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Synthesis by AACVD, Microstructural Characterization and Mechanical Properties of a Cr_2O_3/Fe_3O_4 Nanocomposite

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Nanocomposites are materials that are manufactured as an efficient alternative that can replace microcomposites, in these materials at least one of the phases is in the nanometer range. One of the main advantages of these materials are: high surface area/volume ratio [1]. Chromium oxides have excellent oxidation resistance and chemical stability [2] while magnetite is mainly known for its magnetic properties that have allowed it to be used in different technological areas such as water treatment, pigment in paints, and medicine [3]. Developing a nanocomposite of these two metal oxides is the objective of this work.

Cr_2O_3/Fe_3O_4 nanocomposite particles were synthesized by the aerosol assisted chemical vapor deposition (AACVD) method [4-5]. The precursor solution was prepared using iron (II) chloride, chromium (III) acetate hydroxide (SIGMA Aldrich) with a stoichiometric ratio of 50:50 respectively, in methanol and a final molar concentration of 0.1 mol dm^{-1}, the furnace was set at 723 K and a combination of Ar:air with flow rate of 4:250 $cm^3\ min^{-1}$ respectively was used as carrier gas. The latter two conditions were set to ensure the formation of the Fe_3O_4 phase based on previous publications [4-5].

The synthesized particles were analyzed by SEM and are shown in Figure 1 (a-b). They present a spherical morphology constituted by crystallites, the average size obtained by measuring 75 particles resulted to be 501±144 nm. EDS analysis was performed on different areas illustrated and the results are shown in Figure 1c, in order to estimate the % at. of the elements that make up the particles. The results show that the particles contain a higher amount of Cr with respect to Fe, probably it is due to the chemical reaction rate of chromium oxide is higher than the chemical rate of magnetite. C and Si are also present, due to the solvent used and the support used to prepare the sample. To know the crystalline phases of the material the analysis by GIXRD was made, Figure 1d shows the diffraction spectrum, the crystallinity of the material is appreciated, existing peaks at angles 2θ 30º, 35º, 43º, 53º, 57º and 62º that belong to PDF 00-086-1339 of the magnetite phase (Fe_3O_4) and peaks at angles 2θ: 25º and 63º that belong to PDF 00-084-0315 of the Cr_2O_3 phase. With this analysis, the coexistence of two phases of metal oxides forming a nanocomposite is demonstrated.

The mechanical properties of the particles were measured by nanoindentation, in which a Berkovich tip with a radius of 20 nm was used, to measure the particles these were prepared in a thermoplastic resin (Lucite) with a suitable metallographic preparation. The literature reports the Poisson's ratio of Fe_3O_4 as 0.37 [6] and Cr_2O_3 as 0.25 [7] with these results and taking into account the results obtained in the EDS a Poisson's ratio of 0.3 for the particles was calculated to estimate the elastic modulus and the hardness, the resulting graphs of the particles and the area where the nanoindentation measurements were made can be seen in Figure 2 (a-b). A hardness of 3.2 GPa ± 0.1 and an elastic modulus of 38.3 GPa ± 4.9 were obtained. The most representative details of the particles are the solid morphology, the formation and coexistence of two phases of metal oxides in the particle, which can be a promising nanocomposite for application as a reinforcing material in structures. The second phase will be to use them as reinforcement of a metal matrix by mechanical milling and it is expected to improve the mechanical properties, but further analysis is required.

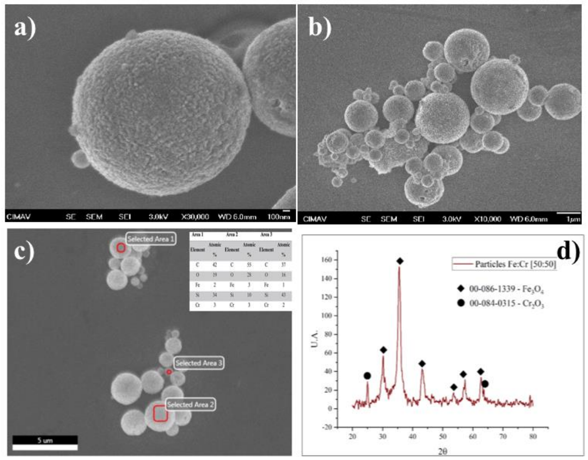

Figure 1. a, b) SEM micrographs of the spherical particles. c) Elemental composition (% at.) of the particles by EDX. d) Crystalline phases obtained by GIXRD. The formation of Cr_2O_3 and Fe_3O_4 phases can be seen, confirming the formation of a nanocomposite.

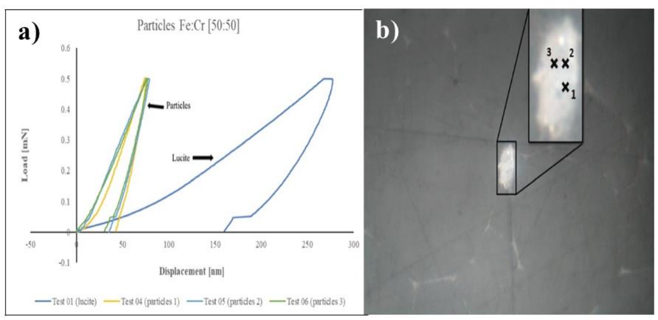

Figure 2. a) Load - displacement diagram obtained by nanoindentation of the particles embedded in Lucite and b) area marked with a rectangle where the particles were measured.

References

[1] P. Camargo, *et al*. (2009). *Materials Research*, *12*(1), 1-39. doi: 10.1590/s1516-14392009000100002
[2] Suryanarayana, C., & Al-Aqeeli, N. (2013). *Progress In Materials Science*, *58*(4), 383-502. doi: 10.1016/j.pmatsci.2012.10.001
[3] J. Carriazo Baños, *et al* (2017). *Revista Colombiana de Química*, *46*(1), 42. doi: 10.15446/rev.colomb.quim.v46n1.62831
[4] B.E. Monárrez-Cordero *et al, J. Alloys Compd.* 615 (2014) S328-S334. doi:10.1016/j.jallcom2014.02.028
[5] P.G. Hernández-Salcedo,*et al J. Alloys Compd.* 643 (2015) S287-S296. doi:10.1016/j.jallcom2014.12.064

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[6] D. Chicot, *et al*, *Mater. Chem. Phys.*, (2011) 129(3) 862-870. doi:10.1016/j.matchemphys.2011.05.056
[7] X. Pang, *et al Adv. Engin. Mater*. (2007) 9(7), 594-599. doi: 10.1002/adem.200700057

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