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Effect of temperature on anodized aluminum alloys

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ABSTRACT

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This research is mainly concerned with the effect of temperature on anodized aluminum alloys with a view to find better physical and chemical properties of aluminum alloy through the microstructure examination. Four different temperatures were used to vary the electrolyte, the best coating (increase in weight) of 0.994g was obtained from the specimen anodized at 30 OC. As the temperature of the electrolyte increases, the coating thickness decreases. The microstructure test revealed finer grain structure on the specimen at 30 OC and the grain on the microstructure decrease as the temperature of the electrolyte increases. Breaking load of 32KN was realized at a temperature of 30 OC and decreases to 26KN at a temperature of 40 OC.

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1. Introduction

Approaches have been taken on metals to protect them from corrosion, making them to have a safer and reliable materials and structures. As civilization increases, man gradually improves upon his tools and structure to have safer and reliable equipment. Aluminum is widely used in industries such as aircraft manufacturing, where aluminum was examine as an excellent metal that would minimize the need for treatment, since it tends to form

an oxide coating that protect itself from corrosion (anodic oxidation on its surface). Loss of lives and economic as been a consequence of corrosion in several engineering field, mechanical engineering as in aircraft industries, Civil engineering as in bridges. (Callister, 1997; www.corrosionist.com)

1.1. Resistance to corrosion

Some metals are more intrinsically resistant to corrosion than others, either due to the fundamental nature of the electrochemical processes involved or due to the details of how reaction products form. For some examples, see galvanic series. If a more susceptible material is used, many techniques can be applied during an item's manufacture and use to protect its materials from damage. The materials most resistant to corrosion are those for which corrosion is thermodynamically unfavorable. Any corrosion products of gold or platinum tend to decompose spontaneously into pure metal, which is why these elements can be found in metallic form on Earth, and is a large part of their intrinsic value. More common "base" metals can only be protected by more temporary means. Some metals have naturally slow reaction kinetics, even though their corrosion is thermodynamically favorable. These include such metals as zinc, magnesium, and cadmium. While corrosion of these metals is continuous and ongoing, it happens at an acceptably slow rate. An extreme example is graphite, which releases large amounts of energy upon oxidation, but has such slow kinetics that it is effectively immune to electrochemical corrosion under normal conditions. (www.wikipedia.com)

1.2. Intergranular corrosion

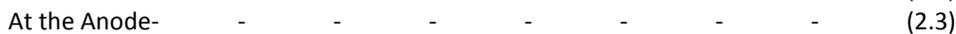
Intergranular corrosion attacks the interior of metals along grain boundaries. It is associated with impurities which tends to deposit at grain boundaries and/or difference in phase precipitated at grain boundaries. Heating of some metals can causes a sensitization or an increase in the level of in homogeneity at grain boundaries. Therefore, some treatment and weldments can result in a propensity for intergranular corrosion. Susceptible materials may also become sensitized if used in operation at a high enough temperature environment to cause changes in internal crystallographic structure. The most predominant susceptible have been observed in stainless and some Aluminum and Nickel-based. (Benjamin et al. 2001)

The major material of construction of modern day aircraft are still about 80% Aluminum, 15% steel, and about 5% titanium. Since this project is centered to aluminum, corrosion control of aluminum alloy will be studied. Aluminum seems to be the king in aircraft construction, though in recent years some new alloys have been applied. These super alloys are still quite expensive for the aircraft homebuilder. With its good strength to weight and cost ratio, aluminum is still used very widely in the industry (www.feedproxy.google.com).

1.3. Theory of anodization

Deposition of aluminum oxide takes place in the electrolytic bath in which high purity aluminum is used as both the cathode and anode in an electrolyte such as dilute acid as a result of the formation of aluminum oxide which is formed at the reaction of the aluminum at the anode with the oxygen evolved from electrolyte. The reaction sequence is as follows;

At the cathode



Thus, hydrogen evolution occurs at the cathode and oxygen is formed at the anode. The oxygen formed at the anode is liberated but react with aluminum to produce an insulation film of Al₂O₃ which is adherent to the based metal

The combine anodic and cathodic reaction is



Thermodynamically, for the above net reaction to occur, the electrode potential (E) must be equal to or greater than 1.667volt. However, in practice, higher voltages are employed in order to overcome resistance over potentials (Malik, 2009).

1.4. Factors influencing the choice of aluminum grade for anodizing

When selecting material for work eventually to be anodized, the manufacturers' choice will be guided by type of finish that is required. In some cases, the mechanical properties of the aluminum will be prime importance, e.g. aircraft components subject to stress in service. Here the choice will be limited and the appearance, attractive or otherwise, may have to be accepted. Where resistant to atmospheric corrosion is the prime requisite and it is often possible to select alloys giving coating that combine good protection and an attractive appearance. Many applications of anodization are mainly decorative and here the choice of alloys is the most extensive, although for the production of very bright film, comparable with bright chromium plating, alloys of special high purity must be used. Apart from the difference in the appearance of anodic film on different alloys, other variation can be introduced by mechanical or chemical pre-treatment of the metal before anodizing. (Malik 2009)

1.5. Review of past research

A lot of work has been done to study the anodization on Aluminum and its alloy because of the extensive use in engineering applications. Babaqi et al, found that 4-Phenyl-1-acetophenone-3-thiosemicarbazone inhibit corrosion on aluminum in Trichloro-acetic acid (TCA) at different temperature using the weight loss technique. They report that the efficiency increase with increasing organic additives concentration up to 7.5×10^{-5} M, where the maximum efficiency is 87.7%. The aluminum surface was now completely covered with inhibitor molecules. Further higher additive concentration led to the decrease of the efficiency which is obviously connected to the orientation kinetics of the adsorbed molecules that led to the lower efficiency. When the temperature is increased, the efficiency of the organic inhibitor is increased.

Malik Idris, (2009) worked on the corrosion effect on Aluminum alloy 7075 and in to different media. The weight loss technique was used to determine the corrosion rate in 1.0M HCl and 1.0M Na. These specimens were allowed to stay in the solution for 504 hours with an interval of 72 hours weight loss measurement. The result shows that in both media, the normal corrosion rate profile of an initial steep rise in corrosion followed by subsequent fall was observed for both anodizing and unanodized specimen but with severe attack on those specimens in 1.0M HCl. The anodized Al-Alloy in both solutions has lesser corrosion rate as compared to the unanodized Alloy.

Yaro, (2005) investigated the effect of voltage, electrolyte concentration and time on the thickness of the anodic coating in an anodizing process. Three sets of experiment were carried out to verify the effect of the abovementioned parameters. In the first experiment, it was observed that the thickness considerably with increasing voltage to a maximum voltage of 7 Volt where the highest coating thickness of 51 μ m was obtained and began to fall. In the second experiment, the highest coating thickness of 51 μ m was obtained at the anodizing time of 40 minutes. From the last experiment, it was observed that the thickness of the coating with increase in electrolyte concentration with maximum coating of 128 μ m at the lowest electrolyte concentration of 20% by volume.

Al- Amin, (2010) investigated the effect of current density on the anodization of aluminum alloy with a view to find a suitable method of enhancing the physical and chemical properties of aluminum. An alloy used was duralumin which was anodized in an aqueous sodium hydroxide acidic solution while varying the current. The experiment was varied between different amperes in six successive experiments. A change in weight and thickness was noticed. After a certain increase in current density, there was a deviation in linearity of the concentration with increase in the current density due to a phenomenon called passivation. The microstructures of the specimen were analysed which reveals the effect of the anodizing process under varying current density.

2. Materials and methods

The materials used for the experiment are; the constituents of the Aluminum Alloy were gotten separately and it was cast at the Department of Metallurgical and Material Engineering, Ahmadu Bello University Zaria. The rods were machined to 17mm in diameter and 60mm in length. The samples were made smooth by thorough grinding with emery abrasive paper in Mechanical Engineering laboratory. The electrolyte was prepared at the Department of Chemistry, Ahmadu Bello University Zaria. Other materials used were beaker, distilled water, abrasive grinding paper, metallurgical microscope, weighing balance, vernier caliper, grinding and polishing machine.

2.1. Sample preparation

The anodizing materials are Battery of 12 V, Water Bath with thermometer, Electrode and Electrolyte. The water bath was filled with water, inside the bath was the electrolyte contained in a beaker. The positive terminal of the battery was connected to the aluminum alloy and negative terminal to the cathode (lead) with wire. The aluminum alloy and lead was placed inside the electrolyte. The negative terminal was disconnected until the experiment was started.

2.2. Anodizing condition

The condition for anodizing used ware; the anodizing voltage of 12 V, anodizing temperature (30 OC, 32 OC, 35 OC and 40 OC.) and the percentage of electrolyte used was 25% H₂SO₄.

During Experiment, the specimen was connected to the battery and placed them in the electrolyte

2.3. Process methods

One experiment was done to determine the effect of temperature on the aluminum alloy. The experiment was carried out with respect to the above stated condition. The experiment was carried out using the charge battery as the source of electricity needed. The positive terminal of the battery was connected to the Aluminum rod, while the negative was connected to the lead which serves as the cathode. The temperature of the electrolyte was varied using water bath by putting the beaker into the bath and set the temperature to the determined Celsius. The temperature of the electrolyte was checked before the experiment using thermometer. This was done for each specimen and the concentration was kept constant throughout the experiment.

2.3. Mechanical test

The test was carried out with the Delison Machine at the strength of material laboratory, Mechanical engineering department, Ahmadu Bello University Zaria. The specimen was marked at a point to serve as the gauge length and was fixed to the clamp of the machine in between the point of the gauge length and the machine was switched ON and the load result was read from the reading meter in kilo newton (KN).

3. Results and discussion

From the experimental work carried out, the following results have been obtained as shown in Table 4.1 and Table 4.2.

Table 4.1
Anodization result.

Temperature (OC)	Weight before experiment (g)	Weight after experiment(g)	Coating (g)
30	83.0406	83.6400	0.994
32	80.5255	80.9255	0.400
35	85.2319	85.5325	0.3006
40	82.2364	82.3020	0.0656

4.1. The graph temperature against thickness

From figure 4.1, it shows that, as temperature of the concentration decreases, the coating increases and vice versa. When the temperature of the electrolyte is lower, the cathode will deposit more oxide film on the aluminum. Therefore coating thickness increases as the temperature of the concentration decreases. In agreement with Malik (2009), insulphuric acid anodization, the film produced is less absorbent than those produced in warm electrolyte.

4.2. The graph of temperature of the specimen against the braking loads

From figure 4.2, the result shows that, the specimen temperature decreases as the braking load increases. The braking load of the unanodized specimen was the same as the specimen at the

temperature of 400C, because the anodization does not usually form at high electrolyte concentration on alloy. This shows that anodization temperature affect the mechanical properties of aluminum alloy.

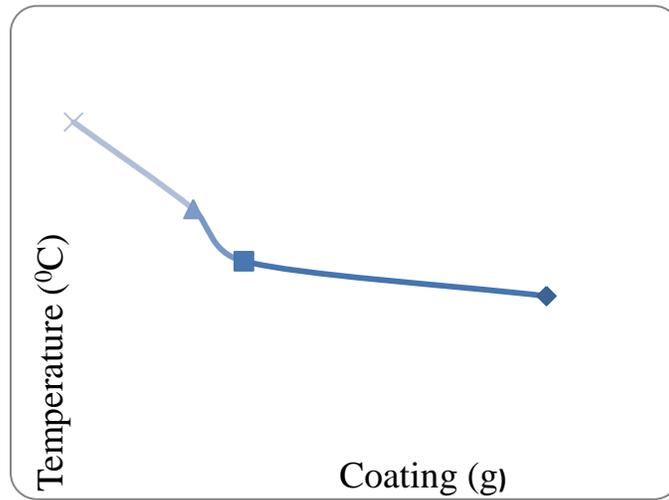


Fig. 4.1. Graph of the temperature against the thickness obtained.

Table 4.2

Tensile test results.

Specimen with temperature	Load obtained (KN.)
Unanodized	26
At 300C	32
At 320C	28
At 350C	27
At 400C	26

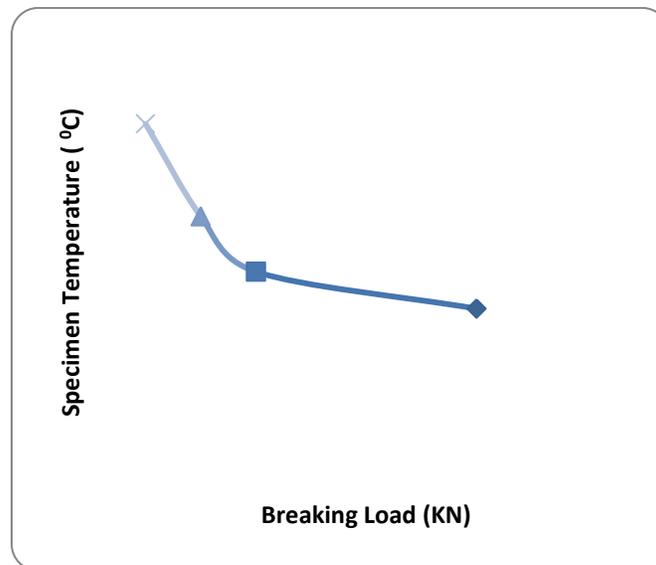


Fig. 4.2. Graph of the specimen temperature plotted against the braking load.

4. Conclusion

After a careful experiment and analysis of the result obtained, the following were noted;

- The aluminum alloy when anodized, has a coat formed on the surface of the alloy as oxide film, therefore reduce corrosion rate.
- The processes of anodizing improve the mechanical properties of the aluminum alloy from the mechanical test conducted.
- The lower the temperature, the thicker and finer the coat formed on the aluminum alloy.
- It was also stated that, highly alloyed material may not form a protective oxide film if the temperature of the concentration is high.
- Anodization performed at lower temperature obtains better mechanical properties.

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