

Extraction of Cobalt (II) form aqueous solution by use 2- [(4- carboxy methylphenyl) azo] -4,5- diphenyl imidazole

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Abstract

2- [(4- Carboxy methylphenyl) azo] -4,5- diphenyl imidazole (4 – CMePADPI) used as sensitive and selective ligand for extraction cobalt (II) ions from aqueous solutions and this application shows the optimum conditions for good extraction was ($pH_{ex} = 11$) which was giving higher distribution ratio (D) and need (10minutes) for shaking the two layers to reach good extraction as well as the optimum concentration of Co^{+2} ions in aqueous phase was ($50\mu g$) ($1.69 \times 10^{-4} M$) to give higher Distribution ratio (D) . Stoichiometric study shows the structure of ion pair complex extraction for Co^{+2} ions with (4CMePADPI) ligand was 1:1 (metal :ligand) [$Co(4 - CMePADPI)^{+2} SO_4^{-2}$ from other hand organic solvent shows there is not any Linear relation between dielectric constant (E) of organic solvent and distribution ratio (D) of extraction ,but there is an effect for the structure of organic solvent .At later the thermodynamic study demonstrate the complexation reaction between Co^{+2} ions and ligand(4 –CMePADPI) was exothermic .

الخلاصة:-

[2- (4-كاربوكسي مثيل فنيل (آزو) -4,5- ثنائي فنيل اميدازول (4-CMePADPI) استعمل كليكاند ذو حساسية وانتقائية لأستخلاص ايونات الكوبلت (II) من المحاليل المائية ، وان هذا التطبيق اظهر الظروف المثلى للأستخلاص كانت ($pH_{ex}=11$) حيث اعطت اعلى نسبة للتوزيع (D) وقد احتاجت عملية الأستخلاص الى رج لمدة (10دقائق) للطورين العضوي والمائي ، اما التركيز الامثل لايونات الكوبلت Co^{+2} في الطور المائي كان $50\mu g$ ($1.69 \times 10^{-4} M$) لتعطي اعلى قيمة لنسبة التوزيع (D) ، اظهرت الدراسة ان تركيب معقد الترابط الايوني المستخلص بين ايون الكوبلت Co^{+2} واليكاند (4-CMeADPI) كان (1:1) (فلز:ليكاند) [$Co(4-CMePADPI)^{+2} SO_4^{-2}$. اما دراسة تأثير المذيب العضوي فاظهرت انه ليس هناك علاقة خطية بين ثابت العزل الكهربائي (E) للمذيبات العضوية ونسب التوزيع (D) لأستخلاص الكوبلت Co^{+2} ، وكذلك اثبتت الدراسة انه هناك تأثير لتركيب المذيب العضوي على عملية الأستخلاص اما دراسة الترموديناميك لعملية الأستخلاص فوضحت ان التفاعل بين ايونات الكوبلت Co^{+2} و الليكاند (4- CMePADPI) كان تفاعل باعث للحرارة Exothermic

1.Introduction :

Sensitivity and selectivity behavior of azo compounds and imidazoles as well as its derivatives for complexation reaction and complex formation for transition metals ,giving growing concern in studying complexes formed by these compounds .2- [(2 – benzimidazole)azo] – 4 – acetamidophenol for extraction Zn (II) and Cd(II)^[1] Extraction Cu (II) and Ag(I) by using 2- [(4- Carboxy methylphenyl) azo] -4,5- diphenyl imidazole^[2] . Extracted group (IIB) elements by 2- [(4-chloro-2- methoxy phenyl) azo] -4,5- diphenyl imidazole^[3] Cu(II) and Ag(I) ions extracted With solvent extraction method by use of 2 –[(6 – naphthyl)azo] -4,5-diphenyl Imidazole^[4] . Synthesized new imidazole ligand and studied its complexes with Cobalt (II), Nickel (II) and Copper (II) .^[5] Another study about chelate complex between imidazole with Copper (II)^[6] Comparison of extraction Zn(II) and Ni(II) By used two different derivatives of imidazole^[7] . studied the complexation of copper(II) , Zinc (II) and Nickel(II) with imidazole derivatives for extraction and spectrophotometric determination^[8] . A ciral complex salen Zn (II) was synthesized and characterized its coordination with imidazole derivatives was studies by UV –Vis spectrophotometric titration and CD spectroscopy^[9] . Benzildithiosemicarbazone (BDTSC) used as sensitive and selective analytical reagent for the extractive spectrophotometric determination of copper (II) , (BDTSC) reacts with in the pH range (1-7) to form yellowish complex^[10] . The solvent

extraction trivalent lanthanides (La,nD,Eu,Ho,Lu) with mixtures of the chelating extractant 1-(2-Thienyl)-4,4,4,-trifluoro -1,3- butane dionethenoyltrifluoro – acetone (HP) and 4-(2-pyridylazo) – resorcin (PAR,S) in CHCl_3 was studied ^[11]. A new polystyrene divinyl benzene resin containing 2-(2-thiazolylazo)-5-dimethylamino-phenol (TAM) functional groups has been synthesized and its sorption behavior for nineteen metal ions including Zr(IV),Hf (V) V(VI) has been investigated by batch and column method ^[12]. In other study used 4-(2-thiazolylazo) –resorcinol for spectrophotometric determination of chromium ^[13].

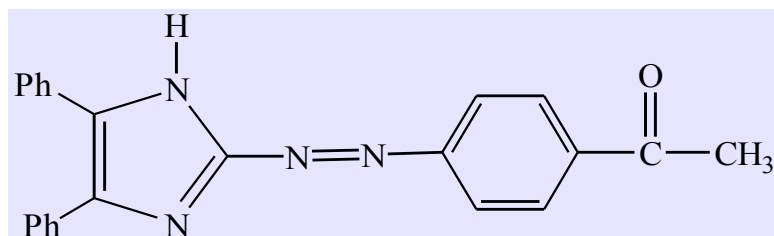
2. Experimental

2.1 Apparatus

Used shimadzu (UV-100-02 spectrophotometer) single beam and UV-1700 double beam spectrophotometer , Japan for absorption measurements also pH – Measurements used (HANNA – pH ZSmeter).

2.2 Reagents and preparations of standard solutions

All reagents and solvent were obtained from commercial source (B.D.H), Merck, fluka and used as received .The ligand 2- [(4- Carboxy methylphenyl) azo] -4,5- diphenyl imidazole (4 – CMePADPI) synthesized as in the thesis ^[2]. Stock solution of Co^{+2} ions (1mg/ml) prepared by dissolved (0.4789 gm) of ($\text{CoSO}_4 \cdot 7\text{H}_2\text{O}$) in distilled water contain (2ml) of concentration sulfuric acid (H_2SO_4) and then put this solution in (100 ml) volumetric flask and complete the volume with distilled water ,other working standard solutions prepared by dilution with distilled water , needful prepared 0.5% solution of 1-Nitroso-2- Naphthol dissolved in glacial acetic acid for determination of Co^{+2} ions in aqueous solution , standard solution of ligand (4-CMePADPI) in concentration of (1×10^{-2} M) prepare by dissolved (0.366gm) of ligand in chloroform by use (100ml) volumetric flask ,also from this solution prepared other standard solution for ligand by dilution with chloroform .



2-[(4-Carboxy methyl phenyl)azo]-4,5-diphenyl imidazole.

Fig(1): structure of ligand used in extraction method.

2.3 .General procedure

For extraction experiments have to take (5ml) of aqueous solution contain exact quantity of Co^{+2} ions at optimum pH ,and then adding (5ml) of organic solution ligand (4- CMePADPI) dissolved in chloroform or other organic solvent . Afterward shaking these two phases for suitable time at room temperature and later separate the two layers and determine Co^{+2} ions remainder in aqueous phases by spectrophotometric method^[14],For (5ml)aqueous phase add (1ml) of (0.5%) 1- Nitroso-2-Naphthol and make pH of solution (pH=4) ,after shaking the solution for (2 minutes) leave the solution for 30 minutes ,after that transfer this solution to separation funnel and extracted the complex by two portions of chloroform each one equal to (5ml), then shaking the chloroform layer with 2ml of HCl and two portions of (2M NaOH) each potion (2ml)at later washing the chloroform layer with distilled water , afterward put the chloroform in (10ml) volumetric flask and complete the volume with chloroform and determine the absorbance of this solution at $\lambda = 415$ nm by use chloroform as blank ,from absorbance values and calibration curve Fig (2) determine the remainder quantity of Ni^{+2} ions in aqueous phase ,but for determine the quantity of Co^{+2} ions

transferred to the organic phase to produce ion pair complex with ligand (4-CMPADPI) used stripping method by shaking the organic phase with three portions of nearly concentrated hydrochloric acid HCl to dissociate the ion pair complex and returning Co^{+2} ions to the aqueous phase and then determine the quantity of Co^{+2} ions by spectrophotometric determination method ,previous method , also possibly determine the quantity of Co^{+2} ions transferred to the organic phase by subtraction the remainder quantity of Co^{+2} ions in aqueous phase from initial quantity , afterward divide the quantity of Co^{+2} ions in organic phase on the quantity of Co^{+2} ions in aqueous phase to determine distribution ratio (D)

3. Result and Discussion

The complexation reaction between the ligand (4- CMePADPI) and Co^{+2} ions depend on many optimum condition to reach this reaction to equilibrium and giving stable ion pair complex as in the equilibria below



3.1.Effect of pH

Extraction of (50 μg) ($1.69 \times 10^{-4}\text{M}$)of Co^{+2} ions in (5ml) aqueous phase at different pH(5 – 12)by use (5ml)of ($1 \times 10^{-4}\text{M}$) ligand (4-CMePADPI) dissolved in chloroform ,after shaking these two layers for 10 minutes at (20C^0) and separate the aqueous phase from the organic phase , afterward determine the quantity of Co^{+2} ions in aqueous and organic phase by following spectrophotometric determination method as clarity in general procedure afterward determine the distribution ratio (D) and Percentage of extraction (E)at each pH, the results in Table (1) and Fig (3) shows the optimum of pH extraction was ($\text{pH}_{\text{ex}} = 11$) . At pH less than optimum value effect to Protonated the imidazol molecule ligand to occupy the pair of electron and minimizing the coordination with Co^{+2} ions and give less stable ion pair complex and decline distribution ratio (D)and percentage of extraction (E) and at pH more than optimum value also decline distribution ratio (D) may be by reason of produce stable species in aqueous phase can not be extracted or by participated the hydroxyl anion in formation of ion pair complex which is soluble in aqueous phase .

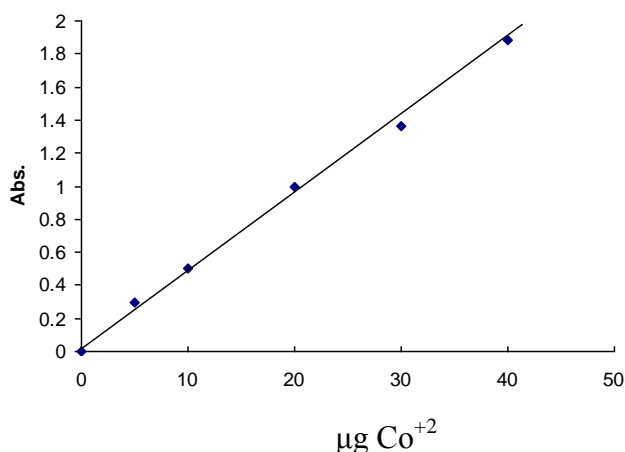


Fig (2): Calibration curve for Co^{+2} ions

$r = 0.989$

$a = \text{intercept} = 0.006$

$b = \text{slope} = 0.03$

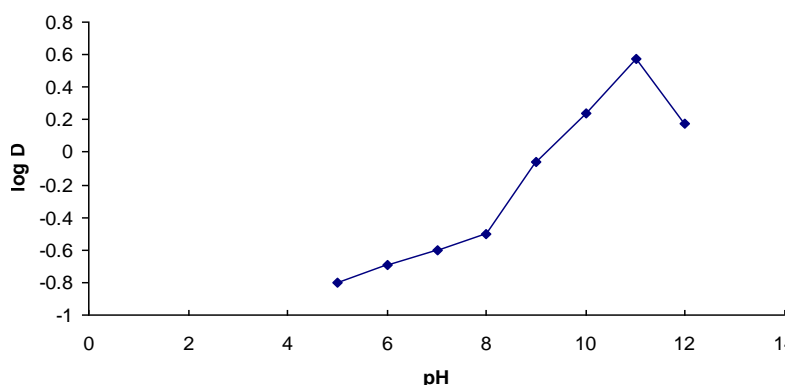
$\text{RSD} = 0.04\%$

$\text{Re} = +0.3\%$

$\text{DL} = 1.7 \times 10^{-5}\text{M}$

Table (1) Effect of pH on the extraction of Co⁺² ions

| pH | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|----|--------|-------|------|-------|-------|-------|-------|-----|
| D | 0.153 | 0.2 | 0.25 | 0.316 | 0.875 | 1.72 | 3.285 | 1.5 |
| E% | 13.27% | 16.7% | 20% | 24% | 46.7% | 63.2% | 76.7% | 60% |



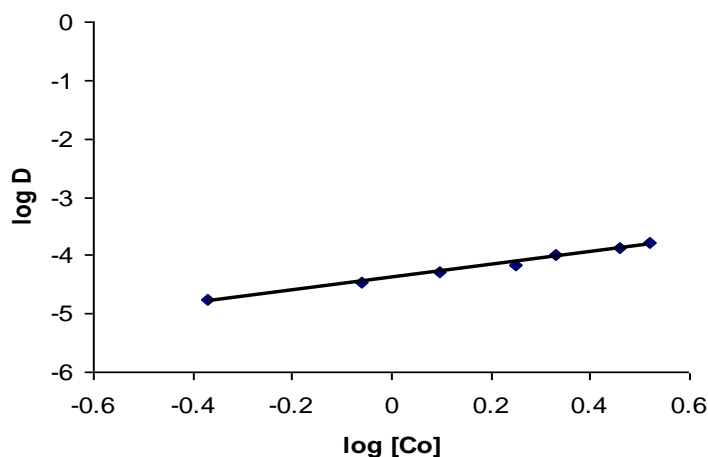
Fig(3): pH effect on the extraction of Co⁺² ions

3.2.Effect of Metal Ion Concentration

Extraction Co⁺² ions from (5ml) aqueous solution contain different quantity of Co⁺² ions (5 -100 µg) (0.17x10⁻⁴ -3.39x10⁻⁴ M) at (pH_{ex} = 11) by using (5ml) ligand solution(4CMePADPI) dissolved in chloroform at (1x10⁻⁴ M) concentration ,shaking these two phases for (10minutes) at (20C⁰) afterward separated aqueous phase from organic phase and determine the remainder quantity of Co⁺² ions in aqueous phase and transfered quantity of Co⁺²ions to the organic phase by following spectrophotometric determination method as clarify in general procedure , after that determine the distribution ratio (D) and percentage of extraction (E). the results in Table (2) and Fig (4) demonstrate the optimum quantity of Co⁺² ions in aqueous phase which giving highest distribution ratio (D)and percentage of extraction (E) was (50µg)(1.69x10⁻⁴ M). The concentration of Co⁺² ions less than optimum concentration not allow to reach the equilibria and minimizing the distribution ratio (D) and percentage of extraction (E) , from other hand the concentration of Co⁺² ions more than optimum value effect to decreasing the distribution ratio (D) and percentage of extraction (E) according to Lechatlier principle

Table (2) effect of Co⁺² ions concentration on the extraction method

| µgCo ⁺² | 5 | 10 | 15 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 100 |
|--|--------|-------|-------|--------|--------|-------|-------|-------|-------|-------|------|
| [Co ⁺²] X10 ⁻⁵ | 1.7 | 3.4 | 5.1 | 6.8 | 10.2 | 13.6 | 16.9 | 20.4 | 23.8 | 27.2 | 33.4 |
| D | 0.43 | 0.87 | 1.25 | 1.78 | 2.13 | 2.86 | 3.285 | 2.74 | 2.22 | 1.89 | 1.53 |
| E% | 30.07% | 46.5% | 55.6% | 64.03% | 68.05% | 74.1% | 76.7% | 73.3% | 68.9% | 65.2% | 60% |
| Slope | 0.62 | | | | | | | | | | |



**Fig (4) Effect of Co^{+2} ions on the extraction method
Slope =0.62**

3.3 Effect of Shaking Time

To study the kinetic side of complexation reaction between ligand molecules ((4- CMePADPI) and Co^{+2} ions to produce the ion pair complex ,extracted 50 μg (1.69×10^{-4} M) Co^{+2} ions in 5ml aqueous solution at pH=11 by(5ml)volume of 1×10^{-4} M ligand (4-CMePADPI) dissolved in chloroform and shaking for different times (5min. – 30 min) at (20C^0) after complete shaking separate aqueous phase from organic phase and determine the remainder and transferred quantities of Co^{+2} ions by followed the spectrophotometric method (1-nitroso -2-naphthol method) which is clarify in general procedure afterward determine distribution ratio (D) and percentage of extraction (E) . The results in Table (3) and Figure (5) shows the optimum shaking time was (10minutes) to reach the equilibrium of complexation reaction but shaking time less than optimum value not allow to reach equilibrium and decrease the distribution ratio (D) and percentage of extraction (E) as well as shaking for time longer than optimum time effect to predominate dissociation equilibria and minimizing distribution ratio (D) and percentage of extraction (E)

Table (3):Effect of shaking time on the extraction method

| Time (min.) | 5 | 10 | 15 | 20 | 25 | 30 |
|-------------|-------|-------|------|-------|-------|-------|
| D | 2.75 | 3.285 | 2.33 | 1.727 | 1.727 | 1.727 |
| E% | 73.3% | 76.7% | 70% | 63.3% | 63.3% | 63.3% |

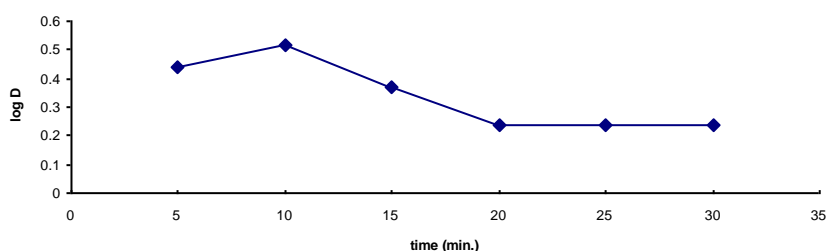


Fig. (5) Effect of shaking time on the extraction method

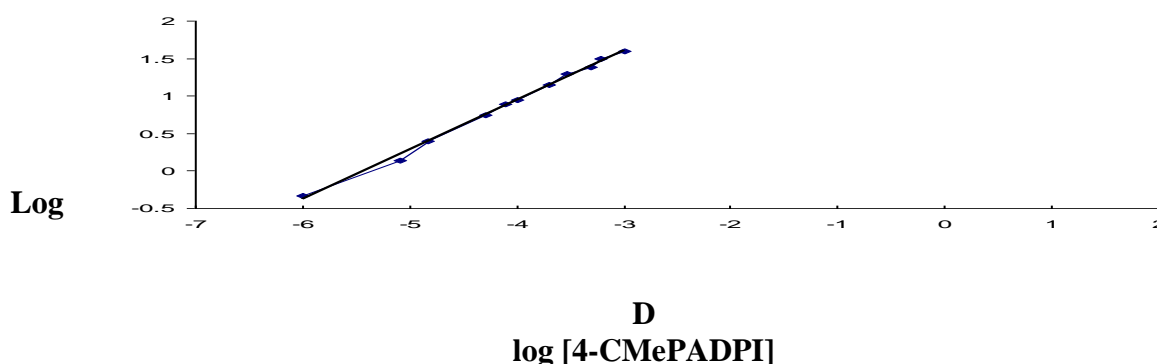
3.4- stoichiometry

3.4.1 Slope Analysis Method

For giving the probable structure of ion pair complex extracted , extraction $50\mu\text{gCo}^{+2}$ ions ($1.69 \times 10^{-4} \text{ M}$) in 5ml aqueous phase at (pH=11) by different concentration of ligand (4-CMeADPI) dissolved in chloroform ($1 \times 10^{-6} \text{ M} - 1 \times 10^{-3} \text{ M}$) after shaking two layers for (10 minutes) at (20C^0) separate organic phase from aqueous phase and determine remainder quantity of Co^{+2} in aqueous phase and transferred quantity of Co^{+2} to the organic phase to produce ion pair complex by following the procedure detailed in general procedure afterward calculate distribution ratio (D) . The results in Table (5) and Figure (6) demonstrate from the slope value the more probable structure of ion pair complex extracted was (1:1) (Metal: Ligand) $[\text{Co} - (4\text{-CMePADPI})]^{+2} \text{SO}_4^{-2}$

Table (5): slope analysis method for extraction of Co^{+2} ions

| | | | | | | | | | | | |
|---------------|--------------------|--------------------|----------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| (4-CMePADPI)M | 1×10^{-6} | 8×10^{-6} | 1.5×10^{-5} | 5×10^{-5} | 8×10^{-5} | 1×10^{-4} | 2×10^{-4} | 3×10^{-4} | 5×10^{-4} | 6×10^{-4} | 1×10^{-3} |
| D | 0.467 | 1.38 | 2.5 | 5.62 | 7.76 | 8.91 | 14.1 | 19.5 | 23.99 | 31.62 | 39.8 |
| slope | 0.643 | | | | | | | | | | |



Fig(6) : slope analysis method for extraction of Co^{+2} ion

From the slope of straight line for different concentration of Co^{+2} at Fig (4) and the slope value of straight line for different concentration of ligand Fig (6) calculate the slope ratio and structure of complex

$$= \frac{0.62}{0.643} = 1.04 \quad \text{---} \quad \text{Slope ratio} = \frac{\text{slope of different of } [\text{Co}^{+2}]}{\text{slope of different of [ligand]}}$$

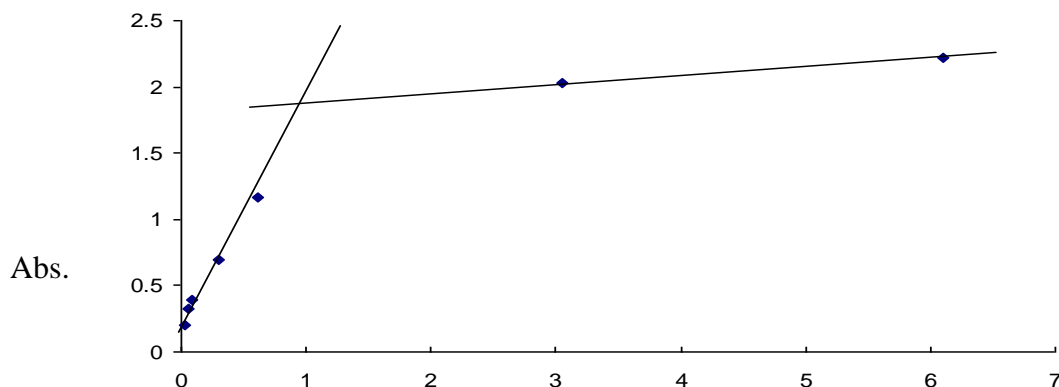
From this result the more probable structure of ion pair complex was (1:1) (metal:ligand) $[\text{Co}^{+2}(4\text{-CMePADPI})]^{+2} \text{SO}_4^{-2}$

3.4.2 . Mole Ratio Method

To be sure of structure for ion pair complex extracted $50\mu\text{g}$ ($1.69 \times 10^{-4} \text{ M}$) Co^{+2} ions in (5ml) aqueous phase at (pH=11) by (5ml) of ligand solution (4-CMePADPI) in ions dissolved in chloroform at different concentration ($5 \times 10^{-6} - 1 \times 10^{-3} \text{ M}$) ,after shaking this two layers for (10 minutes) at (20C^0) and at later separate organic phase from aqueous phase and measurement the absorbance (Abs.) of organic phase at $\lambda=537 \text{ nm}$. by used ligand solution as blank ,afterward plot absorbance values (Abs.) against mole ratio C_L/C_M . The results in Table (6) and Fig. (7) shows structure of ion pair complex extracted was (1:1) (metal: ligand) $[\text{Co} (4\text{-CMePADPI})]^{+2} \text{SO}_4^{-2}$ identify with slope analysis method result.

Table (6): Mole ratio method for extraction of Co⁺² ions

| | | | | | | | |
|--------------------------------|--------------------|--------------------|----------------------|--------------------|--------------------|--------------------|--------------------|
| [4CMePADPI] | 5x10 ⁻⁶ | 1x10 ⁻⁵ | 1.5x10 ⁻⁵ | 5x10 ⁻⁵ | 1x10 ⁻⁴ | 5x10 ⁻⁴ | 1x10 ⁻³ |
| Abs. | 0.207 | 0.33 | 0.39 | 0.69 | 1.17 | 2.03 | 2.219 |
| C _L /C _M | 0.03 | 0.061 | 0.091 | 0.305 | 0.61 | 3.05 | 6.1 |



C_L/C_M

Fig.(7): Mole ratio method for extraction of Co⁺² ions

3.4.3 Continuous Variation Method

Prepared aqueous solution for Co⁺² ions and organic solution for ligand (4-CMePADPI) dissolved in chloroform have the same concentration (1.69x10⁻⁴ M) and then mix different volume of two solutions to maximum volume (5ml) at (pH=11) after shaking the two layers (10min.) at (20C⁰) separate the two layers and measurement the absorbance (Abs.) of organic phase at λ_{max} = 537 nm, by used ligand solution as blank, afterward plot absorbance values (Abs.) against the proportion of metal ions solution volume V_M over total volume of solution after mixed. the results in Table (7) and Fig (8) demonstrate the structure of ion pair complex extracted was (1:1) (Metal : ligand) [Co (4-CMePADPI)]⁺² SO₄⁻².

Table (7) : Continuous variation method for extraction of Co⁺² ions

| | | | | | | | | | |
|-------------------------------|-------|-----|-----|------|-------|------|-----|------|------|
| V _L ml | 4.5 | 4 | 3.5 | 3 | 2.5 | 2 | 1.5 | 1 | 0.5 |
| V _M ml | 0.5 | 1 | 1.5 | 2 | 2.5 | 3 | 3.5 | 4 | 4.5 |
| Abs. | 0.017 | 0.4 | 0.6 | 0.82 | 1.039 | 1.15 | 1.2 | 0.95 | 0.25 |
| V _L V _M | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |

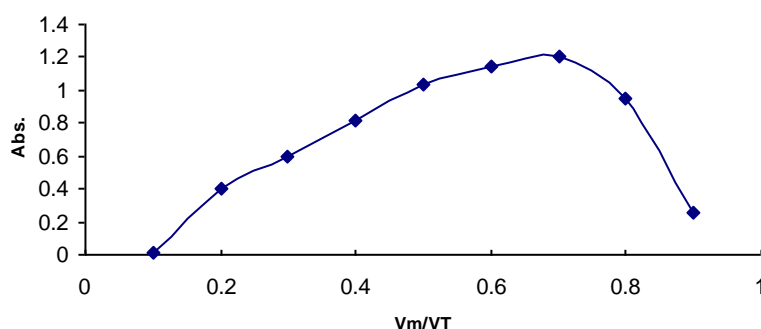


Fig.(8): Continuous variation method for extraction of Co⁺² ions

According to the results in stoichiometric studies the suggested structure of Co⁺²-complex was

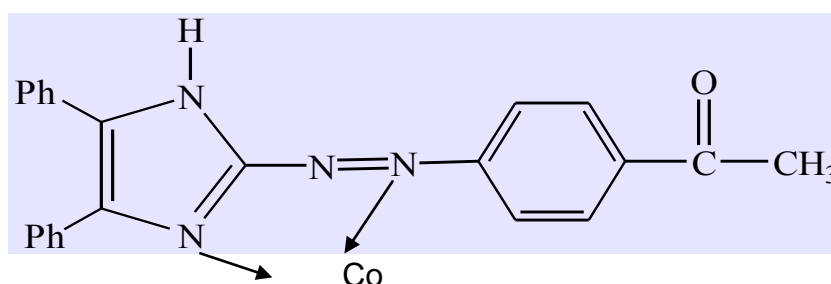


Fig (9): The suggested structure of Co⁺² -complex

3.5 – Organic Solvent Effect

There is an important manner for organic solvent in solvent extraction method ,to clear the importance and behavior extracted (50µg) (1.69x10⁻⁴ M) Co⁺² ions in (5ml) aqueous phase at (pH=11) by (5ml)of ligand solution in (1x10⁻⁴ M) 4-CMePADPI dissolved in different organic solvents differ in dielectric constant (ε) after shaking the two layers for (10 minutes) at (20C⁰) separate the organic phase from the aqueous phase and determine the remainder quantity of Co⁺² ions in aqueous phase and the transfer quantity of Co⁺² ions ,to organic phase to produce ion pair complex by following the spectrophotometric method detailed in general procedure , afterward calculate distribution ratio (D) and percentage of extraction(E) . the results in Table (8) shows there is not any linear relation between distribution ratio (D) and dielectric constant for organic solvents used (ε) as well as illustrated the effect of organic solvent structure on the extraction method and stability of ion pair complex extracted ,and these results shows chloroform very suitable for extracted Co⁺² ions with this ligand to giving higher distribution ratio (D) and percentage of extraction (E) .

Table (8): Organic solvents effect on the extraction of Co⁺² ions

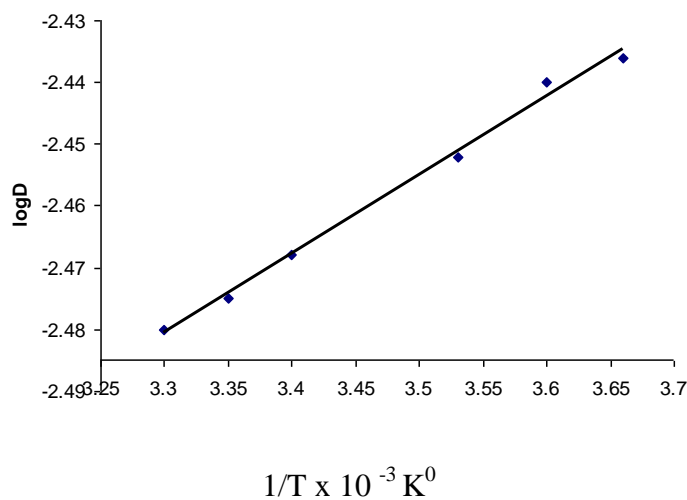
| Organic solvent | ε | D | E% |
|-----------------------|-------|-------|--------|
| Dichloromethane | 9.08 | 0.704 | 41.5% |
| Chloroform | 5.708 | 3.285 | 76.7% |
| Bromobenzene | 5.4 | 0.563 | 36.02% |
| Benzene | 2.804 | 0.470 | 31.97% |
| Carbon tetra chloride | 2.38 | 0.11 | 9.9% |

3.6 –Effect of Temperature

To demonstrate the thermodynamic side of complexation reaction of Co^{+2} ions with ligand (4-CMePADPI) extracted (50 μg) (1.69×10^{-4} M) Co^{+2} ions in (5ml) aqueous phase by (5ml) of (1×10^{-4} M) ligand (4-CMePADPI) dissolved in chloroform at (pH=11) and different temperature (0–30 $^{\circ}\text{C}$) after shaking the two layers in fixed temperature separate organic phase from aqueous phase and determined quantity remainder in aqueous phase and transferred quantity to organic phase for Co^{+2} ions ,at later calculate distribution ratio (D) according to the procedure detailed in general procedure , the results in Table (9) and Figure (10) illustrate the complexation reaction between ligand (4-CMePADPI)and Co^{+2} ions was exothermic reaction , that is mean the coordination association between ligand and Co^{+2} ions decrease with temperature increasing

Table (9): Temperature effect on the extraction of Co^{+2} ions .

| TC^0 | T k | $1/T \text{ k} \times 10^{-3}$ | D | K_{ex} | KJmole^{-1} ΔG_{ex} | $\Delta S_{\text{ex}} \text{ Jmole}^{-1}$ |
|---------------|-----|--------------------------------|-------|--------------------|--|---|
| 0 | 273 | 3.66 | 3.882 | 2.29×10^8 | -42.7 | 156.3 |
| 5 | 278 | 3.6 | 3.651 | 2.16×10^8 | -43.4 | 156 |
| 10 | 283 | 3.53 | 3.466 | 2.05×10^8 | -44.03 | 155.5 |
| 20 | 293 | 3.4 | 3.285 | 1.94×10^8 | -44.5 | 154.8 |
| 25 | 298 | 3.35 | 2.951 | 1.74×10^8 | -45.98 | 154.2 |
| 30 | 303 | 3.3 | 2.462 | 1.46×10^8 | -46.3 | 152.7 |



Fig(10) : Temperature effect on the extraction of Co^{+2} ions

After that calculate extraction constant K_{ex} from the relation ^[2,3,4]

$$D$$

$$K_{\text{ex}} = \frac{D}{[\text{Co}^{+2}]_{\text{aq}} [\text{4-CMePADPI}]_{\text{org}}}$$

Plot $\log K_{\text{ex}}$ against $1/T \text{ K}^0$ and determine the slope of straight line relation and calculate ΔH_{ex}

From the slope value , and $\Delta G_{\text{ex}} , \Delta S_{\text{ex}}$.

$$\text{Slope} = \frac{\Delta H_{\text{ex}}}{2.303 R}$$

$$\Delta G_{\text{ex}} = -R T \ln K_{\text{ex}}$$

$$\Delta G_{\text{ex}} = \Delta H_{\text{ex}} - T \Delta S_{\text{ex}}$$

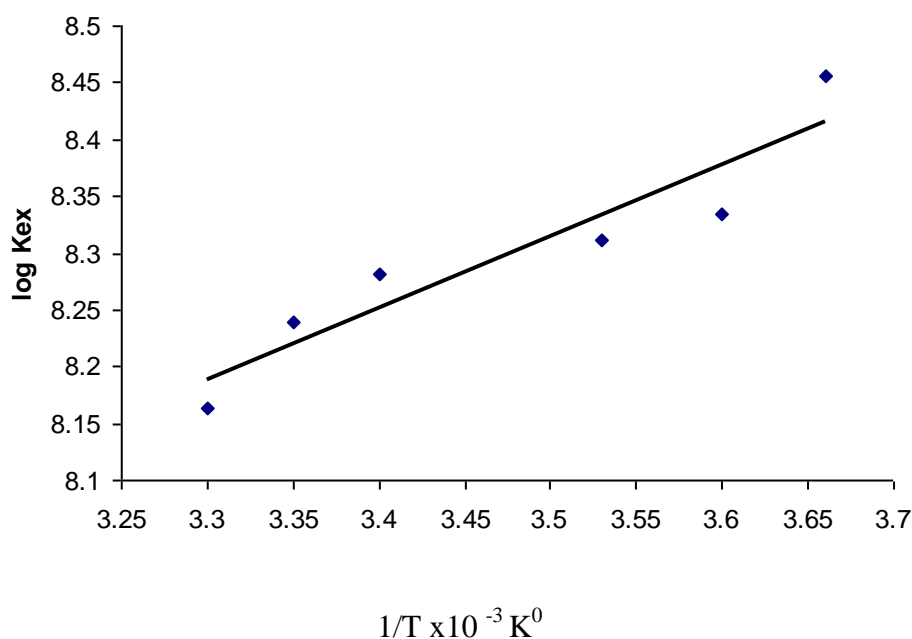


Fig (11) : Temperature effect on the extraction of Co^{+2} ions

After application of these relations , found the value of enthalpy for extraction of Co^{+2} ions was ($\Delta H_{ex} = -0.0203 \text{ KJ mole}^{-1}$) and Gibbs free energy was ($\Delta G_{ex} = -41.25 \text{ KJ mole}^{-1}$) as well as the entropy Was ($\Delta S_{ex} = 151 \text{ J mole}^{-1}$) these results shows from the value of ΔH_{ex} the ion pair complex structure was 1:1 [$\text{Co}(4\text{-CMePADPI})^{+2} \text{SO}_4^{-2}$] which is giving low value for ΔH_{ex} but the high value for ΔS_{ex} reflect that complexation reaction was entropic region [15] .

References

- 1)- G.G. Mohamed , Nadia , E, A, El – Gamel and F. Teixidor "Complexes of 2-(2-benzimidazolylazo) 4- acetamidophenol for extraction of Zn and Cd " polyhedron 2689 – 2696 vol.20(2001) .
- 2)- Ibtihaj Raheem Ali " studies in solvent extraction of Cu and Ag by use of ligand 2-[(4-carboxy methyl Phenyl)azo] -4,5- diphenyl imidazole " thesis of the college of education for girls ,Kufa university ,2005.
- 3)-Zainab Abdul Muttalib "studies in solvent extraction of group(IIb) metal ion by new ligand 2-[(4- Chloro -2-methoxy phenyl) azo]-4,5-diphenyl imidazole" "thesis of college of education for girls –Kufa University ,2005.
- 4)- Alaa Khedhair Hassan "solvent extraction of Cu and Ag as cation by use of ligand 2-[(α -naphthyl) azo] -4,5- diphenyl imidazol]" thesis of college of education for girls – Kufa university ,2006
- 5)- Ibrahim Eden ,Nebahat Demirhan "Synthesis and characterization of a new imidazole ligand and its complex with cobalt (II) ,nickel (II) and copper(II)" UNi AVECATA separation science and technology 559- 562 ,vol.36 (2006) .
- 6)-Carolina Alarcon –payer ,Elena Bugella – Ahamirano , Duane choquesillo –Lazart , Alfons – castimeiras , Josefa. Maria Gonzalez perez "Dinuclear EGTA- copper (II) chelates with imidazole as ligand " Juan .Niclos Gutierrez Inorganic chemistry communication 9(2006) 901 – 906 .
- 7)-Beniamin Lenarcic , Teresa rekyte and Agnieszka Kierzkowska "The comparison of the extraction process of Zn(II) and Ni(II) complexes with 1 –octylimidazole and 1- octyl -2-methylimidazole " XVIII-th ARS SEPARATORIA –Zloty potok ,Poland (2003) .

- 8)- Ibolya Apro –T orok "**copper(II) ,Zinc(II) and Nikel (II) complexes of imidazole containing ligand and inositol derivatives** " ph.D.thesis ,university of szegeed ,Department of inorganic and analytical chemistry Bio coordination chemistri (2002)
- 9)-Ruijnen Yuan Wenjuan Ruan ,Shujun Wang, Yinghui Zhang Xiaoli Li Zhu (**synthesis of chiral salen Zn (II) and its coordination with imidazole derivatives and amino acid ester derivatives** Journal of coordination chemistry 585-595,vol. 59- Issue 6Apri (2006).
- 10)- B.K. Reddy .J.R.Kumar K.J. Reddy ,L.S. Sarma and A.V. Reddy (**A rapid and sensitive extraction spectrophotometric determination of copper(II) in pharmaceutical and environmental samples using benzildithiosemicarbazone**) analytical sciences 423-48 ,vol. 19,march (2003) .
- 11)- Maria Atanassova (**Solvent extraction and separation of Lanthanoids with mixtures of chelating extraction and 4-(2-pyridylazo) resorcinol**) Proc. Estonian Acad sci. chm.. 55-4.202-21 (2006)
- 12)- Won Lee,Si-Eun Iee,Milkyoung Kim,Chang Heon Ieeand Yong-Sang Kim (**A chelating Resin Containing 2-(2-Thazolyazo)-5-dimethyl amino phenol as for some trace metal ion**) IBul.korcan chem.. soc. 1067, vol.23, No. 8,(2002).
- 13)- Lucienes,Carvalho,Antonio Celsos, Costa, Serio L.C. Ferreira Leonardo S.G.Teixeira (**Spectrophoyometric determination of chrominmin steel with 4-(2-thiazolyazo) –resorcinol (TAR) using microwave radiation**) J.BRAZ.chem. soc. Vol.15, No.1, sao pauloJan.feb (2004).
- 14)- Marezenko "**separation and spectrophotometric determination of elements** " copying by Allis Horoodo (1974).
- 15)- A. E .Arifien ,A .H. Amerallah ,R. M. Awadullah and S. M. Sirro . [http:// www. Acadjournal . com /2003/part 2/ P² internet .](http://www.Acadjournal.com/2003/part2/P2internet)