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A Review of Stability Constants with a Reference of Schiff Bases

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Abstract - A stability constant (also known as a formation constant or a binding constant) is an equilibrium constant that controls the formation of a complex in solution. It is a metric measuring the intensity of the interaction between the reagents that produce the complex. Compounds generated by the interaction of a metal ion with a ligand and supramolecular complexes, such as host—guest complexes and anions complexes, are the two types of complexes. The stability constant(s) are used to compute the concentration(s) of the complex(es) in solution. There are several applications in chemistry, biology and medicine. In this paper stability constants with a reference of Schiff bases are reviewed.

Keywords - stability, schiff bases, thermodynamic, ligantional entropy, amino acid

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1. INTRODUCTION

The term "stability" refers to a metal complex's capacity to persist under favorable settings without decomposing and to have a long shelf life. Because a metal complex may be stable to one reagent/condition yet breakdown in the presence of another reagent/condition, the word "stability" cannot be used universally. The stability of metal complexes may be discussed using two separate concepts: thermodynamic stability and kinetic stability. However, a metal complex is said to be stable if it does not react with water, resulting in a decrease in the system's free energy, i.e. thermodynamic stability. The complex, on the other hand, is considered to have kinetic stability if it combines with water to generate a stable product and the reaction proceeds according to a recognized mechanism. For example, the system might not have enough energy to break a powerful link, but if that tie is broken, it can be replaced by a new bond that is stronger than the previous one. The bond dissociation energy, Gibbs free energy, standard electrode potential, pH of the solution, and rate constant or activation energy for substitution processes are all used to determine the stability of a complex chemical in aqueous solution.[1]

2. THERMODYNAMIC ASPECTS

Taking a quick look at thermodynamic factors and how they affect the stability of the species engaged in chemical reactions is a good idea at this point. Thus, the reaction and the species involved may be seen in their entirety.[2]

The values of overall changes in free energy ($\Delta G°$), enthalpy ($\Delta H°$) and entropy ($\Delta S°$) accompanying complexation are determined using the temperature Coefficient and Gibbs-Helmhotz equation. The free energy change G is related to the corresponding equilibrium constant K by the equation

$\Delta G° = -2.303 \, RT \log K$ ……………….. (1.1)

Calculation of the enthalpy change can be carried out by substituting a pair of values K_1 and K_2 at two temperatures T_1 and T_2 into the equation

$\Delta H = 2.303 \, R \, T_1 \, T_2 (\log K_2 - \log K_1 / T_2 – T_1$, .. (1.1a)

But the graphical method is preferred over this method.

However, it is better to use more than two values of K to obtain a graphical solution to the equation $\log K = (\Delta S° - \Delta H/T) / 2.303 \, R$ ....(1.2)

where $\Delta S°$ is the entropy change

If $\Delta H°$ varies appreciably with temperature, it is possible to obtain the values of the parameters a, b and c by fitting at least three values of K to the equation

$\log K = a + bT + cT^2$ ………… (1.3)

The values of AH can be obtained from the relations

$o(\log K) / oT = b + 2cT = \Delta H / 2.303 RT^2$ …….. (1.4)

which may be rewritten as

$$\frac{o(\log K)}{o(1/T)} = \frac{\Delta H^O}{4.576} \quad \text{……………………………………….. (1.5)}$$

If the values of log K obtained at different temperatures are plotted as a function of 1 / T, the gradient of the tangent drawn at the point corresponding to any temperature may be determined and will be equal to -ΔH° /4.576. The value of ΔH° can thus be obtained.

The entropy change can be calculated from equation (1.2) , or from the equation

$\Delta S° = (\Delta H° - \Delta G°)/T$ ……………………… (1.6)

2.1 Thermodynamic functions and their significance

Changes in entropy and enthalpy accompany the complex's development. Evolving complexes prefer entropy increases as the temperature is decreased. Because complex creation is dependent on entropy and enthalpy, they must be examined independently for a more complete understanding of the process. The literature-based thermodynamic data cannot be relied upon in its entirety, because different procedures may yield different results. However, there are still some noticeable tendencies. The heat and entropy fluctuations are favorable for the creation of complexes when there are multiple reactions. However, the format tone of the complex is opposed by entropy or enthalpy change for several processes. Negative entropy changes have been found to significantly hinder the emergence of complex systems. As a result, during the process of complex creation, heat and entropy changes may work together or against one another.[3]

2.2 Ligantional entropy changes

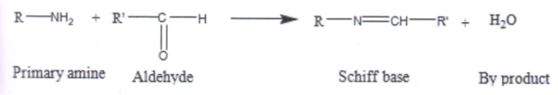
Because translational entropy is converted to vibrational and rotational entropy during complex creation, the entropy change is predicted to be negative. Rotational entropy will contribute to extra losses in the case of polyatomic ligands. As Phipps and Plane shown, linear ions such as N5 and SCN may have rotational entropy that would be lost upon interaction with other molecules. N3's rotational entropy loss was calculated by Evans and Nancollas to be 11 cal.degree mole. SCN's gas-phase rotational entropy loss was found to be 16 cal.degree mole, according to a similar computation. The overall entropy of complex creation can be altered by this variable.[4]

2.3 Ligantional enthalpy changes

The enthalpy changes that occur during complex formation are critical because enthalpy fluctuations can aid or hinder complex development. When the temperature variations are negative, complex formation is encouraged. Aqueous solution complexes with ionic ligands typically have step-wise ligantional enthalpies of 0 to + 5 Kcal/mole. However, in other interactions, such as silver (I) or mercury (II) with cynide or iodide ions, they can be as big as - 10 Kcal/mole. When dealing with neutral unidentate ligands, enthalpy changes are typically between 0 and -5 K cal/mole; however, with neutral multidentate ligands, enthalpy changes can reach -20 K cal/mole!

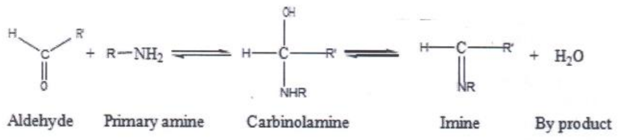
3. SCHIFF BASE

Schiff bases are condensation products of primary amines with carbonyl compounds and they were first reported by Hugo Schiff in 1864. The common structural feature of these compounds is the azomethine group with a general formula RN=CH-R1, where R and R' are alkyl, aryl, cyclo alkyl or heterocyclic groups which may be variously substituted. These compounds are also known as anils, imines or azomethines.[5]



Scheme 1.1 Process of condensation of aldehyde and primary amine

Schiff bases that do not include alkyl substituents are significantly more stable than those with alkyl substitutes. While aliphatic aldehydes are often unstable and rapidly polymerizable, aromatic aldehydes are more stable and successful conjugation and polymerization are more long-lasting. Schiff base production from aldehydes or ketones is an acid or base-catalyzed process that can be reversed by heating.



Scheme 1.2 Process of formation of Schiff base with carbinolamine intermediate

Separation of the product or elimination of water, or sometimes both, is used to bring the formation to a close. Aqueous acid or base can hydrolyze several Schiff bases back to their aldehydes, ketones, and amines, depending on the base or acid used. The process by which Schiff bases are formed is yet another variant on the topic of carbonyl group neucleophilic addition. N-nitrosoamine is used as a neucleophile here. The amine interacts with the aldehyde or ketone in the first stage of the process to produce carbinolamine, an unstable addition product. Acid or base-catalyzed routes are used to remove water from carbinolamine. Carbinolamine undergoes acid-catalyzed dehydration because it is an alcohol.[6]

Schiff base production is catalysed by acids because dehydration of the carbinolamine is often the rate-determining step. However, because amines are basic chemicals, the acid concentration should not be excessive. The production of carbinolamine is prevented if the amine is protonated and rendered non-neucleophilic. Since many Schiff bases are best synthesised at a somewhat acidic pH, this is the preferred method. Base also has a role in dehydration of carbinolamines. E2 elimination of alkyl halides is similar to this reaction, however it is not a concerted reaction. It takes two stages to get there, one of which involves an anionic intermediate. When a Schiff base is formed, an addition reaction is preceded by an elimination reaction. They are good chelating agents due to the ease with which Schiff bases may be synthesised as well as their unique ability to create a five or six-membered structure with the metal ion, especially when an additional functional group is present adjacent to the C=N group. Many studies have shown the relevance of the azomethine group member nitrogen atom's single pair of electrons in its sp^2 hybridised orbital for chemistry and biology. It is possible to trap big and highly coordinated metal ions with the electron-donating groups like azomethines. It is possible to have extraordinary magnetic characteristics and catalytic activity when two or more metal atoms are in close contact in a single cavity. Further research into Schiff base ligands and their complexes is highly sought because of their versatility in biological, analytical, and industrial uses.

3.1 Amino Acid Schiff Base

Due to their physiological and pharmacological properties, Schiff base complexes of amino acids have gained prominence. Due to the existence of an azomethine functional group, complexes of amino acid Schiff bases are thought to represent novel classes of antibacterial and anticancer reagents. The non-enzymatic analogues of the key intermediates in many metabolic reactions involving amino acids, such as transamination, decarboxylation, Schiff base complexes of transition and rare earth metals formed from salicylaldehyde and amino acids have been the focus of various structural investigations. Elimination and racemization reactions have been examined. An amino acid side chain that has a reactive functional group linked to it is considerably more difficult since it enhances ligand's capacity for binding to the metal ion in its centre, which is essential for metabolism.[7] The Schiff base generated amino acid has been suggested as a viable candidate for the generation of a range of multidimentional metal complexes by linking different functional groups with the N-terminal. There is much research on the coordination behaviour of aminoacid-salicylaldehyde ligands with a variety of metal ions. Metallo nucleases having photo-induced nuclease activity are essential for photodynamic therapy of cancer. The binding and cleavage of proteins by metal complexes of Schiff base ligands derived from amino acids have so been widely explored. In the fight against cancer metastasis, these next generation metal-based anticancer medicines are being employed.

4. THE STABILITY OF SCHIFF BASE COMPLEXES

At 25° C., Lane and Kandathil initially explored the acid dissociation constants for three kinds of schiff bases chemically comparable to 8-hydroxyquinoline in 50 percent (v/v) dioxane-water at 25° C. and the stabilities of these ligands with Cu, Ni, and Cd using the Calvin Bjerrum potentiometric method.. For the basicities of ligands, electron donating and hydrogen bonding have been cited as possible explanations, respectively. It has been found that the 4-hydroxy-benzimidazole formation constants are higher than those of the corresponding 8-hydroxyquinoline chelates, but that the ligands with the metal ions studied have lower formation constants than those of the 4-hydroxyquinoline chelates. This is because of the unfavourable steric factors. They found that the stability constants for the metal chelates of Schiff bases rise as the basicity of the ligand increases. The acid dissociation pK values of numerous 13-ketoimines, as well as the formation constants of Cu(11), Be(II), UO (II), Ni(II), Co(II), Zn(11), and Mn(I1), have been published by Martin D.F. Janusonis and Martin (11). The Block and McIntyre approach may be used to make metal chelates using certain of these schiff bases. For the metals investigated, the N-phenyl-ketoamine derivatives based on an acetylacetones skeleton were found to be somewhat more stable than the simple ac-ac complexes (log Kj=10.8 compared to log = 9.55) (II). A similar level of stability is seen in the beryllium-copper complex (log Kj = 10.9,log = 10.5 for Be, compared to log = 10.8,log=10.5 for Be+, compared to log=10.8,log Kj = 10.9 for Cu). Ligands are neither powerful nor weak, but are equivalent in complexing capacity to salicylaldehydes and acetylacetones respectively. B-ketoamine complexes are stable, despite the idea that Be is only weakly complexed with a ligand comprising O and N. Extracting Be into toluene with the N-nBu-salicyldimine and the N-Et derivative was shown to be a good strategy by Green and Alexander.[8]

N-Bu complexes are more easily removed in each case. This may be due to the favourable solvation conditions. The extraction and stability constants of several aromatic schiff base metal chelates have been studied using radiotracers by Stronski. Dissociation constants of Schiff bases derived from salicylaldehyde or its derivative were determined by the use of 1,2 ethylenediamine, 1,3-

propylenediamine, and o-phenylene diamine spectrophotometrically, and the stability constants of Ni(I) and Uranyl chelates were established using the graphical 2-parameter approximation. Cd (II), Pr (II), and Pt (II) extraction rates were studied in relation to electrolyte pH using a $CHCl_3$ solution containing various quadridentate aromatic Schiff bases. 16 aldehydes and their related ketone Schiff base chelates were examined by Nakao et al for their relative stability. In general, the Schiff base chelates of aldehydes are less stable than those of equivalent ketones. The stabilities of unprotonated Schiff bases are analysed spectrophotometrically by Felty, Ekstron, and Leussing to determine equilibrium constants that describe the protonation equilibrium and the production of binary and ternary species between Zn (II) pyridoxal phosphate. The physiochemical characteristics of azomethines and chelate compounds have been explored by Movchan, Kudryavtsev, and Savich. Some transition metal chelate compounds produced by salicyaldehyde and the isomers of the nitroaniline have been determined to have dissociation constants and stability constants. Scientists used picolinic acid's dissociation constant and stability constants of icolinicacid-metal complexed metal complexes to compare these values with one another. They discovered that azomethines are less stable than picol chelate complexes in Icolinic acid. The 0-nitroaniline-based chelates are more stable than the p- and m-nitroaniline complexes in the majority of situations. Schiff base acetyl acetone anthranilic acid, which forms complexes with Pd(II) ad Zn(II), has pK values reported by Mehta, Gupta, and Singhi (pKj = 4.85 and pK = 8.25). (11). Calvin Melchior's modification of Bjerruni's approach yields log Kj = 3.97 for Pd (II) complexes and log = 2.92 for Zn (II) complexes for the metal complexes.

Using the Bjerrum potentiometric technique at 0.1 M ionic strength in 80 percent MeOH, Kogan et al. established the stability constants of certain chelates of Cu(II) and Co(II) with aliphatic Schiff bases and computed the free energies, enthalpies, and entropies of formation. To better understand the stability of metals such as Cu (II) and Zn (II) in dioxane water, Mayadeo and Patel used Schiff bases of 3-Formy1- 4-hydroxybiphenyl. Aniline dissociation constants were measured potentiometrically in a dioxane-water (75:25, v/v) combination at 30°C + 0.1°C for substituted (R) N-(2-Hydroxy-5-phenyl benzyl idene)-4 (R = -CH,-C1.-OCHj or NHCOCH3) anilines. As a result, the data has been analysed for inductive and mesomeric effects of the substitutes (R).[9]

Potentiometrically in ethanol-water mediums of various compositions, Mayadeo and Eizawawy determined the pK values of a few Schiff bases. Some bivalent transition metal chelates formed from Schiff bases have been studied by Omprakash and others, including 2-[(1H-benzimidazole-2- ylmethylene) amino-4-chloro]thiol chelates of heterocyclic Schiff bases. At >u = 0. 1 M (NaC1O.) and 30°C, pH metrically calculated pK and log values in 60 percent aq. dioxane. A study by Jayadevappa and Galgali found that metal complexes of salicyladehyde, such as Cu(II) and Ni(II), Co(II) and Zn(II), and modified salicylaldehyde amino acid schiff bases, were stable. Many transition metal complexes with schiff bases have been studied by Dubey and Wazir, and the order of stability has been established for each one of them. They used the approach described by George and McClure to calculate thermodynamic stabilisation energy values from the log K values of complexes. Using the potentiometric titration approach, Pathak and Joshi have studied the complexes of Zn(I) and Cd(II) with 2-Hydroxy-5-Chloro-acetophenoneanil (NaC10.). Stability constants do not alter much with temperature change, according to the researchers.

The Schiff base produced from sulphafurazole and thiophene -2-aldehyde was studied for its stability and toxicity. Many studies have been done on the isolation and description of solid complexes, but equally significant constitutions are linked to the production of complexes in solution. Analytical reagents such as oximes, anils, and thiosemicarbazones can be produced from Schiff bases. Because of this, we've carried out extensive study into Schiff bases generated via the condensation of substituted amino phenols (e.g. amino benzoic acid, amino acid, or nitroaniline) with diacetyl monoxime.

5. FACTORS AFFECTING STABILITY OF COMPLEXES

The important factors which seem to influence the stability of complexes are summarized below:

a) The basicity of the ligand

As the ligand's basicity grows, so does the stability of the complex. Ligands with greater basicity tend to create stronger covalent connections with transition metals, for example, N and S donor groups, than O. In contrast to ligands with low pK values, high pK values like 8-hydroxyquinoline and picolinic acid may form stable chelate rings with metals, such as iron.

b) Resonance in the chelate

Resonance was shown by Calvin and Wilson to have an effect on chelate formation and stability. A group of salicylaldehydes, 2-hydroxy- 1-naphthaldehyde, was examined for the production of Cu^{++} complexes with acetylacetone and other diketones. As a result, they all gave the identical chelated stable rings and so agreed with each other.

c) Substitution effect

Metal chelate stability may be affected by the substitution of a group in the Chelating agent. It may affect the donor atom's basicity or the resonance of the chelating ring, which may interfere with or improve the chelating ring's resonance.

Or

if the substituted group is responsible for preventing chelation of the ligand molecule or ion around the central metal ion, then the steric effect may be to blame.

d) Steric hindrance

The complex's stability is determined by the steric effect. The stronger the steric interference, the smaller the cation's radius and the larger the ligand's molecule. Transition metals have similar radii for bivalent ions, hence the ligand's geometry is more important than the metal's radii. When comparing ions of varying sizes, this will no longer be the case. A central ion's ligands will be packed in a certain way due to the following factors:

i) The size of the central ion

ii) Structural modifications in the ligand

iii) The orbitals available, since these will impose a particular geometric arrangement of ligands. Copper and substituted malonic acid complexes were researched by Riley for the impact of these steric variables on the stability of copper and substituted malonic acid complexes, as well as the effects of these steric factors on the stability of other transition metal complexes. In the same way, Calvin and Bailas explored the position effect's influence on the stability of copper chelates. When one ligand is substituted with another of a comparable kind, the free energy changes can be used to evaluate the amount of steric hindrance.

e) The size of the chelate ring

Rings of five or six members are preferred since they are free of strain. Rings with six members and two double bonds are the most stable, according to the Bayer strain hypothesis. Rings with five members and no double bonds are the least stable. While a five-membered ring with a single double bond is more stable, a six-membered ring with a single double bond is significantly stronger.

Even if polydentate ligands create a large number of rings, their stability is more dependent on the existence of five or six membered rings than on the total number of rings produced. The chelate's stability reduces as the ring size grows, according to Schwarzenbach and Ackermann. When there are more rings in the chelate, it is not because of any advantages of ring formation that it is more stable.

Instead, the increased number of water molecules that are displaced from the metal coordination space by one donor atom of poly-functional chemical is to blame.[10]

f) Temperature

A well-known fact is that the production constants of metal complexes are affected by temperature fluctuation. The thermodynamic characteristics associated with the production of metal complexes are evaluated by determining log K1 at different temperatures. The many structural and energetic characteristics of metal chelate formation can be better understood with an understanding of these thermodynamic factors. If a process is endothermic or exothermic, the thermodynamic characteristics can tell you if it is spontaneous or not. The ligand-metal bond strength is measured using enthalpies. Entropies, on the other hand, shed light on the molecular structure, such as the chelate effect and steric effects.

g) Effect of metal ions

The relative tendency of different metals to create homopolar bonds with electron donors is governed by two factors:

(1) ionic forces linked to metal ion’s charge and radius; and

(2) the relative tendency of different metals to form homopolar bonds.

Pfeiffer, Thielert, and Glaser determined the order of stability of the following metal complexes in recent years based on their ability to interact with one or two particular ligands.

Cu > Ni > Fe > Zn > Mg

Mellor and Maley used Bjerrum's approach to investigate the stability of salicylaldehyde complexes in a 50 percent dioxan-water medium. As far as maintaining order, they were-

Pd > Cu > Ni > Co > Zn > Cd > Fe > Mn > Mg .

It has been shown that Irving and Williams' data is connected by charting the stability constants against the atomic number of metals. The order Mn< Fe < Co < Ni <Cu> Zn, obtained by thorn indicates correlation between stability and the number of 3d electrons in these transition metals and their ability to from homopolar bonds. Further Martel 1 and Calvin indicated a general relationship between formation constants of metal chelates and the second ionisation potentials of the metal ions. They found that it's easiest to compare the stabilities of various complexes when the metals utilized are all the same. Reversal in Irving and Williams order may occur when comparing the composition of dissimilar metal alloys.

Ion of Fleischer and Powell is significant for metals with closed-shell configurations like lanthanides.

Closed-shell electronic compounds produced by metal ions with effective radii and effective nuclear charges are more stable than open-shell complexes. Metal ions with a closed shell structure are typically symmetrical and include both inert gas and pseudo inert gas metal ions or atoms. An inert gas configuration is assumed for trivalent metal ions of the two inner transition elements, lanthanides and actinides. Because the 4f electrons in rare earth metal complexes are so well insulated and because their ionic sizes are so much greater than those of transition metal ions, it has been presumed that there is no covalent bonding. As with the alkaline earth metal ions, the rare-earth ions attract ligands mostly through overall electrostatic forces. Research on rare earth complexes' stabilities has not provided a definite explanation as to how the complexes' ionic bonding is formed, despite the fact that absorption spectra and magnetic susceptibility data point toward this notion. There have been some intriguing connections found between the logarithmic characteristics of metal ions and ligands. Certain metal-metal relationships, such as how many d' electrons an atom has, or how high its gaseous ionisation potential, are linked to the metal-chelate valence bond idea of bonding. Another method is electrostatic, that include stability relationships to the ionic potential Z/r or the Born equation coefficient Z2/r.

A base's capacity to coordinate is thought to be enhanced by factors such as a higher concentration of negative charge in the coordinating ligand, according to the work of Ives and Riley scientists. Several phenomenons were explained using these concepts. There have been several attempts to establish a linear connection between ligand basic strength and its capacity to form complexes. Larsson took the initial move in this direction. However, it is now well-established that pK (complex) and pK (base) have a linear connection when systems with significant structural similarity are examined. As a result of this, it was hypothesised that the studies would be fruitful if ligands were selected in such a way as to alter the ligand basicity by altering substituents at a cooperating site. Schiff bases are an example of ligands with varying levels of basicity.

6. CONCLUSION

As a result, a number of Schiff base stability constants for Cu, Ni, Co and Zn have been found at various temperatures in an ethanol-water medium with an ionic strength of 0.01 M NaC1O$_4$ (50 percent v/v). Increasing the temperature causes the stability constants of all systems to decrease, demonstrating that chelation is exothermic in nature Ethanol-water systems are known to have a high concentration of metallic chelates, which have been blamed for the negative values in the thermodynamics of the system. The stability constants rise as the ionic radius decreases. As atomic number increases, so do the stability constants of the first transition series divalent metal ions.

REFERENCES

1. Ajlouni A. M., Taha Z. A, Al Momani W., Hijazi A. K, & Mohammad Ebqa'ai, (2012) "Synthesis, characterisation, biological activities, and luminescent properties of lanthanide complexes with N,NO-bis(2-hydroxy-l-naphthylidene)-1,6-hexadiimine", Inorg. Chim Acta, Vol. 388, pp. 120-126.

2. Mohammed A. S., Omer, Liu J.C., Deng W. T. A., & Jin N. Z. (2014) "Syntheses, crystal structures and antioxidant properties of four complexes derived from a new Schiff base ligand(N1E,N2E)-N1,N2-bis(1-(pyrazin-2-ypethylidene)ethane-1,2diamine",Polyhedron Vol.69, pp. 10-14.

3. Kavitha P., Ramachary M., Singavarapu B. V. V. A. and Laxma Reddy K. (2013) "Synthesis, characterisation, biological activity and DNA cleavage study of tridentate Schiff bases and their Co(II)complexes", J. Saudi Chem. Soc., (Article in press) (DOI: 10.1016/j.jscs.2013.03.005.

4. Manish P., Brahmbhattl , Jabali J., Vora2 , Pravin B. & Prajapatil, (2010) 3d-transition metal chelates of schiff base ligand: synthesis, catalysis and antibacterial study kuntal n. Prajapati 1*, reserch general of life Science, bioinformatics, pharmaceutical and chemical sciences www.rjlbpcs.com

5. Chioma F., Sunday N. 0. & Anthony C. E. (2014) medical and pharmaceutical chemistry. P (141-252)

6. Tahaa Z. A., AjlouniA. M., Al Momanib W. and Al-Ghzawia A. A., "Syntheses, characterisation, biological activities and photophysical properties of lanthanides complexes with a tetradentate Schiff base ligand", Spectrochim. Acta A., Vol.81, pp.570-577, 2011.

7. Jadhav S. M., Shelke V. A., Shankarwar S.G., MundeA. S. and ChondhekarT. K., "Synthesis, spectral, thermal, potentiometric and antimicrobial studies of transition metal complexes of tridentate ligand", J. Saudi. Chem. Soc., Vol.18, pp.27-34, 2011.

8. Safaa Eldin H. Etaiwa, Dina M. Abd El-Aziza, Eman H. Abd El- Zaherb and Elham A. Ali, "Synthesis, spectral, antimicrobial and antitumor assessment of Schiff base derived from 2- aminobenzothiazole and its transition metal complexes", Spectrochim. Acta A., Vol.79, pp. 1331-1337, 2011.

9. Kavitha P., Ramachary M., Singavarapu B.V.V.A. and Laxma Reddy K., "Synthesis, characterisation, biological activity and DNA cleavage study of tridentate Schiff bases

and their Co(II)complexes", J. Saudi Chem. Soc., (Article in press) (DOI: 10.1016/j.jscs.2013.03.005), 2013

10. Omer, Jia-Cheng Liu, Wen-Ting Deng A, and Neng-Zhi Jin, "Syntheses, crystal structures and antioxidant properties of four complexes derived from a new Schiff base ligand (N1E,N2E)-N1,N2-bis(1-(pyrazin-2-ypethylidene)ethane-1,2diamine", Polyhedron Vol.69, pp. 10-14, 2014.

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