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Corrosion Behaviour of AL 5082 Reinforced with TiB_2 Nano Composite in Marine Environment

Jahagirdhar A.A.[1], *Pruthviraj R.D.[2], Somashekar H.M.[3], Vishwa Prakash[4]

Author Affiliations
[1]Department of Chemistry, Dr. Ambedkar Institute of Technology, Bengaluru, Karnataka 560056, India
[2]Chemistry R & D Centre, Department of Chemistry, Rajarajeswari College of Engineering, Bengaluru, Karnataka 560074, India
[3]Department of Mechanical Engineering, Dr. Ambedkar Institute of Technology, Bengaluru, Karnataka 560056, India
[4]Department of Chemistry, Bangalore University, Bengaluru, Karnataka 560056, India

***Corresponding Author**
Pruthviraj R.D., Chemistry R & D Centre, Department of Chemistry, Rajarajeswari College of Engineering, Bengaluru, Karnataka 560074, India
E-mail: pruthvirajrd@gmail.com

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ABSTRACT

Based on the application prominent choice of material is essential the development and end use. Aluminium nano composite can be used to replace the conventional aluminium alloy due to its considerable strength. Normally aluminium undergoes corrosion and the corrosion rate can be reduced by reinforcing suitable fillers in nano level. This attempt was made to study the influence of chromium addition to the corrosion behavior of AL 5082/TIB_2 composites. A stir casting technique used to prepare different % at 0, 2, 4, 6% composite of nano TiB_2 when it was immersed in 3.5 wt % from the Nyquist plots and equaling circuit fitting results. The charge transfer resistance values was observed to change from 10 to 3.7 30 to 9.5 19 to 2.8 for 0.3 and 6 wt % chromium content respectively after 72 hours of exposure. The increase in the charge of transferred resistance has obtained with an increasing chromium content has a clear indication of improved resistance to corrosion

Keywords: Al 5082, NaCl, EIS, SEM

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INTRODUCTION

Research and development (R & D) has shifted to the use of monolithic alloys to Nano matrix composite in response to the growing demand in industry for light weight, low cost and high performance materials for structural application. A tremendous progress has been made in the development and characterization of Nano matrix composite for various engineering application [1-4]. According to [3], the potential advantages of Nano matrix composite over monolithic alloys may be attributed to the reason for activated research interest in the past years. Aluminum metal matrix composite have been found to offered superior combination of profile properties in such manner that up to date no existing monolithic material rival [5,6]. This class of composite has been used extensively in numerous structural nonstructural and functional applications. The use of Nano metal composite for building and construction purpose in shipping aerospace automotive defense and warfare common nuclear transportation and petroleum industries has attracted more considerable interest in the recent time [7-14]. The numerous application of Nano metal composite can be trased to its high strength to weight ratio improved stiffness moderately high temperature properties controlled thermal expansion coefficient, enhanced and tailored electrical performance improved abrasion and wear resistance as compared to monolithic aluminum alloys [15]. Although Nano matel composite has demonstrated excellent phyTiB2al mechanical and tribological properties, the challenge of corrosion remain a consistent treat in sea water environment for modern building and construction purposes and host of other state of the art structure application except on very few resistances use of ceramic reinforcement particles in Nano metal composite have been found to experience high corrosion degradation when compared to that of monolithic aluminum alloys. For instance investigated the corrosion behavior of Al5082 TiB_2 composites in chloride solution. While significant research effort have been made on the study of electrochemical corrosion behavior of Nano metal composite reinforced with TiB_2, the use of electrochemical impendence spectroscopy (EIS) technique for the study of the effect of chromium on the corrosion performance of Al5082 TiB_2 composite is reported. The focus of this work was to investigate influence of chromium addition on corrosion behavior of relatively novel Al5082 12% TiB_2 composites in 3 wt. % NaCl using EIS technique the outcome of these study may provide useful insights and data on possible alloy additions for controlling adverse effect of corrosion in Al5082 based composites

EXPERIMENTAL

Specimen

Aluminum 5082 silicon carbide and high purity chromium were used to produce the aluminum composite. This is required amount of raw materials was weighed And melted in a gas furnace with varying amounts of chromium (0.3) and 6 wt. (%) added to the melt and vigorously agitated to allow for good mixing and reheating again before pouring into prepared and moulds. The cast samples were machined and cut into cylindrical section

Electrochemical Measurement

All electrochemical experiments were performed in a conventional three electrode cell using a CH-I software. A silvers/silver chloride (Ag/AgCl) and a platinum wire coiled to give the large surface area where used as a reference and counter electrode respectively. The Aluminum anode sample used as working electrode where cut into cylindrical shape with an exposed surface area of $1cm^2$. the working electrode where prepared by attaching copper wire immersed in a glass tube to the sample using conducting silver paint and epoxy resin such that only 1 phase of each sample was exposed. The exposed surface where wet ground with 1000 grade TiB2 paper washed theory with distilled water and cleaned with acetone prior to testing. That test environment was 4 wt. % NaCl solution where prepared from deionized water and analytical grade reagent.EIS test were performed at open circuit potential (OCP) with the frequency scanned from 100 KHz-100MHz with an alternating current (AC) pertubulation of + 10mV to give the corresponding Nyquist the obtained results where fitted with an equivalent circuit with elements that were deemed to have physical meaning in the system.

RESULT AND DISCUSSION

Open circuit potential

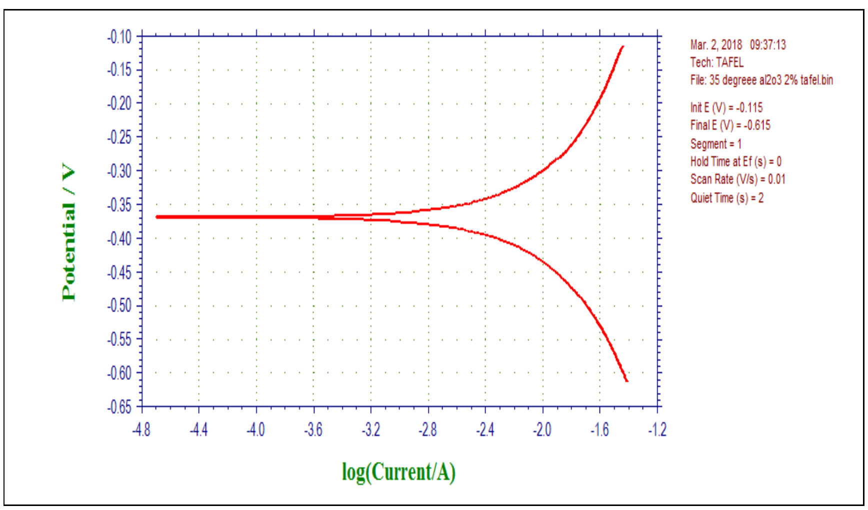
Shows the plot of OCP decay for the Al5082 to 12% TiB_2-xCr composites with 0, 2, 4, 6 TiB_2 Wt. % the OCP was monitored for 2hrs to ensure stability of the system before further electrochemical test where carried out. Significant fluctuation where observed for the 1st 3000S, but after which the composite became relatively stable drifting within 0.05V. The Al5082-12%/TiB_2 composite with 0, 2, 4, 6 wt. % TiB_2 content fad OCP values of -0.70-0.72 and -0.73V measured vs. Ag/AgCl reference electrode. The OCP values are strongly dependent on the chemical composition of the alloys/composites being tested Effects of immersion Time.

Electrochemical Impedance Studies

The EIS behavior of the composite From the electrochemical impedance study, useful information on the electrochemical reactions taking place at the aluminum composite surface was obtained Fig. 2 a, b, c shows the Nyquist plots for the composite with varying chromium content (0, 2, 4, 6) The CH-I software was used to fit the equivalent circuit diagram shown in fig and obtain values for the circuit elements. From the equivalent circuit shows a constant phase element (CPE) was use in place of pure capacitor as it better represent the corrosion phenomenon taking place represent the solution resistance. The impedance of CPE is represented as Where Y0 is the CPE constant j the imaginary unit, and n the CPE power and the angular frequency. The EIS parameters obtained from fitting the equivalent circuit are shown in table 1. Rct and CPE represent the charge transfer resistance and constant phase element. The Rct value is so taken to be equivalent to the polarization resistance Rp. The EIS diagrams (from the Nyquist) for the Al 5082-12% TiB_2 is characterized by a onetime constant (A single semi-circle) he Nyquist plots show clearly that 0, 2, 4, 6 and wt. % content there was significant reduction in the Rct values throughout the period of immersion. At 4 wt. % content the Rct values were generally higher indicating an increasing in corrosion resistance however after the third day of immersion there was a slight increase in Rct values for Al 5082-12% TiB_2 with 0 wt. %. This increase in Rct values is attributed to possible thickening of the passive film on the composite surface. There were no visible sign of pitting on the composite surface confirmed by the absence of any inductive loops on the Nyquist diagrams.

Potentiodynamic polarization studies

Electrochemical studies were carried out at 25.c under static condition. An assembled specimen is carried out in a glass corrossion cell. The electrolyte which was filled with freshly prepared. (Within 24 hrs). The reference electrode and a saturated clomel electrode (SCE) used as the platinum coil as the counter electrode. All measured potential with respect to SCE. The potentiodynamic was performed with a polarization measurments with a princeton applied research potentiostate (model 263A) carried out by a personel computer with dedicated software tested for each specimen 24 hrs open circuit potential (E_{corr}) was measured and performed especially fallowed by the general polarization test from 600 to 1200 mv. The tafel slopes partial anodic process. I_{corr} (corrosion current density) and ZCP zero current potential was detrmined by using the curve fitting corrosion routine of the software.



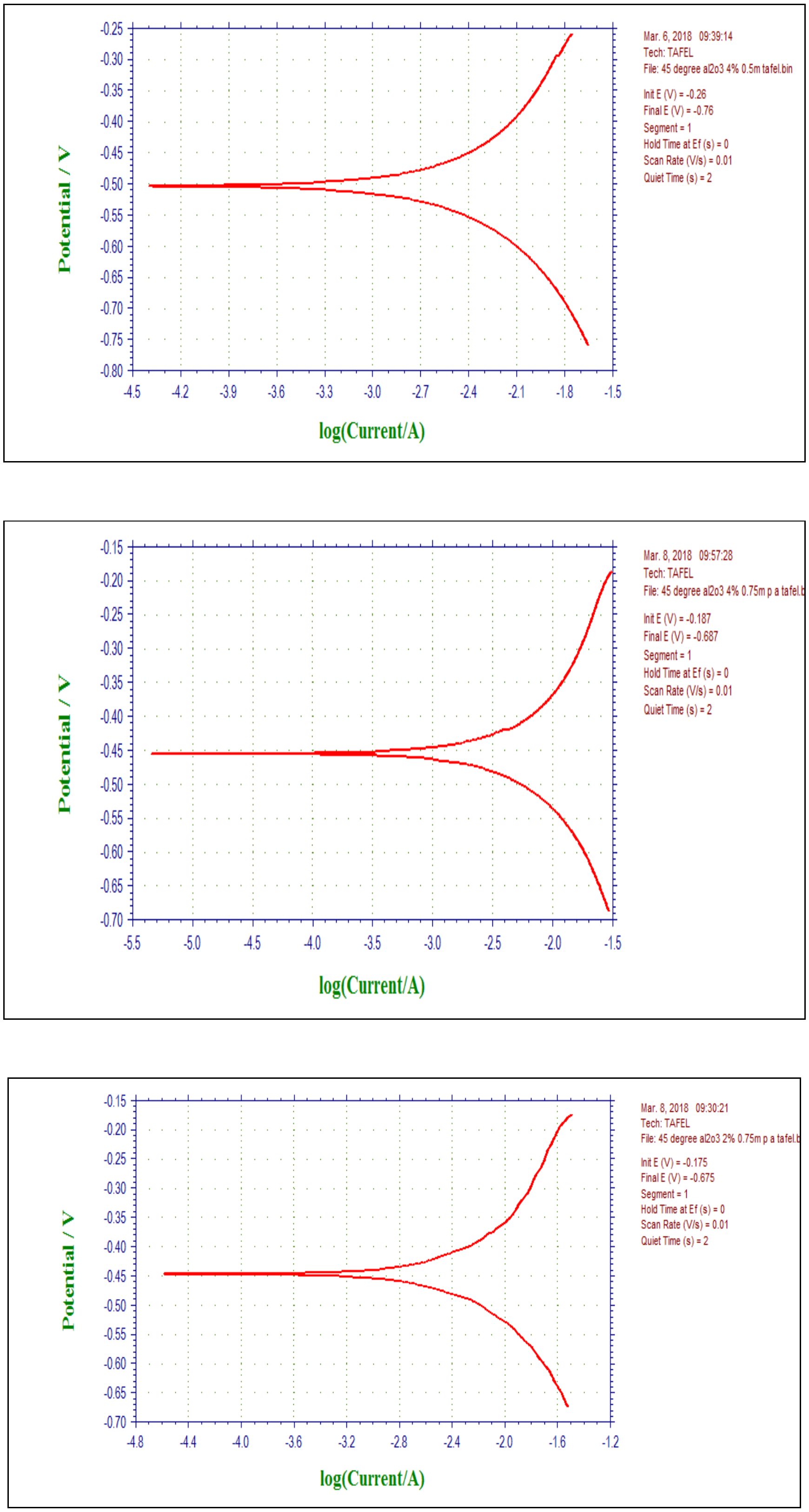


Figure 1: Potentiodynamic studies of Al 5082/TIB_2 in marine environment

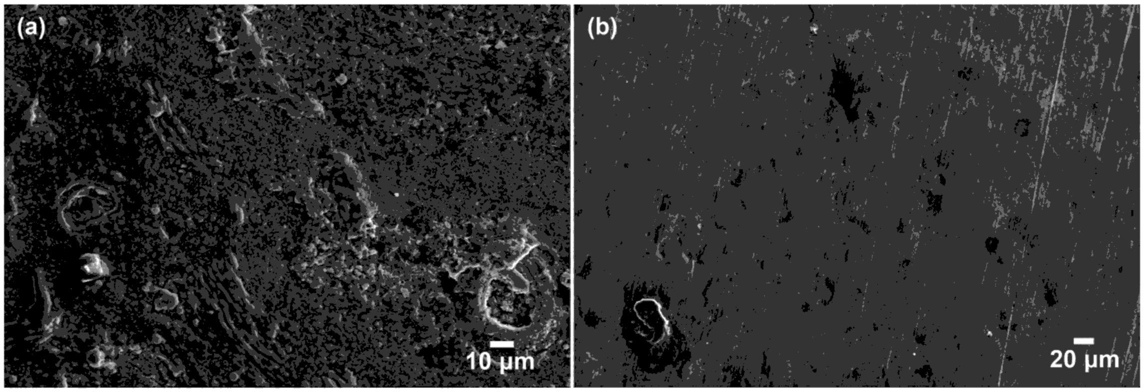
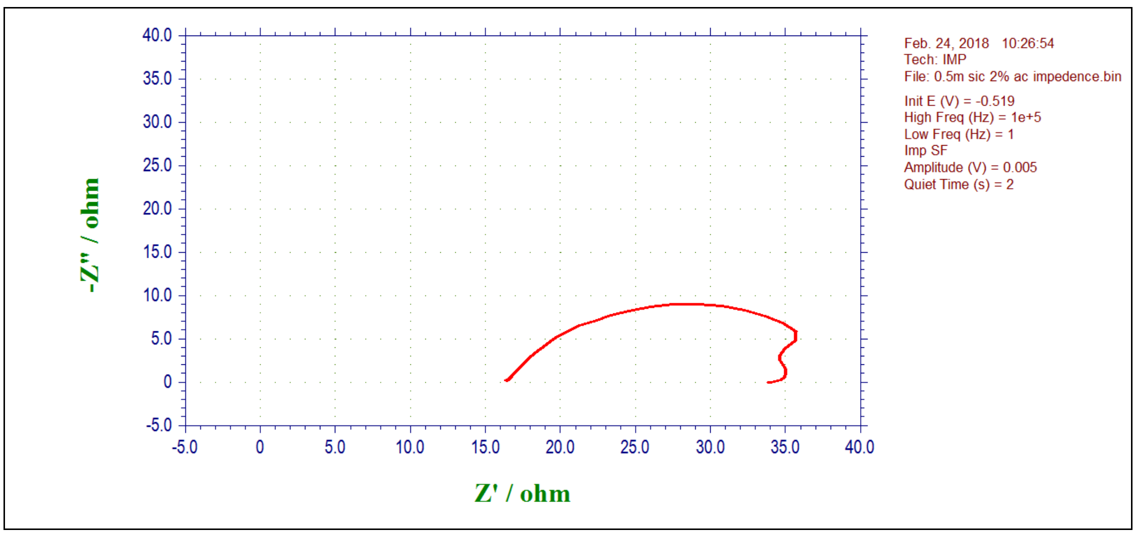
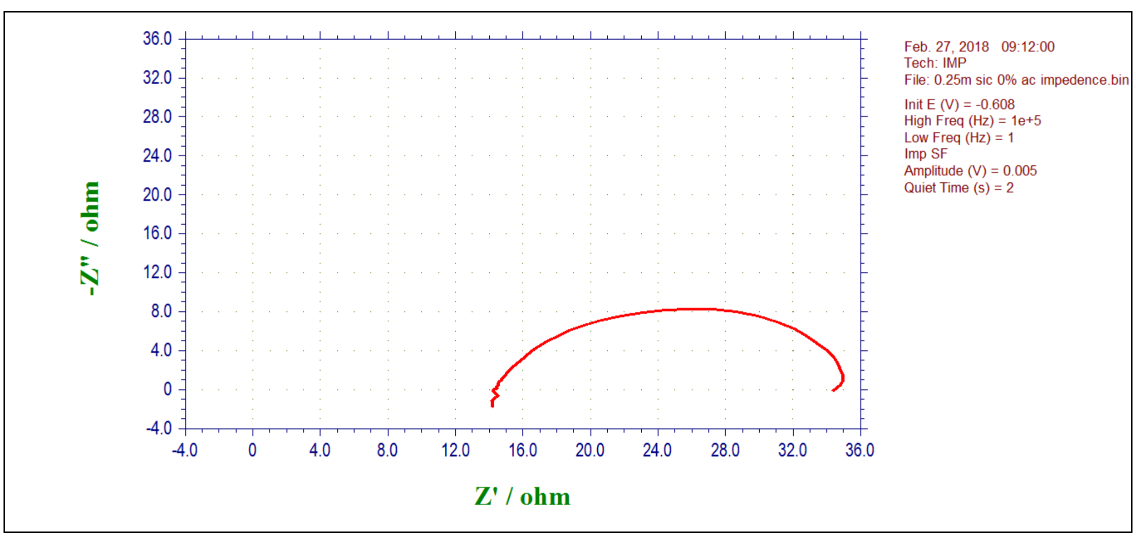


Figure 2: SEM of Al 5082 before and after corrosion in marine environment





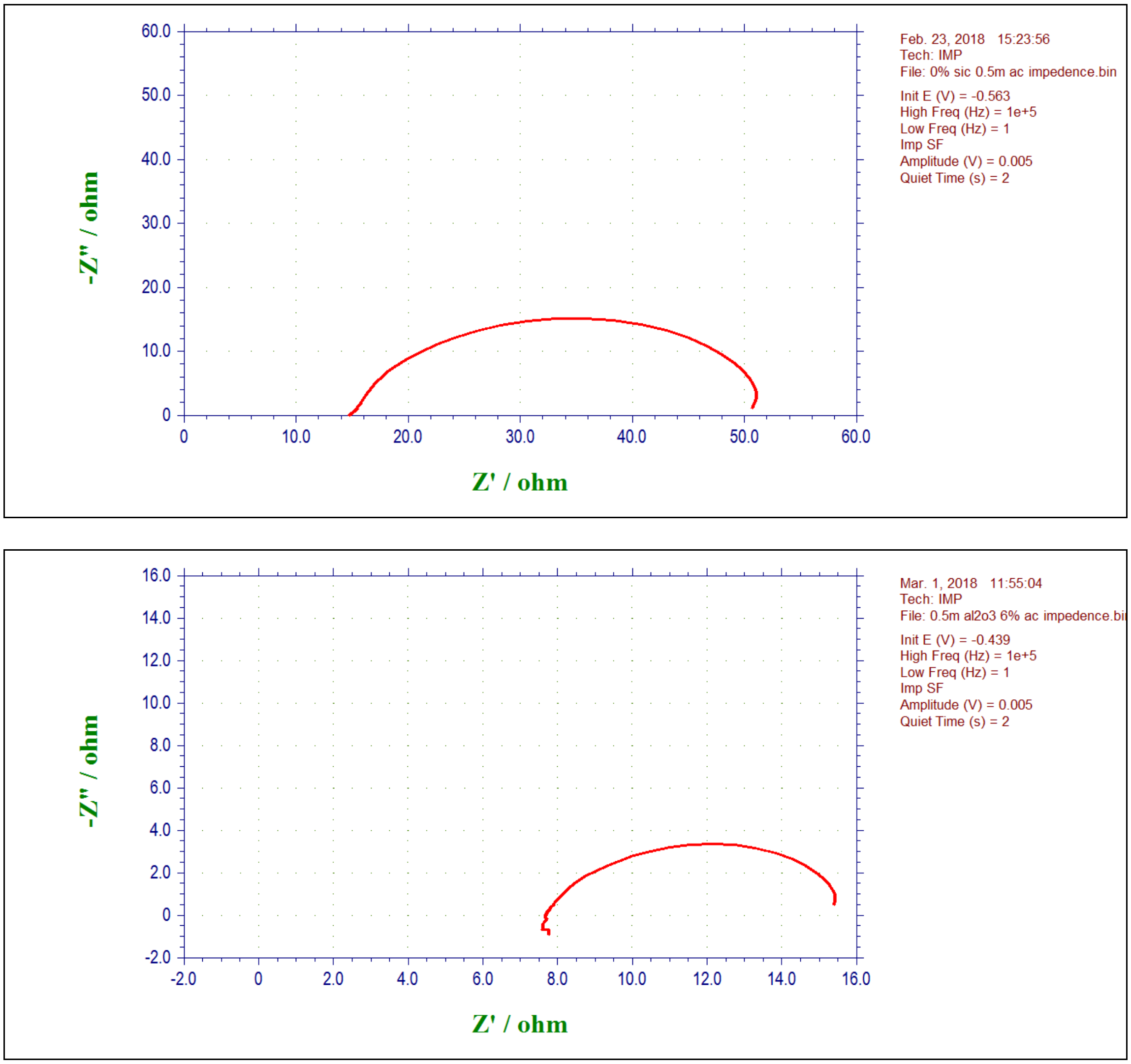


Figure 3: AC impedence studies of Al 5082 in marine environment solution

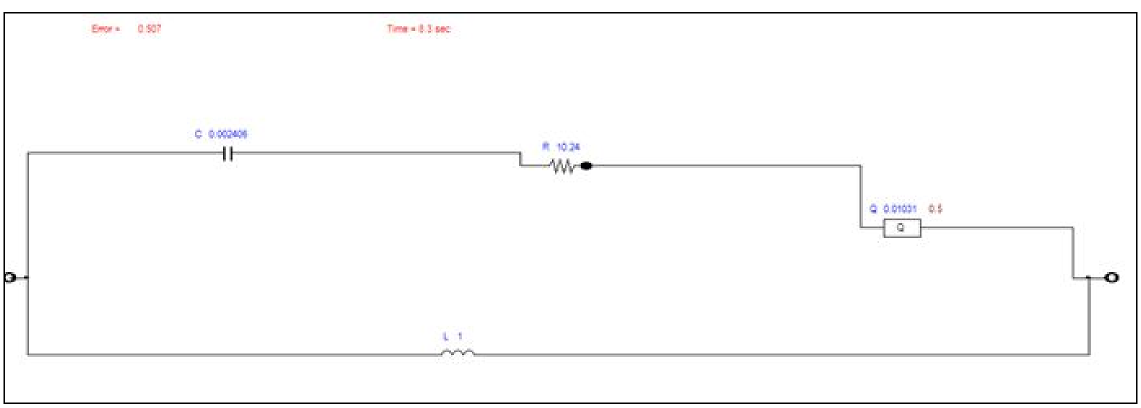


Figure 4: Circuit Diagram of Al 5082 (Curve fit diagram)

CONCLUSION

The effects of Chromium addition on the electrochemical behavior of aluminum 5082nm composite was studied using EIS technique. It also clearly revealed that the corrosion performance of the Al5082-12%C-xCr composite was optimal at 4wt.% chromium content as the obtained charge transfer resistance (Rct) values were relatively larger and reduced at much slower rate as the time of immersion progressed ,implying a greater resistance to corrosion further tests to characterise corrosion behavior .

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