Supporting Information

Water-Soluble Pd Nanoparticles Capped with Glutathione: Synthesis, Characterization and Magnetic Properties

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Synthesis of Pd Nanoparticles under Argon Atmosphere.

The synthesis was carried out under an inert argon atmosphere to avoid possible oxidation of Pd nanoparticles. In a typical synthesis, 39.2 mL of H₂PdCl₄ aqueous solution (10 mM) was added to a three-neck round-bottom flask under Ar flowing atmosphere. The yellow colored H₂PdCl₄ solution was purged with Ar for 1 h. A glutathione solution was prepared by dissolving 0.0420 g of glutathione powder in 10.8 mL of water (purged with Ar) and swiftly injected into the three-neck round-bottom flask through septum. Upon injection of the glutathione solution, the yellow color of H₂PdCl₄ solution was changed to wine red color due to the formation of Pd-glutathione complex (see Figure S1 inset). The reaction mixture was further stirred at 360 rpm for 1 h. Subsequently, the fresh aqueous solution of NaBH₄ was prepared by dissolving 0.148 g of NaBH₄ powder in 6 mL of water (purged with Ar) and added dropwise into the reaction mixture using syringe. On the addition of NaBH₄ solution, the color of reaction solution was changed to black, indicating the formation of Pd nanoparticles. Further, the black colored reaction solution was additionally stirred at 220 rpm for 14 h. The resulting product solution contains various sized Pd nanoparticles in the range
of 1-4 nm and the size purification was carried out by solvent fractionation. Precipitates of Pd nanoparticles were formed upon the addition of different amounts of solvent mixtures (hexane + isopropyl alcohol) and were subsequently separated by centrifugation at 4000 rpm for 10 min. The first fraction was obtained by the addition of 14 mL of hexane and 28 mL of isopropyl alcohol to the product solution with constant stirring. The rest four fractions were subsequently obtained by the addition of 8 mL of isopropyl alcohol to the supernatant from the previous fraction with constant stirring. The Pd nanoparticles were washed three times with methanol. The Pd nanoparticles obtained from first fraction were highly agglomerated. Reasonably monodispersed Pd nanoparticles with four core sizes (3.7 ±0.8, 2.8 ±0.3, 2.4 ±0.2 and 1.7 ±0.2 nm) were obtained from the second, third, fourth and fifth fractions, respectively.

Figure S1. UV-vis absorption spectra of aqueous solutions of H₂PdCl₄ (yellow color), Pd-glutathione complex (wine red color) and Pd nanoparticles (black color) formed during the course of particle synthesis under argon atmosphere.
Figure S2. UV-vis absorption spectra of different sized Pd nanoparticles prepared under air atmosphere. Absorption spectra were normalized to unity at 250 nm for comparison.

Figure S3. HRTEM image of 1.1 nm Pd particles synthesized under air. The particles are poorly crystalline with multiple grain boundaries.
Figure S4. XPS Au 4f spectrum of 2.4 nm glutathione capped Au nanoparticles.
Figure S5. Wide scan XPS survey spectra of glutathione capped (a) 2.4 nm Pd (b) 2.8 nm Pd nanoparticles prepared under air atmosphere.

Table S1. Comparison of transition metal impurities contained in Pd nanoparticles prepared under air and argon atmospheres. Analysis was conducted using ICP-MS.

<table>
<thead>
<tr>
<th>Impurities (ppm)</th>
<th>Fe</th>
<th>Co</th>
<th>Ni</th>
<th>Cr</th>
<th>Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pd NP (Air)</td>
<td>1.1</td>
<td>1.5</td>
<td>5.5</td>
<td>4.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Pd NP (Ar)</td>
<td>1.3</td>
<td>4.5</td>
<td>5.5</td>
<td>4.7</td>
<td>0.5</td>
</tr>
</tbody>
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