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Full length article

Improved mechanical proprieties of "magnesium based composites" with titanium−aluminum hybrids

Muhammad Rashad [a,b,*], Fusheng Pan [a,b,c], Muhammad Asif [d], Jia She [a,b], Ahsan Ullah [e]

[a] College of Materials Science and Engineering, Chongqing University, Chongqing 400044, China
[b] National Engineering Research Center for Magnesium Alloys, Chongqing University, Chongqing 400044, China
[c] Chongqing Academy of Science and Technology, Chongqing, Chongqing 401123, China
[d] School of Materials Science and Engineering, Dalian University of Technology, Dalian 116024, China
[e] Department of Physics, Quaid-i-Azam University, Islamabad 46000, Pakistan

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Abstract

In this study, the effect of micron-sized titanium and aluminum addition on the microstructural, mechanical and work-hardening behavior of pure Mg is investigated. Pure Mg reinforced with 10%Ti and 10%Ti−1%Al particulates were synthesized through semi-powder metallurgy route followed by hot extrusion. Semi-powder metallurgy appears to be promising approach for the synthesis of Mg based composite, as it is free of ball milling. Tensile results indicate that the direct addition of micron-sized 10wt.% titanium particulates to pure Mg, caused an improvement in elastic modulus, 0.2% yield strength, ultimate tensile strength, and failure strain (+72%; +41%; +29%; and +79% respectively). The addition of micron-sized 10wt.% titanium particles along with 1.0wt.% Al particles to pure Mg, resulted in an enhancement in elastic modulus, 0.2% yield strength, ultimate tensile strength, and failure strain (+74%; +56%; +45%; and +241% respectively). Besides tensile test, Vickers hardness and work-hardening behavior of prepared composites were also examined. Impressive failure strain of Mg−10Ti−1Al composite can be attributed to the better compatibility of Ti particulates with Mg due to presence of alloying element Al.

Keywords: Mechanical properties; Microstructure; Powder metallurgy method; Metal matrix composite

1. Introduction

Magnesium alloys are a class of structural materials with increasing industrial interest in automobile service due to their good strength to weight ratio and low density [1]. Mg has hexagonal closed-packed (HCP) structure which leads to low ductility and toughness [2]. The problem of low ductility and tensile strength of Mg can be overcome by incorporation of different kind of reinforcements in the form of particles or fibers. Literature study reveals that ceramic and intermetallic (SiC, TiC, TiB_2, Al_2O_3, Y_2O_3, TiO_2, Mg_2Si etc) reinforcements have been extensively used to increase the strength of monolithic Mg [3−14]. But brittle nature of reinforcements leads to limited ductility of Mg composites. During past decade, carbon nanotubes (CNTs) have been extensively used as reinforcement for magnesium composites. Even though CNT/Mg composites have been extensively investigated, but uniform dispersion of CNTs in the matrix is big challenge for researchers which limit its use for practical

* Corresponding author. College of Materials Science and Engineering, Chongqing University, Chongqing 400044, China.
E-mail address: rashadphy87@gmail.com (M. Rashad).
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applications. This is caused by agglomerates formation due to its one dimensional structure and strong van der Waal attractions between carbon atoms [15,16].

Metallic reinforcement such as titanium has good ductility, strength, hardness and Young's modulus. The main advantage of Ti based Mg alloys it that there is no formation of any brittle inter-metallic compounds between Ti and Mg as shown in Ti−Mg binary phase diagram [17]. The research on hybrid reinforcement is gaining importance in recent years because they have positive influence on the mechanical properties of the Mg composites [18,19]. In 2011, Sankaranarayanan et al. [20] investigated the mechanical behavior of Mg-5.6wt.%Ti-2.5wt.%Al_2O_3 composite. The evaluation of mechanical properties indicated a significant enhancement in tensile strength however failure stain was no more than 6.8%. Similar behavior in strength properties were observed when Cu particulates were added to Mg-5.6wt.%Ti alloy [21]. Recently, Sankaranarayanan et al. Ref. [22] examined the effect of nano-SiC particles on mechanical behavior of Mg-5.6wt.%Ti composites. Room temperature tensile results revealed an

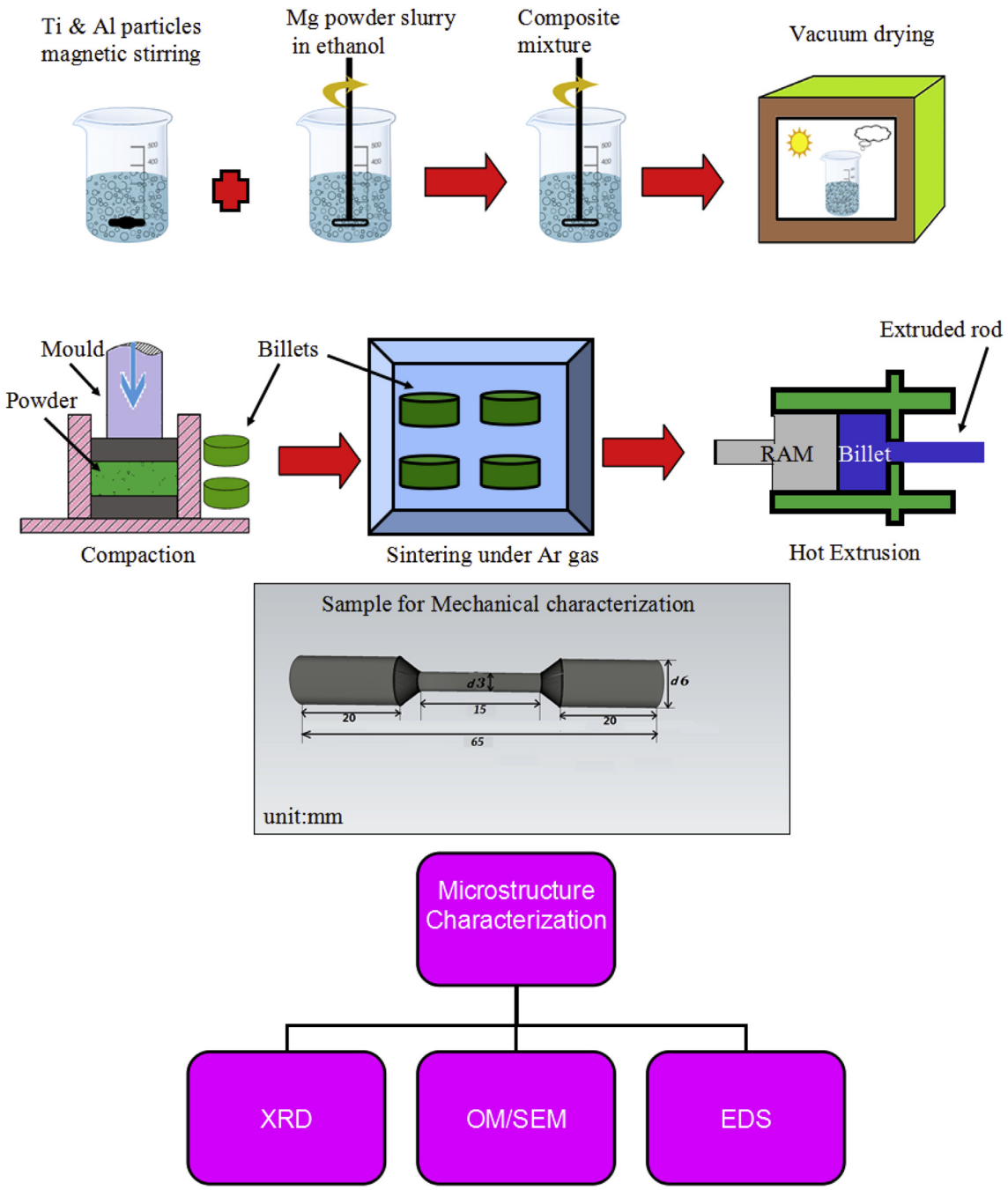

Fig. 1. Flowchart of semi-powder metallurgy method.