

Production of Effective Water-Soluble Corrosion Inhibitors Based on Amino Alcohols

S. M. Gaidar^a, M. Yu. Karelina^b, Hoang Duc Quang^{c,*}, and V. S. Ershov^{b,**}

^a Russian State Agrarian University–Timiryazev Moscow Agricultural Academy, Moscow, Russia

^b Moscow Automobile and Road Construction State Technical University (MADI), Moscow, Russia

^c Southern Branch, Vietnam–Russia Tropical Center, Ho Chi Minh City, Vietnam

*e-mail: quanghoang1510@gmail.com

**e-mail: vsershov21@gmail.com

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Abstract—Amino alcohols are of interest in improving the anticorrosion treatment of metals. On the basis of observation and physicochemical analysis, a technology is proposed for the production of water-soluble corrosion inhibitors. Their composition is optimized. The disadvantages of using amino alcohols are identified. The properties of the complexes formed with metals are determined. The results indicate the relative effectiveness of these inhibitors in treating different metals.

Keywords: corrosion, amino alcohols, water-soluble corrosion inhibitors, physicochemical properties, surfactants, plant matter

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It is of great practical importance to improve anticorrosion treatments and to synthesize new components of corrosion inhibitors. The goal is to produce highly effective and readily available corrosion inhibitors.

There is particular interest in the use of ethanolamine, boric acid, and fatty acids derived from plant oils [1].

Ethanolamine is the most common amino alcohol, accounting for 90–95% of all production. It is mainly used in the production of surfactants, which are employed in organic synthesis, to absorb acidic gases and sulfur-bearing compounds (CO₂, H₂S, SO₂), as reagents in analytical chemistry, for the synthesis of modifiers and antistatic preparations, and in the production of emulsifiers, corrosion inhibitors, and detergents [2]. However, despite its wide use, ethanolamine is potentially of interest for the synthesis of effective corrosion inhibitors.

In the present work, the goal is to create a technology for the production of effective water-soluble corrosion inhibitors on the basis of ethanolamine. The proposed technology is assumed to have the necessary protective effect for different metals.

EXPERIMENTAL MATERIALS AND METHODS

We employ physicochemical analysis and also observation.

Metal cations act as coordination centers, while ethanolamines are ligands associated with those cations through unpaired electrons of the nitrogen atom and hydroxyl group –OH by lateral valence forces (without replacement of the hydrogen) [3]. Thus, the ethanolamines may be coordinated either through oxygen or through nitrogen. We show that triethanolamine forms products of type $MX_2N(C_2H_4OH)_3$ (where $M = Co, Ni, Cu, Cd, Pb, Ca, Mg,$ and Sr). Some are hydrated ($X = OH$).

The structure of this compound is shown in Fig. 1.

This compound includes cyclic groupings. The number of cycles depends on the coordination number of the metal ion. Research on the properties of complex compounds of mono-, di-, and triethanolamines with metals such as Cu, Co, and Fe indicates that ethanolamines may only be used as corrosion inhibitors of ferrous metals. With nonferrous metals, they form readily soluble complexes [4, 5].

A second deficiency of ethanolamine is that it allows microorganisms to flourish in the working media (lubricants, coolants, detergents, etc.). Boric

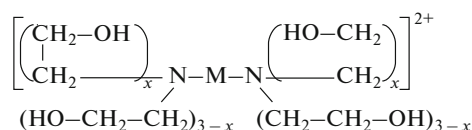


Fig. 1. Addition products of triethanolamine.

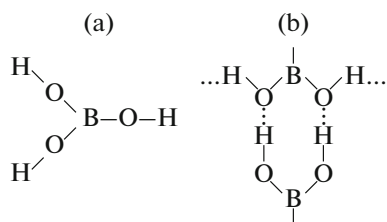


Fig. 2. Structural formula (a) and structure (b) of boric acid.

acid (H_3BO_3) is an effective fungicide [6]. The reaction products of boric acid are known as borates. The boric-acid molecule also permits the formation of polymer compounds.

In the synthesis of such compounds, it is necessary to ensure that growth of the polymer molecule is not accompanied by crosslinking of the growing branches, with the formation of molecules between them. In other words, the polymer molecules must be capable of self-organization and selective reaction with other atomic, ionic, or molecular groupings [7, 8].

A standard method may be used for organic synthesis. One option is the use of reaction groups of three types, which must meet certain logical requirements: for example, no group can react with a similar group; and, if a molecule contains two types of reactive groups, the reactive group in another compound may only react with one of them.

Borates of ethanolamine are formed as result of condensation between boric acid (H_3BO_3) and mono-, di-, and triethanolamines [9].

The compound with two types of reactive groups (mono-, di-, or triethanolamine) is placed in the reaction medium first. Then we add H_3BO_3 , which has three reactive groups of the same type (Fig. 2a).

In boric acid, the individual molecules are linked by hydrogen bonds [10] As a result, boric acid has a crystalline structure similar to that of ice (Fig. 2b).

The interaction energy of the hydrogen bond is 7–15 kcal/mol. Therefore, the H_3BO_3 rapidly breaks down at temperatures above 100°C [11, 12]. The reactive part of the molecule is then activated. A covalent bond is formed with the hydroxyl groups of the ethanolamines.

The first stage of polymerization produces free hydroxyl groups at the ends of the molecules. Each of these is capable of reacting again with the boric acid molecule. In Figs. 3a, 3b, we show such reactions in the production of diethanolamine borates.

The reaction continues until all the reagents have been exhausted or saturation has been reached.

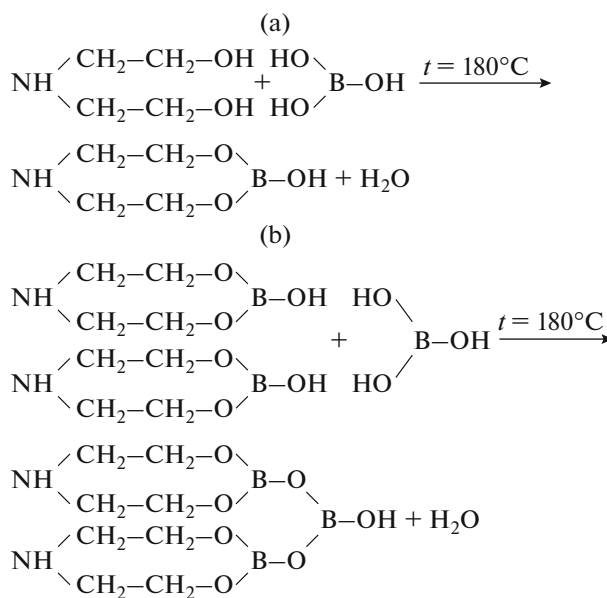


Fig. 3. Stages I (a) and II (b) in the production of diethanolamine borates.

RESULTS AND DISCUSSION

The reaction increases the molecular mass of the compounds; changes the shape and rigidity of the molecules; and increases their diameter. That changes the physicochemical properties of the product (viscosity, solubility, density, etc.).

Increase in molecular density permits the formation of a dense adsorbing layer of inhibitor on the metal surface, ensuring reliable corrosion protection.

The use of 1,2,3-benzotriazole is recommended for the corrosion protection of nonferrous metals (Fig. 4a). It is used to prevent the corrosion of copper and its alloys and is introduced in quantities of 0.1–10% in anticorrosion preparations. In Fig. 4b, we show the complex formed by 1,2,3-benzotriazole with copper cations.

The copper cations are bound in the complex primarily by substitution of H atoms and secondarily on

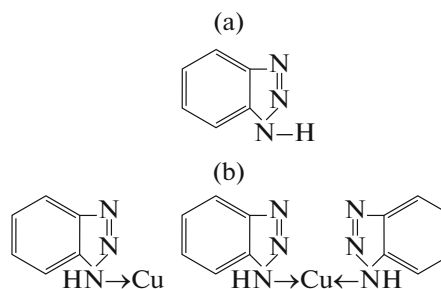


Fig. 4. 1,2,3-Benzotriazole (a) and its complex with copper cations (b).

account of unpaired N atoms. The resulting chelated compound is insoluble and very stable. As a result, the anodic solution of copper is slowed, and the ionization rate of oxygen is decreased because adsorption films are formed.

The solubility of 1,2,3-benzotriazole in water is low. That limits its use in aqueous solutions. In borate form, 1,2,3-benzotriazole dissolves in water at positive temperatures, without limits.

CONCLUSIONS

(1) We have developed a production technology for water-soluble corrosion inhibitors with optimal structure on the basis of amino alcohols. These inhibitors more effectively protect metals against corrosion.

(2) Optimal inhibitor components have been proposed for both ferrous and nonferrous metals.

(3) The results provide the starting point for the production of highly effective anticorrosion agents. We have investigated the role of ethanolamines in the modification of corrosion inhibitors.

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