Insights into the synthesis of Bi_2S_3 nanostructures for Computed Tomography

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Computed tomography (CT) is an X-ray based whole body imaging technique widely used to enhance the contrast among human body tissues because it allows deeper tissue penetration and higher-resolution imaging [1]. Currently, clinically approved CT contrast agents are iodinated molecules or barium suspensions, but to provide a good contrast large doses are needed, and their short circulation time limits their applications. Nanoparticles (NPs) show several advantages in comparison with these small molecules such as high residence times, potentiality for cell-tracking and targeted imaging applications due to their functionalizable surface [2],[3]. In particular, Bi_2S_3 NPs are a good choice because bismuth shows a large X-ray attenuation coefficient which enhances the contrast for small variations of the X-ray voltage. In addition, it is less expensive and also exhibit lower toxicity than other metals with similar X-ray attenuation coefficient. However, there is a lack in the literature of methods enabling a good control over the NP structure.

Here, we show a 2-step method to obtain Bi_2S_3 NPs with tunable shape and size based on the high temperature decomposition of bismuth (III) neodecanoate using different high boiling-point solvents, 1-octadecene and benzyl ether [4]. We have monitored the particle size and shape by tuning the duration of the last step of the reaction from 1 to 120 minutes. After that, we have stabilized the samples in aqueous media by a ligand exchange process.

After the first reaction stage, crystalline 5 nm spherical nanoparticles are obtained. Rod-like-shaped NPs can be grown by further increasing of the reaction time, which yields elongated NPs with 5 nm in width and from 5 nm to 50 nm in length. Despite the good control found in the particle size distribution, particles show poorer crystalline quality as they become elongated, which may be due to a faster growth process. By EELS analysis, we have discarded the presence of any parasitic phase of bismuth oxide. These nanoparticles may pave the way to enable the combination with other materials to achieve multifunctional systems for diagnosis or theranostics.

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Figures

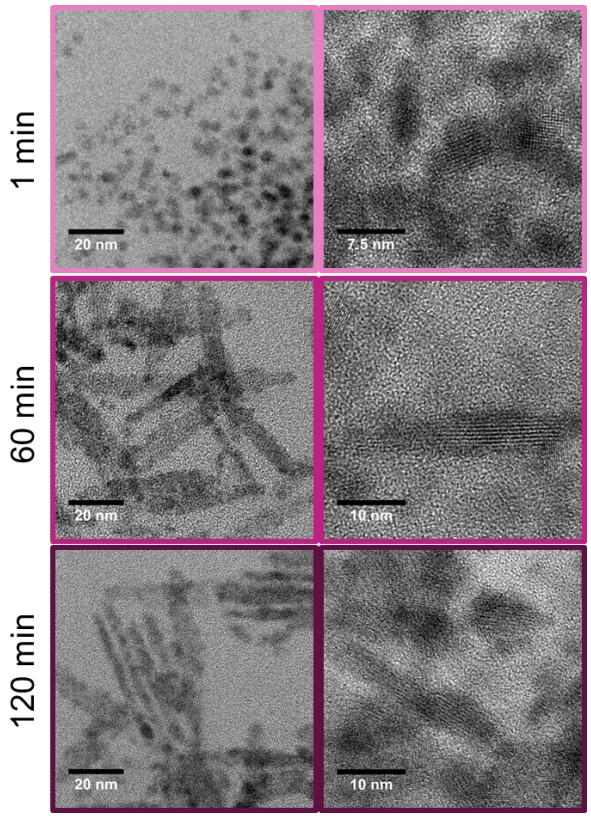

Figure 1. High-resolution transmission electron microscope images of the NPs obtained changing the duration of the last step of the reaction from 1 min to 120 min.