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Synergetic Effect Of Bactericidal Action Of Borates In Solutions Of Synthetic Detergents.

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ABSTACT

The work is devoted to the research of the effect of ethylene diamine tetra acetic acid on the antimicrobial properties of lithium mono borates ($LiBO_2$), sodium mono borates ($NaBO_2$) and potassium mono borates (KBO_2) in the composition of the detergent solution MS-8 with 30 g/l concentration used for cleaning parts during machine repair. Antimicrobial activity of MS-8 solution is negligible. In 14 days the solution is affected by microorganisms and their concentration reaches 10^4 cells/ml. The addition of the investigated borates increases the antimicrobial activity of MS-8 solution and with the addition of sodium mono borate with 30 g/l concentration increases its service life up to 41 days. The ethylene diamine tetra acetic acid was used in the work in order to increase the bactericidal action of borates. When adding sodium mono borate and ethylene diamine tetra acetic acid with concentrations 30 and 1 g/l respectively MS-8 solution is affected by microorganisms only on the 61st day. At the same time, the main characteristics of the cleaning solution do not change significantly throughout the entire antimicrobial action of the preparations. The synergism of the action of mono borates and ethylene diamine tetra acetic acid when used together is associated with the increase in the lytic effect of microbial cells as a result of the water-soluble complexes with Ca^{2+} and Mg^{2+} formations extracted from membrane cells. The research results recommend the investigated composition for improvement the working conditions of workers, increase the service life of solutions of synthetic detergents for cleaning parts, cleaning baths of washing plants, cleaning of solution supply systems, spray nozzles from operational deposits, including microorganisms while additional disposal methods of the waste solution are not required.

Keywords: microbiological pollution, solutions of synthetic detergents, antimicrobial additive, lithium, sodium and potassium mono borates, ethylene diamine tetra acetic acid, synergism.

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INTRODUCTION

The increase in human economic activity led to the change in the physical and chemical characteristics of the biosphere [1]. As a result, the risk of micro organisms exposure to human health has dramatically increased. Many industrial materials and products in the course of operation are exposed to the destructive action of microorganisms – mold fungi, yeast, bacteria, etc., which are widespread in nature. Almost everything that surrounds us is exposed to microbial destruction: metal, concrete, glass, stone, rubber, leather, asphalt, textiles, plastics, coolant, solutions of synthetic detergents (SSD), etc. [2].A special type of corrosion is appeared – «BIOCORROSION» (from Greek bios – life and Late Latin corrosio – corrosive) - destruction of structural materials and anti-corrosion protective coatings under the influence of microorganisms present in the environment, the main factor of development of which is functioning in the environment and on the surface of metal microorganisms (bacteria, fungi) [3].Biological damages, reducing the persistence and resource of mobile equipment and structures cause significant economic and environmental damage, leading to the change in the appearance of the product or material, the violation of their most important operational characteristics [4]. The problem of bio-damage is classified as ecological one [5].

In connection with the expansion of the application scope of various materials the issue of ensuring their resistance to the action of microorganisms is becoming increasingly important.

According to [6] aqueous solutions of SSD when used are susceptible to microbiological damage. At the same time the technological, operational, physicochemical, and sanitary-hygienic properties of these solutions deteriorate, as a result of which the service life is sharply reduced or they become unsuitable for further use for their intended purpose. Asa rule, it is the defeat of SSD solutions by microorganisms leads to their gradual deterioration and premature replacement.

At bio infections the supply system of cleaning solutions, spraying nozzles are also clogged, it is possible the influence of microorganisms (especially mold fungi and yeast-like) on the health of workers (especially for people with reduced immunity, prone to allergic reactions) [7].

Microbiological contamination of water-based SSD solutions is one of the most serious threats to the safety of the technological process and ensuring the quality of the washing of metal parts during the repair of components and assemblies of mobile equipment for agricultural enterprises and the transport complex [8].

After a certain time of use of the antimicrobial additive microorganisms become addictive to it and its efficiency is lost [9], therefore, a constant work is underway to expand and update the range of additives used.

Chemical compounds that are used as an antimicrobial additive should have a broad spectrum of biocidal action and at the same time be of low risk to humans and their environment. In addition, they should be well combined with various materials and not cause corrosion processes protecting them from bio-damage.

In connection with the mentioned above, the search for effective measures to counter the bio-damage of various materials is one of the most important scientific and practical problems that human civilization solves throughout its existence.

The use of various biocides can significantly reduce the intensity of the activity of microorganisms and reduce the risk of biological damage [10]. It is known that the use of boric acid and some borates as antimicrobial preparations [11] which belong to the 4th class according to the degree of danger [12] and additional methods for utilization of the waste solution are not required.

The literature also contains information [13, 14] on the ability of some chemical reagents to increase the bactericidal activity of a number of substances, which is called the synergistic effect at which the maximum bactericidal activity of the agent is achieved.

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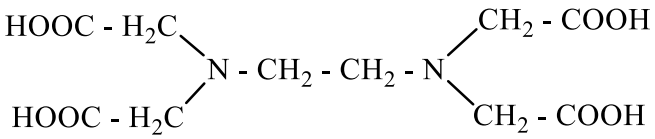
MATERIALS AND METHODS

Materials for experiments

This work is devoted to the study of the effects of ethylene diamine tetra acetic acid (EDTAA), the formula of which is:



on the antimicrobial properties mono borates of lithium ($LiBO_2$), mono borates of sodium ($NaBO_2$)and mono borates of potassium (KBO_2) in the composition of an aqueous solution of the detergent MS-8 with concentration 30 g/l.

The methodology of the experiments

The method for determining the bactericidal properties of mono borates of lithium, sodium and potassium is based on changing the chemical and physicochemical properties of SSD solutions under the influence of the vital activity products of microorganisms. Measuring these or other parameters, it is possible to judge the degree of biodegradation of the washing solution. It is often used the ability of some indicators to change the color of the liquid, depending on the enzymatic activity of microorganisms. This is the method using

2,3,5-triphenyltetrazolium chloride indicator which is used for the express control of biodegradation of SSD solutions [5].

At test 9 ml of MS-8 solution with 30 g/l concentration was poured into a test tube, 1 ml of 5 g/l tri phenyl tetra zolium chloride was added. The tube was placed in a thermostat at temperature of 35 ± 2°C. Every 24 hours the solution color degree was evaluated.

The assessment scale of coolant lesions by microorganisms is given in table 1.

Table 1: The assessment scale of lesion of SSD solutions by microorganisms

Solution color	Point	The number of microorganisms affecting the solution cells/ml
The emulsion has a natural color.	0	0
Slight coloration	1	to 10^4
Partially pink coloration	2	from $10^4$to 10^5
Red coloring of the volume	3	from $10^5$to 10^8
Cherry coloring of the volume	4	from $10^8$to infinity

RESULTS AND DISCUSSIONS

The test results of the microbiological lesion of MS-8 solution with 30 g/l concentration in the presence of borates are shown in Table 2.

As can be seen from Table, 2 the antimicrobial activity of MS-8 solution with 30 g/l concentration is negligible. In 14 days MS-8 solution is affected by microorganisms and their concentration reaches 104 cells/ml. In the result of bio-damage the main physicochemical properties of the washing solution deteriorate: the concentration of MS-8 solution decreases, the stability of the solution, its anti-corrosive properties and pH decrease, a sharp unpleasant odor appears and the color changes.

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Table 2: The bactericidal effect of lithium, sodium and potassium mono borates in the composition of MS-8 solution with 30 g/l concentration

The composition of the solution	Comparative assessment of lesion of the solution, score.									
	Days of observation									
	1-14	15	16-30	31	32	33	34-38	39	40	41
MS-8 solution with concentration 30 g/l	0	1								
MS-8 solution with concentration 30 g/l + + 10 g/l $LiBO_2$	0	0	0	1						
MS-8 solution with concentration 30 g/l + + 20 g/l $LiBO_2$	0	0	0	0	1					
MS-8 solution with concentration 30 g/l + + 30 g/l $LiBO_2$	0	0	0	0	0	1				
MS-8 solution with concentration 30 g/l + + 10 g/l $NaBO_2$	0	0	0	0	0	0	0	1		
MS-8 solution with concentration 30 g/l + + 20 g/l $NaBO_2$	0	0	0	0	0	0	0	0	1	
MS-8 solution with concentration 30 g/l + + 30 g/l $NaBO_2$	0	0	0	0	0	0	0	0	0	1
MS-8 solution with concentration 30 g/l + + 10 g/lKBO_2	0	0	0	0	1					
MS-8 solution with concentration 30 g/l + + 20 g/lKBO_2	0	0	0	0	0	1				
MS-8 solution with concentration 30 g/l + + 30 g/lKBO_2	0	0	0	0	0	1				

When lithium, sodium, potassium mono borates are added the service life of MS-8 solution increases and with the addition of sodium mono borate with 30 g/l concentration it is affected by microorganisms on the 41st day.

In combination with EDTAA, the term of the protective effect of borates in MS-8 solution with 30 g/l concentration is increased to 61 days (Table 3).

Table 3 - The bactericidal effect of lithium, sodium and potassium mono borates in the composition of MS-8 solution with 30 g/l concentration in the presence of EDTAA

The composition of the solution	Comparative assessment of lesion of the solution, score.									
	Days of observation									
	1-14	15	16-42	43	44	45	46-59	60	61	62
MS-8 solution with concentration 30 g/l	0	1								
MS-8 solution with concentration 30 g/l + + 10 g/l $LiBO_2$+ 1 g/l EDTAA	0	0	0	1						
MS-8 solution with concentration 30 g/l +	0	0	0	0	1					

+ 20 g/l $LiBO_2$+ 1 g/l EDTAA										
MS-8 solution with concentration 30 g/l + + 30 g/l $LiBO_2$+ 1 g/l EDTAA	0	0	0	0	0	1				
MS-8 solution with concentration 30 g/l + + 10 g/l $NaBO_2$+ 1 g/l EDTAA	0	0	0	0	0	0	0	1		
MS-8 solution with concentration 30 g/l + + 20 g/l $NaBO_2$+ 1 g/l EDTAA	0	0	0	0	0	0	0	0	1	
MS-8 solution with concentration 30 g/l + + 30 g/l $NaBO_2$+ 1 g/l EDTAA	0	0	0	0	0	0	0	0	0	1
MS-8 solution with concentration 30 g/l + + 10 g/lKBO_2+ 1 g/l EDTAA	0	0	0	0	1					
MS-8 solution with concentration 30 g/l + + 20 g/lKBO_2+ 1 g/l EDTAA	0	0	0	0	0	1				
MS-8 solution with concentration 30 g/l + + 30 g/lKBO_2+ 1 g/l EDTAA	0	0	0	0	0	1				

At the same time the main characteristics of the cleaning solution do not change significantly throughout the entire period of the antimicrobial action of the preparations.

According to [6], synergism of borate action using EDTA is associated with an increase in the lytic effect of microbial cells in the result of the water-soluble complexes formation with $Ca^{2+}$and Mg^{2+} ions extracted from membrane cells.

CONCLUSION

The research results prove that lithium, sodium and potassium mono borates with 30 g/l concentration in MS-8 solution have a relatively high bactericidal effect, but the presence of 1 g/l EDTAA increases the antimicrobial activity of mono borates in the washing solution in 1,5 times. Thus, the addition of the combination of sodium mono borate with 30 g/l concentration with EDTAA with 1 g/l concentration increases the service life of MS-8 solution with 30 g/l concentration up to the 61st day. All this allows us to recommend the investigated composition as an antimicrobial additive to improve the sanitary and hygienic conditions of workers, increase the service life of aqueous solutions of synthetic detergent for cleaning parts, cleaning of washing machines baths and installations, cleaning of the supply system of cleaning solutions, of spray nozzles from operational deposits including microorganisms, the additional methods of disposal of the waste solution is not required.

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