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Tunable Crystallinity of Zinc Gallogermanate Nanoparticles via Organic Ligand-Assisted Biphasic Hydrothermal Synthesis

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Abstract : Zinc gallogermanate (ZGGO) is a persistent phosphor that can emit in the near infrared (NIR) range once dopped with Cr^{3+} enabling its use for in-vivo deep-tissue bio-imaging. Such a property also allows for its application in cancer diagnosis and therapy. Given this, work into developing a synthetic procedure that can be done using common laboratory instruments and equipment as well as understanding ZGGO overall, is in demand. However, the ZGGO nanoparticles must have a size compatible for cell intake to occur while still maintaining sufficient photoluminescence. The nanoparticle must also be made biocompatible by functionalizing the surface for hydrophilic solubility and for high particle uniformity in the final product. Additionally, most research is completed on doped ZGGO, leaving a gap in understanding the base form of ZGGO. It also leaves a gap in understanding how doping affects the synthesis of ZGGO. In this work, the first step of optimizing the particle size via the crystalline size of ZGGO was done with undoped ZGGO using the organic acid, oleic acid (OA) for organic ligand-assisted biphasic hydrothermal synthesis. The effects of this synthesis procedure on ZGGO's crystallinity were evaluated using Powder X-Ray Diffraction (PXRD). OA was selected as the capping ligand as experiments have shown it beneficial in synthesizing sub-10 nm zinc gallate (ZGO) nanoparticles as well as palladium nanocrystals and magnetite (Fe_3O_4) nanoparticles. Later it is possible to substitute OA with a different ligand allowing for hydrophilic solubility. Attenuated Total Reflection Fourier-Transform Infrared (ATR-FTIR) was used to investigate the surface of the nanoparticle to investigate and verify that OA had capped the nanoparticle. PXRD results showed that using this procedure led to improved crystallinity, comparable to the high-purity reagents used on the ZGGO nanoparticles. There was also a change in the crystalline size of the ZGGO nanoparticles. ATR-FTIR showed that once capped ZGGO cannot be annealed as doing so will affect the OA. These results point to this new procedure positively affecting the crystallinity of ZGGO nanoparticles. There are also repeatable implying the procedure is a reliable source of highly crystalline ZGGO nanoparticles. With this completed, the next step will be working on substituting the OA with a hydrophilic ligand. As these ligands effect the solubility of the nanoparticle as well as the pH that the nanoparticles can dissolve in, further research is needed to verify which ligand is best suited for preparing ZGGO for bio-imaging.

Keywords : biphasic hydrothermal synthesis, crystallinity, oleic acid, zinc gallogermanate
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