Synthesis of New Azo–Schiff Base Complexes and Study of their Antibacterial Activity

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Abstract

In this research, we synthesized new azo-schiff base derivatives (4-9). These derivatives of azo compounds (1-3) that synthesized from 4-ethoxyaniline and drivatives of aldehyde such as, 4-aminobenzaldehyde, 4- hydroxybenzaldehyde and 4-ethoxybenzaldehyse to produce azo compounds (1-3). The compounds (1-3) reacted with differents aldehyde such as, isonicotinic hydrazide to produce N'-[(Z)-{3-[(E)-(4-ethoxyphenyl)diazenyl]-4-subs.phenyl}-methylidene]pyridine-4-carbohydrazide derivatives (4-6) and 3-amino pyridine to produce 2-[(E)-(4-ethoxyphenyl)diazenyl]-4-{(E)-[(pyridin-3-yl)imino]-methyl}subsbenzene derivatives (7-9). These compounds were characterization by spectroscopy methods such as, FTIR and 1HNMR. Some compounds (4, 6 and 9) that synthesized tested as antibacterial via used differents types such as, E. coli, Bacillus subtilis, and S. aureus. The activities of these compounds with different bacteria are known by the excellent diffusion methodology applied and derivative (6) gives a more activites from other derivatives.

Keywords: Schiff base, Complexes, Biological activity

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Introduction

A Schiff's base is a chemical molecule with a C=N bond known as an imine or an azomethine (Catalano et al., 2021). The imine compounds could have been produced using microwave technology (Ghanghas et al., 2021) or infrared radiation (Cusin et al., 2021) and using acid, base, Mg(ClO4)2, P2O5/SiO2, ZnCl2, and CaO as catalytic (Klopcic & Dolenc, 2018). Schiff bases compounds have been played a good role in various applications as biological activities, including antifungal, antibacterial, antiproliferative, antimalarial, antiinflammatory, antiviral, and antipyretic (Acharyya & Mukherjee, 2019; Kudryavtsev & Zagulyaeva., 2008).

A known organic molecule with an azo group is an azo molecule (Benkhaya et al., 2020). Most aromatic azo molecules are generated by reacting a diazonium salt compound with organic molecule (Akram et al., 2020). For the treatment of nuclear waste, corrosion control, and metal recovery, azo Schiff base coordination compounds are utilized (Zhi & Zhang, 2019).

Heterocyclic chemistry is dealing with the synthesis inaddition to applications of these heterocycles. The heterocyclic are widely used in nature and necessary. As well as to the heterocyclic compounds essential to life, taking part in an important role in the metabolism of all living cells (Menati et al., 2013). Necessary practical applications embody pigments, copolymers, solvents, antioxidants and processing accelerators within the rubber business. Several heterocyclic are valuable intermediates in synthesis.

In this study, the newly derivatives of schiff bases compounds that synthesized gives a good biological activity againsts differents bacteria by inhibition zone.

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Experimental

Reagents and Solvents

All chemicals that used in study were obtained different companies such as, Merck and Fluka.

Synthesis

Synthesis of 3-[(E)-(4-ethoxyphenyl)diazenyl]-4-subs.benzaldehyde derivatives (1 - 3), (Benkhaya et al., 2020).

We added P-ethoxy aniline (0.01 mole) and 6 ml of 10% HCl solution in a cooling bath. Some drops (2–3) of concentrated hydrochloric acid to test tube number 1. Prepare 1.38 gm of 0.02 mole NaNO2 in distilled water and place 7 ml into test tube No. 2. Add test tube No. 2 to test tube No. 1 when the solution temperature in test tube No. 1 equals (0–5 °C). In test tube number three, make a 0.01 mole of 4-hydroxybenzaldehyde solution in 10 ml of 10% sodium hydroxide. The solution combination should then be added to test tube number 3. After filtering the final solution and collecting the precipitate, the required products were made. Repeat the finally stage by used differents aldehyde derivatives such as, 4-ethoxybenzaldehyde and 4-aminobenzaldehyde.

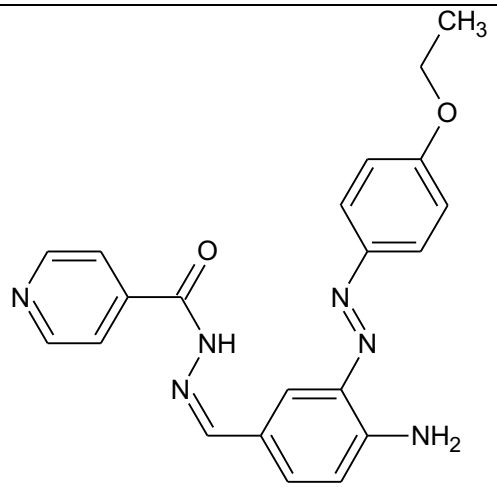
Synthesis N'-[(Z)-{3-[(E)-(4-ethoxyphenyl)diazenyl]-4-subs.phenyl}-methylidene]pyridine-4-carbohydrazidederivatives (4 - 6), (Shah et al., 2020;Segura et al., 2016)

The solution was refluxed for 2 hours that contained reactions: (0.01 mol) of compound (1) and (0.01 mol) isonicotinic hydrazide in EtOH as a solvent and three drops G.G.A glacial acetic acid. Precipitates were produced, and dry filtration was used to collect crystals. The physicochemical properties for derivatives (4-6) listed as table 1.

Synthesis 2-[(E)-(4-ethoxyphenyl)diazenyl]-4-{(E)-[(pyridin-3-yl)imino]-methyl}subsbenzene derivatives (7 - 9), (Shah et al., 2020;Segura et al., 2016)

The solution was refluxed for 2 hours that contained reactions: (0.01 mol) of compound (1) and (0.01 mol) 3-aminopyridine in EtOH as a solvent and three drops G.G.A glacial acetic acid. Precipitates were produced, and dry filtration was used to collect crystals. The physicochemical properties for derivatives (7-9) listed as table 1.

Table 1. The physicochemical properties of synthesized molecules

No.	Chemical Strcuture	M. P (°C)	Colour	Yelled %
4		218 – 222	Brown Yellowish	81

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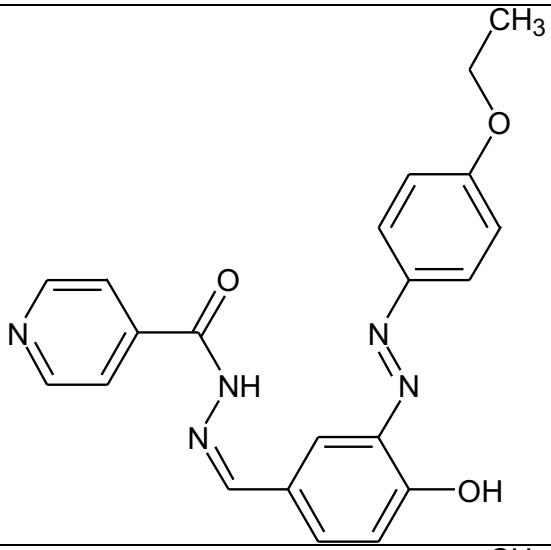
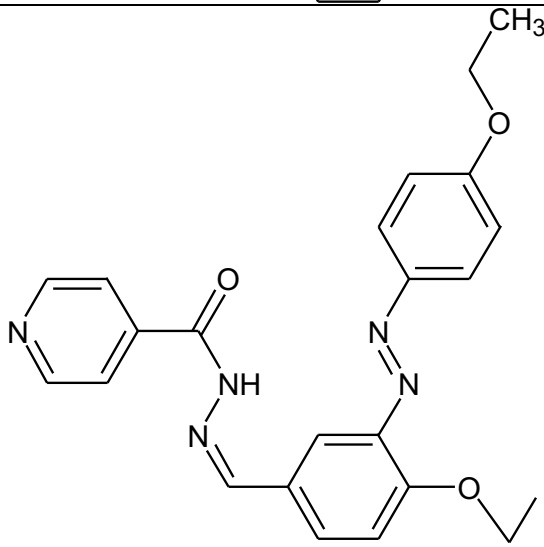
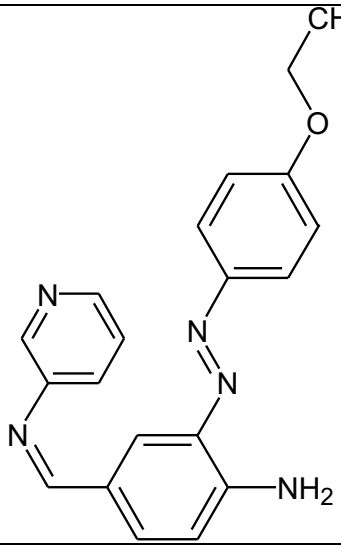
5		202 – 207	Yellow	72
6		194 – 199	Dark Yellow	75
7		222 - 226	Light Yellow	68

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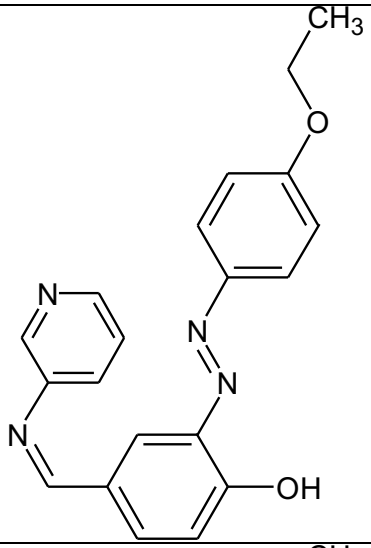
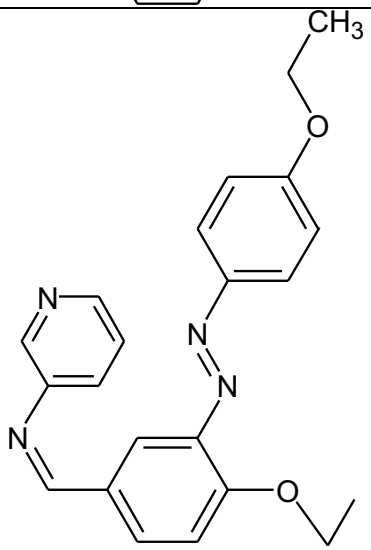
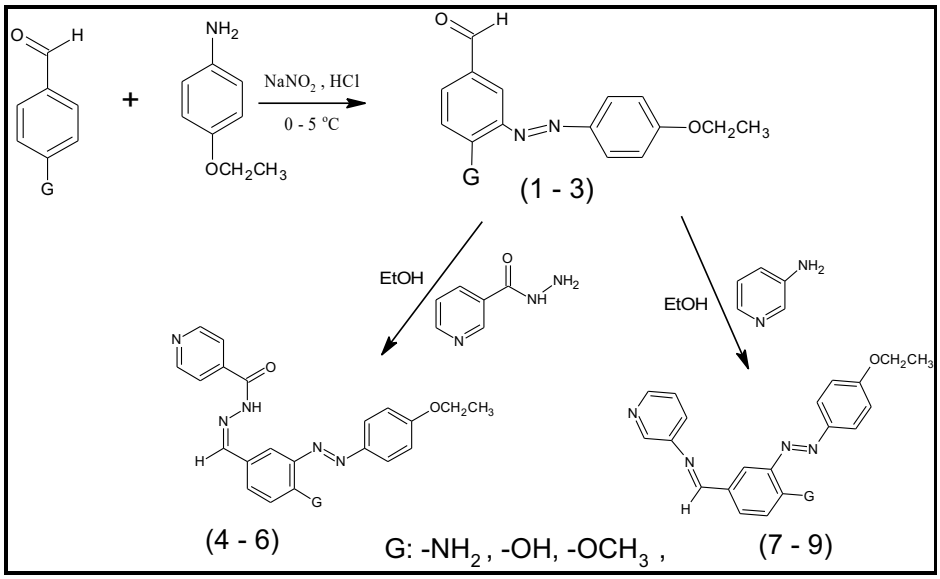
8		233 – 237	Brown Yellow	70
9		246 – 251	Yellow	73



Scheme 1. Reactions of complexes synthesis (4 – 9)

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Results and Discussion

The reaction between isonicotinichydrazide or 3-aminopyridine with 4- substituted-3-(4-ethoxy-phenylazo)-benzaldehyde produced the ligand as azo-Schiff base molecule and used glacial acetic acid (Al-Adilee & Hasan, 2021;Hashim & Mahdi, 2023).

The new azo-Schiff base derivatives (4 - 9) that showed as yellow crystals. Newly prepared azo-Schiff base characterization by differents spectroscopy technology such as, FTIR and HNMR. The bands of (C=O) and (C-H) of aldehyde appeared in compounds(1-3) that synthesized, while disappeared in shciff bases (4-9) and appeared bands of (C=N) of azomethine groups (Hussain & Naji, 2018;Hadi & Kareem, 2020).

FT-IR (cm-1) of compound (1): 3372 and 3160 (NH2), 3066 and 3032 (C-H) of aromatic ring, 2834 (C-H) aliphatic chain, 1719 (C=O) aldehyde and 2716 (C-H) aldehyde, 1602 (C=C) of aromatic, 1523 azo (N=N), (Raman et al., 2009;Liu & Hamon, 2019). As shown in figure 1.

FT-IR (cm-1) of compound (2): 3501 (OH), 3124 and 3055 (C-H) for aromatic ring, 2880 (C-H) aliphatic chain, 1715 (C=O) aldehyde and 2794 (C-H) aldehyde, 1611 (C=C) of aromatic, 1522 (N=N), (Raman et al., 2009;Liu & Hamon, 2019). As shown in figure 2.

FT-IR (cm-1) of compound (3): 3067 (C-H) for aromatic ring, 2971 and 2884 (C-H) aliphatic chain, 1718 (C=O) carbonyl group and 2792 (C-H) of aldehyde (Raman et al., 2009;Liu & Hamon, 2019), 1604 (C=C) od aromatic, 1515 (N=N), (Şahin et al., 2022). As shown in figure 3.

FT-IR (cm-1) of compound (4): 3277 amino group (N-H), 3074 (C-H) for aromatic ring, 2979 and 2834 (C-H) aliphatic chain, 1656 cm-1 (C=O), 1622 (C=N), 1592 (C=C) Aromatic, 1522 (N=N). 1H NMR (400 MHz, DMSO-d6, ppm) 10.321 (s, 1H of -NH), 8.79 – 8.75 (m, 2H of HC-N aromatic), 8.02 – 7.24 (m, H of aromatic), 7.67 – 7.59 (m, H of HC-N aliphatic), 4.03 (2H of -OCH2), 1.43 (d, of –CH3), (Ismail, 2000;Maurya et al., 2005). As shown in figure 4 and 10.

FT-IR (cm-1) of compound (5): 3340 broad band for (O-H), 3046 (C-H) aromatic ring, 2993 (C-H) aliphatic chain , 1649 (C=O), 1622 (C=N), 1574 (C=C) Aromatic, 1524 (N=N). 1H NMR (400 MHz, DMSO-d6, ppm) 10.155 (s, 1H of -OH), 8.77 – 8.76 (m, 2H of HC-N aromatic), 7.77 – 7.04 (m, H of aromatic), 7.65 – 7.56 (m, H of HC-N aliphatic), 3.96 (2H of -OCH2), 1.23 (d, of –CH3), (Ismail, 2000;Maurya et al., 2005). As shown in figure 5 and 11.

FT-IR (cm-1) of compound (6): 3052 (C-H) aromatic ring, 2885 (C-H) aliphatic, 1644 (C=O), 1622 (C=N), 1590 (C=C) Aromatic, 1526 (N=N). 1H NMR (400 MHz, DMSO-d6, ppm) 8.68 – 8.63 (m, 2H of HC-N aromatic), 8.05 – 7.17 (m, H of aromatic), 7.50 (m, H of HC-N aliphatic), 4.00 (2H of -OCH2), 1.31 (d, of –CH3), (Ismail, 2000). As shown in figure 6 and 12.

FT-IR (cm-1) of compound (7): 3341 amino (N-H), 3052 (C-H) for aromatic ring, 2947cm-1 (C-H) for aliphatic chain, 1617 (C=N), 1590 C=C)Aromatic, 1525 (N=N) (21). 1H NMR (400 MHz, DMSO-d6, ppm) 10.25 (s, 1H of NH), 8.49 – 8.42 (m, 2H of HC-N aromatic), 8.07 – 7.03 (m, H of aromatic), 7.68 – 7.69 (m, H of HC-N aliphatic), 4.05 (2H of -OCH2), 1.42 (d, of –CH3), (Maurya et al., 2005). As shown in figure 7 and 13.

FT-IR (cm-1) of compound (8): 3358 broad band for alcohol (OH), 3094 (C-H) aromatic, 2867 (C-H) aliphatic chain, 1625 azomethine (C=N), 1584 (C=C) for aromatic ring, 1513 (N=N). 1H NMR (400 MHz, DMSO-d6, ppm) 10.48 (s, 1H of OH), 8.45 – 8.22 (m, 2H of HC-N

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aromatic), 8.21 – 7.04 (m, H of aromatic), 7.76 – 7.66 (m, H of HC-N aliphatic), 4.05 (2H of -OCH2), 1.42 (d, of –CH3). As shown in figure 8 and 14.

FT-IR (cm-1) of compound (9): 3072 (C-H) for aromatic ring, 2962 (C-H) aliphatic chain, 1627 azomethine(C=N), 1592 (C=C) of aromatic ring, 1522 cm-1 (N=N). 1H NMR (400 MHz, DMSO-d6, ppm) 8.79 – 8.75 (m, 2H of HC-N aromatic), 8.02 – 7.24 (m, H of aromatic), 7.67 – 7.59 (m, H of HC-N aliphatic), 4.03 (2H of -OCH2), 1.43 (d, of –CH3). 1H NMR (400 MHz, DMSO-d6, ppm) 8.49 – 8.21 (m, 2H of HC-N aromatic), 8.215 – 7.04 (m, H of aromatic), 7.55 – 7.54 (m, H of HC-N aliphatic), 4.11 (2H of -OCH2), 1.17 (d, of –CH3). As shown in figure 9 and 15.

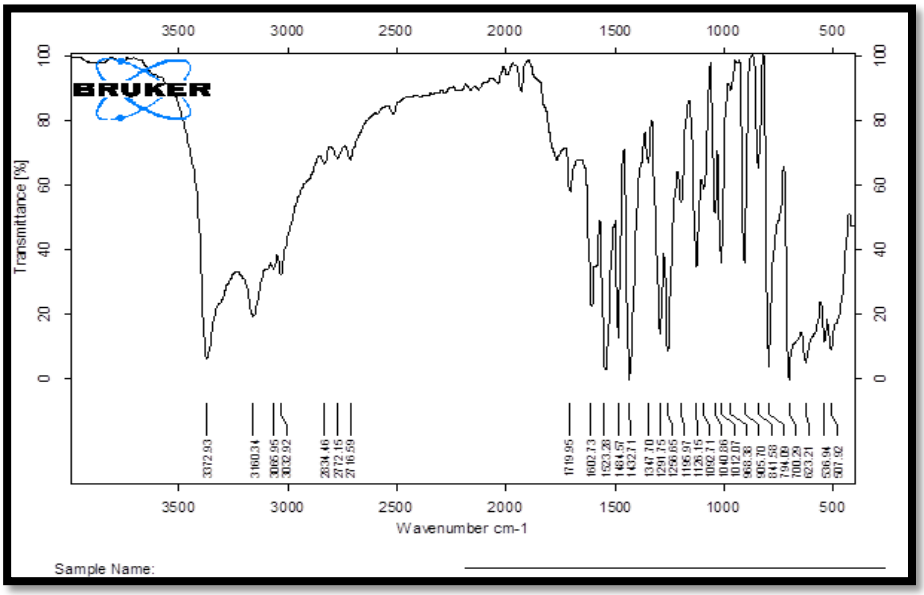

Figure 1. FTIR of derivative 1.

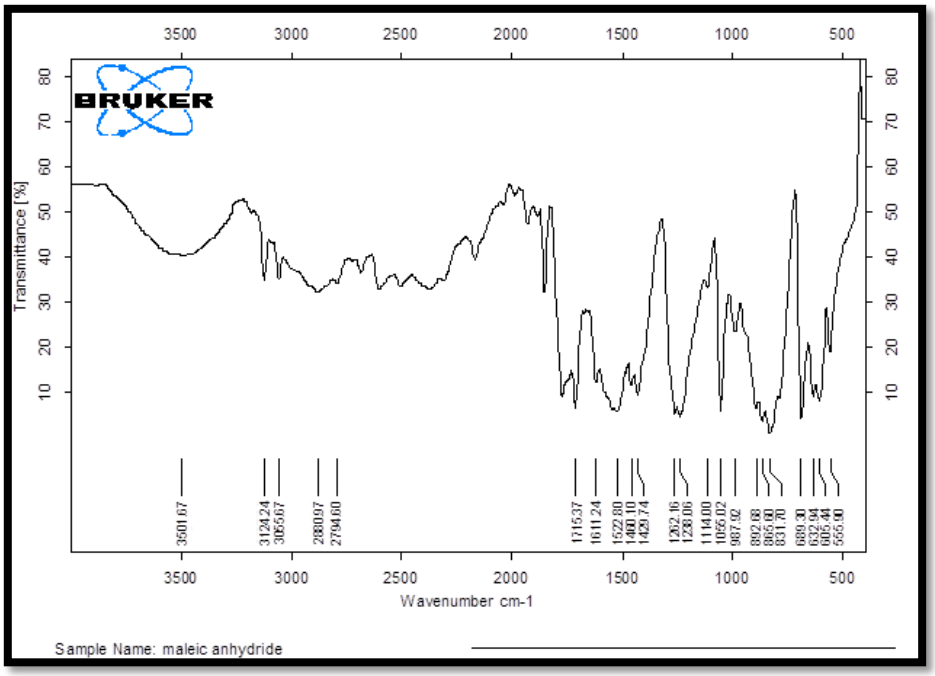

Figure 2. FTIR of derivative 2

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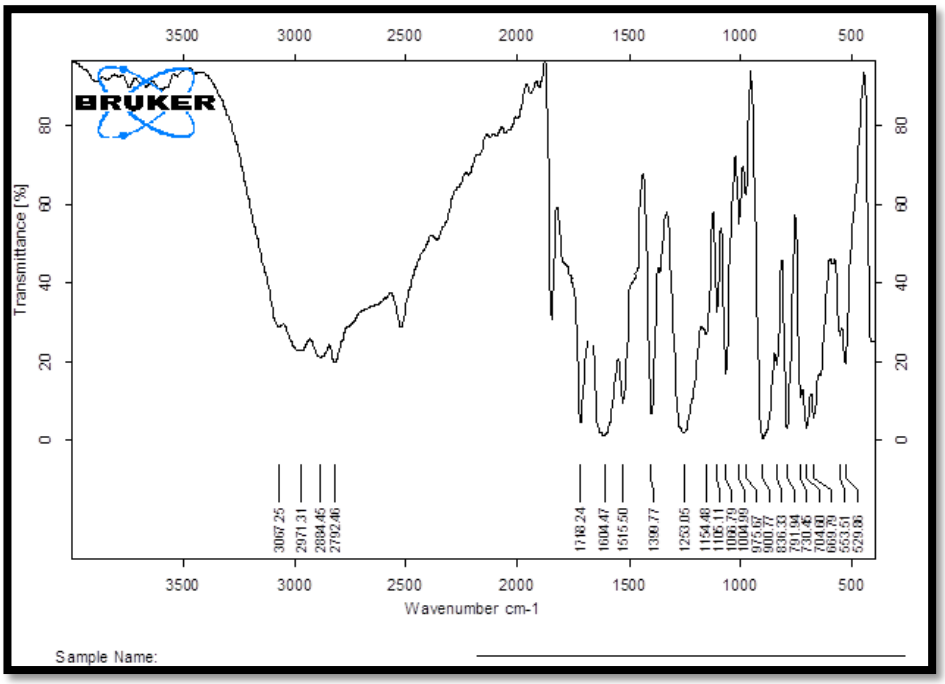

Figure 3. FTIR of derivative 3

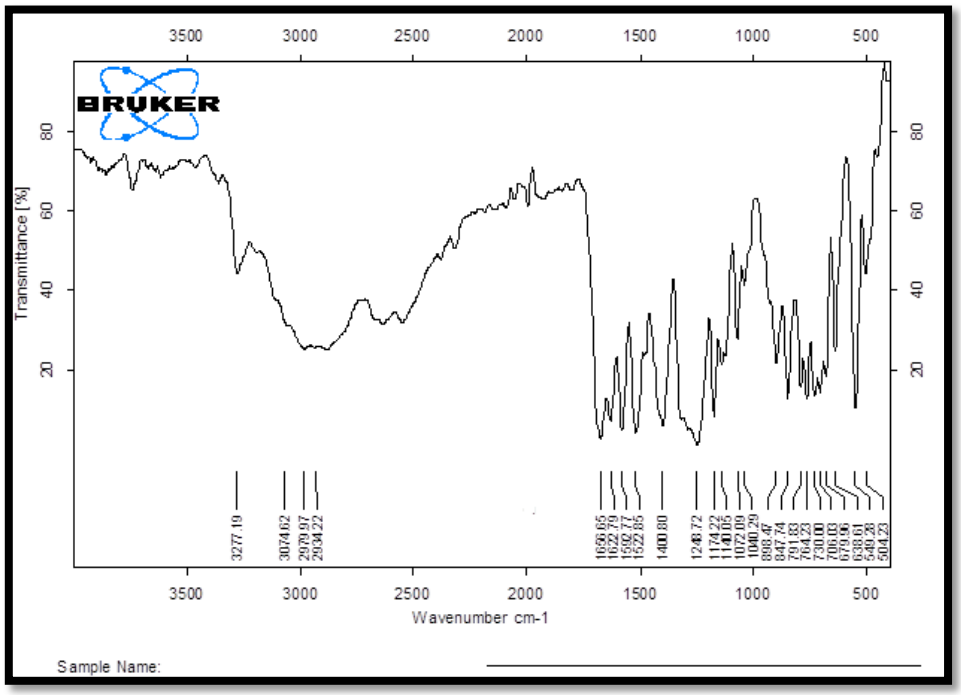

Figure 4. FTIR of derivative 4

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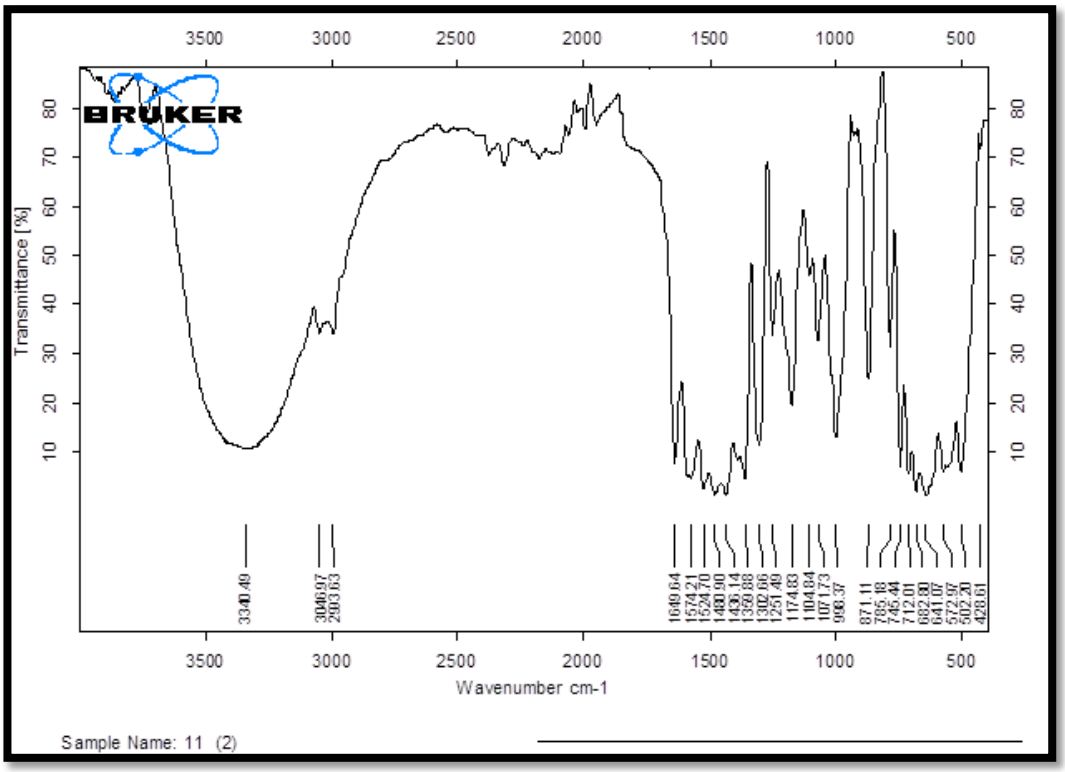

Figure 5. FTIR of derivative 5

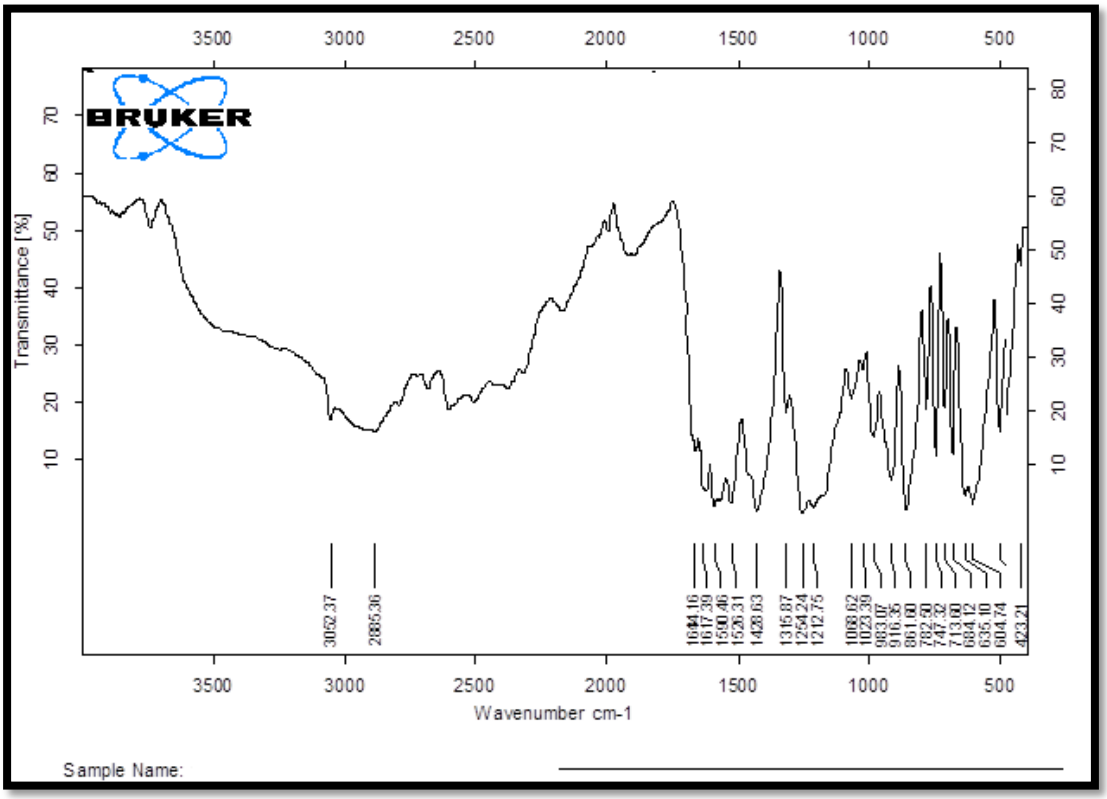

Figure 6. FTIR of derivative 6

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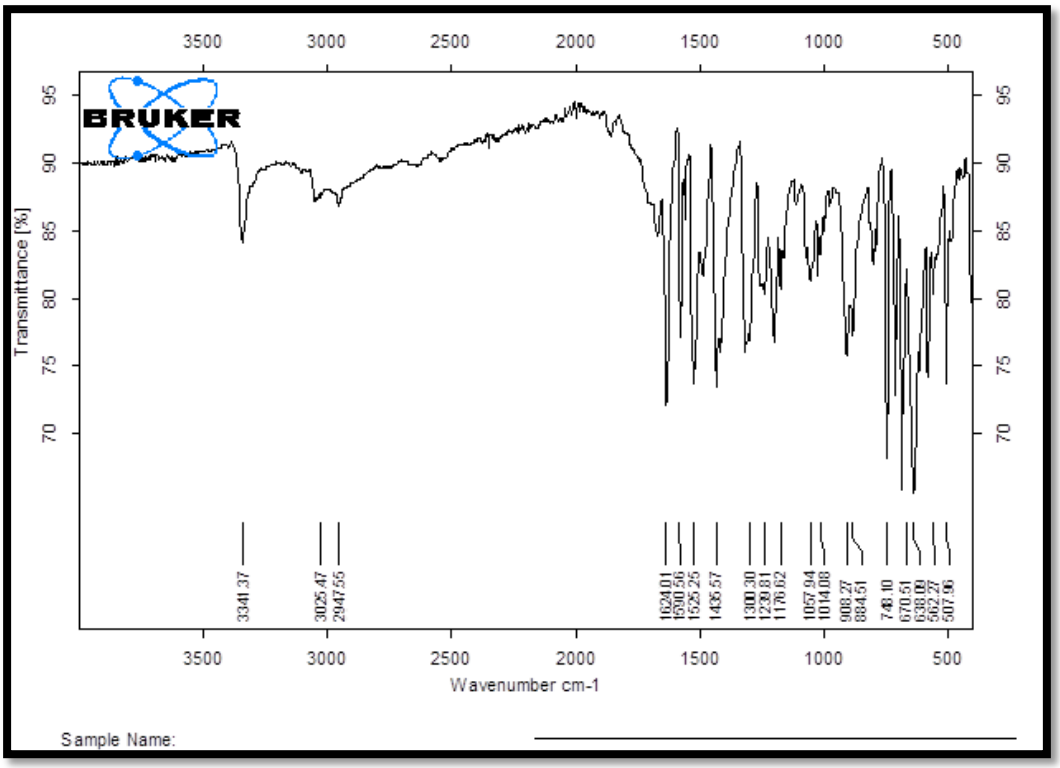

Figure 7. FTIR of derivative 7

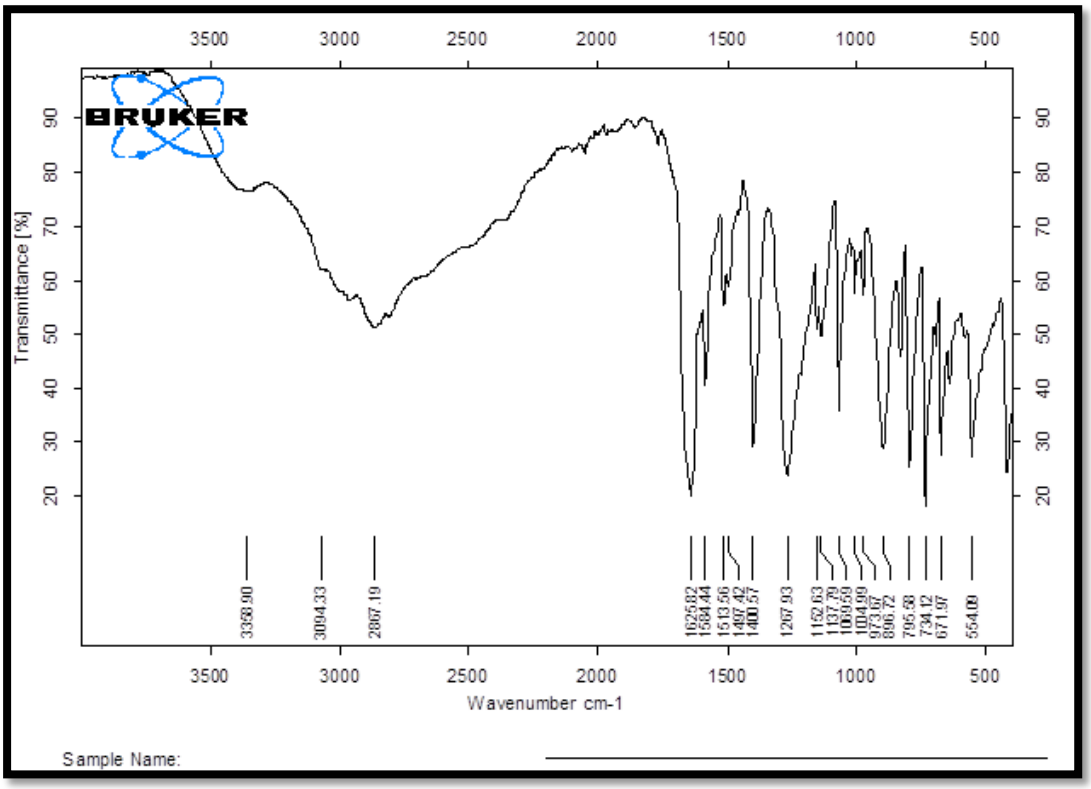

Figure 8. FTIR of derivative 8

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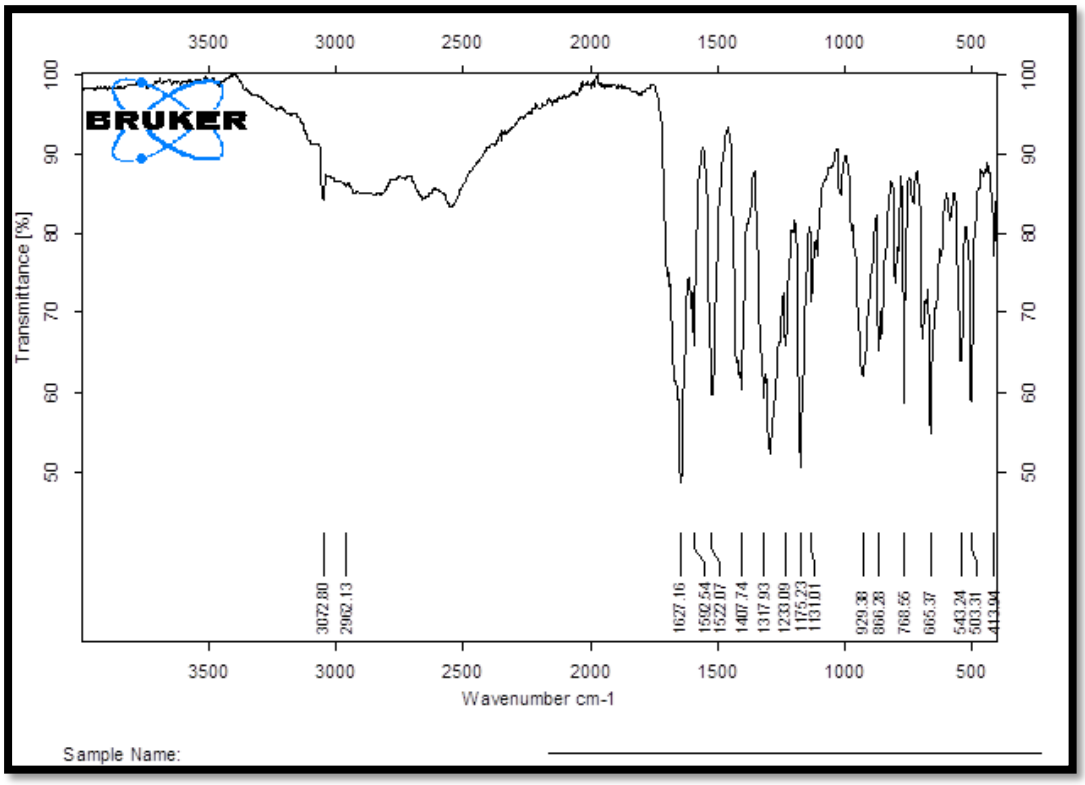

Figure 9. FTIR of derivative 9

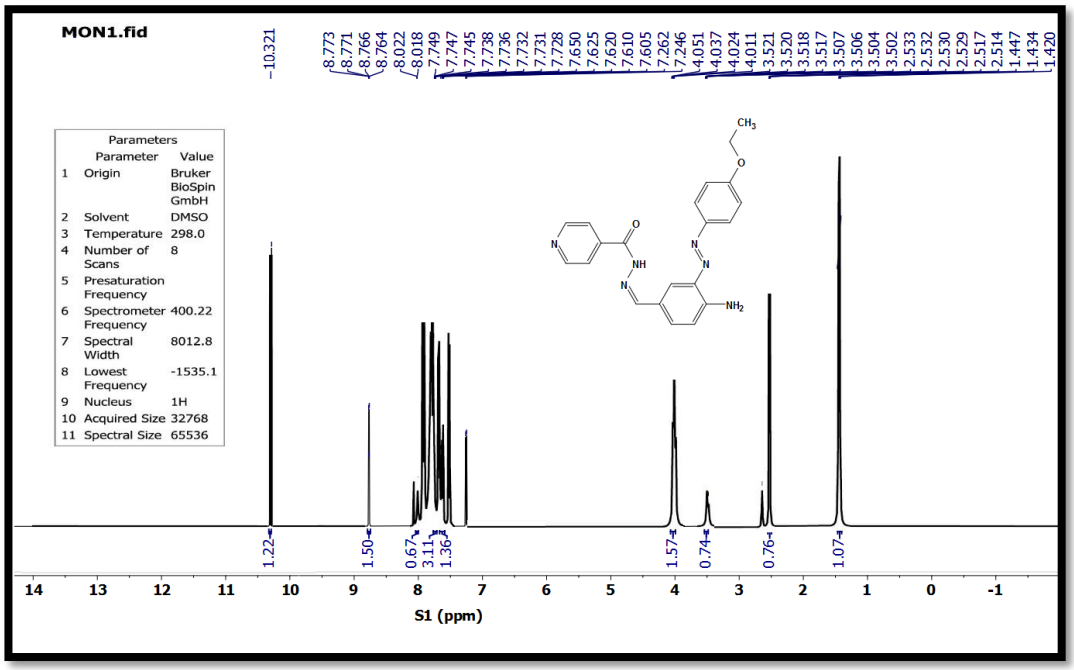

Figure 10. [1]HNMR of derivative 4.

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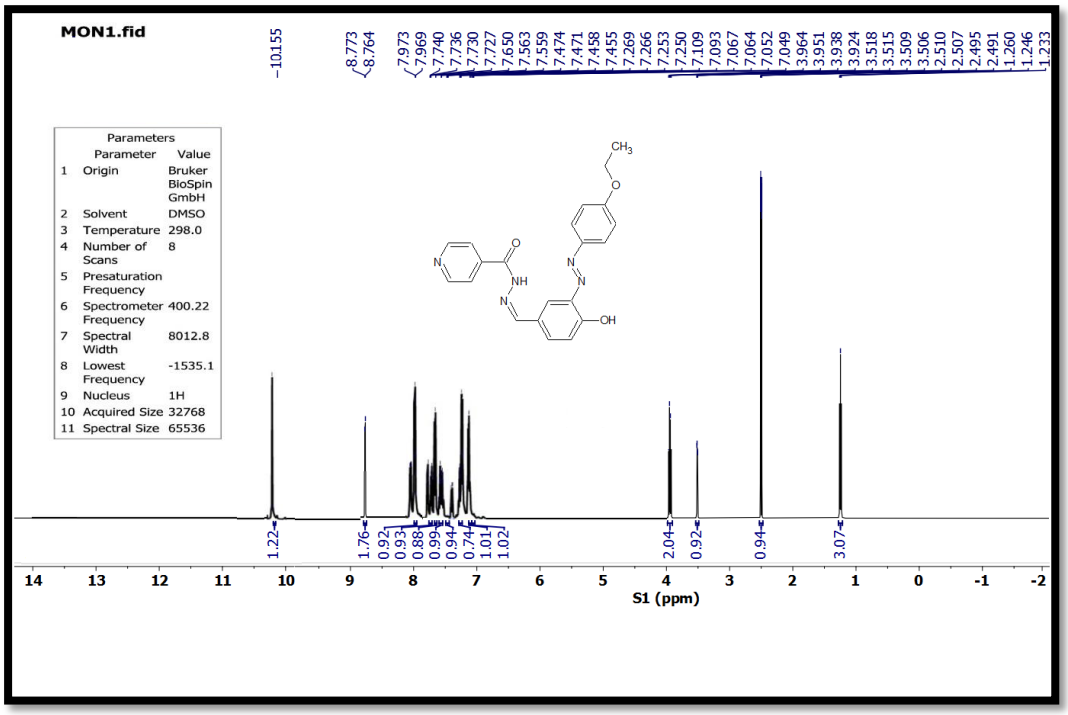

Figure 11. [1]HNMR of derivative 5.

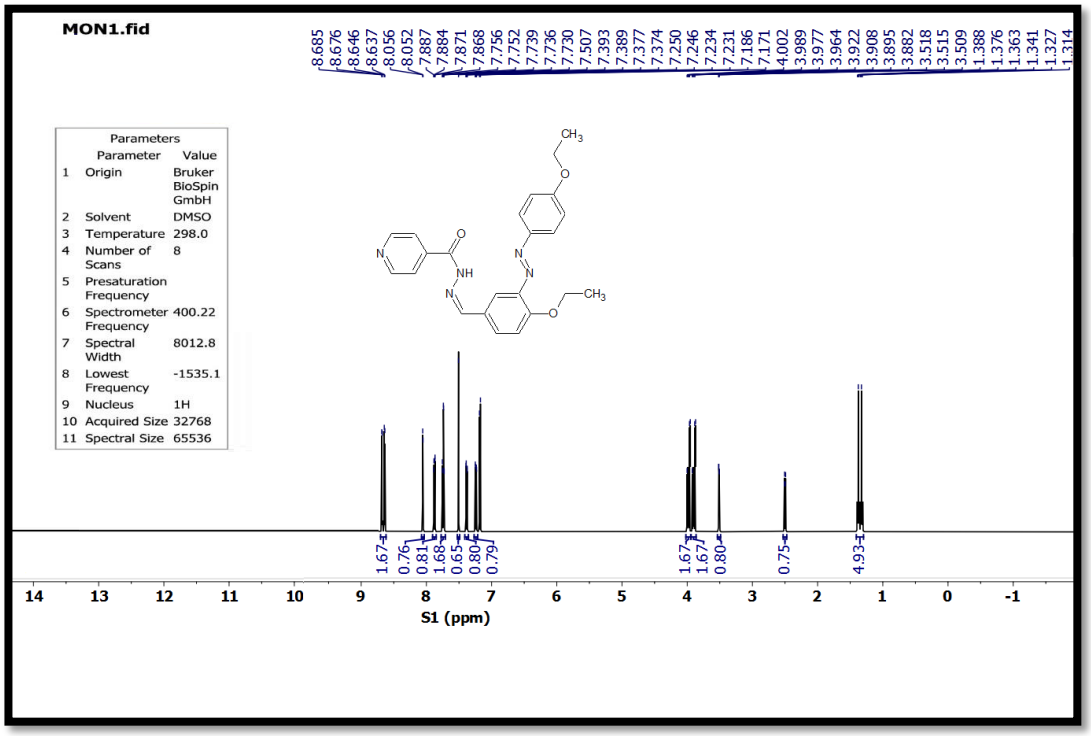

Figure 12. [1]HNMR of derivative 6.

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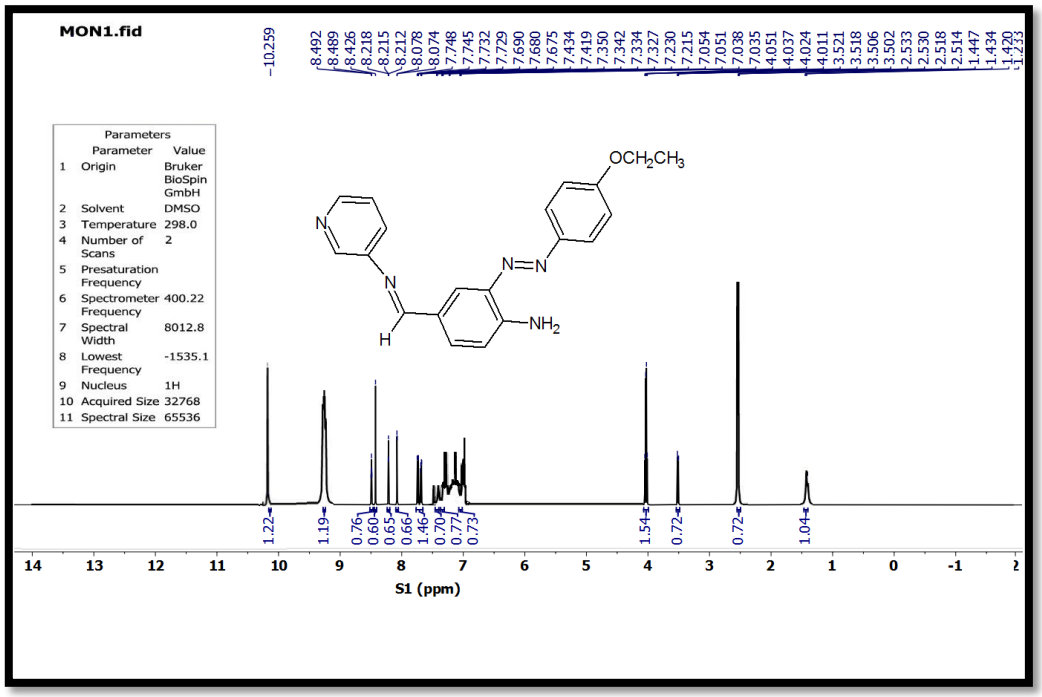

Figure 13. [1]HNMR of derivative 7.

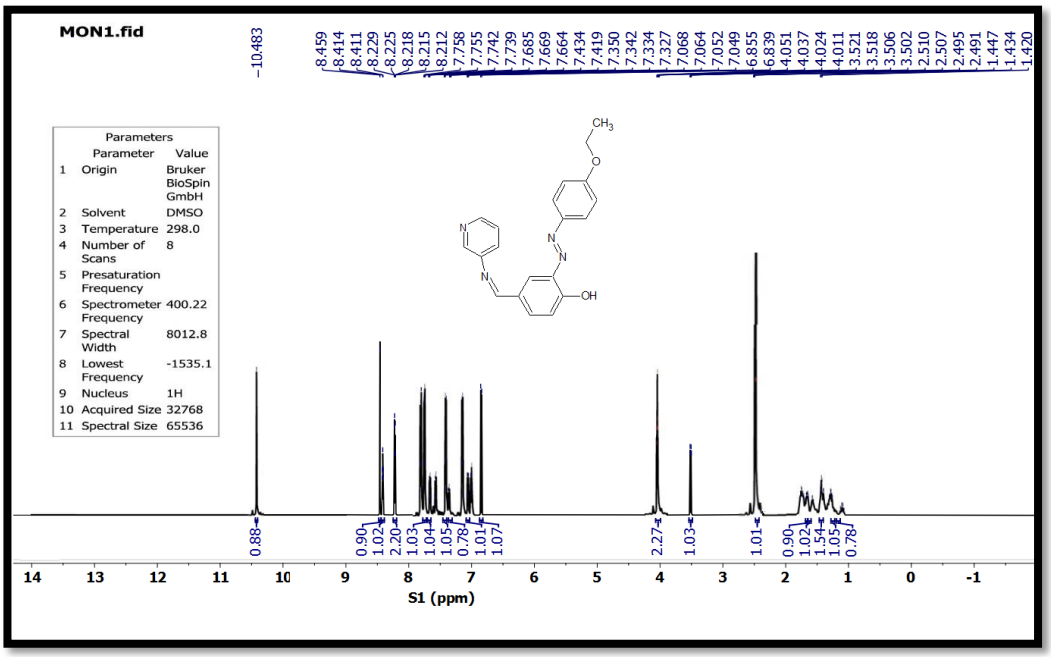

Figure 14. [1]HNMR of derivative 8.

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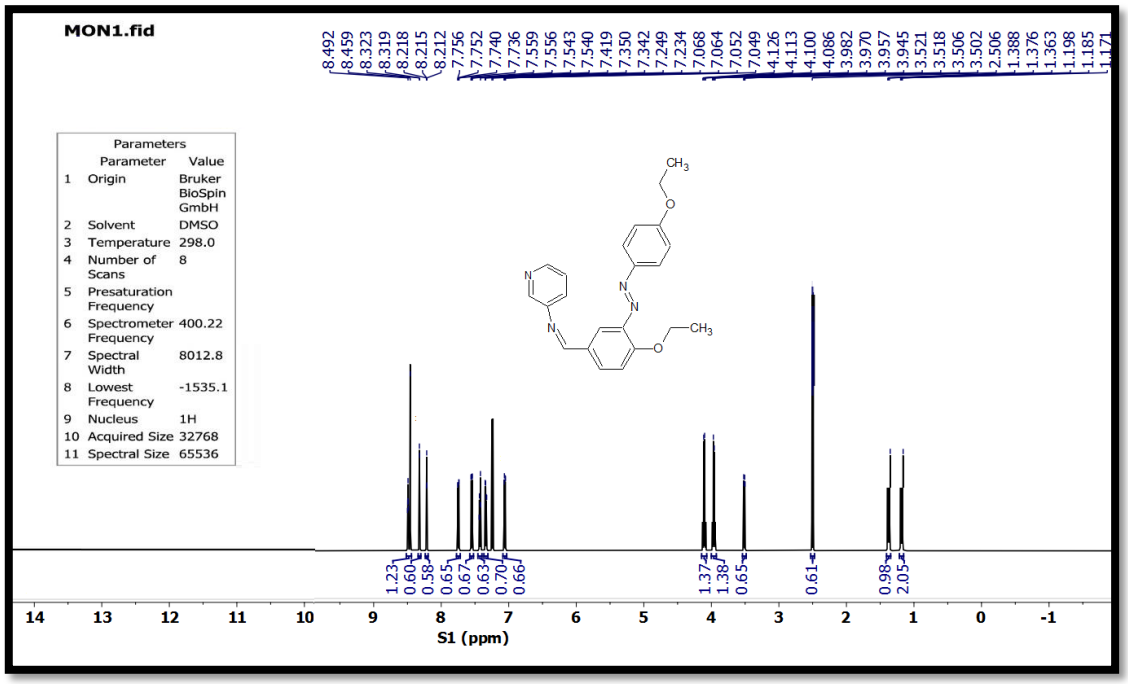

Figure 15. [1]HNMR of derivative 9.

Biological Activity

By using several kinds, including E. coli, Bacillus subtilis, and S. aureus, through the diffusion method, different compounds (4, 6, and 9) that were produced as antibacterials were applied (28-30). Compound 6 work well against any available bacteria. The characteristics of structures, such as activity groups, came back into contact with bacterial cell walls (Sadana et al., 2003; Li & Zhuang, 2020).

Table 2. Biological activities for complexes (4, 6 and 9)

No.	*E. coli*	*Bacillus subtilis*	*S. aureus*
	Zone inhibition (mm)		
4	+	++	+
6	+	++	++
9	++	++	++

Note: + = (less 6 mm), ++ = (more 6 mm)

Conclusion

The Azo-Schiff base derivertives that synthesized from azo compound and differents aldehyde aromatic compounds that characterization by spectroscopic methods. Some these compounds (4, 6 and 9) tested as antibaceria by used different types of bacteria, wthich derivative (6) gives a more activity than other compounds by zone inhibition of all types that used such as E. coli, Bacillus subtilis, and S. aureus.

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