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Size, Phase-Controlled Synthesis, The Nucleation and Growth Mechanisms of $NaYF_4$:Yb/Er Nanocrystals

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ABSTRACT

Near-monodisperse $NaYF_4$:Yb/Er nanoparticles (NPs) with controlled size, phases (α, β) and shapes (sphere, and hexagonal plate) were synthesized by adjusting the NaF-to-RE (RE=Y, Yb, Er) ratios, the reaction temperature and time in the hot surfactant solutions (oleic acid, 1-octadecene) from the improved one-pot thermal decomposition metal trifluoroacetate, and the precursors were prepared via hydrothermal route. The growth kinetics of β-$NaYF_4$ NPs includes several stages: nucleation, growth of α-$NaYF_4$, Ostwald ripening, size shrinkage and growth. The results prove that the temperatures are preferred to the phase transformation compared with the NaF content when other experimental conditions are unchanged. Our work will further facilitate the comprehension of the nucleation and growth mechanisms of the NPs, and provide guidance for their controlled synthesis.

1. Introduction

Upconversion (UC) nanoparticles (NPs) can emit ultraviolet/visible/near-infrared light under near-infrared excitation. The fluorescence light emitters usually violate the well-known principle of the Stokes law which can be simply stated that excitation photons are at a lower energy than emitted ones or, in a nutshell, that input photon energy is weaker than output photon energy [1]. Rare earth ions have excellent optical properties due to their unique 4f shell electronic configuration [2]. Hence, trivalent lanthanide ion (Ln^{3+})-doped UC NPs have attracted a lot of attentions since early 1970s, and it has continued to be studied because of its potential applications such as three-dimensional flat-panel displays [3], solid state lasers [4], solar cells [5], bio-logical probes, labels markers [6, 7], optical storage [8, 9], security printing [8, 10, 11]. Without doubt, among these applications, bio-probes and bio-images applications have been known as one of the most interesting applications. In addition, UC nanomaterials own some extraordinary properties which probably arise from its weak

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