A Comparative Evaluation of the MMC Al 6061/TiB2/12P and the Microstructures and Mechanical Properties of Al 6061 Alloy

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ABSTRACT: Al 6061 alloy is widely used commercially in transportation, construction and similar industries. Apart from its excellent corrosion resistance, it has excellent mechanical properties due to which the alloy finds great application in shipbuilding Al-TiB2 composites are metal matrix composites (MMC). can be produced on site by a salt-iron process. The properties of the Al 6061 alloy as particle inclusions of TiB2 can be further improved. A comparison of the mechanical properties and microstructure of the Al 6061 alloy with the Al–TiB2 metallic matrix composite with 12% by weight of TiB2p by in-situ method is presented.

Key Words: Al 6061 alloy, Al-TiB_2 Metal matrix Composite (MMC), Aluminium MatrixComposite (AMC)

1. INTRODUCTION

Al alloy Al 6061 is widely used in many engineering applications such as transportation and construction where good mechanical properties such as tensile strength and hardness are strictly required. The typical chemical composition of Al 6061 is shown in Table 1. Its excellent corrosion resistance makes it a suitable candidate material for structural applications in shipbuilding. The demand for lightweight, cost-effective, and high-performance materials used in a variety of structural and nonstructural applications has created a need for the production of various types of metal matrix composites (MMCs).

Table1.ChemicalcompositionofAl6061.

Element	Mg	Fe	Si	Cu	Mn	V	Ti	Al
Weight%	1.08	0.17	0.63	0.32	0.52	0.01	0.02	Remainder

In recent years, aluminum alloy-based MMCs have offered designers many additional advantages, as they are particularly suitable for applications requiring good high-temperature strength, good structural stiffness, dimensional stability, light weight, and low thermal expansion. [1-6]. The main benefits of aluminum matrix composites (AMC) include increased strength, increased stiffness, reduced density, improved high temperature properties, controlled coefficient of thermal expansion, thermal/thermal management, improved and tuned electrical performance, Improved wear and abrasion resistance, as well as improved damping capacity [7, 8th]. One such MMC is Al-TiB2p, which contains TiB2 as the dispersed second phase particles. When a molten metal or other liquid phase containing dispersed second phase particles solidifies, interactions occur between the particles and the advancing solidification front. Such interactions also influence front morphology and particle coagulation. The coagulation front pushes out or swallows particles. Therefore, particles can reside at grain boundaries, interdendritic regions, or within the primary particles themselves. This phenomenon occurs in many coagulation processes and has also been observed by others [9, 10]. The influence of particulate silicon carbide on the mechanical behavior of Al 6061 MMC was previously studied by T.S. Shrivatsan et al. al., [11]. The TiB2 particles formed by the in situ reaction process were found to stick together and form aggregates. Feng and Froyen also reported similar findings when AMC was prepared using commercially available pure Al as the matrix [12]. In situ generation of studied AMCs has been widely reported in the literature [12, 13]. However, there are not many reports on the fabrication of AMC using Al 6061 as the matrix alloy and TiB2p as the composite material. The purpose of this study is to compare the mechanical properties and microstructure of cast Al 6061 alloy with those of aluminum MMC containing 12 wt% TiB2p.

2. EXPERIMENTALPROCEDURE

Composite Fabrication

Due to the various advantages mentioned above, as-cast Al 6061 alloy was used in this study. The AMC in this study consists of 12 wt% TiB2 particles in an Al 6061 matrix.

(hereafter referred to as Al 6061/TiB2/12p) was prepared by an in-situ process involving a salt-metal reaction between titanium-containing K2TiF6 and boron at his Department of Mechanical Engineering, CSI College of Engineering, Ooty, South India. In the in situ reaction process, the two salt elements Ti and B mentioned above are introduced into the aluminum melt and react there.

Since the salts are stoichiometrically mixed to form TiB2, TiB2 is the only intermetallic phase formed by the reaction. The reaction scheme used to form the composite material is shown below.

$$3K_2TiF_6+22Al+6KBF_4 \longrightarrow 3Al_3Ti+3AlB_2 + 9KAlF_4+ K_3AlF_6+ \text{Heat} \quad (1)$$

$$3Al_3Ti+3AlB_2 \longrightarrow 12Al+ 3TiB_2 \quad (2)$$

Aluminum rods were melted in an electric resistance furnace using a graphite clay crucible. The melt was brought to a temperature of 840°C. The premixed salt was then added to the molten aluminum alloy and thoroughly stirred every 10 minutes using a graphite rod. The total reaction time allowed at the aforementioned temperatures was 1 h, after which the melt was poured into a cast iron mold to cast rectangular composite panels with size 10 cm x 25 cm as shown in Figure 1. Samples were prepared from cast composite panels to carry out studies to evaluate the metallurgical and mechanical properties.

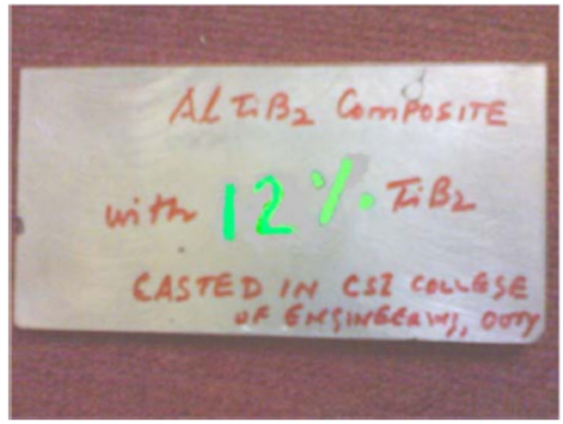


Figure1. Casted Composite Plate

Characterizationof6061AlalloyandAl-TiB_2Composite

Figure 2 shows the X-ray diffraction pattern of the composite material, indicating the presence of TiB2. Optical microscopy examination was performed on both aluminum alloy 6061 and Al MMC.

Use standard metallographic processes. The etchant used was a 0.5% by volume HF aqueous solution. Micrographs taken from above are shown in Figures 3 and 4. The morphology and microstructure of the prepared Al-TiB2 composites as well as the fracture surface of the tensile test samples were observed with a scanning electron microscope (Joel JSM 6360) using Cu-Kα radiation. The scanning electron micrograph and the created fractograph are shown in the figure. 5-7. The Brinell hardness at room temperature was measured at six locations on the top of the composite material, and the average is shown in Table 2. Six tensile test samples prepared according to the ASTM-E08 standard were tested. The average values of the obtained tensile strengths are also shown in Table 2.

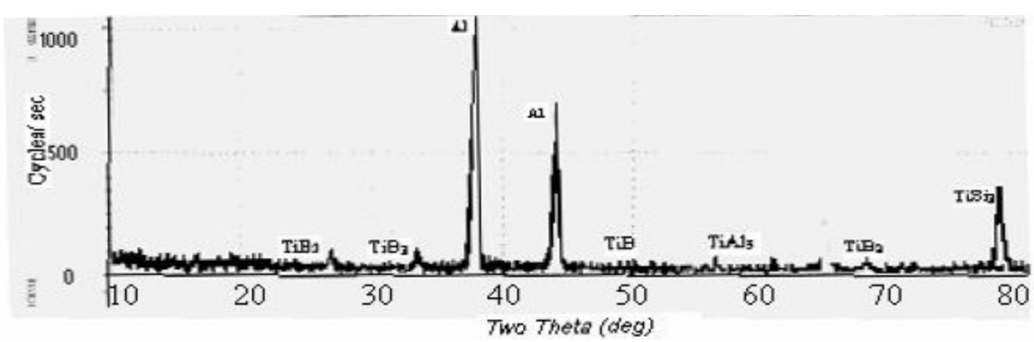


Figure2. X-ray diffraction pattern of the composite.

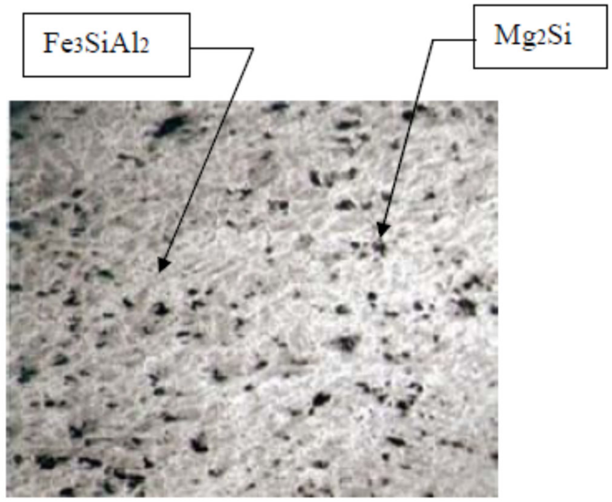


Figure 3. Optical Photomicrograph ofAl6061alloy

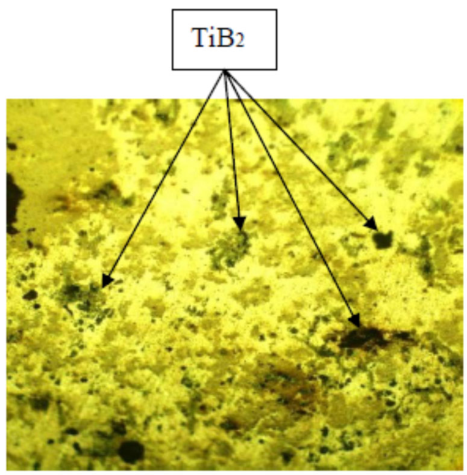
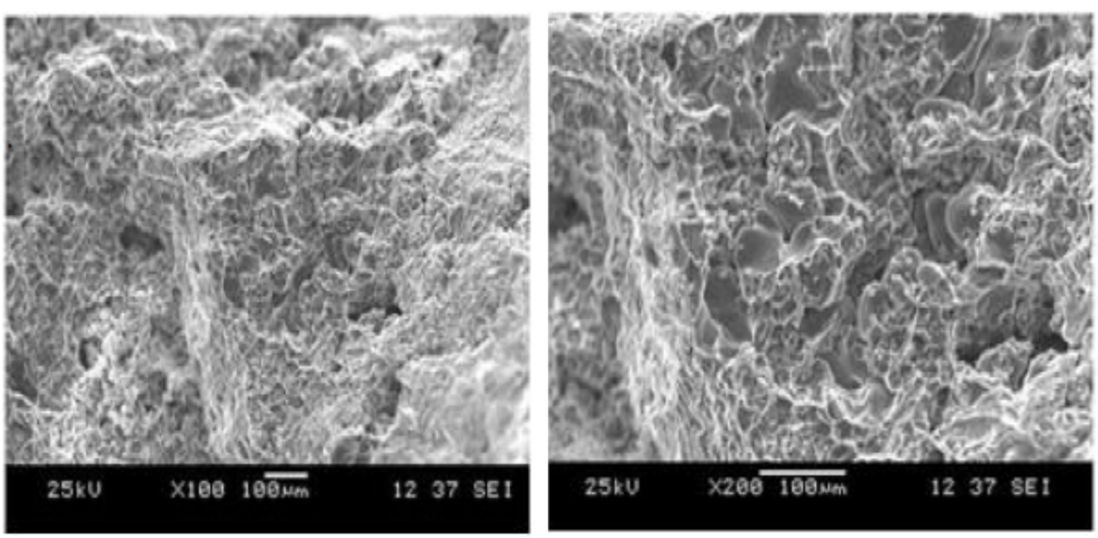


Figure 4. Optical Photomicrograph ofAl-TiB_2composite



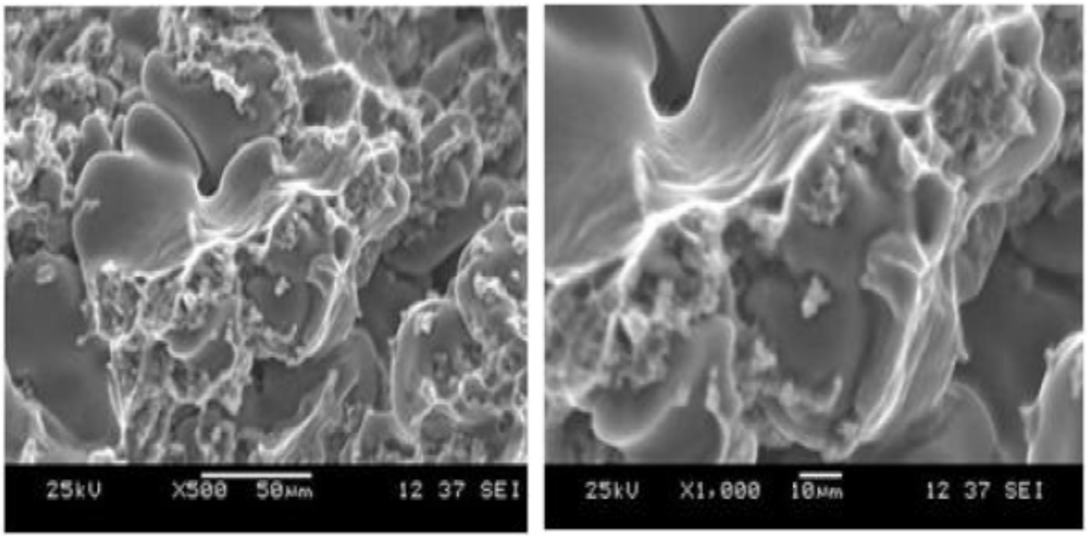


Figure5. ScanningElectronMicrographsoftheAl-TiB2composite formed through the‘ in-situ’ reaction.

Table2. Hardness and Tensile Properties.

Material	Hardness(BHN)	Tensile Strength(MPa)	Young’sModulus(GPa)	% Elongation
Al-6061 (ascast)	62.8	134.8	79.8	8.0
Al-TiB_{2p}	88.6	173.6	94.2	7.0

TensileFracture

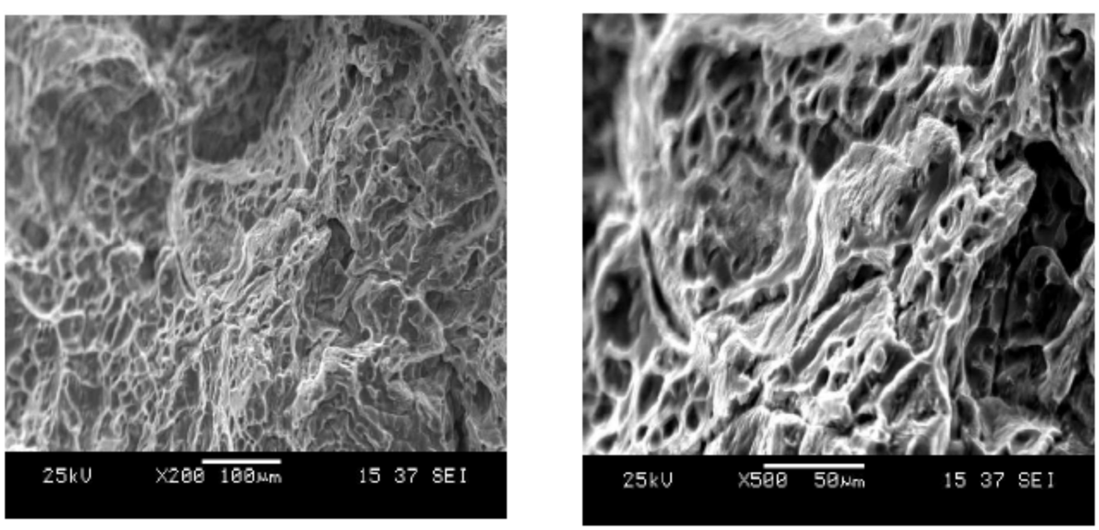
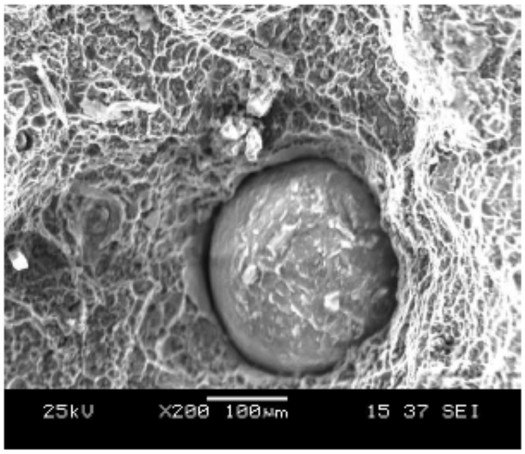


Figure 6 : SEM Factorgraphs of A16061



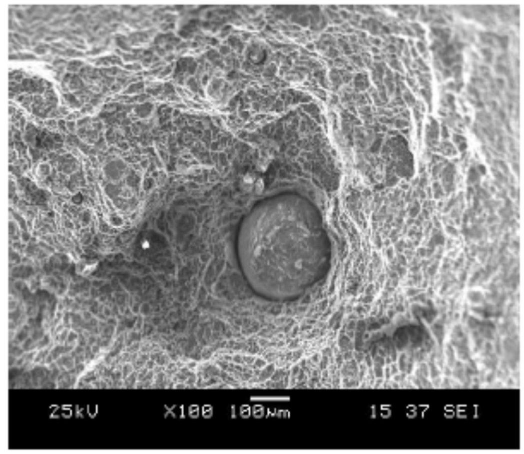


Figure7. SEM Fractographs of Al-TiB_2Composite.

RESULTSANDDISCUSSION

Microstructure Characterization

The X-ray diffraction pattern of the composite shown in Figure 2 shows that the composite is composed of aluminum and TiB2 as well as trace amounts of TiAl3, TiB, and TiSi2. The presence of TiSi2 is mainly due to the use of graphite clay crucibles and the resulting silicon contamination.

clay [14]. Since the two salts K2TiF6 and KBF4 are stoichiometrically mixed to form TiB2, TiB2 is the main intermetallic compound formed by the reaction. This is also confirmed by XRD analysis.

Figure 3 shows that the microstructure of the 6061 aluminum alloy matrix contains Mg2Si particles (black) and Fe3SiAl2 particles (gray). Optical microscopy of the composite shows the presence of reinforcing particles in the form of clusters. From Figure 4, it can be seen that the discontinuous TiB2p reinforcing phases with non-uniform size and irregular shape are randomly distributed in the aluminum alloy matrix. Agglomeration or clustering of his TiB2p reinforcements of different sizes and shapes is observed, resulting in particle-rich and particle-poor regions. The agglomeration sites are characterized by uniformly small and irregularly shaped particles mixed with larger TiB2p of various sizes. In addition to the presence of reinforcing TiB2p, the alloy is enriched with coarse insoluble iron-rich and silicon-rich constituent particles, indicating the presence of impurity elements. H. Iron and silicon can be attributed to aluminum alloys.

The TiB2 particles formed by the in situ reaction process were found to stick together and form aggregates. The tendency of TiB2 particles to form clusters in the Al-TiB2 system was found to be very pronounced, as reported by Jha and Dometakis [14]. This study also revealed that cluster formation of TiB2 particles in the Al matrix is important. The cause of cluster formation is still not clearly understood. Many theories proposed so far suggest that contamination of the TiB2 particle surface is responsible for cluster formation. Reactive elements (such as potassium) from Al3Ti [15], magnesium [14], and residual salts [15] have been suggested as possible surface-active substances. It has also been suggested that particles move through the oxide film and form clusters [17]. The holding temperature was maintained at 840 °C in this experiment, as it has been reported that the change in the microstructure of composites with increasing holding temperature is negligible [12].

Improved Mechanical Propertiesin the Composite

From Table 2, it can be seen that the composite material has higher hardness than the aluminum alloy. The table also shows that the composite material has a higher tensile strength than the reduced ductility 6061 aluminum alloy. The significant improvement in the mechanical properties of the composites compared to aluminum alloys is due to the distribution of TiB2 particles in the matrix.

Figures 6 and 7 show scanning electron micrographs of the fracture surfaces of the samples. The voids shown in the figure are where the reinforcing particles were located within the matrix. In general, MMC often behaves asymmetrically in tension and compression, resulting in higher tensile strengths but lower proportionality limits than monolithic alloys. This behavior of composite materials is related to the factors that determine the plasticity of the matrix and can be divided into two areas: those that affect the stress rate of the matrix, and those that affect the flow properties of the matrix through microstructural changes. You can separate it. This occurs due to the installation of reinforcement

CONCLUSIONS

[1] Al-6061/TiB2/12p composite was successfully prepared by in situ reaction method. Both threads and particle aggregates were present as distinct microstructural features of the composites.

[2] The prepared Al-TiB2 composite had higher hardness, tensile strength, and elastic modulus values than the base alloy.

[3] The ductility of the composite material was found to be slightly lower than that of aluminum alloy 6061.

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