Tailored Synthesis for Morphology Control of Hematite Nanoparticles

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Hematite (a-Fe2O3) is a low-cost stable iron oxide phase used in various applications including solar cells and drug delivery. Its properties, which dictate its applications, are highly morphology-dependent, necessitating controlled synthesis of monodisperse hematite nanostructures. This project employed hydrothermal synthesis as an effective method to precisely tailor the morphology of hematite, via rigorous control of experimental parameters, to address specific application needs. By varying the concentration of precipitating agent NaOH and hence the level of supersaturation, hematite and goethite (a-FeOOH) were obtained via different formation mechanisms. These insights on formation pathways prove imperative in determining the products formed with differing experimental conditions. Furthermore, low concentrations of anions were introduced to effectively control the shape of hematite nanoparticles without affecting product composition. SO42- and PO43- anions resulted in anisotropic crystal growth, producing rhombohedral and ellipsoidal nanoparticles respectively. Magnetic properties of the synthesized nanoparticles were also examined. High coercivity to particle size ratios obtained (6.45 to 17.4) exceeded that reported in previous literature (capped at 2.54). This proves that high coercivities are achievable at the nanoscale, fulfilling the need for both thermal stability and high bit density. This uncovers the unexplored potential of hematite nanoparticles with high shape anisotropy in magnetic nanofilm technology, a cornerstone for diverse fields such as information storage and biomedicine. Overall, this project elucidated the confluence of formation mechanisms of hematite and goethite, and morphology control by SO42- and PO43- anions.

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