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INVESTIGATION OF VITAMIN C AS ENVIRONMENTALLY FRIENDLY CORROSION INHIBITOR OF ALUMINUM ALLOY

K. KAMARSKA

Department of Mathematics, Physics, Chemistry, Faculty of Mechanical Engineering, Technical University of Sofia, Branch Plovdiv, Plovdiv, Bulgaria
E-mail: kamarska@tu-plovdiv.bg

Abstract. The inhibitory effect of vitamin C on the corrosion of aluminum alloy EN AW 2024 in 0.5 M H_2SO_4 was investigated by electrochemical methods, such as open circuit potential and potentiodynamic polarisation. The results show that Vitamin C exhibits a good inhibitory effect on the corrosion of the aluminium alloy EN AW 2024 in 0.5 M H_2SO_4, and as the concentration of vitamin C increases, the inhibitory effect also increases. The reason for the good inhibitory effect is the adsorption of the inhibitor molecules on the surface of the aluminum alloy.

Key words: aluminum alloy, vitamin C, corrosion inhibition, electrochemical technique.

AIMS AND BACKGROUND

Natural compounds, known as ecological inhibitors of corrosion have been increasingly used in recent years to protect aluminum and its alloys from aggressive, corrosive environments.

According to their chemical composition, ecological inhibitors are divided into inorganic and organic environmental inhibitors. Some biopolymers, amino acids, plant extracts and essential oils, as well as a number of organic acids can be used as organic ecological inhibitors. This is possible thanks to their molecules, containing heteroatoms such as O in polar groups or heterocyclic compounds with π-bonds.

More and more frequently biomolecules and low-molecular organic acids such as vitamins are used in practice, as they are natural inhibitors of corrosion for a number of metals and their alloys. Such is, for example, vitamin C which is a water-soluble vitamin and due to its structure and the composition of its molecule, it can be successfully used as an organic environmental inhibitor. The literature review shows that it is used both in acidic (H_2SO_4, HCl) (Refs 1 and 2) and neutral (Na_2SO_4 Na_2CO_3) (Refs 3 and 4) or alkaline media ($Ca(OH)_2$) (Ref. 5). Vitamin C finds application when improving the corrosion resistance of aluminum and zinc anodes, used in the construction of fuel cells. Thanks to the adsorption of the vitamin C on the surface of the anode, a preventive layer is formed, which decreases the corrosion of aluminium and increases the resistance of the fuel cell[6].

This paper studies the inhibitory effect of vitamin C, used as a natural inhibitor, on the corrosion of the aluminum alloy EN AW 2024 in a 0.5 M solution of H_2SO_4.

EXPERIMENTAL

Aluminum alloy EN AW-2024 ($AlCuMg_2$) was used for all the corrosion measurements. The corrosion medium was prepared by water solution of 0.5 M H_2SO_4 (Fluka). Vitamin C (Himax Pharma) was used as an inhibitor.

The corrosion measurements were conducted in a three-electrode cell (a working electrode, a platinum conductor and an Ag/AgCl, sat. KCl) connected to a potentiostat/galvanostat (PAR model 263A). The obtained data were processed by the Power Suite program. The open circuit potential (E_{OCP}) was measured for 200 s in 0.5 M H_2SO_4 and in presence of vitamin C at a concentration from 0.00016 to 0.00048 mM. The potentiodynamic polarisation was conducted at an automatic change of the potential from –0.250 to +0.250 V versus the open circuit potential, at a scan rate of 0.16 mV/s.

RESULTS AND DISCUSSION

The OCP curves for EN AW 2024 in a 0.5 M solution of sulphuric acid both without and with different concentrations of vitamin C at concentrations from 0.00024 to 0.00048 mM (Fig. 1) reflect the effect of vitamin C molecules on the corrosion behaviour of the studied alloy. It is noticed that in a 0.5 M H_2SO_4 in the missing of an inhibitor, the value of E_{OCP} continuously decreases and deviates in a negative direction, reaching –0.510 V at the end of the measurement. After adding an inhibitor, a positive shift of the E_{OCP} value was observed, compared to the E_{OCP} value, obtained without the inhibitor. The difference between the value of E_{OCP} without an inhibitor and the value with an inhibitor at concentrations from 0.00024 to 0.00040 mM is about 0.040–0.065 V. However, as the concentration goes up to 0.00048 mM, the difference is found to be significantly higher (about 0.150 V). It can be noted that with the increase in the oil concentration from 0.00024 to 0.00048 mM, the OCP value is shifted in the positive direction, i.e. the risk of corrosion decreases because the inhibitor molecules form an adsorption protective film on the surface of the alloy.

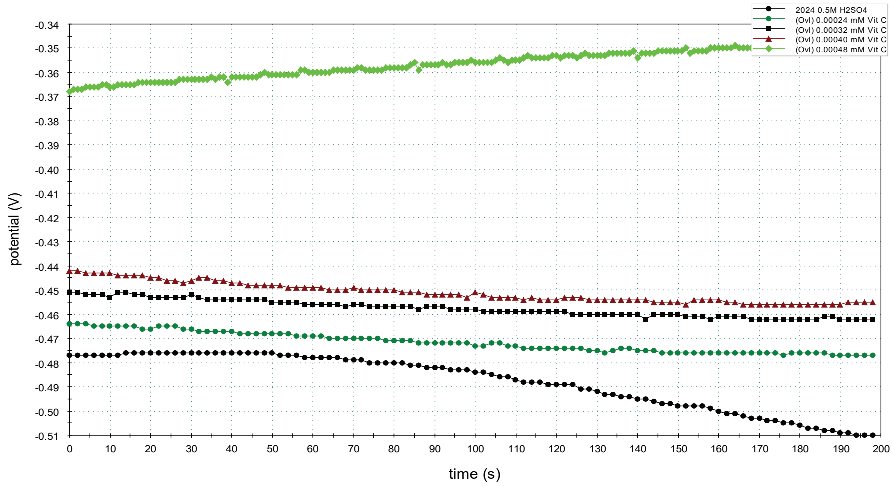

Fig. 1. OCP curves for EN AW 2024 in a 0.5 M solution of sulphuric acid without and with vitamin C

The potentiodynamic polarisation experiment was conducted to establish the inhibitory effect of vitamin C on the corrosion of aluminum alloy 2024 in a 0.5 M H_2SO_4 and to determine the mechanism of inhibition. Table 1 presents the values of the corrosion potential (E_{corr}), corrosion current (I_{corr}), corrosion rate (CR) and the inhibitory effect (η, %) for aluminum alloy 2024 in a 0.5 M solution of H_2SO_4 without and with vitamin C.

Table 1. Electrochemical parameters of EN AW 2024 in a 0.5 M solution of sulphuric acid without and with vitamin C

Concentrations of vitamin C (mM)	E_{corr} (V)	I_{corr} (μA)	CR(mpy)	η (%)
Blank	–0.614	3.934	5.254	–
0.00024	–0.637	1.707	2.246	56.60
0.00032	–0.669	1.586	2.086	59.68
0.00040	–0.693	1.300	1.710	66.95
0.00048	–0.697	0.437	0.575	88.90

The presented values indicate that the rate of corrosion of EN AW 2024 with inhibitor reduces with an increase in the concentration of vitamin C. This can be explained by the formation of a protective layer by adsorbed vitamin C molecules, which interacts with anodic and/or cathodic regions and reduces the speed of the oxidation-reduction processes.

The obtained results show that the effect of inhibition (Fig. 2) goes up with increasing the concentration of vitamin C and reaches an optimal value at a concentration of 0.00048 mM.

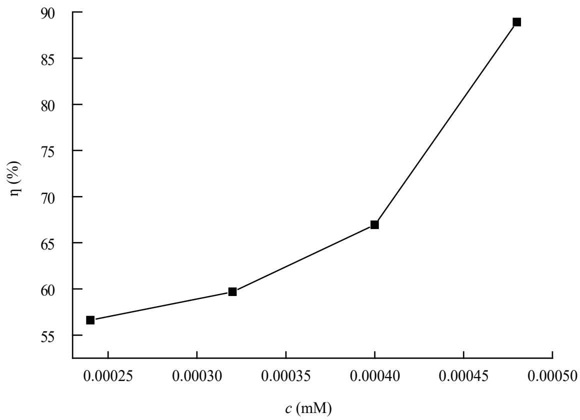

Fig. 2. Change in the effect of inhibition for aluminum alloy 2024 in a 0.5 M sulphuric acid without and with vitamin C

In the vitamin C molecule, there is unshared pair of electrons in the oxygen atom and *p*-electrons, which is a prerequisite for adsorption occurrence. The results show that the oxygen atoms in the vitamin C molecule are the active centres, through which the inhibitor molecules can directly adsorb on the aluminium surface and thus reduce corrosion[7,8].

According to literature sources[9], if the E_{corr} shift is more than 85 mV with respect to the solution without inhibitor, then the inhibitor can be assumed to be of anodic or cathodic type. When the potential shift is less than 0.085 V, then the inhibitor can be taken as a mixed type one. In the conducted study the E_{corr} shift was less than 0.085 V, i.e. under the given experimental conditions, vitamin C acted as a mixed type of inhibitor, capable of slowing down both the cathodic and the anodic reaction.

CONCLUSIONS

The results, obtained from the conducted electrochemical study show that vitamin C demonstrates a good inhibitory effect on the corrosion of aluminum alloy EN AW-2024 in 0.5 M H_2SO_4 (88.90%). The data, obtained during this study show that with increasing the concentration of the inhibitor the values of I_{corr} and CR of the studied alloy decrease. Therefore, vitamin C can be successfully used as a natural inhibitor of corrosion for aluminum alloy EN AW-2024 in a 0.5 M H_2SO_4 as it provides good protection against the studied corrosive environment.

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