PROPERTIES OF INHIBITORS IN PREVENTING CORROSION OF METAL STRUCTURES IN THE OIL AND GAS INDUSTRY

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Abstract. During practical experiments, a corrosion inhibitor based on amines and phosphonates was obtained. This research investigated the application of the obtained corrosion inhibitor in protecting metal surfaces from corrosion and preventing various salts from forming deposits in pipes.

Keywords: *salt deposition inhibitor, amino and phosphonate compounds, chloride and nitrogen medium, protective effect.*

СВОЙСТВА ИНГИБИТОРОВ ДЛЯ ПРЕДОТВРАЩЕНИЯ КОРРОЗИИ МЕТАЛЛИЧЕСКИХ КОНСТРУКЦИЙ В НЕФТЕГАЗОВОЙ ПРОМЫШЛЕННОСТИ

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Аннотация. В ходе практических экспериментов был получен ингибитор коррозии на основе аминов и фосфонатов. В данном исследовании изучалось применение полученного ингибитора для защиты металлических поверхностей от коррозии и предотвращения образования отложений различных солей в трубах.

Ключевые слова: *ингибитор отложения солей, амино- и фосфонатные соединения, хлоридная и азотная среда, защитный эффект.*

Introduction

Today, developing technologies for highly efficient corrosion inhibitors and applying them to protect metal and metal-based structures from corrosion is one of the primary tasks in addressing corrosion-related problems worldwide. Especially today, the economic development of industry and production is inextricably linked to the stable and efficient operation of equipment. However, there are a number of requirements for creating a new generation of corrosion inhibitors, and great attention is being paid to inhibitors that are effective at low concentrations, environmentally friendly, and low-cost. Corrosion inhibitors play a crucial role in the oil and gas industry by protecting pipelines from corrosion in various aggressive, hydrogen sulfide, acidic, carbonate, and aqueous environments.

Currently, modern oil refining industries are also characterized by the use of high-efficiency technological equipment and highly corrosive environments. The duration of time between major overhauls is primarily determined by the corrosion resistance of technological devices and equipment. As a rule, unscheduled equipment repairs, accidents, and related losses of raw materials, semi-finished products, and finished products, as well as metal losses, are caused by metal

corrosion. One of the characteristics of oil refining processes is the use of large-scale metal structures and equipment.

In every oil refinery, the apparatus used for the main oil refining process makes up the majority of the metal equipment and mechanisms, and special attention must be paid to the state of corrosion in this process[1]. The formation of salt deposits leads to well failures and, ultimately, to an increase in the cost of the produced goods. In the oil and gas industry, the deposition of salts forms hard layers in pipelines and drilling equipment, negatively impacting the product flow. This significantly reduces the volume of oil or gas production, resulting in clogging and pressure drops in the pipelines. Furthermore, significant expenses are incurred due to the need to clean or replace the pipes[2].

The inhibition mechanism of corrosion inhibitors is based on preventing or completely stopping the corrosion of metals and metal structures by passivating their surfaces through various physical and chemical mechanisms using a corrosion inhibitor applied at specific concentrations[3].

The results of preparing aqueous solutions of phosphoric and hydrochloric acid-based inhibitors with amine compounds can be seen in Table 1.

Table 1.

Results of mixed salt preparation.

№	Inhibitor	Molar ratio of the inhibitor components			
		Nitrogen compound	Phosphoric acid	Hydrochloric acid	Water
1.	(Ethylendiamine + phosphoric acid) + water	0,12	0,12	-	0,6
	(Ethylendiamine dihydrogen phosphate + hydrochloric acid) + water	0,12	-	0,12	15,357
2.	(Ethylendiamine + phosphoric acid) + water	0,24	0,12	-	0,12
	(Diethylenediamine monohydrophosphate + hydrochloric acid) + water	0,12		0,12	18,963
3.	(Ethylendiamine + phosphoric acid) + water	0,36	0,12	-	1,8
	(Triethiendiamine phosphate +	0,12	-	0,12	22,569

	hydrochloric acid) + water				

Tests were conducted on the protective effectiveness of inhibitors prepared to prevent the accumulation of calcium carbonate and calcium sulfate salts. To model precipitate formation, the waters listed in Table 2 below were used:

Table 2.

Waters based on calcium carbonate and calcium sulfate salts

$CaCO_4$		**$CaCO_3$**	
$CaCl_2$	12,8 g/dm^3	$CaCl_2$	2,89 g/dm^3
$MgCl_2$-6H_2O	1,27 g/dm^3	$MgCl_2$-6H_2O	4,26 g/dm^3
NaCl	19,2 g/dm^3	NaCl	44,3 g/dm^3

According to the test method, after adding the inhibitor to the reservoir water model, the samples with and without the inhibitor—"blank" samples—are kept in a thermostat at 80°C for 5 hours. After cooling the samples, the resulting precipitate is filtered. The residual calcium cation content in the solution was determined by trilonometric titration. The inhibition efficiency (E, %) was calculated using the formula:

$$E=(C_p-C_x)*100/(C_0-C_x), \%,$$

here: C_p- calcium ion content in the sample containing the low-temperature control inhibitor, mg/l; C_x – the amount of calcium ions in the "blank" sample, mg/l; C_0 – the amount of calcium ions in the initial solution, mg/l.

The results of the experimental studies regarding the degree of protection of the developed inhibitors against salt deposits can be seen in Table 3.

Table 3.

Determination of the protective effect of inhibitors against salt deposits

№	**Composition of inhibitors**	**Inhibitor sarfi, mg/l**	**Inhibitor protection coefficient**	
			$CaCO_3$	**$CaCO_4$-2H_2O**
1.	Ethylenediamine dihydrophosphate monochloride	30 60 100	73,4 77,2 84,7	77,2 79,1 85,4
2.	Hydrophosphate bisethylenediamine dichloride	30 60 100	76,4 79,1 86,3	84,2 85,4 88,1
3.	Ethylenediamine chloride phosphate	30 60 100	80,9 85,2 87,9	84,8 86,7 89,4

As shown in Table 3, when the compositions are applied to sulfate and carbonate solutions at concentrations of 30, 60, and 100 mg/l, the inhibitors exhibit a high protective effect against salts—more than 87%. The maximum protective effect is observed when the inhibitor is introduced into the sulfate and carbonate solutions at a dose of 100 mg/l. As can be seen from the table, the values recorded

at various concentrations show that the protective effect of the inhibitors exceeds 89%.

Conclusion: We can see from the physicochemical and test results of this inhibitor that it contains amino groups based on our corrosion inhibitor. Our phosphorus and nitrogen-containing substances show that they can protect against corrosion. The developed mineral salt inhibitors in the obtained new composition exhibit an effective protective effect when administered at concentrations of 30, 60, and 100 mg/l.

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