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Synergistic effect of iodide ions on the corrosion inhibition of steel in 0.5 M H_2SO_4 by new chalcone derivatives

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Abstract

The effect of addition of 4′,4-dihydroxychalcone (P_1), 4-aminochalcone (P_2) and 4-bromo, 4′-methoxychalcone (P_3) on the corrosion of steel in 0.5 M sulphuric acid has been studied by weight loss measurements, potentiodynamic and EIS measurements. We investigate the synergistic effect of iodide ions on the corrosion inhibition of steel in the presence of chalcone derivatives. The corrosion rates of the steel decrease with the increase of the chalcones concentration, while the inhibition efficiencies increase. The addition of iodide ions enhances the inhibition efficiency considerably. The presence of iodide ions increases the degree of surface coverage. The synergism parameters S_Θ and S_I, calculated from surface coverage and the values of inhibition efficiency, in the case of chalcone derivatives are found to be larger than unity. The enhanced inhibition efficiency in the presence of iodide ions is only due to synergism and there is a definite contribution from the inhibitors molecules. *E* (%) obtained from the various methods is in good agreement. Polarisation measurements show also that the compounds act as cathodic inhibitors.

Keywords: Steel; Chalcone; Inhibition; Corrosion; Sulphuric acid; Synergistic effect

1. Introduction

The importance of inhibitive protection in acidic solutions is increased by the fact that steel materials, which are more susceptible to be attacked in aggressive media, are the commonly exposed metals in industrial environments. It is shown that the protective properties of such compounds depend upon their ability to reduce corrosion rate and are enhanced at higher electron densities around the nitrogen atoms [1–7]. Among these compounds, ketones are much known as good inhibitors in aggressive media [8–10].

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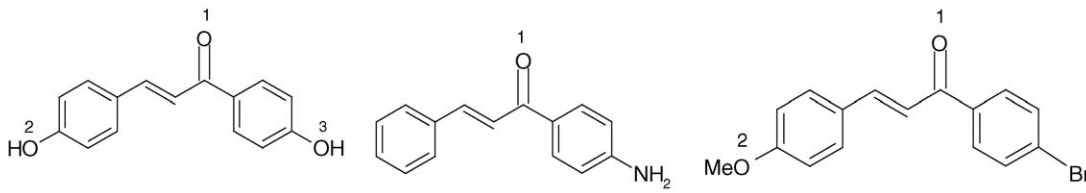

Fig. 1. The molecular structure of chalcone derevatives.

Chalone compounds are known since Egyptian era during the exposure of fresh mommies at sun. Chalconic monomers, also called unsaturated α, β ketones, are the basically unities in the synthesis of photocrosslinking polymers. Chalconic compounds are used in science of art and electronic (printing circuits and colour filters) [11,12].

The inhibitive action of chalcone derivatives on the corrosion of steel in HCl and H_2SO_4 solution is studied in recent work [13,14].

The synergistic influence of halide on the inhibition corrosion of metals by organic compounds is well improved [15–19]. Authors found that halide enhance inhibitive effect of several organic molecules.

In this work, the gravimetric and electrochemical measurements and polarisation resistance are made using steel immersed in molar sulphuric acid without and with addition of chalcone derivatives. Synergistic effect of iodide ions is also studied. The molecular structure of chalcone derivatives is shown in Fig. 1.

2. Experimental details

Chalconic compounds are generally prepared as described elsewhere [20] by condensation of substituted benzaldehyde on ketene. 4′,4-Dihydroxychalcone (P_1) is obtained by addition of *p*-hydroxyacetophenone and *p*-hydroxyabenzaldehyde in ethanol in the presence of potassium hydroxide. 4-Aminochalcone (P_2) is obtained by addition of benzaldehyde and *p*-aminoacetophenone. 4-Bromo, 4′-methoxychalcone (P_3) is obtained by addition of methoxybenzaldehyde and *p*-bromoacetophenone.

Chalcone derevatives are characterised by IR, NMR (1H, 13C) and Mass spectroscopies. The molecular structure of chalcone derivatives are shown in Fig. 1.

Prior to all measurements, the steel samples (0.09% P; 0.38% Si; 0.01% Al; 0.05% Mn; 0.21% C; 0.05% S and the remainder iron) are polished with different emery paper up to 1200 grade, washed thoroughly with bidistilled water degreased and dried with acetone.

The aggressive solution (0.5 M H_2SO_4) was prepared by dilution of Analytical Grade 98% H_2SO_4 with bidistilled water.

Gravimetric measurements are carried out in double walled glass cell equipped with a thermostatic cooling condenser. The solution volume was 100 cm^3. The steel specimens used have a rectangular form (2 cm × 2 cm × 0.05 cm).

Electrochemical measurements are carried out in a conventional three-electrode electrolysis cylindrical Pyrex glass cell. The temperature is controlled at 298 ± 0.5 K. The working electrode (WE) in the form of disc is cut from steel, has a geometric area of 1 cm^2 and is embedded in polytetrafluoroethylene (PTFE). A saturated calomel electrode (SCE) and a platinum electrode are used, as reference and auxiliary electrodes, respectively. The potentiokinetic current–voltage characteristics are recorded with a potentiostat type Amel 549 using a linear sweep generator type Amel 567 at a scan rate of 20 mV/min. Before recording the cathodic polarisation curves, the steel electrode was polarised at −800 mV versus SCE for 10 min. For anodic curves, the potential of the electrode is swept from its corrosion potential after 30 min free corrosion, to more positive values. The test solution is de-aerated for with pure nitrogen. Gas pebbling was maintained through the experiments.

Near E_{corr} a scan through a potential range performs polarisation resistance measurements. The potential range is ± 10 mV around E_{corr}. The resulting current is plotted versus potential. Polarisation resistance (R_p) values are obtained from the current potential plot.

Electrochemical impedance spectroscopy (EIS) is carried out with a Voltalab electrochemical system at E_{corr} after immersion in solution without pebbling.