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RESEARCH ARTICLE

Synthesis and Determination of Stability Constants of a New Coumarin Derivative with some Transition Metal Ions in Acetonitrile

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ABSTRACT

In this work, the synthesis and complexation properties of a new compound, towards certain transition metal ions, (M, where M = Ni, cd, Ag, Zn, Cu) in acetonitrile has been reported. The stoichiometries of complexes were determined using UV- Visible spectroscopy data. The stability constants of complexes were influenced by parameters such as the type of metal, Ligand, counter ion or solvent. In this work the formation constants of the complexes were determined for the synthesized ligand with several metallic cations, in acetonitrile solution by UV - Visible spectrometry.

KEYWORDS: Complexation reaction, (*E*)-1-[2-(2-hydroxybenzylidene amino) ethyl]-3-phenylthiourea; Spectrophotometry, Job's method

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INTRODUCTION:

The synthesis and metal complex structures of substituted triazole ligands have gained considerable attention in recent years [1-5].

Coumarin and its derivatives are used as additives in food, perfumes, cosmetics, pharmaceuticals, agrochemicals [6,7], for their spasmolytic, cardiothioc, antiviral, anticancer properties [8,9] and as laser dyes in the blue- green region. These types of dyes have been employed as labels for fluorescent energy transfer experiments [10,11]. Coumarin compounds also form a group of more than 40 drugs, which are widely used in medicines as anticoagulant, hypertensive, ant arrhythmic and immunomodulant agents [12]. Many coumarins were tested for various kinds of biological activity and their structures established based on chemical analytical techniques and spectroscopic methods [13-18].

Substituted triazoles have been actively studied as bringing ligands toward transition metal ions coordinating through their N atoms [5]. The complexes of triazols are good candidates for the construction of various ligand metal coordination polymers [19-23].

Traditionally, In order to study the complexation of new synthesized ligand with metallic cations, potentiometry, paper electro-phoresis, membrane permeation, affinity capillary electrophoresis, UV- Vis and fluorescence spectroscopy, and mass spectrometry can be used [24-27]. In this study, UV- Vis spectroscopy was chosen because of its simplicity, low cost and availability of the UV- Visible spectrophotometer in most laboratories. In this work the complexation behavior of a newly synthesized ligand L with selected metallic cations have been studied and the stoichiometry and formation constants of the complexes of the synthesized ligand, with several metallic cations in acetonitrile solvent were determined by UV- Visible spectroscopy which was established by NMR and IR spectroscopes.

EXPERIMENTAL:

MATERIALS AND METHODS:

All reagents were of analytical grade, and all solvents were commercially available (from Merck) and used with no further purification. All UV- Visible Studies were carried out on a computerized WPA- Biowave II instrument using a l0 mm quartz cell. IR spectra were obtained using a nexus 670 FT- IR Thermo Nicolet spectrometer using KBr disk. 'H NMR spectra were recorded on 300 MHZ NMR Instrument using TMS as an internal standard in $CDCl_3$. The melting point was determined on an electro thermaldigital melting point apparatus and was uncorrected.

For synthesizing ligand (3): a solution of salicylaldehyde (3 mmol) in absolute ethanol (20 mL) was added to ethylendiamine (3 mmol). The resulting mixture was refluxed for 6 h. After cooling at room temperature, the solid product formed was separated by filtration, washed with diethyl ether and purified by crystallization from ethanol.

For synthesizing a ligand **L** (6): a mixture of compound 3 (1 mmol) and phenyl isothiocyanate (1 mmol) in ethanol (25 mL) was refluxed on a water bath for 6 h. The resulting solution was cooled and the solid was crystallized and separated from ethanol. Yield: 65% MP: 190-195°c. IR (KBr, cm^{-1}): 3381.9, 3147.8, 299o.18, 1599.24, 1540.2, 1510.7, 1442.2, 1265.4, 1204.7, 1075.6, 1030.7, 346.8, 889.7, 748.0, 690.9, 606.7, 469.1; 'HNMR (300 MHz, $CDCl_3$): 3.91(4H, bs, $2CH_2$), 6.84-6.9 (4H, m, ArH), 7.28-7.42 (5H, m, ArH), 8.58 (2H, bs, CH=N and OH), 13.37 (2H, bs, 2NH).

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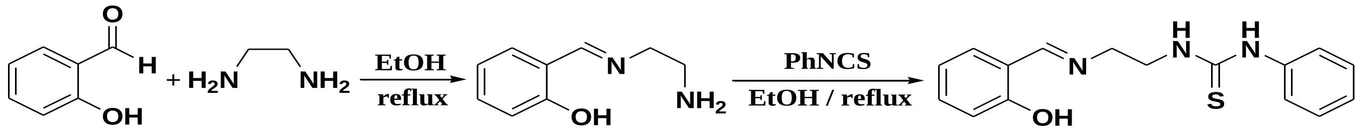


(*E*)-1-(2-hydroxybenzylidene) ethylendiamine

3

(*E*)-1-[2-(2-hydroxybenzylideneamino)ethyl]-3-phenylthiourea

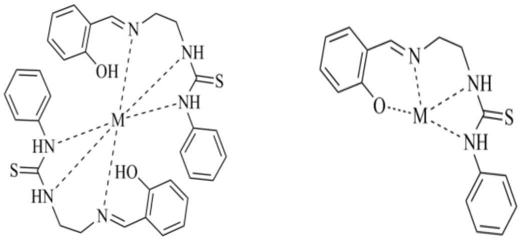
6

Scheme 1: Synthesis rout of ligand (L).

Complex Formation

All solutions were prepared using acetonitrile. Small volumes of concentrated metal cation: solutions (e.g. 0–100 μl from stock solutions with a concentration of 10^{-3}M) were added to ligand solution(s) 2 Ml of a 5×10^{-5}M stock solution). The solutions were thermo stated at 25°c. Examples of the changes in obsorbonce due to complex formation is given in figure1 for cd(II), and figure2 For Ni(II).

These figures clearly show the complexation of M with Ligand. Scheme 1 represents two possible structure of M in complex with L, in both ML and ML_2 types.



A

B

Scheme 2: Possible structure of M^{2+} complex with L, a) Ml and b) Ml_2 types

The stoichiometries of complexes were found using Absorbance/moleratio data, and established also using job method, the continuous variation was employed, between standard solutions of (10^{-3}) M of metal ion solution with the ligand (10^{-3}M).

A series of solutions were prepared in which the total volume is 2 Ml, with different moleratios, (eg. 0-1).

Thus, the formation constants of the resulting complexes in each case were determined using the absorbance- mole ratio dose by a non- linear least squares curve fitting program, KINFIT [28].

RESULTS AND DISCUSSION:

For the case of one step ML_2 complex formation, the following equation could be derived using ligand concentrations equation for simple ML type that is not included here [3].

$M + 2L \Rightarrow ML_2$

$Kf = [ML_2] / [L]^2 [M]$

$C_L = [L] + 2 [ML_2] \quad C_M = [M^{n+}] + [ML_2]$

$Kf \ [L]^3 + (2 Cm - C_L) Kf \ [L]^2 + [L] - C_L = 0$

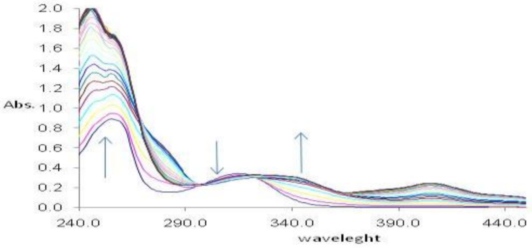


Figure 1: Electronic absorption spectra of the ligand (10^{-3}M) in the presence of Ni^{2+}. [Ni^{2+}]/ [L] Mole ratios are: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3

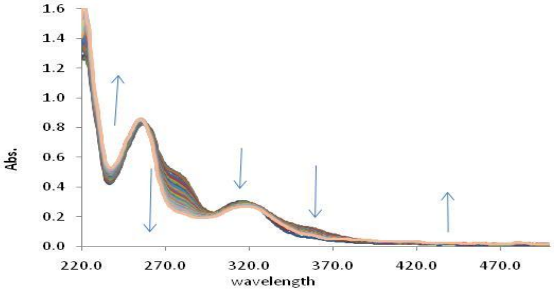


Figure 2: mole ratio of [Cd^{2+}]/ [L] mole ratio are: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.

As it is obvious from figure 2, the ligand solution has two strong bonds at 220 and 250 nm and a weaker and broader absorption at about 330 nm. The Cd^{2+} ion solution just has on absorption bond at about 210 nm. The appearance of new absorption about the 340 nm spectral region and decrease in absorption at 250 nm upon mixing of two reactants in acetonitrile solution must be associated with formation of complex in solution.

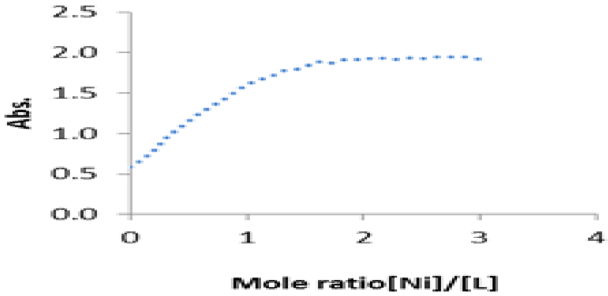


Figure 3: The corresponding Abs. vs. [Ni^{2+}]/ [L] plot at 242 nm.The [Ni^{2+}]/ [L] mole ratio are:0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.

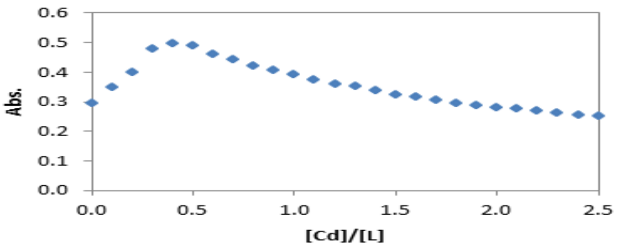


Figure 4: The corresponding abs. vs. $[Cd^{2+}]/[L]$ at 292 nm. The $[Cd^{2+}]/[L]$ mole ratio are: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.

The Absorbance- mole ratio plots show the stoichiometry of M-L as 1:1 in some cases and 1:2 in the others. Figures (3,4). The job's method of continuous variation results which is completely in support of which was mentioned above was shown in figures (5,6).

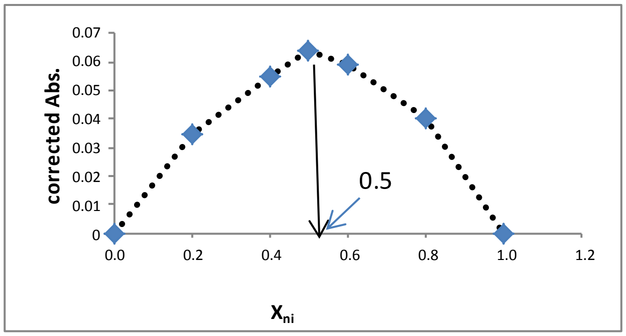


Figure 5: Continuous variation plot for ligand-Ni system in acetonitrile solution; wavelength=329nm.

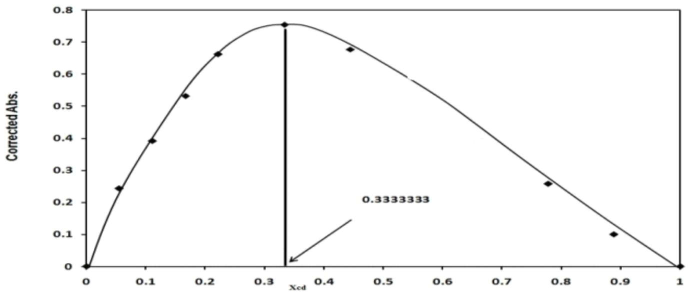


Figure 6: Continuous variation plot for ligand-Cd system in acetonitrile solution; wavelength=300

In order to evaluate further the stoichiometry of M-L complex in acetonitrile solution and hopefully obtain some information about the solution structure of the resulting complex, NMR spectra of ligand individual, and after adding appropriate amounts of metal ions solution, with 1:1 and 1:2 mole ratios were recorded, the resulting data are not included.

The L-M complex in crystalline form was prepared by dissolving measured amounts of Ligand and metal ions in acetonitrile. The resulting solution was then filtered and transferred into crystallization dish. The solutions was allowed to evaporate during about 24 h. the resulting crystalline crystal were collected and dried under vacuum. The IR spectra of L and its isolated solid complex were recorded and the resulting data are included in table 1.

Table 1: Formation constant values for ligand-metal complexes inacetonitrile at 25 °C. (s=strong, b=broad)

	Functional Group	Resulting data of main IR frequencies					
specie		L	L-Ni^{2+}	L-Cd^{2+}	L-Cu^{2+}	L-Zn^{2+}	L-Ag^{+}
Wavenumber (cm^{-1})	Ar-O	1205	1107	1203	1204	1101	1206
Peak Description		s	s	s	s	s	s
Wavenumber (cm^{-1})	N-H	3382	3417	3421	3423	3420	3417
Peak Description		s &b	s &b	s &b	s &b	s &b	s &b

In order to calculate the stability constants, the absorbance – mole ratio data was used by a non–linear least square, curve fitting program and the resulting data are shown in table 2.

Table 2: Formation constant values for Ligand -metal complexes in acetonitrile at 25°C.

Parameter	Ni^{2+}	Cd^{2+}	Cu^{2+}	Zn^{2+}	Ag^{+}
Stiochiometry	ML	ML_2	ML_2	ML	ML_2
pK_f	8.94	8.38	6.45	3.24	2.93

CONCLUSION:

In this work, the synthesis and complexation properties of a new compound, L (E) – 1 – [2- hydroxyl benzyl idien amino) ethyl] -3-has been reported towards certain transition metal ions, (M where M = zn, cu, Cd, Ni, Ag) in acetonitrile. The KINFIT program which was applied to UV- Visible spectroscopy data obtained from monitoring the reaction between L and the selected metal ions was used to determine the stoichiometry of each specie and the corresponding stability constant(s) of the complex (es). Among the tested metallic cations, Ni (II), and Cd (II), were formed the most stable complexes with this ligand. Based on the results of this stady the new synthesized ligand is introduced as a new active emissive probe to detect Ni (II) and Cd (II) by absorption spectroscopy either directly or after preconcentration.

REFERENCES:

1. X. He, J.J. liu, H.M. GVO, M. Shao and M.X. Li, syntheses, topological Networks and properties of Four complexes posed on 4- prmino- 3,5- bis (3-pyridyl) - 1,2,4 – triazolligond, *polyhedron*, vol 29, No 3, 2010, PP. 1062- 1008.
2. K. Liu, X Zhu, J. Wang, B. Liond Y. Zhong Four coordination polymers Derived from 4- Amino- 3,5 – bis (3- pyridyl) -1, 2, 4- triazole and copper sulfate. *Inorganic chemistry communications*, vol. 13, No. 8, 2011, PP. 976-980.
3. Q. G. Zhai, M. C. Hu, Y. Wang, W. J. Ji, S. N. Li and Y. C. Jiang synthesis and characterizations of a Novel dio-type Ag- BPT coordination polymer with tetronuclear Motifs asjoningpoints *Inorganic chemistry communications*, vol 12. No. 4, 2009, PP. 286-289.
4. J. C. Chen, A. J. Zhou, S. Hu, M. L. Tong and Y. X. Tong, synthesis, structure and Magnetic property of a new Mixed- volence copper (1/II) complex Derived from 3,5- bis (pyridine- 2- gl)- 1,2,4- triazol, *Journal of Molecular structure*, vol. 794, 2006, PP. 225-229.
5. R. E. Sabzi, A. Nikoo, Y. Nikzad, M. Babram, K. Akbari, N. SamadiSunthesis and determination of stability constants of a New bis- 1,2,4- triazol ligand for complexation with zine (II), copper (II) and Nickel (II) in Acetonitrile. *American Journal of Analytical chemistry* 2012, 3, 437-442.
6. R.O., Kennedy; R.D., Thornes, *Coumarins: Biology, Applications and Mode of Action*; Wiley &Sons: Chichester, UK, 1997.
7. R.D.H., Murray; J. Mendez; S.A. Brown,*The Natureal Coumarins; Occurrence, Chemistry and Biochemistry*; Wiley & Sons: New York, NY, USA, 1982.
8. D. Egan; R.O. Kennedy; E. Moran; D. Cox; E. Prosser; R.D. Thornes, The pharmacology, metabolism, analysis, and applications of coumarin and coumarin-related compounds. *Drug Metab. Rev.* 1990, *22*, 503–529.
9. M. Gabor *The Pharmacology of Benzopyran Derivatives and Related Compounds*; Akademiai Kiado: Budapest, Hungary, 1988; pp. 91–126.
10. G.G. Guilbault; *Practical Fluorescence. Theory, Methods and Techniques*; Marcel Dekker: New York, NY, USA, 1973; p. 354.
11. D.L. Rathbone; D. Wang; Y. Su; D.C. Billington, Molecular recognition by fluorescent imprinted polymers. *Tetrahedron Lett.* 2000, *41*, 123–126.
12. A.Z. Abyshev; V.A. Gindin;E.V. Semenov; E.M. Agaev; A.A. Abdulla-zade; A.B. Guseinov,Structure and biological properties of 2H-1-benzopyran-2-one (coumarin) derivatives. *Pharm.Chem. J.* 2006, *40*, 607–610.
13. R.I. Al-Bayati; A.A. Hussain Al-Amiery; Y.K. Al-Majedy, Design, synthesis and bioassay of novel coumarins. *Afr. J. Pure Appl. Chem.* 2010, *4*, 74–86.
14. S. Lee; K. Sivakumar; W.S. Shin; F. Xie,; Q. Wang, Synthesis and anti-angiogenesis activity of coumarin derivatives. *Bioorg. Med. Chem. Lett.* 2006, *16*, 4596–4599.
15. V.F.F. Monteiro; L. Mathias; I.J.C. Vieira; J. Schripsema; R. Braz-Filho, Prenylated coumarins, chalcone and new cinnamic acid and dihydrocinnamic acid derivatives from brosimum gaudichaudii. *J. Braz. Chem. Soc.* 2002, *13*, 281–287.
16. V.S.V. Satyanarayana; P. Sreevani; A. Sivakumar; V. Vijayakumar, Synthesis and antimicrobialactivity of new Schiff bases containing coumarin moiety and their spectral characterization. *ARKIVOC* 2008, *xvii*, 221–233.
17. Z. M. Nofal; M. I. El-Zahar;S. S. Abd El-SKarim, Novel coumarin derivatives with expected biological activity. *Molecules* 2000, *5*, 99–113.
18. H.M., Mohamed , A. H. F. Abd El-Wahab, K. A. Ahmed, A. M. E Agrody, A. H. Bedair, F. A. Eid; M. M. Khafagy Synthesis, Reactions and Antimicrobial Activities of 8-Ethoxycoumarin Derivatives. *Molecules* 2012, *17*, 971-988
19. X. F. Xie, S. P. Chne, Z. Q. Xio and S. L. Coo, Construction of metal- organic from works with transitional metal Based on the 3,5- Bis (4- pyridyl)- IH-1, 2, 4 – triazolLigond, *polyhedron* vol. 28, No. 4, 2009, PP. 679-688.
20. M. S. Dyaz – Cruz, J. M Dyaz- Cruz, J. Mendieta, R. Touler and M. Esteban, soft and hard modeling Approoches for determination of stability constants of metal- peptide systems by voltommety, *Analytical Biochemistry*, Vol. 279. No. 2, 2000, PP 189-201.
21. Abbaspour and M. A. Kamyabi, charactenization and Determination of stability constants of copper (II) – 1-his- tridinecomplexation system by using Multiariale curve Resolution Method of visible spectra and twoo hard Modeling Methods in Agueous solutions. *AnalyticaActa*.Vol. 512, No 2, 2004, PP 257- 269.
22. S. K. Sahoo, M. Baral and B. K. Kanungo, "Potentiometric, Spectrophotometric, Theoretical Studies and Binding Properties of a Novel Tripodal Polycatechol-Amine Ligand with Lanthanide(III) Ions," *Polyhedron*, Vol. 25, No. 3, 2006, pp. 722-736.
23. B. Pedras, H. M. Santos, L. Fernandesa, B. Covelo, A. Tamayo, E. Bertolo, J. L. Capelo, T. Aviles and C. Lodeiro, "Sensing Metal Ions with two New

Azomethine- Thiophene Pincer Ligands (NSN): Fluorescence and MALDI-TOF-MS Applications," *Inorganic Chemistry Communications*, Vol. 10, No. 8, 2007, pp. 925-929

24. J. Petit, V. Geertsen, C. Beaucaire and M. Stambouli, "Metal Complexes Stability Constant Determination by Hyphenation of Capillary Electrophoresis with Inductively Coupled Plasma Mass Spectrometry: The Case of 1:1 Metal-to-Ligand Stoichiometry," *Journal of Chromatography A*, Vol. 1216, No. 18, 2009, pp. 4113-4120.

25. B. B. Tewari, "Paper Electrophoretic Determination of the Stability Constants of Binary and Ternary Complexes of Copper(II) and Cobalt(II) with Nitrilotriacetate and Cysteine," *Journal of Chromatography A*, Vol. 1103, No. 1, 2006, pp. 139-144

26. M. Cirri, F. Maestrelli, S. Orlandini, S. Furlanetto, S. Pinzauti and P. Mura, "Determination of Stability Constant Values of Flurbiprofen-Cyclodextrin Complexes Using Different Techniques," *Journal of Pharmaceutical and Biomedical Analysis*, Vol. 37, No. 5, 2005, pp. 995-1002.

27. R. Tauler, A. Smilde and B. R. Kowalski, "Multivariate Curve Resolution Applied to Second Order Data," *Journal of Chemometrics*, Vol. 9, No. 1, 1995, pp. 31-58.

28. M. Shamsipur; S. Ershad; N. Samadi; A.R. Rezvani; H. Hasanzade, The first use of Rh(III) complex as a novel ionophore for thiocyanate selective polymeric membrane electrodes *Talanta* 65, 2005, pp. 991-997