ISSN : 0974 - 7494 Volume 10 Issue 2

Nano Science and Nano Technology
An Indian Journal

Full Paper

NSNTAIJ, 10(2), 2016 [051-054]

Effect of sic nanoparticle on AA2014 alloy in marine environment

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ABSTRACT

Nanocomposites are heterogeneous systems containing matrix and reinforcement. Their physical and mechanical properties can be tailored according to requirement. They are used in automobile, aircraft and marine industries because of their increased corrosion resistance. In this paper weight loss corrosion test, open circuit potential test and potentiostat test are conducted on AA2024/ SiC Nanocomposites in different concentrated neutral chloride solutions like sodium chloride solutions. NanoComposites are prepared by liquid melt metallurgy technique using vortex method. Composites containing 2, 4 and 6 percent of NanoSiC are prepared according to ASTM standards. Specimens are machined and made ready by standard metallographic methods. Weight loss corrosion studies are carried out in 0.035, 0.35 and 3.5% solutions of sodium chloride. The corrosion rate decreases with increase in the exposure time for all specimens in all corrodents in all the methods of testing. Corrosion rate also decreases with the increase in reinforcement content of the Nanocomposites. Hence the Nanocomposites can be used for the manufacture of the equipments used in marine environment so that they lost long.

KEYWORDS

Nano composites;
Corrosion;
AA2024;
Nano silicon carbide;
Vortex.

INTRODUCTION

Metal matrix composites (NCs) reinforced with ceramic particulates, whiskers, has received increasing attention due to their potentially high fracture toughness and strength[1-5]. Particle reinforced aluminum NCs find potential applications in several thermal environments, especially in the automobile engine parts, such as drive shafts, cylinders, pistons, and brake rotors[6], and in space applications. With the exception of noble metals, no metal and alloy is stable in air at room temperature, which tend to form oxides. Most of the metals in the solid or liquid state are morphologically unstable in air at any temperature. An investigation relating to the temperature profiles of the piston area in a diesel engine has shown that the temperature can reach as high as 200-600°c in certain regions of the piston[7]. As the piston and cylinder areas are exposed to high temperature environment, the NCs used here should have sufficient stability as well as good mechanical and chemical strength (oxidation). Oxidation occurring at grain boundaries in alloys and at the interface between particle and matrix in mmcs usually increases intergranular fracture, resulting in premature failure and severe brittleness[8-10]. Therefore, in high-temperature applications, it is essential to have a thorough understanding of the oxidation behaviour of the aluminum NCs.

EXPERIMENTAL PROCEDURE

Material selection

In the present study, liquid metallurgy technique is adopted and AA2024, which exhibits excellent casting properties and reasonable strength, is used as the base alloy AA2024 alloy with good strength is suitable for mass production of lightweight metal castings. The chemical compositions of the AA2024 alloy are given in TABLE 1.

Commercially available silicon carbide nanoparticulates are used as reinforcement.

The testing corrodent medium selected is 0.035, 0.35 and 3.5% solutions of sodium chloride.

Composites preparation

The liquid metallurgy route using vortex technique[11-12] is employed to prepare the Nano composites. The weight percentage of silicon carbide Nao particles used was 2-6 weight percentages in steps 2%. Matrix was also casted in the same way for comparision.

Specimen preparation

For weight loss corrosion test the composite along with matrix were cut in to cylindrical shaped specimens of dimesion18 cm x 18 cm Dimensions of all specimens were noted down using vernier gauge.

Corrosion test

The corrosion tests were conducted at room temperature using the conventional weight loss method. Weighed specimens were immersed in the corrodents and taken out at 24, 48, 72, and 96h. Weight loss was calculated and converted into corrosion rate and expressed in mils penetration per year (mpy)[13].

Corrosion rate is calculated using the following formula

Corrosion Rate in mpy =534W/DAT (1)

Where W is the weight loss in grams, D is density of the specimen gm/cc, A is the area of the specimen ($inch^2$) and T is the exposure time in hours.

RESULTS AND DISCUSSION

Figures 1 to 3 give the corrosion rate of Nano composites by conventional weight loss method

Effect of exposure time

In weight loss corrosion test (Figures 1-3) it is observed that NCs and matrix exhibit a decrease in corrosion rate with increase in test duration in all concentrations of sodium chloride solutions. It is clear from graphs that the corrosion resistances of the composites are higher when compared to that of matrix in all mediums. The phenomenon of gradually decreasing corrosion rate indicates a possible passivation of the matrix alloy. De Salazar et al[14] explained that the protective black film consists of hydrogen hydroxy chloride film, which retards the forward reaction. Castle et al[15] pointed out that the black film consists of aluminium hydroxide compound. This layer protects further corrosion in acid media. But exact chemical nature of such protective film is still not established.

Effect of silicon carbide content

From the Figures1-3, it can be clearly observed that for NCs, corrosion rate decreases monotonically with increase in silicon carbide content. In the present case, the corrosion rate of the composites as well as the matrix alloy is predominantly due to the formation of pits, cracks on the surface. In the case

TABLE 1 : Chemical composition of AA2024 alloy

Component	Wt. %	Component	Wt. %	Component	Wt. %
Al	90.4 - 95	Mg	0.2 - 0.8	Si	0.5 - 1.2
Cr	Max 0.1	Mn	0.4 - 1.2	Ti	Max 0.15
Cu	3.9 - 5	Other, each	Max 0.05	Zn	Max 0.25
Fe	Max 0.7	Other, total	Max 0.15		

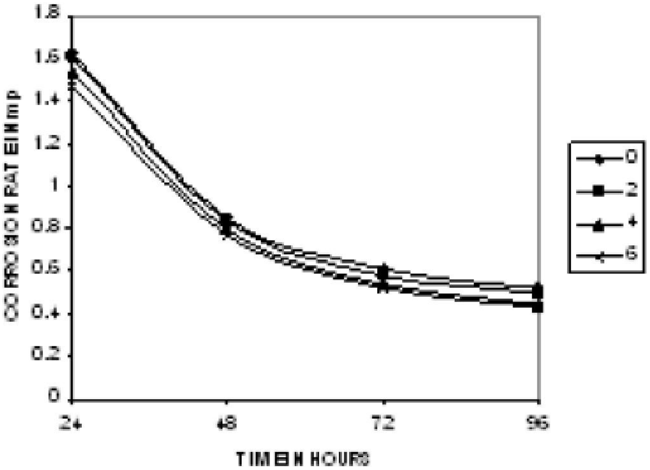

Figure 1 : Weight loss corrosion in 0.035% sodium chloride solution

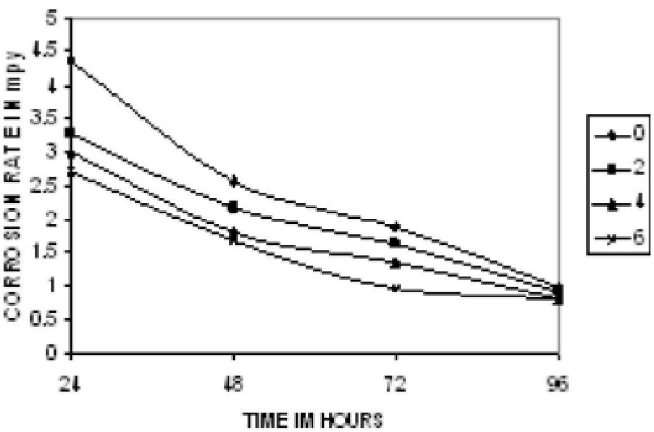

Figure 2 : Weight loss corrosion in 0.35% sodium chloride solution

of the base alloy, the severity of the base used induces crack formation on the surface, which eventually leads to the formation of pits, thereby causing the loss of material. The presence of cracks and pits on the base alloy surface was observed clearly, since there is no reinforcement provided in any form the base alloy fails to provide any sort of resistance to the basic medium. Hence the weight loss in the case of un-reinforced alloy is higher than in the case of composites. Same explanation can also be adopted to open circuit potential test.

CONCLUSIONS

Al 7075 based NCs reinforced with 2, 4 to 6% of silicon carbide particulates were successfully produced by liquid melt metallurgical technique.

The rate of corrosion of both the alloy and composite decreased with time duration.

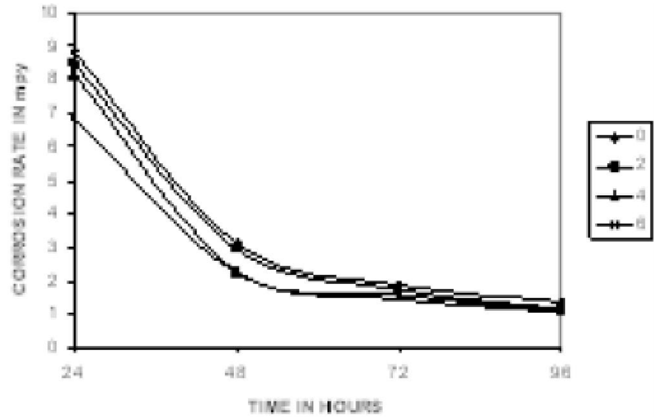

Figure 3 : Weight loss corrosion in 3.5% sodium chloride solution

The potential developed by both the alloy and composite decreased with time duration.

Normality of NaCl plays a significant role in the corrosion of NCs. Corrosion rate of the alloy and NCs increased with increase in the concentration of NaCl solutions. The cathodic polarization curves were function of the normality of NaCl and reinforcement concentration with hydrogen reduction increasing with increase in reinforcement.

The corrosion rate of the composites was lower than that of the corresponding matrix alloy.

The corrosion by weight loss of the composite decreased with increase in the weight percentage of the reinforcement.

The use of NCs in bearing applications in marine environment more suitable than matrix alloy

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