

Controlled Synthesis and Characterization of Noble Metal Nanoparticles

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ABSTRACT

In this work, monodispersed, well-shaped platinum (3.2 - 6.4 nm), rhodium (2.4 - 5.1 nm), and palladium (3.2 - 5.3 nm) nanoparticles capped with poly(vinylpyrrolidone) (PVP) were synthesized by a polyol reduction method in an ethylene glycol solution at temperature of 190°C. The influences of synthetic parameters on the size and morphology of the noble metal nanoparticles have been systematically investigated. The noble metal nanoparticles were characterized by means of UV-vis, laser scattering particle size distribution analysis (LSPSDA) and transmission electron microscopy (TEM). The experimental results showed that the particle size of metal nanoparticles, the morphology of which was spherical, increased with the raise of metal precursor concentration as well as the amount of PVP. The optimal molar ratio of PVP/metal and metal precursor concentration for the fabrication of Pt, Rh, and Pd nanoparticles with uniform distribution were 10 and 0.1 mM, respectively. The morphologies of the Rh nanoparticles with the size of 5.1 nm were polygons, including hexagons, pentagons, and triangles.

Keywords: Polyol Reduction; Pt; Rh; Pd Nanoparticles; Poly(vinylpyrrolidone)

1. Introduction

Noble metal nanoparticles (NPs) with a narrow size distribution are valuable technological importance because of their unique physico-chemical properties and applications in the fields of catalysis, information storage, optoelectronics, sensors, fine chemicals synthesis, oil refining processes, and fuel cell technology. Uniformity of particle size minimizes the dispersion of important properties that are critical in these operations, such as surface chemical activity and magnetic as well as electronic properties [1-7]. Thus, much attention has been paid in recent years to develop methods of synthesizing monodispersed and size/shape controlled noble metal nanoparticles (Pt [8-10], Rh [11-13], Pd [14,15], Ir [16], Au [17,18], and Ag [19,20]) by tuning the particle growth kinetics in the processes of fabricating. Recent years, many effective methods have been developed including seeded growth by polyol reduction [21], thermolysis of organometallics [22], modified polyol methods [23], and micelle techniques [24]. Since Pt, Rh, and Pd are important noble metals, the synthesis of the noble metal nanoparticles with size and shape regulated has thus become a fundamental research focus. For instance, Somorjai [11,21] reported that the Rh nanocrystals with morphologies of multipod, cube, horn, and cuboctahedra were synthesized successfully by the seeded growth in a

polyol system. Xia and co-workers [23] investigated the synthesis and stability of Rh multipods in a polyol system, which showed interesting surface plasmonic properties. By an organometallic approach, Son and co-workers [22] prepared monodispersed oleyl amine-capped Rh tetrahedral nanocrystals, which displayed excellent arenes hydrogenation activities. Mukul [25] had demonstrated 1D nanostructures composed of Rh (0) and Rh (II) prepared by solution-phase synthetic approach. However, there was little work on the systematically investigation of size control in fabricating monodispersed Pt, Rh, and Pd nanoparticles.

In this paper, we report a one-step polyol synthesis of monodispersed, well-shaped Pt (3.2 - 6.4 nm), Rh (2.4 - 5.1 nm), and Pd (3.2 - 5.3 nm) nanoparticles at temperature of 190°C in a polyol system, using ethylene glycol as the reducing solvent and poly(vinylpyrrolidone) as the capping agent. The varieties of particle size with an increasing in precursor concentration and the ratio of metal/PVP were illustrated. Especially, Rh nanoparticles in a smaller size (5.1 nm) were polygons, such as hexagons, pentagons, and triangles. The size of the Rh nanoparticles is smaller than that reported before.

2. Experimental

2.1. Chemicals and Reagents

Hexachloroplatinum Acid Hydrate (H₂PtCl₆·6H₂O, 99.9%),

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