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ZAŠTITA POCINČANOG ČELIKA ZELENIM INHIBITORIMA KOROZIJE

GREEN INHIBITORS FOR CORROSION PROTECTION OF GALVANIZED STEEL

ABSTRACT:

Zinc is one of the most used metallic materials in the industry. It is mostly used for protection of steel from corrosion, production of sheet metal, pipes, machine parts and as an alloying element. The hot-dip galvanizing process prevents corrosion by creating galvanic protection of the steel. The galvanized coating is metallurgically bonded to steel and forming an impermeable barrier between the steel substrate and the corrosive environment. The use of zinc as a corrosion-resistant coating is usually limited to atmospheric corrosion, while in more aggressive environments it is necessary to protect the steel by other methods of corrosion protection. In this paper, the influence of four types of inhibitors was investigated in order to improve corrosion resistance and prevent the formation of white rust of hot-dip galvanized steel screws in fresh water, 1% NaCl salt water and distilled water. Green inhibitors have been shown to be successful in protecting zinc coating in solutions with increased chloride ion concentrations.

CONCLUSION:

The results of this study are summarized as follows:

Electrochemical DC tests showed that the best corrosion resistance in fresh water and distilled water was achieved with Inhibitor 1-VCI, while L-tryptophan showed best results in 1% NaCl solution.

Electrochemical impedance spectroscopy showed that L-tryptophan provide highest layer resistance, but negatively influenced on surface functionality of the fasteners and their aesthetic requirements. Inhibitor 1-VCI showed best protective properties in fresh water and distilled water without changing surface condition of the bolts.

SEM and EDX analysis of galvanized steel samples showed higher oxygen content in L-tryptophan inhibitor film, which is very important for the adsorption process and the formation of a protective inhibitor layer on the zinc coating.

FTIR spectra of tested inhibitors on galvanized steel samples showed that bonds of inhibitors 1-VCI, Inhibitor 2 and Inhibitor 3 belong to a carboxylic acid group, whereas L-tryptophan to amino acids.

L-tryptophan acts more as an anodic than a cathodic inhibitor in all tested media.

1. INTRODUCTION

Hot-dip galvanizing prevents corrosion by offering barrier and galvanic protection to the base steel. The galvanized coating is metallurgically bonded to the underlying steel, forming an impervious barrier between the steel substrate and the corrosive environment. The corrosion rate of zinc in water and aqueous solutions can be significantly reduced by use of an appropriate corrosion inhibitor. Recently, the influence of organic, environmentally-friendly corrosion inhibitors for zinc protection is increasingly being investigated. One of these environmentally-friendly corrosion inhibitors is L-tryptophan, an amino acid from the indole group, which showed good properties in zinc protection in sodium chloride solution at a concentration of 1 x 10^{-2} mol/L. His molecular structure consists of an indole ring, nitrogen and oxygen atoms, which are crucial to create a thin monomolecular film on the metal surface and prevent metal contact with aqueous solutions. The inhibition capability of those compounds was depended to their molecular structure, their concentration, corrosive medium, metallic surface nature and to other factors.

2. EXPERIMENTAL

The experimental study included gravimetric analysis and visual assessment, electrochemical polarization measurements, electrochemical impedance spectroscopy, SEM and EDX analysis and ATR-FTIR spectrometry of galvanized steel bolts in fresh water, 1% NaCl salt water, and distilled water, with and without inhibitor.

3. RESULTS AND DISCUSSION

From the visual assessment results obtained after 24 hours immersion of the samples in aqueous solutions with and without inhibitors, it is apparent that the Inhibitor 1 (samples 1.1 and 1.2) in water and distilled water showed best results, that is, no visible corrosion occurrence, whereas in 1% NaCl solution the surface changes are more pronounced in the form of black spots. The results are shown in Table 1.

Table 1. Samples of galvanized bolts after 24 hours in solutions with and without inhibitors

Solution	No inhibitor	Inhibitor 1-VCI	Inhibitor 2	Inhibitor 3	L-tryptophan
Fresh water (samples 1)					
Distilled water (samples 2)					
1% NaCl (samples 3)					

Tafel extrapolation measurements provide important information about the kinetics of anodic and cathodic reactions. Comparing the determined corrosion rate, it was found that Inhibitor 1-VCI showed the best protection properties in fresh water and distilled water, while L-tryptophan showed the best protecting in 1% NaCl solution. The potentiodynamic polarization curves (Tafel diagrams) of uninhibited and inhibited galvanized steel samples after 1 hour in fresh water, distilled water and 1% NaCl solution are given in Figures 1, 2 and 3.

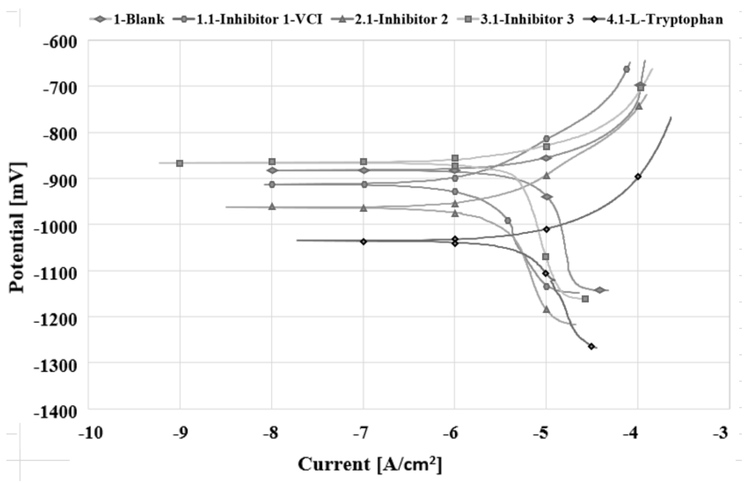

Figure 1. Polarization curves of tested inhibitors, compared to unprotected galvanized steel in fresh water

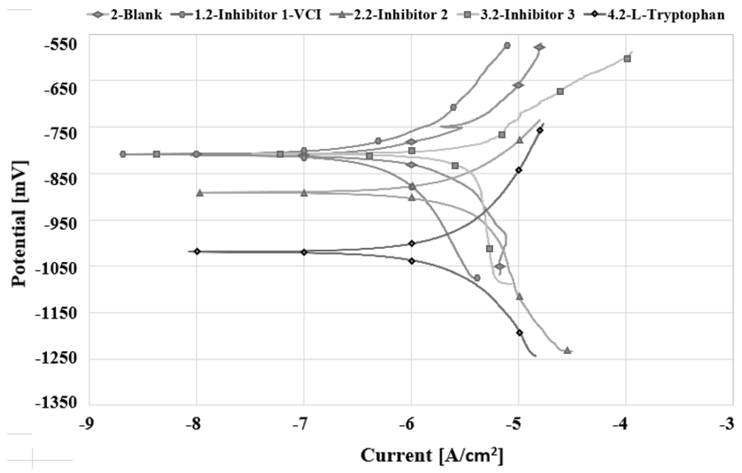

Figure 2. Polarization curves of tested inhibitors, compared to unprotected galvanized steel in distilled water

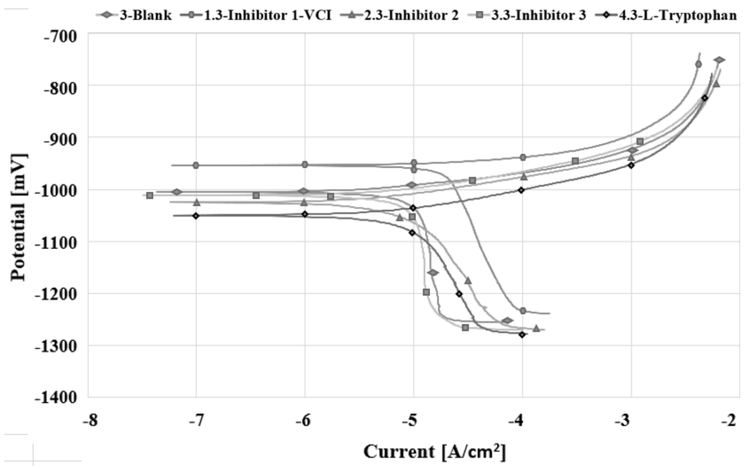

Figure 3. Polarization curves of tested inhibitors, compared to unprotected galvanized steel in 1 % NaCl solution

From the phase angle of the tested inhibitors, the L-tryptophan showed the best protective properties in 1% NaCl, that is, the phase angle is 90°. The Phase angle diagram is presented in Figure 4.

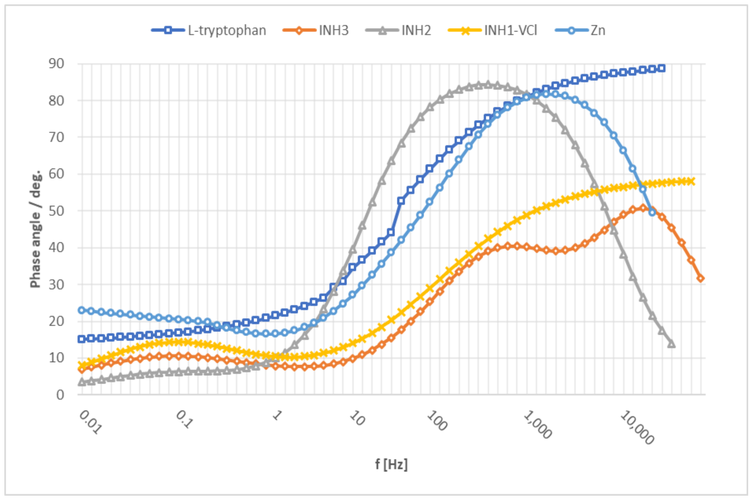

Figure 4. The Phase angle diagram of all tested samples 24 h immersion in 1% NaCl solution

SEM analysis showed irregularities on all examined samples i.e. an uneven layer of zinc coating on the surface or chloride depositions from the aqueous solutions. On the samples treated with L-tryptophan, sedimentation of white clusters was visible on the surface. EDX analysis shown that L-tryptophan treated samples were found to contain oxygen, which is very important for the process of adsorption of the inhibitor compound on the metal surface. The presence of oxygen was also confirmed on samples protected with vapour phase corrosion inhibitor 1-VCI, showing that both corrosion inhibitors act as an adsorption inhibitor. SEM view of inhibitor layer after 24 hours in distilled water is given in Figure 5.

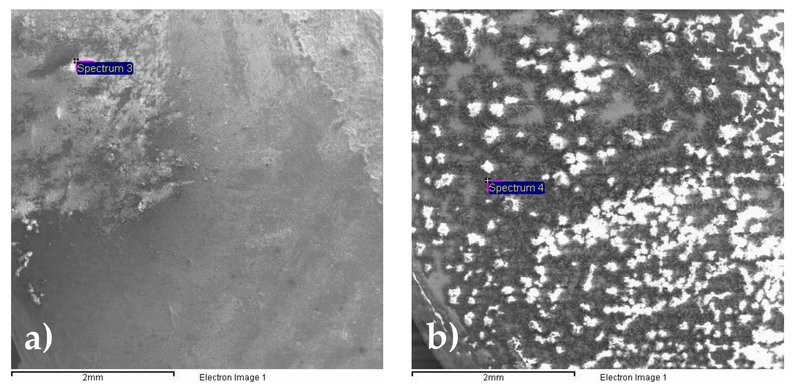

Figure 5. SEM view of inhibitor layer after 24 hours in distilled water; a) Inhibitor 1-VCI and b) L-Tryptophan

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