



## Investigating Mechanism of Collector Concentration on the Selective Separation of Gallium from Zinc Using Ion Flotation

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**ABSTRACT:** Zinc is an impure element in acidic solutions obtained from gallium sources; therefore, the selective separation of gallium from zinc using sodium dodecyl sulfate as an anionic collector was investigated by flotation. The effect of the collector concentration on the selective separation of Ga(III) from Zn(II) were studied at pH=2. The results indicated that the size of Ga(III)-cupferron complexes formed in aqueous solution were significantly affected on the selective separation of gallium from zinc. Also, the results indicated that the optimum selective separation of gallium at an equimolar solution of Ga(III) and Al(III) ( $1.5 \times 10^{-4}$  M) obtained after the addition of  $4.5 \times 10^{-4}$  M sodium dodecyl sulfate to solution. The separation mechanism of flotation and the Ga(III)-cupferron complexes formed was studied using UV-visible spectroscopy, conductimetric analyze, dynamic light scattering and scanning electron microscopy (SEM).

### Review History:

Received: 6 December 2015

Revised: 5 April 2016

Accepted: 9 August 2016

Available Online: 18 August 2018

### Keywords:

Flotation

Gallium

Selective Separation

Interaction

Conductimetric

### 1- Introduction

Gallium is a chemical element in group 13 of the periodic table. Gallium was discovered by French chemist Paul Emile Lecoq de Boisbaudran in 1875 [1]. Gallium does not exist as a free element in the Earth's crust. The abundance in the lithosphere is approximately 10 ppm [2]. Gallium is produced exclusively as a by-product during the processing of the bauxite and sphalerite. Gallium arsenide makes up 95% of the annual global gallium consumption at USA. This element has wide application in the electronic industry. Gallium combined with arsenic [gallium arsenide (GaAs)] is used as a semiconductor in photovoltaic cells, super computers, light emitting diodes (LED), microwave transceivers, DVDs, solar cells, and other electronic devices [3]. In this study, because zinc is as an impurity element in the acidic solutions of gallium sources, the selective extraction of gallium from zinc using the anionic surface-active agent sodium dodecyl sulfate (SDS) was tested by ion flotation. During ion-flotation, a solution is initially homogeneous, but, after the addition of a surfactant (collector) with the opposite ionic charge of the colligend, the solution becomes heterogeneous, and insoluble complexes (sublate) are formed. The sublate (the colligend-collector product) attaches preferentially to the bubbles passing through the solution. Then bubbles are transferred

to the top of the column [4]. In this study, the effect of the collector concentration on the selective separation of Ga(III) from Zn(II) were studied at pH=2.

### 2- Results and discussion

The results of experiments on the investigated flotation system ( $\text{Ga}(\text{NO}_3)_3\text{-Zn}(\text{NO}_3)_2\text{-H}_2\text{O}$ ) are presented in Figure 1. The results of the experiment in this study showed that an increasing the collector concentration, the level of Ga(III) removal increased but the selectivity coefficient of gallium over zinc first increased and then rapidly decreased.

To investigate the effect of the collector concentration on the selective separation of Ga(III) from Zn(II), the interaction of Ga(III) or Zn(II) ions with SDS was analyzed at pH=2.1 using conductimetric analyze. Figure 2 shows the conductimetric of 1 mM  $\text{Ga}^{3+}$  solution at pH= 2.1 in the presence of increasing amount of SDS. A critical minimum concentration ( $r > 1$ ) is necessary for the insoluble interaction between SDS and Ga(III). Previous studies have shown this point as the critical aggregation concentration (cac).

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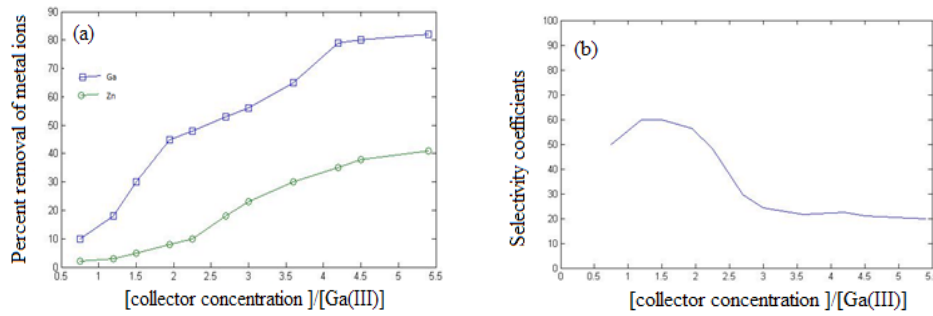


Figure 1. (a) Effect of the collector concentration on the percentage removal of Ga(III) and Zn(II) at pH 2. (b) Selectivity coefficients of Ga(III) over Zn(II) for the different collector concentration values

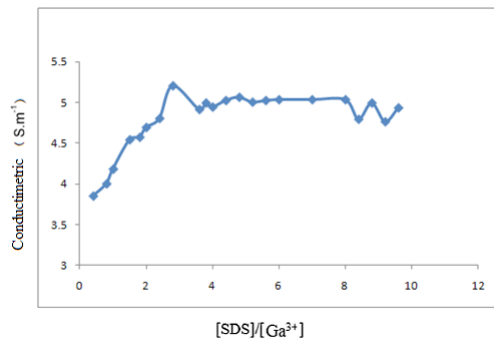


Figure 2. Effect of the collector concentration on the conductimetric of 1 mM Ga<sup>3+</sup> solution

Different mechanisms (foam fractionation, ion flotation) may occur during ion-flotation, owing to the solubility of the collector-collegend product shown in Figure 3. Precipitate and micelle formation are also illustrated in this figure.

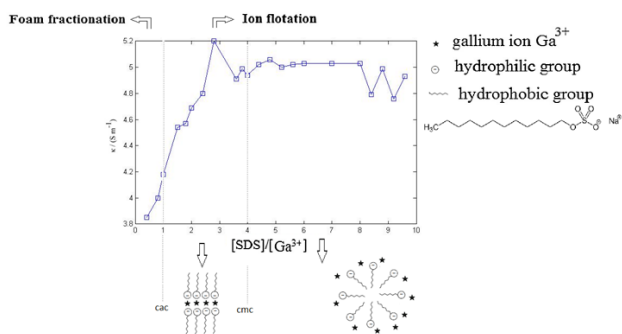
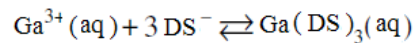


Figure 3. Different ion-flotation operation mechanisms with increasing SDS concentration at pH=2.1

### 3- Conclusions

- The results indicated that selective separation of Ga(III) is possible
- Different mechanisms (foam fractionation, ion flotation) occurred with collector concentration value.
- The association stoichiometry between SDS and Ga(III) was 2.8 and it could be explained by the following relationship:



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Please cite this article using:

Z. Bahri, B. Rezai, E. Kowsari, Investigating mechanism of collector concentration on the selective separation of gallium from zinc using ion flotation, *Amirkabir J. Civil Eng.*, 50(6) (2019) 1145-1154.

DOI: 10.22060/ceej.2018.11202.4987

