Journal of Molecular Liquids 216 (2016) 724–731

Contents lists available at ScienceDirect

Journal of Molecular Liquids

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

Extraction, characterization and anti-corrosion activity of *Mentha pulegium* oil: Weight loss, electrochemical, thermodynamic and surface studies

A. Khadraoui [a,c,*], A. Khelifa [a], M. Hadjmeliani [b], R. Mehdaoui [a], K. Hachama [c], A. Tidu [d], Z. Azari [b], I.B. Obot [e], A. Zarrouk [f]

[a] Laboratoire de Génie chimique, Département de Génie des Procédés, Faculté de Technologie, Université de Blida 1, BP 270, Route de Soumaâ, 09000 Blida, Algéria
[b] Laboratoire de Fiabilité Mécanique de Metz, ENIM, Ile de Saulcy, 57045 Metz Cedex, France
[c] Laboratoire de la valorisation des substances naturelles, Université Djilali Bounaama, Khemis-miliana, Algéria
[d] Laboratoire LEM3, Ile du Saulcy, F-57045 Metz-cedex 01, France
[e] Center of Research Excellence in Corrosion, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia
[f] LCAE-URAC18, Faculty of Science, Mohammed first University, Po Box 717, 60000 Oujda, Morocco

ARTICLE INFO

Article history:
Received 13 November 2015
Accepted 2 February 2016
Available online 16 February 2016

Keywords:
Acid inhibition
Carbon steel
Weight loss
Polarization
EIS
AFM

ABSTRACT

The corrosion inhibition of carbon steel in 1M HCl solution by *Mentha pulegium* oil was investigated using weight loss, potentiodynamic polarization and electrochemical impedance spectroscopic techniques (EIS). Surface characterization was performed using optical profiler images and AFM analysis. The effect of temperature on the corrosion behavior of carbon steel was studied in the range of 298–338 K. Inhibition efficiency of 81% was achieved with 3 mL/L of *M. pulegium* oil at 298 K. The adsorption of the inhibitor molecules on the steel surface obeys the Temkin adsorption isotherm and involves physical adsorption. The thermodynamic calculation results indicate strong interaction between inhibitor molecules and carbon steel surface. The polarization studies showed that the oil acts as mixed-type inhibitor with predominance cathodic. Double layer capacitance, (C_{dl}) decrease indicates that a layer was form indicating the formation of a surface film. This reflects that the inhibitor does retard the corrosion rate.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

The study of carbon steel corrosion is a subject of both academic and industrial importance because of the increased industrial applications of acid solutions [1,2]. In recent times, corrosion prevention favors the use of environmentally friendly chemicals with low or zero toxicity. Due to the toxicity of most inorganic corrosion inhibitors, such as chromate and phosphate, the use of organic molecules and plant extracts as corrosion inhibitor is becoming increasingly popular. Recently, environmental regulations have limited the use of toxic corrosion inhibitors. Thus, natural products (e.g. vegetable oil) and other environmentally-friendly materials, have gained much attention as a possible replacement to inorganic corrosion inhibitors because they are cheap, biodegradable, and in high abundance.

The inhibition actions of these inhibitors are usually attributed to their interactions with the metal surface via physical or chemical adsorption processes [3], which takes place through the replacement of water molecules by organic inhibitor molecules from the metal surface [5]. In general, the adsorption of an inhibitor on a metal surface depends on the nature and the surface charge of the metal, the adsorption mode, its chemical structure, and the type of the electrolyte solution [4].

The study of the relationship between adsorption and corrosion inhibition is of great importance; since the corrosion inhibition is a surface process and the degree of protection of metal is a function of adsorption [6,7]. It is generally accepted that organic compounds containing heteroatoms with high electron density such as phosphorus, nitrogen, sulfur, and oxygen as well as those containing multiple bonds are effective corrosion inhibitor [8–10]. Literature report indicates that molecules containing both nitrogen and sulfur in their molecular structure exhibited greater corrosion inhibition efficiency in comparison with those containing only one of these atoms [11–15].

Natural products have been reported as corrosion inhibitors for different metals in various environments [16–31]. The significance of this area of research is primarily due to the fact that natural products are environmentally friendly and ecologically acceptable. The yield of these natural products as well as the corrosion inhibition abilities of the plant extracts vary widely depending on the part of the plant and its location. *Mentha pulegium* used in the present investigation is a native and perennial aromatic herb of the Mediterranean region, but it is also widely grown in many parts of the world mostly in temperate

* Corresponding author at: Laboratoire de Génie chimique, Département de Génie des Procédés, Faculté de Technologie, Université de Blida 1, BP 270, Route de Soumaâ, 09000 Blida, Algéria
E-mail address: khadraoui.abdelkader@gmail.com (A. Khadraoui).

http://dx.doi.org/10.1016/j.molliq.2016.02.005
0167-7322/© 2016 Elsevier B.V. All rights reserved.