Study the Factors Affecting Cadmium Ions Extraction from Aqueous Two-Phase System Using Potassium Iodide

دراسة العوامل المؤثرة على أستخلاص أيونات الكادميوم من أنظمة المحاليل المائية ثنائية الطور(بولي أثيلين كلايكول-كبريتات الصوديوم) بأستخدام يوديد البوتاسيوم كعامل أذابة

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Abstract

The extraction of Cd (II) was studied in an aqueous PEG-Na_2SO_4 two phase system, formed from a water soluble polymer (poly ethylene glycol) and inorganic salt (Na_2SO_4), in the presence of iodide ions (potassium iodide) as extractant . For the system consisting of mixture of 50 wt% PEG and 15 wt% Na_2SO_4 aqueous solution , % Cd removed was determined as a function of Initial concentrations of Cd (II) , Concentration of (KI) solvent , Phase ratio (PEG /Na_2SO_4) , and Molecular weight of the (PEG) polymer .

The experimental results measured by atomic absorption spectrometer model (PERKIN – ELMER 5000) and it shows that for a given aqueous two-phase system, the extraction behavior of Cd (II) is increased with increasing of the four variables above.

The optimum results for the extraction of Cd (II) determined for mixtures consisting of (0.5ml) of Initial Concentration of Cd(II), (0.28ml) of KI, phase ratio (PEG/Na_2SO_4) equal to 4 for the molecular weight of PEG (3000, 8000, 20000) g/g mole which reach's to (94, 95, and 97 %) respectively.

الخلاصة:-

درست عملية أستخلاص أيونات الكادميوم في أنظمة المحاليل المائية ثنائية الطور والمتكونة من بوليمر البولي أثيلين كلايكول المذاب في الماء المقطر وملح كبريتات الصوديوم غير العضوي بوجود أيونات اليود (يوديد البوتاسيوم) كعامل استخلاص .

النظام يتكون من خليط من محلول (50% بولي أثيلين كلايكول) و محلول (15%) كبريتات الصوديوم كنسب وزنية .أوجدت النسب المئوية لاستخلاص الكادميوم بدلالة تراكيز الكادميوم الابتدائية , تركيز يوديد البوتاسيوم الابتدائية , نسبة الطور(بولي أثيلين كلايكول / كبريتات الصوديوم) , والوزن الجزيئي للبوليمر المستخدم .

تم فحص النتائج باستخدام جهاز الامتصاص الذري وأظهرت النتائج العملية أن سلوكية أستخلاص أيونات الكادميوم تزداد بصورة أساسية بأزدياد التراكيز الابتدائية للكادميوم ، والتراكيز الابتدائية للمذيب(يوديد البوتاسيوم) ، ونسبة الطور بين البوليمر والملح و الوزن الجزيئي للبوليمر المستخدم .

أن أفضل النسب المئوية لاستخلاص أيونات الكادميوم كانت للخلائط المتكونة من (0.5) ملم تركيز أبتدائي للكادميوم , (0.28) ملم تركيز أبتدائي للمذيب (يوديد البوتاسيوم), (4) نسبة طور (بولي أثيلين كلايكول / كبريتات الصوديوم) و وزن جزيئي للبولي أثيلين كلايكول (20000,8000,3000) غرام / غرام مول ، حيث وصلت الى (97،95،94)% على التوالي.

1. Introduction

When Water – soluble Polymers and certain inorganic salts, or two dissimilar water soluble polymers are dissolved into water together, two phases can be formed. This is known as an aqueous two phase system (ATPS) or aqueous biphasic systems (ABS). [1]

As two – phase systems they are suitable for carrying out liquid-liquid separations of various solutes such as biomolecules, metal ions, and particulates. [2-6]

Liquid – liquid extraction is one of the most effective techniques for separation and enrichment of metal ions and is widely used not only for analytical applications but also for industrial ones. [7]

In recent years, ATPS have also been applied to separation or recovery of metal ions from aqueous solutions instead of conventional liquid- liquid extraction with organic solvents due to the limitation of usage of toxic, flammable, and volatile organic solvents.[8-11]

Poly ethylene glycols (PEGs) are exclusively used in combination with inorganic salts such as Na_2SO_4. PEGs are non toxic, non flammable, and non volatile, so that the PEG- based aqueous two-phase system can be regarded as environmentally friendly. [8, 12]

Some metal ions (Bi (III), Pb (II), Zn (II), Cu (II), Cd (II), can be extracted into PEG-rich phase using halide ions like iodide ions by an ion-pair extraction mechanism similar to the extraction of metal halide complexes with ethers or ketenes. [13-15]

The metal ions extraction in aqueous PEG-inorganic salt two- phase systems depend on:

- The formed aqueous two- phase system characteristics (determined by the type and molecular mass of PEG , type of inorganic salt and their concentrations , system PH , temperature , presence of neutral or charged inert species).
- The properties of metallic extracted species (hydration degree, charge, dimension, etc.) [12]

In this study the extraction behavior of Cd (II) in different concentrations of (PEG- Na_2SO_4) aqueous two- phase systems was investigated as a function of initial concentrations of Cd (II) added to the mixtures, using variable amounts of iodide ions as the extracting agents. The effect of molecular weight of PEGs on the efficiency of extraction of Cd (II) was also investigated.

2. Experimental:

2.1. Materials:

- 50 wt% of Poly Ethylene Glycol (PEG) was prepared by dissolving each of solid PEGs with molecular weight (3000, 8000, and 20000) in deionized water.
- 15 wt% of inorganic salt (Na_2SO_4) anhydrous was dissolved in deionized water.
- 4g/l of iodide ion solution was obtained by dissolving solid potassium iodide (KI) with deionized water.
- 2 g/l of cadmium ion stock solution was obtained by dissolving solid Cadmium Sulphate ($CdSO_4$) with deionized to get Cd (II) solution.

Material	Company	Purity
PEG	Aldrich (Milwaukee, WI , USA)	99 %
KI	Fisher Scientific Company , New Jersey ,USA	99 %
$CdSO_4$	Riedel_Dehuen, Germany	99 %
Na_2SO_4	Aldrich (Milwaukee, WI , USA)	99 %
H_2SO_4	Hazard , Gainland Chemical Company , UK	98 %

2.2. Procedure:

The Cd Extraction experiments were carried out as follows:

1. For each Sample an aqueous two – phase system was prepared by mixing (2ml) of a 50% (w/w) (PEG 3000) solution and (4ml) of 15% (w/w) Na_2SO_4 solution using stirred vessel.
2. (0.1-0.5ml) of Cd (II) Solution and (0.12ml) of KI solution were added to the mixture above.
3. In all experiments the temperature and PH of the solution were kept constant at 25^{o}C using thermo stated water bath and 2.5 by adding small amount of H_2SO_4 respectively. The mixing time was fixed to about (10) min using Stop watch. followed by (10) min. of centrifugation at (2000) rpm to get two immiscible phases which are shown in fig. (1).

4. Just before analysis, the two immiscible phases were carefully separated with Pasteur pipettes and placed into separated tubes.
5. Equal volumes (1ml) for each phase were measured for Cd (II) by means of atomic absorption spectrometer model (PERKIN – ELMER 5000).
6. The procedure above was repeated for the concentration ratio of (KI/Na_2SO_4) of (0.03, 0.05, and 0.07).
7. Phase ratio (PEG/ Na_2SO_4) with (1, 2, 3 and 4) was studied for the mixtures which had the best extraction percent of the cadmium ions acting from stage (6).
8. The molecular weight of the (PEG) polymer with (8000, and 20000) g/gmole was studied for the mixtures which had the best extraction percent of the cadmium ions acting from stage (7).
9. the percent removed (%) of Cd(II) was calculated by using the following equation :

$$\textbf{Percent Removed (\%)} = [(Cd_i - Cd_o)/Cd_i]*100$$

Where:
Cd_i = initial concentration of cadmium.
Cd_o = concentration of cadmium in PEG phase.

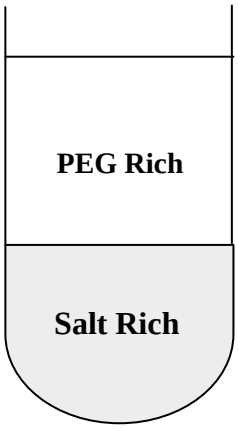

Figure (1): Schematic representation of the formation of aqueous two- phase system

3. Results and Discussion:

- **Effect of Initial Concentration of Cadmium on the Extraction of Cadmium Ions:**

Figure (2) shows the effect of the initial concentration of Cd(II) on the percent removed of Cd(II) , the other variables such as phase ratio (PEG/Na_2SO_4) of (0.5), KI solution of (0.12 ml) of (4g/l) , and PEG molecular weight of (3000) were kept constant.
The result shows that the percent removed of Cd(II) increaces with increasing the initial concentration of Cd(II) .
At the beginning, the extraction of Cd(II) is very low because Cd (II) remains predominantly in the salt- rich phase of the extraction system. increasing Cd (II) concentration in the mixture decreases the solute hydration because the size of metal molecules become larger which leads to chemical interaction between metal ions and the PEG molecules at the interface , so that the extraction of Cd(II) was increased gradually. Similar results were obtained by Laura Bulgariu, Dumitrue Bulgariu .[15]

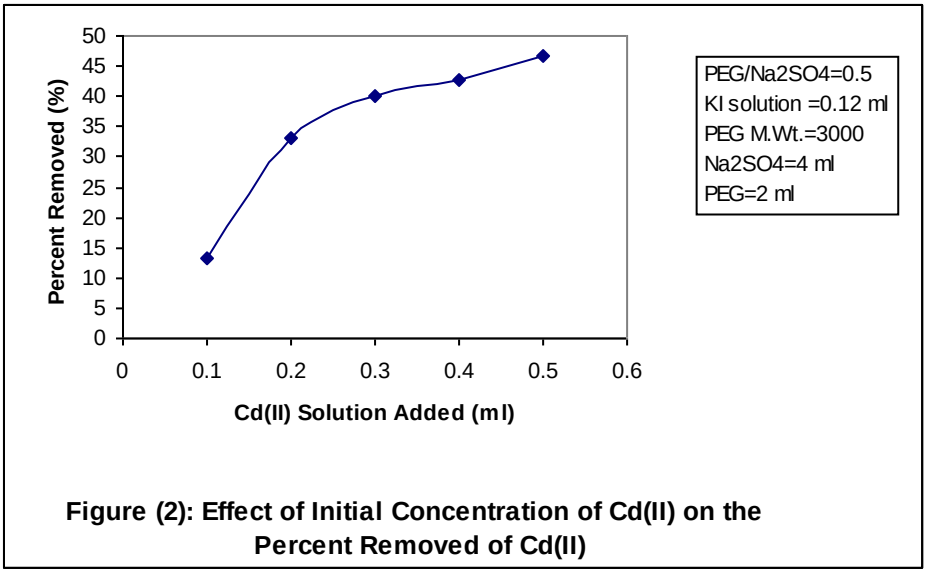

Figure (2): Effect of Initial Concentration of Cd(II) on the Percent Removed of Cd(II)

- **Effect of Solvent Concentration (KI) on the Extraction of Cadmium Ions:**

Figure (3) shows the effect of solvent concentration (KI) on the percent removed of Cd(II) , the other variables such as phase ratio (PEG/Na_2SO_4) of (0.5), initial concentration of Cd(II) of (0.5 ml), and PEG molecular weight of (3000) were kept constant.

The result shows that the percent removed of Cd(II) increaces with increasing the solvent concentration (KI).

Over all results behavior indicate that the extraction of Cd(II) is increases with the increasing of the concentration of the extracting agent in the prepared mixtures, this may be attributed to increase the stability of the cadmium halide species going from iodide ions, the low hydration of the extractant and the more polares able halide ions forms stronger complexes with Cd (II).

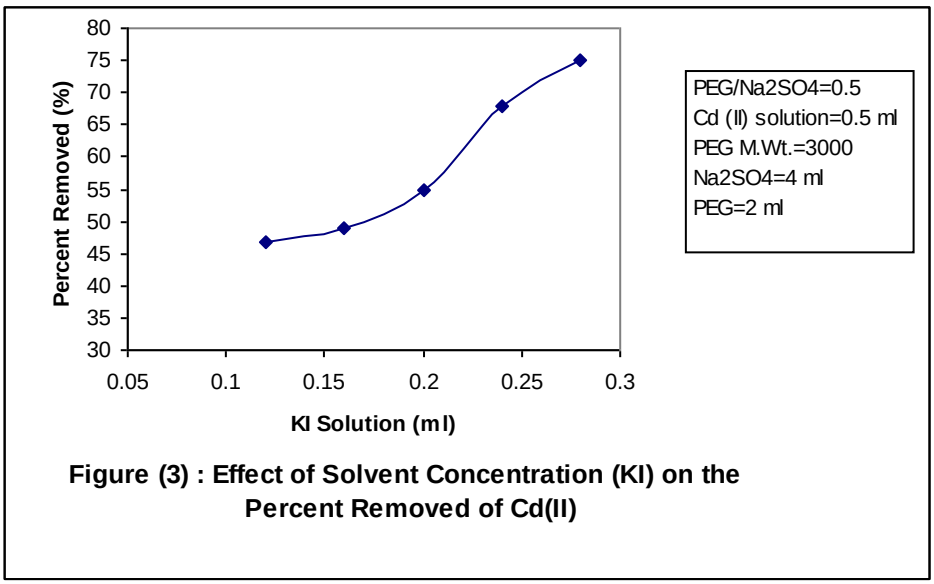

Figure (3) : Effect of Solvent Concentration (KI) on the Percent Removed of Cd(II)

- **Effect of Phase Ratio (PEG/Na_2SO_4) on the Extraction of Cadmium Ions:**

Figure (4) shows the effect of phase ratio (PEG/ Na_2SO_4)on the percent removed of Cd(II) , the other variables such as KI solution of (0.28 ml) initial concentration of Cd(II) of (0.5 ml), and PEG molecular weight of (3000) were kept constant.

The over all results above indicates that the extraction of Cd(II) is increases with increasing of PEG/Na_2SO_4 volumetric fraction. This may be attributed to increase the PEG rich phase hydrophobicity makes the number of extractant from extracted species to be higher. Thus an efficient extraction system can be prepared in which the difference in the concentration of PEG and the inorganic salt in the two formed phases are large. [24]

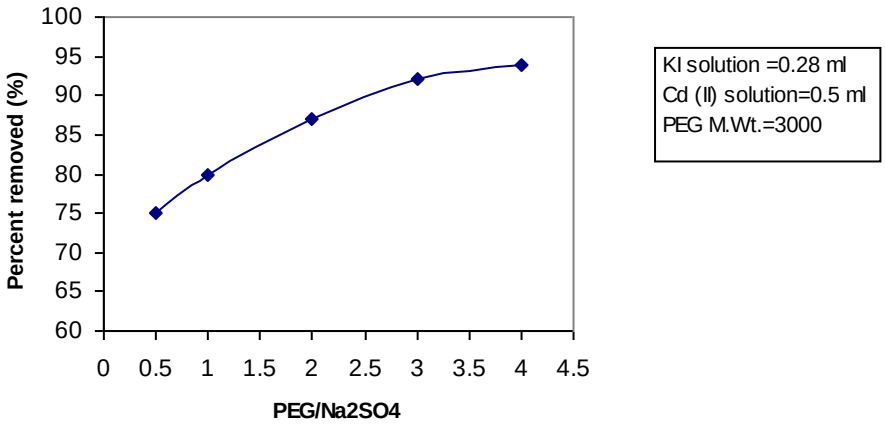

Figure (4) : Effect of Phase Ratio(PEG/Na2SO4) on the Percent Removed of Cd(II)

- **Effect of Molecular Weight of PEG on the Extraction of Cadmium Ions:**

Figure (5) shows the effect of the molecular weight of PEGon the percent removed of Cd(II) , the other variables such as KI solution of (0.28 ml) initial concentration of Cd(II) of (0.5 ml) were kept constant.

Results above the extraction of Cd(II) are increase with increasing of molecular weight of polymer due to increasing the size of molecules of PEG which causes decreasing the hydration of the system. The results value was very narrow range because percent removed of Cd (II) had good values in changing the PEG/Na_2SO_4 phase ratio.

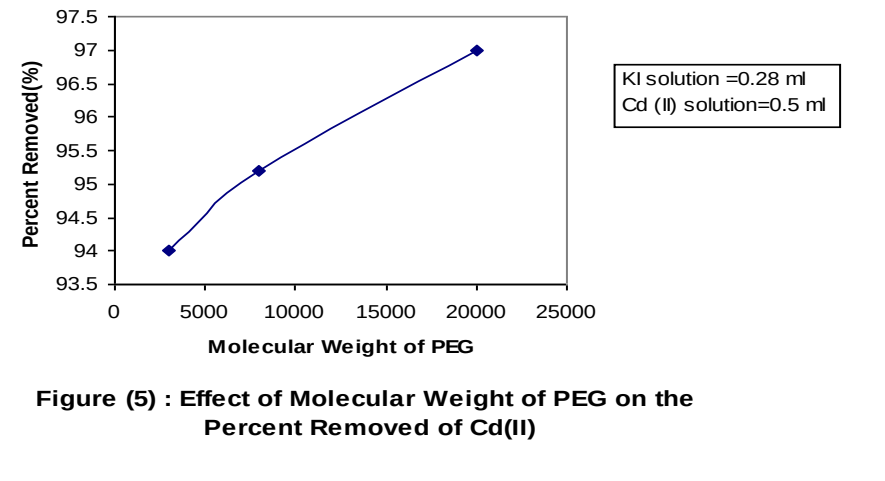

Figure (5) : Effect of Molecular Weight of PEG on the Percent Removed of Cd(II)

Conclusions:

- The extraction of Cd (II) ions was increased with the increasing of initial concentration of Cd (II), concentration of (KI) solvent, phase ratio (PEG /Na_2SO_4), and the molecular weight of the (PEG) polymer.
- Efficient extraction reached to (94) % was obtained in the mixture had the experimental conditions of (0.5ml) of Cd solution, (0.28ml) of KI solution, and (PEG_{3000}/Na_2SO_4) equal to (4) volumetric fraction.

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