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Yttrium Chloride as Corrosion Inhibitor for 6061Al- SiC Composites in 1:1 mixture of HNO_3 + HCl

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Abstract: **The corrosion studies were conducted on Al 6061-15% SiC composites in a 1:1 mixture of HNO_3 and HCl solution of different concentrations viz. 1M, 0.5M and 0.1M at 30, 40 and 50ºC using Tafel Extrapolation Technique. Corrosion Inhibition studies were carried out using Yttrium Chloride in different concentrations viz. 50, 100 and 200 ppm. From the data gathered, various thermodynamic and kinetic parameters were calculated. Al – SiC composite was found to be severe to corrosion in 1M HCl+HNO_3.The corrosion rate of composite increases with increase in temperature. Yttrium Chloride is found to be effective in decreasingthe corrosion rates about 91% inhibition was observed at 200 ppm concentration of the inhibitor in HCl+HNO_3.The efficiency of inhibition increases with concentration of inhibitor.**

Index Terms: **Al 6061-SiC composites, 1:1 mixture of HNO_3 and HCl, Corrosion inhibition, Yttrium Chloride inhibitor, physisorption, Frumkin adsorption isotherm.**

I. Introduction

Aluminum alloys 6061 reinforced with SiC have a wide range of applications like space engineering anddefense [1-5]. There is a decrease in Corrosion resistance of Aluminium Silicon carbide composites compared to its base alloy. A protective oxide layer increases corrosion resistance of Aluminium alloys. But inclusion of SiC particles causes discontinuities in the surface film and increases the number of sites where corrosion can be initiated and makes the composite more vulnerable [1,2,3,6-9]. The intensity of pitting corrosion observed on 6061 Aluminium Silicon carbide composite was greater compared to corresponding unreinforced alloys. It is also showing that corrosion of composites greater than the base alloy. [10]

II. Literature Survey

[1] P. D Reena Kumari, Jagannath Nayak and A. Nityananda Shetty studied the inhibition action of 3-Ethyl-4-amino-5-mercapto-1,2,4-triazole on 6061 Aluminium Silicon carbide composites in sodium hydroxide solution by using potentiodynamic polarization and electrochemical impedance spectroscopy. They found that adsorption of inhibitors on composite through physisorption.

[2] Geetha Mable Pinto , Jagannath Nayak & A. Nityananda Shetty studied inhibition action of 4-(N,N-Dimethylamino) Benzaldehyde Thiosemicarbazone on 6061 Aluminium Silicon carbide composites in Sulfuric acid medium of different concentrations at various temperatures using Tafel Extrapolation and AC impedance spectroscopy. They observed 70% inhibition efficiency in 0.5 M sulfuric acid. The adsorption of inhibitors on composite was found to be through physisorption. [3] Geetha Mable Pinto , Jagannath Nayak & A. Nityananda Shetty studied the corrosion behavior of 6061 Aluminium Silicon carbide composites in different concentrations of 1:1 hydrochloric acid and sulphuric acid medium at different temperatures. The results showed that an increase in the corrosion rate of composite with temperature and concentration of medium.

III. Experimental Procedure

A. Material

The 6061 Aluminium Silicon carbide composites, having SiC particles of size 25 microns and 99.8% purity, were casted in the form of cylinders. The composites were extruded at 450^0C- 500^0C. The tests were conducted on composite in extruded rod form of 11.5 mm diameter. The composition of the composite under use is presented in Table.I and the microstructure is shown in Fig.1

TABLE I.
Composition of Base (6061 Al) Alloy

Element	Cu	Mg	Si	Cr	Al
Weight %	0.25	1.0	0.6	0.25	Balance

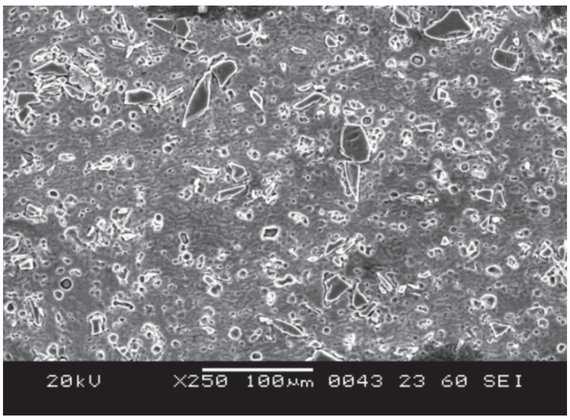

Figure 1. Microstructure of the 6061 Al-SiC sample Etchant: Keller's reagent

CVR Journal of Science and Technology, Volume 18, June 2020
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B. Medium

The corrosion studies were conducted in a 1:1 mixture of HNO_3 and HCl solution of different concentrations viz. 0.1M, 0.5M and 1M at three temperatures; 30, 40 and 50ºC. Inhibition studies were carried out using Yttrium Chloride which was used at different concentrations viz. 50, 100 and 200 ppm.

C. Method

Tafel extrapolation studies were performed on cross sectional surface of cylindrical 6061 Aluminium Silicon carbide composites by exposing the surface to acid medium with and without inhibitor at above testing conditions by using CH instrument electrochemical analyzer. For each test, corrosion potential and corrosion current density were determined from a graph between PotentialE) and log i. Then, Corrosion rate and inhibition efficiencies were calculated by using following formula

$$CR = \frac{0.129 \text{ X } EW \text{ X } i_{corr}}{D}$$

Where CR is the corrosion rate in mpy; i_{corr} is the corrosion current density in μA/ cm^2, EW is the equivalent weight and D is the density.
The surface coverage (θ) is calculated as

$$\theta = \frac{(i_{corr\ (uninh)} - i_{corr\ (inh)})}{i_{corr\ (uninh)}}$$

Where, $i_{corr(uninh)}$ is the corrosion current density in the absence of inhibitor and $i_{corr(inh)}$ is the corrosion current density in the presence of inhibitor.
The percentage inhibition efficiency (% IE) = θ× 100.

IV. RESULTS AND DISCUSSIONS

A. Corrosion behavior in 1:1mixture of $HNO_3$and HCL medium

The corrosion rates were determined using Tafel extrapolation technique as mentioned earlier and typical plots are shown in following figures

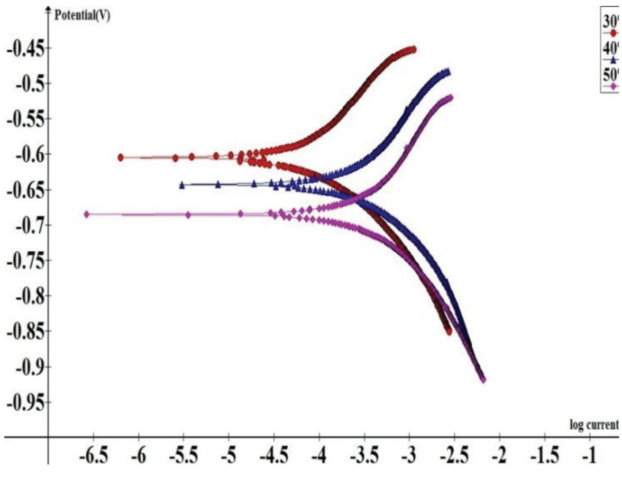

Figure 2. Tafel plot for 0.1M (HNO_3 +HCl) solution at different temperatures.

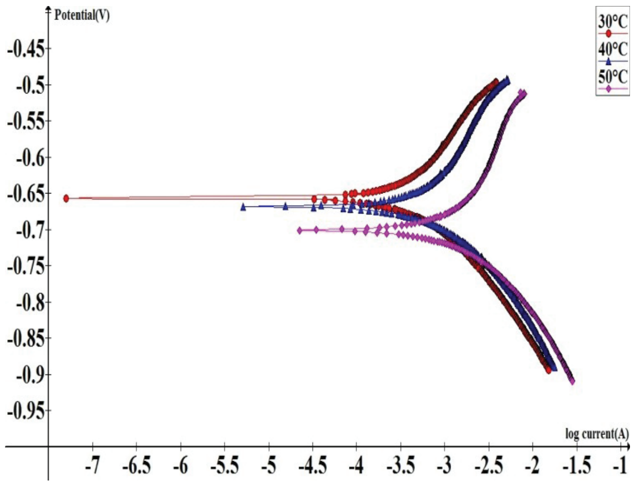

Figure 3. Tafel plot for 0.5M (HNO_3 +HCl) at different temperatures

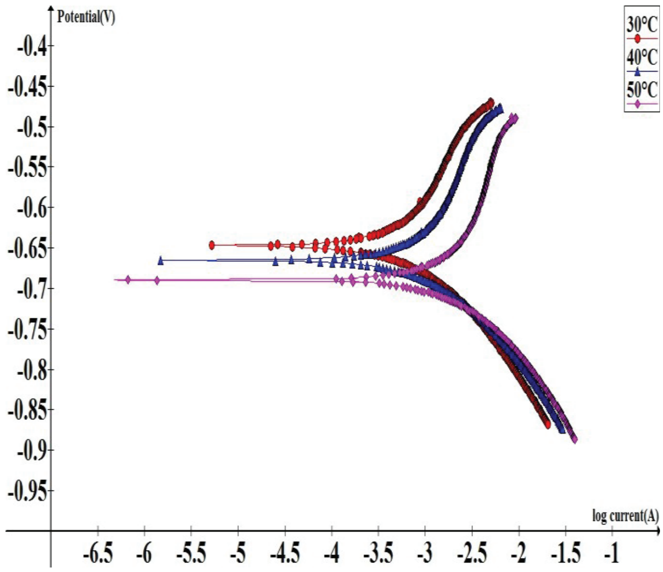

Figure 4. Tafel plot for 1 M (HNO_3 +HCl) at different temperatures

CVR Journal of Science and Technology, Volume 18, June 2020
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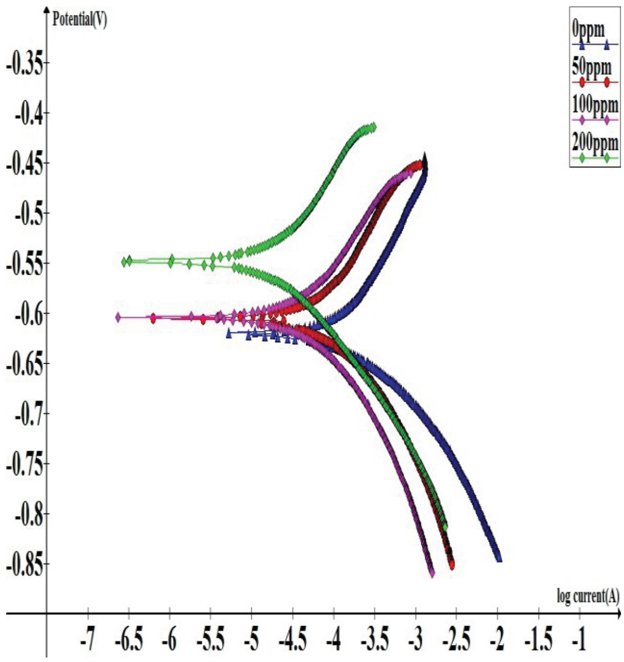

Figure 5. Tafel plot for 0.1 M (HNO_3 +HCl) at 30^0C with different concentrations of Yittrium chloride

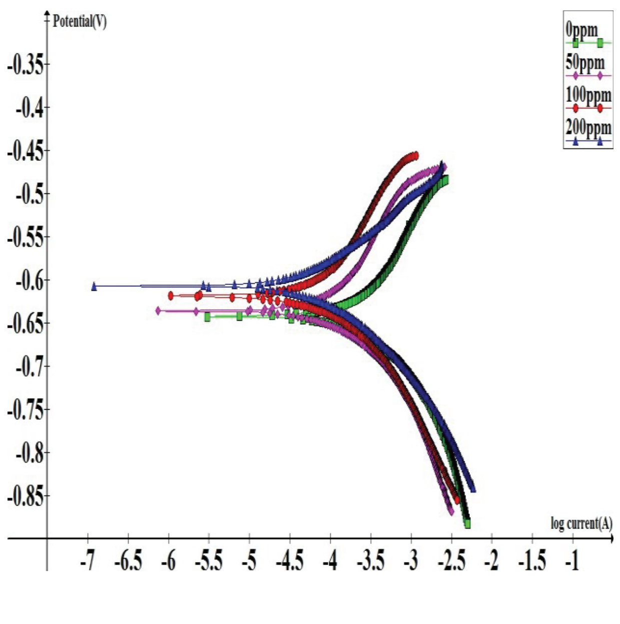

Figure 6. Tafel plot for 0.1 M (HNO_3 +HCl) at 40^0C with different concentrations of Yittrium chloride

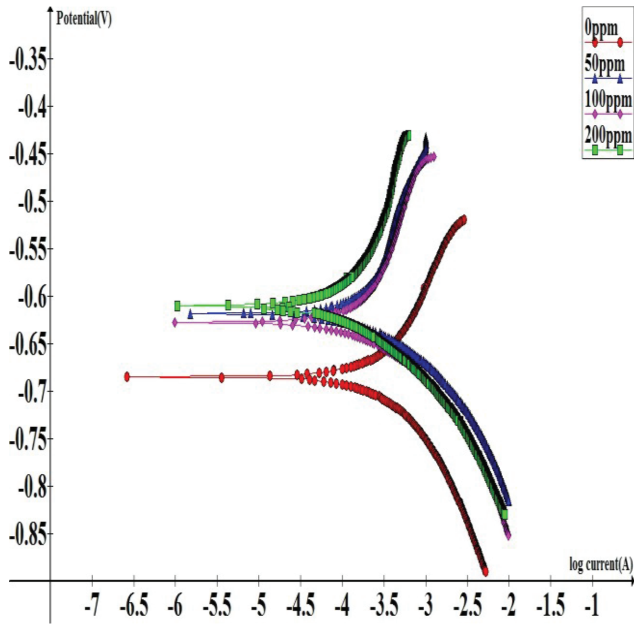

Figure 7. Tafel plot for 0.1 M (HNO_3 +HCl) at 50^0C with different concentrations of Yittrium chloride.

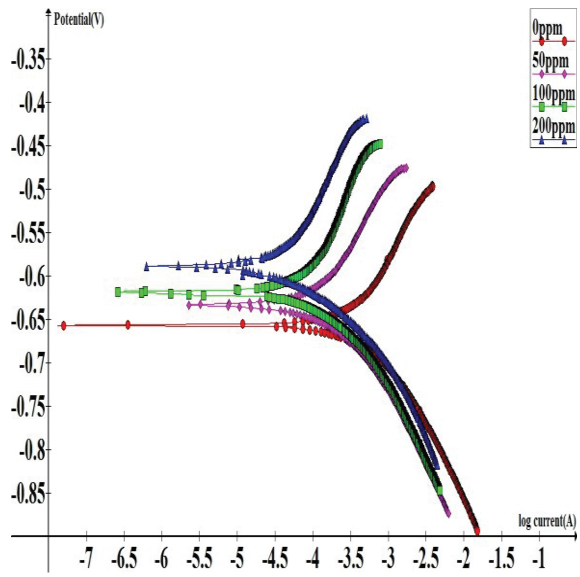

Figure 8. Tafel plot for 0.5 M (HNO_3 +HCl) at 30^0C with different concentrations of Yittrium chloride

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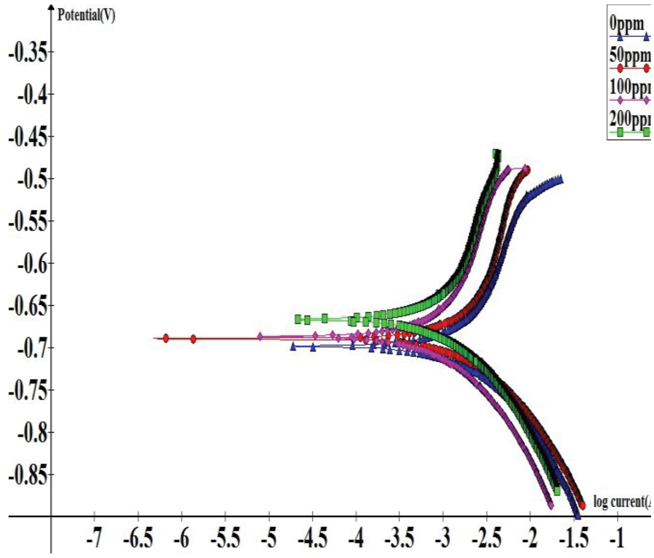

Figure 9. Tafel plot for 1 M (HNO_3 +HCl) at 50^{0}C with different concentrations of Yittrium chloride.

Average values of corrosion rates in 1:1 mixture of HNO_3 + HClsolution obtained for different temperatures are presented in the Table. II

TABLE II.
CORROSION RATES OF 6061AI-SIC COMPOSITE IN DIFFERENT CONCENTRATIONS OF (HNO_3+HCL) AT DIFFERENT TEMPERATURES

Medium	Temperature (°C)	Corrosion Rate (mpy)
1M HCl+HNO3	30	450.46
	40	1030.17
	50	1579.57
0.5M HCl+HNO3	30	235.21
	40	730.63
	50	1183.84
0.1M HCl+HNO3	30	118.93
	40	334.81
	50	370.55

The above table shows that corrosion rate increases as temperature increases at each concentration of medium. And, corrosion rate increases as the concentration of medium increases.

Average values of corrosion rates after adding inhibitor in various concentrations to different concentrations of HNO_3+HCLat different temperatures is presented in Table III.

TABLE III.
CORROSION RATES OF 6061AI-SIC COMPOSITE IN DIFFERENT CONCENTRATIONS OF (HNO_3+HCL) AT DIFFERENT TEMPERATURES WITH YTTRIUM CHLORIDE

Medium	Temperature (°C)	Corrosion Rate (mpy)			
		Inhibitor concentration			
		0ppm	50ppm	100ppm	200ppm
1M HCl+HNO3	30	450.46	135.05	88.94	83.77
	40	1030.17	798	742.63	657.59
	50	1579.57	1263.2	847.04	765.37
0.5M HCl+HNO3	30	235.21	93.12	77.46	62.47
	40	519.4	519.4	458.46	330.86
	50	1183.84	848.72	775.05	594.44
0.1M HCl+HNO3	30	118.93	79.69	24.73	10.63
	40	334.81	160.52	98.93	56.41
	50	370.55	215.29	135.05	68.03

The above table is showing that addition of inhibitors decreased the corrosion rate at each temperature and concentration of the medium.

TABLE IV.
INHIBITION EFFICIENCY OF YTTRIUM CHLORIDE IN 1:1(HNO_3 +HCL)

Medium	Temperature (°C)	Inhibition efficiency (%)		
		Inhibitor concentration		
		50ppm	50ppm	50ppm
1M HCl+HNO3	30	70.54	80.6	81.7
	40	22.9	27.9	51.53
	50	20.2	46.3	36.16
0.5M HCl+HNO3	30	62	67.06	73.43
	40	30.2	38.2	55.4
	50	28.3	34.5	49.78
0.1M HCl+HNO3	30	32.9	79.2	91.05
	40	52.05	70.45	82.77
	50	36.4	60.1	79.92

From the above table, we can see thata maximum inhibition efficiency of about 91% was achieved with 200 ppm of inhibitor addition in 0.1M (HCl+HNO_3) at 30°C.

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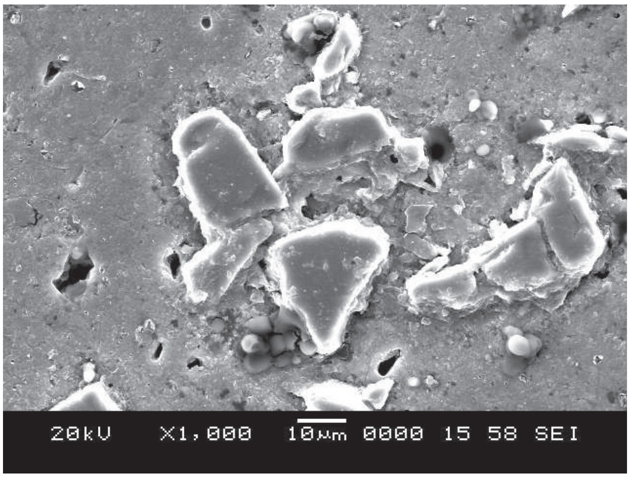

Figure 10. Corroded sample of 6061 Al-SiC in 1M HCl+HNO_3 at 30°C.

The SEM image of the corroded sample as shown in the Fig. 10 indicates that there is uniform corrosion along with corrosion around SiC particles. This is because of the galvanic effect between particle and the matrix in which matrix acts as anode.

V. Conclusions

- 6061 Aluminium Silicon carbide composite is subjected to corrosion in 1:1 (HCl+HNO_3) solution.
- Corrosion rate of composite increases with increase in temperature and with increase in concentration.
- An addition of 200 ppm Yttrium Chloride achieved91% inhibition efficiency and is found to be effective inhibitor

References

[1] P.D. Reena Kumari, Jagannath Nayak and A. Nityananda Shetty, PortugaliaeElectrochimica Acta, 29 (2011), 445-462.
[2] Geetha Mable Pinto, Jagannath Nayak and A. Nityananda Shetty,Synthesis and Reactivity in Inorganic, MetalOrganic and Nano-Metal Chemistry, 41 (2011) 127-140.
[3] Geetha Mabel Pinto, Jagannath Nayak and A. Nityananda Shetty, Int. J. Electochem. SCI. 4 (2009), 1452-1468.
[4] C. Monticelli, F. Zucchi, G. Brunoro, G. Trabanelli, *J. Appl. Electrochemistry*, 27(1997)325
[5] A. Pardo, M.C. Merino, S. Merino, F. Viejo, M. Carboneras, R. Arrabal, *Corrosion Science*, 47(2005) 1750.
[6] A. Pardo, M.C. Merino, S. Merino, M. D. Lopez, F. Viejo, M. Carboneras, *Mater. Corros.*, 54(2003) 311.
[7] C. E. Da Costa, F. Velasco, J. M. Toralba, *Rev. Metal. Madrid.*, 36(2000)179.
[8] P. K. Rohatgi, *JounalofMetals,* 43(**4**) (1991)10.
[9] A. J. Trowsdale, B. Noble, S. J. Harris, I. S. R. Gibbins, G. E. Thomson, G. C. Wood, *Corrosion Science*, 38(1996) 177.
[10] R. C. Paciej, V. s. Agarwala, *Corrosion* 42(1986)718.