

Corrosion Mechanism of Pure Aluminium in Aqueous Alkaline Solution

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Brief Note

Aluminium is a chemical element with the atomic number 13 and the symbol Al. Aluminium has a lower density than other common metals, approximately one-third that of steel. When exposed to air, it forms a protective layer of oxide on the surface due to its high affinity for oxygen. Aluminium is a weak metal in the boron group chemically; as is common for the group, aluminium forms compounds primarily in the +3 oxidation state. Because the aluminium cation Al^{3+} is small and highly charged, it is polarising, and the bonds formed by aluminium tend to be covalent. Danish physicist Hans Christian Orsted announced the discovery of aluminium in 1825. Aluminum and its alloys are passivating metals, along with titanium, chromium, and high-alloy steels. The naturally formed native oxide layer on the aluminium surface is primarily composed of aluminium oxide Al_2O_3 . The layer is thermodynamically stable between pH 4 and 9, where aluminium has the highest corrosion resistance. In 1856, French chemist Henri Étienne Sainte-Claire Deville began the first industrial production of aluminium. The Hall–Héroult process, developed independently by French engineer Paul Héroult and American engineer Charles Martin Hall in 1886, made aluminium much more accessible to the general public. Corrosion is a natural process that transforms refined metals into more chemically stable forms such as oxide, hydroxide, carbonate, or sulphide. It is the gradual decomposition of materials (usually metals) as a result of chemical and/or electrochemical reactions with their surroundings. In its most common sense, this refers to the electrochemical oxidation of metals in the presence of an oxidant such as oxygen or sulphates. The formation of iron oxides, known as rusting, is a well-known example of electrochemical corrosion. This type of damage typically results in the formation of oxide(s) or salt(s) of the original metal, resulting in a distinct orange coloration. Passivation is extremely effective at reducing corrosion damage, but even a high-quality alloy will corrode if its ability to form a passivating film is hampered. The proper selection of the right grade of material for the specific environment is critical for this group of materials' long-term performance.

Many structural alloys corrode simply by being exposed to moisture in the air, but the process can be greatly influenced by certain substances. Corrosion can be concentrated locally, forming a pit or crack, or it can spread across a large area, corroding the surface more or less uniformly. Corrosion chemistry is complex; it can be thought of as an electrochemical phenomenon. During

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corrosion, oxidation occurs at a specific spot on the surface of an iron object, and that spot acts as an anode. The electrons released at this anodic spot move through the metal to another spot on the metal, where they reduce oxygen in the presence of H^+ (which is thought to be present). It is frequently possible to remove corrosion products chemically. For example, phosphoric acid in the form of naval jelly is frequently used to remove rust from ferrous tools or surfaces. Corrosion removal is not the same as electro polishing, which removes some layers of the underlying metal to create a smooth surface. Phosphoric acid, for example, can be used to electro polish copper. The problem of aluminium corrosion in alkaline media arises in a variety of practical situations, ranging from its potential use as an anode material in energy storage devices, through pre-treatment processes prior to anodization or for aesthetic purposes, to the alkaline nature of various cleaning agents used on working elements and constructions. Several organic inhibitors have been shown to be effective corrosion inhibitors for aluminium and its alloys. Their inhibition effect is determined by the structure of the molecule, whether the functional groups are electron donors or acceptors, and the number of such groups per molecule [15, 16]. It is worth noting that the most effective inhibitors are based on molecules with heteroatoms, such as oxygen, nitrogen, phosphorus, sulphur, and aromatic rings.

An open circuit potential transient, potentiodynamic polarisation experiment, and A.C. impedance spectroscopy were used to investigate the corrosion of pure aluminium in alkaline solution. The steady-state value of the open circuit potential ($E_{ocp,ss}$) of pure aluminium in alkaline solution was found to decrease as the rotation rate of the specimen increased, which is attributed to the

enhanced anodic reaction. The extent of anodic polarisation for the aluminium dissolution reaction on pure aluminium at $E_{ocp,ss}$ was found to be greater than that for the water reduction reaction. Understanding the mechanism by which inhibitor molecules interact with the protected metal surface is critical in the selection

of the most efficient corrosion inhibitors, especially in the case of green inhibitors based on natural extracts. The use of Dynamic Electrochemical Impedance Spectroscopy in galvanostatic mode (g-DEIS) to determine adsorption isotherms allowed for the confirmation of various forms of dihydroxybenzene interaction.