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SEPARATION OF IRON IONS FROM SOLUTIONS OF HYDROMETALLURGICAL INDUSTRIES BY LIQUID EXTRACTION METHOD

In the article, the author considers the problem of choosing a method of extracting valuable components from the production solutions of hydrometallurgical production. For this purpose, it is promising to use the liquid extraction method. With the help of this method, in the field of metallurgy, during the production of non-ferrous metals, technological solutions can be used to remove iron ions. Depletion of mineral reserves requires the use of only poor natural materials for industrial enterprises. One of the promising methods of separating metal ions from poor solutions by freeing them from co-existing elements and obtaining a concentrated solution is extraction. In addition, the extraction method is only effective in processing high-iron solutions, because it allows to significantly reduce the amount of iron that goes to the heap. The use of liquid extraction method in the purification of solutions from iron ions significantly facilitates the separation of iron ions from non-ferrous metal ions. The conducted study showed that, when the concentration of the organic phase is correctly determined, it is possible to use toluene as a solvent and trialkylamine (TAA) as a reagent for the separation of iron ions from technological solutions containing acid. The obtained data showed that the use of toluene as a solvent and trialkylamine (TAA) as a reagent during extraction is promising.

Keywords: liquid extraction, extractant, raffinate, iron ions, toluene, trialkylamine.

Introduction

The growth of accumulated wastes of hydrometallurgical industries, as well as the difficulty of mining and processing of poor ores require the search for alternative technologies of ore processing. In the last 20 years, the tendency of decreasing the amount of metals in mined ores is observed, and often their amount in the ores corresponds to the amount in the waste of metallurgical productions. In addition, there is information that 80 % of the useful component extracted during the processing of ores of mining and metallurgical enterprises goes to waste. The question of choosing a method of extracting valuable components from the production solutions of hydrometallurgical production is a controversial issue. Liquid extraction method is one such method. It has significant advantages over sedimentation and filtration methods [1].

Materials and methods

Liquid extraction is the process of transferring one or more dissolved substances from a liquid phase to another phase. The second phase (extractant) is completely insoluble or partially soluble in the first phase, but it dissolves substances absorbed from the first phase. The initial aqueous solution containing the dispersant is in direct contact with the extractant. As a result, two phases are formed:

1) The extractant is a separate organic phase enriched with a dispersant.

2) Raffinate is an aqueous phase in which there is no dispersant at all.

The main stages of liquid extraction:

1) Connecting media and dispersing phases;

2) Separation of phases into extract (separated phase) and raffinate (depleted phase) by forming layers;

3) Separation of the target components from the extract and regeneration of the extractant by distillation or re-extraction (reverse process to liquid extraction);

4) Washing the extract to reduce the amount of the original solution removed mechanically [6].

When the extract obtained as a result of extraction is treated with certain aqueous solutions, the target components are transferred to the solution or precipitate. This process is called the reextraction process.

Phase separation of the emulsion formed during extraction is usually performed in two stages. First, large droplets settle (float) rapidly, and large droplets coalesce. Very small droplets remain in the form of «fog», which settles very slowly. Various devices are used to speed up this process.

The mechanism of the extraction process is shown in Fig. 1. In this picture you can see the extraction mechanism: after adding an extractant to the original

solution and mixing it, the extract and the raffinate containing the solute can be separated [8].

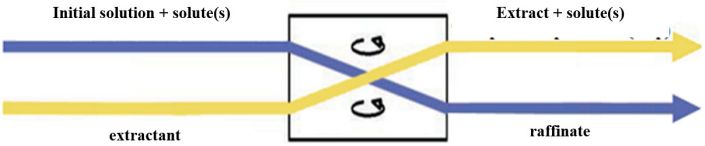

Figure 1 – The mechanism of the extraction process

The extraction process is important for many industries, because it allows the purification of many impurities and the separation of pure substances. Areas of application are:

- chemical;
- oil processing;
- food;
- metallurgy;
- pharmaceutical.

With the help of this method, in the field of metallurgy, during the production of non-ferrous metals, technological solutions can be used to remove iron ions.

Depletion of mineral reserves requires the use of only poor natural materials for industrial enterprises. One of the promising methods of separating metal ions from poor solutions by freeing them from co-existing elements and obtaining a concentrated solution is extraction. Among them, the extraction of iron ions is also important for the metallurgical industry.

The history of iron ion extraction is long. This is because this process is a model of extraction systems consisting of the separation of metal halide complexes with oxygen-containing extractants [7].

Salts of iron and non-ferrous metals are present in the solutions obtained during the leaching of poor raw materials, concentrated and underground leaching solutions, waste water, mine and mining waters. It is difficult to separate iron and non-ferrous ions from such solutions by precipitation. Fe (II) ions are precipitated by hydrolysis together with the basic ions of non-ferrous metals. Fe (III) ions are precipitated in the more acidic zone, but with them also ions of non-ferrous metals and organic impurities are precipitated, because Fe (III) are coagulants. Therefore, liquid extraction of iron from solutions is a promising area of hydrometallurgy. In addition, the extraction method is only effective in processing high-iron solutions, because it allows to significantly reduce the amount of iron that goes to the heap [2].

For some enterprises that produce non-ferrous metals, the presence of iron ions in process solutions adversely affects the process and makes it difficult to obtain pure products. The use of liquid extraction method in the purification of solutions from iron ions greatly facilitates the separation of iron ions from non-ferrous metal ions [9].

The proposed method has a number of advantages:

- this method can be used for solutions with acidity from 10 to 70 grams per liter;
- significantly simplifies the work of production when the equipment is selected correctly;
- the shelf life of the extractant is long;
- the possibility of purifying the extractant from iron ions using the reextraction method;
- processing of separated iron is easy.

Research execution plan.

1) Selection of an extractant (solvent and reagent) suitable for the separation of iron ions from the process solution.

2) Determination of the ratio of organic and aqueous liquid phase required for analysis.

3) Determination of the limiting solubility of iron ions in the selected extractant.

4) Selection of a suitable re-extracting solution for cleaning the extractant from iron ions [3].

Conducting research.

The following organic solvents were used as extractants:

- diesel fuel;
- chloroform;
- isobutyl alcohol;
- toluene.

The following substances were used as reagents:

- Cyanex – 272;
- tributyl phosphate (TBF);
- trialkylamine (TAA);
- Aliquat.

After a number of studies, toluene was chosen as the solvent and trialkylamine as the reagent for the extraction of iron ions. The ratio of organic and aqueous phases was 2/1. The maximum solubility of iron ions in the obtained compound was 6 g/dm^3 [2].

Sulfuric acid with a concentration of 120 g/dm^3 was chosen as a re-extracting agent.

After carrying out all the experiments to determine the extractant, determine the ratio of the organic phase to the aqueous phase, determine the limiting solubility and the re-extracting solution, the first experiment with the process solution was performed.

After the end of mixing, the separation of the two phases took place immediately. The obtained results are presented in Table 1.

Table 1 – Research results

	Concentration of Fe mg/dm^3	Concentration of H_2SO_4, g/dm^3
Initial Solution	2352	23
Solution after mixing	54	20
Re-extracted solution	2184	-

Summing up the experiment, it can be observed that the mixture of toluene and trialkylamine is correctly selected as an extractant for the process solution of non-ferrous metals with iron ions. Because after extraction, it can be observed that the concentration of iron ions in the aqueous phase drops sharply (the concentration of iron ions in the initial solution is 2352 mg/dm^3, and the concentration after extraction is 54 mg/dm^3) and the degree of purification was 97,7 % [10].

Re-extraction (purification) of the extractant from iron ions with sulfuric acid was successful. The concentration of iron ions in the re-extracted solution was 2184 mg/dm^3 and losses were low (7 %).

The obtained results showed that this extractant (toluene and trialkylamine) can be used for the separation of iron ions in the future. The experiment was repeated 22 times with this extractant, and the results were completely consistent.

The influence of various factors on the distribution of iron ions between phases was studied in 300 ml separatory funnels during intensive shaking for 15 minutes. It was determined in advance that this time would be enough to reach chemical equilibrium. After the division into layers, two phases were separated [3, 4].

The concentration of the reagent in the solvents was chosen so that 1 gram of the reagent was in 100 ml of the solvent. The ratio of organic and aqueous phase was 1/1.

The aqueous phase contains iron ions and sulfuric acid and their amounts are given in Table 2.

Table 2 – Composition of the aqueous phase

Components	Amount, g/dm^3
Con. Fe	3,3
Con. H_2SO_4	20

Mixing of one sample was done manually at 15 min intervals.

Results and discussion

After testing all the solvents and reagents mentioned above, the following results were obtained (Figure 2).

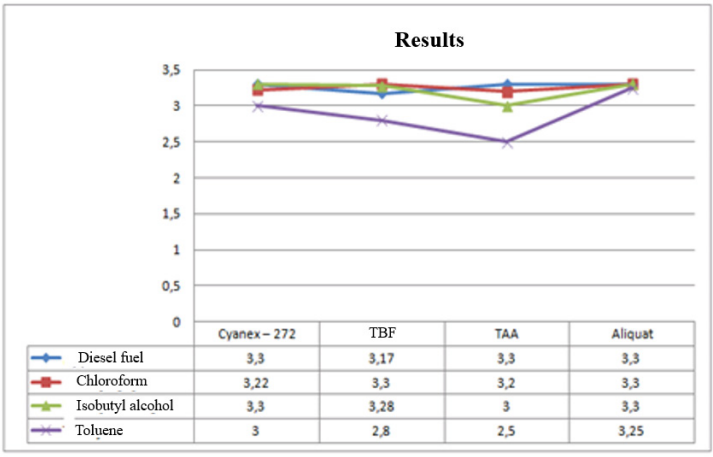

Figure 2 – Test results

Conclusions

Summarizing this test, it was shown that when the concentration of the organic phase is correctly determined, the use of toluene and trialkylamine (TAA) as a reagent for the separation of iron ions from technological solutions containing acid is more suitable than the use of a mixture of other solvents and reagents. In the purple line in Figure 2, it can be seen that the TAA reagent is effective when using toluene as a solvent (the point corresponding to 2.5). The obtained data showed that the use of toluene as a solvent and trialkylamine (TAA) as a reagent during extraction is promising [1, 4].

To fully complete the test, the following determinations will need to be made in the future:

- the effective concentration of the reagent in the solvent;
- effective ratio of organic and aqueous phases;
- limit of solubility of iron ions in the mixture of solvent and reagent;
- determination of the re-extracting solution for cleaning the extractant from iron ions. This will require further research [5].

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ГИДРОМЕТАЛЛУРГИЯЛЫҚ ӨНЕРКӘСІПТЕРДІҢ ЕРІТІМДЕРІНЕН ТЕМІР ИОНДАРЫН СҰЙЫҚТЫ ЭКСТРАКЦИЯЛЫҚ ӘДІСІМЕН БӨЛУ

Мақалада автор гидрометаллургиялық өндірістің алынатын өнімдік ерітінділерінен құнды компоненттерді бөліп алу әдісін таңдау мәселесін қарастырады. Бұл мақсатта сұйықтық экстракция әдісін қолдану перспективалы болып табылады. Бұл әдістің көмегімен металлургия саласында түсті металдарды өндіру кезінде технологиялық ерітінділерді темір иондарынан тазартуда қолдануға болады. Кен орындарының қорының азаюы өнеркәсіптік кәсіпорынға небары кедей табиғи материалдарды қолдануды қажет етеді. Кедей ерітінділерден металл иондарын бірге болатын элементтерден босатумен және концентрленген ерітінді алумен бөліп алудың перспективалы әдісінің бірі экстракциялау болып табылады. Сонымен қатар экстракциялық әдіс жоғарытемірлі ерітінділерді өңдеуде небары тиімді болып табылады, себебі ол темірдің үйіндіге кететін мөлшерін елеулі төмендетуге мүмкіншілік береді. Ерітінділерді темір иондарынан тазартуда сұйықтық экстракция әдісін қолдану темір иондарын түсті металдар иондарынан бөліп алуды елеулі жеңілдетеді. Орындалған зерттеуде органикалық фазаның концентрациясын дұрыс анықтаған кезде, еріткіш ретінде толуолды және реагент ретінде триалкиламинді (ТАА) құрамында қышқыл бар технологиялық ертінділерден темір иондарын бөліп алуға қолдану жарамды болатынын көрсетті. Алынған мәліметтер экстракциялау кезінде еріткіш ретінде толуолды және реагент ретінде триалкиламинді (ТАА) қолдану перспективалы болатынын көрсетті.

Кілтті сөздер: сұйықтық экстракция, экстрагент, рафинат, темір иондары, толуол, триалкиламин.

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ВЫДЕЛЕНИЕ ИОНОВ ЖЕЛЕЗА ИЗ РАСТВОРОВ ГИДРОМЕТАЛЛУРГИЧЕСКИХ ПРОИЗВОДСТВ МЕТОДОМ ЖИДКОСТНОЙ ЭКСТРАКЦИИ

В статье автор рассматривает проблему выбора способа извлечения ценных компонентов из технологических растворов гидрометаллургического производства. Для этой цели перспективно использовать метод жидкостной экстракции. С помощью этого метода в области металлургии при производстве цветных металлов можно использовать технологические растворы для удаления ионов железа. Истощение запасов полезных ископаемых требует использования только бедных природных материалов для промышленных предприятий. Одним из перспективных методов выделения ионов металлов из бедных растворов путем освобождения их от сосуществующих элементов и получения концентрированного раствора является экстракция. Кроме того, экстракционный метод эффективен только при переработке высокожелезистых растворов, поскольку позволяет значительно уменьшить количество железа, идущего в кучу. Применение метода жидкостной экстракции при очистке растворов от ионов железа значительно облегчает отделение ионов железа от ионов цветных металлов. Проведенное исследование показало, что при правильном определении концентрации органической фазы возможно использование толуола в качестве растворителя и триалкиламина (ТАА) в качестве реагента для выделения ионов железа из технологических растворов, содержащих кислоту. Полученные данные показали перспективность использования толуола в качестве растворителя и триалкиламина (ТАА) в качестве реагента при экстракции.

Ключевые слова: жидкостная экстракция, экстрагент, рафинат, ионы железа, толуол, триалкиламин.

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