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The Effect of Process Control Agent on the Oxidation of Nanocrystalline Mechanically Alloyed AlCoCrFeMnNi Powders

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The mechanical alloying (MA) of high entropy alloys (HEA) and the production of nano-crystalline powders by ball milling have attracted much attention from researchers in recent decades owing to their several advantages. MA induces high energy impacts on the powder by collision between balls and particles causing severe plastic deformation, repeated fracturing and cold welding of the particles. There are two methods to prevent the severe cold welding: the first one is to decrease the temperature of the milling vial and the second one is to add process control agent (PCA) to the powders [1, 2]. Typically, a PCA is an additive used in the milling process in order to control the balance between the fracture and cold welding of particles. In addition to severe plastic deformation and cold welding of particles, the oxidation of powders also can be controlled using an adequate PCA. The aim of this work is evaluate the particle size distribution (PSD), morphology, and oxidation of HEA using different PCA during MA.

The equiatomic AlCoCrFeMnNi powders were processed by MA. Pure elements (each of them at least 99.9% purity) were used as the raw material. The millings were performed by using a high energy mill Spex 8000. Milling media and container are done by hardened steel. Milling conditions were set to 10 h of milling time, powder mass 8.5 g and a ball-to-powder ratio of 5:1. To prevent contamination, the balls and vial were coated with nominal composition elemental powders and milling was performed under Ar atmosphere. In order to investigate the effects of PCA on the MA mechanism, methanol, n-heptane and stearic acid were chosen as PCAs. The study of PSD, morphology and oxidation of HEA was carried out by means of a Malvern2000 laser dispersion system, a scanning electron microscope HITACHI SU3500, a thermogravimetric analyzer SDT Q 600 TA and elemental analyzer CHNS-O CE EA 1110.

Figure 1a shows the thermogravimetric analysis (TGA) graph and oxygen quantification present in the alloyed powders. The powders with methanol as PCA present higher values of oxygen and the powders with stearic acid a greater weight gain, while those powders with n-heptane are kept at lower values. Figure 1b shows the PSD of the powders with different PCA after of MA. It is observed a Gaussian type distribution in the powders with n-heptane and stearic acid, and a bimodal type distribution in the powder with methanol. Figure 2 shows the morphology of the powders with different PAC after the MA. It is concluded that AlCoCrFeMnNi alloy powder oxidation can be reduced by the use of n-heptane, however a larger particle size is obtained in comparison to the obtained by methanol, since methanol reduces the cold welding process and increases the dust fracture.

References:

[1] Wonsik Lee, S. I. Kwun, J Alloys Compd **695** (2017), p. 462.
[2] L. Shaw *et al,* Metall. Mater. Trans A **34(1)** (2003), p. 159.

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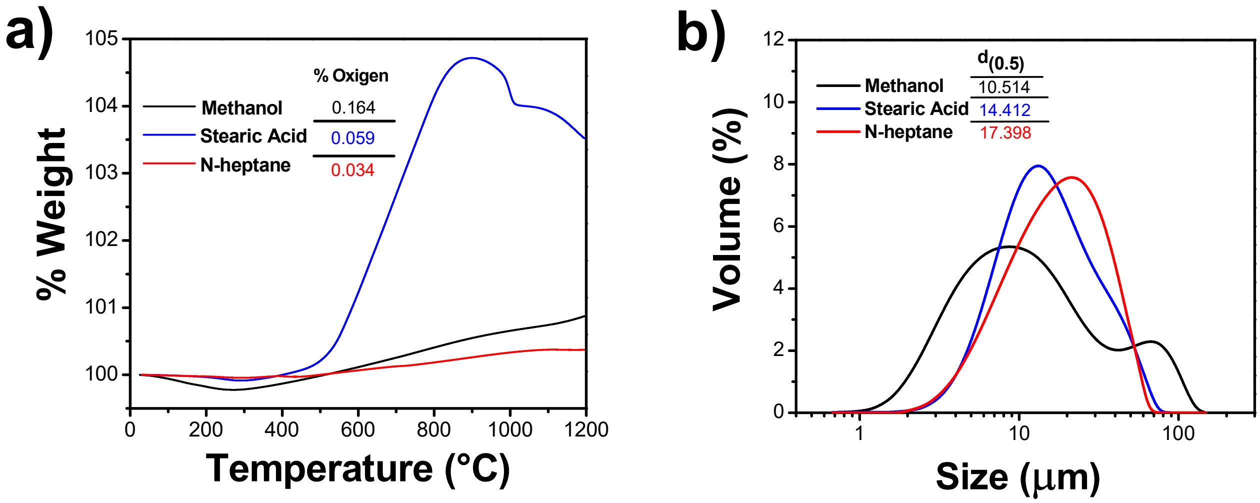

Figure 1. Show TGA graph/oxygen quantification (a) and particle size distribution graph (b) corresponding to methanol, N-heptane and stearic acid.

a) Methanol **b) Stearic acid** **c) N-heptane**

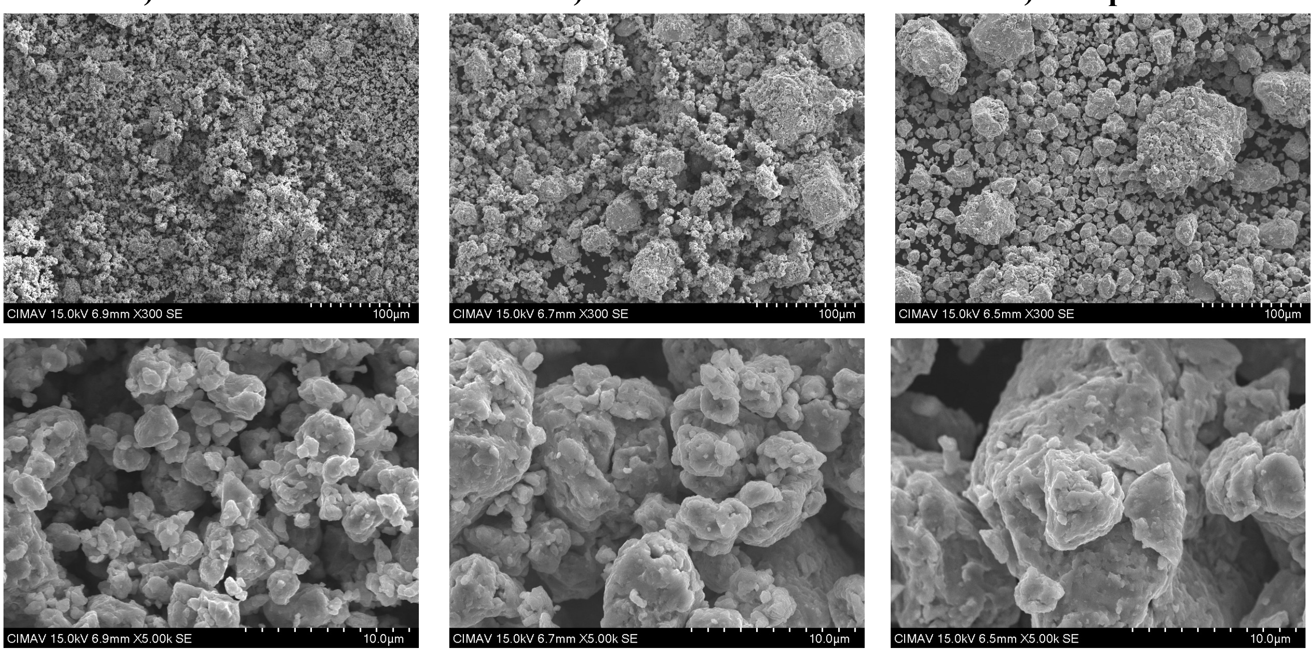

Figure 2. SE-SEM Micrographs of the AlCoCrFeMnNi alloyed powder obtained by the 3 different PCA, a) Methanol, b) Stearic acid and c) N-heptane.

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