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Review JoMCCT

Synthesis, Characterization of New Imidazolidin-4-One Containing Azo Compound Derived from Acetylacetone as Antibacterial and Antioxidant Agents

Hanan Faleh Mohsein[1,*]

Abstract

In the present study, new derivatives of imidazolidine-4-one was prepared. Which involved reactions to diazonium salt of o-methoxy aniline with acetylacetone in the presence of sodium hydroxide, and isolating the azo compound as a brown precipitate. The azo diketone reacts efficiently with aromatic amine derivatives to produce Schiff bases as light yellow and dark brown precipitates, and from this Schiff bases three derivatives of imidazolidine-4-one was prepared by reacting with three types of amino acids. The physiochemical properties of synthesized derivatives include melting point, color, and yield were determined, and the synthesized derivatives were characterized using infrared spectroscopy (FT-IR), (^{1}H-NMR) and (^{13}C-NMR) Nuclear magnetic resonance and their purity was confirmed by thin layer chromatography., Azo compounds have numerous applications in spectroscopic analysis, and their complexes with metal ions in aqueous and organic solutions are called spectroscopic reagents in clinical and pharmaceutical chemistry, food products, and as inhibitors of bacterial growth, such as E. coli causing gout and bacteria causing chronic bowel diseases. The Compounds containing an azomethine group (-CH=N) which form by the condensation of an active carbonyl compound with primary amine are known Schiff bases. The reaction is reversible and removes water to drive the reaction into completion to gain a good product. When Schiff bases derived from aromatic aldehydes and aromatic amines have a broad assortment of applications in many fields like biological, analytical and inorganic chemistry. Aromatic cycles are valued artificial prototypes for the realization of different structures with individual natal, treatment and quantifiable assets. These compounds were evaluated as antibacterial activity against Acinetobacter baumannii and Staphylococcus aureus and antioxidant activity.

Keywords: Azo compound, Schiff base, Imidazolidin-4-one, Antibacterial agents, Aromatic cycles

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INTRODUCTION

Amino acids or (A. As) are better known as the nutritive substrates for protein synthesis; in addition, they can also involvement as bioactive molecules in nutrition metabolism [1]. food derived peptides and amino acids, generated after the hydrolysis of protein, are known to act several regulatory activities like anticancer, antihypertensive, anti-diabetic, anti-microbial and anti-oxidative. Thus, these molecules represent a great benefit for the evolution of biopharmaceutical, nutraceutical and functional food industries [2]. Researchers have increasingly focused on organic azo reagents, particularly in recent times, due to

their important properties, including high stability resulting from resonance and the presence of the N=N double bond between the two nitrogen atoms. They also exhibit rapid reaction with metal ions and high sensitivity and selectivity [3-5]. Imidazole azo compounds are of great importance in all branches of chemistry, such as extraction, adsorption, and the colorimetric determination of metallic elements [6,7]. Due to their high chemical activity, imidazole azo reagents are used in clinical and pharmaceutical chemistry, such as the reagent BIAMB, which is used to inhibit a type of true fungus [8, 9], also in industrial applications [10-12]. Aromatic heterocycles are valuable synthetic templates for the formation of new compounds with specific biological, pharmaceutical and material properties [13], in addition to small fused heterocyclic molecules acting as highly functionalized scaffolding and are recognized "pharmacophores" of a number of medicinally and biologically active useful molecules [14,15]. The imidazole ring or (1,3-diaza-2,4-cyclopentadiene) with the formula $C_3H_4N_2$is a planar, five heterocyclic aromatic molecules with "3"atoms of C and "2"atoms of N in the positions 1 and 3, it is classified as alkaloid [16-18]. This ring is a component of many important natural products, like nucleic acid and purine [19]. The imidazole ring has remarkable significance in medicine, pharmacy and biology. Besides this, it is also reported that imidazole compounds are one of the effective antifungal agents [20-24].

MATERIAL AND METHODS

All reactants and solvents used in this study are available from Sigma Aldrich and Fluka companies. Melting points were determined on the electro-thermal capillary apparatus, FT-IR spectra were recorded on a Shimadzu 8400S spectrophotometer in the (4000-400) cm^{-1} range using KBr discs. The ^{1}HNMR and ^{13}CNMR spectrum were recorded on Bruker 300 MHz spectrophotometer in DMSO-d6 using (TMS) as internal reference.

General procedure for synthesis of Azo Compound (O)

The azo derivative was prepared by dissolving *o*-methoxy aniline (1 mmole) in (2 ml) of concentrated hydrochloric acid and (20 ml) of distilled water. Cool the solution at (0 – 5) °C using an ice-water bath. Then sodium nitrite solution was prepared by dissolving (1 mmole) in (10 ml) of distilled water and it was then added drop wise to the first solution with stirring. Then a solution of acetyl acetone was prepared by dissolving (1 mmole) in (20 ml) of ethanol and (5 ml) of (10 %) sodium hydroxide and cooled to (0 – 5)$_o$C ,The two solutions were mixed by adding the diazonium solution in drop wise and stirring at (0 – 5)$_o$C for 2 hours for obtaining the coupling agent. The result compound was precipitated, filtered and washed well with ethanol.

Compound (O) (*E)-3-(2-methoxyphenyl) diazinyl) pentane-2,4-dione*

Brown powder, yield 85.6%, m.p:134-136°C: The characteristic bands in FT-IR spectrum in cm^{-1}:

(1685) C=O stretching vibration band, (1581) C=C stretching vibration band of aromatic ring, (1435) N=N stretching vibration band of azo group.

^{1}H-NMR (300MHz, DMSO-d_6) in ppm: 3.88 (s,3H, OCH_3); 2.52 (s,3H, CO-CH_3); 3.48 (s,1H, CH-N=N); 6.43-8.16 (m,4H, aromatic).

^{13}C-NMR (75MHz, DMSO-d_6) in ppm: 25.79 (C, $COCH_3$) ,59.68 (C, OCH_3); 95.39 (CH-N=N-);111.33-144.61(C, aromatic ring),190.36 (C, C=O).

General procedure for synthesis of Schiff base Compounds (O_1&O_2)

(5 mmol.) of the Azo compound The record in the first step in 30 mL of ethanol and then add (10 mmol.) of 2-amino pyrimidine and 2-amino benzothiazole dissolved in (20) mL ethanol absolute and (2-3) drops of the acetic acid ethanol and then taken in around bottom flask and stir the mixture for 20 minutes and then the reaction mixture was refluxed for (12h) and then it was cooled to room temperature. Solid obtained was separated and wash with ethanol absolute.

Compound (O1) (*2E,4E)-3-((E)-(2-methoxyphenyl) diazinyl)-N2, N4-di(pyrimidin-2-yl) pentane-2,4-diimine*

Light yellow powder, yield 80.3%, m.p:153-155°C. The characteristic bands in FT-IR spectrum in cm^{-1}:

(1625) C=N stretching vibration band, (1600) C=C stretching vibration band of aromatic ring, (1433) N=N stretching vibration band of azo group.

^{1}H-NMR (300MHz, DMSO-d_6) in ppm: 4.92 (s,3H, OCH_3); 2.41 (s,3H, CO-CH_3); 3.47 (s,1H, CH-N=N); 6.92-8.77 (m,4H, aromatic).

^{13}C-NMR (75MHz, DMSO-d_6) in ppm: 19.86 (C, $COCH_3$); 58.67(C, OCH_3); 92.27 (CH-N=N-);112.73-159.83(C, aromatic ring),184.87 (C, C=N).

Compound (O2) *(2E,4E)-N2, N4-bis(benzo[d]thiazol-2-yl)-3-((E)-(2-methoxyphenyl) diazinyl) pentane-2,4-diimine*

Dark brown powder, yield 78.9%, m.p:196-198°C: The characteristic bands in FT-IR spectrum in cm^{-1}:

(1627) C=N stretching vibration band, (1595) C=C stretching vibration band of aromatic ring, (1485) N=N stretching vibration band of azo group.

^{1}H-NMR (300MHz, DMSO-d_6) in ppm: 3.91 (s,3H, OCH_3); 2.52 (s,3H, CO-CH_3); 3.41 (s,1H, CH-N=N); 6.34-8.05 (m,4H, aromatic).

^{13}C-NMR (75MHz, DMSO-d_6) in ppm: 20.01 (C, $COCH_3$); 58.70(C, OCH_3); 93.20 (CH-N=N-);112.10-155.52(C, aromatic ring),163.79-167.86 (C, C=N).

General procedure for synthesis of Imidazolidine derivatives (O_{11}, O_{12}, O_{13}, O_{21}, O_{22}, O_{23})

A mixture of compounds O_1, O_2 (5 mmol.) and appropriate α-amino acid, namely Tyrosine, Cysteine and Phenylalanine (10 mmol.) in (15 ml) T.H.F. was refluxed for 24h. The mixture was poured into ice water. The precipitate obtained was filtered and recrystallized from ethanol and T.H.F (1:3) to give compounds.

Compound (O_{11}) (E)-2,2'-(((2-methoxyphenyl) diazinyl) methylene) bis(3-(benzo[d]thiazol-2-yl)-5-(mercaptomethyl)-2-methylimidazolidin-one)

Light brown powder, yield 66.72%, m.p:163-165°C. The characteristic bands in FT-IR spectrum in cm^{-1}:

(1680) C=O Lactame stretching vibration band, (1610) C=N stretching vibration band of pyrimidine ring, (1595) C=C stretching vibration band of aromatic ring, (1450) N=N stretching vibration band of azo group, (3309) NH imidazolidine ring.

^{1}H-NMR (300MHz, DMSO-d_6) in ppm: 3.99 (s,1H, Imidazole ring); 3.52 (s,3H, OCH_3); 3.94 (s,1H, CH-N=N); 2.42(s,3H, CH_3); 2.49(t,2H, CH_2SH); 7.08-8.81 (m,4H, aromatic); 6.96 (s,1H, NH), 14.55 (s,1H, SH).

^{13}C-NMR (75MHz, D MSO-d_6) in ppm: 31.68 (C, CH_2SH); 26.92 (C, CH_3) 56.65(C, OCH_3); 61.72(C, CH imidazole ring), 72.09(C, C-N imidazole ring) 83.63(CH-N=N-);112.43-134.05(C, aromatic ring), 148.42(C, C=N), 196.72 (C, C=O).

Compound (O_{12}) (E)-2,2'-(((2-methoxyphenyl) diazinyl) methylene) bis(5-benzyl-2-methyl-3-(pyrimidin-2-yl) imidazolidin-4-one)

Yellow powder, yield 69.2%, m.p:112-113°C. The characteristic bands in FT-IR spectrum in cm^{-1}:

(1673) C=O Lactame stretching vibration band, (1612) C=N stretching vibration band of pyrimidine ring, (1598) C=C stretching vibration band of aromatic ring, (1445) N=N stretching vibration band of azo group, (3294) NH imidazolidine ring.

^{1}H-NMR (300MHz, DMSO-d_6) in ppm: 3.08 (s,1H, CH imidazole ring); 3.68 (s,3H, OCH_3); 3.98 (s,1H, CH-N=N); 1.28(s,3H, CH_3); 2.62(t,2H, CH_2ph); 6.45-8.15 (m,4H, aromatic); 6.34 (s,1H, NH).

^{13}C-NMR (75MHz, DMSO-d_6) in ppm: 58.88 (C, CH_2ph); 25.79 (C, CH_3) 72.32(C, OCH_3); 80.16(C, CH imidazole ring), 91.26 (CH-N=N-);111.33-144.61(C, aromatic ring), 154.68(C, C=N), 190.36 (C, C=O).

Compound (O_{13}) (E)-2,2'-(((2-methoxyphenyl) diazinyl) methylene) bis(5-(4-hydroxybenzyl)-2-methyl-3-(pyrimidin-2-yl) imidazolidin-4-one)

Orange powder, yield 59.3%, m.p:140-1143°C. The characteristic bands in FT-IR spectrum in cm^{-1}:

(1682) C=O Lactame stretching vibration band, (1618) C=N stretching vibration band of pyrimidine ring, (1592) C=C stretching vibration band of aromatic ring, (1437) N=N stretching vibration band of azo group, (3402) ph-OH stretching vibration band of OH group; (3357) NH imidazolidine ring.

^{1}H-NMR (300MHz, DMSO-d_6) in ppm: 3.93 (s,3H, CO-CH-NH); 3.50 (s,1H, CH-N=N); 7.09-8.47 (m,4H, aromatic); 6.61 (s,1H, NH imdazolidine);10.41(s,1H, OH).

^{13}C-NMR (75MHz, DMSO-d_6) in ppm: 31.61 (C, CH_2ph); 26.89 (C, CH_3) 56.65(C, OCH_3); 80.48(C, CH imidazole ring), 96.18 (CH-N=N-);112.46-134.07(C, aromatic ring), 148.48(C, C=N), 196.77 (C, C=O).

Compound (O_{21}) (E)-2,2'-(((2-methoxyphenyl) diazinyl) methylene) bis(3-(benzo[d]thiazol-2-yl)-5-(mercaptomethyl)-2-methylimidazolidin-4-one)

Yellow powder, yield 70.22%, m.p:200-202°C: The characteristic bands in FT-IR spectrum in cm^{-1}:

(1690) C=O Lactame stretching vibration band, (1620) C=N stretching vibration band of benzimidazole, (1602) C=C stretching vibration band of aromatic ring (1440) N=N stretching vibration band of azo group, (2610) stretching vibration band of SH group , (3259) NH imidazolidine ring.

^{1}H-NMR (300MHz, DMSO-d_6) in ppm: 3.45 (s,3H, OCH_3); 4.49 (s,1H, CO-CH-NH); 3.94 (s,1H, CH-N=N); 6.60 (s,1H, NH imdazolidine); 7.06-8.07 (m,4H, aromatic); 14.55 (s,1H, SH).

^{13}C-NMR (75MHz, DMSO-d_6) in ppm: 31.68 (C, CH_2SH); 26.92 (C, CH_3) 56.65(C, OCH_3); 77.23(C, C-N imidazole ring) 92.70 (CH-N=N-);112.43-112.43-134.04 (C, aromatic ring), 148.42 (C, C=N)., 197.14 (C, C=O).

Compound (O_{22}) (E)-2,2'-(((2-methoxyphenyl) diazinyl) methylene) bis(3-(benzo[d]thiazol-2-yl)-5-benzyl-2-methylimidazolidin-4-one)

Dark orange powder, yield 67.8%, m.p:186-188°C: The characteristic bands in FT-IR spectrum in cm^{-1}:

(1678) C=O Lactame stretching vibration band, (1600) C=N stretching vibration band of benzimidazole, (1580) C=C stretching vibration band of aromatic ring, (1420) N=N stretching vibration band of azo group; (3330) NH imidazolidine ring.

[1]H-NMR (300MHz, DMSO-d6) in ppm: 3.47 (s,3H, OCH_3); 4.45 (s,3H, CO-CH-$NH_)$; 3.05 (s,1H, CH-N=N); 2.41(s,2H, CH_2-ph); 6.81 (s,1H, NH imdazolidine); 7.68-7.88 (m,4H, aromatic).

[13]C-NMR (75MHz, DMSO-d6) in ppm: 59.59 (C, CH_2ph); 25.79 (C, CH_3) 67.86(C, OCH_3); 75.31(C, CH imidazole ring), 111.33-144.61(C, aromatic rig), 154.68(C, C=N), 190.36 (C, C=O).

Compound (O_{23}) (E)-2,2'-(((2-methoxyphenyl) diazinyl) methylene) bis(3-(benzo[d]thiazol-2-yl)-5-(4-hydroxybenzyl)-2-methylimidazolidin-4-one)

Light yellow powder, yield 77.5%, m.p:222-223°C. The characteristic bands in FT-IR spectrum in cm^{-1}:

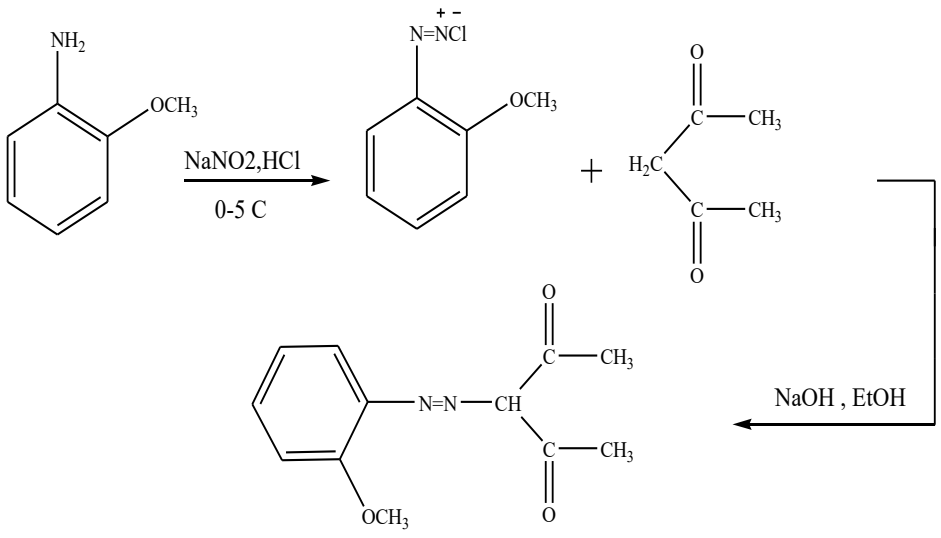
(1666) C=O Lactame stretching vibration band, (1597) C=N stretching vibration band of benzimidazole, (1502) C=C stretching vibration band of aromatic ring (1400) N=N stretching vibration band of azo group, (3310) ph-OH stretching vibration band of OH group; (3250) NH imidazolidine ring.

[1]H-NMR (300MHz, DMSO-d6) in ppm: 3.41 (s,3H, OCH_3); 4.42 (s,1H, CO-CH-NH); 3.91 (s,1H, CH-N=N);2.1(s,2H, CH_2-ph); 6.36 (s,1H, NH imdazolidine);6.72-7.42 (m,12H, aromatic); 11.08 (s,1H, OH).

[13]C-NMR (75MHz, DMSO-d6) in ppm: 32.23 (C, CH_2ph); 25.70 (C, CH_3) 56.85(C, OCH_3); 61.31(C, CH imidazole ring), 72.44 (CH-N=N-);112.07-148.77(C, aromatic ring), 165.11(C, C=N), 192.14 (C, C=O)., All data in Figure 1- 21.

RESULT AND DISCUSSION

A current study, various of Imidazolidine derivatives were synthesized, then studied via spectral characterization like FT.IR-Spectra, 1H-NMR Spectra and 13C-NMR Spectra for some of them, other studies represented by (Melting points, Antibacterial, Antioxidant) All the results explained in Table 1 and figures 22-24.



(*E*)-3-((2-methoxyphenyl)diazenyl)pentane-2,4-dione

[O]

Figure 1. Preparation of Azo Compound (O).

Spectral Investigation

The Azo compound (O) was identified by the appearance of stretching band of azo group at (1435) cm-1 and stretching band of a carbonyl group in (1685) cm-1 and (C=C)aromatic (1581) cm-1, and stretching band of (C-H)aliphatic at(2937) cm-1 .1HNMR spectrum for (O) characteristic signal at ppm: (s,1H,N=N)δ 3.48 ,(s,3H,CO-CH_3) δ 2.52 ,(m H for benzene ring) (δ 6.43-8.16) and (s,3H, OCH_3) δ 3.88 .13C-NMR spectrum for (O) characteristic signals at ppm: C (CH-N=N) 95.39,C (Aromatic rings)111.33-144.61, C(C=O) 190.36 , DMSO (solvent) 40.04.

This research uses new derivative of Azo compound to prepare Schiff bases derivatives (O1,O2) were reacted with 2-aminopyrimidine and 2-aminobenzothiazole as well as disappearance carbonyl group and the imine group (-C=N) appeared in the range (1600-1595cm-1) respectively. While the compounds were determined using 1H-NMR . There was a signal at δ 3.47-3.41 ppm of the (1H-CH-N=N) . 13C-NMR spectrum for (O1,O2) characteristic signals at ppm: C (C=N) 184.87-167.86 , C (CH-N=N) 92.27-93.20 , (C,OCH3) at 58.67-58.70 while a signal from the solvent employed (DMSO) appeared at the site (40 ppm).Imidazolidine derivatives (O_{11},O_{12},O_{13},O_{21},O_{22},O_{23}) prepare were reacted the Schiff bases with different amino acids as well as the lactame group (-N-C=O) is appeared in the range (1766-1700cm-1) while lactame group (-N-C=O) is appeared in the range (1690-1663 cm-1) , While the compounds were determined using 1H-NMR . There were signals at ppm: δ3.98-3.05 (s,1H,CH-N=N) , 6.91-6.34 (s,1H,NH). 13C-NMR spectrum for (O_{11},O_{12},O_{13},O_{21},O_{22},O_{23}) characteristic signals at ppm: (197.14-190.36) (C,C=O) lactame, 40.04 DMSO (solvent).

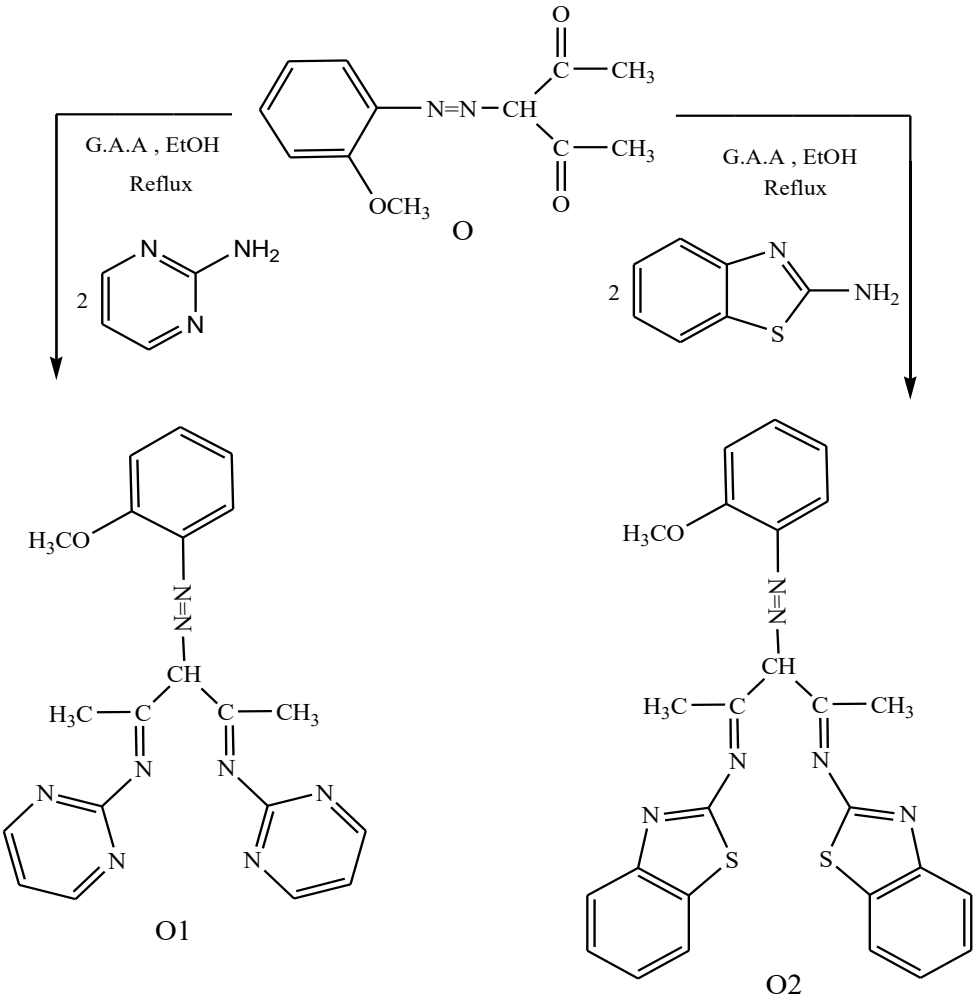


Figure 2. Preparation of Schiff base derivatives O_1&O_2

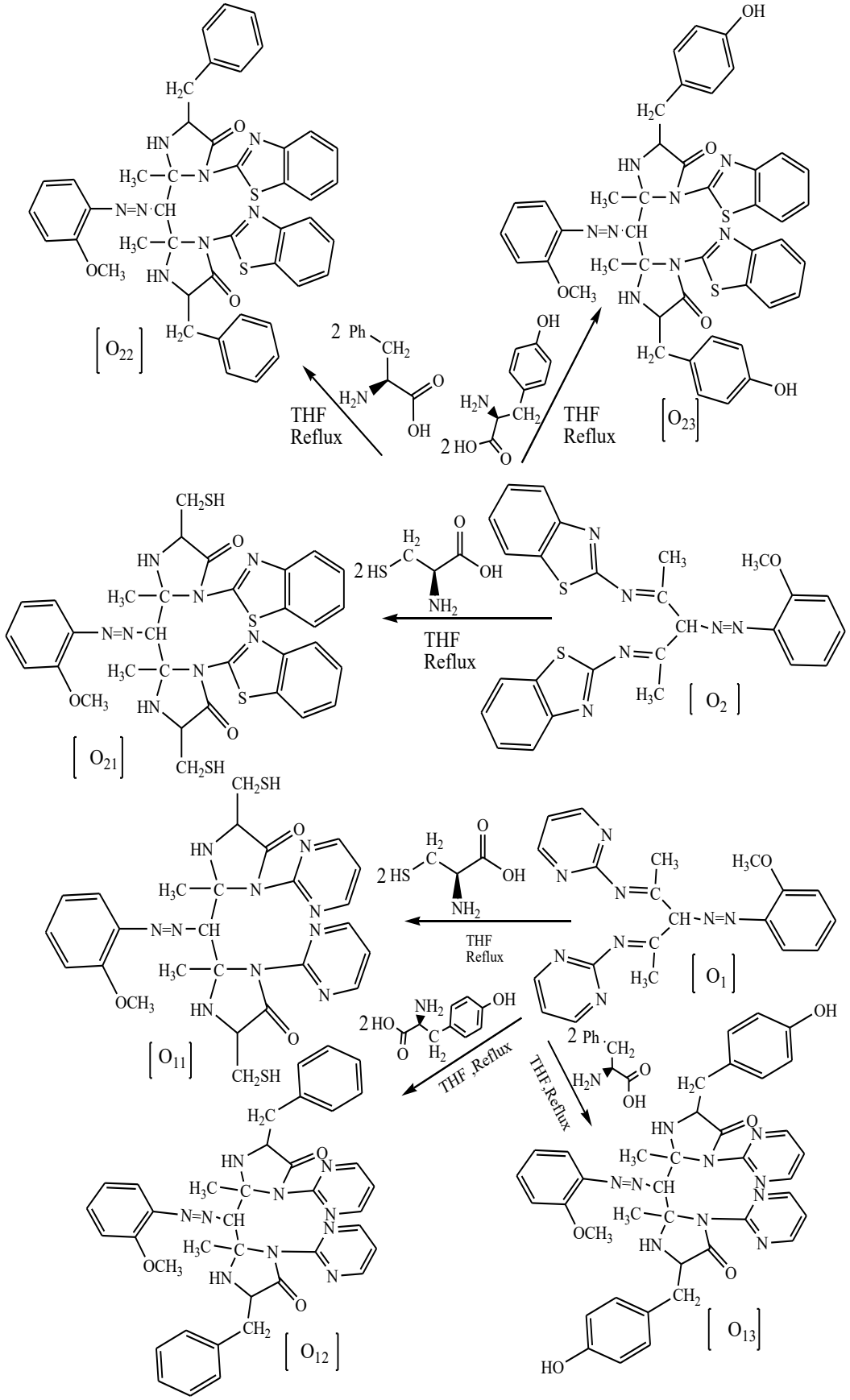


Figure 3. Preparation of Imidazolidine derivatives (O_{11}, O_{12}, O_{13}, O_{21}, O_{22}, O_{23})

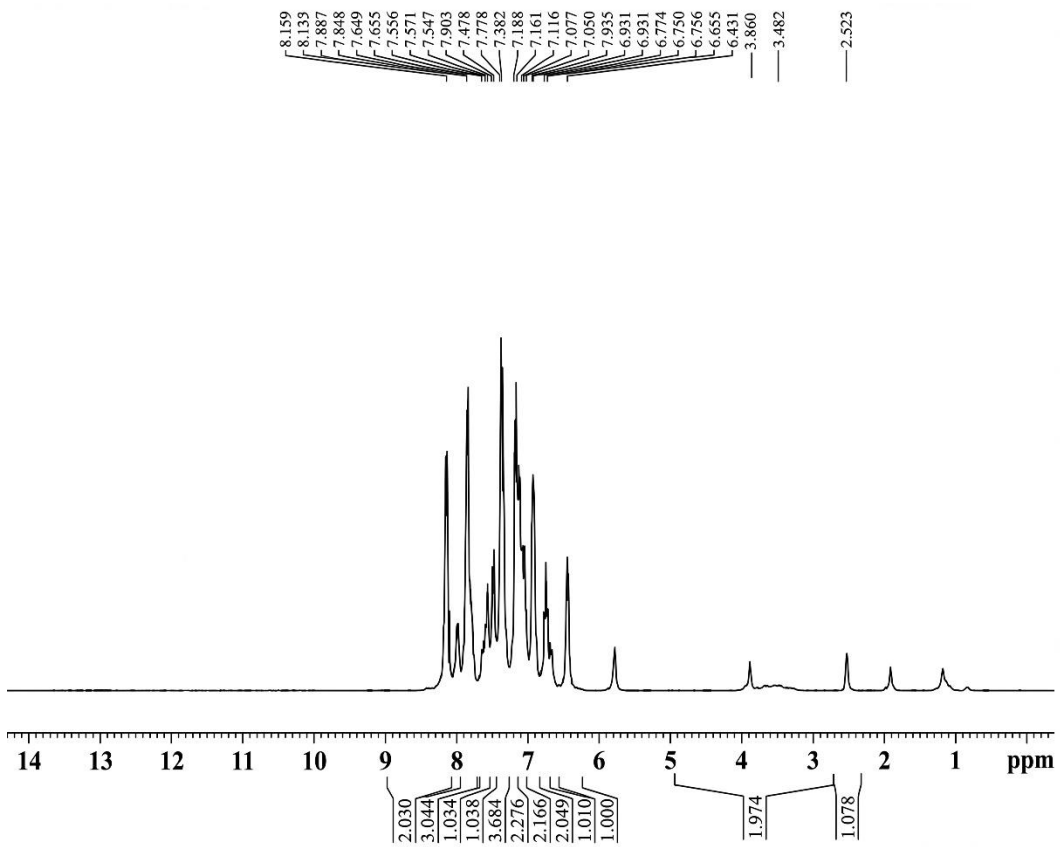


Figure 4. ^{1}H-NMR of Comp. O.

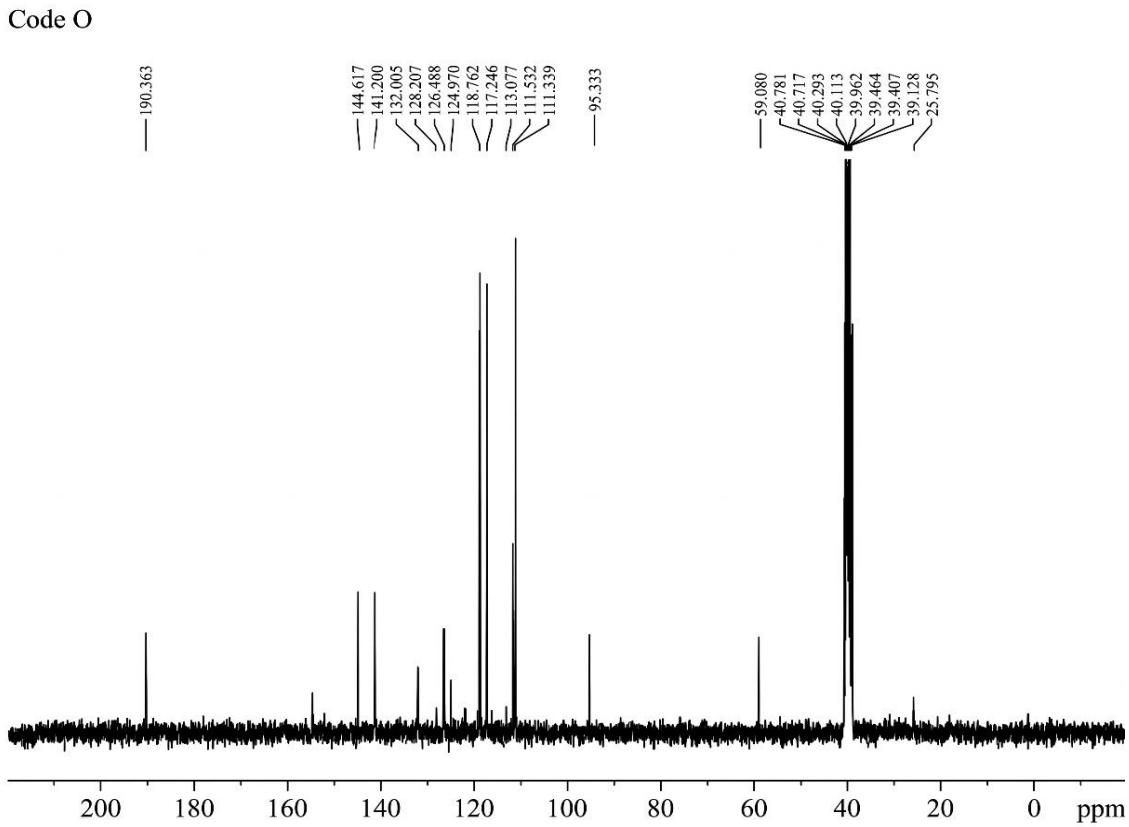


Figure 5. ^{13}C-NMR of Comp. O.

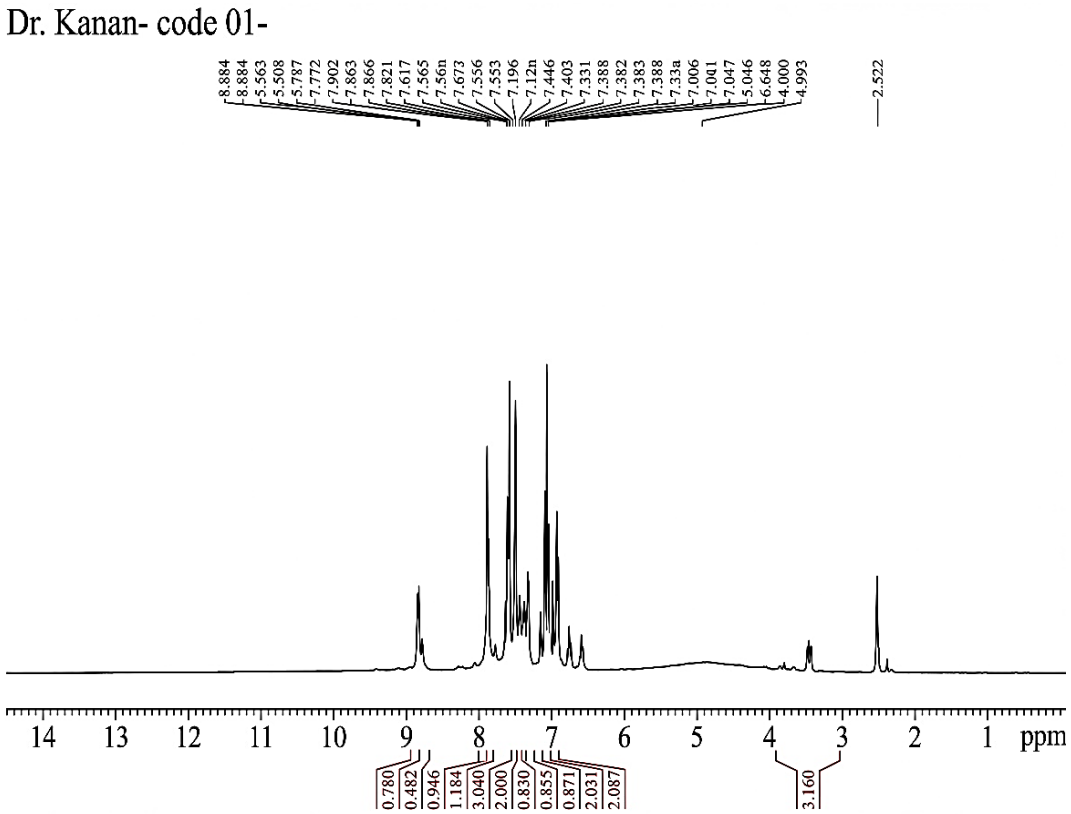


Figure 6. ^{1}H-NMR of Comp. O_1

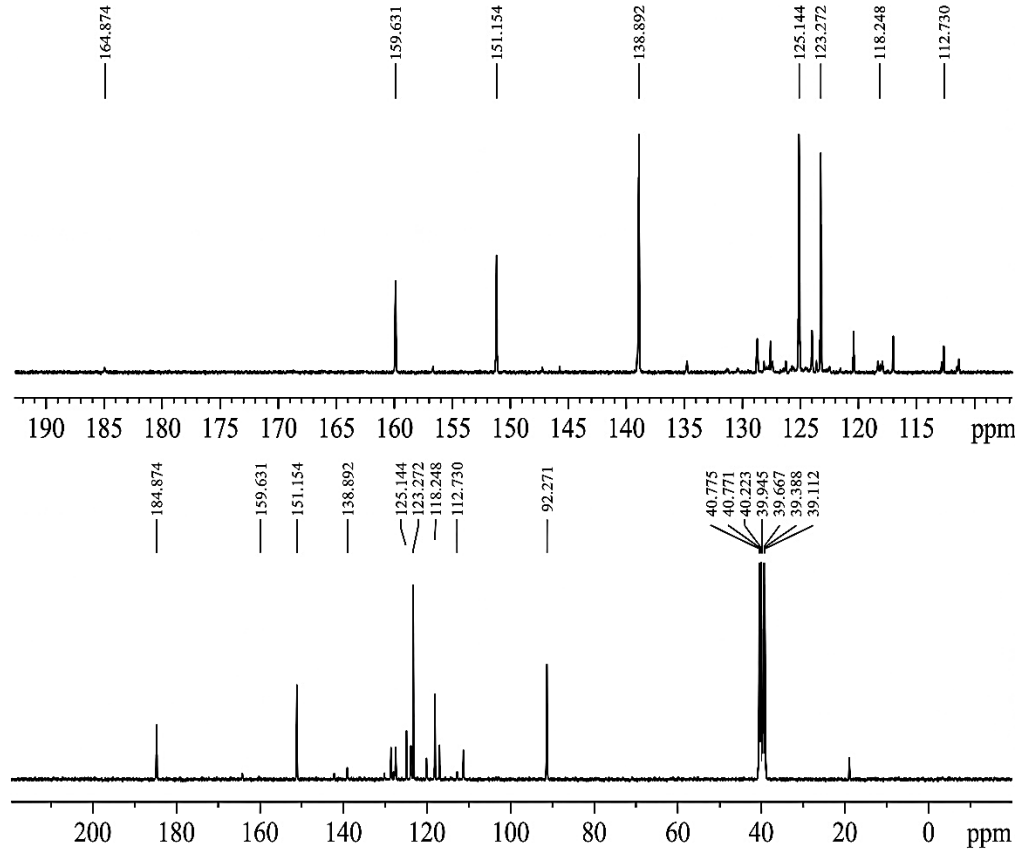


Figure 7. ^{13}C-NMR of Comp. O_1.

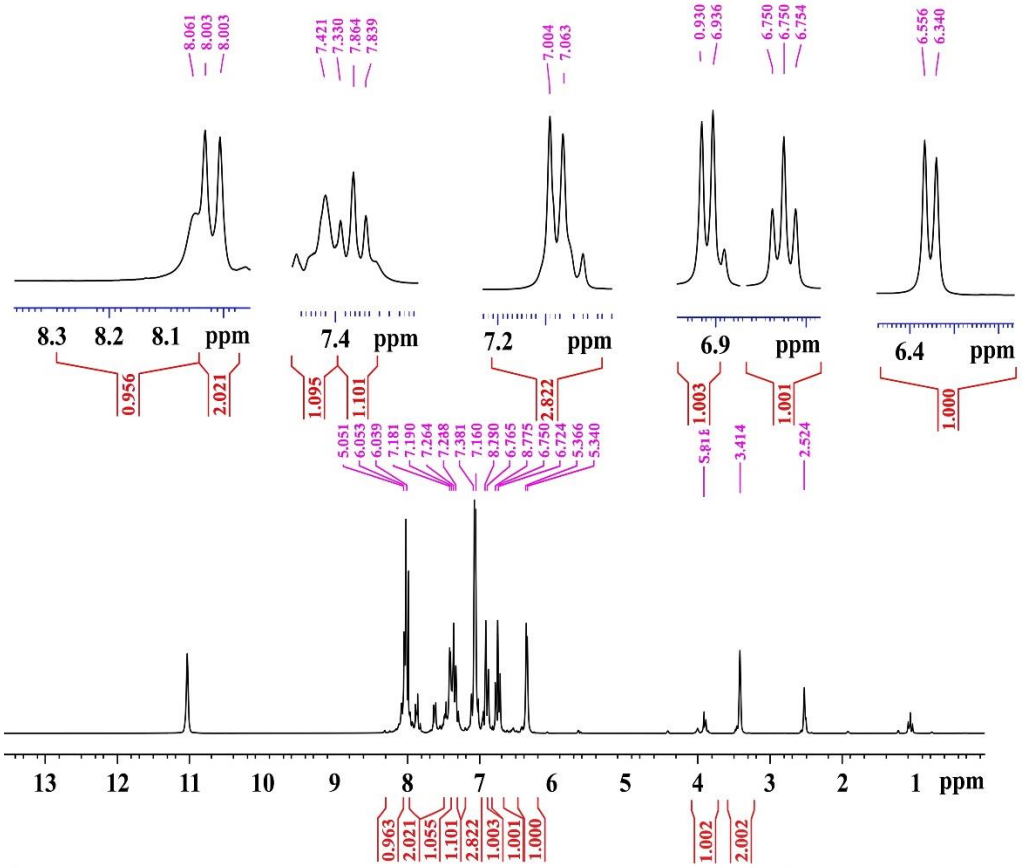


Figure 8. ^{1}H-NMR of Comp. O_2.

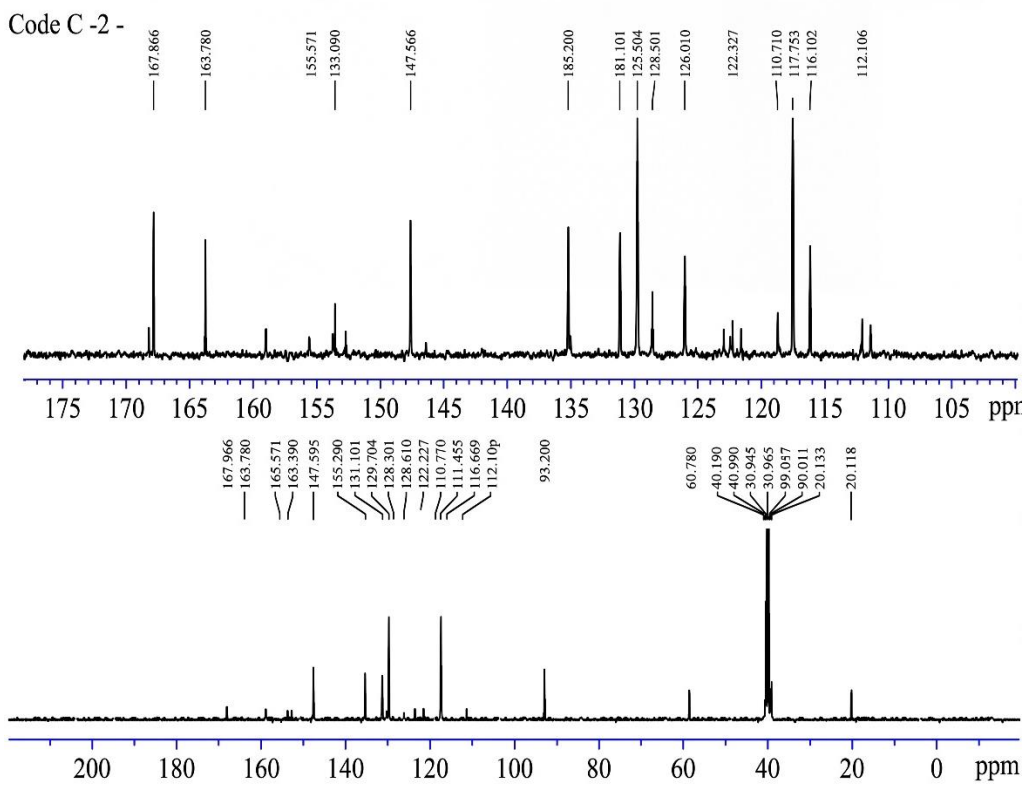


Figure 9. ^{13}C-NMR of Comp. O_2.

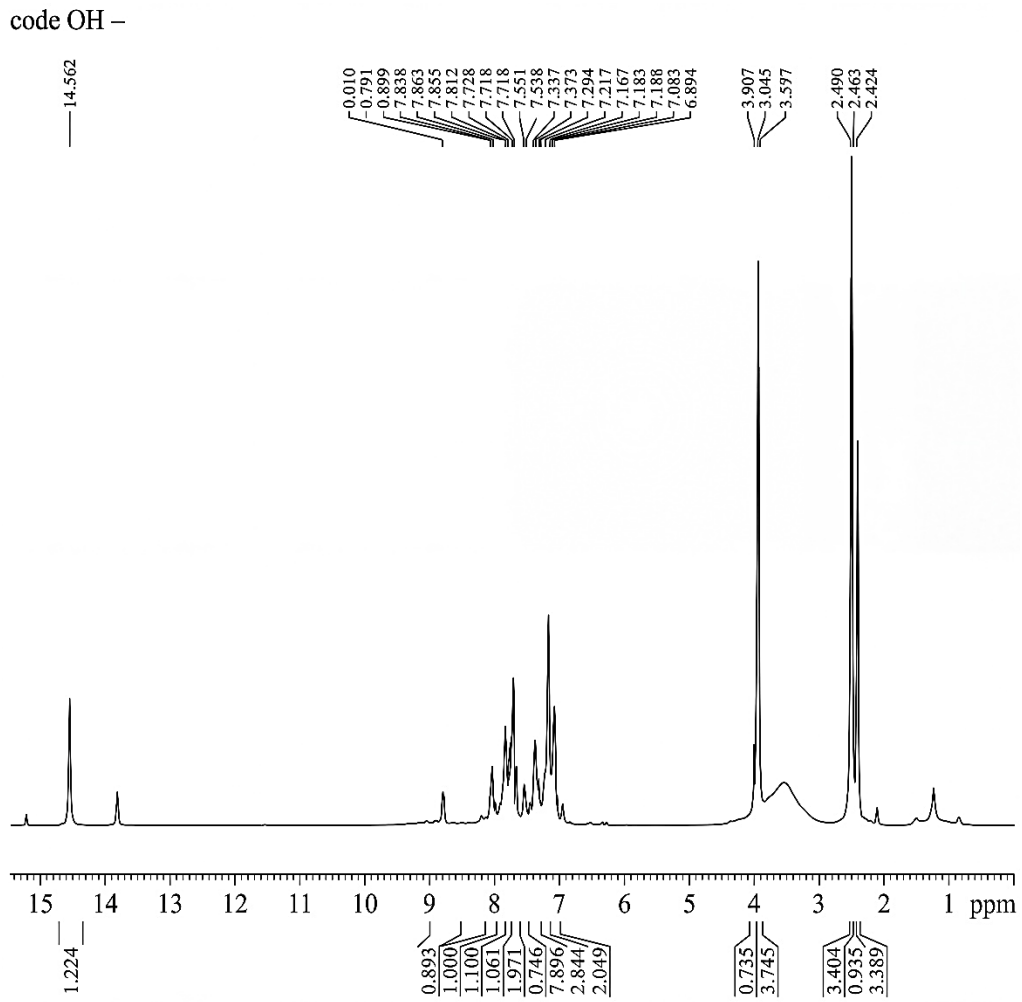


Figure 10. ^{1}H-NMR of Comp. O_{11}

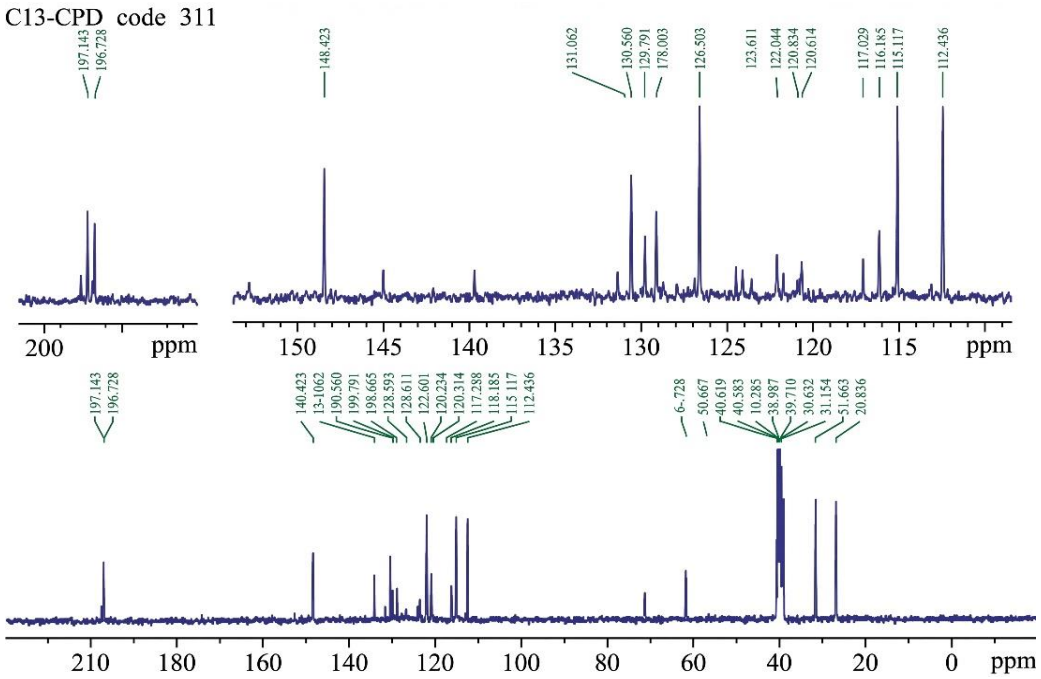


Figure 11. ^{13}C-NMR of Comp. O_{11}

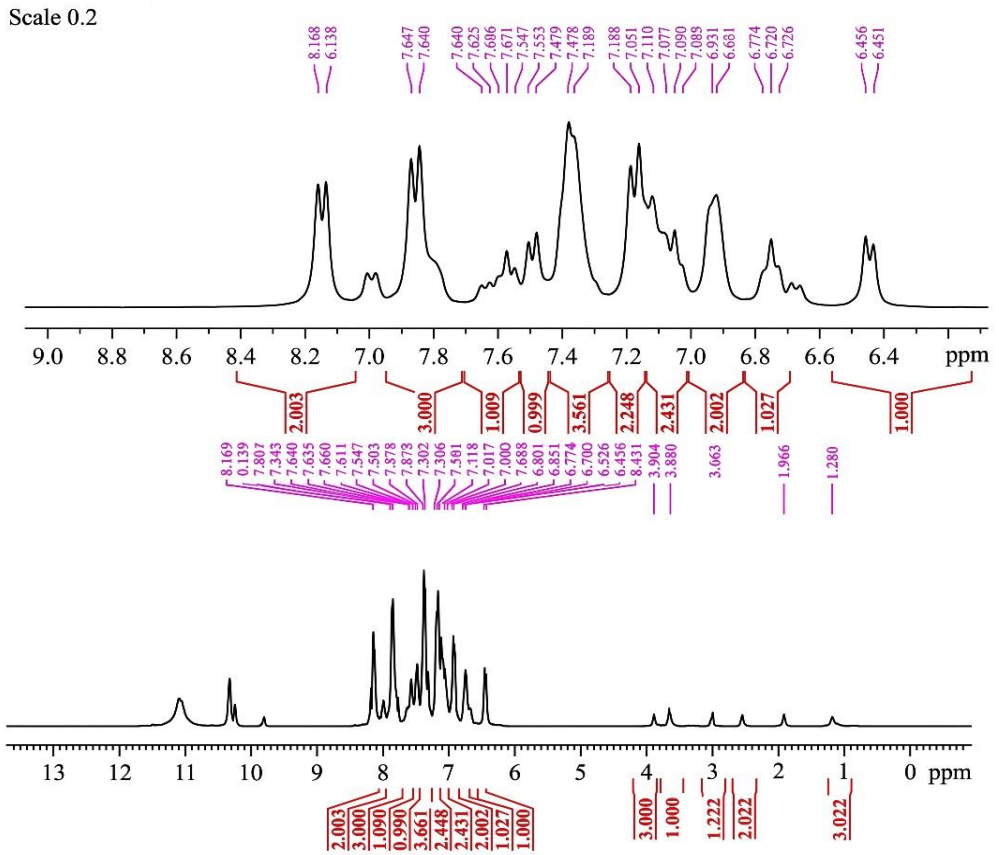


Figure 12. ^{1}H-NMR of Comp. O_{12}

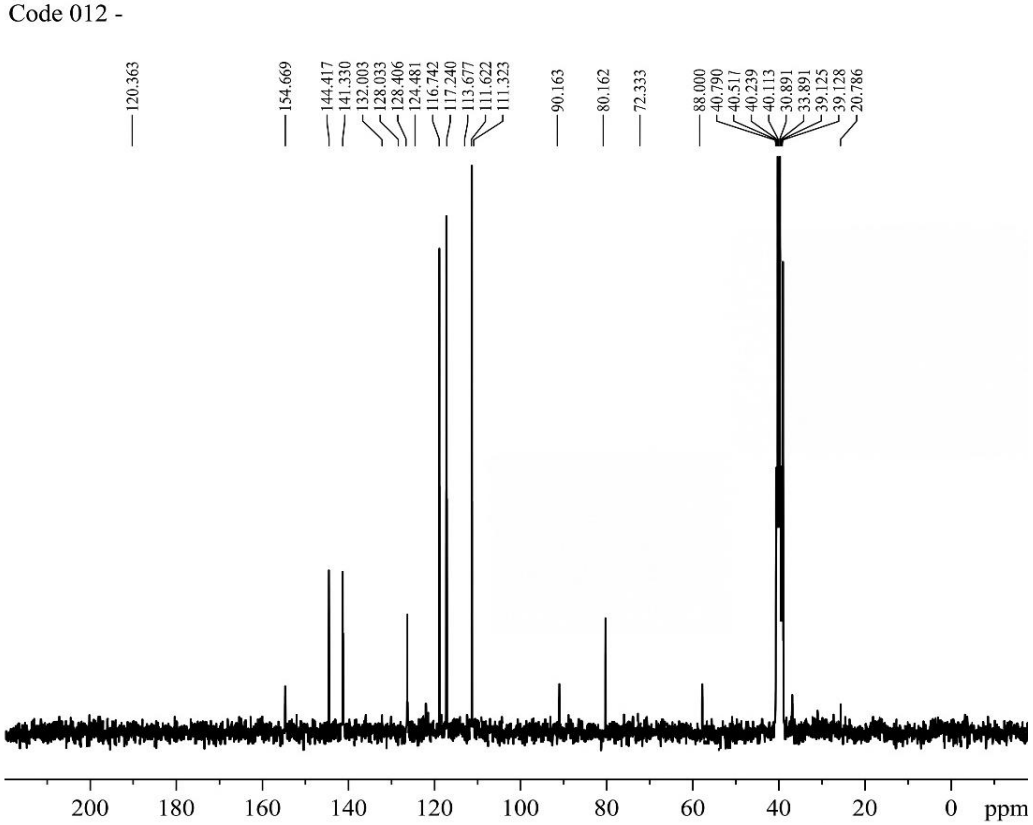


Figure 13. ^{13}C-NMR of Comp. O_{12}

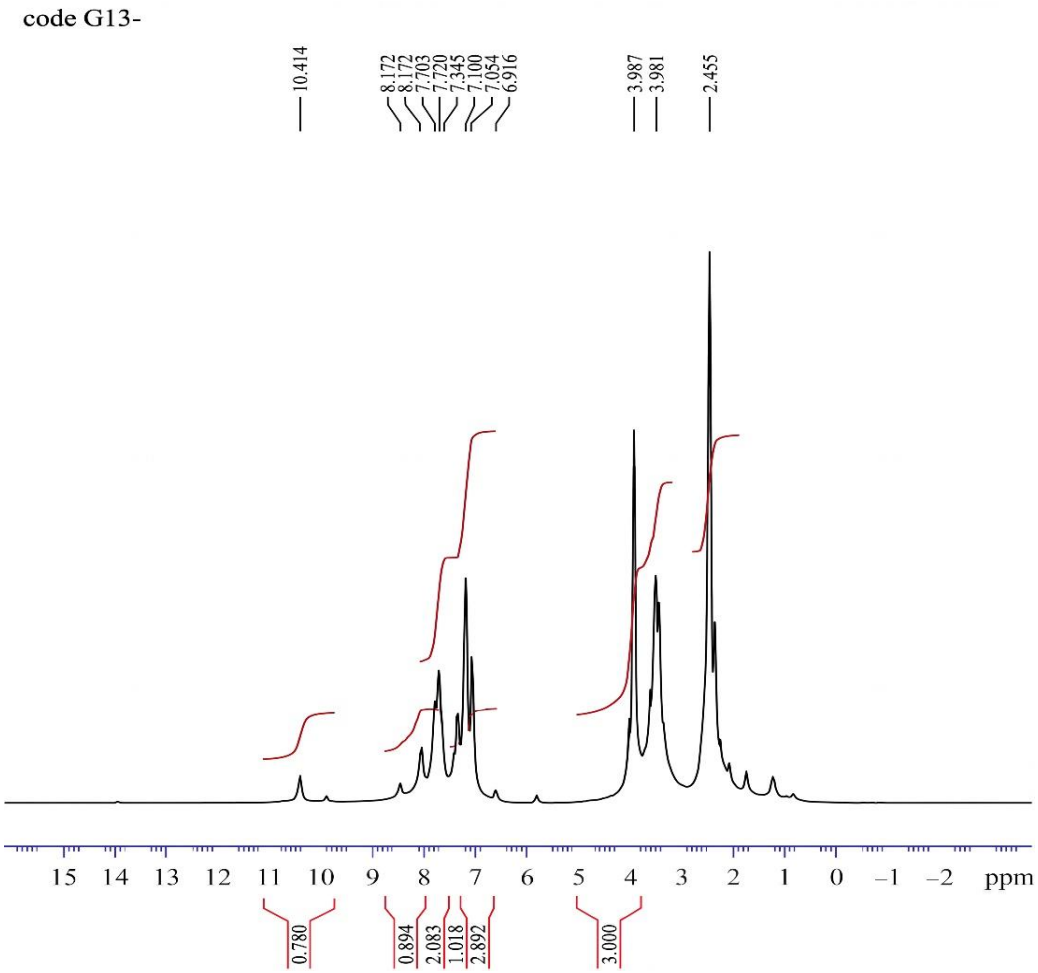


Figure 14. ^{1}H-NMR of Comp. O_{13}

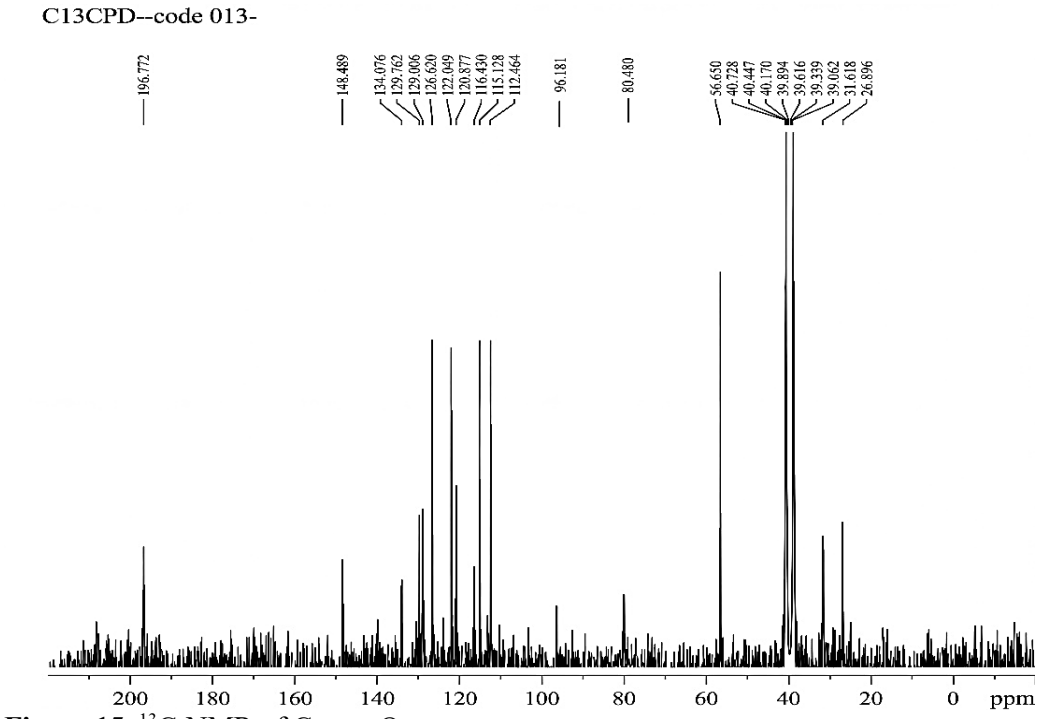


Figure 15. ^{13}C-NMR of Comp. O_{13}.

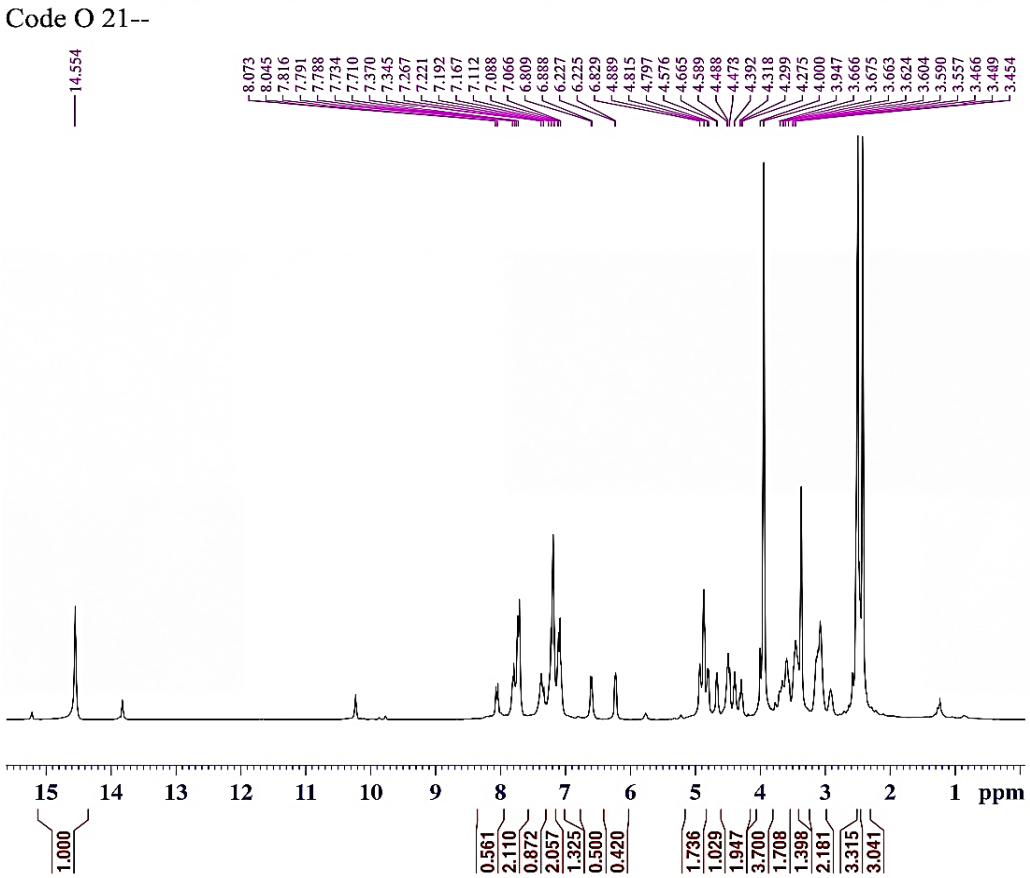


Figure 16. ^{1}H-NMR of Comp. O_{21}.

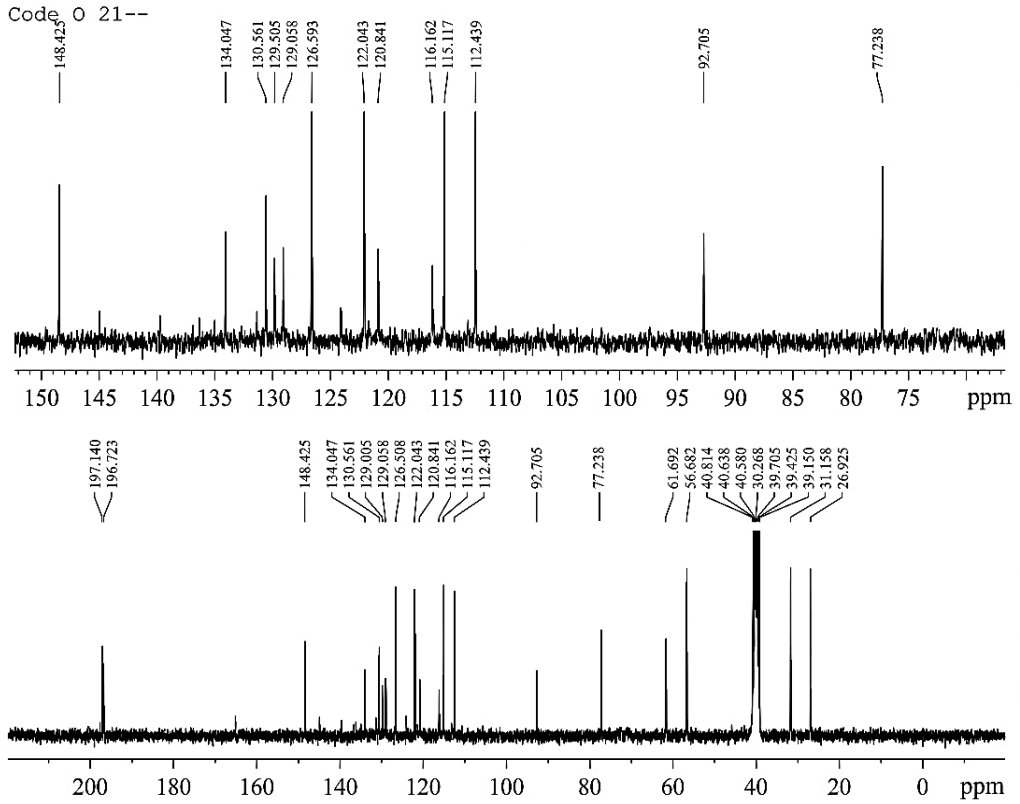


Figure 17. ^{13}C-NMR of Comp. O_{21}.

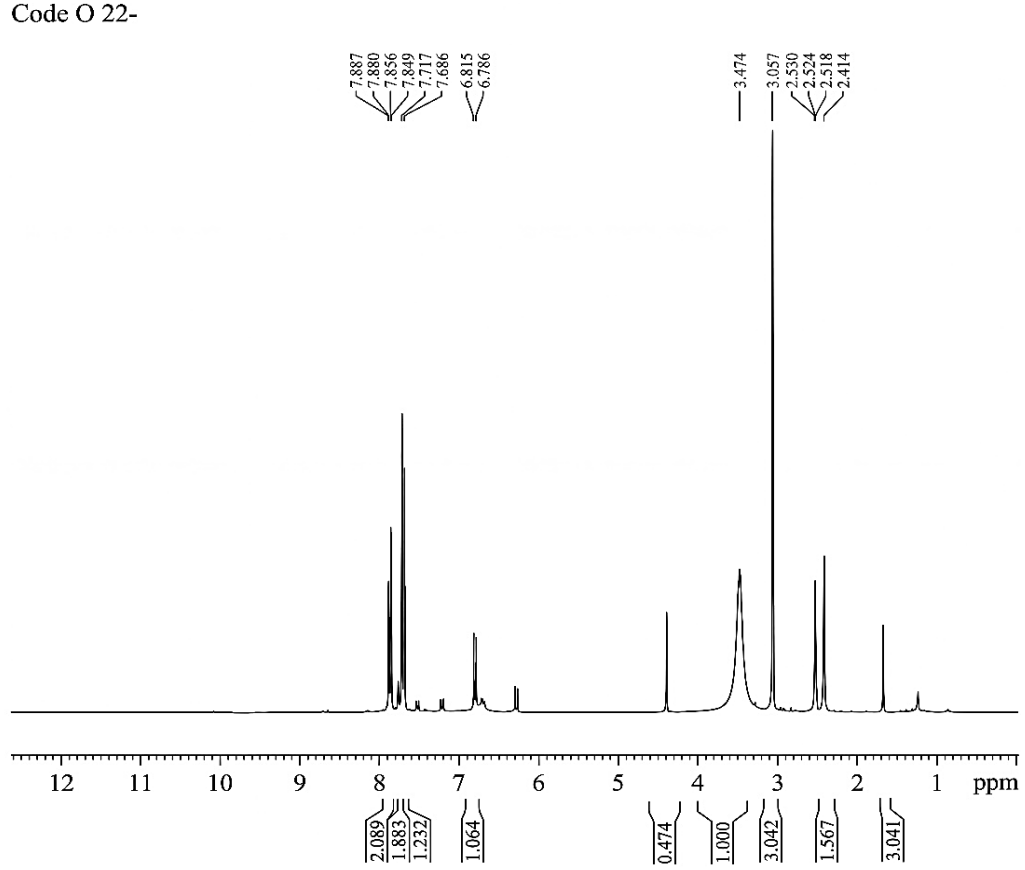


Figure 18. ^{1}H-NMR of Comp. O_{22}.

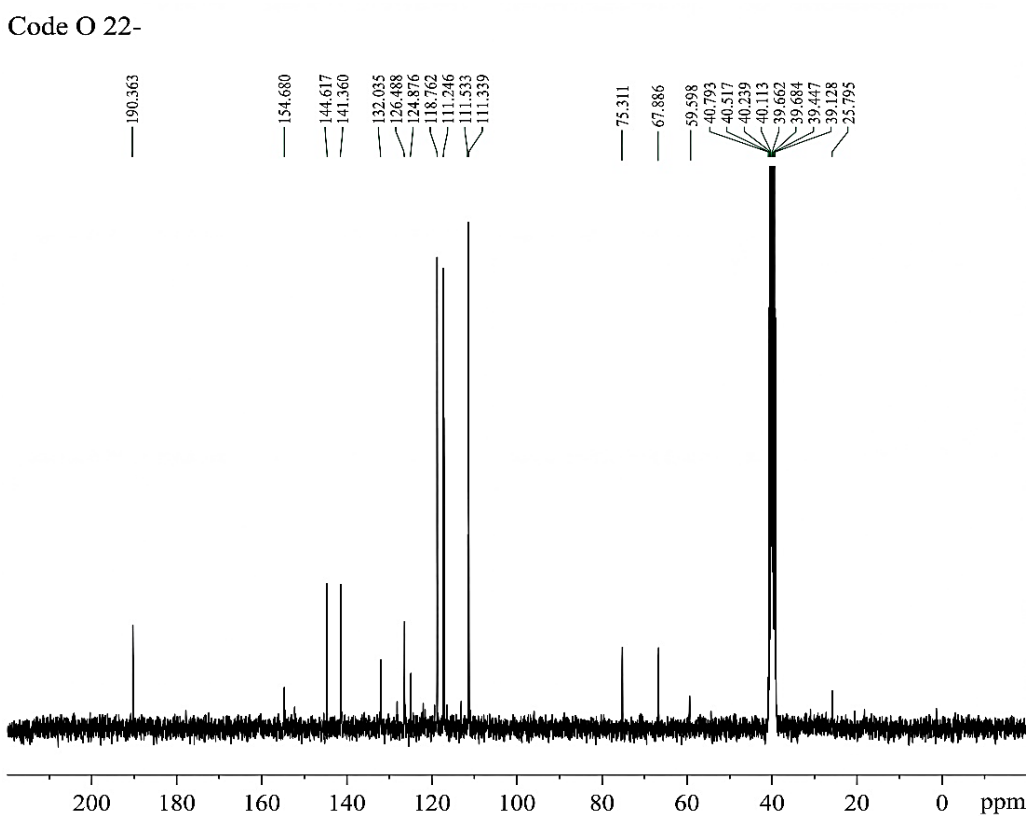


Figure 19. ^{13}C-NMR of Comp. O_{22}.

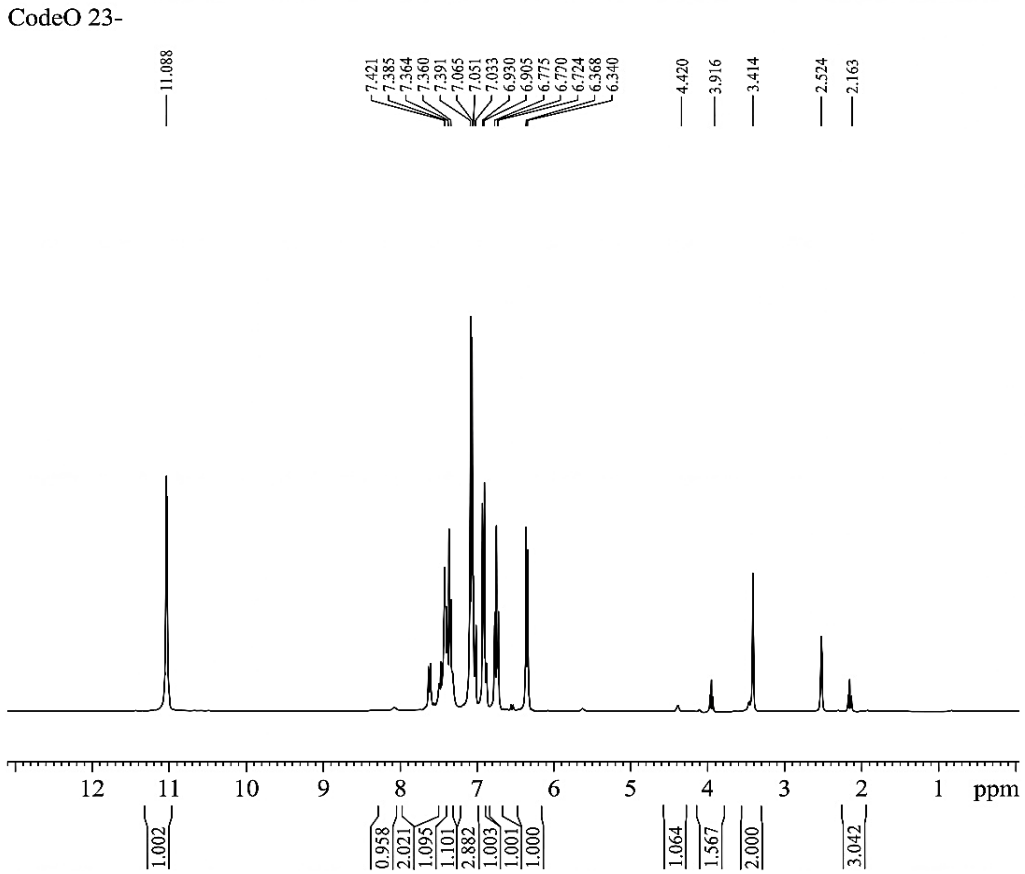


Figure 20. ^{1}H-NMR of Comp. O_{23}

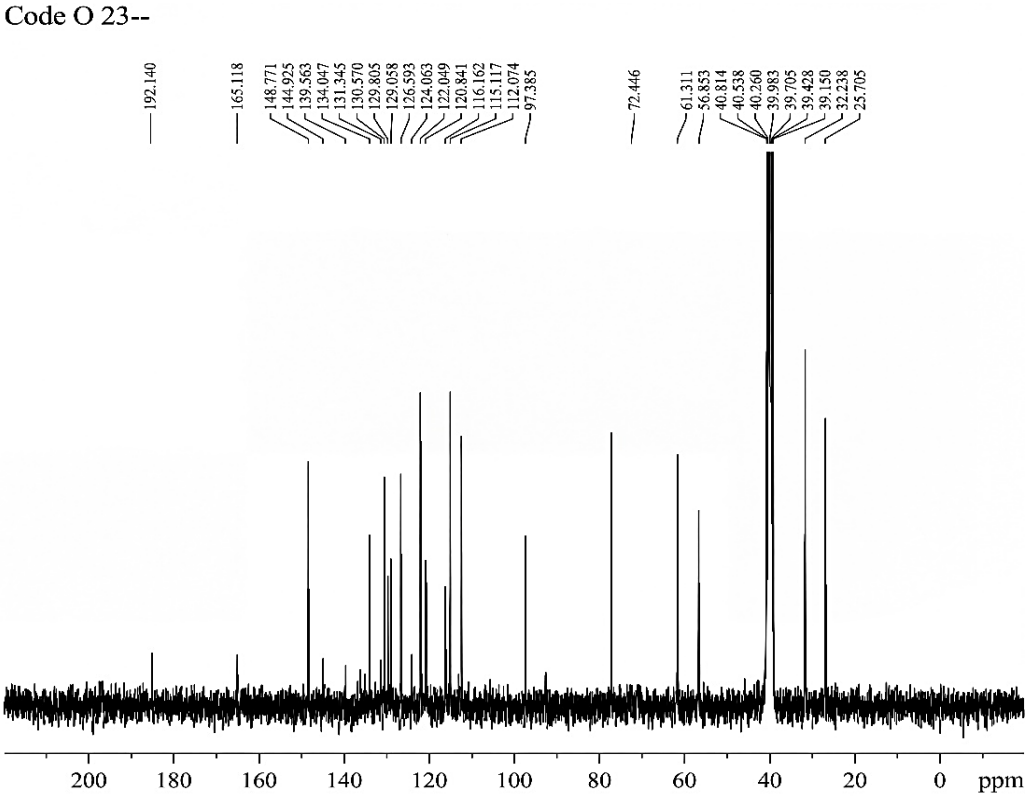


Figure 21. ^{13}C-NMR of Comp. O_{23}

BIOLOGICAL ACTIVITY

Antibacterial activity

The search for highly effective organic compounds against pathogens has become essential in the field of medicinal chemistry due to the increasing challenges associated with bacterial resistance to antibiotics. In this study, a range of novel organic compounds were designed and synthesized, and the efficacy of 6 derivatives (O_{11}, O_{12}, O_{13}, O_{21}, O_{22}, O_{23})) was tested against two of the most resistant and dangerous strains of bacteria, *Acinetobacter baumannii* and *Staphylococcus aureus*. The biological activity of the compounds was evaluated using the agar well diffusion method. The results showed that some compounds exhibited significant activity against the bacterial strains, with the response clearly being concentration-dependent, as shown in Table 1. Compound O_{21} exhibited the highest inhibition rates against Gram-positive Staphylococcus aureus, as shown in Figures 22. Against Gram-negative Acinetobacter baumannii, compound O_{11} being the most effective at an inhibition diameter of 27 mm. This high activity is attributed to the presence of rich groups that, likely contribute to enhanced interaction with bacterial targets, as illustrated in Figures 22 and 23. These results indicate that the synthesized compounds possess promising antibacterial potential, supporting their possible development within innovative pharmacological strategies aimed at combating antibiotic resistance.

Antioxidant activity

In light of the rapid advancements in organic chemistry, compounds with antioxidant activity are receiving considerable attention due to their vital role in combating oxidative stress, which is linked to numerous degenerative diseases. In this study, three novel organic compounds (O_{21}, O_{22}, and O_{23} were designed and synthesized, and their antioxidant efficacy was evaluated compared to ascorbic acid, a well-established reference antioxidant. Advanced analytical techniques, such as the DPPH free radical inhibition assay and electrochemical activity measurements, were employed to determine the efficacy

Table 1. Antibacterial activity of some synthetic derivatives

Mate	Con. (µg. mL)	A. B	Staph.
O_{11}	1	27	26
	0.5	19	20
	0.25	15	18
	0.125	9	12
O_{12}	1	21	23
	0.5	16	17
	0.25	13	11
	0.125	6	9
O_{13}	1	18	24
	0.5	16	20
	0.25	11	17
	0.125	8	12
O_{21}	1	21	29
	0.5	17	21
	0.25	13	18
	0.125	5	14
O_{22}	1	19	25
	0.5	16	19
	0.25	13	14
	0.125	7	8
O_{23}	1	22	26
	0.5	16	20
	0.25	11	16
	0.125	7	10

of these compounds. Compounds O_{21} and O_{23} exhibited the highest inhibition rates compared to ascorbic acid at a concentration of 1 mg/ml. This is attributed to their content of nitrogen and sulfur atoms, as well as electron-rich hydroxyl groups, which enable them to bind to free radicals and inhibit oxidation processes. These results highlight the promising potential of these compounds as antioxidants, paving the way for their use in pharmaceutical and industrial applications explained in Figure 24.

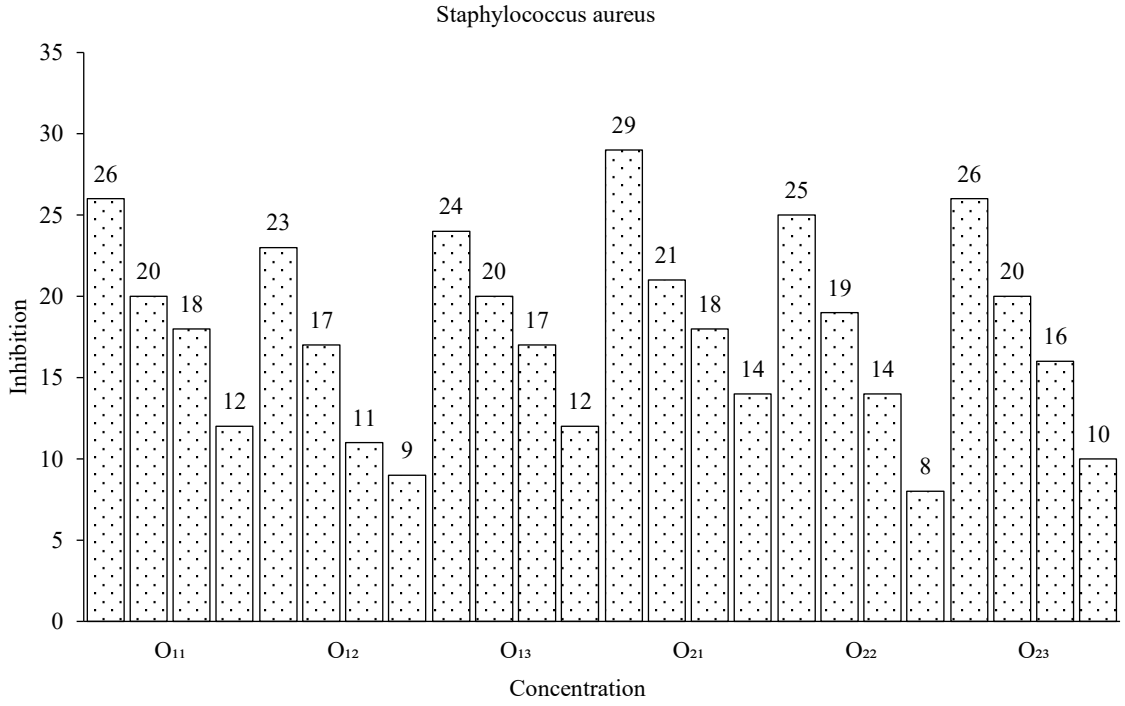


Figure 22. Antibacterial Activity against *Staphylococcus aureus*.

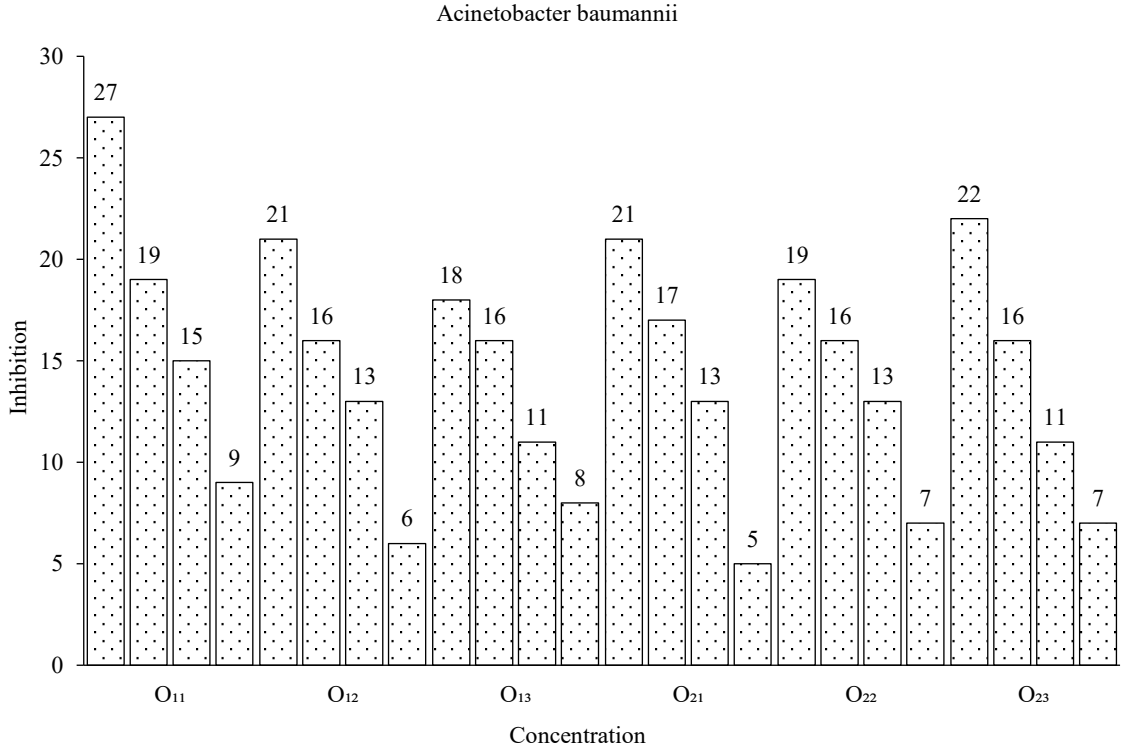
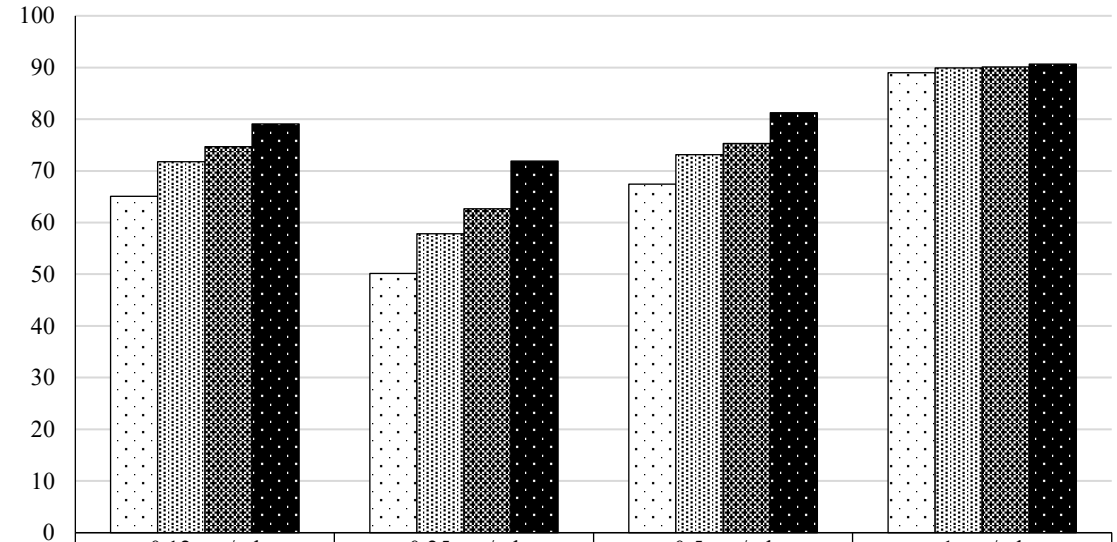


Figure 23. Antibacterial Activity against *Acinetobacter baumannii*.



	0.12 mg/ml	0.25 mg/ml	0.5 mg/ml	1 mg/ml
O21	65.07	50.15	67.41	88.962
O22	71.79	57.82	73.12	89.924
O23	74.7	62.67	75.33	90.105
AA	79.066	71.92	81.25	90.65

Figure 24. Antioxidant Activity of some prepared compounds.

CONCLUSION

In the present study, a series of novel imidazolidine derivatives incorporating azo linkages were successfully synthesized through a multi-step synthetic pathway involving azo coupling, Schiff base formation, and subsequent cyclization with various amino acids. The synthesized compounds were obtained in good yields as stable crystalline solids, facilitating their purification and handling. Structural elucidation and confirmation were carried out using comprehensive spectral analyses, including FT-IR, ^{1}H-NMR, and ^{13}C-NMR techniques, which verified the successful formation of the targeted functional groups such as azo (–N=N–), imine (–C=N–), and lactam (–N–C=O) moieties.

The biological evaluation of the synthesized derivatives revealed significant antibacterial activity against both Gram-positive *Staphylococcus aureus* and Gram-negative *Acinetobacter baumannii*. Among the tested compounds, O_{11} and O_{21} demonstrated superior inhibitory effects, which can be attributed to the presence of electron-donating and heteroatom-rich functional groups that enhance interaction with microbial targets. The observed concentration-dependent activity further supports their potential as effective antimicrobial agents.

In addition to antibacterial properties, selected compounds (O_{21}, O_{22}, and O_{23}) exhibited promising antioxidant activity when evaluated using DPPH radical scavenging assays. Notably, compounds O_{21} and O_{23} showed inhibition efficiencies comparable to the standard ascorbic acid, indicating strong free radical scavenging ability. This enhanced antioxidant behavior is likely due to the presence of conjugated systems, heteroatoms such as nitrogen and sulfur, and electron-rich substituents that stabilize free radicals.

Overall, the integration of azo functionality with imidazolidine frameworks has proven to be a valuable strategy in the development of biologically active compounds. The dual antibacterial and antioxidant activities observed in this study highlight the therapeutic potential of these derivatives. Future work should focus on detailed mechanistic studies, toxicity profiling, and in vivo evaluations to further explore their applicability in pharmaceutical development.

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