Available online at www.sciencedirect.com
SCIENCE DIRECT®
Corrosion Science 47 (2005) 273–278
CORROSION SCIENCE
www.elsevier.com/locate/corsci

Short Communication

The adsorption and corrosion inhibition of some cationic gemini surfactants on carbon steel surface in hydrochloric acid

Ling-Guang Qiu *, An-Jian Xie, Yu-Hua Shen

School of Chemistry and Chemical Engineering, Anhui University, 3rd, Feixi Road, Hefei, Anhui 230039, China

Received 16 June 2003; accepted 11 May 2004
Available online 2 July 2004

Abstract

The adsorption and corrosion inhibition of the gemini surfactants 1,2-ethane bis(dimethyl alkyl (C_nH_{2n+1}) ammonium bromide) (designated as $n-2-n$, $n = 10$, 12 and 16) on the steel surface in 1 M hydrochloride acid were studied using the weight loss method. It was found that the adsorption of the gemini surfactants on the steel surface is the main reason to cause the steel corrosion inhibition in hydrochloride acid, and the inhibition efficiency increases with the increase of surfactant concentration and reaches the maximum value near the CMC. A possible adsorption model of gemini surfactant onto the metal surface was also discussed.

Keywords: Gemini surfactants; Cationic surfactants; Acid corrosion (C); Acid inhibition (C); Steel (A); Adsorption

1. Introduction

The adsorption of the surfactants on metal surface can markedly change the corrosion-resisting property of the metal [1–5], so the study of the relations between the adsorption and corrosion inhibition is of great importance. Recently, a new generation of surfactants, gemini surfactants, which contain two hydrophilic groups

* Corresponding author. Tel.: +86-551-510-7301; fax: +86-551-510-7342.
E-mail address: lgahu@163.com (L.-G. Qiu).

0010-938X/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.corsci.2004.05.009

and two hydrophobic groups in the molecule, have attracted great interest. These surfactants are about 3 orders of magnitude more efficient at reducing surface tension and more than 2 orders of magnitude more efficient at forming micelles than conventional surfactants. Many gemini surfactants have been synthesized, and a considerable number of investigations have been reported on their unusual physicochemical properties, including their high surface activity, unusual changes of viscosity, unusual micelle structure, and aberrant aggregation behavior [6–10].

In most of the available literature on corrosion inhibition of metal, various conventional single-chained surfactants with different structures were selected as the inhibitors, and effects of the structure and the adsorption of the surfactants on corrosion inhibition have been studied widely. However, there are few reports on the use of gemini surfactants as inhibitor of metal corrosion till now [11,12], and the adsorption of gemini surfactants on the metal surface is rarely studied. In this paper, we describe the adsorption and corrosion inhibition of the gemini surfactants 1,2-ethane bis(dimethyl alkyl (C_nH_{2n+1}) ammonium bromide) ($n = 10$, 12 and 16) on the steel surface in hydrochloride acid using the weight loss method. The result shows that the adsorption of surfactants could prevent steel from weight loss, and a possible adsorption model of gemini surfactant onto the metal surface was given.

2. Experimental procedure

Gemini surfactants 1,2-ethane bis(dimethyl alkyl (C_nH_{2n+1}) ammonium bromide) ($n = 10$, 12 and 16) were prepared from *N*, *N*, *N*′,*N*′-tetramethylethylenediamine and the corresponding alkyl bromides of $n = 10$, 12 and 16 according to Ref. [11]. The products were purified by repeated recrystallization, and the purity was confirmed by elemental analysis as fellows. 10–2–10, calculated for $C_{26}H_{58}N_2Br_2$: C, 55.91; H, 10.47; N, 5.02%. Found: C, 56.73; H, 11.28; N, 4.81%; 12–2–12, calculated for $C_{30}H_{66}N_2Br_2$: C, 58.62; H, 10.82; N, 4.56%. Found: C, 57.27; H, 10.23; N, 4.16%; 16–2–16, calculated for $C_{38}H_{82}N_2Br_2$: C, 62.79; H, 11.37; N, 3.85%. Found: C, 63.21; H, 11.96; N, 3.44%.

The surface tensions were determined by Krüss DSA10-MK2 Drop Shape Analysis System and the temperature was maintained precisely at 25 °C. CMC values of surfactants were 6.5×10^{-3}, 5.7×10^{-4} and 3.2×10^{-5} mol/l for 10–2–10, 12–2–12, and 16–2–16, respectively, according to the break points in plots of the surface tension versus log molar concentration of Gemini surfactants.

For weight loss measurements, rectangular specimens of 30×30 mm A_3 carbon steel were polished with 600 grade of emery paper, degreased with acetone, then rinsed with distilled water and acetone, and finally dried. After weighing accurately, the specimens were immersed in 100 ml of 1 M hydrochloride acid at 25 °C. After 4 h, the steel sheets were taken out, washed with water and acetone, then dried and weighted accurately. Then the gemini surfactants in various concentrations were added and the aforementioned tests were repeated. All the tests were repeated three times in the experiment, and the inhibition efficiency (E%) is calculated by the relation