

## **Performance Evaluation of Zinc Deposited Mild Steel in Chloride Medium.**

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The effect of deposited mild steel under plating variable influence was investigated in a chloride medium. The results showed homogeneous layer with improved surface adhesion after deposition. The distance between the anode and the cathode on voltage, plating time and coating thickness were observed. The mild steel was deposited into solution of zinc bath for varying voltage between 0.6 v and 1.0v. It was discovered that the sample plated at 1.0v for 15 minutes gives the best plating surface finish. Analytical study using potentiostat/galvanostat, focused ion beam scanning electron microscopy (FIB-SEM), XRD and AFM were used to determine the surface characterization, topography and corrosion evaluation of the substrate.

**Keywords:** Performance evaluation, deposition, parameter

### **1. INTRODUCTION**

The impact of corrosion on a system is mostly a surface phenomenon. One of the key factors in any corrosion situation is the medium. This has found a wider influence on material strength and performance behavior. Environment is a variable that can change with time and conditions, it affects a metal corresponds to the microenvironmental conditions. (1-2)

However, chloride solutions are of high application in industry and most manufacturing sector, for cleaning agent and other medical function. Due to aggrieved strength of chloride application, electrodeposited metal were made to withstand and reduce this environmental hazard (2-3). Zinc coatings are considered as one of the main methods used for the corrosion protection of steel (3-8). The usage in industrial sectors as a protective coating for large quantities of products and other fabricated ferrous metal parts are enormous. Acid zinc bath are used where it is desirable to have a high plating rate with maximum current efficiency and good deposition depends mainly on the nature

of bath constituents, the substrate surface, and time of plating (5-8). In this investigation, performance studies of the deposited steel under voltage influence are look into. SEM, AFM and XRD were employed for this surface characterization and corrosion examination.

## 2. EXPERIMENTAL METHOD

The chemicals used were of AR grade and easily soluble in water. For preparation of the solutions, distilled water was used. Surface preparation was done on the polishing machine with different grades of emery paper. The pickling of the samples was done in diluted H<sub>2</sub>SO<sub>4</sub> acid solution; this was to remove all organic contaminants and oxides. The substrate was electrolytic degreased with alkaline solution by passing current into the solution for about 5 minutes and subsequent cleaning in water, to remove all grease or oily contaminants. Mild steel substrate of dimension 1x3x0.2cm was analyzed and used for this investigation using energy dispersion spectrometer as showed in figure 1 below.

**Figure 1.** Percentage spectrometres analyses of mild steel substrat as receive.

Element	% Content						
P	0.0066	Fe	99.4	A	10.125	B	0.0009
Zn	0.022	Co	0.0057	Si	0.028	S	0.018
As	0.0059	Ti	0.001	Mn	0.397	Nb	0.0046
Zr	0.0016	Pb	< 0.0020	Ni	0.025	V	0.0075
La	0.0018	Mg	0.002	Mo	< 0.0020	Bi	0.0024
Cr	0.0075	W	< 0.010	Ce	< 0.0040	Ca	0.017
C	0.131	Cu	0.035	Sn	< 0.001		

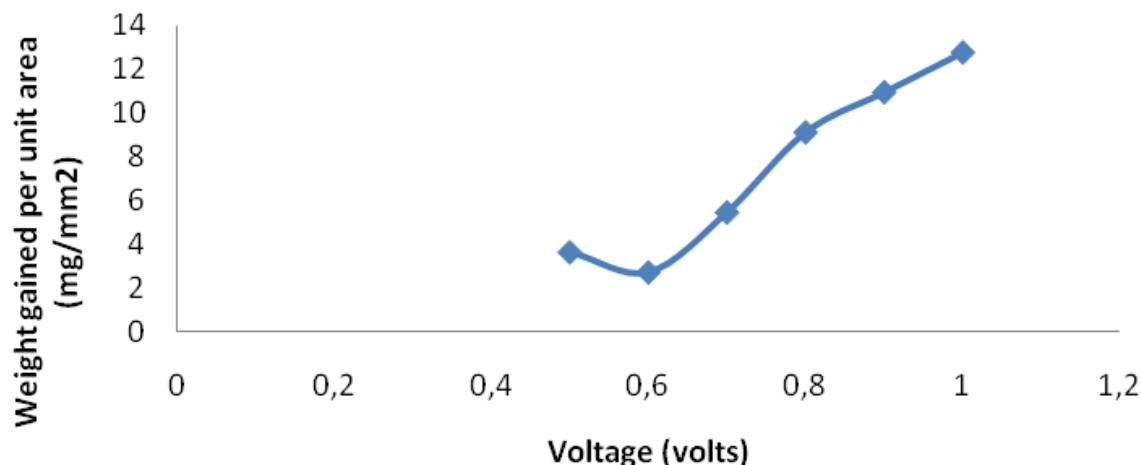
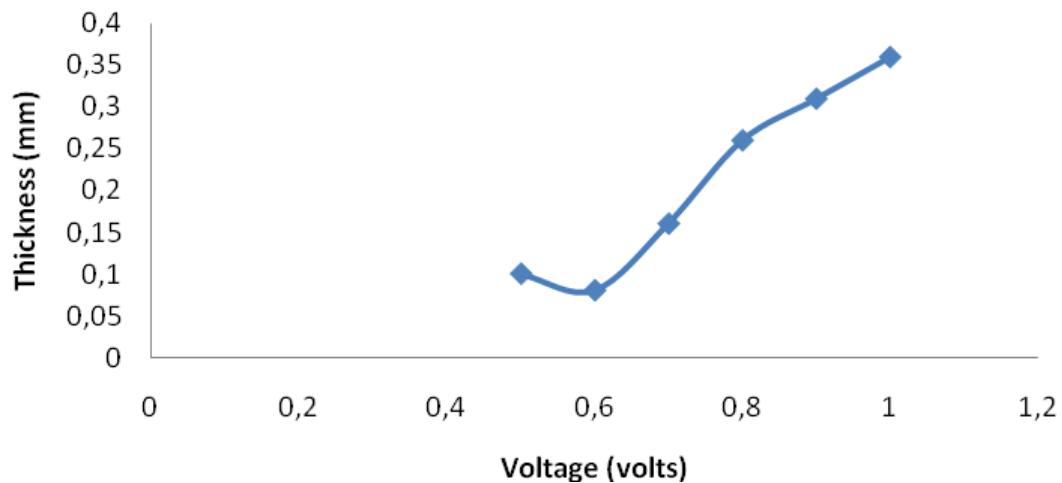
Electrolytically degreased metal substrate was immersed in a solution of dissolved zinc salts and made the cathode by connecting it to the negative terminal of the rectifier of the electroplating bath. The anode was also immersed and connected to the positive terminal of the rectifier. The anode was made of pure Zinc rod about 99.98%. The following plating parameters were varied, the voltage between the 0.6V and 1.0V. The substrates were plated at time variation of 10 to 35 minutes. Finally, the samples were rinsed and air dried.

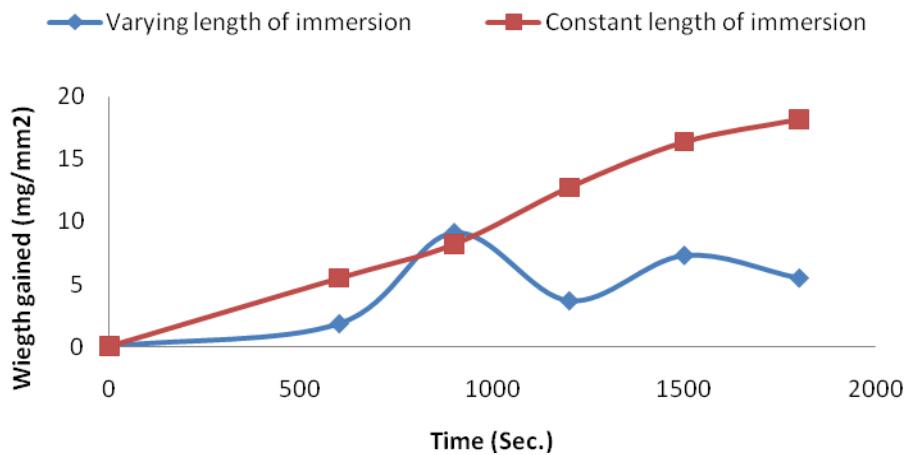
## 3. RESULTS AND DISCUSSION

The performance evaluation of zinc deposited mild steel was critically study by cyclic voltmetric method through a 273 powered potentiostat/galvanostat in sodium chloride medium. The result obtained for the two deposited metal at 0.6 and 1.0V are obtained in table 2.

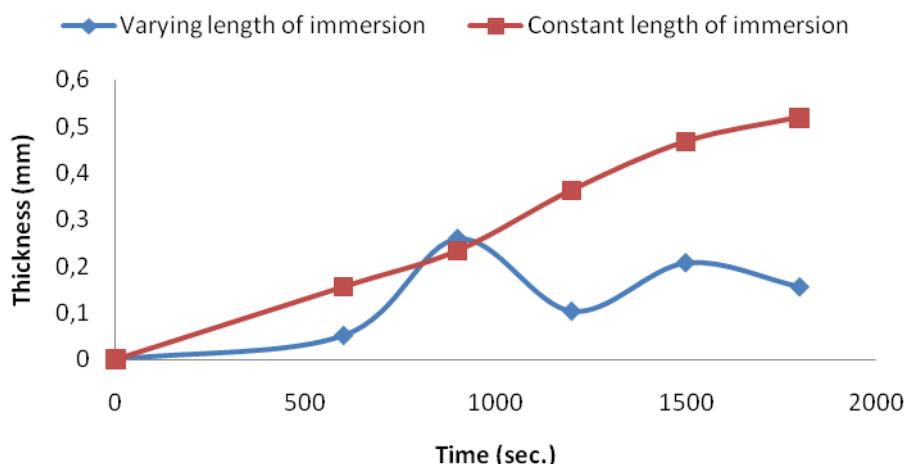
**Table 2.** The corrosion analysis of Zn under different voltage.

Sample	Icorr (A)	Icorr A/Cm <sup>2</sup>	Corr rate mm/yr	Ecorr abs	Ecorr cal
0.6	3.524E-4	1.172E-2	9.902E+1	-1.032	-1.033
1.0	2.886E-5	1.423E-4	8.346E+1	-0.630	-0.733

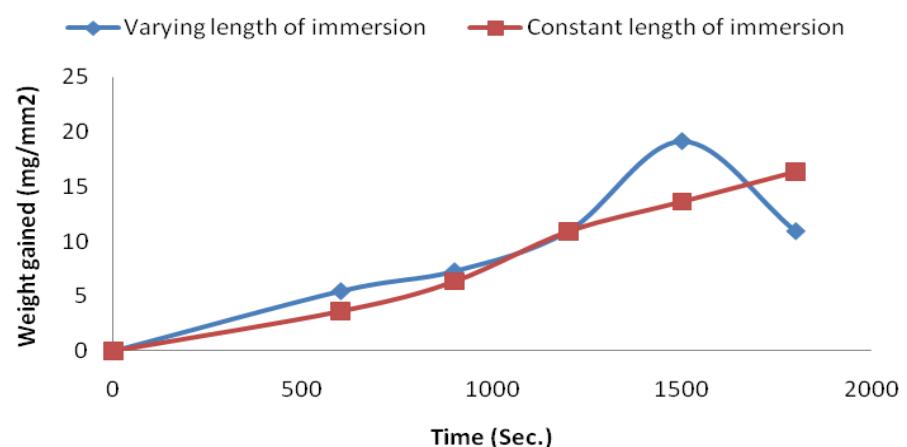
**3.1. Plating Parameter Evaluations****Figure 1.** Plot showing weight (mg/mm<sup>2</sup>) of zinc electrodeposited on low carbon steel against voltage (volts) at 10 min. and distance 10cm from the anode**Figure 2.** Plot showing the thickness (mm) of zinc electrodeposited on low carbon steel against voltage (volts) at 10 min. and distance 10cm from the anode



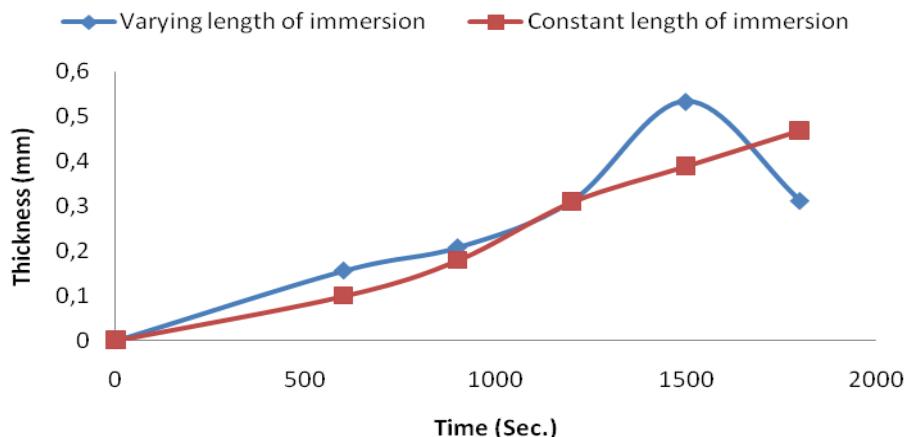
**Figure 3.** Plot showing the weight ( $\text{mg}/\text{mm}^2$ ) of zinc plated on carbon steel gained per time (sec.) at cathode to anode distance of 10 cm



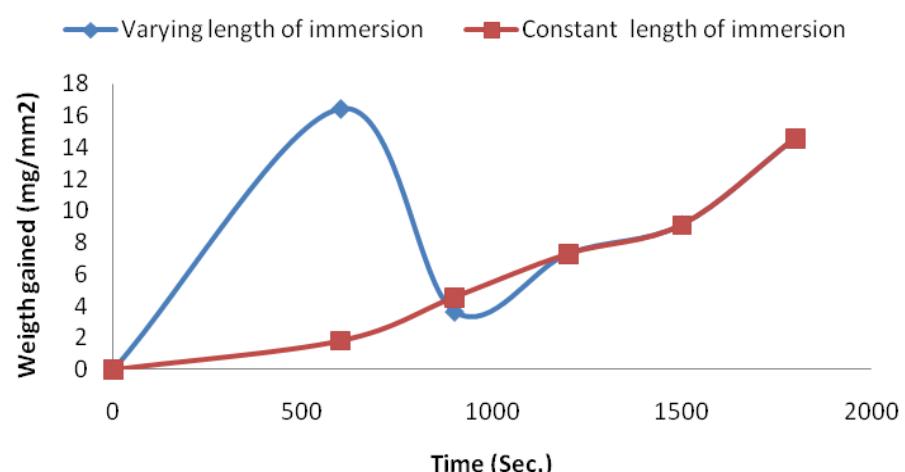
**Figure 4.** Plot showing the thickness (mm) of zinc plated on carbon steel per time (sec.) at cathode to anode distance of 10 cm



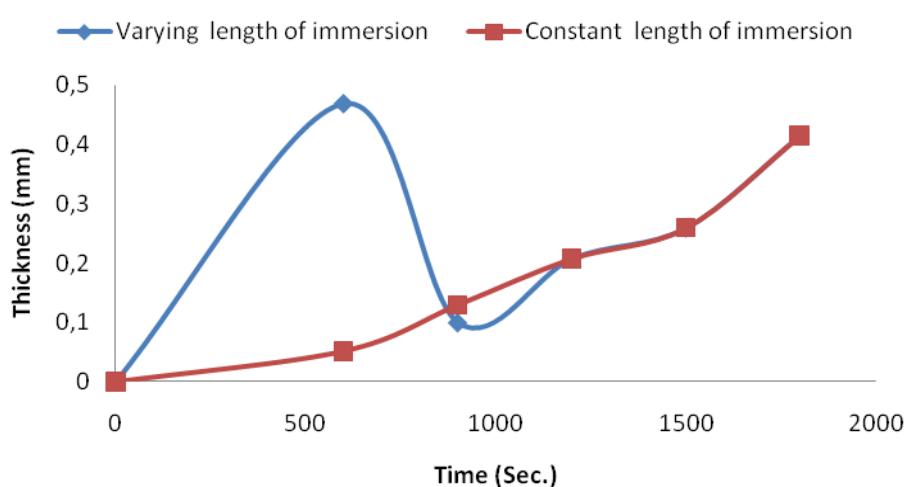
**Figure 5.** Plot showing the weight ( $\text{mg}/\text{mm}^2$ ) of zinc plated on carbon steel gained per time (sec.) at cathode to anode distance of 20 cm



**Figure 6.** Plot showing the thickness (mm) of zinc plated on carbon steel per time (sec.) at cathode to anode distance of 20 cm



**Figure 7.** Plot showing the weight (mg/mm<sup>2</sup>) of zinc plated on carbon steel gained per time (sec.) at cathode to anode distance of 30 cm



**Figure 8.** Plot showing the thickness (mm) of zinc plated on carbon steel per time (sec.) at cathode to anode distance of 30 cm

### 3.2. Electrochemical Study

The performance evaluation of Zn deposition on mild steel in 3.65 mol dm<sup>-3</sup> NaCl solutions in Table 2 shows the relative effectiveness of each substrate at 0.6 and 1.0V. It can be said that the corrosion activity of substrate at 10V has a better surface adhesion owing to the fact that the influence of the environment was limited on the behavioral view of the deposited metal in a chloride environment compare to the former. From critical observation bright and compact Zn layer was maintained after the test at 10V which represents higher life time than the porous Zn coating obtained at 0.6V. Critical look from cyclic volt metric curve in fig. 12, suggests that the better corrosion resistance of the Zn coatings from the bath is due to the presence of increase voltage, which leads to an ennoblement of the coating. Monitoring of the *E* proved to be a suitable measurement to assess the various stages of dissolution showing the evolution of the *E* with immersion time for the electrodeposited Zn coatings immersed in aerated 3.65 mol dm<sup>-3</sup> NaCl at room temperature.

### 3.3. Influence of voltage variation on weight gained

Critical look at figure 1-3 shows general increase in weight gained as the voltage increases. For the voltage range between 0.6V and 1.0V full surface adhesion was not obtained which was due to low voltage applied. The 1.0V was chosen at the best plating voltage, this is due to the fact that the 1.0V presents the best physical properties and good surface homogeneity. The appearance of the substrate became dull and deposition poor due to patchy films of coat on the surface of the steel sample at 1.0V.

### 3.4. Influence of plating time on weight gained

Figures 3, 4 and 5 show the relationship between the weights gained, thickness and voltage on time of plating for 10cm, 20cm, and 30cm, distance of object from the anode. For constant depth of immersion and varying distance values, weight gained increases as the plating time increase. Figures 6, 7 and 8 also show the same phenomenon for the thickness of coat film.

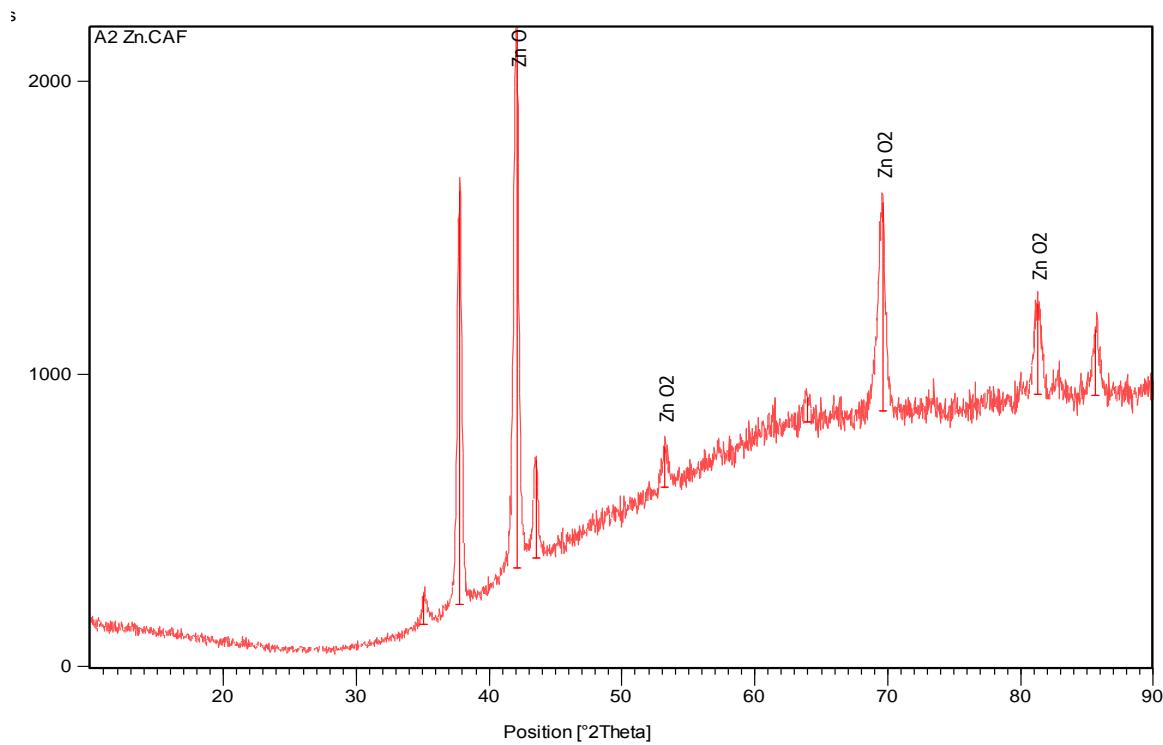
### 3.5. XRD Analysis

XRD diffraction patterns obtained on the electrodeposits in 0.6V and 1.0V are given in Fig. 9a and 9b, hence, at 6V and 1.0V. Zinc phase was seen at different peak level.

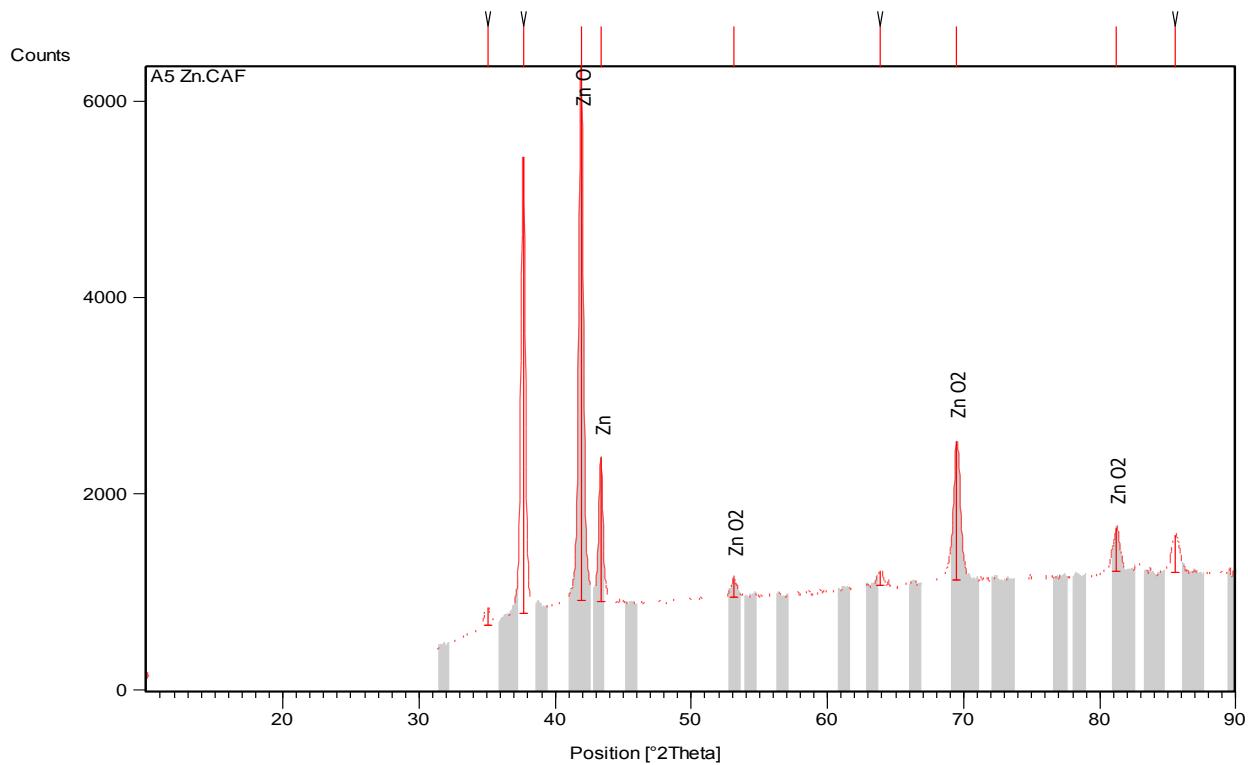
### 3.6. Morphological study

#### SEM/AFM

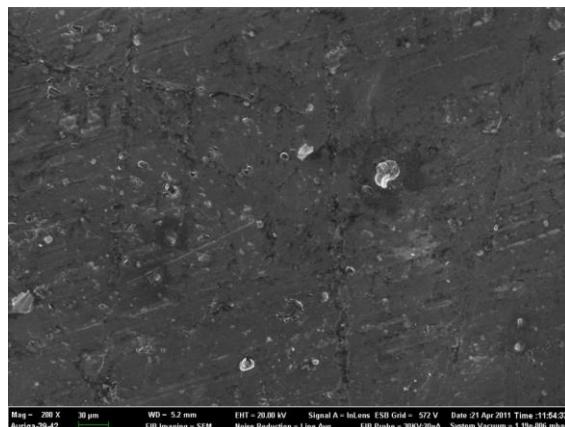
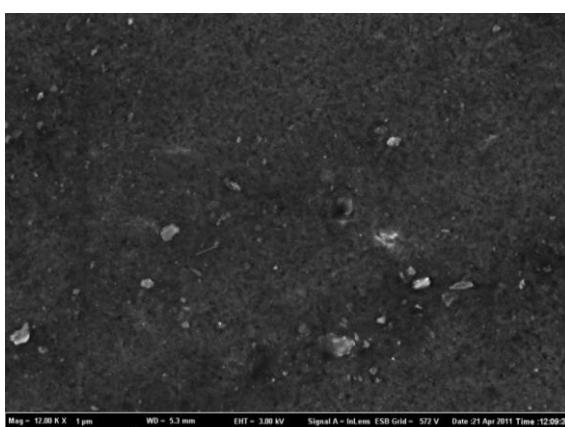
Focused ion beam-Scanning electron microscopy, FIB-SEM and AFM, was used to investigate the surface morphology and topography of zinc deposited galvanostatically at different current densities.



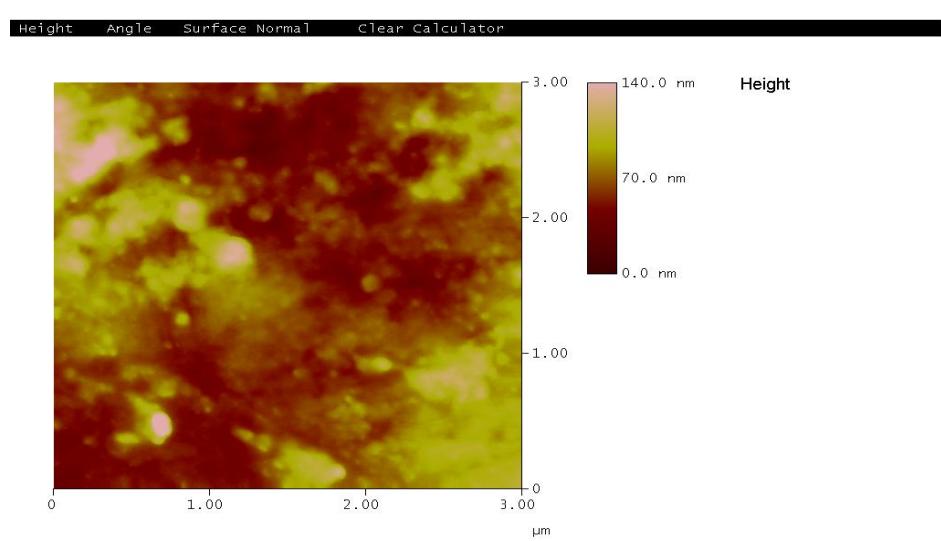
**Figure 9.** XRD patterns of the electrodeposits obtained from Zn at 0.6V plating



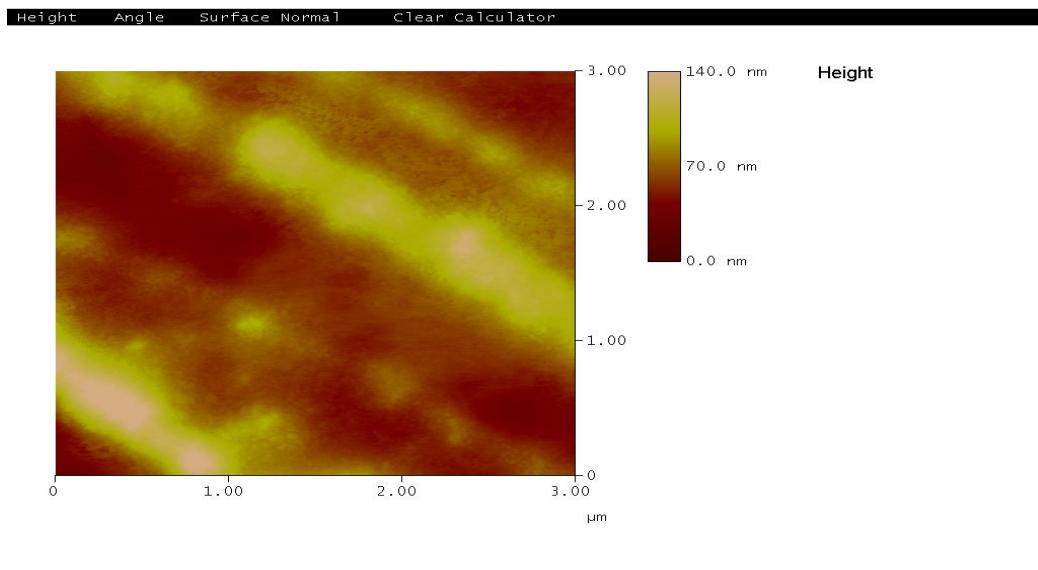
**Figure 9b.** XRD patterns of the electrodeposits obtained from Zn plating bath with 1.0 Volt

**A****B**

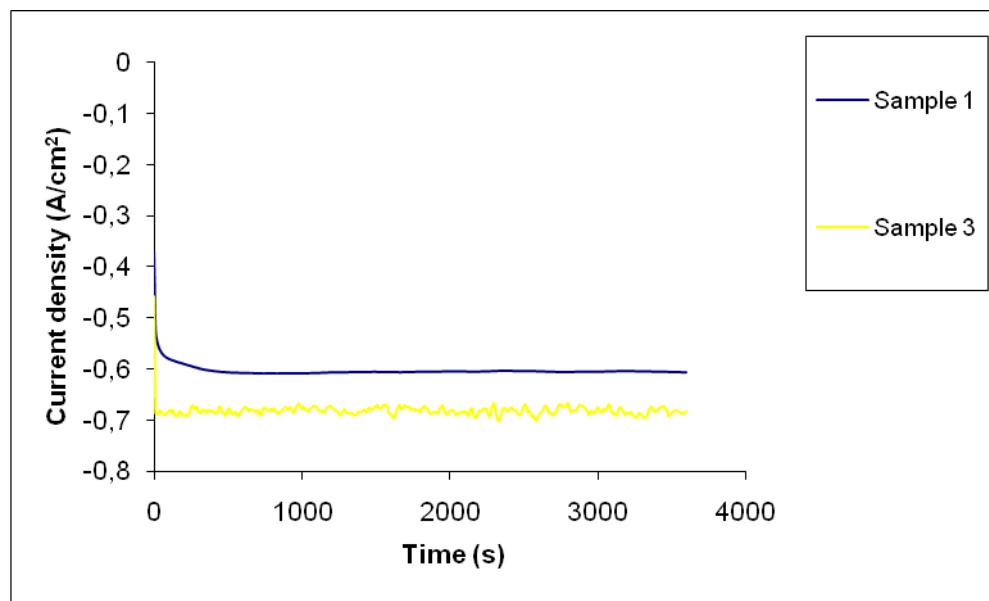
**Figure 10** **A)** SEM photograph of the deposit obtained from Zn plating bath with. T=328 K, c.d.=0.6 A/dm<sup>2</sup> time=15 minutes. **B)** SEM photograph of the deposit obtained from Zn plating T=328 K, c.d.=1.0 A/dm<sup>2</sup>, time=15 minutes.



**Figure 11a.** AFM photograph of the deposit obtained from zn electrodeposition in 0.8V



**Figure 11b.** AFM photograph of the deposit obtained from Zn electrodeposition in 0.8V



**Figure 12.** Cyclic volt metric obtained on Zn deposition in 3.65mol/dm<sup>3</sup>

#### 4. CONCLUSION

After vivid study of deposited zinc on the mild steel, the performance evaluation was systematically observed and a homogeneous and coherent surface morphology was maintained. However, at 1.0V there is stability in mechanical and physical properties obtained on plated substrates after corrosion investigation.

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