CHEMISTRY

STUDIES ON TIN (IV) - BASED ION-EXCHANGERS

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ABSTRACT

The antimonate (V), tungstate (VI), molybdate (VI), and arsenate (III) of tin (IV) have been synthesized. Sorption of nickel and magnesium on these sample has been studied at pH 4.0 as a function of nickel ion and magnesium ion concentration. The sorption of nickel was found to decrease in the order molybdate (VI), antimonate (V), tungstate (VI), and arsenate (III). The trend of adsorption of magnesium was similar to that of nickel. The distribution coefficients of nickel and magnesium on the four samples for various initial cation concentrations established the selectivity Ni > Mg. Repeated treatment of the samples with 1.0 M NaC1 and 1.0 M HNO_3 solutions tended to decrease the capacities to certain minimum values.

Keywords: Tin (IV)-based, Ion-Exchangers, nickel, magnesium, adsorption isotherm.

INTRODUCTION

The rapid development in nuclear energy, hydrometallurgy of rare elements, and water purification, have necessitated the synthesis of highly selective ion-exchanging materials resistant to chemicals, temperature changes and radiation, and of more convenient properties than commercial organic or natural inorganic ion-exchangers. Several hydrous oxides and acidic salts of multivalent metals have been described as ion-exchangers [1-5]. The acidic salts of tin (IV) are generally compounds of the type $Sn(HXO_4)_2.yH_2O$ where X is the metal cation from the acidic group. The cation-exchange properties arise from the presence of readily exchangeable hydrogen ions associated with the anionic groups present in the salt. The sorption of metal ions on these salts can be represented by the following exchange mechanisms:

$$nSnXH + M^{n+} \rightleftharpoons (SnX)_n M^{n+} + nH^+$$

In this study, the adsorption of nickel and magnesium on four acidic salts of tin (IV) is investigated. The effect of regeneration on the capacity is also studied.

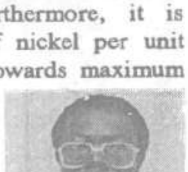
EXPERIMENTAL

The molybdate (VI), tungstate (VI), and arsenate (III) of tin (IV) were prepared by mixing 0.10 M aqueous solutions of $SnC1_4$ and 0.20 M solutions of ammonium molybdate, sodium tungstate and sodium arsenate (III), respectively. Tin (IV) antimonate (V) was prepared by mixing 0.15 M tin (IV) chloride solution with 0.3 M antimony (V) chloride solution in 4.0 M HC1. The pH was adjusted with ammonia solution to pH 2.0. The precipitates were allowed to stand for 24 hours at room temperature and then washed with distilled water by decantation, filtered off and dried at 40°C. The samples were treated with 2.0 M trioxo nitrate (V) acid to convert them into the hydrogen form and finally washed with demineralised water and dried again at 40°C. For sorption studies the samples were ground in a porcelain mortar and sieved to 100 - 200 mesh size.

The sodium ion capacity of the samples in the hydrogen form and the sorption experiments were carried out by the methods described earlier [5]. To examine the reversibility of the exchange, the samples were repeatedly treated with 1.0 M sodium chloride solution and regenerated with 1.0 M trioxo nitrate (V) acid. The four exchangers were packed in separate columns and treated with 1.0 M sodium chloride solution until all replaceable hydrogen atoms have been replaced with sodium atoms. The samples were then thoroughly washed with demineralized water to remove excess sodium ions and dried at 40°C. They were then put into columns, treated with 1.0 M trioxo nitrate (V) acid, washed with demineralized water and dried at 40°C. The sodium ion capacities were then determined. The process was repeated till five regeneration were made.

RESULTS AND DISCUSSION

Figures 1 and 2 summarize the results for the sorption of nickel and magnesium, respectively, on the four samples. The sorption of nickel decreases in the order molybdate, antimonate, tungstate, and arsenate. Furthermore, it is observed that the adsorption of nickel per unit weight of the samples tended towards maximum



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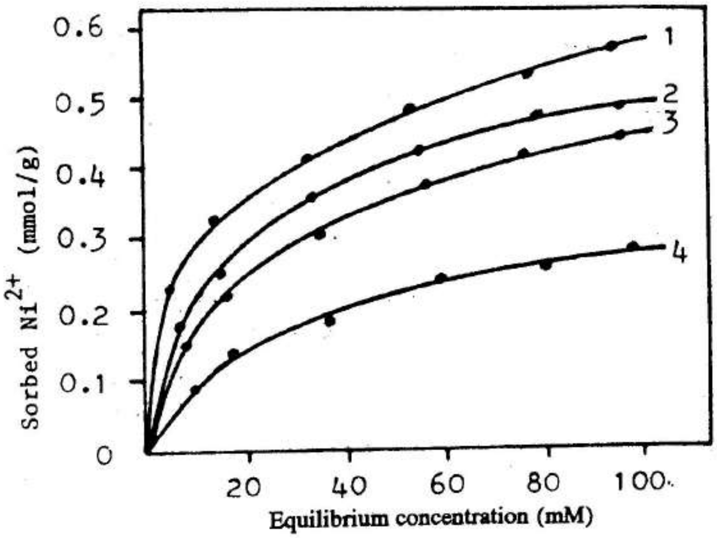

Fig. 1: Sorption of nickel on the molybdate (1), tungstate (2), antimonate (3), and arsenate (4), of tin.

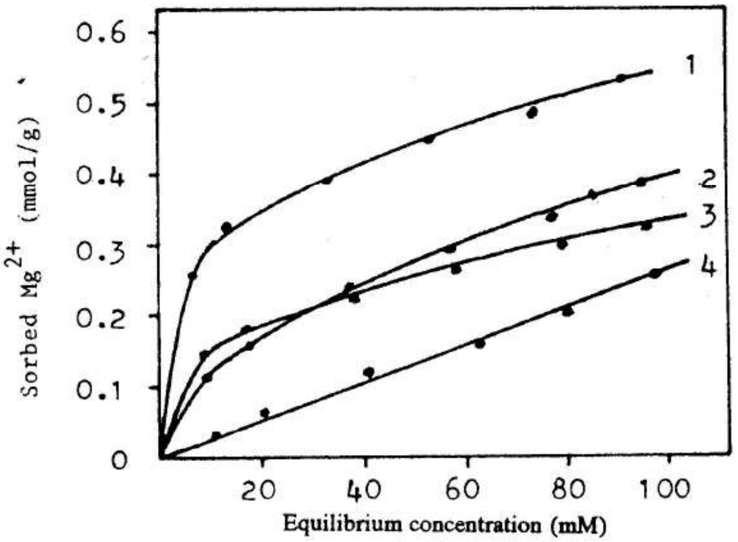

Figure 2.

rption of magnesium on the molybdate (1), gstate (2), antimonate (3), and arsenate (4), tin.

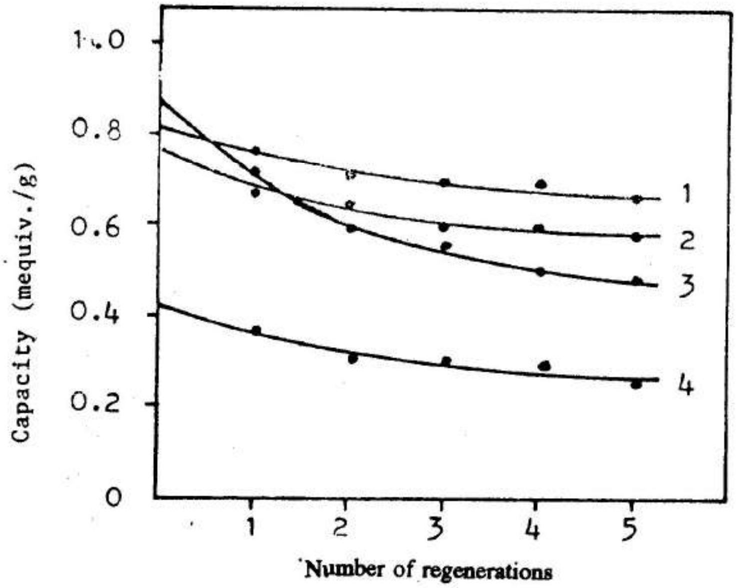

Figure 3.

Effect of regeneration on capacity: antimonate (1), tungstate (2) molybdate (3), and arsenate (4).

values. The trend of adsorption of magnesium is similar to that of nickel. Tin (IV) molybdate adsorbed the greatest amount of magnesium; the smallest amount of magnesium is adsorbed by tin (IV) arsenate. Adsorption of magnesium on tin (IV) arsenate increased linearly with increase in the initial concentration of magnesium ions up to about 0.1 M. Between 0.02 M and 0.1 M, the adsorption on the other samples was approximately proportional to the initial concentration of magnesium ions. For concentrations less than 0.02 M, tin (IV) antimonate adsorbed more magnesium than did tin (IV) tungstate; between 0.02 M and 0.1 M the reverse was the case.

Table 1 gives the calculated distribution coefficients of nickel and magnesium on the four samples. From the values it is observed that the selectivity Ni > Mg is established on all the samples. This trend is in agreement with the adsorption of these ions on synthetic organic resins [6]. In table 2 are given both the ion-exchange capacities and the per cent loss after 5 regeneration. It is observed that the amount of nickel sorbed is proportional to the capacity of the sample. The dependence of the exchange capacity on the number of regeneration is of interest if the samples are to be used in column operations. A decrease in capacity after 5 regeneration is observed for all the samples; tin (IV) molybdate had the greatest per cent decrease, and tin (IV) antimonate the smallest. The decrease in exchange capacity is probably due to the dissolution of the exchanger in the trioxo nitrate (IV) acid during regeneration. However, it can be observed from Figure 3 that the exchange capacities approach minimum values.

Table 1: K_D Values for nickel and magnesium (in parentheses)

Ion-exchanger	Initial cation concentrations ($mmol.dm^{-3}$) of nickel and magnesium					
	10	20	40	60	80	100
Tin (IV) molybdate	50.4 (46.1)	24.1 (25.0)	13.1 (11.7)	9.1 (8.4)	7.4 (6.8)	6.3 (5.8)
Tin (IV) antimonate	26.7 (18.7)	16.8 (10.5)	10.8 (5.6)	7.9 (4.7)	6.3 (3.9)	5.2 (3.4)
Tin (IV) tungstate	21.0 (14.2)	14.4 (9.4)	9.1 (6.5)	6.9 (5.2)	5.7 (4.4)	5.0 (4.0)
Tin (IV) arsenate	9.6 (3.7)	8.3 (2.9)	5.1 (2.9)	4.2 (2.6)	3.4 (2.5)	3.[illegible] (2.[illegible])

Table 2 : Ion-exchange capacities and per cent loss of capacity on repeated regeneration

Exchanger	Capacity ($mequiv.g^{-1}$)	Per cent loss (%)
Tin (IV) molybdate	0.89	44.8
Tin (IV) antimonate	0.81	15.4
Tin (IV) tungstate	0.78	23.1
Tin (IV) arsenate	0.43	34.4

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