CHAPTER 2

SYNTHESIS AND CHARACTERISATION OF A FEW NITRONES

2.1. Abstract

Nitrones constitute a unique class of 1,3-dipoles. It can act as a suitable substrate for the synthesis of nitrogen and oxygen heterocycles. In this chapter we briefly describe the synthesis and characterisation of a few nitrones.

2.2. Introduction

Nitrone (azomethine *N*-oxide) is an allyl anion type 1,3-dipole (Figure 1). The name nitrone was coined by Pfeiffer[1] in 1916 from 'nitrogen-ketone' as it shows similarity with carbonyl group in facilitating the removal of a proton from a nearby carbon under basic condition. This 1,3-dipole was first prepared by Beckmann in 1890.[2]

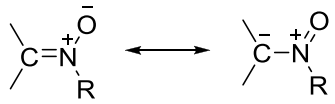


Figure 2.1

The observed dipole moment shows a dominance of azomethine *N*-oxide structure for most of the nitrones, which means the major

fraction of the negative charge is concentrated on terminal oxygen than the α-carbon atom.[3] So this group of compounds show nucleophilic character in majority of its reactions. Based on the presence of a proton on *α*-carbon, nitrones are classified into aldonitrones and ketonitrones (Figure 2.2). Aldonitrones are those having a proton on the *α-C*, but in the case of ketonitrone, the *α*-carbon is substituted with alkyl, aryl or with both alkyl and aryl groups.

Figure 2.2

Due to the presence of a double bond in the structure, nitrones exhibit geometrical isomerism. It was first established in 1918 for *α*-phenyl-*α*-(*p*-tolyl)-*N*-methylnitrone.[4] The configuration of isomers were assigned on the basis of dipole moment measurement.[5] The dipole moment value of *Z*-isomer will be higher than that of the *E*-isomer. By the use of thermal as well as photochemical methods the geometrical isomers can be interconverted. The geometrical isomers of *α*-phenyl-*N*-*t*-butylnitrone are given below (Figure 2.3).[6]

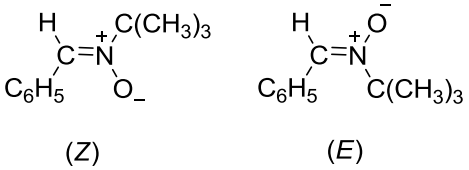
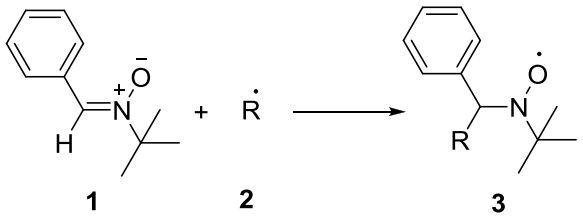


Figure 2.3

2.2.1. Applications of Nitrones

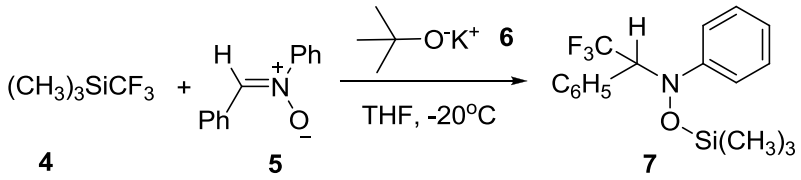
Nitrones are frequently used as spin trapping agents in biological systems.[7-17] Spin trapping is a reliable method to detect free radicals whose life time is too short to identify in the EPR spectrum. This technique is based on the fast reaction between a short lived free radical and a suitable diamagnetic molecule (a spin trap). Here the product will be a relatively long lived paramagnetic species whose EPR signals can be recorded and analysed. Addition of nitrone spin trap to a reactive free radical results the formation of nitroxide, a fairly stable detectable radical (Scheme 2.1). This technique is used to study the effect of reactive oxygen species (ROS) and oxygen centered free radicals (OFR) such as superoxides, alkoxy, peroxy, hydroperoxy and hydroxyl radicals in diseases like arteriosclerosis, neurodegenerative diseases, cellular aging etc. 5,5-Dimethyl-1-pyrroline-*N*-oxide (DMPO), 5-diethoxyphosphoranyl-5-methyl-1-pyrroline-*N*-oxide (DEPMPO) and 5-*tert*-butoxycarbonyl-5-methyl-1-pyrroline *N*-oxide (BMPO) are the commonly used spin trapping agents. Recent studies reveal that nitrones exhibit antioxidant properties also.



1 2 3

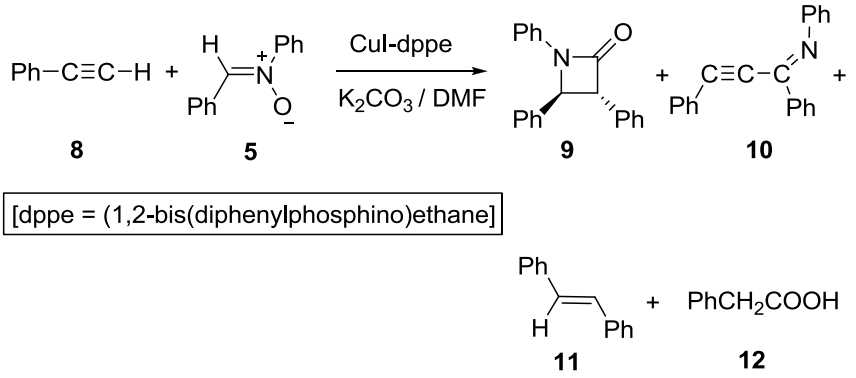
Scheme 2.1

Nitrones are successful candidates in many organic syntheses since they exhibit both electrophilic and nucleophilic character.[18-24] For example, addition of (trifluoromethyl)trimethylsilane (**4**) to *α,N*-diphenylnitrone (**5**) resulted in the formation of an *α*-(trifluoromethyl)-*N*-hydroxyl amine derivative **7**. In this case, the trifluoromethylgroup was added to the electrophilic carbon of the diphenylnitrone **5** (Scheme 2.2).[25]



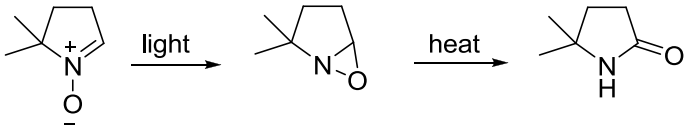
Scheme 2.2

Nucleophilic character of nitrones was illustrated by the reaction of **5** with phenylacetylene (**8**) in presence of CuI-dppe catalyst (Scheme 2.3).[26] Here the coupling products **9** and **12** were obtained in major yield compared to the redox products **11** and **12**.



Scheme 2.3

Nitrones undergo interesting rearrangements under the influence of heat, light and a variety of reagents.[27]



13 14 15

Scheme 2.4

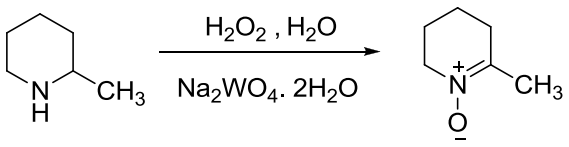
One of the most important class of reactions by nitrones are the 1,3-dipolar cycloaddition reactions, where nitrones react with electron deficient unsaturated compounds to form a wide variety of heterocycles.[28-37] Most of these compounds are as such or precursors of biologically active compounds. Some remarkable reactions of nitrones with Burgess reagent was also reported.[38-39]

2.2.2. Methods for the Synthesis of Nitrones

Numerous methods are available for the synthesis of nitrones since this particular class of compounds have a wide variety of applications.

2.2.2.1. Oxidation of Secondary Amines

Nitrones can be prepared by the oxidation of secondary amines using peroxides as oxidant (Scheme 2.5).[40] Hydrogen peroxide or urea-hydrogen peroxide complex (UHP) is used as the oxidant and selenium dioxide[41] or sodium tungstate[42] is used as the catalyst in many cases.



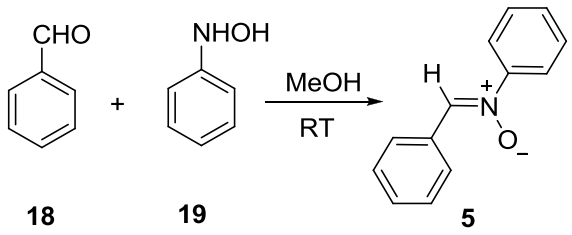
16 **17**

Scheme 2.5

Goti and Murray in independent experiments described the synthesis of nitrones from secondary amines where methyltrioxorhenium was used as the catalyst with UHP.[43-44] An electrochemical oxidation method was also introduced for the synthesis of nitrones from *N*-hydroxy secondary amines where sodium iodide is used as the supporting electrolyte.[45] Carollina *et al.* reported a viable metal-free procedure for the preparation of nitrones from secondary amines using oxone in a biphasic basic medium as the single oxidant.[46]

2.2.2.2. Condensation of Carbonyl Compounds with Hydroxylamines

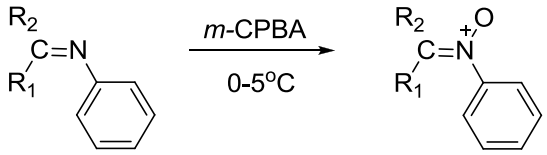
Condensation reaction of aldehyde with *N*-substituted hydroxylamines is a common procedure for the synthesis of diarylnitrones (Scheme 2.6).[47] Here the hydroxylamine derivative **19** is either prepared or formed *in situ* by the reduction of corresponding nitro compounds with zinc powder in presence of weak acids like ammonium chloride or accetic acid. Increased yield of nitrone and significant reduction in reaction time is achieved if microwave irradiation is used in the condensation process.



Scheme 2.6

2.2.2.3. Oxidation of Imines

Imines on oxidation with peracids (Scheme 2.7)[48] or dimethyldioxirane[49] give better yield of nitrone under specific conditions where the possibility for oxaziridine formation is minimized. Potassium permanganate can also be used as oxidising agent under phase transfer condition for the synthesis of nitrones from corresponding imine derivatives.[50]

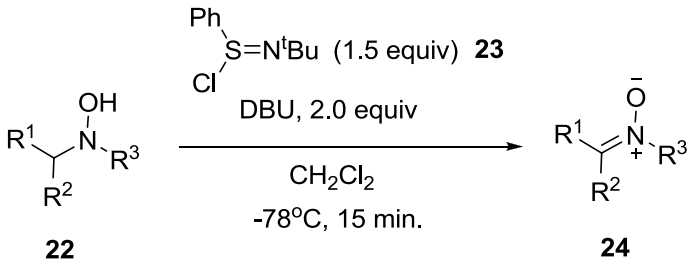


Scheme 2.7

2.2.2.4. Oxidation of *N,N*-Disubstituted Hydroxylamines

Another convenient method for the synthesis of cyclic as well as acyclic nitrones is the oxidation of corresponding *N,N*-disubstituted hydroxylamines with suitable oxidising agents such as yellow mercuric oxide,[51] potassium ferricyanide,[52] *t*-butyl hydroperoxide,[53] molecular oxygen,[54] active lead oxide,[55] potassium permanganate[56] etc. Jun-ichi Matsuo and co-workers reported the use of *N-t-*

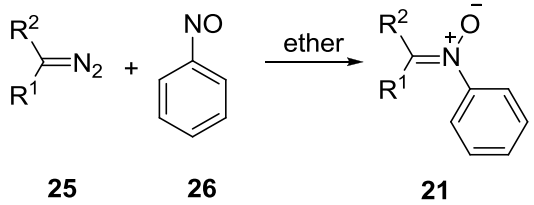
butylbenzenesulfinimidoyl chloride as a suitable oxidant for the synthesis of nitrones from various *N*,*N*-disubstituted hydroxylamines (Scheme 2.8).[57]



Scheme 2.8

2.2.2.5. Condensation of Diazo Compounds with Nitroso Arenes

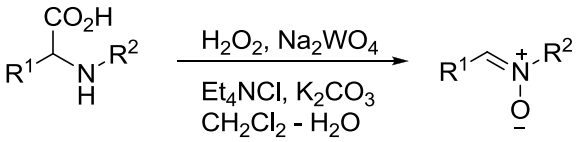
One of the successful methods for the synthesis of ketonitrones is the condensation reaction of corresponding diazo compounds with nitroso arenes (Scheme 2.9).[58] Here the reaction takes place vigorously with the evolution of nitrogen and at the end of the reaction the nitrone derivative is precipitated in appreciable yield.



Scheme 2.9

2.2.2.6. Decarboxylative Oxidation of *N*-Alkyl-α-aminoacids

Murahashi and co-workers reported a novel procedure, where nitrone was synthesized from *N*-alkyl-α-aminoacids (Scheme 2.10).[59] Tungstate-catalyzed oxidation of the aminoacid derivative was attained by the use of H_2O_2 under phase transfer conditions.



27 **28**

Scheme 2.10

In the present investigation, we employed several methods for the preparation of target nitrones. Selection of any particular method was based on availability of appropriate starting materials and reagents.

2.3. Results and Discussion

To study the 1,3-dipolar cycloaddition reaction between nitrone and electron deficient acetylenes, we synthesized a few ketonitrones and one aldonitrone (Figure 2.4) by adapting reported procedures.

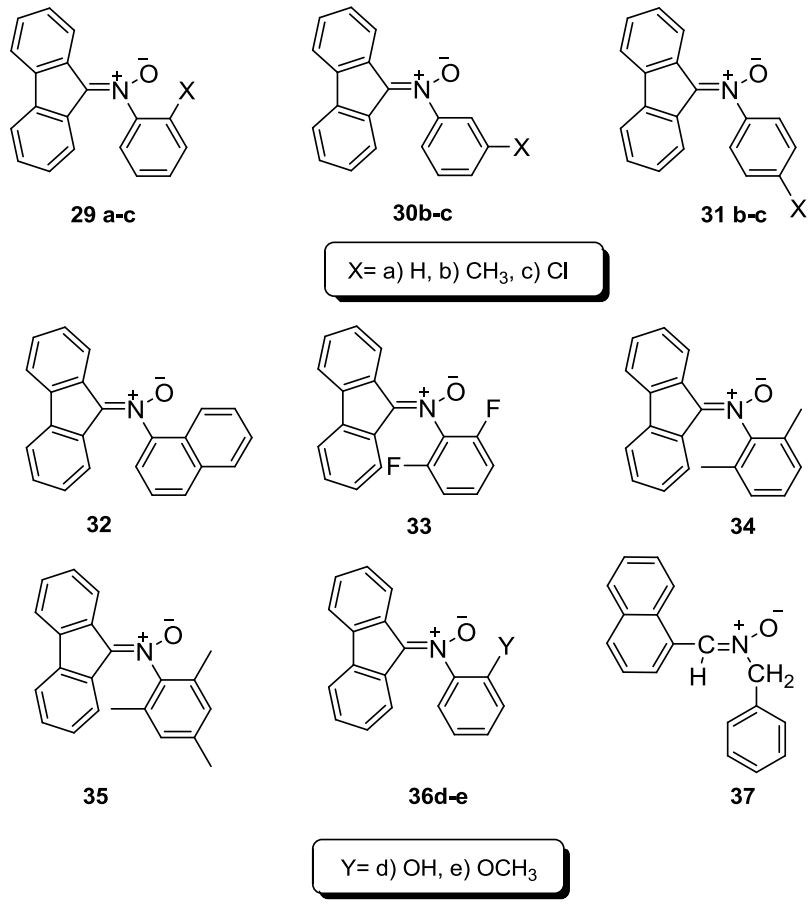
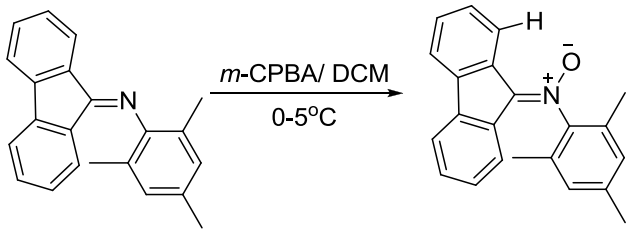


Figure 2.4

2.3.1. Synthesis of *N*-Fluorenylidene-*N*-arylnitrones [29a-b, 30b, 31b, 32, 34, 35, 36d-e.]

For the synthesis of nitrones, we oxidised the corresponding imines with *m*-CPBA. In the procedure, the required amount of *m*-CPBA in DCM was added in small portions to the solution of imines at 0-5°C. The reaction mixture was stirred for 5h. For example, in the synthesis of *N*-fluorenylidene-*N*-(2,4,6-dimethylphenyl)nitrone (**35**), fluorenylidene-*N*-(2,4,6-dimethylphenyl)imine (**38**) in DCM at 0°C was treated with *m*-

CPBA in dichloromethane (Scheme 2.11). The reaction mixture was stirred for 5h maintaining the low temperature. After the completion of the reaction, the pure nitrone derivative **35** was separated by recrystallizing the crude product from a 1:1 mixture of dichloromethane-hexane solvents.



Scheme 2.11

The synthesized nitrone **35** was identified on the basis of elemental analysis, and its structure was further confirmed from spectral data analysis. The peaks at 1540 and 1256 cm^{-1} in the IR spectrum indicated the C=N and the N→O stretching frequencies respectively, which are characteristic peaks for the nitrone group of compounds. In the ^1H NMR spectrum, H-*1* proton of the fluorene ring appeared as a multiplet at δ 9.01-8.99. The high downfield shift of the H-*1* proton is due of the presence of the negatively charged oxygen in its vicinity. The peaks at δ 6.95-6.91 (m, 1H) and at δ 5.82 (d, *J* = 8Hz, 1H) showed the H-*7* and the H-*8* protons respectively. The upfield shift of these protons compared to other aromatic protons may be due to its closeness to the shielding cone of *N*-aryl group. The methyl protons appeared at δ 2.40 (s, 3H) and at δ 2.18 (s, 6H), in the ^1H NMR spectrum (Figure 2.5).

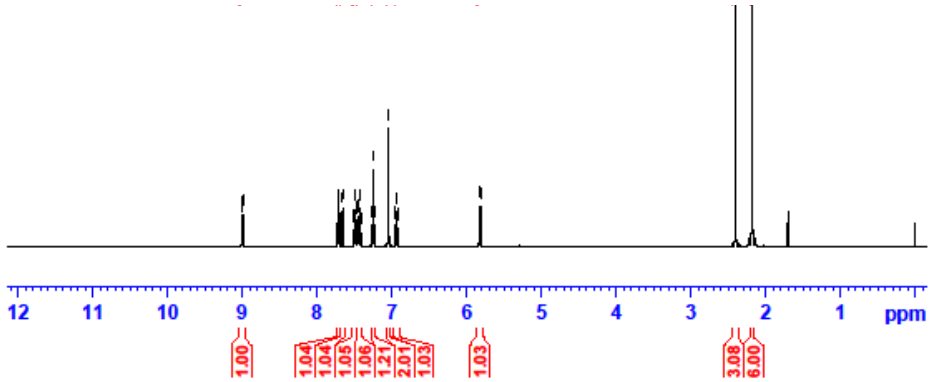


Figure 2.5 ^{1}H NMR spectrum of **35**

The ^{13}C NMR spectrum of **35** showed several signals at δ 145.76, 143.66, 139.50, 139.09, 131.90, 131.22, 131.02, 130.42, 129.87, 129.11, 128.84, 127.92, 127.18, 122.62, 120.17, 119.57, 21.26, 16.50 (Figure 2.6). Of these, the signal at δ 145.76 has been assigned to *C-9* of fluorene ring whereas the signals from δ 143.66 to 119.57 were assigned to aromatic carbons. The peak at δ 21.26 of the ^{13}C NMR spectrum showed the methyl carbon at the para position of the *N*-phenyl ring and the peak at δ 16.50 indicated the methyl carbons at the ortho positions.

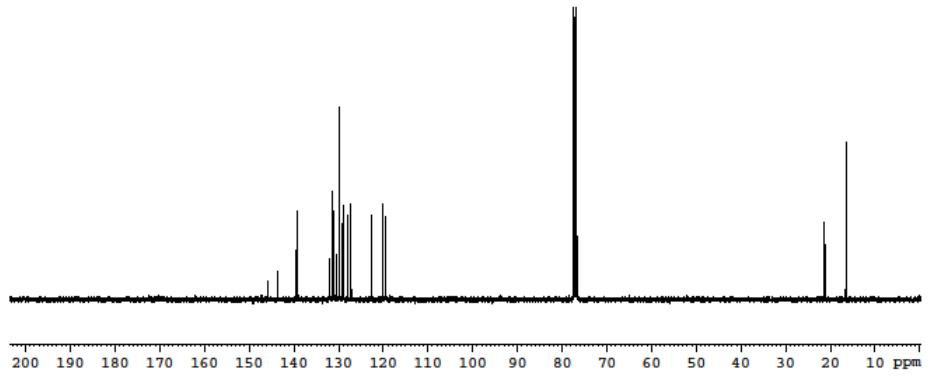
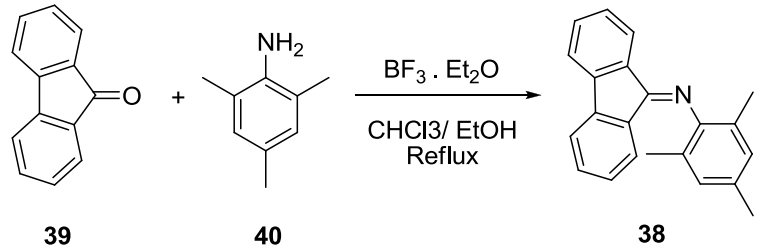


Figure 2.6 ^{13}C NMR spectrum of **35**

Imines were synthesized by the condensation of fluorenone with aryl amines in the presence of an acid catalysts such as BF_3 etherate, *p*-toluene sulphonic acid etc. For example, *N*-fluorenylidene-*N*-(2,4,6-dimethylphenyl)amine (**38**) was prepared by refluxing a mixture of fluorenone **39** and 2,4,6-trimethylaniline (**40**) in chloroform for about 15 min (Scheme 2.12). The reaction mixture was cooled and concentrated. The pure imine derivative was obtained by recrystallizing the crude product from chloroform-ethanol (1:3 ratio) solvent system.



39 **40** **38**

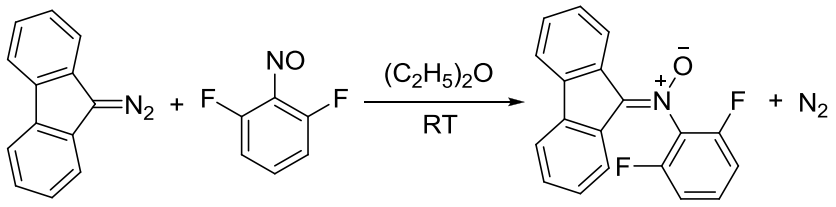
Scheme 2.12

All the imine derivatives prepared were identified by analysing the mass data and these are used as such for the oxidation step.

2.3.2. Synthesis of *N*-Fluorenylidene-*N*-arylnitrones [29 c, 30c, 31c, 33]

Condensation reaction of the corresponding nitrosoarenes with diazofluorene resulted in the formation of nitrones. In the synthesis of **33** diazofluorene (**41**) and 1,3-difluoro-2-nitrosobenzene (**42**) was reacted in diethylether (Scheme 2.13). The reaction was vigorous with nitrogen evolution and after a few minutes, the product precipitated out from the

reaction mixture. Nitrone **33** was purified by recrystallization from ethyl alcohol.



41 **42** **33**

Scheme 2.13

Structure of the nitrone **33** was arrived at on the basis of analytical and spectral data. In the IR spectrum of **33** , the peak at 1249 cm^{-1} showed the N→O stretching frequency, and peak at 1557 cm^{-1} showed presence of the C=N bond. In the ^1H NMR spectrum (Figure 2.7), the H-*1* proton of the fluorenyl ring appeared as multiplet at δ 8.96-8.94 and the H-*7* and the H-*8* protons appeared as multiplet at δ 7.00-6.95 and as doublet at δ 6.03 respectively. All other aromatic protons extended as multiplet from, δ 7.70-7.18 (m, 8H) in the ^1H NMR spectrum.

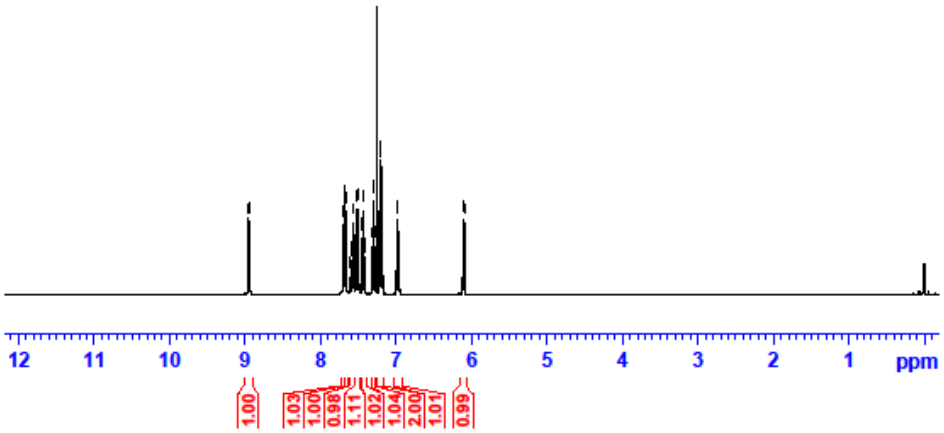


Figure 2.7 ^{1}H NMR spectrum of **33**

The ^{13}C NMR spectrum showed several signals at δ 157.09, 154.56, 139. 73, 139.36, 131.92, 131.83, 131.57, 131.47, 129.95, 129.11, 127.88, 127.62, 122.04, 120.66, 119.78, 113.31, 113.09 and all the signals were assigned to aromatic carbons (Figure 2.8).

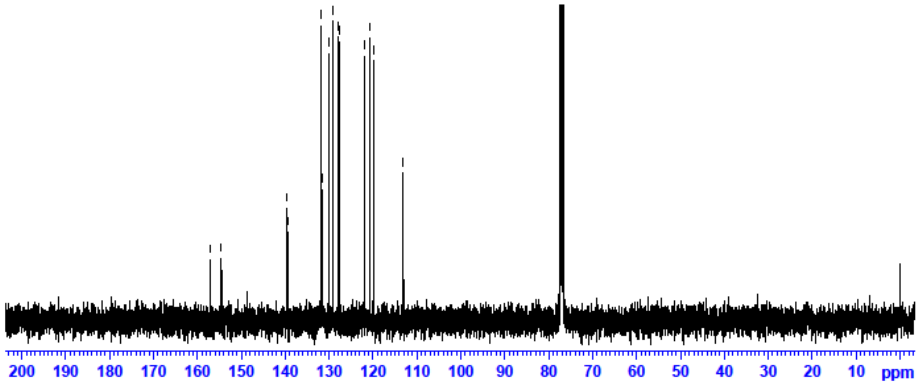
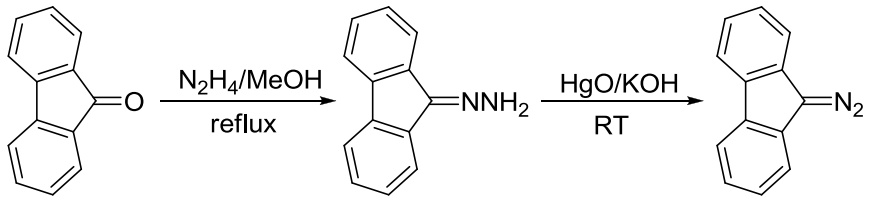


Figure 2.8 ^{13}C NMR spectrum of **33**

Diazofluorene (**41**) was synthesized by the oxidation of fluorenone hydrazone (**43**) with yellow HgO. Here, **43** was prepared by

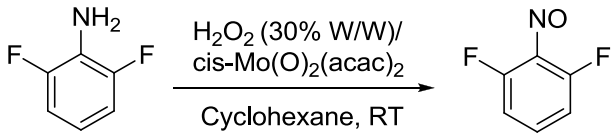
the condensation of fluorenone (**39**) with excess of hydrazine hydrate in refluxing methanol (Scheme 2.14).



39 **43** **41**

Scheme 2.14

For the synthesis of the corresponding nitroso derivatives, we adopted the procedure reported by Porta *et al*. Here 2,6-difluoroaniline (**44)** in cyclohexane was reacted with 30% H_2O_2 in presence of catalytic amount of *cis*-$Mo(O)_2(acac)_2$ at room temperature under aerobic conditions (Scheme 2.15). After 2h, the reaction mixture was filtered and concentrated to obtain the solid mass of nitroso derivative **42**.



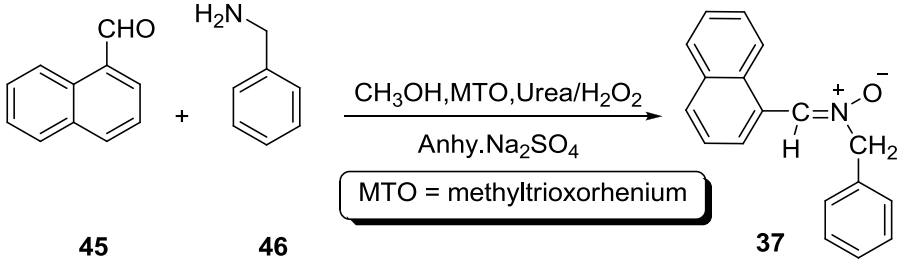
44 **42**

Scheme 2.15

Nitroso derivatives prepared were identified by analysing the mass data and these were used without any further purification for the oxidation step.

2.3.3. Synthesis of *N*-Naphthylidene-*N*-benzylnitrone [37]

Nitrone **37** was prepared by one pot reaction of 1-naphthaldehyde (**45**) with benzylamine (**46**) in presence of urea hydrogen peroxide complex and methyltrioxorhenium catalyst (Scheme 2.16).[5] The product formed was isolated by column chromatography on neutral alumina.



Scheme 2.16

Nitrone **37** obtained was analysed on the basis of analytical and spectral data. In the ^{1}H NMR spectrum (Figure 2.9), the proton attached to the α-C was indicated by the singlet at δ 8.11. The CH_2 protons were indicated by the singlet at δ 5.14 (s, 2H). The doublet at δ 9.45 (d, 1H, *J* = 6.8Hz) showed the H-*1* proton on the naphthyl ring. The presence of negatively charged oxygen near the H-*1* is responsible for its higher δ value compared to other aromatic protons. All other protons appeared as multiplet from δ 7.83-7.35 in the ^{1}H NMR spectrum.

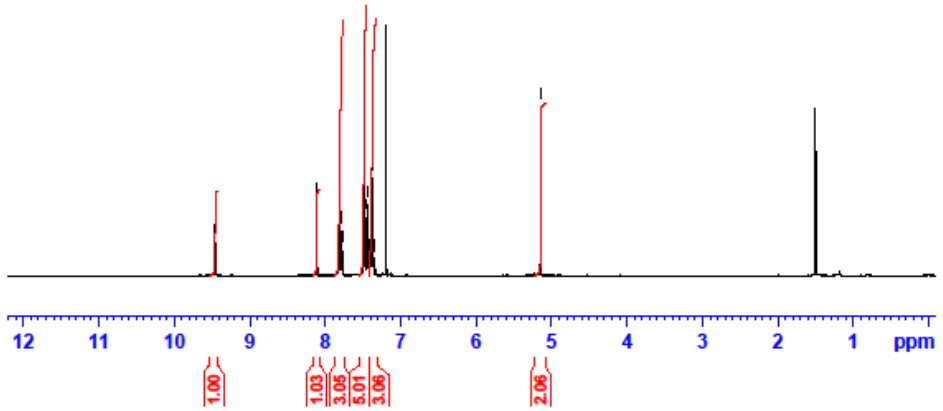


Figure 2.9 ^{1}H NMR spectrum of **37**

The $-CH_2$ carbon in the nitrone was indicated by the peak at δ 72.07 in the ^{13}C NMR spectrum (Figure 2.10). All the other carbons appeared between δ 133.48-121.52.

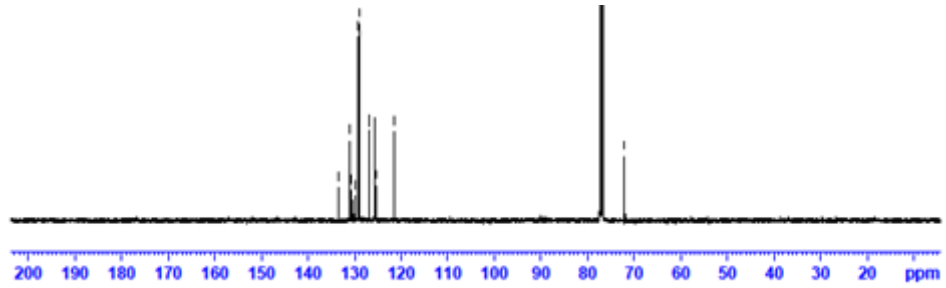


Figure 2.10 ^{13}C NMR spectrum of **37**

2.4. Experimental Section

2.4.1. General Techniques

All reactions were carried out using oven dried glasswares. All experiments were done with distilled and dried solvents by using standard protocols. All starting materials were purchased from either *Sigma-Aldrich*

or *Spectrochem Chemicals* and were used without further purification. Progress of the reaction and chromatographic separations were monitored by dried and activated silica gel TLC plates (aluminium sheets coated with silica gel, *E. Merck*) and alumina plates (TLC grade alumina coated on glass plates) Visualisation of TLC plates was accomplished by exposure to iodine vapours or UV lamp. Separation and purification of compounds were done by column chromatography using either silica gel (*Spectrochem Chemicals*, 60-120 mesh) or neutral alumina (*Spectrochem Chemicals)*. The products were further purified by recrystallization from suitable solvent systems. Solvent eluted from column chromatography was concentrated using *Heidolph* rotary evaporator. Melting points are uncorrected and were determined on a *Neolab* melting point apparatus. Infra-red spectra were recorded using *Jasco 4100* and *ABB Bomem (MB Series)* FT-IR spectrometers. The ^{1}H and ^{13}C NMR spectra were recorded at 400 MHz *Bruker Avance III* FT-NMR spectrometer with tetramethylsilane (TMS) as internal standard. Chemical shifts (δ) are reported in parts per million (ppm) downfield of TMS. Elemental analysis was performed using *Elementar Systeme (Vario EL III)*. Molecular mass was determined by electron impact (EI) method using GC-MS (*Agilent GC-7890A, Mass-5975C*) and fast atom bombardment (FAB) using *JMS 600 JEOL* mass spectrometer.

2.4.2. General Procedure for the Synthesis of *N*-Fluorenylidene-*N*-arylamines

A mixture of flurenone (10 mmol), amine (16 mmol) and BF_3-etherate (1 mL) in 30 mL $CHCl_3$ containing EtOH (5 mL) was refluxed for about 15 minutes. The resulting solution was then concentrated and cooled. The residue obtained was recrystallized from a 1:3 mixture of

chloroform-ethanol to give yellow crystals of *N*-fluorenylidene-*N*-arylamines.

2.4.3. General Procedure for the Synthesis of *N*-Fluorenylidene-*N*-arylnitrones from Imines

To a solution of imine (10 mmol) in 10 mL DCM at 0-5^{o}C, *m*-CPBA (11 mmol) in 5 mL DCM was added with stirring. The reaction mixture was then stirred for 5h keeping the low temperature. After the completion, excess *m*-CPBA was removed by filtration, and the filtrate was washed twice with Na_2CO_3 solution and finally with water. After the organic layer was evaporated, the residue obtained was recrystallized from a 1:1 mixture of DCM/hexane to give *N*-fluorenylidene-*N*-arylnitrones in good yield.

2.4.4. General Procedure for the Synthesis of Nitrosobenzenes

The catalyst *cis*-$Mo(O)_2(acac)_2$ (1 mmol) in cyclohexane (50 mL) was stirred for about 10 min at room temperature under aerobic condition. The amine (10 mmol) followed by 30% H_2O_2 (50 mmol) were added to the light orange suspension thus produced. The reaction mixture was then stirred for another one hour under aerobic condition. It was then filtered and dried over anhydrous Na_2SO_4. Filtrate was concentrated and cooled. The solid mass thus obtained was allowed to melt, so that the pure nitroso derivatives got precipitated.

2.4.5. General Procedure for the Synthesis of Nitrones from Nitrosoarenes and Diazofluorene

A mixture of diazofluorene (10 mmol) and appropriate nitrosoarenes (10 mmol) in 40 mL of dry diethyl ether was stirred for about 1h. During the course of reaction, nitrogen was evolved, red colour of the reaction mixture got vanished and yellow precipitate was formed. The precipitate formed was filtered, dried and recrystallized from ethanol to give yellow crystals of nitrone

2.4.6. Spectral and Analytical Data of Significant Compounds

2.4.6.1. Fluorenone Hydrazone (43)

Fluorenone hydrazone was prepared by a reported procedure (81% yield, mp 148 °C).[60]

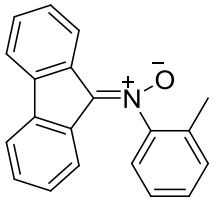
2.4.6.2. 9-Diazofluorene (41)

9-Diazofluorene was prepared by a reported procedure (85% yield, mp 94 °C).[61]

2.4.6.3. *N*-Fluorenylidene-*N*-phenylnitrone (29a)

N-Fluorenylidene-*N*-phenylnitrone was prepared by a reported procedure (85%, mp 194 °C).[58]

2.4.6.4. *N*-Fluorenylidene-*N*-(2-methylphenyl) nitrone (29b)



Yield: 83% ; **mp:** 145 °C.

IR ν_{max} (KBr): 3061cm^{-1} (=C-H stretch), 1540 cm^{-1} (C=N stretch), 1250 cm^{-1} (N→O stretch).

^{1}H NMR ($CDCl_3$): δ 8.97-8.95 (m, 1H), 7.73-7.23 (m, 9H), 5.75 (d, *J* = 8Hz, 2H), 2.28 (s, 3H).

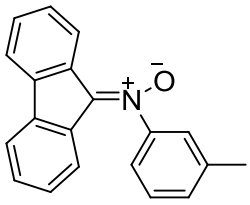
^{13}C NMR ($CDCl_3$): δ: 146.31, 139.23, 139.14, 132.04, 131.95, 131.71, 131.18, 130.59, 130.14, 129.20, 128.91, 127.77, 127.64, 127.19, 123.79, 123.20, 120.21, 119.62, 16.43.

MS: *m/z* 285 (M^+), 286 (M+1).

Elemental analysis calculated for $C_{20}H_{15}NO$:- C: 84.19, H: 5.30, N: 4.91.

Found: C: 84.26, H: 5.22, N: 4.87.

2.4.6.5. *N*-Fluorenylidene-*N*-(3-methylphenyl) nitrone (30b)



Yield: 80%; **mp:** 112 °C.

IR ν_{max} (KBr): 3050 cm^{-1} (=C-H stretch), 1540 cm^{-1} (C=N stretch), 1261 cm^{-1} (N→O stretch).

^{1}H NMR ($CDCl_3$): δ 8.92 (d, *J* = 7.2, 1H), 7.72 -7.23 (m, 9H), 6.94-6.90 (m, 1H), 5.95 (d, *J* = 8 Hz, 1H), 2.46 (s, 3H).

^{13}C NMR ($CDCl_3$): δ 140.59, 139.31, 132.42, 131.14, 131.04, 129.91, 129.11,

128.90, 127.30, 127.10, 124.26, 123.97, 120.79, 120.16, 119.60. 21.35.

MS:- *m/z* 285 (M^+), 286 (M+1).

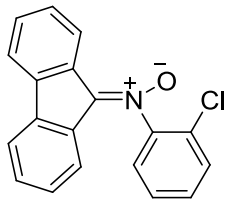
Elemental analysis calculated for $C_{20}H_{15}NO$:- C: 84.19, H: 5.30, N: 4.91.

Found: C: 84.24, H: 5.29, N: 4.94.

2.4.6.6. *N*-Fluorenylidene-*N*-(4-methylphenyl)nitrone (31b)

N-Fluorenylidene-*N*-(4-methylphenyl)nitrone was prepared by a known procedure (83% yield, mp 164 °C).[58]

2.4.6.7. *N*-Fluorenylidene-*N*-(2-chlorophenyl) nitrone (29c)



Yield: 76%; **mp:** 117 °C.

IR ν_{max} (KBr): 3061 cm^{-1} (=C-H stretch), 1548 cm^{-1} (C=N stretch), 1245 cm^{-1} (N→O stretch).

^{1}H NMR ($CDCl_3$): δ δ = 8.96-8.94 (m, 1H), 7.71 -6.90 (m, 10H), 5.82 (d, *J* = 8Hz, 1H).

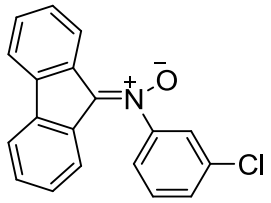
^{13}C NMR ($CDCl_3$): δ: 146.67, 144.37, 139.51, 139.36, 131.90, 131.56, 131.27, 131.23, 130.31, 129.57, 129.03, 128.70, 128.21, 127.71, 127.45, 122.90, 120.40, 119.71.

MS: *m/z* 305 (M^+), 306 (M+1).

Elemental analysis calculated for $C_{19}H_{12}ClNO$:- C: 74.64, H: 3.96, N: 4.58.

Found: C: 74.55, H: 3. 95, N: 4.55.

2.4.6.8. *N*-Fluorenylidene-*N*-(3-chlorophenyl) nitrone (30c)



Yield: 79%; **mp:** 123 °C.

IR ν_{max} (KBr): 3055 cm^{-1} (=C-H stretch), 1538 cm^{-1} (C=N stretch), 1256 cm^{-1} (N→O stretch).

^{1}H NMR ($CDCl_3$): δ 8.90-8.88 (m, 1H), 7.72 -6.93 (m, 10H), 6.01 (d, *J* = 8 Hz, 1H).

^{13}C NMR ($CDCl_3$): δ 147.67, 146.02, 139.45, 139.20, 135.81, 132.22, 131.50, 131. 26, 130.63, 130.48, 129.51, 129.01, 127.48, 127.18, 124.50, 123.74, 122.20, 120.39, 119.73.

MS:- *m/z* 305 (M^+), 306 (M+1).

Elemental analysis calculated for $C_{19}H_{12}ClNO$:- C: 74.64, H: 3.96, N: 4.58. Found: C: 74.58, H: 3.94, N: 4.56.

2.4.6.9. *N*-Fluorenylidene-*N*-(4-chlorophenyl)nitrone (31c)

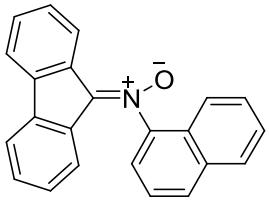
N-Fluorenylidene-*N*-(4-chlorophenyl)nitrone was synthesized by a known procedure (78%, mp 194 ^oC).[58]

2.4.6.10. *N*-Fluorenylidene-*N*-naphthylnitrone (32)

Yield: 79%; **mp:** 157 °C.

IR ν_{max} (KBr): 3050 cm^{-1} (=C-H stretch), 1536 cm^{-1} (C=N stretch), 1250 cm^{-1} (N→O stretch).

^{1}H NMR ($CDCl_3$): δ 9.091 (d, *J* = 8Hz, 1H), 7.139-7.987 (m, 12H), 6.69 (t, *J* = 8Hz, 1H),



5.52 (d, *J* = 8Hz, 1H).

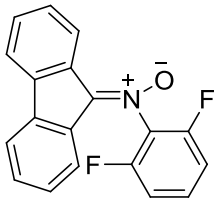
^{13}C NMR ($CDCl_3$): δ 146.84, 143.50, 139.32, 134.58, 132.25, 131.35, 130.41, 130.33, 129.12, 128.98, 128.23, 128.14, 127.44, 127.40, 126.58, 125.58, 123.72, 122.35, 121.17, 120.15, 119.68.

MS:- *m/z* 321 (M^+), 322 (M+1).

Elemental analysis calculated for $C_{23}H_{15}NO$:- C: 85.96, H: 4.70, N: 4.36.

Found: C: 85.87, H: 4.68, N: 4.35.

2.4.6.11. *N*-Fluorenylidene-*N*-(2,6-difluorophenyl)nitrone (33)



Yield: 76%; **mp:** 220 °C.

IR ν_{max} (KBr): 3056 cm^{-1} (=C-H stretch), 1557 cm^{-1} (C=N stretch), 1249 cm^{-1} (N→O stretch).

^{1}H NMR ($CDCl_3$): δ 8.96-8.94 (m, 1H), 7.70-7.18 (m, 8H), 7.00-6.95 (m, 1H), 6.10 (d, *J* = 8Hz, 1H).

^{13}C NMR ($CDCl_3$): δ 157.09, 154.56, 139.73, 139.36, 131.92, 131.83, 131.57, 131.47, 129.95, 129.11, 127.88, 127.62, 122.04, 120.66, 119.78, 113.31, 113.09.

MS:- *m/z* 307 (M^+), 308 (M+1).

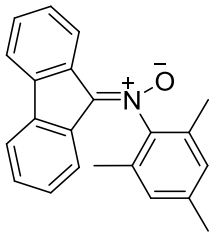
Elemental analysis calculated for $C_{19}H_{11}F_2NO$:- C: 74.26, H: 3.61, N: 4.56.

Found: C: 74.18, H: 3.57, N: 4.54.

2.4.6.12. *N*-Fluorenylidene-*N*-(2,6-dimethylphenyl)nitrone (34)

N-Fluorenylidene-*N*-(2,6-dimethylphenyl)nitrone was prepared by a known procedure (78% yield, mp 154 °C).[62]

2.4.6.13. *N*-Fluorenylidene-*N*-(2,4,6-trimethylphenyl) nitrone (35)



Yield: 79%; **mp:** 213 °C.

IR ν_{max} (KBr): 3055 cm^{-1} (=C-H stretch), 1540 cm^{-1} (C=N stretch), 1256 cm^{-1} (N→O stretch).

^{1}H NMR ($CDCl_3$): δ 9.01-8.99 (m, 1H), 7.72-7.04 (m, 7H), 6.95-6.91 (m, 1H), 5.82 (d, *J* = 8Hz, 1H), 2.40 (s, 3H), 2.18 (s, 6H).

^{13}C NMR ($CDCl_3$): δ 145.76, 143.66, 139.50, 139.09, 131.90, 131.22, 131.02, 130.42, 129.87, 129.11, 128.84, 127.92, 127.18, 122.62, 120.17, 119.57, 21.26, 16.50.

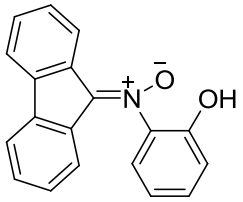
MS:- *m/z* 313 (M^+), 314 (M+1).

Elemental analysis calculated for $C_{22}H_{19}NO$:- C: 84.31, H: 6.11, N: 4.47. Found: C: 84.29, H: 6.09, N: 4.46.

2.4.6.14. *N*-Fluorenylidene-*N*-(2-hydroxyphenyl)nitrone (36d)

Yield: 72%; **mp:** 160 °C.

IR ν_{max} (KBr): 3057 cm^{-1} (=C-H stretch), 1558 cm^{-1} (C=N stretch), 1251 cm^{-1} (N→O stretch).



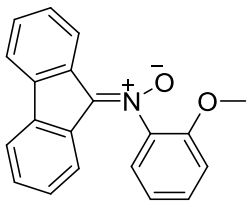
^{1}H NMR ($CDCl_3$): δ 8.92-8.89 (m, 1H), 7.69-6.95 (m, 11H), 6.63 (d, *J* = 8Hz, 1H).

^{13}C NMR ($CDCl_3$): δ 161.04, 152.25, 147.53 140.02, 139.92, 132.82, 132.67, 132.29, 132.11, 130.38, 130.34, 128.98, 127.96, 127.57, 125.12, 124.71, 120.35, 119.83, 119.75, 119.48.

MS:- *m/z* 287 (M^+), 288 (M+1).

Elemental analysis calculated for $C_{19}H_{13}NO_2$:- C: 79.43, H: 4.56, N: 4.88. Found: C: 79.39, H: 4.55, N: 4.85.

2.4.6.15. *N*-Fluorenylidene-*N*-(2-methoxyphenyl)nitrone (36e)



Yield: 80%; **mp:** 134 °C.

IR ν_{max} (KBr): 3056 cm^{-1} (=C-H stretch), 1548 cm^{-1} (C=N stretch), 1266 cm^{-1} (N→O stretch).

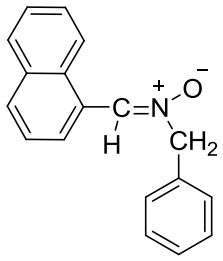
^{1}H NMR ($CDCl_3$): δ 8.99-8.96 (m, 1H), 6.89 (m, 10H), 5.94 (d, *J* = 7.6 Hz, 1H), 3.79 (s, 3H).

^{13}C NMR ($CDCl_3$): δ 152.10, 139.32, 139.15, 136.16, 132.27, 131.46, 131.14, 130.84, 129.13, 128.90, 127.49, 127.40, 125.30, 123.13, 121.61, 120.17, 119.52, 113.05, 56.12.

MS:- *m/z* 301 (M^+), 302 (M+1).

Elemental analysis calculated for $C_{20}H_{15}NO_2$:- C: 79.72, H: 5.02, N: 4.65. Found: C: 79.69, H: 5.01, N: 4.62.

2.4.6.16. *N*-Naphthylidene-*N*-benzyl nitrone (37)



Yield: 77%; **mp:** 82°C.

IR ν_{max} (KBr): 3056 cm^{-1} (=C-H stretch), 1572 cm^{-1} (C=N stretch), 1268 cm^{-1} (N→O stretch).

^{1}H NMR ($CDCl_3$): δ 9.45 (d, *J* = 6.8Hz, 1H), 8.11 (s, 1H), 7.83-7.77 (m, 3H), 7.49-7.35 (m, 8H), 5.14 (s, 2H).

^{13}C NMR ($CDCl_3$): δ 133.48, 133.40, 130.97, 130.63, 129.96, 129.31, 129.29, 129.09, 126.86, 126.83, 125.81, 125.75, 125.41, 121.52, 72.07.

MS:- *m/z* 261 (M^+), 262 (M+1).

Elemental analysis calculated for $C_{18}H_{15}NO_2$:- C: 82.73, H: 5.79, N: 5.36.

Found: C: 82.67, H: 5.76, N: 5.34.

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