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Bis-Schiff bases of isatin as new and environmentally benign corrosion inhibitor for mild steel

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ABSTRACT

Inhibition effect of three bis-Schiff bases of isatin namely (2-methoxybenzylidene) hydrazono) indolin-2-one (HZ-1), (2-hydroxybenzylidene) hydrazono) indolin-2-one (HZ-2) and (4-nitrobenzylidene) hydrazono) indolin-2-one (HZ-3) was studied on mild steel corrosion in 1.0 M HCl by gravimetric measurements, electrochemical impedance spectroscopy (EIS), potentiodynamic polarization and quantum chemical study. The values of activation energy (E_a), equilibrium constant (K_{ads}), free energy of adsorption ΔG°_{ads}, activation enthalpy ΔH^{*} and activation entropy ΔS^{*}were discussed. The adsorption of inhibitors on metal followed Langmuir's adsorption isotherm. SEM and EDX observations confirmed the existence of protective inhibitor film on metal surface. Quantum chemical study supports the comparative inhibition effect of HZs.

1. Introduction

Mild steel is one of the most important engineering materials, which due to its low cost and excellent mechanical properties is widely used as a construction material. The mild steel is severely attacked in acid solutions which are used in various industries during pickling cleaning of industrial equipments and acidization of oil wells etc [1–4]. Inhibited acid solutions are commonly used to reduce the corrosive attack of acid on metals. The use of inhibitors is specific for different systems and thus it needs to be used thoroughly. These inhibitors decreases the corrosion processes by increasing the anodic or cathodic polarization behavior, reducing the movement or diffusion of ions and increasing the electrical resistance of the metallic surface [5]. Now a day's research is going on for the development of "green" corrosion inhibitors by using cheap, effective molecules with low or "zero" environmental impact. So, in order to achieve this we have synthesized Schiff bases of isatin.

The Schiff base of isatin not only exhibit wide rang of biological activities such as anticonvulsant, analgesic, anti-inflammatory, antidepressant, pro-apoptotic, cytotoxicity, antioxidant, and antimicrobial but also act as efficient corrosion inhibitors [6–9]. In view of these observations we have synthesized three Schiff bases namely (2-methoxybenzylidene) hydrazono) indolin-2-one (HZ-1), (2-hydroxybenzylidene) hydrazono) indolin-2-one (HZ-2) and (4-nitrobenzylidene) hydrazono) indolin-2-one (HZ-3) to investigate their corrosion inhibiting properties on corrosion of mild steel in HCl by using gravimetric measurements, polarization measurements, electrochemical impedance spectroscopy, quantum chemical calculations, scanning electron microscope (SEM) and energy dispersive X-ray spectroscopy (EDX). Previously reported Schiff bases showed inhibition efficiency (75–93%) at (490–1740 mg L^{-1}) concentration [10–13]. The studied Schiff bases give the best inhibition efficiency of 92.3% at only 250 mg L^{-1}.

The selection of these compounds as a corrosion inhibitor is based on the following considerations (a) they are non-toxic (LD_{50} > 2000 mg/kg bw) and excellent anti-glycating agent [9], (b) can be easily synthesized from relatively cheap chemicals, (c) contain electronegative nitrogen, oxygen and aromatic ring which acts as active centers for adsorption on metal surface. Previously, some isatin derived Schiff bases have been used as corrosion inhibitors by our research group [6–8]. According to literature survey, to date, no work has been carried out on these Schiff base compounds as corrosion inhibitors.

2. Experimental

2.1. Materials

Mild steel strips having composition of (wt%): C = 0.076, Mn = 0.192, P = 0.012, Si = 0.026, Cr = 0.050, Al = 0.023 and balance Fe were used for corrosion test. The dimension of mild steel which were used in gravimetric and electrochemical experiments

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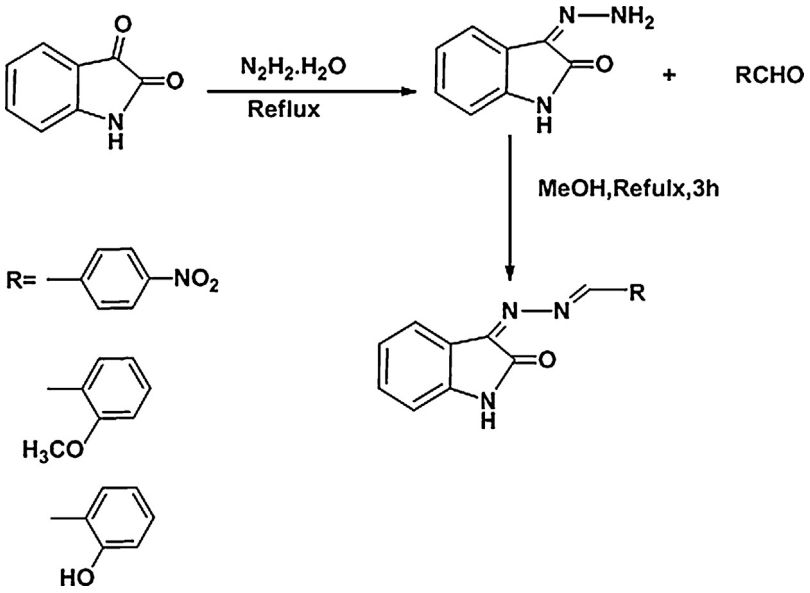


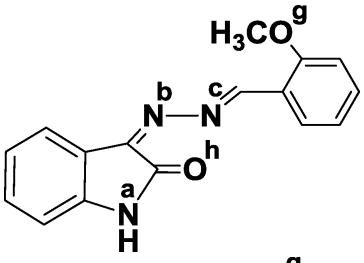
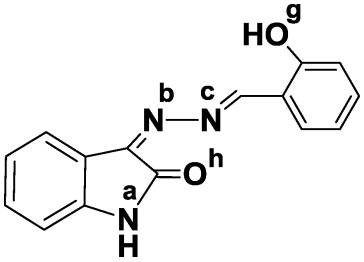
Scheme 1. Synthetic route of HZs.

were 2.5 cm × 2 cm × 0.025 cm and 8 cm × 1 cm × 0.025 cm, respectively and finally mild steel strips were abraded with SiC abrasive papers of grade 600, 800, 1000 and 1200 respectively, degreased with acetone and dried. The test solution, 1.0 M HCl was prepared by dilution of analytical grade 37% HCl with double distilled water. The concentration range of HZs employed was 50–250 mg L^{-1}.

2.2. Inhibitors

The isatin Schiff bases were synthesized according to previously reported method (Scheme 1) [9]. The products were purified by recrystallization from methanol. The chemical structure, abbreviations and IUPAC names of synthesized compounds are given in Table 1.

Table 1
Molecular structure and analytical data of HZs.

Inhibitor	Structure
(2-Methoxybenzylidene) hydrazono) indolin-2-one (HZ-1)	
(2-Hydroxybenzylidene) hydrazono) indolin-2-one (HZ-2)	
(4-Nitrobenzylidene) hydrazono) indolin-2-one (HZ-3)