand groups for the synthesis of C_3 symmetric compounds possessing 1,3,4-oxadiazole heterocyclic segment in their structures. After synthesizing the oxadiazole derivatives with a reactive free phenolic group in their structure the stage was set to carry out a coupling reaction with a functionalized C_3 symmetric compound. 1,3,5–Trisbromomethyl–2,4,6–trimethylbenzene **34** being a common C_3 symmetric starting material used in the present work, was employed here. The reaction between the phenolic oxadiazoles with 1,3,5–trisbromomethyl–2,4,6–trimethyl- benzene was carried out in acetone using K_2CO_3 at room temperature within a few hours of time in good yields. Thus this approach is a convergent approach to tripodal oxadiazoles in which different 1,3,4-oxadiazole derivatives were prepared separately starting from *p*-hydroxybenzoic acid by using heterocyclization as a key step and were brought together employing C_3 symmetric bridging moiety providing C_3 symmetric environment leading to the tripodal compounds **35**.



Scheme 3.5 ***Threefold coupling of oxadiazoles to tripodal compound***

The spectral characteristics of these compounds supported the proposed symmetrical structures. In infrared spectra, the presence of alkyl chains was marked with $\nu_{C–H}$

between 2900 to 2850 cm^{-1} along with bending vibrations in the fingerprint region (~1374). The aromatic $\nu_{C=C}$ and $\nu_{C=N}$ were observed as strong bands at 1610 and 1495 cm^{-1} with shoulders appearing on the lower frequency band or with both of them. The presence of ether linkage resulted in the strong bands at 1251 and 1171 cm^{-1} due to $\nu_{O\text{-}Ar}$ and $\nu_{O\text{-}R}$.

^{1}H NMR of these compounds show the presence of central aromatic ring with two singlets observed at δ 2.51 for three protons of the methyl groups and at δ 5.2 for two protons situated on the carbon having ether linkage. All the other features in ^{1}H NMR spectra due to the presence of alkyl chains and two *para* substituted aromatic rings continued to appear as they were in uncoupled 2,5-disubstitued-1,3,4-oxadiazoles but with disappearance of hydroxyl proton signal.

Similarly, in ^{13}C-NMR spectra four additional carbon signals are observed due to central aromatic ring with methyl group carbons appearing at δ 16.1, methyleneoxy group carbons observed at δ 65.2 and quaternary aromatic carbons at δ 131.4 and 139.7. There is no significant change in the chemical shift values of the other carbon signals present in the podand groups from that observed for the uncoupled oxadiazoles.

All the newly synthesized C_3 symmetric tris-1,3,4-oxadiazoles were characterized with the help of high resolution mass spectrometer having Q-TOF mass analyzer by using ESI technique. The molecular ion peaks for these compounds were observed as $(M+Na)^+$ in all the cases.

As the tripodal compounds possess alkyl chains having different carbon chain lengths as end groups, they were expected to exhibit thermotropic liquid crystalline properties. Some of the randomly selected compounds were observed under polarizing microscope with heating stage attached to observe their thermotropic behavior. None of the compounds had characteristic liquid crystalline property for the pure tripodal compounds. It was observed that with a gradual increase in chain length, the melting points decrease in a stepwise manner from 210 for butyl chain compound to 165 °C for octadecyl chain possessing derivative (Figure 16). These compounds can further be studied for their lyotropic property and as a mixture with other liquid crystalline materials such as cholesteryl liquid crystals.

As the tripodal compounds contained oxadiazole heterocyclic nuclei in their structure, the tripodal compounds were subjected to screen for their preliminary antimicrobial activity against two representative bacteria *S. aureus* (gram-positive) and *E. coli* (gram-negative). The compounds with C-8, C-12 and C-18 showed moderate to good antibacterial activity against both the bacteria while the compound with C-16 chain length had moderate inhibitory activity against *S. aureus* but not against *E. coli.* The bacterial activity results have been summarized in Table 3.1.5.

Table 3.1.5 ***Yields, melting points and*** **MIC values** ***of tris-1,3,4-oxadiazoles***

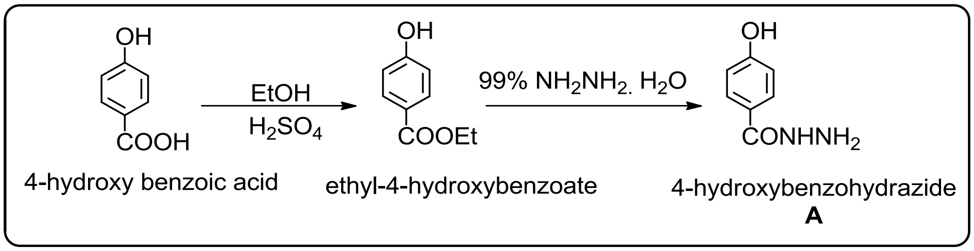
Sample ID	**A =** alkyl chain	Yield [%]	M.P. [°C]	**MIC μg/ml** *S. aureus*	*E. coli*
35a	$–(CH2)_3CH_3$	65	210	125	125
35b	$–(CH2)_5CH_3$	72	200	>125	>125
35c	$–(CH2)_6CH_3$	50	195	>125	>125
35d	$–(CH2)_7CH_3$	62	190	**62.5**	**62.5**
35e	$–(CH2)_9CH_3$	64	185	125	125
35f	$–(CH2)_{11}CH_3$	71	173	**31.25**	**31.25**
35g	$–(CH2)_{15}CH_3$	57	170	**62.5**	125
35h	$–(CH2)_{17}CH_3$	55	165	**31.25**	**31.25**

3.8 CONCLUSION

In this chapter C_3 symmetric compounds having 1,3,4-oxadiazole heterocycle as a part structure in the podand groups were prepared by two different synthesis strategies namely linear synthesis and convergent synthesis. The synthesis of tris-oxadiazoles in the linear approach involved the synthesis of different C_3 symmetric hydrazones from the tris-aldehydes and aromatic hydrazides. While the convergent synthesis involved the preparation of unsymmetrical diacylhydrazines as starting materials for the preparation of the corresponding 1,3,4-oxadiazoles. The formation of 1,3,4-oxadiazoles also differ in both the cases. One of them involved oxidative heterocyclization while the other involved dehydrative heterocyclization to form 1,3,4-oxadiazoles. The resulting final tripodal compounds had greater diversity when prepared through the linear approach compared to when prepared from convergent approach where the final compounds differ only in their chain length and the positions of the other linkages are fixed. The success in both the synthesis strategies has been achieved in the current piece of work. Compounds with long alkyl chain lengths were subjected to LC property study and preliminary antibacterial screening.

3.9 EXPERIMENTAL

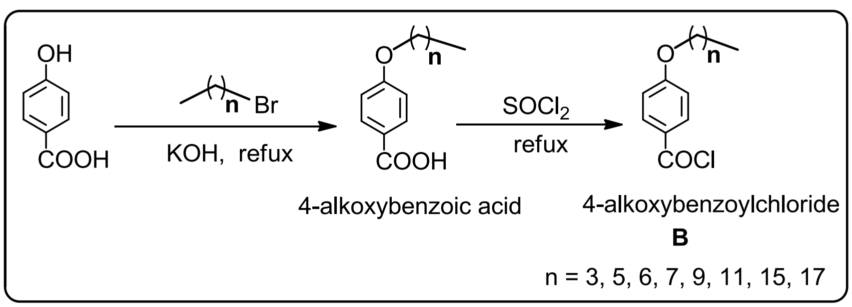
3.9.1 Ethyl–4–hydroxybenzoate and 4–hydroxybenzhydrazide (A)[53]



A mixture of 4–hydroxybenzoic acid (5.0 g, 36.2 mmol) and absolute ethanol (50 ml) and conc. H_2SO_4 (2-3 drops) was refluxed for 4 hours. The solvent was evaporated under reduced pressure to a small volume and poured in water followed by the addition of saturated $NaHCO_3$ solution. The crude product was filtered and crystallized from ethanol to yield ethyl-4-hydroxy benzoate. Yield: 4.99 g (83%); mp: 115 °C (*Lit*. 116–118 °C).[53]

Ethyl–4–hydroxybenzoate (4.5 g, 27 mmol) and hydrazine hydrate (99%) (10 ml) were mixed and refluxed for 4 hours. The reaction mixture was cooled and filtered. White crystalline solid was washed with cold water and recrystallized from ethanol giving the *p*-hydroxy benzhydrazide. Yield 4.3 g (93%); mp: 267 °C (*Lit*. 267 °C).[54]

3.9.2 4–Alkoxybenzoyl chloride (B)

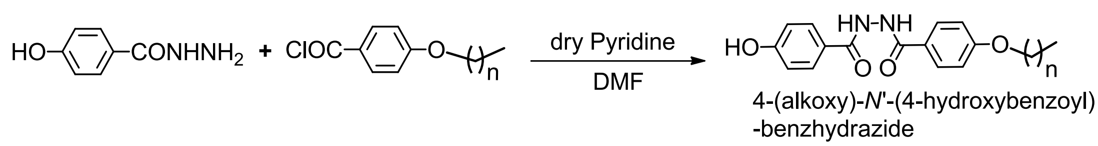


General procedure: 4-Hydroxybenzoicacid (1.0 g, 7.24 mmol) and an alkyl bromide (9.13 mmol) were dissolved in ethanol (30-40 ml) as solvent and KOH (16.0 mmol) was added. The resulting mixture was refluxed for 4 hours and then KOH (14.5 mmol) was added and was continued to reflux for 1 hour. Excess of solvent was evaporated under vacuum and crude product was washed with water and crystallized from EtOH.[55] All the

4-alkoxybenzoic acids were found to have melting points matching with that of the reported ones.[55b]

All the synthesized 4–alkoxybenzoic acids were reacted with an excess (10 times w/v) thionyl chloride ($SOCl_2$) in the presence of pyridine by refluxing for 2–3 hours after which excess of $SOCl_2$ was removed and the resulting 4–alkoxybenzoyl chloride derivatives were employed for the next reaction without further purification/analysis.

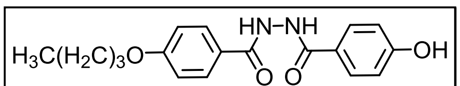
3.9.3 1–(4–Alkoxybenzoyl)–2–(4–hydroxybenzoyl)–hydrazines 32



32a-h

To a stirred solution of 4-hydroxybenzhydrazide **A** (0.5 g, 3.3 mmol) in DMF (50 ml) containing pyridine (5.0 ml), was added a solution of an acid chloride **B** (4.3 mmol, 1.3 equiv) in THF (10.0 ml) dropwise during 10 to 15 minutes of time. The resulting mixture was stirred at room temperature overnight (10-12 h). Solvents were removed under reduced pressure and ice-water was added to separate crude products which were filtered and crystallized from ethanol to get the desired diacylhydrazines **32**.

4-Butoxy-N′-(4-hydroxybenzoyl)benzhydrazide (32a)

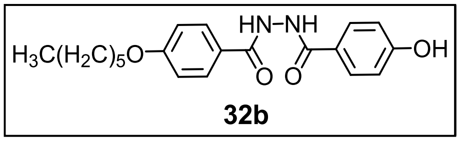


32a

32a was prepared from **4-butoxybenzoyl chloride** (0.9 g, 4.3 mmol) and 4-hydroxybenzhydrazide (0.5 g, 4.3 mmol) following the general procedure described as a white solid. Yield: 0.1 g, 80%; mp: 213 °C.

IR (KBr) : 3221, 2957, 2872, 1732, 1607, 1150, 1255, 1171 cm^{-1}; **^{1}H NMR (DMSO –*d*$_6$) :** δ (ppm) 0.93 (3H, t, $–CH_3$), 1.41-1.47 (2H, q), 1.71 (2H, t), 4.02-4.07 (2H, t), 6.83-6.85 (2H, d, J = 8.4 Hz), 7.02-7.04 (2H, d, J = 8.4 Hz), 7.80-7.82 (2H, d, J = 8.0 Hz), 7.89-7.91 (2H, d, J = 8.8 Hz), 10.09-10.24 (3H, –OH, –NH–NH–); **^{13}C NMR (DMSO–*d*$_6$) :** δ (ppm) 14.1 ($–CH_3$), 19.1 and 31.1 ($–CH_2$), 67.8 ($–OCH_2$), 114.5, 115.4, 123.7, 125.1, 129.8, 129.9, 161.0, 161.9, 165.8, 166.0; **TOF MS ES+ :** *m/z* calculated for $C_{18}H_{20}N_2O_4$: 328.1423, found: (*m/z*) 329.1646 ($(M+H)^+$, 50%), 351.1462 ($(M+Na)^+$, 100%), 177.1068 ($C_{11}H_{13}O_2$).

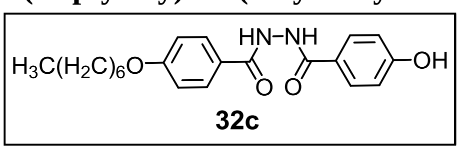
4-(Hexyloxy)-N′-(4-hydroxybenzoyl)benzhydrazide (32b)



32b was prepared from **4-hexyloxybenzoyl chloride** (1.0 g, 4.3 mmol) and *p*-hydroxybenzhydrazide (0.5 g, 4.3 mmol) following the general procedure described as a white solid. Yield: 1.0 g, 88%; mp: 205 °C.

IR (KBr) : 3209, 2920, 1658, 1609, 1570, 1498, 1255 cm^{-1}; ^{1}**H NMR (DMSO –*d*$_6$) :** δ (ppm) 0.89 (3H, t, $–CH_3$), 1.30-1.44 (6H, m), 1.69-1.76 (2H, m), 4.03 (2H, t), 6.83-6.85 (2H, d, *J* = 8.8 Hz), 7.01-7.04 (2H, d, *J* = 8.8 Hz), 7.78-7.80 (2H, d, *J* = 8.4 Hz), 7.87-7.89 (2H, d, *J* = 8.8 Hz), 10.17-10.24 (3H, –OH, –NH–NH–); ^{13}**C NMR (DMSO –*d*$_6$) :** δ (ppm) 14.3 ($–CH_3$), 22.5, 25.6, 28.9 and 31.4 ($–CH_2$), 68.1 ($–OCH_2$), 114.5, 115.4, 123.7, 125.1, 129.7, 129.9, 161.0, 161.8, 165.8, 166.0; **ESI (Mass):** *m/z* calculated for $C_{20}H_{24}N_2O_4$: 356.1736, found: (*m/z*) 355.89 M^+, 204.95 ($C_{13}H_{17}O_2$).

4-(Heptyloxy)-N′-(4-hydroxybenzoyl)benzhydrazide (32c)

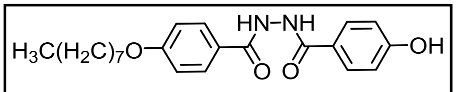


32c was prepared from **4-heptyloxybenzoyl chloride** (1.0 g, 4.0 mmol) and *p*-hydroxybenzhydrazide (0.47 g, 3.13 mmol) following the general procedure described as a white solid. Yield: 0.8 g, 69%; mp: 196 °C.

IR (KBr) : 3251, 2926, 2854, 1688, 1642, 1609, 1532, 1507, 1292, 1249 cm^{-1}; ^{1}**H NMR (DMSO –*d*$_6$) :** δ (ppm) 0.87 (3H, t, $–CH_3$), 1.28-1.41 (8H, m), 1.71-1.74 (2H, m), 4.03 (2H, t), 6.83-6.85 (2H, d, *J* = 8.8 Hz), 6.9-7.03 (2H, d, *J* = 8.4 Hz), 7.78-7.80 (2H, d, *J* = 8.4 Hz), 7.87-7.89 (2H, d, *J* = 8.4 Hz), 10.17-10.24 (2H, d, –HN–NH–); ^{13}**C NMR (DMSO–*d*$_6$) :** δ (ppm) 14.4 ($–CH_3$), 22.5, 25.8, 28.8, 29.0, and 31.6 ($–CH_2$), 68.1 ($–OCH_2$), 114.5, 115.4, 123.7, 125.1, 129.7, 129.9, 131.7, 161.0, 161.8, 165.8, 166.0;

TOF MS ES+ : *m/z* calculated for $C_{21}H_{26}N_2O_4$: 370.1893, found: (*m/z*) 371.2118 ($(M+H)^+$, 70%), 393.1931 ($(M+Na)^+$, 100%), 219.1537 ($C_{14}H_{19}O_2$).

4-(Octyloxy)-N′-(4-hydroxybenzoyl)benzhydrazide (32d)

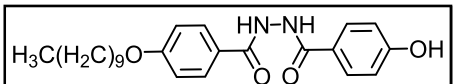


32d

32d was prepared from **4-octyloxybenzoyl chloride** (1.0 g, 3.64 mmol) and 4-hydroxybenzhydrazide (0.43 g, 2.8 mmol) following the general procedure described above as a solid. Yield: 0.763 g, 71%; mp: 184 °C

IR (KBr) : 3266, 2924, 2854, 1671, 1609, 1509, 1287, 1258 cm^{-1}; **^{1}H NMR (DMSO-*d$_6$*): δ** (ppm) 0.86 (3H, t, $–CH_3$), 1.27-1.42 (10H, m), 1.69-1.76 (2H, m), 4.04 (2H, t), 6.83-6.85 (2H, d, *J* = 8.4 Hz), 7.01-7.03 (2H, d, *J* = 8.4 Hz), 7.78-7.80 (2H, d, *J* = 8.4 Hz), 7.87-7.89 (2H, d, *J* = 8.4 Hz), 10.09-10.22 (3H, d, –HN–NH–, –OH); **^{13}C NMR (DMSO-*d$_6$*): δ** (ppm) 14.4 ($–CH_3$), 22.5, 25.9, 29.0, 29.1, 29.1, and 31.6 ($–CH_2$), 68.1 ($–OCH_2$), 114.5, 115.4, 123.7, 125.1, 129.7, 129.9, 161.0, 161.8, 165.8, 166.0; **TOF MS ES+ :** *m/z* calculated for $C_{22}H_{28}N_2O_4$: 384.2049, found: (*m/z*) 385.2279 ($(M+H)^+$, 100%), 407.2096 ($(M+Na^+)$, 50%), 233.1698 ($C_{15}H_{21}O_2$).

4-(Decyloxy)-N′-(4-hydroxybenzoyl)benzhydrazide (32e)

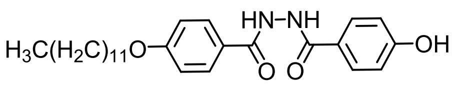


32e

32e was prepared from **4-decyloxybenzoyl chloride** (0.98 g, 3.3 mmol) and *p*-hydroxybenzhydrazide (0.39 g, 2.53 mmol) following the general procedure described as a white solid. Yield: 0.74 g, 71%; mp: 175 °C.

IR (KBr) : 3244, 2919, 2851, 1688, 1642, 1605, 1508, 1252, 1172 cm^{-1}; **^{1}H NMR (DMSO –*d$_6$*) :** δ (ppm) 0.85(3H, t, $–CH_3$), 1.25-1.40 (14H, m), 1.69-1.72 (2H, m), 4.02 (2H, t), 6.83-6.85 (2H, d, *J* = 8.8 Hz), 7.0-7.03 (2H, d, *J* = 8.8 Hz), 7.78-7.80 (2H, d, *J* = 8.4 Hz), 7.86-7.88 (2H, d, *J* = 8.8 Hz), 10.18-10.25 (3H, –NH–NH–, –OH); **^{13}C NMR (DMSO–*d$_6$*) :** δ (ppm) 14.4 ($–CH_3$), 22.5, 25.9, 29.0, 29.1, 29.2, 29.4, 29.4, and 31.7 ($–CH_2$), 68.1 ($–OCH_2$), 114.5, 115.4, 123.6, 125.0, 129.7, 129.9, 161.0, 161.8, 165.9, 166.1; **TOF MS ES+:** *m/z* calculated for $C_{24}H_{32}N_2O_4$: 412.2362, found: (*m/z*) 413.2609 ((M+H)$^+$, 100%), 435.2444 (M+Na)$^+$, 20%), 261.2007 ($C_{17}H_{25}O_2$).

4-(Dodecyloxy)-N′-(4-hydroxybenzoyl)benzhydrazide (32f)

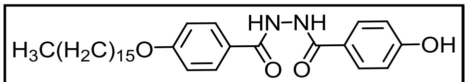


32f

32f was prepared from **4-dodecyloxybenzoyl chloride** (1.0 g, 3.2 mmol) and *p*-hydroxybenzhydrazide (0.37 g, 2.5 mmol) following the general procedure described as a white solid. Yield: 0.77 g, 71%; mp: 160 °C.

IR (KBr) : 3508, 3347, 2919, 2851, 1651, 1597, 1554, 1506, 1445, 1252 cm^{-1}; **^{1}H NMR (DMSO –*d*$_6$) :** δ (ppm) 0.85 (3H, t, –CH_3), 1.24-1.41 (17H, m), 1.70-1.74 (2H, m), 4.03 (2H, t), 6.83-6.85 (2H, d, *J* = 8.8 Hz), 7.01-7.03 (2H, d, *J* = 8.8 Hz), 7.78-7.80 (2H, d, *J* = 8.8 Hz), 7.87-7.89 (2H, d, *J* = 8.8 Hz), 10.13-10.25 (3H, –OH, –NH–NH–); **^{13}C NMR (DMSO –*d*$_6$) :** δ (ppm) 14.4 (–CH_3), 22.5, 25.9, 29.0, 29.1, 29.2, 29.4, 29.4, 29.5 and 31.7 (–CH_2), 68.1 (–OCH_2), 114.5, 115.4, 123.7, 125.1, 129.7, 129.9, 161.0, 161.8, 165.8, 166.0; **TOF MS ES+ :** *m/z* calculated for $C_{26}H_{36}N_2O_4$: 440.2675, found: (*m/z*) 441.2891 ((M+H)$^+$, 100%), 463.2737 ((M+Na)$^+$, 20%), 289.2331 ($C_{19}H_{29}O$).

4-(Hexadecyloxy)-N′-(4-hydroxybenzoyl)benzhydrazide (32g)



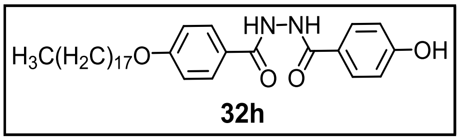
32g

32g was prepared from **4-hexadecyloxybenzoyl chloride** (1.26 g, 3.42 mmol) and *p*-hydroxybenzhydrazide (0.4 g, 2.63 mmol) following the general procedure described as a solid. Yield: 1.30 g, 80%; mp: 153 °C.

IR (KBr) : 3245, 2918, 2849, 1687, 1643, 1610, 1507, 1462, 1295, 1249, 1177 cm^{-1}; **^{1}H NMR (DMSO –*d*$_6$) :** δ (ppm) 0.84(3H, t, –CH_3), 1.23-1.40 (27H, m), 1.68-1.73 (2H, m), 4.02 (2H, t), 6.83-6.85 (2H, d, *J* = 8.8 Hz), 7.00-7.02 (2H, d, *J* = 8.8 Hz), 7.78-7.80 (2H, d, *J* = 8.8 Hz), 7.86-7.88 (2H, d, *J* = 8.8 Hz), 10.12-10.22 (3H, –OH, –NH–NH–); **^{13}C NMR (DMSO –*d*$_6$) :** δ (ppm) 14.3 (–CH_3), 22.5, 25.9, 29.1, 29.2, 29.4 and 31.7 (–CH_2), 68.1 (–OCH_2), 114.5, 115.4, 123.7, 125.0, 129.7, 129.9, 161.0, 161.8, 165.9, 166.1; **TOF**

MS ES+ : *m/z* calculated for $C_{30}H_{44}N_2O_4$: 496.3301, found: (*m/z*) 497.3530 ($(M+H)^+$, 100%), 519.3367 ($(M+Na)^+$, 80%).

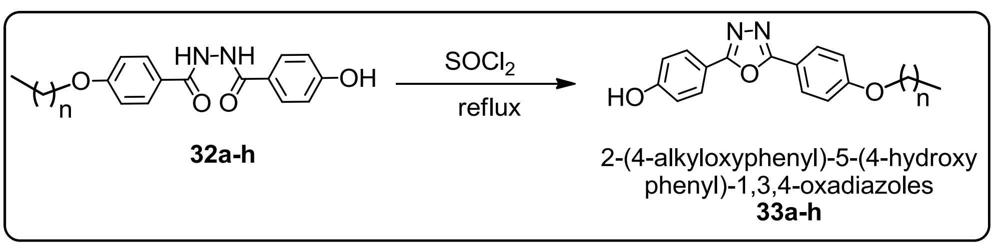
4-(Octadecyloxy)-N′-(4-hydroxybenzoyl)benzhydrazide (32h)



32h was prepared from **4-octadecyloxybenzoyl chloride** (1.22 g, 3.1 mmol) and *p*-hydroxybenzhydrazide (0.36 g, 2.4 mmol) following the general procedure described as a white solid. Yield: 0.95 g, 76%; mp: 141 °C.

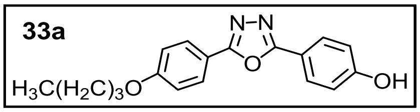
IR (KBr) : 3245, 2918, 2849, 1688, 1642, 1507, 1249, 1177 cm^{-1}; **^{1}H NMR (DMSO–*d*$_6$) :** δ (ppm) 0.84 (3H, t, $–CH_3$), 1.23-1.40 (30H, m), 1.70-1.73 (2H, m), 4.02(2H, t), 6.82-6.85 (2H, d, J = 8.4 Hz), 7.00-7.02 (2H, d, J = 8.8 Hz), 7.77-7.80 (2H, d, J = 8.4 Hz), 7.86-7.88 (2H, d, J = 8.4 Hz), 10.13-10.24 (3H, t, –OH, –NH–NH–); **^{13}C NMR (DMSO–*d*$_6$) :** δ (ppm) 14.4 ($–CH_3$), 22.5, 25.9, 29.0, 29.1, 29.2, 29.4 and 31.7 ($–CH_2$), 68.1 ($–OCH_2$), 114.5, 115.4, 123.7, 125.1, 129.7, 129.9, 161.0, 161.8, 165.8, 166.0; **TOF MS ES+ :** *m/z* calculated for $C_{32}H_{48}N_2O_4$: 524.3614, found: (*m/z*) 525.3840 ($(M+H)^+$, 100%), 547.3640 ($(M+Na)^+$, 50%).

3.9.4 2-(4-Alkyloxyphenyl)-5-(4-hydroxyphenyl)-1,3,4–oxadiazoles derivatives 33



1–(4–Alkoxybenzoyl)–2–(4–hydroxybenzoyl)–hydrazine **32** were mixed with thionyl chloride $SOCl_2$ (10 times w/v) and pyridine (0.5 ml), the resulting mixture was refluxed for 8-10 h (overnight) when the reaction was completed (TLC), excess of $SOCl_2$ was removed under reduced pressure and ice water was added to get the crude products which were filtered, dried and subjected to column chromatography (EtOAc : petroleum ether; 2 : 8 → 3 : 7) giving the corresponding 1,3,4-oxadiazoles **33** as white products.

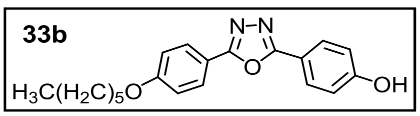
4-(5-(4-Butoxyphenyl)-1,3,4-oxadiazol-2-yl)phenol (33a)



33a was prepared from diacylhydrazide **32a** (0.7 g, 2.13 mmol) following the general procedure described above as a white solid. Yield: 0.44 g, 67%; mp: 203 °C.

IR (KBr) : 3122, 2955, 1610, 1495, 1257, 1174 cm^{-1}; **^{1}H NMR (DMSO –d_6) :** δ (ppm) 0.93 (3H, t, $–CH_3$), 1.47-1.55 (2H, m), 1.79-1.85 (2H, m), 4.04 (2H, t), 6.94-6.93 (4H, d, *J* = 9.2 Hz), 7.03-7.04 (1H, d), 8.05-8.07 (2H, dd, *J* = 8.2 Hz); **^{13}C NMR (DMSO –d_6) :** δ (ppm)14.1 ($–CH_3$), 19.1 and 31.0 ($–CH_2$), 68.0 ($–OCH_2$), 114.7, 115.6, 116.1, 116.6, 128.7, 128.9, 161.1, 161.8, 163.6, 164.1; **TOF MS ES+ (Mass):** *m/z* calculated for $C_{18}H_{18}N_2O_3$: 310.1317, found: (*m/z*) 311.1190 $(M+H)^+$, 333.1006 $(M+Na)^+$.

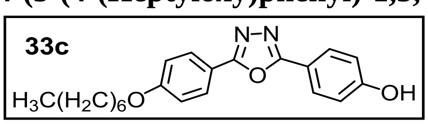
4-(5-(4-(Hexyloxy)phenyl)-1,3,4-oxadiazol-2-yl)phenol (33b)



33b was prepared from diacylhydrazide **32b** (0.7 g, 1.96 mmol) following the general procedure described as a solid. Yield: 0.45 g, 64%; mp: 197 °C.

IR (KBr) : 3112, 2956, 2918, 2849, 1611, 1501, 1263, 1173 cm^{-1}; **^{1}H NMR (DMSO–d_6) :** δ (ppm) 0.88 (3H, t, $–CH_3$), 1.29-1.44 (6H, m), 1.70-1.77 (2H, m), 4.05 (2H, t), 6.95-6.97 (6H, d, *J* = 8.8 Hz), 7.12-7.14 (6H, d, *J* = 8.4 Hz), 7.93-7.95 (6H, d, *J* = 8.8 Hz), 7.99-8.02 (6H, d, *J* = 9.2 Hz), 10.33 (3H, s, –OH); **^{13}C NMR (DMSO–d_6) :** δ (ppm) 14.3 ($–CH_3$), 22.5, 25.5, 28.9 and 31.4 ($–CH_2$), 68.3 ($–OCH_2$), 114.7, 115.7, 116.1, 116.6, 128.7, 128.9, 161.1, 161.8, 163.7, 164.1; **TOF MS ES+ (Mass):** *m/z* calculated for $C_{20}H_{22}N_2O_3$: 338.1630, found: (*m/z*) 339.1483 $(M+H)^+$, 361.1288 $(M+Na)^+$.

4-(5-(4-(Heptyloxy)phenyl)-1,3,4-oxadiazol-2-yl)phenol (33c)

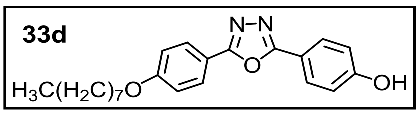


33c was prepared from diacylhydrazide **32c** (1.0 g, 2.7 mmol) following the general procedure described as a white solid. Yield: 0.7 g, 74%; mp: 189 °C.

IR (KBr) : 3112, 2952, 2848, 2952, 2924, 1611, 1495, 1389, 1261, 1171 cm^{-1}; **^{1}H NMR (DMSO –d_6) :** δ (ppm) 0.86 (3H, t, $–CH_3$), 1.27-1.41 (8H, m), 1.71-1.74 (2H, m), 4.04

(2H, t), 6.95-6.98 (2H, d, *J* = 8.8 Hz), 7.11-7.13 (2H, d, *J* = 8.8 Hz), 7.92-7.94 (2H, d, *J* = 8.8 Hz), 7.99-8.01 (2H, d, *J* = 8.8 Hz), 10.29 (1H, –OH); **^{13}C NMR (DMSO –*d*$_6$) :** δ (ppm) 14.3 (–CH_3), 22.5, 25.8, 28.8, 29.0 and 31.6 (–CH_2), 68.1 (–OCH_2), 114.7, 115.6, 116.1, 116.6, 128.7, 128.9, 161.1, 161.8, 163.7, 164.1; **TOF MS ES+ (Mass):** *m/z* calculated for $C_{21}H_{24}N_2O_3$: 352.1787, found: (*m/z*) 353.1623 $(M+H)^+$, 375.1452 $(M+Na)^+$.

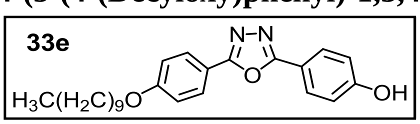
4-(5-(4-(Octyloxy)phenyl)-1,3,4-oxadiazol-2-yl)phenol (33d)



33d was prepared from diacylhydrazide **32d** (0.56 g, 1.45 mmol) following the general procedure described as a white solid. Yield: 0.32 g, 60%; mp: 166 °C.

IR (KBr) : 3118, 2924, 2852, 1611, 1494, 1387, 1261, 1171 cm^{-1}; **^{1}H NMR (DMS –*d*$_6$) :** δ (ppm) 0.85 (3H, t, –CH_3), 1.26-1.43 (20H, m), 1.71-1.75 (2H, m), 4.05(2H, t), 6.95-6.97 (2H, d, *J* = 7.8 Hz), 7.12-7.14 (2H, d, *J* = 9.2 Hz), 7.92-7.94 (2H, d, *J* = 8.8 Hz), 7.99-8.01 (2H, d, *J* = 8.8 Hz), 10.29 (1H, –OH); **^{13}C NMR (DMSO–*d*$_6$) :** δ (ppm) 14.4 (–CH_3), 22.5, 25.9, 29.0, 29.1, 29.1 and 31.6 (–OCH_2), 68.3 (–OCH_2), 114.7, 115.7, 116.1, 116.6, 128.7, 128.9, 161.1, 161.8, 163.7, 164.1; **TOF MS ES+ (Mass):** *m/z* calculated for $C_{22}H_{26}N_2O_3$: 366.1943, found: (*m/z*) 367.1776 $(M+H)^+$, 389.1579 $(M+Na)^+$.

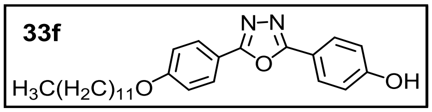
4-(5-(4-(Decyloxy)phenyl)-1,3,4-oxadiazol-2-yl)phenol (33e)



33e was prepared from diacylhydrazide **32e** (0.6g, 1.45 mmol) following the general procedure described above as solid. Yield: 0.4 g, 70%; mp: 160 °C.

IR (KBr) : 3114, 2923, 2850, 1610, 1495, 1387, 1259, 1172 cm^{-1}; **^{1}H NMR (DMSO–*d*$_6$) :** δ (ppm) 0.84 (3H, t, –CH_3), 1.24-1.42 (16H, m), 1.70-1.74 (2H, m), 4.04 (2H, t), 6.95-6.97 (2H, d, *J* = 8.8 Hz), 7.11-7.13 (2H, d, *J* = 9.2 Hz), 7.92-7.94 (2H, d, *J* = 8.2 Hz), 7.99-8.01 (2H, d, *J* = 8.8 Hz), 10.29 (1H, –OH); **^{13}C NMR (DMSO-*d*$_6$) :** δ (ppm) 14.3 (–CH_3), 22.5, 25.8, 28.9, 29.1, 29.2, 29.4, 29.4, 31.7 (–OCH_2), 68.3 (–OCH_2), 114.7, 115.6, 116.1, 116.6, 128.7, 128.9, 161.1, 161.8, 163.7, 164.1; **TOF MS ES+ (Mass):** *m/z* calculated for $C_{24}H_{30}N_2O_3$: 394.2256, found: (*m/z*) 395.2083 $(M+H)^+$, 417.1931 $(M+Na)^+$.

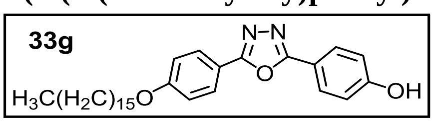
4-(5-(4-(Dodecyloxy)phenyl)-1,3,4-oxadiazol-2-yl)phenol (33f)



33f was prepared from diacylhydrazide **32f** (0.88 g, 2.0 mmol) following the general procedure described above as solid. Yield: 0.45 g, 58%; mp: 135 °C

IR (KBr) : 1613, 1503, 1316, 1217, 1172 cm^{-1}; **^{1}H NMR (DMSO-*d*$_6$) :** δ (ppm) 0.84 (3H, t, $-CH_3$), 1.23-1.43 (20H, m), 1.71-1.75 (2H, m), 4.05 (2H, t), 6.95-6.97 (2H, d, *J* = 8.8 Hz), 7.12-7.14 (2H, d, *J* = 9.2 Hz), 7.92-7.94 (2H, d, *J* = 8.2 Hz), 7.99-8.01 (2H, d, *J* = 8.8 Hz), 10.29 (1H, –OH); **^{13}C NMR (DMSO-*d*$_6$) :** δ (ppm) 14.4 ($-CH_3$), 22.5, 25.8, 28.9, 29.1, 29.4, 29.4, 29.4, 31.7 ($-OCH_2$), 68.3 ($-OCH_2$), 114.7, 115.7, 116.1, 116.6, 128.7, 128.9, 161.1, 161.8, 163.7, 164.1; **TOF MS ES+ (Mass):** *m/z* calculated for $C_{26}H_{34}N_2O_3$: 422.2569, found: (*m/z*) 423.2376 $(M+H)^+$, 445.2183 $(M+Na)^+$.

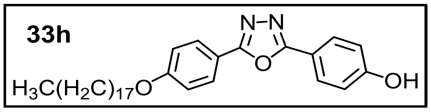
4-(5-(4-(Hexadecyloxy)phenyl)-1,3,4-oxadiazol-2-yl)phenol (33g)



33g was prepared from diacylhydrazide **32g** (1.0 g, 2.0 mmol) following the general procedure described as a white solid. Yield: 0.5 g, 52%; mp: 128 °C.

IR (KBr) : 2922, 1609, 1498, 1447, 1299, 1255, 1171 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 0.91 (3H, t, $-CH_3$), 1.22-1.50 (26H, m), 1.79-1.86 (2H, m), 4.04(2H, t), 7.01-7.03 (2H, dd, *J* = 7.2 Hz), 7.08-7.10 (2H, dd, *J* = 7.7 Hz), 8.01-8.06 (4H, q); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 18.9 ($-CH_3$), 27.3, 30.6, 33.7, 33.9, 33.9, 34.2, 34.2, 34.3, 36.5, 44.2, 44.4, 44.6, 44.8, 45.0, 45.2 and 45.4 ($-OCH_2$), 72.9 ($-OCH_2$), 119.6, 119.7, 120.9, 133.1, 133.2, 165.6, 166.5, 168.5, 169.0; **TOF MS ES (Mass):** *m/z* calculated for $C_{30}H_{42}N_2O_3$: 478.3195, found: (*m/z*) 477.2639 ($(M-H)^+$, 40%).

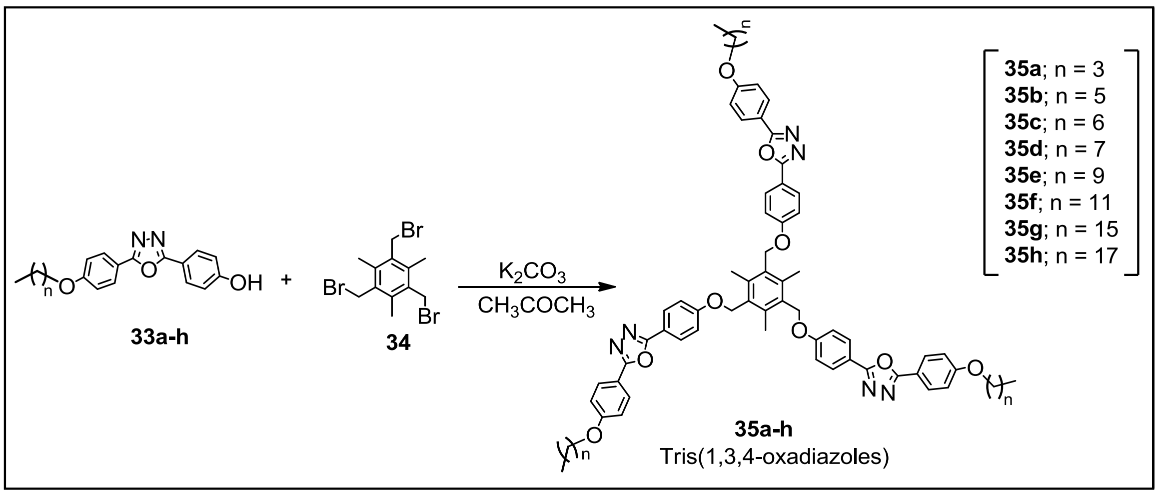
4-(5-(4-(Octadecyloxy)phenyl)-1,3,4-oxadiazol-2-yl)phenol (33h)



33h was prepared from diacylhydrazide **32h** (1.0 g, 1.9 mmol) following the general procedure described as a white solid. Yield: 0.6 g, 62%; mp: 126 °C.

IR (KBr) : 2916, 2849, 1613, 1497, 1257, 1169 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 0.89 (3H, t, –CH_3), 1.22-1.49 (27H, m), 1.81-1.85 (2H, m), 4.05 (2H, t), 7.02-7.05 (4H, m), 8.02-8.07 (4H, m); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 18.8 (–CH_3), 27.3, 30.6, 33.7, 33.9, 34.1, 34.2 and 36.5 (–CH_2), 72.9 (–OCH_2), 119.7, 120.9, 133.1, 133.2, 165.5, 166.9, 168.5, 169.0; **ESI (Mass):** *m/z* calculated for $C_{32}H_{46}N_2O_3$: 506.3508, found: (*m/z*) 507.3747 ($(M+H)^+$, 100%).

3.9.5 *C*$_3$ Symmetric tris-1,3,4-oxadiazoles 35



A solution of 1,3,5–tris(bromomethyl)–2,4,6–trimethylbenzene **34** (0.5 g, 0.25 mmol) in acetone (10.0 ml) was added dropwise to a stirred mixture of 1,3,4–oxadiazole **33** (0.25 mmol, 3.0 equiv) and K_2CO_3 (1.5 mmol, 6.0 equiv) in acetone (70 ml) placed in a 2 necked R.B. flask (250 ml) and the resulting mixture was stirred at room temperature for 2-3 h time until completion of the reaction (TLC). Solvent was evaporated under reduced pressure and water was added to get crude solid products which was purified by column chromatography (EtOAc : petroleum ether; 2 : 3 → 7 : 3) to get the corresponding tripodal compound as a white solid. The compounds with C16 and C18 chain lengths were eluted with 1% methanol in MDC.

1,3,5–Tris[4–{5–(4–butoxyphenyl)–1,3,4–oxadiazol–2–yl}–phenyloxymethyl]–2,4,6–trimethylbenzene (35a)

35a was prepared from **33a** (0.23 g, 0.75 mmol), **34** (0.1 g, 0.25 mmol) and K_2CO_3 (0.2 g, 1.5 mmol) following the general procedure described above as a white solid. Yield: 0.18 g, 65%; mp: 210 °C.

IR (KBr) : 2975, 2871, 1709, 1610, 1494, 1251, 1171 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 1.01 (9H, t, –CH_3), 1.51-1.56 (6H, m), 1.79-1.86 (6H, m), 2.51 (9H, s, Ar–CH_3), 4.05 (6H, t, –OCH_2–), 5.23 (6H, s, $ArOCH_2$), 7.02-7.05 (6H, d, J = 8.8 Hz), 7.17-7.19 (6H, d, 8.8 Hz), 8.06-8.08 (6H, d, J = 9.2 Hz), 8.12-8.14 (6H, d, J = 9.2 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 13.8 and 16.0 (–CH_3), 19.2, 31.1 and 67.9 (–OCH_2), 65.1 (Ar-OCH_2), 114.9, 115.1, 116.2, 117.0, 128.6, 128.7, 131.4, 139.7, 161.6, 161.8, 163.9, 164.2; **HRMS (TOF MS ES+):** *m/z* calculated for $C_{66}H_{66}N_6O_9$: 1086.4891, found: (*m/z*) 1109.4761 $(M+Na)^+$.

1,3,5–Tris[4–{5–(4–hexyloxyphenyl)–1,3,4–oxadiazol–2–yl}–phenyloxymethyl]-2,4,6-trimethylbenzene (35b)

35b (0.213 g, 72%) was prepared from **33b** (0.25 g, 0.75 mmol), **34** (0.1 g, 0.25 mmol) and K_2CO_3 (0.2 g, 1.5 mmol) following the general procedure described as a white solid. mp: 200 °C.

IR (KBr) : 2931, 2860, 1611, 1494, 1251, 1172 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 0.95 (9H, t, –CH_3), 1.35-1.39 (12H, m), 1.48-1.52 (6H, m), 1.80-1.87 (6H, m), 2.51 (9H, s, –CH_3), 4.06 (6H, t), 5.24 (6H, s, $ArOCH_2$), 7.03-7.05 (6H, d, J = 9.2 Hz), 7.17-7.19 (6H, d, 8.8 Hz), 8.07-8.09 (6H, d, J = 8.4 Hz), 8.12-8.15 (6H, d, J = 8.8 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 14.0 and 16.0 (–CH_3), 22.6, 25.6, 29.1, 31.5, 32.3 and 68.2 (–OCH_2), 65.1 ($ArOCH_2$), 114.9, 115.0, 116.2, 117.0, 128.6, 131.4, 132.0, 139.7, 161.6, 161.8, 163.9, 164.2; **HRMS (TOF MS ES+):** *m/z* calculated for $C_{72}H_{78}N_6O_9$: 1170.5830, found: (*m/z*) 1193.5723 $(M+Na)^+$.

1,3,5–Tris[4–{5–(4–heptyloxyphenyl)–1,3,4-oxadiazol–2–yl}-phenyloxymethyl]-2,4,6-trimethylbenzene (35c)

35c was prepared from **33c** (0.26 g, 0.75 mmol), **34** (0.1 g, 0.25 mmol) and K_2CO_3 (0.2 g, 1.5 mmol) following the general procedure described as a white solid. Yield: 0.15 g, 50%; mp: 195 °C.

IR (KBr) : 2926, 2855, 1610, 1495, 1303, 1250, 1171 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 1.33 (9H, t, –CH_3), 1.33-1.51 (24H, m), 1.80-1.87 (6H, m), 2.51 (9H, s, –CH_3), 4.05 (6H, t), 5.23 (6H, s, Ar-OCH_2–), 7.02-7.04 (6H, d, J = 8.4 Hz), 7.16-7.19 (6H, d, 8.8 Hz), 8.06-8.08 (6H, d, J = 8.8 Hz), 8.11-8.13 (6H, d, J = 8.8 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 14.1 and 16.0 (–CH_3), 22.6, 25.9, 29.0, 31.7, 68.2 (–OCH_2), 65.1 (Ar-OCH_2), 114.9, 115.0, 116.2, 117.0, 128.5, 128.6, 131.4, 139.7, 161.6, 161.8, 163.9, 164.2; **HRMS (TOF MS ES+):** *m/z* calculated for $C_{75}H_{84}N_6O_9$: 1212.6300, found: (*m/z*) 1235.6156 $(M+Na)^+$.

1,3,5–Tris[4–{5–(4–octyloxyphenyl)–1,3,4–oxadiazol–2–yl}–phenyloxymethyl]-2,4,6-trimethylbenzene (35d)

35d was prepared from **33d** (0.275 g, 0.75 mmol), **34** (0.1 g, 0.25 mmol) and K_2CO_3 (0.2 g, 1.5 mmol) following the general procedure described as a white solid. Yield: 0.16 g, 62%; mp: 190 °C.

IR (KBr) : 2924, 2853, 1611, 1494, 1250, 1171 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 1.31 (9H, t, –CH_3), 1.31-1.53 (30H, m), 1.80-1.87 (6H, m), 2.51 (9H, s, –CH_3), 4.05 (6H, t), 5.24 (6H, s, ArOCH_2), 7.02-7.05 (6H, d, J = 8.8 Hz), 7.17-7.19 (6H, d, 8.8 Hz), 8.07-8.09 (6H, d, J = 8.8 Hz), 8.12-8.14 (6H, d, J = 8.8 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 14.1 and 16.1 (–CH_3), 22.6, 26.0, 29.1, 29.2, 29.3, 31.8 and 68.2 (–OCH_2), 65.4 (ArOCH_2), 114.9, 115.1, 128.6, 128.7, 131.4, 139.8, 161.8, 163.9; **HRMS (TOF MS ES+):** *m/z* calculated for $C_{78}H_{90}N_6O_9$: 1254.6769, found: (*m/z*) 1277.6640 $(M+Na)^+$.

1,3,5–Tris[4–{5–(4–decyloxyphenyl)–1,3,4–oxadiazol–2–yl}–phenyloxymethyl]-2,4,6-trimethylbenzene (35e)

35e was prepared from **33e** (0.29 g, 0.75 mmol), **34** (0.1 g, 0.25 mmol) and K_2CO_3 (0.2 g, 1.5 mmol) following the general procedure described as a white solid. Yield: 0.21 g, 64%; mp: 185 °C.

IR (KBr) : 2922, 2852, 1611, 1494, 1251, 1171 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 1.29 (9H, t, $–CH_3$), 1.29-1.66 (42H, m), 1.80-1.87 (6H, m), 2.51 (9H, s, $–CH_3$), 4.05 (6H, t), 5.23 (6H, s, $ArOCH_2$), 7.02-7.03 (6H, dd, J_{ortho} = 7.0 Hz), 7.17-7.19 (6H, d, 8.8 Hz), 8.06-8.08 (6H, dd, J_{ortho} = 8.0 Hz), 8.12-8.14 (6H, d, J = 8.4 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 14.1 and 16.0 ($–CH_3$), 22.7, 26.0, 29.1, 29.3, 29.3, 31.9 and 68.2 ($–OCH_2$), 65.1 ($ArOCH_2$), 114.9, 115.0, 116.2, 117.0, 128.5, 128.6, 131.4, 139.7, 161.6, 161.8, 163.9, 164.2; **HRMS (TOF MS ES+):** *m/z* calculated for $C_{84}H_{102}N_6O_9$: 1338.7708, found: (*m/z*) 1361.7602 $(M+Na)^+$.

1,3,5–Tris[4-{5-(4–dodecyloxyphenyl)-1,3,4-oxadiazol-2-yl}-phenyloxymethyl]-2,4,6-trimethylbenzene (35f)

35f was prepared from **33f** (0.32 g, 0.75 mmol), **34** (0.1 g, 0.25 mmol) and K_2CO_3 (0.2 g, 1.5 mmol) following the general procedure described as a white solid. Yield: 0.25 g, 71%; mp: 173 °C.

IR (KBr) : 2920, 2851, 1611, 1494, 1251, 1170 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 0.91 (9H, t, $–CH_3$), 1.28-1.50 (54H, m), 1.80-1.87 (6H, m), 2.51 (9H, s, $–CH_3$), 4.05(6H, t), 5.23 (6H, s, $ArOCH_2$), 7.02-7.03 (6H, d, J = 8.8 Hz), 7.16-7.19 (6H, d, 8.4 Hz), 8.06-8.08 (6H, d, J = 8.8 Hz), 8.11-8.13 (6H, d, J = 8.8 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 14.1 and 16.0 ($–CH_3$), 22.7, 26.0, 29.1, 29.3, 29.5, 29.6, 29.6, 31.9 and 68.2 ($–OCH_2$), 65.1 (Ar-OCH_2), 114.9, 115.0, 116.2, 117.0, 128.5, 128.6, 131.4, 139.7, 161.6, 161.8, 163.9, 164.2; **HRMS (TOF MS ES+):** *m/z* calculated for $C_{90}H_{114}N_6O_9$: 1422.8647, found: (*m/z*) 1445.88518 $(M+Na)^+$.

1,3,5–Tris[4–{5–(4–hexadecyloxyphenyl)–1,3,4–oxadiazol–2–yl}–phenyloxymethyl]–2,4,6–trimethylbenzene (35g)

35g was prepared from **33g** (0.36 g, 0.75 mmol), **2** (0.1 g, 0.25 mmol) and K_2CO_3 (0.2 g, 1.5 mmol) following the general procedure described as a white solid. Yield: 0.23 g, 57%; mp: 170 °C.

IR (KBr) : 2917, 2850, 1612, 1493, 1252, 1170 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 0.89 (9H, t, $–CH_3$), 1.28-1.51 (78H, m), 1.82-1.85 (6H, m), 2.52 (9H, s, $–CH_3$), 4.05(6H, t), 5.24 (6H, s, Ar-OCH_2), 7.02-7.04 (6H, dd, J_{ortho} = 7.0 Hz), 7.16-7.19 (6H, d, 9.2 Hz), 8.05-8.08 (6H, dd, J_{ortho} = 7.2 Hz), 8.11-8.13 (6H, d, J = 8.8 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 14.1 and 16.0 (–CH_3), 22.7, 26.0, 29.1, 29.3, 29.5, 29.6, 29.6, 29.7, 31.9 and 68.2 (–OCH_2), 65.1 (Ar-OCH_2) 114.9, 115.0, 116.2, 117.0, 128.5, 128.6, 131.4, 139.7, 161.6, 161.8, 163.9, 164.2; **Mass (TOF MS ES+):** *m/z* calculated for $C_{102}H_{138}N_6O_9$: 1591.0525, found: (*m/z*) 701.5052 as base peak.

1,3,5–Tris[4–{5–(4–octadecyloxyphenyl)–1,3,4–oxadiazol–2–yl}–phenyloxymethyl]–2,4,6–trimethylbenzene (35h)

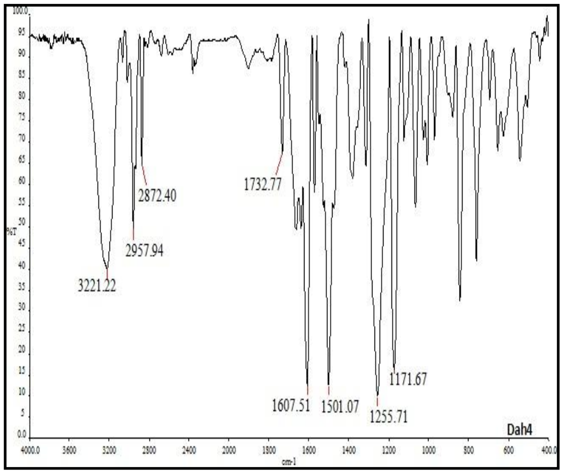
35h was prepared from **33h** (0.38 g, 0.75 mmol), **34** (0.1 g, 0.25 mmol) and K_2CO_3 (0.2 g, 1.5 mmol) following the general procedure described as a white solid. Yield: 0.20 g, 55%; mp: 165 °C.

IR (KBr) : 2917, 2849, 1611, 1494, 1251, 1171 cm^{-1}; **^{1}H NMR (CDCl$_3$) :** δ (ppm) 0.89 (9H, t, –CH_3), 1.27-1.49 (90H, m), 1.82-1.85 (6H, m), 2.52 (9H, s, –CH_3), 4.05 (6H, t), 5.24 (6H, s, Ar-OCH_2–), 7.02-7.04 (6H, dd, J_{ortho} = 6.8 Hz), 7.17-7.19 (6H, d, 9.2 Hz), 8.06-8.08 (6H, dd, J_{ortho} = 6.8 Hz), 8.11-8.14 (6H, d, J = 9.2 Hz); **^{13}C NMR (CDCl$_3$) :** δ (ppm) 14.1 (–CH_3), 16.0 (Ar–CH_3), 22.6, 29.1, 29.3, 29.5, 29.5, 29.6, 29.6, 31.9, and 68.3 (–OCH_2), 65.2 (Ar-OCH_2), 115.0, 115.1, 116.1, 116.9, 128.6, 128.7, 131.4, 139.6, 161.6, 161.9, 163.9, 164.2; **Mass (TOF MS ES+):** *m/z* calculated for $C_{108}H_{150}N_6O_9$: 1675.1464, found: (*m/z*) 701.5052 as base peak.

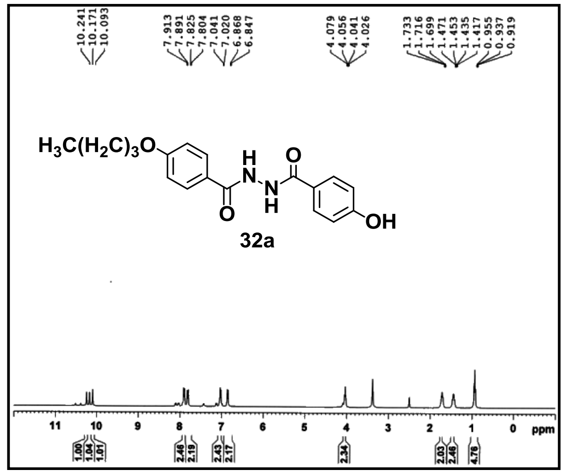
4.0 SPECTRAL DATA

4.0.1 Diacyhydrazines

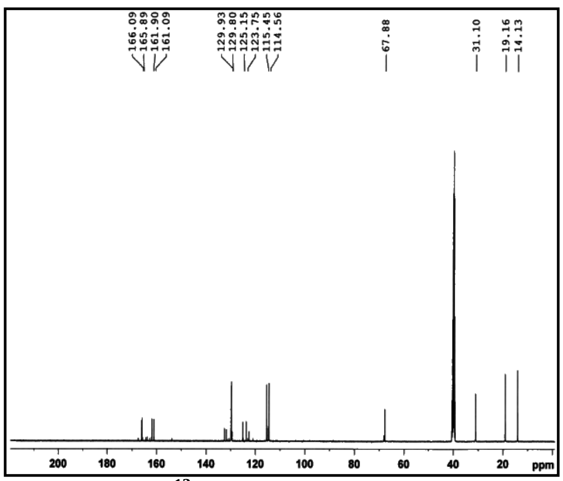
Compound 32a



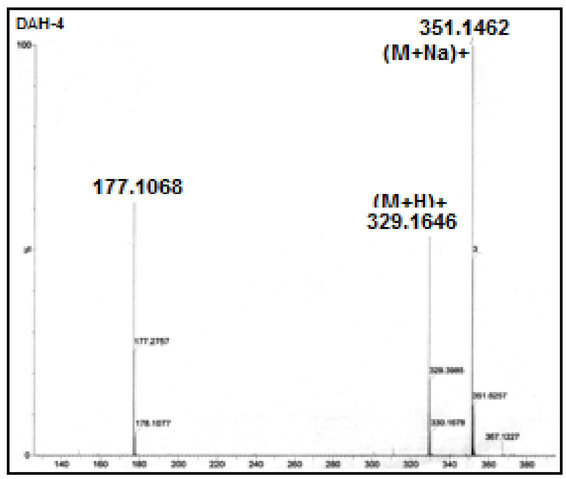
Spectrum 122. IR of 32a



Spectrum 123. ^{1}H NMR of 32a

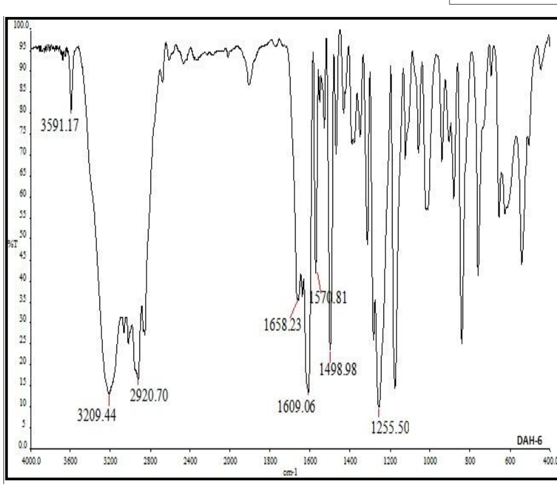


Spectrum 124. ^{13}C NMR of 32a

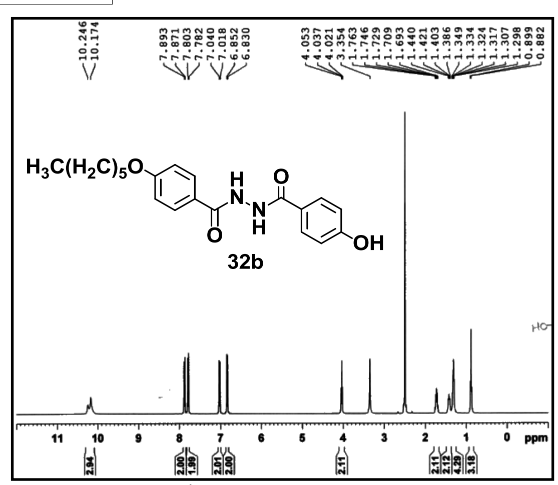


Spectrum 125. Mass of 32a

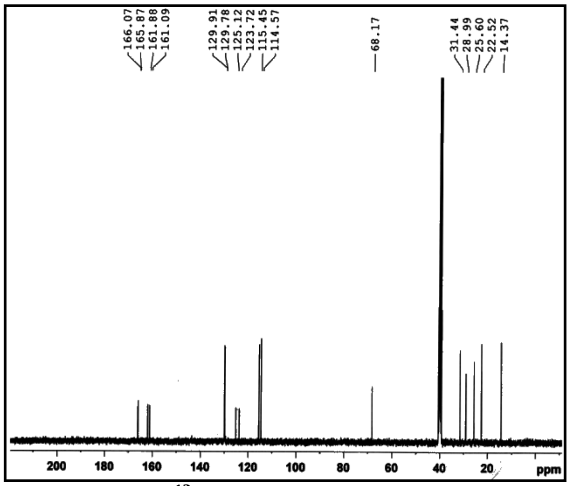
Compound 32b



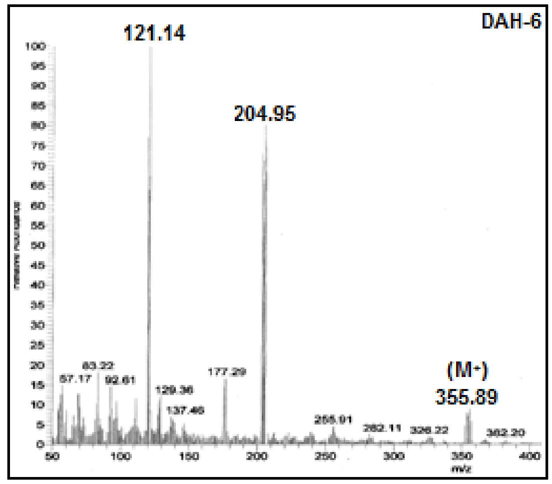
Spectrum 126. IR of 32b



Spectrum 127. ^{1}H NMR of 32b

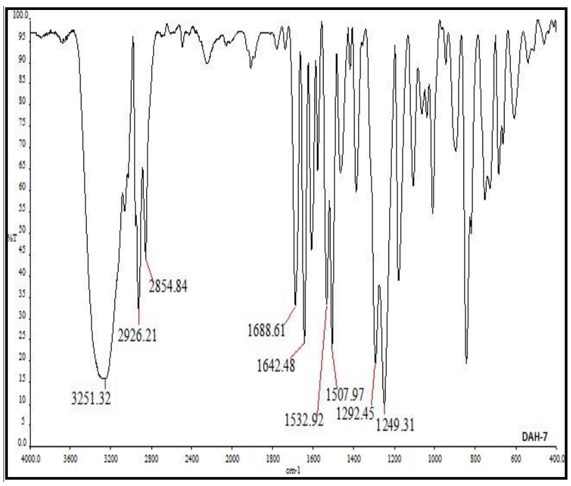


Spectrum 128. ^{13}C NMR of 32b

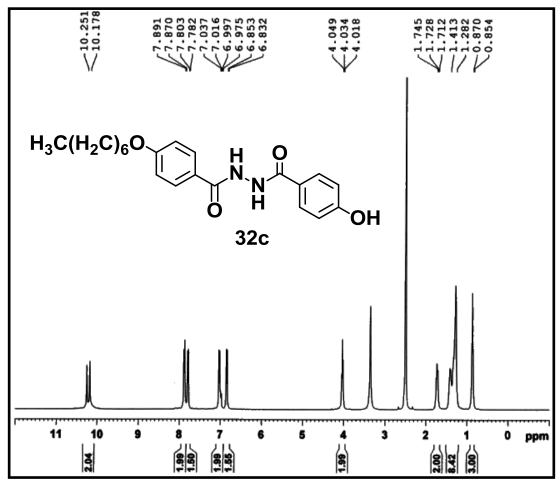


Spectrum 129. Mass of 32b

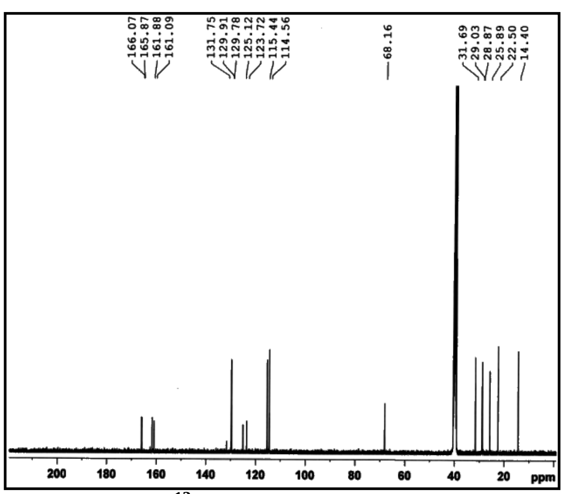
Compound 32c



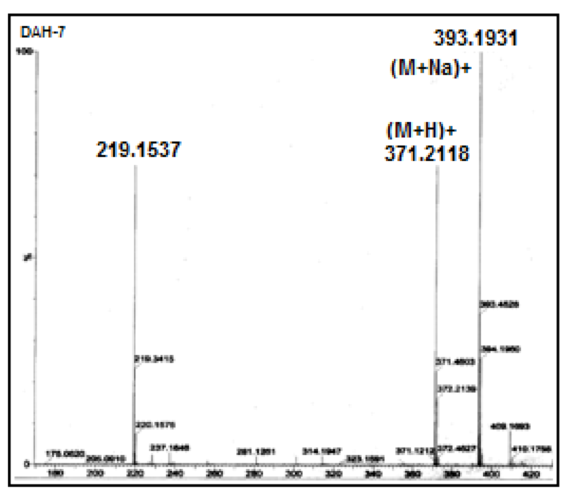
Spectrum 130. IR of 32c



Spectrum 131. ^{1}H NMR of 32c

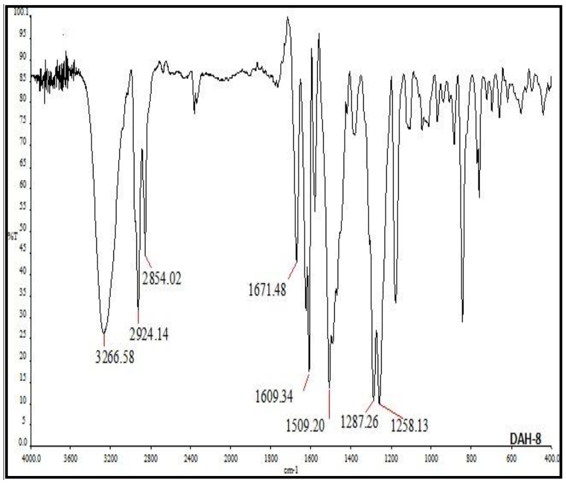


Spectrum 132. ^{13}C NMR of 32c

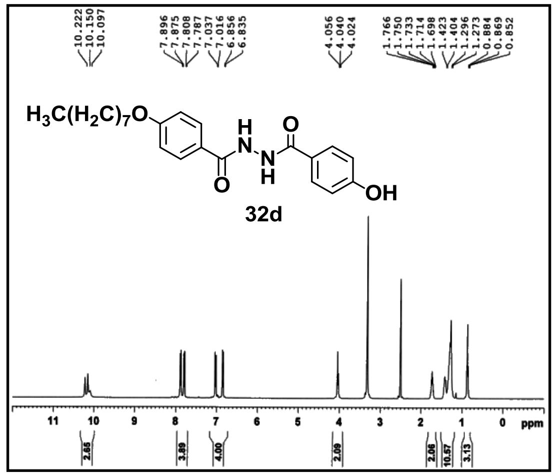


Spectrum 133. Mass of 32c

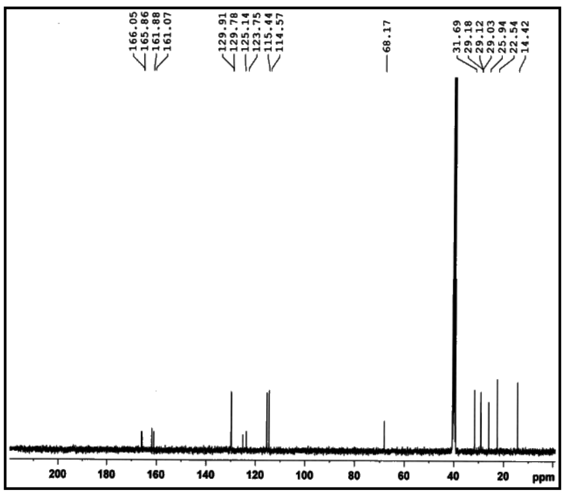
Compound 32d



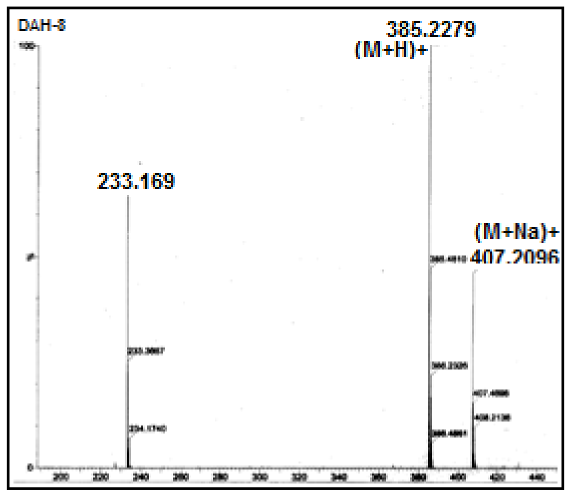
Spectrum 134. IR of 32d



Spectrum 135. [1]H NMR of 32d

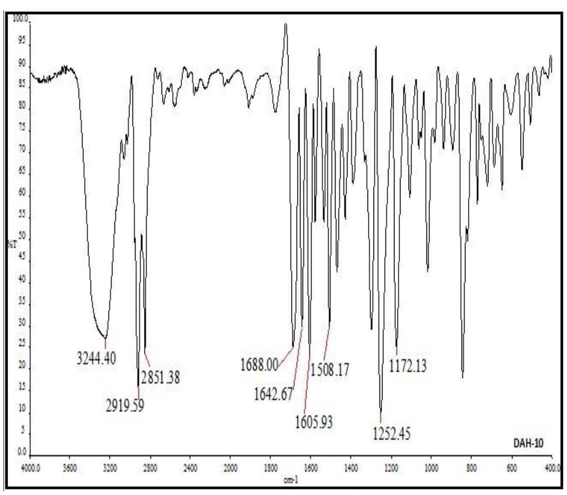


Spectrum 136. [13]C NMR of 32d

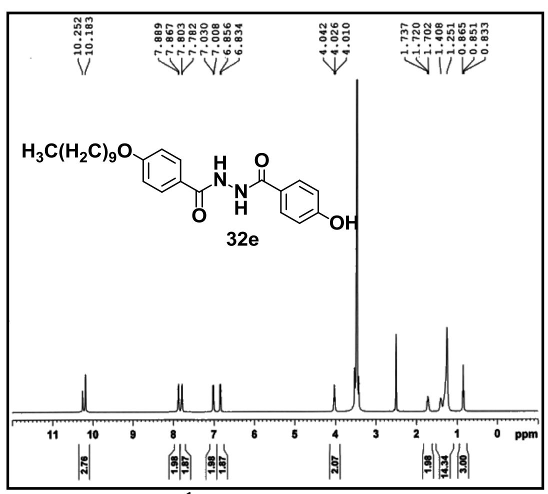


Spectrum 137. Mass of 32d

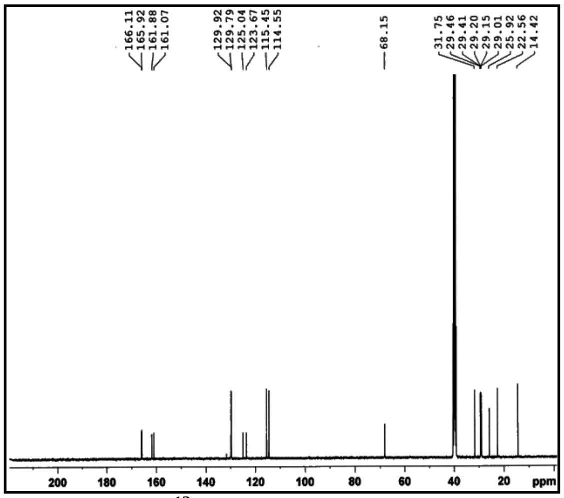
Compound 32e



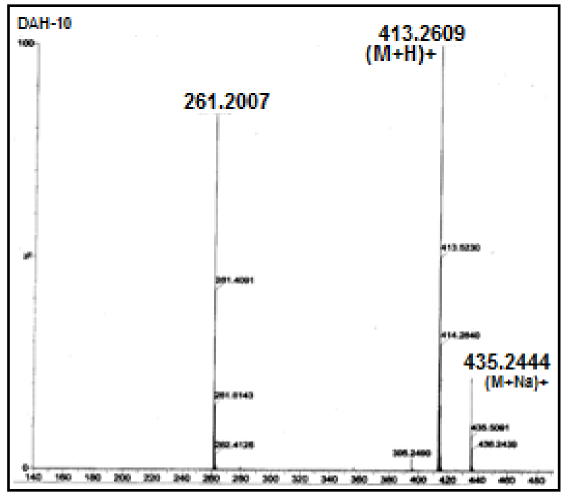
Spectrum 138. IR of 32e



Spectrum 139. [1]H NMR of 32e

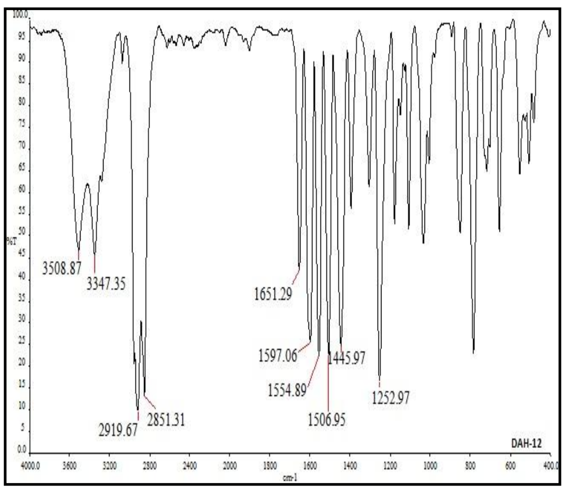


Spectrum 140. ^{13}C NMR of 32e

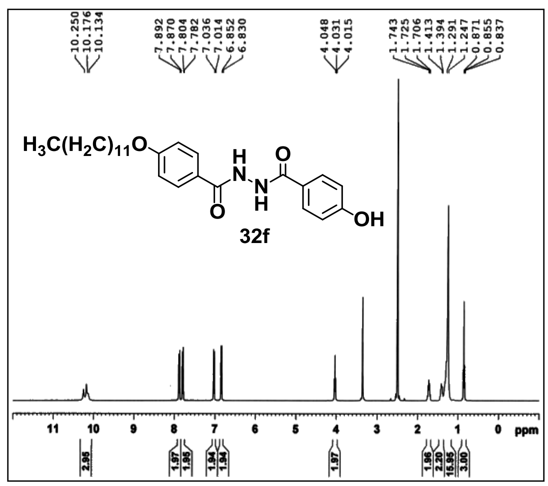


Spectrum 141. Mass of 32e

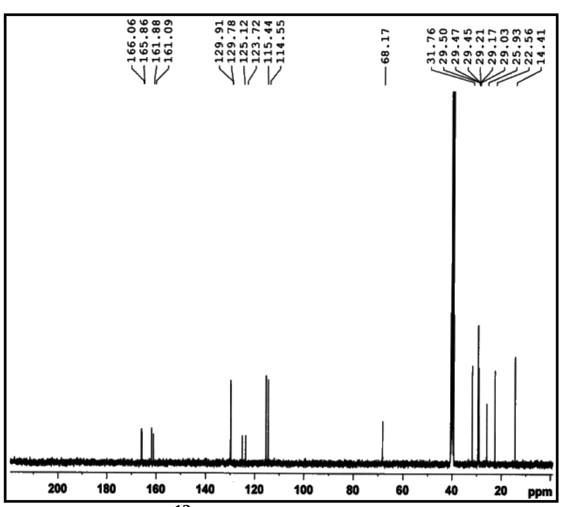
Compound 32f



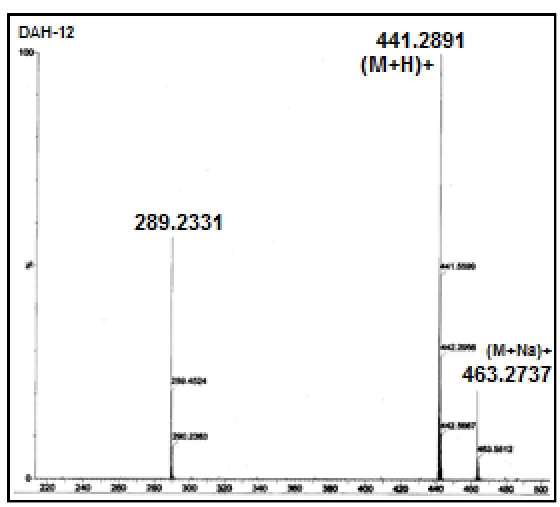
Spectrum 142. IR of 32f



Spectrum 143. ^{1}H NMR of 32f

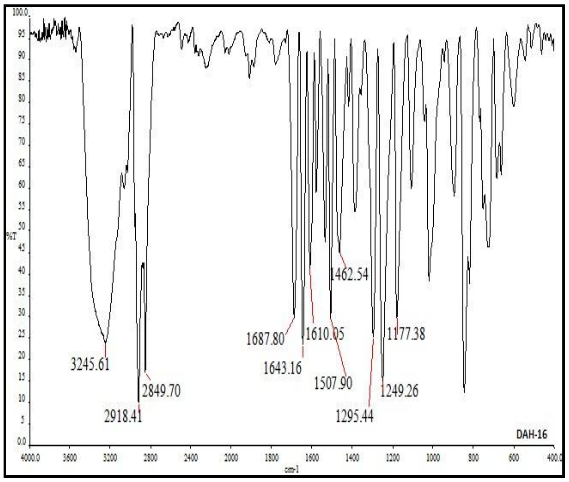


Spectrum 144. ^{13}C NMR of 32f

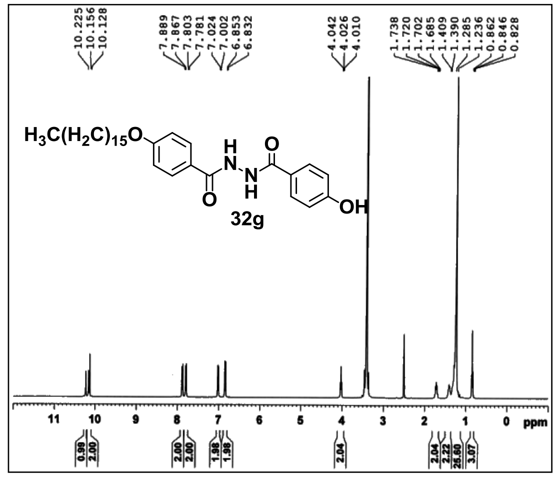


Spectrum 145. Mass of 32f

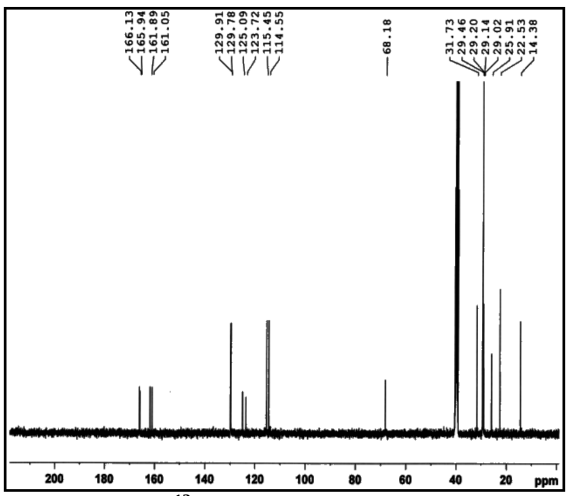
Compound 32g



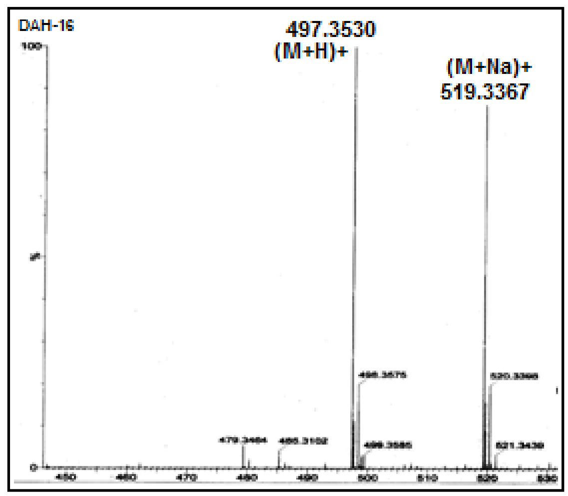
Spectrum 146. IR of 32g



Spectrum 147. ^{1}H NMR of 32g

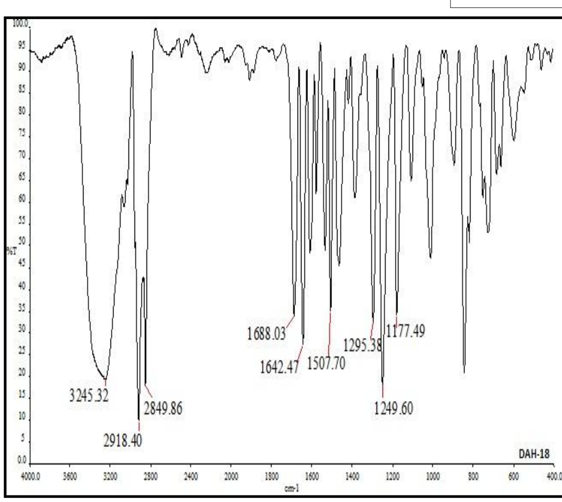


Spectrum 148. ^{13}C NMR of 32g

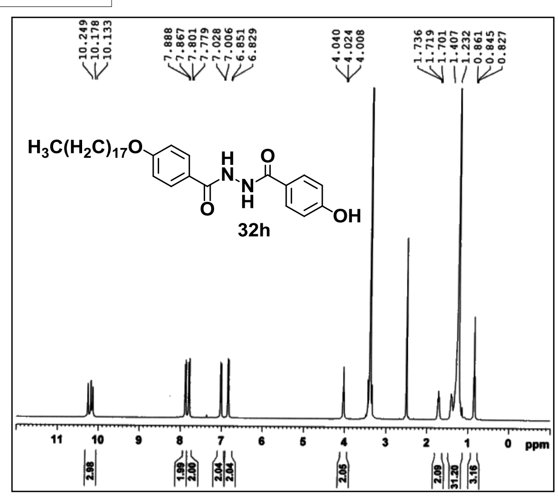


Spectrum 149. Mass of 32g

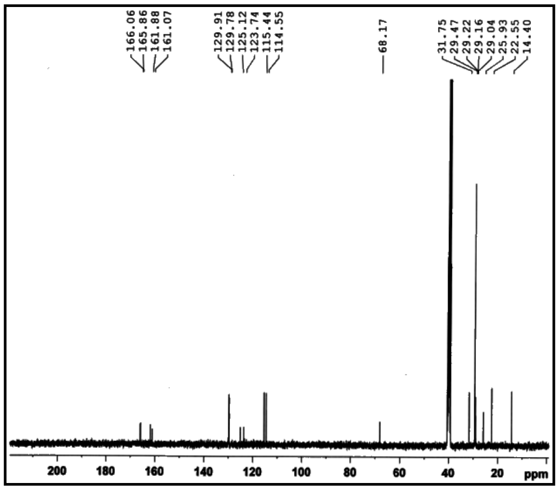
Compound 32h



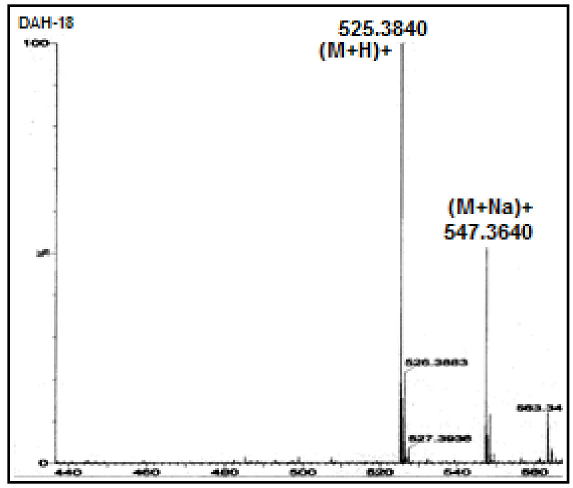
Spectrum 150. IR of 32h



Spectrum 151. ^{1}H NMR of 32h



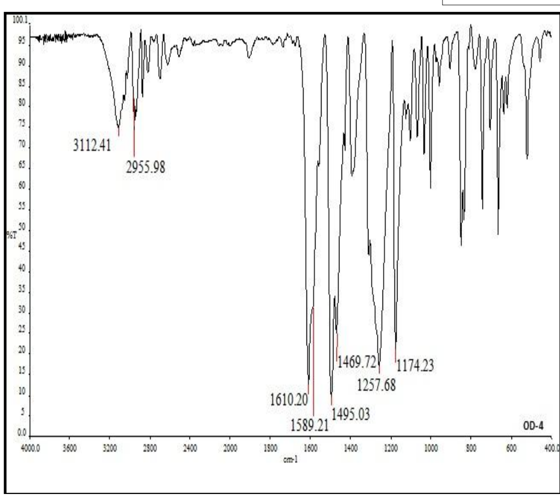
Spectrum 152. ^{13}C NMR of 32g



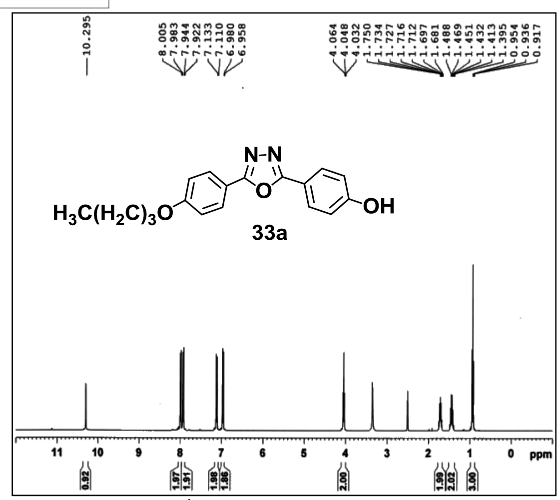
Spectrum 153. Mass of 32g

4.0.2 Unsymmetrical 2,5-disubstituted-1,3,4-oxadiazoles

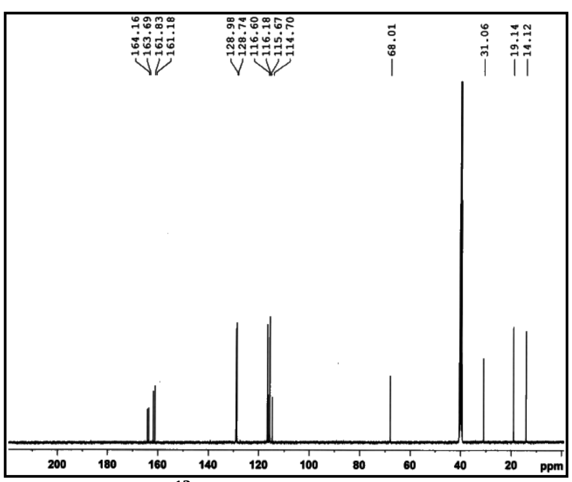
Compound 33a



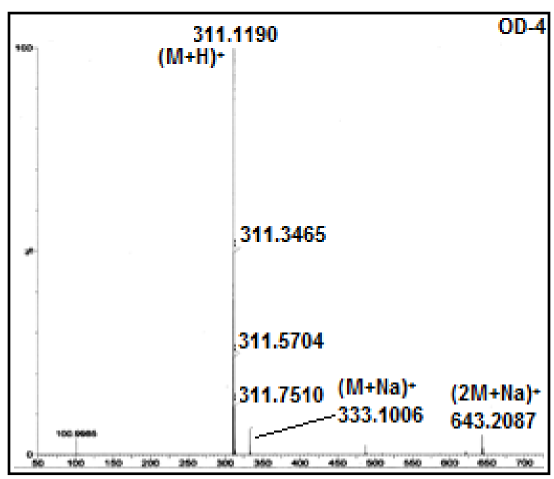
Spectrum 154. IR of 33a



Spectrum 155. ^{1}H NMR of 33a

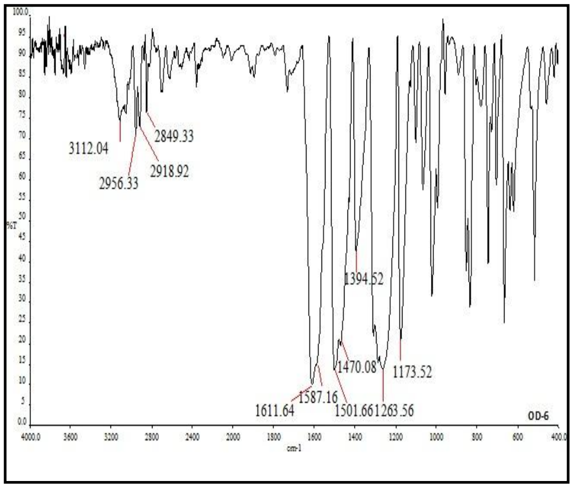


Spectrum 156. ^{13}C NMR of 33a

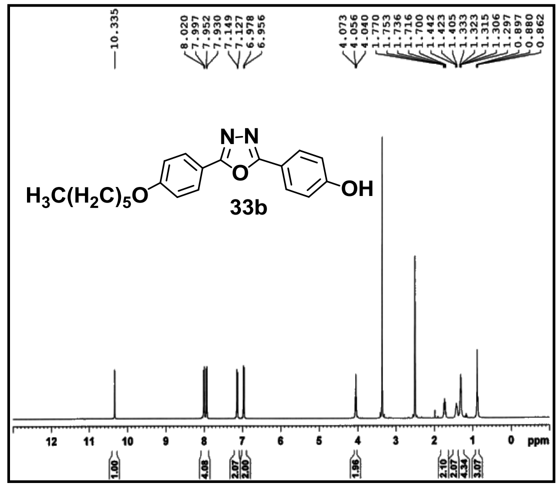


Spectrum 157. Mass of 33a

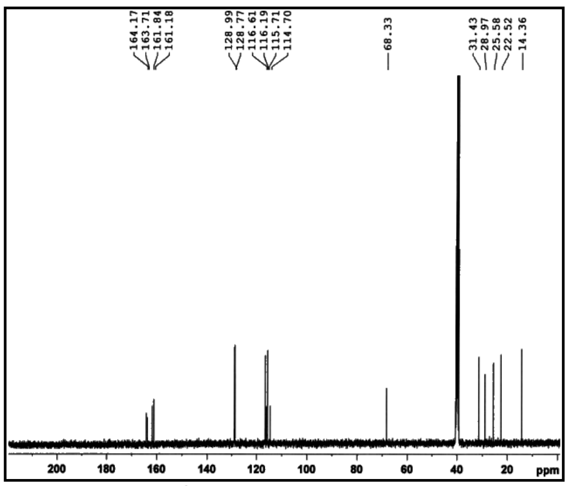
Compound 33b



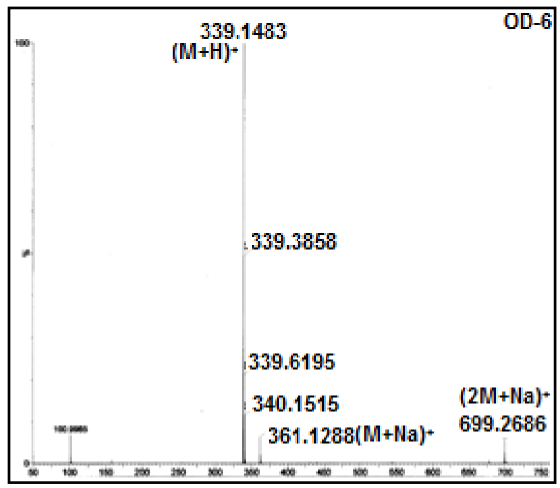
Spectrum 158. IR of 33b



Spectrum 159. [1]H NMR of 33b

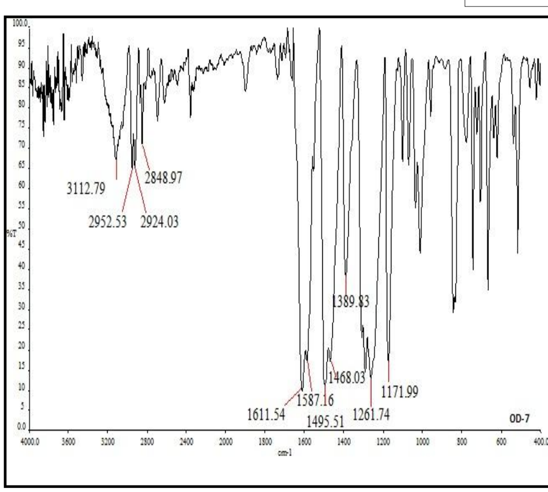


Spectrum 160. [13]C NMR of 33b

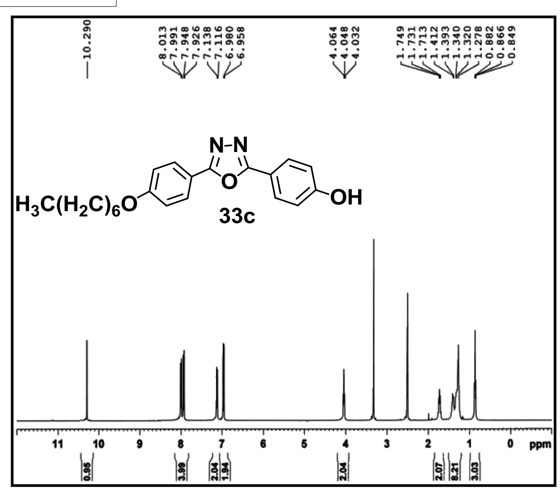


Spectrum 161. Mass of 33b

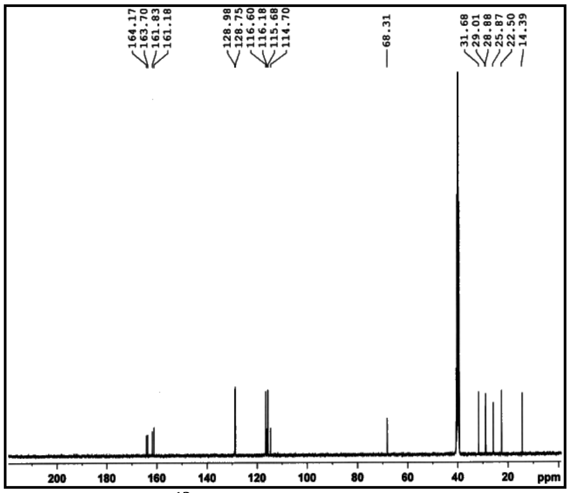
Compound 33c



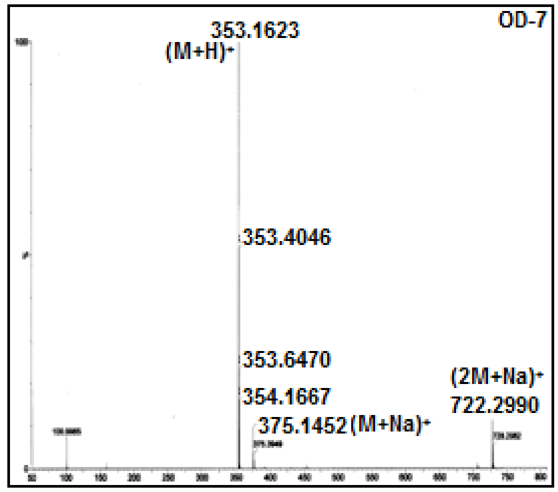
Spectrum 162. IR of 33c



Spectrum 163. [1]H NMR of 33c

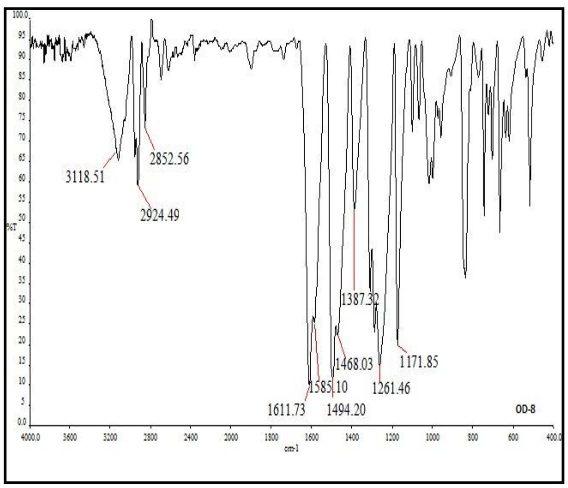


Spectrum 164. ^{13}C NMR of 33c

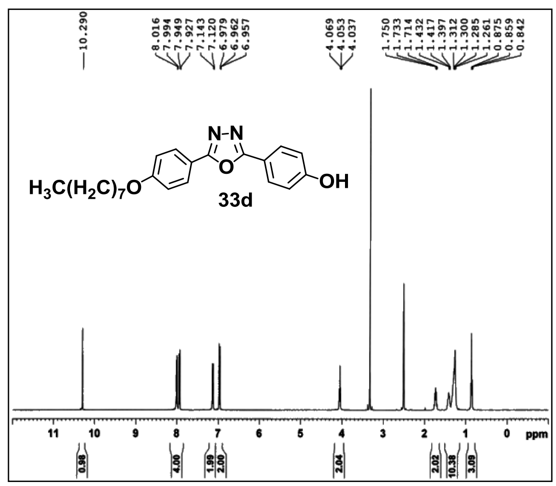


Spectrum 165. Mass of 33c

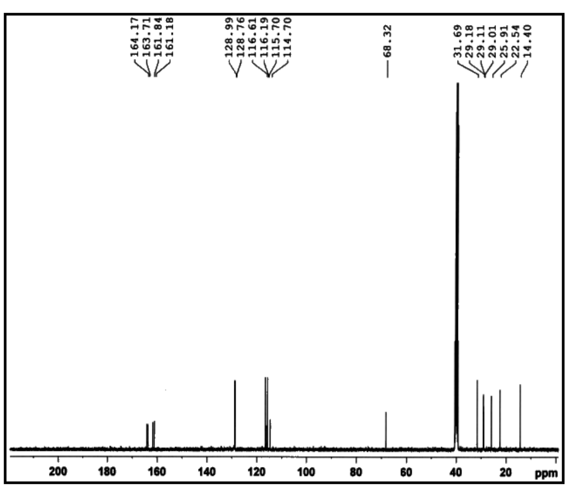
Compound 33d



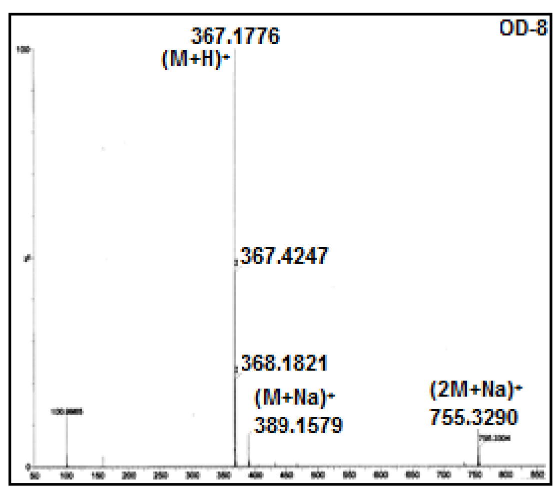
Spectrum 166. IR of 33d



Spectrum 167. ^{1}H NMR of 33d

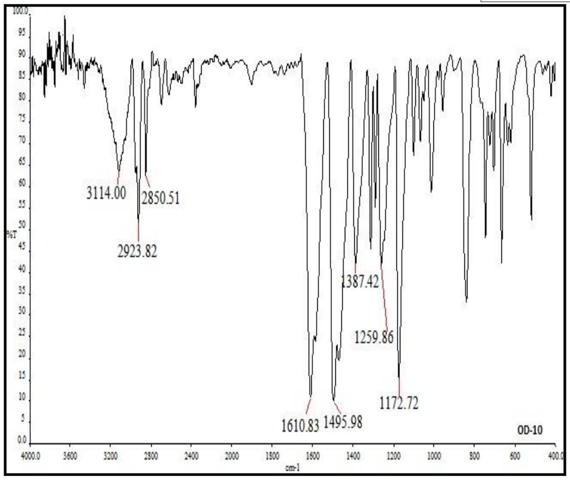


Spectrum 168. ^{13}C NMR of 33d

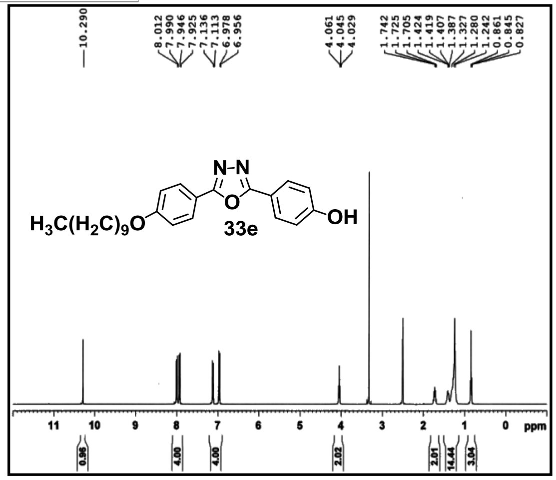


Spectrum 169. Mass of 33d

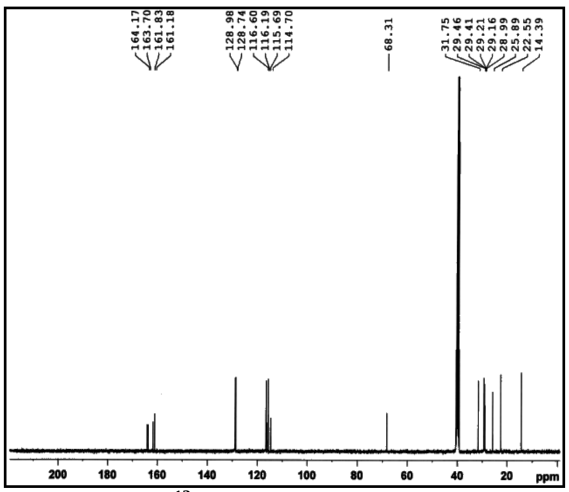
Compound 33e



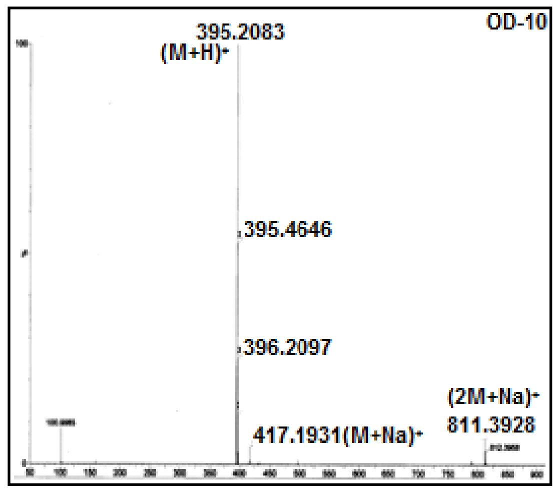
Spectrum 170. IR of 33e



Spectrum 171. ^{1}H NMR of 33e

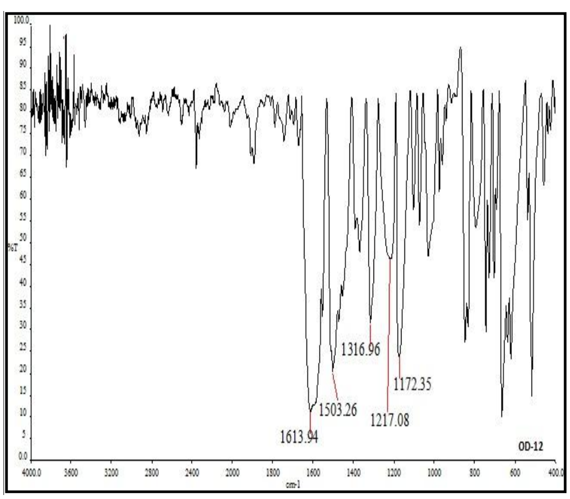


Spectrum 172. ^{13}C NMR of 33e

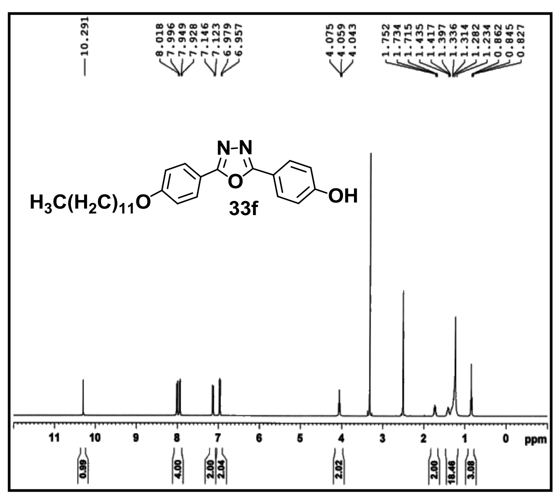


Spectrum 173. Mass of 33e

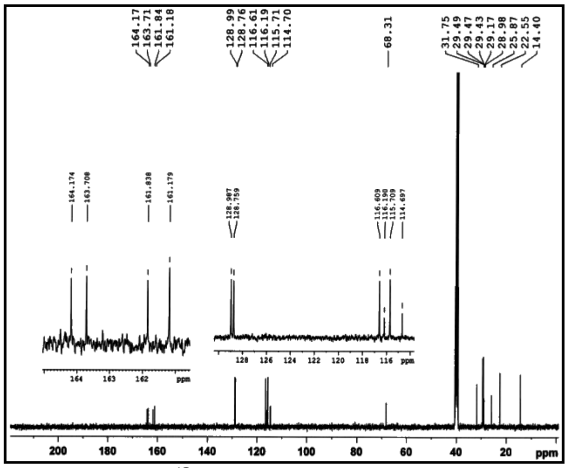
Compound 33f



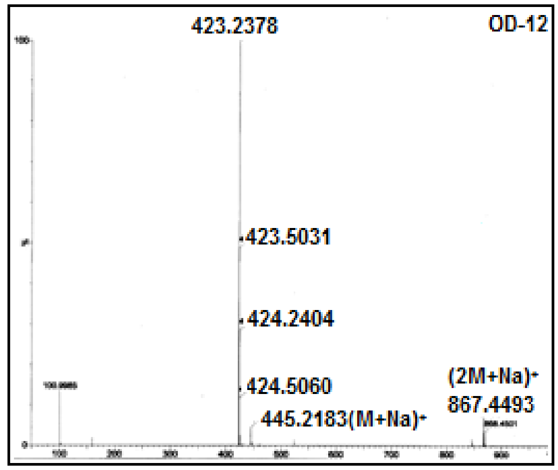
Spectrum 174. IR of 33f



Spectrum 175. ^{1}H NMR of 33f

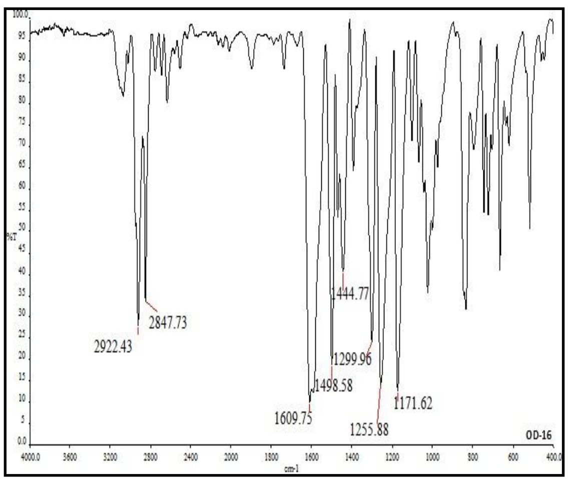


Spectrum 176. ^{13}**C NMR of 33f**

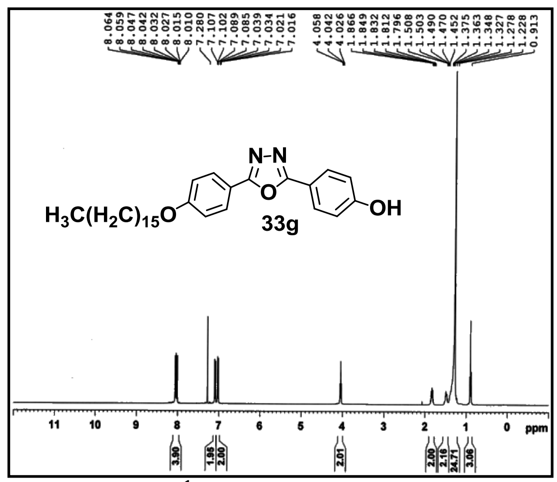


Spectrum 177. Mass of 33f

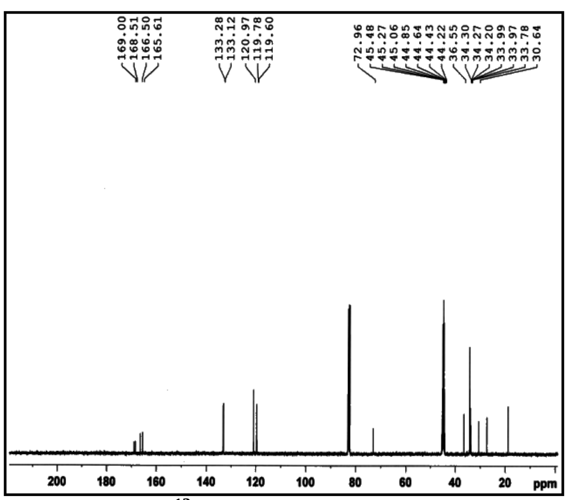
Compound 33g



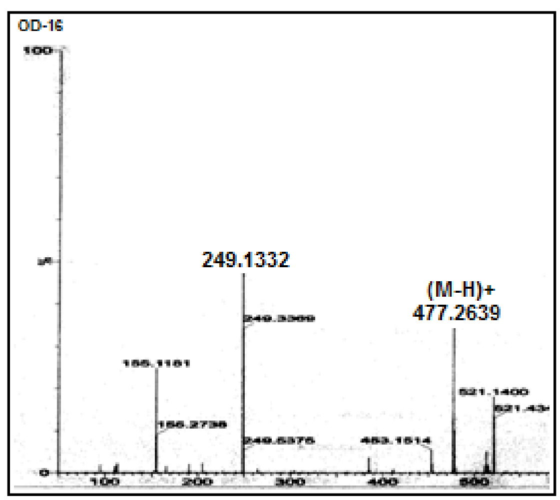
Spectrum 178. IR of 33g



Spectrum 179. ^{1}**H NMR of 33g**

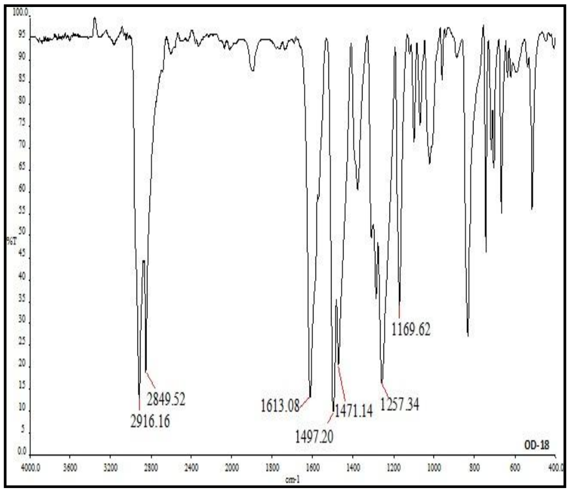


Spectrum 180. ^{13}**C NMR of 33g**

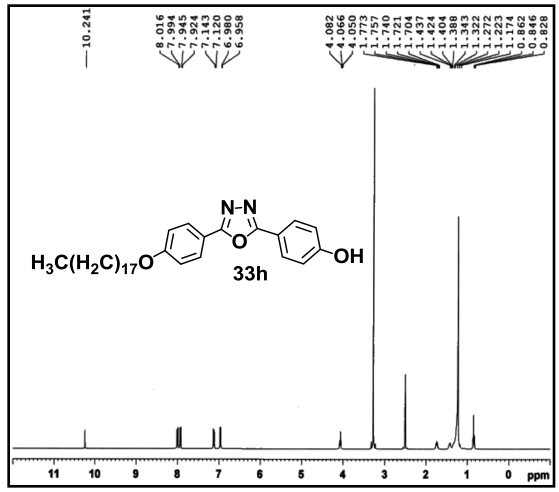


Spectrum 181. Mass of 33g

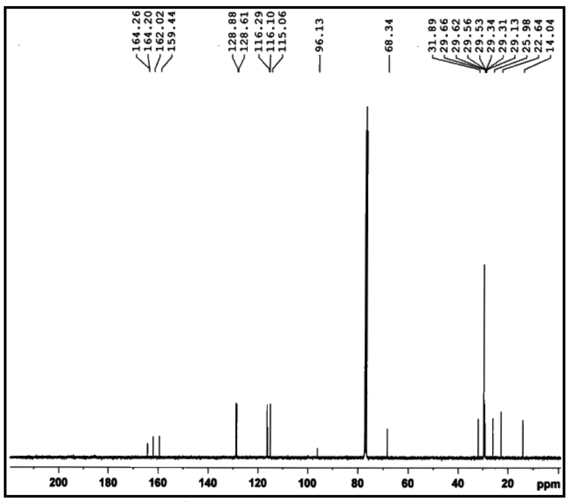
Compound 33h



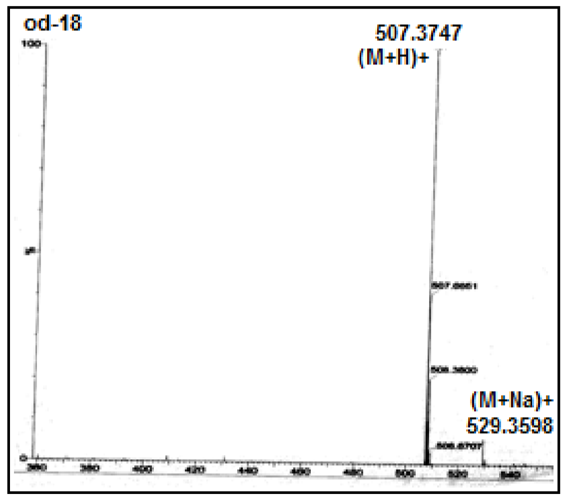
Spectrum 182. IR of 33h



Spectrum 183. ^{1}H NMR of 33h



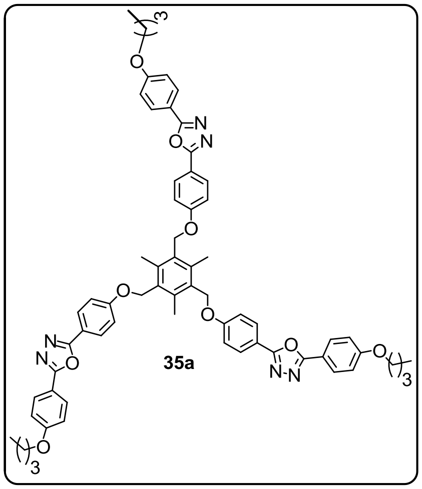
Spectrum 184. ^{13}C NMR of 33h

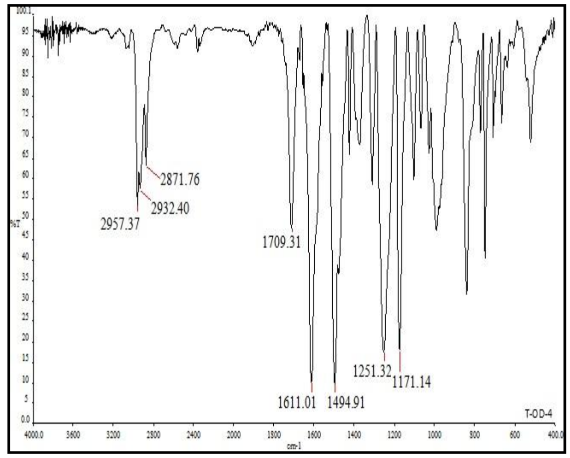


Spectrum 185. Mass of 33h

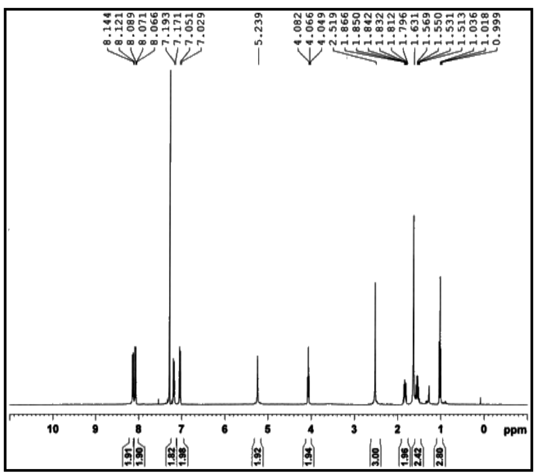
4.0.3 Tris-2,5-disubstituted-1,3,4-oxadiazoles

Compound 35a

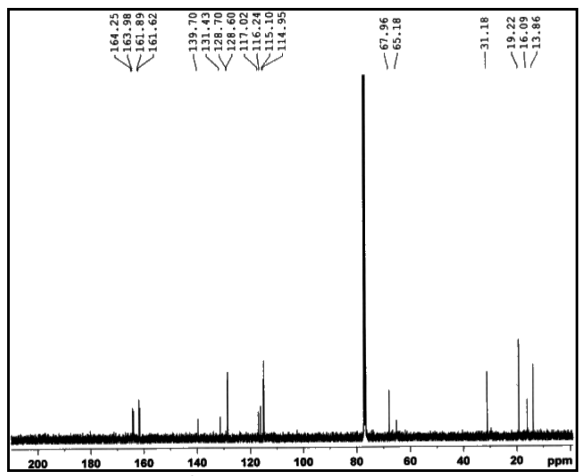




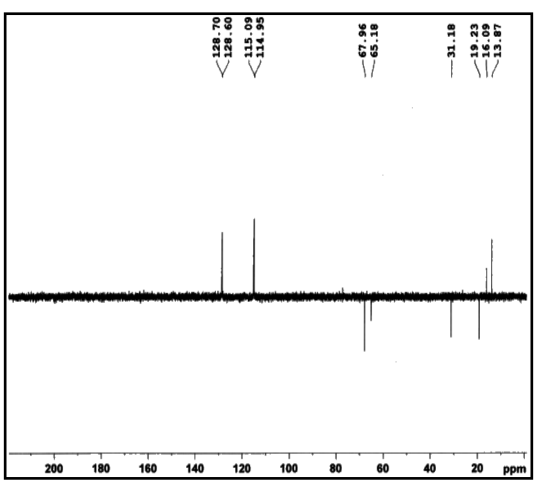
Spectrum 186. IR of 35a



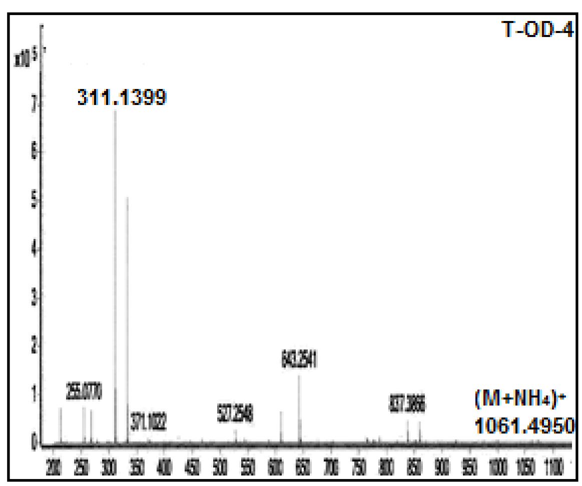
Spectrum 187. ^{1}H NMR of 35a



Spectrum 188. ^{13}C NMR of 35a

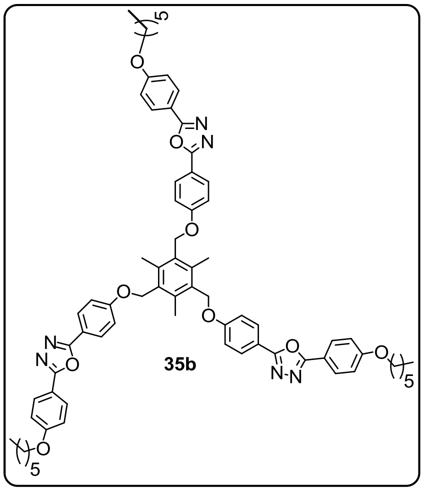


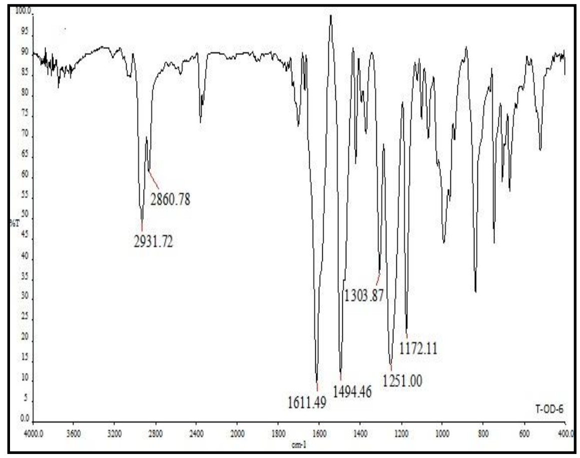
Spectrum 189. DEPT135 of 35a



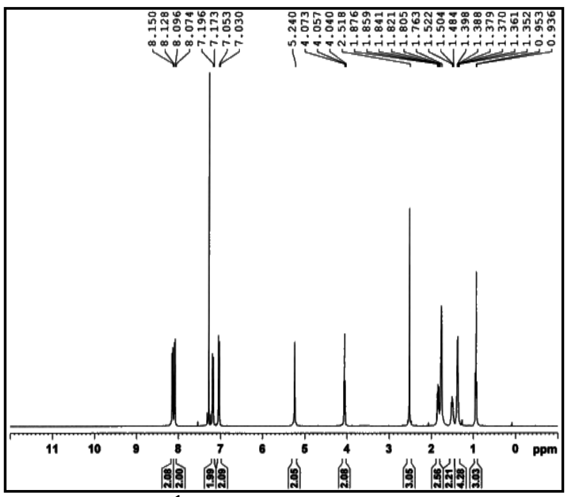
Spectrum 190. Mass of 35a

Compound 35b

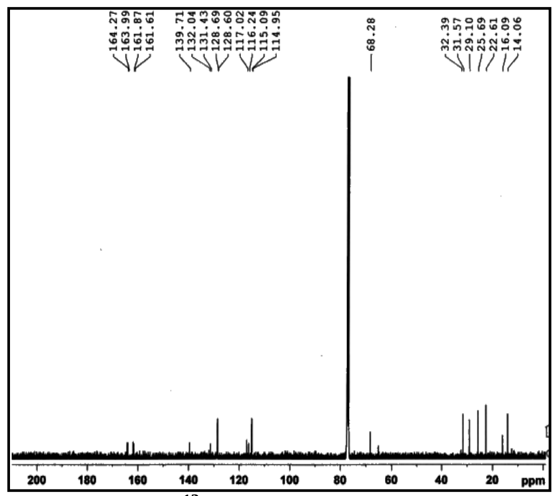




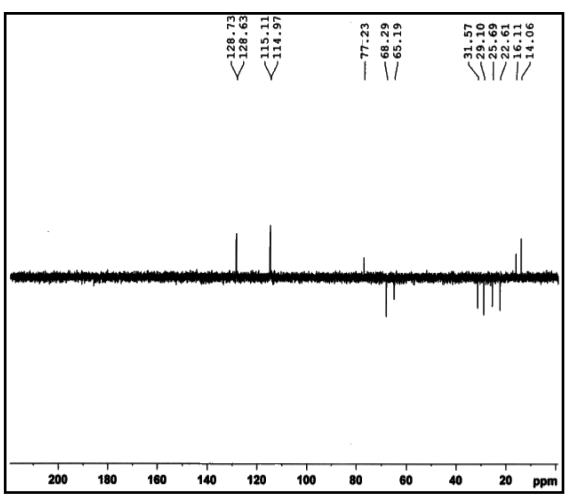
Spectrum 191. IR of 35b



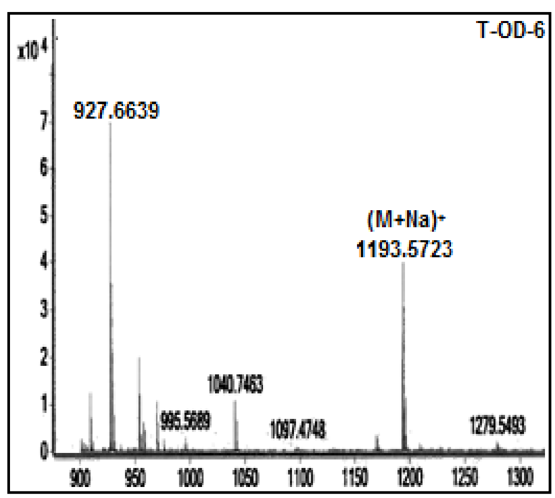
Spectrum 192. [1]H NMR of 35b



Spectrum 193. [13]C NMR of 35b

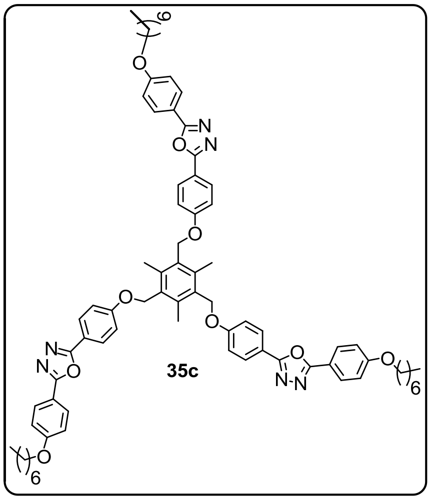


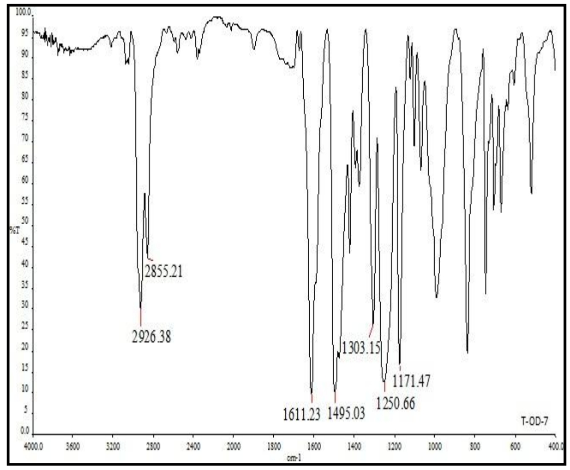
Spectrum 194. DEPT135 of 35b



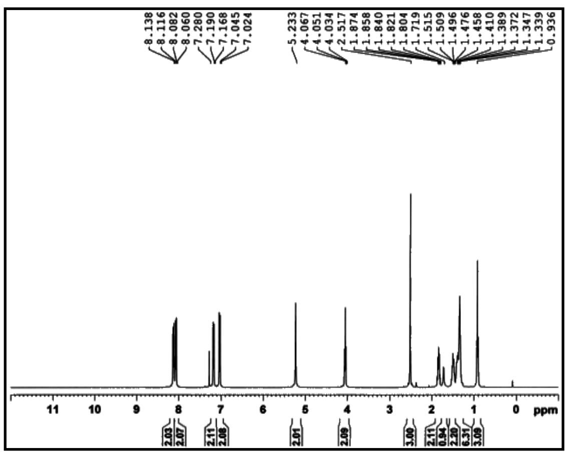
Spectrum 195. Mass of 35b

Compound 35c

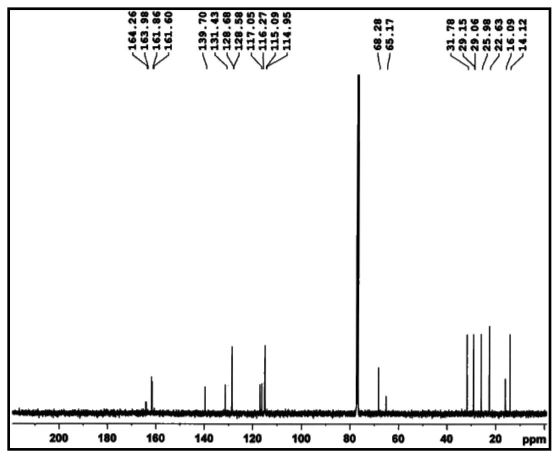




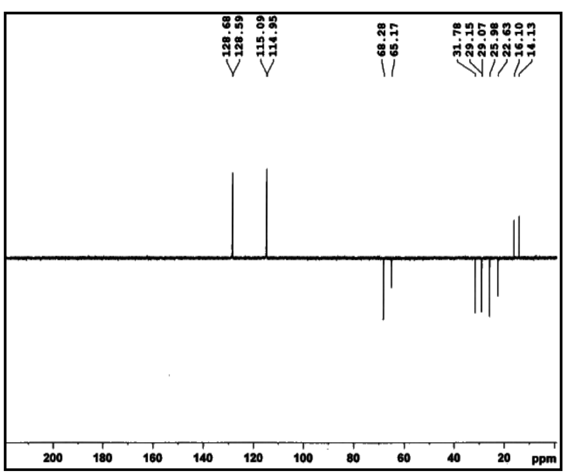
Spectrum 196. IR of 35c



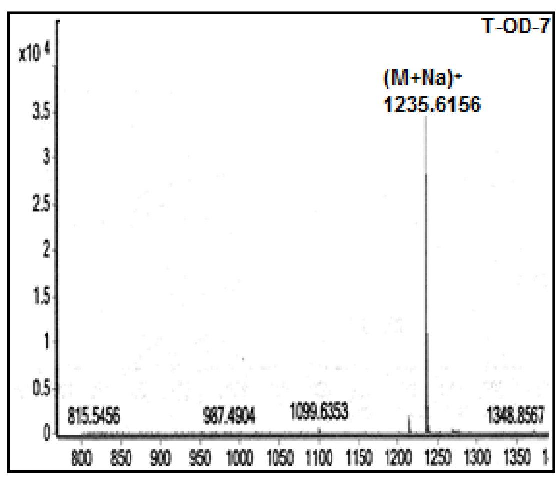
Spectrum 197. [1]H NMR of 35c



Spectrum 198. [13]C NMR of 35c

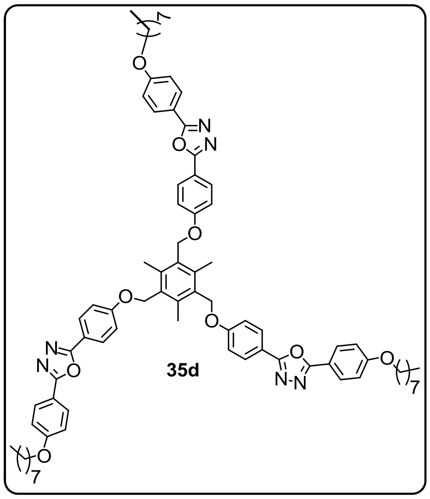


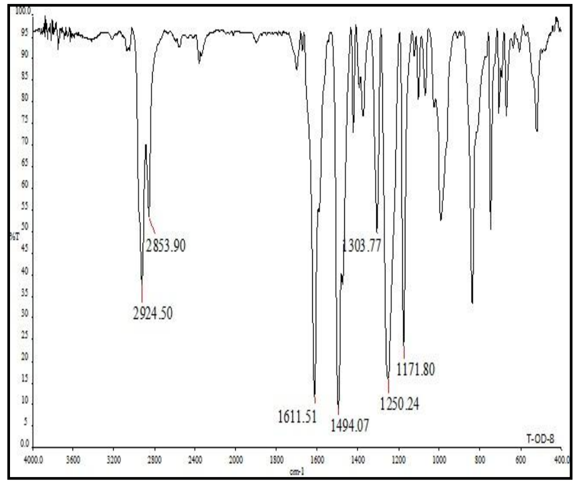
Spectrum 199. DEPT135 of 35c



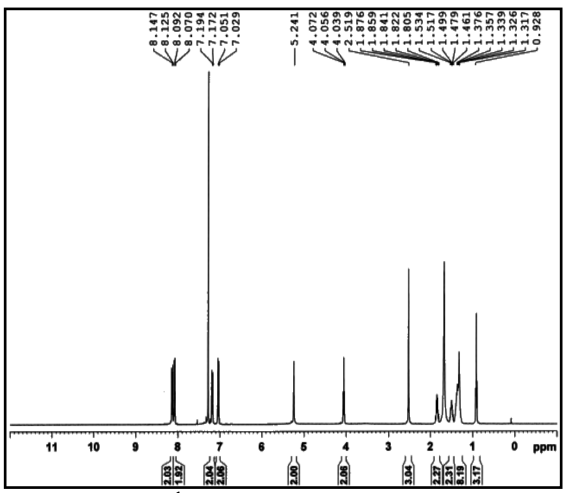
Spectrum 200. Mass of 35c

Compound 35d

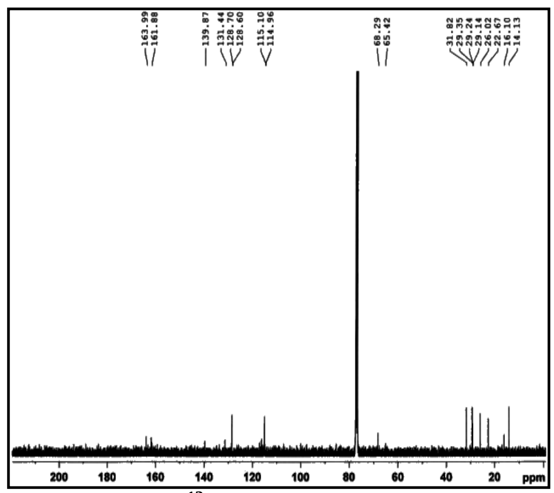




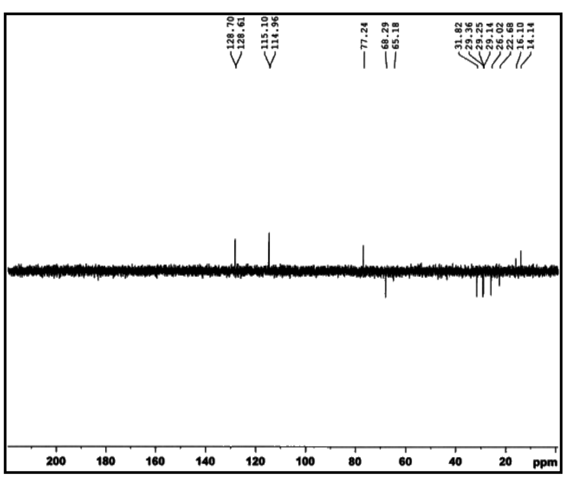
Spectrum 201. IR of 35d



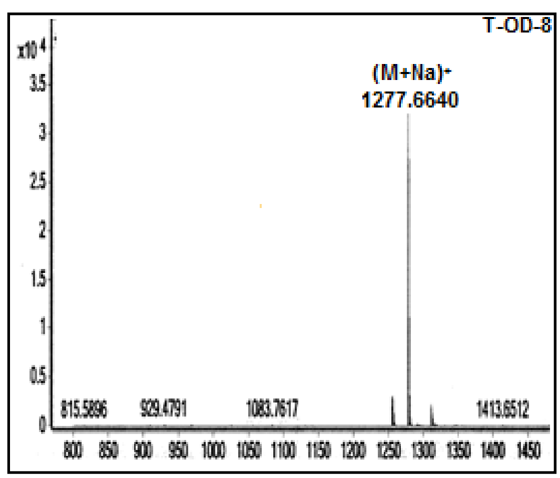
Spectrum 202. ^{1}H NMR of 35d



Spectrum 203. ^{13}C NMR of 35d

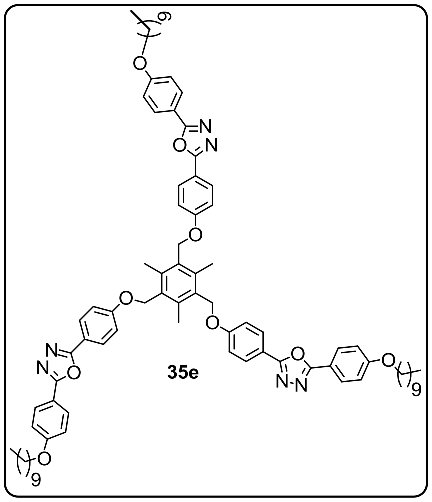


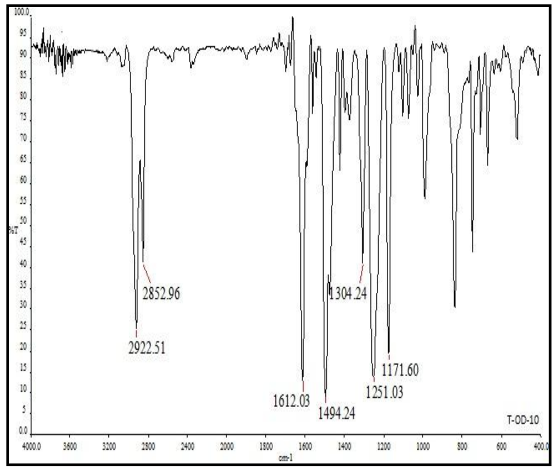
Spectrum 204. DEPT135 of 35d



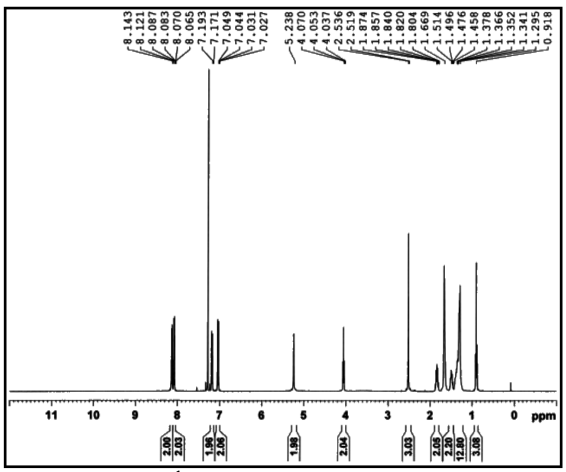
Spectrum 205. Mass of 35d

Compound 35e

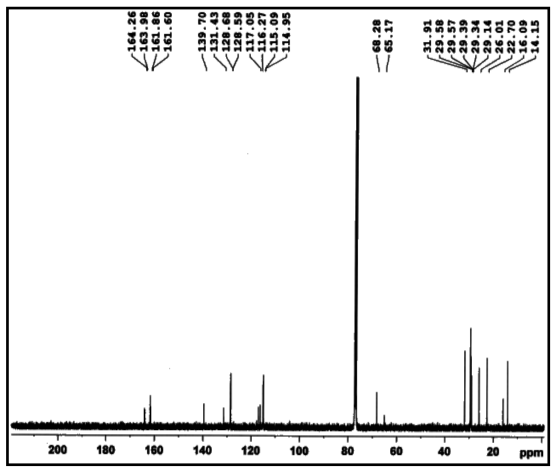




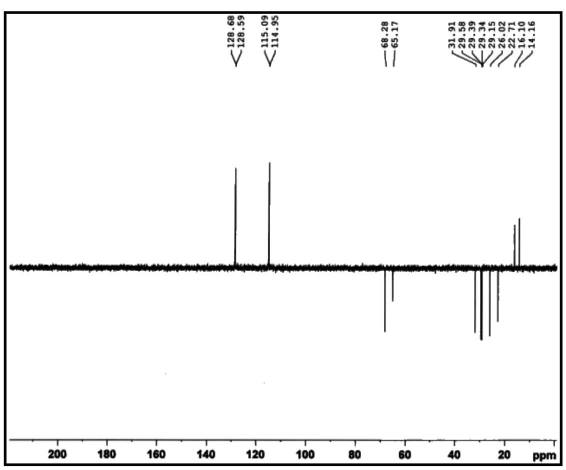
Spectrum 206. IR of 35e



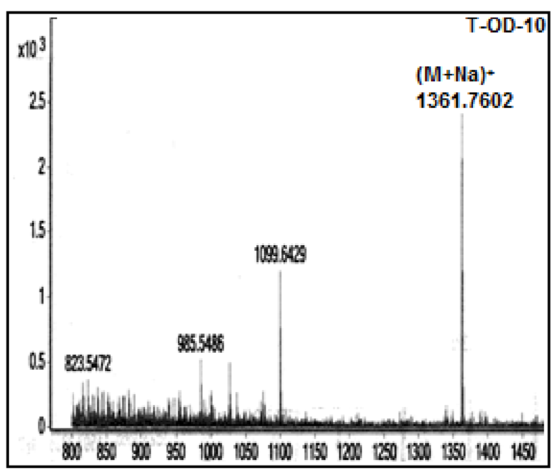
Spectrum 207. ^{1}H NMR of 35e



Spectrum 208. ^{13}C NMR of 35e

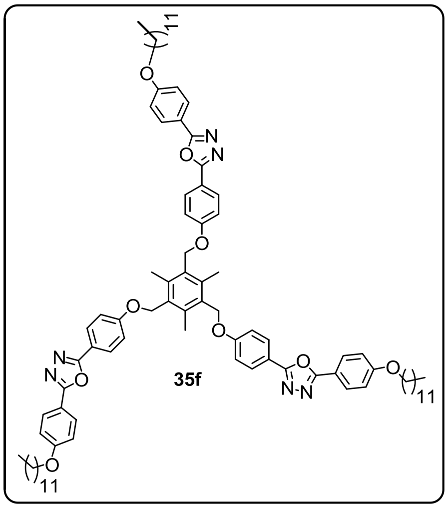


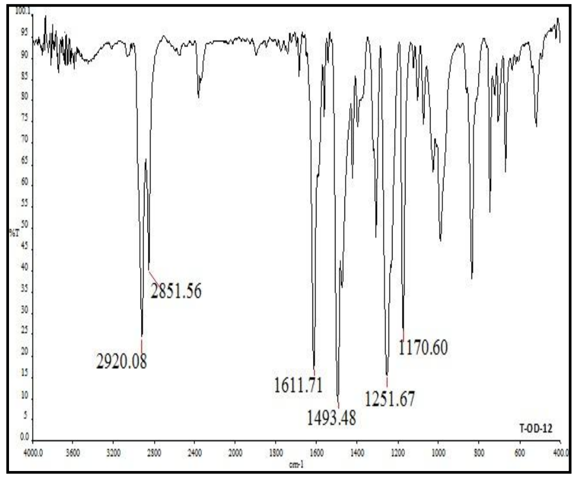
Spectrum 209. DEPT135 of 35e



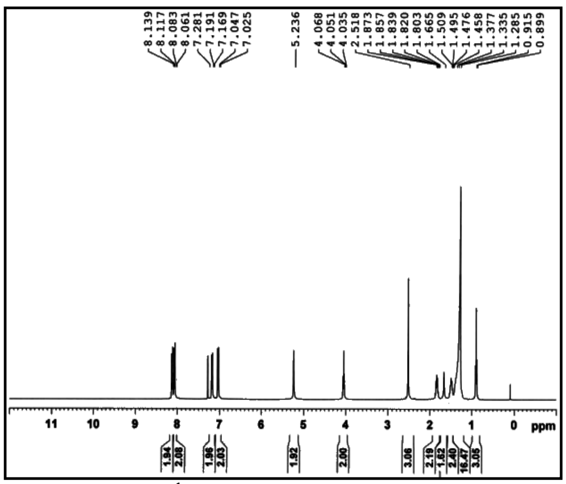
Spectrum 210. Mass of 35e

Compound 35f

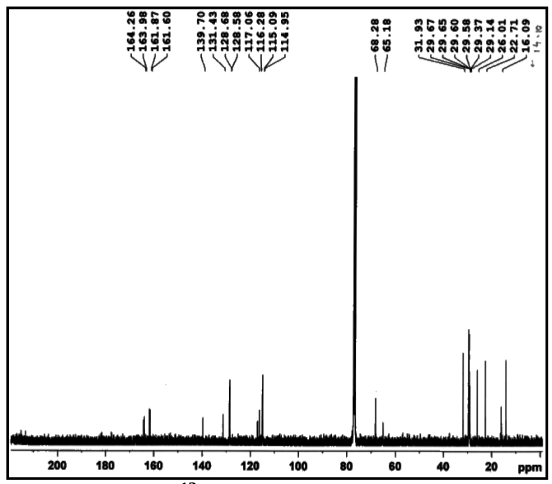




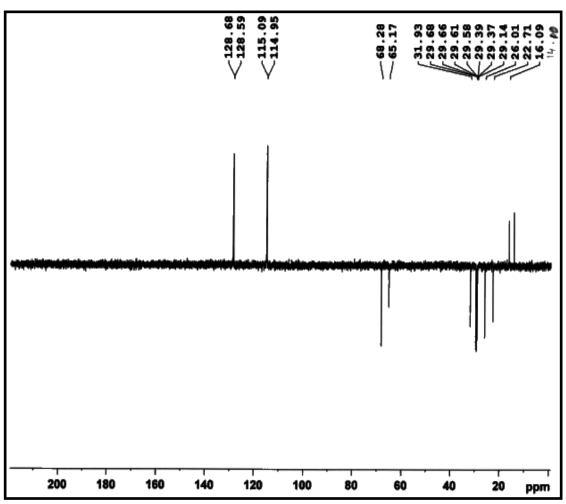
Spectrum 211. IR of 35f



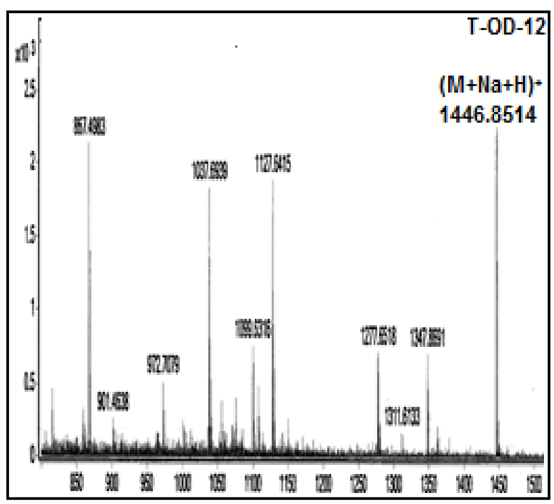
Spectrum 212. ^{1}H NMR of 35f



Spectrum 213. ^{13}C NMR of 35f

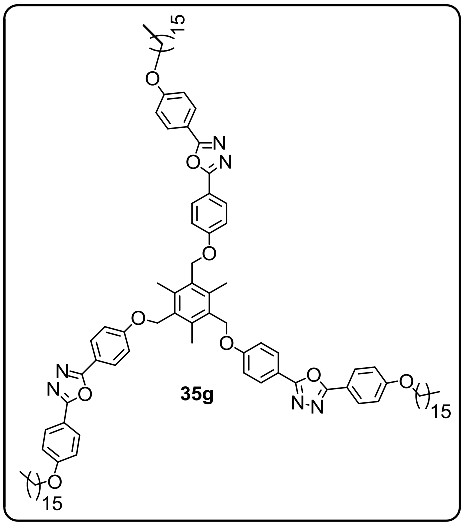


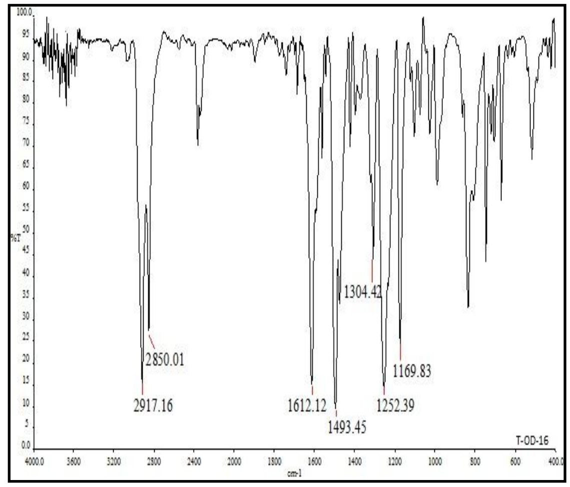
Spectrum 214. DEPT135 of 35f



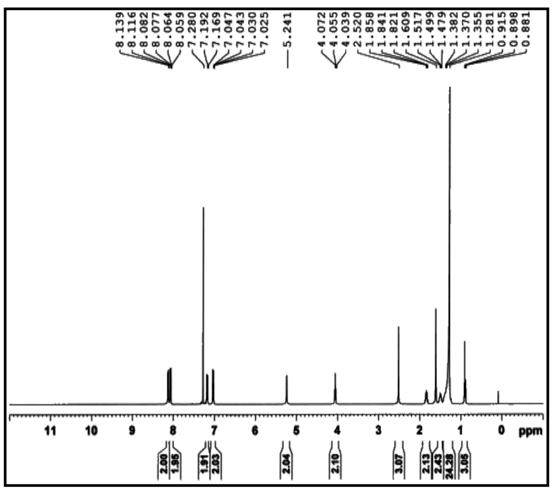
Spectrum 215. Mass of 35f

Compound 35g

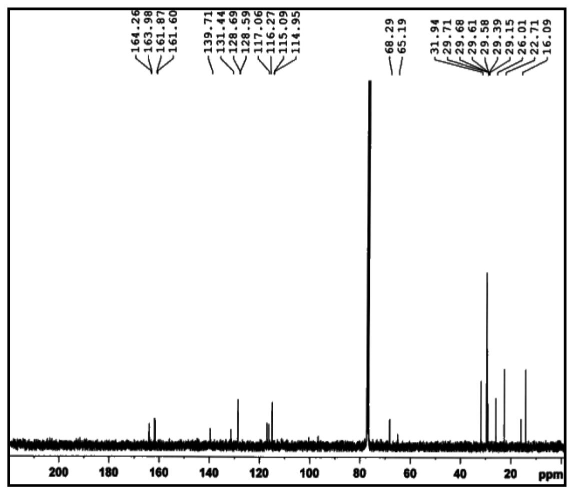




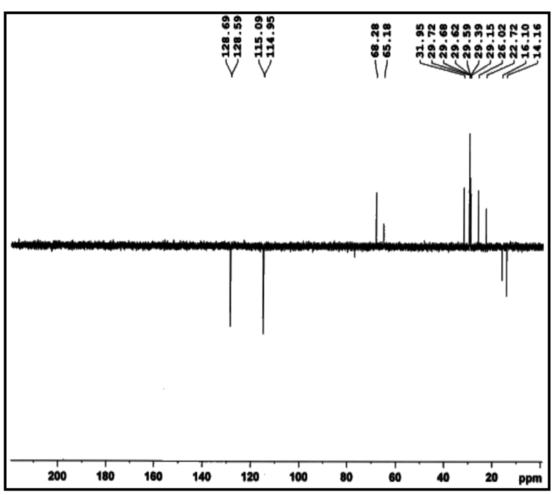
Spectrum 216. IR of 35g



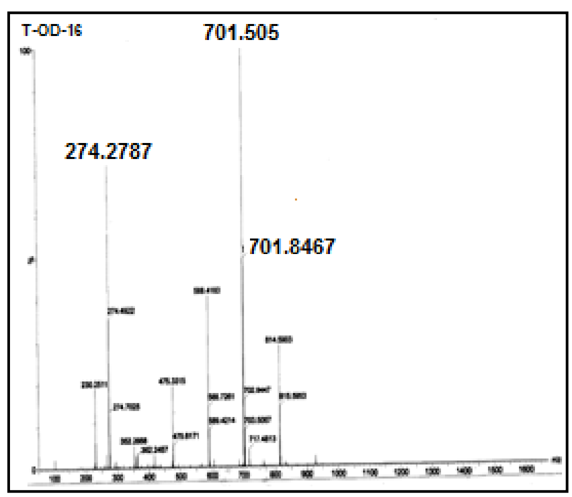
Spectrum 217. ^{1}H NMR of 35g



Spectrum 218. ^{13}C NMR of 35g

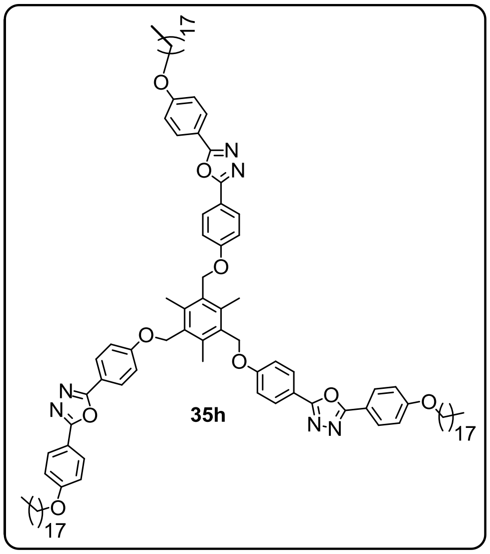


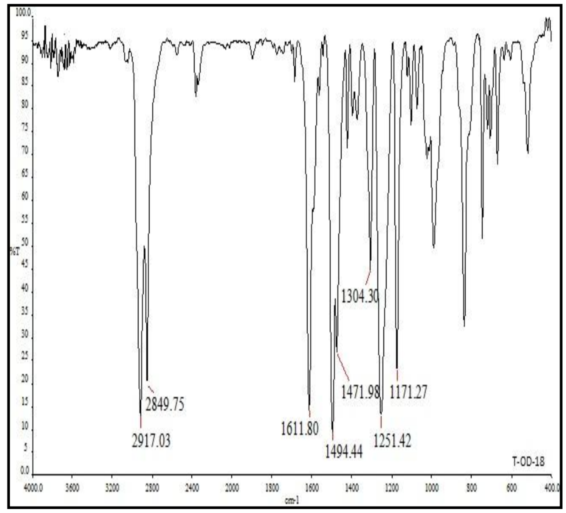
Spectrum 219. DEPT135 of 35g



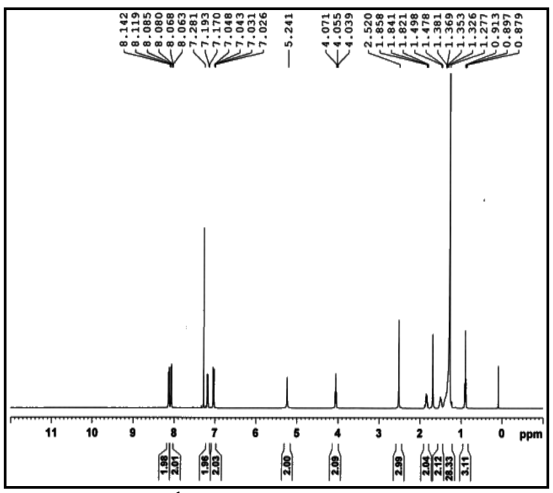
Spectrum 220. Mass of 35g

Compound 35h

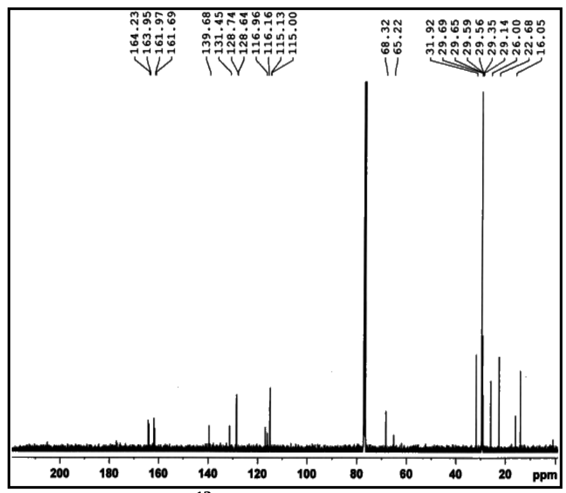




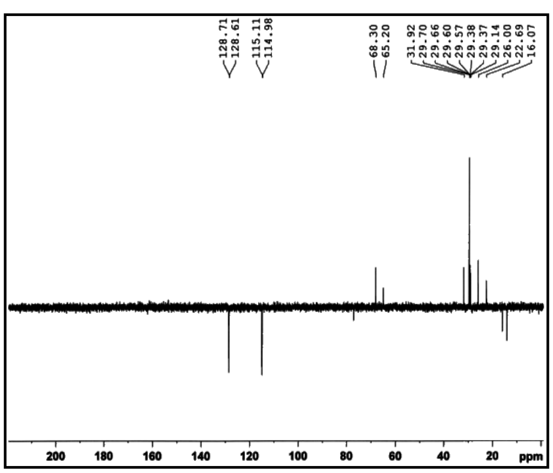
Spectrum 221. IR of 35h



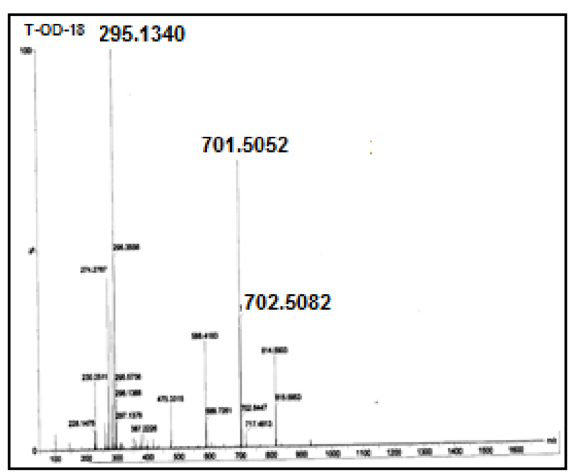
Spectrum 222. ^{1}H NMR of 35h



Spectrum 223. ^{13}C NMR of 35h



Spectrum 224. DEPT135 of 35h



Spectrum 225. Mass of 10h

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