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Corrosion inhibition of iron in acidic solutions by alkyl quaternary ammonium halides: Correlation between inhibition efficiency and molecular structure

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Abstract

The corrosion inhibition of iron in 0.5 M H_2SO_4 solutions by alkyl quaternary ammonium halides (AQAH) inhibitors has been studied by potentiodynamic polarization curves and electrochemical impedance spectroscopy (EIS) measurements. The correlation between inhibition efficiency and molecular structure of the AQAH compounds is investigated. The results show that besides the concentration, the structure of alkyl groups and the type of halide ions of these AQAH inhibitors greatly influence the inhibition efficiency. Data obtained from EIS measurements are analyzed to model the corrosion inhibition process through appropriate equivalent circuit models.

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1. Introduction

Iron and its alloy have been used widely in a variety of industries. However, it subjects to severe damages by corrosion in aggressive environments. As one of the protective measures, corrosion inhibitors are effective to decrease the corrosion rate of metals. Many mechanisms have been proposed for the inhibition of metal corrosion by organic inhibitors. Nowadays, researches in this field focus on the relationship between inhibition efficiency and molecular structures of organic inhibitors, especially the adsorption orientation of the inhibitors on the metal surface [1–3]. Generally, it has been assumed that the first stage in the action mechanism of the inhibitor in the aggressive acid media is based on its adsorption on the

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metal surface. The processes of adsorption of inhibitors are influenced by the nature and surface of the metal, the chemical structure of the organic inhibitor, the distribution of charge in the molecule, the type of aggressive electrolyte and the type of interaction between organic molecules and the metallic surface [2,4,5].

It has been reported that quaternary ammonium inhibitors are important as inhibitor additives in hydrochloric and sulfuric acids. The effect of concentrations, functional groups and halide ions of quaternary ammonium inhibitors on the corrosion of iron and steel have been studied extensively [4,6–10]. The synergistic effect between the organic cations and the halide anions is considered to be an important factor in inhibiting action on metal corrosion [4,11]. However, the inhibition mechanism of the quaternary ammonium inhibitors for iron corrosion in acidic media has still not been understood completely. The present study is, therefore, carried out to establish the effect of changing functional and structural groups/correlations on the characteristics of the molecular structure and inhibition efficiency of the alkyl quaternary ammonium halides (AQAH) inhibitors, and also to correlate the corrosion currents measured with the physicochemical properties of the molecules in terms of their electric and steric parameters.

2. Experimental

The chemical structures of the investigated alkyl quaternary ammonium halides inhibitors are shown in Fig. 1. These inhibitors and sulfuric acid are AR grade regents and used as received. All solutions are prepared with de-ionized water. The working electrode has the form of a disc cut from Armco iron rod (99.99%) with diameter of 2.0 mm which is embedded in epoxy resin. Prior to each experiment, the working surface is polished with 1000–1600 grit emery papers, rinsed with triply redistilled water, degreased with acetone and dried at room temperature. Thenceforth, the fresh working electrode is immersed in blank or inhibitor-containing solutions for 30 min to attain a stable open circuit potential. Electrochemical experiments are performed using a double-compartment glass cell with standard three-electrode configuration as reported in our work [12]. A saturated calomel electrode (SCE) and a platinum sheet electrode are used, respectively, as a reference and counter electrodes. All potentials reported here are referred to the SCE. The three-electrode glass cell is thermostated at 30 ± 1 °C. Electrochemical measurements and data analysis and fitting are performed with IM6 electrochemical workstation (Zahner, Germany). The potentiodynamic polarization curves are obtained

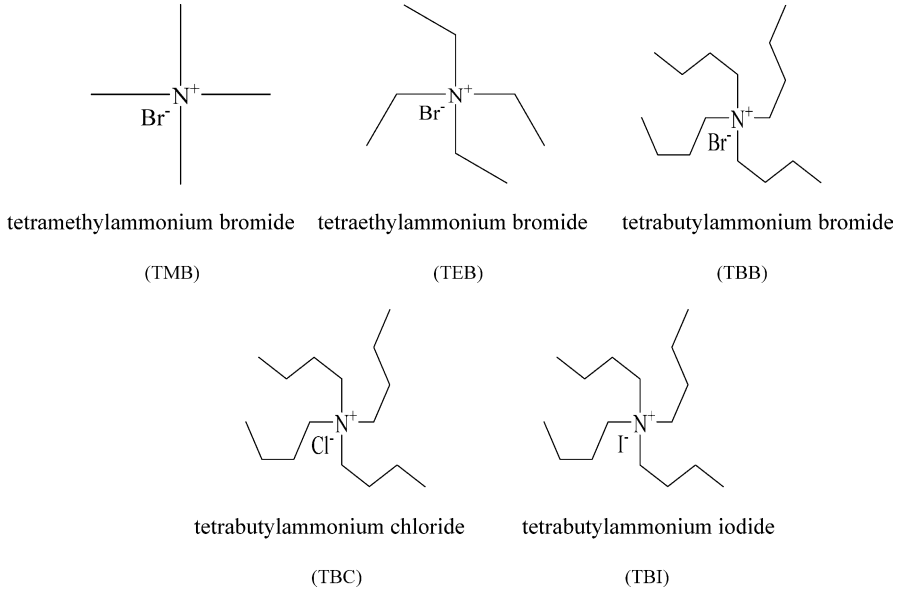

Fig. 1. Chemical structure of alkyl quaternary ammonium halides.