

Removal of the Sm (III) and Eu (III) from aqueous solutions by ion flotation

Olga Lobacheva, Dmitriy Chirkst, Igor Berlinskiy

St.-Petersburg State Mining Institute, Faculty of Metallurgy, Dep. of General and Physical Chemistry, V. I., 21-st Line 2, 199106, St.-Petersburg, Russia, E-mail: olga-59@yandex.ru

Ion flotation process application in solutions contained of the rare-earth elements are presented. Our results on separation and removal of some metals (Sm (III) and Eu (III)) by use of the sodium dodecyl sulphate are given.

1 Introduction

Ion flotation was first introduced by F. Sebba (1959). In this process gas bubbles generated in solution are used to extract matter from an aqueous phase into the foam. The aqueous phase contains the mixture of solute (in particular, surface inactive ions) and a surfactant (in our case – sodium dodecyl sulfate - NaDS) can be adsorbed at the gas/liquid interface.

The surfactant (*collector*) is an ion of opposite charge to the surface – inactive ion (*colligend*), and thus cations and anions are floated with anionic and cationic collectors, respectively. It is possible, however, for the collector to be uncharged and to attach itself to the colligend by coordination. The collector-colligend product is known as sublate. As a rule the concentration of collector and colligend are low ($10^{-4} - 10^{-3}$ mol/l), and flotation occurs from a true solutions (Adsorptive bubble separation techniques/Ed. by R. Lemlich, Acad. Press, N.Y., L., 1972).

The present work is concerned the investigations of the ion flotation process in aqueous solutions containing Sm(III) and Eu (III) and sodium dodecyl sulfate as collector. The selectivity of ordinary ionisable surfactants (collectors) towards cations and/or anions is limited. A combination of the ion selectivity of the carriers with sufficient water solubility and surface activity could provide a new generation of collectors or ion flotation process. Moreover the removal and extraction of the rare earth elements from dilute aqueous solutions is one of significant task of environmental engineering.

Because the sublate formed in ion flotation is a chemical compound of the collector and the colligend, the ratio of the two required for complete flotation must at least be a stoichiometric one. Therefore, too little collector will have the same overall effect as too much, in that removals of colligend will not be complete:



Me^{+3} – ion of Sm (III) or Eu (III), DS^- - dodecylsulfate-ion.

Evidently rare earth elements are most important material in modern nanotechnologies in industry, science and innovative techniques. Rare earth metals are use in practically all branches of economy, mechanic engineering, aeronautical, medical and space engineering [1], [2].

The main task in this region of industry is to find new agents for the removal of the rare earth elements and theoretical model of the extraction one.

Our investigation is divided on 2 studies: 1 - definition of the thermodynamic characteristics (distribution coefficient and coefficient of recovery) in samarium (III) and evropium (III) aqueous solutions by use surface-active substance - NaDS ; 2 - determination the optimal regime for the removal of the Sm (III) and Eu (III) from leach solutions of the eudialite stocks.

2 Experimental Study

Experiments were carried out in the laboratory flotation apparatus 137B-FL or 135B-FL with a flotation cell of 0,5 dm³ and 1,0 dm³ volume accordingly. Flotation cell was made of the plexiglas. The airflow rate was 100 cm³/min and controlled by a rota meter. The initial volume of aqueous solution was 200 mL at 25⁰C.

Flotation scheme of the removal of the Sm⁺³ and Eu⁺³ from aqueous solutions is present in Fig.1.

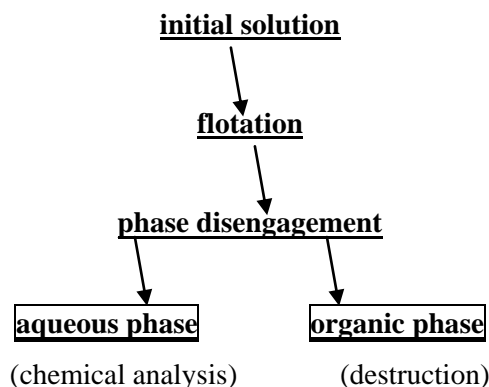


Fig.1 Scheme of ion flotation process

According to the foam separation technique the surfactant (sodium dodecylsulfate) was added to the bulk aqueous phase containing of the cations of Sm and Eu. The initial concentration of the nitric salts of these elements was 10⁻³ mol/L. The floated adsorbed solute was collected in the foam. The residual concentrations of rare earth metals in equilibrium aqueous phase and organic phase (foam) were determined by photometric method with indicator arsenazo (III). Content dodecylsulfate - ions were determined by potentiometric titration using ion selective electrode that was produced on physical chemistry department of the Saint-Petersburg University.

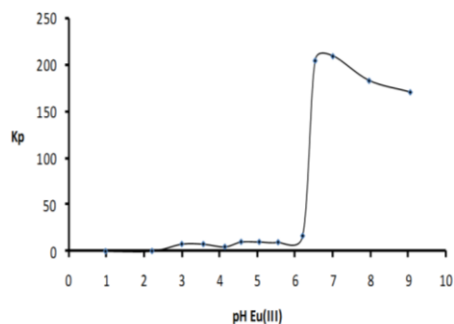
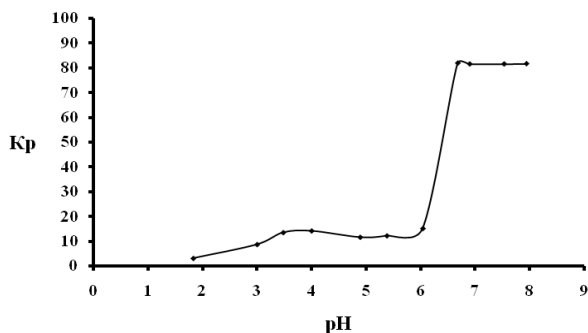
The Sm(NO₃) – NaDS – H₂O and Eu(NO₃) – NaDS – H₂O systems were studied at different pH. All the reagents used were of analytical grade, and for those experiments changing the pH values, it was adjusted with NaOH 1 M or HNO₃ 2 M. Amount of the NADS corresponded to stoichiometric quantity that compose 3·10⁻³ mol/L (NaDS concentration was selected to lie well below the critical micelle concentration (CCM of the NaDS is 8·10⁻³ mol/L).

Our experimental data on ion flotation in the aqueous solutions containing rare earth elements and surfactant are given in the Table 2.

3 Results and discussion

Figure 2 and Figure 3 compare the ion flotation behavior of Sm⁺³ and Eu⁺³ ions with sodium dodecylsulfate at different pH. K – distribution coefficient of metal ions between aqueous and organic phases was analyzed relative to concentration [Me⁺³] in foam to concentration [Me⁺³] in rest solutions correspondingly:

$$K = [\text{Me}^{+3}]_{\text{org}} / [\text{Me}^{+3}]_{\text{aq}}$$

**Fig.2. Removal Eu^{+3} by ion flotation process****Fig.3. Removal Sm^{+3} by ion flotation process**

As stated in our experiments the removal of Eu^{+3} by ion flotation with NADS starts at $\text{pH} = 6,3$ whereas extraction of Sm^{+3} begin at $\text{pH} = 6,0$. These data allow to affirm: if we change values of the pH it's possible to reach certain selectivity in the removal of rare earth elements from dilute solutions.

This result is highly significant for potential applications of ion flotation process for revelation of the best conditions for the removal of rare earth elements.

Table 1. Chemical composition of the eudialite ores (% , mass.) [3-7]

COMPONENT	VARIETY 1	VARIETY 2
FeO	10,0	9,57
MnO	0,65	0,60
ZrO ₂	2,73	2,10
Ta ₂ O ₅	0,02	0,016
Nb ₂ O ₅	0,44	0,370
SrO	0,45	0,430
La ₂ O ₃	0,11	0,156
Ce ₂ O ₃	0,36	0,142
Nd ₂ O ₃	0,09	0,058
Sm ₂ O ₃	0,03	0,019
Cd ₂ O ₃	0,0160	0,0148
Dy ₂ O ₃	0,0015	0,0011
Ho ₂ O ₃	0,0031	0,0025
Er ₂ O ₃	0,0071	0,0060
Tu ₂ O ₃	0,0019	0,0015
Yb ₂ O ₃	0,0074	0,0040
Lu ₂ O ₃	0,0023	0,0017
$\Sigma \text{R}_2\text{O}_3$	0,6234	0,4066
Y ₂ O ₃	0,0920	0,0700

Table 2. Experimental data on ion flotation process of rare earth elements at different pH from aqueous solutions

pH	[Sm ⁺³], in the foam, x 10 ³ mol/L	[Sm ⁺³], residual concentration, x 10 ⁴ mol/L	K, [Sm] _{org} /[Sm] _{aq} distribution coefficient	[Eu ⁺³], in the foam, x 10 ³ mol/L	[Eu ⁺³], residual concentration, x 10 ⁴ mol/L	K, [Eu] _{org} /[Eu] _{aq} distribution coefficient
2,0	1,69	5,64	3,0	0,12	3,00	0,4
3,0	2,03	2,36	8,6	2,20	2,88	7,9
3,5	1,86	1,39	13,4	1,86	2,36	7,9
4,0	1,83	1,30	14,1	1,00	2,10	5,2
4,9	1,97	1,71	11,5	1,83	1,79	8,2
5,5	2,22	1,83	12,1	1,77	1,79	9,8
6,1	1,98	1,31	15,0	1,74	1,05	16,6
6,7	1,90	0,23	81,9	2,29	0,11	204,0
7,0	1,52	0,19	81,5	1,73	0,08	208,8
7,9	1,25	0,15	81,6	1,65	0,09	182,6
9,0	1,15	0,13	85,3	1,80	0,10	170,3

4 Conclusions

Ion flotation shows promise for treating dilute solutions and effluents. In addition, however, it is clear from the foregoing discussion of the process that it is unsuitable for concentrated solutions. As stated ion flotation requires a stoichiometric equivalent of collector, and the solubility of surface active collectors in aqueous solutions is very limited. In addition to it being difficult to exceed the CCM when preparing collector solutions for the investigations.

5 Acknowledgments

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