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CORROSION PROTECTION OF STRUCTURAL STEEL

The anti-corrosion performance of fatty acid coated mild steel samples is studied. Samples of structural steel coated with collector reagents deposited from surfactant in ethanol solution, and overcoated with an epoxy barrier paint. A quantitative corrosion rate was determined by linear polarization resistance method using biopotentiostat/galvanostat 400. A coating morphology was determined by scanning electronic microscopy. A test for hydrophobic surface of steel by surfactant was done. Prior to measuring the corrosion rate, mechanical and chemical treatments were performed to prepare the test specimens. Overcoating the metal samples with epoxy barrier paint after exposing them with surfactant the corrosion rate can be inhibited by 34-35µm/year.

Key words: *corrosion, linear polarization resistance, coating, surfactant.*

Introduction

By conducting a corrosion-prevention study of steel structures, their metal erosion can be reduced to 15-35 %. It is equivalent to 375-875 billion dollars worldwide [1]. Precise identification of causes of corrosion and selection of an appropriate protection method against corrosion becomes important not only in Mongolia but also globally. Corrosion is generally iron oxidation process, or change in the metal composition due to environmental effects. Velocity of corrosion process and types of corrosion depend on both internal and external factors. Internal factors include metal composition, surface state, internal deformation and voltage. The external factors of an environment which surround the metal, relative humidity, temperature, sulfur dioxide and chloride [2]. From iron oxides, +2, +3 are more stable than –2, –1, 0, +1 . In acids, iron is in Fe^{2+}, Fe^{3+} ion and in the alkaline environment iron forms $Fe(OH)_2$, $Fe(OH)_3$ and $HFeO_2^-$ as a product [3]. This variety of oxidation properties is highly dependent on acid and alkaline environments[4]. In industrial practice it is important to protect metals from corrosion, especially in acidic and alkaline environment. There are many corrosion researches, such as coating metals with polyaniline [5-7], coating metals by producing Fatty-acid-metall-ion complex [8] and researches on TIN PVD coating [9]. Electrochemical methods are used widely in corrosion researches [5, 8–11]. Passivation of metal corrosion reagents are different depending on environmental conditions (air, acidic, alkaline, neutral). Anodic inhibitors include substances that have oxidizing properties with respect to metals(reducers), they can be nitrite salts, chromates, etc. There are also anode film-forming inhibitors. These include surfactants that passivate corrosion [12].

In this study, authors aimed to investigate the chemical composition of steel samples and the corrosion rate dependence on their chemical compositions. Characterising mechanism of protection of steel against corrosion with differing chemical compositions was studied with the help of surfactants.

1. Material and methodology

1.1. Preparation of electrodes

The electrodes were mechanically treated prior to use and chemically cleaned to remove the external mixtures. When preparing electrodes, it is best to make a rectangular shape which is suitable for testing. Cutting process used rotating persecutor 150 mm and manual cutter AG7108 INGCO. Prior prepared electrode surface was polished with 80, 120, 180, 320, 500, 1000 mm emery paper by using Knuth Rotor 2. After mechanical cleaning, for the purpose to separate samples from other mixtures, also, prepare for experiment the chemical treatment was done. Reference or counter electrode was prepared before each test. In order to cleanse reference electrode 3M an anion containing potassium chloride solution were used, which later heated to boil and rinsed again. Before the use of the counter electrode electrode for electrochemical measurement, metal has to be rinsed by non-soluble acid for metals and removed the acid residue by distilled water.

1.2. Corrosion rate experiment

Out of many methods the electrochemical polarization method is the most common and widely used method to determine corrosion rate. Therefore, the corrosion rate was determined by galvanostatic polarization techniques using µстат 400, that was connected to the computer with the Drop view 2.0 software by USB. This is a computer controlled electrochemical measurement system. It consists of data-acquisition system and a potentiostat/galvanostat. 3 electrode system was applied to perform linear sweep voltammeter and working electrode was as the sample, which was prepared and polished for the experiment. The reference electrode was silver chloride electrode (3M KCl). The corrosion rate of steel determined by Tafel polarization was relatively easier and faster than traditional methods [5–6, 13].

1.3. Hydrophobic surface of steel sample

The samples were oxidized with oxidizing reagent in low setting. Then, the samples were exposed by fatty acid 4-24 hours and were coated with epoxy barrier paint after the drying process in room temperature.

2. Results and Discussion

2.1. Determination of corrosion rate

Corrosion rate was measured by using μStat400 biopotentiostat/galvanostat instrument using linear sweep voltammetry and the result was calculated by linear polarization resistance method [13; 14]. The results are shown in Table 1.

Table 1

The results of corrosion rate of steel samples

№	Samples	Corrosion rate (μm/year)
1.	IS* industrial steel	36,96
2.	IBSF-industrial black steel floor	22,59
3.	IGSF industrial grey steel floor	33,25

It can be clearly seen that the corrosion rate depends on the metal designation and chemical composition. The corrosion rate is used to assess the corrosion resistance of metals. The speed of corrosion is expressed in μm/year, which is the numerical value of the metal loss per year.

2.2. SEM morphology inspection

The IS-industrial steel samples were covered by protective layer were inspected by Scanning electronic microscopy (SEM) analysis. SEM (shown in Figure 1) revealed many micro and nano structures on the carbon steel surfaces coated by monocarboxylic fatty acids, sodium oleate and thiourea, which were essential for affording the hydrophobic properties.

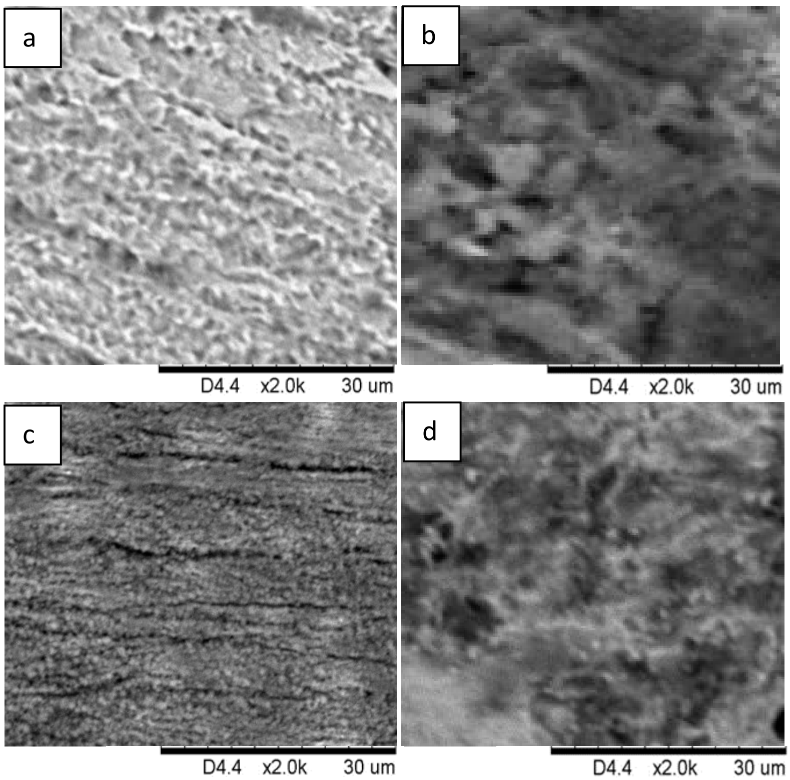

Fig.1-a: SEM image of uncoated carbon steel. 1-b: SEM image of monocarboxylic fatty acids coated. 1-c: SEM image of sodium oleate coated. 2-d: SEM image of thiourea coated

2.3. The results of surfactant covered steel samples' corrosion rate

The corrosion rate (current) data can be obtained by the Tafel extrapolation method, where large cathodic and anodic polarizations provide the cathodic and anodic polarization curves for the respective corrosion processes [7–11]. Extrapolation of these curves to their point of intersection provides both the corrosion potential and the corrosion current. Tafel measurements of three samples' configurations after 24 hours exposure and dried in room temperature then overcoated with an epoxy barrier paint are shown in Figure 2 summarizes the corrosion rates obtained from the Tafel measurements.

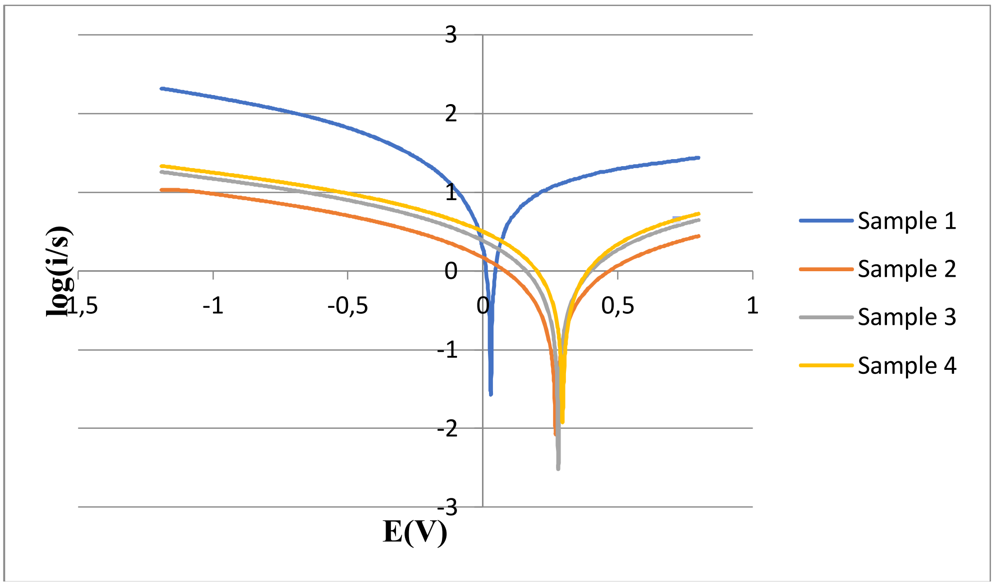

Figure 2. Current density potentio-dynamic curves of coating with protection layer structure and reference uncoated carbon steel:

Sample 1 – Uncoated carbon steel, Sample 2 – Monocarboxylic fatty acids coated
Sample 3 – Sodium oleate coated, Sample 4 – Tiourea coated.

From these results it is concluded that the coating method decreases metal corrosion rate by 34-35µm/year.

Conclusion

The corrosion rate of the samples was 22.59-37-25 µm / year, it shows that our tested samples can be included in the classification C3 (medium quality) of MNS ISO 9223: 2004 – "Corrosion of metals and alloys. Classification of Corrosion into Air".

Overcoating the metal samples with epoxy barrier paint after exposing them with surfactant the corrosion rate can be inhibited by 34-35µm/year.

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КОРРОЗИОННАЯ ЗАЩИТА КОНСТРУКЦИОННОЙ СТАЛИ

Исследованы антикоррозионные свойства образцов мягкой стали с жирнокислотным покрытием. Образцы конструкционной стали, покрытые коллекторными реагентами, осаждали из поверхностно-активного вещества в растворе этанола и покрывали эпоксидной барьерной краской. Количественную скорость коррозии определяли методом линейного сопротивления поляризации с использованием биопотенциостата / гальваностата 400. Морфологию покрытия определяли сканирующей электронной микроскопией. Проведено испытание гидрофобной поверхности стали поверхностно-активным веществом. Перед измерением скорости коррозии были проведены механические и химические обработки для подготовки испытуемых образцов. При нанесении покрытия на металлические образцы эпоксидной барьерной краской после воздействия на них поверхностно-активного вещества скорость коррозии может быть снижена на 34-35 мкм / год.

Ключевые слова: *коррозия, сопротивление линейной поляризации, покрытие, поверхностно-активное вещество.*