

A natural extract of tobacco rob as scale and corrosion inhibitor in artificial seawater



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HIGHLIGHTS

- TRE as corrosion inhibitor for Q235 was investigated in artificial seawater.
- TRE on Q235 surface has been confirmed by SEM and XPS analysis.
- TRE has an excellent scale inhibition in artificial seawater.
- SEM and XRD implied that the scale deposits were changed in the presence of TRE.

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ABSTRACT

The corrosion inhibition performance of tobacco rob extract (TRE) for Q235 corrosion in artificial seawater was investigated by potentiodynamic polarization. The experimental results indicate that TRE has good corrosion inhibition performance and the inhibition efficiency increased with the increase of TRE concentration. Scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS) indicated that the corrosion inhibition is due to the formation of a chemisorbed film on the steel. The anti-scale property of TRE in artificial seawater was also studied by static tests for scale and the scale deposits were analyzed by X-ray diffraction (XRD) and SEM, respectively. The results showed that the scale deposits surface morphology and size were changed in the presence of TRE. The corrosion and scale inhibition results indicated the potential use of TRE as an efficient corrosion and scale inhibitor in artificial seawater.

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1. Introduction

Water is the most essential substance for all life on earth and a precious resource for human civilization [1]. The demand of water in industrial processes has increased significantly with the development of iron and steel production, power generation, chemicals production, which has intensified the shortage of water resources. Therefore, seawater has been used for as cooling water or desalination to alleviate the pressure on water supply in recent years. However, seawater with high salinity and a great variety of micro-organism result in corrosion and scale formation [2,3], which lead to many operational problems, economic losses and even risk of lives [4,5].

The use of corrosion and scale inhibitors is one of the most common methods to control corrosion and scale deposition [6–8]. Synthetic organic compounds containing hetero atoms nitrogen such as benzotriazole (BTA) [9,10], 2-((dehydroabietylamine) methyl)-6-methoxy

xyphenol (DMP) [11], 2-(2-([2-(4-Pyridylcarbonyl) hydrazono] methyl) phenoxy) acetic acid (PMA) [12] 3-amino-1,2,4-triazole-5-thiol (ATAT) [6], and 4,5-dichloro-2-n-octyl-4-isothiazolin-3-one (DCOIT) [13] were used as corrosion inhibitors due to the adsorption of hetero atoms on metal surface. Most corrosion and scale inhibitors are synthetic polymers containing phosphate groups, sulfonate groups and carboxylic acids [14], such as poly (acrylic acid) (PAA) as scale inhibitors in seawater [14] and Phosphonic Chitosan (Ph-Ch) as corrosion inhibitor for carbon steel in seawater [15]. Recently, polyaspartic acid derivative [3] with functional group of carboxylic acid had good corrosion and scale inhibition performance in natural seawater. Although the above mentioned synthetic compounds had good anti-corrosion and anti-scaling performance, most of them are non-biodegradable and expensive, which confine their development and applications in industry. Besides, traditional treatment methods of used seawater are for the production of salt [16] or discharge to sea [17,18]. The above mentioned synthetic compounds are nutrients during the eutrophication process after discharge to sea, which lead to eutrophication. With the increasing environmental awareness, the exploitation of environmental friendly corrosion and scale inhibitors is one of the focus researches.

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Recently, plant extracts have again been used as environmentally acceptable, renewable and readily available scale inhibitors. Plant extracts can be extracted conveniently with lower cost, which is more ecological compared with conventional synthetic inhibitors [19–21]. The use of plant extracts such as olive leaf [4], saffron [22], *Vernonia amygdalina* [23], leaves extract of African star apple [24], damsisa [25] and lupine seed [26] as effective scale and corrosion inhibitors have been reported. The inhibition performance of plant extracts is due to the presence of alkaloid, tannin, glycosides and amino acids [23].

The tobacco extracts are biodegradable, environmentally friendly and renewable [27]. The main constituents identified in tobacco are organic acids, phenolic compounds, carbohydrate compounds and nicotine [27–31]. Previous work indicated that tobacco extract had inhibitive property for steel or aluminium in 1–3.5% NaCl solution or HCl solution [27–30,32,33]. Tobacco rob accounts for more than 60% weight of the tobacco plants, which was usually treated by burning as agricultural waste. So the reutilization and the exploitation for potential bio-energy would be necessary.

Our previous work showed that TRE had good scale and corrosion inhibition properties for carbon steel in circulating cooling water [34]. No information on tobacco rob used as corrosion inhibitor and scale inhibitor for seawater has been reported. Herein, we studied scale and corrosion performance of TRE in artificial seawater. The corrosion inhibition and anti-scale properties of TRE in artificial seawater were investigated by potentiodynamic polarization and static tests. The surface of Q235 steel was observed by SEM and XPS analyses. And the scale inhibition mechanism was also proposed according to the results of SEM and XRD.

2. Experimental

2.1. Preparation of TRE

The dried TR powder (8.0 g) was soaked in flask of three necked with distilled water (100 mL) and refluxed for 2 h at 100 °C. After cooling to room temperature, the mixture was filtered and then the filtrate diluted to 100 mL. The residue was dried at 105 °C for the removal of water for 12 h. The concentration of extract was 34 mg mL⁻¹, which was determined according to the weight of the dried residue.

2.2. Preparation of artificial seawater

The standard seawater solution was prepared according to (ASTM standard D1141-98(2013) American Society for Testing Materials) (shown in Table 1) [35]. 0.1 M NaOH solution was used to adjust the pH of seawater solution to 8.2. All artificial seawater used in the experiments was obtained through evaporation of the above mentioned standard seawater to two fold of its original concentration.

2.3. Methods for evaluation the corrosion and scale inhibition of TRE

2.3.1. Electrochemical studies for corrosion inhibition

CHI660C electrochemical analyzer was used for electrochemical measurements. The working electrode was a square cut of Q235 steel coupons with surface area 1 cm². A platinum sheet and a saturated calomel electrode (SCE) were used as auxiliary and reference electrodes respectively. The working electrode and the reference electrode were connected via a salt bridge. In order to minimize the ohmic voltage error, the salt bridge was as close as possible to the electrode surface. The working electrode was polished mechanically, washed with acetone, distilled water and dried before measurement. The potentiodynamic

polarization measurements conduct from scans ± 500 mV relative to the open circuit potential (OCP) at scan rate of 0.57 mV s⁻¹.

2.3.2. Static tests for scale inhibition

Static tests for scale were conducted according to the Chinese National Standard method [3]. The tests were maintained for 10 h at a certain temperature with a certain amount of TRE. The remaining Ca²⁺ was determined by EDTA titration after cooling to room temperature. The scale inhibition efficiency was calculated as follows:

$$\eta = \frac{\rho_1 - \rho_2}{N\rho_0 - \rho_2} \times 100\% \quad (1)$$

Where ρ_1 is mass concentration of Ca²⁺ with TRE after heating (mg L⁻¹); ρ_2 is mass concentration of Ca²⁺ without TRE after heating (mg L⁻¹); ρ_0 is the mass concentration of Ca²⁺ of the blank solution before heating (mg L⁻¹); and N is a concentration factor for artificial seawater.

2.4. Infrared spectroscopy

Fourier transform infrared spectroscopy (FT-IR) spectra were recorded on a FT-IR spectrometer (Bruker Tensor 27) using the KBr pellet technique. The sample of TRE adsorbed on Q235 steel was obtained after the immersion of the test coupons in artificial seawater with 150 mg L⁻¹ TRE for 12 h. After the immersion, the test coupons were dried at 60 °C for 10 h. The film formed on test coupons was carefully scratched off and analyzed by the FT-IR spectrometer.

2.5. Surface analysis

2.5.1. Surface analysis for corrosion inhibition

The test coupons were immersed in 200 mL of artificial seawater with TRE 150 mg L⁻¹ at 60 °C and washed with distilled water and then dried in air at 25 °C. The structural and topographical information was obtained using scanning electron microscope (SEM NOVA NA NOSEM 450) and X-ray photoelectron spectroscopy (XPS UIVAC-PHI PHI5000 VERSAPROBE). The monochromatized Al-K α X-ray source was operated in the constant analyzer energy mode. The internal calibration was referenced to the C 1s energy at 285 eV for aliphatic like species.

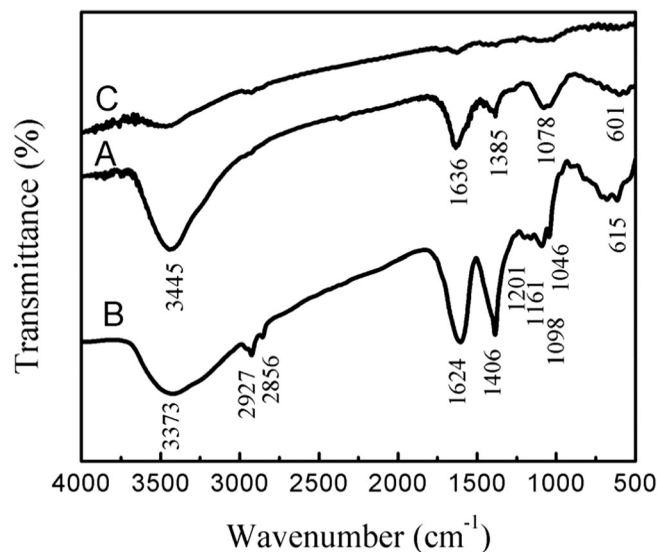


Fig. 1. FT-IR spectra of samples: (A) TRE adsorbed on Q235 steel, (B) TRE, and (C) Q235 steel.

Table 1

Chemical composition of artificial seawater.

Compound	MgCl ₂	NaCl	NaF	NaHCO ₃	H ₃ BO ₃	CaCl ₂	SrCl ₂	KCl	KBr	Na ₂ SO ₄
C(g L ⁻¹)	5.20	24.5	0.003	0.201	0.027	1.16	0.025	0.695	0.101	4.09

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