

Study on Flotation Separation of Mercury (II) by sodium chloride-potassium iodide-octadecyl trimethyl ammonium chloride system

Xinrong Wen^{1,a} and Changqing Tu^{1,b}

¹College of Chemistry and Environment, Jiaying University, Meizhou, Guangdong 514015, China

^awxrong5093@hotmail.com, ^btcq@jyu.edu.cn

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Abstract: The flotation separation behaviours of mercury (II) by sodium chloride-potassium iodide-octadecyl trimethyl ammonium chloride system were studied. The effects of different parameters, such as the dosages of KI and octadecyl trimethyl ammonium chloride (OTMAC), various salts and acidity etc. on the flotation yield of Hg^{2+} have been investigated. The results showed that by controlling pH 3.0, in the presence of 0.5 g NaCl, when 0.10 mol/L KI was 0.20 mL and 0.0050 mol/L OTMAC solution was 0.50 mL respectively, the formed water-insoluble ternary association complex of $(\text{OTMAC})_2(\text{HgI}_4)$ floated above water phase and liquid-solid phases were formed with clear interface, Hg^{2+} was floated quantitatively. While Zn^{2+} , Fe^{3+} , Ni^{2+} , Mn^{2+} , Co^{2+} and Cu^{2+} could not be floated in this condition. Therefore, the quantitative separation of Hg^{2+} from these metal ions could be achieved without any masking agent. A new method of flotation separation of trace mercury was established. The proposed method has been successfully applied to the flotation separation of Hg^{2+} in the sample of synthetic water and the flotation yield was 95.5%~96.5%.

Introduction

Mercury is a kind of heavy metal with strong toxicity to humans, animals and the environment, and it is one of the main inorganic elements causing environmental pollution. The content of mercury in environment is an important factor in environmental monitoring. Since the content of Hg^{2+} in environment is usually very low, separation and enrichment must be carried out before measurement. There are many other methods to separate and enrich $\text{Hg}(\text{II})$, such as extraction separation^[1-2], column-chromatographic separation^[3], solid phase extraction separation^[4], chromatographic separation^[5], micellar high-performance liquid chromatography^[6]. But all the aforesaid methods have used an organic solvent as extractant or need complicated instrumentation. Salt-ternary association complex-water system not only has the advantages of liquid-solid extraction system without organic solvent^[7-8], but also has characteristics such as rapid split-phase rate and clear interface between phases and less reagent. There have been some reports about flotation separation of metal ions by salt-ternary association complex-water system^[9-11].

In this paper we have studied the flotation separation of mercury(II) by sodium chloride-potassium iodide-octadecyl trimethyl ammonium chloride system. The results showed that in the presence of 0.5 g NaCl, water-insoluble ternary association complex of $(\text{OTMAC})_2(\text{HgI}_4)$ was produced by Hg^{2+} , I^- and OTMAC cation (OTMAC^+), which floated above the salt-water phase and liquid-solid phase was formed with clear interface. During the formation of the two phases, Hg^{2+} was floated quantitatively, while Zn^{2+} , Fe^{3+} , Ni^{2+} , Mn^{2+} , Co^{2+} and Cu^{2+} not be floated. Therefore, Hg^{2+}

could be separated successfully from those metal ions without any masking agent by flotation at pH 3.0. A method of flotation separation of mercury(II) was established, and it has been used for the flotation separation of mercury (II) in the sample of synthetic water with satisfactory results. Compared this system with the organic solvent extraction flotation method and the fourth flotation method^[12-13], harmful organic solvent and complicated instrumentations were avoided in this method.

Experiment

Instruments and Reagents

A Model 723S spectrophotometer (Shanghai No.3 Analysis Equipment Plant) was used for photometric measurements.

KI solution: 0.10 mol/L. Borax solution: 0.10 mol/L. Triton X-100 solution: 10%. Octadecyl trimethyl ammonium chloride (OTMAC) solution: 0.0050 mol/L. 1.0×10^{-3} mol/L of 2-(5-bromo-2-pyridylazo)-5-diethylaminophenol (5-Br-PADAP) ethanol solution was prepared by dissolving 0.1746 g of 5-Br-PADAP in 500 mL of ethanol. The metal ion standard solutions were prepared according to reference [14a], and buffer solutions of different pH were prepared as references [14b].

All reagents were of analytically purity grade and distilled water was used.

Methods

50 μg of Hg^{2+} , a given amount of 0.10 mol/L KI solution and 0.0050 mol/L OTMAC solution were added into a 25 mL ground color comparison tube. Then adjust the pH with buffer solutions and dilute the mixture to 10.0 mL with water. 0.5 g NaCl was added and shaken adequately and they were kept still for a moment. 1.00 mL salt-water sample in the lower layer was transferred into another 25 mL ground color comparison tube, and 1.5 mL of 0.001 mol/L 5-Br-PADAP ethanol solution and 3.0 mL of 0.1 mol/L borax solution and 0.5 mL of 10% Triton X-100 were added. The content of Hg^{2+} was determined at 565 nm with reagent as blank after color appearance and dilution to the mark. The precipitation by filtration was also dissolved in ethanol, and the content of Hg^{2+} was determined in the same method. The flotation yield E was calculated according to the determination results. Photometric analysis of other metal ions was referring the reference^[15].

Results and Discussions

Effect of KI dosage on the flotation yield of Hg^{2+}

The effect of KI dosage on the flotation yield of Hg^{2+} was investigated. It was found that the flotation yield of Hg^{2+} increased with the increase of KI dosage. When the dosage of KI was 0.20 mL or more, Hg^{2+} could be completely floated. Hence, 0.20 mL of 0.10 mol/L KI solution was chosen in the following experiments.

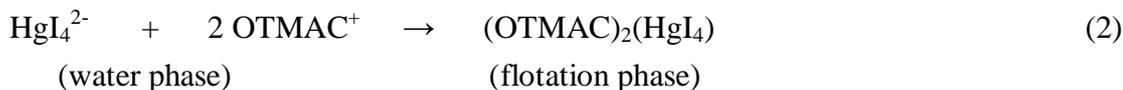
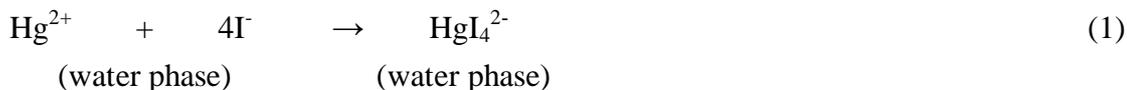
Effect of OTMAC dosage on the flotation yield of Hg^{2+}

The effect of OTMAC dosage on the flotation yield of Hg^{2+} was studied. It could be seen that with the increase of OTMAC dosage, the flotation yield of Hg^{2+} increased. When the dosage of OTMAC was up to 0.40 mL, the flotation yield of Hg^{2+} was 100%. Superfluous OTMAC would not affect the flotation yield of Hg^{2+} . Hence, 0.50 mL of 0.0050 mol/L OTMAC solution was chosen for all further studies.

Flotation mechanism

Based on the results above, only in the simultaneous presence of OTMAC and KI, can Hg^{2+} react with them to form water-insoluble matter and be floated. Therefore it is deduced that the

water-insoluble matter is the precipitation of ternary association complex formed by Hg^{2+} and I^- , OTMAC⁺, and the flotation mechanism of Hg^{2+} was presumed:



Effect of different salts on the flotation yield of Hg^{2+}

The effect of different salts including NaCl, KNO_3 , $(\text{NH}_4)_2\text{SO}_4$ and NaBr on liquid-solid divarication and the flotation yield of Hg^{2+} were investigated. The results showed that the liquid-solid divarication could be realized at the presence of NaCl, while the liquid-solid divarication could not be realized in the presence of KNO_3 , $(\text{NH}_4)_2\text{SO}_4$ and NaBr. The presence of NaCl speeded up liquid-solid divarication and made the interface clearer between two phases, and consequently Hg^{2+} was floated faster. When NaCl dosage was 0.5~2.0 g, the flotation yield of Hg^{2+} were 100%. These data allowed us to conduce that 0.5 g of NaCl can make liquid-solid phase separation perfectly. Therefore, 0.5 g NaCl was chosen in the further studies.

Effect of pH on the flotation yield of metal ions

Under the optimum conditions, the effects of pH on the flotation yield of different metal ions were investigated (Fig. 1). The experimental results showed that in the pH range 1.0 ~ 7.0 the flotation yield of Hg^{2+} was not affected by pH, or the flotation yield of Hg^{2+} remained 100%. While the flotation yield of Zn^{2+} , Fe^{3+} , Ni^{2+} , Mn^{2+} , Co^{2+} and Cu^{2+} were zero or almost zero at pH=3.0. Therefore, by controlling pH 3.0, the separation of Hg^{2+} from these metal ions could be achieved by flotation.

Flotation separation experiments

Under the chosen conditions, the separations of Hg^{2+} from Zn^{2+} , Fe^{3+} , Ni^{2+} , Mn^{2+} , Co^{2+} and Cu^{2+} in synthesized samples of binary and polybasic system were studied respectively at pH 3.0. The results shown

in Table 1 and Table 2.

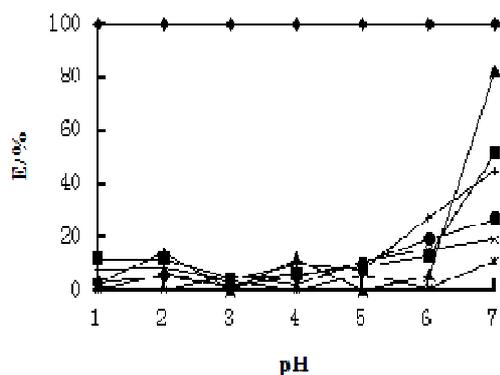


Fig. 1 Effect of pH on the enrichment yield of different metal ions

Me^{n+} : 50 μg ; OTMAC ($0.0050 \text{ mol} \cdot \text{L}^{-1}$): 0.50 mL; KI ($0.10 \text{ mol} \cdot \text{L}^{-1}$): 0.20 mL; NaCl: 0.5 g.

◆- Hg^{2+} ; ■- Zn^{2+} ; ▲- Fe^{3+} ; ×- Ni^{2+} ; * - Mn^{2+} ; ●- Co^{2+} ; - Cu^{2+}

Table 1. The flotation separation results of Hg²⁺ from binary- mixed ions (pH=3.0)

Mixed ions	Dosage of metal ions(μg)		Content of metal ions in water phase (μg)		Flotation yield(E/%)	
	Hg	Me	Hg	Me	Hg	Me
Hg ²⁺ - Zn ²⁺	50	50	0.2	49.3	99.6	1.4
	50	200	0	189.4	100	5.3
	50	400	0.1	380.7	99.8	4.8
Hg ²⁺ - Fe ³⁺	50	50	0	48.9	100	2.2
	50	200	0.3	193.2	99.4	3.4
	50	400	0	389.6	100	2.6
Hg ²⁺ - Ni ²⁺	50	50	0.2	47.3	99.6	5.4
	50	200	0	201.4	100	-0.7
	50	400	0	400.9	100	-0.2
Hg ²⁺ - Mn ²⁺	50	50	0.1	47.6	99.8	4.8
	50	200	0.2	203.3	99.6	-1.7
	50	400	0	382.5	100	4.4
Hg ²⁺ - Co ²⁺	50	50	0	47.3	100	5.4
	50	200	0.2	193.9	99.6	3.1
	50	400	0	381.0	100	4.8
Hg ²⁺ - Cu ²⁺	50	50	0	45.2	100	9.6
	50	200	0.2	187.9	99.6	6.1
	50	400	0.3	361.0	99.4	9.8

Me represents the other metal ions except Hg²⁺

Table 2 The flotation separation results of Hg²⁺ from polybasic-mixed ions (pH3.0)

Number of the synthesized samples	1	2	3	4
Hg ²⁺ added (μg)	100.0	200.0	400.0	500.0
Zn ²⁺ ,Fe ³⁺ ,Ni ²⁺ ,Mn ²⁺ ,Co ²⁺ and Cu ²⁺ added (μg)	30.0	40.0	50.0	100.0
Hg ²⁺ found in solid phase (μg)	96.5	192.6	382.2	477.6
Flotation yield of Hg ²⁺ (%)	96.5	96.3	95.6	95.5

Conclusion

In this paper, the flotation separation of mercury (II) from Zn²⁺,Fe³⁺,Ni²⁺,Mn²⁺,Co²⁺ and Cu²⁺ was reported. By controlling pH 3.0, in NaCl-KI-OTMAC system, Hg²⁺ could quantitatively form water-insoluble ternary association complex (OTMAC)₂(HgI₄) and be floated. In the same conditions, Zn²⁺,Fe³⁺,Ni²⁺,Mn²⁺,Co²⁺ and Cu²⁺ could not be floated or the flotation yield were very low. Therefore, the flotation separation of Hg²⁺ from these metal ions could be achieved. The proposed method has been successfully used for the flotation separation of Hg²⁺ in the sample of synthetic water, and the flotation yield was 95.5%~96.5%. It was obvious that the study on this system had certain practical significance on establishing a new method of flotation separation and determination of Hg²⁺.

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