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AL/TIB2 METAL MATRIX COMPOSITES OBTAINED THROUGH IN-SITU TECHNIQUE

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Abstract: *The objective of this paper is to present the manufacturing of Al/TiB_2 in-situ composites using the exothermic reaction in the Al - K_2TiF_6 - KBF_4 system. Composites with aluminum matrix and TiB_2 particles have excellent mechanical strength, high resistance to wear and corrosion due to thermodynamic stability of particles in the matrix.*
Key words: *particles of TiB_2, in-situ composites, aluminum matrix*

1. INTRODUCTION

In the last decades the aluminum matrix composites reinforced with discontinues particles represent a priority field in structural composite researches.

Metal matrix composites have been manufactured by various techniques such as powder metallurgy, spray deposition and several casting methods such as rheocasting, squeeze-casting, stir-casting and compo-casting, but there exist some challenges in manufacturing the discontinuously reinforced metal matrix composites. One of the main problems lies in the thermodynamic instability of reinforcing ceramic phases in the matrix [1, 2, 6, 8, 9].

In-situ method for manufacturing of these composites, comes into sight in the middle of '80 years, offers a thermodynamic stability of fine and disperses particles into the aluminum matrix due to the fact that germination and reinforcement particles growth take place exact in the alloy matrix, ensureing a strong connection at the interface between particles and matrix [5].

In-situ fabrication of the metal matrix composites is a process, in which dispersed (reinforcing) phase is formed in the matrix as a result of precipitation from the melt during its cooling and solidification.

In-situ technique involves a chemical reaction resulting in the formation of a very fine and thermodynamically stable reinforcing phase within a metal matrix [10].

Prasad et al. studied KBF_4 and K_2TiF_6 salts, using differential thermal analysis (DTA), differential scanning calorimetry (DSC) and thermo-gravimetry (TG) up to 1073 ^oC. Prasad et al. also examined the reactions between two salts and aluminum [7].

Donaldson et al. examined the reaction between salts and aluminum by XRD analysis of the slag, as well as the transfer efficiency of the Ti and B from salt to aluminum by chemical analysis of the alloy [4].

The purpose of this paper is to present the results of fabrication of in-situ Al/TiB_2 composites using the exothermic reaction between metallic melt and salts containing boron (from KBF_4) and titanium (from K_2TiF_6).

2. EXPERIMENTAL PROCEDURE

In-situ Al/TiB_2 composites were manufactured with an exothermic reaction process via KBF_4 and K_2TiF_6 salts. As matrix was used 6xxx series aluminum alloys (Al-Cu-Mg-Si), the chemical composition being presented in Table 1.

Alloy	Si	Fe	Cu	Mn	Mg	Zn	Ti	Al
6060	0.47	0.21	0.02	0.015	0.61	0.029	0.010	Bal.
6063	0.43	0.22	0.01	0.014	0.43	0.017	0.013	Bal.

Tab. 1. Chemical composition of aluminum alloys, wt.%

The aluminum alloys 6xxx series were selected as matrix because it possesses medium strength, good formability, machinability, weldability and corrosion resistance compared to other grades of aluminum alloys.

The composites elaboration was realized in an electric furnace with KANTHAL resistance and graphite crucible, equipped with control devices and temperature control (nickel chromium-nickel aluminum thermocouple and temperature regulator with a $\pm 5^oC$ deviation).

The fabrication of in-situ Al/TiB_2 metal matrix composites is based on a process in which boron (from KBF_4) and titanium (from K_2TiF_6) containing salts react with molten aluminum to generate in-situ TiB_2 particles, at temperatures between 750 - 950 ^oC.

Also, was added cryolite (Na_3AlF_6) which has the role to eliminate aluminum oxide in dros. The other role of cryolite is taking as activator, decreasing activated energy and accelerating the in-situ reaction.

A pre-weighted mixture of K_2TiF_6 and KBF_4 salts was mixed and preheated at 300 ^oC for 2 hours in order to eliminate humidity.

The exothermic reaction between the salts yield in-situ formed TiB_2 particles is:

$$3K_2TiF_6+6KBF_4+10Al=4K_3AlF_3+6AlF_3+3TiB_2 \quad (1)$$

The salts react with the molten aluminum alloy such that the boron and titanium enter the aluminum and combine to form in-situ TiB_2 particles. The remaining cryolite slag (dross) is removed from the surface and the molten composites were cast into a mold.

The reactions that occur in the simultaneous introduction of fluorides K_2TiF_6 and KBF_4 in liquid aluminum alloy are very complex and involves reaction in melt, diffusion processes through the boundary layer between melt salt and melt metal, reactions inside of the salt particle and gas formation.

Since the chemical reaction took place entirely in the aluminum molten, no oxidation layer on the surfaces of the TiB_2 particles could be formed.

In-situ TiB_2 particles are formed in one of two ways. The first is that TiB_2 forms directly at the interface between aluminum and the flux. The formation and dispersion of this kind of boride particles is strongly influenced by the alloy elements. The second is that titanium and boron disperse into the aluminum melt when K_2TiF_6 and KBF_4 are reduced by aluminum and subsequently react to form TiB_2 particles.

3. CHARACTERIZATION OF COMPOSITES

The composites obtained have been characterization by electron microscopy (with EDS) and also through X-ray diffraction (XRD).

From the figure 1 results that the reaction between liquid aluminum and complex mixture fluorides (K_2TiF_6 and KBF_4) led to obtaining a composite material with a TiB_2 particles fine array.

Titanium boride particles are hexagonal shape, with almost echiaxa shape, and are situated at the grain boundaries. Average size of particles is 1-1,20 μm.

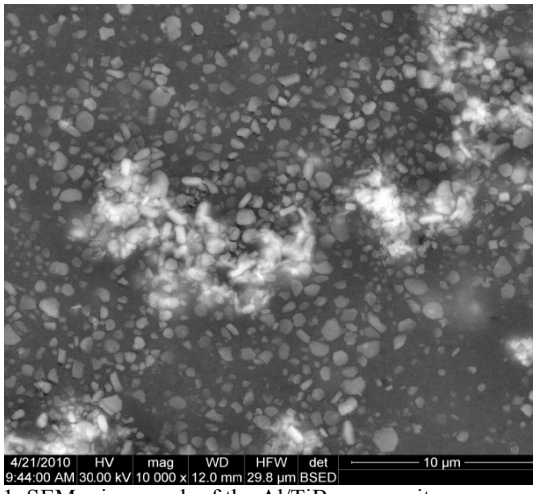

Fig. 1. SEM micrograph of the Al/TiB_2 composite

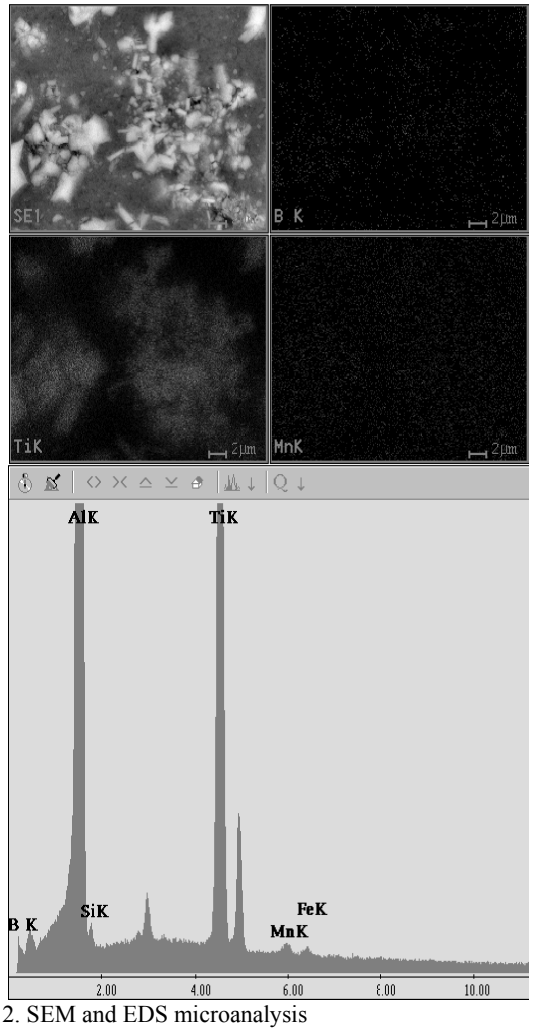

Fig. 2. SEM and EDS microanalysis

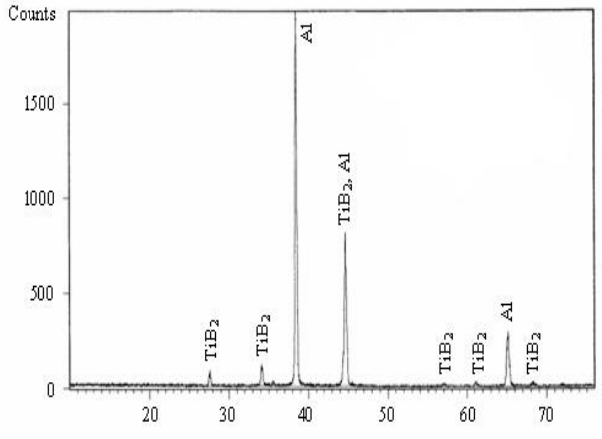

Fig. 3. X-ray diffraction (XRD) pattern of Al/TiB_2 composite

Figure 3 shows an X-ray diffraction (XRD) pattern of the Al/TiB_2 composite. The pattern reveals the presence of aluminum and TiB_2 peaks, indicating that TiB_2 particles are formed in the composite, only.

4. CONCLUSIONS

From the results obtained, the following may be concluded:

In-situ composites Al/TiB_2 were produced with an exothermic reaction in the Al - K_2TiF_6 - KBF_4 system, at 750 - 950 ^oC.

Cryolite salts was added as activator and reacting with Al_2O_3 to form drosses.

The reaction mixture of salts (K_2TiF_6 and KBF_4) with aluminum alloy is highly exothermic.

X-ray diffraction analysis (XRD) and EDS microanalysis confirmed the presence of TiB_2 particles.

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