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# Physical Distribution of Nanometric Particles into an Al-based Composite Synthesized by Means of Mechanical Milling

I. Estrada-Guel*,**, C. Carreño-Gallardo*,**, R. Pérez-Bustamante and R. Martínez-Sánchez*.

* Centro de Investigación en Materiales Avanzados (CIMAV) Miguel de Cervantes No. 120, 31109, Chihuahua, Chih., México.
** Universidad Autónoma Metropolitana, Departamento de Materiales, Av. San Pablo # 180, Col Reynosa-Tamaulipas CP 02200, México, D.F.

Aluminum matrix composites reinforced with ceramic particles are attractive structural materials that combine aluminum inherent properties [1] with an increased elastic modulus, enhanced heat and wear resistance [2,3] due to the addition of ceramic insoluble particles [4] incorporated into the Al-matrix by a variety of processes [2]. In order to obtain a superior performance, one of the main challenges is achieving a homogeneous distribution of the reinforcement particles into metal matrix, avoiding agglomeration, which deteriorates the final mechanical properties of the composite [5]. On the other hand, particle size is an important variable [6], usually smaller particle size means higher mechanical resistance. Mechanical milling (MM) is a useful method for improving the strengthening by particle distribution [1] and particle size refinement [7].

The aim of this work is to produce an aluminum-graphite composite, and evaluate the effect of milling process over the characteristics and distribution of graphite particles into aluminum matrix. An Al-composite was synthesized by means of MM method. Raw materials were pure aluminum powder and previously metallized graphite (MG). MG was produced from graphite and copper powders mixture, milled in a high-energy Spex mill during 4 hours. MG-Al-1.0 (wt. %) mixture was processed in a Simoloyer mill for 10h. Milled sample was pressed under ~950 MPa under uniaxial load, sintered under vacuum for three hours at 823 K and hot extruded in order to obtain cylindrical samples. Microstructural characterization was done using a SEM JEOL model JEM-9320FIB and a TEM JEOL JEM-2200FS, both equipped with EDSs analyzers.

Fig. 1 shows an SEM composite image showing brittle graphite particles broken during the MM process and homogeneously dispersed into metallic matrix. Due high atomic weight of copper, these particles are brilliant and easily recognized by contrast. An EDS chemical analysis obtained from one particle shows presence of carbon and copper. A close view of the particle shows that particle is formed from very tiny sub-particles in form of clusters.

On the other hand, TEM studies (Fig. 2) show that single MG particles are nanometric in size; a copper core with an exterior thin coat of carbon composes these particles. This layer is enough to maintain the particles insoluble into aluminum matrix during hot processing; otherwise will be easily dissolved due high solubility of copper in aluminum especially at high temperature.

Microscopical evidences showed a good distribution of nanoparticles into aluminum matrix, particles are nanometric in size and remain insoluble in form of clusters and isolated particles even with hot processing.

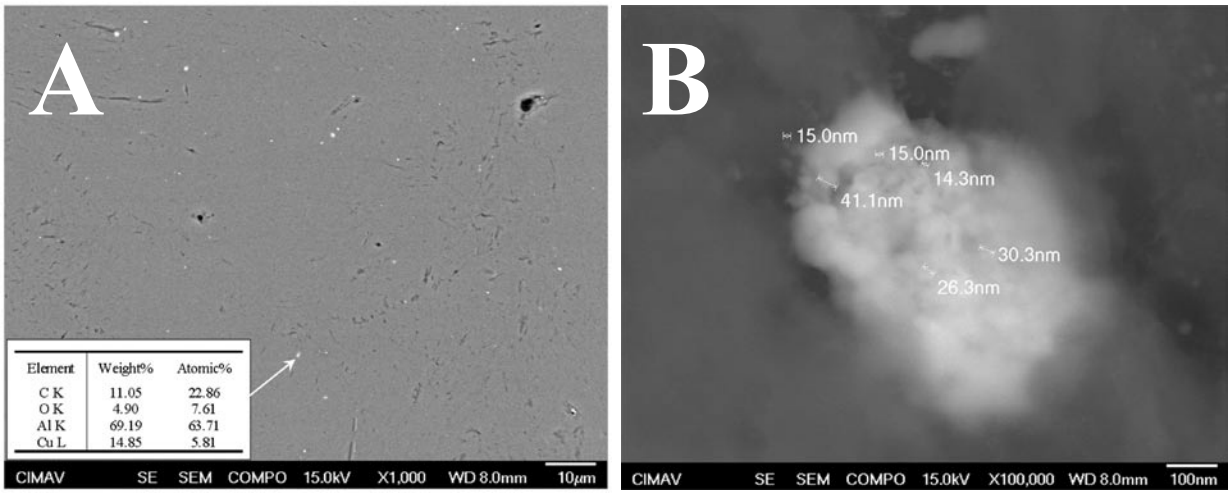


FIG. 1. SEM backscattered image of an Al-MG composite showing the distribution and size of added particles after milling and sintering. A) EDS analysis of a single particle showing C and Cu presence. B) Magnification of a MG particle and some measurements of sub-particles.

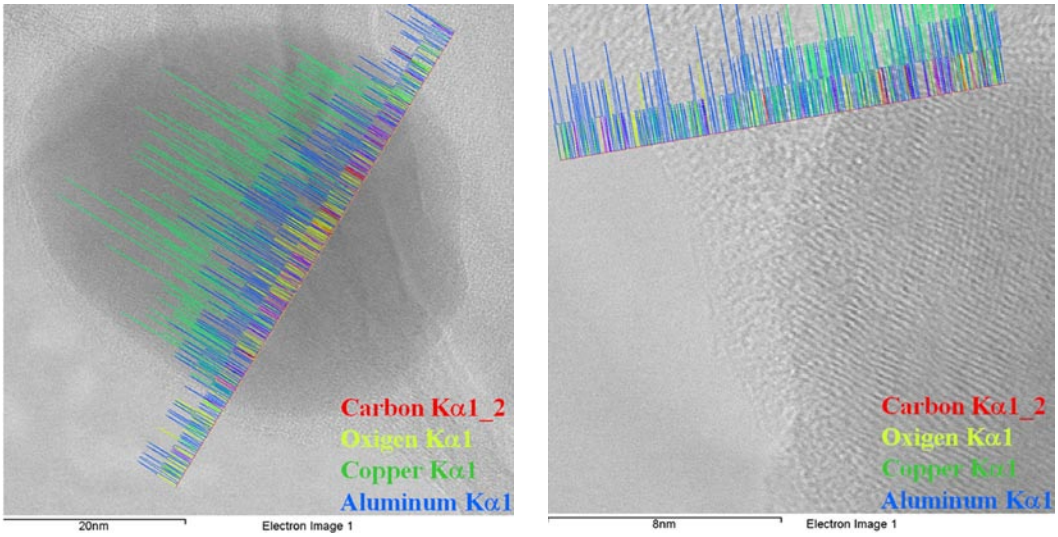


FIG. 2. TEM images of a single particle in an Al-MG composite showing the chemical distribution of components.

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