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Separation of Iron (III) and Cobalt (II) by Liquid Ion Exchanger

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Abstract

Changes of rate of extraction of iron (III) and cobalt (II) were investigated by use of liquid anion exchanger (Amberlite LA-1). Iron (III) and cobalt (II) were able to be extracted by 6 N hydrochloric acid solution from their mixture nearly 100% and 14%, respectively. They were easily separated by successive extractions.

I. Introduction

Extractive separation of various metals is now being carried out by use of liquid ion exchanger. This experiment aims to extend the use of the exchangers, and the authors investigated the changes of the rate of extraction depend on the concentration of hydrochloric acid solution of iron (III) and cobalt (II) by use of anion exchanger (Amberlite LA-1), and could attain isolation of the both metals by repeating extractive separation of 6 N hydrochloric acid solution, and at which normality a broad difference exists in the rate of extraction between the two.

II. Preparation of the Reagents

II-1. Preparation of Anion Exchanger (Amberlite LA-1)

In order to investigate the difference of the extraction rate to be caused by the concentration, the authors selected kerosene and benzene as the solvents, and which were prepared into solutions, 10-30% LA-1/kerosene, and 10-30% LA-1/benzene, these were then adjusted with 3 N hydrochloric acid into Cl-form exchanger.

II-2. Measurement of Exchange Capacity of Amberlite LA-1

Thus prepared solution, 10% LA-1/kerosene in the Cl-form, was exchanged with 1 N potassium sulfate, then the isolated chloride ions were titrated with 0.1 N silver nitrate. The result was 2.11 mili-equivalent for one ml of Amberlite LA-1. Hence,

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the concentration of iron (III) and cobalt (II) to be extracted from the solution were assigned as 1/5 of the exchange capacity of LA-1.

II · 3. Preparation of Standard Sample Solution

Ferric chloride was used as the standard solution of iron (III), which was dissolved into 0.05 N hydrochloric acid, and which was 0.51 mg per ml by colorimetric determination using the thiocyanate method. As the standard solution of cobalt(II), cobalt chloride was used and determined as 0.81 mg per ml upon colorimetry using the nitroso-R salt method.

III. Extraction of Iron (III) and Cobalt (II) from Hydrochloric Soutlion Acid by Use of Amberlite LA-1

III · 1. Changes in the Extraction Rate Depend on the Concentrations of Amberlite LA-1 Solution and of Hydrochlorid Acid

Selection of solvents for liquid ion exchanger is critical to extractabilities of ions. Kerosene and benzene were chosen as solvents in this research. Extractions were made by adding 20 ml each of standard cobalt (II) solution and 10–30 % LA-1/kerosene solution followed by 2–3 min. shaking and 5 min. settling. After complete separation the aqueous layer was taken out for colorimetric determinations of cobalt (II) by nitroso-R salt method. The results are shown in Table 1.

Table 1. Extraction of Cobalt (II) from
6 N Hydrochloric Acid Solution.
Co (II): 0.81 mg/ml

| Solvent & Concentration of LA-1 | Extractability of Co(II), % |
|---------------------------------|-----------------------------|
| LA-1/kerosene 10 % | 54.5 |
| " 20 % | 64.2 |
| " 30 % | 71.2 |
| LA-1/Benzene 10 % | 42.1 |
| " 20 % | 70.5 |
| " 30 % | 95.3 |

As shown in Table 1, it is more effective to use benzene for the extraction of cobalt (II). However, the authors selected kerosene which gives less extraction rate for cobalt (II) and greater for iron (III), inasmuch as the purpose of the experiment is to utilize the maximum difference between the extraction rate of iron (III) and that of the cobalt(II).

III · 2. Extraction of Iron (III) and Cobalt (II) from Hydrochloric Acid Solution

The results shown in Fig. 1 and Fig. 2 were obtained for the changes of extaction rate of iron (III) and cobalt (II) by use of both, 10 % LA-1/kerosene solution

and 30 % LA—1/benzene solution which were preliminarily exchanged into Cl-form. The values indicated are the mean of two determinations.

Iron (III) and cobalt (II) were stripped from 30 % Amberlite LA—1/benzene with a half volume 0.1 N hydrochloric acid solution. Successive three extractions for Iron (III) and two for cobalt (II) were enough for complete recovery of them.

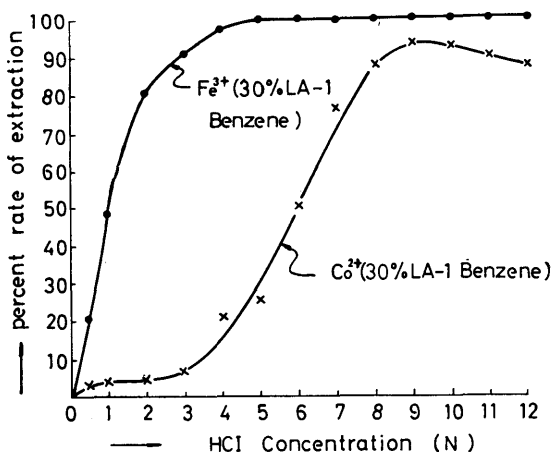


Fig. 1. Rate of Extraction of Fe (III) and Co (II) by Use of Amberlite LA—1/Benzen Solution.
Standard samples:
Fe (III) 0.51 mg/ml.
Co (II) 0.81 mg/ml.

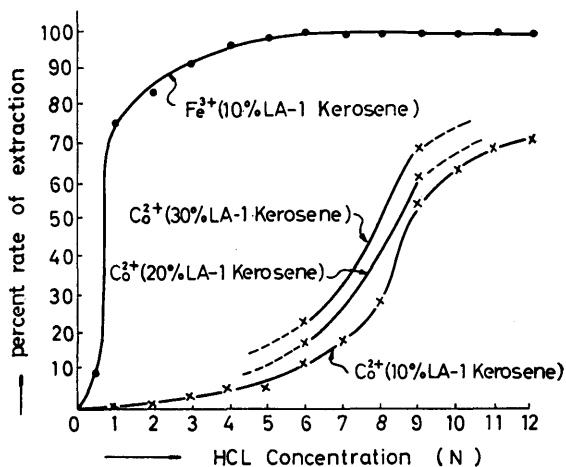


Fig. 2. Rate of Extaction of Fe (III) and Co (II) by Use of Amberlite LA—1/Kerosene Solution.
Standard samples:
Fe (III) 0.51 mg/ml
Co (II) 0.81 mg/ml.

IV. Analytical Results and Discussions

The curves in Fig. 2 indicate that LA—1/kerosene solutions give slow stand-up for cobalt (II) extractions compared with LA—1/benzene solution in Fig. 1. Iron (III) and cobalt (II) were separated by successive three extractions with 10% LA—1/kerosene solution from 6 N hydrochloric acid solution of metallic ions, and the results are shown in Table 2.

Table 2. Separation of Iron (III) and Cobalt (II).

| sample No. | Ions taken (mg) | | Found (mg) | | Differences (%) | |
|------------|-----------------|---------|------------|---------|-----------------|---------|
| | Fe (III) | Co (II) | Fe (III) | Co (II) | Fe (III) | Co (II) |
| 1 | 9.21 | 1.62 | 9.19 | 1.58 | 0.2 | 2.5 |
| 2 | 8.19 | 3.24 | 8.15 | 3.19 | 0.5 | 1.5 |
| 3 | 6.82 | 5.40 | 6.80 | 5.31 | 0.3 | 1.7 |
| 4 | 5.13 | 8.11 | 5.10 | 8.00 | 0.6 | 1.3 |
| 5 | 3.40 | 10.80 | 3.30 | 10.00 | 0.3 | 4.6 |
| 6 | 2.05 | 12.97 | 2.00 | 12.70 | 0.3 | 2.1 |
| 7 | 1.05 | 14.59 | 0.95 | 14.30 | 0.7 | 1.9 |

There are previous reports^{1) 2) 3)} that iron (III) can be extracted 100 percent by use of Amberlite LA—1 and —2. In this paper, the authors performed quick separations of iron (III) and the cobalt (II) by the difference in the extraction rate between the two. H. A. Mahlman⁴⁾ et al. reported the extraction of cobalt (II) by use of methyldiethylamine. This method of separation of iron (III) and cobalt (II) by solvent extraction system is rapid, simple and sharp, and could be applied to separations of other members of transition series.⁵⁾

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