STUDIES OF THE PROCESSES OF PHYSICAL AND CHEMICAL DESTRUCTION OF HARD ROCKS BY VARIOUS SOLUTIONS OF SURFACTANTS

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ABSTRACT

At modern mining enterprises in the Republic of Uzbekistan and abroad, an open method for the development of deposits of ore minerals is widely used. It is actual to apply various chemical reagents, surfactants that allow intensification of the mine-tunneling in geologically complicated mountainous areas of Uzbekistan in the near future i.e. increase in the productivity of technical means, detection of the cracks, development of the methods for softening hard rocks and improvement of its technical and economic indicators.

In the research work, the solubility of seven surfactants in tap water at temperatures of 20÷60^o C was studied. It was found that the solubility of all surfactants increases when the temperature of water rises, except for the surfactants Calcium Alkylbenzenesulfonate (insoluble) and Sobstock, which showed no noticeable changes in solubility.

The study of the effect of adsorption decrease in the strength of rocks, due to the appearance or existence of free surface energy at the solid-liquid interface during the adsorption of surfactant molecules and ions from solution to intensify the process of destruction and dispersion of rocks and save energy and material resources, is very promising.

Scope of the results.The obtained results are recommended to be used in the field of adsorption decrease in the strength of hard rocks using oligomeric surfactants.

PURPOSE OF THE STUDY. The simplest and the most cost-effective way of changing the properties and state of a rock mass is its physical and chemical treatment with aqueous solutions of surface-active substances (surfactants) and electrolytes. This effect is based on the decrease in strength by means of adsorption, which makes it possible to reduce the energy costs for the destruction of rocks.

KEYWORDS: various chemicals, surfactants, crack detection, aqueous solution of surfactants, adsorption strength reduction, surface tension, refractive indices of solutions.

INTRODUCTION. One of the most important tasks of mining industry, which needs to be solved in the near future, is the tunneling of mountainous areas in the complicated geological conditions of Uzbekistan, is the use of various chemical reagents, surfactants, which make it possible to intensify the mine-tunneling, i.e. increase the productivity of technical means, detect the presence of cracks, develop methods for softening hard rocks and improve its technical and economic indicators.

In the 30s of the XX century, the outstanding scientist chemist Academician P.A. Rehbinder began to study the performance of solid surfaces and purposefully set the task of regulating and controlling its properties, which in the 60s led him to make the greatest discovery about the possibility of surface destruction due to chemical interaction and adsorption decrease in the strength of solid surfaces with the help of surfactants (surfactant) [1].

The simplest and most economical way to change the properties and state of a rock mass is its physical and chemical treatment with aqueous solutions of surface-active substances (surfactants) and electrolytes. This effect is based on the adsorption reduction of strength, which makes it possible to reduce the energy costs for the destruction of rocks. The study of the effect of the adsorption reduction of free surface energy at the solid-liquid interface during the adsorption of surfactant molecules and ions from solution to intensify energy and material saving during the destruction and dispersion of rocks is extremely promising [2].

Aqueous solutions of surfactants intensify the processes of destruction of rocks, contributing to an increase in drilling speed, a decrease in tool wear and strength of the rocks being destroyed, etc. Aqueous solutions of surfactants in the mining and coal industries began to be used only in recent decades. To further improve the efficiency of using aqueous solutions of surfactants in mining, further laboratory studies of the processes of physical and chemical destruction of hard rocks by solutions of surfactants and electrolytes, and assessment of the degree of molecular affinity between surfactants and rock are necessary. The choice of a surfactant solution with optimal properties should be carried out using indicators that reflect the process of physicochemical interaction of surfactant and rock at the interfacial boundary, as well as the magnitude of the suspension effect, sedimentation time and soak time.

METHODS. In this work, the solubility of seven surfactants in tap water at temperatures of 20–60 ^{0}C was studied. It was found that the solubility of all surfactants increases with increasing temperature, except for the surfactants Calcium Alkylbenzenesulfonate (insoluble) and Sobstock, in which there were no noticeable changes in solubility[3].

The surface tension of all studied surfactant solutions at concentrations of 0.0–0.4% (g/100 g of solution) decreases with increasing concentration from 72 mN/m in water to 30–35 N/m, the strongest decrease in a is observed in solutions of geronol CF -8201 and geronol V -87 and the smallest decrease in σ- in solutions of OP-10 .

The refractive indices of solutions of all studied surfactants in the concentration range of 0.0÷0.025% do not change, then with increasing concentration they increase almost linearly in solutions of "OP-10" and "Sobstock", and in other cases *n* increase non-linearly.

The results of studying the characteristics of surfactants (CF -8201, CF-8901, OP-10, FF / 4, V-87 and Sobstock) with increasing concentration are shown in Fig. 1-6.

For the surfactant solutions ofCF -8901 in the concentration range of 0.0÷0.4%, a monotonous increase in the *pH* of the solution is observed, while in the Sobstock solutions a maximum *pH value is detected*. In the remaining solutions of the studied surfactants, a minimum is observed in the dependence of *pH* on concentration: for solutions of geronol V -87 at ~ 0.12%, for CF - 8201 at ~ 0.07%, for FF /4 at ~ 0.2% and for OP -10 at ~0.23%, respectively. The behavior of the electrical conductivity of the studied surfactant solutions depending on the concentration is similar to the concentration dependence of *pH* .

RESULTS. The paper studied the moisture absorption of six types of rocks (limestone, pink granite, granite, gray granite, marble and dolomite) in surfactant solutions. It showed that dolomite has the maximum water absorption and porosity, and marble has the minimum. Among the three types of granite, gray granite has the highest water absorption and porosity. In limestone, these parameters are less than in granites, but more than in marble.

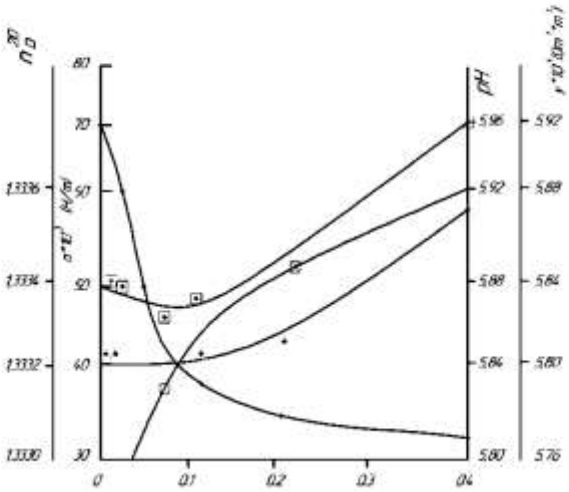


Fig. 1. Change in surfactant characteristics (CF-8201) with increase

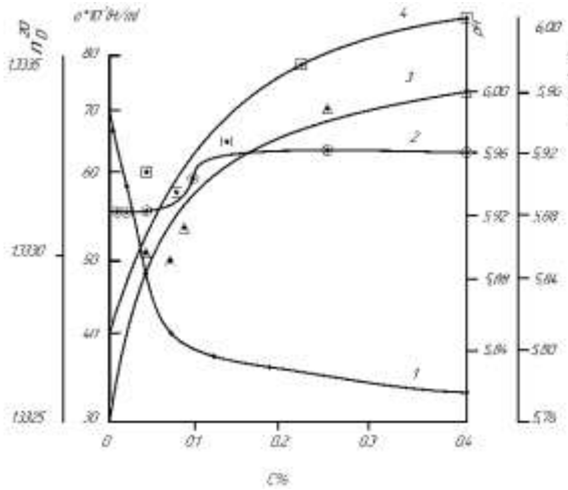
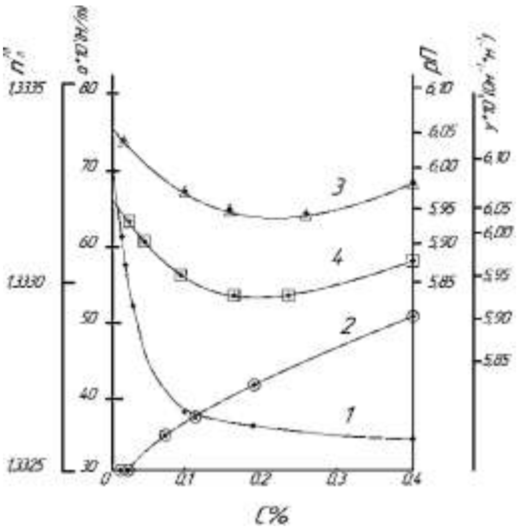


Fig. 2. Changes in surfactant characteristics (CF-8901) with increasing concentration: 1 - surface tension



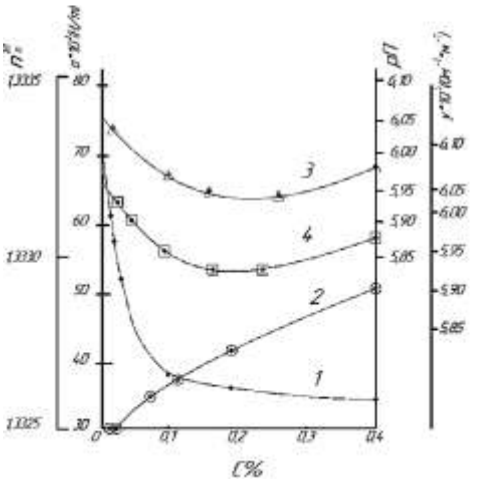


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Fig. 3. Changes in the characteristics of surfactants (OP-10) with increasing concentration: 1 - surface tension (σ), 2 - refractive index (p), 3 - hydrogen index (pH), 4 - electrical conductivity (γ).

Fig. 4. Changes in surfactant characteristics (FF / 4) with increasing concentration: 1 - surface tension (σ), 2 - refractive index (p), 3 - hydrogen index (pH), 4 - electrical conductivity (γ).

Comparison of dry and water-saturated (tap water) states of samples of six rocks showed that the compressive strength in the water-saturated state decreases in limestone by 16%, pink granite by 28%, granite by 2.5%, gray granite by 4%, marble by 8 .4% and dolomite by 64% [4].

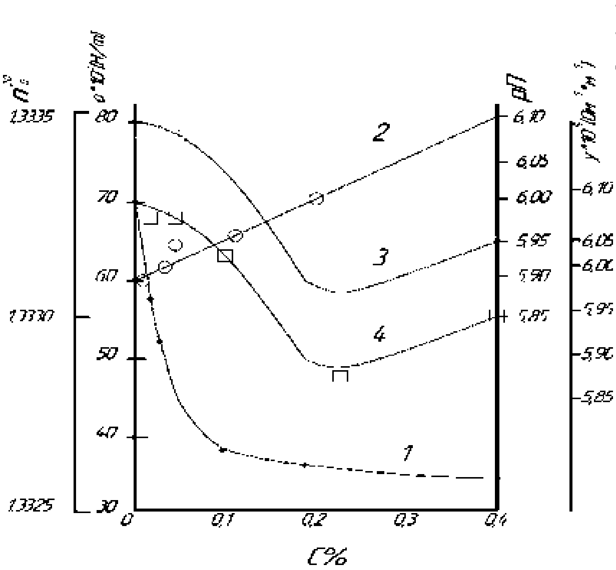

Fig. 5. Changes in surfactant characteristics (V-87) with increasing concentration: 1 - surface tension (σ), 2 - refractive index (n), 3 - hydrogen index (pH), 4 - electrical conductivity (γ).

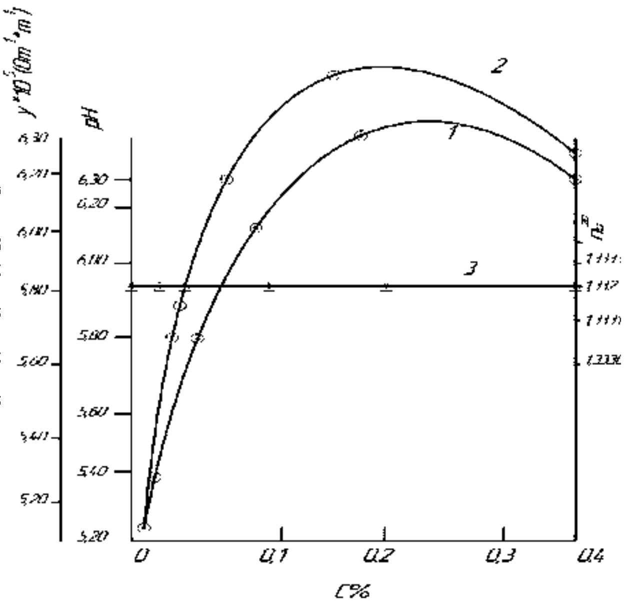

Fig. 6. Changes in surfactant characteristics (Sobstock) with increasing concentration: 1 - surface tension (σ), 2 - refractive index (n), 3 - hydrogen index (pH), 4 - electrical conductivity (γ).

The decrease in compressive strength of surfactants saturated with aqueous solutions of 0.1% concentration of rock samples for limestone is greatest in the CF -8201 solution (38%), in the FF /4 solution and in the Sobstock solution about 25%; for pink granite in solution V -87 about 43%; for granite in the V-87 solution, about 17% and in the Sobstock solution, about 18%; for gray granite in, solution V -87, OP-10 and "Sobstock" about 18%; for marble, on the contrary, an increase in strength is observed in all surfactant solutions; for dolomite, the most dramatic decrease in strength is observed in all surfactant l solutions from 40% in Sobstock solutions to 77% in CF -8201 solutions.

For limestone, the best strength reducers are 0.1% solutions of the emulsifier CF -8201 and Sobstock ; for pink granite - 0.1% solution of emulsifier V -87; for granite - 0.1% solutions of emulsifier V -87 and " Sobstock "; for gray granite - 0.1% solutions of the emulsifier V -87, OP-10 and Sobstock ; for dolomite - 0.1% solutions of any of the six surfactants, but 0.1% solutions of emulsifier V -87 have the greatest effect ; for marble - all six types of surfactants increase its strength.

The study of the work of the suspension effect showed that the greatest suspension effect with a solution of all surfactants is obtained for marble. If we compare the suspension effect with a solution of each surfactant separately for each type of rock, we observe that CF -8201 solutions give the maximum suspension effect with limestone and pink granite; solutions CF -8901 - with gray granite and marble; solutions OP-10 - with marble, dolomite and limestone; solutions FF /4 - with gray granite, marble and pink granite; solutions V -87 - with marble and gray granite; Sobstock solutions - with gray granite. The smallest suspension effect is observed for solutions of OP-10 with gray granite; for mortars V -87 with limestone and mortars CF -8201 with gray granite.

The dependence of the coefficient of surface tension of aqueous solutions of surfactants on the concentration of CF -8201, CF-8901, OP-10, FF / 4 and V-87 is shown in Fig. 7 and fig.8.

CONCLUSIONS. In this work, it turned out to be a difficult task to detect the effect of surfactants on the physical properties of rocks by ultrasonic methods due to the large attenuation of USW at frequencies above 10 MHz and multiple reflections of an ultrasonic pulse at the boundaries of microcracks and microcavities. As a result, the interference of multiply reflected ultrasonic waves propagating inside the sample leads to a violation of the regularity of echo signals on the oscilloscope screen, which makes it impossible to carry out ultrasonic measurements [5–7]. Thus, in order to conduct reliable ultrasonic studies, it is necessary to switch to lower frequencies (of the order of 0.2÷1MHz) at which the wavelength is noticeably larger than the characteristic sizes of microcracksand microcavities.

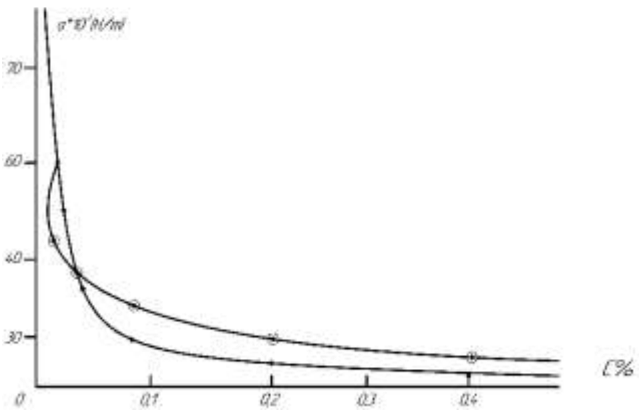

Fig.7. The dependence of the surface tension coefficient of aqueous solutions of surfactants on the concentration: 1-CF-8201, 2-CF-8901

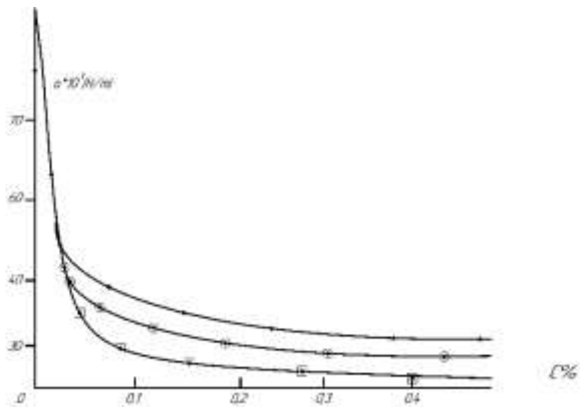

Fig.8. The dependence of the surface tension

coefficient of aqueous solutions of surfactants on th

e concentration:

1–OP-10, 2–FF/4, 3-V-87.

The study of the effect of adsorption reduction of strength of rocks, due to the appearance or existence of free surface energy at the interphase boundary solid-liquid during the adsorption of molecules and ions of surfactants from solution to intensify the process of destruction and dispersion of rocks and save energy and material resources is very promising [8].

The experimental studies presented by us in the field of adsorption decrease in the strength of hard rocks with the use of oligomeric surfactants is a continuation of the works known before us and a logical addition to the ideas. The solved problems of works known to us before us were the scientific grain for formulating the provisions submitted for defense, which, in particular, were:

- The use of the physico-chemical method of destruction, i.e. Reducing the strength of hard rocks by surfactant solutions during the operation of tunneling machines provides a significant reduction in energy consumption, wear resistance and an increase in the service life of drilling and cutting tools.
- Use oligomeric surfactants obtained on the basis of local raw materials, which today are waste and secondary resources for the chemical and food industries of the republic.
- Describe the possible proposed chemical scheme of the interaction of aqueous solutions of oligomeric surfactants with the surface of solid rocks and the compounds formed at the sites of cracks.
- Saturation of rocks with solutions of surfactants and oligomeric surfactants provides a corresponding decrease in strength characteristics by 1.6-3.2 times and surface energy by 3.5-7.5 times.

REFERENCES

[1] Edelstein O.A., Shobolova L.P., Makarov Yu.S. Changes in the properties of rocks under the influence of adsorption-active media. On Sat. Issues of managing the state of the mountain range. 1984, M, You p.224, S.80-86.

[2] Khalimov I., Sharafutdinov U.Z., Yuldoshev A.S., Avezova D.A. Modeling of processes of underground leaching, hydraulic fracturing and clogging. Mountain Bulletin of Uzbekistan. No. 2 (81) 2020 From 8-11.

[3] Alikulov Sh.Sh. Khalimov I.U., Khamidov S.B., Alimov M.U. Intensification of the parameters of underground leaching of uranium from low-permeability ores on the example of uranium deposits. UNIVERSUM: TECHNICAL SCIENCES. 2020, pp. 57-62.

[4] Turaev AS, Zhiyanov AB, Buriev Sh.U. Study of the influence of the ratio of the sample height to its diameter on the strength and deformation properties of rocks. Mountain Bulletin of Uzbekistan. №1 (80) 2020 C . 18-21.

[5] Norov Yu.D., Nasirov U.F., Mislibaev I.T., Zhiyanov A.B. Technique for studying

the weakening of the strength of rocks under repeated loads . Mountain Bulletin of Uzbekistan. No. 3 (58) 2014. C 61-63.

[6] Mislibaev I.T., Zhiyanov A.B., Jabbarov M., Zairova F.Yu. Methods of research on the weakening of the strength of a rock mass during the production of mass explosions. Mountain Bulletin of Uzbekistan. No. 3 (58) 2014. C 58-60.

[7] Mislibaev I.T., Zhiyanov A.B., Zairova F.Yu. Analysis of studies of fatigue fracture of rocks under multicyclic loads. Mining Bulletin of Uzbekistan No. 1 (56) 2014, pp. 20-22.

[8] Zhiyanov A.B., Buriev Sh.U., Razhabboev I.M. , Karshiboev Sh.B. Ways of intensification of underground leaching of uranium from hard -to-recover ores of deposits of Uzbekistan. Bulletin of science and education. No. 15(93) 2020. pp. 16-18.