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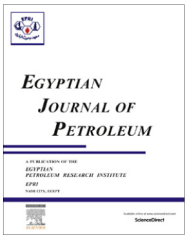

FULL LENGTH ARTICLE

Synthesis of non-ionic surfactants based on alkylene diamine and evaluation of their corrosion inhibition efficiency on carbon steel in formation water

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KEYWORDS

Potentiodynamic polarization;
Quantum calculations;
Inhibition efficiency;
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Abstract The inhibitive effects of newly synthesized non-ionic surfactant based on alkylene diamine surfactants on X-65 carbon steel in formation water was investigated by means of electrochemical techniques and quantum chemical study. These derivatives were characterized by FT-IR, and the surface tension and thermodynamic parameters were calculated. The polarization showed that the inhibition efficiency of the prepared compounds was increased with increasing the length of the internal alkyl chain between the two terminal amino groups of diamine. The electronic properties obtained using quantum chemical approach were correlated with the experimental inhibition efficiencies. The surface morphology of carbon steel was investigated using SEM.

1. Introduction

Carbon steel has been widely employed as construction materials for pipe work in the oil and gas production such as down hole tubular, piping systems and transmission pipelines [1]. Corrosion in the oil field appears as leak in tanks, casing, tubing, pipeline and other equipment. This process changes the base metal to another type of materials. The most corrosive environment in oil field operations is caused by trace amounts of oxygen entering into a sour brine system, as well as the large amounts of carbon dioxide and hydrogen sulfide present in a deep oil well water (formation water) [2]. This type of corrosion forms a scale which varies from dense and adherent to loose, porous and thick [3]. Corrosion inhibitors (mainly, surfactants) are widely employed in the petroleum industry to protect iron and steel equipment used in drilling, production, transport and refining of hydrocarbons [4,5]. The efficiency of the inhibition film depends on the inhibitor concentration and contact time with the metal surface. In fact, introducing of ethylene oxides into surfactant molecule (ethoxylation) increases the inhibiting effect of surfactant [6]. The presence of these groups increases the solubility of surfactant and hence the extent of its adsorption on the metal surface increases and consequently its inhibitive action improves. Many studies on the inhibition of the corrosion of carbon steel by some ethoxylated surfactants have been carried out in different corrosive environments [7–11]. Quantum chemical methods have already proven to be very useful in determining the molecular structure

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Table 1 Chemical Composition of Carbon Steel alloy in wt%.

Element	C	Mn	Si	S	P	Cr	Ni	V	Al	Mo	Cu	Fe
Content (wt%)	0.09	1.52	0.22	0.05	0.01	0.02	0.04	0.002	0.04	0.004	0.02	Rest

Table 2 Chemical composition and physical properties of deep oil wells formation water used in this investigation.

Property	Value
Density (g/cm^3)	1.044
Turbidity (FAU)	263
PH	6.38
Salinity as NaCl (mg/l)	120.29
Ionic species	**Value**
Sulfate	6.5 (mg/l)
Phosphate	0.771 (mg/l)
Bi-carbonate	143 (mg/l)
Chloride	7300 (mg/l)
Vanadium as V_2O_5	450 (μg/l)
Iron ferrous	23 (mg/l)
Iron, total	42 (mg/l)
Calcium	800 (mg/l)
Magnesium	364 (mg/l)
Barium	105 (mg/l)
Potassium	250 (mg/l)
Zinc	1.359 (mg/l)

as well as elucidating the electronic structure and reactivity [12]. Thus, it has become a common practice to carry out quantum chemical calculations in corrosion inhibition studies. The concept of assessing the efficiency of a corrosion inhibitor with the help of computational chemistry is to search for compounds with desired properties using chemical intuition and experience into a mathematically quantified and computerized form. Once a correlation between the structure and activity or property is found, any number of compounds, including those not yet synthesized, can be readily screened employing computational methodology [13] and a set of mathematical equations which are capable of representing accurately the chemical phenomenon under study [14,15]. The study of corrosion processes and their inhibition by organic inhibitors is a very active field of research [16]. Many researchers report that the inhibitory effect mainly depends on some physicochemical and electronic properties of the organic inhibitor, which relate to its functional groups, steric effects, electronic density of donor atoms, and orbital character of donating electrons, and so on [17,18]. The inhibiting mechanism is generally explained by the formation of a physical and/or chemically adsorbed film on the metal surface [19,20]. This work aims to synthesis new ethoxylated non-ionic surfactants based on 1,4 diaminobutane, 1,6 diaminohexane and 1,8 diaminooctane. The work should be extended to evaluate them as corrosion inhibitors for carbon steel pipelines in deep oil wells formation water. The HOMO and LUMO calculations were used to evaluate the corrosion inhibition efficiency of these surfactants in the light helping of computational chemistry to the practical finding by potentiodynamic techniques.

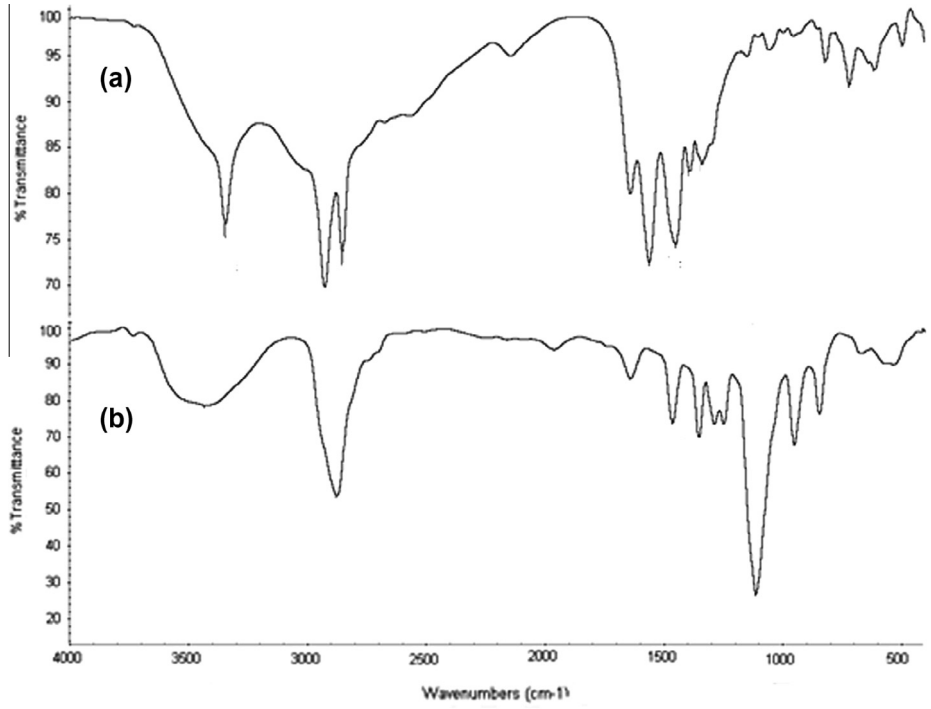

Figure 1 FTIR spectra for (a) pure 1,8 diaminoctane, (b) ethoxylated 1,8 diaminoctane.