Synthesis of oil-soluble corrosion inhibitors from raw materials of plant origin

S M Gaidar¹, M Yu Karelina², Hoang Duc Quang³ and A A Akulov⁴

¹ Russian State Agrarian University - Moscow Timiryazev Agricultural Academy, Russia, Moscow, Timiryazevskaya str., 49, 8 (916) 789-25-76
² Federal State Budgetary Educational Institution of Higher Education «Moscow Automobile and Road State Technical University (MADI), Russia, Moscow, Leningradskyave. 64, 8 (499) 155-03-74
³ Southern Branch of the Russian-Vietnamese Tropical Research Technology Center, Vietnam, Ho Chi Minh City, Street 3/2, 3
⁴ Federal State Budgetary Educational Institution of Higher Education «Moscow Automobile and Road State Technical University (MADI), Russia, Moscow, Leningradskyave., 64

E-mail: ter34t@mail.ru, quanghoang1510@gmail.com

Abstract. The use of low-soluble corrosion inhibitors based on raw materials of plant origin is one of the most promising methods of metalwork processing to prevent corrosion. Carbon acids with carbon radicals are used for the synthesis of such inhibitors, which participate in the formation of hydrophobic part of the molecule. It is known that the hydrophilic part of the molecule causes solubility in water, and the hydrophobic part - in hydrocarbons. The study found that by changing the structure of the hydrophilic and hydrophobic parts it is possible to obtain a substance that will dissolve in water as well as in hydrocarbons. The obtained organic compounds can be used as corrosion inhibitors, antiwear and antiadhesive additives. Therefore, by synthesizing carboxylic acids with various radicals and using them for treating metal surfaces, we can obtain not only anti-corrosion properties of the metal, but also anti-wear and anti-adhesion properties, which makes it possible to use inhibitors not only for protection against corrosion, but also for extending the service life of loaded or rubbing metal surfaces.

1. Introduction
Currently existing corrosion inhibitors are based on synthetic raw materials. Obtaining corrosion inhibitors synthesized on the basis of raw materials of plant origin for the purpose of processing metal structures by them is the most promising research in this field of science. Obtaining low-soluble properties of plant-derived inhibitors is the main objective of this research study.

Research into the synthesis of low-soluble corrosion inhibitors based on plant-based raw materials in science is one of the least studied ways to create surfactants to protect metal structures from environmental influences and further oxidation of the metal surface.

2. Materials and methods
To obtain oil-soluble organic compounds, molecules of which have chemisorption capacity, carboxylic acids are used as an active ingredient. In the synthesis of corrosion inhibitors, carboxylic acids with hydrocarbon radicals are used; in the synthesis of antiwear additives, acids with...
hydrocarbon or perfluorinated radicals are used. Radicals are involved in the formation of the hydrophobic part of the molecule.

Figure 1 shows the structural formula of fatty acid amide (FAA) obtained as a result of the polycondensation reaction of carboxylic acids with ethanolamine borate.

In the synthesis of FAA were used:

- carboxylic acids CH$_3$(CH$_2$)$_n$COOH; C F$_3$(CF$_2$)$_n$COOH
- diethanolamine
- boric acid H$_3$BO$_3$.

As a result of the synthesis, organic compounds (Figure 1) with an asymmetric molecular structure were obtained, containing a hydrophobic radical (for compounds with a perfluorinated radical, it is lyophobic) and a hydrophilic part.

\[ \text{Figure 1. Structural formula of fatty acid amide} \]
The hydrophilic part of the molecule contains two functional groups:

\[ \text{CON} \]

amid and \(-\text{OH}\)hydroxyl, which cause chemisorption activity. Such molecules belong to non-ionic surfactants that do not dissociate in aqueous solution with formation of ions.

It is known that the hydrophilic part of the molecule causes solubility in water, while the hydrophobic part causes solubility in hydrocarbons. By changing the structure of the hydrophilic and hydrophobic parts, it is possible to obtain a substance that will dissolve in water as well as in hydrocarbons. Molecule structure depends on the ratio of ingredients in the synthesis, in this case there are three: carboxylic acid, diethanolamine and boric acid.

The molecules of the resulting compound are adsorbed on the metal surface due to the hydrogen bond, which is provided by hydrogen of the hydroxyl group. The hydrogen bond (7...15 kcal/mol) is energetically more than 10 times higher than Van der Waals forces. It easily displaces adsorbed water from the metal surface, which is very important in the preservation of wet surfaces. Undivided electrons of the nitrogen atom in the amide form complex compounds with metal cations.

In the course of a field study of all compounds it was found that the organic compounds obtained could be used as corrosion inhibitors, antiwear and anti-adhesion additives.

To obtain polyfunctional properties, benzotriazole is included in the fatty acid amide composition.

3. Results and discussion
As a result of the research it was proved possible to synthesize insoluble corrosion inhibitors based on raw materials of plant origin, which is a new method of metal processing to prevent oxidation and further rusting.

Also, by means of a field study, the anti-wear and anti-adhesion properties of organic compounds were proved, which allows their use to extend the life of loaded and rubbing surfaces of metals.

4. Conclusions
Researches on the synthesis of low-soluble corrosion inhibitors based on raw materials of plant origin have shown the possibility of giving anticorrosive properties to metal constructions. Other properties of these surfactants have also been identified, which allows their scope of application to be expanded.

Metal inhibitors based on synthetic raw materials do not have such a wide area of application, which makes them less in demand, as compared to low-soluble inhibitors based on plant-based raw materials.

As a result of the research, the possibility of synthesizing oil-soluble corrosion inhibitors from vegetable raw materials has been shown. This will protect the metal surface from corrosion by displacing water molecules from it. This technology will protect metal structures in regions with high humidity, which will increase their service life. It also means a complete opportunity to abandon the processing of metals using petroleum products.

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References
1. Gaidar S M 2015 *Planning and analysis of the experiment: a textbook* (Moscow: Publishing house of the federal state scientific institution Rosinformagrotech)
2. Karelina M Yu, Petrovskaia E A, Pydrin A V 2015 Optimization of inhibited composition to ensure the preservation of agricultural machinery *Proceedings of GOSNITI* Vol 121 pp 89–93
3. Karelina M Yu, Pydrin A V 2015 Optimal inhibited composition for anticorrosive treatment of agricultural machinery and equipment *Innovative directions of development of technologies and technical means of agricultural mechanization. Proceedings of the International Scientific and Practical Conference devoted to the 100th anniversary of the Department of Agricultural Machinery of the Agroengineering Faculty of the Voronezh State Agrarian University named after Emperor Peter I. The Russian Federation Ministry of Agriculture; Voronezh State Agrarian University named after Emperor Peter I.* 110-115
4. Kuznetsov Yu I 2002 Current state of the theory of metal corrosion inhibition *Protection of metals* Vol 38 2 122–131
5. Semenova I V, Florianovich G M, Khoroshilov A V 2002 *Corrosion and corrosion protection* (Moscow: FIZMATLIT)
6. Gaidar S M 2017 *Technology of agricultural machinery storage: training manual* (Moscow: publishing house of the federal state scientific institution Rosinformagrotech)
7. Gaidar S M 2011 *Theory and practice of creating corrosion inhibitors for conservation of agricultural machinery. Monograph* (Moscow: publishing house of the federal state scientific institution Rosinformagrotech)