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Effect of Tungsten Carbide Reinforcing Particle on Wear Behavior in Aluminum Matrix Composites Synthesized through Powder Metallurgy.

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Aluminum Matrix Composites (AMCs) have attracted significant scientific attention for advanced engineering as structural and functional applications. This type of composite generally uses carbides or oxides materials and provides additional strength to the alloy, mainly in the elastic modulus, yield stress (YS), the ultimate tensile strength, and wear resistance [1]. On the other hand, the wear behavior of AMCs has been extensively studied in consideration of their potential applications in the aerospace and automobile sectors. In particular, ceramic reinforcements such as SiC and TiC, ZrO, B4C, and SnO2 improved the tribological properties of AMCs, including sliding and wear resistance under abrasive, lubricated, and dry sliding conditions [2]. Thus, this study's main objective was to investigate the effect of WC particles' addition in the Al-Cu-Mg system on the abrasive wear property using a pin on disc test.

The composite powders were fabricated by mixing the simultaneously elemental powder in the appropriate percentage to obtain the chemical composition of Al-4Cu-1.5Mg alloy with 1, 2, and 3 wt.% of tungsten carbide (WC). Powders were compacted, sintered (500 °C, 3h), extruded, and finally underwent an annealing process (420 °C, 3 h). For comparison, an unreinforced alloy was prepared by the same route. Samples were prepared for the wear test (10 mm in high and 9.5 mm in diameter). Such samples were loaded through a vertical specimen holder against a horizontal rotating disc covered with a cantilever mechanism's abrasive mediums. Samples underwent the sliding wear tests against the SiC abrasive papers of 180, 240, and 400 grit and loads of 3.0 N and 5.0 N. The worn samples' microstructure was studied by scanning electron microscopy through a Hitachi SU 3500 microscope.

Figure 1 shows the Al-Cu-Mg system's wear behavior and its composites with loads of 3.0 and 5.0 N over abrasive SiC paper with different grain sizes. The values indicate a decreasing behavior as the particle size decreases in both cases, 3 and 5 N. Besides, indicates that the wear rate is higher for a pressure of 5 N. For SiC paper with a smaller grit size (78 µm), the values show a general decreasing trend as a function of the WC content. The values of the larger grit size (22 µm) show a similar general trend between the Al–Cu–Mg system and the composites. Figure 2 show SEM-SE micrographs of the worn surfaces of the Al–Cu–Mg alloy (a), Al-4Cu-1.5Mg/3WC composite (b), and their corresponding cross-sections (c) and (d), respectively. The Al-Cu-Mg alloy showed more significant delamination, and larger grooves than the composite. This behavior can be observed in the cross-section where the grooves have a greater width, 15.7 µm and 12.1 µm for the alloy and the composite (see red arrow in Fig. 4c), respectively. The delamination is attributed to the plastic deformation of the material resulting in subsurface cracks that nucleate and propagate, leading to the formation of sheet-like wear features. Besides, higher plastic deformation and a rougher surface are present in the Al–Cu–Mg alloy than the composite, which presents a smoother surface. This behavior indicates a sensible reduction in plastic deformation corroborated by the smaller and less abundant subsurface cracks by increasing the hardness of the composite due to the excellent distribution of the reinforcing particles (Fig. 4d).

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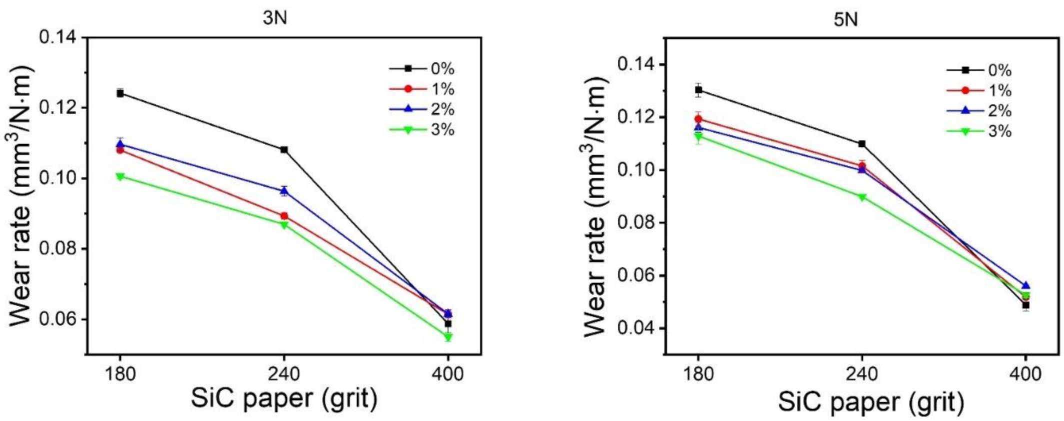

Figure 1. Wear rate of the Al-4Cu-1.5Mg alloy and the composites with 1, 2, and 3 WC (wt. %) during the pin-on-disc test at 3 and 5 N of loads on SiC paper with a different particle size 78 (180 grit), 52 (240 grit), and 22 µm (400 grit).

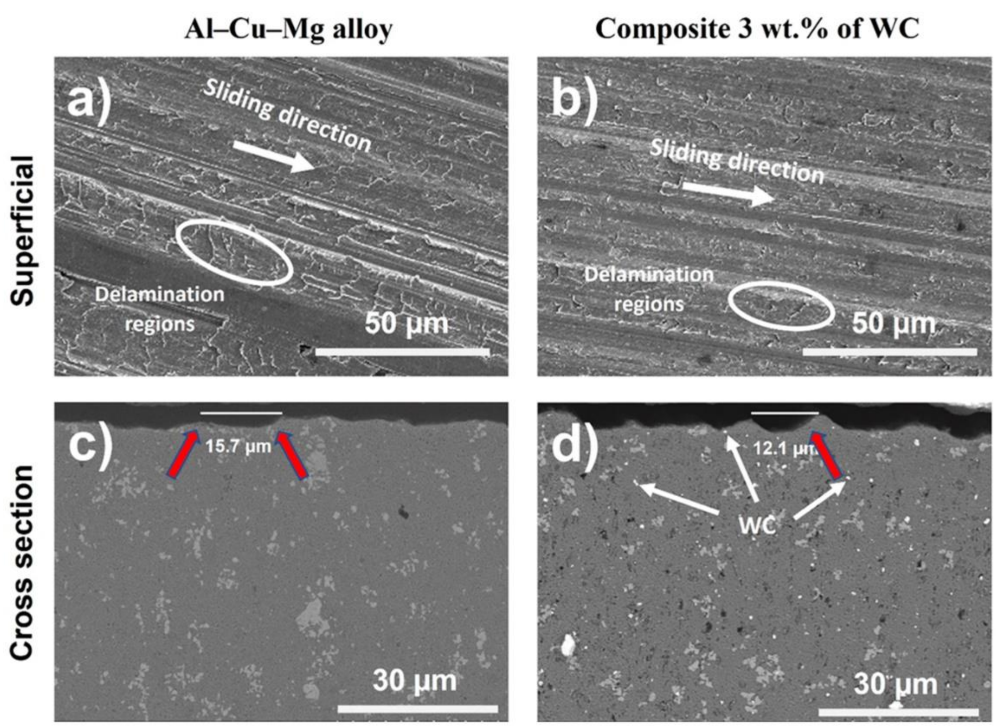

Figure 2. SEM-SE micrographs of the worn surfaces in the Al-4Cu-1.5Mg alloy (a) and the Al-4Cu-1.5Mg/3WC (b) and their cross-sectional micrographs (c) and (d), respectively. The samples were subjected to wear through SiC paper of 78 µm (180 grit) at 5 N of pressure and a sliding distance of 300 m.

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