a

b

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 coat-

ing 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.