The synthesis of polygonal Au by a facile route

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Metal nanoparticles have attracted more and more attention in recent years because of their potential applications both in mesoscopic research and in the development of nanodevices [1]. To date, many methods have been used to prepare nanomaterials, such as vapor–liquid–solid (VLS) growth [2–5], electrodeposition [6–8], solid–liquid phase arc discharge method [9–11], microemulision method [12], and the template self-assembly process [13–16]. Furthermore, most synthetic efforts have been directed toward carbon nanotubes [17, 18], semiconductor [19–21], and binary oxide [22, 23] nanoscales. Little attention have been put to the metal nanoparticles. In fact the metal nanoparticles have unique properties, which differ from those of bulk and atomic species [24–26]. The difference is determined by the electronic structure of the metal nanoparticles and extremely large surface area with high percentage of surface atoms. Metal nanoparticles have many good characters, such as the lower melting point (over 500°C for 5 nm particles of Au compared with that of the bulk materials [27]), high electric conductivity, and unique optical properties [28]. Au nanoparticles, as an amplification tag, have been the subject of research directed at gene analysis [29] and antibody or antigen detection [30] due to their easy preparation, high density, large dielectric constant, and biocompatibility [31]. In this paper, we report the synthesis and characterization of triangular and polygonal Au by a liquid-phase method.

1. Experimental

All chemicals are analytical grade and used without further purification. 0.01 M $HAuCl_4$ was dissolved with ethylene glycol, and then a certain amount of poly (vinyl pyrrolidone) was added. The mixture was injected into 10 ml ethylene glycol and refluxed at 170°C with a magnetic stirring. The products were centrifuged and washed with distilled water and absolute ethanol in sequence. Finally the golden products were dried at 50°C. The structure and morphology properties of products were characterized by several techniques. Powder X-ray diffraction (XRD) data were collected using a Rigaku D/MAX 2400 diffractometer with Cu-Kα radiation ($\lambda = 1.5418$ Å). The transmission electron microscopy (TEM; Hitachi 600, Japan) was used to observe the morphology.

2. Results and discussion

Fig. 1 shows the X-ray powder diffraction pattern of the product. It is identified as pure Au powders (JCPDS No. 04-0784). The crystalline structure of Au powders was further characterized using an X-ray diffractometer as shown in Fig. 1. All these diffraction peaks, including not only the peak positions but also their relative intensities, can be perfectly indexed into the crystalline structure of Au. The result is in accordance with the standard spectrum (JCPDS, No. 04-0784).

The morphology of the products was observed by TEM as shown in Fig. 2. The products dispersed very well and the morphology of which could be obviously observed. It can be seen that Au crystals are triangular and polygonal. The selected area electron diffraction (SAED) results taken from one of Au powders indicate that the Au is monocrystalline and matches well with the XRD results.

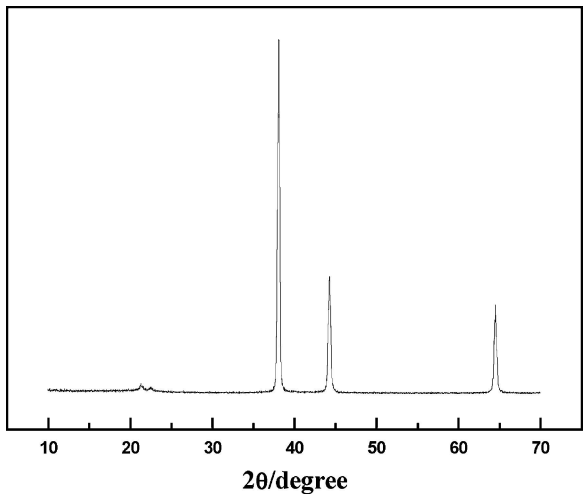

Figure 1 XRD patterns for the sample.

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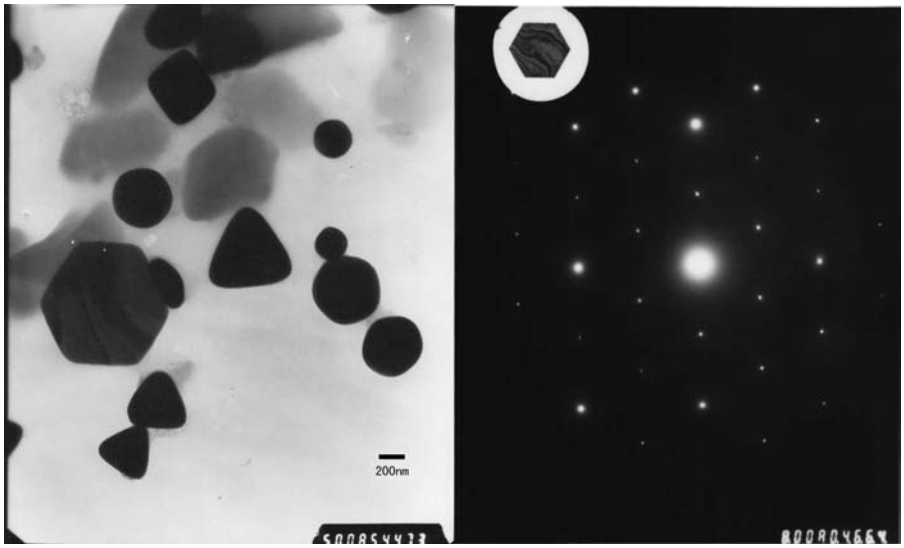

Figure 2 TEM images of Au. (A) light field; (B) SAED.

The dark field confirmed that the obtained Au nanocrystals had well-defined crystallinity.

Although the exact mechanism for the formation of these polygonal nanostructures is still unclear, it should be noted that the growth of the nanoparticles is not catalyst assisted or seed-mediated. The use of the polymeric reagent to control the morphological evolution of metal nanostructures in the liquid phase has been extensively explored [32]. It has been generally accepted that the polymeric reagent kinetically controls the growth rates of various faces of metals through selective adsorption and desorption on these surfaces. It looks like that the functional groups of the polymeric reagent are related to the metal surfaces. This shows that the anisotropic growth of Au may be affected by polyvinylpyrrolidone (PVP). It can be suggested that a well-defined layer of PVP on the plate may prevent the plate from further growing, which may lead to the formation of the triangular and polygonal Gold.

3. Conclusion

Au nanoparticles were synthesized based on a simple liquid-phase process. The XRD and TEM show that the product is triangular and polygonal. Given the generality of this approach, we hope to extend our synthetic method to prepare other metal nanoparticles.

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