TEM and Mechanical Characterization in Al-C Composite

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Aluminum-graphite Al-C novel composites have been produced using the Mechanical Alloying process (MA). The mechanics properties of the obtained composites have been evaluated. σ_y values reached in the composites are considerably higher than that reported for pure aluminum. There is a direct relationship between σ_y and final metal-coated graphite content in the composite. σ_y values increase as the nominal C content increases as well. The most important hardening element was the graphite. The simplicity of the process it is major attribute. Al (99.9 % pure, -200 mesh in size) and previously metal-coated graphite (-300 mesh) powders were used as raw materials. Different compositions of metal-coated graphite were studied, C-15%Me, C-25%Me, C-35%Me and C- 45%Me. Three mixtures of Al-based metal-matrix-composites (MMC´s) were obtained, Al-0.5%wt metal-coated graphite (MCG), Al-1.0%wt MCG and Al-2.0%wt MCG. Each mixture was mechanically milled in a high energy shaker mill (SPEX-8000) during 1 h. Argon was used as milling atmosphere. Devices and milling media used were made from hardened steel. The milling ball to powder weight ratio was 5 to 1.

Table I shows, nomenclature, nominal composition and different compositions of material employed in the present work. It also includes theoretical density (ρ), maximum and minimum σ_y values reported for sintered samples during the compression tests. ρ values of all compositions studied in the present work are very

close to that reported for pure aluminum (~2.7g/cm^3). From this table it is observed that σ_y has a direct relationship with nominal concentration of graphite in the composite.

Different case was the effect of the copper; in this case, there is no relationship with final mechanical properties. Obtained data of σ_y are higher than those of several as-cast Al-alloys reported in literature, and very close to that heat treated (T6) Al-alloys. Figure 1 shows a direct relationship between σ_y and final MCG content in the composite. At low content (concentration) of MCG there is less data dispersion.

During compression testing it was observed that the composite corresponding to the composition Al-

2.0 % MCG showed less ductility without exhibiting substantial increase in σ_y. From the Table I and Figure 1, it is observed that for the composite Al-0.5 MCG samples with less Cu content showed higher σ_y, confirming that the main hardening element was the dispersed graphite into Al matrix. Figure 2 shows a representative TEM micrograph of a reinforced particle of composite Al-1.0% MCG in the as-sintered condition. The small size of particle is evident. As it has been reported above, graphite particles are coated by a Cu film. This is more evident in the inset square. The thickness of coating it is smaller to 10 nm. TEM studies are currently being carried out on the C-Cu film interphase and on Al-film interphase.

Table I.- General results obtained in the Al-based composites.

Composite	Composition MCG	Nominal Composition (wt %)		$\sigma_{y\ min}$ (MPa)	$\sigma_{y\ max}$ (MPa)	ρ (theoretical) (g/cm^3)
		Cu	C			
Al-0.5 MCG	C-45 % wt Cu	0.225	0.275	**170.9**	**173.3**	2.7129
	C-35 % wt Cu	0.175	0.325	**176.0**	**174.8**	2.7095
	C-25 % wt Cu	0.125	0.375	**180.4**	**182.0**	2.7062
	C-15 % wt Cu	0.075	0.425	**183.6**	**184.8**	2.7028
Al-1.0 MCG	C-45 % wt Cu	0.450	0.550	**208.1**	**212.9**	2.7258
	C-35 % wt Cu	0.350	0.650	**228.4**	**229.6**	2.7191
	C-25 % wt Cu	0.250	0.750	**251.8**	**281.9**	2.7124
	C-15 % wt Cu	0.150	0.850	**244.2**	**250.6**	2.7057
Al-2.0 MCG	C-45 % wt Cu	0.900	1.100	**252.2**	**268.1**	2.7515
	C-35 % wt Cu	0.700	1.300	**264.4**	**268.0**	2.7381
	C-25 % wt Cu	0.500	1.500	**309.3**	**312.8**	2.7247
	C-15 % wt Cu	0.300	1.700	**299.7**	**310.4**	2.7113

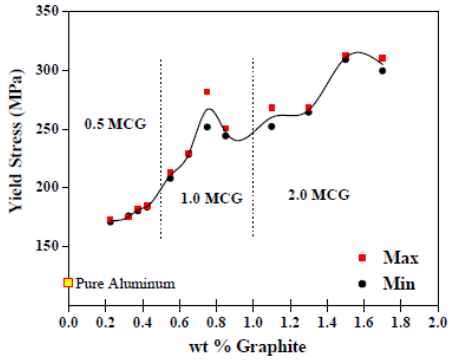

Figure 1.- Yield Stress as a function of nominal % graphite in composites. Dotted lines shows the regions corresponding to different composite compositions.

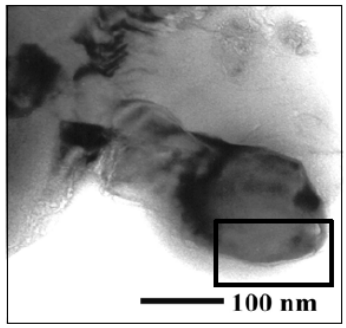

Figure 2.- TEM micrograph showing a graphite particle embedded into Al matrix. Inset square shows the evidence of Cu cover.