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Facile synthesis of starch-scaffolded bimetallic Au-Pt nanostructure and electrocatalysis

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A facile, one-pot synthesis procedure has been developed for the preparation of two types of bimetallic Au-Pt nanostructures. By controlling the timing and conditions of the syntheses, gold nanoparticle (AuNP) cores (1) with an atomically thin platinum shell nanoparticles, and (2) encapsulated in a porous network of 2-3 nm platinum nanoparticles (PtNPs) can be prepared, denoted Au@Pt NPs and nanoflowers (NFs), respectively.

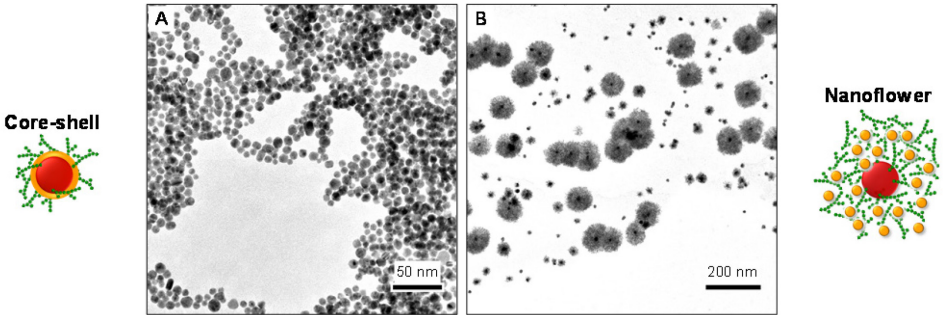

Figure 1. Transmission electron micrographs of (A) Au-Pt core-shell NPs, Au@Pt NPs and (B) Au cores encapsulated by a porous network of 2-3 nm PtNPs.

The exact concentration of Pt precursor and the dynamics of its reduction are critical for core-shell formation as rapid precursor reduction leads to unwanted nucleation of PtNPs. Formation of an atomically thin Pt shell leads to a drastic change in optical properties. The localized surface plasmon resonance (LSPR) of the Au core is almost completely dampened and the colloid changes color from red to brown. Meanwhile, no significant change in particle size is detectable by transmission electron microscopy (TEM). Electrochemical characterization of the Au@Pt NPs reveals a large Pt response confirming the formation of a core-shell structure.

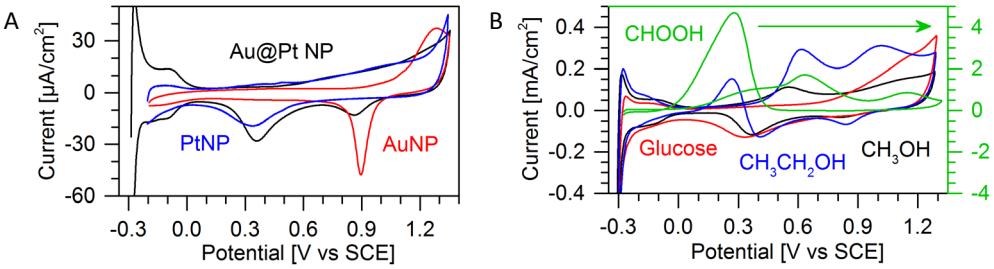

Figure 2. (A) Cyclic voltammograms of Au@Pt NPs, AuNPs and PtNPs on glassy carbon electrode (GCE) in 0.1 M H_2SO_4. (B) Cyclic voltammograms of Au@Pt NPs on GCE in 0.1 M H_2SO_4 with 0.1 M methanol, glucose, ethanol or formic acid. Scan rate is 50 mW/s in all cases.

The as-synthesized Au@Pt NPs were tested as catalysts for electrocatalytic oxidation of small organic fuel molecules, i.e. methanol, ethanol and formic acid. Especially promising results were obtained for formic acid oxidation during which the Au@Pt NPs showed good resistance towards poisoning.

The AuNP core size can be controlled through a seeded growth approach from 8 to 80 nm. Varying the reaction conditions during shell synthesis enabled the formation of a porous network of individual 2-3 nm PtNPs surrounding a single AuNP core rather than the thin shell deposited directly on the AuNP. Nanoflowers with PtNP network shells from a few nm to more than 100 nm were prepared.