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PHYSICOCHEMICAL and FLOTATION CHARACTERISTICS of NEW FOAMING AGENT – SVIM PRODUCED from FUSEL OIL

Abstract: It is presented technological parameters for synthesis of foaming agent SVIM from fusel oil of Talgar and Aydabul (Astana, Kazakhstan) alcohol factories on pilot apparatus and determined its surface properties. Moreover physicochemical properties of new reagent were studied and laboratory trials on enrichment of gold-containing ores with new reagent application were carried out. Also laboratory trials on flotation of sulfide gold-arsenous ores of Balazhal deposit (East Kazakhstan) with application of foaming agents MIBK and SVIM were conducted. Thus, it was determined content of gold –1.7 g/t, silver – 2.2 g/t, and content, %: copper -0.004, lead - <0.02, zinc – 0.046, iron – 4.27, overall sulfur -1.88, sulfate sulfur – 0.12, arsenic – 0.37, silicon dioxide – 58.9, overall carbon – 1.79, including carbonate carbon – 1.15 in ore. As a result of rational analysis to determine of gold configuration in ore of Balazhal deposit it was determined, that in the ore, comminuted to size 80.5 % of class -0.074 mm (content of class with size -0.044 mm – 63.0 %) there are, %: 20.35 – free gold, and 19.19 – free gold with clean surface. There are forms of gold, %: in splice – 46.52, association with sulfuric minerals – 29.65 and with stone – 3.48. Furthermore granules of gold with size – 0.025-0.05 mm are predominated. Configuration of gold granules with clean surface is cloggy and granules of gold covered with oxide films – needle-shaped dendrite. Enhancement of foaming capacity and flotation activity of SVIM is connected with oxidation and etherification of dry fusel oil. In presence of catalyst – sulphuric acid optimal amount of hydrophobic - hydrophilic groups are generated, that provides approximately the same bubbles. This bubbles create favourable conditions for capture of ore particles in comparison with bubbles with polydisperse composition of basic reagents. Results of this investigation showed, that by application of SVIM concentration of gold increases on 6,9 g/t, and extraction of gold into gold-containing concentrate in comparison with foaming agent MIBK increases by 0,74 %.

Keywords: fusel oil, foaming agents, foaming power, gold-containing concentrate, gold-bearing ore flotation, benefication.

Introduction. The current state of processing of complex composition of ores shows the almost complete absence of production in Kazakhstan of highly selective and effective flotation reagents such as collectors and foaming agents. Sharp decrease in assortment of regents and the high cost of imported reagents requires creation of production of new flotation reagents and reagent regimes on their basis for the introduction in mineral processing plants. Actuality and significant value of the work has the development of synthesis methods of effective flotation reagents from hydrocarbon feedstock available in Kazakhstan. Currently, Kazakhstan has a large number of fusel oils (FO) — unclaimed wastes of alcohol production. Total amount of FO are approximately 850 m3 a year. [1].

Synthesis and application of new flotation reagents are aimed to replace toxic reagents with non-toxic or less toxic; finding more selectively acting collectors, foaming agents, modifiers and reagents with well degradable properties under chemical or thermal treatment [2]. Since the required assortment of flotation reagents causes not only the technical and economic parameters and opportunities of the flotation process, but also to a great extent provides in crisis situations safety of the country. Therefore it is important not only to evaluate the current situation with production of reagents in the country, but also to develop research projects directed on diversification and development of new more efficient flotation reagents.

The main flotation agents in mining and metallurgical industry of Kazakhstan are foaming agents T-92 and T-94 (1.3-dioxane derivatives), MIBK, foaming agents made in China as well as organophosphorus and sulfhydryl collectors (aerofloats, potassium and sodium salts of xanthogenates of primary alcohols) [1]. However, they are produced abroad, which increases the import dependence of the state.

Therefore, the development of new methods for the preparation of environmentally safe and cheap flotation reagents based on raw materials of Kazakhstan and the development of new reagent regimes with their application for the flotation of gold-bearing ores is an urgent and timely task.

Experimental part. *Technique of carrying experiments***.** On the basis of averaged and dried fusel oil was obtained new foaming agent SWIM on pilot in-

stallation R-620 (Selecta, Spain). The reagent was obtained from fraction of alcohols C3-C9 isolated from fusel oils with further air oxidation for 3-5 hours in the presence of a catalyst - a mixture of sulfuric and acetic acids. The resulting mixture formed acetosulfoesters containing mainly isoamyl ester of acetic acid that gives reagent pear odor of essence. It was investigated technological characteristics, physico-chemical and foaming properties of new foaming agents.

For the investigations 5 kg purified sample of fusel oil from waste of Talgar and Aydabul (Astana) alcohol factories by averaging of fusel oil from different parties and drying of moisture was prepared.

Fractional distillation of fusel oil was carried out. According to the literature [3] and the fractional distillation fusel oil, the main component of dry fusel oil is isoamyl alcohol with content of more than 50 %. Fractional composition of fusel oils was determined on apparatus AVR-LAB-1 for atmospheric distillation of oils. For this purpose 100 ml of fusel oil was loaded to the distillation flask and the fractions was taken after every 10 ^{0}C. Determination was carried out without and with pre-drying of initial fusel oils of Talgar and Aydabul alcohol factories. Results of fractional composition are shown in tables 1 and 2.

Table 1 – Fractional composition of fusel oil of Aydabul alcohol factory

Number of fraction	Interval of temperature, 0C	Volume of distillate (without drying), ml	Volume of distillate, (after drying), ml
1	70-80		2,7
2	80-90	45,0	13,5
3	90-100	5,2	13,0
4	100-110	1,7	4,8
5	110-120	2,1	24,0
6	120-128	40,2	37,0
7	residual	5,7	3,6
Total		99,9	98,6

Table 2 – Fractional composition of fusel oil of Talgar alcohol factory

Number of fraction	Interval of temperature, ^{0}C	Volume of distillate (without drying), ml	Volume of distillate, (after drying), ml
1	70-80		2,8
2	80-90	46,0	13,0
3	90-100	4,1	12,0
4	100-110	1,6	5,1
5	110-120	2,3	25,0
6	120-128	40,0	36,0
7	residual	5,9	4,0
Total		99,9	97,9

Analyses of the data in Tables 1 and 2 shows that the pre-drying of fusel oil with potassium carbonate allows to increase the content of the fraction in the temperature range 100-128 ^{o}C from 49.7 % to 69.4 % (fusel oil of Aydabul alcohol factory), 100-128 ^{o}C from 46.8 % to 70.1 % (fusel oil of Talgat alcohol factory). These data indicate that for esterification of fusel oil requires predrying or salting of raw materials - fusel oil. This pretreatment allows increasing the content of isomeric structure of alcohols.

The physicochemical properties of dehydrated fusel oils of Talgar and Aydabul alcohol factories are investigated. The results of analysis are shown in Table 3.

Gas chromatography-mass spectrometry analysis showed that the main components of fusel oil of Talgar and Aydabul alcohol factories after drying in all the fractions until 128°C are ethyl, propyl, isobutyl, and isoamyl alcohols. They accounted 96 % of mentioned fractions.

Table 3 –Results of physical and chemical analysis of the dried and homogenized fusels of Talgar and Aydabul alcohol factory

Name of the component	Index of refraction, n_D^{20}	Specific gravity, d d_n^{20}	Boiling temperature, °C
Fusel oil of Talgar distilling plant	1,3950	0,816	82,5-142
Fusel oil of Aydabul distilling plant	1,4020	0,818	83,0-143

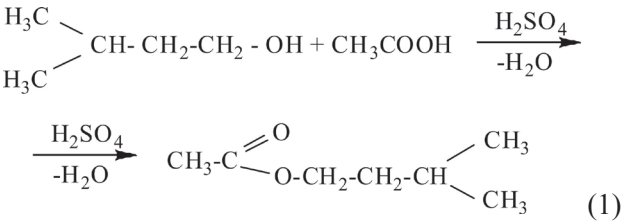
The dried fusel oil of Talgar alcohol factory contains 68 % of iso-amyl alcohol fraction, 17 % of isobutyl alcohol, 3 % of propyl alcohol and 5 % of ethanol. The dried fusel oil of Talgar alcohol factory contains 69.4 % of iso-amyl alcohol, 18 % of isobutyl alcohol, 3.8 % of propanol and 6 % of ethanol.

Swim reagents were synthesized on pilot installation of fusel oil of Talgar and Aydabul alcohol factories (Figure 1). Then they were oxidized by atmospheric oxygen for 3-5 hours in the presence of an acidic catalyst - a mixture of sulfuric and acetic acid in the ratio 3: 0.75-1.

The process for obtaining reagent comprises two stages:

1 Fusel oil oxidation by atmospheric oxygen in the presence of a catalyst (8-12 %) for five hours at the temperature not more than 30º C;

2 The neutralization of the oxidized fraction was carried out with 30 % of caustic solution with specific gravity 1.330 g/cm^3 and recommended excess of caustic no more than 20 %. In this case the mass fraction of sodium hydroxide is not less than 2.5 %. This produces mixture of acetosulfoesters containing mainly isoamyl ester of acetic acid, that giving to reagent an odor of pear essence. Further the mixture was neutralized with 10 % of sodium hydroxide. The content of residual sodium hydroxide is not less than 3 %. The esterification of fusel oil (1) consists more than 50 % of isoamyl alcohol proceeds as follows:



(1)

Proposed foaming agent is oil with light brown color, that has an odor of pear essence, is non-toxic and has good foaming properties with a monolayer foam.

Method for synthesis of Svim on pilot reactor (R-620) (Selecta, Spain):

Synthesis of of foaming agent (volume 4.0 l.). In the pilot reactor were added 1321.20 g of acetic acid in portions with stirring and 400 ml of 96 % H2SO4 (the temperature should not rise above 35°C). Then the mass was cooled to 20°C. After cooling under good stirring for 3 hours was added dropwise 4.0 L of dry fusel oils. The temperature of reaction should not be above 25 °C.

After adding the total amount of fusel oil, the reaction mass was stirred for 30 minutes.

Neutralization of the product. Without waiting for separation of the reaction mass (during 1-2 hours), an equal volume of water was carefully poured into the reaction mixture. A heat generation is observed. Then the water layer is poured through the lower valve and the product washed with water. After this the water is poured out and the product is washed with 25 % aqueous solution of NaOH. As a result was obtained 3.0 l of flotation reagent with pH = 8.0-8.5 and specific gravity = 0.8424 g/cm^3.

A representative sample of foaming agent Svim was obtained in an amount of 20 kg with a content of the main substance 91 %.

Figure 1 – Image of pilot installation (R-620) (Selecta, Spain) for synthesis of flotation reagents

IR analyzes of reagent SVIM was conducted. The spectra were obtained on a FTIR spectrometer «Avatar 370" in the spectral range 4000-250 cm^{-1}. For this purpose was taken suspension of a preparation in vaseline oil on the window KRS-5 and as a reference spectrum - spectrum of vaseline oil was taken. The attachment for experiments: Transmission E.S.P. Svim (Figure2). In trial was established the presence of compounds: 3-Methyl-1-butanol at 2960, 2934, 2876, 2738, 1469, 1430, 1387, 1369, 1172, 1126, 1054, 1010, 968, 942, 921, 904, 838, 765 cm^{-1}, 2-Methyl-1-propanol – 2960, 2933, 2876, 1387, 1369, 942, 904, 819 cm^{-1}, denatured alcohol – 1089, 1054, 882 cm^{-1}. The stretching vibrations of the group C═O are 1743, 1724 cm^{-1}. The absorption band with maximum at wave number 1260 cm^{-1} falls in the range of asymmetric stretching vibrations of C-O-C esters, lactones, etc., as well as the stretching vibrations C═S. Deformative fluctuations δ NON are 1651 cm^{-1} for water molecules.

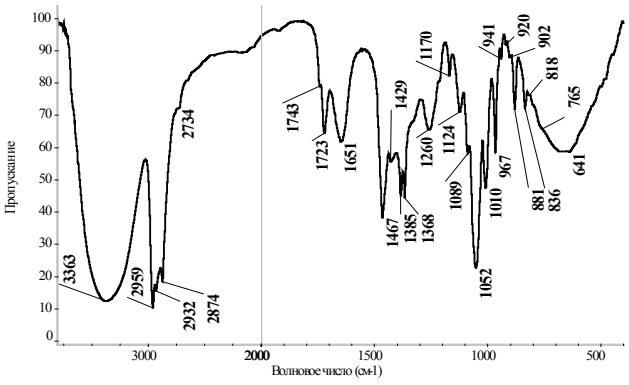


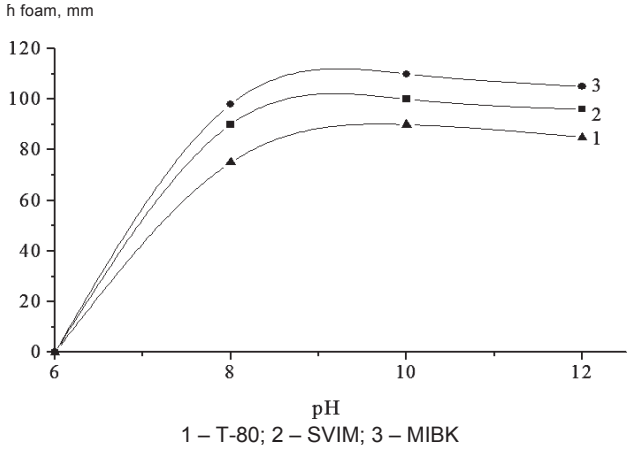
Figure 2- The infrared absorption spectrum of the sample with SVIM

The correct choice of of foaming agent allows significantly increase of the flotation results. This is because the flotation velocity of recleaning in the foam and circulation of the solid phase is largely determined by the properties of the foam [4].

The necessity to select the of foaming agent is determined by its ability to change the proportion of physically adsorbed molecules in sorption layer of the collector [5]. Stabilization of the flotation foam is caused mainly due to the hydrophobic solid phase. Adsorption on of foaming agent on particle-free areas of the bubble surface allows increasing foam strength of [6-8].

It was conducted investigations to establish the foaming ability of newly synthesized foaming agent Svim in comparison with traditional foaming agents MIBK and T-80 in a special unit.

Foaming ability of reagent was determined as follows: from the original foaming solution was prepared 1 % solution. This solution was used to prepare foams. For this purpose portion of the foam solution (10-12 ml) was poured into a foam generator, which was connected to microcompressor and bubbled through the previously cleaned and humidified air solution. When a certain amount of foam was achieved air supply was stopped. Foam and liquid volume in the foam was measured every 15-20 seconds. Then was calculated multiplicity of the foam for each foaming agent. The foaming ability of foaming agent Svim was determined foam volume of two-phase foam at different pH. Its stability depends on the consumption of reagents in comparison with MIBK and T-80. Investigation of the properties of the new foaming reagent Swim-TA (Figure 3) shows that Swim in comparison with T-80 has higher foaming capacity, but less than MIBK.



1 – T-80; 2 – SVIM; 3 – MIBK

Figure 3 – Foaming ability of Swim, MIBK and T-80- reagents depending on pH

Selection of methyl isobutyl ketone (MIBK), that is widely used in Russia and foreign countries, is due to the ability of a water soluble reagent that does not have sharp or unpleasant smell, form a fragile mobile foam due to the isomeric structure of molecules and the presence in the composition of the polar oxygenate hydroxyl groups CH_3-CHOH-CH_2- CH $(CH_3)_2$, at the same time imparting high adsorptive activity and effective foaming properties [6]. Another advantage of MIBK (another name isohexyl alcohol or 4-methyl-2-pentanol), recognized as a very promising reference foaming agent is self-purification of reservoirs when it hits in residual amount. However MIBK concedes on flotation activity Swim, which may be associated with improved foaming properties and flotation activity of Swim under certain pH in comparison with traditional foaming agent T-80, which may be associated with the formation of uniformly loaded foams. They are quickly destroyed in the gutters, that can intensify flotation process by increasing the fixing strength of air bubbles on the surface of the mineral particles. However by oxidation and esterification of dried fusel oil in the presence of catalyst-sulfuric acid are forming hydrophobically optimal amount of hydrophilic groups providing approximately equal bubbles. These bubbles create favorable conditions for capturing of mineral particles in comparison with bubbles with polydisperse composition of basic reagents.

The obtained solution generating of foams increases with increase of pH (Figure 3). It has particularly strong position, starting from pH 6 and has a maximum value at a pH of 10 or more, which indicates that the foaming properties of the synthesized foaming agent fulfill the requirements to the flotation conditions by concentration of gold ores.

Table 4 shows the parameters characterizing the quality of the foams generated in a 1 % solution of foaming.

Table 4 – Parameters characterized the quality of foams generated in a 1 % solutions of foaming agents – SWIM, MIBK and T-80

Foaming agent	Volume V, ml	Multiplicity $K_{t=30\ c}$	Maximum capillary pressure in channels, Plateau $\Delta P_{max,}$	Dispersity аЧ	Surface tencion of solution, σ mN/m
SVIM	112	110	180	1,1	40,0
MIBK	118	155	190	1,3	39,4
T-80	100	180	168	1,0	41,0

Results and Discussion. The comparative laboratory tests of foaming agents MIBK and Swim on sulfide gold-arsenous ore of Balazhal (East Kazakhstan) deposits was carried out.

The ore contains: gold - 1.7 ppm, silver - 2.2 ppm, copper - 0.004 %, lead - < 0.02 %, zinc - 0.046 %, iron - 4.27 %, total sulfur - 1.88 % sulfur of sulphate - 0.12 %, arsenic - 0.37 %, silica - 58.9 %, total carbon - 1.79 % including carbon of the carbonate - 1.15 %.

Rational analysis to determine the form of finding gold in the ore deposits Balazhal shows: in ore milled to a particle size 80.5 % with class 0.074 mm (0.044 mm class contains 63.0 %) contained 20.35 % of the free gold. In which connection 19.19 % is free gold with a clean surface. The splices contain 46.52 % of gold. Moreover with sulfide minerals is associated 29.65 % of gold and with the rock - 3.48 %. Gold grains with size of 0.025-0.05 mm are prevailing. Gold grains have clean surface, are cloddy, acicular, dendritic and coated with oxide films.

Investigation of ore flotation of Balazhal deposit. For investigations of the flotation was used reagent modes, using the following reagents:

– isobutyl xanthogenate (dry, activity 84.5 %).

– MIBK (methyl isobutyl carbinol, isohexyl alcohol, 2-methylbutanol-4, oily liquid, 100 % activity).

– copper sulfate $CuSO_4 \cdot 5H_2O$ (copper sulfate pentahydrate), actyvator. Content of basic (copper sulfate pentahydrate)-96-98 %.

– betamin C – polyglucoside, food grade, powder or granules, depressor. The content of the basic substance - 97,0 %. It has a complete solubility in water.

In flotation practice of similar gold-bearing ores are widely used as collectors-isobutyl and diisobutyl xanthogenates and aerofloats [9]. Therefore for comparison of experiments on flotation of sulfide ores of Balazhal deposit was used isobutyl xanthogenate.

The priority is the ore milling operation to 80.5 % of the class -0,074 mm, since in this case in the flotation concentrate is extracted maximum amount of gold - 82.35 %. In the flotation practice are noted a good floatability of sulfides and free gold with natural pH in the basic flotation operations [10]. Pyrite and arsenopyrite are effectively floated at pH = 8. In weakly acidic medium (pH=6.5-6.8) exists a difference in the oxidation of arsenopyrite and pyrite.

At aeration they oxidized by atmospheric oxygen. Moreover arsenopyrite loses floatability quickly than pyrite. In this article an effective flotation of sulfides at pH = 8.4-9.0 is established.

For the purpose of activation of sulfides (pyrite, arsenopyrite) was tested the effect of copper sulfate for depression carbonaceous minerals and polyglucoside Betamin C. A full assessment of actions of investigated foaming agents carried out on the developed technological scheme allowing obtaining final tailings for gold content. Scheme of trials in a closed loop is shown in Figure 4, the results of closed trials - in Table 5. Moreover it was carried out the fractional flow of reactants.

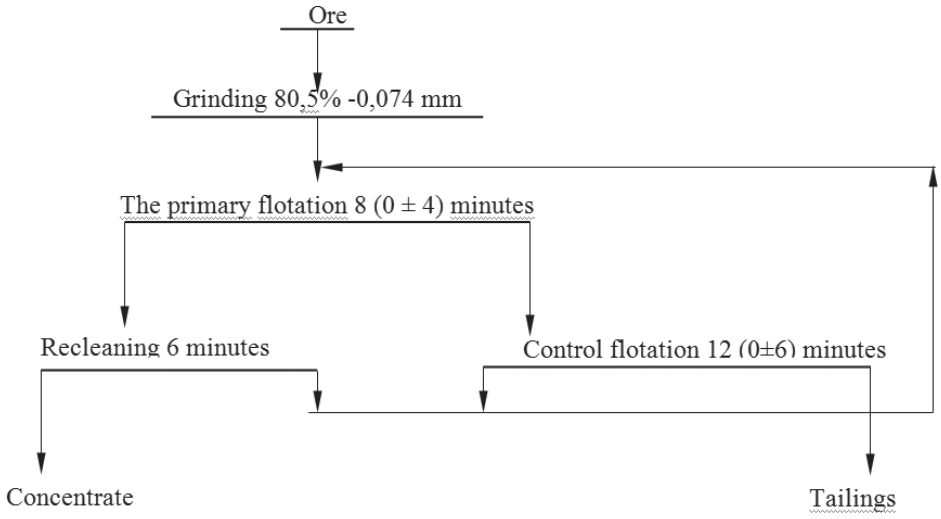


Figure 4– Scheme of ore flotation of Balazhal deposit in a closed loop

The results of investigation in closed loop confirmed that flotation of sulfide gold-arsenous ore of Balazhal (Eastern Kazakhstan) deposit with the usage of new foaming agent SVIM can effectively replace MIBC in the flotation of similar sulfide gold ores.

It is shown that application of a foaming agent Swim increases gold content to 6.9 ppm. Wherein gold recovery in gold concentrate amounts 94.81 % and is 0.74 % higher than MIBK. Thus the total cost of blowing agents are as follows: MIBK - 140 ppm, SVIM-160 ppm.

Thus, the new foaming agent SVIM in comparison with base foaming agent are low-cost and more flotation active because of the optimal ratio of hydrophilic-hydrophobic balance in its molecule.

Table 5 – Results of trials of flotation separation of gold from ore Balazhal deposit with different foaming agents in a closed cycle

Name of the product	Outlet, %	Content, ppm, %		Extraction, %		Condition of trials
		Au	As	Au	As	
Trial Concentrate	6,96	23,3	4,36	94,07	87,87	Primary flotation: time – 8 (0±4) minutes; pH – 8,4; Betamin C – 50+50 ppm; $CuSO_4$ – 250+200 ppm; isobutyl xanthogenate – 90+70 ppm; MIBK–60 + 40 ppm. Control flotation: time – 12 (0±6) minutes; $CuSO_4$ – 50+50 ppm; isobutyl xanthogenate – 30+30 ppm; MIBK – 20+20 ppm. Recleaning: time – 4 minutes
Tailings of dump	93,04	0,11	0,045	5,93	12,13	
Ore	100,0	1,72	0,35	100,0	100,0	
Trial Concentrate	5,32	30,2	5,82	94,81	88,61	Primary flotation: time – 8 (0±4) min; pH – 8,42; Betamin C – 50+50 ppm; $CuSO_4$ – 250+200 ppm; isobutyl xanthogenate – 90+70 ppm; SVIM –60 + 60 ppm. Control flotation: time – 12 (0±6) minutes; $CuSO_4$ – 50+50 ppm; isobutyl xanthogenate – 30+30 ppm; SVIM – 20+20 ppm. Recleaning: time – 4 minutes
Tailings of dump	94,68	0,1	0,042	5,57	11,39	
Ore	100,0	1,7	0,35	100,0	100,0	

Conclusions. It carried out works on synthesis new foaming agent SVIM from из averaged and fusel oil dried in a pilot installation R-620 (Selecta, Spain). It was investigated its physicochemical properties, conducted laboratory trials on the flotation of gold-bearing ores with their application. Also it was investigated foaming properties of new foaming agent SWIM at different pH and depending on the consumption of reagents in comparison with MIBK and T-80. It is shown that SWIM in comparison with MIBK has lower foaming properties and in comparison with T-80 its foaming ability is higher. However, in spite of this Swim in comparison with basic foaming agents has increased flotation activity due to the formation of bubbles with approximately the same size.

Comparative laboratory trials were carried out on the flotation of sulfide gold-arsenous ore of Balazhal deposit (East Kazakhstan) with the usage of foaming agents MIBK and SVIM. A full evaluation of actions of investigated foaming agents was carried out by developed technological scheme allowing obtaining of final tailings on the minimum content of gold. In this case the fractional flow of the reactants was carried out. The results showed that by the usage of SVIM gold content in the concentrate is increased to 23.3 ppm to 30.2 ppm. The gold recovery in gold-containing concentrate is increased by 0.74 % in comparison with MIBK and amounts 94.81 %.

At the same time, total expenditures of foaming agents amounted: MIBK - 140 ppm, SVIM -160 ppm. Thus, the reagent SVIM enables significantly increase of the quality of concentrate. The gold recovery is at the level of basic foaming agents.

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ТҮЙІНДЕМЕ

Талғар және Айдабұл (Астаналық) спиртзауыттарының қалдығы болып саналатын сивуха майынан көбіктендіргіш СВИМ-ді пилотты қондырғыда синтездеудің технологиялық параметрлері және олардың беттік қасиеттері анықталды. Жаңа реагентердің физикалық-химиялық қасиеттері зерттелінді және оларды алтын құрамды кендерді байытуға қолдана отырып зертханалық тәжірибелер жүргізілді. Балажал кенорнындағы (Шығыс Қазақстан) сульфидті алтын-күшән құрамды кеннің флотациясына МИБК және СВИМ көбіктендіргіштерін қолдану арқылы зертханалық тәжірбиелер жүргізілді. Кеннің құрамында төмендегідей заттар анықталды: алтын – 1,7 г/т, күміс – 2,2 г/т, мыс – 0,004 %, қорғасын – <0,02 %, мырыш – 0,046 %, темір – 4,27 %, жалпы күкірт – 1,88 %, сульфат күйінде күкірт – 0,12 %, күшән – 0,37 %, кремний қос тотығы – 58,9 %, жалпы көміртек – 1,79 %, соның ішінде карбонатты көміртек – 1,15 %. Балажал кенорнындағы кенді -0,074 мм класты 80,5 %-ға ұнтақтап (-0,044 мм кластың мөлшері 63,0 %- құрады) рационалды талдау жүргізгенде шыққан нәтижелер: бос күйіндегі алтын - 20,35 %, соның ішінде 19,19 % алтын таза бетті. Жанасқан алтын – 46,52 %; сульфид минералдарымен ассоциацияланған - 29,65 %, бос жыныспен ассоциацияланған - 3,48 %. Алтынның дәндерінің 0,025-0,05 мм өлшемі басым. Алтынның таза беттегі пішіні түйіршік тәріздес, ал тотық қабыршықпен қапталған алтын ине тәріздес, дендритті. СВИМ-нің көбіктүзгіштік қабілеттілігі мен флотактивтілігінің жоғары болуы құрғатылған сивуха майын күкірт қышқылы катализаторы қатысында тотықтырып және этерификацияға ұшыратқанда оңтайлы гидрофобты-гидрофилді топтар шамамен бірдей өлшемді көпіршіктер түзілуін қамтамасыз етуіне байланысты түсіндіруге болады. Мұндай көпіршіктер базалық реагенттердің полидисперсті құрамды көпіршіктерімен салыстырғанда минералдардың беттеріне оңай жабысуға мүмкіндік туғызады. Нәтижесінде СВИМ - ді қолданғанда, алтынқұрамды концентраттағы алтынның үлесі 6,9 г/т жоғарылады, ал оның бөлініп шығуы МИБК- мен салыстырғанда 0,74 % артты.

Түйінді сөздер: сивуха майы, көбіктендіргіштер, көбіктендіргіш қабілеттілігі, алтынқұрамды кен, флотация.

РЕЗЮМЕ

Отработаны технологические параметры синтеза вспенивателя СВИМ из сивушных масел Талгарского и Айдабульского (г. Астана) спиртзаводов на пилотной установке и определены его поверхностные свойства. Изучены физико-химические свойства нового реагента, проведены лабораторные опыты по обогащению золотосодержащих руд с его применением. Проведены лабораторные опыты по флотации на сульфидной золотомышьяковистой руде месторождения Балажал (Восточный Казахстан) с использованием вспенивателей МИБК и СВИМ. В руде содержится: золота – 1,7 г/т, серебра – 2,2 г/т, а также, %: меди – 0,004, свинца – <0,02, цинка – 0,046, железа – 4,27, серы общей – 1,88, серы сульфатной – 0,12, мышьяка – 0,37, двуокиси кремния – 58,9, углерода общего – 1,79, в том числе углерода карбонатного – 1,15. По результатам рационального анализа на определение форм нахождения золота в руде месторождения Балажал установлено, что в руде, измельченной до крупности 80,5 % класса -0,074 мм (содержание класса -0,044 мм – 63,0 %) содержится, %: 20,35 – свободного золота, причем 19,19 – свободное золото с чистой поверхностью. Формы нахождения золота, %: в сростках – 46,52, с сульфидными минералами ассоциировано – 29,65, с породой ассоциировано – 3,48. Преобладают зерна золота размерами 0,025-0,05 мм. Форма зерен золота с чистой поверхностью комковатая, а зерен золота, покрытого окисными пленками – игольчатая, дендритная. Улучшение пенообразующей способности и флотоактивности СВИМ может быть связано тем, что при окислении и этерификации осушенного сивушного масла в присутствии катализатора серной кислоты образуются оптимальные количества гидрофобно-гидрофильных групп, обеспечивающие приблизительно одинаковые пузырьки. Такие пузырьки создают благоприятные условия для захвата минеральных частиц, по сравнению с пузырьками полидисперсного состава базовых реагентов. Результаты показали, что при использовании СВИМ содержание золота повышается на 6,9 г/т, а извлечение золота в золотосодержащий концентрат увеличивается, по сравнению МИБК на 0,74 %.

Ключевые слова: сивушное масло, вспениватели, пенообразующая способность, золотосодержащая руда, флотация, обогащение.

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