The Effect of Citric Acid Concentration on the Corrosion Rate of Aluminum Alloy Type (AA 7001)

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ABSTRACT

The main purpose of this research is to study the concentration influence of citric acid on the corrosion rate of aluminum alloy type (AA 7001), samples of aluminum alloy were merged in different concentrations of the acid at various durations, the results showed that the less corrosion rate was at 25% concentration after 120 day and the higher rate was at 10% after 30 day.

Keywords: aluminum alloys, chemical corrosion.

تأثير تركيز محلول الستريك على معدل التآكل لسبيكة الألمنيوم النوع (AA 7001)

الخلاصة

يهدف هذا البحث إلى دراسة تأثير تركيز محلول ألستريك على معدل التآكل لسبيكة الألمنيوم النوع (AA 7001) لما له من تطبيقات في الصناعات الغذائية ، استخدمت في هذه الدراسة تراكيز مختلفة من المحلول وغمرت عينة سبيكة الألمنيوم فيها بأزمان متنوعة ، استنتجت من خلال النتائج إن اقل معدل تآكل كان عند التركيز 25% بعد 120 يوما وكان أعلى معدل تآكل عند التركيز 10% بعد 30 يوما .

الكلمات المرشدة :- سبائك الألمنيوم ، التآكل الكيمياوي.

INTRODUCTION

Aluminum alloys has many industrial applications such as airplane bodies, space research and food canning because it's easy to extract and has light weight [1,3] Corrosion is defined as destructive chemical or electrochemical reaction between the metal and its environment, which results in the formation of oxide or some other compounds. Corrosion begins at the surface and then spreads in the interior of the metal. It depends on the temperature, mechanical stress, erosion and concentration of the reactants. Most metals get corroded due to chemical attack by other materials, water or environment [1, 2]

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The wastage of metals due to corrosion has become an important engineering problem. Probably no other source of waste, except that of human life, is of greater concern to all [2]

The industrial civilization depends in a crucial way upon the stability of metals in their moist atmospheres which can be achieved if their surfaces are isolated from the normal terrestrial environment, if not they develop cracks and break upon strain with catastrophic suddenness. Their surfaces are transformed into oxides which peel off or they just dissolve away [3]

The main purpose of this research is to study the effect of citric acid on the corrosion rate of aluminum alloy type (AA 7001), the citric acid which is found in the most food and drinking canning act as a solvent and react with the aluminum surface making small pitting in the surface by removing some particles from them [7,8]

The natural protection from this attack is the aluminum affinity with oxygen , this reaction make layers of aluminum oxide , the only way to break this relationship is by increasing the merge duration as long as possible , so all canning manufacturing process has expire dates even it does not have preservative materials [5,8]

In other hand, increasing the acid concentration leads to more passive state, so it does not have much effect on corrosion rate.

EXPERIMENTAL WORK

Material Selection and Preparation

The material selection was wrought aluminum alloy with (2*2) cm square dimensions, after primary cleaning it soaked to the different concentration of citric acid ($C_6H_8O_7$) with 99.5% purity with different times [4]

Chemical properties

The chemical composition for the aluminum alloy plate was illustrated in table (1)

Soaking Parameters

The procedures contain the following steps:-

1- Cleaning the aluminum specimen to remove any dust or unwanted particles and measuring the initial weight (Wo).

2- Merge the specimen in one concentration of citric acid (5%) as a begin.

3- Holding the steady state mixture to a different time (20 days as a begin).

4- After this period of time, clean the specimen by using pure water then in alcohol liquid then drying it in the air and then measuring the final weight (Wt).

5- Return the specimen to the 5% citric acid and leave it to the other period of time (30 – 50 – 80 – 120) days .

6- Measuring the final weight after each period of time and after the cleaning.

7- Return the procedure from point (2) to point (6) for the other concentration of citric acid (10-15-20-25) %, and put all data in one table.

8- Calculate the corrosion rate.

Corrosion Rate Calculation

In this experiment, to calculate the corrosion rate, the weight loss technique is used. Corrosion rate (C.R) is estimated by the equation: -

$$C.R = (1.44\Delta W/ A *t*S.G) *10^{-3} \text{ (mpy)} \quad \text{….. (1)}$$

Where : ΔW= the different in weight loss after period of time. (Wo-Wt) in grams
t= time in days, A =surface area (mm^2), S.G = specific gravity.

RESULTS AND DISCUSSIONS

The first five diagrams is the relationship curve between corrosion rate (in x-axis) and time in days (in y – axis) for different concentrations of citric acid.

In fig (1) and (2) the delay in corrosion rate after several days (passive state) caused by the oxygen layers concentration on the surface of the aluminum which is act as a protection media for the corrosive environment .

Aluminum has high affinity for oxygen to form aluminum oxide -Al_2O_3 (amorphous alumina), because of the difference in value of alumina voltage, γ-Al_2O_3 is coming from crystalline oxide in the anodic alumina film on Al-substrate.

Voids and slits appeared in the attached layer because the transformation to γ-Al_2O_3 leads to more internal stress and volume shrinkage than that of the transformation to amorphous Al_2O_3.

So after several layers, the protection area will be brittle, so it breaks down and the corrosion rate will be increased again after the transport passive zone.

In fig (3), (4) and (5), the oxide layer will appear again after the passive state in the highly concentration of citric acid because of change in polar voltage for the metal which is make another series of oxide reactions.

The crystalline oxide can sustain a higher voltage, it has a higher relative dielectric constant, and possesses a lower ionic conductivity.

So γ-Al_2O_3 will appear again and the voids in the outer layer cause to the oxide film after several times to failure.

The second five diagrams give the relationship curves between corrosion rate (in x-axis) and concentration of citric acid. (In y – axis) for different times.

In fig (6) , (7) , (8) and (10) we saw the delay in corrosion rate at certain concentration of citric acid (10%) , while in fig (9) the passive state caused by the oxygen layers began at 20% concentration of citric acid.

Again γ-Al_2O_3 which produced from the affinity of aluminum with oxygen and the high voltage of oxygen, many layer with several days put marks on the attached layer with the acid which after period of time cause to collapse.

CONCLUSIONS

From the above results, we could conclude the following:

1-Less corrosion rate was at 25% concentration of citric acid after 120 day and the higher rate was at 10% after 30 day.

2-All charts have the passive state zone caused by the oxygen layers.

3-High concentration of citric acid (15, 20 and 25) % have two different passive state zone (80 and 120 days).

4-The periods (80) days and (120) days have notice effect on the passive zone.
5-Increasing the acid concentration lead to more passive state.
6-Increasing the duration of soaking process lead to more corrosion attack.

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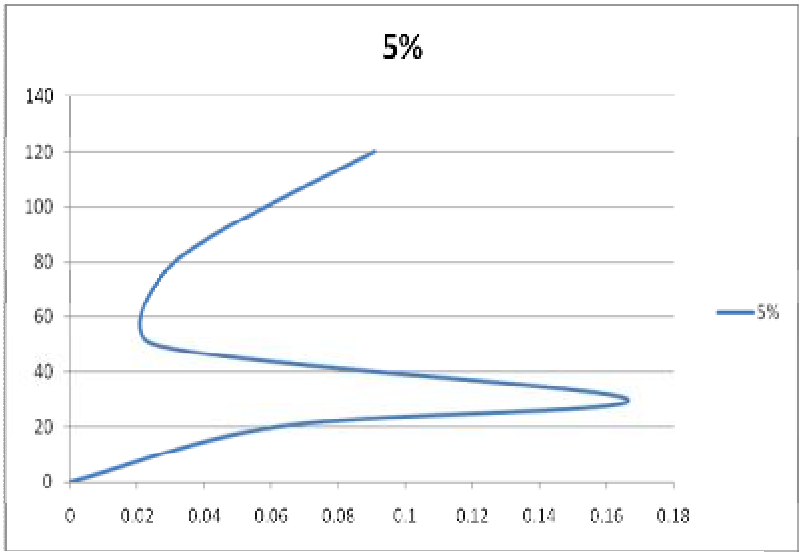
Table (1) Chemical Composition for Al-Specimen type (AA7001) [6]

Element	Al	Zn	Mg	Cu	Mn	Si
Weight %	85%	8.0	3.4	2.6	0.2	0. 35

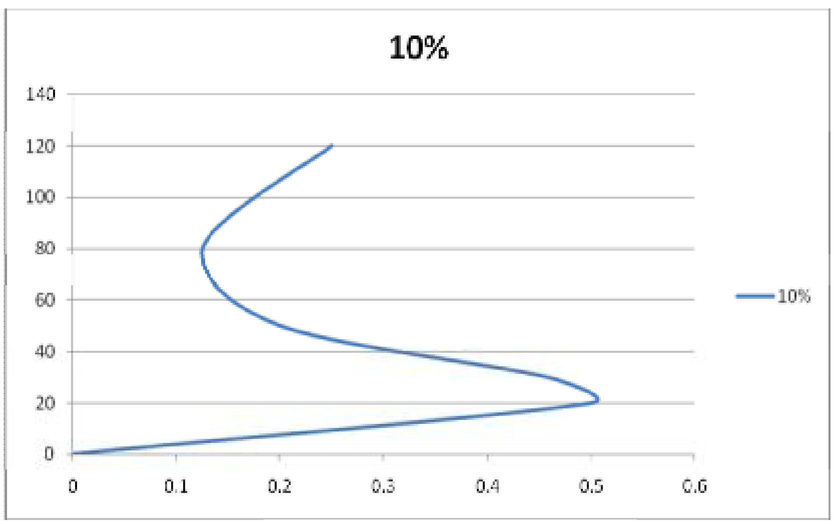
Time (days)



Corrosion rate (mpy)

Figure (1) Relationship between corrosion rates in mpy and time in days at 5% acid concentration

Time (days)



Corrosion rate (mpy)

Figure (2) Relationship between Corrosion Rates in mpy and Time in Days at 10% Acid Concentration.

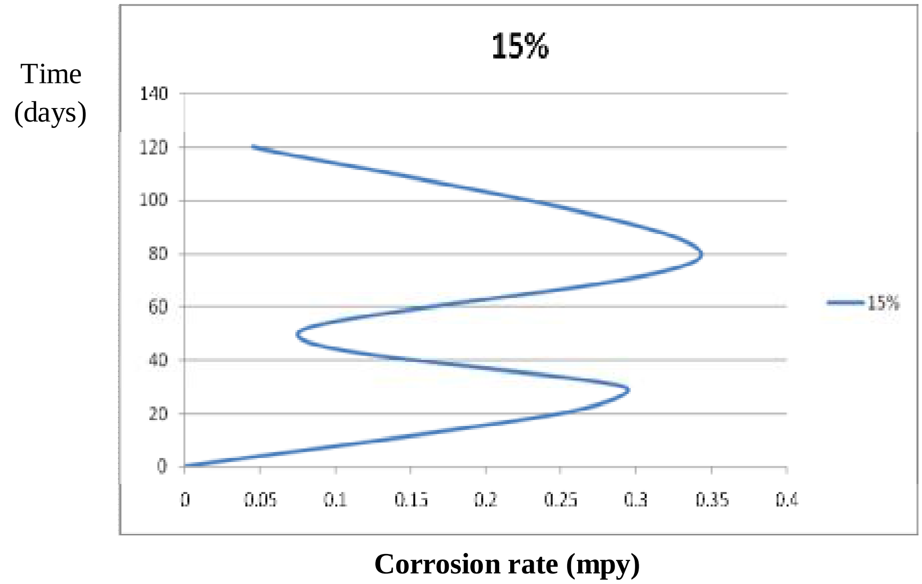


Figure (3) Relationship between Corrosion Rates in mpy and Time in Days at 15% acid Concentration.

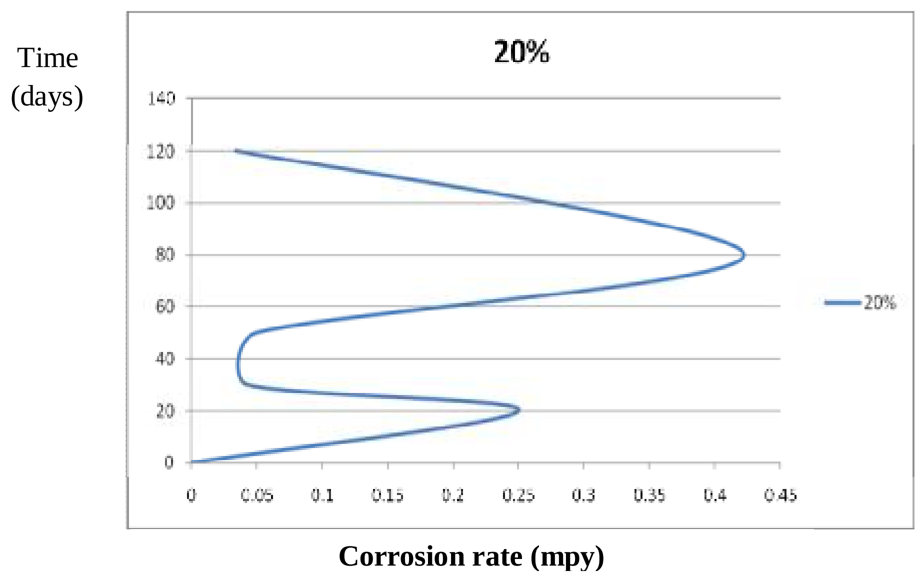


Figure (4) Relationship between Corrosion Rates in mpy and Time in Days at 20% acid Concentration.

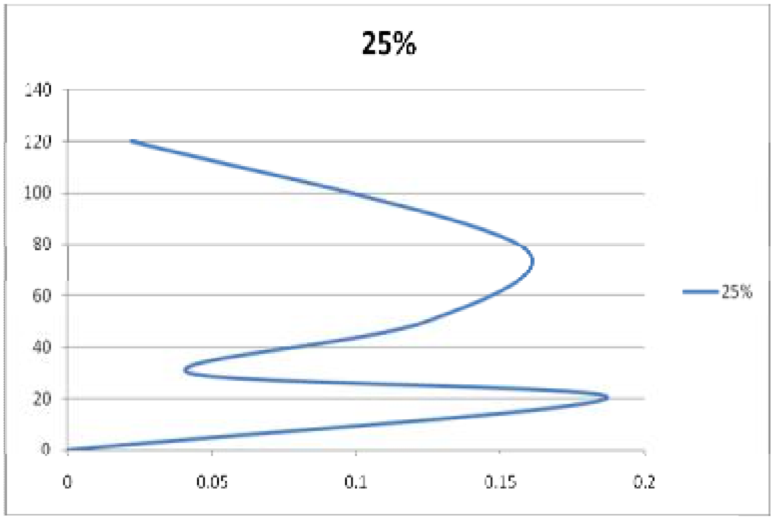


Figure (5) Relationship between Corrosion Rates in mpy and Time in Days at 25% acid Concentration.

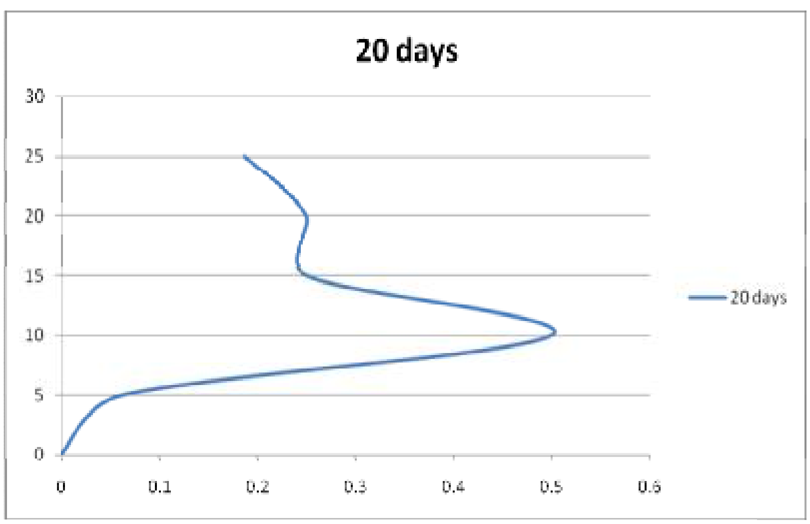


Figure (6) Relationship between Corrosion Rates in mpy and acid Concentration at 20 Days.

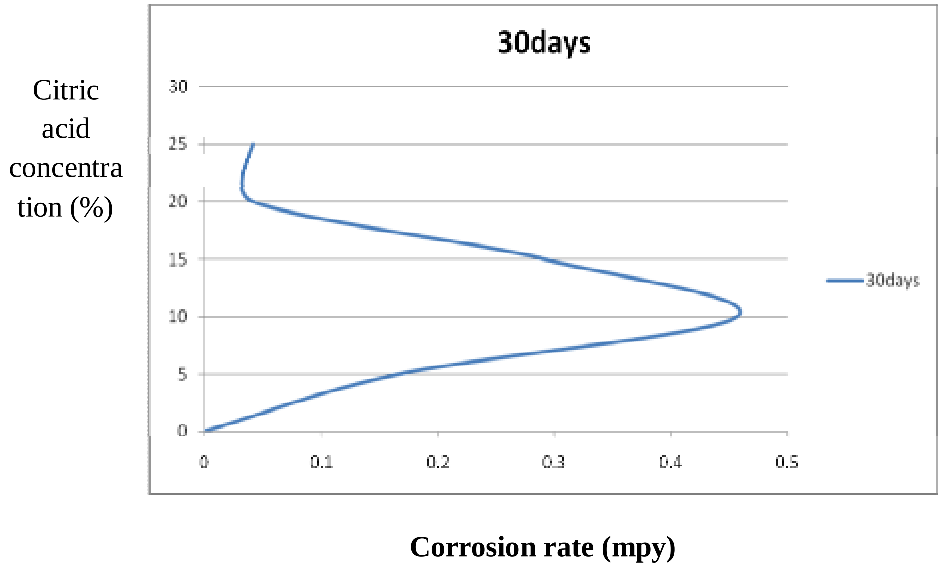


Figure (7) Relationship between Corrosion Rates in mpy and acid Concentration at 30 Days

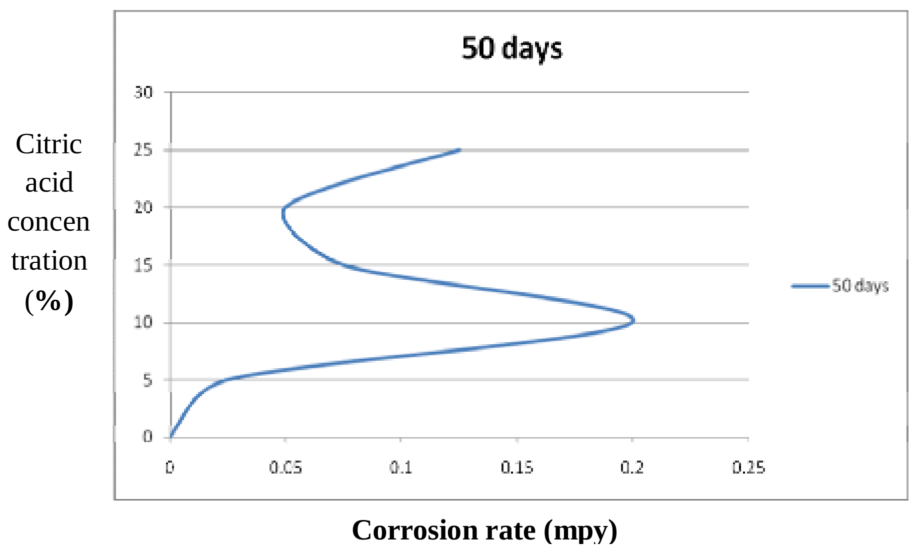
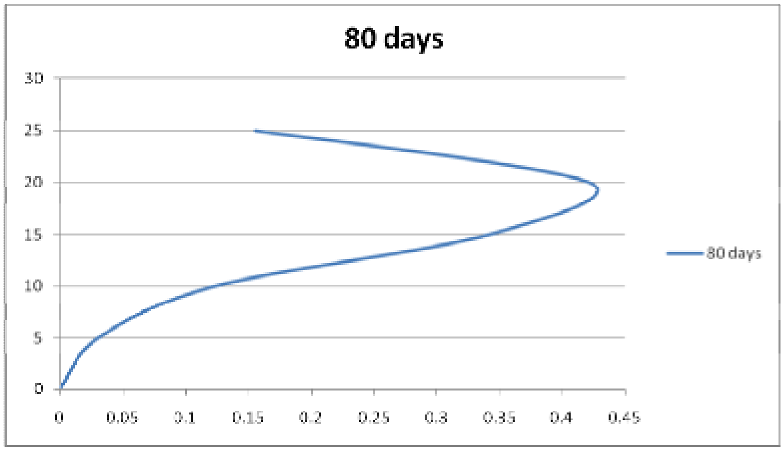


Figure (8) Corrosion Rate in mpy and acid Concentration at 50 Days

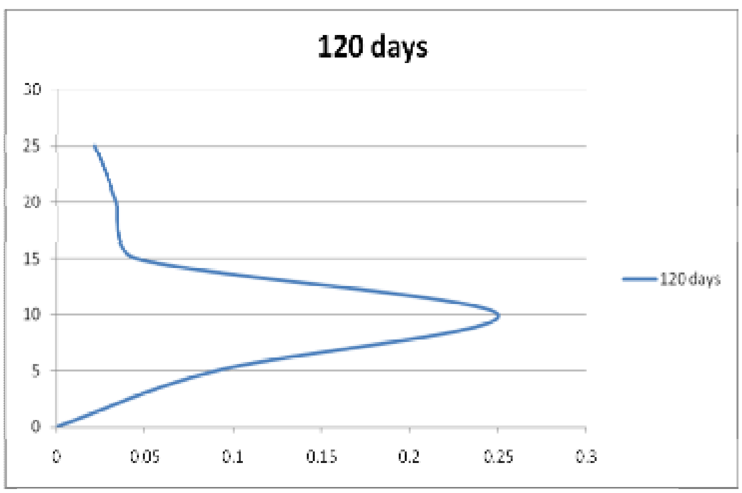
Citric acid concentration (%)



Corrosion rate (mpy)

Figure (9) Relationship between Corrosion Rates in mpy and acid Concentration at 80 Days

Citric acid concentration (%)



Corrosion rate (mpy)

Figure (10) Relationship between Corrosion Rates in mpy and acid Concentration at 120 Days