Effect of SiC particle size on the mechanical properties of closed aluminum foams

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Article Information

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The main targets of this research are the synthesis of aluminum foams with micro- and nano-scale SiC reinforcements and the assessment of their mechanical properties and cellular structures. For this purpose, the equal weight percents of micro- and nano-SiC particles were added to premixed aluminum, TiH_2 and Si powders. Then, the foaming process was applied under identical conditions for two nano and micro samples. Finally, uniaxial compression tests were carried out to survey the energy absorption of two nano and micro closed-cell foams. The obtained results indicated that the reinforced aluminum foam with nano-SiC particles exhibited compressive strength in the range of about 28 times higher than the micro-SiC foam. Moreover, scanning electron microscopy images revealed the reinforced aluminum foam with micro-SiC particles contained cellular structure with significant cell wall ruptures, while incorporation of nano-scale reinforcement improved the cell wall thickness uniformity without any considerable ruptures.

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Aluminum foams according to their pores morphology can be divided in open-cell and closed-cell structures. Closed-cell aluminum foams, due to extraordinary energy absorption capabilities, have been widely used in automotive and building applications. Besides, the excellent combination of good mechanical properties (especially characteristic strength and stiffness) as well as light weight make aluminum foam a promising candidate for different applications [1]. Two common methods for fabrication of metal foams are casting and powder metallurgy [2]. In powder metallurgy method, metal powders are mixed with foaming agent such as TiH_2 and $CaCO_3$ which drives the expansion of the precursor due to gas releasing during foaming step [3, 4]. In order to stabilize the precursor and improve the mechanical properties of metallic foams, ceramic particles were added to precursors. Kennedy et al. reported the effect of TiB_2 on the structure and mechanical properties of aluminum foams produced by powder metallurgy (PM) [5].

Al_2O_3 is another ceramic compound that can be used as stabilizer which increases the mechanical properties of produced aluminum foams produced by powder metallurgy technique [6]. Silicon carbide (SiC) particles were also used by Elbir et al. [7]. Their results showed that the compressive strength of prepared PM aluminum foams increased and the extent of the liquid metal drainage reduced obviously. However, in comparison with other researches, the aluminum foam reinforced by SiC presented more brittle behavior [7].

The most researches have been focused on the incorporation of micron-sized ceramic particles within aluminum foam structures. Due to the positive effect of nano particles on the mechanical behavior of metallic matrix composites, it is essential to investigate the role of nano-sized ceramic additives in the energy absorption and cellular structure of the closed-cell aluminum composite foams. In this research, in order to compare the effect of reinforcement particle size on the mechanical properties and morphology of foam cells, the same weight percents of micro and nano silicon carbide particles added to premixed precursor using the powder metallurgy method, and the foaming step was carried out under identical conditions.

Experimental procedure

In the present work, aluminum, silicon powder, nano- and micro-SiC particles and TiH_2 powders were used as matrix, alloying element, reinforcement and blowing agent, respectively. Table 1 shows the particle size of raw materials for preparing the precursor for this research. For fabrication of

Material	Size
Nano-sized SiC	50 nm
Micron-sized SiC	80 µm
Aluminum	63 µm
TiH_2	44 µm
Silicon	75 µm

Table 1: Raw powder materials