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Preparation of Gold-Polypyrrole Core-shell Nanoparticles

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The core-shell particles consisting of a nano-sized gold colloidal core and polypyrrole (Ppy) shell were simply prepared by using adsorbed cationic surfactants (cetyl pyrridinium chloride:CPC) arrays as template. The Ppy shell layers were effectively deposited under a condition where the CPC are adsorbed as bilayers on the surfaces of gold nanoparticles (Au). The Au-Ppy core-shell nanoparticles were found to be stable colloidal dispersion in aqueous media with 45 nm in diameter employed Ppy shell with 10 nm thickness.

Keywords core-shell particle; gold nanoparticle; colloidal dispersion

INTRODUCTION

The modification of nanoparticle surfaces is currently an active area of research and of great technological interest[1]. The characteristics of nanoparticles can be tailored to meet their special purpose through the surface modification. This is accomplished by a number of ways such as coatings by plasma[2], grafting by surface polymerization[3], and encapsulating by self-assembled monolayers or polymers[4]. Core-shell

nanoparticles have a great potential in the construction of optical nanocomposites[5]. A conducting polymer, polypyrrole (Ppy), will be a good candidate as a shell of the metal nanoparticle for the EL application because of its electrical property. In this paper, we expand the scope of adsorbed surfactant bilayers as a template developing a simple methodology to prepare a metal conducting polymer core-shell nanoparticles.

EXPERIMENTAL

Au particles were simply prepared following known procedures[6]. 5 mL of 1 wt % sodium citrate solution was added into 85 mL of boiling solution of $AuCl_3$ (0.19 mM) and the mixture was refluxed for 30 min to give Au dispersed in water. A Ppy shell on Au can be formed as follows: 10 mL of Au solutions were placed into three different test tubes with 3 mM of purified pyrrole plus 1.6 mM of CPC. The vials were placed in a bath at 25 °C. After 24 hrs, an equimolar amount of $FeCl_3$ (based on the pyrrole) was added as a concentrated solution. After another 24 hrs, we characterized Au and Ppy-coated Au using a transmission electron microscope (TEM, JEOL JEM-2000FXZ). We separated out the free Ppy in the solution by repeating both a centrifugation and a dispersion process.

RESULTS AND DISCUSSION

Figure 1(a) shows the TEM image of the prepared Au particles. We see that the Au particles were produced as elongated spherical shapes of about 25 nm in diameter. Since the surfaces of Au were negatively

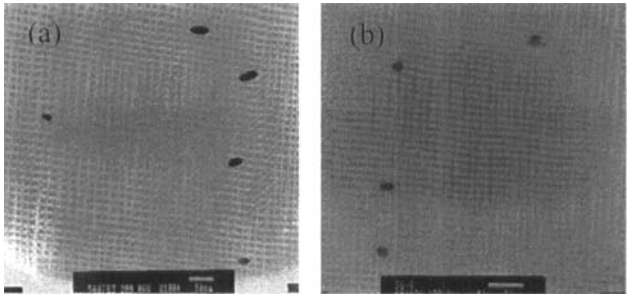

FIGURE 1. Schematic of the adsorbed CPC used as template for the preparation of shells on colloidal core particles.

charged due to citrate anions, adsorbed self-assembled arrays on the Au surface were formed by simply adding CPC into the gold solution. We used it as a template for the formation of thin Ppy films on the Au particles. During the polymerization, there was no indication of precipitation. Even after 3 months, only a stable colloid was formed from the resulting mixture. We thought the stability of a core-shell nanoparticles would originate from the following facts. In the presence of CPC, Ppy could not overgrow either in the aqueous phase or on the surface of Au particles because adsorbed CPC on Au and free CPC in the aqueous phase would render a confined environment for the growth of Ppy. Under the same condition except CPC not added, however, a macroscopic precipitation was observed even during the polymerization.

The TEM images of the Au-Ppy nanoparticles prepared were shown in Figure 1(b). According to the TEM images, we can see that Ppy was grown uniformly on Au with the thickness of about 10 nm. Although these results showed that the structures of adsorbed surfactant arrays were not very critical for the formation of Ppy shells on gold nanoparticles, indeed, the presence of the adsorbed surfactants arrays

was critical for the production of stable Au-Ppy core-shell nanoparticles.

CONCLUSION

We have prepared Au-Ppy nanoparticles (45 nm) coated with ultra-thin Ppy films by simply using adsorbed surfactant arrays on Au as a template. The resulting Au-Ppy nanoparticles showed the electronic interaction between Au nanoparticles (25 nm) and ultra-thin Ppy films (10 nm thickness).

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