Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/9728
DOI URL: http://dx.doi.org/10.21474/IJAR01/9728

RESEARCH ARTICLE

TAFEL POLARIZATION AND IMPEDANCE STUDIES OF AL-7075 ALLOY AND ITS COMPOSITES IN DIFFERENT MEDIUM.

Sravanthi.M[1], Dr.K.G.Manjunatha[2], Dr.Saifulla Khan[3] and Sunitha N[4]

1. Assistant professor, Department of Chemistry,AMC Engineeing College, Banneerghatta Main Road, Bangalore,Karnataka-560083, India.
2. Prof. and HOD R&D Centre, Department of Engineering Chemistry, Ghousia College of Engineering, Ramanagaram, Bangalore, Karnataka-56215, India.
3. Assistant professor, Department of Chemistry, Ghousia college of Engineering, B.M Road, Ramanagaram – Bangalore, Karnataka-562159, India.
4. Assistant Professor, Department of Chemistry, City Engineering College, Kanakapura Road, Bangalore, Karnataka-560083, India.

……………………………………………………………………………………………………....

Manuscript Info

……………………….

Manuscript History
Received: 09 July 2019
Final Accepted: 12 August 2019
Published: September 2019

Key words:-
Al7075, OCP, Tafel polarization, EIS and SEM.

Abstract

…………………………………………………………………

Aluminum metal matrix composites because of their high potential in satisfying the recent demands have a wide variety of applications in aviation, defense system, and automobile industries. It has been noticed in research that the properties of composites can be enhanced by the addition of ceramic particles like SiC and graphite to metal matrix composites. This paper attempts on corrosion studies of Al 7075 base alloy/SiC/graphite based composites in different inorganic acid mediums (0.1M HCl,0.1M H_2SO_4 medium) and neutral chloride medium (3.5% NaCl medium) by making use of Tafel Polarization Technique and Electrochemical Impedance Spectroscopy Technique. Test samples were casted by taking the various percent of SiC/graphite by stir casting method as per ASTM standards. Electrochemical studies tell us about the polarization resistance and the diameter of the capacitive loops above the real axis of base alloy and composites increases in neutral chloride medium compared to different inorganic acid mediums thus it confirms that the corrosion rate in neutral chloride medium is less compared to inorganic acid mediums.Composites exhibit more resistance towards corrosion compared to Al7075 base alloy was confirmed from Ecorr and Icorr values and it was also confirmed hybrid composites are more resistant to corrosion in all the mediums.Results from Electrochemical Impedance Spectroscopy Technique and Tafel Polarization Technique were in concurrence with each other.SEM images confirm the distribution of reinforcement particulates in the metal matrix and let out the rate of degradation of alloy and composites in different mediums.

……………………………………………………………………………………………………....

Corresponding Author:- Sravanthi.M.
Address:-Assistant professor, Department of Chemistry, AMC Engineeing College, Banneerghatta Main Road, Bangalore,Karnataka 560083 India.

Introduction:-

Aluminum metal matrix composites have dazzled most recognition as a base metal in metal matrix composites (MMCs) because of its high solidarity to lightweight, high strength, and ease of machining, better electrical and thermal conductivity. They have wide scope for the basic applications; particularly for aviation and automobile engineering as they withstand high temperatures and have enhanced mechanical properties on reinforcement [1-5]. Hybrid aluminum metal matrix composite materials substitute conventional materials as a result of their enhanced properties like high strength, improved hardness and resistance towards creep [6-8].

Al7075 alloy compounds are utilized as they have huge impediments such as quality and firmness. In AMMCs the reinforcement influences on corrosion rate and wear resistance.The properties of alloys are expanded on the incorporation of ceramic particulate into their matrix phase [9, 10]. Ceramic particles, for example, B_4C, Al_2O_3 and SiC are normally utilized as support stages in the composite materials. Among the various ceramic particles, silicon carbide (SiC) has different focal points, for example, amazing thermal conductivity, great functionality, high machinability and ease, as a result, it forms better composites with aluminum without any intermetamorphosis. Graphite is outstanding strong lubricant and its existence in base alloy causes grid matrix compound self-greasing up. Aluminum composites strengthened with graphite were developing potential similar to SiC for aviation needs and their enhanced mechanical properties attracted significant logical regard for the investigation of their conceivable appropriateness to high-innovation novel applications, for example cylinders bearings, bushings and so forth. A few techniques have been utilized to prepare composites including in situ processing, spray casting, powder metallurgy, stir casting techniques and squeeze casting. Among various processes, because of its ease of preparation and flexibility stir casting method is one of the promising routes that were commercially practiced.

Bhushan et.al [11] analyzed by stir casting method the preparation and microstructural investigations of base alloy–SiC MMCs. Suresha and Sridhara et.al [12] have declared that in the case of hybrid composites with equal quantities of SiC and graphite, hardness increased up to 2.5wt% of reinforcement and then decreased. The improvement in hardness may be due to the extension of SiC particulates and later the decrement in hardness was attributed to the superseding impact of delicate graphite particles.

Jelena scepanovic et.al [13] studied on corrosion behavior of Al-Mg-Cu alloys in uninhibited and inhibited 0.5M NaCl solutions.Corrosion rates and other corrosion parameters were estimated as a function of sample compositions. Estimations were performed utilizing potentiodynamic polarization, electrochemical impedance studies, and linear polarization tests. Based on sample compositions corrosion rates and other erosion parameters were evaluated.

Bagesh Bihari et.al [14] attempted to develop $Al7075/Al_2O_3$/graphite particulate metal matrix composites through stir casting method utilizing metallic molds and to study the corrosion tendencies. Preheated particles were added to the lattice as reinforcement. Corrosion tests were directed by utilizing weight-loss method, Potentiodynamic polarization technique and electrochemical impedance spectroscopy method where 3.5% NaCl solution was utilized as corrodent. It was noticed that the metal matrix composites corrosion rate was lower than that of Al7075 base material under the destructive environment.

In MMCs corrosion of composites is one of the major existing problems, the rate of corrosion is greatly influenced by reinforcement. The addition of reinforcements in base alloy may influence the protective oxide layers of metal surface which effects corrosion resistance, as a result of irregularity.The parameters that influence corrosion resistance of the AMMC's are fabrication methodology,elemental composition, reinforcement, porosity, miniaturized scale down breaks, lingering stresses and development of intermetallic fragile stages, and so on. From the literature review, it was noticed that work has been done on enhancement of mechanical properties and corrosion tendencies of Al7075 alloy in the acid medium of different concentrations and sea environments. But no literature seems to be available on comparative study of corrosion tendencies in different mediums.

The objective of the present investigation is focused to evaluate the corrosion behavior of Al7075 base alloy and its MMCs with the addition of a different percentage of SiC and HMMCs with SiC, graphite particulates in different inorganic acid mediums and neutral chloride medium by using Tafel Polarization Technique (TPT) and Electrochemical Impedance Spectroscopy (EIS) Technique.

Experimental procedure:-

Material and reinforcement particles

The base material chosen for existing work is Al 7075 alloy which is monetarily accessible in the form of ingots procured from fenfe metallurgicals. SiC and graphite particles in micron size were used for reinforcement.The chemical composition of base material and properties of reinforcement particles are tabulated in Table 1and Table 2.

Table 1:-Composition of Al-7075 alloy in Wt%

Cu	Fe	Mg	Mn	Si	Zn	Cr	Ti	Al
1.55	0.4	2.82	0.11	0.27	6.03	0.2	0.15	Balance

Table 2:-Properties of Silicon carbide and Graphite

Properties	Silicon Carbide	Graphite
Symbol	SiC	C
Colour	Green to bluish black	Black,grey
Crystal structure	Hexagonal	Hexagonal cubic
Mass	Molar mass 40.0962 g mol^{-1}	Aomic mass 12.0107 amu
Density (gcm^{-3})	3.16	2.266
Hardness (mohs scale)	9	1-2
Fracture toughness	4.6	1.4

Preparation of composite material

Stir casting is the most affordable method utilized for the fabrication of composite specimens with discontinuous fibers or particulates. The ingots of base alloy compounds were heated to its melt temperature in the furnace and stirred vigorously at a speed of 400-450 rpm to create a vortex and preheated and uncoated SiC were added to vortex and the resultant alloy was cooled to form a semi solid-state in the furnace. In an identical way, hybridcomposites with equal amounts of SiC and graphite and base alloy matrix without any reinforcement is also casted for comparison. MMCs and HMMCs and base alloy were prepared by using standard procedures [15-17].

Rectangular sample preparation

Casted composites and pure alloy matrix were cut into rectangular species of length 6cm length, 2.1cm width and 1.5 mm thickness by the abrasive cutting wheel as per ASTM G69-80 standard. The exposed flat surface of the mounted part of these composites and matrix were polished as per standard metallographic practice followed by polishing with 80,100, 240, 320, 400, 600,800 and1000 grit size emery papers and finally polishing by diamond paste to obtain mirror finish; degreased in acetone and dried before subjecting them to polarization studies [18,19].

Medium

The medium preferred for corrosion testing are standard solutions of inorganic acids having a concentration of 0.1M (0.1 M HCl and H_2SO_4) and 3.5% neutral chloride (3.5 % NaCl) solution.

Electrochemical studies

The CHI608E-series, electrochemical work station model having software CHI Version 16.01, the potential control range of ±10 V and current range around ± 250 mA procured from CH Instruments U.S.A have been used for electrochemical analysis (figure 1). The instrument is very fast and gives an exceptionally wide dynamic scope of exploratory time scales of prepared composites and Al7075 base alloy to ascertain the corrosion characteristics. The electrochemical cell with three compartments made up of pyrex glass having corroding medium,counter electrode (CE) as platinum, and Ag/Agcl electrode as reference electrode (RE) and the rectangular Al7075 specimens of length 6cm length and width 2.1cm and thickness around 1.5 mm as the working electrode (WE) were used for electrochemical measurements. TPT and EIS measurements were carried out using an electrochemical work station instrument (EWS) at ambient temperature.

Figure 1:- Electrochemical analyzer model (CHI608E)

Evaluation of corrosion rate by polarization techniques

The potentiodynamic Polarization is one of the parameters, which empowers to measure the corrosion rate.During these processes two different approaches such as current and potential were apparently controlled and the resulting current during the electrochemical process is measured. The two different techniques used in measuring the corrosion rate are the Linear Polarization method and Tafel's polarization method.

Linear polarization method:

Potentiodynamic polarization studies of base alloy and its composites have been carried out by bringing standard inorganic acid solutions of 0.1M concentration and 3.5 % of neutral chloride solutions in contact with base matrix alloy and its composites [2% SiC, 4% SiC & hybrid (SiC and graphite)] which were used as a WE for 400sec to generate steady- state open circuit potential (OCP). Polarization studies were carried out at a scan rate of 1mV /S and the OCP values were recorded for base alloy and its composites in different mediums. The OCP, corrosion current density (Icorr) and the corrosion potential (Ecorr) were noted for Al7075 base alloy and its composites in different medium using EWS [20-22].

The corrosion rate was ascertained from the following equation and the results were recorded in Table 4.

$$\text{Corrosion rate (mpy)} = \frac{0.129 \times A \times Icorr}{D \times n} \qquad (1)$$

Where,

mpy = mille-inches per year, I_{corr} = Corrosion current density (Acm^{-2}) , A = Atomic mass (g) ,n = Valency

D = Density of the corroding species (gcm^{-3})

Tafel polarization method:

Finely polished specimens of base matrix alloy and its composites of surface area around 1.0 cm^2 were in contact with inorganic acid and neutral chloride mediums. By anodic and cathodic polarization of the specimen with respect to OCP from+0.250 mV to -0.250 mV at a scan rate of 1mV/S the potentiodynamic current–potential curves were recorded [23,24]. The potential (E) vs. log current density (log i) curves were recorded. The nature of polarization curves predicts the rate of corrosion.

EIS method:

Impedance measurements were carried out by making use of AC signal of small amplitude around 10 mV and 10^{-5} Hz – 1MHz frequency range and Nyquist plots were recorded at OCP for different corrodents [25,26]. The resistance between WE and RE is computed from the Z'' vs Z' plot.

SEM analysis

Investigation of the surface morphology of base alloy and its composites in the presence of different medium was carried out using TESCAN VEGA-3 model scanning electron microscopy. SEM images of mirror- finished base alloy, 2%, 4% and hybrid composites after EIS studies were recorded [27].

Results and discussion:-

Effect of reinforcement

The SiC and graphite distribution on reinforcement in Al7075 base alloy will influence the corrosion rate of the base alloy and its composites. If the distribution of reinforced particles is not proper or the formation of any precipitates during reinforcement may lead to an increase in the corrosion rate of composites due to localized corrosion**.** The rate of cooling and solidification of ingots plays an important role in the distribution of the ceramic particulates in the ingots and formation of precipitates at intermetallic regions which leads to intense corrosion. The increase in corrosion rate in some composites as shown in Table-4 in HCl and NaCl medium is due to the formation of precipitates like MgO_2 and $CuAl_2$ which are cathodic to base matrix on reinforcement confirmed from the elemental analysis [9,10,28-30]. In case of hybrid composites slight increase in corrosion rate might be due to galvanic coupling in presence of graphite and also may be due to formation of Al_4C_3 at the interface during fabrication processing, hydrolysis of Al_4C_3 on exposure to moisture leads to fissures at graphite base matrix interface which may leads to pitting corrosion. [31-34].

Electrochemical measurements

OCP measurements:

The OCP plots were recorded for the Al7075 base alloy and its composites in different mediums 0.1M HCl, 0.1M H_2SO_4 and 3.5% NaCl medium (figure 2-4). The drift in OCP value depends on the presence and absence of oxygen and nature of corroding material. It was noticed from results OCP values increases in a positive direction as SiC content increases in different inorganic acid medium and 3.5% neutral chloride medium [35]. But in hybrid composites there is a slight decrease in OCP value in inorganic HCl and neutral NaCl mediums, maybe due to the presence of graphite, galvanic coupling takes place in hybrid composites. The measured OCP is tabulated in Table 3. The shift in OCP value to a higher value is a good sign indicating that composites are more resistant to corrosion.

Table 3:- OCP values of Al7075 base alloy and its SiC composites in different medium

Al7075 matrix alloy and its composites	**Open circuit potentials (Ecorr) values in volts in different medium**		
	HCl (0.1M)	**H_2SO_4 (0.1M)**	**NaCl (3.5%)**
0 %	-0.70597	-0.61037	-0.80870
2 %	-0.68048	- 0.59513	-0.76287
4 %	-0.68677	-0.59221	-0.75290
Hybrid (SiC+G)	-0.6926	-0.57372	-0.76115

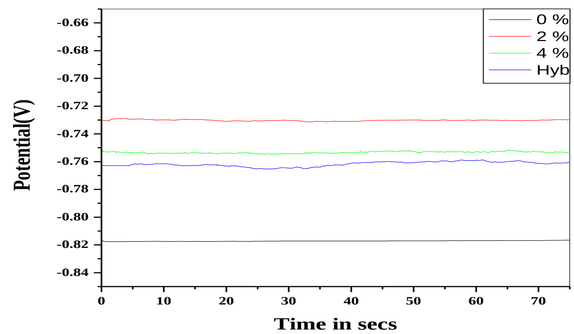


Figure 2:-OCP for base alloy alloy, 2%, 4% and Hybrid composites in 3.5 % NaCl medium

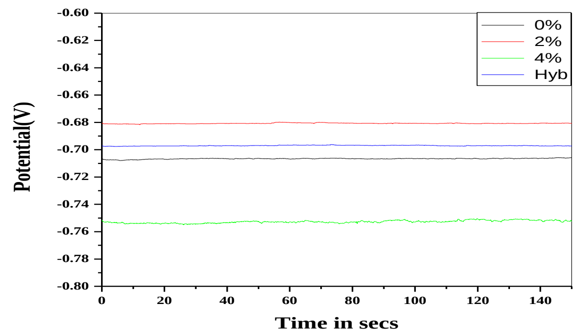


Figure 3:- OCP for base alloy alloy, 2%, 4% and Hybrid composites in 0.1M HCl medium

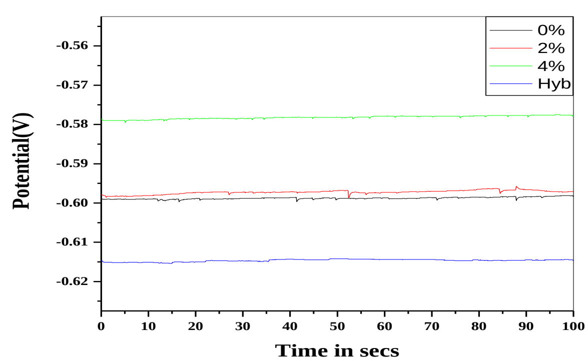


Figure 4:-OCP for base alloy, 2%, 4% and Hybrid composites in 0.1 M H_2SO_4 medium

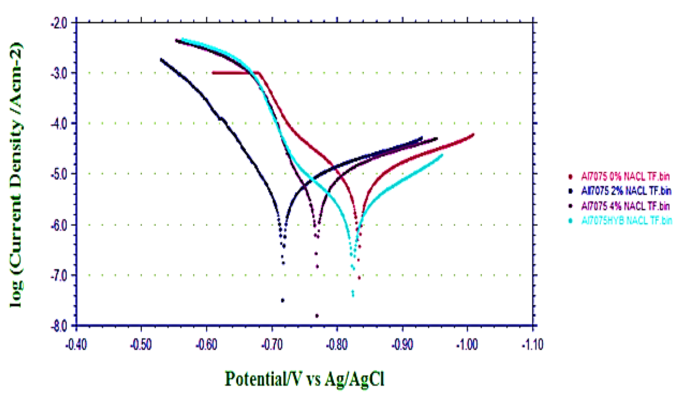
Tafel polarization measurements:

The polarization resistance approach measures corrosion rates at faster rate over a finite period of time compared to other techniques.Tafel extrapolation plots of Al7075 base alloy and its composites (figure 7) results in linear polarization resistance (Rp), slopes of linear sections Beta anodic slope (**β**a), Beta cathodic slope (**β**c) and intersection of extrapolated linear sections of cathodic and anodic curves gives corrosion current density (icorr) and Ecorr are tabulated in the Table 4.It may be noticed from the Tafel plot that Icorr values and corrosion rate decreases in composites with increase in SiC content compared to Al7075 base alloy.In inorganic acid mediums, corrosion rate increases as polarization curves are shifted to a high current density region compared to neutral chloride medium. Superimposed Tafel Polarization plots for Al7075 base alloy and its composites in 3.5% NaCl, 0.1M HCl and 0.1M H_2SO_4 medium are plotted (figure 5) and whereas (figure 6) superimposed Tafel Polarization plots for Al7075 base alloy and its composites in various mediums are shown. The corrosion potential and corrosion current values obtained on extrapolation (figure 7).The micro galvanic couple of SiC with base alloy causes pitting corrosion. The decrease in corrosion rate noticed in case of the composites may be as a result of the decoupling of conducting SiC debris with base alloy after the interfacial corrosion product, therefore galvanic effect between them is removed [36]. Polarization analysis indicates polarization resistance R_p of Al7075 base alloy and its composites in various medium increases in the order NaCl > H_2SO_4 > HCl (figure 10).It also shows from Table 4 in hybrid composites Rp is higher in all mediums thus it is affirmed from Tafel measurements that corrosion tendencies are less in neutral chloride medium compared to various inorganic acid mediums and hybrid composites are more resistant to corrosion in all the mediums. The corrosion rate increases in the order as follows HCl > H_2SO_4 > NaCl.

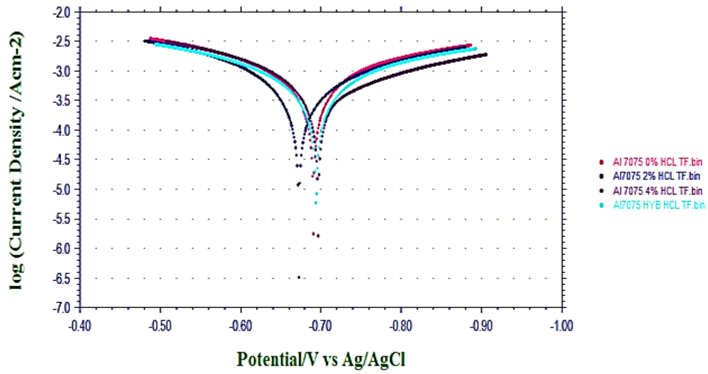
Table 4:-Corrosion rates, I corr, Rp, βa and βc of Al 7075 base alloy and its composites in different mediums

Medium	Percentage of SiC	Ba	Bc	R_P (ohm)	I_{Cor}(Acm^{-2}) in 10^{-4}	Corrosion Rate (mpy) in 1 0^{-4}
0.1M HCl	0 %	4.890	4.052	58	8.380	3.4412
	2 %	5.123	5.021	81	5.307	2.1851
	4 %	4.928	4.354	65	7.165	2.9583
	Hybrid	4.871	4.420	72	6.508	2.6897
0.1M H_2SO_4	0 %	4.239	5.612	119	3.715	1.5296
	2 %	3.959	5.805	125	3.570	1.4754
	4 %	3.990	5.845	152	2.913	1.1962
	Hybrid	4.155	6.170	181	2.323	0.9591
3.5 % NaCl	0 %	13.225	4.965	3514	0.068	2.8084
	2 %	15.972	5.091	4997	0.041	0.0170
	4 %	19.094	4.982	3718	0.048	0.0199
	Hybrid	20.011	7.637	10891	0.014	0.0059

a)



b)



c)

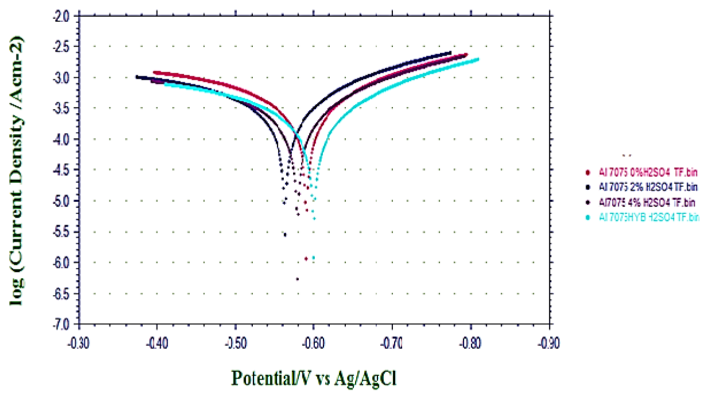
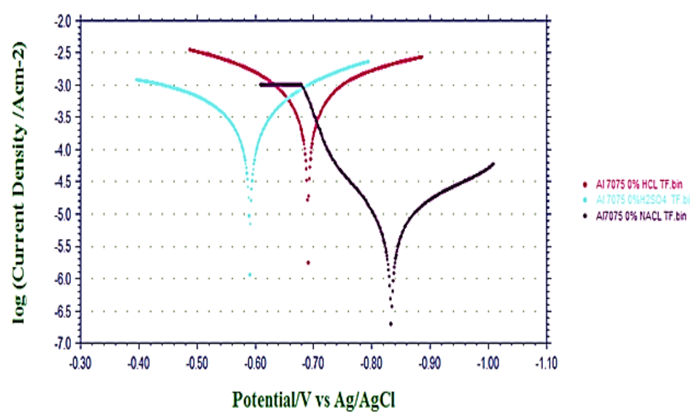
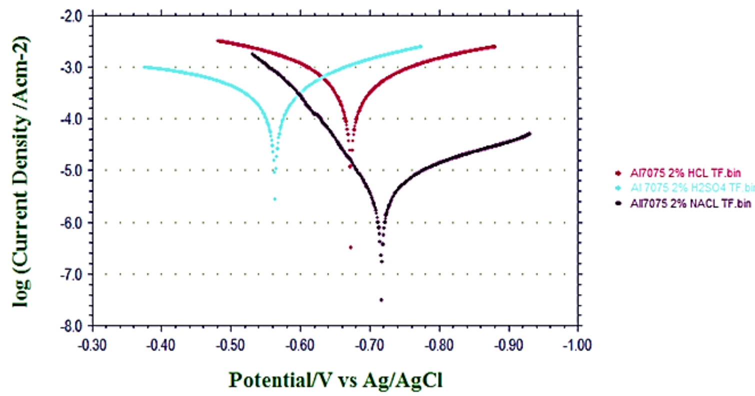


Figure 5:-Tafel Polarization plots for Al7075 base alloy , 2%, 4% and Hybrid composites in 3.5% NaCl , 0.1M HCl and 0.1M H_2SO_4 medium

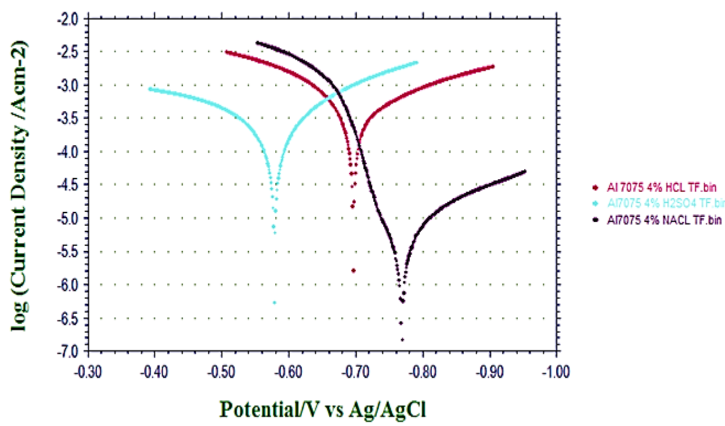
a)



b)



c)



d)

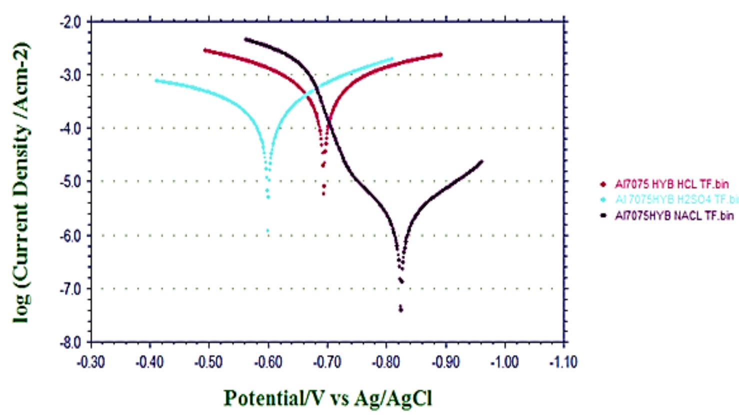


Figure 6:-Tafel Polarization plots for Al7075 base alloy, 2%, 4% and Hybrid composites in different mediums

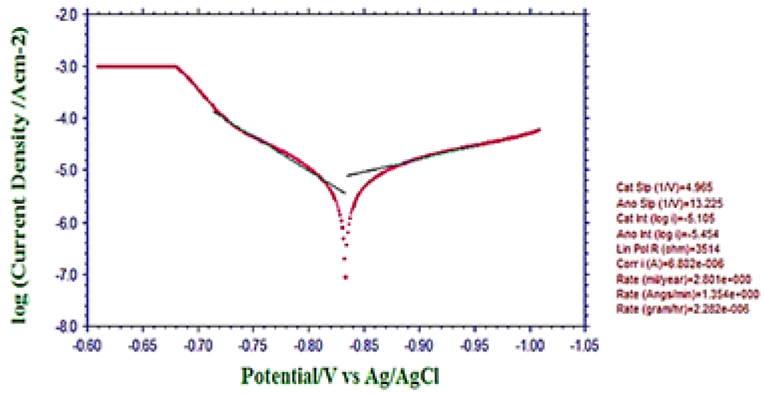
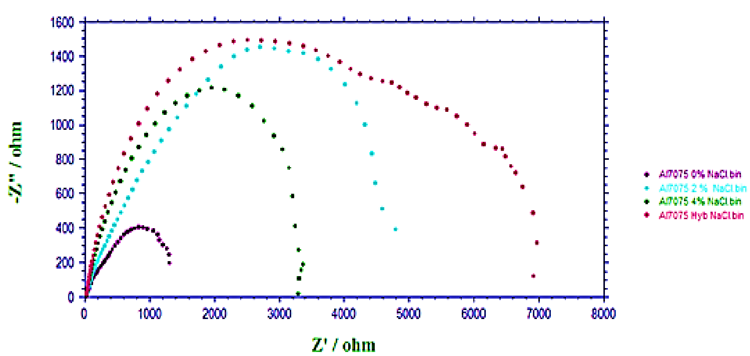


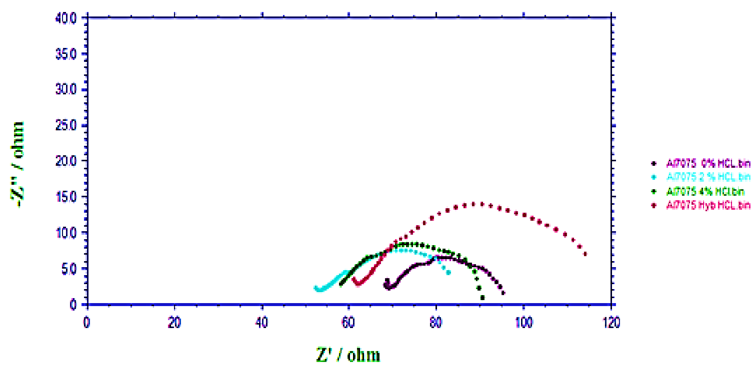
Figure 7:-Tafel extrapolation plots of Al7075 base alloy in 3.5 % neutral chloride medium

EIS measurements:
The corrosion tendencies were investigated at OCP by EIS for the Al7075 base alloy and its composites in inorganic acid mediums, and 3.5 % of neutral chloride medium and Nyquist plots were recorded. The impedance spectrum shows high-frequency capacitive loop (HF) ascribed to the presence of protective oxide film on the surface of metal and low -frequency inductive loop (LF) attributed to the relaxation process obtained by diffusion of ions on and into the oxide film [37]. R(QR (LR) equivalent circuit model for the Metal/ electrolyte interface is used to fit the experimental data of Al7075 base alloy and its 2%, 4 % and hybrid composites .The Nyquist plot with its equivalent circuit model R (QR (LR) of Al7075 base alloy in 0.1M HCl medium is shown (figure 9). It can be visualized from the superimposed Nyquist plot (figure 8) with increment of SiC content in composites the diameter of the capacitive loops above the real axis increases in all mediums as the resistance of the surface oxide film on the composites increases and the diameter of semicircle in neutral chloride medium is higher compared to inorganic acid mediums and also diameter of hybrid composites is larger in all mediums which can be noticed from capacitive loops. From the diameter of semicircles of impedance plots it is obvious that the corrosion process is mainly under charge transfer (RCt) control [38, 39]. So it is affirmed from EIS analysis the rate of corrosion is less in neutral chloride medium compared to various inorganic acid mediums. The increase in the diameter of the semicircle in hybrid composites confirms that hybrid samples are more resistant to corrosion.

a)



b)



c)

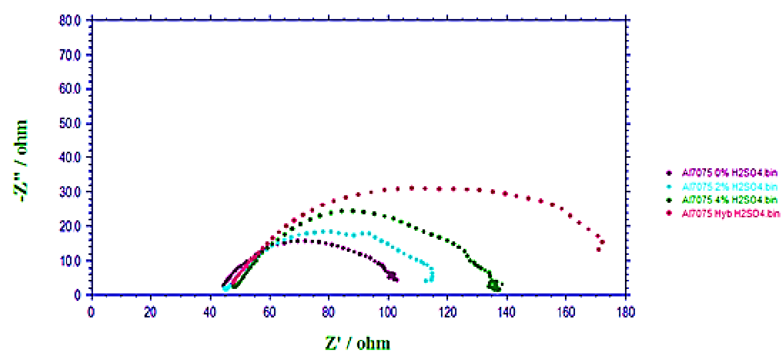


Figure 8:-Nyquist plots for Al7075 base alloy, 2%, 4% and Hybrid composites in 3.5 %NaCl , 0.1M HCl and 0.1 M H_2SO_4 medium .

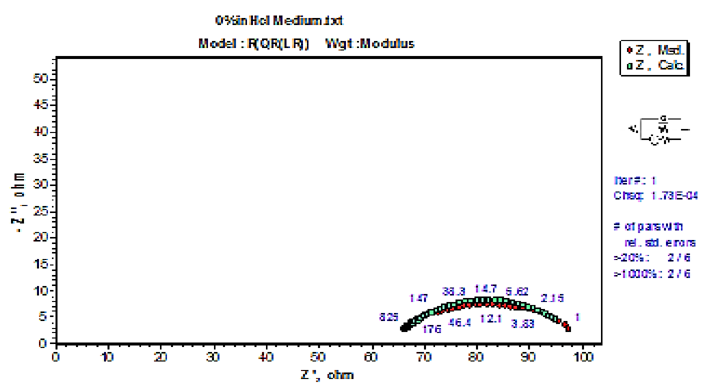


Figure 9:- Nyquist plot with equivalent circuit model of Al7075 base alloy in 0.1M HCl medium

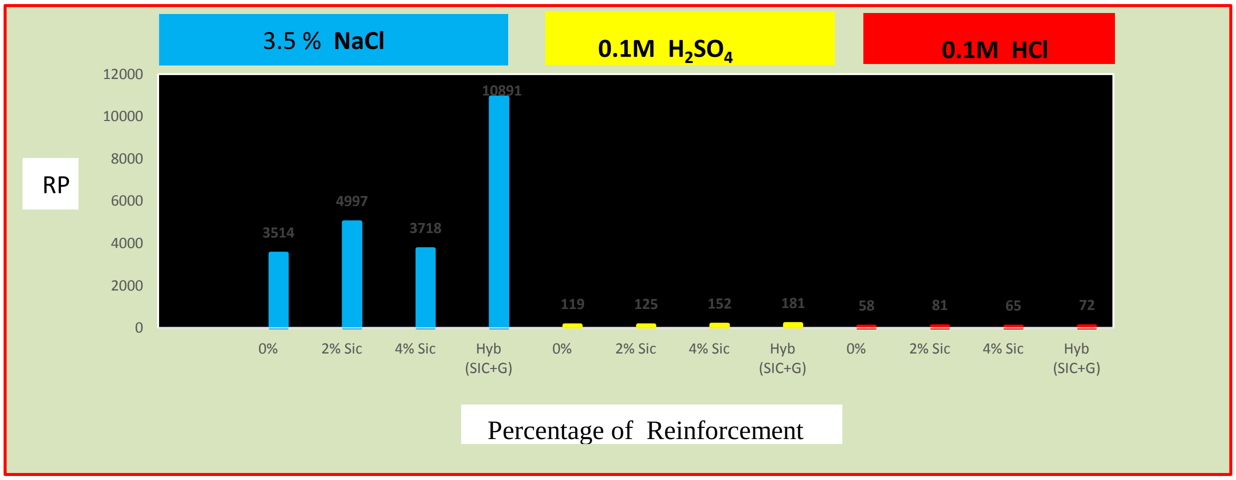


Figure 10:- Resistance Polarisation Verses Percentage of SiC and Graphite Reinforcement in the Al7075 base alloy using 3.5% NaCl , 0.1M H_2SO_4 and 0.1M HCl medium

Effect of medium on mechanism of corrosion

Aluminium and its alloys on aerial oxidation initially covered with an oxide film of amorphous alumina which on exposed to electrolyte solution it thickens by the formation of crystalline hydrated alumina.

$$Al + 3OH^- \rightarrow Al(OH)_3 + 3e^- \quad (2)$$

$$2Al(OH)_3 \rightarrow Al_2O_3\,3H_2O \quad (3)$$

In acidic solutions, the corrosion which is anodic process results in the dissolution of the metal ions from the oxide metal surface into the solution.

HCl medium:

Anodic reaction:

At Al and acid electrolyte interface, the dissolution of Al can be written as follows

$$Al + H_2O \Leftrightarrow Al(OH)ads + H^+ + e^- \quad (4)$$

$$Al(OH)ads \rightarrow Al(OH)^+ + e^- \quad (5)$$

$$Al(OH) \Leftrightarrow Al^{3+} + OH^- \quad (6)$$

In a hydrochloric acid medium, Aluminium chloride formation occurs at the interface as follows

$$HCl + Al \rightarrow Al(HCl) + H_2 \quad (7)$$

$$Al(HCl) \rightarrow Al(Cl)_2 + HCl \quad (8)$$

The Icorr of composites is less than Al7075 base alloy but in 4% composite, the increase in Icorr may be due to the formation of Aluminum chloride at the interface or some dislocations during reinforcement**.**

Cathodic reaction:

The cathodic process is the discharge of hydrogen ions to produce hydrogen gas.

$$H^+ + e- \rightarrow H(ads) \quad (9)$$

$$H(ads) \rightarrow H_2 \quad (10)$$

The positive shift in the corrosion potential Ecorr indicates that the corrosion current increases in anodic direction [40-41]. But in 4% and hybrid composite, the Ecorr shifts in negative direction as cathodic current increases .

H_2SO_4 medium:

The protective oxide film $Al_2O_3\,(H_2O)_n$ is formed on the surface if the oxide film is porous and discontinues it can be destroyed by the bisulphate anions HSO_4^- or SO_4^{2-} [42].

The decrease in Icorr rate in composites due to the protective nature of more compact nonporous $Al_2O_33H_2O$ layer formed on the surface of base alloy.

Anodic reaction:

$$4Al + nH_2O + 3O_2 \rightarrow 2\,Al_2O_3\,(H_2O)_n \quad (11)$$

$$Al_2O_3(H_2O)n+3HSO_4^- + 3H^+ \leftrightarrow Al_2[(SO_4)_3(H_2O)n]ads + 3H_2O \quad (12)$$

Cathodic reaction:

$$Al_2O_3 + H_3O + e^- \leftrightarrow Al_2O_3\,(H_2O) + ½\,H_2 \quad (13)$$

Ecorr value shifts in positive direction in base alloy, 2% and 4% composites it indicates increase in anodic current, but in hybrid composites Ecorr shifts towards negative direction as cathodic current increases due to presence of graphite.

NaCl medium:

Anodic reaction:

The passivation process of the formation of Al_2O_3 takes place on surface [43-44].

$$Al + 3Cl^- \rightarrow AlCl_3^- + 3e^- \quad (14)$$

$$2AlCl_3 + 3H_2O \rightarrow Al_2O_3 + 6H^+ + 6Cl^- \quad (15)$$

Cathodic reaction:

The cathodic reaction is the reduction of oxygen.

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^- \quad (16)$$

Icorr decreases in this medium due to the presence of passive alumina layer Al_2O_3 on the surface that protects from attack of corrosive chloride ions. The slight increase in Icorr and corrosion rate in 4% composite may be due to the formation of some dislocations during reinforcement. Ecorr shifts in a positive direction in base alloy and 2% composite indicates increase in anodic current but in 4% and hybrid composite it shifts towards negative direction.

Micro structural analysis

The surface morphology of base alloy and its composites was assessed by SEM after corrosion tests in different mediums. The SEM images of degraded base alloy sample and its MMCs is shown in (figure 11-13) shows pretty much uniform assault and less degradation of compound in neutral chloride medium. The higher rate of corrosion in 4% HCl medium may be due to the presence of intermetallic precipitates at grains. Galvanic coupling because of the presence of graphite may likewise result in a slight increment in corrosion rate in hybrid samples in corrosive acid chloride medium can be clearly inspected in SEM pictures.

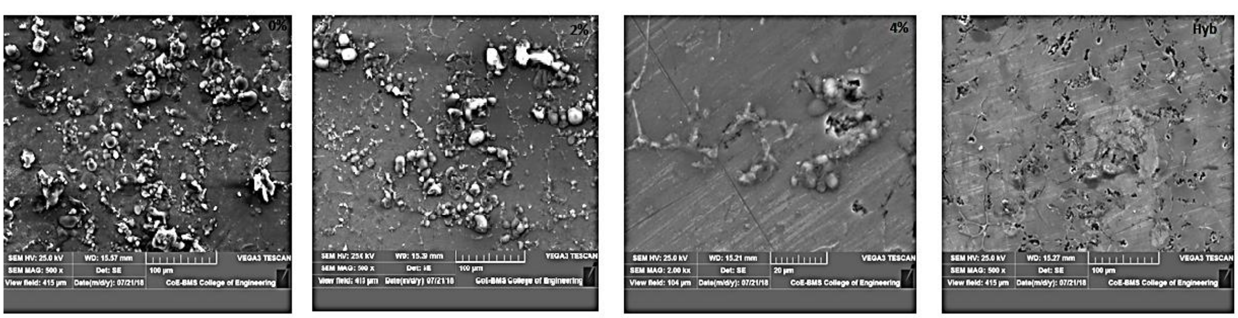


Figure 11:-SEM micrograph of Al7075 base alloy, 2%, 4% and Hybrid composites corrosion in 3.5 % NaCl medium

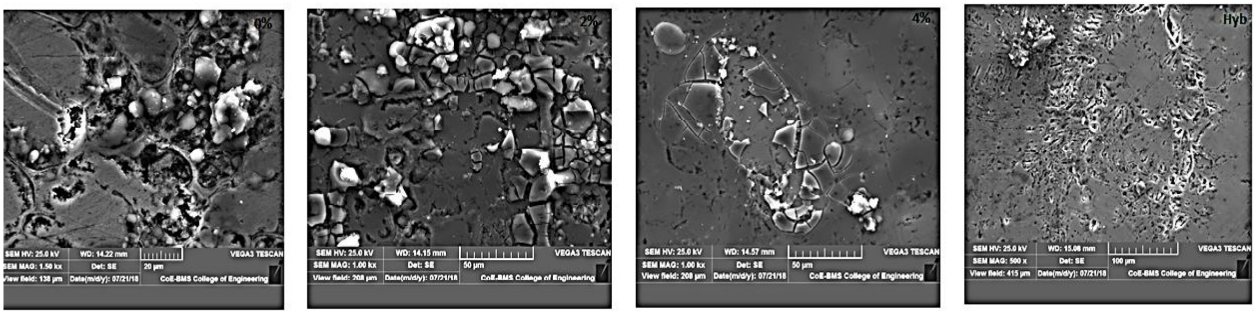


Figure 12:-SEM micrograph of Al7075 base alloy, 2%, 4% and Hybrid composites corrosion in 0.1M HCl medium

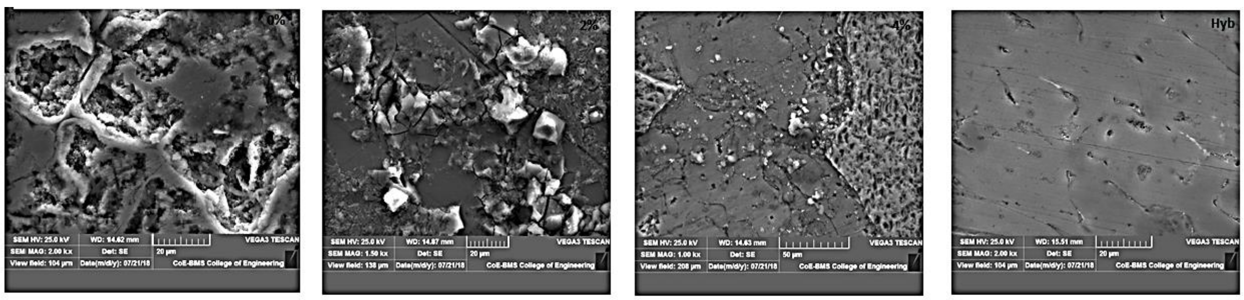


Figure 13:-SEM micrograph of Al7075 base alloy, 2%, 4% and Hybrid composites corrosion in 0.1 M H_2SO_4 medium

Conclusion:-

In this work ,the corrosion aspects of Al 7075 base alloy and its SiC reinforced composites (2% 4% and hybrid) were experimentally assessed using OCP, TPT and EIS techniques in various inorganic acid mediums of 0.1M concentration and 3.5 % of neutral chloride medium and results were concluded as follows.

1. Electrochemical studies of corrosion behavior of Al7075 base alloy and its composites show that corrosion resistance of composites is greater than that of base matrix alloy.
2. The shift in OCP value to positive direction is a good sign indicating that composites are more resistant to corrosion than Al7075 base alloy.
3. Hybrid composites exhibit better corrosion resistance than compared to other composites and base matrix alloy.
4. In the case of 4% composites in HCl and NaCl mediums slight increase in corrosion rate may be due to the formation of intermetallic precipitates at the grains. But in hybrid composites, galvanic coupling and fissures at graphite matrix interface results increase in corrosion rate in acid chloride medium.
5. From the Tafel analysis results it was confirmed, as the Rp values increases in neutral chloride medium compared to different inorganic acid mediums, therefore, corrosion rate in 3.5% neutral chloride medium is less compared to 0.1M inorganic acid mediums.
6. Impedance spectra confirm that the resistance towards corrosion is more in 3.5% neutral chloride medium compared to 0.1M inorganic acid mediums and hybrid composites are more resistant towards corrosion.
7. SEM images show the surface deterioration of both Al7075 base alloy and composites was more in inorganic acid mediums compared to neutral chloride medium. It shows the presence of intermetallic precipitates in some composites in inorganic acid mediums.
8. The results from both TPT, EIS were concordant with each other, they confirm that the corrosion rate in neutral chloride medium is less compared to inorganic acid mediums and composites are more resistant towards corrosion.
9. Tafel graphs show Icorr and corrosion rates are less in composites compared to Al7075 base alloy.

Acknowledgement:-

Authors sincerely express gratitude towards Vision Group on Science and Technology (VGST/GRD114), Government of Karnataka for subsidizing this research work and also R&D Center, Department of Chemistry, Ghousia College of Engineering, Ramanagaram.

Compilance with ethical standards
Conflict of interest on behalf of all authors I states that there is no conflict of interest.

References:-

1. Miracle DB, Donaldson SL (2001): Introduction to Composites. ASM Hand Book of Composite Material p 21
2. Muzakkir, A. K. (2014): An Overview on Effect of Reinforcement and Process Parameters on Properties of Aluminium Based Metal Matrix, International Journal of Research in Engineering and Science 2 10
3. Gowri Shankar M C, Jayashree (2013) :Individual and Combined Effect of Reinforcements on Stir Cast Aluminium Metal Matrix Composites.A Review,International Journal of Current Engineering and Technology 3
4. Wagner (2005): Evolution of Aluminium Alloys for aeronautics After the Two World Wars, MetallurgiaI Taliana 9 (6) : 9-21
5. Kakani SL, Kakani A (2004): Material science New age international publishers, India 593-61
6. Saravanan C, Subramanian K, Ananda Krishnan V, Sankara Narayanan R (2015): Effect of Particulate Reinforced Aluminium Metal Matrix Composite Mechanics and Mechanical Engineering 19 (1) : 23–30
7. Suresha S , Sridhara B K (2010): Effect of addition of graphite particulates on the wear behaviour in aluminium –silicon carbide graphite composites Materials and Design 31 : 1804-1812
8. Uvaraj C and Natarajan N (2012): Comparison on Al6061 and Al7075 with SiC and B4C reinforcement hybrid metal matrix composites IJART 2 :1–1
9. Gunasekaran T, Akilan M , Anandbabu S S , Deeapk kumar N, and Arunprasath D (2016): The Effect of Various Reinforcements on Aluminium Alloy (Al7075) – A Review International Conference on Systems, Science, Control, Communication, Engineering and Technology : 872-877
10. Kumar Bhushan, Rajesh , Kumar and Sudhir (2011): Influence of SiC Particles Distribution and Their Weight Percentage on 7075 Al Alloy Journal of Materials Engineering and Performance 20 : 317-323 doi. 10.1007/s11665-010-9681-6
11. Rajesh Kumar, Bhushan , Sudhir Kumar and Das S (2013): Fabrication and characterization of 7075 Al alloy reinforced with SiC particulates International Journal of Advanced Manufacturing Technology :5-8 ISSN-1433-3015 doi:10.1007/s00170-012-4200-6
12. Suresha, Sridhara B K (2012): Friction characteristics of aluminium silicon carbide graphite hybrid composites, Mater Des 34 : 576-583
13. jelena scepanovic, Dragan Radonjic, Darko Vuksanovic (2018): Investigation of AlMgCu Alloy Corrosion in 0.5M NaCl Polarization and EIS studies Int. J. Electrochem. Sci 13 : 8623 – 8632 doi: 10.20964/2018.09.45
14. Bagesh Bihari, Srijan Prabhakar and Anil Kumar Singh (2018): Corrosion Behaviour of Al 7075/Al2O3/Graphite Hybrid Composite in 3.5% Sodium Chloride Solution International Journal of Engineering Research & Technology 7 (01) ISSN:2278-0181
15. Boopathiraam C, Sambathkumar M (2019): Mechanical Behaviour of Al7075 [B_4C/TiC] Hybrid Metal Matrix Composite using Stir Casting Process International Journal of Engineering Research & Technology ICONEEEA – 2k19 7 02
16. Laxmi and Sunil Kumar (2017): Fabrication and Testing of Aluminium 6061 Alloy & Silicon Carbide Metal Matrix Composites International Research Journal of Engineering and Technology 04 06
17. Rajesh Kumar, Gangaram Bhandare, Parshuram M. Sonawane (2013): Preparation of Aluminium Matrix Composite by Using Stir Casting Method, International Journal of Engineering and Advanced Technology 3 2
18. Sravanthi M and Manjunatha K G (2018): Corrosion Studies of As Casted and Heat Treated Aluminium-7075 Composites Materials Today Proceedings 10 5 p 22581– 22594
19. Batluri Tilak Chandra ,Sanjeevamurthy and Shiva Shankar H S (2016): Corrosion Studies of Al7075 - Albite Particulate Metal Matrix Composites in Sodium Chloride Solution ISSN 0973-4589 11 1 p 71-77
20. Saifulla Khan and Manjunatha K G (2018): Electrochemical analysis of corrosion behavior of Al6061-SiC /graphite composite in various medium 7 3 p 225-235 doi:10.5281/zenodo.1198986
21. Ananda Murthy H C, Somit Kumar Singh (2015): Influence of TiC particulate reinforcement on the corrosion behaviour of Al 6061 metal matrix composites Adv. Mater. Lett., 6 7 p 633-640 doi: 10.5185/amlett.2015.5654
22. Ramya D R and Pruthviraj R D (2017): Potentiodynamic Studies of Aluminium 2024 Alloy in Different Concentration of Hydrochloric Acid Medium at Laboratory Temperature Journal of Material Sciences ISSN 2321-6212 5 4 p 120-126 doi: 10.4172 /2321-6212.1000199
23. Matter E A, Kozhukharov S, Machkova M and Kozhukharov V (2015) : J. Chem. Technol. Metal 50 52

24. Pruthviraj and Rashmi M M (2018): Corrosion behavior of 7075 Aluminium alloy in different concentration of potassium hydroxide at different temperatures.
25. Wilson Nguyen, Jacob Duncan F, Thomas Devine M and Claudia Ostertag P(2018): Electrochemical polarization and impedance of reinforced concrete and hybrid fiber-reinforced concrete under cracked matrix conditions Electrochimica Acta 271 : 319-336
26. Pilic Zora , Martinovic and Ivana (2017): A Comparative Study on the Electrochemical Behaviour of Aluminium and 8090 Al- Li-Cu-Mg Alloy in Acid Rain Solution International Journal of Electrochemical Science12 : 3576–3588 doi: 10.20964/2017.05.46
27. Pavitra Ajagol , Anjan B N, Rajaneesh N Marigoudar and Preetham Kumar G V (2018): Effect of SiC Reinforcement on Microstructure and Mechanical Properties of Aluminum Metal Matrix Composite", IOP Conf. Series: Materials Science and Engineering 376 :012057 doi:10.1088/1757-899X/376/1/012057
28. Goswami, Ramasis, Lynch, Stanley, Holroyd, Knight N J H P, Steven , Holtz and Ronald (2012): Evolution of Grain Boundary Precipitates in Al 7075 upon aging and correlation with stress corrosion cracking behavior metallurgical and materials transactions A. 44 doi:10.1007/s11661-012-1413-0
29. Odusote J K, Adeleke A A and Ajayi PA (2015): Mechanical properties and microstructure of precipitation-hardened Al-Cu-Zn alloys 12 :3033-3042 doi:10.15282/ijame.12.2015.17.0252
30. Zaki Ahmad, Amir Farzaneh and Abdul Aleem B J Corrosion Behavior of Aluminium Metal Matrix Composite Recent Trends in Processing and Degradation of Aluminium Alloys Intech.com 16 :385-406
31. Bobic B, Mitrovic S, Babic M , Bobic I (2010): Corrosion of Metal-Matrix Composites with Aluminium Alloy Substrate Tribology in industry 32 :3-11
32. Afifi M A (2014): Corrosion Behavior of Zinc-Graphite Metal Matrix Composite in 1 M of HCl ISRN Corrosion 2014 Article ID 279856 : 8 doi:10.1155/2014/279856
33. Payan S, Petitcorps Y le, Olive J M and Saadaoui H (2001): Experimental procedure to analyze the corrosion mechanisms at the carbon/aluminum interface in composite materials Composites A 32 3-4 : 585–589 View at Publisher View at Google Scholar View at Scopus
34. Buonanno M A , Latanision R M , Hihara L H and Chiang J F (1991): Corrosion of graphite aluminum metal matrix compositesTech. Rep Office of Naval Research Arlington Va USA View at Google Scholar
35. Chaubey, Singh N V K and Quraishi M A (2017):Electrochemical approachof Kalmegh leaf extract on the corrosion behavior of aluminium alloy in alkaline solution Int J Ind Chem 8:75 doi:10.1007/s40090-016-0103-y
36. Murthy H C, Ananda , Bheema Raju V and Shivakumara C (2013): Effect of TiN particulate reinforcement on corrosive behaviour of aluminium 6061 composites in chloride medium Bulletin of Materials Science 36 doi:10.1007/s12034-013-0560-2
37. Prabhu D F and Padmalatha (2013):Studies of Corrosion of Aluminium and 6063 Aluminium Alloy in Phosphoric Acid Medium 5 6 : 2690-2705
38. Pruthviraj and Rashmi M M (2018): Corrosion behavior of 7075 aluminium alloy in different concentration of potassium hydroxide at different temperatures www.ijrar.org 5,04 E-ISSN 2348-1269 : 528-535
39. Montecelli C, Zucchi F, Brunoro G and Trabanelli G (1997): Corrosion and corrosion inhibition of alumina particulate/aluminium alloys metal matrix composites in neutral chloride solutions. J. Appl. Electrochem 27: 325-334
40. Pruthviraj RD, Rashmi M (2016): Electrochemical Studies of Aluminium 7075 Alloy in Different Concentration of Acid Chloride Medium J Material Sci Eng 5: 221 doi:10.4172/2169-0022.1000221
41. Qu Q,Jiang S,Bai W,Li L (2007): Effect of ethylene diamine. tetra acetic acid disodium on the corrosion of cold rolled steel in the presence of benzotriazole in hydrochloric acid. Electrochem Acta 52: 6811-6820
42. Arellanes-Lozada P, Olivares-Xometl O, Guzman-Lucero D, Likh-anova NV, Dominguez-Aguilar MA, Lijanova IV, Arce-Estrada E (2014): The inhibition of aluminum corrosion in sulfuric acid by poly (1-vinyl-3-alkyl-imidazoliu hexafluorophosphate). Materials 7:5711–5734. https ://doi.org/10.3390/ma708 571134
43. Nady H, Mohamed M, Rabiei E l, Samy M (2017): Corrosion behavior and electrochemical properties of carbon steel, commercial pure titanium, copper and copper–aluminum–nickel alloy in 3.5% sodium chloride containing sulfide ions 26 1 :79-94
44. Kear, G., Barker, B.D, Stokes, K (2004):Journal of Applied Electrochemistry 34:1235. https://doi.org/10.1007/s10800-004-1758.