Solvent Extraction Method for the Separation of Cerium(III) as Cations From Aqueous Media By use 4-[N-(5-methyl isoxazol-3-yl)benzene sulfonamide azo]-1- Naphthol Coupled With Spectroscopic Method For Determination

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الخلاصة

تم استخلاص أيونات السيريوم Ce^{3+} من الطور المائي باستعمال الكاشف N-(5-methyl isoxazol-3-yl)benzene sulfonamide azo]-1- Naphthol وقد اظهرت القيمة المثلى للدالة الحامضية pH_{ex} لأستخلاص ايونات Ce^{3+} من الطور المائي كمعقد ترابط ايوني كان (pH = 9) الذي أعطى قيمة نسبة التوزيع (D). كذلك تجربة الاستخلاص لتراكيز مختلفة من ايونات Ce^{3+} في الطور المائي باستعمال الكاشف العضوي و مذاب في الكلوروفورم أظهرت ان 100 µg Ce^{3+} يعتبر هو التركيز الامثل الذي يعطي أعلى قيمة لنسبة التوزيع (D) من جانب آخر تجربة الاستخلاص حول تأثير زمن الرج فقد أظهرت ان الرج لزمن مقداره (10 min.) كان هو الزمن الامثل الذي يعطي أعلى قيمة لنسبة التوزيع (D). اما دراسة تركيب معقد الترابط الأيوني المستخلص إلى الطور العضوي فقد تمت بإجراء اربعه أنواع من التجارب وهي طريقة تحليل الميل وطريقة النسب المولية وطريقة التغيرات المستمرة وقد أثبتت التجارب الثلاث بان لمعقد الترابط الأيوني المستخلص الى الطور العضوي له تركيب ساندويج بنسبة مولية (M : L) 1:1 . إما دراسة تأثير المذيب العضوي على عملية الاستخلاص فقد أثبتت التجربة باستخدام عدد من المذيبات العضوية المختلفة في ثابت العزل الكهربائي لها انه ليس هناك اية علاقة خطية بين ثابت العزل الكهربائي للمذيبات العضوية المختلفة وقيم نسب التوزيع (D) في هذه المذيبات ولكن أظهر مذيب الكلوروفورم تأثير ملحوظ على عملية الاستخلاص وأعطى أعلى قيم لنسب التوزيع (D).

Abstract

Extraction experiments for Ce^{+3} ion from aqueous phase by new laboratory prepared Azo derivation as complexation agent 4- [N-(5-methyl isoxazol-3-yl)benezen sulfonamide azo]-1- Naphthol (AMBN) shows the optimum conditions for this extraction method was (pH= 9) (10 minutes) shaking time and 100µg ($1.5x10^{-4}$M) concentration of Ce^{+3} ion in aqueous phase. Organic solvents effect study shows there is not any linear relation between distribution ratio (D) for extraction of Ce^{+3} ion and dielectric constant (ε)for organic solvents used but there is un effect for organic solvent structure on the extraction of Ce^{+3} ion and distribution ratio (D) values. Stoichiometric studies demonstrated the more probable structure ion pair complex extracted for Ce^{+3} was 1:1 .

Key word: *Cerium(II) , Solvent extraction , 4- [N-(5-methyl isoxazol-3-yl)benezen sulfonamide azo]-1- Naphthol.*

Introduction

Previously used the azo compounds and its derivatives for the extraction methods and used to spectrophotometric determination of transition elements, determination of Ce(IV)using acetophenone 2,5dihydroxy, semicarbazone. The complex has been quantitatively extracted into n-Butanol at pH 4.0.The molar absorptivity is 2564.1 L $mol^{-1}cm^{-1}$ and Sandell's sensitivity is 0.02484 µg cm^{-2} respectively. This method applied to determination of Ce(IV) synthetic and commercial samples[1]. Recover La and Ce from Indian red mud in sulfuric acid medium. The method includes acid leaching of red mud pulp and subsequent liquid–liquid extraction of the leached metals with different organic extractants, in order to establish the technical feasibility of extraction and separation simultaneously. Maximum recovery of La (99.9%) was recorded with 3 M H_2SO_4 at ambient (35 °C) temperature, S/L ratio of 10 g/L and agitation rate of 200 rpm in 1 h time. While 99.9% Ce recovery was achieved at 75 °C and solid/liquid ratio of 10 g/L in 3 M H_2SO_4. Significant specificity for complete extraction of La, Ce and Sc by Cyanex 301 was noted as compared to the solvents such as DEHPA and Cyanex 272[2]. A spectrophotometric method has been developed for the determination of Ce(IV) using Hydrazinecarboxymide2-[(2-hydroxyphenyl) methylene-1 as an extractive reagent. The reagent forms a light yellow colored complex which has been quantitatively extracted into n-butanol at pH 9.7. The method obeys Beer's law over a range of 1-10 ppm. The molar absorptivity is 4.9312×10^5 L $mol^{-1}cm^{-1}$ and Sandell's sensitivity is 0.02083 µg cm^{-2}. The propose method is very sensitive and selective. This method applied to synthetic and commercial samples[3].Extraction of Cd^{2+}, Ni^{2+}, Pb^{2+}, and Zn^{2+} from environmental waste using n-benzoyl-n-phenyl hydroxylamine (BPA). Study the effects of solvents, pH, stripping agents, extraction time, and interference of other ions on the recoveries. These metals can be quantitatively extracted between the pH 6.5-10. 1M HNO_3, 4M HNO_3, 1M HCl, and 5M HNO_3 can be used as stripping agents to achieve the maximum percentage recovery of Cd^{2+}, Ni^{2+}, Pb^{2+}, and Zn^{2+}, respectively [4]. Extraction of micro amount Coper (II) and Nickel(II)by organic reagent2-[(3-Acyl methyl phenyl)azo]-4,5-di phenyl imidazole(3-AMePADPI) and spectophotometric determination of Copper (II) and Nickel(II) used for in different samples, studies conditions for complex formation was pH= 8 and 11 , shaking time 15 minutes for Cu^{+2} and Ni^{+2} respectively[5].

Experimental

Apparatus

A biochrom double beam UV-Vis Spectrophotometer model (biochrom libra S60) (A Harvard Bio science company, Cambridge UK). Working at wave length 350-1100nm spectral bond width 2nm .Equipped with 10mm path length cell holder in sample and reference positions. pH measurement carried out by pH –meter , WTW CE ,E163694, (Germany), Melting point measured by Stuart Scientific COLTD,220-240(Britain). As well as for studied the structure of organic reagent prepared used FT-IR 8400 S(CE), Shimadzu corporation. Element analysis carried out by Micro analytical unit, 1108 C.H.N elemental analysis.

Reagents

Materials and Solutions

All chemical materials received from commercial sources with high purity and used as received stock solution of cerium (II)1 mg/mL was prepared by dissolved 0.309 g of $Ce(NO_3)_3.6H_2O$ in 9mL distilled water contain 1 mL of conc. HNO_3 and dilute to 100mL with distilled in a volumetric flask, 1×10^{-2}M (AMBN)in Chloroform prepared by dissolving 0.410 from (AMBN)in 100ml of $CHCl_3$, 8-Hydroxyquinoline(1%)prepared by dissolved 1gm in 100mL ethanol,1% phenolphthalein solution in ethanol this solution prepared by dissolve 1gm from phenolphthalein in 100mL ethanol by using volumetric flask, ammonia (1+1) [6].

Synthesis of organic reagent

The organic reagents was prepared according to the procedure published elsewhere [7] by dissolving (2.5g0.01mole) of 4-amino-N-(5-methylisoxazol-3-yl) benezensulfo- amide. in a solution of 4 mL concentrated HCl and 25 mL distilled water. After cooling this solution to 0 °C, 0.7 g of sodium nitrite dissolved in 10 mL distilled water was added with maintaining the temperature at 0°C. The mixture was set aside for 15 min to complete diazotization reaction. Thereafter, the diazonium solution was added drop by drop into a solution of (1.44 g, 0.01 mole) of 1-Naphthol and 1.2 g sodium hydroxide dissolved in 150 mL ethyl alcohol with keeping temperature at 0°C. After complete addition, the content was left for two hours, then 150 mL of cooled distilled water and control the pH of solution at 6 with HCl, a brown powder product was precipitated after left for 24 h. The brown precipitate was filtered off, washed with cold water, crystallized twice from hot absolute ethanol and dried over $CaCl_2$ to give yield of 79%, Mp (147-148˚C) and chemical formula of $C_{20}N_4O4H_{16}S$ with Mw. (408.4

g mol-1) .The azo reagent synthesized in this work were identified by UV – Vis. FTIR and C.H.N elemental analysis. This reagent does not dissolved in water, but it dissolves in organic solvent such ethanol, chloroform, Acetone, DMF etc.

The UV-Vis. spectrum and IR spectrum as well as the results obtained by C.H.N. study in **Figures 1,2** and **Table 1** demonstrate the structure of azo ligand prepared.

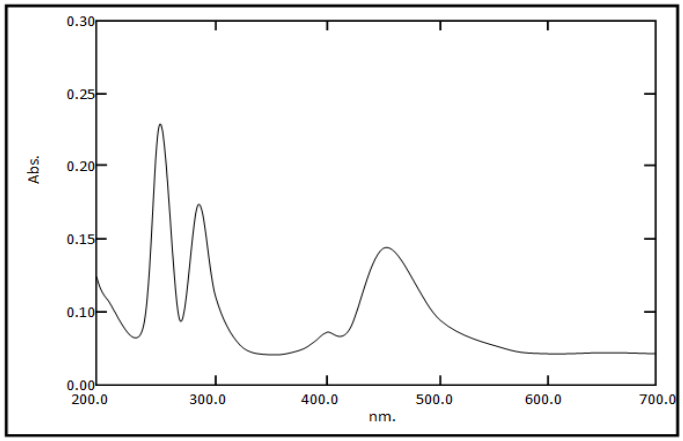


Fig. 1: UV-Vis. spectrum of organic reagent 4-[N-(5-methyl isoxazol-3yl) benzene sulfoamide azo]-1-naphthol

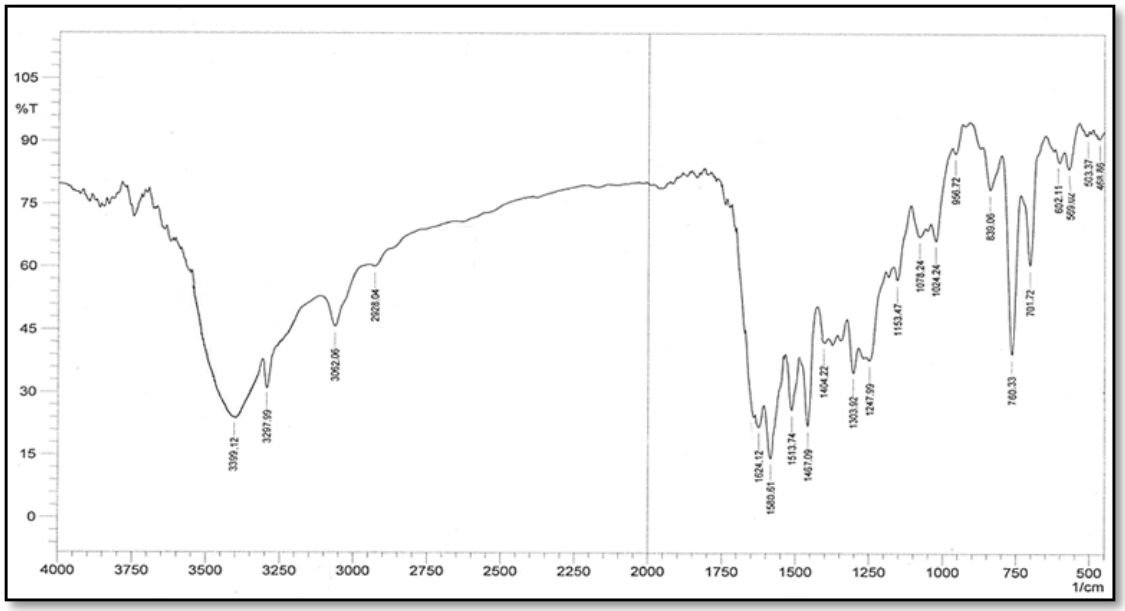


Fig. 2: IR-spectrum of organic reagent 4-[N-(5-methyl isoxazol-3yl) benzene sulfoamide azo]-1-naphthol

Table 1: Spectral data of the organic reagent[8,9]

a\ UV-Visible spectral peaks (nm).

peaks(nm)	***Assignments***
250	π-π* very small sensitive absorption.
285	π-π* middle sensitive absorption.
449	n-π* visible region high sensitive absorption.

b\ **I**R spectral bands (cm^{-1})

Bands (cm^{-1})	***Assignments***
3399.12-602.11	p e olic H stretching and bending
3062.06	aromatioc CH stretching
1624.12-1404.22	C=N stretching and bending
1467.09	for -N=N-
1303.92-1153.47	for, S=O
701.72	for rings of naphtol
1513.74	C=C stretching
3297.99	N-H stretching

c / C.H.N.S

Element	***Theoretical results***	***Experimental results***
% C	58.81	58.63
% H	3.95	3.91
% N	13.72	13.68
%S	7.85	7.75

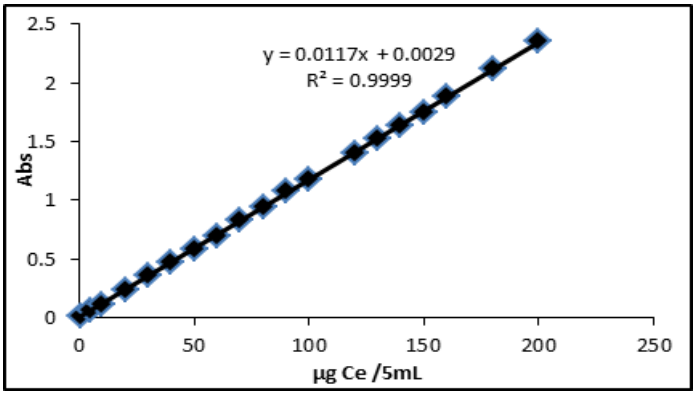


Fig. 3: Calibration curve of Ce^{3+} by 8-Hydroxyquinoline method**.**

General Procedure

For extraction experiments have to take (5 mL) of aqueous phase contain exact quantity of Ce^{+3} ions at optimum pH, and then adding (5 mL) of organic phase contain exact concentration of organic reagent dissolved in organic solvent, afterward shaken the two phases at optimum time, after complete shaking separate the two layers and determine the Ce^{+3} ions remainder in aqueous phase by spectrophotometric method [6] which involved for (5 mL) aqueous solution then add 1 mL of oxine solution,1 drop of 1% phenolphthalein solution in ethanol, and ammonia (1+1) until the solution is became rose coloured. Add 1 mL of ammonia (1+1) (the pH should be within 9.9-10.6) and transfer the solution to a separating funnel. Shake the solution with 2 portions of $CHC1_3$ (5 min shaking with each portion). Dilute the combined extracts with chloroform to 25 mL in a standard flask, as well as measure the absorbance of organic phase at λ_{max} against organic reagent as blank. The concentration of residual Ce^{+3} ions in aqueous phase was determined from regression line of calibration curve of Ce^{+3} in **Figure 3** as well as the concentration of the extracted Ce^{+3} determined by subtraction remainder quantity from origin quantity in aqueous solution .Of stripping method for determination transferred quantity of Ce^{3+} to organic phase include shaking organic phase with three portion of 5mL 1:1 concentrated HCl and determined the stripped Cerium (III) by 8-Hydroxyquinoline spectrophotometric method . the experiments show the transferred quantity of Ce^{3+} determined by Stripping equal to the same quantity determined by subtraction ,then used subtraction method to determine transfered quantity became easy and faster

Results and Discussion

Absorption UV–Vis spectrum

Absorption UV–Vis spectrum in **Figure 4** shows maximum absorption for ion pair complex extracted at λ_{max}= 507nm

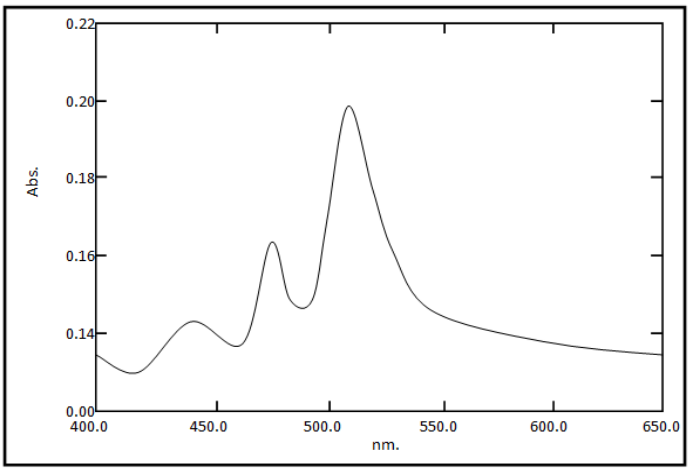


Fig. 4:absorption UV–Vis spectrum for ion pair complex

Effect of acidic function

Extracted 100µg Ce^{3+} ($1.5x10^{-4}$M) in 5mL aqueous phase with 5ml of (1×10^{-4}M) organic reagent solution (AMBN) dissolved in chloroform at different pH of aqueous phase (6-12) and shaking the two phases for (10 minutes) after that separate the two phases and determination of distribution ratio (D) as in the general method, as well as determine absorbance of organic phase against organic reagent as blank. The result as in **Figures 5, 6**.

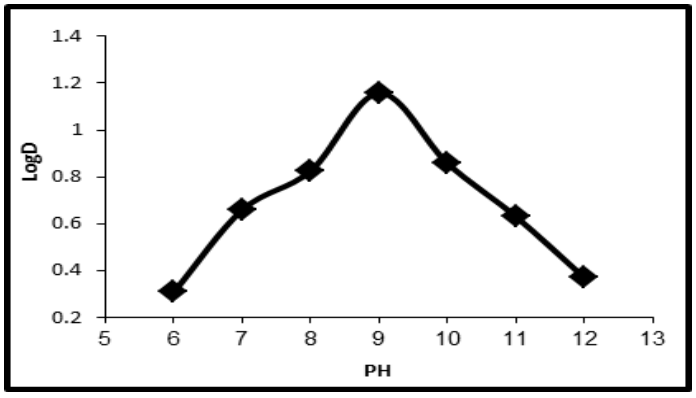


Fig. 5:D=f(pH)

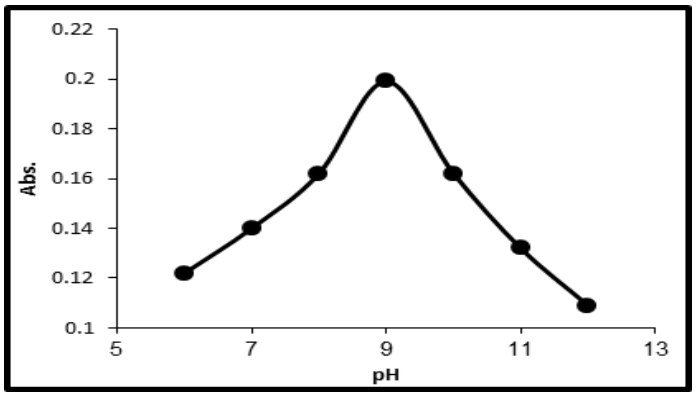


Fig. 6: Effect of pH on complex formation as extraction

The results shows optimum pH for extraction was pH=9 at the pH obtained higher Absorbance and D- value that is measure reached higher extraction .Efficiency at this pH and at pH less than pH=9 lour suitable to reach favorable thermodynamic equilibrium for extraction and by decrease pH value increase hydration shell of Ce3+ as well as increase protonated of complexing agent and decrease complexation, but at pH value more than optimum value also lead to decrease extraction efficiency

Effect of Metal ion concentration

Extraction of different concentrations of Ce^{3+} ions(1-130) µg in(5ml) aqueous solution at(pH=9) by(5ml) of ($1x10^{-4}$ M of AMBN) dissolved in chloroform , shaking the two layers for suitable time, and separate the two layers and determine the remainder quantity of Ce^{+3} ion in aqueous phase by followed spectrophotometric method [6], and calculation distribution ratio (D) as well as determine absorbance of organic phase at λ_{max}=507nm against organic reagent as blank.

The result was as in **Figures 7,8**.

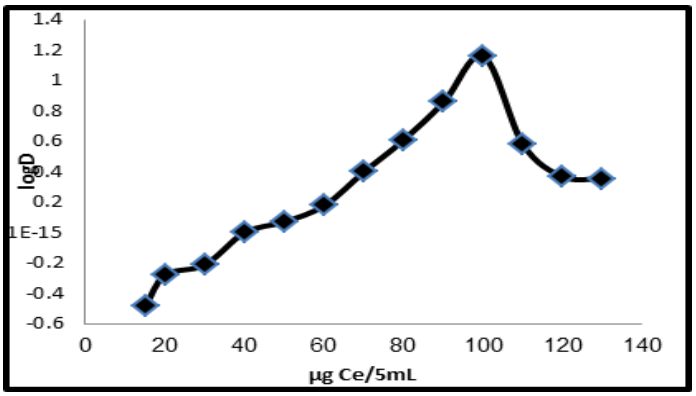


Fig. 7: Effect of Ce^{3+} concentration on activity of extraction and D value

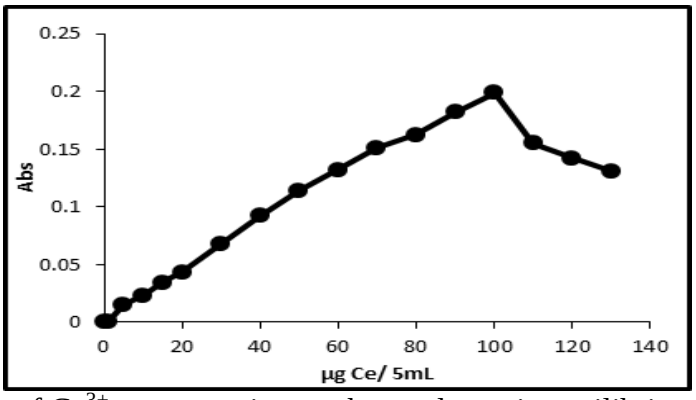


Fig. 8: Effect of Ce^{3+} concentration on thermodynamic equilibrium for complex formation and extraction

According to thermodynamic equilibrium for complexation reaction:

$Ce^{3+}{}_{aq} + (AMBN)_{org} + 2NO_3^-{}_{aq} \leftrightarrow [Ce(AMBN)]^{+2;}(NO_3^-)_{2\ org}$

The results show 100µg Ce^{3+}/5mL was the optimum concentration giving higher efficiency of extraction because effect to increase rate of forward direction of thermodynamic equilibrium that is mean increase formation and extraction of ion pair complex concentration of Ce^{3+} less than optimum value not enough to reach favorable thermodynamic equilibrium that is mean decrease in ion association complex formation and extraction so that Absorbance and D-value from other hand any concentration of Ce^{3+} more than optimum value effect to decline extraction efficiency and decrease absorbance and D-value because effect to increase rate of back ward direction of thermodynamic equilibrium according to the Le Chatelier principle and mass action law.

Effect of shaking time

For the kinetic side of the extraction methods are carried out by studying the effect of shaking time on the extraction activity and distribution ratio values. After extracted 100µg Ce^{+3} ions in 5ml aqueous phase at (pH=9) by 5ml of (1×10^{-4} M) organic reagent (AMBN) dissolved in chloroform by different shaking time, the results of this study in **Figure 9,10** demonstrate the optimum shaking time of two layers was (10min.) to reach the equilibria of extraction and at this time obtain the maximum distribution ratio value (D), and Absorbance at 507nm shaking time but less than optimum no allow to reached the equilibria of extraction, so that she shaking time more than optimum favorite the dissociation equilibria and minimize the distribution ratio(D)and absorbance.

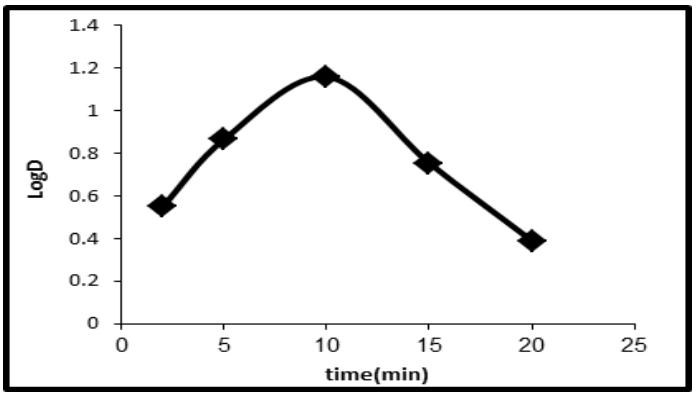


Fig. 9:D=f(shaking times)

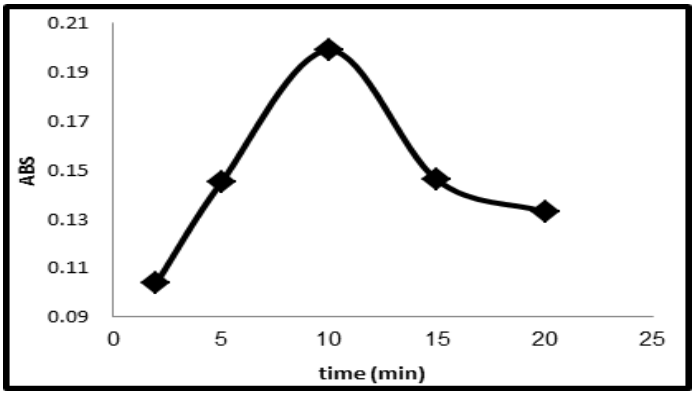


Fig. 10: shaking time effect on complex formation and extraction

Effect of organic solvent:

According to solvent extraction method which is depends on the organic solvent used in extraction method. Extracted 100µg Ce^{3+} ions from 5mL aqueous phase by 5mL (1×10^{-4} M) organic reagent (AMBN) dissolved in different organic solvent differ in dielectric constant after shaking the two phase for 10mintes ,so separate organic phase from aqueous phase determine D-value according to the procedure detailed in the general method the results was as in the **Table 2** .the results show there not any linear relation between Distribution ratio and Dielectric constant of organic solution ,that is mine there is not effect for polarity of organic solvent on extraction activity but there in un effect for organic solvent structure this result reflect participation organic solvent in complex formation .

Thermodynamic parameter for extraction in different organic solvent include transfere free energy ΔG_t and association constant k_A as well as extraction constant k_{ex} and free energy of extraction ΔG_{ex} by application relation s below

The results in **Table 2** showed free energy of transition ΔG_t for Ce^{3+} ions from aqueous phase to organic phase increase with dielectric constant of organic solvents decrease but k_{ex} and ΔG_{ex} showed the high value by using Chloroform organic solvent which demonstrate

sharing organic solvent and increase the stability of ion pair complex extracted and increase the approach between the cation and anion association complex extraction which is contact ion pair or loose ion pair.

Table 2: Organic solvent effect on the extraction of Ce^{3+}ions and ΔG_t , k_A , k_{ex} , ΔG_{ex}

Organic Solvents	*ε*	*Abs. at λ_{max}=507*	*D*	*%E*	*-ΔGt*	*$K_A x10^4$*	*$K_{ex} x10^8$*	*-ΔGex*
Nitro benzene	**35.74**	**0.164**	**4.88**	**83**	**0.025**	**4.1**	**17.026**	**53.24**
Amyl alcohol	**15.8**	**0.138**	**1.56**	**61**	**0.084**	**1.8**	**1.747**	**48.09**
1,2-Dichloro ethane	**10.65**	**0.171**	**5.99**	**85.7**	**0.135**	**4.9**	**19.71**	**53.57**
Dichloro methane	**9.08**	**0.144**	**1.63**	**62**	**0.163**	**1.85**	**1.901**	**48.28**
Chlorobenzene	**5.708**	**0.129**	**0.85**	**46**	**0.271**	**1.31**	**0.518**	**45.35**
Bromo benzene	**5.4**	**0.157**	**2.84**	**74**	**0.288**	**2.7**	**4.875**	**50.41**
Chloroform	**4.806**	**0.199**	**14.38**	**93.5**	**0.326**	**10.8**	**129.619**	**57.83**
Benzene	**2.804**	**0.16**	**3.54**	**78**	**0.574**	**3.2**	**7.362**	**51.34**
Toluene	**2.438**	**0.176**	**7.33**	**88**	**0.664**	**5.84**	**29.66**	**54.49**
Carbone tetrachloride	**2.38**	**0.183**	**7.69**	**88.5**	**0.680**	**6.1**	**35.37**	**54.89**

Stoichiometry

By using for spectrophotometric methods to know the more probable structure of complex extracted into layer which are slope analysis, mole ratio, continuous variation method, slope ratio. The results are as in **Figures 9–12**.

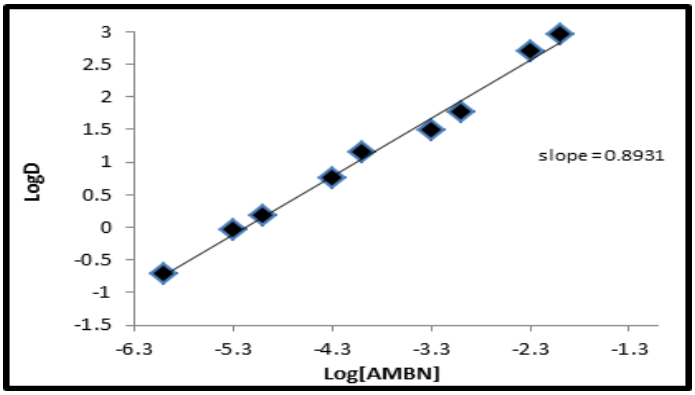


Fig. 9: Slope analysis method

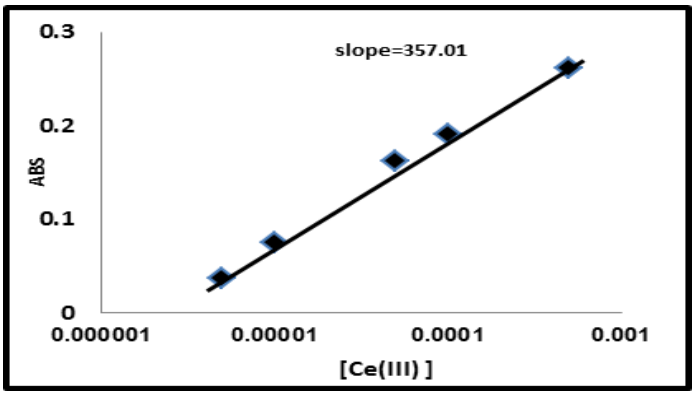


Fig. 10-a: Slope ratio method change organic reagent concentration

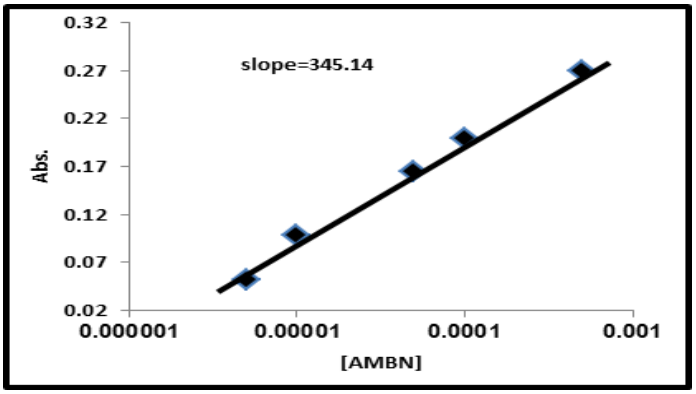


Fig. 10-b: Slope ratio method change metal ion concentration

$$\text{Slope ratio} = \frac{345.1}{357.01} = 0.966$$

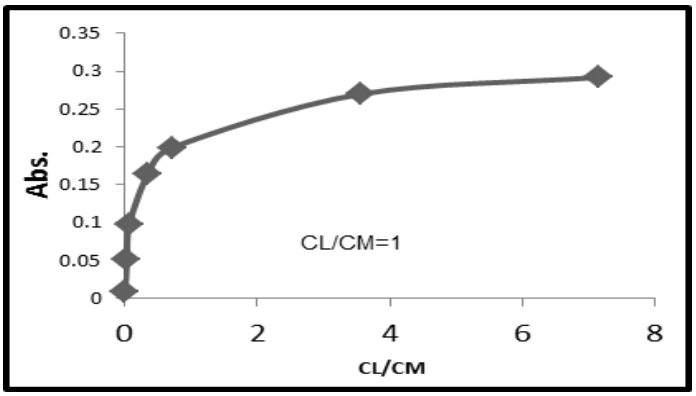


Fig. 11: Mole ratio Method

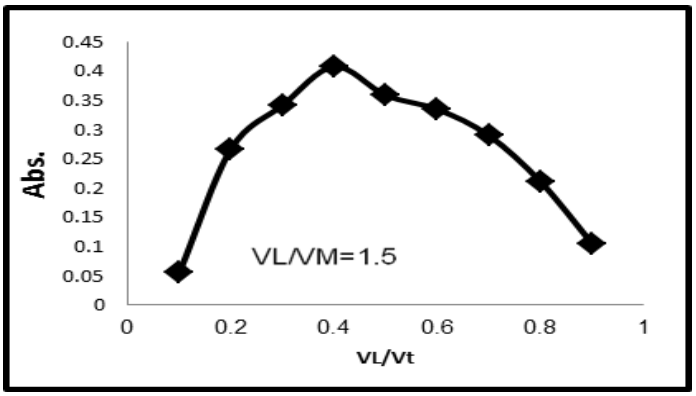
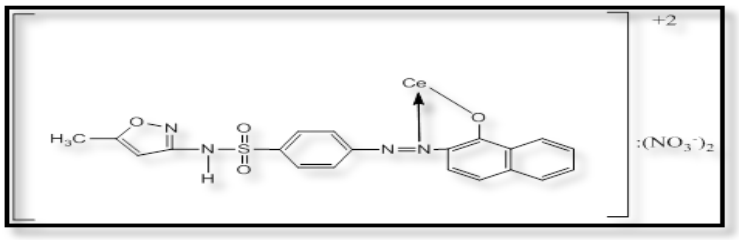


Fig. 12: Job Method

All these methods show the more probable structure of complex extracted was 1:1 Ce^{+3} : (AMBN)



Temperature Effect

Extraction of 100 µg Ce^{3+} ion from aqueous phase at (pH = 9) by 5mL of (1×10^{-4} M) (AMBN) dissolved in chloroform in different temperature after shaking the two layer for 10mintes and separate organic phase from the aqueous phase and calculate distribution ratio D at each temperature according to the procedure detailled in the general method .afterward determined extraction constant Kex by application the relation below

$$K_{ex} = \frac{D}{[Ce^{3+}]_{eq}[AMBN]_{org}}$$

The results was as in **Figures 13,14**.

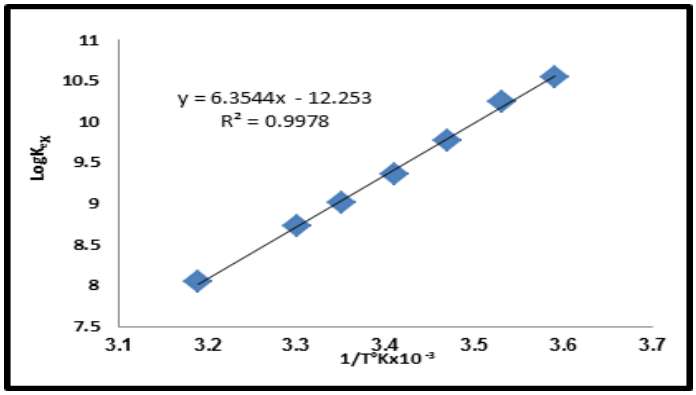


Fig. 13:K_{ex}=f(T K)

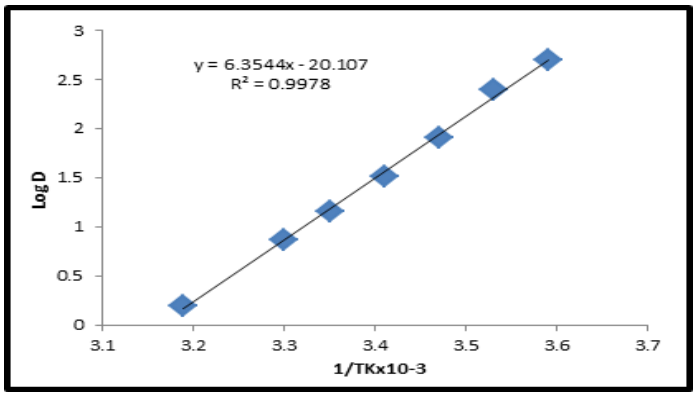


Fig. 14:D=F(TK)

The results show the complexation reaction and extraction thermodynamic was exothermic behavior the thermodynamic data of extraction Ce^{3+} ions was ΔH_{ex} = -0.122 kJ.mol^{-1}, ΔG_{ex} = -51.41 kJ.mol^{-1} and ΔS_{ex} = 172.103 Jk^{-1}.mol^{-1}

Synergism effect

Extracted (100µg)Ce^{+3} according to solvent extraction using of organic reagent (AMBN) at (pH =9) and in presence different concentration of tributyl phosphate (TBP) or Methyl isobutyl ketone (MIBK) by 5mL organic solution of (AMBN) dissolved in chloroform at (1x10^{-4}M) concentration after separation organic phase from aqueous phase determine the absorbance of organic phase ,as well as calculate distribution ratio D at each concentration of (TBP) or (MIBK),according to 8-Hydroxyquinoline spectrophotometric method[9] detailled in general method the results was as in **Figures 15,16**.

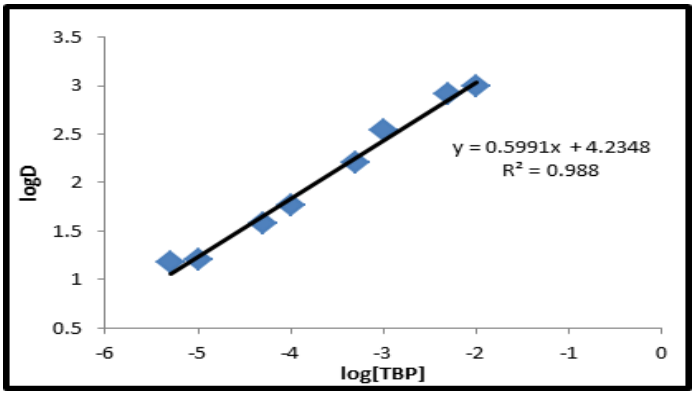


Fig. 15: synergism effect with TBP

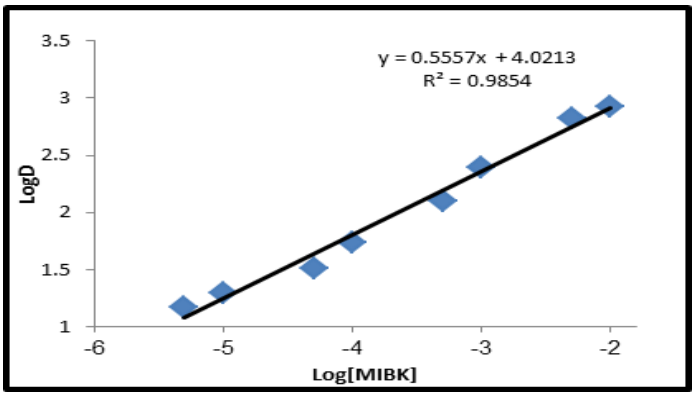


Fig. 16: synergism effect with MIBK

The results from the slope values demonstrate there is one molecule of TBP or MIBK participate in the complex structure extracted $[Ce^{3+}(AMBN^{-})(TBP)]^{2+};NO3^{-}$ or $[Ce^{3+}(AMBN^{-})(MIBK)]^{2+};NO3^{-}$ from other hand the participation of TBP or MIBK get enhancement in distribution ratio (D) which is replace molecule of water with TBP or MIBK coordinate to the coordination shell of metal ion to increase the partition of complex to the organic phase and increase distribution ratio (D).

Methanol effect

Extraction metal cations from 5ml aqueous solution by 5ml organic reagent solution at (1×10^{-4} M) dissolved in chloroform in presence different percentage of methanol and after separation organic phase from aqueous phase and determination distribution ratio(D),then plot log D and absorbance against methanol % get graphs in **Figures 17,18**.

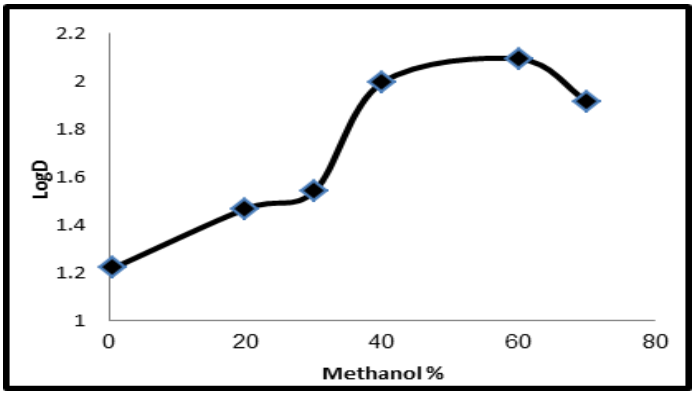


Fig. 17:D=f(CH3OH%)

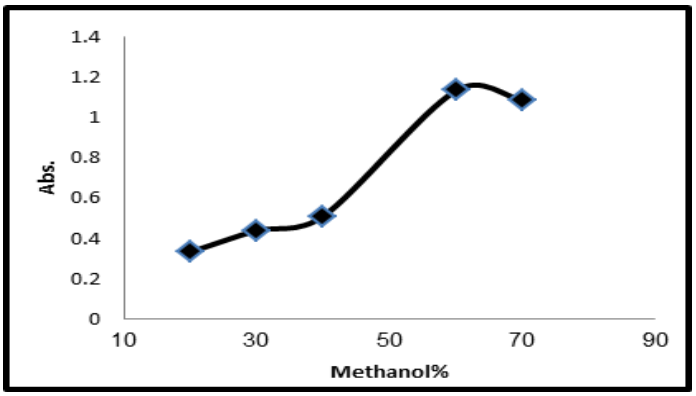


Fig. 18: Abs.=f(CH3OH%)

The result shows existence of methanol in aqueous phase effect to rising extraction efficiency by reason of destroyed hydration shell of Ce(III) ions and perform free and increase the chance of binding metal ion with organic reagent AMBN ,as well as the results show extraction efficiency increased with increasing percentage method until optimum percentage of methanol 60% but percentage methanol more than optimum effect to decline extraction efficiency because effect to more decrease polarity of water and in this case partitioning some of organic reagent AMBN to the aqueous phase at shaking and decrease complex formation and extraction.

Effect of electrolyte salts

Extraction Ce^{+3} ion from 5ml aqueous solution by 5mL of ($1x10^{-4}$M)AMBN dissolved in chloroform at optimum condition and in presence 0.1M some electrolyte according to general method previously detailed and determined Absorbance of organic phase and the distribution ratio D the results was as in **Table 3**.

Table 3: effect of electrolyte salts on extraction efficiency of Ce(III)

Electrolyte Salts	***Absorbance at λ=507 nm***	***D***
LiCl	*0.436*	*25.3*
NaCl	*0.385*	*24.6*
KCl	*0.321*	*21.2*
NH_4Cl	*0.203*	*18.2*
$MgCl_2$	*0.282*	*21.7*
$CaCl_2$	*0.276*	*19*
$SrCl_2$	*0.205*	*16.2*

The results show all electrolytes used giving enhancement in extraction efficiency , and this rising in extraction efficiency charge of a function for ionic diameter of electrolyte cation whereas smallest ionic diameter giving highest extraction efficiency because with drawing

more water molecules for it hydration shell and destroy the hidration shell of Ce(III) , then Li^{+} giving highest rising extraction and other having larger cation giving less rising extraction

Effect of interferences

Extracted Ce^{+3} at optimum condition at according to general method detailled in presence some cations interferences and determined Absorbance of organic phase and the distribution ratio D the results was as in **Table 4**.

Table 4: interference effect on extraction efficiency

Interferences	***Absorbance at λ=507nm***	***D***
$CuCl_2$	0.024	0.72
$CoCl_2$	0.041	0.78
$NiCl_2$	0.05	1.27
$HgCl_2$	0.067	1.94
$MnCl_2$	0.098	4.26
$AgNO_3$	0.037	4
$Pb(NO_3)_2$	0.034	0.75

The results show all cations giving interference with Ce(III) but in different iffinity with organic reagent AMBN this belongs to behaviour and nature metal cation as well as nead different optimum condition for complex formation

Spectrophotometric Determination

Solvent extraction as sensitive and selective method used for spectrophotometric determination of Ce^{3+} in different samples such as soil, vegetable, fruit etc. The samples digestion it have been using dry digestion method[10]. Prepared calibration curve at λ_{max}=507nm to the determination Ce^{3+} in different samples. Afterward prepared sample solution according to Solvent extraction method and after separation the two layers measured the absorbance of organic phase at λ_{max}=507nm against organic reagent solution as blank.

Detection limit	*0.000145 mol /L*	*RSD*	*0.007709 %*
Sandel's sensitivits	*0.0101385 mg cm^{-2}*	*$\mathcal{E}$*	*1382.022 L $mol^{-1}cm^{-1}$*

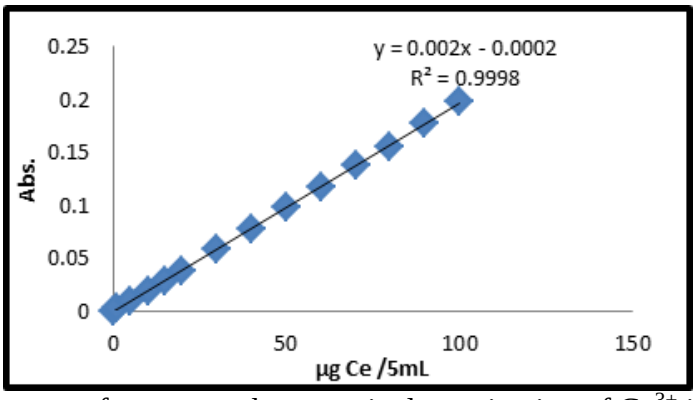


Fig. 19: Calibration curve for spectrophotometric determination of Ce^{3+} in different samples

The application

Table 5: Accumulated quantity of Ce(III) in different samples.

The samples	*ppmCe^{+3}*
Bones	*0.66*
Baby hair	*0.3*
Traffic cop hair	*0.375*
Cow meat(Beef)	*0.275*
White meat of Chicken	*0.2*
Fish *farms*	*0.291*
Radish	*0.4*
Onion	*0.120*
Orange(Egypt)	*0.200*
Pomegranate(Egypt)	*0.225*
Banana	*0.275*

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