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Study of adsorption of Sn(II) on synthetic three component adsorbent and to develop a method to recycle it from e-waste

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ABSTRACT

In the present investigation, a technology has been developed for the separation of tin which will be applied for its recovery from the touchscreen of the mobile (E-Waste) to the extent of 92.14 ± 2.28% employing batch adsorption method. Synthetic three component adsorbing material, zirconium phosphosilicate (ZPS) material has been used as a solid phase in the adsorption. Amount of tin recovered by adsorption has been determined by using UV-Visible Spectrophotometer. (Equitronics, EQ-825) and $8.5x10^{-3}$ M Sodium morpholine thiocarbamate solution as a spectrophotometric reagent. Sn(II) forms a colored complex at slightly acidic medium with the solution of the reagent having maximum adsorption at 390nm. The technique is optimized by varying amount of adsorbent (ZPS), pH, time of adsorption, etc. Under the optimum conditions of adsorption, the effect of various anions and cations in the adsorption of Sn (II) also has been studied. Interfering cations has been masked by using suitable masking agents so as to make the process more selective. It has been observed 100mg of adsorbent is sufficient to recover 5µg of tin at pH 2 and contact time of 6.0 min. The method thus developed has been applied to recover the amount of tin from the water samples spiked with tin and Indium.

Keywords— *Three-component adsorbent, E-waste, Batch adsorption technique, Spectrophotometry*

1. INTRODUCTION

E-waste such as a mobile display, touchscreen. LCD panels and electronic gadgets contain toxic elements like Hg, Pd, Cd, Ba, In, Sn etc., and affect bacterial activities in water and soil. Tin in the form of organic compounds is harmful to living organisms. Organic tin compounds disturb growth, reproduction, enzymatic system. The exposure mainly takes place. A human can absorb organic tin compounds through the skin, food, and breathing. Acute effects of tin poisoning include Eye & skin irritation, headache, stomachaches, sickness, and dizziness, breathlessness and urination problem. Depressions, liver damage, malfunctioning of the immune system, chromosomal damage, shortage of RBC, etc. The aim of the work is to develop a method to recycle tin from the E-waste by adsorption on synthetic inorganic ion exchanger followed by its spectrophotometric determination. Adsorption is a process in which atoms or molecules move from a bulk phase onto a solid or liquid surface. At the molecular level, adsorption is due to attractive interactions between a surface and the species being adsorbed. Various methods are available for the separation of trace elements present in diverse matrices. Of these, the use of inorganic ion exchanger is one of the most selective and reliable technique[1]. Many inorganic ion exchangers have been synthesized and their use in various elemental separations have been explored[2,3]. In the separation of cations, inorganic ion exchangers are preferred due to their outstanding resistance to chemicals and temperature.

Spectrophotometric determination of tin has been reported in the literature[4,5,6]. Among this Morpholine thiocarbamate, a spectrophotometric method for the detection of tin(II) was selected for the spectrophotometric determination of tin to study the adsorption of tin on ZPS. The stable Sn(II) complex with the reagent Morpholine thiocarbamate obeys Beer-Lambert's law in the range 0 to 8µg and having maximum absorption at 390nm[7]. The method does not require advanced instrumentation, expensive chemicals and can be easily carried out within an hour.

2. EXPERIMENTAL

2.1 Chemicals and reagents

All the chemicals used were of AR grade. For all dilutions double distilled deionized water was used. 1.0 mg/ml metal ion solution of Sn (II) was prepared by dissolving AR grade stannic chloride ($SnCl_2$) in a minimum amount of conc HCl and was warmed to get a clear solution and was standardized gravimetrically by the methods given by the Vogel[8]. All the other metal ion solutions (10mg/ml) were prepared by dissolving their appropriate salts in double distilled deionized water. The strength of the solutions was determined by the usual method. $8.5x10^{-3}$ M sodium morpholine thiocarbamate solution was used.4M sodium acetate solution was used to maintain the pH.

3. PROCEDURE

The adsorbing material was prepared by the method as reported by Naumann[9] and was made active by keeping in contact with 1M HCl for overnight followed by filtering, drying and sizing. 10 cm^3 solution containing 5.0 µg of Sn (II) whose pH adjusted at 2.0 was added to 100 mg of ZPS in a cone capacity of 25 cm^3. The mixture was equilibrated, centrifuged using high-speed centrifuge machine and the supernatant liquid was collected in 25 cm^3 standard measuring flask. 4M sodium acetate buffer was added to maintain pH 5 of the solution. Colour was developed by adding 1cm^3 of $8.5x10^{-3}$ M sodium morpholine thiocarbamate solution. Absorbance was measured on Equiptronics made UV-Visible digital spectrophotometer EQ-825 at 390 nm against blank. Percentage adsorption was calculated by using the standard formula.

4. RESULTS AND DISCUSSION

4.1 Preparation and composition of Zirconium phosphosilicate

The exchanger Zirconium phosphosilicate was prepared by the method as reported by Naumann. The weight percentage of ZrO_2, P_2O_5 and SiO_2 were determined gravimetrically (Table 1) and was found to be in close agreement with the values reported in literature[10].

Table 1: Composition of Zirconium Phosphosilicate Ion-Exchanger

	Weight %		
Composition	**ZrO_2**	**SiO_2**	**P_2O_5**
Observed	18.33	49.66	21.46
Expected	19.13*	48.18*	20.76*

* Result obtained by Baetsle et al[10].

4.2 Effect of pH

The effect of pH in the adsorption of 5.0µg Sn (II) on 100 mg of ZPS was studied. It was observed that the adsorption of Sn (II) in the pH range was maximum at pH 2.0 and decreased to pH 7.0 and thereafter again increased with increase in pH. From Fig. 3, it is clear that the percentage adsorption of 5.0 µg of Sn (II) on 100.0 mg of ZPS is maximum at pH 2.0. Hence all further adsorption studies were carried at pH 2.0.

Table 2: Effect of pH (Amount of Sn (II): 5.0µg, Amoount of ZPS: 100mg, Time of Contact: 6.0min,Temperature: 28±2^{0}C)

pH	% Adsorption	pH	% Adsorption
2.0	92.08	6.0	60.78
2.0	90.11	7.0	65.32
2.0	94.25	8.0	69.11
3.0	80.32	9.0	71.34
4.0	71.11	10.0	75.64
5.0	65.23	11.0	79.22

Reproducibility = 92.14 ± 2.28 %

4.3 Effect of amount of adsorbent

The effect of the amount of ZPS on the adsorption of 5.0µg Sn (II) was studied at pH 2.0 as mentioned above. The amount of ZPS was varied from 50 mg to 250 mg. Table. 3, reveals that 100 mg of ZPS was adequate for the maximum adsorption of 5.0µg Sn (II) at pH 2.0.

Table 3: Effect of amount of adsorbent (Amount of Sn (II): 5.0µg, pH: 2.0, Time of Contact: 6.0 min, Temperature: 28±2^{0}C)

Amount of ZPS(mg)	% Adsorption	Amount of ZPS(mg)	% Adsorption
50.0	60.32	150.0	91.06
75.0	70.12	200.0	90.56
100.0	92.08	225.0	91.11
125.0	91.54	250.0	89.22

4.4 Effect of time of contact

The effect of time of contact in the adsorption of 5.0µg Sn (II) on 100 mg of stannic oxide was studied. From the fig.5, it is clear that 6.0 minutes are sufficient for maximum adsorption of 5.0µg of Sn (II) over 100 mg of ZPS at pH 2.0.

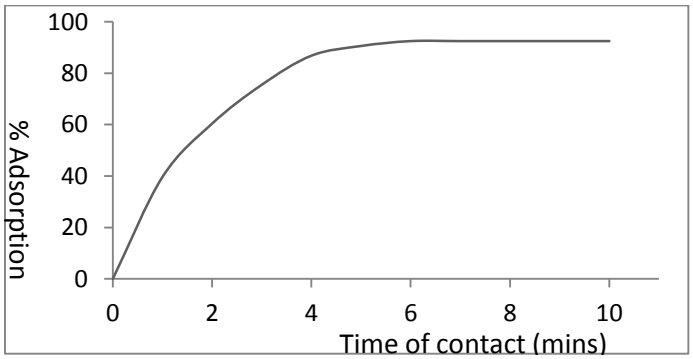

Fig. 1: Effect of time of contact

By studying various parameters in the adsorption of Sn (II) over ZPS, it is observed that 100 mg of zirconium phosphosilicate is sufficient for maximum adsorption of 5.0µg of Sn (II) at pH 2.0 and contact time of 6.0 minutes.

4.5 Reproducibility

Reproducibility of the method was evaluated by repeating the adsorption of Sn (II) at ideal conditions three times as mentioned above and was found to be 92.14 ± 2.28%.

4.6 Interference of various anions

The effect of different anions in the percentage adsorption of Sn (II) was investigated by taking the anions as a salt of Na^+, K^+ or NH_4^+ under experimental conditions as mentioned above. It was observed that 25.0mg each of chloride, bromide, iodide, acetate, bromate, tartrate, perchlorate, borate and EDTA did not interfere in the adsorption of Sn(II). 10 mg of oxalate, fluoride, phosphate citrate, dichromate, thiocyanate, cyanide, nitrate, nitrite ions did not interfere in the adsorption of Sn(II). The interference of of anions was removed by decomposing them or by precipitation prior to adsorption.

4.7 Interference of various cations

The interference of various cations (5.0 µg each) in the adsorption of Sn(II) on ZPS under the optimum conditions was also studied. it is observed that Zr(IV), Ce(IV), K(I), Be(II), Na(I), Co(II), La(III) and Mo(VI) were adsorbed up to 10%. Ca(II, Hg(II), V(III), In(III), Tl(I), Cr (II), Mn(II), Al(III) and Ag(I) were adsorbed in the range of 11% to 25%. whereas, Tl(I), Mn(II), Fe(II), Fe(III), Zn(II) were adsorbed in the range of 26% to 50 %. Ni(II), Mg(II) ,Sr(II) ,Ba(II) ,Cd(II), Cu(II) As(III), Sb(III), As(V) and Sb(V) were adsorbed in the range of 50% to 60%. Interference of interfering cations was masked by using a suitable masking agent or by increasing the amount of interfering cation so as to make the method more selective.

5. RECOVERY OF SN(II) IN A WATER SPIKED WITH SN(II) AND IN(III)

Water samples containing the different composition of Sn(II) and In(III) were analysed by employing the method developed. .The percentage recovery of Sn(II) was evaluated by performing analysis in triplicate. The results obtained are as in Table 4.

Table 4: Recovery of Tin in a spiked water sample

Spiked water sample	Amount Added(µg)		Amount Found(µg)		Recovery of Tin (%)
	Sn(II)	In(III)	Sn(II)	Mean	
Sample I	10.0	76.0	8.72	8.78±0.049	87.88
			8.84		
Sample II	5.0	38.0	8.78	4.47±0.037	89.45
			4.43		
			4.52		

6. CONCLUSION

From the above discussions it is clear that for the adsorption of 5.0µg of Sn(II), 100 mg of zirconium Phosphosilicate is sufficient for maximum adsorption at pH 2.0 when equilibrated for 6.0 minutes. The interference of various cations can be masked by using a suitable masking agent so as to make the method more selective. The method developed for the adsorption and determination of Sn(II) has been applied for the determination of Sn(II) from various water samples spiked with In(III) and Sn(II). The method is simple, selective and gives reproducible results. 4.47±0.037 µg of Sn(II) can be recovered in a sample of E-waste containing 5.0 µg of Sn(II) and a varying amount of In(III).

7. REFERENCES

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