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ZINC COATINGS FROM ALKALINE ELECTROLYTES WITH SURFACTANTS

N.A. Vysotskaya[1], B.N. Kabylbekova[1,✉], G.M. Adyrbekova[2], A.S. Tukibayeva[1], R.S. Spabekova[3], A. Zh. Suigenbayeva[1] and L. D. Aikozova[1]

[1]M. Auezov South Kazakhstan University, /Department of Chemistry and the Basics of Chemical Technology, Tauke Khan av. 5, 160001, Shymkent, Kazakhstan

[2]M. Auezov South Kazakhstan University /Department of Chemistry, Tauke Khan av. 5, 160001, Shymkent, Kazakhstan

[3]M. Auezov South Kazakhstan University /Department of Physics, Tauke Khan av. 5, 160001, Shymkent, Kazakhstan

✉Corresponding Author: kabylbekova.b@list.ru

ABSTRACT

Alkaline-cyanide electrolytes of galvanizing have a good scattering ability, which creates conditions for obtaining high-quality zinc coatings due to the formation of soluble complexes of sodium cyanide and caustic sodium alkali, which can ensure the stability of the electrolyte and the constancy of the composition of the cyanide electrolyte. These conditions cause additional difficulties associated with regulating the composition of the electrolyte. The disadvantage of cyanide alkaline electrolytes of galvanizing is also a high sensitivity to a number of impurities in the electrolyte, the release of which is associated with difficulties. We have studied the effect of surfactants (thiourea derivative of dialkylphosphorous acids) on the scattering ability of an alkaline electrolyte capable of producing zinc coatings in the current density range of 0.5-3.5 A/dm^2, at a temperature of 20°C, with confirmation of the quality of the obtained coatings by energy dispersion and electron microscopic analysis on a JSM-6$_{490}$LV scanning electron microscope with INSAEnergu energy dispersion microanalysis and HKL-Basic structural analysis with a useful magnification of 300

Keywords: Cyanide Alkaline Electrolytes, Surfactants, Electrodeposition, Thiourea Derivatives, Microanalysis.

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INTRODUCTION

Zinc coatings with a fine shiny structure and a uniform distribution of metal on the surface of complex-profiled metal products are obtained from cyanide electrolytes with a high scattering ability.[1]

In alkaline non-cyanide electrolytes, the cathode polarization is weakly expressed and has a diffusive character, with a small value of the limiting current, represented by a value of the order of several millivolts (7-10 MV). In such conditions, there is no possibility of obtaining a high-quality metal coating.[2]

In modern electroplating, various techniques and methods are used to obtain high-quality metal coatings on metal and non-metal surfaces protected from corrosion. At the same time, researchers are trying to use non-toxic, affordable, inexpensive electrolytes containing zinc mainly in the form of complexes such as Na2 [Zn (OH) 4], stable in composition and capable of containing surfactants in their composition, of giving high-quality metal coatings, including zinc in a wide range of current density at low temperatures, but with high current efficiency.[3,4]

The recovery of zinc ions from alkaline electrolytes is controlled by the stage of electron transition (discharge); at the same time, the role of diffusion inhibition is also significant, which is in good agreement with the literature data.[5]

The authors[6-9] investigated the effect of surfactants containing thiourea on the quality of zinc coatings in acidic zinc electrolytes. It has been found to positively affect the quality of the coatings.

Purpose of the Study

The research aimed to obtain high-quality zinc coatings from alkaline electrolytes containing a thiourea derivative of dialkyl phosphorous acids and a mixture of this surfactant with a tin salt.

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EXPERIMENTAL

The main components of the zincate electrolyte were complex salt $Na_2[Zn(OH)_4]$ and free alkali NaOH. The electrolyte was prepared by dissolving freshly prepared zinc hydroxide in a hot alkali solution. Steel cathodes were degreased with soda, pickled with 0.1 N sulfuric acid solution, surfactant - thiourea derivative, anodes made of electrolytic zinc. Before the start of electrodeposition, the cathodes were weighed, and their surface was measured to calculate the current strength.

The theoretical mass of the deposited zinc was calculated according to the Faraday law. From the difference in the mass of zinc deposited and calculated theoretically, the current output (W) was calculated in%.

The installation for carrying out the electrodeposition process consisted of an electrolyzer, an ammeter, a rheostat, and a direct current source with a total voltage of 220V.

RESULTS AND DISCUSSION

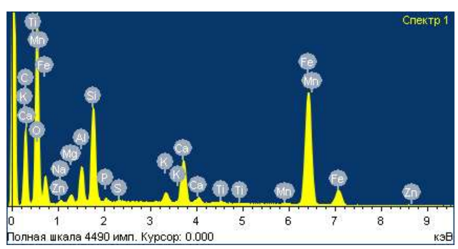
Table-1 shows the appearance of zinc coatings obtained from electrolyte without surfactant, wt. The obtained zinc coatings do not correspond to the required quality: coatings are spongy, coarse-crystalline, dark or gray, peeling off at high current densities, with burnt-on edges. Such a structure of zinc coating is not able to effectively protect metal products from corrosion; an aggressive environment will quickly cover the surface of the product through pores and destroy it. The current output is low (91-%).[6-9]

Figure-1 shows the weight% of elements in the coating and the appearance of the zinc coating obtained at a current density of 2 A/dm^2. As can be seen from the figure, the coating is dark gray, coarse-crystalline, loose, and porous.

Table-1: Indicators of the Quality of Zinc Coatings in Electrolyte without Surfactants

I_k, A/dm^2	t, ºC	C_{Zn}, %	Zinc Coating Appearance	Coating Thickness, microns
1	20	91,0	Dark, spongy, coarse crystalline	1,82
1,5	20	91,6	Dark gray, coarse crystalline	1,74
2	20	92,2	Dark gray, loose	1,70
2,5	20	90,7	Dark, along the edges of the burn	1,42
3	20	90,1	Dark, flaking	1,21
3,5	20	89,4	Dark, burnt	1,34

Element	Weight %
C	6.78
O	3.21
Si	0.33
Fe	10.54
Zn	79.14



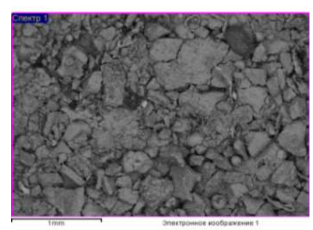


Fig.-1: Structure of Zinc Coating from Electrolyte without Surfactant

The additive understudy is readily soluble in water. Preliminarily, 0.5 g/l of additives were introduced into the heated water, dissolved and introduced into the electrolyte composition. Electrodeposition of zinc was carried out in a wide range of current densities. Zinc coating quality indicators are summarized in Table-2. Table-2 shows the appearance of zinc coatings obtained from an electrolyte with a surfactant - $(C_7H_{15}O)_2POH(S)C(S)(NH_2)_2$

Table-2: Indicators of the Quality of Zinc Coatings in Electrolyte with Surfactants

I_k, A/dm^2	t,ºC	Weight$_s$, %	Zinc Coating Appearance	Coating Thickness, mcm
1	20	96,4	Lightgray, loose	2,13
1,5	20	96,8	Light, withspots,	2,02
2	20	98,2	Light, coarse-crystalline	2,25

2,5	20	97,9	Light, loose	2,12
3	20	95,9	Light with burnt	2,12
3,5	20	94,8	Light, flakes off	2,08

The table shows that the presence of surfactants in the electrolyte has a favorable effect on the quality of the zinc coating. Although the zinc coating does not differ in fineness, it is light, an order of magnitude higher than its thickness. Pores in the coating are visible. It should be noted that the zinc current efficiency is significantly higher (98%).

Figure-2 shows the weight% of elements in the coating and the appearance of the zinc coating obtained at a current density of 2 A/dm^2. As can be seen from the figure, the coating is light, coarse-crystalline, loose, and, therefore, porous.

Element	Weight %
C	1.62
O	3.53
Si	0.21
Fe	1.79
S	4.0
P	3,65
Zn	85,2

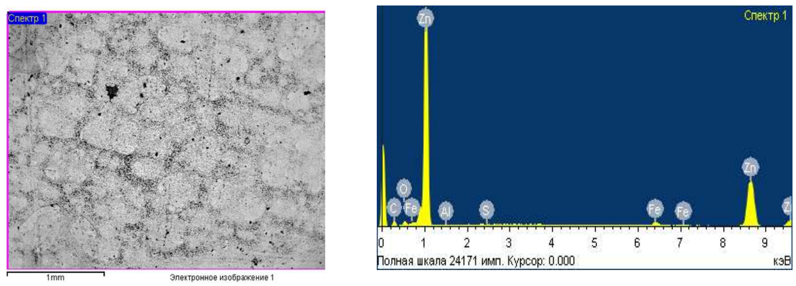


Fig.-2: Structure of Zinc Coating from Electrolyte with Surfactant at Current Density 2A/dm^2

Based on the research data in the literature[7-10], in order to obtain better zinc coatings, we added small amounts of sodium stannate salt (2.5 g/l) to the alkaline zincate electrolyte with surfactants.

The data of the obtained indicators of the quality of coatings are shown in Table-3.

Table-3: Quality Indicators of Zinc Coatings from Electrolyte with a Mixture of Surfactants, g/l:(0.5 surfactant + 2.5 Na_2SnO_2)

I_k, A/dm^2	t,^{o}C	Weight$_{Zn}$, %	Zinc Coating Appearance	Coating Thickness, mcm
1	20	96,2	Light, dense	2,18
1,5	20	96,9	Light, dense	2,22
2	20	98,6	Light, finecrystalline	2,71
2,5	20	97,1	Light, dense,	2,67
3	20	96,9	Lightgray, dense	2,39
3,5	20	95,5	Lightgray	2,38

From the indicators in Table-3 and Fig.-3, a significant improvement in the quality of the zinc coating can be seen. A light, denser coating with minor pores, zinc current efficiency, is practically the same.

Element	Weight, %
C	1.62
O	2.73
Si	0.51
Fe	1.79
S	3.8
P	2,15
Na	1,12
Zn	86.28

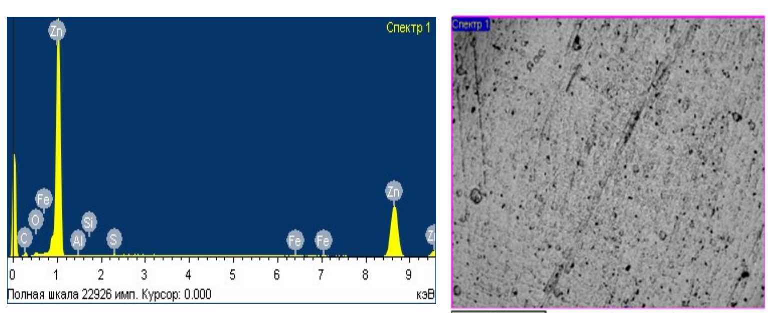


Fig.-3: Structure of Zinc Coating from an Electrolyte Containing a Mixture: (Surfactant + Sodium Stannate) at 2 A/dm^2

The test results at a different concentration of the surfactant mixture in the electrolyte are shown in Table-4.

Table-4: Quality Indicators of Zinc Coatings from Electrolyte with a Mixture of Surfactants, g/l:(1.5 Surfactants + 1.5 Na_2SnO_2)

I_k, A/dm^2	t,ºC	Weight$_{Zn}$, %	Zinc Coating Appearance	Coating Thickness, mcm
1	20	97,1	Light, dense with spots	2,01
1,5	20	97,8	Light, dense	2,14
2	20	98,9	Light, dense	2,62
2,5	20	97,6	Light, dense,	2,78
3	20	97,9	Lightgray	2,41
3,5	20	96,4	Lightgray	2,18

The quality indicators of the zinc coating in Table-4 are almost the same as those in Table-3; however, from Fig.-4 we see a picture of a denser zinc coating, non-porous.

Element	Weight, %
C	1.60
O	2.73
Si	0.51
Fe	1.79
S	4.1
P	2,17
Na	0,9
Zn	86.40

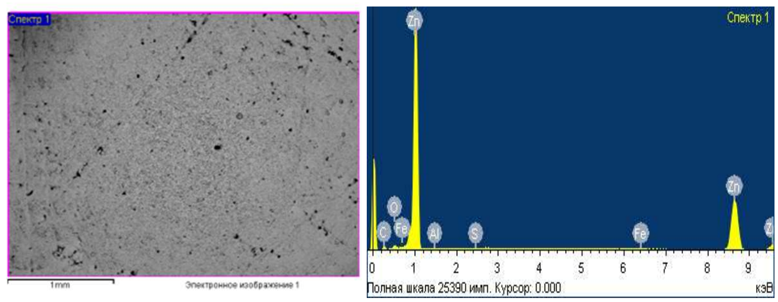


Fig.-4: Structure of Zinc Coating from an Electrolyte Containing a Mixture: (Surfactant + Sodium Stannate) at 2 A/dm^2

The value of surfactants in electrolytes for the processes of applying metal coatings to products in order to protect against corrosion is great. Many authors have established the adsorption of surfactants on the cathode surface, the incorporation of its components (H, C, P, S) into the cathode coating. Such introduction of non-metals into the coating cause's disruption of the crystallization process promotes the deposition of a fine-grained structure, and, consequently, improves the quality of the coating. Energy dispersive microanalysis of zinc coatings obtained at a certain concentration in the electrolyte of a mixture of surfactant and tin salt, the inclusion of hydrogen, carbon and sulfur and phosphorus, sodium in the coating is observed.

CONCLUSION

1. A positive effect of surfactants on the quality of zinc coatings in alkaline zincate electrolytes has been established.
2. A positive effect of the mixture (surfactant + sodium stannate) on the quality of zinc coatings has been established.
3. The positive effect of surfactants on the current efficiency (W) of zinc in alkaline zincate electrolytes has been established.

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