

OBTAINED AND INVESTIGATION OF THE ECOLOGICAL FILM-FORMING ANTICORROSION OIL COMPOSITIONS (FAOC), REDUCING OIL CONSUMPTION DURING EXPLOITATION

Aleksandar Dimitrov*, Dobromir Yordanov, Petko Petkov

*University "Prof. Dr. Assen Zlatarov", Department of Industrial Technologies and Management, 1' Prof. Yakimov Street, Burgas, Bulgaria
al_dim_2000@yahoo.com, dobromirj@abv.bg, pst_petkov@abv.bg*

Received October 30, 2011, Accepted April 15, 2012

Abstract

It's obtained ecological film-forming anticorrosion oil compositions (FAOC) and it's investigated their surfaces and protection properties. It's investigated the influence of the different components. It's known that the content of inhibitor of corrosion over 5 % leads to improvement of the properties of the obtained mixtures and that presence of different thickener, determine influence of their usage. It's known optimum thickness of the layer from ecological film-forming anticorrosion oil compositions (FAOC).

Keywords: Corrosion inhibitor; Mechanism; Surface properties; Protected properties; Ecology.

1. Introduction

Corrosion of metals is one of the most important and challenging problems in industry [1]. It is well known that most of the heterocyclic compounds which have a compact structure possess antioxidant, anticorrosion, and antiwear properties [2-4].

Therefore, the development of inhibiting films able to protect the underlying metal from corrosion has been the subject of numerous investigations [5, 6]. The corrosion inhibition efficiency of organic compounds is related to their adsorption properties. Adsorption depends on the nature and the state of the metal surface, on the type of corrosive medium and on the chemical structure of the inhibitor [7]. Studies report that the adsorption of the organic inhibitors mainly depends on some physicochemical properties of the molecule, related to its functional groups, to the possible steric effects and electronic density of donor atoms; adsorption is supposed also to depend on the possible interaction of p-orbitals of the inhibitor with d-orbitals of the surface atoms, which induce greater adsorption of the inhibitor molecules onto the surface of carbon steel, leading to the formation of a corrosion protecting film [8].

A lubrication system consists of moving surfaces under load with a lubricant in between. Lubrication is achieved by utilizing the physical and chemical properties of the lubricating fluid. Physical properties such as density, viscosity, heat capacity, thermal conductivity, and the temperature-pressure-viscosity relationships determine the ability of the lubricant to operate under hydrodynamic lubrication. Chemical properties such as solvency, dispersancy, detergency, antiwear, anticorrosion, frictional properties, and antioxidant capacity are crucial to successful boundary lubrication. Some properties are controlled by the chemical composition of the base oils, and some properties are controlled by chemical additives designed for that purpose [9].

Most of the base oils are petroleum- or mineral oil derived. The basestock must be viscous enough to maintain a lubricant film under operating conditions but should be as fluid as possible to remove heat and to avoid power loss due to viscous drag. It should also be stable under thermal and oxidative stresses, have low volatility and possess some ability to control friction and wear by itself. The ability to dissolve chemical additives but to be inert toward metal surfaces, rubber seals and gaskets for instance is all important [9].

Petroleum basestocks are selected hydrocarbon fractions derived from crude oils. They generally consist of molecules containing 18-40 carbon atoms in three basic hydrocarbon types: paraffins, aromatics, and naphthenes (cycloparaffins). Most of the molecules are of the mixed type containing two or more basic hydrocarbon structures. These base stocks also contain a small percentage of compounds containing heteroatoms, such as sulfur,

nitrogen, or oxygen, substituted in the various hydrocarbon structures. Typical molecular structures are illustrated in Fig. 1 [9].

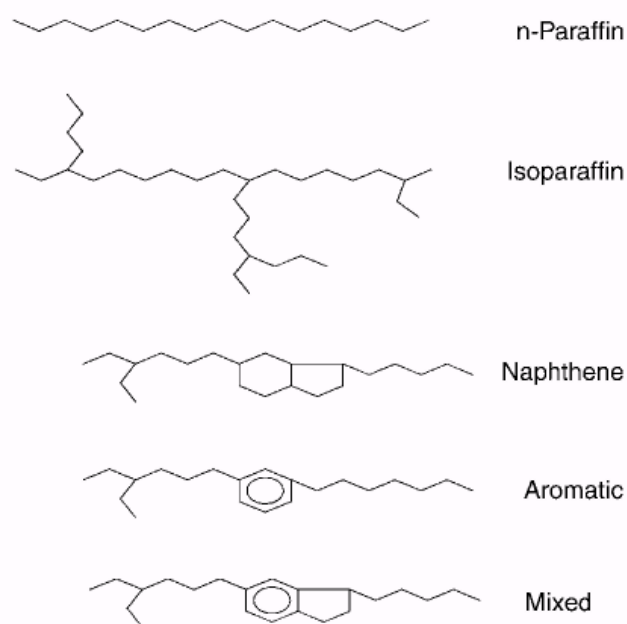


Fig. 1. Molecular structures of base oil molecules.

Ecological film-forming anticorrosion oil compositions (FAOC) are a new and comparatively little known class of conservation materials with long-term potentials. FAOC are special compositions of different materials soluble in organic or inorganic solvents. After they are laid on the protected metal surface, the solvent evaporates and a solid, semi-solid or soft coating with different thickness is formed. Thus, they can be used to protect various metal products from corrosion and corrosion - mechanical wear. FAOC consist of several types of components: oil-soluble corrosion inhibitor; thickener; plasticizer; and a solvent [10-13].

2. Experimental

Depending on the resources of our chemical industry, studies were focused on several components of film-forming anticorrosion oil compositional: CIC-2A (oil-soluble corrosion inhibitor); medium viscous paraffin (thickener); mineral oil (plasticizer); mineral turpentine (solvent).

Mixtures were prepared by the following technology: the plasticizer was put in a 500 ml glass in a quantity from 20 to 90% and, being continuously stirred; it was heated in a water bath at 85÷90°C. The thickener was added to it in amounts from 5 to 50 % and the mixture was homogenized for 30÷45 minutes. The corresponding oil-soluble corrosion inhibitor was then added in amounts from 1 to 20%. The mixture was homogenized for 30 minutes more. Then heating was stopped and at temperature 45°C the necessary amount of the solvent was added, stirring going on as long as possible.

In order to determine the protection effect of different film-forming anticorrosion oil compositions depending on the thickness of the film, tests were carried out by the following standard methods:

1. Bulgarian State Standard (BSS) 14353-77. Determining the protection ability against aggressive gases and vapours in a chamber "Aggressive medium" (7 days and nights, 33°C, 100% humidity). Conditions are created periodically for the formation of a certain amount of sulphur oxide.

2. BSS 14354-77. Determining the protection stability against salts in a "Salty fog" chamber (10 days and nights, 80°C, 100% humidity) by periodically creating conditions for the formation of fog from a 5% aqueous solution of sodium chloride.

3. BSS 14355-77. Determining the protection stability against humid heat-climate regime in a "Humidity" chamber (7 hours per each 24 hours for a period of 12 days and nights) at changing temperature and moving moist air in the chamber.

4. BSS 14558-77. Determining the protection ability against condensation water in a "Condensation water" chamber (7 days and nights, 30°C, 100% humidity).

3. Results and discussion

The present study showed that the amount of the various components mixed to obtain FAOC varies in the following ranges: oil-soluble corrosion inhibitor (CIC) - from 1 to 20%; thickener (T) - from 5 to 50%; plasticizer (P) - from 20 to 90%; solvent (S) - from 4 to 20%. The recipe of the obtained FAOC is given in Table 1.

Table 1 Recipe of the obtained FAOC.

Nº	Oil-soluble corrosion inhibitor (CIC), %	Thickener, %	Plasticizer, %	Solvent, %
1.	1	5	90	4
2.	5	25	50	20
3.	10	30	40	20
4.	13	35	35	17
5.	20	50	20	10

Mixtures with different consistency were obtained, which determines various fields of their application. These mixtures were subjected to a number of physicochemical tests to study their effect. The experimental results are shown in Table 2.

Table 2 Test results for the FAOC obtained.

Nº	PARAMETERS	Nº of Table 1		
		1	4	5
		(Thickener: intermediate viscosity paraffin)		
1.	PHYSICOCHEMICAL PROPERTIES			
1.1.	The time needed for the film to dry completely, h	28,1	69,7	52,9
1.2.	The time needed for the film to form, min	26,5	66,7	49,1
1.3.	Colloidal stability, %	92,3	88,9	67,4
1.4.	Flow temperature, °C	54,8	79,3	80,3
2.	ELECTROCHEMICAL PROPERTIES			
2.1.	Total resistance, R, Ω	2394	1751	1529
2.2.	Change of the resistance on the film at 500 and 20000 Hz, ΔR, Ω/cm ²	429	418	405
2.3.	Relative polarization resistance, RPR, %	59	62	68
2.4.	Relative omic resistance, ROR, %	55	58	63
2.5.	Change of the capacitive on the film at 500 and 20000 Hz, ΔC, μF/cm ²	5,1	6,7	7,4
2.6.	Coefficient of inhibition	2,0	2,1	2,8
2.7.	Permittivity	2,54	2,73	2,98
3.	SURFACE-ACTIVE PROPERTIES			
3.1.	Water-replacing, mm: - d1	119	125	139
	- d2	123	129	139
	- d3	123	130	139
3.2.	Surface tension, mN/m	35	40	42
3.3.	Limited wet angle, °: - FAOC	184	181	175
	- Water on the FAOC	62	121	170
4.	PROTECTION PROPERTIES			
4.1.	Conservation of metal surfaces, beforehand wet with 3% NaCl, % damaged surface: - Steel 3	48	13	8
	- Steel 10	42	11	7
	- Bronze	30	0	0
4.2.	Protection properties in:			
	A) Chamber "Humidity" (BSS 14355-77)			
	- Steel 08 kp, number of cycle	4	6	9
	- Cooper, bal	3	2	1
	B) Chamber "Aggressive medium" (BSS 14353-77), mg "AM"	2,5124	1,9472	0,8135
	C) Chamber "Condensation water" (BSS 14558-77), g/m ²	2,3024	1,3517	0,6081
	D) Chamber "Salty fog" (BSS 14354-77), g/m ²	48,17	9,29	4,94
4.3.	Velocity of protection, Z, % damaged surface	2	1	0

It was found that the time needed for the film to form and dry completely, depends exclusively on the amount of the solvent used to obtain FAOC. Colloidal stability mainly depends on the plasticizer and the amount of the solvent in the film-forming anticorrosion oil compositions. Flow temperature depends in the first place on the amount and the type of the thickener. Total resistance characterizes the isolation ability of the film with regard to the electrochemical reactions taking place. It was found that the values for this parameter depend on the density of the film formed and the polarity of the consisting components. When the film is subjected to energy of alternating frequency, its stability changes.

This process is studied taking into account the value for ΔR . Increasing the amount of the polar components in the film-forming anticorrosion oil compositions, the values for RPR increase. On the same basis, the values for ROR show that the density of the film formed mostly depends on the amount of the thickener. Water-replacing properties of FAOC depend on the polar molecules present in them. This is also the case with the values for their surface tension. Increasing the amount of the inhibitor, the increase in the surface tension of FAOC influences the size of the drops when FAOC are dispersed.

At the same time, eventual water on the FAOC film will remain in the form of tiny drops and will repel from the surface. This property is particularly important for conservation of metal equipment and installations. The increased amount of inhibitors in the mixtures makes it possible to avoid preparation and drying of the conserved surfaces beforehand. The protection of products made of non-ferrous metals is stronger. By making complex tests it was found that FAOC possess very good protection properties. The compositions containing low-viscosity paraffin can be used as conservation oils. The use of petroleum results in the production of FAOC which are suitable for conservation of metal equipment stored for a long time (up to 2 years) at comparatively higher temperatures (up to 40°C). For longer conservation (more than 2 years) at changing temperatures, FAOC containing ceresin as a thickener are more suitable. This type of thickener forms the most stable and the densest film on the protected metal surfaces. If the amount of the inhibitor in the compositions is less than 5 %, they should not be used to protect wet and moist surfaces.

Using an "Aggressive medium" chamber, conditions similar to a strongly aggressive industrial medium are created. The test aims at determining the stability of low-carbon steel protected by conservation oil under these conditions.

The test made in a "Salty fog" chamber provides information about the ability of the conservation material to protect low-carbon steel in sea-weather conditions.

In the "Humidity" chamber, conditions for 100% humidity can also be created, the heating of water and the movement of the air in the chamber taking place in a cyclic recurrence. The test aims at determining the ability of the inhibited conservation oils to protect low-carbon steel and electrolyte copper (99,9%).

In the "Condensation water" chamber, the protected metal surface was subjected to washing and corrosion by condensation water drops running down because of the natural slope.

The results from the corrosion tests carried out by the corresponding standard methods are given in Table 3.

It was found that increasing the thickness of the film leads to an increase in its protection effect. These tests showed that the optimum size of the layer of the ecological film-forming anticorrosion oil compositions (FAOC) should not exceed 100 μm . This depends on the type of the thickener and the energy of the adsorption-chemisorptions and adhesion-cohesion interactions in the film formed.

The results obtained show that the ecological film-forming anticorrosion oil compositions (FAOC) under study can be used to solve some very old problems connected with technical equipment kept under conditions of temporary, seasonal or long outage. This problem is particularly important for motor transport which is subjected to strong electrochemical corrosion, especially in winter because of the antifreeze operations on the road network. The properties of ecological film-forming anticorrosion oil compositions (FAOC) with different consistency make it possible to take measures for protecting not only the outer surfaces of vehicles but also to conserve inner surfaces, which are difficult to reach, by injection through specially made openings.

Table 3 Effect of the film thickness on the protection properties of FAOC.

N° of composition on the FAOC at Table 1.	Thickener (Intermediate viscosity paraffin)	CORROSION TESTS (BSS)					
		Thickness of the film μm	Steel 08 kp number of cycle	Cooper bal	14355-77	14558-77	14354-77
					mg "AM"	g/m ²	g/m ²
2	10-20	4	3	2,1080	1,6837	13,19	
3	10-20	4	3	2,0974	1,6617	12,94	
5	10-20	5	2	2,0351	1,5984	12,70	
2	20-35	5	2	2,0227	1,5513	12,63	
3	20-35	5	2	2,0199	1,5247	12,57	
5	20-35	5	2	2,0091	1,5049	12,50	
2	35-50	5	2	2,0017	1,4813	12,46	
3	35-50	5	2	1,9913	1,4784	12,03	
5	35-50	6	1	1,7991	1,4291	11,53	
2	50-100	7	1	1,7845	1,2056	11,75	
3	50-100	7	1	1,7729	0,1971	11,41	
5	50-100	8	0	1,6120	1,1252	10,59	
2	100-150	8	0	1,1738	0,9156	9,77	
3	100-150	8	0	1,1057	0,9037	9,13	
5	100-150	9	0	0,9981	0,8794	8,58	
2	150-200	10	0	0,1738	0,9156	9,77	
3	150-200	11	0	1,1057	0,9037	9,13	
5	150-200	12	0	0,9981	0,8794	8,58	
2	200-300	13	0	0,8974	0,8413	8,35	
3	200-300	13	0	0,8324	0,8324	8,01	
5	200-300	14	0	0,8711	0,8117	7,49	
2	300-400	14	0	0,8750	0,8074	7,17	
3	300-400	14	0	0,8694	0,8003	7,05	
5	300-400	15	0	0,8603	0,7974	6,90	
2	400-500	14	0	0,8538	0,7941	6,98	
3	400-500	15	0	0,8494	0,7886	6,11	
5	400-500	16	0	0,8403	0,7421	5,94	

4. Conclusion

Ecological film-forming anticorrosion oil compositions (FAOC) were studied in order to determine the influence of the consisting components on their protection effect.

An increase in the amount of the inhibitor over 5 % results in improving physicochemical, protection and surface-active properties and makes it possible to avoid preliminary preparation and drying of the protected surfaces.

A good protection effect is achieved when the layer of the ecological film-forming anticorrosion oil compositions (FAOC) is not more than 100 μm thick.

The presence of different thickeners leads to a change in the field of application of the ecological film-forming anticorrosion oil compositions (FAOC), the weather conditions and the time of usage.

References

- [1] Aiad, I.A., Hafiz, A.A., El-Awady, M.Y., Habib, A.O.: *J. Surfact Deterg.*, 2010, 13, 247-254.
- [2] Bhatlacharya, A., Singh, T., Verma, V., Nakagama, K.: *Wear*, 1990, 136, 345-352.
- [3] Davis, R.H., Famg, L.O., Horodysky, A.G.: US Patent 4,908,144.
- [4] Karol, T.J., *Eur. Pat. Appl.*, EP 0,209,730.
- [5] Scendo, M., Hepel, M.: *J. Electroanal. Chem.*, 2008, 613, 35-50.
- [6] Otmacic, H., Stupnisek-Lisak, E.: *Electrochim. Acta*, 2003, 48, 985-991.
- [7] Bentiss, F., Lagrenee, M., Traisnel, M., Hornez, J.C.: *Corrosion Sci.*, 1999, 41, 789-803.
- [8] Bentiss F., Traisnel, M., Lagrenee, M.: *J. Appl. Electrochem.*, 2001, 31, 41-48.
- [9] Hsu, S.M.: *Tribology International*, 2004, 37, 553-559.
- [10] Shechter, U.N., Zubareva, M.A., Bogdanov, I.S.: *Chimia i tehnologia topliv i masel*, 1989, 3, 43. (in Russian)
- [11] Shechter, U.N., Zaskalko, P.P.: *Chimia i tehnologia topliv i masel*, 1984, 2, 55. (in Russian)
- [12] Engmin A.B., Konslin, A.V., Ivanova, T.N.: *Chimia i tehnologia topliv i masel*, 1984, 3, 74. (in Russian).
- [13] Estivao, L., Rascimento, R.: *Corrosion Science*, 2001, 43, 1133-1153.