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INFLUENCE OF SURFACTANTS ON THE SCATTERING ABILITY OF SULPHATE ELECTROLYTES OF CADMIUM PLATING AND THE QUALITY OF CADMIUM COATINGS

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ABSTRACT
The effect of surfactants - calcium phenolate (phenolates of tertiary aminophenols), which has a significant size (1286 g/mol) and high activity (adsorbability) in electrolytes and has a positive effect on the scattering ability of the cadmium electrolyte, as well as on the quality of cadmium coatings was studied in this work. In the work, the usual parameters of the cadmium electrodeposition process, such as electrolyte composition, current density, temperature, and deposition time were used. The quality of the obtained cadmium coatings by using a new surfactant in the process of electrocrystallization of cadmium was determined on a JSM-6490LV scanning electron microscope with INSAEnergu energy dispersive microanalysis and HKL-Basic structural analysis systems with a useful magnification of 300.000.
Keywords: Surfactant, Scattering Ability, Electrolytic Cadmium Plating, Energy Dispersive Microanalysis.
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INTRODUCTION
An electrolytic zinc plating, cadmium plating and other types of coatings are widely used in electroplating. In this, obtaining the coatings with desired properties is an important task. Cadmium coating is the main type of coatings used to protect against corrosion of steel parts operated in all climatic condition, which is due to the combination of the universal properties of cadmium coatings such as high plasticity, solderability, good protective performance in combination with corrosion resistance in humid sea climates underground mines.[1-7]
It is known that during the flow of electrochemical reactions under conditions of metal electrodeposition, the reaction rates can be different in different parts of the electrode surface. This is largely determined by the current distribution (current density) on the electrode surface. The distribution of the current in the process of electrocrystallization is not always uniform and this leads to the fact that different values of the potential (E) are reached in different areas of the electrode surface, and, therefore, the deposition rates on the surface areas are different, while the treatment of individual areas of the electrode surface with coatings is different. In some areas of the electrode surface, electrodeposition takes place, while in other areas of the electrode surface this process does not take place.[8,9]
The electrolytes have high or low scattering power under electrodeposition conditions. Complex cyanide electrolytes usually have a high scattering power, which is highly toxic and expensive. Sulphuric acid electrolytes are simple in composition, available and cheap, and have a low scattering power.
In work[10] was studied the obtaining of aliminium metal matrix composite and was achieved the uniform distribution of ceramic particles on the surface of the material by friction stir processing. This method is used to improve the distribution of particles on the surface of studied materials.
In previous studies, we have investigated protective zinc coatings from acid electrolytes of zinc-plating[11] and the modification of the obtaining process of galvanic composite coatings based on zinc.[12]

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The purpose of the research is to modify the process of electrocrystallization of cadmium by increasing the scattering ability of the sulphuric acid electrolyte of cadmium plating, equipped with effective surfactants.

EXPERIMENTAL

The components for the preparation of the cadmium plating electrolyte were of the chemically pure grade, surfactant - calcium phenolate of considerable size (phenolates of tertiary aminophenols), the cathodes (steel plates) were mechanically treated with sandpaper of increasing numbers, degreased with a mixture of Eshka and soda, pickled in 0.1 N sulphuric acid solution, were dried in ethanol, the anodes were made of chemically pure cadmium (*KD-0*). Working current density is 0.5 - 3.5 A/dm^2, temperature is 20-30 °C. In order to establish the positive effect of the surfactant on the scattering ability of the electrolyte, a cell with a collapsible angular cathode was used.

On the measured surface of steel samples and a given current density (from 0.5 to 3.0 A/dm^2), the current strength was calculated and recorded on an ammeter. From the difference of the cadmium mass, deposited on the cathode surface and calculated theoretically according to Faraday's law, the current efficiency (CE) was calculated in %. The porosity of the coating was determined by the method described in[7]. A cell with a collapsible angular cathode was used to determine the scattering power of the cadmium plating electrolyte; a scanning electron microscope with 300.000 effective magnification, in combination with a *Varian ProStar* high-performance liquid chromatography, allows the identification of various impurities and inclusions in the investigated cadmium coating.

RESULTS AND DISCUSSION

Table-1 shows the indicators of the composition and appearance of cadmium coatings, obtained from the specified electrolyte, which does not contain surfactants, for 0.5 hours at the temperature of 20 °C.

Table-1: Indicators of the Quality of Cadmium Coatings, Obtained from Electrolyte without Surfactant

i_k, A/dm^2	CE, %	The appearance of cadmium coatings	Thickness, micron	The porosity of cadmium coatings	Microscope Indicators	
					Impurities in coating	% Cd in coating
1.0	94.6	Gray, coarse-grained	13.8	Porous	C, O, Fe, Si	86.4
2.0	94.9	Gray, coarse-grained	14.5	Porous	C, O, Si, Fe	84.20
3.5	94.7	Light gray, coarse-grained	11.6	Porous	C, O, Si, Fe	82.05

From the data in the table, it can be seen that in the range of studied current densities, the cadmium coatings are coarse-grained, porous and current efficiency (CE) of cadmium formation is low.

Figure-1 shows the structure of cadmium coating and the quantitative composition of the components in cadmium coating, obtained at the current density of 2 A/dm^2.

Element	Weight, %
O	4.07
Fe	10.42
Si	0.51
C	0.80
Cd	84.20

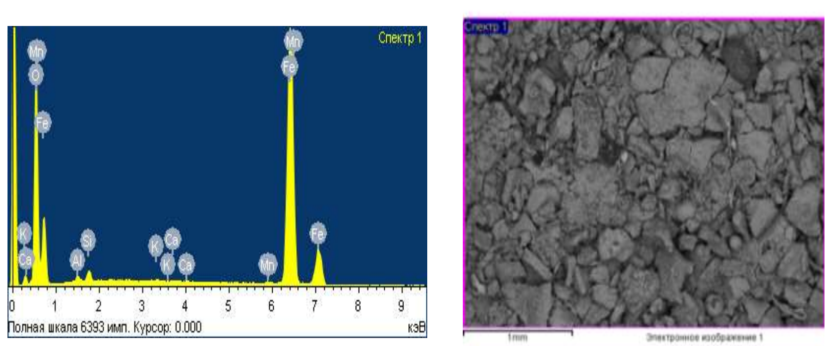

Fig.-1: Structure of Cadmium Coating and Composition of Impurities in the Coating without Surfactant

The figure shows the porosity of the cadmium coating, the shade of the cadmium coating is gray. Due to the low scattering power of the cadmium plating electrolyte, we see a coarse-crystalline cadmium coating. Such a porous cadmium coating, in the conditions of a marine climate and the humidity of underground mines, will not provide proper protection of metal products from corrosion.
Table-2 shows the indicators of composition and quality of the obtained cadmium coatings from specified electrolyte with the addition of surfactant (sodium phenolate) in the amount of 0.5 g/l.

Table-2: Indicators of the Quality of Cadmium Coatings, Obtained from Electrolyte with Surfactants

i_k, A/dm^2	CE, %	Appearance of cadmium coatings	Thickness, micron	Porosity of cadmium coatings	Microscope Indicators	
					Impurities in coating	% Cd in coating
1.0	98.2	Light, fine-grained	17.5	Non-porous	C, O, Fe, Si, S, P, Na	86.4
2.0	98.7	Light, fine-grained	19.5	Non-porous	C, O, Si, Fe, S, P, Na	84.20
3.5	98.4	Light, fine-grained	21.6	Non-porous	C, O, Si, Fe, S, P, Na	82.05

It can be seen from the table that, in the range of studied current densities, the cadmium coatings are light and non-porous. At the same time, the current efficiency of cadmium formation rises.
Figure-2 shows the structure of cadmium coating and the quantitative composition of components in cadmium coating, obtained at the current density of 2 A/dm^2.

Element	Weight, %
C	0.62
O	3.50
Si	0.21
Fe	2.70
S	3.0
P	1.20
Na	1.4
Cd	87.37

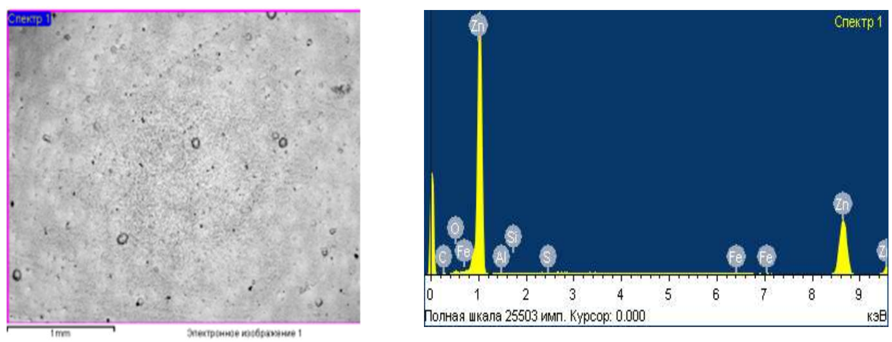

Fig.-2: Structure of Cadmium Coating and Composition of Impurities in the Coating with Surfactants

The figure shows that the cadmium coating is light, non-porous. In the composition of the coating, we see a certain amount of inclusions of sulphur and phosphorus. However, their inclusion, as can be seen, does not adversely affect the quality of cadmium coatings.[13]
The properties and quality of metal coatings, in particular cadmium, are determined not only by the structure, color, luster but also by the uniformity of metal distribution over the thickness of the surface of the coated products, which depends on the current density and the deposition time.[14,15] In order to confirm the stated assumption about the positive effect of surfactants on the quality of cadmium coatings, we carried out studies to establish the scattering ability of the investigated electrolyte with surfactants.
For determination and comparison of the hiding power of the cadmium plating electrolyte, we have chosen as a reference electrolyte sulphate-ammonium electrolyte of cadmium plating, the scattering ability of which is quite high.[16]
Based on the researches carried out, the regularities of distribution of current and metal from the compared electrolytes have been established and a graphical dependence of the metal distribution on different sections of the cathode was plotted depending on the current density (Fig.-3).
By the slope of the curves of Fig.-3, one can judge the scattering ability of the electrolyte. The smoother the slope of the curve (2) in the figure, the better the dissipation power of the electrolyte and vice versa, the curve (1). Consequently, the surfactant has a positive effect on the scattering ability of the cadmium electrolyte.

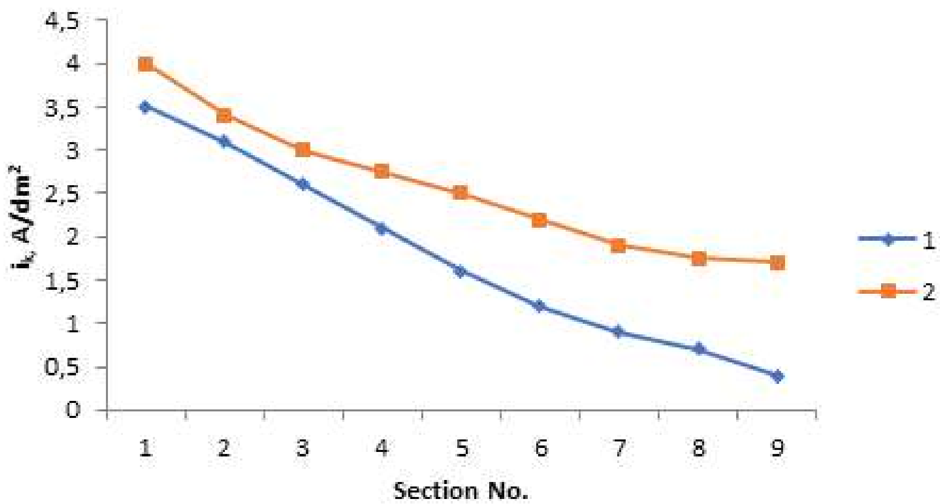

Fig.-3: Dependence of Section No. on the Current Density from the Electrolyte without Surfactant (Curve 1) and from the Electrolyte with Surfactant (Curve 2)

However, from the uniformity of the current distribution, one cannot judge the uniformity of the distribution of the metal, which is expressed by the ratio of the mass of deposited cadmium in the near section to the mass of deposited cadmium in the far section of the cathode (m_{near}/m_{far}). The distribution of the metal coincides with the secondary distribution of the current only when the metal yield in the near and far sections of the cathode is the same, i.e. when the current efficiency is practically independent of the current density, as shown in Fig.-4.

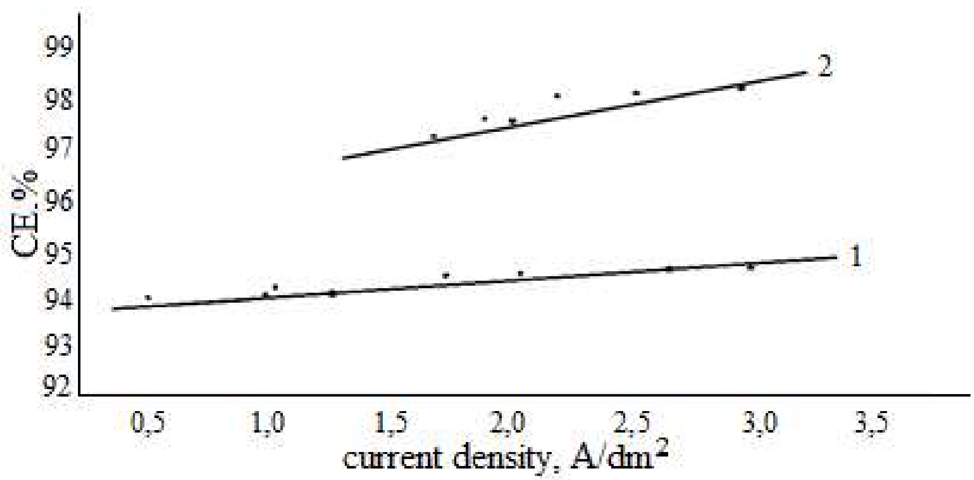

Fig.-4: Dependence of the Current Efficiency on the Current Density in the Electrolyte without Surfactant (Curve 1) and with Surfactant (Curve 2)

As can be seen from the figure, the current efficiency of cadmium practically does not change with increasing the current density; therefore, the distribution of the metal is in direct proportion to the distribution of the current. Due to the high value of the electrochemical potential of cadmium (2.1 g/A·h) in comparison with zinc, nickel, copper, when assessing the current density and current efficiency, the cadmium coating can be increased almost twice as soon as these metals, while having a high current efficiency of cadmium.

CONCLUSION

Based on the results obtained, the value of the surfactant in the cadmium plating electrolyte should be specially noted. Presumably, when they are adsorbed on the cathode surface, mainly in the region of the zero-charge potential, non-metallic impurities - hydrogen, carbon, sulphur, phosphorus and others present in the surfactant composition - can be included in the cathode deposit. The inclusion of non-metals in the cathode coating causes a violation of the process of their normal crystallization, the cathode coating becomes fine-grained, highly dispersed, and non-porous. The cathode coating becomes spongy, powdery in an excess of surfactants. The energy dispersive microanalysis of cadmium coatings, obtained at their low concentration in the electrolyte (0.1 g/l) as a result of their adsorption and reduction showed the inclusion of hydrogen, carbon and sulphur and phosphorus in the cadmium coating. Based on the fact that the sulphur in the surfactant molecule is in the sulphide state, the surfactant adsorption is even more enhanced.

So, the positive effect of surfactants on the quality of cadmium coatings, on the scattering ability of sulphate electrolyte of cadmium plating and on the current efficiency (CE) of cadmium formation has been established.

REFERENCES

1. Yu. M. Averina, N. P. Nyrkov, D. A. Shuvalov, N. A. Moiseeva and Yu. N. Kapustin, *Advances in Chemistry and Chemical Technology*, **32**, 14(2018)
2. D. A. Shuvalov, E. A. Arkhipov, N. S. Grigoryan, D. A. Zhirukhin, K. N. Smirnov and T. A. Vagramyan, *Advances in Chemistry and Chemical Technology*, **32**, 14(2018)
3. E. A. Arkhipov, N. S. Grigoryan, D. A. Shuvalov, D. A. Zhirukhin, K. N. Smirnov and T. A. Vahramyan, *Electroplating and Surface Treatment*, **26**, 4(2018)
4. N. A. Vysotskaya, B. N. Kabylbekova, A. A. Anarbaev, E. Dossayev, M. R. Karumbaeva and V. Zh. Sailau, Patent of the Republic Kazakhstan, 34703 (2020).
5. N.A. Vysotskaya, B.N. Kabylbekova, L.D. Aikozova, K.A. Bekzhigitova, International Conference "Industrial Technologies and Engineering" - 2020, Shymkent, pp. 115-119 (2020)
6. A. A. Nikiforov, K. N. Smirnov, D. V. Kravchenko, E. A. Arkhipov, L. I. Zakirova and S. S. Vinogradov*, Trudy Vserossiyskogo nauchno-issledovatel'skogo instituta aviatsionnykh materialov (VIAM) [in Russian: All-Russian Research Institute of Aviation Materials],* **12**, 48(2016), https://doi.org/10.18577/2307-6046-2016-0-12-12-12
7. N. A. Vysotskaya, B. N. Kabylbekova, K. Isabayeva and G. A. Bitanova, Auezov Readings -16: The Fourth Industrial Revolution: New Opportunities for Modernizing Kazakhstan in the Field of Science, Education, Culture, Shymkent, pp. 89-92 (2018)
8. V. L. Kubasov and S. A. Zaretsky, Fundamentals of Electrochemistry, Moscow, Chemistry, p.167 (2010).
9. V.M. Bayramov, Fundamentals of electrochemistry. Academy of Sciences of the Russian Federation, Moscow, p.280 (2005)
10. M. Rajaram Narayanan, S. Nallusamy. *Rasayan Journal of Chemistry,* **11(1)**, 355(2018), http://dx.doi.org/10.7324/RJC.2018.1112047
11. N. A. Vysotskaya, B. N. Kabylbekova, K.A. Bekzhigitova, L.D. Aikozova., G.M. Adyrbekova, L.A. Zhurhabayeva, and E. N. Abdulova, *Rasayan Journal of Chemistry,* **13(4)**, 1342(2020), https://doi.org/10.31788/RJC.2020.1335841
12. N. A. Vysotskaya, B. N. Kabylbekova, K. A. Bekzhigitova, R. Spabekova, K. T. Kurbanbekov, G. K. Ormanova, E. G. Lukin, *News of the Academy of Sciences of the Republic of Kazakhstan,* **3(435)**, 122(2019), https://doi.org/10.32014/2019.2518-170X.77
13. P. Abdurazova, Sh. Koshkarbayeva, M. Satayev, N. Dzhakipbekova and Y. Raiymbekov, *Rasayan Journal of Chemistry*, **13(1)**, 346 (2020), http://dx.doi.org/10.31788/RJC.2020.1315539
14. M.V. Pomogayev, V.M. Pomogayeva and A.V. Volkovich, *Practice of Corrosion Protection,* **2**, 28(2003)
15. M.V. Pomogayev, Doctoral Thesis, Scientific Institute of the Russian Chemical Technical University, Novomoskovsk, Russia (2004)
16. D.V. Kravchenko, Ph. D. Thesis, D. I. Mendeleyev Russian Chemical Technology University, Moscow, Russia (2018)

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