Desalination 384 (2016) 60–67

Contents lists available at ScienceDirect

Desalination

journal homepage: www.elsevier.com/locate/desal

Inhibition activity of Seaweed extract for mild carbon steel corrosion in saline formation water

M.A. Deyab

Egyptian Petroleum Research Institute (EPRI), Nasr City, Cairo, Egypt

HIGHLIGHTS

- Seaweed extract inhibited mild C-steel corrosion in saline formation water.
- Corrosion inhibition by Seaweed extract is due to the constituents in the extract.
- The adsorption phenomenon obeys the Temkin adsorption isotherm.
- The inhibition efficiency increased with the Seaweed extract concentration.
- The maximum efficiency obtained was 93%, whereas at 328 K it declined to 85%.

ARTICLE INFO

Article history:
Received 19 September 2015
Received in revised form 29 January 2016
Accepted 2 February 2016
Available online 10 February 2016

Keywords:
Carbon steel
Saline formation water
Electrochemical
Weight loss
Seaweed extract

ABSTRACT

The inhibition effect of Seaweed extract on the corrosion of mild carbon steel in saline formation water was studied by weight loss, polarization and electrochemical impedance spectroscopy (EIS) methods. Scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX) examinations of the electrode surface have also been carried out. The effect of Seaweed extract on the corrosion rate was determined at various temperatures and concentrations. The inhibition efficiency increases with the increase in Seaweed extract concentration but decreases with the rise in temperature. The adsorption of constituents of Seaweed extract obeyed the Temkin adsorption isotherm. Polarization results revealed that Seaweed extract suppresses the anodic reaction. The kinetic parameters of the corrosion process were evaluated and discussed.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

Saline formation water (also called produced water, oilfield brine, oilfield waste water or connate water) is water that occurs in association with oil and gas in reservoir rocks and is present in the rocks immediately before drilling. The properties of this water vary considerably depending on the geographic location of the field, the geological formation with which the produced water has been in contact for thousands of years and the type of hydrocarbon product being produced [1]. Salts in formation water are primarily chlorides and sulfides of Ca, Mg and Na. Formation water may contain high level of chlorides as much as 10 times more than sea water [2]. In oil and gas industries, the presence of formation water often causes severe corrosion problem for carbon steel pipelines [3].

Employment of organic inhibitors is one of the most significant strategies for protecting carbon steel against corrosion in oil field [4].

Although many synthetic compounds show good anticorrosive activity, most of them are highly toxic to both human beings and the environment, and they are often expensive and non-biodegradable [5]. Thus, the use of natural products as corrosion inhibitors has become a key area of research because plant extracts are viewed as an incredibly rich source of naturally synthesized chemical compounds that are biodegradable in nature and can be extracted by simple procedures with low cost [6,7].

The extracts of leaves, peels, seeds, fruits and roots [8–10] have been reported as effective corrosion inhibitors in different aggressive environments. Plant extracts constitute several organic compounds which have corrosion inhibiting abilities [11].

The corrosion inhibition efficiency of plant extracts is related to their adsorption properties. Studies reported that the adsorption of plant extract constituents mainly depends on some physiochemical properties of the molecule, related to its functional groups, to the possible steric effects and electronic density of donor atoms [12].

Seaweeds are marine macro algae and primitive type plants, growing abundantly in the shallow waters of sea, estuaries and backwaters.

E-mail address: hamadadeiab@yahoo.com.

http://dx.doi.org/10.1016/j.desal.2016.02.001
0011-9164/© 2016 Elsevier B.V. All rights reserved.

They flourish wherever rocky, coral or suitable substrates are available for their attachment. They belong to three groups namely green, brown and red based on their pigmentation, morphological and anatomical characters. Seaweeds have been used since ancient times as food, fodder, fertilizer and as source of medicinal drugs. Today Seaweeds are the raw material for industrial production of agar, align and carrageenan. Seaweed extract contains a wide variety of organic compounds such as vitamin C, polysaccharides, free fatty acid and amino acid [13].

This study reports the inhibition effect of Seaweed extract on the mild carbon steel corrosion in saline formation water in the temperature range 298–328 K using weight loss, electrochemical measurements and complemented with SEM–EDX analysis.

2. Experimental

2.1. Sample preparation

Rectangular samples of a 3×1 cm^2 area have been cut from a large sheet of mild carbon steel with composition (in wt.%) C 0.19, Si 0.35, P 0.018, Cr 0.04, Mo 0.03, Ni 0.017, Cu 0.02, Al 0.06, and Fe (balance). The samples were polished, a hole was drilled at one end and numbered by punching. During the study the samples were abraded with successively fine grade emery papers, washed with absolute ethanol and acetone at 298 K for 5 min, rinsed with doubly distilled water, dried, weighed and stored in desiccators for further use.

2.2. Weight loss measurements

All weight loss tests were carried out according to ASTM Committee G01. Specimens were initially weighed in an electronic balance. Weighed samples were immersed in 100 mL of saline formation water without and with different concentrations of the extract in the temperature range 298–328 K for 24 h. They are then taken out and washed thoroughly with tap water, rinsed with distilled water, dried, stored in desiccators and reweighed.

From the change in weight of specimens the corrosion rate (C_R) was calculated using the following relationship:

$$C_R = \lambda W/ATD \quad (1)$$

where λ is constant (3.45×10^6), W is the loss in weight (g), A is the surface area of the specimen (cm^2), T is the time of exposure (h), and D is the density of the carbon steel (g/cm^3).

The inhibition efficiency (I_{wt}%) is calculated according to the following equation:

$$I_{wt}\% = \left[\left(C_{R(0)} - C_R\right)/C_{R(0)}\right] \times 100 \quad (2)$$

where $C_{R(0)}$ and C_R are the values of corrosion rates of mild carbon steel in uninhibited and inhibited solutions, respectively.

2.3. Electrochemical measurements

For electrochemical measurements, the investigated electrodes were cut as cylindrical rods, welded with a Cu-wire for electrical connection and mounted into glass tubes of appropriate diameter using Araldite to offer an active flat disk shaped surface of (0.458 cm^2) geometric area. Prior to each experiment, the surface pre-treatment of the working electrode mentioned in weight loss measurements was performed. A conventional electrochemical cell with a capacity of 100 mL was used containing three compartments for working, platinum spiral counter and reference electrodes. The standard calomel electrode (SCE) was used as the reference electrode; the platinum electrode was used as an auxiliary electrode. All potentials were measured versus SCE. A schematic of the electrochemical cell setup is shown in Fig. 1.

Electrochemical measurements were performed using A Potentiostat/Galvanostat (EG&G model 273) connected to a personal computer. Various electrochemical parameters were simultaneously determined using M352 corrosion software.

The potentiodynamic polarization curves were carried out at a scan rate of 0.5 mV s^{-1}. The logarithmic current density was plotted against the electrode potential. These polarization curves exhibit Tafel-type behavior. Applied potential vs. logarithmic current density was plotted and an extrapolation of a linear portion to the corrosion potential gives the corrosion current density.

For EIS measurements, the experiments were carried out at open circuit potential with voltage amplitude 10 mV in a frequency range of 0.01 Hz to 100 kHz. All measurements were conducted after immersion for 30 min in solution to stabilize the steady state potential.

The inhibiting efficiency of extract is evaluated from polarization (I_p%) and EIS (I_R%) measurements by the following equations:

$$I_p\% = \left[\left(j_{corr(0)} - j_{corr}\right)/j_{corr(0)}\right] \times 100 \quad (3)$$

$$I_R\% = \left[\left(R_{ct} - R_{ct0}\right)/R_{ct}\right] \times 100 \quad (4)$$

where $j_{corr(0)}$ is the corrosion current density without extract, j_{corr} is the corrosion current density with extract, R_{ct0} is the charge transfer resistance without extract and R_{ct} is the charge transfer resistance with extract.

In order to reduce the possibility of error, weight loss and electrochemical experiments were carried out in triplicate. The average values of corrosion rate will be recorded. In addition, the standard deviation will be calculated as the value of the experimental error.

2.4. Seaweed extract

Seaweed extract was purchased from Symrise Company as a trade name Extapone® Seaweed extract and used without further purification. It is an aqueous extract. The main chemical components of Seaweed extract are carbohydrates (22.3 ± 0.42), proteins (5.6 ± 0.35%), lipids (2.34 ± 0.22), amino acids (508 μmol amino acid/g sample), and vitamin C (25 mg/100 g). The concentration of Seaweed extract used in experiments was varied from 0.3 to 1.2% (v/v). The biologically active compounds in Seaweed extract are stable at open air and also at a working temperature of 328 K.

2.5. Corrosive solution

The corrosive solution used was saline formation water (pH = 7.2) free of oils and greases. Saline formation water was collected from an oil field in Ra's Gharib area of Egypt. with the chemical composition (mg/L): 29538 Na^+, 55311 Cl^-, 980 K^+, 350 SO_4^{2-}, 420 HCO_3^-, 477 Ca^{2+} and 632 Mg^{2+}. The chemical composition of the saline formation water was determined by an ionic chromatograph instrument.

In this study, saline formation water without Seaweed extract was used as a blank solution.

2.6. SEM–EDX analysis

The surfaces of the mild carbon steel samples after exposure to saline formation water in the absence and presence of Seaweed extract for 24 h were examined by scanning electron microscopy coupled with energy dispersive X-ray (SEM/EDX) spectroscopy (JEOL-JEM 1200 EX II electron microscope).

Download English Version:

https://daneshyari.com/en/article/622805

Download Persian Version:

https://daneshyari.com/article/622805

Daneshyari.com