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Comparative Analyses of Inhibitors against Salt Deposition and Corrosion in Circulating Water Supply Systems

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Abstract: This article looks at how water affects pipes and how to stop metal from getting rusty and damaged by salt. Different types of inhibitors are used to keep equipment and pipelines working for a long time. Inhibitors used in recycling water supply systems in the oil and gas industry have to meet certain special rules. We need to make a chemical that stops metal from rusting and stops salt from building up in water systems at oil refineries.

Keywords: corrosion, salt deposition, inhibitor, Hydroxyethylidene diphosphonic acid, Phenomenon-95.

On a global scale, special attention is paid to the development of new compositions of salt deposition and corrosion inhibitors with multifunctional properties, reducing their consumption when using corrosion protection of water circulation systems. Much attention is paid to scientific research on the reduction of salt deposition and corrosion in water circulation systems. Therefore, the development of modern methods of corrosion protection of water circulation systems of oil refineries is one of the urgent problems and requires its solution.

To date, certain theoretical and practical results have been achieved in Uzbekistan on the development of new highly effective salt deposition and corrosion inhibitors and their compositions based on local raw materials, technologies for protecting water circulation systems using them. Non-traditional methods of intensifying the processes of protection against salt deposition and corrosion have been developed and mastered.

Protection of equipment and pipelines from corrosion and corrosion-mechanical destruction can be carried out in various ways: using corrosion inhibitors, protective linings, electrochemical protection, technological methods, corrosion-resistant materials.

Of the listed methods, the most effective and promising is the use of inhibitors [1; 2]. This method has the following advantages: 1) commissioning into the system without disrupting the technological process almost anywhere; 2) with low capital costs, it reduces the number of accidents; 3) in most cases, it is the most economical way of protection, allowing the use of conventional carbon steels.

There are special requirements for inhibitors for the oil and gas industry. Along with the main purpose, inhibitors should have low protective concentrations, be non-toxic, and not pollute the environment. In practice, there are few inhibitors that satisfy all these requirements at the same time. The range of inhibitors used in the oil and gas industry is small. High-molecular organic substances containing heteroatoms of nitrogen, sulfur, oxygen, phosphorus are used, which are adsorption-active centers, nitrogen-containing substances are more often used. Inhibitors based on mineral and inorganic compounds are also used [3].

The need for widespread use of cheap and effective inhibitors poses the task for researchers to obtain them on the basis of large-tonnage waste or intermediates of chemical and petrochemical industries. Examples of this approach are known. Thus, the inhibitors of the "ИКИХП" series are waste products of oil production. According to the mechanism of action, they are inhibitors of the mixed- cathode-anode type, with preferential inhibition of the anode process.

A number of other drugs also follow from inhibitors produced from similar raw materials. Thus, "Мунсор-3" provides corrosion protection of steel St3 in a model wastewater solution saturated with carbon dioxide. "СНПХ-43Р" is also recommended for the protection of carbon steel in mineralized aqueous media.

Waste and intermediates of caprolactam production (corrosion inhibitor "КРЦ-3") are offered as a corrosion inhibitor for the oil and gas industry. The "Донбасс-1" inhibitor is a waste product of the coke industry. Nitrated oils are a waste product of chemical production. The "Минкор-3" inhibitor manufactured from the latter in mineralized water provides a degree of protection of structural steels of 80-95% with a salt content of up to 200 g/l in the presence of oxygen. Another example is the use of waste from the chemical production of "Nitrogen". The inhibitors produced from it are the film-forming "НИИФОХ" and the water-soluble "РГУ-1". It is proposed to obtain inhibitors from similar wastes to protect steel oil and gas equipment in 2-phase hydrogen sulfide-containing media from corrosion and salt deposition.

Inhibitors are also classified according to the class of chemical compounds used for their production. A large group consists of steel corrosion inhibitors based on pyridine derivatives. Thus, inhibitors "И-1-А", "И-1-В", "И-3-А", "И-3-Д", "Север" are a mixture of alkylpyridines obtained by condensation of paraldehyde with ammonia.

Many of the patented hydrogen sulfide corrosion inhibitors are compounds based on organic amines, for example, aliphatic amines. The inhibitory ability of ethylamine has been studied when the state of the steel surface changes. It is shown that the protective effect of quaternary ammonium salts of aliphatic amines in a hydrogen sulfide medium depends on the structure of the initial amine. The initial amines are obtained by ammonolysis of primary alcohols, from butyl to nonyl. Considerations have been made about the effect of their structure on the degree of corrosion inhibition [4].

Electrochemical methods are used to study the mechanism of inhibition. Many organic compounds inhibit the anodic component of the steel dissolution process. Such inhibitors are more effective the more they exhibit both blocking and energetic effects of corrosion inhibition. It has been shown that inhibitors based on pyridine derivatives with electrophilic substituents are adsorbed to metal physically, and with nonelectrophilic ones - specifically or chemically. It was found that in an aromatic amine, the introduction of large nucleophilic substituents in the meta-position to the reaction center leads to an increase in the inhibition efficiency, which is associated with the adsorption of their molecules on the surface of steel [5].

Summing up, it can be argued that, firstly, inhibition of corrosion of titanium plates of heat exchangers in the Ferghana Oil Refinery cleaning system is the most optimal way to combat corrosion and salt deposition. That is why the development, creation and implementation of multifunctional compositions capable of providing, in relation to the purification system of titanium plates of heat exchangers, Ferghana Oil Refinery, aimed at protecting against corrosion and salt deposition, as well as biofouling, inexpensive, based on local raw materials or waste, and therefore economically feasible, is an urgent task.

In the circulating water supply of the Ferghana Oil Refinery, the water and cleaning solution supply system is made of carbon steel and cast iron. Sulfate and chloride ions can be considered aggressive ions in the water used. In addition, the proposed corrosion and salt deposition inhibitor may additionally contain various ions in its composition. Therefore, the selection of a composition to protect the supply system of the cleaning solution was supposed to be carried out in water containing sulfate, chloride and nitrate ions [7].

In water and neutral aqueous solutions, according to the results of a literary and patent search for inhibitory protection, such inorganic compounds as chromates, phosphates, amines, nitrites, silicates, salts of organic acid - benzoates and others are currently widely used as an inhibitor (moderator) of corrosion of steel and cast iron. It is with the use of some of them that our attention will be directed to solving the tasks set.

In oil refining industries, water is used as a technological raw material and as a coolant, i.e. for cooling and heating equipment, including for cleaning and cooling oil refining products.

The results of the monitoring of the waters used in the internal water supply of the Ferghana Oil Refinery and Bukhara Oil Refinery showed the presence of corrosion and salt deposition processes, which negatively affect the efficiency of the heat exchange equipment and to avoid this problem, the plant uses an imported corrosion and salt deposition inhibitor "Hydroxyethylidene diphosphonic acid" and "Phenomenon-95T".

The analysis of the scientific and technical literature and the initial data of the Ferghana Oil Refinery and Bukhara Oil Refinery, on the analysis of water supply systems, allowed us to purposefully approach the issue of selecting new corrosion inhibitors and salt deposition for the water supply systems of the Ferghana Oil Refinery and Bukhara Oil Refinery.

Industrial tests of new compositions of corrosion inhibitors and salt deposition in the cooling water used in the circulating water supply system of the Ferghana Oil Refinery and Bukhara Oil Refinery were carried out.

The results of the conducted studies on the degree of corrosion protection when using the developed salt deposition inhibitors are presented in Table-1.

Table-1. Comparative effectiveness of corrosion inhibition by reagents "Phenomenon-95T", "ИОНХ-1", "ГПУЩ" of circulating cooling water of the Bukhara Oil Refinery internal water supply and inhibition of salt deposition by the method of thermostatically controlled in a model solution

№	The name of the sample	Corrosion rate, g/m2•h	Degree of corrosion protection, %	The effectiveness of salt deposition inhibition, ($Э_{исо}$), %
1	without an inhibitor	-	-	
2	Phenomenon-95T	0,13625	0	47,4
3	ИОНХ-1	0,383	34,3	84,2
4	ГПУЩ	0,00146	97,5	73,7

Industrial tests of new compositions of corrosion inhibitors and salt deposits in the water of the Ferghana Oil Refinery recycling water supply were also carried out.

Corrosion and salt deposition inhibitors "ГПМЩ", "ИОНХ-1" were tested in comparison with the imported salt deposition inhibitor "Hydroxyethylidene diphosphonic acid". Using the method on the "ИСО-1" salt deposition device and the gravimetric method was used to determine the degree of corrosion inhibition. The results obtained are shown in Table-2 [6].

Table-2. Comparative effectiveness of inhibition of salt deposition by reagents "ГПМЩ", "ИОНХ-1" and "Hydroxyethylidene diphosphonic acid" on the "ИСО-1" device and the effectiveness of corrosion inhibition [9]

№	Solutions	Corrosion rate, *Vk*, g/m2•h	Degree of protection, (Z) from corrosion, %	The effectiveness of salt deposition inhibition, %
1	without an inhibitor	-	-	-
2	ИОНХ-1	0,0000083722	59,25	89,41
3	ГПМЩ	0,0000064287	68,71	91,76
4	Hydroxyethylidene diphosphonic acid	0,0000245186	0	94,11

As evidenced (Table-1) by the studies conducted, the developed salt deposition inhibitors are more effective in inhibiting corrosion relative to "Phenomenon-95T". The highest activity in the inhibitory ability to corrosion is shown by "ГПУЩ" – 97.5%, and in the inhibition of salt deposition is 73.7%.

According to the results obtained (Table-2) of the studies conducted in the table, the most effective in inhibiting corrosion and salt deposition in the circulating waters of the Ferghana Oil Refinery used for depositing heat exchange equipment is the preparation "ГПМЩ", which have a degree of corrosion protection of 68.71%, and in terms of the effectiveness of inhibiting salt deposition of 91.76% and are recommended for industrial tests.

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