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Note

Morphology control of the produced Ag nanoparticles by soft-template technique

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Abstract

The morphology of the produced Ag nanoparticle is controlled successfully by UV irradiating the reaction solution of AgAc/ethyl alcohol/1-octadeconal/1-dodecanethiol. With use of a novel solution such as soft template, Ag nanorods with different sizes and different ratios of length to diameter can be obtained by adjusting the concentrations of the solution compositions.

Keywords: Morphology control; UV irradiation; Nanorod; Soft-template technique

1. Introduction

One-dimensional (1-D) structures with nanoscale diameters such as nanowires, nanorods, and nanotubes are currently the focus of much research because of their special properties [1]. Nanostructured noble metallic clusters, especially 1-D nanomaterials, can be used as catalysts or as magnetic, electronic, or photonic materials [2–4]. Many methods have been involved in the synthesis of 1-D nanostructured materials, particularly a template-assisted technique. Besides using hard templates such as a carbon nanotube and anodized aluminia as templates to produce 1-D nanomaterials [5,6], soft templates such as polymer [7], block copolymers [8], Langmuir–Blodgett (LB) films [9], DNA molecules [10], sodium dodecyl sulfate (SDS) micelles-*co*-polymer gel [11], and solvents [12] were also employed as templates. Recent developments on the theme of "vesicle template" are highlighted. This theme has attracted attention as, in principle, it represents a unique opportunity in the morphological construction of materials by direct imprinting of the shape and texture of the template. Hubert et al. [13] reported a vesicle-templating route to construct submicrometer hollow polymer particles, Jiang et al. [14] reported a synthesis route to construct a 1-D silver nanostructure in a lamellar liquid crystalline array of oleate vesicles by UV irradiation. Surfactants have been extensively used as protective agents in the preparation of nanoparticles. It has been demonstrated that the concentration and the surrounding medium of the surfactant have a great influence on the shape and the size of the obtained nanoparticles [15,16]. Here, we report the formation of a silver nanorod in ethyl alcohol/octadeconal/1-dodecanethiol solution.

2. Experimental

In a typical experimental procedure, AgAc at different concentrations was dissolved into the ethyl alcohol containing 1-octadeconal and 1-dodecanethiol as the surfactant. The reaction solutions were irradiated by UV light for a certain time to obtain the products.

The characterizations of the TEM images of the products were taken with a JEOL 2010 transmission electron microscope.

3. Results and discussion

The synthesis of Ag nanoparticles using the simple UV photoreduction technique had been reported by Huang et al. [17]. In this report, the same UV photochemical reduction method was utilized to synthesize Ag nanoparticles and control their morphologies in a novel AgAc/ethyl alcohol/1-octadeconal/1-dodecanethiol solution. Herein, the influences of the solution compositions on the morphologies of the

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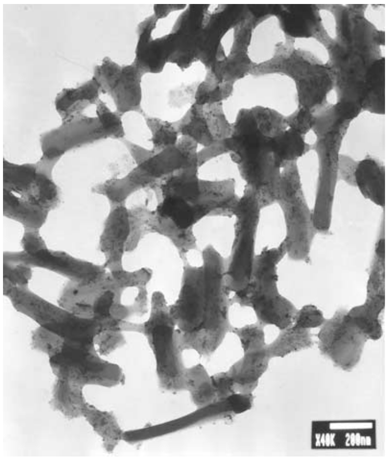

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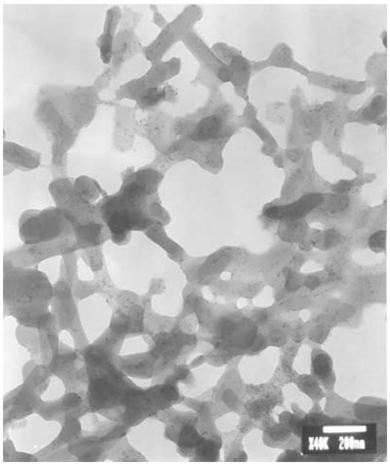

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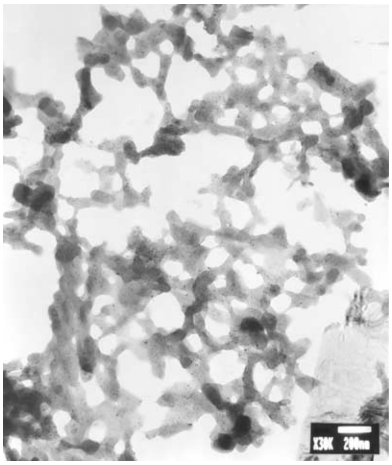

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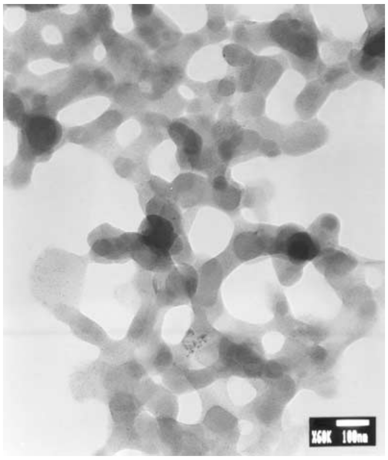

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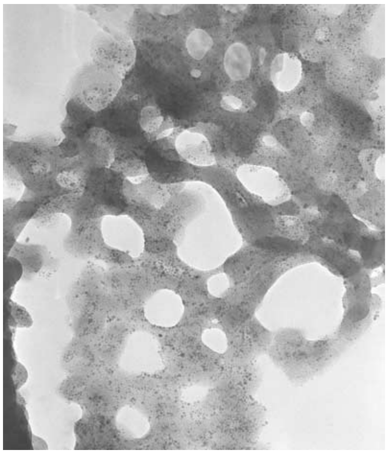

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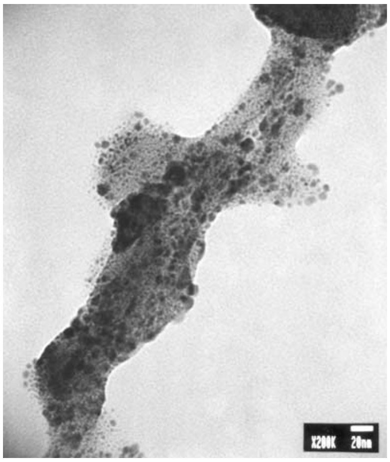
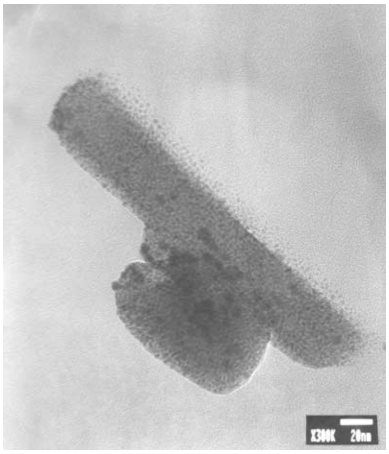


(f)



(g)

Fig. 1. (a) The concentration of AgAc is 0.12 g/l, 1-octadeconal is 10 g/l, and the volume ratio of ethyl alcohol to 1-dodecanethiol is 5 : 15; the irradiation time is 30 h. (b) The concentration of AgAc is 0.5 g/l, 1-octadeconal is 20 g/l, and the volume ratio of ethyl alcohol to 1-dodecanethiol is 10 : 10; the irradiation time is 30 h. (c) The concentration of AgAc is 0.085 g/l, 1-octadeconal is 10 g/l, and the volume ratio of ethyl alcohol to 1-dodecanethiol is 5 : 15; the irradiation time is 30 h. (d) The concentration of AgAc is 2.5 g/l, 1-octadeconal is 40 g/l, and the volume ratio of ethyl alcohol to 1-dodecanethiol is 15 : 5; the irradiation time is 30 h. (e) The concentration of AgAc is 0.12 g/l, 1-octadeconal is 10 g/l, and the volume ratio of ethyl alcohol to 1-dodecanethiol is 5 : 15; the irradiation time is 10 h. (f) The concentration of AgAc is 0.12 g/l, 1-octadeconal is 10 g/l, and the volume ratio of ethyl alcohol to 1-dodecanethiol is 5 : 15; the irradiation time is 15 h. (g) The concentration of AgAc is 0.12 g/l, 1-octadeconal is 10 g/l, and the volume ratio of ethyl alcohol to 1-dodecanethiol is 5 : 15; the irradiation time is 20 h.

products were studied. The TEM images in Fig. 1 showed the morphologies of the samples corresponding to different experimental conditions.

Figure 1a showed the TEM image of the sample corresponding to 0.12 g/l AgAc and 10 g/l 1-octadeconal in the reaction solution with the volume ratio 5 : 15 of ethyl alcohol to 1-dodecanethiol. It was found that the Ag nanorods are 100 nm × 500 nm in size after 30 h of irradiation.

It was noticed that the morphologies of the products were closely related to the compositions of the solutions. It was obvious, from Figs. 1b and 1c, which displayed the TEM images of the samples corresponding to the different concentrations of the compositions, that the ratio of the length to the diameter of the nanorod could be tuned by changing the concentrations of the compositions.

In the experimental procedures, the concentrations of both 1-octadeconal and 1-dodecanethiol in the reaction solutions played important roles in the formation of silver nanorods. The nanorods were not found from our TEM results of the samples corresponding to the irradiated solutions' absence of the 1-dodecanethiol or 1-octadeconal. It is noticed that the morphology is not nanorod but nanonet if the concentration of 1-octadeconal is too high or the volume ratio of 1-dodecanethiol decreased greatly in the solution, as we can see from Fig. 1d.

To study the formation procedure of the nanorod, the TEM images of the irradiated solution, which were in accord with sample a, with different irradiation times are shown in Figs. 1e–1g. Figure 1e shows the TEM of the sample irradiated for 10 h; it is noticed that the initially produced Ag nanoparticles were absorbed on the netlike substrate, which is supposed to form by the solution system, with the increasing UV irradiation time; it is found in Fig. 1f, which is in accordance with the solution irradiated for 15 h, that the nanonet was destroyed, and the produced Ag nanoparticles were further aggregated to be rodlike, which is shown in Fig. 1g. We suppose that both 1-octadeconal and 1-dodecanethiol play important roles in the formation of a netlike substrate, destroying of the substrate, and further oriented growth of the nanoparticles. The co-action of the 1-octadeconal and 1-dodecanethiol in the reaction solution forms a relatively stable nanonet, which was used as a kind of template. With the aggregation of the produced Ag nanoparticles, the nanonet was destroyed from the weaker link of the nanonet, and the co-action of the 1-octadeconal and 1-dodecanethiol, which can be considered as a soft template, enabled further oriented growth of the initially aggregated nanoparticles. It is supposed that the higher concentration of 1-octadeconal or the lower volume ratio of 1-dodecanethiol in the solution make the link of the nanonet stronger, which is harder to destroy with further reaction and resulted in the formation of a nanonet. Further details of the influences of 1-octadeconal and 1-dodecanethiol on the whole procedure of the formation of the nanorod are forthcoming.

4. Conclusions

In summary, the Ag nanorods are successfully synthesized, and the sizes and the ratios of the length–diameter of the nanorods can be tuned by changing the concentrations of the compositions of the reaction solutions; both 1-octadeconal and 1-dodecanethiol play important roles in the formation of nanorods.

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