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Investigation of Corrosion Resistance of Magnesium Alloy AZ91 Immersed in Sodium Chloride Solution at Various Concentrations Utilizing the Linear Polarization Method

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ABSTRACT

When using the linear polarization method to calculate corrosion rates for coated and uncoated samples. Tafel plot experiments were used to calculate the values of βa and ßc used in estimating the wear rate.

It was found that in uncoated and coated samples, the corrosion rate increases with increasing sodium chloride concentration. However, in the case of uncoated specimens, the increase in wear rate is more pronounced.

According to the most recent findings, applying surface treatment while sodium stagnate solution is present significantly improves the AZ91 magnesium alloy's capacity to withstand corrosion. For instance, the CRs for the coated and uncoated samples are 122 mpy and 81.4 mpy, respectively, at 7 percent NaCl. Electrochemical testing shows that the surface treatment improves corrosion resistance by 33.3 percent and lowers corrosion rate by 33.3 percent.

KEYWORDS: *Calculate Corrosion Rates, Coated Samples, Magnesium Alloy, AZ91 Magnesium, Corrosion Resistance, Surface Treatment*

INTRODUCTION

Current structural applications for magnesium alloys include those in the electrical, automotive, aerospace, and other sectors. The material's high strength-to-weight ratio and relatively high stiffness are expected to lead to an increase in applications., particularly in those that involve component mobility or portability. [1]

The poor wear resistance and corrosion resistance of magnesium-based materials are some of the difficulties in its use. To increase the wear and corrosion resistance of magnesium components, surface treatments are often used. Therefore, the way the Mg-AZ91C alloy corrodes in aqueous solutions with different concentrations of NaCl primer and stripping conditions was studied. [2]

To enhance the corrosion resistance of AZ91C, accelerated corrosion experiments were conducted by; implementing the linear polarization technique by exposing.

The potential range of the working electrode was adjusted to 25 mV above and below the corrosion potential (E_{corr}) at a sampling rate of 0.1 mV/s. [3]

1. Technique
   - To determine the corrosion rate following the immersion test, the weight loss (W) is first computed and then inserted in the equation. (1)

$$C, R = \frac{534 \times W}{D \times A \times T} \qquad (1)$$

Where: C.R., corrosion rate, mpy; W, weight loss, mg; D, alloy density, g/cm^3; A, specimen surface area, in 2; T, exposure period, in hours. [4]

- Accelerated corrosion testing is performed as follows: using linear polarization techniques, the working electrode is exposed to potentials 25 mV, The sampling rate is below the corrosion potential (E_{corr}) at 0.1 mV/s. Polarization resistance (RP), also known as corrosion current (I_{corr}) and therefore corrosion rate (C.R), can be related to the slope of a potential versus current (E/I) plot Using equation (2). [5]

$$I_{carr}(A) = \frac{\beta_a \times \beta_c}{2.3 \times (\beta_a + \beta_c) \times R_c} \qquad (2)$$

Where: Icorr is the corrosion current; $\beta_a$the slope of the anodic plot; β_c the slope of the cathodic plot; and RP is the polarization resistance.

$$Icorr(\mu/cm^2) = \frac{10^6 \times lcorr}{a} \qquad (3)$$

Where: $I_{corr}(\mu/cm^2)$is the corrosion current density aThe exposure area = 0.785 cm^2.

$$C.R = \frac{0.13 \times Icorr \times eq.wt}{D} \qquad (4)$$

Where: C.R. the corrosion rate (mpy); eq.wt the equivalent weight of the material (magnesium) = 12, D density of the alloy = 1.738 g/cm^3.[6]

Results and Discussion

1. Electrochemical measurements (without inhibitor)

The ability of coated and uncoated samples to resist corrosion was tested using solutions of 1, 3, 5, and 7 percent NaCl. Samples with a surface area of 0.785 cm^2 received the solution.

The corrosion rates of coated and uncoated samples are determined using the linear polarization technique. The values of ßa and ßc used in the calculation of corrosion rate were calculated from the Tafel plot experiments. [7]

In (Fig. 1- 2) and Table, the corrosion rates of the coated and uncoated samples are displayed. These graphs demonstrate how the CR changes as the concentration of the NaCl solution increases. As the concentration of NaCl grows, both coated and untreated samples see an increase in corrosion rate.However; the increase in corrosion rate is more pronounced in the case of uncoated samples. The corrosion rate increased from 30.2 mpy at 1% NaCl to 122 mpy at 7% NaCl for the uncoated samples and from 19 mpy at 1% NaCl to 81.4 mpy at 7% NaCl for the coated samples. The present results indicate that surface treatment of AZ91 magnesium alloy in the presence of sodium stannate solution enhances the corrosion resistance of the alloy to a marked extent. For example, in 7% NaCl, CR is 122 mpy and 81.4 mpy of the uncoated and coated sample, respectively. This indicates that the surface treatment reduces the corrosion rate (i.e., enhances the corrosion resistance) by an electrochemical test to 33.3 percent. It should be noted that these results are in good accord with weight reduction measurements.

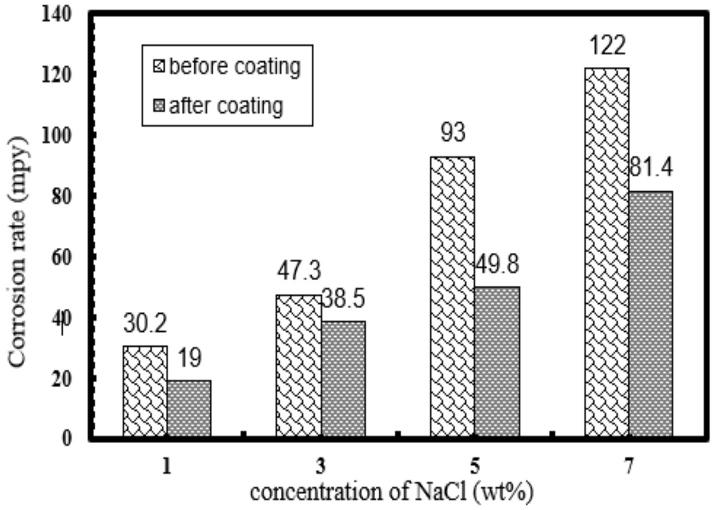

Fig. 2 Comparison between corrosion rate for uncoated samples and coated samples in different concentrations of NaCl

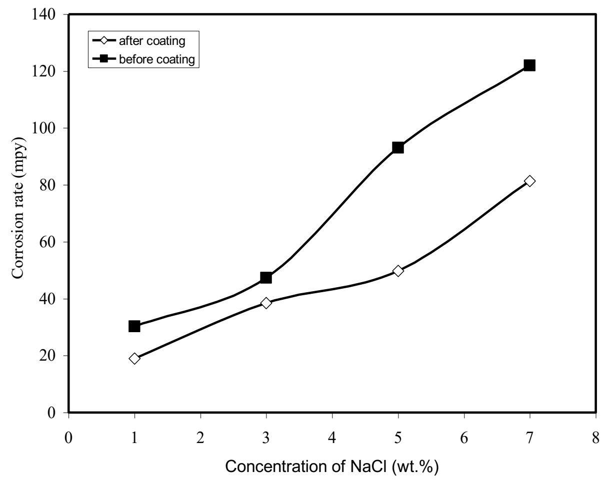

Fig. 1 Corrosion effects of different NaCl

Table 1. Results of the Electrochemical Test for AZ91C in different concentrations of NaCl Solution at pH=7

Conditions	E_{corr} (mV)	β_a	β_c	R_p (ohm)	I_{corr} (µA/cm 2)	Corrosion rate, mpy
(1% NaCl) before coating	-1416	0.188	0.159	1.415 x10^3	33.72	30.2
{3% NaCl) before coating	-1462	0.349	0.141	1.055 x10^3	52.7	47.3
(5% NaCl) before coating	-1480	0.148	0.131	3.715 x10^2	103.6	93
(7% NaCl) before coating	-1519	0.202	0065	1.76 x10^2	154.86	122
(1% NaCl) after coating	-1351	0.127	0.058	1.011 x10^3	21.17	19
(3% NaCl) after coating	-1386	0.104	0.037	3.524 x10^2	42.9	38.5
(5% NaCl) after coating	-1452	0.59	0.049	3.545 x10^2	55.48	49.8
(7% NaCl) after coating	-1462	0.417	0.76	3.926 x10^2	90.24	81.4

2. Electrochemical measurements (with inhibitor)

The obtained results of this investigation are listed in Table (2) and depicted in (Fig. 3- 4) These figures show the Effect of different concentrations of the

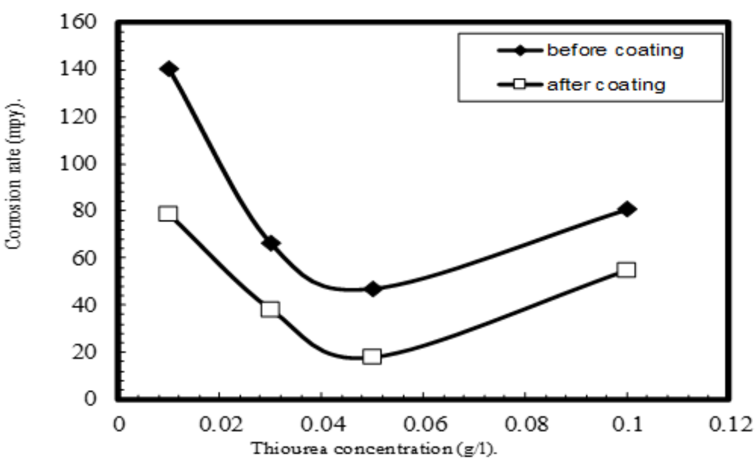

Fig. 3 Effect of NaCl concentration on

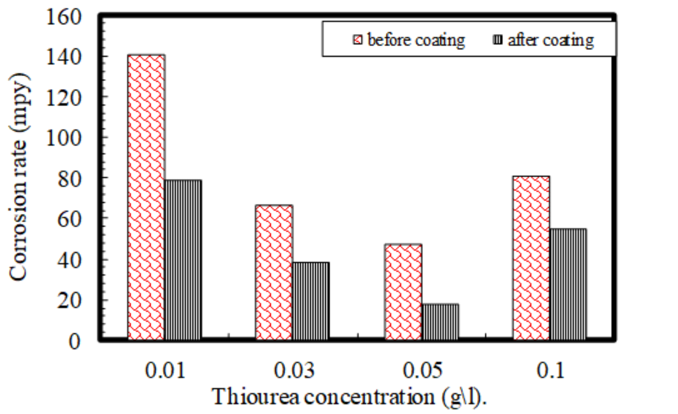

Fig. 4 Comparison between corrosion rate for uncoated samples and coated samples in different concentrations of Thiourea

Table 2 Results of the Electrochemical Test for AZ91C in different concentrations of thiourea at 5% NaCl Solution.

Conditions	E_{corr} (mV)	β_a	β_c	R_p (ohm)	l_{corr} (μA/cm2)	Corrosion rate, mpy
(0.01g/l thiourea) before coating	-1487	0.234	0.108	2.619 x10^2	156.27	140.2
(0.03g/l thiourea) before coating	-1393	0.178	0.068	3.694 x10^2	60.43	66
(0.05g/l thiourea) before coating	-1351	0.237	0.168	1.011 x10^2	53.85	47.07
(0.1 g/l thiourea) before coating	-1401	0.208	0.07	3.23 x10^2	89.8	80.6
(0.01g/l thiourea) after coating	-1469	0.212	0.09	3.989 x10^2	87.72	78.74
(0.03g/l thiourea) after coating	-1414	0.018	0.015	1.02 x10^2	44.43	39.87
(0.05g/l thiourea) after coating	-1387	0.297	0.122	2.432 x10^3	19.69	17.67
(0.1 g/l thiourea) after coating	-1432	0.213	0.062	2.11 x10^2	62.7	54.8

Conclusions

- In solutions with concentrations of 1, 3, 5, and 7 percent NaCl, we evaluated the samples' ability to resist corrosion, both coated and uncoated. Samples with a surface area of 0.785 cm^2 were exposed to the solution.
- The linear polarization technique is used to calculate the rates of corrosion of coated and uncoated samples. The Tafel plot experiments were utilized to calculate the values of ßa and ßc used in the corrosion rate estimate.
- NaCl concentration increases the rate of corrosion for both coated and untreated samples. However, in the case of uncoated samples, the rise in corrosion rate is more pronounced.
- For the uncoated samples, the corrosion rate went from 30.2 mpy at 1% NaCl to 122 mpy at 7% NaCl, while for the coated samples, it climbed from 19 mpy at 1% NaCl to 81.4 mpy at 7% NaCl.
- The present results show that the corrosion resistance of AZ91 magnesium alloy is greatly enhanced by surface treatment in the presence of sodium stagnate solution.
- According to the electrochemical test, the surface treatment decreases (i.e., enhances corrosion resistance) to 33.3%. The current findings demonstrate that surface treatment in the presence of sodium stagnate solution significantly improves the corrosion resistance of the magnesium alloy AZ91.
- More study is needed to completely understand how components added to magnesium alloys affect corrosion resistance.
- Models that properly explain the production stages and manage the microtextures and surface structures must be created in order to increase the corrosion resistance of cured magnesium alloys following coating damage.

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