Available online at www.sciencedirect.com

ScienceDirect

Materials Chemistry and Physics 108 (2008) 283–289

MATERIALS CHEMISTRY AND PHYSICS

www.elsevier.com/locate/matchemphys

Quinol-2-thione compounds as corrosion inhibitors for mild steel in acid solution

R.A. Prabhu [a], T.V. Venkatesha [b,*], A.V. Shanbhag [c], B.M. Praveen [b], G.M. Kulkarni [d], R.G. Kalkhambkar [d]

[a] *Department of Chemistry, M.G.C. Arts, Commerce and G.H.D. Science College, Siddapur (U.K.), Karnataka, India*
[b] *Department of P.G. Studies and Research in Chemistry, Kuvempu University, Shankaraghatta 577451, Karnataka, India*
[c] *Department of Chemistry, S.D.M. College, Honavar (U.K.), Karnataka, India*
[d] *Department of Chemistry, Karnataka Science College, Dharwad, Karnataka, India*

Received 2 June 2007; received in revised form 23 September 2007; accepted 27 September 2007

Abstract

The corrosion inhibition effect of 3-[(E)-(phenylimino)methyl]quinoline-2-thione (PMQT), 3{(E)-[(4-chlorophenyl)imino]methyl}quinoline-2-thione (CPMQT) and 3{(E)-[(4-fluorophenyl)imino]methyl}quinoline-2-thione (FPMQT) on mild steel in 1 mol dm^{-3} HCl has been determined by mass loss, polarization and impedance (EIS) methods at 300 K. The investigated results showed that the corrosion rate decreased significantly with increase in the concentration of inhibitors. The shape of polarization profiles of all the three compounds indicated their mixed-type nature of inhibition. The inhibition efficiencies decreased in the order FPMQT > CPMQT > PMQT. The adsorption of the compounds on the mild steel surface obeys Langmuir's adsorption isotherm. The surface morphology of the tested mild steel specimens in the presence and absence of inhibitors was studied by using the respective images of SEM. FTIR studies were undertaken to confirm the interaction of molecules with surface atoms of the mild steel and established the adsorption process.

Keywords: Schiff's bases; Corrosion inhibitors; Mild steel; Adsorption isotherms; Hydrochloric acid solution

1. Introduction

Metals and alloys are used in different developmental activities and are susceptible to corrosion due to their thermodynamic instability especially in aggressive media. Among these the mild steel an alloy, which is one of the commercial forms of iron and is very prone to corrosion particularly in acidic medium. Acidic solutions are extensively used for different purposes in chemical laboratories and in several industrial processes such as acid pickling, acid cleaning, acid descaling and oil well acidizing, etc. [1]. Specific chemical compounds are often used as inhibitors in these processes mainly to control the metal dissolution reaction and thereby increased the service life of steel materials. Most of the well-known acid inhibitors are either aliphatic or aromatic compounds possessing nitrogen, sulfur, oxygen atoms in their functional groups along with multiple bonds. The influence of such compounds on corrosion inhibition of steel has been investigated by some workers [2,3]. Many Schiff's bases have been reported as corrosion inhibitors for steel [4–6]. A few research reports [7,8] revealed that the inhibition efficiency of Schiff's bases is much higher than that of corresponding aldehydes and amines. However there are research reports to show the still higher inhibition efficiencies exhibited by some thione compounds than the Schiff's bases [9,3]. Also the thiol compounds have been known for their ability to form monolayer films on many metals [10]. Further, the existing literature revealed that no single inhibitor exhibited 100% corrosion inhibition efficiency. Always there is great demand for developing such efficient inhibitors for controlling the corrosion process.

The objective of the present paper is to focus on the inhibition action of newly synthesized Schiff's base compounds FPMQT, CPMQT and PMQT on the corrosion of mild steel in 1 mol dm^{-3} HCl at 300 K. The work is carried out to establish the effective concentration for good inhibition action. The inhibition efficiencies of these compounds are determined by

* Corresponding author. Tel.: +91 8182242571; fax: +91 8282256255.
E-mail address: drtvvenkatesha@yahoo.co.uk (T.V. Venkatesha).

0254-0584/$ – see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.matchemphys.2007.09.038

Table 1
The physical and analytical data of prepared compounds

Compounds	Formula	Molecular mass	Melting point (°C)	Solvent
PMQT	$C_{16}H_{12}N_2S$	264.3	239	Ethanol/dioxan
CPMQT	$C_{16}H_{11}ClN_2S$	298.8	248	Ethanol/dioxan
FPMQT	$C_{16}H_{11}FN_2S$	282.3	261	Ethanol/dioxan

using mass loss, polarization and impedance (EIS) methods. Further, the work deals with the study of mechanism of inhibition through adsorption. The surface morphology study is undertaken to establish good corrosion protection of the thione compounds.

2. Experimental

2.1. Inhibitors

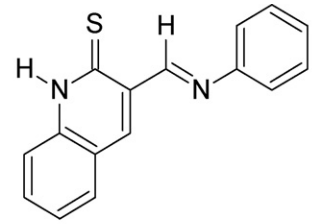
PMQT, CPMQT and FPMQT were synthesized [11] by stirring the mixture of equimolar 2-mercapto-3-formylquinoline (0.004 mol) and substituted anilines (0.004 mol) in 20 ml ethanol:acetic acid (4:1) medium at room temperature for 6 h. After completion of the reaction the separated solid was filtered, washed with excess of alcohol (30 ml), dried and crystallized from ethanol dioxin mixture. The inhibitor solutions were prepared in ethanol:triple distilled water (25:75) mixture within a concentration range 2×10^{-5} to 5×10^{-3} mol dm^{-3}. The physical and analytical data of the prepared compounds are given in Table 1. The chemical stable structures of the investigated inhibitor compounds are given in Fig. 1.

2.2. Aggressive solution

The 1 mol dm^{-3} HCl, was prepared by using A.R. grade HCl and triple distilled water. All experimental observations were performed in aerated and stirred solutions.

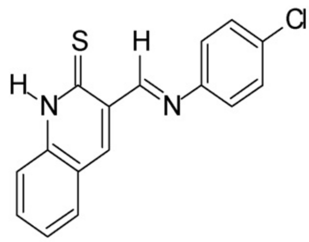
Table 2
Corrosion parameters in 1.0 mol dm^{-3} HCl obtained from the mass measurements at 300 K

C (mol dm^{-3})	Corrosion rate (mm Y^{-1})	ηwl (%)
Blank	21.73	–
PMQT		
2×10^{-5}	18.43	15
5×10^{-5}	15.16	30
2×10^{-4}	8.22	62
1×10^{-3}	3.03	86
5×10^{-3}	0.866	96
CPMQT		
2×10^{-5}	18.2	16
5×10^{-5}	14.5	33
2×10^{-4}	7.14	67
1×10^{-3}	2	90
5×10^{-3}	0.433	98
FPMQT		
2×10^{-5}	17.32	20
5×10^{-5}	12.77	41
2×10^{-4}	5.3	75
1×10^{-3}	1.3	94
5×10^{-3}	0.002	99



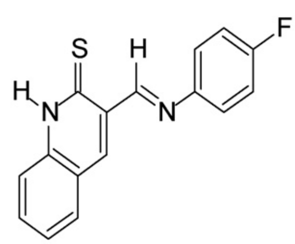
3-[(*E*)-(phenylimino)methyl]quinoline-2(1*H*)-thione

PMQT



3-{(*E*)-[(4-chlorophenyl)imino]methyl}quinoline-2(1*H*)-thione

CPMQT



3-{(*E*)-[(4-fluorophenyl)imino]methyl}quinoline-2(1*H*)-thione

FPMQT

Fig. 1. Structures of studied Schiff's bases.

2.3. Metal samples

Mild steel specimens having compositions 0.04% C, 0.35% Mn, 0.022% P, 0.036% S and the remainder being Fe were used. The specimens of dimension 5 cm × 1 cm × 0.1 cm were used for mass loss method and of 1 cm^2 (exposed) with a 5 cm long stem (isolated with araldite resin) were used for polarization and electrochemical impedance methods. They were mechanically polished using emery papers of grade no. 220, 600, 1000 and 1200 followed by washing in acetone, triple distilled water and then dried.

2.4. Mass loss measurements

The mass loss of the cleaned and dried specimens in 1 mol dm^{-3} HCl in the absence and presence of various concentrations (2×10^{-5} to 5×10^{-3} mol dm^{-3}) of PMQT, CPMQT and FPMQT were determined after 240 min of immersion. Duplicate experiments were conducted in each case. The results obtained in original and duplicate sets agree and average mass loss was noted. The specimens were washed with ethanol and triple distilled water and dried before weighing. The inhibition efficiencies (ηwl (%)) were calculated using the relation:

$$\eta \text{wl}\,(\%) = \frac{w - w'}{w} \times 100 \qquad (1)$$