MICROBIOLOGY, VIROLOGY AND IMMUNOLOGY

FOOD ADDITIVES AS FACTOR OF MICROBIAL CORROSION OF STEEL

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Industrial equipment simultaneously undergoes several types of corrosion, approximately 50% of corrosion cost is due to microbiologically influenced corrosion [1, p. 290]. Types of industrial objects that destroyed with the participation of microorganisms are equipment of treatment facilities, industrials equipment for food industries, etc. During the operation of treatment facilities (especially in the initial stages of water treatment in the presence of a sufficient amount of nutrients) in anaerobic conditions on the surface of metal structures a sulfidogenic biofilm is formed – the place of active corrosion processes [1, p. 333]. Food additives that are widely used and fall into waste water can be sources of carbon and sulfur for corrosive microorganisms.

The aim of the present work was to study influence of food additives on the corrosion behavior of mild steel in neutral water-salt medium containing corrosion-aggressive microorganisms.

For the study were selected Food Additives (table 1) recommended by the Codex General Standard for Food Additives in GENERAL STANDARD FOR FOOD ADDITIVES CODEX STAN 192-1995 (GSFA).

Table 1

Studied Food Additives

№	Name	E number
I	Pentasodium triphosphate	E451
II	Maltodextrin	E459

The biocorrosion tests were performed with the help of gravimetric method. The mild steel St3ps coupons (surface area 0,002 m^2) were used for the gravimetric testing. Before being placed in the corrosive medium, the steel samples were cleaned with acetone, and weighed with analytical scales accurate to 5 10^{-5} g. Samples soaking time was 240 hours under 300K. Biocorrosion rate with or without the food additives was calculated with the help of the formula: $k_m = \Delta m/(S \cdot \tau)$, were Δm – weight loss in g; S – area in m^2; τ – exposure time in hours). Corrosion inhibition coefficient was calculated with the help of the formula: $\gamma_m = k_m/k_m^{/}$, where, k_m, $k_m^{/}$ is the corrosion rate with and without the food additives. The inhibition efficiency was calculated using the following equation: ($IE_{\%} = (1 - 1/\gamma_m) \cdot 100\%$). Food additives concentrations – 1 and 3 g/l.

Model medium Postgate «B» [2, p. 458] with enrichment culture of sulfate-reducing bacteria (SRB) was used as a testing corrosive medium (pH 7,5). The enrichment culture method in the liquid elective medium Postgate «B» provided the culture of SRB from biofilm, was gathered from the metal equipment surfaces of sewage treatment constructions (Chenihiv) [3, p. 499]. Initial titre of SRB in corrosive medium was 10^9 cell/ml. The number of bacteria was calculated using the method of decimal serial dilution during the bacteria seeding to liquid selective medium Postgate «B». The biofilm cells, which appeared on the surface of steel samples during tests, were gathered into the fixed volume of (20 ml) 0,1H of phosphate buffer (pH=7) with the help of ultrasound with a frequency of 25 kHz (30s) using UZM-003/n. The resulting swab was used in cultivating and calculating the adhered bacteria cells [4, p.125].

The degree of influence (S,%) of the studied food additives on bacteria sulfatereduction was calculated using the formula: $S = ((C\text{-}C')/C) \times 100\%$, where C and C′ are the average hydrogen sulphide concentration with and without the food additives accordingly, mg/l. The concentration of biogenic hydrogen sulfide was measured with iodometric titration [5, p. 178].

For surface analysis biofilms on steel surface it's were examined with scanning electron microscope (SEM). To fix the grown biofilm to the steel surface, the coupons were immersed for 1 h in a 2% glutaraldehyde solution, dehydrated with 4 ethanol solutions (15 min each) of volume%, 25%, 50%, 75% and 100% successively, air dried overnight [6, p. 830]. After fixation, the coupons were examined using field emission scanning electron microscopy FEIE-SEM XL 30. With the help of electron microscope the picture was taken in the mode of functioning in secondary electrons. Maximum residual pressure in the microscope pillar was no more than 6,7·10-4 Pa under the gun current of 76 mA.

Statistical analysis of experimental data for the reliability level 95% was conducted with help of Microsoft Excel. The experiment was conducted three times.

The studied food additives impact on the St3ps steel corrosion rate in water-salt medium Postgate «B» (table. 2). Food additive I (3 g/l) increase rate of microbial corrosion of steel in 1,52 times, but food additive II decrease it in 5,24 times. With a decrease in the concentration of food additives to 1 g/l, their influence on microbial corrosion indicators is slightly reduced.

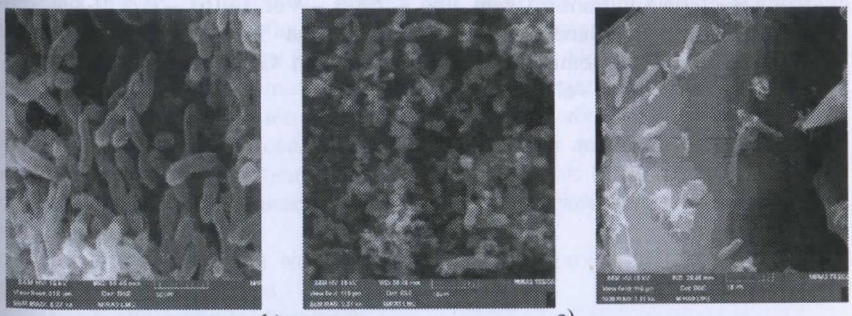
Table 2

Influence of various concentrations of food additives on parameters of microbial corrosion of steel St3ps

Food additive	$k_m \cdot 10^3$, $g \cdot m^{-2} \cdot h^{-1}$	γ_m	S,%	$k_m \cdot 10^3$, $g \cdot m^{-2} \cdot h^{-1}$	γ_m	S,%	Quantity of SRB	
							In solution, cell/ml	In biofilm, cell/sm^2
	1 g/l			3 g/l				
-	22,05	-	-	22,05	-	-	10^7	10^5
I	30,25	0,73	+2	33,41	0,66	+28	10^7	10^8
II	9,99	2,21	–18	4,21	5,24	–80	10^7	10^4

Additive II has had an impact on bacterial sulfatereduction and on biofilm formation less powerful on SRB quantity and (table 2). Thus, food additives influence on microbial corrosion of St3ps steel is caused by their action on microbiological factor.

Photos of the surface of the samples St3ps steel with biofilm, which formed during exposure in a corrosive medium without food additives and with additives I and II, differ significantly At the absence of food additives biofilm (Fig. 1-a) represents the accumulation of bacteria which are unevenly distributed in the polymer matrix. There is a high density of microorganisms on separate plots. The adsorbed cells form lush colonies. Bacteria's morphology is curved rod. These are general characteristics of SRB [7, p. 640].



a) b) c)

Fig. 1. FE-SEM images (×8000) for the biofilm developed on St3ps steel surface after exposure to Postgate B medium with SRB culture: a) without food additives; b) with food additive I; c) with food additive II

Microphotography of a biofilm with food additive I (Fig. 1-b) that accelerates microbial corrosion illustrates the presence of black corrosion products, bacterial cells and exopolymer fibers. The appearance is a gelatinous, oily mixture. Additive II (Fig. 1-c) contributes to the formation of a biofilm (transparent in appearance substance) with protective properties. There are only separate bacteria on steel surface.

Food additives are influential on mild steel microbial corrosion rate. At the presence of E451 (Pentasodium triphosphate) and E459 (Maltodextrin) in corrosive medium, on the surface of the steel are formed biofilm with various morphologies. As a result, 3 g/l of Maltodextrin were identified as factor for inhibition of microbic corrosion with efficiency of 80,1%, Pentasodium triphosphate increase microbe corrosion by 1,52 times.

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