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Shape evolution of citrate capped gold nanoparticles in seeding approach

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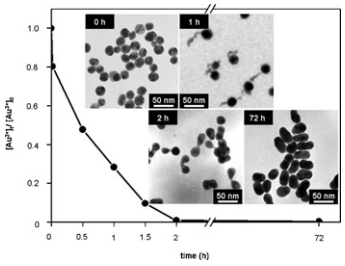
HIGHLIGHTS

- Citrate capped Au nanoparticles evolved from dot into tadpole, dumbbell and rod in seeding approach.
- Preferential growth along {1 1 0} facet contributed to shape evolution of the seeds from dot to tadpole.
- The particles evolved from tadpole into dumbbell upon the reduced growth rate and ripening.
- Finally the particles became rod in shape attributed to the intraparticle ripening.

GRAPHICAL ABSTRACT



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ABSTRACT

Shape evolution of gold nanoparticles in seeding approach in which 25 nm citrate capped gold dots were used as the seeds and the mixtures of tetrachloroauric acid and sodium citrate as the growth solutions was investigated systematically and quantitatively. The citrate capped gold nanoparticles presented shape evolution from dot-shaped to tadpole-like, dumbbell-shaped and rod-like along the reaction. It is identified that the preferential growth along {1 1 0} facet of the face-centered cubic gold seeds related to activity of the gold precursors contributed to the shape evolution from dot-shaped to tadpole-like nanoparticles at the early stage of the reaction. The tadpole-like particles evolved to the dumbbell-shaped ones due to the reduced growth rate and ripening of the gold nanoparticles. Finally, the dumbbell-shaped particles became rod-like in shape attributed to the intraparticle ripening of the gold nanoparticles. This work implies the possibility to control over the shape of the gold nanoparticles in seeding approach in presence of weak ligands such as citrate.

1. Introduction

During the past decade, extensive attentions have been paid to control over the size and shape of Au nanoparticles since their electric and optical properties are both shape and size dependent [1–3]. Seeding approach has been proven to be an effective route to prepare Au nanoparticles with different size and shape. In such approach, different sized spherical Au nanoparticles can be readily obtained by changing size of the Au seeds and concentration of Au(III) ions in the growth solution [4–7]. If appropriate capping agents such as cetyltrimethylammonium bromide (CTAB), PVP etc., which can be adsorbed predominantly on definite facets of the gold nanoparticles, are introduced into the reaction system, anisotropic gold nanoparticles with different shapes including stars, tetrapods, triangles, cubes, rods etc. can be successfully synthesized as a result of the preferential growth along one or two facets of the face-centered cubic gold nanoparticles [8–23]. For example, Gou and Murphy reported that the synthesis of gold nanorods by 4 nm CTAB capped gold dots as seeds and the mixture of $HAuCl_4$ and ascorbic acid as growth solution [9]. Mirkin and co-workers prepared gold nanotriangles by using 5.2 nm citrate capped gold dots as the seeds and the mixture of $HAuCl_4$, ascorbic acid and CTAB as the growth solutions [10]. A few anisotropic Au nanoparticles can also be prepared in absence of the special capping agent [24–28]. Gu

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