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Corrosion Behavior of Recycling Al- Alloy Based Metal Matrix Composites Reinforced by Nano particles

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Abstract: ***The present work aims to preparation and investigation of the corrosion behavior of recycling Al alloy based metal matrix composite reinforced with nano SiC with weight percentage (2%, 4%, 6%, and 8%) and particle size 52 nm were evaluated. The composites were fabricated using liquid metallurgy (stir casting process). The corrosion rates of composites were calculated using potentiostatic measurements in 3.5% NaCl solution.. The results showed that Al/SiC nanocomposites have higher corrosion resistance than aluminum matrix.***

The corrosion resistance was found to be increased by increasing of the weight percentage of the nanoparticles The Al/8% nano $(SiC)_P$ composites exhibited the highest corrosion resistance among all the investigated nanocomposites. The microstructure indicate that the strong interfacial bonding between the matrix alloy and reinforcement.

Keywords: Recycling Al, Nano SiC Particles, Metal Matrix Composite, Stir casting, Corrosion Resistance & Potentiostatic Measurements.

1. INTRODUCTION

Aluminum-based metal matrix composites (MMCs) become attractive for the automotive and aerospace industries when a light weight and near-net-shape component is desired. Aluminum-based MMCs are well known for their high wear resistance, improved elevated temperatures tensile and fatigue strengths[1]. The mechanical and tribological characteristics of MMCs have been extensively studied [2], while corrosion characteristics are of increasing importance as MMCs become candidates for use in specific components subjected to corrosive media. Generally, the corrosion resistance of aluminum-based MMCs is less than the monolithic alloys, due to several reasons such as the crevices at the matrix/ reinforcement interface ,manufacturing defects, internal stress, microstructural differences and galvanic effects due to coupling of the matrix and reinforcement [3]. The composites were produced by stir casting are easier to produce and are compatible with further processing such as machining, welding and deformation [4]. Aluminum matrix composites, an epitome of metal matrix composites have been given much attention by researchers due to the light weight, high strength, ductility, low melting point and corrosion resistance offered by aluminum alloys [5]. As a result, they have been used extensively in aerospace, automotive, recreational and marine industries. The application of these materials in the marine industries exposes the materials to chloride ions which could attack and deplete the materials [6].

Metal matrix composites (MMCs) reinforced with nano-particles, also called Metal Matrix nano-Composites (MMnCs), are being investigated world wide in recent years, owing to their promising properties suitable for a large number of functional and structural applications. The reduced size of the reinforcement phase down to the nano-scale is such that interaction of particles with dislocations becomes of significant importance and, when added to other strengthening effects typically found in conventional MMCs, results in a remarkable improvement of mechanical properties [7].

2. LITERATURE REVIEW

Several studies have indicated that the corrosion resistance of particle-reinforced composites depends on the composition of the base alloy, reinforcing particles, and corrosive environment. Other factors include the fabrication routes for the composites, volume fraction of the reinforcing particles, and the temperature of the corrosive medium.

Greetha Mable Pinto et al. [8] Investigated the corrosion behavior of SiC particulate reinforced in aluminum metal matrix composites. The results obtained from Tafel extrapolation technique and Electrochemical impedance spectroscopy were in good agreement. The results showed an increase in the corrosion rate with increases in temperature as well as the increase in the concentration of the corrosion media. M. Zakaria [9] studied the corrosion behavior and the microstructure of Al/ SiC metal matrix composite with volume fraction up to 15 vol% and various particle size 3, 6 and 11µm that fabricated by powder metallurgy. It was found that corrosion rate at room temperature for Al/SiC composite better than pure Aluminum in 3.5 wt % NaCl aqueous solution. Increasing the volume fraction of SiC resulted in increasing the corrosion resistance of the composite, while reducing the particle size of SiC enhanced the corrosion resistance of SiC composite. The corrosion rate decreased with the long duration exposure. B.Babu, et al., [10] studied the corrosion behavior of aluminium alloy/10 % silicon carbide reinforced particulate composite in severe environments have been evaluated, the media are 5 weight percent NaCl solution.· The weight loss, the percentage weight loss, and the corrosion rate expressed in mmpy all agree with the physical appearance of the specimens after the exposure time of the test. Kenneth K. Alaneme, et al, [11] investigated the influence of corn cob ash on the corrosion and wear performance of Al-Mg-Si hybrid composites reinforced with varied weight ratios of silicon carbide and corn cob ash. The results show that hybrid composites exhibited excellent corrosion resistance in a 3.5% NaCl environment.

Many researchers have tried to investigate the corrosion properties of composites and to find the effect of micro particulates and volume fractions on corrosion test parameters on aluminum metal matrix composites.

THE AIM OF PRESENT WORK:

Is to produce a metal matrix composite material by using a recycling Aluminum alloys reinforced with nano materials with varying weight percentage in order to enhance the corrosion resistance of the composite in 3.5 wt.% NaCl solution.

3. METHODS AND MATERIALS

Materials

For the production of metal matrix composite, the materials used are an Al wire and Al A 2024 (as a matrix material) that reinforced with (2 %, 4%, 6%, and 8%) weight percentage of 52 nm diameter SiC particles. This metal matrix composite was prepared using a liquid metallurgy (stir casting process). The chemical composition of Al wire and Al 2024 are shown in table (I& II).

Table I: The Chemical Composition of Al Wire.

Element	Cu %	Si %	Mg %	Fe %	Mn %	Al %
Composition %	0.275	0.77	1.02	0.412	0.0532	Balance

Table II: The Chemical Composition of AA2024.

Element	Cu %	Si %	Mg %	Fe %	Mn %	Al %
Composition %	1.38	0.0907	2.29	0.193	0.0259	Balance

Composite preparation:

A composite materials are produced using a stir casting process [12], Al wire and Al 2024 alloy were melted in a graphite crucible and mixed with nano SiC particles using a stirrer. The melt was degassed using hexachlorethane to get rid of impurities and gases. The stirrer speed lowered vertically up to 3 cm from the bottom of the crucible. The speed of the stirrer was gradually raised to 800 rpm. At 650 C° the SiC Nano particles were introduced into the molten. The nano particles were packaged in aluminum foil. After the addition of silicon carbide powder, stirring was continued for 10 min to get better distribution. The melt was kept in the crucible for one minute without stirring. The slag were removed and the melt poured in the graphite mold as shown in figure (1).

Figure 1 Graphite mold

Polarization measurements

All experiments were carried out in (500) ml of test solution by using a three electrodes cell with saturated calomel electrode (SCE) as a reference, platinum electrode as counter electrode and the cylindrical specimens of the alloy with active flat disc of (0.78) cm^2 as the working electrode. All the values of potential are therefore referred to the SCE. Finely polished composite and base alloy specimens were exposed to corrosion medium and allowed to establish a steady stat open circuit potentially, followed by polarization measurements at a scan rate of (3) mV/s for Tafel plots. Fig. (2) Shows the experimental set up for electrochemical measurement.

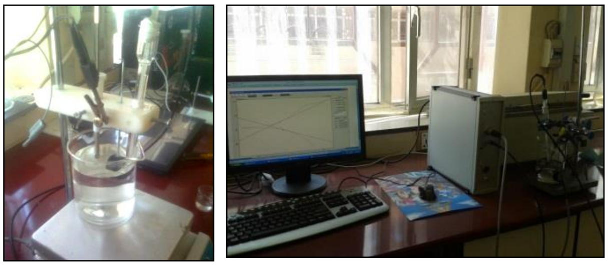

Figure. 2 Experimental set up for electrochemical measurement.

The values of corrosion current density (i_{corr}) were obtained from the point of intersection of both linear parts of the anodic and cathodic polarization curves with the stationary corrosion potential (E_{corr}).

Corrosion rate can be calculate by using the following equation [13]:

$$corrosion\ rate = \frac{3.27\times10^{-3}}{\rho} \times i_{corr} \times EW \quad (1)$$

Where , i_{corr} (in μA/cm^2) is the corrosion current density, EW in (gm) is the equivalent weight of the corroding species, and ρ in (g/ cm^3) is the density of the corroding species.

4. RESULTS & DISCUSSION

Particle size analysis:
Nano silicon carbide particle size was analyzed using a laser diffraction particle size distribution analyzer (90) plus particle sizing software ver.
The results show that the mean particle size of nano Silicon carbide powder was determined to be 52.8nm with particle analyzer as shown in fig. (3).

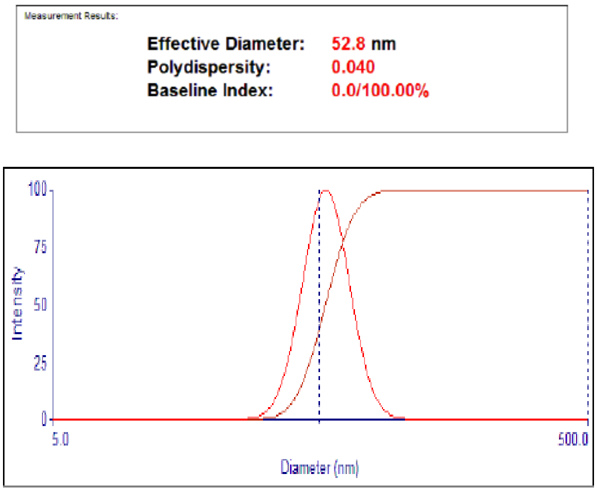

Figure 3 Particle size distribution of nano silicon carbide

Microstructure Analysis
The microstructure was studied by an optical microscope in order to examine the microstructure and the formed phases using metallographic microscope. The samples are etched using Keller's solution that contain 3ml HF, 6ml HNO_3 and rest of H_2O.
The microstructure shown in figure (4) better dispersion of reinforcement in the matrix. As the weight percentage of nano SiC increases in the matrix, the reinforcement particles increases and the inter particle space decreases. There is no indication of agglomeration of reinforcement in the matrix.
The microstructure is dendritic, the primary dendrites are fragmented because of mechanical stirring that explains the improvement in the possibility of incorporating and entrapping nano-sized particles within the interdendritic interface developing during the solidification of the dispersed alloys.

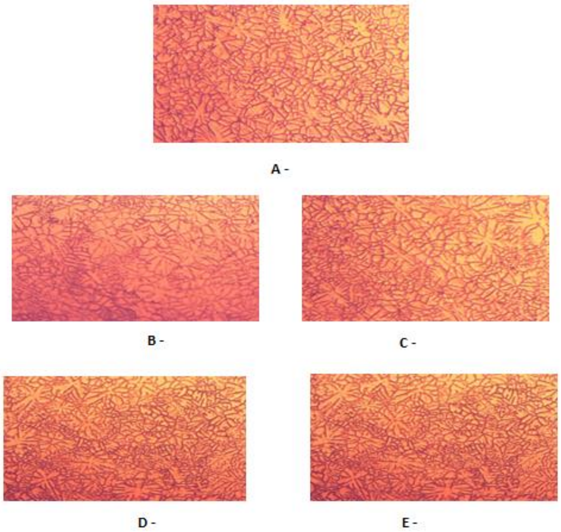

Figure 4 Microstructure of nano silicon carbide particles at different weight percent of nano silicon carbide particulates in recycled Al alloy- matrix(X40).
A) 0% wt. B) 2% wt. C) 4% wt. D) 6% wt. E) 8% wt.

Corrosion behavior in 3.5% NaCl Solution
The corrosion parameters of recycled aluminum alloy and its composites in 3.5% solution NaCl are given in table (III) . It can be clearly observed that corrosion rate of unreinforced alloy is higher than in the case of composites due to nano SiC is hardly affected by salt medium and not affect the corrosion mechanism of the composite.

Table (III) Corrosion parameters of recycled aluminum alloy and its composites in (3.5% NaCl) solution

Composite Recycled Al/nano SiC	(3.5% NaCl) solution		
	i_{corr} ($\mu A/cm^2$)	E_{corr} (mV)	Corrosion Rate (mm/y)
0%	47.46	-1150.3	0. 4746
2%	28.69	-1103.4	0.2869
4%	20.27	-1088.7	0.2027
6%	9.25	-1092.1	0.0925
8%	5.63	-1008.4	0.0563

It can be observed from the polarization curves Figures (5) to (9) and Table (III) that the corrosion current density (i_{corr}) values and the corrosion rate decreases with increase in nano SiC content in the composites.
The addition of hard particles into the alloy can increase the corrosion resistance by the physical properties of reinforcement. Uniform dispersion of reinforcement particles in an aluminium alloy which shows the better corrosion resistance. Increasing the weight percentages of the reinforcement particles (nano SiC) increasing the corrosion resistance of the composite [14]. From table III, it has been found that the recycled Al/ 8%nano SiC composites show better corrosion resistance when

compared with the base Al and SiC nanoparticulates are ceramic materials and they remain inert..

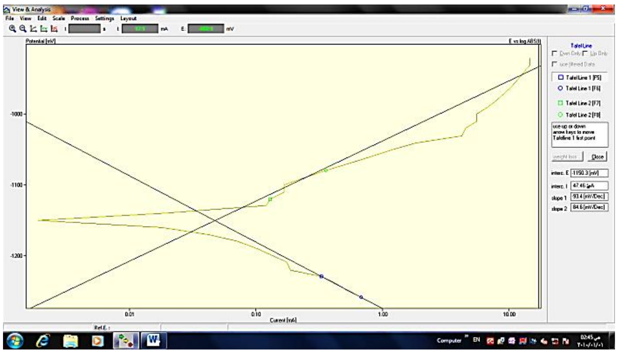

Figure 5 Polarization curves for recycled aluminum alloy in (3.5% NaCl) solution

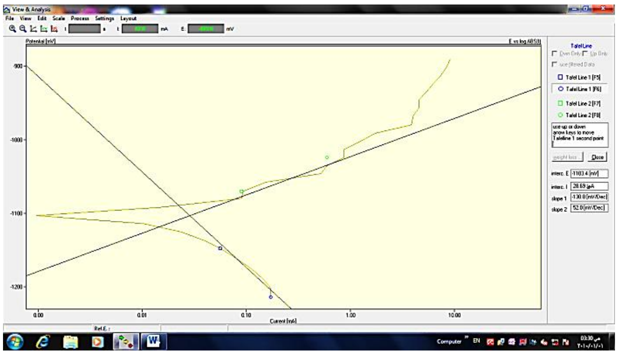

Figure 6 Polarization curves for recycled aluminum alloy/2% nano SiC composite in (3.5% NaCl) solution

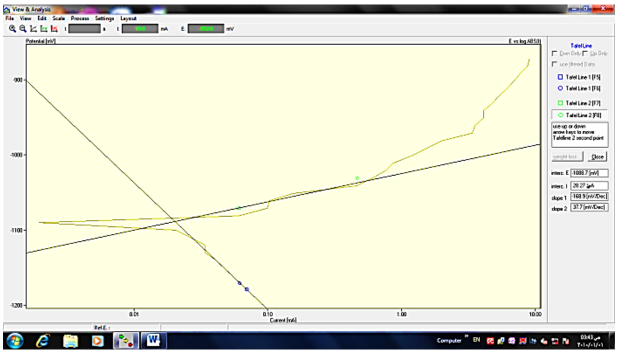

Figure 7 Polarization curves for recycled aluminum alloy/4% nano SiC composite in (3.5% NaCl) solution

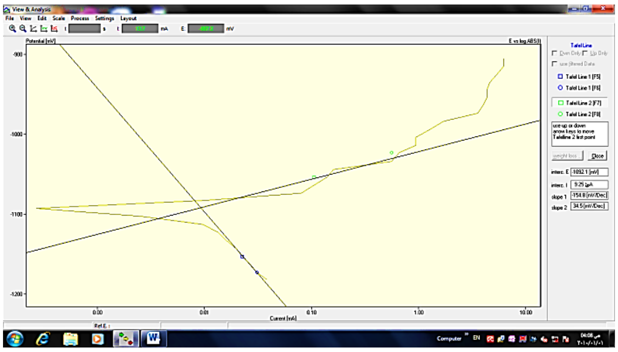

Figure 8 Polarization curves for recycled aluminum alloy/6% nano SiC composite in (3.5% NaCl) solution

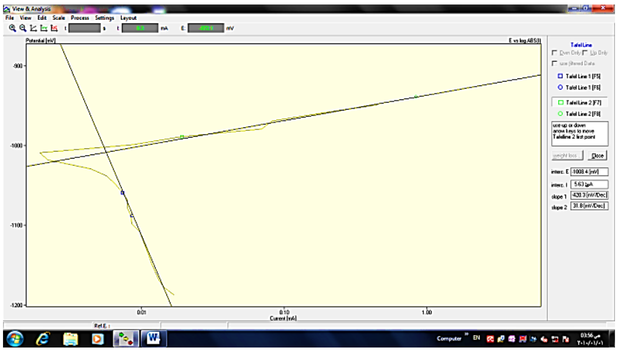

Figure 9 Polarization curves for recycled aluminum alloy/8% nano SiC composite in (3.5% NaCl) solution

5. CONCLUSION

According to the results obtained from the current investigation, the following conclusions can be pointed out:

- The recycled Al/ nano SiC composites exhibited higher corrosion resistance in (3.5%NaCl solution) than the base alloy.
- Corrosion current density values (i_{corr}) decrese with increase in nano SiC content in the composites for (3.5% NaCl solution).
- The Al composite reinforced with 8% nano SiC exhibited higher corrosion resistance due to SiC nanoparticulates are ceramic materials and they remain inert.
- The microstructure of recycled aluminum alloy reinforced with nano SiC particles seem to be distributed uniformly and strong interfacial bonding between the matrix alloy and reinforcement. Thus, increased nanoparticles with weight percentage increases the corrosion resistance of the composite

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