Metrohm Autolab

Application Area: Corrosion

Corrosion Part 1 – Basic concepts

Keywords

Corrosion; Electrochemical methods; Forms of corrosion

Summary

Corrosion refers to a process that involves deterioration or degradation of metal. The most common example of corrosion is the formation of rust on steel. Most corrosion phenomena are of electrochemical nature and consist of at least two reactions on the surface of the corroding metal. One of the reactions is the oxidation (e.g., dissolution of iron) also referred to as the anodic partial reaction. The other is a reduction reaction (e.g., reduction of oxygen), and is referred to as the cathodic partial reaction. The products of the electrochemical reactions can react with each other non-electrochemically to form the final product (e.g., rust). For example, the corrosion of iron to form rust proceeds according to the overall reaction:

$$2\,Fe + 2\,H_2O + O_2 \rightarrow 2\,Fe(OH)_2$$

This reaction includes the dissolution of iron, the reduction of oxygen and formation of rust:

$Fe \rightarrow Fe^{2+} + 2\,e^-$ (Anodic)

$2\,H_2O + O_2 + 4\,e^- \rightarrow 4\,OH^-$ (Cathodic)

$Fe^{2+} + 2\,OH^- \rightarrow Fe(OH)_2$ (Chemical)

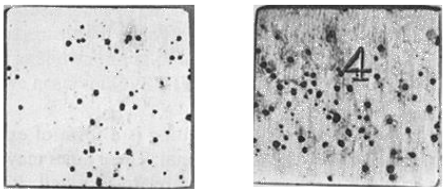
Types of Corrosion

Uniform Corrosion

Uniform corrosion is characterized by corrosive attack proceeding evenly over the entire surface area, or a large fraction of the area of the metal under attack. Uniform corrosion results in loss of material until failure. This is the most widespread form of corrosion that is observed.

Pitting Corrosion

Pitting corrosion is a localized form of corrosion by which pits or "pin holes" are produced in the material. Pitting is considered to be more dangerous than uniform corrosion damage because it is more difficult to predict and design against. Corrosion products often cover the pits making the detection often very difficult. A small, narrow pit with minimal overall metal loss can lead to the failure of an entire engineering system.



Crevice Corrosion

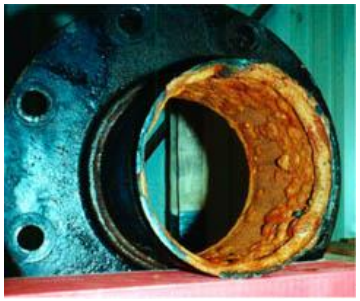
Crevice corrosion is a localized form of corrosion that occurs in the presence of stagnant solution in a small (micro) crevice. Local chemistry changes in crevices (shielded areas) such as those formed under gaskets, washers, insulation material, fastener heads, surface deposits, disbonded coatings, threads, lap joints and clamps, can result in crevice corrosion.

Galvanic Corrosion

Galvanic corrosion refers to corrosion damage induced when two dissimilar metals are coupled in a corrosive electrolyte. When a galvanic couple forms, one of the metals in the couple becomes the anode and corrodes faster than it would all by itself, while the other becomes the cathode and corrodes slower than it would alone. Either (or both) metal in the couple may or may not corrode by itself (themselves) in seawater.

Microbiologically Induced Corrosion

Microbiologically Induced Corrosion (MIC) refers to corrosion caused by biological organisms or microbes. These microbes are categorized by common characteristics such as their by-products (i.e., sludge producing) or compounds they effect (i.e., sulfur oxidizing). They all fall into one of two groups based upon their oxygen requirements; one being aerobic (requires oxygen) such as sulfur oxidizing bacteria, and the other being anaerobic, (requires little or no oxygen), such as sulfate reducing bacteria.



Electrochemical Characterization methods

Linear sweep voltammetry

Linear sweep voltammetry (LSV) is one of the most commonly used methods for characterizing corrosion phenomenon. It involves sweeping the potential of the working electrode and measuring the current response. With LSV, valuable information regarding the corrosion mechanisms, corrosion rate and susceptibility of specific materials to corrosion in various environments can be obtained.

Electrochemical impedance spectroscopy

In recent years Electrochemical Impedance Spectroscopy (EIS) has been successfully applied to the study of corrosion systems. One of the advantages of EIS is the possibility of using very small amplitude signals without significantly disturbing the properties being measured.

Electrochemical Noise

During localized corrosion, electrochemical noise (ECN) is generated by a combination of stochastic (random) processes, such as breakdown of passive films and repassivation. ECN involves the measurement of the current and/or potential noise and analysis of the data using Fast Fourier Transform (FFT).

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For more information

Additional information about this application note and the associated NOVA software procedure is available from your local **Metrohm distributor**. Additional instrument specification information can be found at **www.metrohm.com/electrochemistry.**