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bout OMICS Group Conferences

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INFLUENCE OF NANODISPERSIONS ON CORROSION BEHAVIOUR OF ALUMINUM METAL MATRIX NANOCOMPOSITES FABRICATED USING POWDER METALLURGY ROUTE

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Introduction

- Particulate reinforced metal matrix composites (MMCs) combine two or more materials that have different corrosion potentials and corrosion characteristics.
- Reinforcement ceramic particles, such as SiC or Al_2O_3 particles, may interact electrochemically, chemically, or physically with the matrix leading to accelerated corrosion.

Introduction

- In addition, galvanic interactions between the ceramic particles and matrix can also accelerate corrosion.
- Preferential corrosion along a particle matrix interface can lead to rapid penetration along the large interfacial areas in composites.

Introduction

- Corrosion resistance is one of the candidate properties that it is believed to be enhanced by the addition of ceramic nanoparticulates to metal matrix such as aluminum and its alloys.

Aim of the Investigation

- The aim of the present investigation is to study the electrochemical corrosion behavior of both Al/SiC and Al/Al_2O_3 nanocomposites in 3.5 wt.-% NaCl solution.
- The nanocomposites were fabricated using the conventional powder metallurgy route.
- The effect of the nanoparticulates type, size and volume fraction on the electrochemical corrosion characteristics was extensively studied.

Experimental Work

Materials

- Commercially pure Al powder having minimum purity of 99.7% was used as a matrix.
- The Al powders have size range of 10–100 µm.
- Both nano-SiC and nano-Al_2O_3 particulates were used as reinforcing particles.
- The SiC and Al_2O_3 particulates have two different average sizes, typically, 200 nm (from 100 nm to 300 nm) and 60 nm (from 20 nm to 100 nm).
- Several Al-based MMNCs containing 1, 3 and 5 vol.-% of the nano- SiC and Al_2O_3 particulates were prepared using powder metallurgy route.

Fabrication of MMNCs

- The fabrication method includes the following steps: (1) mixing, (2) cold compaction, (3) sintering and finally (4) hot extrusion.

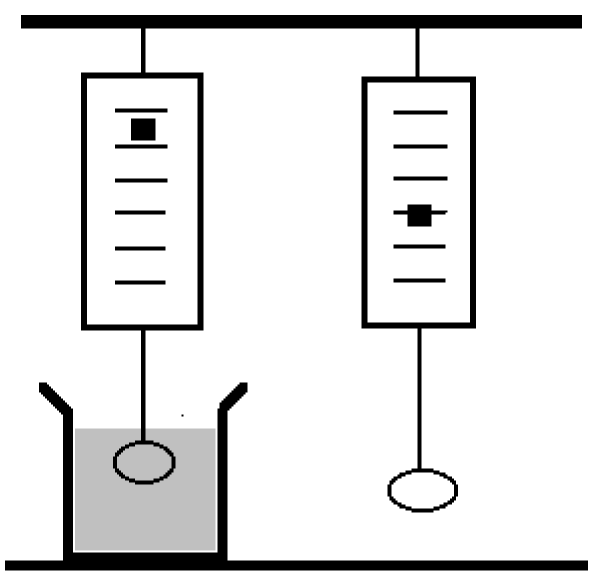
Photographs shows the compaction die arrangement.

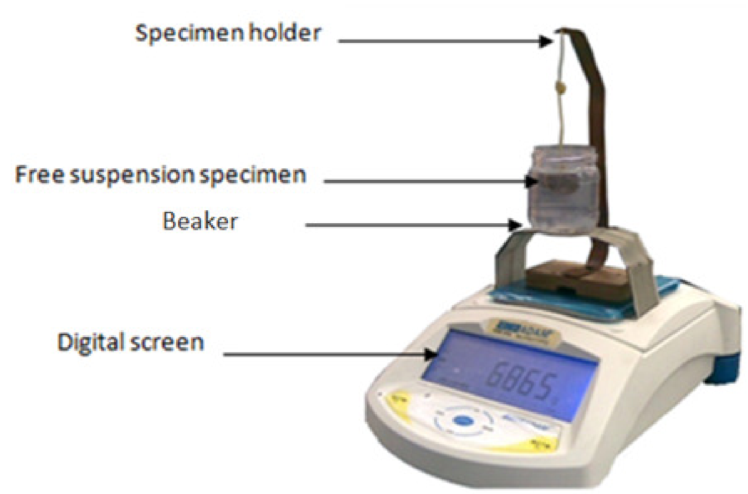
Photographs show the extrusion die arrangemen

The Porosity of MMNCs

- The bulk porosity of the fabricated Al/SiC and Al/Al_2O_3 MMNCs was measured using the water displacement (Archimedean density) approach.

Archimedes' Principle



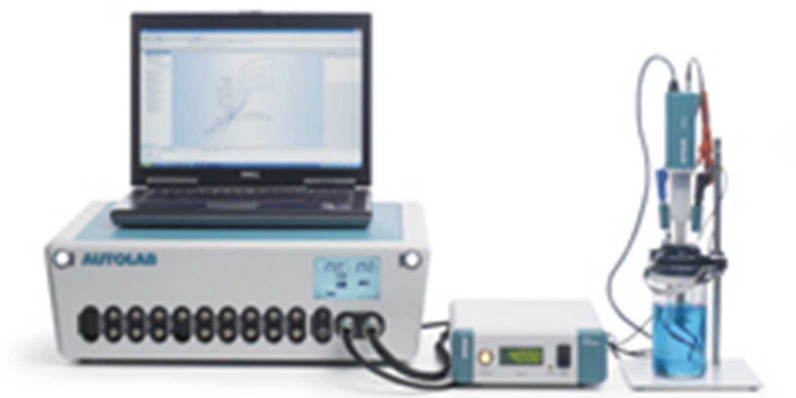


The Microstructure of MMNCs

- The microstructure of the aluminum MMNCs was examined using both optical microscope (OM) and Scanning Electron Microscope (FESEM).

Corrosion Tests

- Linear polarization tests were performed on the investigated the nanocomposites.
- Anode polarisation curves using a measurement system consisting of the AutoLab PGSTAT128N potentiostat including differential electrometer amplifier were constructed.
- The PGSTAT128N equipped with FRA2 module and NOVA software for impedance measurements.



Corrosion Tests

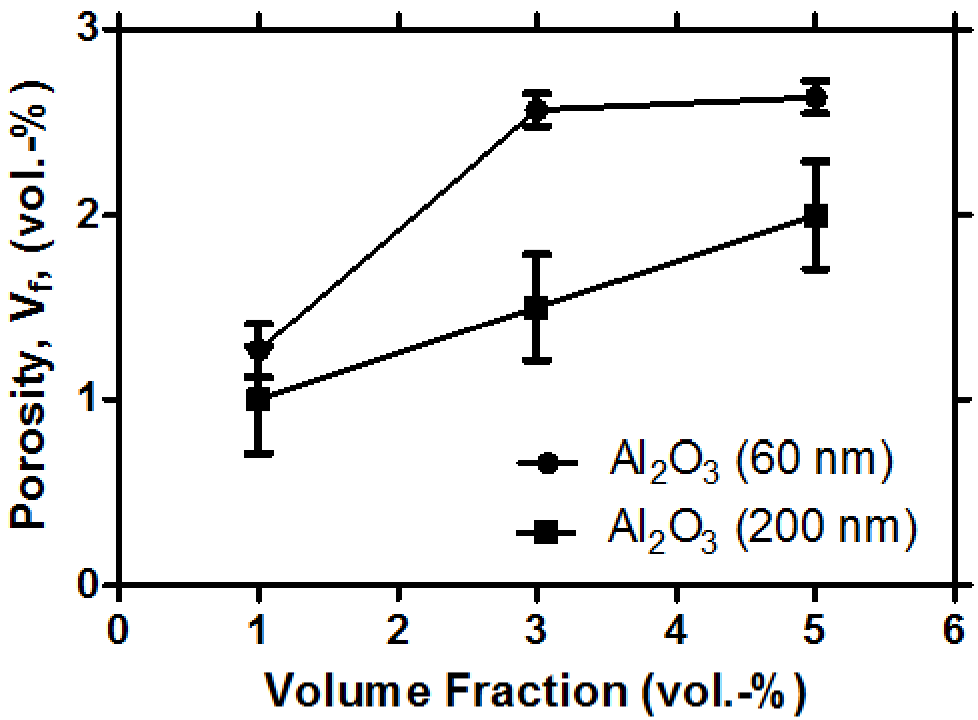
- The nanocomposite materials featured the examined electrode that were ground and polished with the method used in the practical metallographic techniques.
- The inspected surfaces of the specimens were washed with acetone immediately before the examinations.
- Specimens prepared in this way were tested in the 3.5 wt.-% water NaCl solution.
- The surface area of the examined specimens was about 1 cm^2.
- The tests were carried out at room temperature.

Corrosion Tests

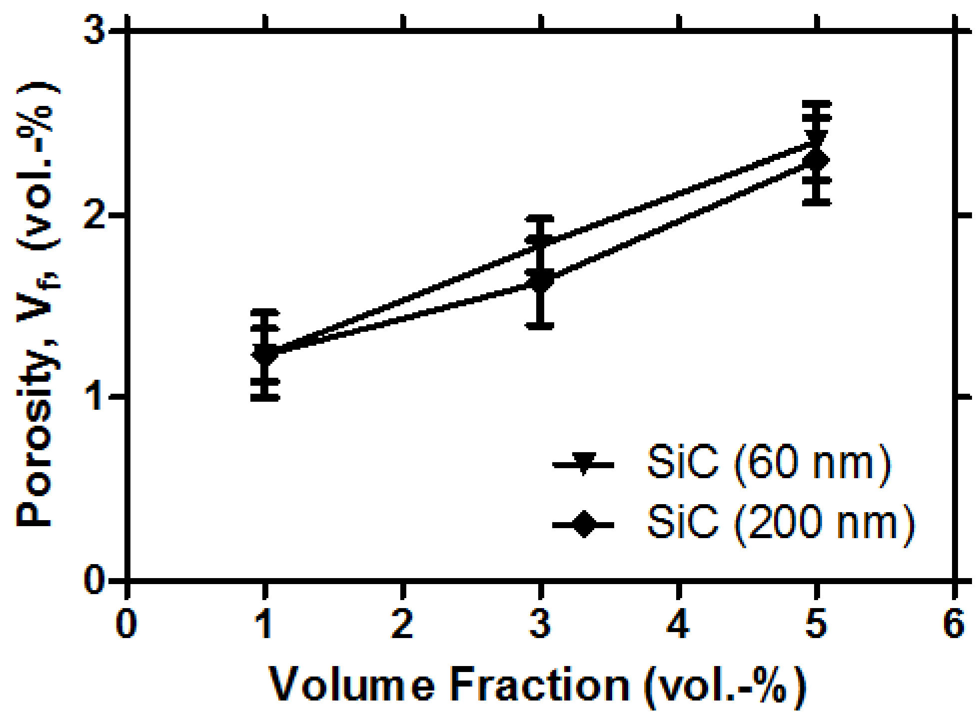
- The electrochemical tests were carried out in the two-electrode corrosion cell has a volume of 400 ml.
- The platinum electrode was the auxiliary one, and the reference electrode was the saturated calomel electrode.
- Potential change rate was 30 mV/min.
- The corrosion current (I_{corr}) in mA, corrosion potential (E_{corr}) in mV, polarization resistance (R_p) in kΩ and corrosion rate (CR) in (mm/year) were calculated from the electrochemical tests.

Results & Discussion

Porosity of Nanocomposites



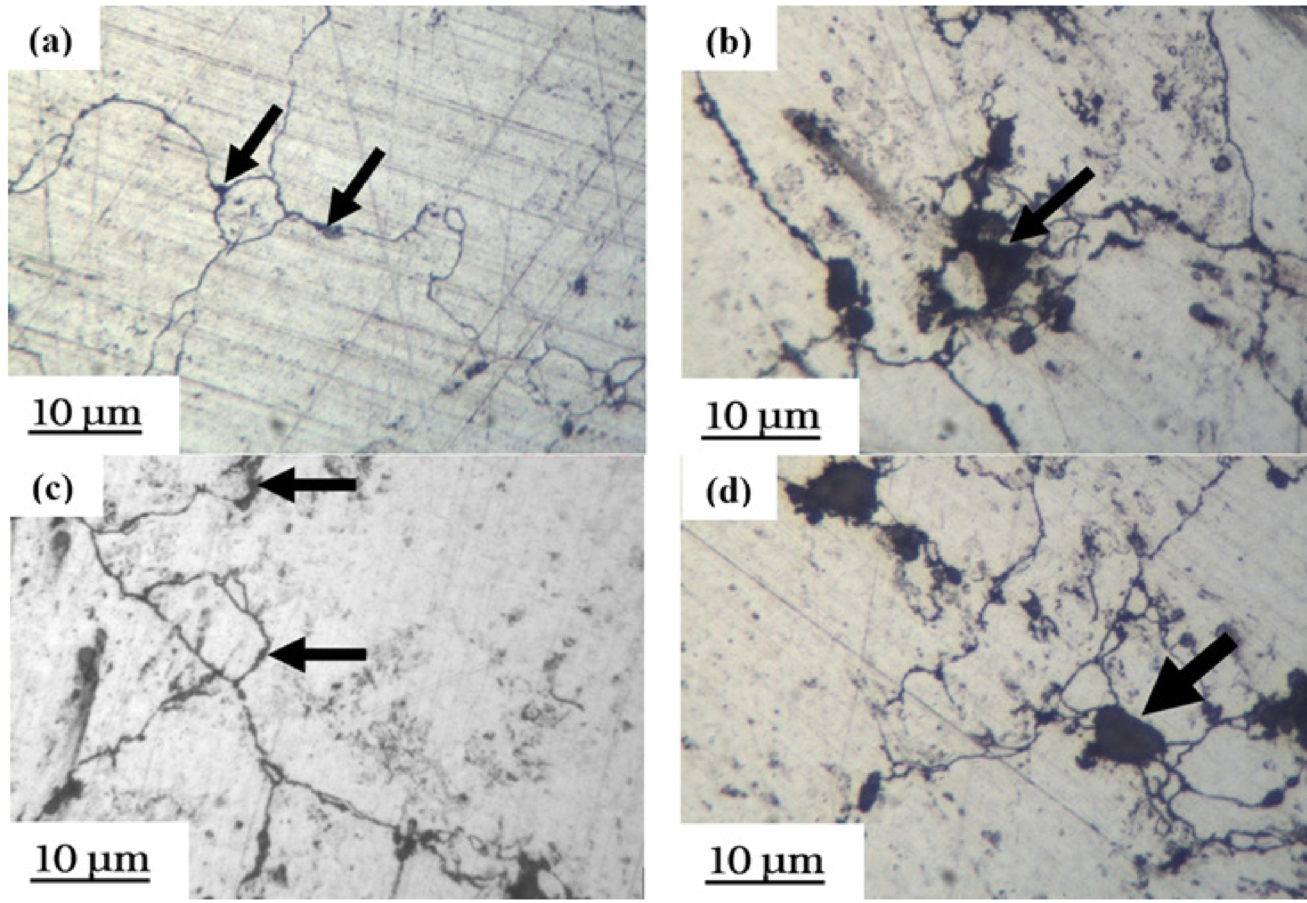
(a)



(b)

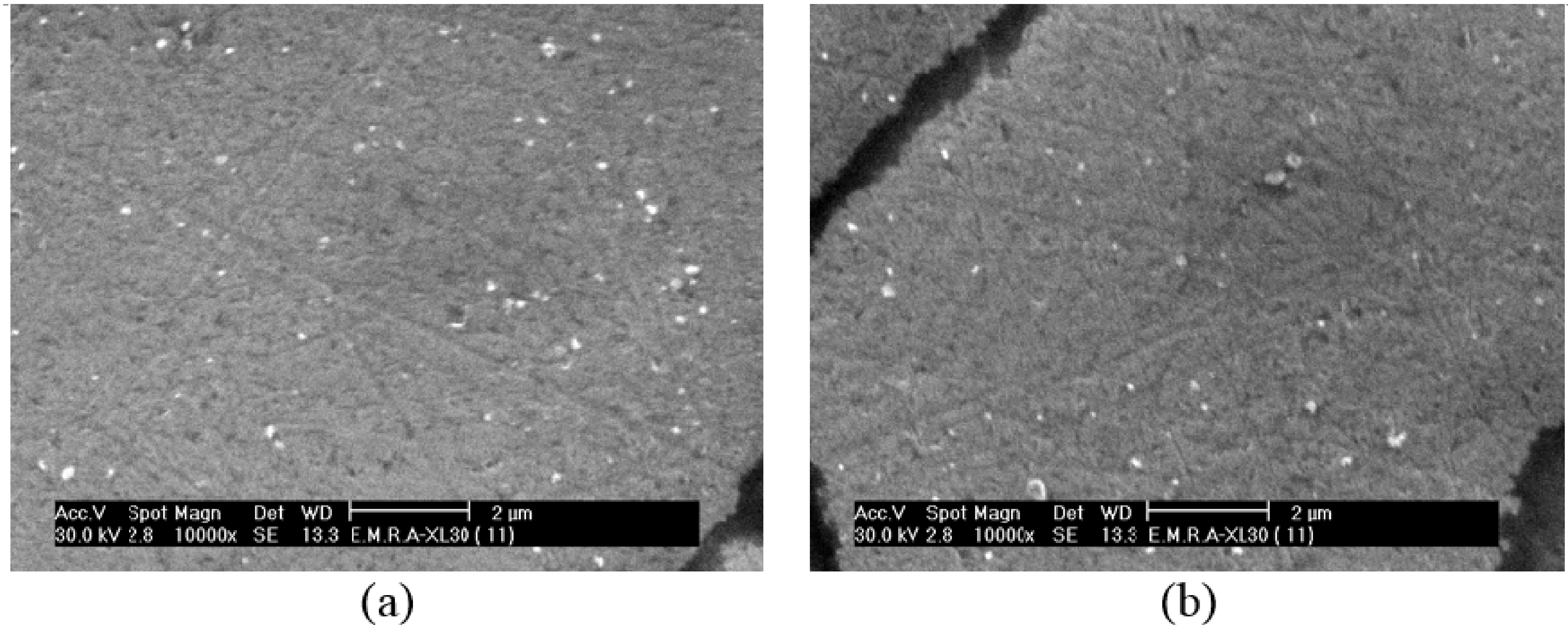
Variation of the bulk porosity of the MMNCs after extrusion with the volume fraction of the (a) Al_2O_3 and (b) SiC nano-particulates having different sizes

Microstructure of Nanocomposites



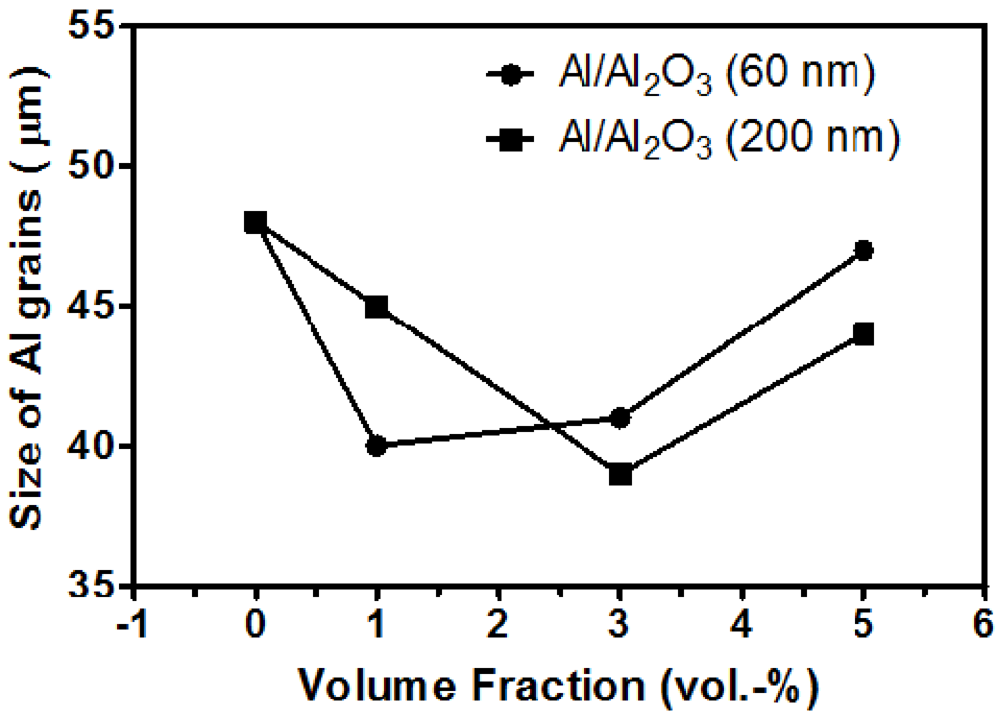
Optical micrographs of (a) Al/1 vol.-%Al_2O_3, (b) Al/5 vol.-%Al_2O_3, (c) Al/1 vol.-%SiC and (d) Al/5 vol.-%SiC nanocomposites. Both SiC and Al_2O_3 have average size of 60 nm.

Microstructure of Nanocomposites

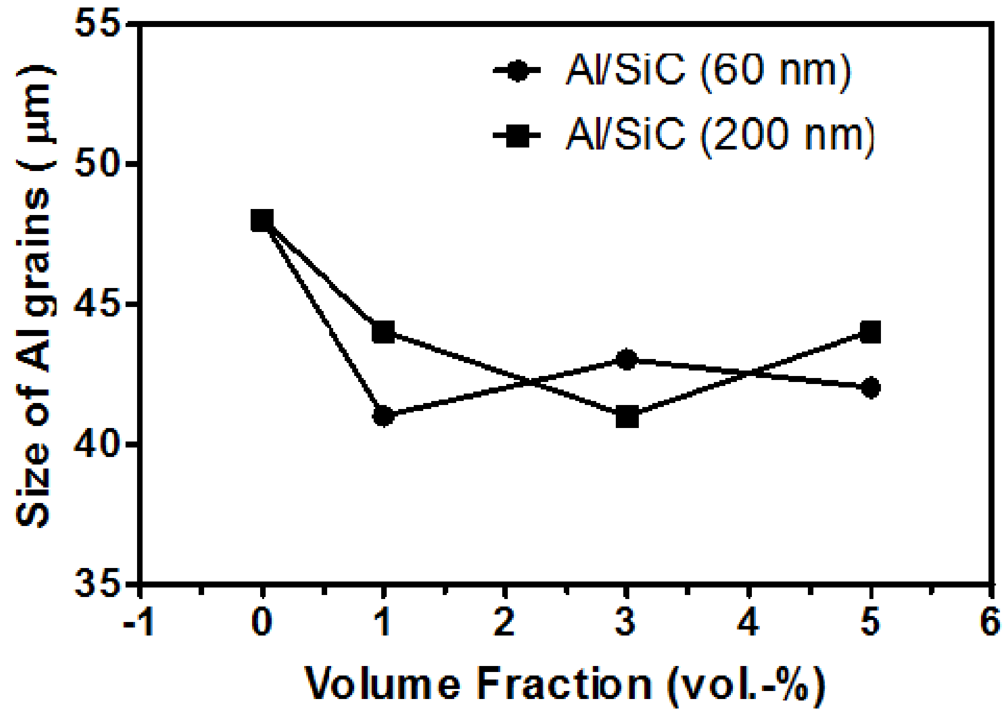


SEM micrographs of (a) Al/3 vol.-%Al_2O_3 (60 nm) and (b) Al/3 vol.-%SiC (200 nm) nanocomposites.

Microstructure of Nanocomposites



(a)

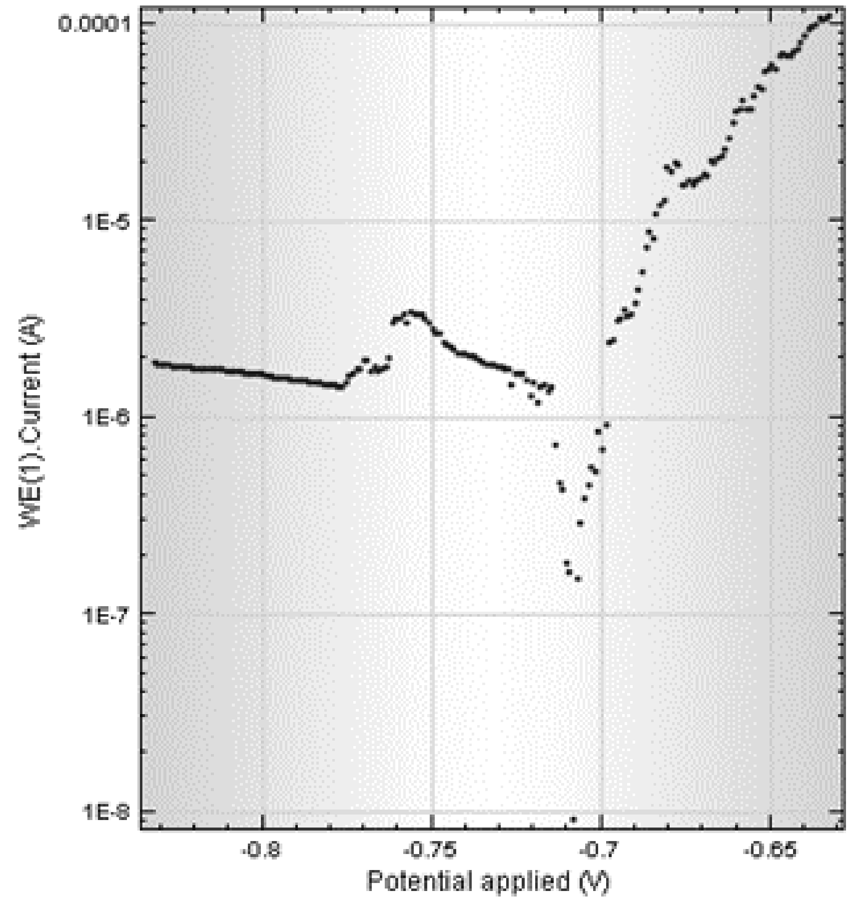


(b)

Variation of the average size of Al grains with the volume fraction of (a) Al_2O_3 (b) SiC nanoparticulates having different sizes.

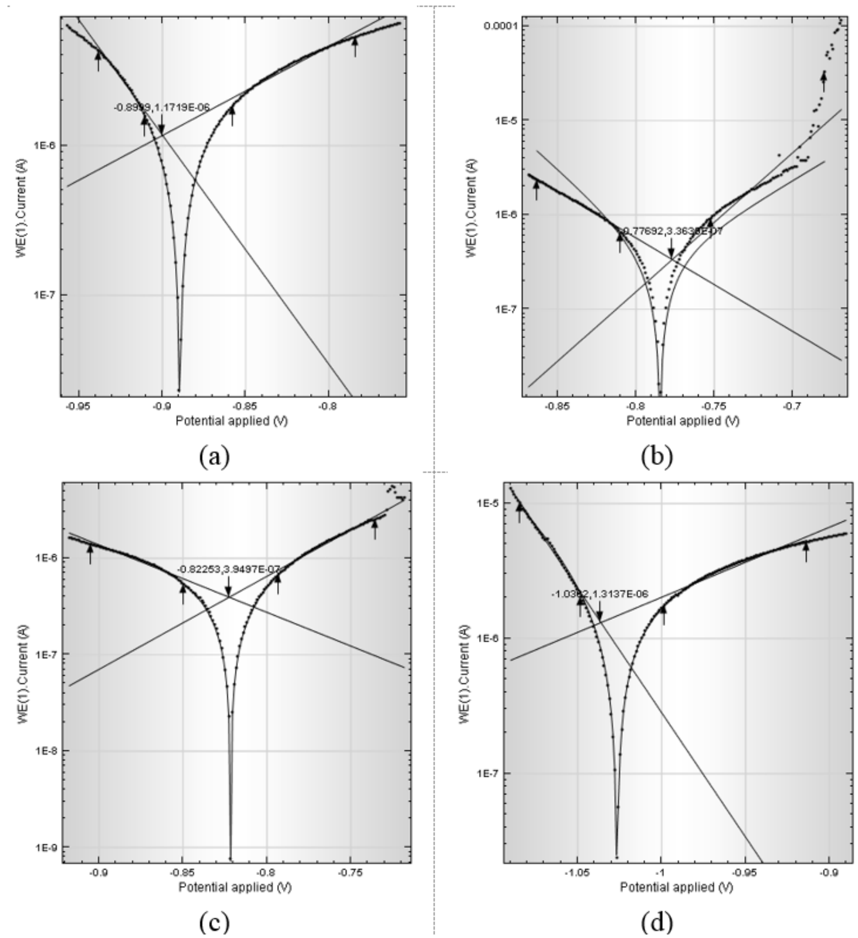
CORROSION BEHAVIOUR OF Al Matrix

- The results revealed that the I_{corr}, E_{corr}, R_p and CR of the pure Al matrix were about 0.0036 mA, -700 mV, 4.66 kΩ and 0.0397 mm/yr, respectively.



CORROSION BEHAVIOUR OF Al/Al_2O_3 NANOCOMPOSITES

Polarization curves for Al/Al_2O_3 nanocomposite samples in 3.5 wt.% NaCl solution; (a) 1 vol.% (60 nm), (b) 5 vol.% (60 nm), (c) 1 vol.% (200 nm), (d) 5 vol.% (200 nm).

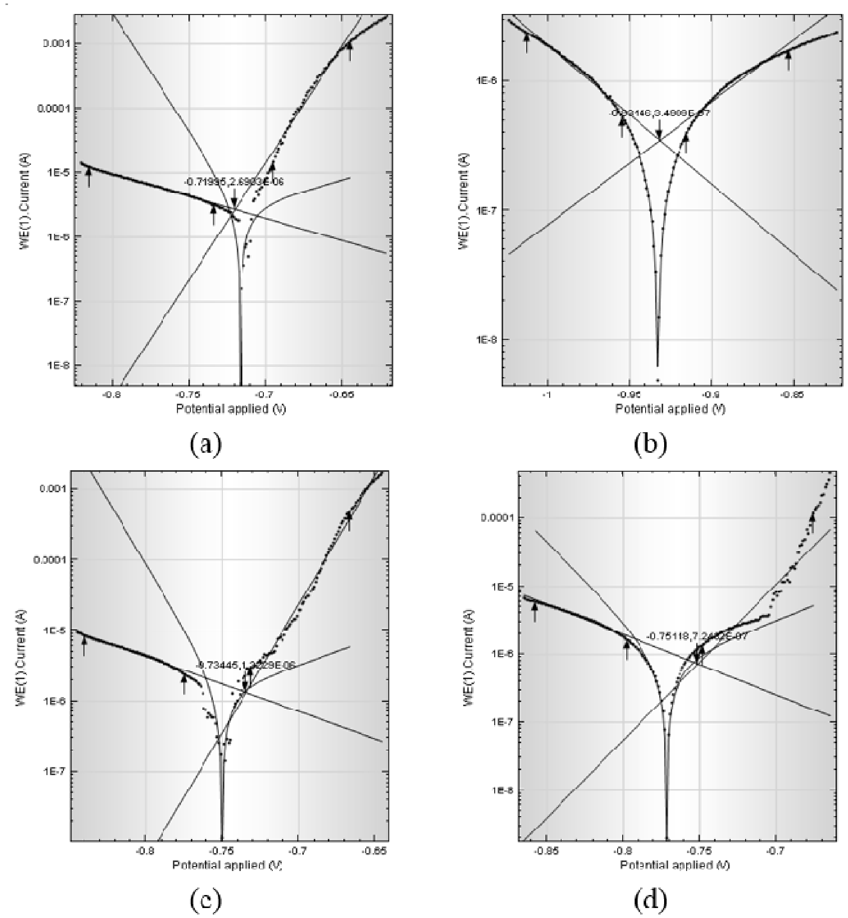


CORROSION BEHAVIOUR OF Al/Al_2O_3 NANOCOMPOSITES

E_{corr}, I_{corr}, R_p and CR values for different Al/Al_2O_3 nanocomposite samples in 3.5.% wt.-% NaCl solution.

Material Type	Particle Size (μm)	Volume Fraction (Vol.%)	E_{Corr} (mV)	I_{corr} (mA)	Corrosion Rate (mm/year)	Polarization Resistance (kΩ)
Al/Al_2O_3	60	1	-896	0.00327	0.16988	14.9890
		3	-803	0.00153	0.08063	11.7460
		5	-777	0.33635	0.01758	52.4230
	200	1	-883	0.00190	0.09964	46.9900
		3	-716	0.55915	0.02910	13.2960
		5	-1036	0.00217	0.11244	12.7960

CORROSION BEHAVIOUR OF Al/SiC NANOCOMPOSITES



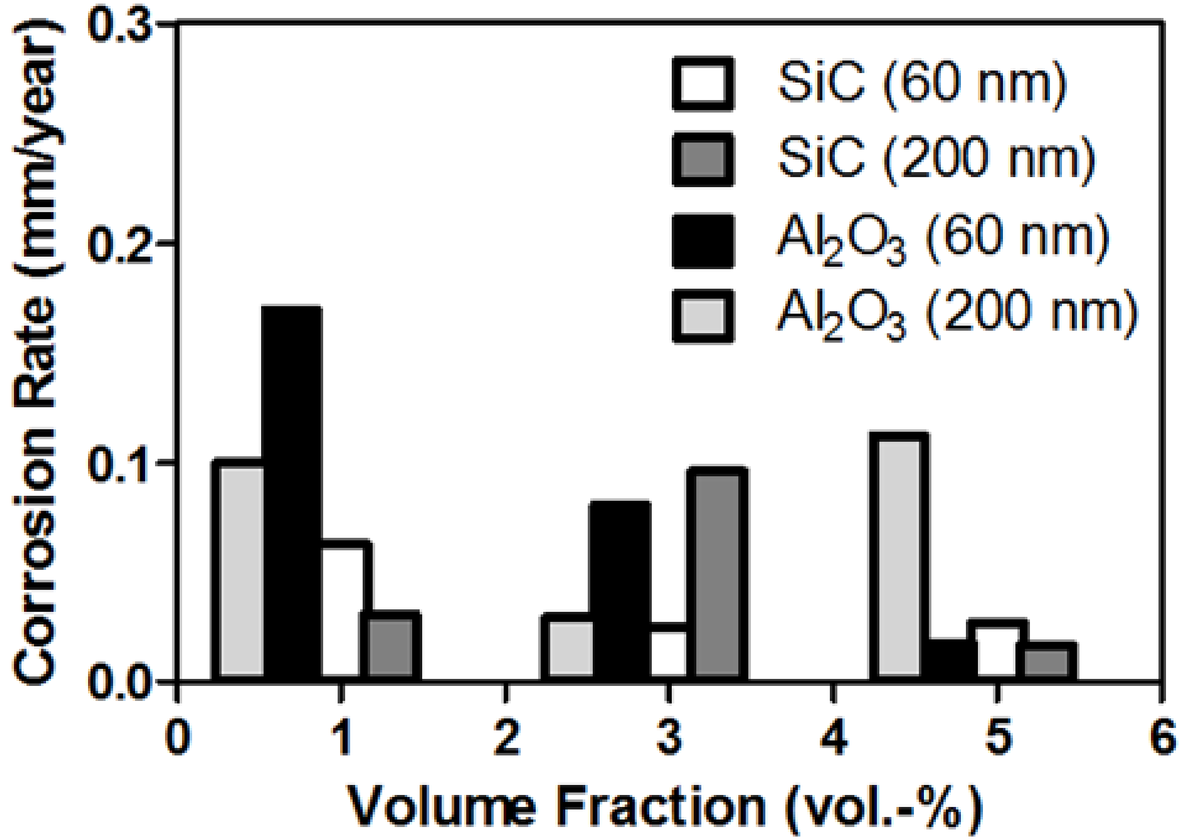
Polarization curves for Al/SiC nanocomposite samples in 3.5 wt.% NaCl solution; (a) 1 vol.% (60 nm), (b) 5 vol.% (60 nm), (c) 1 vol.% (200 nm), (d) 5 vol.% (200 nm).

CORROSION BEHAVIOUR OF Al/SiC NANOCOMPOSITES

E_{corr}, I_{corr}, R_p and CR values for different Al/SiC nanocomposite samples in 3.5.% wt.-% NaCl solution.

Material Type	Particle Size (µm)	Volume Fraction (Vol.%)	E_{Corr} (mV)	I_{corr} (mA)	Corrosion Rate (mm/year)	Polarization Resistance (kΩ)
Al/SiC	60	1	-720	0.00269	0.062615	3.73510
		3	-681	0.00107	0.025095	10.7190
		5	-931	0.00117	0.027146	43.2900
	200	1	-734	0.00132	0.030675	7.42570
		3	-716	0.00412	0.095916	2.25770
		5	-751	0.72432	0.016733	18.8480

Comparison between the corrosion rates of the Al/SiC and Al/Al_2O_3 nanocomposites



Comparison between the corrosion rates of the Al/SiC and Al/Al_2O_3 nanocomposites at different sizes and volume fractions of the nanoparticulates.

Conclusions

Conclusions

Based on the results presented, the following conclusions can be draw:

1. Dispersion of both Al_2O_3 and SiC nanoparticulates in pure Al matrix using powder metallurgy route can assist in improving the corrosion resistance of Al. However, the correct choice of the volume fraction and the size of the nanoparticulates as well as the processing parameters plays an important role in determining the corrosion behavior of the nanocomposites.

2. Generally, the Al/SiC nanocomposites exhibited lower corrosion rates in 3.5 wt.-% NaCl solution than the Al/Al_2O_3 nanocomposites. The Al/5 vol.-% SiC (200 nm) nanocomposites exhibited the lowest corrosion resistance among all the investigated materials even the pure Al matrix.

Conclusions (Cont.)

3. The corrosion rates of the 60 nm Al/SiC and Al_2O_3 nanocomposites in 3.5 wt.-% NaCl solution was reduced with increasing of the volume fraction of the nanoparticulates.
4. The Al/SiC nanocomposites exhibited better corrosion resistance in 3.5 wt.% NaCl solution than the Al Al_2O_3 nanocomposites.

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