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STUDY OF THE ABILITY OF THE STRAIN *ACIDITHIOBACILLUS FERROOXIDANS COAL 17* TO COAL DESULFURIZATION

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Volatile sulfur compounds, such as SO_2, H_2S, SO_3, belong to the group of the most toxic substances that are constant and noxious pollutants of the atmosphere. Sulfur dioxide is mainly formed as a product of combustion of fossil fuels containing sulfur. According to the statistics 50 to 70 million tons of sulfur is emitted to the atmosphere in the world each year [4, 5].

Most often coals contain pyritic and organic sulfur. As a result of oxidation these coals may also include elemental and sulfate sulfur. The predominant impurity of coal is inorganic sulfur, which can be removed by physical methods. The remaining organic sulfur can be eliminated by chemical methods, which are very expensive, or by heat processing using the temperature at which sulfur bonds break up. Heat processing also allows the removal of pyritic sulfur [4, 5].

Recently, a new solution for the challenge of the elimination of organic and inorganic sulfur from coal has been presented. It is based on the use of bacteria. The relevant processes run in ambient temperature and under ambient pressure, which makes this approach attractive and profitable. The method is based on the ability of autotrophic bacteria to oxidize the reduced forms of sulfur and to transform them into soluble, easy-to-wash-out compounds. The most frequently used species of such bacteria are *Acidithiobacillus ferrooxidans, Acidithiobacillus thiooxidans* and *Acidithiobacillus acidophilus* [4, 5].

Bacterial activity depends on the specific characteristics of applied species of microorganisms, coal type and content, available surface area of the substrate, temperature, pH value, and the quantity of bacteria per unit of coal mass. The time for biodesulfurization varies from a few months, for coal extracted in dumps, to a few days when the refined form of coal is stirred in the medium ensuring bacterial growth.

The research is aimed to study the ability of pure culture of *Acidithiobacillus ferrooxidans Coal 17* to desulfurization of coal from mine "Chervonogradska" (Chervonograd, Lviv region, Ukraine).

Materials and methods. In our study, we used strain *Acidithiobacillus ferrooxidans Coal 17*. The wide range of pH values (2-5) in which these bacteria are active, their exceptional tolerance to heavy metals, low temperatures they require and the fact they are autotropic make it possible to use them for a large industrial processes. The additional advantage of the proposed approach is the formation of ferric sulfate that is an active oxidant of many sulfide minerals and allows extraction of many metals including rare ones. The indication of biological desulfurization of coal from the mine "Chervonogradska" using the strain *Acidithiobacillus ferrooxidans Coal 17* was the object of the study. The experiments were carried out using the media that were recommended for cultivation of acidophilic bacteria (table 1) [1, 2, 3]. The initial content of sulfur in coal was 2.6-2.8 %%. The results of desulfurization were defined as a significant decrease in the percentage of sulfur content in coal compared to the initial level.

Table1

Composition of nutrient media

Component	Lethen medium	9K medium	Modified 9K medium
$(NH_4)_2SO_4$	0,15	3,0	0,2
KCl	0,0	0,1	0,1
KH_2PO_4	0,1	0,5	0,1
$MgSO_4 \cdot 7H_2O$	0,5	0,5	0,4
$Ca(NO_3)_2 \cdot 4H_2O$	0,01	0,1	0,0
Yeast extract	0,0	0,0	0,2

In addition to these cultural media, FeSO4×$7H_2O$ was used as an energy source in a concentration of 44.5 g/L (to Lethen and 9K media), 25.0 g/L (to modified 9K medium), and 15.0 g/L (to Lethen medium). Also, the solid/liquid phase ratio (S: L) had been varied from 1: 5 to 1:10. Investigation of the intensity of the bacterial desulfurization process was carried out at pH ≤ 2,0 and at a temperature of 30,0 ± 2,0 °C during 7 days under standard conditions.

Results. The obtained results indicate that the maximum quantity of *Acidithiobacillus ferrooxidans Coal 17* (7.3 ± 0.9 × 105 CFU/ml) was reported when using the Lethen medium which contained 44.5 g/L of ferrous sulfate and with the solid/liquid phase ratio of 1:10 (table 2). Similarly, pretty high levels of *Acidithiobacillus ferrooxidans Coal 17* (6.8 ± 0.5 × 105 CFU/ml, 5.3 ± 0.23 × 105 CFU/ml and 5.3 ± 0.4 × 105 CFU/ml) were registered when using 9K and modified 9K media (test indices Var4, Var5, Var6).

Table 2

Indicators of the desulfurization process effectiveness when using known cultural media

Test indices	Combinations of nutrients, energy sources and phase ratios	Measured indicators	
		CFU/ml	S(%)
Var1	Lethen medium, S: L = 1: 5, $FeSO_4 \times 7H_2O$ = 15,0 g/dm^3	1,5 ± 0,4×10^5	1,85
Var2	Lethen medium, S: L = 1: 5, $FeSO_4 \times 7H_2O$ = 44,5 g/dm^3	1,9 ± 0,07×10^5	1,9
Var3	Lethen medium, S: L = 1: 10, $FeSO_4 \times 7H_2O$ = 44,5 g/dm^3	7,3 ± 0,9×10^5	1,7
Var4	9K medium, S: L = 1: 5, $FeSO_4 \times 7H_2O$ = 44,5 g/dm^3	5,3 ± 0,4×10^5	1,99
Var5	9K medium, S: L = 1: 10, $FeSO_4 \times 7H_2O$ = 44,5 g/dm^3	5,3 ± 0,23×10^5	1,95
Var6	Modifie 9K medium, S: L = 1: 5, $FeSO_4 \times 7H_2O$ = 25,0 g/dm^3	6,8 ± 0,5×10^5	1,4

However, after 7 days of cultivation, the quantity of the microorganisms declined significantly in all variants. For instance, for the variant of the experiment which was showing the maximum figures before (Var3), the decrease in the number was more than 2 orders of magnitude (5,3 ± 0,2 × 103 CFU/ml). For Var4, Var5 and

Var6 a significant decrease was also observed, too (5,0 ± 0,03 × 103 CFU/ml, 4,8 ± 0,03 × 104 CFU/ml and 3,2 ± 0, 1 × 104 CFU/ml, respectively).

According to the results of the study, it can be said that strain *Acidithiobacillus ferrooxidans Coal 17* shows the ability to desulfurization of coal and it can be used to develop the industrial technology of biodesulfurization. It may be that additional steps of coal cleaning would be required after the bioitechnological processing, but the usage of such technology has significant positive economical impact to the overall process of coal treatment.

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