

IRON-GOLD CORE-SHELL NANOPARTICLE FORMATION UTILIZING NONIONIC SURFACTANTS AND REVERSE MICELLES

J.R. Marin¹, M. D. Shultz², J.M. Laza¹, E. E. Carpenter², J.L.Vilas¹, L.M. Leon¹

¹*Basque Country University, B^o Sarriena s/n, Leioa, Spain*

²*Virginia Commonwealth University, Richmond, VA, USA*

marin@gaiker.es

In recent years, the nanoparticles which present onion-like structures are of great interest due to the combination of the metallic core properties with other properties of a metallic or oxide shell [1]. This can allow for deceleration of oxidation or protection in aqueous solutions, which enables use in many different applications [2]. Previous work in the literature has shown the use of CTAB as a surfactant to form a micro-emulsion for the synthesis of iron-gold core-shell nanoparticles [3]. In this research, a new kind of micellar system is used to produce a gold coated iron onion-like structure. This new system was performed by using nonylphenoxy poly(ethyleneoxy) ethanol (IGEPAL NP7 or NP4 depending on the number of ethyleneoxy groups) as a non-ionic surfactant in a water-in-oil reverse micelle system. Details of the IGEPAL system and some of the advantages over ionic systems have been presented in the literature [4]. This work reports on the iron-gold core-shell nanoparticles synthesized by this method and the affect of parameters such as metal concentrations, metal to metal ratios, and water to surfactant ratios were investigated to give insight into the mechanism of this synthetic procedure.

Powder X-ray diffraction (XRD) patterns for the nanoparticles showed no evidence of crystalline iron oxide in the diffraction pattern and only revealed peaks that reference to α -Fe and Au as seen in Figure 1. From previous work, the Fe in the core is most likely distorted through the incorporation of boron or existing in a disordered iron oxide structure [5,6], and thus XRD pattern only confirms crystalline Au. The diffraction data was collected a few weeks post synthesis and exposure to air, thus showing a resistance to oxidation by the absence of iron oxide peaks. Transmission electron microscopy (TEM) images indicate the presence of core-shell structures with a mean diameter of 15.7 nm with a shell thickness of 2.7 nm. Magnetic characterization via vibrating sample magnetometry (VSM) showed a saturation magnetization of 18 emu/g, which is comparable to iron-gold core-shells found in the literature [3,7,8], especially since the mass of the gold is also included in this value.

Mechanistic insight was gained for the core-shell formation from the results of varying the before mentioned parameters. When lowering the metal concentrations and maintaining the Au/Fe ratio, the mean diameter seen on TEM stayed constant while the size distribution increased. This increase in size distribution was also due to what appeared to be two different particle morphologies; one core-shell and one solid particle. Then, upon increasing the Au/Fe ratio, the size distribution decreased as well did the morphological distribution. There are two possible contributing factors for this observation. First, there may be a critical concentration gradient required to exchange enough material fast enough between micelles to induce core-shell formation. The second factor is that the Au is growing by an islanding mechanism around the Fe core. If there is not enough Au reaching the core particle fast enough to fill in the island forms on the surface, then the Au breaks off the core particle and grows to form separate particles. This approach to the core-shell formation explains the size and

morphology distributions, as well as the presence of darker zones in the shell that are more present when increasing the Au/Fe ratio. Smaller sizes were also reached when maintaining a “critical” concentration of metals, while decreasing the water/surfactant ratio in the reverse micelle system.

References:

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Figures:

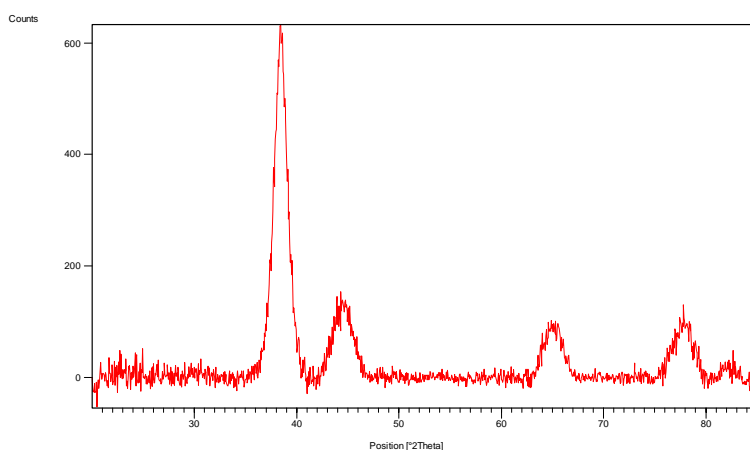


Figure 1. Powder X-ray diffraction pattern of iron-gold core-shell nanoparticles synthesized by the IGEPAL systems.