# Comparative analysis of the corrosion resistance data of aluminium alloy 4032 and 4004, magnesium titanium alloy and aluminium vanadium alloy in dilute $H_2SO_4$, NaCl and acid chloride solutions

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**Abstract.** Comparative study of the corrosion resistance of Al 4032, Al 4004, Mg-Ti and Al-V alloy were performed in $H_2SO_4$ solution, NaCl solution and $H_2SO_4$/NaCl solution for 480 h. Mg-Ti exhibited the highest corrosion rate values in $H_2SO_4$ solution, culminating at values between 0.242 mm/y and 6.081 mm/y compared to Al 4004 and Al 4032 which exhibited the lowest values. Corrosion rate of Al-V were generally stable but exhibited a parabolic behavior beyond 0.025 M $H_2SO_4$ concentration. In NaCl, Mg-Ti alloy exhibited the highest corrosion rate values culminating at values from 0.180 mm/y to 0.794 mm/y. Al 4004 and Al-V alloys exhibited the lowest corrosion rate values. The corrosion rate of Al 4032 was generally stable throughout the exposure hours. Admixture of $H_2SO_4$ and NaCl did not significantly influence the corrosion resistance of the alloys. ANOVA statistical data for Al 4032, Al 4004 and Al-V alloys in NaCl solution are statistically irrelevant with respect to corrosion resistance of the alloys compared to the value for Mg-Ti where electrolyte concentration is statistically relevant with statistical relevance factor of 96.94%. Electrolyte concentration is the only statistically relevant variation influencing the corrosion resistance for the alloys in $H_2SO_4$ with values of 98.44%, 97.66%, 94.96% and 98.38%. This was also observed in $H_2SO_4$/NaCl solution with corresponding values of 90.02%, 94.35%, 91.71% and 86.7%. The highest mean values for Al 4032, Mg-Ti, Al 4004 and Al-V alloys occurred at 0.05 M, 0.0125 M and 0.00625 M $H_2SO_4$ solutions. Mg-Ti exhibits the highest mean corrosion rate values of 5.93 mm/y while Al-V exhibits the lowest values -0.10 mm/y. The SD values were generally low. The mean corrosion rate values for Al 4032, Al 4004 and Al-V alloys in NaCl are significantly below 0 compared to Mg-Ti whose values are greater than 0 but relatively low.

## 1 Introduction

Aluminum metal ranks in production tonnage behind steel, and its growth has continued to increase annually. Aluminium has a density lower than that of other common metals, about one-third that of steel [1]. Aluminium properties can be customized to fit particular industrial requirements or preferences resulting in different aluminium alloy grades and series, temper and fabrication modes. They can be processed through a multiplicity of shapes and sizes [2]. 100% aluminium content from its ore has appreciable resistance to corrosion, however, its application is limited due to its limited structural strength. The alloys consist of the base metal and main alloying elements such as Cu, Mn, Si, Mg, Zn. Aluminum alloys are widely applied in aerospace, automobile, as cladding material in nuclear reactors, marine, machinery and equipment, construction, refrigeration, and air conditioners etc. due to its light weight, high strength-to-weight ratio, recyclability, ductility, electrical and heat conductivity, cryogenic applications, non-ferromagnetic properties and corrosion resistance [3-5]. They are largely selected for its significant weight reduction properties which invariably decreases $CO_2$ emissions. The metallurgical characteristics of aluminium significantly influences its corrosion resistance properties [6-10]. The corrosion resistance of aluminium alloys in specific environments is comparatively greater than the corrosion resistance carbon steels as a result of the presence a non-porous passive oxide on its surface. There are some conditions under which the protective is stable. In conditions with high concentrations of $Cl^-$, $SO_4^{2-}$, thiosulphates etc. the oxide weakens, thus increasing the vulnerability of aluminium alloy to corrosion [11, 12]. The life expectancy and degradation resistance of aluminium alloys during application is of utmost importance especially in industrial establishments where the operating environment is a major concern. S, NO, $Cl^-$ etc. reacts with atmospheric water to produce acids from the combustion of fossil fuels. It is worthy of note that there are other corrosion prevention methods. However, appropriate material selection is the most cost effective [13-17]. Anionic solutions and some others can be harmful to aluminum surfaces when in contact at certain concentrations [18]. The efficient use of aluminum alloy depends directly choice of requisite alloy grade and on ensuring it operates optimally under specific conditions, while minimizing the risk of corrosion. This manuscript evaluates data the corrosion resistance of al alloy 4032, 4004, and Al-V alloy and Mg-Ti alloy for comparative study.

## 2 Material and methods

4032 (Al 4032) and 4004 (Al 4004) Alalloys, Al-V alloy (AlV) and Mg-Ti alloy (MgTi) were obtained from automobile parts. The elemental compositions of the alloys from Energy Dispersive Spectrometry using PhenomWorld scanning electron microscope are shown in Table 1. The alloys were cut into 3 sets of 5 test samples using a portable hand cutting tool. The samples were grinded and smoothened using grit papers of 80, 120, 220, 800 and 1000 grits. 3 sets of electrolyte solutions were prepared. Set 1 consist of 0.1 M $H_2SO_4$, 0.05 M $H_2SO_4$, 0.025 M $H_2SO_4$, 0.0125 M $H_2SO_4$ and 0.00625M $H_2SO_4$ solution. Set 2 consist of 0.5% NaCl, 1.5% NaCl, 2.5% NaCl, 3.5% NaCl and 4.5% NaCl solution while set 3 consist of 0.00625 M $H_2SO_4$/0.5% NaCl, 0.00625 M $H_2SO_4$/1.5% NaCl, 0.00625 M $H_2SO_4$/2.5% NaCl, 0.00625 M $H_2SO_4$/3.5% NaCl and 0.00625 M $H_2SO_4$/4.5% NaCl solution at 200 mL each. They were prepared by dilution of analar grade of $H_2SO_4$ (98% $H_2SO_4$) and recrystallized NaCl with distilled $H_2O$. Weight measured Al 4032, Al 4004, Al-V and Mg-Ti samples were individually and fully submerged in the prepared electrolytes for 480 h at ambient room temperature. The alloy samples were weighed every 24 h with Ohaus analytical weighing balance. Results of corrosion rate values at each electrolyte concentration are shown from Tables 1 to 3. Corrosion rate was calculated from the equation below;

$$C_R = \frac{87.6W}{DAT} \quad (1)$$

Where $W$ represents weight loss in grams, $D$ represents density in g/cm$^2$, $A$ represents area in cm$^2$, and $T$ represents time of exposure in hours. $W$ was determined from the difference between the initial weight of the samples (maintained for 480 h) and every final weight gottenevery 24 h interval for a total of 480 h.

Table 1 Elemental %Wt. composition of Al 4032, Mg-Ti, Al 4004 and Al-V

| Al 4032 | | Mg-Ti | | Al 4004 | | Al-V | |
|---|---|---|---|---|---|---|---|
| **Element Symbol** | **%Wt. Conc.** | **Element Symbol** | **%Wt. Conc.** | **Element Symbol** | **%Wt. Conc.** | **Element Symbol** | **%Wt. Conc.** |
| Al | 85.08 | Mg | 73.26 | Al | 89.05 | V | 89.41 |
| Si | 14.18 | Ti | 22.34 | Si | 10.04 | Al | 9.25 |
| Fe | 0.74 | Dy | 3.51 | Fe | 0.5 | N | 0.82 |
| Cu | 0.41 | C | 0.89 | Cu | 0.41 | C | 0.52 |
| Cu | 0.41 | - | - | | | | |

## 3 Results and discussion

### 3.1 Corrosion rate studies

Comparative study of the corrosion resistance of Al 4032, Al 4004, Mg-Ti and Al-V alloy were performed in $H_2SO_4$ solution (0.00625 M – 0.1 M concentration), NaCl solution (0.5% - 4.5% concentration) and $H_2SO_4$/NaCl solution (0.00625 M $H_2SO_4$ at 0.5% to 4.5% NaCl concentration) for 480 h. Table 2a shows the corrosion rate results of Al 4032 and Mg-Ti and Table 2b shows the corrosion rate results for Al 4004 and Al-V in $H_2SO_4$ solution. Observation of the Tables shows the corrosion rate values of the alloys generally vary with time. Secondly, Mg-Ti alloy exhibited the highest corrosion rate values at 24 h initiation compared to Al 4004 and Al-V alloys which generally exhibited the lowest values indicating the highest corrosion resistance in $H_2SO_4$ solution from onset. Corrosion rate of Mg-Ti initiated at values between 4.689 mm/y and 9.234 mm/y. There was a significant decrease in corrosion rate to values between 1.461 mm/y and 6.240 mm/y at 96 h. Beyond 96 h, corrosion rate was generally stable culminating at values between 0.242 mm/y and 6.081 mm/y. Al 4004, initiated between 0.0010 mm/y and 0.0023 mm/y and subsequently increased to values between 0.0008 mm/y and 0.0035 mm/y at 120 to 144 h. Thereafter, it decreased to values between 0.0002 mm/y and 0.0023 mm/y. Corrosion rate of Al-V were generally stable throughout the exposure hour from 0.00625 M to 0.025 M $H_2SO_4$ concentration. Beyond 0.025 M $H_2SO_4$, the corrosion rate exhibited a parabolic behavior, increasing to highest values at 144 h, before later decreasing in value till 480 h of exposure. Al 4032 was generally stable at 0.1 M $H_2SO_4$ till 480 h of exposure. These observations contrast the data in Table 3a and 3b. Tables 3a and 3b shows the corrosion rate data for Al 4032 and Mg-Ti, and Al 4004 and Al-V alloys in NaCl solution at 0.5% to 4.5% concentration. In NaCl solution, Mg-Ti alloy exhibited the highest corrosion rate values generally, initiating at between 0.072 mm/y and 0.505 mm/y at 2 h of exposure and culminating at values between 0.180 mm/y and 0.794 mm/y. The corrosion rate data indicates significant variation with exposure time. This reveals the mild instability of the alloy surface within the electrolyte. Al 4004 alloy exhibited the lowest corrosion rate values of -0.0004 mm/y to -0.0012 mm/y at 24 h, and values between -0.0003 mm/y and -0.0004 mm/y at 480 h of exposure. Although the Al-V alloy exhibited corrosion rates figures comparable to Al 4004 from 384 h to 480 h at all NaCl concentrations. Its lowest and highest values are -0.00002 mm/y and -0.00005 mm/y. The corrosion rate of Al 4032 was generally stable throughout the exposure hours with final values between -0.141 mm/y and -0.458 mm/y in NaCl solution. Admixture of $H_2SO_4$ and NaCl significantly influence the corrosion resistance of the alloys. Table 4a shows the corrosion rate values for Al 4032 and Mg-Ti alloys, while Table 4b shows the corresponding values for Al 4004 and Al-V in 0.0062 M $H_2SO_4$ solution at 0.5% to 4.5% NaCl concentration. Corrosion rate of Al 4032 and Mg-Ti alloy significantly increased to 0.136 mm/y and 3.664 mm/y (Al 4032), and 5.771 mm/y and 84.115 mm/y (Mg-Ti) at 24 h in the acid-chloride solution. Observation of the data trend shows that the corrosion rate for both alloys significantly decreased at all NaCl concentrations till 120 h where stability was attained with minimal variation of corrosion rate values. At 480 h of exposure the corrosion rate for Al 4032 varied from -0.126 mm/y to -0.868 mm/y while the corresponding values for Mg-Ti varies from 0.242 mm/y to 5.338 mm/y. Al 4004 and Al-V alloys exhibited comparatively lower corrosion rate values compared to Al 4032 and Mg-Ti in the acid chloride solution. Generally, their corrosion rate decreased before attaining relative stability at 96 h and 70 h respectively. Decrease in corrosion rate signifies increase in corrosion resistance of both alloys with respect to time due to growth of the protective oxide on the metal alloys. Nevertheless, in the acid chloride solution, corrosion rate of the four alloys decreased with respect to exposure time. In NaCl solution, Mg-Ti, Al 4032 and Al-V alloys displays increase in corrosion rate values with respect to exposure time, while the corrosion rate of Al 4032 was generally stable after 72 h of exposure. In $H_2SO_4$ solution, corrosion rate of the alloys varied non-linearly with respect to exposure time.

Table 2a Corrosion rate data for Al 4032 and Mg-Ti in $H_2SO_4$ solution (0.00625 M to 0.1 M $H_2SO_4$ concentration)

| **Alloy** | **Al 4032** | | | | | **Mg-Ti** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Electrolyte Conc. (M) / Exposure Time (h)** | **0.00625 M $H_2SO_4$** | **0.0125 M $H_2SO_4$** | **0.025 M $H_2SO_4$** | **0.05 M $H_2SO_4$** | **0.1 M $H_2SO_4$** | **0.00625 M $H_2SO_4$** | **0.0125 M $H_2SO_4$** | **0.025 M $H_2SO_4$** | **0.05 M $H_2SO_4$** | **0.1 M $H_2SO_4$** |
| 24 | 1.900 | 2.103 | 2.191 | 2.476 | 1.086 | 5.771 | 9.234 | 4.689 | 9.162 | 8.657 |
| 48 | 1.866 | 2.035 | 2.188 | 2.459 | 1.612 | 3.246 | 7.899 | 3.102 | 7.070 | 3.823 |
| 72 | 1.617 | 2.013 | 2.199 | 2.454 | 1.244 | 2.260 | 6.661 | 2.308 | 6.204 | 2.140 |
| 96 | 1.264 | 1.908 | 2.196 | 2.459 | 0.916 | 1.641 | 6.240 | 1.984 | 5.753 | 1.461 |
| 120 | 0.814 | 1.574 | 2.198 | 2.436 | 0.692 | 1.385 | 6.103 | 1.688 | 5.295 | 0.880 |
| 144 | 0.605 | 1.221 | 2.199 | 2.465 | 0.407 | 1.347 | 6.264 | 1.527 | 4.773 | 0.890 |
| 168 | 0.572 | 1.037 | 1.992 | 2.452 | 0.354 | 1.329 | 6.307 | 1.422 | 4.710 | 0.690 |
| 192 | 0.416 | 0.704 | 1.781 | 2.493 | 0.483 | 1.641 | 6.033 | 1.380 | 4.572 | 0.622 |
| 216 | 0.407 | 0.663 | 1.677 | 2.518 | 0.629 | 1.779 | 5.643 | 1.258 | 4.385 | 0.778 |
| 240 | 0.404 | 0.685 | 1.723 | 2.500 | 0.658 | 1.948 | 5.555 | 1.198 | 4.235 | 0.592 |
| 264 | 0.441 | 0.734 | 1.782 | 2.556 | 0.534 | 2.118 | 5.424 | 1.239 | 4.309 | 0.334 |
| 288 | 0.495 | 0.848 | 1.761 | 2.570 | 0.515 | 2.272 | 5.392 | 1.088 | 4.310 | 0.361 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 312 | 0.519 | 0.945 | 1.756 | 2.589 | 0.514 | 2.175 | 5.333 | 1.038 | 4.645 | 0.372 |
| 336 | 0.535 | 0.904 | 1.611 | 2.501 | 0.417 | 2.185 | 6.276 | 1.051 | 4.931 | 0.381 |
| 360 | 0.446 | 1.031 | 1.617 | 2.422 | 0.328 | 2.939 | 6.257 | 1.010 | 5.574 | 0.245 |
| 384 | 0.411 | 1.026 | 1.599 | 2.438 | 0.352 | 2.913 | 6.317 | 1.096 | 5.744 | 0.325 |
| 408 | 0.379 | 0.950 | 1.526 | 2.434 | 0.321 | 2.796 | 6.234 | 1.103 | 5.958 | 0.373 |
| 432 | 0.322 | 0.908 | 1.381 | 2.375 | 0.288 | 2.741 | 6.104 | 1.106 | 5.807 | 0.269 |
| 456 | 0.307 | 0.839 | 1.419 | 2.325 | 0.230 | 2.673 | 5.931 | 1.097 | 5.536 | 0.247 |
| 480 | 0.149 | 0.724 | 1.245 | 2.313 | 0.132 | 2.622 | 6.081 | 1.086 | 5.338 | 0.242 |

Table 2b Corrosion rate data for Al 4004 and Al-V in $H_2SO_4$ solution (0.00625 M to 0.1 M $H_2SO_4$ concentration)

| **Alloy** | **Al 4004** | | | | | **Al-V** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Electrolyte Conc. (M) / Exposure Time (h)** | **0.00625 M $H_2SO_4$** | **0.0125 M $H_2SO_4$** | **0.025 M $H_2SO_4$** | **0.05 M $H_2SO_4$** | **0.1 M $H_2SO_4$** | **0.00625 M $H_2SO_4$** | **0.0125 M $H_2SO_4$** | **0.025 M $H_2SO_4$** | **0.05 M $H_2SO_4$** | **0.1 M $H_2SO_4$** |
| 24 | 2.315 | 1.566 | 1.464 | 1.090 | 1.021 | 1.098 | 1.183 | -0.127 | -0.042 | 0.549 |
| 48 | 2.843 | 1.771 | 1.498 | 1.124 | 0.953 | 2.683 | 2.197 | -0.063 | -0.021 | 0.613 |
| 72 | 3.008 | 2.134 | 1.668 | 1.169 | 0.987 | 4.323 | 3.126 | -0.056 | -0.141 | 0.732 |
| 96 | 3.252 | 2.392 | 1.745 | 1.251 | 1.081 | 5.450 | 4.161 | -0.011 | -0.032 | 0.687 |
| 120 | 3.398 | 2.506 | 1.832 | 1.185 | 1.042 | 6.143 | 4.647 | -0.017 | -0.093 | 0.566 |
| 144 | 3.547 | 2.576 | 1.833 | 0.948 | 0.811 | 6.640 | 4.851 | -0.028 | -0.085 | 0.465 |
| 168 | 3.361 | 2.505 | 1.639 | 0.793 | 0.652 | 6.439 | 4.611 | -0.042 | -0.048 | 0.398 |
| 192 | 3.379 | 2.503 | 1.456 | 0.689 | 0.502 | 6.194 | 4.203 | -0.122 | -0.090 | 0.401 |
| 216 | 3.208 | 2.467 | 1.317 | 0.586 | 0.443 | 5.760 | 3.873 | -0.028 | -0.094 | 0.296 |
| 240 | 3.204 | 2.363 | 1.164 | 0.490 | 0.361 | 5.441 | 3.608 | -0.063 | -0.072 | 0.258 |
| 264 | 2.981 | 2.238 | 1.130 | 0.464 | 0.310 | 5.142 | 3.357 | -0.035 | -0.058 | 0.330 |
| 288 | 2.809 | 2.273 | 1.061 | 0.516 | 0.247 | 4.957 | 3.221 | -0.123 | -0.120 | 0.310 |
| 312 | 2.616 | 2.268 | 1.042 | 0.477 | 0.220 | 4.751 | 3.266 | -0.091 | -0.081 | 0.283 |
| 336 | 2.308 | 2.038 | 1.009 | 0.433 | 0.195 | 4.566 | 3.093 | -0.134 | -0.139 | 0.247 |
| 360 | 2.252 | 1.966 | 1.058 | 0.381 | 0.173 | 4.388 | 2.895 | -0.152 | -0.104 | 0.231 |
| 384 | 2.247 | 1.871 | 1.056 | 0.377 | 0.157 | 4.341 | 2.783 | -0.074 | -0.092 | 0.275 |
| 408 | 2.073 | 1.779 | 1.007 | 0.348 | 0.130 | 4.148 | 2.694 | -0.087 | -0.090 | 0.241 |
| 432 | 2.060 | 1.723 | 0.940 | 0.316 | 0.115 | 3.917 | 2.652 | -0.108 | -0.045 | 0.221 |
| 456 | 2.045 | 1.559 | 0.941 | 0.312 | 0.102 | 3.900 | 2.610 | -0.071 | -0.136 | 0.218 |
| 480 | 2.002 | 1.616 | 0.924 | 0.300 | 0.083 | 3.779 | 2.543 | -0.106 | -0.125 | 0.216 |

Table 3a Corrosion rate data for Al 4032 and Mg-Ti in NaCl solution (0.5% to 4.5% NaCl concentration)

| **Alloy** | **Al 4032** | | | | | **Mg-Ti** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Electrolyte Conc. (%) / Exp. Time (h)** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** |
| 24 | -0.204 | 1.425 | -1.764 | 0.068 | -1.696 | 0.072 | 0.144 | 0.505 | 0.216 | 0.072 |
| 48 | -0.339 | 0.305 | -1.357 | -0.305 | -0.695 | 0.144 | 0.252 | 0.325 | 0.144 | 0.289 |
| 72 | -0.373 | 0.124 | -0.667 | -0.407 | -0.792 | 0.120 | 0.265 | 0.265 | 0.192 | 0.289 |
| 96 | -0.390 | -0.068 | -0.670 | -0.339 | -0.806 | 0.126 | 0.234 | 0.216 | 0.216 | 0.343 |
| 120 | -0.373 | -0.068 | -0.617 | -0.380 | -0.773 | 0.173 | 0.202 | 0.188 | 0.202 | 0.534 |
| 144 | -0.300 | -0.232 | -0.639 | -0.413 | -0.712 | 0.180 | 0.180 | 0.180 | 0.180 | 0.565 |
| 168 | -0.330 | -0.291 | -0.693 | -0.393 | -0.649 | 0.299 | 0.165 | 0.175 | 0.196 | 0.639 |
| 192 | -0.271 | -0.250 | -0.560 | -0.428 | -0.632 | 0.379 | 0.162 | 0.117 | 0.171 | 0.794 |
| 216 | -0.234 | -0.283 | -0.433 | -0.324 | -0.580 | 0.409 | 0.160 | 0.128 | 0.192 | 0.818 |
| 240 | -0.282 | -0.322 | -0.495 | -0.326 | -0.594 | 0.447 | 0.180 | 0.137 | 0.173 | 0.952 |
| 264 | -0.253 | -0.148 | -0.463 | -0.305 | -0.595 | 0.479 | 0.210 | 0.144 | 0.230 | 0.984 |
| 288 | -0.283 | -0.139 | -0.435 | -0.314 | -0.633 | 0.493 | 0.204 | 0.222 | 0.234 | 0.938 |
| 312 | -0.297 | -0.224 | -0.407 | -0.318 | -0.551 | 0.505 | 0.200 | 0.244 | 0.266 | 0.943 |
| 336 | -0.237 | -0.194 | -0.385 | -0.305 | -0.480 | 0.505 | 0.211 | 0.278 | 0.237 | 0.902 |
| 360 | -0.317 | -0.183 | -0.351 | -0.301 | -0.475 | 0.510 | 0.289 | 0.289 | 0.192 | 0.875 |
| 384 | -0.273 | -0.201 | -0.377 | -0.276 | -0.509 | 0.500 | 0.320 | 0.275 | 0.185 | 0.848 |
| 408 | -0.221 | -0.158 | -0.345 | -0.251 | -0.451 | 0.475 | 0.310 | 0.255 | 0.187 | 0.844 |
| 432 | -0.256 | -0.224 | -0.362 | -0.256 | -0.477 | 0.461 | 0.313 | 0.256 | 0.168 | 0.810 |
| 456 | -0.202 | -0.182 | -0.362 | -0.246 | -0.421 | 0.501 | 0.323 | 0.243 | 0.171 | 0.790 |
| 480 | -0.200 | -0.141 | -0.319 | -0.243 | -0.458 | 0.493 | 0.332 | 0.234 | 0.180 | 0.794 |

Table 3b Corrosion rate data for Al 4004 and Al-V in NaCl solution (0.5% to 4.5% NaCl concentration)

| **Alloy** | **Al 4004** | | | | | **Al-V** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Electrolyte Conc. (%) / Exp. Time (h)** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** |
| 24 | -0.0004 | -0.0007 | -0.0011 | -0.0011 | -0.0012 | -0.084 | -0.296 | -1.310 | -0.972 | -1.183 |
| 48 | -0.0003 | -0.0005 | -0.0008 | -0.0010 | -0.0008 | -0.148 | -0.148 | -0.718 | -0.549 | -0.549 |
| 72 | -0.0003 | -0.0005 | -0.0007 | -0.0008 | -0.0007 | -0.084 | -0.070 | -0.408 | -0.338 | -0.394 |
| 96 | -0.0003 | -0.0006 | -0.0008 | -0.0009 | -0.0008 | -0.084 | -0.116 | -0.180 | -0.296 | -0.317 |
| 120 | -0.0003 | -0.0006 | -0.0008 | -0.0007 | -0.0009 | -0.084 | -0.101 | -0.237 | -0.262 | -0.287 |
| 144 | -0.0003 | -0.0005 | -0.0008 | -0.0007 | -0.0008 | -0.077 | -0.106 | -0.204 | -0.239 | -0.282 |
| 168 | -0.0003 | -0.0006 | -0.0008 | -0.0007 | -0.0008 | -0.060 | -0.151 | -0.205 | -0.223 | -0.247 |
| 192 | -0.0003 | -0.0006 | -0.0007 | -0.0007 | -0.0007 | -0.074 | -0.185 | -0.232 | -0.217 | -0.227 |
| 216 | -0.0004 | -0.0006 | -0.0007 | -0.0007 | -0.0007 | -0.056 | -0.117 | -0.141 | -0.221 | -0.221 |
| 240 | -0.0003 | -0.0006 | -0.0006 | -0.0007 | -0.0007 | -0.046 | -0.089 | -0.114 | -0.152 | -0.194 |
| 264 | -0.0003 | -0.0004 | -0.0006 | -0.0006 | -0.0007 | -0.054 | -0.123 | -0.181 | -0.181 | -0.181 |
| 288 | -0.0003 | -0.0004 | -0.0006 | -0.0005 | -0.0006 | -0.053 | -0.106 | -0.162 | -0.176 | -0.183 |
| 312 | -0.0003 | -0.0005 | -0.0005 | -0.0005 | -0.0006 | -0.052 | -0.120 | -0.143 | -0.182 | -0.162 |
| 336 | -0.0003 | -0.0004 | -0.0005 | -0.0005 | -0.0006 | -0.051 | -0.112 | -0.148 | -0.178 | -0.151 |
| 360 | -0.0003 | -0.0004 | -0.0004 | -0.0005 | -0.0005 | -0.051 | -0.141 | -0.135 | -0.169 | -0.175 |
| 384 | -0.0003 | -0.0003 | -0.0004 | -0.0005 | -0.0005 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | -0.0002 |
| 408 | -0.0003 | -0.0003 | -0.0005 | -0.0004 | -0.0006 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | -0.0002 |
| 432 | -0.0003 | -0.0004 | -0.0004 | -0.0004 | -0.0005 | 0.0000 | -0.0002 | -0.0002 | -0.0003 | -0.0003 |
| 456 | -0.0003 | -0.0004 | -0.0004 | -0.0004 | -0.0004 | 0.0000 | -0.0002 | -0.0003 | -0.0002 | -0.0003 |
| 480 | -0.0003 | -0.0004 | -0.0004 | -0.0004 | -0.0004 | -0.0001 | -0.0002 | -0.0002 | -0.0002 | -0.0004 |

Table 4a Corrosion rate data for Al 4032 and Mg-Ti in 0.00625 M $H_2SO_4$/NaCl solution at 0.5% to 4.5% NaCl concentration

| **Alloy** | **Al 4032** | | | | | **Mg-Ti** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Electrolyte Conc. (%) / Exposure Time (h)** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** |
| 24 | 3.664 | 1.798 | 0.136 | 2.748 | 3.257 | 5.771 | 33.906 | 1.082 | 84.115 | 8.657 |
| 48 | 1.374 | 0.187 | -0.119 | 0.424 | -0.509 | 3.246 | 15.727 | 3.102 | 42.166 | 3.823 |
| 72 | 0.780 | -0.464 | -0.961 | -0.242 | -1.040 | 2.260 | 10.484 | 2.308 | 28.327 | 2.140 |
| 96 | 0.288 | -0.602 | -1.196 | -0.645 | -1.119 | 1.641 | 6.240 | 1.984 | 21.263 | 1.461 |
| 120 | 0.047 | -0.787 | -1.337 | -0.624 | -1.024 | 1.385 | 4.660 | 1.688 | 17.039 | 0.880 |
| 144 | -0.034 | -0.780 | -1.108 | -0.661 | -1.040 | 1.347 | 3.763 | 1.527 | 14.296 | 0.890 |
| 168 | -0.097 | -0.727 | -1.110 | -0.974 | -1.270 | 1.329 | 3.215 | 1.422 | 12.800 | 0.690 |
| 192 | -0.059 | -0.810 | -1.060 | -0.954 | -1.153 | 3.805 | 4.049 | 1.380 | 11.371 | 0.622 |
| 216 | -0.049 | -0.675 | -1.014 | -0.859 | -1.138 | 3.831 | 5.242 | 1.258 | 10.172 | 0.778 |
| 240 | -0.010 | -0.821 | -0.970 | -0.868 | -1.082 | 3.679 | 5.338 | 1.198 | 9.191 | 0.592 |
| 264 | -0.015 | -0.608 | -0.962 | -0.830 | -1.184 | 3.430 | 5.456 | 1.895 | 8.552 | 0.334 |
| 288 | 0.011 | -0.678 | -0.958 | -0.789 | -1.004 | 4.076 | 5.032 | 1.088 | 7.935 | 0.361 |
| 312 | 0.089 | -0.595 | -0.832 | -0.827 | -0.898 | 3.840 | 7.331 | 1.038 | 7.403 | 0.372 |
| 336 | -0.005 | -0.446 | -0.729 | -0.722 | -0.819 | 2.700 | 6.276 | 1.051 | 6.951 | 0.381 |
| 360 | 0.041 | -0.423 | -0.737 | -0.780 | -0.975 | 2.939 | 6.065 | 1.010 | 6.536 | 0.245 |
| 384 | 0.064 | -0.380 | -0.820 | -0.617 | -0.799 | 2.913 | 5.690 | 1.096 | 6.195 | 0.325 |
| 408 | -0.022 | -0.337 | -0.613 | -0.563 | -0.790 | 2.796 | 5.258 | 1.103 | 5.958 | 0.373 |
| 432 | -0.034 | -0.334 | -0.720 | -0.607 | -0.940 | 2.741 | 5.182 | 1.106 | 5.807 | 0.269 |
| 456 | -0.030 | -0.368 | -0.757 | -0.618 | -0.703 | 2.673 | 6.925 | 1.097 | 5.536 | 0.247 |
| 480 | -0.126 | -0.433 | -0.645 | -0.616 | -0.868 | 2.622 | 6.586 | 1.086 | 5.338 | 0.242 |

Table 4b Corrosion rate data for Al 4004 and Al-V in 0.00625 M $H_2SO_4$/NaCl solution at 0.5% to 4.5% NaCl concentration

| **Alloy** | **Al 4004** | | | | | **Al-V** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Electrolyte Conc. (%) / Exposure Time (h)** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** |
| 24 | 1.668 | 1.021 | 1.771 | 0.306 | 2.417 | 0.591 | 0.211 | 0.422 | 0.127 | 0.380 |
| 48 | 1.379 | 0.715 | 0.749 | -0.579 | 0.868 | 0.465 | -0.042 | -0.084 | 0.106 | 0.359 |
| 72 | 0.874 | 0.386 | 0.125 | -0.772 | 0.284 | 0.422 | -0.099 | -0.141 | 0.113 | 0.338 |
| 96 | 0.417 | -0.077 | -0.553 | -0.962 | -0.613 | 0.359 | -0.074 | -0.127 | 0.127 | 0.306 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 120 | 0.211 | -0.306 | -0.674 | -0.906 | -0.681 | 0.355 | -0.051 | -0.118 | 0.118 | 0.313 |
| 144 | 0.113 | -0.301 | -0.732 | -0.914 | -0.755 | 0.331 | -0.056 | -0.127 | 0.113 | 0.303 |
| 168 | 0.015 | -0.433 | -0.822 | -0.890 | -0.939 | 0.290 | -0.042 | -0.115 | 0.121 | 0.278 |
| 192 | -0.051 | -0.451 | -0.749 | -0.924 | -1.004 | 0.253 | -0.048 | -0.121 | 0.132 | 0.264 |
| 216 | -0.079 | -0.416 | -0.768 | -0.968 | -0.980 | 0.263 | -0.038 | -0.122 | 0.127 | 0.253 |
| 240 | -0.119 | -0.463 | -0.725 | -0.916 | -0.940 | 0.237 | -0.034 | -0.123 | 0.127 | 0.258 |
| 264 | -0.127 | -0.566 | -0.870 | -0.891 | -0.929 | 0.215 | -0.035 | -0.127 | 0.127 | 0.250 |
| 288 | -0.179 | -0.565 | -0.817 | -0.826 | -0.996 | 0.229 | -0.035 | -0.109 | 0.134 | 0.218 |
| 312 | -0.217 | -0.636 | -0.867 | -0.786 | -1.011 | 0.218 | -0.052 | -0.104 | 0.130 | 0.198 |
| 336 | -0.207 | -0.613 | -0.737 | -0.817 | -0.941 | 0.190 | -0.051 | -0.103 | 0.136 | 0.205 |
| 360 | -0.241 | -0.590 | -0.626 | -0.747 | -1.024 | 0.180 | -0.051 | -0.101 | 0.130 | 0.180 |
| 384 | -0.257 | -0.509 | -0.604 | -0.689 | -0.968 | 0.172 | -0.050 | -0.087 | 0.127 | 0.180 |
| 408 | -0.270 | -0.483 | -0.575 | -0.691 | -0.939 | 0.154 | -0.045 | -0.092 | 0.117 | 0.169 |
| 432 | -0.305 | -0.613 | -0.673 | -0.757 | -0.914 | 0.129 | -0.033 | -0.082 | 0.108 | 0.143 |
| 456 | -0.281 | -0.556 | -0.679 | -0.726 | -0.875 | 0.116 | -0.051 | -0.080 | 0.076 | 0.116 |
| 480 | -0.298 | -0.473 | -0.707 | -0.667 | -0.868 | 0.049 | -0.068 | -0.063 | 0.059 | 0.061 |

### 3.2 Statistical analysis

ANOVA statistical method was applied to evaluate the statistical importance of electrolyte concentration and exposure time on the corrosion resistance of Al 4032, Mg-Ti, Al 4004 and Al-V. The ANOVA results are shown in Table 5a, 5b and 5c. Table 5a shows the ANOVA results for Al 4032, Mg-Ti, Al 4004 and Al-V alloys from $H_2SO_4$ solution. Table 5b shows the corresponding results from NaCl solution while Table 5c shows the results from $H_2SO_4$/NaCl solution. The statistical significance factor represents the numerical significance of electrolyte concentration and exposure time on the corrosion resistance of the alloys. The theoretical significance factor depicts the mathematical value wherewith the mean square ratio must be higher than, in order for the statistical significance factor to be relevant. The mean square ratios of the electrolyte concentration and exposure time for Al 4032, Al 4004 and Al-V alloys in NaCl solution (Table 5b) are lower than the theoretical significance factor. Hence both sources of variation are statistically irrelevant with regards to influence on the corrosion resistance of the alloys. However, electrolyte concentration is statistically relevant for Mg-Ti in NaCl solution with statistical relevance factor of 96.94%. In $H_2SO_4$ solution, electrolyte concentration is the only statistically relevant source of variation influencing the corrosion resistance of the four alloys with values of 97.63%, 97.66%, 94.96% and 98.38%. Similar trend was observed in Table 3c where the electrolyte concentration significantly responsible (on statistical basis) for the corrosion resistance behaviour of the four alloys with corresponding values of 90.02%, 94.35%, 92.48% and 90.62%. The ANOVA results shows that electrolyte concentration significantly influences the corrosion resistance of the alloy studied compared to exposure time.

Table 5a ANOVA data for corrosion resistance of Al 4032, Mg-Ti, Al 4004 and Al-V alloys from $H_2SO_4$ solution

| **Al 4032** | | | | **Mg-Ti** | | | |
|---|---|---|---|---|---|---|---|
| **Source of Variation** | **Mean Square Ratio (F)** | **Theoretical Significance Factor** | **Statistical Relevance Factor, F (%)** | **Source of Variation** | **Mean Square Ratio (F)** | **Theoretical Significance Factor** | **Statistical Relevance Factor, F (%)** |
| Electrolyte Concentration | 8.58 | 2.63 | 97.63 | Electrolyte Concentration | 9.51 | 2.63 | 97.66 |
| Exposure Time | -3.91 | 2.15 | -100.01 | Exposure Time | -3.90 | 2.15 | -90.05 |
| **Al 4004** | | | | **Al-V** | | | |
| **Source of Variation** | **Mean Square Ratio (F)** | **Theoretical Significance Factor** | **Statistical Significance Factor, F (%)** | **Source of Variation** | **Mean Square Ratio (F)** | **Theoretical Significance Factor** | **Statistical Significance Factor, F (%)** |
| Electrolyte Concentration | 9.11 | 2.63 | 94.96 | Electrolyte Concentration | 27.12 | 2.63 | 98.38 |
| Exposure Time | -3.79 | 2.15 | -88.82 | Exposure Time | -3.80 | 2.15 | -31.03 |

Table 5b ANOVA data for corrosion resistance of Al 4032, Mg-Ti, Al 4004 and Al-V alloys from NaCl solution

| **Al 4032** | | | | **Mg-Ti** | | | |
|---|---|---|---|---|---|---|---|
| **Source of Variation** | **Mean Square Ratio (F)** | **Theoretical Significance Factor** | **Statistical Significance Factor, F (%)** | **Source of Variation** | **Mean Square Ratio (F)** | **Theoretical Significance Factor** | **Statistical Significance Factor, F (%)** |
| Electrolyte Concentration | 2.18 | 2.63 | 87.63 | Electrolyte Concentration | 6.27 | 2.63 | 96.94 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Exposure Time | -3.86 | 2.15 | -350.14 | Exposure Time | -3.91 | 2.15 | -136.09 |
| **Al 4004** | | | | **Al-V** | | | |
| **Source of Variation** | **Mean Square Ratio (F)** | **Theoretical Significance Factor** | **Statistical Significance Factor, F (%)** | **Source of Variation** | **Mean Square Ratio (F)** | **Theoretical Significance Factor** | **Statistical Significance Factor, F (%)** |
| Electrolyte Concentration | 0.63 | 2.63 | 61.07 | Electrolyte Concentration | 0.923 | 2.63 | 9.31 |
| Exposure Time | -3.84 | 2.15 | -843.32 | Exposure Time | -0.004 | 2.15 | -0.09 |

Table 5c ANOVA data for corrosion resistance of Al 4032, Mg-Ti, Al 4004 and Al-V alloys from $H_2SO_4$/NaCl solution

| **Al 4032** | | | | **Mg-Ti** | | | |
|---|---|---|---|---|---|---|---|
| **Source of Variation** | **Mean Square Ratio (F)** | **Theoretical Significance Factor** | **Statistical Relevance Factor, F (%)** | **Source of Variation** | **Mean Square Ratio (F)** | **Theoretical Significance Factor** | **Statistical Relevance Factor, F (%)** |
| Electrolyte Concentration | 5.34 | 2.63 | 90.02 | Electrolyte Concentration | 9.19 | 2.63 | 94.35 |
| Exposure Time | -3.74 | 2.15 | -141.83 | Exposure Time | -3.76 | 2.15 | -86.76 |
| **Al 4004** | | | | **Al-V** | | | |
| **Source of Variation** | **Mean Square Ratio (F)** | **Theoretical Significance Factor** | **Statistical Relevance Factor, F (%)** | **Source of Variation** | **Mean Square Ratio (F)** | **Theoretical Significance Factor** | **Statistical Relevance Factor, F (%)** |
| Electrolyte Concentration | 2.40 | 2.63 | 92.48 | Electrolyte Concentration | 38.12 | 2.63 | 90.62 |
| Exposure Time | -3.91 | 2.15 | -339.47 | Exposure Time | -2.25 | 2.15 | -12.02 |

### 3.3 Standard deviation, mean and margin of error

Results for standard deviation (SD), mean data values and margin of error for Al 4032, Mg-Ti, Al 4004 and Al-V alloys from $H_2SO_4$, NaCl and $H_2SO_4$/NaCl solution are shown in Table 6a, 6b and 6c. The highest mean values for Al 4032, Mg-Ti, Al 4004 and Al-V alloys occurred at 0.05 M, 0.0125 M and 0.00625 M $H_2SO_4$ solutions. This indicates the highest mean deterioration of the alloys with respect to $H_2SO_4$ concentration and corrosion rate values. Table 6a also shows that Mg-Ti exhibits the highest mean corrosion rate values (5.93) at 0.0125 M $H_2SO_4$ concentration while Al-V exhibits the lowest values (-0.10) at 0.025 M and 0.05 M $H_2SO_4$ solution. However, the mean data values exhibited by Al 4004 (0.00234, 0.00194, 0.00101, 0.0003 and 0.00017) depicts generally higher corrosion resistance and thermodynamic stability of the alloy surface compared to the corresponding values for the other alloys. The SD values in Table 6a shows the extent of variation of the corrosion rate values from mean data values in $H_2SO_4$ solution. Al 4032, Al 4004 and Al-V alloys generally exhibit low SD values indicating minimal variation of the corrosion rate results from the mean value during the exposure hours. It indicates thermodynamic stability of the alloy surfaces during interaction with the corrosive species. This observation excludes Mg-Ti whose SD values are relatively high. The proportion of Al 4032 corrosion rate below 1 mm/y is 60% compared to 20% for Mg-Ti and 100% for Al 4004 and Al-V alloys. In Table 6b, the mean corrosion rate values for Al 4032, Al 4004 and Al-V alloys are significantly below 0, among which Al 4004 alloy exhibits the lowest values. The shows generally strong corrosion resistance of the alloys in NaCl solution at all concentrations. However, this observation excludes Mg-Ti alloy whose mean data values are greater than 0 but relatively low. Generally, the SD values in Table 6b are significantly low, although Al 4004 depicts the lowest values. The proportion of data for all the alloys exhibiting values below 1 mm/y for the alloys in NaCl is 100%. In Table 6c, the mean data values for Mg-Ti is significantly greater than 1 at all concentrations excluding 4.5% NaCl concentration. This contrast the values obtained for the other alloys indicating relatively lower corrosion resistance for Mg-Ti. Similar to the SD values earlier discussed, the SD values for the alloys in $H_2SO_4$/NaCl solution are generally low indication stability of the surface properties of the alloys during 480 h of exposure. The proportion of data for Al 4032, Al 4004 and Al-V alloys with corrosion rate below 1 mm/y is 100%. This contrast the corresponding values for Mg-Ti at 11%.

Table 6a Data for standard deviation, mean and margin of error for Al 4032, Mg-Ti, Al 4004 and Al-V alloys in $H_2SO_4$ solution

| **Al 4032** | | | | | |
|---|---|---|---|---|---|
| **Concentration (%)** | **0.00625M $H_2SO_4$** | **0.0125M $H_2SO_4$** | **0.025M $H_2SO_4$** | **0.05M $H_2SO_4$** | **0.1M $H_2SO_4$** |
| **SD** | 0.18 | 0.11 | 0.18 | 0.099 | 0.13 |
| **Mean** | 0.40 | 0.89 | 1.57 | 2.45 | 0.36 |
| **Margin of Error** | 13.58% | | **Data below 1 mm/y** | 60% | |
| **Mg-Ti** | | | | | |

| Concentration (%) | 0.00625M $H_2SO_4$ | 0.0125M $H_2SO_4$ | 0.025M $H_2SO_4$ | 0.05M $H_2SO_4$ | 0.1M $H_2SO_4$ |
|---|---|---|---|---|---|
| **SD** | 0.32 | 0.40 | 0.06 | 0.62 | 0.06 |
| **Mean** | 2.54 | 5.93 | 1.09 | 5.22 | 0.31 |
| **Margin of Error** | 11% | | **Data below 1 mm/y** | 20% | |
| **Al 4004** | | | | | |
| **Concentration (%)** | **0.00625M $H_2SO_4$** | **0.0125M $H_2SO_4$** | **0.025M $H_2SO_4$** | **0.05M $H_2SO_4$** | **0.1M $H_2SO_4$** |
| **SD** | 0.00035 | 0.00027 | 0.000088 | 0.000088 | 0.000067 |
| **Mean** | 0.00234 | 0.00194 | 0.00101 | 0.00039 | 0.00017 |
| **Margin of Error** | 0.00% | | **Data below 1 mm/y** | 100% | |
| **Al-V** | | | | | |
| **Concentration (%)** | **0.00625M $H_2SO_4$** | **0.0125M $H_2SO_4$** | **0.025M $H_2SO_4$** | **0.05M $H_2SO_4$** | **0.1M $H_2SO_4$** |
| **SD** | 0.47 | 0.30 | 0.03 | 0.03 | 0.04 |
| **Mean** | 4.39 | 2.91 | -0.10 | -0.10 | 0.26 |
| **Margin of Error** | 14% | | **Data below 1 mm/y** | 100% | |

Table 6b Data for standard deviation, mean and margin of error for Al 4032, Mg-Ti, Al 4004 and Al-V alloys in NaCl solution

| **Al 4032** | | | | | |
|---|---|---|---|---|---|
| **Concentration (%)** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** |
| **SD** | 0.04 | 0.03 | 0.04 | 0.03 | 0.07 |
| **Mean** | -0.25 | -0.18 | -0.38 | -0.28 | -0.51 |
| **Margin of Error** | 0.00% | | **Data below 1 mm/y** | 100% | |
| **Mg-Ti** | | | | | |
| **Concentration (%)** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** |
| **SD** | 0.02 | 0.06 | 0.04 | 0.03 | 0.07 |
| **Mean** | 0.49 | 0.27 | 0.24 | 0.21 | 0.87 |
| **Margin of Error** | 0% | | **Data below 1 mm/y** | 100% | |
| **Al 4004** | | | | | |
| **Concentration (%)** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** |
| **SD** | 0.00 | 0.000412 | 0.00009 | 0.000075 | 0.000105 |
| **Mean** | -0.0003 | -0.00039 | -0.00047 | -0.00047 | -0.00054 |
| **Margin of Error** | 0% | | **Data below 1 mm/y** | 100% | |
| **Al-V** | | | | | |
| **Concentration (%)** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** |
| **SD** | 0.03 | 0.06 | 0.08 | 0.09 | 0.09 |
| **Mean** | -0.03 | -0.06 | -0.08 | -0.09 | -0.09 |
| **Margin of Error** | 0% | | **Data below 1 mm/y** | 100% | |

Table 6c Data for standard deviation, mean and margin of error for Al 4032, Mg-Ti, Al 4004 and Al-V alloys in $H_2SO_4$/NaCl solution

| **Al 4032** | | | | | |
|---|---|---|---|---|---|
| **Concentration (%)** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** |
| **SD** | 0.06 | 0.12 | 0.12 | 0.10 | 0.14 |
| **Mean** | -0.003 | -0.46 | -0.78 | -0.70 | -0.90 |
| **Margin of Error** | 0% | | **Data below 1 mm/y** | 100% | |
| **Mg-Ti** | | | | | |
| **Concentration (%)** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** |
| **SD** | 0.52 | 0.79 | 0.26 | 1.07 | 0.06 |

| | | | | | |
|---|---|---|---|---|---|
| **Mean** | 3.07 | 5.98 | 1.16 | 6.62 | 0.31 |
| **Margin of Error** | 0% | | **Data below 1 mm/y** | 11% | |
| **Al 4004** | | | | | |
| **Concentration (%)** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** |
| **SD** | 0.06 | 0.06 | 0.11 | 0.07 | 0.05 |
| **Mean** | -0.238 | -0.560 | -0.716 | -0.760 | -0.947 |
| **Margin of Error** | 0% | | **Data below 1 mm/y** | 100% | |
| **Al-V** | | | | | |
| **Concentration (%)** | **0.5% NaCl** | **1.5% NaCl** | **2.5% NaCl** | **3.5% NaCl** | **4.5% NaCl** |
| **SD** | 0.06 | 0.01 | 0.09 | 0.03 | 0.05 |
| **Mean** | 0.17 | -0.05 | -0.09 | 0.11 | 0.17 |
| **Margin of Error** | 0% | | **Data below 1 mm/y** | 100% | |

## Conclusion

Al 4032, Mg-Ti, Al 4004 and Al-V alloys were studied in $H_2SO_4$, NaCl and $H_2SO_4$/NaCl solution. The alloys generally exhibited low corrosion rate values, signifying good applicability in such environments. However, Mg-Ti proves to be the most vulnerable alloy to corrosion, exhibiting the higest corrosion rate values in all the electrolytes. Al 4004 alloy displays the lowest corrosion rate values, signifying its high resistance to corrosion. The alloys were generally stable after about 120 h of exposure with not significant increase or decrease in corrosion rate signifying thermodynamic stability during the exposure hours. Data from ANOVA statistical method showed that the source of variation for Al 4032, Al 4004 and Al-V alloys in NaCl solution are indeterminate statistically compared to Mg-Ti where electrolyte concentration is statistically relevant and strongly influences the corrosion behaviour of the alloy. Similar observation occurred in $H_2SO_4$ and $H_2SO_4$/NaCl solution where electrolyte concentration represents the only statistically relevant variation influencing the corrosion resistance of the alloys. Generally, the alloys exhibit low SD values in the electrolytes due to limited variation of corrosion rate values from mean values.

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