RESVERATROL AS CORROSION INHIBITOR FOR METALS IN WINE AND FOOD INDUSTRIES

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Abstract

This paper presents preliminary results obtained in the case of Resveratrol used as corrosion inhibitor for stainless steel, carbon steel, polished and brushed aluminum in ethanol solutions. Electrochemical behavior of Resveratrol in ethanol solutions has been studied by cyclic voltammetry on platinum electrode. Information about the inhibitory effect mechanism was provided by kinetic parameters calculated with Tafel method from linear polarization curves. Corrosion rate diminution of studied electrodes in the presence of Resveratrol can be assigned to the adsorption of inhibitor molecules on the sample surface, or depositing corrosion products onto metal surface, blocking the active sites.

Introduction

Wine industry contributes to the food position of industry as one of the three largest markets worldwide, which also includes the energy and water industries based on production, number of consumers, and economic and social significance [1]. As above mentioned industries, the wine industry is subject of corrosion.

High quality materials represent a key factor for whole food industry, especially wine production [2]. Corrosion resistance is the main property to be considered when choosing materials for winery equipment. Preserving of the organoleptic characteristics: taste, fragrance and color is the crucial element in order to achieve high quality wines [2]. Industrial alcoholic fermentation containers are made of stainless steel. Aluminum is used in wine industry as material component for cans and screw caps [3].

The wine quality is dependent on approximately eight hundred components [2]. It can be expected the change of percentage of any one of these components to affect the quality of wines.

Resveratrol (3,5,4′-trihydroxy-trans-stilbene) is a stilbenoid, a natural phenol, and at the same time a naturally produced phytoalexin by several plantsas response to the injuries or attacks of pathogens such as bacteria or fungi [4].

Resveratrol is also found in the skin of grapes, blueberries, raspberries and mulberries. Considerably higher amounts of Resveratrol is contained in red wines than in white wines because, although it is present in ripe grapes of both red and white varieties, the concentration is higher in the red berries [5,6].

The inhibitory properties of Resveratrol on the corrosion process of stainless steel, carbon steel, polished and brushed aluminum in ethanol solutions offers considerable prospects for the wine industry, also being defined as a natural, eco-friendly corrosion inhibitor in alcoholic media.

Experimental

Electrochemical measurements were carried out using BioLogic SP150 potentiostat/ galvanostat

in a conventional three-electrode cell systems. Stainless steel, carbon steel polished and brushed aluminum samples were used as working electrode. The counter electrode was graphite, and Ag/AgCl acted as reference electrode. Electrochemical experiments were performed in 12% ethanol added in 0.25 M Na_2SO_4 solution, in order to determine the corrosion potential and corrosion current. Electrochemical behavior of Resveratrol in test solutions was studied by cyclic voltammetry on platinum electrode.
To determine the inhibitor effect of Resveratrol on the corrosion rate of the four samples in test solution, 10^{-5} mol L^{-1} concentration has been used in preliminary studies. Resveratrol ($C_{14}H_{12}O_3$) exists in two isomeric forms, as trans- and cis-resveratrol. Both chemical structures are presented in figure 1 [6].

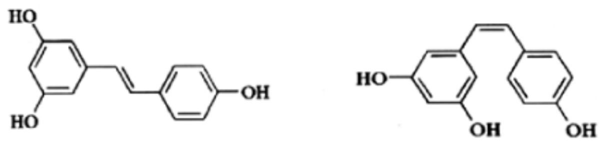
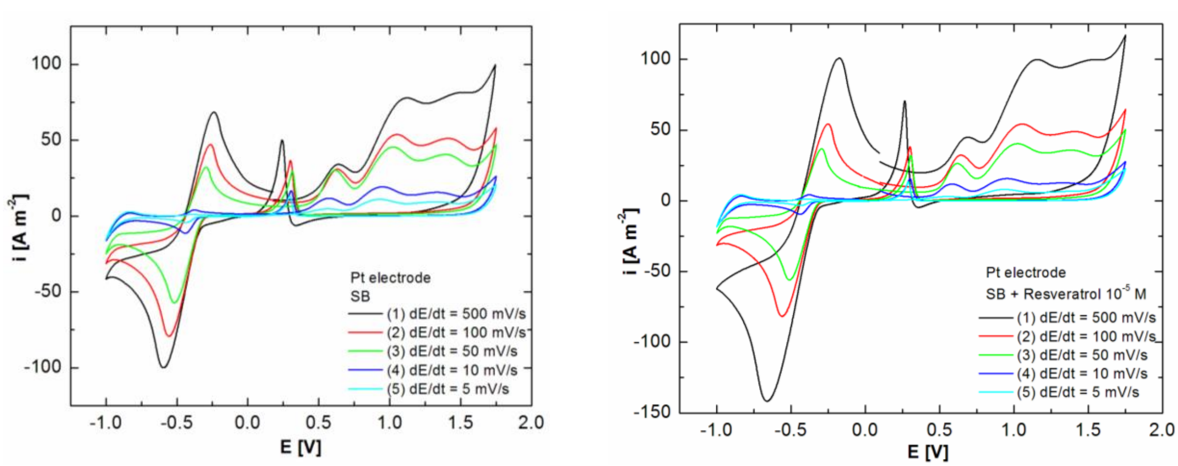


Figure 1. Chemical structures of *trans*- and *cis*- resveratrol [6].

Results and discussion

Preliminary information about how Resveratrol can influence the corrosion process of test electrodes are provided by its electrochemical behavior on platinum electrode in alcoholic solution, emphasised by cyclic voltammetry.



a) b)

Figure 2. Cyclic voltammograms on Pt electrode in 0.25 mol $L^{-1}Na_2SO_4$ + 12% ethanol (SB) in the absence (a) and presence of 10^{-5} mol L^{-1} Resveratrol (b), at different scan rates.

In figure 2, cyclic voltammograms recorded at different scan rates, between 500 and 5 mV s^{-1}, on Pt electrode, in 0.25 mol $L^{-1}Na_2SO_4$ + 12% ethanol solution without (Fig.2a) and with Resveratrol (Fig.2b) are shown. The base curve obtained in blank solution has the characteristic polarization curve drawn in ethanol solutions.
In order to identify how Resveratrol influences the electrode processes, cyclic curves without and with Resveratrol (dE/dt = 10 mV s^{-1}) are presented comparative in figure 3.
The way Resveratrol acts as corrosion inhibitor for test electrodes in alcoholic solution and its effect on the corrosion rate can be estimated by Tafel polarization method. The potentiodynamic polarization curves recorded without and with 10^{-5}mol L^{-1} Resveratrol are shown in figure 4 for

stainless steel and carbon steel electrodes and in figure 5 for polished and brushed aluminum electrodes.

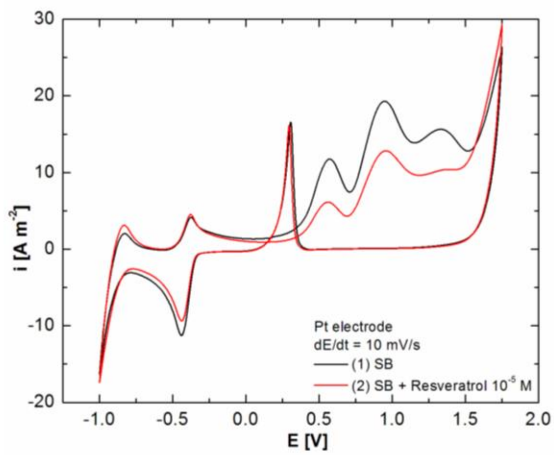
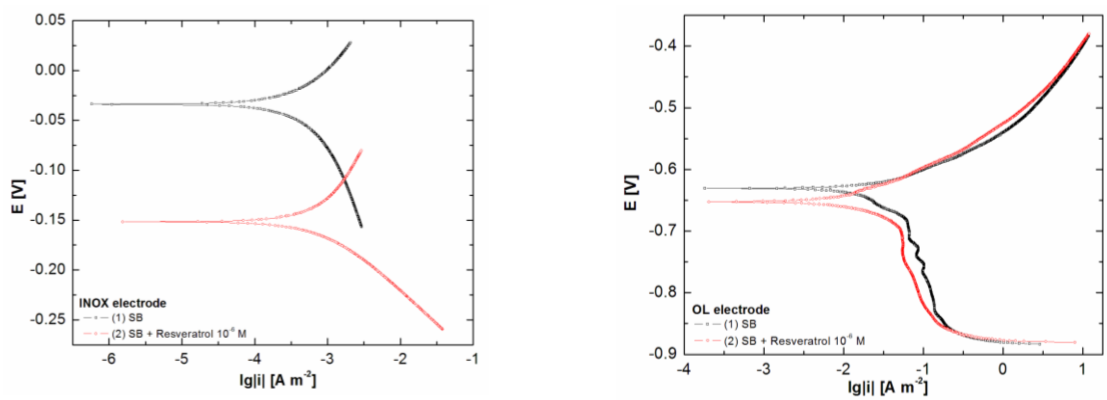
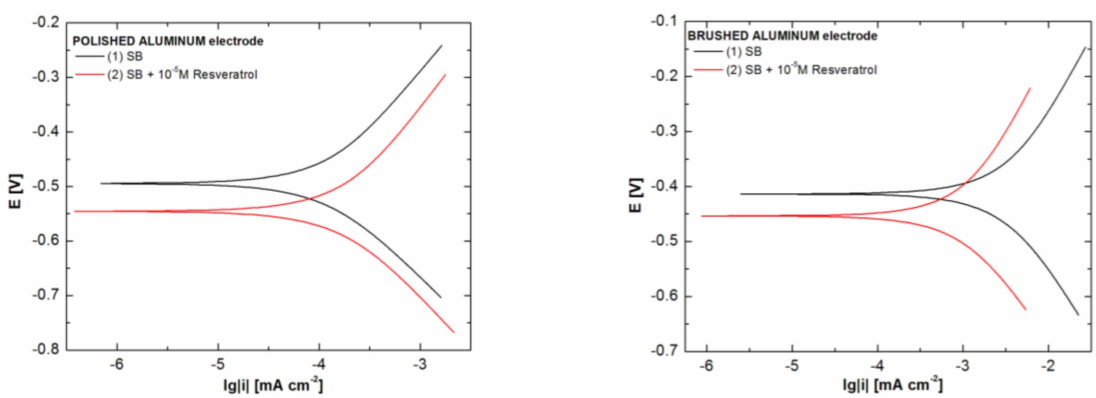


Figure 3. Cyclic voltammograms on Pt electrode in 0.25 mol L^{-1} Na_2SO_4+ 12% ethanol (SB) in the absence/presence of 10^{-5}mol L^{-1} Resveratrol at 10 mV s^{-1} scan rate.



a) b)

Figure 4. Linear polarization curves on stainless steel (a) and carbon steel electrode (b) in test solutions in the absence/presence of 10^{-5}mol L^{-1} Resveratrol, scan rate: 1 mV s^{-1}.



a) b)

Figure 5. Linear polarization curves on polished (a) and brushed aluminumelectrodes (b) in test solutions in the absence/presence of 10^{-5}mol L^{-1} Resveratrol, scan rate: 1 mV s^{-1}.

Numerical values of corrosion current density (i_{corr}), corrosion potential (E_{corr}), anodic Tafel slope (b_a), cathodic Tafel slope (b_c) and polarization resistance (R_p) were obtained from polarization profiles extrapolating potentiodynamic curves from figures 4 and 5 using BioLogics software.The inhibition efficiency (IE) has been calculated using equation (1). All obtained values are given in Table 1.

$$IE(\%) = \left(\frac{i_{corr}^{o} - i_{corr}^{inh}}{i_{corr}^{o}}\right) \times 100 \qquad (1)$$

where i_{corr}^{0} and i_{corr}^{inh} are the uninhibited and inhibited corrosion current densities, respectively.

Table 1. Polarization parameters for test electrodes corrosion process in 0.25 mol L^{-1} Na_2SO_4 + 12% ethanol solution in the absence/presence of Resveratrol, at 25°C.

Electrode	**Inh.conc. [M]**	i_{corr}, [μA cm^{-2}]	E_{corr}, [mV]	$-b_c$, [mV dec^{-1}]	b_a, [mV dec^{-1}]	R_p, [kΩ]	v_{corr}, [mm an^{-1}] · 10^3	*IE*, %
Stainless steel	0	0.148	-33.7	253	108	187	3.3	-
	10^{-5}	0.078	-151.7	68	154	314	2	47.3
Carbon steel	0	5.22	-630	369	69	2.1	132	-
	10^{-5}	2.49	-653	243	82.3	3.4	58	52.3
Polished Al	0	0.162	-494	205	242	223	4.5	-
	10^{-5}	0.067	-545	201	236	654	1.8	58.6
Brushed Al	0	1.112	-413	259	288	22	37	-
	10^{-5}	0.404	-453	229	298	50	16	63.7

Conclusion

Preliminary studies confirm that Resveratrol has promising corrosion inhibition properties for stainless steel, carbon steel, polished and brushed aluminum in alcoholic solutions. Resveratrol can be added to the list of non-toxic and effective green corrosion inhibitors in wine industry from renewable sources.

Acknowledgements

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