

Research Article

**Stress Corrosion Studies Of Aluminum 2024 Hybrid Composites at 1N HCl solution using High temperature autoclave**

**Corresponding author: PRUTHVIRAJ.R.D \***  
**RAMYA D R<sup>1</sup>, H.M.SOMASHEKAR<sup>2</sup>**

\* Chemistry R&D Centre, Department of chemistry, RajaRajeswari College of Engg, Bengaluru, Karnataka

<sup>1</sup> Research Scholar, Chemistry R&D Centre, Department of chemistry, RajaRajeswari College of Engg, Bengaluru, Karnataka

<sup>2</sup> Department of Mechanical Engg, Dr. Ambedkar Institute of Technology, Bangalore, Karnataka, India

**Received on: 20-04-2020; Revised and Accepted on: 27-04-2020**

**ABSTRACT**

The present work is to have a look at stress corrosion behaviour of Aluminium 2024 hybrid composites containing 2% Al<sub>2</sub>O<sub>3</sub> and 2, four and 6 weight probabilities of silicon carbide particulates. Composites are synthetic through stir casting approach like liquid melt metallurgy method using vortex method. Three factor loaded specimens, typically flat strips of measurement 8mm thickness, 40mm wide and 150mm lengthy have been machined from the composites by using adopting widespread metallographic manner for the strain corrosion checking out. Matrix alloy turned into also machined in the same manner for comparison. Stress corrosion exams were conducted in a stainless steel autoclave by using static weight loss method for different exposure time, normality and temperature of the hydrochloric acid medium. Stressed specimens additionally subjected to test the mechanical residences like ultimate tensile electricity and located that its fee with respect to hybrid composite material accelerated after subjecting them for stress corrosion. The corrosion costs of hybrid composites have been decrease than the ones of Aluminium 2024 matrix alloy underneath all conditions. Hence hybrid composites can be preferred in vicinity of metallic or alloy in numerous applications.

**KEYWORDS:** Aluminium 2024, Autoclave, Al<sub>2</sub>O<sub>3</sub>, Silicon carbide, Vortex method.

**INTRODUCTION:**

**1. Introduction**

Aluminium primarily based hybrid metal matrix composites discovered to possess higher hardness, tensile strength, toughness. Hybrid composites are the ones materials which encompass two specific reinforcement materials. They can be of organic or inorganic origin. The presence of two exceptional reinforcements will virtually affect the mechanical, tribological and machining residences. Identified reinforcements graphite, alumina and Al<sub>2</sub>O<sub>3</sub> alters the mechanical and tribological behaviour and influences the machinability. 1 Aluminium 2024 alloy is a member inside the institution of hypo eutectic Al-Si alloys and has a huge variety of software in the automobile and avionics industries. The alloy undergoes solidification in a large temperature c program language period and is amenable to

remedy in the semi strong state as well as casting. Aluminium 2024 alloy is used as a matrix for acquiring composites, which have an superior wear resistance, beneficial mechanical residences at room temperature and stronger mechanical properties at multiplied temperatures. 2K.Vinutha et al<sup>3</sup> studied the strain corrosion behaviour of aluminium 2024 based steel matrix composites reinforced with titanium dioxide particulates in hydrochloric acid and record that because the concentration of acid, time of publicity and temperature increases the corrosion rate of the composites will increase.

**Corresponding Author:**

Pruthviraj. R. D

Chemistry R&D Centre

Department of chemistry, Raja Rajeswari College of Engg, Bengaluru, Karnataka, India

Email: [pruthvirajrd@gmail.com](mailto:pruthvirajrd@gmail.com)

DOI: <https://doi.org/10.5281/zenodo.3768701>

However as the proportion of reinforcement increases, stress corrosion rate decreases in all concentrations of hydrochloric acid. Hence they advocate that composites are extra appropriate than matrix alloy in a scenario where cloth experiences pressure. H.V.Jayaprakash et al studied the stress corrosion studies of Aluminium 7075 alloy strengthened with beryl particulates. Composite materials have been synthetic by way of liquid softening metallurgy method the usage of vortex method. They subjected the composites of Aluminium 7075 with unique chances of beryl particulates to stress corrosion in hydrochloric acid and report that growth in awareness, time of publicity and temperature will without a doubt have affect in the boom of stress corrosion rate. But the growth in reinforcement content material will without a doubt lessen the corrosion rate no matter the above stated points. K.N.Chandrashekhara et al<sup>5</sup> manufactured composite substances comprising of Aluminium 6013 as matrix and purple mud particulates as reinforcement and subjected them to pressure corrosion studies in a stainless-steel autoclave using special concentrated answers of hydrochloric acid. The exams had been carried out at different variety of temperature and various time of exposure. The results obtained with the aid of them famous that reinforcement will behave as inert fabric and not affected by any corrosion medium and decreases corrosion rate with growth in time of publicity. Extensive literature survey offers a file that so far stress corrosion studies of Aluminium 2024 hybrid composites have not been conducted.

#### EXPERIMENTAL DETAILS

Matrix cloth selected in this take a look at is Aluminium 2024 alloy which is to be had commercially. Table 1 given beneath offers the composition of the matrix alloy.

**TABLE 1:** Composition of Aluminium 2024 alloy matrix

Met al	Si	F e	C u	M n	Mg	Z n	Ti	Othe rs	Al
%	6.5-7.5	0.2	0.2	0.1	0.25-0.4	0.1	0.2	0.15	Balan ce

Reinforcement materials used in this work are first-rate powdered Al<sub>2</sub>O<sub>3</sub> and particulates of Silicon carbide of length 50-80 microns. Al<sub>2</sub>O<sub>3</sub> is a waste obtained in thermal electricity stations after the combustion of coal. It is located to incorporate oxides of many metals. It is procured from Raichur Thermal Power station, Shaktinagar, Karnataka. Silicon carbide particulates is to be had commercially. Hybrid composite substances of the alloy is synthetic with the aid of liquid melt metallurgy approach adopted by way of P.V.Krupakara.<sup>6</sup>The Aluminium 2024 alloy changed into delivered into a backside pouring electric powered furnace and heated upto 650o C .The alloy matrix became subjected to stirring with the help of mechanical impeller to create a well depth vortex .Then Al<sub>2</sub>O<sub>3</sub> and silicon carbide particulates preheated at about 340o C in a muffle furnace are brought into molten alloy matrix. The combination is then stirred constantly at 320 rpm. The molten combination is poured into the preheated everlasting iron moulds. Composite fabric together with 2% Al<sub>2</sub>O<sub>3</sub> and 2, 4 and 6 weight chances of silicon carbide had been synthetic. To compare the outcomes of hybrid composites matrix alloy turned into additionally casted within the same way. The medium used to test pressure corrosion become extraordinary concentrated answers of hydrochloric acid. Three factor loaded specimens are normally flat strip of 8 mm thickness, forty mm huge and 150 mm long dimensions and have been machined from the hybrid composite substances and the matrix alloy for strain corrosion trying out. Before checking out, the specimen surfaces were floor with silicon carbide paper of 1000 grit and then polished in steps of 1 to 3m diamond paste to acquire a mirror floor finish. After next rinsing

with water and acetone, the specimens have been weighed precisely to four decimal places via an automated electronic balance earlier than testing. Autoclaves are often used for strain corrosion testing at excessive temperature and pressure. The Teflon coating protects the autoclave from severe competitive environments. Figure 1 suggests stainless-steel autoclave used on this examine. Fig 2 shows the bracket used to load corrosion specimen to be positioned inside the autoclave.



FIGURE 1: Stainless steel autoclave

FIGURE 2: Bracket holding the specimen

The tests were conducted in different concentrated solutions of hydrochloric acid by subjecting the specimens to different exposure time and a wide range of temperature.

**RESULTS AND DISCUSSION**

The results of pressure corrosion tests of Aluminium 2024 hybrid composites reinforced with Al<sub>2</sub>O<sub>3</sub> and silicon carbide at distinct awareness, time of publicity and temperature are given inside the figures 3 to 5.

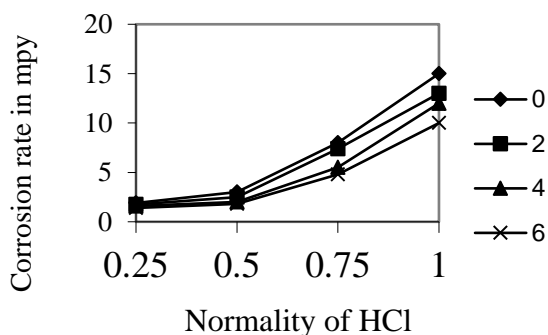


FIGURE 3: Corrosion rate against concentration of HCl

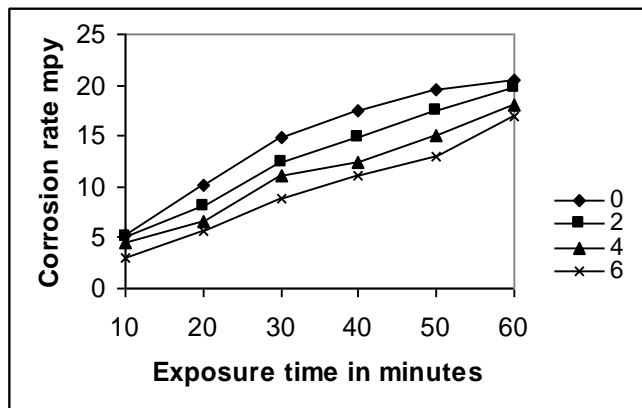


FIGURE 4: Corrosion rate against time in minutes At 100°C for 30 minutes at 100°C in 1 N HCl

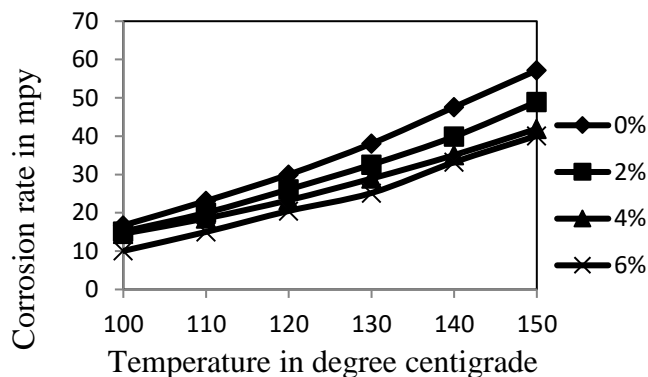


FIGURE 5: Corrosion rate against temperature in 1 N HCl for 30 minutes

**Effect of concentration**

The plot of the pressure corrosion price verses special concentrations of HCl at a thousand C for 30 minutes of publicity time is proven in determine three. The 4 curves represent the proportion of silicon carbide within the hybrid composites. It is sincerely observed that the pressure corrosion fees of the specimens growth with boom in the concentrations of the HCl. The corrosion price of specimen in 1NHCl answer is more than the corresponding corrosion rate in 0.25 N. The corrosion costs are at once encouraged by outside variables, along with

temperature of corrodent answer, attention of hydrogen in answer, specimen publicity time and specimen area.

### Effect of test duration

Stress corrosion rate as opposed to exposure time of Aluminium 2024 and its hybrid composites at 1000C is proven in Fig. The corrosion rates of both matrix alloy and hybrid composites boom with boom in the publicity time. From literature survey on Aluminium composites<sup>7,8,9</sup> it is discovered that within the absence of strain, the corrosion fee decreases with duration of the check. The lower of corrosion rate might be because of the sluggish deposition of hydroxide layer. But inside the strain corrosion study the corrosion price increases with increase in exposure time and it may be because of the cracking of aluminium hydroxide film fashioned between the steel and corrosion medium upon software of strain. With growth in time the thickness of the  $Al(OH)_3$  layer will increase which is prone to cracking. Hence the corrosion price increases with exposure time.

### Effect of temperature

The pressure corrosion charges of Aluminium 2024 and its hybrid composites in 1N HCl for 30 minutes exposure time at distinctive temperatures is proven in parent 5. Corrosion charge become observed to boom with increase in temperature. This is attributed to the extended diffusion charge of hydrogen with increase in temperature. Hydrogen is determined to evolve even if aluminium is uncovered to boiling water. The hydrogen generation and its entry into metal may additionally possibly be a localized action other than a preferred surface phenomenon. Hydrogen permeation is related to the kinetics and mechanism of hydrogen technology on the external floor of the sample.

Aluminium dissolves in corrodent answer with era of hydrogen.

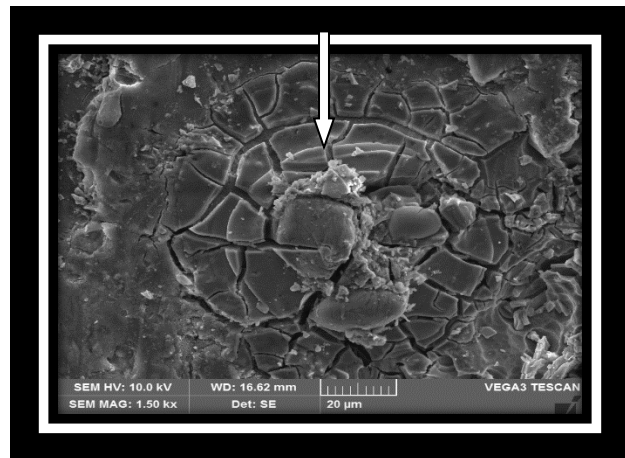
### Effect of reinforcement

The reinforcement particles are inert and subsequently do not react with the matrix alloy. The price of corrosion for both the matrix alloy and reinforced composite will increase with publicity time, normality and temperature. However, the growth in corrosion charge is lower for the hybrid composites in comparison to base Aluminum 2024 alloy below all conditions. The interface between the matrix alloy and the reinforcement is the weakest a part of particulate reinforced composites. Hence the character of the interfacial bond is important within the corrosion process. Since the composites display advanced mechanical properties, it may be claimed that the interface between aluminum and reinforced particle is pretty strong<sup>10</sup>. This would have encouraged the improvement within the corrosion resistance of those composites. In aid of this, it has been discovered that because the reinforcement particle content is accelerated there may be discount in corrosion charge.

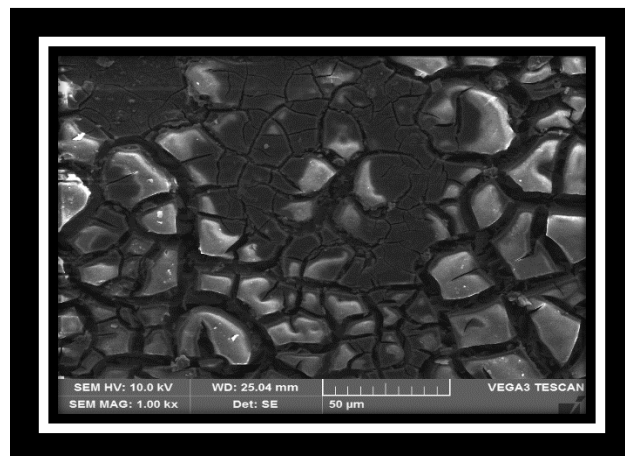
The decrease in the corrosion price with increase in reinforcement content material may also be because of the formation of magnesium intermetallic compound at the interface at some point of casting as discussed by way of Trazaskoma<sup>11</sup>. The magnesium intermetallic compound is more energetic than the matrix alloy, which is clear from the presence of pits on the interface. The lively nature of the crevices may additionally cathodically protect the remainder of the matrix and restriction pit formation and propagation. Magnesium depletion zones have an anodic behaviour in terms of the adjoining zones that have better Mg contents (cathodic zones). The corrosion of the

composites takes place preferentially close to the intermetallic phases inclusive of Mg<sub>2</sub>Si (noble precipitate) because of the minor Mg content material inside the adjacent matrix. The lower in the corrosion fee with increase in reinforcement content material may additionally be because of the formation of magnesium intermetallic compound on the interface for the duration of casting as discussed with the aid of Trazaskoma<sup>11</sup>. The magnesium intermetallic compound is greater lively than the matrix alloy, which is clear from the presence of pits on the interface. The lively nature of the crevices may also cathodically guard the the rest of the matrix and limit pit formation and propagation.

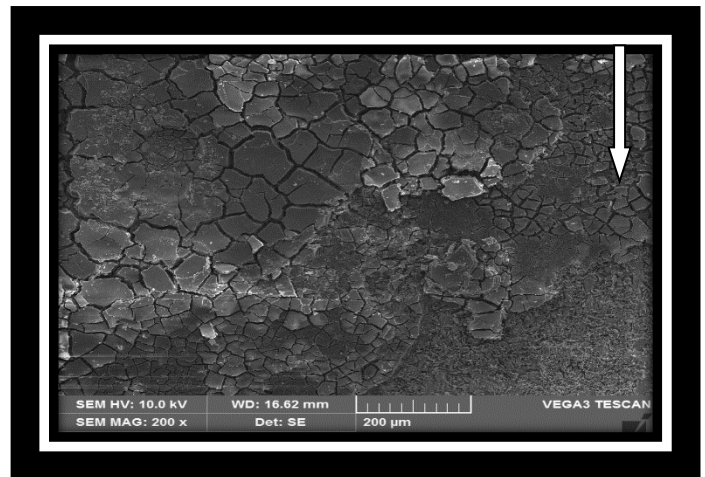
**SEM IMAGES OF AFTER STRESS CORROSION TEST:**



**a) Corrosion test(0%-Al2024alloy)**



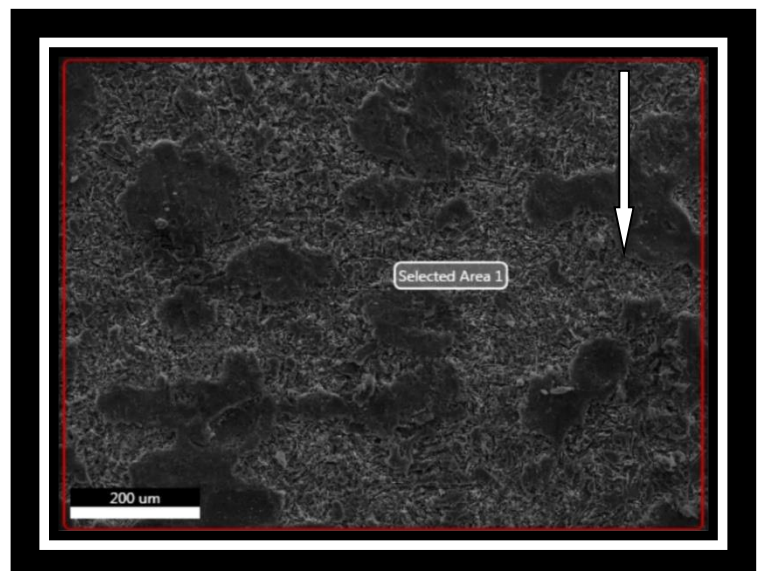
**b) corrosion test(2%+2%-Al2024alloy)**



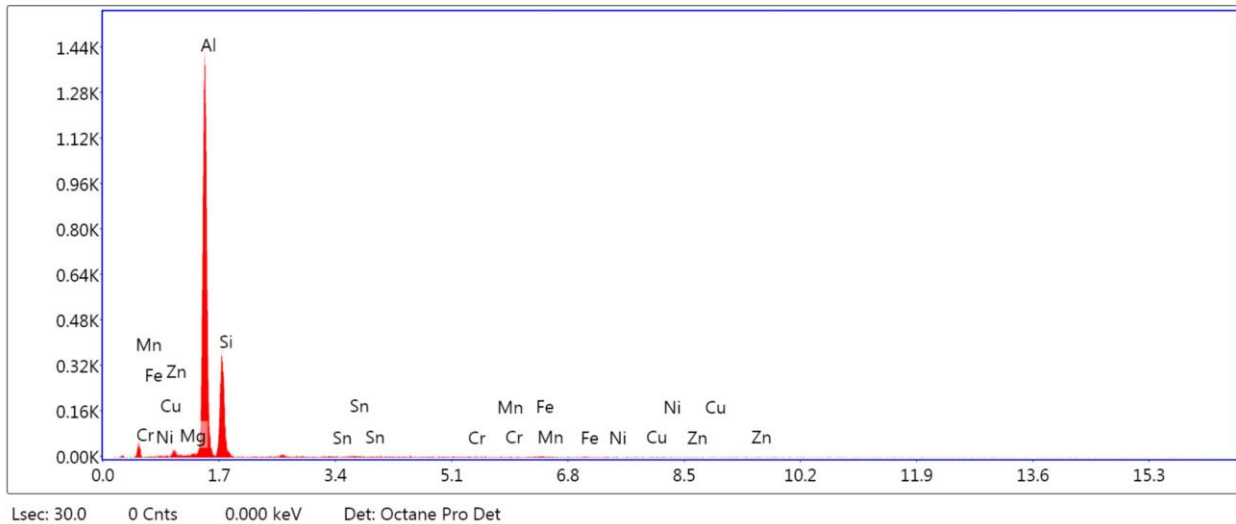
**c) Corrosion test (2%+4%-Al2024alloy)**

Fig.6 Fig.a shows the stress corrosion test without reinforcement of Al<sub>2</sub>O<sub>3</sub> and SiC Hybrid composites, Fig.b shows the stress corrosion test with reinforcement of Al<sub>2</sub>O<sub>3</sub>(2%) and SiC (2%)Hybrid composites, Fig.c shows the stress corrosion test with reinforcement of Al<sub>2</sub>O<sub>3</sub>(2%) and SiC(4%) Hybrid composites,

EDAX OF AL 2024 ALLOY (SELECTED AREA)



Hence hybrid composites are greater appropriate for excessive temperature applications.



## CONCLUSION

Hybrid composites of Aluminium 2024 alloy strengthened with fixed weight percentage of Al<sub>2</sub>O<sub>3</sub> and varying percentage of silicon carbide particulates are synthetic by liquid softening metallurgy method the usage of vortex technique.

The change of strain corrosion of each the matrix alloy and reinforced hybrid composites growth with publicity time, attention and temperature.

However, the growth in corrosion price is decrease for the hybrid composites in comparison to base Aluminium 2024 alloy underneath all conditions.

As the share of silicon carbide increases inside the matrix alloy corrosion fee decreases in all concentrations, time of exposure and temperatures.

## REFERENCES

1. Kammuluri Baburaja, TejaSainadh S, Sri Karthik D, J Kuldeep, V Gowtham, Manufacturing and Machining Challenges of Hybrid Aluminium Metal Matrix Composites , IOP Conference Series, *Material Science and Engineering*, ICMAEM, 225, 2017, 1-9
2. Z. Mišković, I. Bobić, S. Tripković, A. Rac, A. Vencl, The Structure and Mechanical Properties of an Aluminium A356 Alloy Base Composite With Al<sub>2</sub>O<sub>3</sub> Particle Additions, *Tribology in industry*, 28(3&4), 2006, 23-27.
3. K.Vinutha, P.V. Krupakara, H.R. Radha, Stress Corrosion Studies of Titanium Dioxide Particulate Reinforced ALUMINIUM 2024 Metal matrix Composites, International Journal of Trend in Scientific and Development (IJTSRD), *International Open Access Journal*, 2(6), 2018, 1007-1011

4. H.V.Jayaprakash, Naddoni Sachin Govind, P.V.Krupakara, Stress Corrosion Behavior of Aluminium 7075/ Beryl Composites, *International Journal for Research in Applied Science and Engineering Technology*, 5(XII), 2017, 450-454.
5. Chandrashekara K N, Dr. B.Narasimha Murthy, Dr.P.V.Krupakara, Stress Corrosion Studies of Aluminium6013-RedMud Metal Matrix Composites, *Journal of Chemistry and Chemical Sciences*, 7(9),2017, 640-646,
6. P.V. Krupakara, Corrosion Characterization of Al6061/Red Mud Metal Matrix Composites, *PortugaliaeElectrochimicaActa*, 31(3), 2013,157-164
7. Ashok S D, Mamatha G P, Venkatesha T V, Pruthviraj R D,Krupakara P V, "Stress Corrosion Studies of Silicon Carbide Particulate Reinforced Aluminium 7075 Metal Matrix Composites" *Journal of materials and Metallurgical Engineering Research*, 1(1), (2015), 1-6
8. P.V. Krupakara, "Open Circuit Potential Studies of ALUMINIUM 2024 / SiCMMC's in Acid Chloride Mediums" Proceedings of Eight International Symposium on Advances,*inElectrochemical Science and Technology*, ISAEST- 8, 93, (2006).
9. H.C. Ananda Murthy, P.F. Sanaulla and V. Bheema Raju, Corrosion behaviour of TiO<sub>2</sub> particulate reinforced Al-6063 composites in sodium sulphate medium, *Inter. J. Appl.Chem*, 6, 225, (2010).
10. R. D. Pruthviraj and P. V. Krupakara, Influence of SiC additions on Mechanical Properties in the Zn-Al alloy (ALUMINIUM 2024), *Inter. J. Mat. Sci*, 2, 59, (2007).

**How to cite this article:**

**Author Name. Pruthviraj. R. D. Stress Corrosion Studies Of Aluminum 2024 Hybrid Composites at 1N HCl solution using High temperature autoclave. AJAN 2020;1(1): 9-15**

**DOI: <https://doi.org/10.5281/zenodo.3768701>**