Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2015, 7(11):121-130

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Determination of Cd(II) in food and water samples using 2-hydroxy-N'-(1-(pyridin-2-yl)ethylidene)benzohydrazide as a sensitive analytical reagent

P. Nityananda Kumar Reddy[1], G. Trivikram Reddy[2], Sangita D. Kumar[3], A. V. R. Reddy[3], S. Nazneen Parveen[1] and N. C. Gangi Reddy*[2]

[1]Department of Environmental Sciences, Yogi Vemana University, Kadapa, A.P., India
[2]Department of Chemistry, Yogi Vemana University, Kadapa, A.P., India
[3]Analytical Chemistry Division, Bhabha Atomic Research Centre (BARC), Trombay, Mumbai, India

---

ABSTRACT

2-hydroxy-N'-(1-(pyridin-2-yl)ethylidene)benzohydrazide (HPEBH)is found to be a selective and sensitive reagent for the determination of Cd(II) in food, water and synthetic samples. HPEBH forms green colored complex (Cd-HPEBH) with Cd(II) in aqueous DMF at pH 6.0 shows maximum absorbance at 358nm, whereas ligand shows at 310nm.. It is observed that the color development is immediate and stable for more than 48 hrs. Beer's law is obeyed in the range of 1.12-11.2 µg mL^{-1} of Cd(II), with a correlation coefficient 0.9993. The molar absorptivity (ε) and Sandell's sensitivity of the complex are 6.66×10^{4} $L.mol^{-1}.cm^{-1}$and 0.028 µg mL^{-1} respectively. The metal to reagent ratio is found to be 1:1 by the method of Job's and mole ratio methods. The optimized method has been successfully applied for the determination of Cd (II) in food, water and synthetic samples in presence of diverse ions. It is also observed that the obtained results are in good agreement with AAS method. The proposed method is fairly sensitive and reproducible.

Keywords: Cd(II), food, water samples, spectrophotometry and 2-hydroxy--N'(1(pyridin2yl)ethylidene) benzohydrazide

---

INTRODUCTION

Cadmium is a very poisonous element, which is biologically nonessential environmental pollutant [1,2]. It affects the physical and biochemical mechanism of living systems. Trace amount of cadmium present in various environmental matrices such as water, soil, plants and food materials. According to EPA the acceptable limit of cadmium in drinking water is 0.05 mg L^{-1} [3]. Cadmium is used in Ni-Cd batteries, pigments, coating and plating and as stabilizers for plastics [4,5]. Cadmium is also used as a barrier to control the nuclear fission because it absorbs neutrons. The effects of acute cadmium poisoning are kidney problems, anemia, bone marrow disorders and destruction of red blood cells [6]. Low levels of exposure to cadmium over prolonged periods causes high blood pressure, prostate cancer, kidney damage, lung cancer and flu-like disorders [7]. Cadmium intake takes place in human beings via various food materials like liver, mushrooms, shell fish, mussels, cocoa powder and dried sea weed [8]. Due to its poisonous nature on every organ system, it has great importance to determine the trace levels of cadmium in environmental matrices. Generally, cadmium has been determined by FAAS, ETAAS, ICP-AES, ICP-MS and spectrophotometric methods. Among these, spectrophotometric methods are cheaper, suitable for automation and have comparable sensitivity. However, the reported spectrometric methods for the determination of cadmium suffer from one or more disadvantages like sensitivity, selectivity, severe interferences and procedural complications [9,10]. To the best of my knowledge, none has been utilized 2-hydroxy-N'-(1-(pyridin-2-yl) ethylidene)benzohydrazide (HPEBH) as a analytical reagent for the determination of Cd (II) in environmental matrices.

In the present communication, we developed a simple spectrophotometric method for the determination of Cd(II) in food, water and synthetic samples using 2-hydroxy-N'-(1-(pyridin-2-yl) ethylidene)benzohydrazide (HPEBH) as a fairly sensitive and selective analytical reagent.

Table 1: Comparison of present method with other reported spectrophotometric methods

S. No.	Reagent	λ_{max} (nm)	pH	Beer's range (ppm)	$\varepsilon \times 10^4$ L.mol^{-1} cm^{-1}	Ref
1	4-Hdroxy3, 5dimethoxy benzaldehyde-4-hydroxybenzoylhydrazone (HDMBHBH)	400	9.0	0.112-1.12	4.81	9
2	Cinnamaldehyde 4-hydroxy benzoylhydrazone (CMHBH)	383	8.0-9.0	0.056-0.562	5.6	10
3	5-methylthiophene-2-carbaxaldehydethiosemicarbazone(5-MTAT)	360	5.0-7.0	0.225- 2.25	4.0	11
4	Bipyridyl glyoxal bis(4-phenyl-3-thiosemicarbazone)	385	9.3	-	4.61	12
5	1,2 Napyhaquinone-2- thiosemicarbazone 4-sulfonic acid	520	6.0-7.0	-	1.9	13
6	Glyoxal dithiosemicarbazone(GDT)	427	9.0-11.0	-	1.3	14
7	Phenanahraquinonemonosemicarbazone (PQMS)	480	9.0	-	1.5	15
8	2-hydroxy-N'-(1-(pyridin-2-yl) ethylidene)benzohydrazide	358	6.0	1.12-11.2	6.66	PM

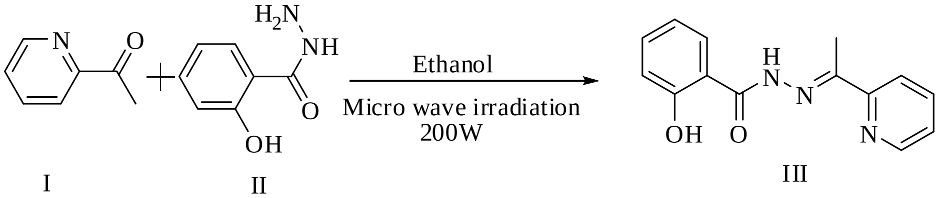
EXPERIMENTAL SECTION

Apparatus: For absorbance studies a Double beam UV-Visible spectrophotometer (Shimadzu model UV-1800) with a 1.0 cm quartz cell is used and for measurement of pH (Systronics model 3305) pH meter is used respectively. Melting point is determined and is uncorrected. For comparative analysis Flame atomic absorption spectrophotometer (Shimadzu model No: AA-6300) is used. ^{1}H NMR spectrum of the ligand is recorded on Jeol 400 MHz NMR spectrometer (JNM-400) and mass spectrum of the ligand is recorded on Shimadzu-LCMS with ESI probe (LC-2010EV). All glassware are washed with a mixture of concentrated sulfuric acid and nitric acid (1:1) before use.

Reagents and solutions: All the chemicals used are of analytical reagent grade or the highest purity available (Across or Merck). DMF and double distilled water are used throughout the experiment.

Preparation and characterization of 2-hydroxy-N'-(1-(pyridin-2-yl)ethylidene)benzohydrazide (HPEBH): Synthesis of 2-hydroxy-N'-(1-(pyridin-2-yl)ethylidene)benzohydrazide (HPEBH) is reported by conventional method [16]. In the present study, we developed a green synthetic route for the synthesis of HPEBH by using microwave irradiation.

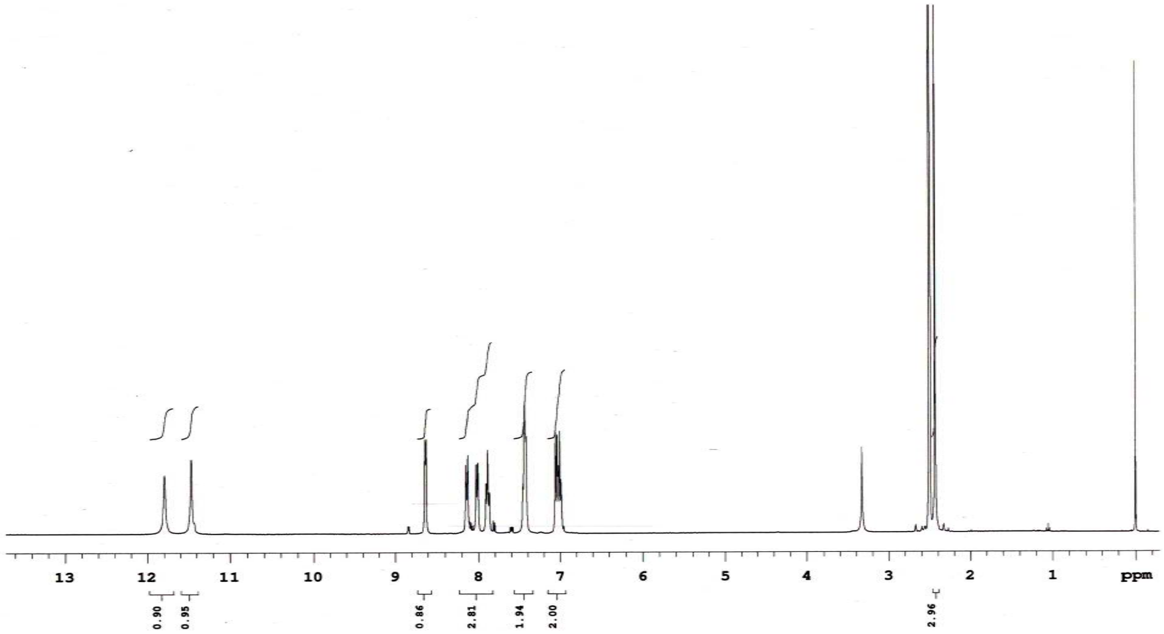
Microwave method: In a 100-mL beaker, 2-Acetyl pyridine (I) [1 gm, 7.3 mmol] and salicyl hydrazide (II) [1.1 gm, 7.3 mmol] are dissolved in 10 mL of ethanol. The beaker is placed in a domestic microwave oven at 200 watts for 30-45 sec. The progress of the reaction is monitored by TLC. After completion of the reaction, the reaction mixture is cooled to RT and then washed twice with cold ethanol. Finally, the obtained crude product (III) is re-crystallized from hot ethanol. The structure of the synthesized compound is confirmed by ^{1}H NMR and mass spectral data.



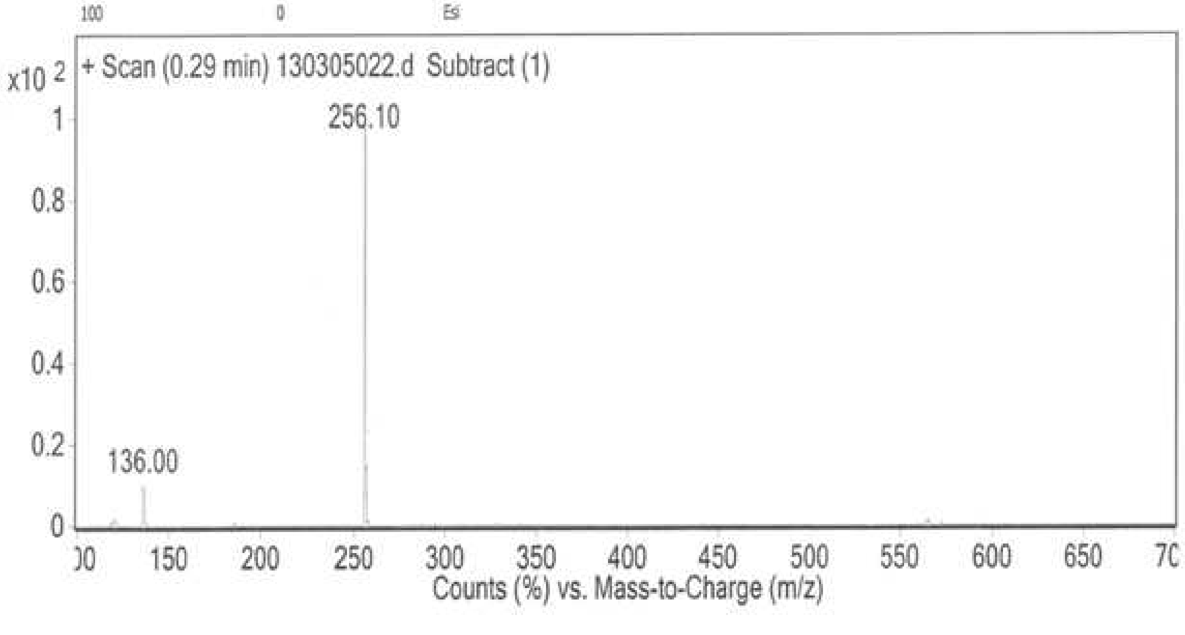
Scheme 1: Preparation of 2-hydroxy-N'-(1-(pyridin-2-yl)ethylidene)benzohydrazide (HPEBH)

Characterization data of HPEBH

Colorless solid; Yield: 1.73 gm (92%); mp 238-240°C.; ^{1}H NMR (400 MHz, DMSO-d_6): δ 11.80 (s, 1H, -NH), 11.47, (s, 1H, -OH), 8.63 (d, 1H, *J*=4.4 Hz, arom H), 8.14 (d, 1H, *J*=7.6 Hz, arom H), 8.02 (d, 1H, *J*=7.2 Hz, arom H) 7.89(t, 1H, *J*=7.6 Hz, arom H), 7.44 (t, 1H, *J*=7.6 Hz, arom H), 7.06-6.99 (m, 2H, arom H), 2.50 (s, 3H, -CH_3); MS (ESI): $(M+H)^+$ 256.10.



^{1}H NMR spectrum of 2-hydroxy-N'-(1-(pyridin-2-yl)ethylidene)benzohydrazide (HPEBH)



Mass spectrum of 2-hydroxy-N'-(1-(pyridin-2-yl)ethylidene)benzohydrazide (HPEBH)

Preparation of 0.01M reagent (HPEBH) solution: 0.01M HPEBH solution is prepared by dissolving 256 mg of HPEBH in DMF and made up to the mark in a 100-mL volumetric flask with DMF. Dilute solutions are prepared from this stock solution. Solution.

Preparation of cadmium (II) stock solution: 0.01M cadmium solution is prepared by dissolving 321 mg of cadmium sulphate ($CdSO_4 .8H_2O$) (Merck) in de-ionised water containing few drops of concentrated sulphuric acid and made up to the mark in a 100-mL volumetric flask. Aliquots of this solution are standardized with EDTA using xylenol orange as an indicator [17]. Dilute solutions are prepared from this stock solution. Solutions of large number of inorganic ions and complexing agents are prepared from their analytical grade or equivalent grade and water soluble salt.

Sodium thiosulphate solution: A 100 ml stock solution of sodium thiosulphate ion (0.1% w/v) was prepared by dissolving 100 mg of sodium thiosulphate (Merck) in (100 mL) de-ionized water.

Preparation of buffer solutions:
Hydrochloric acid (1.0M) and sodium acetate (1.0M) are mixed to get the required pH (1.0-3.5); 0.2M sodium acetate and 0.2M acetic acid are mixed to get the required pH (4.0-6.0) and 0.01M Potassium di hydrogen phosphate and 0.01M di sodium hydrogen phosphate are mixed to get the required pH (pH 7.0). The pH of the above buffer solutions are measured by a pH meter and finally adjusted suitably.

General analytical procedure for the determination of cadmium (II):
An aliquot (1.0 mL) of the solution containing known amount of cadmium(II), 4.0 mL of sodium acetate-acetic acid buffer solution (pH 6.0), 1.0 mL of 0.01% thiosulphate solution and 1.0 mL of reagent (HPEBH) of required concentration are mixed in a 10-mL volumetric flask and the resulting solution is diluted up to the mark with double distilled water. The absorbance of this solution is measured at 358 nm, against the reagent blank.

RESULTS AND DISCUSSION

In aqueous DMF, in presence of 0.01% thiosulphate solution at pH 6.0 Cd(II) reacts with HPEBH and forms a green colored complex, which shows maximum absorbance at 358 nm, against the reagent blank. Hence a detailed study has been undertaken for the determination of Cd(II) using HPEBH by spectrophotometric method. The optimized method is successfully applied for the determination of Cd(II) in water, food and synthetic samples alone or in presence of diverse ions.

Absorption spectra of HPEBH and Cd(II)-HPEBH-complex: Initially absorption spectrum of the HPEBH is recorded against the solvent blank. The absorption spectrum of Cd(II)- HPEBH complex is recorded against the ligand blank. The absorption spectrum of both complex and ligand are shown in the figure 1. From the absorption spectra, it is clear that the ligand shows maximum absorbance at 312 nm, where as the complex shows maximum absorption at 358 nm. Therefore, all the spectral measurements are carried out at 358 nm.

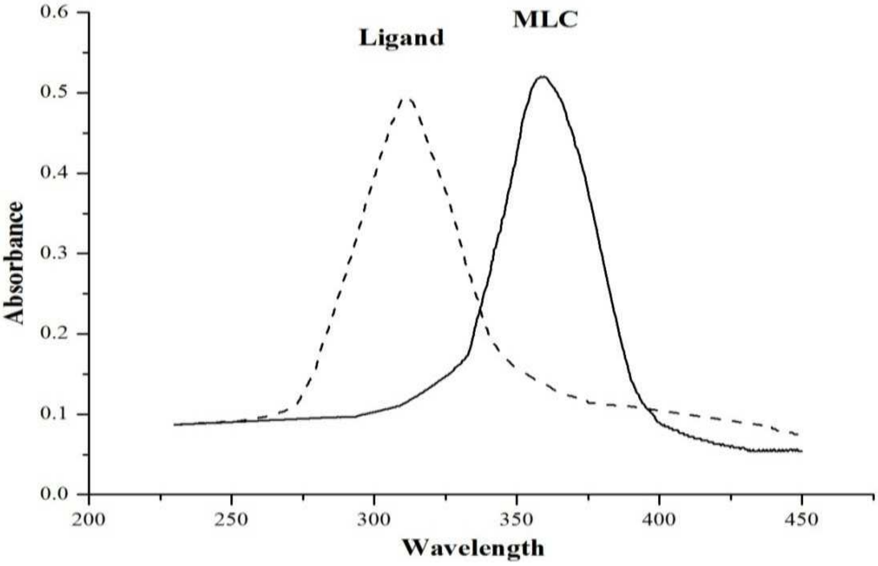


Fig. 1: (A) Absorption spectrum of ligand (HPEBH) Vs. solvent (DMF) blank (B) Absorption spectrum of Cd (II)-HPEBH complex (MLC) Vs. Ligand blank; Cd(II) =1.0 mL of $1.0x10^{-4}$M, HPEBH =1.0 mL of ($1.0x10^{-4}$M), and pH = 6.0

Effect of pH: Into a series of 10-mL volumetric flasks, 1.0 mL of Cd(II) solution ($1.0x10^{-4}$M), 1.0 mL of ligand solution ($1.0x10^{-4}$M), 1.0 mL of 0.01% thiosulphate solution and 4.0 mL of buffer of varying pH (1.0 - 7.0) are added and made up to the mark with double distilled water and the absorbance is measured against reagent blank at 358 nm. The absorbance increases from pH: 1.0-6.0 then decreases. From this study it is optimized that the pH 6.0 is the optimum pH for further studies. (Figure 2)

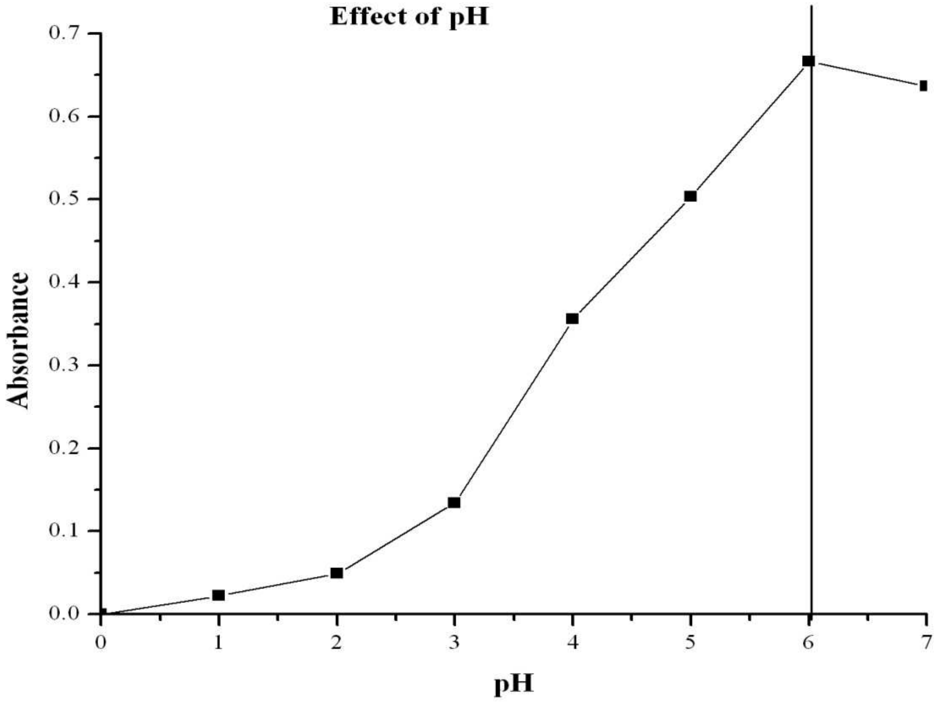


Fig.2: Effect of pH on the absorbance of Cd (II)-HPEBH complex; Cd (II) = 1.0 mL of $1.0x10^{-4}$M; HPEBH =1.0 mL of $1.0x10^{-4}$M; λ_{max} = 358 nm

Applicability of Beer's law: The known aliquots of 10.0 mL solutions, each containing constant volumes of 4.0 mL of buffer (pH 6.0), 1.0 mL of 0.01% of thiosulphate solution, 1.0 mL of 1.0×10^{-4}M of reagent and 1.0 mL of Cd (II) solutions of concentrations in the range from 0.10×10^{-4} to 1.0×10^{-4}M (1.12-11.2 μg mL^{-1}) are prepared. The absorbance of these solutions is measured at 358 nm. A graph plotted between the amount of Cd(II) and its absorbance is as shown in Figure 3. From the graph it is observed that, a linear plot passing through the origin obeys Beer's law in the range from 1.12-11.2μg mL^{-1} of Cd (II). The correlation coefficient is 0.9993 which indicates the linearity between the two variables. The molar absorptivity coefficient and sandal's sensitivity of the complex are found to be $6.66x10^4$ L mol^{-1} cm^{-1} and 0.028 μg cm^{-2} respectively.

Job's method of continuous variation: Equi-molar solutions of Cd (II) ion and reagent HPEBH (1.0×10^{-4}M concentration each) is prepared. The metal and reagent solutions are mixed in different proportions, keeping the total volume of metal and ligand is constant at 5.0 mL. In each case, 4.0 mL of sodium acetate-acetic acid buffer (pH 6.0),1.0 mL of 0.01% of thiosulphate solution are added to the mixture and the total volume of the solution is made up to 10.0 mL with double distilled water. The absorbances of all the solutions are measured at 358 nm against their reagent blanks. The corresponding graph (Figure 4) is drawn between absorbance and V_M/V_L+V_M (where V_L and V_M are the volumes of the reagent and the metal, respectively).From the graph it is identified that the composition of metal to ligand complex is 1:1 ratio. The composition of the M-L complex is further confirmed by Molar ratio method (Figure 5 and Figure 6).

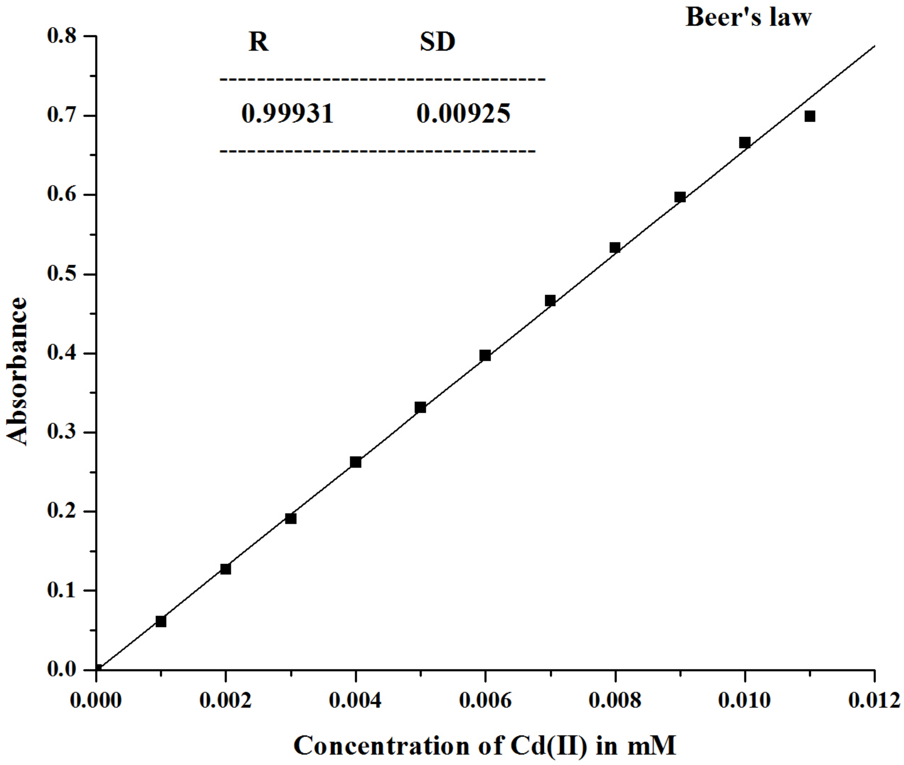


Fig 3: Applicability of Beer's Law: HPEBH = 1.0 mL of 1.0 x 10^{-4}M, Cd (II) =1.0 mL of (0.1x10^{-4}M - 1.0x 10^{-4} M), pH= 6.0 and λ $_{max}$ = 358 nm

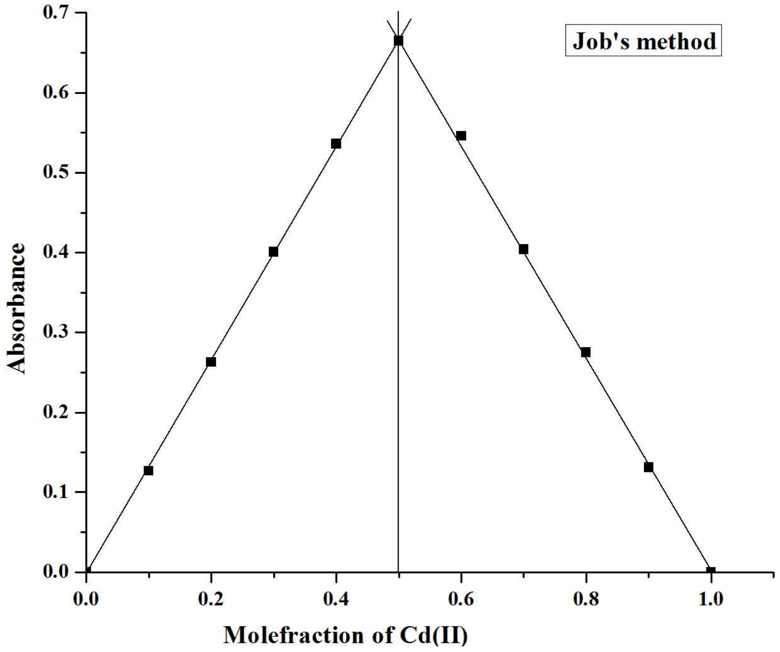


Fig. 4: Job's method of continuous variations for stoichiometric ratio between Cd (II) and HPEBH (1.0×10^{-4}M concentration each); pH=6.0 and λ $_{max}$ = 358 nm

Mole ratio method:

a) Effect of ligand concentration: In to a 10-mL volumetric flask 1.0 mL of $1.0x10^{-4}$M Cd (II) solution, 4.0 mL of buffer pH 6.0, 1.0 mL of 0.01% of thiosulphate solution and 1.0 mL of varying amounts of ($1x10^{-5}$ to $3.0x10^{-4}$M) reagent (HPEBH) are added and made up to the mark with double distilled water and measured the absorbance at 358 nm against the corresponding reagent blanks. From the results, it is clear that 1.0 mole of ligand is necessary for the maximum recovery of 1.0 mole of Cd (II). The results are plotted in the graph 5.

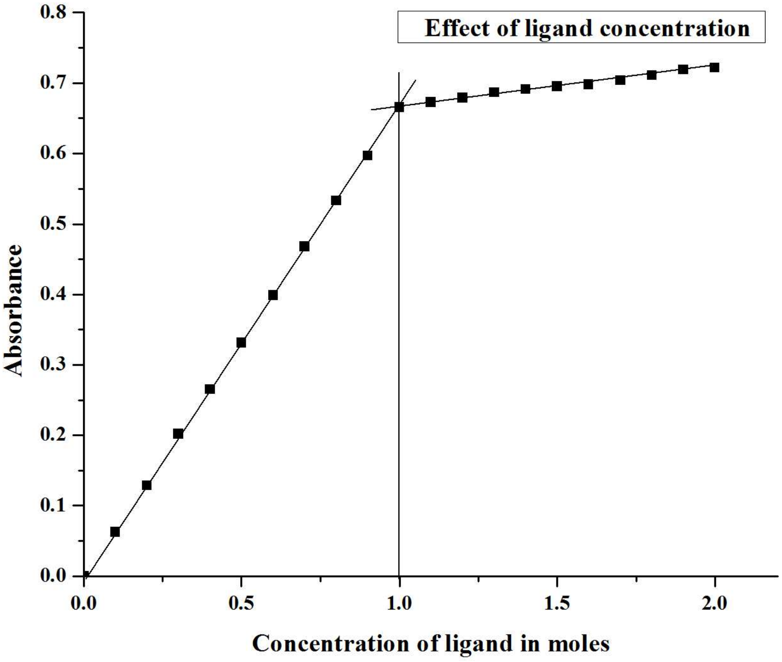


Fig. 5:Effect of Ligand concentration: HPEBH = 1.0 mL of ($1.0x 10^{-5}$ -$3x10^{-4}$M), Cd (II) =1.0 mL of ($1.0x 10^{-4}$ M), pH=6.0 and λ_{max} = 358 nm

b)Effect of metal ion concentration:

Different molar excesses of Cd (II) are added to the fixed amount of HPEBH and absorbance is measured according to the standard procedure. It is observed that the reagent (HPEBH) and the metal (Cd(II)) molar ratio is 1:1. Based on the above two methods the composition of the Cd (II)-HPEBH complex is confirmed as 1:1 ratio.

Effect of foreign Ions:

The effect of various cations which are generally associated with the metal ion on the determination of the Cd(II) is studied by measuring the absorbance of the cadmium complex containing 1 μg mL^{-1} of Cd(II) in solution. The effect of foreign ions on complexation is studied by taking 1.0 mL of Cd(II) solution, 1.0 mL of required concentration of the foreign ion solution, 4.0 mL of sodium acetate-acetic acid buffer (pH 6.0) and 1.0 mL of HPEBH solution in a 10-mL standard flask. The total volume of the solution is brought to 10.0 mL with double distilled water. The experiment is repeated by changing the concentration of the diverse ion. The absorbance is measured at 358 nm. A change of ± 0.02 is taken as the tolerance limit for interference.

The results indicated that Ca(II), Mg(II), Hg(II) and Mn(II) do not interfere even when present up to 5000 µg. Interference due to Al(III) and Cr(III) can be tolerated up to 2000 µg, whereas Mo(VI)and W(V) can be tolerated up to 1000 µg only. Extraction of cadmium (II) is not possible in the presence of Cu(II), Co(II), Ni(II), Fe (II) Zn(II), Pd(II), and Pb(II), due to their severe interference, even when present in trace amount. In the presence of thiocyanate and oxalate, determination of Cd(II) is not possible. 1% potassium iodide is used for removal of interference of Ni(II), Co(II). Zn(II) and Pb(II) in the pH range studied.

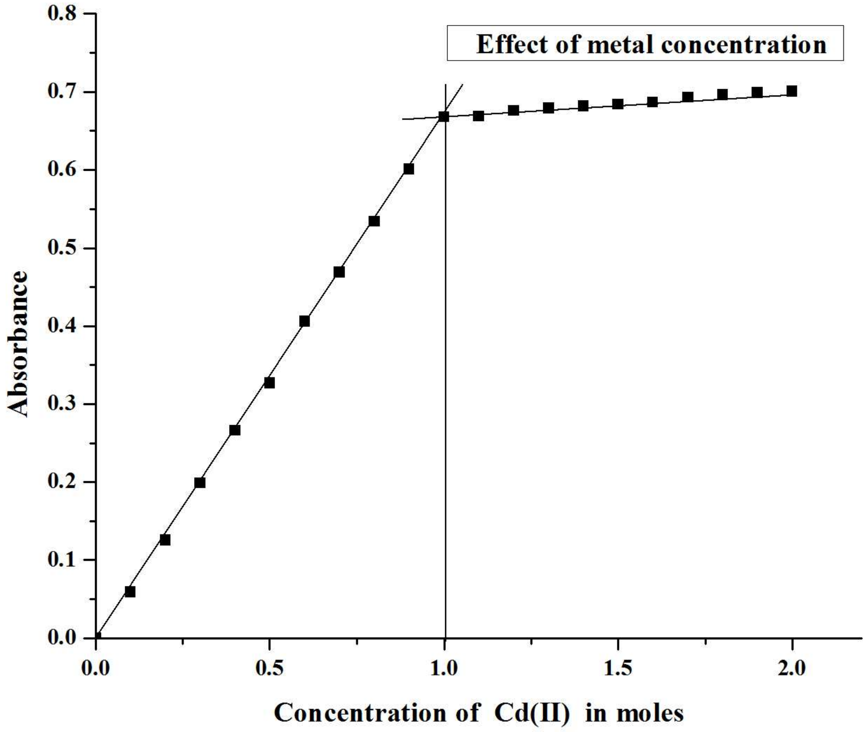


Fig. 6: Effect of metal concentration: HPEBH =1.0 mL of 1.0x 10^{-4} M, Cd (II) =1.0 mL of (0.1x10^{-4}M-1.0x 10^{-4} M), pH=6.0 and λ_{max} = 358 nm

Table 2: Tolerance limit of Foreign ions

Foreign ions	Tolerance limit	remarks
Ca(II), Mg(II), Hg(II) and Mn(II)	5000 µg	Less interference
Al(III) and Cr(III)	2000 µg	Less interference
Mo(VI) and W(V)	1000 µg	Moderate interference
Cu(II), ^{a}Co(II), ^{a}Ni (II), ^{a}Fe (II), ^{a}Zn(II) and ^{a}Pb(II)	200 µg	More interference

^{a}masked with 1.0 % Potassium iodide

Scope of the method:

The optimized method is successfully applied for the determination of Cd (II) in environmental matrices like food and water samples.

Table 3: Concentration levels of Cd(II) in food samples

S. No.	Name of the Sample	Scientific name	Concentration of Cd(II) By AAS Method^a(ppm)	Concentration of Cd(II) in the present method(ppm)*	Standard Deviation
1	Wheat grain	*Triticum aesivum*	0.010	0.009	0.0006
2	Cabbage	*Brassica oleracea*	0.61	0.59	0.0040
3	Carrot	*Daucas carota*	0.037	0.035	0.0004
4	Potato	*Solanum tuberosum*	0.000	0.000	0.0000
5	Tomato	*Lycopersicon esculentum*	0.02	0.01	0.0020
6	Vepaku	*Azadirachta indica*	0.309	0.307	0.0006
7	Thotakura	*Amaranthus gangeticus*	0.110	0.107	0.0010
8	Chukkaku	*Rumex vesicarius*	0.093	0.091	0.0006
9	Caulif flower green	*Brassica deraceavarbatuties*	0.160	0.157	0.0010

**Average of five readings* *^{a}Atomic absorption spectroscopy*

Table 4: Determination of Cd (II) in water samples

Sample	Cd(II) (μg/L)- (Spiked)	Concentration of Cd(II) by AAS Method	concentration of Cd(II) by present method	Recovery (%)
Waste water[1]	100	102.10	101.98	101.98
	500	510.10	510.00	102.00
Sea water[2]	100	101.80	101.50	101.50
	500	507.6	507.55	101.51
Tap water[3]	100	101.00	100.98	100.98
	500	505.03	504,50	100.90

[1] *Collected from industrial area, Kadapa.* [2] *Bay of Bengal, Nellore.* [3] *Yogi Vemana University, Kadapa.*

Determination of Cd(II) in food and water samples : Food and water samples are collected from various places in and around Kadapa, A.P. India. The collected samples are digested as per the procedure reported in the literature [18, 19]. The prepared solutions are analyzed according to the optimized procedure. The obtained results are shown in table-3 and table-4.

Preparation of synthetic mixtures:

Metal ion solutions of Cu^{2+}, Fe^{2+}, Co^{2+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Hg^{2+}, Pd^{2+}, Pb^{2+} and $Cd^{2+}$are prepared from Merck-analytical grade stock standards of concentration 1000mg/L. The synthetic water solutions are then prepared by mixing the different metal ions as prescribed in the table.5. The aliquot is analyzed for Cd(II), using HPEBH adopting the recommended procedure.

Table 5: Determination of Cd(II) in synthetic water samples

Samples	Metal 1 (2μg/mL)	Metal 2 (2μg/mL)	Metal 3 (2μg/mL)	Metal 4 (4μg/mL)	AAS (μg/mL)	Present Method (μg/mL)	% of recovery
1	Fe	Co	Ni	Cd	3.97	3.96	99.00
2	Co	Ni	Mn	Cd	3.99	3.98	99.50
3	Fe	Zn	Ni	Cd	3.97	3.95	98.75
4	Pb	Co	Ni	Cd	3.96	3.96	99.00
5	Cu	Pd	Mn	Cd	3.98	3.96	99.00

CONCLUSION

A rapid spectrophotometric method for the determination of Cd(II) in food materials, water and synthetic samples has been developed by using fairly sensitive and selective HPEBH as an analytical reagent. The proposed method offers advantages like good sensitivity, selectivity, reliability, reproducibility, less interference and immediate color development. The developed method is found to be quantitative comparable to other standard methods. The molar absorptivity of the complex (6.66 $x10^4$ L $mol^{-1}cm^{-1}$) reveals that the ligand is highly sensitive for Cd (II) when compared with other hydrazones. Hence, HPEBH is an alternative ligand for the spectrophotometric determination of trace amount of Cd (II) in various environmental matrices.

Acknowledgement

We gratefully acknowledge financial support from the Department of Atomic Energy-Board of Research in Nuclear Sciences (Bhabha Atomic Research Centre), Mumbai, India through a major research project (No. 2011/37C/52/BRNS/2264).

REFERENCES

[1] MM Key; AF Henschel; J Butter; RN Ligo; IR Tabershaed. (Eds), U.S. Department of Health, Education and Welfare, Us Government Printing Washington, D.C., **1977**, 265-279.

[2] SE Ghazy. *Sep. Sci. Technol*, **1995,** 30(6), 933-936.

[3] D M Taylor ; D R Williams. Trace Element Medicine and Chelation Therapy, *The* Royal Society of Chemistry, Cambridge., **1995**, 22 ,7445-7451.

[4] R Salim; M Al-subu; E Sahrhage. *Sci. Health A.,* **1992**, 27 (3), 603-627.

[5] CW Cheung; JF Porter; G Mckay. *J Chem. Technol. Biotechnol.,* **2000,** 75(11), 963.-970.

[6] A Lisa. Friedrich; M Norman Halden. *Environmental Science Technolog.*, **2010**, 44(5), 1551-1558.

[7] M Jamaluddin Ahmed; D A Chowdhury; M. Ahasanul Haque. Proceedings of International Conference on Industrial Pollution and Control Technologies, Y. Anjaneyulu (Ed.), Allied Publishers Limited, Hyderabad, **1997**, 976-986.

[8] Y Hirano; J Nakajima; K Oguma; Y Terui . Ni, Pd and Th was investigated for use with platform atomization. *J. Anal. Sci.*, **2001**, 17, 1073.

[9] D Gopala Krishna; N Devanna; B Chandrasekhar. *International journal of analytical and bioanalytical chemistry.*, **2011**, 1 (1), 1-8.

[10] D Gopala Krishna; N Devanna; B Chandrasekhar. *International journal of pharma and bio sciences* , **2010**, 1 (3) , 1-19.

[11] D Nagarjuna Reddy; K Vasudeva Reddy; T Sreenivasulu Reddy;K Hussain Reddy. *Advances in Applied Science Research,* **2011,** 2 (4), 328-337.

[12] JM Baustista Rabriguez; JM CanoPavon. *Talanta,* **1980**, 27, 923-926.

[13] V Vajagand; M Jaredic. *Chem. Anal. (Warsaw)*, **1975**, 20, 1125.

[14] S Hoshi; T Yotsuyangi; K Amoura. *Bunseki Kagaku*. **1977,** 26, 592.

[15] F Kmail; PP Sinha; SK Sindhwani. *J. Inst. Chem. (India)*. **1982,** 54, 119.

[16] P Barbazan; R Carballo;E M Vazquez-Lopez. *Cryst Eng Comm*, **2007**, 9, 668-675.

[17] AI Vogel. A Textbook of Quantitative Inorganic Analysis, 3rd edition, Longman Green publishers, London, U.K, **1961**, 444.

[18] P Nityananda Kumar Reddy; G Trivikram Reddy; Kumar Ms. Sangita; AVR Reddy; S Nazneen Parveen; NC Gangi Reddy, *Der Pharmacia Lettre*, **2015**, 7 (1), 292-302.

[19] S Adinarayana Reddy; K Janardhan Reddy; A Varada Reddy, *J Chin Chem Soc.*, **2010**, 57, 236-243.