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Using of rust converters for deposition of anti-corrosion coatings

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ABSTRACT

This work is devoted to the study of phosphate coatings formed on the surface of iron samples from Tzinkar rust converter solutions manufactured in industry. The optimal conditions for the deposition of anticorrosion coatings from a solution of the Tzinkar rust converter in the presence of accelerators of nitrophenol, sodium m-nitrobenzosulfonate and hydroxylamine are determined. It was shown that the coatings deposited from Tzinkar the presence of an accelerator of sodium m-nitrobenzosulfonate with a concentration of 5 g/l at a deposition temperature of 40 °C and a deposition time of 10 min had the highest corrosion resistance. The corrosion resistance of such coatings is 180 s according to the Akimov method, while the corrosion resistance of coatings deposited from the phosphating solution FR under the same conditions is 25 s. The study of deposited anticorrosion coatings from Tzinkar solution was carried out using the EM method with OLYMPUS LEXTOLS 4100 microscope. The thickness of the coatings was determined using a thickness gauge of galvanic coatings Constant K6C. Coating strength was determined on a PosiTestAT. It was shown that the addition of 0.5 g/l m-nitrobenzosulfonate to the Tzinkar solution promotes the formation of a uniform fine-crystalline coating with the smallest thickness of 5.2 μm and the highest adhesion of 3.7 MPa with the surface of the iron sample in comparison with other accelerators.

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1. Introduction

Among the ways to obtain anti-corrosion coatings, phosphate solutions are most widely used due to their efficiency, economic feasibility and technological simplicity [1,2]. However, the use of phosphate anti-corrosion coatings becomes effective with appropriate preparation of the surface of metal samples, which include machining, degreasing, etching, and surface activation [3–5]. Unlike phosphating solutions used in industry, the use of rust converters, which allow obtaining anti-corrosion coatings with high protective ability and good adhesion, does not imply preliminary preparation of the surface of metal samples. This circumstance greatly simplifies the process of applying anti-corrosion coatings and is of particular interest. To successfully carry out the processes of phosphate films deposition with a high protective ability, phosphating accelerators of both oxidative and reducing effect are used [5,6]. It should be noted that the effect of accelerators when using rust converters for the preparation of protective anticorrosive coatings is not well understood. The aim of this work was to study the possibility of using rust converters produced in industry as solutions for the formation of phosphating coatings on the surface of iron samples and to compare them with known phosphating solution. The novelty of the work consists in the fact that the effect of phosphate accelerators on the corrosion resistance, thickness and adhesion of formed anticorrosion coatings in solutions of rust converters was first investigated.

2. Methods and materials

Corrosion-resistant coatings were deposited on samples of cold-rolled steel grade (Art. 08PS) using rust converter Tzinkar and phosphate solutions FR having the following composition:

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Table 1
Effect of phosphate accelerators on the corrosion resistance of phosphate coatings on an iron (08PS) substrate.

Phosphate solution	Accelerator	Accelerator concentration, (g/l)	Temperature of deposition, (t,°C)	Time of deposition (min)	Protective ability (corrosion resistance)(s)
FR	m-nbs	5.0	40	10	25
	nitrophenol	2.5	40	10	34
	hydroxylamine	5.0	40	10	110
	hydroxylamine	50.0	40	10	95
Tzinkar	m-nbs	5.0	40	10	180
	nitrophenol	2.5	40	10	110
	hydroxylamine	5.0	40	10	93

ZnO – 1.16 g/l; $NiNO_3 \cdot 6H_2O$ – 0.5208 g/l; HNO_3 – 0.614 ml; H_3PO_4 –1.472 ml; NaOH – 0.252 g/l. Nitrophenol, sodium m-nitrobenzosulfonate (m-nbs) and hydroxylamine were applied as phosphating accelerators. As samples were used sheets of cold-rolled steel grade (Art. 08PS). Metal plates were pretreated with abrasive material, followed by washing with distilled water.

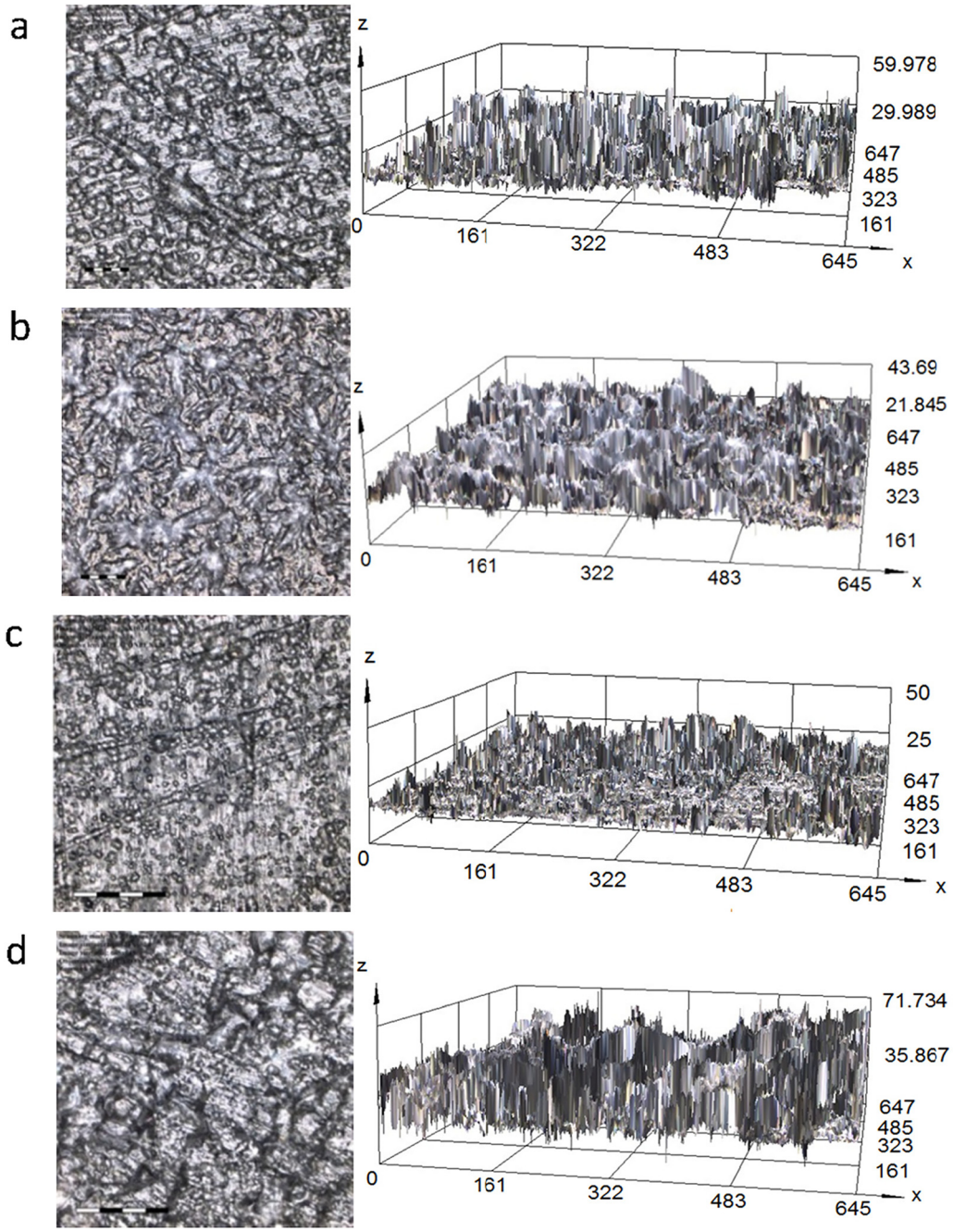

Fig. 1. 2d and 3d micrographs of iron samples without coating and with deposited phosphate coatings from Tzinkar solution in the presence of various accelerators. a – Tzinkar without an accelerator; Tzinkar in the presence of accelerators: (b) – m-NBS (5 g l); (c) – nitrophenol (2.5 g/l); (d) – hydroxylamine – (5 g/l).

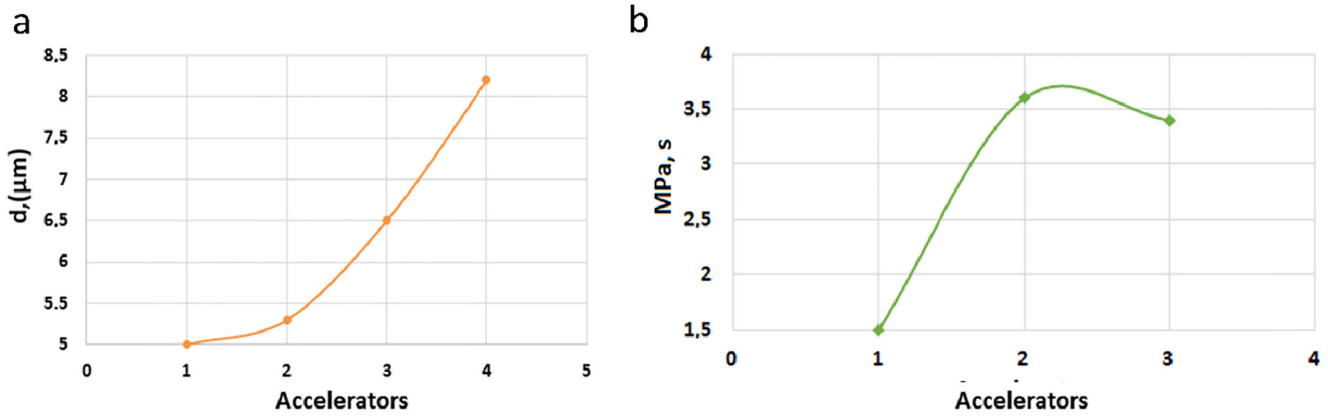

Fig. 2. (a) dependence of the thickness of the phosphate coating on the nature of the accelerator, without accelerators (1), m-NBS – 5 g/l (2), nitrophenol – 2.5 g/l (3), hydroxylamine – 5 g/l (4) (b) dependence of the phosphate coating adhesion strength on the nature of the accelerator, the composition of the deposition solution: Tzincar + nitrophenol (2.5 g/l) (1), Tzincar + m-NBS (5 g/l) (2), Tzincar + hydroxylamine (5 g/l) (3).

Phosphate coatings were precipitated at a temperature of 40 °C, a deposition time of 10 min, a stirring speed of 500 rpm. After coating, the plates were dried at a temperature of 120 °C for 20 min. Corrosion resistance of coatings was determined by the Akimov method [7]. The surface structure of iron samples with a phosphate coating was studied using an OLYMPUS LEXTOLS 4100 microscope. The thickness of the coatings was determined using a K6Ts galvanic coating thickness gauge. The adhesion strength of the coating was determined using a Posi Test AT digital adhesiometer.

3. Results and discussion

Table 1 shows the effect of phosphating accelerators of sodium m-nitrobenzosulfonate (m-nbs), nitophenol and hydroxylamine on the corrosion resistance of phosphate coatings on an iron substrate deposited from FR phosphate solutions and rust converter Tzinkar. Corrosion resistance by the Akimov method was determined under optimal conditions for the formation of phosphate coatings.

According to the data obtained in the phosphating solution of FR, the most significant effect on the corrosion resistance of the phosphate coating on the surface of iron samples is observed in the presence of hydroxylamine – 110 s with a concentration of 5 g/l, at a deposition temperature of 40 °C and a deposition time of 10 min. Sodium m-nitrobenzosulfonate (m-nbs) have the least effect on the corrosion resistance of phosphate coatings – 25 s., and nitrophenol – 34 s.

The effect of accelerators on the corrosion resistance of phosphate coatings obtained under similar conditions from the Tzinkar solutions used differs markedly in the corrosion resistance of coatings deposited from FR phosphate solution. In the presence of a phosphating solution nitrophenol corrosion resistance of the formed coating is 110 s, and in the presence of hydroxylamine – 93 s.

The effect of phosphating accelerators on the structure, thickness and adhesion of formed phosphate coatings in the Tzinkar solution was studied. Fig. 1 shows micrographs of the surface structure of iron samples with phosphate coatings deposited from solution in the presence of various accelerators under optimal conditions.

According to Fig. 1 the surface treatment of an iron sample with a Tzinkar rust converter in the absence of accelerators leads to the formation of an inhomogeneous surface with large particles (Fig. 1a). The corrosion resistance of the phosphate coating in this case is 75 s. With the addition of m-NBS to the Tzinkar solution, the surface of the formed coating becomes uniform with a smaller particle size (Fig. 1b). The corrosion resistance of the phosphate coating in this case is 180 s. In the presence of a nitrophenol accelerator, the formation of a fine-grained coating is observed, which is characterized by a more uniform particle size with a corrosion resistance of 110 (Fig. 1c). When hydroxylamine is added to the Tzinkar solution, a uniform coating with larger particles is formed (Fig. 1d). The corrosion resistance of such a coating is 93 s

The effect of the nature of accelerators on the thickness and adhesion of anticorrosion coatings from the Tsinkar solution was studied. Fig. 2 shows the effect of the nature of the accelerator on the thickness and adhesion of formable coatings from Tzincar solution under optimal deposition conditions.

According to Fig. 2, the nature of the accelerator has a significant effect on the thickness and adhesion of the formed anticorrosion coatings from Tzincar solution on the surface of iron samples. The smallest coating thickness (Fig. 2a) and the highest adhesive strength (Fig. 2b) are observed when using m-NBS as an accelerator.

4. Conclusion

Based on the data received, the possibility of using the Tzincar rust converters, produced in industry, as a phosphating solution for deposition phosphate coatings on iron substrates was found. It is shown, that nitrogen-containing compounds (nitrophenol, sodium 3-nitrobenzosulfonate and hydroxylamine) can be used as accelerators of the phosphating process in Tzincar solutions. However, the effect of phosphate accelerators on the corrosion resistance of phosphate coatings from Tzincar rust converter solution is significantly different from the corrosion resistance of coatings deposited from the RF phosphate solution.

CRediT authorship contribution statement

A. Bold: Supervision, Project administration, Writing - review & editing. **L.A. Fogel:** Conceptualization, Writing - original draft. **V.N. Statsyuk:** Investigation, Methodology. **L.R. Sassykova:** Investigation. **U. Sultanbek:** Investigation, Methodology, Formal analysis. **S. Ait:** Investigation, Methodology, Formal analysis. **Zh. Zh. Tilepbergen:** Investigation, Methodology, Formal analysis. **T.A. Vagramyan:** Investigation. **A.A. Abrashov:** Investigation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] I.A. Kazarinov, A.A. Makhmmod, N.M. Trepak, L.A. Isaicheva, Eurasian Union Scientists 3 (2016) 101–105.
[2] M. Tamilselvi, P. Kamaray, M. Arthanareeswari, S. Devikala, Appl. Surf. Sci. 327 (2015) 218–225.
[3] Y. Xie, M. Chen, D. Xie, L. Zhong, X. Zhang, Corros. Sci. 128 (2017) 1–8.
[4] D.N. Chandra, J. Surf. Eng. Mater. Adv. Technol. 3 (2013) 94–105.
[5] A.A. Abrashov, N.N. Chamashkina, G.A. Yur'eva, N.S. Grigoryan, T.A. Vagramyan, Electroplating Surf. Treat. 20 (2012) 7–12.
[6] V.N. Statsyuk, L.A. Fogel, A. Bold, U. Sultanbek, Zh. Tilepbergen, Rasayan J. Chem. 13 (2020) 339–345.
[7] State Standard (SS) 9.302-88. ESZKS. Metallic and Nonmetallic Coatings. Methods of Accelerated Corrosion Tests.