

# VOLTAGE NOISE MEASUREMENTS DURING STAINING OF 6061 ALUMINIUM ALLOY EXPOSED TO HUMID ATMOSPHERES

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Electrochemical noise generation during staining of 6061 aluminium alloy exposed to 60 to 100% RH at 323 K has been measured. The noise power values ( $\nabla^2$ ) were obtained from the auto correlation of voltage time data. On exposure of aluminium alloy to 80 to 100% RH, considerable staining have been observed. During staining the noise power values were found to increase from  $10^{-6}$  ( $\nabla^2$ ) to  $10^{-4}$  ( $\nabla^2$ ) and a considerable weight gain was also observed. However, on exposure of aluminium alloy to 60% RH no staining was observed and the noise power value remained around  $10^{-8}$  ( $\nabla^2$ ). After passivation treatment of aluminium alloy in 50%  $\text{HNO}_3$  or with chromate treatment the noise power values remained at a low level of  $10^{-8}$  ( $\nabla^2$ ) till the protective power of the coating remained unaffected.

Keyword: Noise measurement and staining aluminium

## INTRODUCTION

Aluminium and its alloys undergo black to grey staining when exposed to humid atmosphere due to condensation of moisture or rain on the surfaces [1-3]. The degree of staining does not depend on the composition of water and the staining rate is mainly controlled by the rate of diffusion of oxygen into the thin film of water condensed [4]. The stained area is mostly bayerite ( $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ ) with the thickness of 2500-5000 Å [1]. Of all the aluminium alloys aluminium-magnesium alloys are highly susceptible to water staining due to formation of magnesium oxide film [5].

The electrochemical noise analysis has been applied widely for studying pitting corrosion of aluminium [6-8], protection of conversion coating on aluminium in chloride media [9], stress corrosion cracking [10] and evaluation of inhibitors [11,12].

In the present work, the electrochemical noise generated during staining of AA 6061 aluminium alloy exposed to humid atmospheres has been studied. In addition, the performance of passivation treatment and chromate conversion treatment for the control of staining of AA 6061 aluminium alloy has also been evaluated by noise method.

## EXPERIMENTAL

The aluminium alloy AA 6061 specimens were cut from the sheet and cleaned in 4% NaOH solution. For noise measurement two identical electrodes of 5 mm x 5 mm size were stacked together with a teflon tape insulator in between the two electrodes and exposed to 60%, 80% and 100% RH at 323 K. The voltage fluctuations of the two electrodes and the autocorrelation function were measured in the bandwidth of 20 mHz to 1 Hz using signal processor (1200 Soartron, UK). The noise power values, were obtained from the auto correlation function at time  $t = 0$ .

The passivation treatment was carried out by immersing the 6061 aluminium alloy specimens in 50%  $\text{HNO}_3$  for 1 hour and the chromate conversion coating was obtained from the following bath.

Chromic acid	...	4 gpl
Sodium chromate	...	3.5 gpl
Sodium fluoride	...	0.8 gpl
Treatment time	...	10 min.
Operating temperature	...	291 K

The performance of these treatments was studied in 100% RH at 323 K.

Weight gain measurements were made by using the specimens of size 2 cm x 5 cm by exposing to moist atmosphere for a period of 120 hours. The required RH was obtained from the glycerol-water mixture.

### RESULTS

The variation of noise power values ( $\nabla^2$ ) during staining of 6061 aluminium alloy exposed to 60, 80 and 100% RH with time is shown in Fig. 1. Due to increase in staining rate when aluminium is exposed to 80% and 100% RH, the noise power values tend to increase from  $10^{-6}$  ( $\nabla^2$ ) to  $10^{-4}$  ( $\nabla^2$ ) with time. The rate of staining in these relative humidities are 8.0 mg/sq.dm/day and 10.9 mg/sq.dm/day. However on exposure of AA 6061 at 60% RH, the noise power values remained in the range of  $10^{-2}$  ( $\nabla^2$ ) and no staining was observed. In this case the rate of staining has been found to be 6.2 mg/sq.cm/day.

The performance of passivation treatment and chromate conversion coating of 6061 aluminium alloy towards staining has been evaluated by measuring the noise power values on exposure to 100% RH at 323 K. The magnitude of the

variation of noise power is shown in Fig. 2. In the case of passivated aluminium alloy, the noise power values remained at the level of  $10^{-8}$  ( $\nabla^2$ ) for about 2 days and then found to be increased to  $10^{-6}$  ( $\nabla^2$ ) due to initiation of staining. The rate of staining was 10.9 mg/sq.dm/day.

However in the case of chromate conversion coated 6061 aluminium alloy, the noise power values remained at  $10^{-8}$  ( $\nabla^2$ ) for the duration of the study and was free from staining. The weight gain was found to be negligible.

### DISCUSSION

On exposure of aluminium and its alloys to humid atmosphere, black or brown staining takes place due to the formation of thick bayerite film. The black appearance of such film is attributed to the entrapment of unoxidized aluminium ions in the film [13]. In such cases, due to the movement of the aluminium ions through the film during staining an increase noise power. But due to this fact, on exposure of 6061 aluminium alloy to 80% and 100% RH, there is an increase of noise power by 100 times with time. However on exposure of 6061 alloy at 60% RH oxidation of

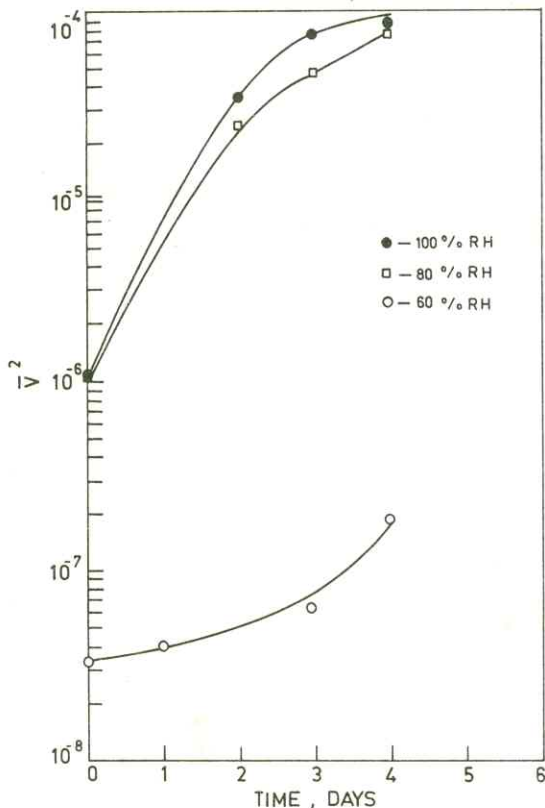


Fig. 1: Variation of noise power with time for 6061 aluminium alloy exposed to different humidities at 323 K

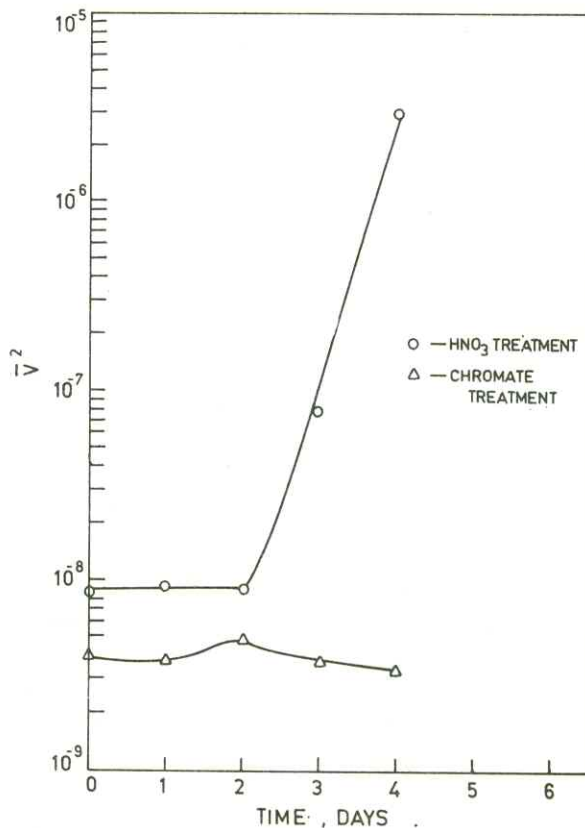


Fig. 2: Variation of noise power with time for treated 6061 aluminium alloy exposed to 100% RH at 323 K

aluminium does not take place and hence, the noise power values remained at a low level. This is also evident from the weight gain data of 6061 aluminium alloy exposed to 60% RH.

The noise power values for passivated aluminium and chromate conversion coated aluminium are found to be less than  $10^{-8}$  ( $\nabla^2$ ) due to oxidation of aluminium by these films. However, in the case of passivated aluminium, the noise power values tend to increase after two days exposure at 100% RH due to rupture of the film and further oxidation of aluminium. This fact is also supported by the visual inspection that the black stain formation has been observed in the case of passivated 6061 alloy after two days exposure. Since the chromate film on aluminium protects it from the formation of black stains, the noise power values remained at very low values.

### CONCLUSION

Staining of 6061 aluminium alloy takes place when they are exposed to higher humidities. During staining, the noise power values increase by 100 times. Passivation treatment by nitric acid prevents staining of 6061 aluminium alloy initially. Chromate conversion coating prevents from staining of 6061 aluminium alloy. The effectiveness of the treatments can be monitored by noise power measurements.

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