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Treatment of Paint-Containing Wastewater for Industrial Needs Using Electrochemical Method

R V Potolovsky^a, A A Sakharova^b, E V Moskvicheva^c, Y Y Yuryev^d,

V I Klimenko^e

Institute of Architecture and Construction Volgograd State Technical University,
400074, Akademicheskayast., 1, Volgograd, Russia

E-mail: ^atusera@mail.ru, ^bsax.nastya@yandex.ru, ^cviv_vgasu@mail.ru, ^dyuriy-yuriev@yandex.ru, ^evasa_klim@mail.ru

Abstract. The article proposed a method of purification of wastewater generated in the production process of water-dispersion paints and varnishes. After electrochemical treatment, purified water can be used at the enterprise for equipment washing, and after special preparation and in the production of water-dispersion paints and varnishes. Water is irreversibly used for the technological processes of preparing water dispersion paints and only the water used for washing the equipment and returnable packaging is discharged into the sewage system only after mechanical cleaning with a high content of dissolved organic substances.

Introduction

As is known, the composition of water-dispersion LKM includes numerous components of organic and inorganic nature, such as dispersions of copolymers with different (often complex) monomer composition, dispersants, organic and inorganic pigments and fillers, thickeners, defoamers, preservatives, antifreezes, and others. additives, which, in turn, are compositions consisting of a mixture of several organic compounds. Suspension, which is the wastewater after washing the paint equipment, is extremely stable to sedimentation thanks to the appropriate technology of grinding pigments and fillers.

The composition of paintwork materials contains anti-flocking additives that ensure the irreversibility of such a suspension for a long time. Such drains do not comply with sanitary norms and rules of their reception in the city sewer, and also create the danger of clogging of collectors and, as a result, a possible failure of the system of municipal drains. Solving the problem of wastewater treatment generated during the production of water-dispersion coatings is a difficult task [1]. In recent years, the question of the primary treatment of such wastewater has been resolved in some papers [2–13]. However, the question of the full involvement of pre-treated effluents in the circulating water supply of enterprises remains open.

Additional purification of wastewater is necessary before using them in the systems of recycling and recycling water supply of industrial enterprises [14].

The depth of the final treatment of wastewater used in the closed water supply systems of enterprises depends on the technological requirements for its quality indicators and in some cases these requirements may be less stringent than the quality of treated water before being discharged into water bodies.

In further studies, well-known recipes for water-dispersion LKM [15]. The content of organic substances in wastewater was estimated using IK-spectrum obtained on a IK- Fourier spectrometer



FCM-1201 with an MNPVO-36 prefix (a prefix of a multiple disturbed full reflection of the horizontal type with a zinc selenide cell) («Monitoring»). To analyze the purification efficiency, turbidity was measured using a HACH turbidimeter, type 2100AN. Turbidity was measured in NTU turbidity units.

Results

Based on the composition of the water fraction (Table 1), formed after the first (coarse) purification stage, the main part of the contamination is in the dissolved organic matter, but also in small quantities, there are suspended substances. The most acceptable for this type of wastewater is the use of electrolysis [16].

Table 1. Water fraction after mechanical sewage treatment

Pollutant name	Concentration, g / l	Turbidity, NTU
Foam		
Aluminosilicate hollow microspheres	20.5	-
Water fraction		
Na ₆ P ₆ O ₁₈	5.1	
C _{10.5} H _{21.0}	7.3	
ID-20	5.1	
CH ₂ O	0.4	485
TiO ₂	1.0	
Styrene-acrylic dispersion	0.7	
Sediment (coagulum)		
Styrene-acrylic dispersion;	57.0	
CaCO ₃	9.3	
TiO ₂	9.0	-
C _{10.5} H _{21.0}	0.05	

The electrochemical method involves the destruction of organic substances that occurs at the anode with the formation of first organic acids, and then carbon dioxide and water.

Purification of fine particles under the action of an electric field takes place with the destruction of the electrostatic stabilization of particles that aggregate.

The destruction of dissolved organic substances occurs under the influence of atomic oxygen formed in the anode space. The amount of atomic oxygen, and, consequently, the intensity of oxidation of organic substances depends on the current density. At low densities (below 100 A / m²), a significant part of oxygen is emitted as a gas and does not participate in oxidation.

When conducting experiments, special attention is paid to the choice of anode material since electrochemical treatment of wastewater will be carried out by oxidation of organic substances at the anode. The main difficulty in cleaning arises due to the fact that most metals are thermodynamically unstable under conditions of anodic polarization (their dissolution or passivation occurs). The main factor determining the suitability of a material as anodes is sufficient mechanical strength, ease of manufacture and chemical resistance to aggressive media.

It is known that the process of anodic oxidation of organic substances significantly depends on the pH of the medium [17].

The influence of the temperature of solutions as an accelerator of most chemical reactions is also great [18].

Thus, for the successful implementation of electrical treatment, an appropriate selection of the anode material and certain processing parameters: current density, effluent treatment time, temperature and pH of the medium is necessary [19].

To determine the magnitude of the oxidation potential of the dissolved organic substances, the current density and the anode material, polarization curves of the anode process were obtained. When removing the polarization curves, platinum, graphite, and stainless steel were used as the anode material. Studies were conducted on 8 model solutions containing inorganic and organic substances of the same concentration as in real effluents, and separate fractions of substances. The composition of the model solutions are presented in table 2.

Table 2. Composition of model solutions for studying the kinetics of the process of electro-oxidation of organic substances

№solution	The name of the components	Concentration, g / l
1	-Na ₆ P ₆ O ₁₈	5.1
	-C _{10.5} H _{21.0}	7.3
	-TiO ₂	1.0
	-Styrene-acrylic dispersion	0.7
2	-Na ₆ P ₆ O ₁₈	5.1
	-C _{10.5} H _{21.0}	7.3
	-ИД-20	5.1
	-CH ₂ O	0.4
	-TiO ₂	1.0
	-Styrene-acrylic dispersion	0.7
3	-Na ₆ P ₆ O ₁₈	5.1
	-CH ₂ O	0.4
4	-Na ₆ P ₆ O ₁₈	5.1
	-C _{10.5} H _{21.0}	7.3
5	-Na ₆ P ₆ O ₁₈	5.1
	-ИД-20	5.1
6	-C _{10.5} H _{21.0}	7.3
	-ИД-20	5.1
	-CH ₂ O	0.4
	-Na ₆ P ₆ O ₁₈	5.1
7	-Na ₆ P ₆ O ₁₈	5.1
	-ИД-20	5.1
	-TiO ₂	1.0
	-Styrene-acrylic dispersion	0.7
8	-Na ₆ P ₆ O ₁₈	5.1
	-CH ₂ O	0.4
	-TiO ₂	1.0
	-Styrene-acrylic dispersion	0.7

The polarization curves of the anode space were removed using the PI-50-1.1 potentiostat and are presented in figures 1-8.

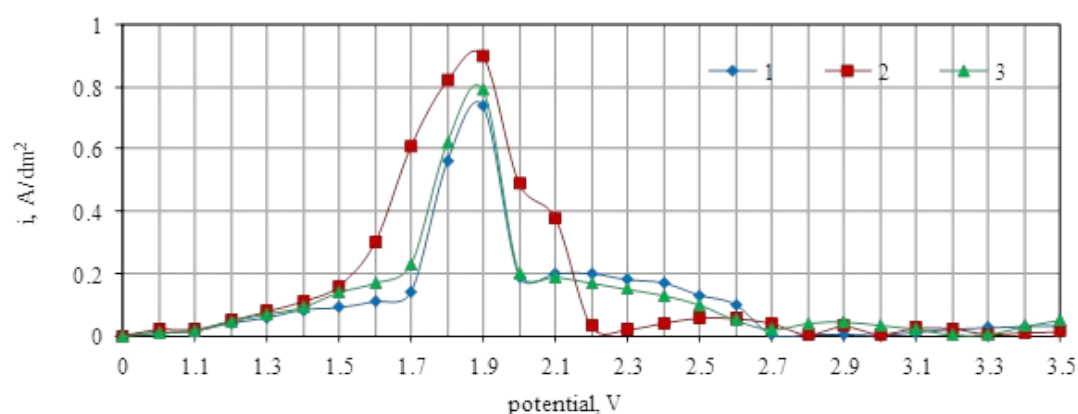


Figure 1. The dependence of the oxidation potential on the current density (model solution № 1): 1 - platinum anode; 2 - graphite anode; 3 - stainless steel anode

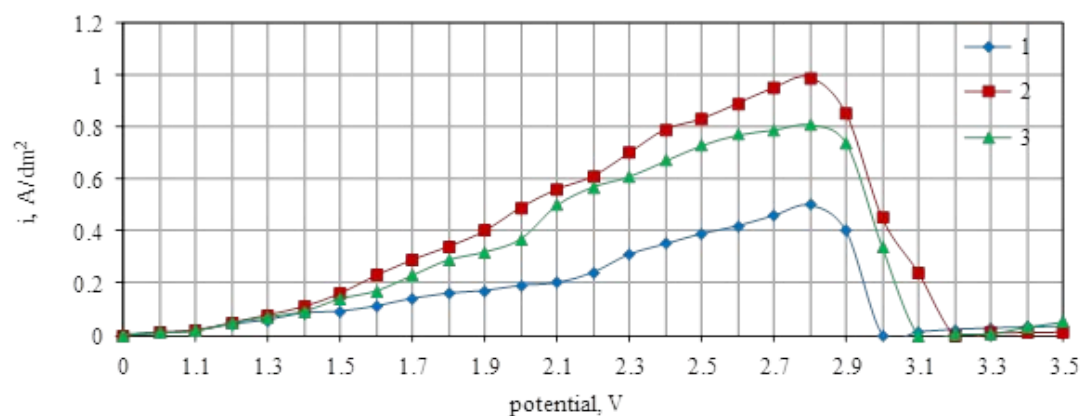


Figure 2. Dependence of the oxidation potential on the current density (model solution № 2): 1 - platinum anode; 2 - graphite anode; 3 - stainless steel anode

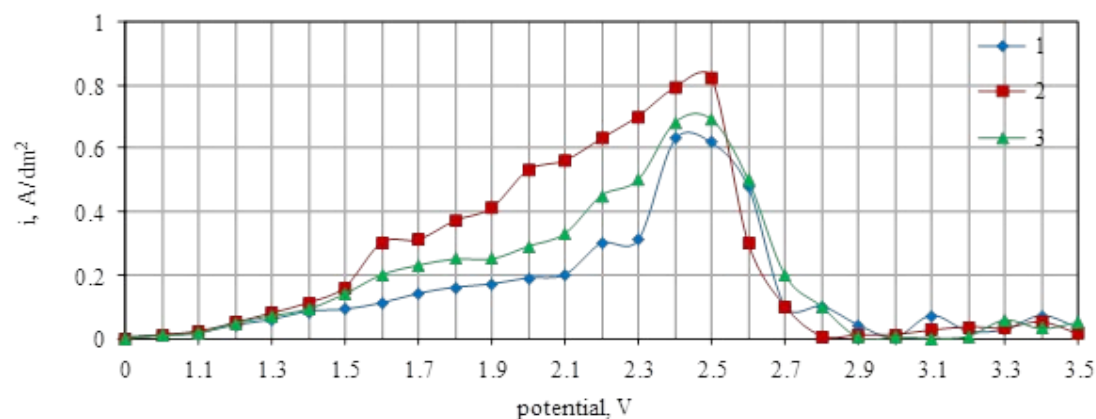


Figure 3. Dependence of the oxidation potential on the current density (model solution № 3): 1 - platinum anode; 2 - graphite anode; 3 - stainless steel anode

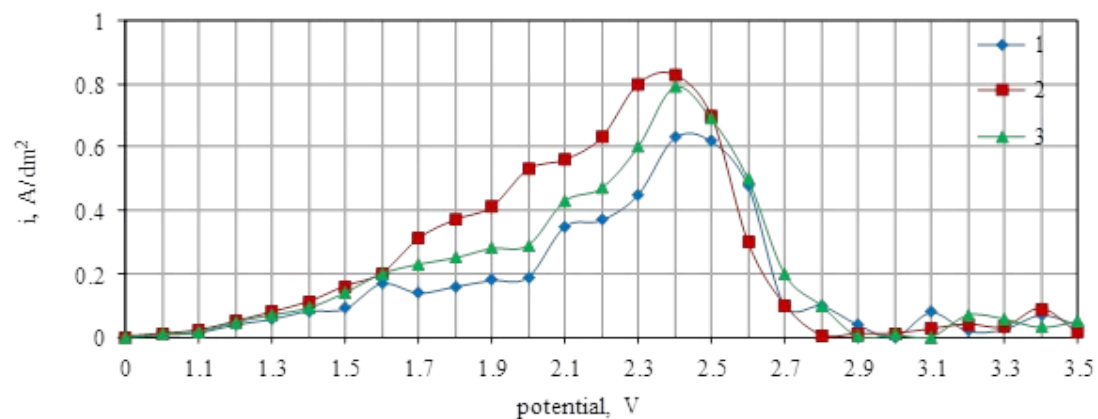


Figure 4. The dependence of the oxidation potential on the current density (model solution № 4):
1 - platinum anode; 2 - graphite anode; 3 - stainless steel anode

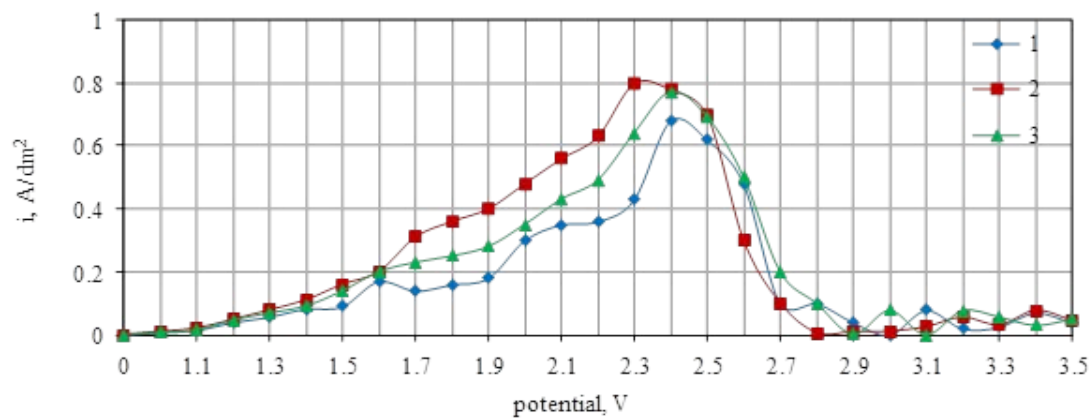


Figure 5. The dependence of the oxidation potential on the current density (model solution № 5):
1 - platinum anode; 2 - graphite anode; 3 - stainless steel anode

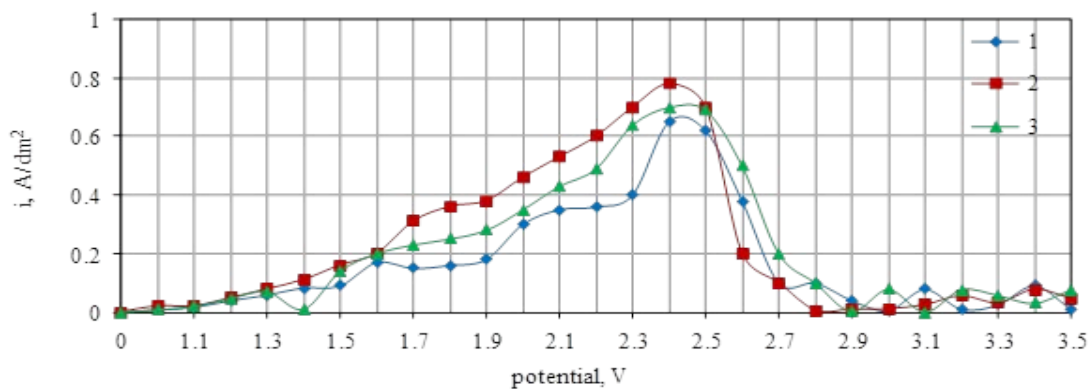


Figure 6. The dependence of the oxidation potential on the current density (model solution № 6):
1 - platinum anode; 2 - graphite anode; 3 - stainless steel anode

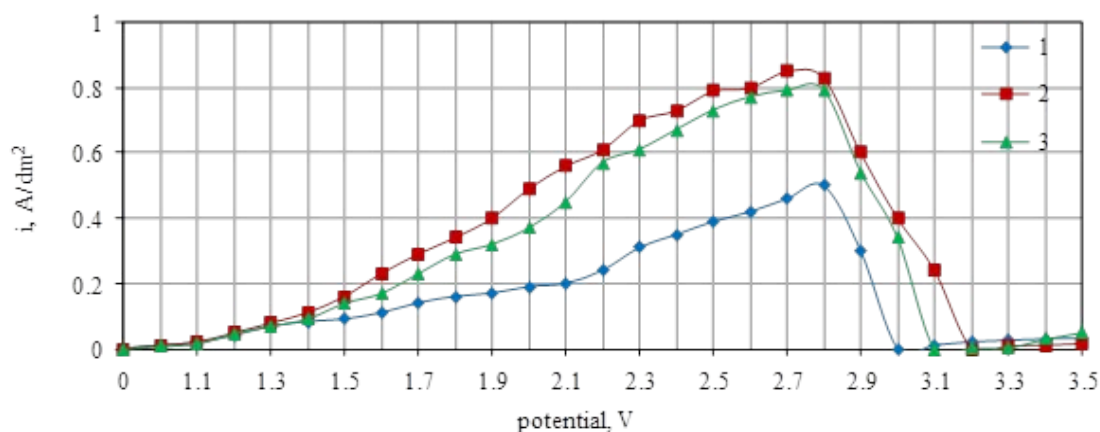


Figure 7. The dependence of the oxidation potential on the current density (model solution № 7): 1 - platinum anode; 2 - graphite anode; 3 - stainless steel anode

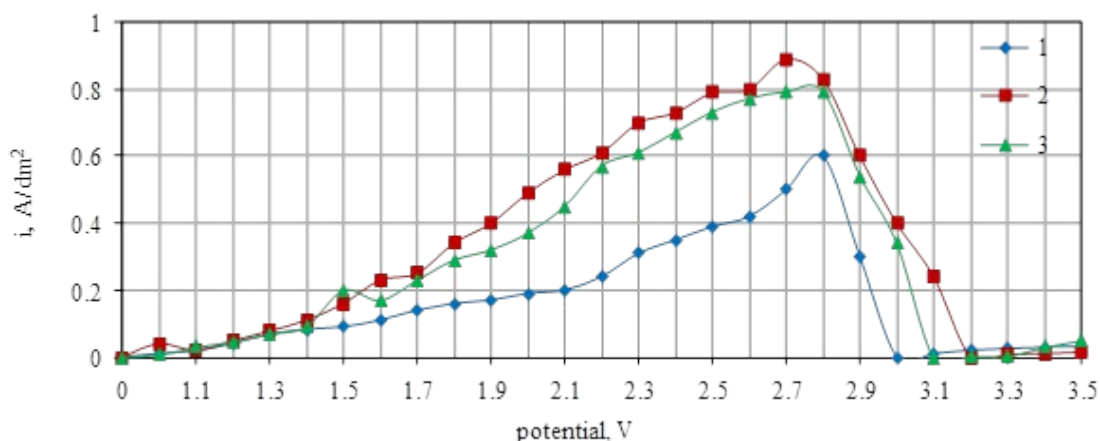


Figure 8. The dependence of the oxidation potential on the current density (model solution № 8): 1 - platinum anode; 2 - graphite anode; 3 - stainless steel anode

The study allows us to conclude that the highest current density required to achieve the oxidation potential of the full list of organic substances ($C_{10.5}H_{21.0}$; ID-20; CH_2O ; $C_{10.5}H_{21.0}$) during electro-oxidation on the anode surface is 1.0 A/dm^2 , the smallest is 0.5 A/dm^2 . It is seen that the process of electro-oxidation took place at lower densities on the platinum anode, however, the use of platinum anodes is impractical. When using graphite anodes, the highest current density was observed. It is revealed that the best option is to use stainless steel anodes. To clarify the choice of anode material, studies were conducted on real and model solutions containing the entire spectrum of organic pollutants in a wide range of their concentrations.

Additional sedimentation after electrochemical treatment is the final stage of the entire complex of purification of polymer-containing wastewater. During the electrochemical cleaning, a precipitate was formed in the anode and cathode spaces. The precipitate has a flocculent structure and in the first minutes after the treatment with an electric current, part of it floats to the surface of the treated solution. After the end of the treatment of the solution, precipitation of the flakes occurs for some time. Curves of the kinetics of secondary sedimentation - (E) from (τ) were obtained experimentally according to the standard technique [20]. Analyzes to determine the effectiveness of wastewater treatment were carried out according to standard methods (figure 9) [21,22]. Water samples were taken strictly from the middle of the height of the layer of sedimentation.

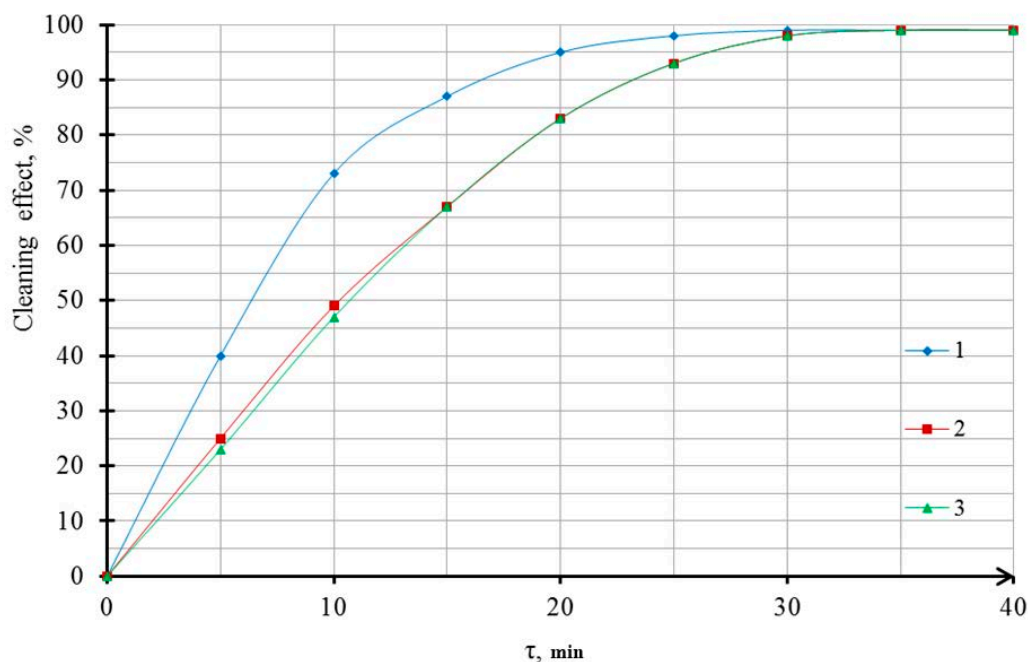


Figure 9. Dependence of the cleaning effect on the duration of settling: 1-model solution №1; 2-model solution №2; 3 - real wastewater.

Table 3. Chemical composition of waste water

Name pollutant	Concentration, g / l		Turbidity, NTU	
	Before cleaning	After electrochemical cleaning and settling	before	after
Waterfraction				
Na ₆ P ₆ O ₁₈	5.1	0.001	485	15
C _{10.5} H _{21.0}	7.3	0.004		
ИД-20	5.1	0.001		
CH ₂ O	0.4	0.005		
TiO ₂	1.0	-		
Styrene-acrylic dispersion	0.7	-		

Conclusions and recommendations

After analyzing the experimental data, we can see that the maximum degree of sewage afterpurification is achieved by settling after electrochemical treatment for 35 minutes. The chemical composition of wastewater after electrochemical treatment is shown in table 3. Based on the above, we can conclude that the water purified by the electrochemical method can be used at the enterprise to wash equipment, and after special preparation and in the production of water-dispersion paints and varnishes, which are products of the enterprise producing them.

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