

Extraction of indium, cadmium and thallium by salts of dinonylnaphthalene sulphonic acid

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Abstract. Extraction of indium, cadmium and thallium by salts of dinonylnaphthalene sulphonic acid was studied from sodium, potassium and calcium media. The results showed that HD and its salts formed aggregates and behaved as liquid cation exchangers. The extent of aggregation was studied by vapour pressure osmometry. A comparison was also made using analogous solid cation exchangers.

Keywords. Dinonylnaphthalene sulphonic acid; extraction of indium, cadmium and thallium; Liquid cation exchange; solid cation exchange.

1. Introduction

Ion exchange and solvent extraction have several features in common and are commonly grouped together. A study of indium, cadmium and thallium was made using dinonylnaphthalene sulphonic acid (HD) from perchloric acid media (Sudersanan and Sundaram 1976). A study of the extraction of these elements using salts of HD from different media is reported in this paper.

2. Experimental

Experiments on solvent extraction were carried out with salts of HD prepared by equilibration of HD in benzene with the corresponding salts, three equilibrations being sufficient to ensure complete conversion. Other experimental details on solvent extraction and ion exchange have been described earlier (Sudersanan and Sundaram 1976). All experiments were carried out at $30 \pm 1^\circ\text{C}$.

3. Results and discussion

Earlier studies on the extraction of metals by HD from acid medium indicated an ion exchange mode of extraction. Studies using HD are in general meagre and hence it is of interest to investigate the extraction of metals from other salt media so that the influence of pH of the media can be minimised.

Extraction of indium, cadmium and thallium was studied from sodium media using sodium form of HD as a function of the concentration of sodium perchlorate. The activity coefficients, reported in literature (Parsons 1959), were used

to obtain the plots of $\log D$ vs $\log a_{\text{Na}^+}$ (figure 1). Small variations in pH had no influence on the extraction and the slopes of 2.4, 2.0 and 1.2 respectively for indium, cadmium and thallium were as expected on the basis of the ion exchange reaction. Studies were also made as a function of the concentration of NaD. The slopes of the plots were found to be unity indicating aggregation of the extractants. Similar dependences were also observed for extraction from perchloric acid media.

Aggregation of HD has been estimated under different conditions as 2-3 (Little and Singletary 1964) while high aggregation numbers have been reported for NaD in dry benzene by vapour pressure and fluorescence depolarisation measurements (Kaufman 1962). The aggregation of sodium and other salts in wet benzene under the experimental conditions of extraction was evaluated from isopiestic molecular weight measurements in view of the disparity in the values. Studies were made as described earlier (Sudersanan and Sundaram 1976) and the results are presented in table 1. The results indicated an aggregation number of 3-4

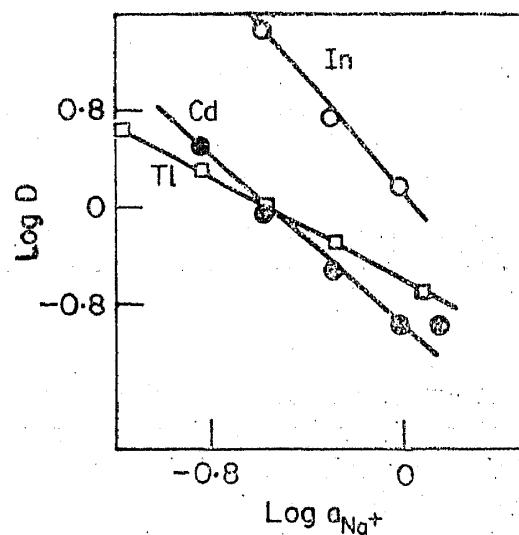


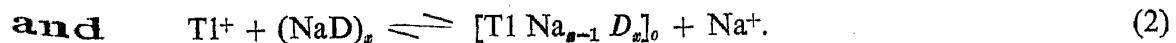
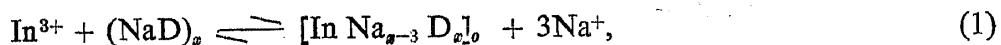
Figure 1. Plot of $\log D$ vs $\log a_{\text{Na}^+}$.

Table 1. Aggregation of salts of dinonylnaphthalene sulphonic acid (HD).

System	Conc. (%)	Formality (mM)	Experimental molarity (mM)	Degree of aggregation
HD	2.0	15.0	5.3	Trimer
NaD	2.0	15.0	3.8	Trimer-tetramer
KD	2.0	15.0	3.5	do
CdD	2.0	15.0	4.0	do
InD	2.0	15.0	4.1	do
TlD	2.0	15.0	6.8	Dimer-trimer
NaD	5.0	37.5	8.7	Trimer-tetramer

in the case of NaD and KD. The aggregation was also studied from chloroform which, as a hydrogen bonding solvent, affected the extent of aggregation of HD but that of sodium or potassium salts was not affected considerably. Indium, cadmium and thallium salts also indicate aggregation comparable in magnitude to sodium or potassium salts.

In view of the aggregation of NaD, the dependence of extraction on the charge of the metal and on the first power of the concentration of NaD can be explained, the extraction mechanisms represented as



A comparison of the behaviour of NaD was also made using a solid cation exchanger, Dowex 50W-X8 in sodium form. The plot of $\log D$ vs $\log a_{\text{Na}^+}$ (figure 2) were curves for indium, cadmium and thallium. The trend of extraction was, however, in agreement with the results obtained by solvent extraction.

Extraction of metals in benzene was also studied from potassium media. The results are presented in figure 3. Similar results were also obtained using Dowex 50W-X8 from this media.

Studies were also made from calcium media using indium and cadmium as representative metal ions. The results presented in figure 4 showed extraction to be inversely proportional to the concentration of calcium ions and directly proportional to that of the ligand. The slopes of $\log D$ vs $\log a_{\text{Ca}}$ were 1.5 and 1.0 for indium and cadmium respectively in agreement with the ion exchange of the metal with doubly charged calcium ions. The dependence on the concentration of CaD was unity suggesting the aggregate nature of the extractant.

Extraction studies using liquid cation exchangers are of importance since the pH of the aqueous phase does not affect the extraction from salt media. The extraction can be equally effective from acid as well as neutral salt media. This

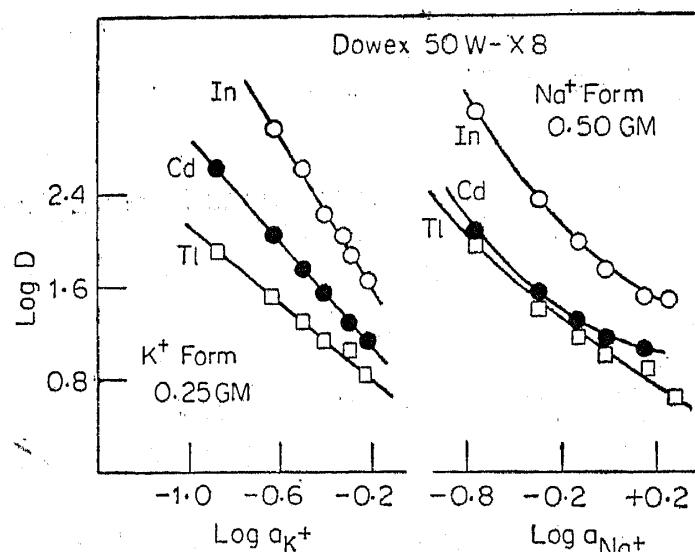


Figure 2. Plot of $\log D$ vs $\log a_{\text{Na}^+}$ or $\log a_{\text{K}^+}$.

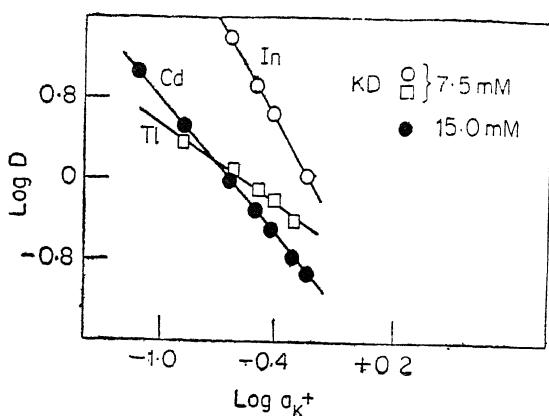


Figure 3. Plot of $\log D$ vs $\log a_{K^+}$.

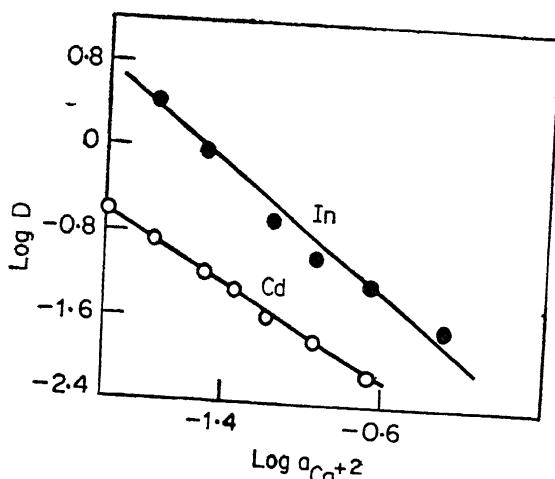


Figure 4. Plot of $\log D$ vs $\log a_{Ca^{+2}}$.

is an advantage over the use of chelating agents which are pH dependent and do not extract from solutions of low pH.

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