APPLICATION OF THIAZOLE AND TRIAZOLE COMPOUNDS IN CARBON STEEL CORROSION PROTECTION

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To mak, ayah, family and friends…

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ABSTRACT

Inhibitory effect of 2-mercaptobenzothiazole (MBT) and 1,2,3-benzotriazole (BTA) on corrosion of carbon steel in 1.0 M HCl and seawater sample respectively has been studied using weight loss method. All measurements show that inhibition efficiencies of BTA and MBT increased with increase in inhibitor concentration and temperature in 1.0 M HCl and seawater sample. The results of the investigation show that the compound BTA and MBT have fairly good inhibiting properties with inhibition efficiencies of 98.24% for BTA and 92.98% for MBT in seawater sample while 87.49% for BTA and 30.15% for MBT in 1.0 M HCl, at 90 °C. Adsorption of these inhibitors follows the Langmuir adsorption isotherm. Thermodynamic adsorption parameters (K_{ads}, ΔG_{ads}) of BTA and MBT were calculated using the Langmuir adsorption isotherm. The adsorptions of BTA and MBT on carbon steel are spontaneous processes in 1.0 M HCl and seawater sample, indicated by the negative values of ΔG_{ads}.

ABSTRAK

Kesan hambatan oleh 2-mercaptobenzothiazol (MBT) dan 1,2,3-benzotriazol (BTA) terhadap pengaratan keluli karbon dalam larutan asid hidroklorik (HCl) 1.0 M dan sampel air laut telah dikaji menggunakan teknik pengurangan berat. Berdasarkan analisis yang dilakukan, kecekapan hambatan oleh BTA dan MBT terhadap pengaratan keluli karbon di dalam HCl 1.0 M dan sampel air laut meningkat dengan peningkatan kepekatan bahan hambatan dan suhu medium rendaman. Hasil kajian menunjukkan BTA dan MBT mempunyai ciri-ciri hambatan kakisan yang agak bagus dengan kecekapan hambatan sebanyak 98.24% untuk BTA dan 92.98% untuk MBT di dalam sampel air laut manakala 87.49% untuk BTA dan 30.15% untuk MBT di dalam HCl 1.0 M pada suhu 90 °C. Proses penjerapan kedua-dua bahan hambatan kakisan tersebut di dalam HCl 1.0 M dan sampel air laut adalah mematuhi isoterma penjerapan Langmuir. Parameter penjerapan termodinamik iaitu pemalar penjerapan (K_{ads}) dan tenaga bebas Gibbs (ΔG_{ads}) telah dikira mengikut persamaan isoterma penjerapan Langmuir. Hasil kajian termodinamik memberikan nilai ΔG_{ads} yang negatif menunjukkan proses penjerapan bahan hambatan BTA dan MBT ke atas keluli karbon di dalam HCl 1.0 M dan sampel air laut adalah spontan.

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LIST OF SYMBOLS

ΔG_{ads}	-	Free energy of adsorption
°C	-	Degree Celsius
θ	-	Degree of surface coverage
%	-	percent
C	-	Inhibitor concentration
f	-	Factor of energetic inhomogeneity
g	-	Gram
h	-	Hour
K_{ads}	-	Equilibrium constant of adsorption process
kg	-	Kilogram
M	-	Molar
mg	-	Milligram
mg cm^{-2} h^{-1}	-	Milligram per centimeter square per hour
mL	-	Milliliter
mm	-	Millimeter
ppm	-	Part per million
R^2	-	Correlation coefficient

LIST OF ABBREVIATIONS

APM	-	Ammonium polymolybdate
ASTM	-	American Standard for Testing Materials Society
BTA	-	1,2,3-benzotriazole
EDX	-	Energy dispersive X-ray spectrometer
FESEM	-	Field emission scanning electron microscopy
GA	-	Gum Arabic
IE	-	Inhibition efficiency
MBT	-	2-mercaptobenzothiazole
MDEA	-	Methyldiethanolamine
PAE	-	*P. amarus* extract
PEG	-	Polyethylene glycol
PVC	-	Polyvinyl chloride
SAMs	-	Self assembled monolayers
VCI	-	Volatile corrosion inhibitor
VPI	-	Vapor phase inhibitor
ZPC	-	Zero point charge

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Corrosion is a naturally occurring phenomenon commonly defined as the deterioration of a substance (usually a metal) or its properties because of a reaction with its environment (Delinder *et al*., 1984). Like other natural hazards such as earthquakes or severe weather disturbances, corrosion can cause dangerous and expensive damage to everything from automobiles, home appliances, drinking water systems, pipelines, bridges, and public buildings (Treseder, 1991).

Corrosion is one of the major problems affecting the performance, safety and appearance of materials (Rim-rukeh *et al*., 2006). In many industries, the need to use constructional materials safely, but cost effectively, is a primary consideration. Corrosion affects all areas of the economy and it has been estimated that the cost of corrosion represent 4% of the gross national product. These numbers include direct losses for replacement of corroded materials and equipment ruined by corrosion, indirect losses include cost of repair and loss of production, cost of corrosion protection and cost of corrosion prevention (Landolt, 2006).

Frequently, physical requirements can be satisfied easily, but corrosion effects seriously complicate the selection of suitable materials. Generally, increase corrosion resistance can only be obtained at increased cost. Despite continuing advances in corrosion resistant materials, the use of the chemical inhibitors often remains the most practical and cost effective means of preventing corrosion (Al-Sarawy *et al*., 2008).

Figure 1.1 and Figure 1.2 show the examples of corrosion effect in which gas pipelines have been damaged by external corrosion.

Figure 1.1: Piece of gas pipeline with external corrosion (Thompson, 2001)

Figure 1.2: Ruptured gas pipeline due to corrosion (Thompson, 2001)

1.2 Problem Statement

The inhibition efficiency of organic compounds is strongly dependent on the structure and chemical properties of the layer formed on the metal surface under particular experimental conditions (El-Rehim *et al*., 2001). It is also dependent on the state of the metal surface, type of corrosive medium, composition of the steel and the chemical structure of the inhibitor (Azhar *et al*., 2001). Studies report that the adsorption of the organic inhibitors mainly depends on some physical-chemical properties of the molecule related to its functional group, as well as on the strength of the inhibitor–metal bond (Samide *et al*., 2005). It is also necessary to investigate the effectiveness of inhibitors under severe conditions, such as acidic and sea water, that might occurr to a carbon steel. To date, there is no report found in the literature regarding the use of 2-mercaptobenzothiazole and 1,2,3-benzotriazole for carbon steel inhibition under acidic and sea water conditions. Therefore, this study on inhibition of carbon steel corrosion by a thiazole and a triazole compounds was carried out.

1.3 Research Objectives

The objectives of this research are:

1. to investigate the inhibition efficiency of 1,2,3-benzotriazole (BTA) (Figure 1.3) and 2-mercaptobenzothiazole (MBT) (Figure 1.4) towards carbon steel in acidic and sea water conditions respectively,

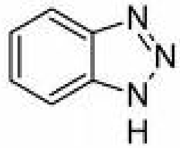

Figure 1.3: Structure of 1,2,3-benzotriazole (BTA)

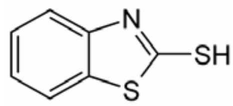

Figure 1.4: Structure of 2-mercaptobenzothiazole (MBT)

2. to study the effect of temperature on the corrosion rate and thermodynamic parameters related to the corrosion process,

1.4 Scope of the Study

This study was limited to the effects of 2-mercaptobenzothiazole (MBT) and 1,2,3-benzotriazole (BTA) as corrosion inhibitors for carbon steel corrosion protection under acidic and sea water conditions respectively. The technique applied in this study was a chemical technique that involved weight loss experiments. The study also involved elemental analysis of the carbon steel used and the microstructure of the carbon steel coupons with and without the application of inhibitors.

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