



Synthesis, Characterization and Antimicrobial activity of Cobalt (II) Complexes with Pyrimidine derivatives

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Abstract

In this paper synthesis, spectral and antibacterial studies of Cobalt (II) complexes with pyrimidine derivatives have been reported. Elemental analysis, infrared, electronic spectra and magnetic susceptibility studies have been used for characterisation. Antimicrobial activities of these pyrimidine derivatives and its complexes have also been described. These complexes show UV bands in region about 11376 cm⁻¹ to 26315 cm⁻¹ and tentative assignment ⁴T_{1g}(F)→⁴T_{2g}(F), ⁴T_{1g}(F)→⁴A_{2g}(F), ⁴T_{1g}(F)→⁴T_{1g}(P) transitions. Co (II) complexes have been concluded octahedral environment with magnetic moment 3.87 BM. The microwave method of synthesis of complexes have been found easier, convenient and ecofriendly.

Keywords: Co (II), Microwave, Amide, Antimicrobial, Supramolecule.

Introduction

Amides acts strategically in environment. Proteins are main constituents of animal's body and proteins are chemically polyamide¹. Transition Metal amide complexes contain one or more -CONH₂ groups or its simple derivatives attached to transition metal. Metal amides are mono, di-or poly nuclear and nitrogen is in a three coordinated environment in these complexes. Metal amide is an important building unit of many biological and natural products compounds like porphyrin, chlorophyll and cynocobalmine etc.²⁻⁸. Cobalt is a constituent element of many alloys. CoCO₃ is used in ceramic industries⁹. Cobalt is found in smoke from forest and bush fires, seawater, soil, volcanic emission. In many industries i.e. manufacture or disposal of paints, varnishes, ceramics, inks, enamels motor vehicle exhaust cobalt emitted in environment¹⁰. Human add cobalt by releasing small amount into the atmosphere from coal combustion and mining. Radioactive isotope of cobalt metal is released by nuclear power plant operation and nuclear accidents but not present in the environment naturally. Because cobalt metal has relatively short half-life time so this is not particularly dangerous¹¹. Cobalt is a central metal of the vitamin B₁₂. The usually quantity of vitamin B₁₂ is 2-5 mg in adult body. Meat, kidney and liver are good dietary sources of cobalt. Cobalt is used in treatment of anaemia during woman pregnancy, because cobalt induces the productivity of RBC. The inhalation of contaminated air by high concentration of cobalt results asthma and pneumonia. Plants grew in defective soils they have been collected small particles of cobalt, when we eat fruits and seeds of these plant we defected from dieses i.e. vision problems, nausea and vomiting, thyroid damage and heart problem¹². Cobalt inferiority is combined with the incidence of par tuberculosis the ruminant analog of Crohn's disease in human

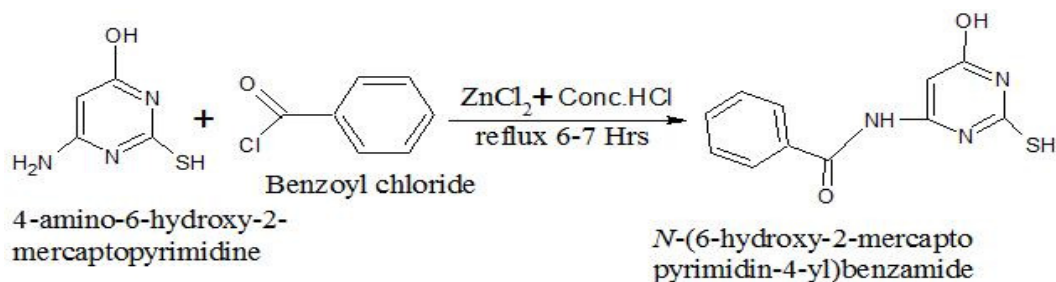
body¹³. This work has been designed to carry out Green synthesis and evaluate the biological activity of Co (II)-transition metal complexes.

Materials and Methods

Apparatus: EC Double Beam UV-VIS Spectrophotometer; IR spectra were recorded on Bruker Optic Model Alpha (FT-IR) (Zn-Se Optics, ATR) (4000-400 cm⁻¹) using KBr disc; TLC (Thin layer chromatography) of all compounds (ligands and complexes) measured by using Silica Gel; Microwave synthesis was carried out by microwave oven 2450MHz, 800W and GMBR (Green Microwave Biochemical Reactor). All biological activities have been carried out with horizontal laminar, BIFR, Bikaner.; Melting point of all compounds was recorded in a Sulphuric acid bath or by using Beckmann M.pt. apparatus.

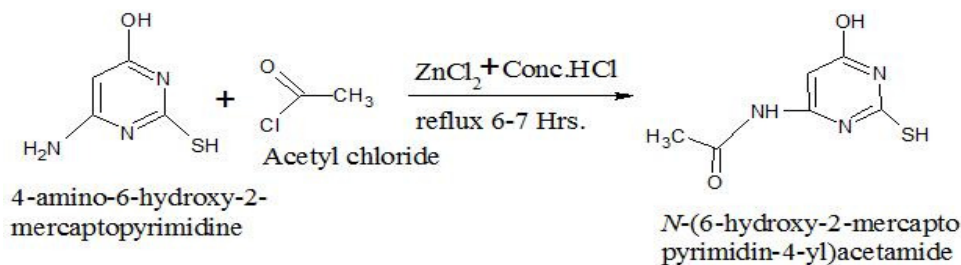
Experimental: Synthesis of Co (II) complexes with pyrimidine derivatives: For the synthesise of Cobalt (II) compound with pyrimidine derivatives ligands, Cobalt Chloride solution (1mmol in 30 ml ethyl alcohol) has been taken in a 250 ml round bottom flask, in this solution respective amide ligands (i.e. N6H2MC4PB, N6H2MC4PA, N26DH4PB, N26DH4PA) (3 mol) was added slowly with constant stirring. The reaction mixture was keeps on a magnetic stirrer with constant stirring for 6-7 hours at 20-25°C.

As an alternative, a novel method of synthesis has been developed as per the principles of green chemistry, in which, either the reaction was irradiate in a domestic microwave oven at 600 W for 2.00-5.00 min. on alumina bed or reaction mixture in the solvent or the slurry of reaction mixture was exposed in a microwave reactor at 600 W maintaining different time intervals



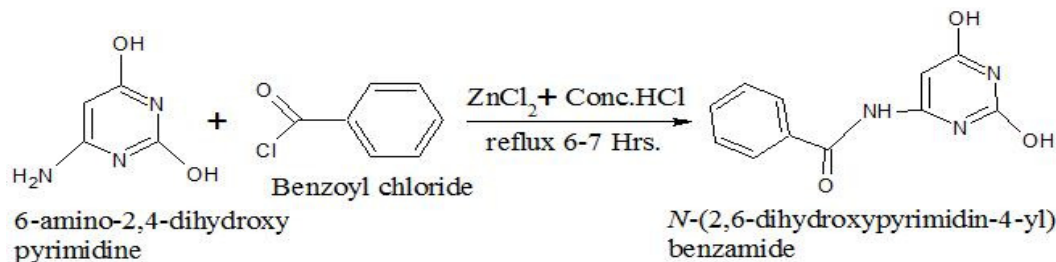
Scheme-1

Synthesis of N-(6-hydroxy-2-mercaptopyrimidin-4-yl)benzamide (N6H2MC4PB) by conventional method



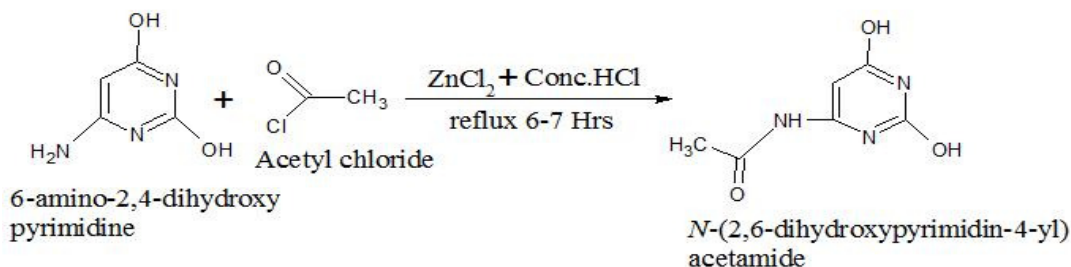
Scheme-2

Synthesis of N-(6-hydroxy-2-mercaptopyrimidin-4-yl)acetamide (N6H2MC4PA) by conventional method



Scheme-3

Synthesis of N-(2,6-dihydroxypyrimidin-4-yl)benzamide (N26DH4PB) by conventional method



Scheme-4

Synthesis of N-(2,6-dihydroxypyrimidin-4-yl)benzamide (N26DH4PA) by conventional method

with respect to occasional and or definite inspection of TLC data. The solid precipitate obtained in both the methods was separated and crystallized. Crystals were purified and recrystallized with alcohol and dry under vacuum¹⁴.

Results and Discussion

Amide group containing ligands which are formed from pyrimidine derivatives react with various Co (II) salts at

20-25°C. The colours of complexes varied from pink to blood red. These complexes were found to be crystalline state and stable in normal laboratory condition over a longer time, insoluble in normally organic solvents, these complexes are easily soluble in DMSO. The physicochemical characteristics of complexes are presented in Table-1. The values of λ_{max} indicate that the complexes are non-electrolytic in nature¹⁵. Observed values of C, H, N and cobalt analytically estimated are well in accordance with calculated values.

Table-1
Physicochemical characteristics of Cobalt (II) Complexes

Complexes	Colour	m.p (°C)	Reaction period		Yield %		Elemental analysis Calculated (Found)%		
			Conventional Method (hrs.)	Microwave Method (min.)	Conventional Method	Microwave Method	C	H	N
[Co-(N6H2MC4PB) ₃].Cl ₂	Off white	301	6.5	2.00	40	50	45.46 (45.42)	3.09 (3.00)	14.46 (14.40)
[Co-(N6H2MC4PA) ₃].Cl ₂	Off white	310	7	2.30	45	50	31.53 (31.45)	3.06 (2.96)	18.39 (18.32)
[Co-(N26DH4PB) ₃].Cl ₂	Yellow	312	7	2.00	40	60	48.11 (48.05)	3.28 (3.20)	15.30 (15.20)
[Co-(N26DH4PA) ₃].Cl ₂	Yellow	320	6	2.00	50	60	33.90 (33.84)	3.29 (3.22)	19.78 (19.72)

IR Spectral data: The characteristic IR wave numbers of these complexes are shown in Table-3. The negative shift in IR bands in the range 3163- 3418 cm⁻¹ assigned for ν(C=O) (amide-I) suggests the involvement of amide oxygen in coordination to metal¹⁶. It is indicated by the decrease and increase in the wave number of C=O and C-N bonds respectively, as a result of bond lengthening of C = O bond and bond shortening of C-N bond, in the IR spectral data. Participation of amide O, in coordination to metal is further confirmed by shifting of amide I and II bands, towards higher wave length. New weak broad peaks in IR region 425-530 cm⁻¹ and 474 544 cm⁻¹ are due to bands M-N and M-O respectively¹⁷.

(N26DH4PA)₃.Cl₂ the decrease in C=O stretching frequency is much lesser than all other complexes, which is suggestive of poor coordination through carbonyl O, even than complex is stable and its stability can be correlated to the formation of supramolecule due to intramolecular hydrogen bonding in between -OH of second position and carbonyl oxygen which is reported by a peak observed at 3647 cm⁻¹. Structure of complexes has showed in figure 3 to figure 4¹⁸.

In complexes Figure-1 to 4 pyrimidinyl nitrogen participates in bonding, which has been confirmed by the 16-87 cm⁻¹ negative shifting of pyrimidinyl ring peak in complexes to the comparison of ligands.

In the complexes [Co-(N26DH4PB)₃].Cl₂ and [Co-

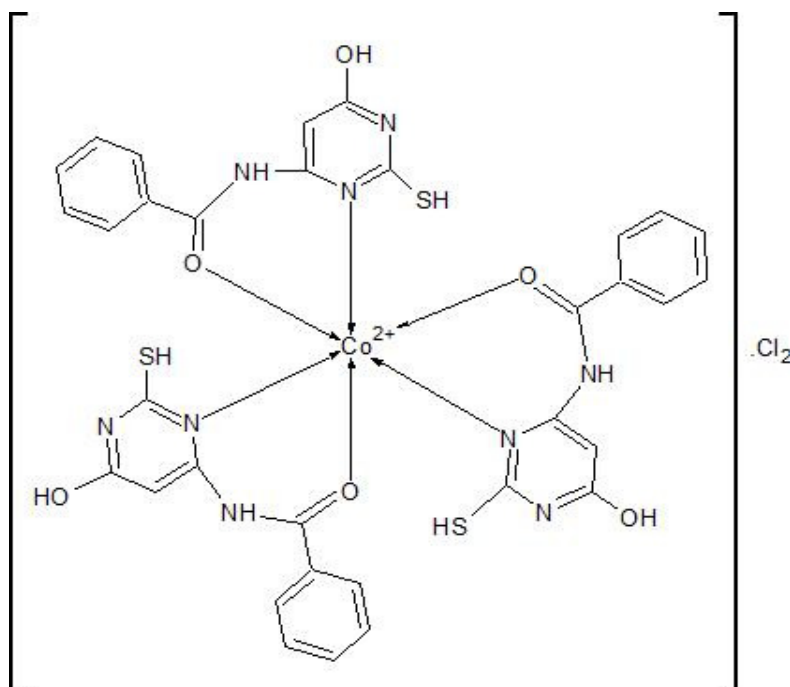


Figure-1
Tentative Structure of Complex [Co-(N6H2MC4PB)₃].Cl₂

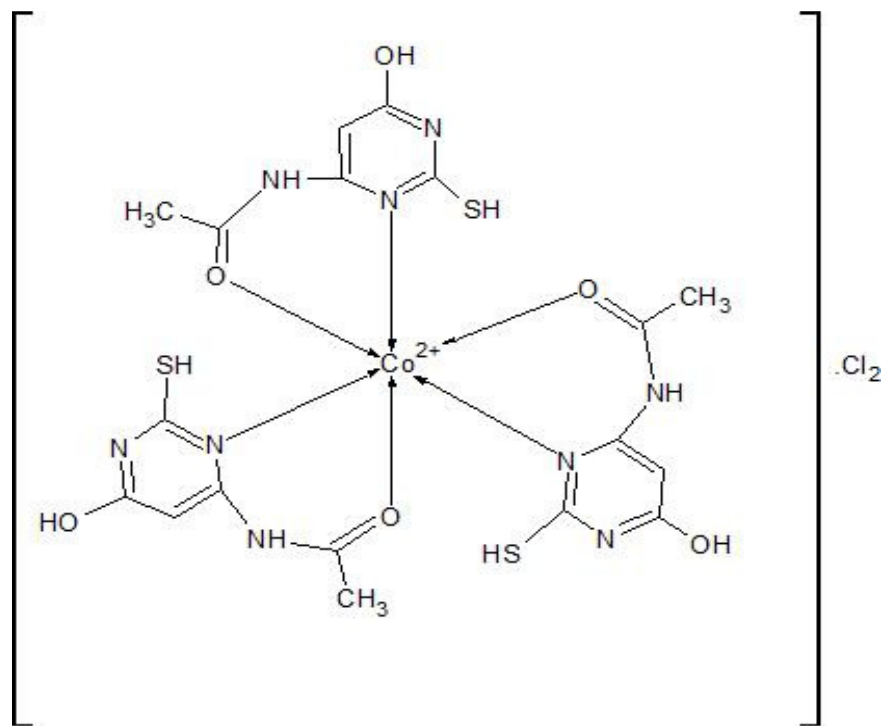


Figure-2
Tentative Structure of Complex [Co-(N6H2MC4PA)₃]Cl₂

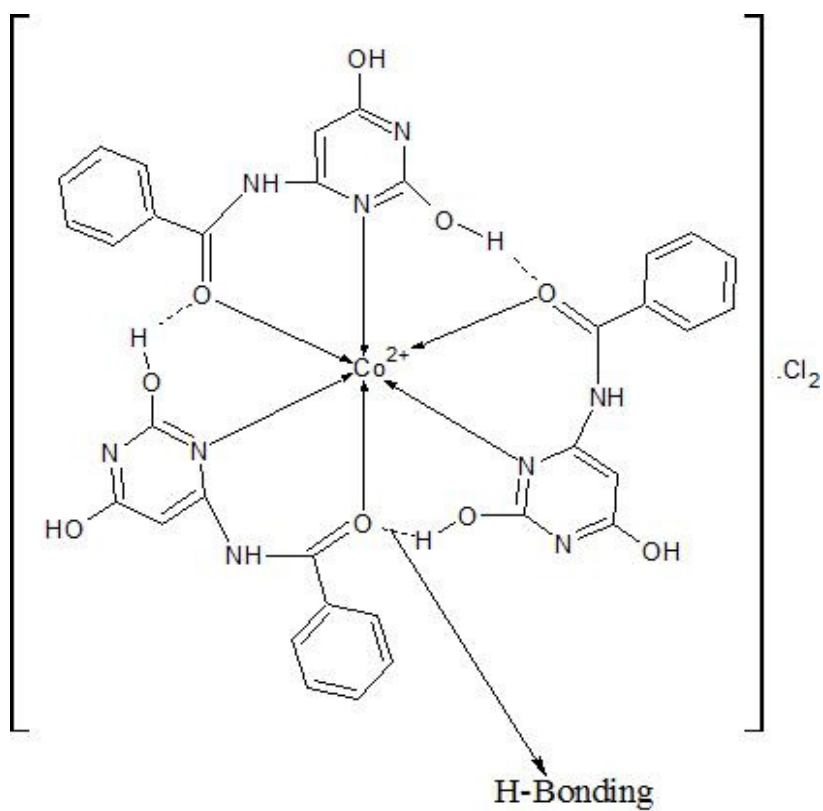


Figure-3
Tentative Structure of Complex [Co-(N26DH4PB)₃]Cl₂

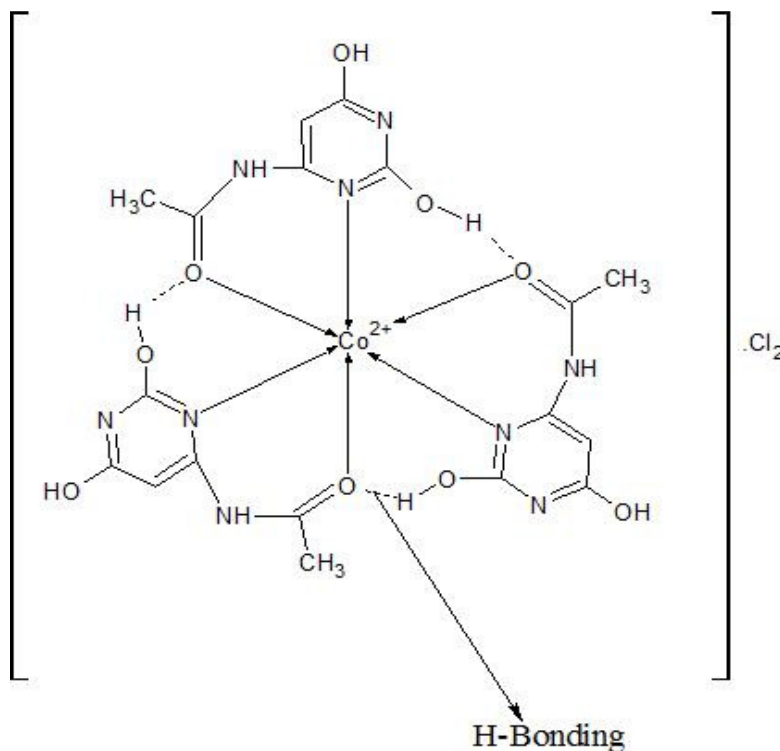


Figure-4
Tentative Structure of Complex [Co-(N26DH4PA)₃]Cl₂

These observations have ambiguous and support the final structural conclusions of the complexes and the mode of bonding in them.

Magnetic studies: The magnetic studies have been reported in solid state at 298°K and the outcome of the observations shown in Table-2.

The magnetic moment of the synthesized complexes in the ranges from 4.58-5.10 BM, which correspond three unpaired electrons. This indicates a quartet ground state term ⁴F (S = 3/2) which is the case of Co (II) (d⁷). The complexes under the present study have shown higher value of magnetic moment than the spin only value (3.87 BM) and this may be due to orbital contribution. Octahedral geometry of the cobalt complexes is further ascertained by the study of the electronic spectra.

Table- 2
Electronic Spectral and Magnetic data of synthesized compounds

Ligand and Complex	R _f value	μ _{eff} (BM)	Uv-Vis Bands λ _{max} (cm ⁻¹)	Uv-vis transition	Expected Geometry
[Co-(N6H2MC4PB) ₃]Cl ₂	(0.638) ^f	4.78	11862, 14347, 15698, 16806, 18281, 20120, 24509, 27322	⁴ T _{1g} (F) → ⁴ T _{2g} (F), ⁴ T _{1g} (F) → ⁴ A _{2g} (F) ⁴ T _{1g} (F) → ⁴ T _{1g} (P)	Distorted Oh
[Co-(N6H2MC4PA) ₃]Cl ₂	(0.900) ^h	4.84	11198, 13440, 14836, 17094, 18867, 20161, 22271, 24509,	⁴ T _{1g} (F) → ⁴ T _{2g} (F), ⁴ T _{1g} (F) → ⁴ A _{2g} (F) ⁴ T _{1g} (F) → ⁴ T _{1g} (P)	Distorted Oh
[Co-(N26DH4PB) ₃]Cl ₂	(0.720) ^h	4.58	11876, 13297, 14064, 14577, 15337, 15698, 18248, 20120, 21598, 26881	⁴ T _{1g} (F) → ⁴ T _{2g} (F), ⁴ T _{1g} (F) → ⁴ A _{2g} (F) ⁴ T _{1g} (F) → ⁴ T _{1g} (P)	Distorted Oh
[Co-(N26DH4PA) ₃]Cl ₂	(0.750) ^a	4.70	11363, 13717, 14792, 15432, 16129, 17006, 18903, 20746, 23419, 24630	⁴ T _{1g} (F) → ⁴ T _{2g} (F), ⁴ T _{1g} (F) → ⁴ A _{2g} (F) ⁴ T _{1g} (F) → ⁴ T _{1g} (P)	Distorted Oh

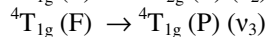
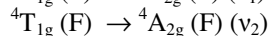
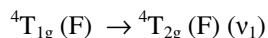
a = CH₃COOC₂H₅: CCl₄ (2:8), b = CH₃COOC₂H₅: CCl₄ (4:6), c = CH₃COOC₂H₅: CCl₄ (5:5), e = CH₃COOC₂H₅: CH₃COCH₃ (5:5)
f = CH₃COCH₃: CCl₄ (5:5), h = CH₃COCH₃: CCl₄ (7:3).

Table-3
Vibrational spectral Data of synthesise compounds

Complexes	ν_{N-H} (amide)	$(\nu_{C=O})^x$	$(\nu_{C-N+\delta N-H})^y$	$(\nu_{N-H+\delta C-N})^z$	Pyrimidinyl	ν_{M-N}	ν_{M-O}	ν_{M-cl}
N6H2MC4PB	3163	1706	1421	1284	1685			
[Co-(N6H2MC4PB) ₃ Cl ₂]	3178	1637	1540	1398	1617	488	535	----
N6H2MC4PA	3175	1715	1340	1242	1683			
[Co-(N6H2MC4PA) ₃ Cl ₂]	3213	1617	1456	1396	1658	489	540	----
N26DH4PB	3353	1714	1422	1282	1582			
[Co-(N26DH4PB) ₃ Cl ₂]	3392	1698	1456	1396	1541	474	503	----
N26DH4PA	3196	1716	1284	1249	1416			
[Co-(N26DH4PA) ₃ Cl ₂]	3199	1706	1356	1291	1400	485	544	----

x: - amide – I band, y: - amide – II band, z: - amide – III band

Uv-Vis Spectra: The Cobalt (II) ion has the $3d^7$ electronic configuration which in octahedral fields may give rise to either high spin $t_{2g}^5 e_g^2$ or low spin $t_{2g}^6 e_g^1$, complexes rather high values of the ligand field splitting parameter ($Dq > 150 \text{ cm}^{-1}$) are in fact required to cause spin pairing with cobalt (II). Therefore, it will be assumed that the weak crystal field is in good approximation for complexes containing metal ions. Based on the fact that cobalt (II) metal ion has ground state term 4F and the higher state having the same spin multiplicity in 4P . Thus, in octahedral complexes following transitions should be expected:



These transitions occur around 8000, 17000 and 20,000 cm^{-1} respectively. The ν_2 transition is very weak and often appears as a shoulder. The solution spectral data of cobalt (II) complexes are presented in Table-2 and shown in Figure-1 to 4. The complexes of cobalt (II) under the present study show two bands centred at 8000-11000 cm^{-1} , 13000-16800 cm^{-1} and 20000-23000 cm^{-1} . These bands are typical of high spin octahedral complexes and may be assigned to $^4T_{1g}(F) \rightarrow ^4T_{2g}(F) (\nu_1)$, $^4T_{1g}(F) \rightarrow ^4A_{2g}(F) (\nu_2)$ and $^4T_{1g}(F) \rightarrow ^4T_{1g}(P) (\nu_3)$ respectively.

Thermal Studies: The complexes of Cobalt (II) with the amide group containing ligands show first order kinetics in their

thermal decomposition reaction. This is based on a straight line plot of Coats and Redfern (for $n = 1$). Activation energy (E_a) has been calculated by the linearization method of Goats and Redfern. The thermal studies give the description about the thermal stability of the complexes. It has been observed that no decomposition takes place at room temperature and complexes are fairly stable well above the room temperature. The initial decomposition started above 500K.

Conclusion

On the basis of above observations following points can be concluded for the concrete, structure's of cobalt complexes of the amide group containing ligands. From magnetic susceptibility measurements, it is clear that cobalt (II) having magnetic moment values in the range 4.9-5.2 BM (higher than spin only value of 3.87 BM due to orbitally contribution). Electronic spectral studies further support the octahedral geometry adopted by the cobalt complexes on the basis of various characteristic absorption bands. The complexes synthesized by novel green method are at par with conventional synthesis and in many cases yield was found to be better than conventional synthesis.

Two complexes are found to exist in supramolecular structure due to which this synthesis, observation and report have become unique and there is a scope of further investigation. Antimicrobial activity of pyrimidinyl derivatives and their Cobalt (II) complexes are shown Figure-5 to 6.

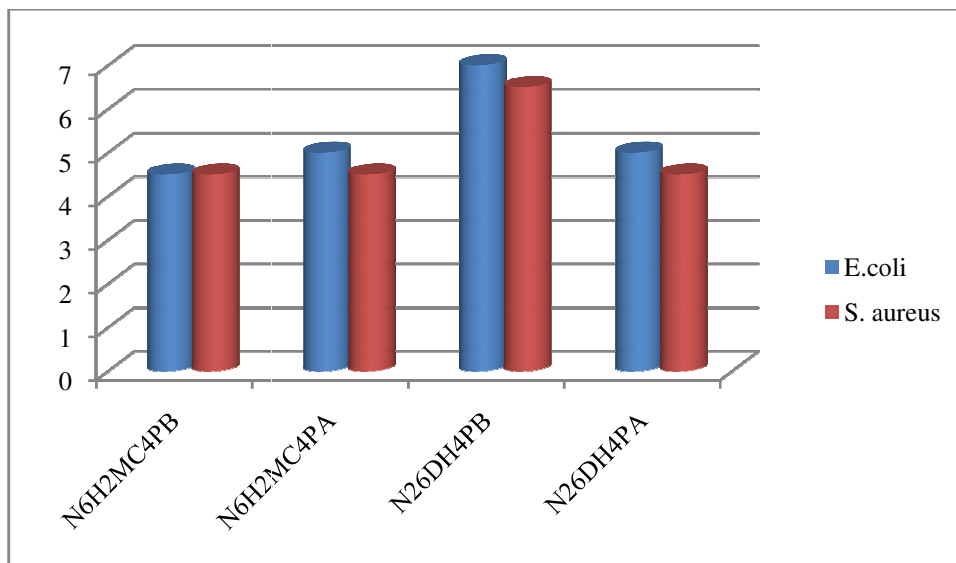


Figure-5
Biological activity of pyrimidine derivatives

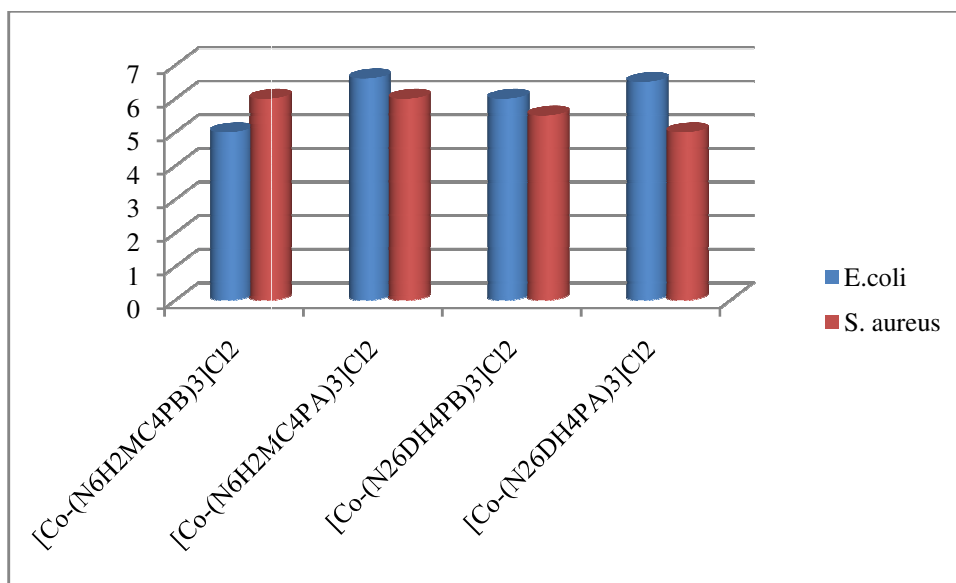


Figure-6
Antimicrobial activity of Co (II) complexes

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References

1. Pecoraro V.L., Baker M.J., Butler W.M. and Bonadies J.A., (1987). Manganese Complexes of Relevance to Enzymes Containing Multinuclear Manganese Centers, *Recueil Trav. Chim.*, 106, 221.
2. Garg B.S, Bhojak N., Sharma R.K., Bist J.S. and Mittal S. (1999). Separation and preconcentration of metal ions and their estimation in vitamin, steel and milk sample using o-vanillin-immobilized silica gel. *Talanta*, 48(1), 49-55.
3. Bhojak N., Gudasaria D.D., Khiwani N. and Jain R. (2007). Microwave Assisted Synthesis Spectral and Antibacterial Investigations on Complexes of Mn (II)

- With Amide Containing Ligands. *E-Journal of Chemistry*, 4(2), 232-237.
4. Garg B.S., Bhojak N. and Nandan D. (2005). Micellar spectrofluorimetric determination of lead (II) in natural water, waste water and egg samples with N-(2'-pyridyl)-2- hydroxybenzamide. *Ind. J. Chem.*, 44A, 1504.
 5. Raja Ram, Verma K.K., Solanki K. and Bhojak N. (2015). Microwave assisted synthesis, spectral and antibacterial investigations on complexes of Co (II) with amide containing ligands. *International Journal of New Technologies in Science and Engineering*, 2(6), 92-100.
 6. Verma K.K., Soni Gupta P., Solanki K. and Bhojak N. (2015). Microwave Assisted Synthesis, Characterisation and Anti microbial activities of few Cobalt (II) Thiosemicarbazones Complexes. *World Journal of pharmacy and pharmaceutical sciences.*, 4(11), 1673-1683.
 7. Raja Ram, Verma K.K., Bhandari H.S. and Bhojak N. (2015). Microwave assisted synthesis, spectral and antibacterial investigations on complexes of Ni (II) with amide group containing ligands. *IARJSET*, 2(11), 40-43.
 8. Singh B. and Bhojak N. (2008). Microwave assisted synthesis, spectral and antibacterial investigations on complexes of Mn (II) with amide containing ligands. *RJC*, 1(1), 105-109.
 9. David Pines S. and David Recknow A. (2002). Effect of Dissolved Cobalt (II) on the ozonation of Oxalic Acid. *Environ. Sci. Technol.*, 36(19), 4046-4051.
 10. Akira Kurata (1974). Cobalt content in the shallow sea sediments. *Journal of Oceanography*, 30(4), 199-202.
 11. Sharma R.M., Panigrahi S. and Azeez P.A. (1987). Effect of cobalt on the primary productivity of *Spirulina platensis*. *Bulletin of Environmental Contamination and Toxicology*, 39(4), 716.
 12. Bresson C., Esnouf S., Lamouroux C., Solari P.L. and Auwer Den X.A.S. (2006). Investigation of biorelevant cobalt complexes in aqueous media. *New J. Chem.*, 30, 416-424.
 13. Yan Y., Neville A. and Dowson D. (2007). Tribo-corrosion properties of cobalt-based medical implant alloys in Simulated Biological Environments. *Wear*, 263, 1105.
 14. Yadav N. and Bhojak N. (2013). Microwave assisted synthesis, spectral and antibacterial investigation on Co (II) complexes with amide ligands. *The Int. J. Eng. Sci.*, 2(2), 166-168.
 15. Kabanos T.A. and Tsangaris J.M. (1984). Deprotonated and non-deprotonated complexes of *n*- (2-aminophenyl) pyridine-2-carboxamide and *n*-(3-aminophenyl)pyridine-2- carboxamide with Co(II), Ni(II), Cu(II) and Pd (II). *J. Coord. Chem.*, 13(2), 89- 103.
 16. Nonoyama M. and Yamasaki K. (1973). Cobalt (II) and copper (II) complexes of several potentially terdentate N-substituted picolinamides. *Inorg. Chem. Acta.*, 7, 676-680.
 17. Barnes D.J., Champman R.L., Stephen F.S. and Vagg R.S. (1981). Studies on the metal amide bond. II. Metal complexes of the flexible N4 ligand N, N-bis (2-pyridinecarboxamide) 1, 2-ethane. *Inorg. Chem. Acta*, 51, 155-162.
 18. Kokunov Y.V., Gorbunova Y.E., Kovalev V.V. and Kozyukhin S.A. (2013). *Russian Journal of Inorganic Chemistry*, 58 (10), 1187-1192.