

One-step preparation and characterization of PDDA-protected gold nanoparticles

Hongjun Chen^{a,b}, Yuling Wang^{a,b}, Yizhe Wang^{a,b}, Shaojun Dong^{a,b,*}, Erkang Wang^{a,b,**}

^a Chinese Academy of Sciences, State Key Laboratory of Electroanalytical Chemistry, Changchun Institute of Applied Chemistry, Changchun, Jilin 130022, People's Republic of China

^b Graduate School of the Chinese Academy of Sciences, Beijing 100039, People's Republic of China

Received 22 July 2005; received in revised form 8 November 2005; accepted 13 November 2005

Available online 7 December 2005

Abstract

Poly(diallyl dimethylammonium) chloride (PDDA), an ordinary and watersoluble cationic polyelectrolyte, was investigated for its ability to generate and stabilize gold colloids from a chloroauric acid precursor. In this reaction, PDDA acted as both reducing and stabilizing agents for gold nanoparticles (AuNPs). More importantly, PDDA is a quaternary ammonium polyelectrolyte, which shows that the scope of the reducing and stabilizing agents for metal nanoparticles can be extended from the amine-containing molecules to quaternary ammonium polyelectrolytes or salts. UV–vis spectroscopy, transmission electron microscopy (TEM), X-ray photoelectron spectra (XPS) and Fourier transform infrared (FTIR) were used to characterize the synthetic AuNPs. The PDDA-protected AuNPs obtained are very stable and have relative narrow size distribution. © 2005 Elsevier Ltd. All rights reserved.

Keywords: One-step preparation; Poly(diallyl dimethylammonium) chloride; Quaternary ammonium polyelectrolytes

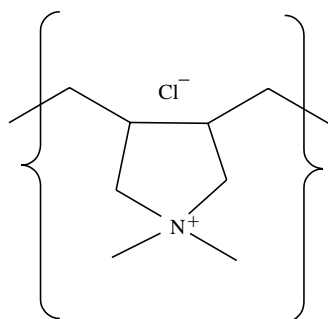
1. Introduction

In recent years, metal nanoparticles have attracted considerable attention because of their unique optical, electrical and other properties [1–3]. Gold nanoparticles (AuNPs) are the most stable metal nanoparticles and have been widely studied. Up to now, various methods for the preparation of AuNPs have been reported and reviewed, which include chemical reduction, photolysis, radiolysis, sonochemistry and thermolysis reduction, two-phase synthesis methods and etc. [4]. Among them, the most convenient and popular method is chemical reduction in which metal ions are reduced by a reducing agent such as sodium borohydride, sodium citrate, hydrogen, and alcohol [5–7]. To avoid aggregation of metal colloids, a common strategy is to use a protecting agent such as thiols, surfactants, polymers, and dendrimers that can also control the particle size and introduce functionality to the particle surface [8–11].

Polyelectrolytes are often used to modify substrate surface and colloids, exploiting the electrostatic attraction for their deposition [12,13]. As a branch of charged polymer, polyelectrolytes can be deposited on substrate surfaces layer-by-layer, enabling to control the total polymer thickness by the number of layers deposited [14]. Because of electrosteric stabilization, polyelectrolytes can also be used as stabilizing agents for colloids [15]. Mayer and co-workers investigated various polyelectrolytes as colloid stabilizers in solution where Ag^+ was reduced with the addition of KBH_4 [16]. Youk et al. described the preparation of AuNPs from a polyelectrolyte complex solution of terthiophene amphiphiles [17]. However, the result was not satisfactory due to the time-consuming of preparation and the poor stability of as-prepared colloids. Irshad et al. reported the preparation of AuNPs using poly(sodium acrylate), which acted as both reducing and stabilizing agents [18]. However, any insoluble materials need to be filtered and removed in the synthetic procedure and AuNPs formed by polyelectrolytes were found to be less uniform in size and shape. One-step synthesis of polyelectrolyte-protected AuNPs with the use of linear polyethylenimine to serve as reducing and protecting agent has been recently reported from our laboratory [19]. In this article, we reported a heat-treatment-based strategy for preparation of polyelectrolyte-protected AuNPs with the use of poly(diallyl dimethylammonium) chloride (PDDA, as shown in Scheme 1) to act

* Corresponding authors. Address: Chinese Academy of Sciences, State Key Laboratory of Electroanalytical Chemistry, Changchun Institute of Applied Chemistry, Changchun, Jilin 130022, People's Republic of China. Tel.: +86 431 5261011; fax: +86 431 5689711.

E-mail address: dongsj@ciac.jl.cn (S. Dong).



Scheme 1. The molecular structure of PDDA.

both as the reducing and stabilizing agents simultaneously. According to our knowledge, this is the first report about synthesis of AuNPs by using the quaternary ammonium polyelectrolyte, which extends the scope of both the reducing and stabilizing agents for preparation of metal nanoparticles from the amine-containing molecules to quaternary ammonium polyelectrolytes or salts.

2. Experimental section

PDDA (50% wt in water, molecular weight 20000) was purchased from Aldrich and HAuCl_4 and NaOH from Beijing Chem. Co. All reagents were used as received without further purification. The water used was purified through a Millipore system. In a typical experiment, 250 μL PDDA (4 wt% in water), 40 mL water, 200 μL 0.5 M NaOH and 100 μL HAuCl_4 (10 mg/mL) were added into a beaker. After thoroughly mixed for 2 min, the mixed solution maintained at 100 $^\circ\text{C}$ for several minutes until the color of the solution changed to red and no further color change occurred. Through accurately control the reaction time and use an inverted culture dish covered on the beaker to avoid the reaction liquid vaporized rapidly, we can get reproducible result.

UV–vis spectra were collected on a CARY 500 Scan UV–vis–near infrared (UV–vis–NIR) spectrophotometer. TEM measurements were made on a JEOL 2000 transmission electron microscope operated at an accelerating voltage of 200 kV. The sample for TEM characterization was prepared by placing a drop of colloidal solution on carbon-coated copper grid and dried at room temperature. Analysis of the X-ray photoelectron spectra (XPS) was performed on an ESCLAB MKII using Mg as the exciting source. The sample for XPS characterization was prepared by placing 100 μL of the AuNP on a clean glass slide. Fourier transform infrared (FTIR) was carried out using a Nicolet 520 SXFTIR spectrometer. The spectra were obtained by spreading the samples on CaF_2 with an average of 120 scans and 4 cm^{-1} resolutions.

3. Results and discussion

Information about the AuNPs concentration (absorbance), particle size (position of λ_{max}), and dispersity of particle size in solution (width of absorbance band) can be obtained from

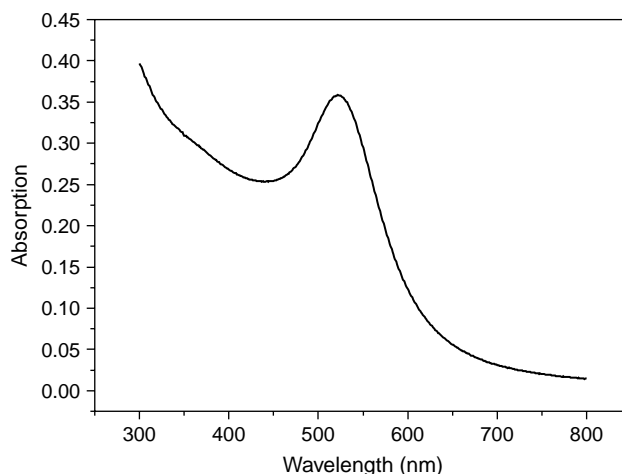


Fig. 1. UV–vis absorption spectrum of an aqueous solution of PDDA-protected AuNPs.

the optical spectra of gold colloids solution. Fig. 1 gives the UV–vis spectrum of the gold colloids, showing a characteristic surface plasmon absorption center at 522 nm, which is typical for AuNPs of about 12 nm in diameter [20].

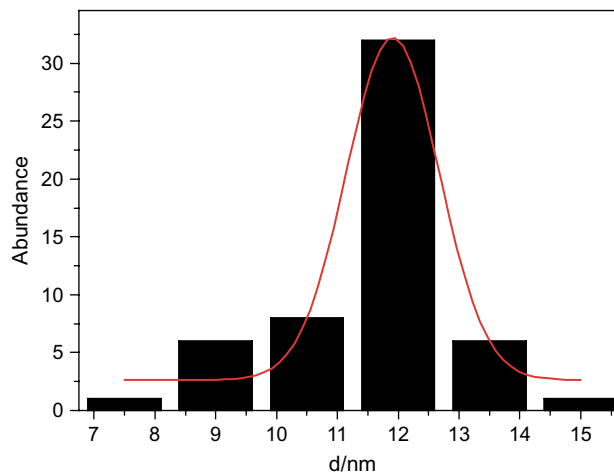
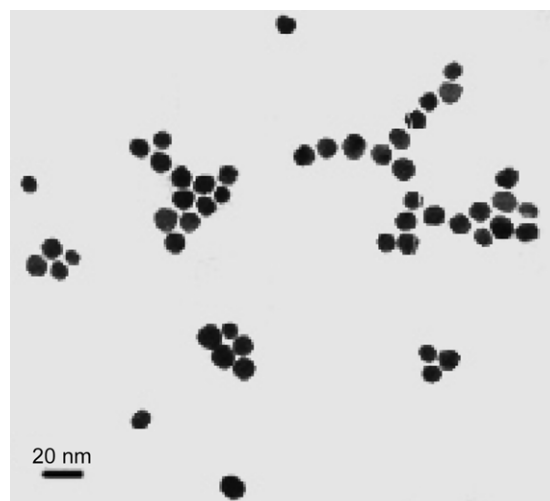


Fig. 2. Typical TEM image (up) and the corresponding particle size distribution histogram (bottom) of PDDA-protected AuNPs.

Download English Version:

<https://daneshyari.com/en/article/5189428>

Download Persian Version:

<https://daneshyari.com/article/5189428>

[Daneshyari.com](https://daneshyari.com)