

# Design and Synthesis of Iron (II) Complexes with Schiff Base Derived from 7-Aminocephalosporanic Acid and Heterocyclic Aldehydes

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**Abstract:** The reaction of an Iron (II) acetate with a Schiff base which is prepared from the condensation of benzaldehyde, Salicylaldehyde, Indole-3-carboxyaldehyde or Furfuraldehyde with (6R, 7R)-3-(acetyloxymethyl)-7-amino-8-oxo-5-thia-1-azabicyclo [4.2.0]oct-2-ene-2-carboxylic acid (7-ACA) in a 1: 1 molar ratio, respectively, resulted in a novel set of Iron (II) complexes. The coordination behaviour of Schiff bases towards iron atoms has been studied using a variety of methods, including elemental analysis, conductance measurements, molecular weight estimations, IR, and 1H NMR spectrum investigations.

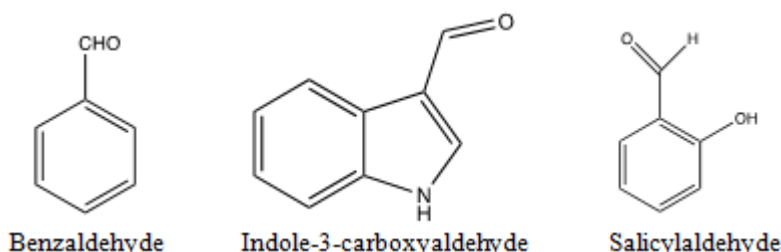
**Keywords:** Schiff base, Iron (II) acetate, benzaldehyde, Salicylaldehyde, Indole-3-carboxy-aldehyde, Furfuraldehyde, Metal complexes, 7-aminocephalosporanic acid, Amino acids, IR, Elemental analysis.

## 1. Introduction

The Schiff bases, which are formed by condensation of amino acids with carbonyl compounds, are another kind of ligand with a-NH donor system, and their metal complexes have attracted a lot of attention<sup>1-6</sup>. By reacting their metal acetates with the heterocyclic ligand, a new heterocyclic methyl-substituted pyridine Schiff base transition metal complexes of diverse metal complexes were developed and produced. Spectroscopic data was used to describe all freshly produced metal complexes, and they were screened for elemental analysis, IR, ESR, and magnetic susceptibility, which revealed square planar and octahedral geometry. Synthesized metal complexes' antibacterial and antioxidant activity provide moderate to excellent results<sup>7</sup>. A novel family of heterocyclic Schiff base complexes has been created via condensation of nicotinohydrazide with different heterocyclic aldehydes, followed by metalation with Co (II) and Cu (II) metal ions.

The chemical structures of Cu (II) and Co (II) complexes were validated by spectral and magnetic data, and the geometry of Cu (II) and Co (II) complexes was square-planar or distorted tetrahedral. The crystalline structures of the metal complexes were supported by Xray diffraction data rather than the amorphous form of the parent Schiff bases. According to a thermographic study, metal complexes are more heat stable than Schiff base ligands. Schiff base ligands and their metal complexes were tested against Gram-positive bacteria like Staphylococcus aureus and Bacillus subtilis, Gram-negative bacteria like E. coli and Proteus vulgaris, and fungi like Aspergillus flavus and Candida albicans. According to antimicrobial inhibitory data<sup>8</sup>, metal complexes have more antibacterial activity than their Schiff base ligands.

It was, therefore, considered of interest to synthesize Fe (II) derivatives of Schiff bases derived by the condensation of benzaldehyde, Salicylaldehyde, Indole-3-carboxyaldehyde or Furfuraldehyde with amino acids. In this paper, we are communicating the results of these studies. The structures of the starting materials are shown in fig.1.



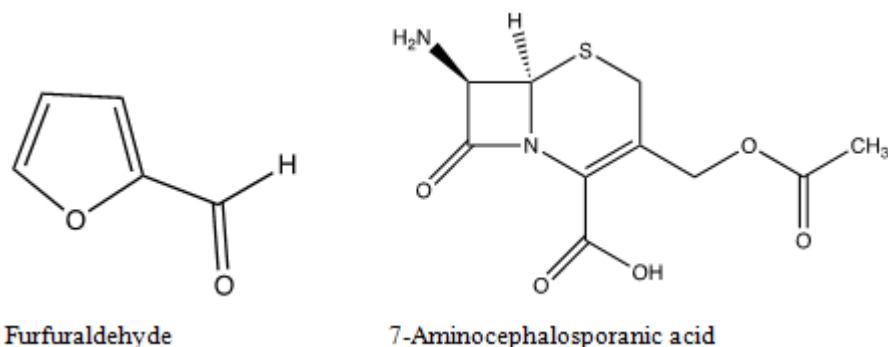


Figure 1: Structures of Aldehydes and Amino Acids

## 2. Experimental

The entire chemicals used in this work are of AR grade, the solvents were dried by standard method and all reactions were carried out under an anhydrous and oxygen-free atmosphere.

### Synthesis of ligands

The Schiff bases were prepared by the condensation benzaldehyde, Salicylaldehyde, Indole-3-carboxyaldehyde or Furfuraldehyde with 7-Aminocephalosporanic acid (7-ACA) in 1: 1 molar ratio using methanol as the reaction medium, respectively. They were then refluxed for 6hours. The Schiff bases crystallised after cooling and were washed with methanol. These were dried and acetone recrystallized. Figure 2 shows the structures of the ligands that were prepared. The main characteristics and analysis of these Schiff bases were recorded in Table 1.

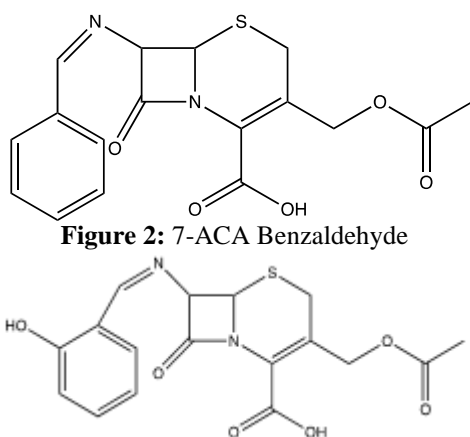
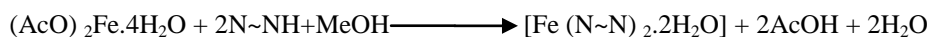


Figure 2: 7-ACA Benzaldehyde



The bi-functional tridentate Schiff base ligand is represented by N~NH. Coloured solids (Table 2) arise from the reaction, which are soluble in DMSO and DMF. These, on the other hand, are vulnerable to humidity and aerial oxidation. The produced compounds had conductance values  $< 50 \text{ Ohm}^{-1}\cdot\text{cm}^2\cdot\text{mol}^{-1}$ , indicating that they were non-electrolytic<sup>9-11</sup>. The Rast Camphor Method, which also assesses the molecular weight of the complexes, demonstrated that they were monomeric.

Figure 3: 7-ACA Salicylaldehyde

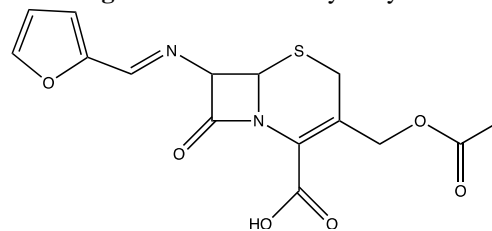


Figure 4: 7-ACAFurfuraldehyde

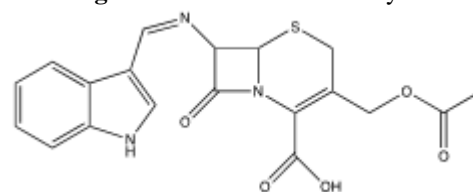


Figure 5: 7-ACA Indole-3-Carboxyaldehyde

### Synthesis of Iron (II) Complexes

In methanol as the reaction medium, the iron (II) acetate was combined with the ligand in a 1: 2 molar ratio. The contents were refluxed for 6-8 hours, and the reaction's progress was tracked by measuring the amount of acetic acid in the azeotrope. The solvent was removed, and the products were washed with dry cyclohexane several times before being dried in vacuo. Table 2 lists the key properties and analyses of these substances. In a 1: 2 molar ratio, the reaction of Iron (II) acetate with the ligands and methanol can be described as follows:

## 3. Results and Discussion

### IR Spectra

When the IR spectra of the ligands and their corresponding Iron complexes are compared, it is clear that the chelate is formed by the oxygen and nitrogen of the ligand moieties. Medium intensity lines seen in the area of  $3300 \text{ cm}^{-1}$  in the infrared spectra of the ligands were assigned to the hydrogen-bonded  $\nu\text{OH}$  vibrations<sup>12-14</sup>, which vanish in the resultant complexes, implying probable deprotonation on complexation and the creation of the Fe-O bond.

Due to the C=N stretching frequency in free ligands<sup>15</sup>, all ligands exhibit clear and strong bands in the area 1610-1625  $\text{cm}^{-1}$ . In the spectra of complexes, it shifts to the lower frequency range (10  $\text{cm}^{-1}$ ). The fall in frequency can be linked to the creation of Fe←N bonds, which results in a decrease in the C=N bond order. The presence of two new medium intensity bands at around 450  $\text{cm}^{-1}$  to 470  $\text{cm}^{-1}$  due to M-O vibrations and at 530  $\text{cm}^{-1}$  to 550  $\text{cm}^{-1}$  due to M-N vibrations<sup>16-17</sup> was revealed in the low-frequency region of the spectra.

The phenolic C-O stretching vibrations may be responsible for a strong band in the ligands at 1280  $\text{cm}^{-1}$ . A shift of this band to a higher frequency (1300  $\text{cm}^{-1}$ ) in the resultant complexes implies ligand interaction through the phenolic oxygen. In addition, due to C=N vibration, a sharp band at 1600  $\text{cm}^{-1}$  was seen during the formation of the Iron complex with methanol.

### <sup>1</sup>H NMR Spectra

The diamagnetic character of Fe (II) metal complexes allowed the <sup>1</sup>H NMR spectra to be scanned in DMSO-d<sub>6</sub>. The magnetic field of the NMR instrument is not affected by diamagnetic Iron metal complexes, whereas the magnetic field of the NMR instrument is affected by paramagnetic Iron metal complexes. The -OH proton signal is found at  $\delta$ 12.69 ppm and the -COOH proton signal is found at  $\delta$ 11.00 ppm in the spectra of ligands. In the equivalent metal complexes, these absorptions vanish. Due to the creation of a co-ordinate bond between the nitrogen and metal atom, the proton signal for the azomethine proton signals at  $\delta$ 8.10 ppm shifts downfield in the spectra of the corresponding metal complexes. For the aromatic protons, the ligand shows a complex multiplet signal in the range of  $\delta$ 8.48 to  $\delta$ 5.75 ppm, and for the metal complexes, it remains in nearly the same location [-CH<sub>2</sub>,-CH (CH<sub>3</sub>)<sub>2</sub>,-CH (CH<sub>3</sub>)-CH<sub>2</sub>-CH<sub>3</sub> at  $\delta$ 3.2 ppm,  $\delta$ 2.19 ppm, and  $\delta$ 1.45-3.15 ppm, respectively.

### Electronic Spectra

DMF has also been used to record the electronic spectra of ligands and their Iron complexes. The spectra of ligands show broadband at ~370 nm and ~350 nm, which can be attributed to the azomethine group's n- $\pi^*$  transition. This band shifts in Iron complexes, appearing at ~415 nm and ~400 nm, showing that the azomethine nitrogen is coordinated to the Iron atom.

These freshly synthesised derivatives can be assigned the following structure based on spectral data and element analysis, as shown below:

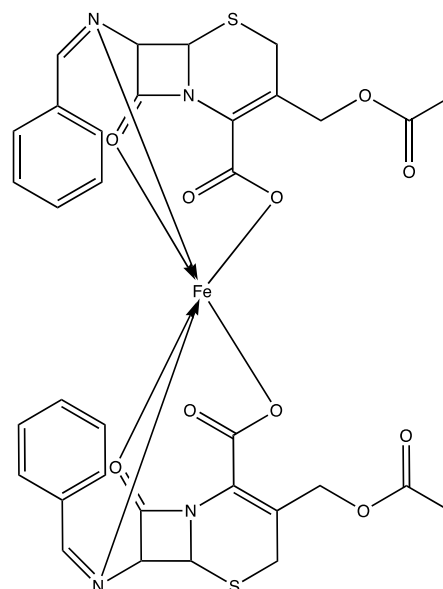


Figure 6: 7-ACA Benzaldehyde Iron Complex

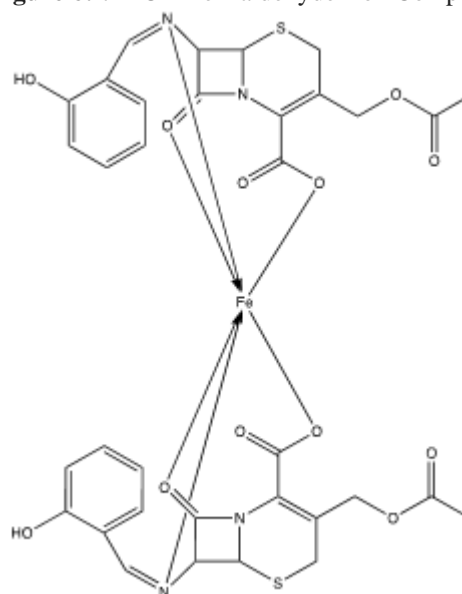


Figure 7: 7-ACA Salicylaldehyde Iron Complex

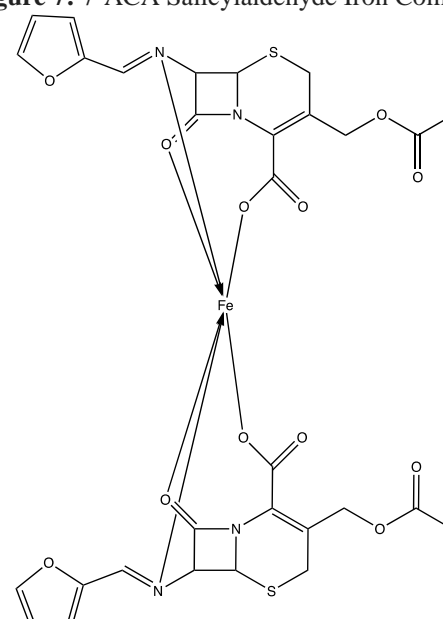


Figure 8: 7-ACA Furfuraldehyde Iron Complex

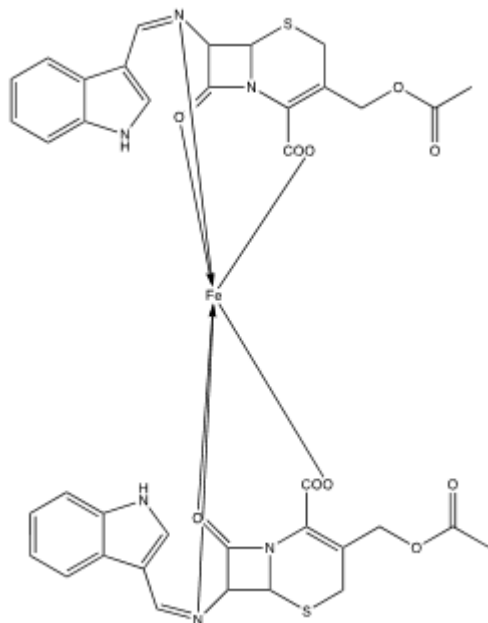


Figure 9: 7-ACA Indolecarboxyaldehyde Iron Complex

**d) Measurements**

Kjeldahl's method was used to calculate nitrogen. The complexes were examined as previously stated<sup>12</sup>. KBr discs were used to record infrared spectra on a Perkin-Elmer-577 spectrophotometer in the 400-200  $\text{cm}^{-1}$  range. The PMR spectra were obtained using a Perkin-Elmer Model RB-12 spectrometer with  $\text{DMSO-d}_6$  as the solvent and TMS as the internal standard. A systronics conductivity bridge model was used to quantify molar conductance in anhydrous DMF at 36°C. The Rast camphor technique was used to determine the molecular weights.

**Table 1:** Elemental analysis of Ligands

Sr. No.	Name of the Ligand (Molecular formula)	Molecular Weight	Melting Point (°C)	Colour of the ligand	% of carbon found (Calc.)	% of hydrogen found (Calc.)	% of nitrogen found (Calc.)	% of oxygen found (Calc.)	% of sulfur found (Calc.)
01	7-ACA Benzaldehyde ( $L_1$ ) ( $C_{17}H_{16}N_2O_5S$ )	358.61 (360.38)	174	Off-White	56.21 (56.66)	4.08 (4.47)	7.32 (7.77)	21.88 (22.20)	8.01 (8.90)
02	7-ACA Salicylaldehyde ( $L_2$ ) ( $C_{17}H_{16}N_2O_6S$ )	373.37 (376.38)	170	Off-White	53.83 (54.25)	3.92 (4.28)	7.01 (7.44)	25.09 (25.51)	7.93 (8.52)
03	7-ACA Furfuraldehyde ( $L_3$ ) ( $C_{15}H_{14}N_2O_6S$ )	346.78 (350.35)	198	Yellowish -Brown	51.09 (51.42)	3.67 (4.03)	7.66 (8.00)	27.00 (27.40)	8.69 (9.15)
04	7-ACA Indolecarboxyaldehyde ( $L_4$ ) ( $C_{19}H_{17}N_3O_5S$ )	325.23 (327.36)	158	Brown	56.89 (58.70)	3.86 (4.00)	12.27 (12.84)	14.18 (14.66)	9.63 (9.80)

**Table 2:** Elemental Analysis of Iron (II) complexes

Sr. No.	Name of the Complex (Molecular formula)	Molecular Weight	Melting Point (°C)	Colour of the ligand	% of carbon found (Calc.)	% of hydrogen found (Calc.)	% of nitrogen found (Calc.)	% of oxygen found (Calc.)	% of sulfur found (Calc.)	% of Iron found (Calc.)
01	7-ACA BenzaldehydeFe Complex Fe ( $C_{17}H_{15}N_2O_5S$ ) <sub>2</sub>	771.28 (774.59)	92	Light Yellow solid	52.41 (52.72)	3.80 (3.90)	7.09 (7.23)	20.21 (20.65)	8.16 (8.28)	6.93 (7.21)
02	7-ACA SalicylaldehydeFe Complex Fe ( $C_{17}H_{15}N_2O_6S$ ) <sub>2</sub>	801.11 (806.59)	167	Off white solid	50.16 (50.63)	3.34 (3.75)	6.45 (6.95)	23.57 (23.80)	7.66 (7.95)	6.56 (6.92)
03	7-ACA FurfuraldehydeFe Complex Fe ( $C_{15}H_{13}N_2O_6S$ ) <sub>2</sub>	749.89 (754.51)	125	Yellow solid	47.15 (47.76)	3.24 (3.47)	7.11 (7.43)	25.22 (25.45)	8.16 (8.50)	7.04 (7.40)
04	7-ACA Indole-3-carboxyaldehyde Fe Complex Fe ( $C_{19}H_{16}N_3O_5S$ ) <sub>2</sub>		182	Light Yellow solid	53.20 (53.53)	3.61 (3.78)	9.74 (9.86)	18.19 (18.76)	7.32 (7.52)	6.23 (6.55)

**4. Acknowledgement**

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