

# Synthesis of rambutan-like hybrid nanospheres of Au-P123

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## Abstract

**A simple method to prepare the rambutan-like hybrid nanospheres of Au-P123 is presented. The rambutan-like hybrid nanospheres of Au-P123 were characterized by transmission electron microscopy (TEM), Electron diffraction patterns and UV-vis absorption spectroscopy.**

**Keywords:** rambutan-like; hybrid nanosphere; Au; triblock copolymer

## Introduction

The synthesis and characterization of Au nanoparticles (AuNPs) have attracted great attention due to their potential applications in optoelectronics, electronics, catalysis, and other areas [1]. The size- and shape dependent physical properties of AuNPs provide tunable materials with broad potential applications, and the fabrication of structurally complex nanoparticles further enhances their functionality [2-10]. Xia and Sun suggested that AuNPs have potentially useful size and shape dependent properties. The intrinsic properties of gold nanoparticle are mainly determined by size, shape, composition, crystallinity, and structure [11]. The synthesis of nanoparticles with desired size/shape has, therefore, enormous importance, especially in the compelling field of nanotechnology [12].

Block copolymers have been known to form micelles. The composition of block copolymers can be tuned to affect the formation of micelles or aggregates of shapes other than spheres [13]. The use of block copolymer micelles is a significant research field for the synthesis of stabilized AuNPs. Sakai and Alexandridis have demonstrated the shape and size controlled synthesis of colloidal gold in the presence of various triblock polymers (TBP) [14-16]. They have shown that how the structural modifications of TBPs influence the morphologies of colloidal gold. Bakshi reported that "raspberry type" AuNPs-TBP aggregates have been observed in which nanoparticles of 2-3 nm have been uniformly distributed throughout the TBP micelle. Moreover, apart from such aggregates, prominent ordered morphologies of nanoparticles such as rod, sphere, triangle, and hexagonal have also been observed with much larger dimensions. They believed that has been attributed to the nucleation process occurring in the mixed micelles rather than in the micelles of single TBP components [13].

Synthesis of the rambutan-like hybrid nanospheres of Au-P123 by a self-assembly method is reported here. This new shape of Au-P123 hybrid nanoparticles has the morphology similar to a rambutan (a tropical fruit). This new shape, rambutan-like nanospheres of polyaniline has been reported by Wan's group [17]. The rambutan-like hybrid nanospheres of Au-P123 are characterized by transmission electron microscopy (TEM) and UV-vis absorption spectroscopy.

## Experimental techniques

The Au-P123 hybrid Nanospheres were synthesized by a self-assembly method, in our experiments, we prepared two types of solutions by varying the concentration of P123, the detail of which is described below. Initially, 0.02 g HAuCl<sub>4</sub> is dissolved in 200 ml double-distilled water, which forms a 200 ml aqueous solution. Then the aqueous solution is divided into two aliquots (i.e. 100 ml). 0.75 g and 0.5 g of P123 powder (MW approximately 5750, PEO(20)-PPO(70)-PEO(20)),

was purchased from BASF, Germany) were added to the freshly prepared two  $\text{HAuCl}_4$  aliquots respectively, and they were labeled as (a) and (b). Both mixtures were stirred for 3 hours at room temperature. The color of all the reaction mixtures changes from colorless to purplish red, while the color changing occurs at different time and the final color of these mixtures are almost the same (See Table 1).

## Results and discussion

Figure 1 shows the UV-vis absorption spectra of pure P123 aqueous solution and AuNPs in the presence of different concentrations of TBP: 0.75%, and 0.5%. A clear surface plasmon (SP) band is observed around 539 nm indicating the presence of AuNPs [18]. The absorption peak centered at  $\sim 220$  nm is attributed to the gold (III) chloride solutions [19]. This result is also supported by the solutions' final color, which is presented in Table 1.

**Table 1**

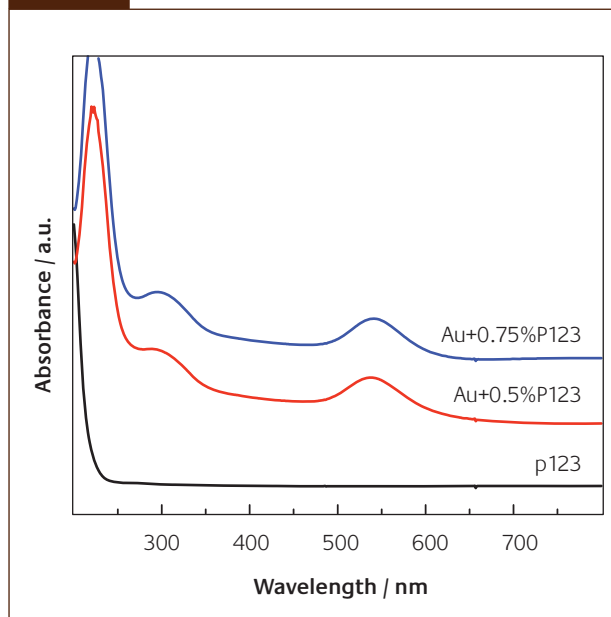
*Chemical compositions of the alloys used*

Concentration/%	Time/min	Color
0.75	25	Purplish red
0.50	31	Purplish red

To gain further information on the particle size and shape, the TEM images for these two samples are presented in Figure 2(a) and 2(b). As can be seen in the figure, the new shape, rambutan-like nanospheres were observed in the presence of 0.75% and 0.5% P123 (Figure 2(a) and 2(b), respectively). These nanoparticles have a size distribution of between 150 and 210 nm. To clearly see the morphology of the rambutan-like hybrid nanospheres of Au-P123, a clear TEM image of a single particle is presented in Figure 3(a). The size of nanosphere is about 165 nm. The electron diffraction pattern for this rambutan-like nanosphere, which is shown in Figure 3(b). The diffraction pattern indicates polycrystalline material because of the beam focusing on a collection of individual (crystalline) particles. The formation of Au nanoparticle is further confirmed by high resolution TEM, which is presented in Figure 3(c) which indicates crystal lattices of Gold.

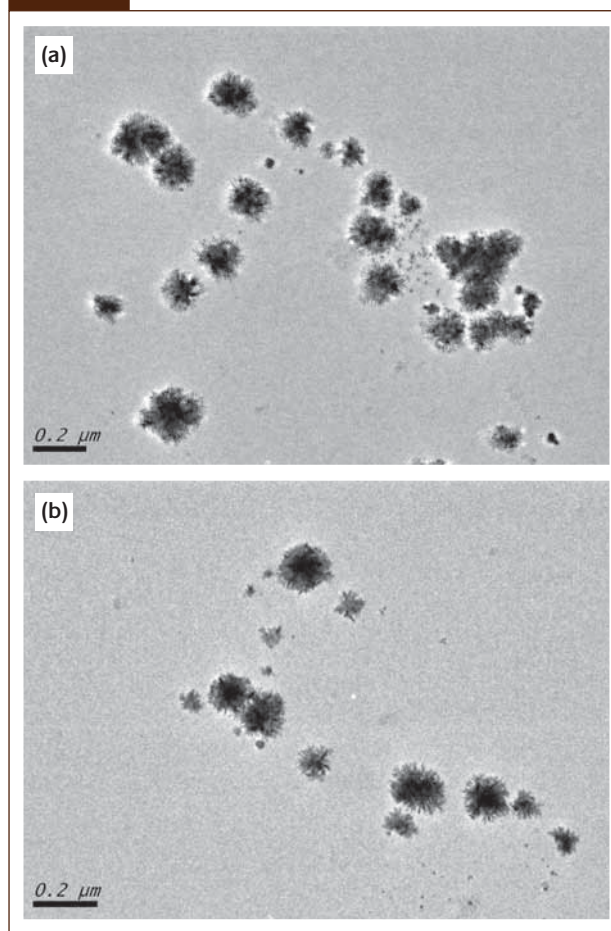
Interesting triangular flower shapes shown in Figure 3(d) was observed. However only a few nanoparticles of this type were present. They are also attributed to the self assembly of P123 and gold nanoparticles. This is a new shape not previously reported.

**Figure 1**



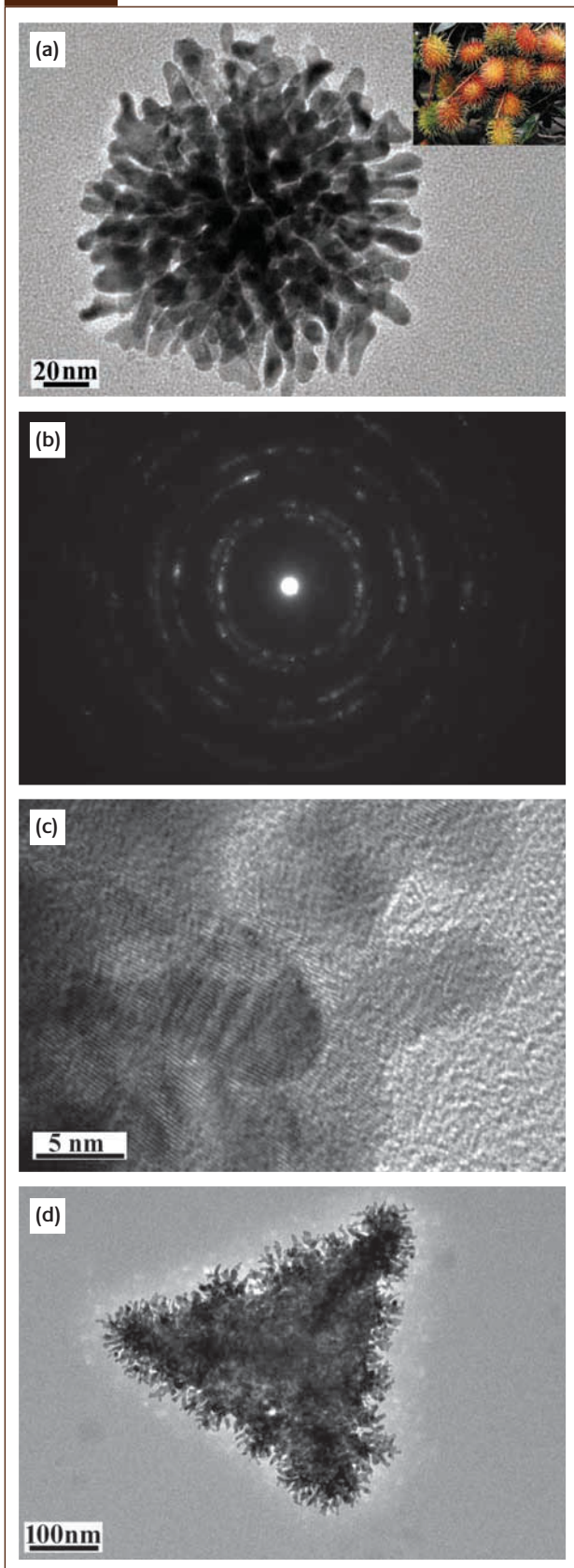
*UV-vis spectra of pure P123 and  $\text{HAuCl}_4 + \text{P123}$  at  $\text{HAuCl}_4 = 2.94 \times 10^{-4} \text{ mol dm}^{-3}$*

**Figure 2**



*Representative TEM images of AuNPs in the presence of different concentration of P123: (a) 0.75%, and (b) 0.5% at  $\text{HAuCl}_4 = \text{HAuCl}_4 = 2.94 \times 10^{-4} \text{ mol dm}^{-3}$*

Figure 3



(a) Representative TEM image of the rambutan-like hybrid nanospheres of Au-P123, inset: a photograph of rambutan; (b) Electron diffraction patterns obtained by aligning the electron beam perpendicular to a rambutan-like hybrid nanosphere of Au-P123; (c) TEM image of soft spines of the rambutan-like hybrid nanosphere of Au-P123; (d) TEM image of triangular flower-like hybrid nanoparticles of Au-P123

## Conclusion

The present study clearly shows that “rambutan” type morphologies of Au nanoparticle can be obtained from the formation of AuNPs synthesized in the presence of P123 micelles. During the process of synthesis, P123 acts as a dopant, soft template and reductant. Control of nanoparticle shape may initially seem like a scientific curiosity, but its goal goes far beyond aesthetic appeal [20]. Potential applications are in drug delivery, biosensors and areas where superhydrophobic properties are desirable.

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## About the authors



**Chun Mao** received his Ph.D. degree in polymer science at Nanjing University, China in 2004. He is currently a Research Fellow at the Jiangsu Key Laboratory of Biofunctional Materials Research Group in Nanjing Normal University. His research activities focus on the preparation, characterization and application of bionanoparticles and biopolymers.



**Jian Shen** has been a professor of Nanjing University since 1996. In 2002, he moved to Nanjing Normal University and served as an adjunct professor of Nanjing University. Now he is the director of Jiangsu Key Laboratory of Biofunctional Materials, the director of Engineering Research Center of Interface Chemistry, Nanjing University, and the Chairman of the Nanjing Chemical and Chemical Industry Society. His primary research interests include surface and interface chemistry, polymer nanocomposites and biomacromolecules.



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