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Studies on the corrosion resistance of Al7075 / SiC metal matrix composites in an alkaline environment

Manoharan E K, Singanan M*

Department of Chemistry, Presidency College (Autonomous), Chennai-600005, Tamil Nadu, India

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ABSTRACT

Metal matrix composites are of interest every day due to their lightweight, improved mechanical properties, and increased corrosion resistance. They are used in the aeronautical, aerospace, marine, and automotive industries. A variety of methods can estimate Their corrosion properties. The open-circuit potential studies are also a tool for evaluating the corrosion of composite materials. This research paper focuses on studying open circuit potential determination of the aluminium 7075 alloys reinforced with silicon carbide particulate in differently concentrated sodium hydroxide solutions. The composite materials were prepared by adding 2, 4, 6, 8 and 10 weight percentages of silicon carbide to the aluminium base metal liquid melt metallurgy technique (Vortex method). The silicon carbide used as reinforcement in size range of 50 – 80 μm, which is commercially available. The SiC particulates material is had been preheated to 400°C and introduced into the liquid melt of Al7075 at a rate of 100 g/m, under constant agitating condition using a mechanical stirrer system for 3 to 4 minutes. Rectangular specimens of 2 cm length, 1cm width and 1 mm thickness were used for the experiments. 1sq.cm area of the specimens was exposed to sodium hydroxide medium. Open circuit potential experiments test was conducted using a multimeter and calomel electrode system. The potential observed for 2, 4, 6, 8 and 10% silicon carbide composites were less than the potential of matrix alloy for a range of 30 hours.

*Corresponding Author

Name: Singanan M
Phone: +91 7200411065
Email: mssinganan@yahoo.co.in

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INTRODUCTION

The metal matrix composites (MMCs) were produced using the base metallic element aluminium (7075) by adding SiC particulates as reinforcement material. It has several advantages. The composite materials are used in many applications due to their distinct properties such as high, combined strength [1], sensible wear resistance [2], higher thermal conduction [3], strong anti-dampening properties [4], and lower thermal enlargement constant with lower density [5]. Such characteristics of MMCs boost their applications in automotive and tribological applications. Several researchers [6–8] points out that the extent of corrosion in quartz-zinc-aluminium MMCs inflated with the increase in reinforcement content which prevents the discriminatory acidic attack at the matrix reinforcement interface [9]. Despite these factors, the corrosion behaviour of MMCs is highly influenced by the presence of reinforcement in the alloy system [10]. The corrosion behaviour of MMCs well depends on the number of reinforcement particles [11]. This investigation aims to know the role reinforcement of silicon carbide on the aluminium metallic element (7075) using open circuit potential principles in a 0.25 N, 0.5 N and 1.0 N NaOH solution corrosion testing mediums.

MATERIALS AND METHOD

Material selection

The elemental composition of various possible metals present in the alloy Al7075 is given in table 1.

The essential physical properties of the silicon carbide as reinforcement material in this study is very important. Sic's specific gravity is of 3.22, with a hardness of 9.1 to 9.5 on the Moh's scale.

Preparation of composites

The composite materials were prepared using a liquid melt metallurgical process involving vortex principles. [12]. The silicon carbide used as reinforcement in size range of 50 – 80 μm, which is commercially available. The SiC particulates material is had been preheated to 400°C and introduced into the liquid melt of Al7075 at a rate of 100 g/m, under constant agitating condition using a mechanical stirrer system for 3 to 4 minutes. The composites are having a weight percentage of 2, 4, 6, 8, and 10 were prepared. The specimens were prepared as bar castings and used in further experiments.

Rectangular specimens with a length of 2 cm, a width of 1 cm, and a thickness of 1 mm are machined from the castings using the regular metallographic techniques and connected to a circuit containing aluminium wire, calomel electrode, and a multimeter and immersed with the test solutions of NaOH [Figures 1, 2 and 3].

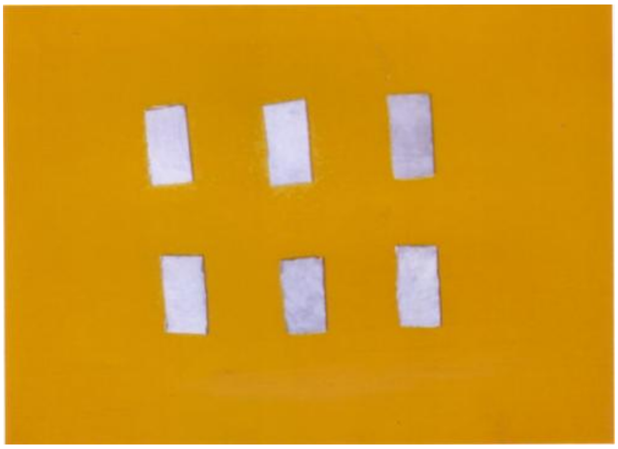

Figure 1: Specimens for corrosion test

Open circuit potential test

The open-circuit potential is also called corrosion potential. This experiment is based on the measurement of the open circuit potential in the form of potentiometric experiments. The technique is very simple and produces reliable corrosion studies of various metals and alloys in different corrosion environments. It has many vital applications.

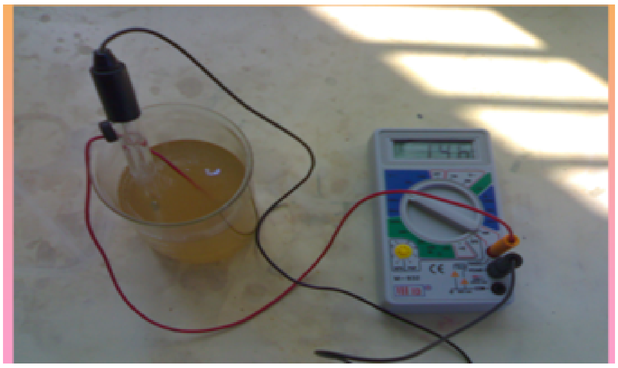

Figure 2: OCP single specimen experiment

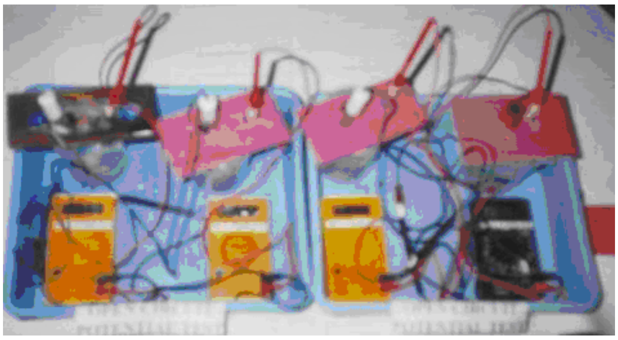

Figure 3: OCP experimental model

The experimental unit is functioning in 9 volts capacity cell. In the experiment, the specimens of the MMCs are held by an aluminium wire, and this aluminium wire is suitably sealed by using Teflon tap to prevent the touch or exposure to the corrosion medium. All the experimental specimens were made as an anode, and the counter electrode was a cathode, which will serve as a reference electrode. It is normally, a standard calomel electrode. All the specimens were washed with distilled water and further cleaned in acetone for five minutes and air-dried before testing in corrosion medium. The electrodes are connected to a multimeter, and the same is switched on to measure the DC voltage developed during the experimental process in differently concentrated solutions of sodium hydroxide. The voltage developed in the corrosion process is recorded for every hour for 30 hours till the potential observed becomes constant. The procedure is repeated for all the five experimental specimens and a reference of Al7075 ally (0% SiC) in all sodium hydroxide solutions. The results are then validated with the response to the potential developed and the time of exposure in the corrosion environment. The results were presented systematically in a graphical form to quickly understand the corrosion tendency of the produced metal-metal matrix alloys system.

Table 1: Composition of aluminium 7075

Metal	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
%	0.6	0.5	1.1	0.2	0.8	0.1	0.2	0.1	Balance

RESULTS AND DISCUSSION

The electrical circuit potentials developed during the corrosion process in sodium hydroxide medium of concentrations of 0.25 N, 0.5 N and 1.0 N were presented [Figures 4, 5 and 6].

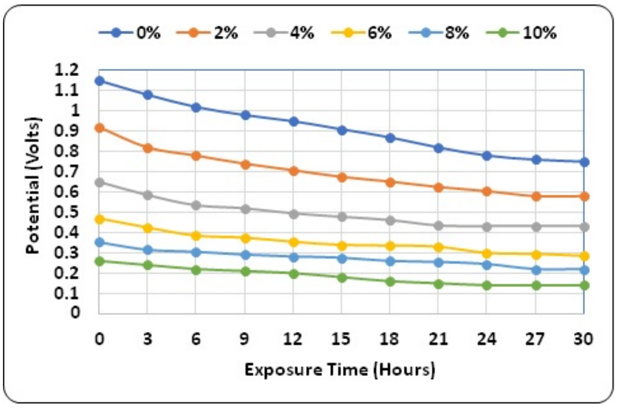

Figure 4: Open circuit potential test in 0.25 N NaOH

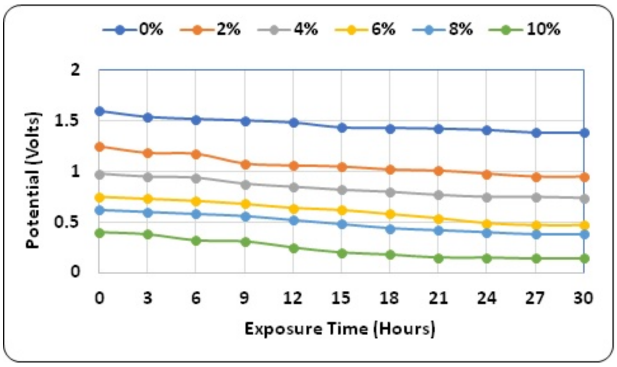

Figure 5: Open circuit potential test in 0.5 N NaOH

Corrosion behaviour

In the result analysis, it well observed that from the beginning, the potential decreases up to 30 hrs of exposure time and then the potential remains constant due to passivation. This is possibly due to the development of non-porous, insoluble. An adherent layer of aluminium oxide can be predicted, which may prevent corrosion, and there will decrease in corrosion tendency. Increase in the percentage of silicon carbide material in the metal-metal matrix results in a marked decrease in potential development. This result indicates that the increase of corrosion resistance is well observed when the amount

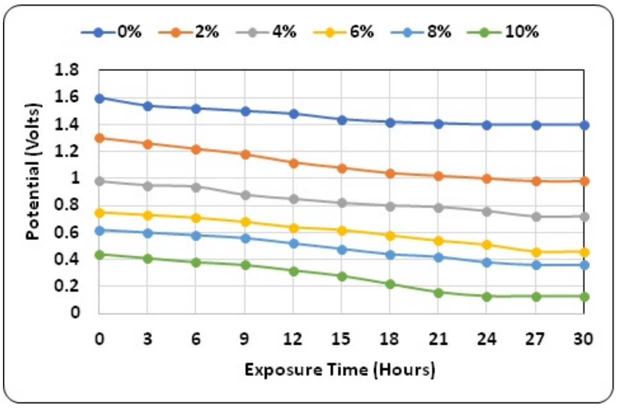

Figure 6: Open circuit potential test in 1.0 N NaOH

of the reinforcement material increases to 10% composite. Similarly, Lakshmi et al., [13] obtained consistent electric circuit potential tests in the corrosion medium of potassium chloride solutions.

Effect of reinforcement

It will be seen from the graph that within the hydrated oxide medium, the ceramic reinforcement particles function associate dielectric and stay inert throughout the test. Thus, the potential decreases with a rise in carbide content in MMCs, which can decrease the world of alloy exposure with an increase in the reinforcement. Less exposure of the MMCs area to aggressive acid environments in corrosion testing led to lesser pitting as well as corrosion than that of the matrix alloy. Jayaprakash et al., [14] additionally report that the inert nature of reinforcement will certainly enhance resistance to corrosion of MMCs. The particulates of silicon carbide act as a physical barrier to the corrosion reaction and cut back potential growth.

Aluminium alloy contains major amount of zinc, hence it is anodic to aluminum as per the galvanic series. Zinc corrodes faster than aluminum. Silicon carbide particulates act as physical barrier to the corrosion reaction and reduce the potential development. Decrease in hydrogen evolution decreases the corrosion rate. From electrochemical point of view aluminium 7075 matrix is anodic when compared with aluminium 7075 / silicon carbide MMCs. The potential difference between matrix and interfacial region of alloying elements is maximum. The effect becomes greater in view of the large weight percentage of the silicon carbide particulates. Jayaprakash *et al.,* [15] also reported similar research findings in their research work.

Reinforcements in the MMCs cut back the density of corrosion effectively. The pits on the matrix alloy were more when compared with those of MMCs. This may be due to the exposure of less matrix alloy surface in MMCs than matrix alloy, by the addition of reinforcement.

CONCLUSION

The following conclusions are derived from the results of the research work.

- Corrosion behaviour of Al7075 MMCs was tested by open circuit potential technique.

- The open circuit potential method appears to decrease for thirty hrs of exposure and remains constant after for matrix and composites.

- Potential developed for every hour decreases with increased reinforcement weight share from the matrix to 10% composite.

- With improved strengthening, the degree of corrosion injury has been minimized.

- The use of MMCs in bearing applications in the alkaline setting is more acceptable than matrix alloys.

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Conflict of Interest

The authors declare that no conflict of interest is associated with this research study.

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ABOUT AUTHORS

Singanan M

Dr. M. SINGANAN, M.Sc., Ph.D.,
Assistant Professor of Chemistry, Presidency College (Autonomous), Chennai - 600005, Tamil Nadu, India.

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