

## Cadmium (II) Separation and Quantification in Wastewater Using A System Using Ionic Liquid Flotation and Bisolvent of Ester

\*Dr. Beena Agarwal

### Abstract

In this research, a bisolvent system made of an ester and an ionic liquid flotation system is used to separate and quantify cadmium (II) in wastewater. Due to its toxicity and tendency for bioaccumulation, cadmium pollution of wastewater is a serious environmental issue. Therefore, effective and trustworthy techniques for its measurement and eradication are crucial. The suggested approach increases the flotation efficiency and selectivity for cadmium (II) ions by combining the usage of a bisolvent system made up of an ester and an ionic liquid.

According to previously reported studies,  $\text{Cd}^{2+}$  could interact with KI to generate  $\text{CdI}_4^{2-}$  and when that compound was combined with rhodamine B, it resulted in  $(\text{RhB})_2(\text{CdI}_4)$ . To ascertain association, a ternary bisolvent comprising It used an ester and ionic liquid flotation technique. The ideal concentrations of rhodamine B, acetic acid and potassium iodide were 4, 8, and 20 mL, respectively, in the ionic liquid [Bmim]  $\text{BF}_4$ . The best removal efficiency was 95.68% during a 15-minute flotation time with an Air was supplied at a flow rate of 30 mL/min and a 38% mass fraction of  $(\text{NH}_4)_2\text{SO}_4$  solution. The results of the experiments showed that ionic liquids performed better than conventional organic solvents.

### Introduction

One of the main sources of cadmium emissions into the environment are cadmium-nickel batteries, the metal plating, pigment, stabilizer, phosphate fertilizers, and alloy industries. Cadmium is a poisonous element that is present in nature and is regarded as a contaminant coming from industrial and agricultural sources. Human population exposure to cadmium via food, water, and air may have an impact on reproductive, immunological, and cardiovascular systems as well as organs such the kidney, liver, and lungs. One of the persistently difficult endeavors in the field of analytical chemistry involves the ongoing efforts to detect the presence of trace amounts of cadmium in water, which calls for very sensitive and precise analytical techniques. For the pre-concentration of trace elements in water samples, several techniques based on solvent extraction, ion exchange, membrane filtration, cloud point extraction, co-precipitation, and solid phase extraction have been developed.

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The organic solvent flotation system (OSFS) provides several advantages compared to the methods mentioned previously. These advantages include high efficiency (with a recovery rate above 95%), rapidity, significant enrichment factor, lower detection limits, a straightforward and convenient process, and the ability to remove and recover both organic and inorganic substances. Nonetheless, there is a concern regarding the potential contamination of the environment's water supply due to the use of organic solvents. This concern has been addressed by introducing ionic liquids, which are environmentally friendly and sustainable solvents that can replace organic solvents. The ionic liquid-flotation system (ILFS) not only encompasses the advantages of the OSFS but also introduces supplementary benefits. These include improved efficiency, heightened stability, environmental protection, zero pollution, superior separation properties, and a larger enrichment factor. By employing the ILFS, these advantages are incorporated into the flotation process, providing enhanced performance and a more sustainable approach to separation and recovery. To deal with the challenge of separating and characterizing cadmium in wastewater, the ILFS has been specifically designed and implemented in this study.

Room temperature ionic liquids (RTILs) are a class of novel organic salts that are liquid at room temperature and include organic cations and different anions. Ionic liquids can in up to 1018 different varieties, according to published research. In recent years, room-temperature ionic liquids have emerged as viable alternatives to traditional solvents in the field of material separation. These ionic liquids possess distinctive qualities that make them highly suitable for this purpose. Notably, they have low vapour pressure, ensuring minimal evaporation and reducing the risk of inhalation or environmental release. Their excellent stability in water allows for effective utilization even in aqueous environments. Additionally, they exhibit favourable viscosity and density characteristics, enabling efficient mixing and separation processes. The thermal stability of room-temperature ionic liquids ensures their robust performance under various temperature conditions. Moreover, their non-volatility eliminates concerns associated with hazardous emissions. Lastly, these ionic liquids demonstrate selective solubility, making them capable of targeting specific materials for separation. Together, these unique qualities contribute to the increasing adoption of room-temperature ionic liquids as versatile and environmentally friendly solvents in material separation applications.

High efficiency ( $R > 95\%$ ), speed, and the ability to remove and recover both organic and inorganic species are some of flotation's key features as a separation technique. The separation of heavy metals is a problem that is crucial for the 21<sup>st</sup> century, according to many researches. The objective of this work was to extract cadmium (II) from wastewater utilizing a solvent flotation technique based on ionic liquids (ILSF). In this flotation process, instead of the traditional hydrophilic organic solvents, ionic liquids were employed.

The ideal circumstances were also identified based on the experiment's maximum flotation removal of ionic cadmium and the shape of the ternary ionic associate. Research and optimization were done on the impacts of the experimental factors. The technique may be used to measure  $\text{Cd}^{2+}$  in natural water and has a good level of sensitivity and selectivity.

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### Methodology

The Cd<sup>2+</sup> content at 572 nm was measured using an ultraviolet visible spectrophotometer (UV-2550). A Shengci pH-25 meter was used to test the pH of the solution. Flotation was done using a homemade flotation apparatus that contained a 50 cm tall by 3 cm wide plexy glass column. The bottom of the column had a stone filter (10–15 cm, porosity of 4) for generating tiny air bubbles. Less than 1.1 atm of pressure, air bubbles were produced using a nitrogen cylinder, and the gas flow rate was also controlled with a rotary flowmeter (LZB/LZY).

Unless specified otherwise, all the chemical reagents utilized in this investigation were of analytical quality. Standard stock solutions of (1.0 x 10<sup>-4</sup> mol/L) were made by dissolving 0.1834 g of CdCl<sub>2</sub>, 0.1659 g of KI, and 0.4790 g of rhodamine B in 100 mL of distilled water, respectively. 5.72 mL of AcOH were dissolved in 100 mL of distilled water to create a stock of AcOH solution with a concentration of 0.1 mol/L. The ternary ionic association (RhB)<sub>2</sub>(CdI<sub>4</sub>) is formed using these common aqueous solutions. To regulate the iron strength, 152 g of solid (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> was dissolved in 248 mL of distilled water to provide a solution with a 38% mass fraction. The flotation process successfully recovered the ternary ionic associate by employing the ionic liquid [Bmim] BF<sub>4</sub>.

In every test, a 5 mL solution containing Cd<sup>2+</sup> ions at a specified concentration of 1.0 x 10<sup>-4</sup> mol/L was prepared. Subsequently, 50 mL of distilled water was sequentially added to the solution along with KI, rhodamine B (RhB), and AcOH stock solution. To ensure thorough mixing and complete reaction, the solution was agitated for approximately 20 minutes. Then, the solution was transferred to the flotation column, where it was subjected to a 38% mass fraction (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> solution. To facilitate the extraction of the ternary ionic associate, a combined solution consisting of ionic liquid and acetic ether (in a 1:1 ratio) was utilized due to the higher density of the ionic liquid compared to water. Once the solution was added to the column and the gas flow rate was maintained, the generation of bubbles ensued. Subsequently, the absorbance of the solvent phase was measured at 572 nm.

### RESULTS AND DISCUSSION

**Absorption Curve: Illustrating light absorption:** In addition to investigating the absorption curve of the ternary ionic associate solution, the absorption curve was also examined, the absorption curves of rhodamine B (at a specified concentration of 1.0 x 10<sup>-4</sup> mol/L), a blank reagent, and the ionic liquid were also measured. Rhodamine B's highest absorption wavelength was at 554 nm, whereas that of its ternary ionic companion was at 572 nm, as seen in Fig. 1. Since the wave crest clearly has a red shift, determination in this study was done at 572 nm.

**Effects of acetic acid:** The impact of AcOH on the formation of the ternary associate is seen in Fig. 2. As can be observed, the absorbency rose steadily from 1 to 8 mL as the quantity of AcOH increased. At 8 mL of AcOH, the maximum absorbency was recorded. The absorbency remained constant up to 12 mL. As the quantity of AcOH rises beyond 12 mL, there are negligible reductions in absorbency, as seen in Fig. 2. So, 8 mL was chosen as the recommended quantity of AcOH

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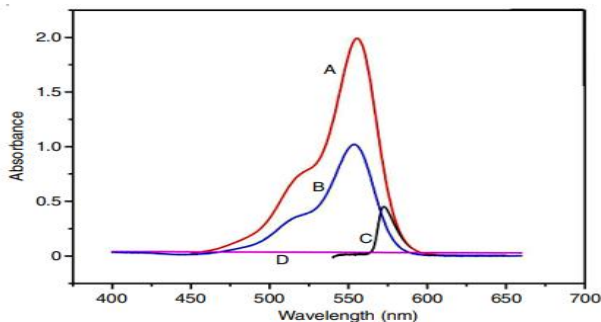


Fig. no. 1 Curve of absorption

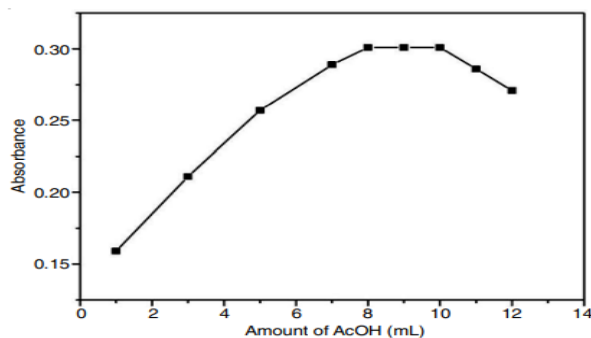


Fig. no. 2 Effects of acetic acid

**Effects of KI:** On forming the ternary association, the impact of KI standard solution was examined. The absorbency increased from 10 mL to 20 mL with an increase in KI. At 20 mL, the absorbency reached its peak.

After that, the absorbency started to stay the same as the KI concentration increased after 20 mL. Therefore, 20 mL was determined to be the ideal quantity of KI.

**Effects of rhodamine B:** Rhodamine B's contribution to the formation of the ternary association is seen in Fig. 3. Rhodamine B absorbency increased steadily from 1 to 4 mL with increasing rhodamine B concentration. The maximum absorption was observed at a rhodamine B dosage of 4 mL, indicating that this particular dosage was selected as the optimal choice.

**Effect of reaction time:** The study focused on investigating the effect of response time, and it was found that increasing the response time up to 20 minutes led to a noticeable impact, the absorbency increased steadily and remained stable. It seems that ternary associate completely formed over a

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specific quantity of time. This has to do with the chemical kinetics of reaction rate. As a consequence, 20 minutes was designated as the ternary ionic associate's optimal response time.

**Effects of flotation time:** The greatest amount of absorption was noted after 15 minutes of floating. As flotation duration increases beyond the first 15 minutes, the absorbency of cadmium remains consistent. The recommended flotation period was 15 minutes.

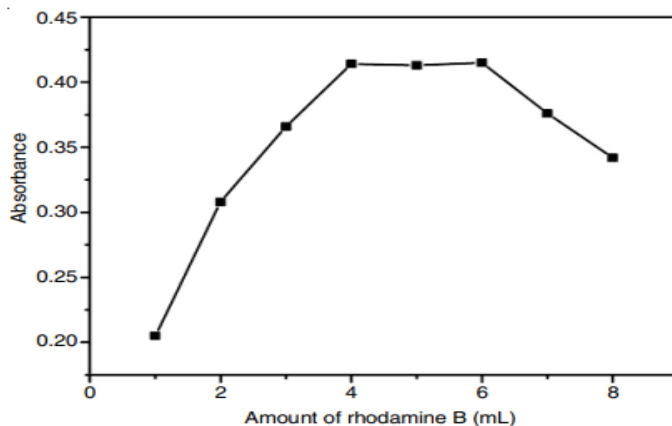


Fig. no. 3 - Effects of rhodamine B

**Standard flotation curve:** To determine the ideal flotation conditions, the quantity of  $\text{Cd}^{2+}$  was adjusted from 1 to 7 mL. As depicted in Figure 4, a linear regression trend was observed consistently across the range of 1 to 7 mL. The equation for the linear regression was found to be  $y = 0.04693x + 0.30629$ , with an  $R^2$  value of 0.99407.

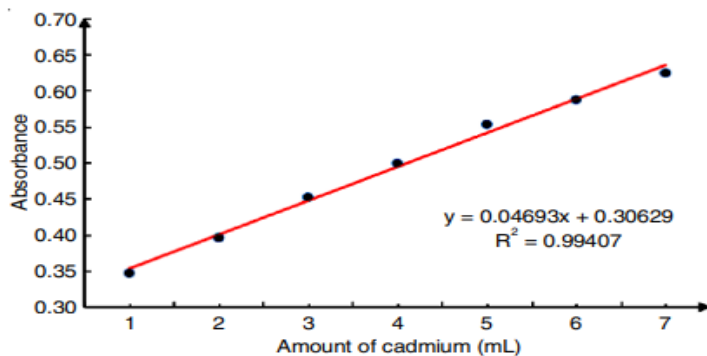


Fig. No. 4 - Standard flotation curve

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**Cadmium (II) concentration assessment in wastewater sample:** To identify the presence of Cd (II) ions, a sample of wastewater was collected from the agricultural area in close proximity. The obtained results were then compared to those obtained from a conventional experiment conducted on the sample. The findings are presented in Table 1.

**Table 1 - Analysis Results for Cadmium (II) in Environmental Water Sample (n = 5)**

Sample	Mean Value ( $\mu\text{g/L}$ ) (n = x)	RSD (%) (n = 5)	Added ( $\text{mg/L}$ )	Total ( $\text{mg/L}$ )	Recovery (%)
1.	81.5	2.77	50.0	124.1	96.4
2.	64.7	3.2	50.0	119.7	103.3
3.	98.2	2.3	50.0	143.1	92.9

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**References:**

1. F. Fu and Q. Wang, J. Environ. Manage, 92, 407 (2011); <https://doi.org/10.1016/j.jenvman.2010.11.011>.
2. S.P. Liu, Z.F. Liu and H.Q. Luo, Anal. Chim. Acta, 407, 255 (2000); [https://doi.org/10.1016/S0003-2670\(99\)00816-8](https://doi.org/10.1016/S0003-2670(99)00816-8).
3. L. Järup and A. Åkesson, Toxicol. Appl. Pharmacol., 238, 201 (2009); <https://doi.org/10.1016/j.taap.2009.04.020>.
4. M.H. Salmani, M. Davoodi, M.H. Ehrampoush, M.T. Ghaneian and M.H. Fallahzadah, Iran. J. Environ. Health Sci. Eng., 10, 16 (2013); <https://doi.org/10.1186/1735-2746-10-16>.
5. Q. Cheng and H. Dong, Mikrochim. Acta, 150, 59 (2005); (2005); <https://doi.org/10.1007/s00604-005-0333-8>
6. M.K. Jha, V. Kumar, J. Jeong and J. Lee, Hydrometallurgy, 111-112, 1 (2012); <https://doi.org/10.1016/j.hydromet.2011.09.001>.
7. C.W. Wong, J.P. Barford, G. Chen and G. McKay, J. Environ. Chem. Eng., 2, 698 (2014); <https://doi.org/10.1016/j.jece.2013.11.010>

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8. M. Aliabadi, M. Irani, J. Ismaeili, H. Piri and M.J. Parnian, Chem. Eng. J., 220, 237 (2013); <https://doi.org/10.1016/j.cej.2013.01.021>
9. M. Ghaedi, A. Shokrollahi, K. Niknam, E. Niknam, A. Najibi and M. Soylak, J. Hazard. Mater., 168, 1022 (2009); <https://doi.org/10.1016/j.jhazmat.2009.02.130>
10. E.L. Silva, P.S. Roldan and M.F. Giné, J. Hazard. Mater, 171, 1133 (2009); <https://doi.org/10.1016/j.jhazmat.2009.06.127>.
11. E.L. Silva and P.S. Roldan, J. Hazard. Mater, 161, 142 (2009); <https://doi.org/10.1016/j.jhazmat.2008.03.100>.
12. T. Oymak, S. Tokalioglu, V. Yilmaz, Z. Kartal and D. Aydin, Food Chem., 113, 1314 (2009); <https://doi.org/10.1016/j.foodchem.2008.08.064>.

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