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Corrosion resistance studies of aluminium 7075 / SiC composites materials in an acidic environment

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ABSTRACT

The aluminium and silicon carbide-based composite (Al-SiC) material was prepared using commercially available analytical grade Al7075 alloy and SiC. Here the silicon carbide is used as reinforcement particles in the composites. The metal composites were developed using liquid melt techniques (Vortex method). The reinforcement material is introduced in different weight fractions in the range of 0 to 10% in this process. These Al-SiC specimens were used for assessment of its corrosion properties. The acid corrosion experiments were carried out at room temperature (30 $\pm 1^{o}$C). The corrosion characteristics were estimated using the conventional weight loss method according to the procedure of ASTM G69-80. The composites performance was evaluated using microstructural analysis and the corrosion resistance tendency in different acidic environmental conditions. The SEM micrographs picture reveals that reinforcement particle was distributed uniformly. The corrosion test was conducted in HCl medium from 0.25N, 0.5N, 1M and 1.5 M respectively. The Al-SiC specimens were dipped in different HCl medium for four days in six experimental baths. Specimens were taken out from each test medium for every 24 hours and tested for its corrosion characteristics. It is observed that the corrosion rate in all HCl medium decreases with an increase in exposure time. This is due to the passivation of the Al-SiC surface induced by aluminium. It was observed that at the 10 w/w % of the aluminium metal matrix composite have higher corrosion resistance than the base alloy.

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INTRODUCTION

The metal composites (Al-SiCs) have higher strength at high temperature, enhanced shock-resistance properties, and moderately higher wear resistance and toughness [1, 2]. Corrosion can affect the composite of the metal in many ways. It also depends on its design and the prevailing environmental conditions. Studying corrosion resistance of Al-based materials is highly significant for automotive and aircraft applications. The parts are prone to corrosive media like saltwater, acidic and other alkaline media [3, 4].

Al7075 alloys are used for various industrial applications. However, it has some selective shortcomings like material strength and stiffness. Apart from that, it has excellent characteristic properties such as very high strength to weight ratio, good ductility, high toughness, low density, high thermal conductivity and good formability [5]. The main problem is with this alloy is that they have low wear resistance ascribed to severe plastic deformation and material removal under different wear conditions.

The above-mentioned characteristics are altered by adding the selective inert stoneware particles into the aluminium alloy matrix [6, 7]. Silicon carbide (SiC) is chemically ideal for the aluminium interface. The Al-SiCs have vital advantages such as greater strength, better rigidity, strong corrosion-resistance, resistance in high-temperature, low coefficient of thermal expansion and better-quality wear resistance capabilities [8–10]. Due to passivation, aluminium and its alloys exhibit better corrosion resistance power in almost all corrosive mediums. Therefore, investigation of aluminium alloys' corrosion properties and their composites in the different acidic environment is of prime importance in any industrial applications. The present work deals with corrosion characterization of aluminium 7075-SiC composite material.

MATERIALS AND METHODS

Composite and test specimen preparation

In the present research work commercially available silicon carbide of 50-80μM size is used as reinforcement material. The samples of Al-SiCs are prepared by adding pre-heated SiC particulates of 2, 4, 6, 8, and 10 w/w per cent respectively to the molten aluminium 7075 alloys liquid melt condition. The original Aluminium 7075 alloy cast is used for comparison. Cylindrical bars of castings are used for further experimental studies. A cylindrical specimen of the Al-SiCs of size 20 mm x 20mm was used for corrosion studies. All the specimens are subjected to the usual metallographic process, like grinding and shaping outlined in the literature [11].

Corrosion resistance studies

The corrosion resistance test was conducted at the HCl acid concentration of 0.25N, 0.5N, 1.0N, and 1.5 N, respectively. The cylindrical bars of the Al-SiCs sample are placed in the respective corrosion medium for 96 hours. The cylindrical bars are taken out at 24-hour intervals from each experimental bath, and the weight loss is measured. The corrosion characterization of the Al-SiC was calculated using the static weight-loss corrosion method as per ASTM standards G69-80.

The following formula was used for the determination of the corrosion rate of the Al-SiCs. Corrosion rate = 534 W/DAT may [12]. Where w is the difference between the initial weight and final weight, i.e., weight loss, D is the alloy density, A is the area exposed in a square inch, and T is the time of exposure in hours.

RESULTS AND DISCUSSION

The elemental composition of commercially available Al075 alloy used and properties of matrix and reinforcement material in the present research work was given in Table 1 & Table 2 [13] .

SEM Analysis

Figure 1 (A&B) shows the scanning electron microscopic (SEM) images of the Al-SiCs. The results clearly show that the hybrid system's spreading of reinforcement material was very uniform [14, 15]. Figure 1B clearly shows that the surface was corroded and it tends to get the peel off from the matrix. It has also been found that the particle is corrupted in its environment. The corroded parts can be seen as micro cracks and pitting from SEM images after exposing the material to corrosion medium (Figure 1 B).

Corrosion tests

The analytical results obtained for the weight-loss corrosion of Al-SiC composites and the pure alloy in 0.25N, 0.5N, 1.0N, and 1.5 N were in Figures 2, 3, 4 and 5 respectively. The results indicate that the corrosion resistance of the composite increases with increasing time of exposure increases. The decreasing corrosion rate trend indicates the possible passivation of the matrix alloy and creates an everlasting layer affecting the corrosion in the material surface. In acid media, this layer prevents further corrosion in Al-SiCs. Dixit [16] fabricated Al 7075 hybrid composite with SiC and graphite as reinforcements. They observed a similar trend of decreasing the corrosion rate with increasing exposure time.

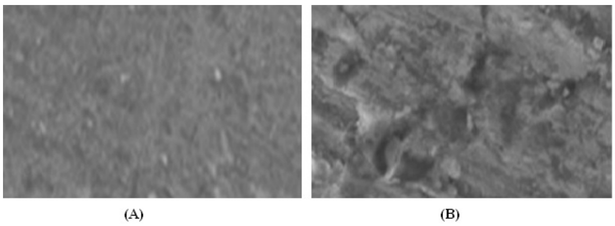

Figure 1: (A) SEMpicture of Al7075 (B) SEM picture of Al-SiC with 10%SiC.

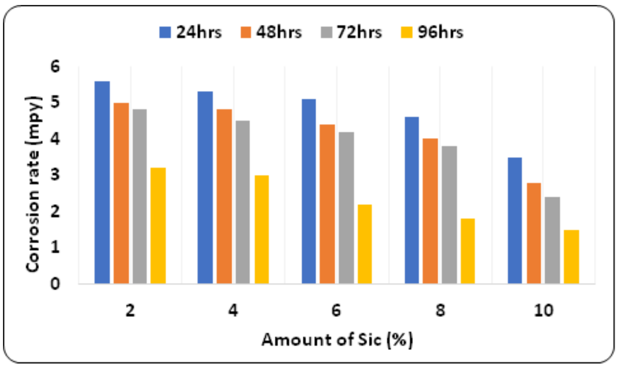

Figure 2: Corrosionrate of Al-SiC at 0.025 N HCl.

Effect of exposure time

Table 1: Elemental composition of Al7075 alloy

Element	Cu	Cr	Mn	Mg	Si	Ti	Zn	Fe	Al
%	1.8	0.2	0.4	1.9	0.5	0.15	3.25	0.5	Rest

Table 2: Properties of matrix and reinforcement material

Properties	Al7075	SiC
Elastic Modulus (Gpa)	70 - 80	410
Density (g/mL)	2.81	3.1
Poisson's Ratio	0.33	0.14
Hardness (HB500)	60	2800
Tensile Strength (T)/ Compressive Strength (C) (Mpa)	220 (T)	3900 (C)

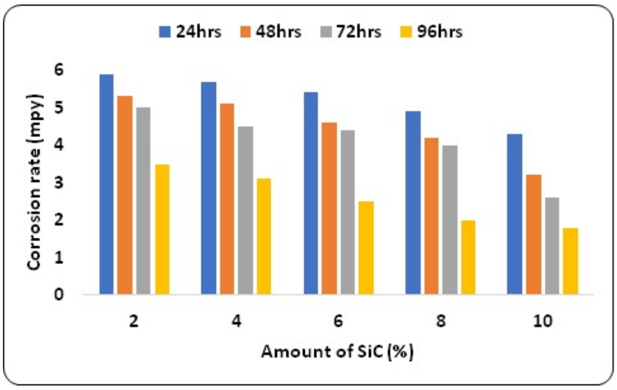

Figure 3: Corrosionrate of MMC at 0.5 N HCl.

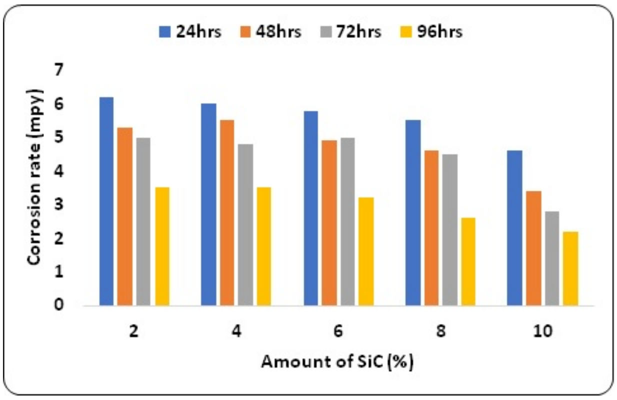

Figure 4: Corrosionrate of AL-SiC at 1.0 N HCl.

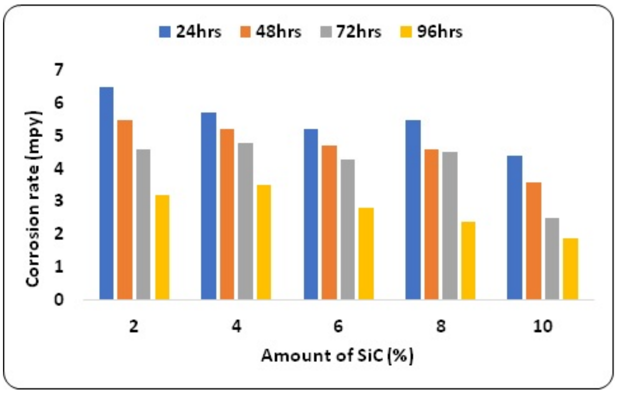

Figure 5: Corrosionrate of Al-SiC at 1.5 N HCl.

The exposure time played a significant role while measuring the corrosion rate. It is evident that as the duration of the test was increased, the corrosion rate of composite decreased or corrosion resistance was increased. Similar findings were found by Basavaraj *et al.,* [17] when used the Al 7075 composite with CNT and E Glass fibres as reinforcement. Suresh *et al.,* [18] investigated the corrosion behaviour of Al 7075/ SiC composite reinforced with nano silicon carbide and observed that the hybrid composite showed much higher corrosion resistance to single reinforced composite. In corrosive media like 3.5% sodium chloride, hydrochloric acid, and sulphuric acid.

CONCLUSION

The following conclusion was derived from the results of the corrosion study.

- Al-SiC composites material having 2 to 10 weight per cent of SiC has been successfully prepared using liquid melt metallurgy technique (LMM).
- The quality of silicon carbide in Aluminium 7075 alloys plays a significant role in the material's corrosion resistance.
- Weight loss of specimen decreased with an increase in weight per cent of SiC when exposed to HCl media.
- It was well observed from the images of SEM microphotographs of Al-SiC composites, which indicates the formation of the pitting corrosion on the material surface.
- The increase in corrosion resistance of Al7075 grade aluminium metal-matrix composite specimens containing a variety of per cent SiC, maybe due to the development of a passive layer on the specimen surface that serves as a protective layer and inhibits corrosion.
- In all concentrations of acid chloride solutions, the

corrosion rate of both the alloy and composite material decreased with an increase of exposure time.

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Conflict of Interest

The authors declare that they have no conflict of interest for this study.

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