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# An Environmentally Beningn Solvent Free Novel Methods for the Synthesis of Metal Complexes Using Imidazo[4,5-F] 1,10-Phenanthroline and their Derivatives and Biological Activities

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**Abstract:** *$MnL^1$,$CuL^1$,$CoL^1$,$NiL^1$,$CrL^1$,$FeL^1$ and $ZnL^1$ ($L^1$ = [2,4,6-trihydroxy phenyl ] Imidazo[4,5] 1,10-phenanthroline),$MnL^2$,$CuL^2$,$CoL^2$,$NiL^2$,$CrL^2$,$FeL^2$ and $ZnL^2$ ($L^2$ = (5-Bromo,3-Methoxy Phenyl) Imidazo [4,5] 1,10- Phenanthroline), $MnL^3$,$CuL^3$,$CoL^3$,$NiL^3$,$CrL^3$,$FeL^3$ and $ZnL^3$ ($L^3$=2,4,6-trifluro phenyl Imidazo [4,5] 1,10-phenanthroline), $MnL^4$,$CuL^4$,$CoL^4$,$NiL^4$,$CrL^4$,$FeL^4$ and $ZnL^4$ ($L^4$=4-ethyl phenyl Imidazo[4,5] 1,10-phenanthroline), $MnL^5$,$CuL^5$,$CoL^5$,$NiL^5$,$CrL^5$,$FeL^5$ and $ZnL^5$ ($L^5$=4-hydroxy,3,5-dimethyl phenyl Imidazo[4,5] 1,10-phenanthroline) complexes were synthesized. $L^1$, $L^2$,$L^3$,$L^4$ and $L^5$ ligands were prepared by the condensation of 1,10-phenanthroline-5,6-dione with 2,4,6-Trihydroxy benzaldehyde, 5-Bromo,3-methoxy benzaldehyde ,2,4,6-Trifluro Benzaldehyde,4-Ethyl Benzaldehyde,4-Hydroxy 3,5-dimethyl Benzaldehyde respectively. The structures of the compounds were determined by elemental analyses, IR, UV-Visible, 1H-NMR and Mass Spectra. Antibacterial activity of the ligands and their metal complexes were tested against selected bacteria by disc diffusion method.*

**Keywords:** *1, 10-Phenanthroline, Imidazole, complex, antibacterial activity.*

## 1. INTRODUCTION

$L^1$, $L^2$, $L^3$, $L^4$ and $L^5$, Imidazo[4,5-f] 10-Phenanthroline is an important class in organic chemistry ,these compounds have interesting biological activities such as antimycobacterial (1), antimicrobial, Antituberculosis(2), antitumorals(3), anti-inflammatory(4), antimalarial(5), anticonvulsant(6) ,anticancer(7) and anti-HIV(8). The known methods of synthesis "L" suffers from one or other limitation such as harsh reaction conditions ,expensive reagents, low yields and relatively long reaction time. Because of that the research still continuous to synthesize the novel "L" with better methodology in terms of implicitly ecofriendly and economic viability which is achieved by using few drops of ethyl alcohol /acetic acid. For this article we report synthesis of novel "L" derived from [5,6-f] 10-Phenanthroline in acetic acid /$SnCl_2$ ,Potassium Ferrocyanate as a catalyst by grinding method synthesis of organic compounds by grinding method has the advantages of shorter time, higher yield, mild reaction condition as well as being environment friendly(9) thus grinding method comes under the title Green Chemistry, This synthesized "L" are also assayed for antibacterial activities.

## 2. MATERIALS AND PHYSICAL MEASUREMENTS

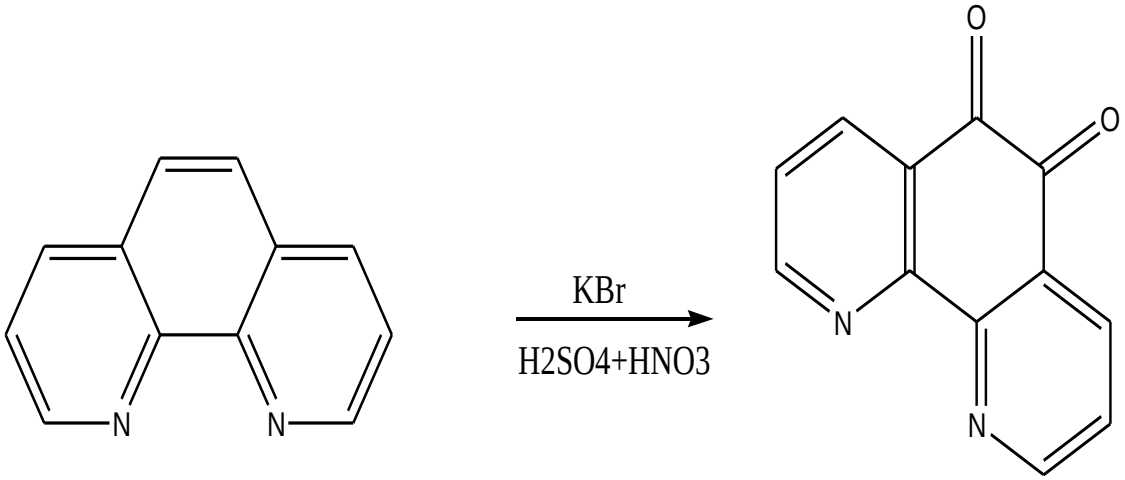
Melting point of synthesized compounds were determined in open-glass capillaries on a stuart-SMP10 melting point apparatus and are uncorrected .Elemental analyses (C, H, N) were performed by using a Leco 932 elemental analyzer. 1H NMR spectra were recorded on a Bruker 300 MHz spectrometer in DMSO-d6. The IR spectra were obtained using KBr discs on an Ati Unicam Mattson 1000 Series FT-IR spectrophotometer. The electronic absorption spectra in the 200–1100 nm range were obtained in DMF on a Shimadzu UV-1700 UV-Visible spectrophotometer mass spectral data were obtained using Positive ESI-MS m/z spectra Magnetic

susceptibility measurements were carried out by the Gouy method at room temperature using Hg[Co(SCN)4] as a reference for calibrant. Conductivities of a 10–3Msolution of the complexes were measured in DMF at 25 °C using a CMD 750 WPA model conductivity meter.

## 3. PROCEDURE

**StepI.** *Synthesis of 1,10-Phenanthroline[5,6-dione]*

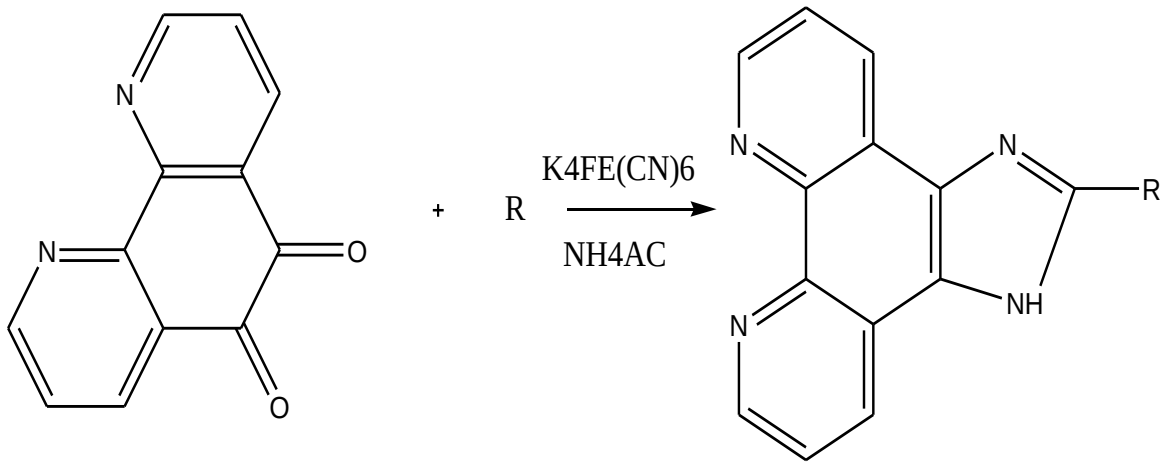
A mixture of 50.4mmol of 1,10 –Phenanthroline is mixed thoroughly with 50.4mmol of KBr, then added 150ml of Conc.$H_2SO_4$ drop wise later 50ml of $HNO_3$ is added similarly in a drop wise manner by maintaining the temperature at $0^0$C-$10^0$C,then refluxed for 5hrs to eliminate Bromine ,till the yellow colour mixture obtained. The obtained mixture is neutralized with dilute $NaHCO_3$ and the compound is extracted with dichloro methane, later the organic layer is separated to get the product.




*1,10-PHENANTHROLINE[5,6]DIONEIR*:;$1^H$NMR:(CDCl3,300MHz),8.08(2H,CAr-H),7.24(2H,Car-H),8.79(2H,CAr–H);IR;(KBr,cm-1)v3375,3025,2927,1591,1147,758,701,538 MS(ESI): *m/z* 205 $[M+H]^+$

**StepII.** ***Synthesis of Ligands ($L^1$, $L^2$,$L^3$,$L^4$and $L^5$)***

A Mixture of (1 mmol) of 1,10-phenanthroline[5,6]dione, (2.89 mmol) of substituted benzaldehyde derivates was crushed in a mortar pistel at room temperature thoroughly using $K_4Fe(CN)_6$ as catalyst then added few drops of glacial acetic acid to get the product, then the progress of reaction was monitored by TLC. After completion of the reaction the crude product was washed with water, dried and purified by column chromatography, "For all the Ligands" same procedure is followed using 20% methanol in benzene (1:1) .



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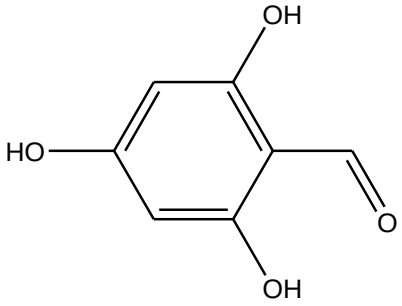
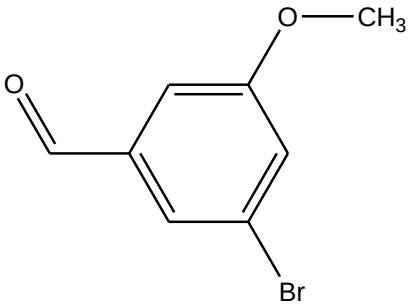
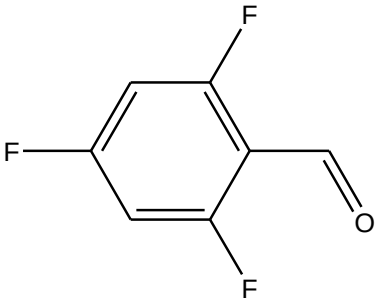
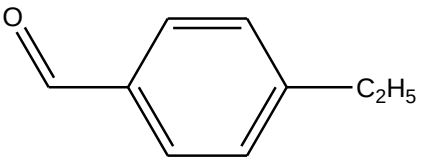
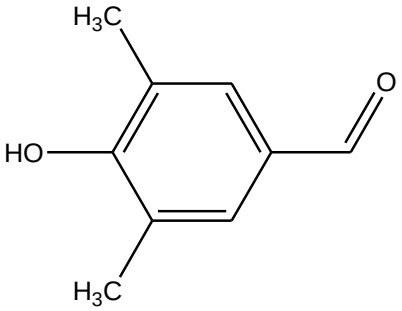
R= 


R= 


R= 


R= 


R= 


*[2,4,6-TRIHYDROXY PHENYL ]IMIDAZO[4,5] 1,10-PHENANTHROLINE* IR: (KBr,cm-1)v:3274–2456,1604,1591,1563,1544,1508,1256; $^{1H}$ NMR:(CDCl3,300MHz), 8.81 (2H,m,CAr – H),8.00 (2H,m,CAr – H), 7.26–5.82 (4H, m, CAr – H), and 5.00 (3H, m, CAr –OH) 5.00 (1H, s, NH) ; MS(ESI): *m/z* 348 $[M+H]^+$

*(5-BROMO,3-METHOXY PHENYL) IMIDAZO[4,5] 1,10-PHENANTHROLINE* IR:(KBr,cm-1)v:3254–2436,1574,1561,1543,1514,1498,1156; $^{1H}$ NMR:(CDCl3,300MHz), 8.81 (2H,m,CAr – H),8.00 (2H,m,CAr – H), 6.90-7.26 (2H, m, CAr – H), 5.00 (1H, s, NH) and 3.73 (3H, s,OCH3); MS(ESI): *m/z* 409 $[M+H]^+$

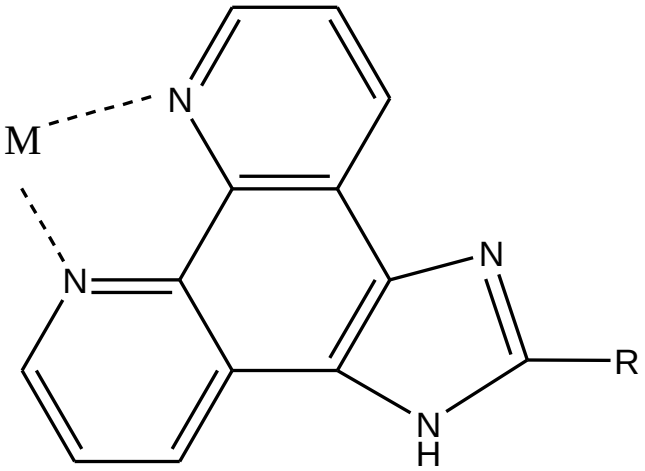
*2,4,6-TRIFLURO PHENYL IMIDAZO[4,5] 1,10-PHENANTHROLINE* IR:(KBr,cm-1)v:3200–2256,1590,1481,1326,1373,1408,1120,780,765; $1^H$ NMR:(CDCl3,300MHz), 8.81 (2H,m,CAr – H),8.00 (2H,m,CAr – H), 7.26 (2H, m, CAr – H), 5.00 (1H, s, NH) and ,6.51(2H,m,CAr-H);MS(ESI): *m/z* 359 $[M+H]^+$

*4-ETHYL PHENYLIMIDAZO[4,5] 1,10-PHENANTHROLINE* IR:(KBr,cm-1)v:3290,3140–2456,1599,1483,1539,1511,1479,1198; $1^H$ NMR:(CDCl3,300MHz), 8.81 (2H,m,CAr – H),8.00 (2H,m,CAr – H), 7.26 (2H, m, CAr – H), 5.00 (1H, s, NH) and ,7.18-7.43(4H,m,CAr-H) and 1.24(2H,s,CH),2.59(2H,s,CH); MS(ESI): *m/z* 320 $[M+H]^+$

*4-HYDROXY,3,5-DIMETHYL PHENYL IMIDAZO[4,5] 1,10-PHENANTHROLINE* IR:(KBr,cm-1)v:3054–2356,1579,1399,1339,1411,1391,1298; $1^H$ NMR:(CDCl3,300MHz), 8.81 (2H,m,CAr – H),8.00 (2H,m,CAr – H), 7.26 (2H, m, CAr – H), 5.00 (1H, s, NH) 5.00 (1H, s, OH) ,6.92(2H,m,CAr-H) and 2.35(6H,s,CH), MS(ESI): *m/z* 338 $[M+H]^+$

**StepIII.** *Synthesis of Complexes*

(1mmol) of liquid in 20ml of methanol is added to (1mmol) metal chelated methanolic solution, reflux for 4 to 5 hours then the complex is precipitated, filter it and wash it with methanol then the precipitate is dried. Then the purity tested with TLC.




Where M=Cr, Mn, Fe, Co, Ni, Cu and Zn

## 4. ANTIBACTERIAL ACTIVITY

The in vitro antibacterial screening effects of newly synthesized ligands ($L^1$, $L^2$,$L^3$,$L^4$and $L^5$) and their metal complexes were tested against various bacterial strains, (Gram Positive and Gram Negative)viz., *E.Coli, S.aureus B.subtilis and K.Pneumonae* The antibacterial activities were evaluated by disc diffusion method using nutrient agar medium for antibacterial activity. All bacteria were inoculated into Nutrient Broth (Difco) and incubated for 24 hr. In the agar well diffusion method (Mueller-Hinton Agar (Oxoid) for bacteria), the dilution plate method was used to enumerate microorganisms (105 bacteria per mL) for 24 hr. Using a sterilized cork borer (6mmdiameter), wells were dug in the culture plates. Metal complexes and ligands were performed at the fixed concentration of 2000 μg mL–1 and compounds dissolved in DMF. Compounds dissolved in DMF were added (75 μL) to these wells. The Petri dishes were left at 4 °C for 2 h and then the plates were incubated at 37 °C and 30 °C for bacteria (18–24 h). At the end of the period, inhibition zones formed on the medium were evaluated is millimeters. DMF was used as negative control under similar conditions for comparison. Ampicillin (AMP) was used as the reference drug in positive controls. The experiments were performed in triplicate.

## 5. STATISTICAL ANALYSIS

In this study, repeated measures analysis of variance was used to evaluate the data. Ligands and their metal complexes were analyzed antibacterial activity at different temperatures. Statistical significance was determined using Duncan multiple comparison test and Bonferroni multiple comparison test was used for grouping within subject factors. SPSS 15.0, version 8, software was used in the statistical analyses.

## 6. RESULTS AND DISCUSSION

Elemental analyses indicate that the metal: ligand ratio is 1:1. The ligands $L^1$, $L^2$, $L^3$, $L^4$ and $L^5$ were soluble in EtOH, DMF and DMSO, and the complexes in DMF and DMSO. The melting points of the all compounds were observed. In IR spectra of $L^1$, $L^2$, $L^3$, $L^4$ and $L^5$, the bands are observed between 3300-3200 cm–1 as broad bands are due to the OH stretching vibrations of H2O molecules. The broadened band between 3100–2900 cm–1 in IR spectra of the $L^1$, $L^2$ ,$L^3$,$L^4$ and $L^5$ ligands is due to the stretching vibrations of the both NH of the imidazole ring and intramolecular hydrogen bonding (O–H...N) formed between phenolic OH and nitrogen atom of C=N group of imidazole ring. The same band was observed in IR spectra of metal complexes of these ligands. This observation confirmed that phenolic OH and nitrogen (C=N) of the imidazole ring do not participate in coordination. Moreover, the stretching vibration of the C=N group (imidazole ring) of the ligands $L^1$, $L^2$ ,$L^3$,$L^4$ and $L^5$ were not significantly affected in their complexes, indicating that the nitrogen atom of this group is not involved in coordination for all the complexes. On the other hand, the bands of the C=N (phenanthroline ring) and C=C (Aromatic) groups were shifted to higher frequencies in all the complexes of $L^1$, $L^2$, $L^3$, $L^4$ and $L^5$ the band at 1563 cm–1 in the free ligand was shifted to higher frequencies (1577 cm–1) in their complexes, that indicates the participation of the C=N (phenanthroline ring) groups in coordination of the metal ion. The bands of the N-H and O–H...N groups in all the complexes of $L^1$, $L^2$ ,$L^3$,$L^4$ and $L^5$ shifted to negative frequencies after complexations. The N-H, O–H...N and Ar-O-CH3 groups in all complexes of $L^1$, $L^2$ ,$L^3$,$L^4$ and $L^5$ .The negative frequency shifts of these groups may be attributed to flow of electrons from these groups to the phenanthroline ring due to electron flow from the nitrogen atom of the phenanthroline ring to the metal ion after complexations.

## 7. CONCLUSION

In this study, imidazole and phenanthroline containing $L^1$, $L^2$, $L^3$, $L^4$ and $L^5$ complexes were synthesized and characterized. According to the IR data of the compounds, ligands ($L^1$, $L^2$, $L^3$, $L^4$ and $L^5$) are coordinated to the metal ions through nitrogen atoms of the C=N (phenanthroline ring) groups. The results obtained from this research demonstrated that all synthesized compounds have antibacterial activity against the bacterial strains. In this sense, we think that the ligands and their metal complexes might be effective as antibacterial agents against bacteria.

## ACKNOWLEDGEMENT

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