INFLUENCE OF ORGANIC ADDITIVES ON THE EFFICIENCY OF ELECTROFLOTATION EXTRACTION OF A MIXTURE OF METALS

HEIN THU AUNG

Defence Services Academy, Department of Chemistry, Pyin Oo Lwin, Mandalay Division, Myanmar,
ag.heinthu@gmail.com

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Abstract

The issue of treating wastewater system of metallurgical and heavy metal compounds industries has been increasingly paid more attention in ecology system nowadays. The study assessed the effect of adding surfactants or flocculants to the wastewater system with the efficiency of electroflotation extraction of metals from aqueous media. It has been founded that the addition of flocculants (cationic/anionic/nonionic) can increase the purification efficiency by 1–3% for all systems under study, regardless of the anionic composition of the water being treated. The addition of cationic and anionic surfactants has not effected significanty on the purification process, but the addition of a nonionic surfactant significantly inhibits the flotation process.

Keywords: Electroflotation, flocculant, surfactants, metals, wastewater treatment

1. INTRODUCTION

Quite a lot of works has been devoted to the issues of treating wastewater from various industries of heavy metal compounds [1-2]. High level of toxicity and tendency to bioaccumulate pose a difficult task for the researchers to develop new highly effective purification methods [3].

The most important technological task is to organize recycling of valuable components (Zero Waste) and the water cycle (reducing water consumption within the framework of the concept of sustainable development) [4-6]. This issue is the most relevant for enterprises in the metallurgical industrial sectors, since they are the main source of heavy metal compounds to enter environmental practice, such as electrochemical, mining, hydrometallurgical industries.

An equally important aspect, from an economic point of view, is the maximum extraction and recycling of metal-containing concentrates recovered in wastewater treatment processes.

The method of electroflotation extraction is the most effective system for slightly soluble compounds of heavy metals in the wastewater from the point of view of energy and resource saving. During the flotation process, between 95–99% of sparingly soluble compounds of heavy and non-ferrous metals can be removed from wastewater, and result of flotation-concentrate after heat treatment can be returned to production [7-8].

2. EXPERIMENTAL

In this study, the electroflotation process was carried out on a laboratory installation described in detail in [7-8]. Solutions were prepared from high-purity sulfates of the corresponding metals produced by Sigma Aldrich (Germany). The concentration of Fe^{2+}, Ni^{2+}, Zn^{2+}, Co^{2+}, Cu^{2+} ions was 20 mg/dm^3 for each metal or ΣMe 100 mg/dm^3. Background electrolytes: Na_2SO_4, NaCl, $NaNO_3$, Na_2PO_4, Na_2CO_3 (Sigma Aldrich) with a concentration of g/L; pH = 10.0 (the most effective value [2, 3, 7]; current density = 0.4 A/L.

Residual concentrations of metal ions were determined by atomic emission spectroscopy with magnetic plasma according to the previously described method [9-10].

The diagram in **Figure 1** presents data on the effect of adding various flocculants (cationic/anionic/nonionic) on the efficiency of electroflotation purification of model water (with different background electrolytes) from a mixture of slightly soluble metal compounds.

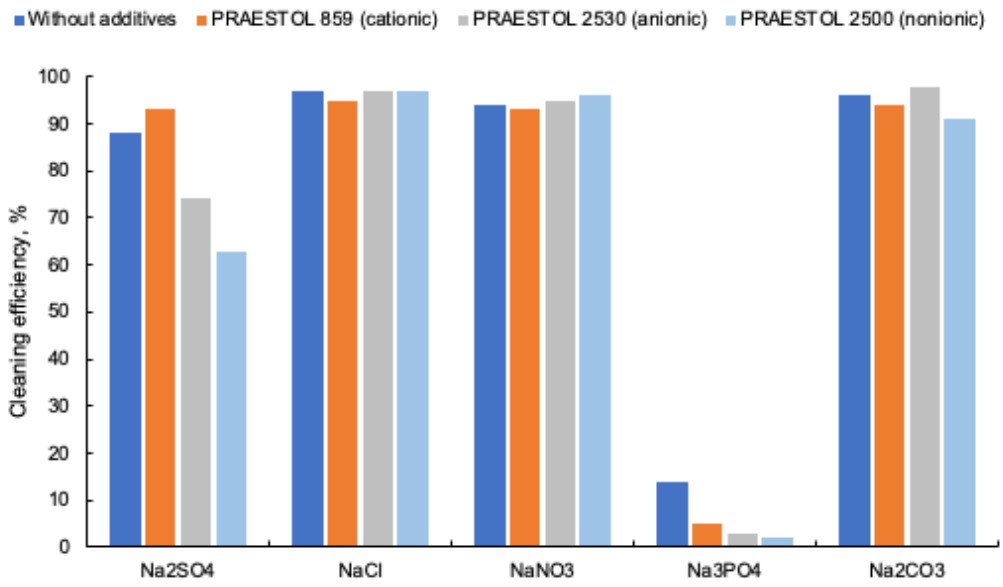

Figure 1 Effect of flocculant addition on the efficiency of electroflotation recovery of a mixture of metal

According to the graph data in **Figure 1**, the addition of flocculant allows to increase the purification efficiency by 1-3%, which, taking into account extremely strict standards for the residual metal content in purified water, is undoubtedly a good result.

Analyzing the data, it can be concluded that the electroflotation process is the most effective method in a chloride/nitrate/carbonate-containing system, and the presence of a sulfate anion reduces the overall efficiency by an average of 10-20%.

The process of electrofloatation in a phosphate-containing system proceeds much worse compared to other systems. The introduction of a flocculant into a system containing a phosphate anion almost completely inhibits the electroflotation process. This phenomenon is probably due to a change in the level of adhesion at the dispersed particle (in this case metal phosphates): gas bubble interface.

The diagram in **Figure 2** presents data on the effect of adding various surfactants (cationic/anionic/nonionic) on the efficiency of electroflotation purification of model water (with different background electrolytes) from a mixture of slightly soluble metal compounds.

The chart data in **Figure 2** shows that the presence of surfactants in the system can have an inhibitory effect on the flotation process, while anionic surfactants most clearly demonstrate process depression.

The introduction of a cationic surfactant into the phosphate-containing system made it possible to increase the efficiency of extracting a mixture of sparingly soluble metals by 5 times, which indicates the influence of the surfactant on the process of adhesion of metal phosphates on the surface of gas bubbles.

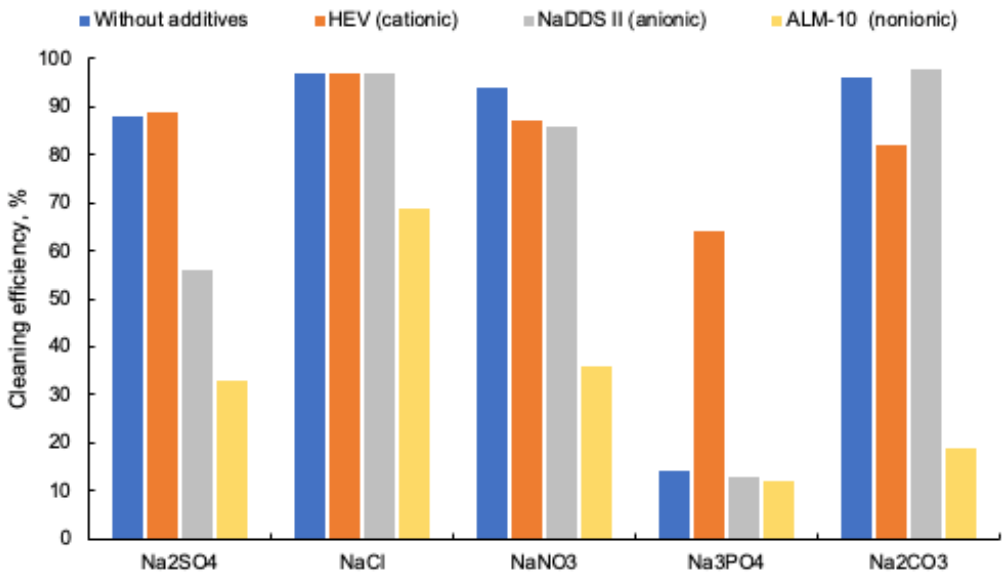

Figure 2 Effect of surfactant addition on the efficiency of electroflotation extraction of a mixture of metals

CONCLUSION

Based on the work done, it can be concluded that the introduction of a flocculant into the system minimizes the residual concentrations of heavy metals in the treated water. In addition to increasing efficiency, the introduction of flocculant intensifies the processes of sediment separation and collection, flotation sludge is more easily dehydrated and collected on the surface of the installation.

Data on the effect of various surfactants on efficiency can be used in the organization of a wastewater collection system in order to prevent flotation inhibitors from entering wastewater which was sent for treatment.

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REFERENCES

[1] INCE, M., KAPLAN İNCE, O. An overview of adsorption technique for heavy metal removal from water/wastewater: A critical review. *International Journal of Pure and Applied Sciences*. 2017, vol. 2. pp. 10-19. DOI: 10.29132/ijpas.372335

[2] QASEM, N.A.A., MOHAMMED, R.H., LAWAL, D.U. Removal of heavy metal ions from wastewater: a comprehensive and critical review. *Clean Water*. 2021, vol. **4**, no. 36. https://doi.org/10.1038/s41545-021-00127-0

[3] CHEN, Q., YAO, Y., LI, X., LU, J., ZHOU, J., HUANG, Z. Comparison of heavy metal removals from aqueous solutions by chemical precipitation and characteristics of precipitates. *Journal of Water Process Engineering*. 2018, vol. 26. pp. 289-300. https://doi.org/10.1016/j.jwpe.2018.11.003

[4] AVERINA, J.M., KALIAKINA, G.E., ZHUKOV, D.Y. KURBATOV, A.Y. SHUMOVA, V.S. Development and design of a closed water use cycle. In *19th International Multidisciplinary Scientific Geoconference (SGEM 2019*). Bulgary 2019, vol. 19 of 3.1., pp. 145–152. DOI: 10.5593/sgem2019/3.1/S12.019

[5] DE MELLO SANTOS, V.H., CAMPOS, T.L.R., ESPUNY, M. et al. Towards a green industry through cleaner production development. *Environmental Science and Pollution Research (ESPR).* 2022, vol. 29. pp. 349–370. DOI: 10.1007/s11356-021-16615-2

[6] KUZIN, E.N., KRUCHININA, N.E. Titanium-containing coagulants for foundry wastewater treatment. *CIS Iron and Steel Review*. 2020, vol. 20, no. 2. pp. 66–69. DOI:10.17580/cisisr.2020.02.14

[7] KOLESNIKOV, A.V., PYAE AUNG, DAVYDKOVA, T.V., KOLESNIKOV, V.A. Establishment of regularities of electroflotation extraction of non-ferrous metal (Cu, Ni, Zn, Co, Fe) hydroxides from wastewater of various compositions in the presence of industrial surfactants. *Nonferrous Metals*. 2021, no. 1. pp. 3-9. DOI: 10.17580/nfm.2021.01.01

[8] THU AUNG HEIN, PYAE AUNG, ZAW HTAY THAN, KOLESNIKOV, A.V.. Study of the efficiency of electroflotation process on a mixture of heavy hydroxides and nonferrous metals in various electrolytes. In: *29th International Conference on Metallurgy and Materials*. Czech Republic: METAL 2020, pp. 1019-1023.

[9] KUZIN, E.N. Application of the method of atomic emission spectroscopy with microwave (magnetic) plasma in the processes of identification of the chemical composition of steelmaking waste. *Ferrous Metals*. 2022, no. 10. pp. 79-82. DOI: 10.17580/chm.2022.10.13

[10] KUZIN, E.N., KRUCHININA, N.E. Obtaining complex coagulants based on mineral concentrates and their use in water purification processes. *Ore Enrichment*. 2019. No. 3. pp. 43-48. DOI: 10.17580/or.2019.03.07