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One-pot wet-chemical co-reduction synthesis of bimetallic gold–platinum nanochains supported on reduced graphene oxide with enhanced electrocatalytic activity

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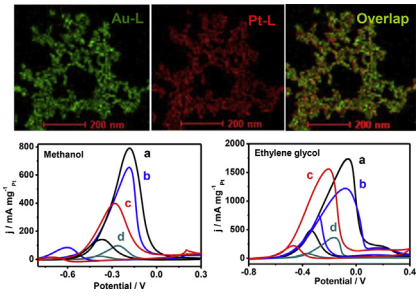
HIGHLIGHTS

- Bimetallic Au–Pt nanochains/RGO is prepared by a simple one-pot wet-chemical co-reduction method.
- Caffeine, a natural alkaloid, is employed as a capping agent and a structure-directing agent.
- There is no any seed, template, surfactant or polymer involved.
- The as-prepared nanocomposites exhibit highly electrocatalytic performances for methanol and EG oxidation reactions.

GRAPHICAL ABSTRACT



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ABSTRACT

In this work, a simple, rapid and facile one-pot wet-chemical co-reduction method is developed for synthesis of bimetallic Au–Pt alloyed nanochains supported on reduced graphene oxide (Au–Pt NCs/RGO), in which caffeine is acted as a capping agent and a structure-directing agent, while no any seed, template, surfactant or polymer involved. The as-prepared nanocomposites display enlarged electrochemical active surface area, significantly enhanced catalytic activity and better stability for methanol and ethylene glycol oxidation, compared with commercial Pt–C (Pt 50 wt%), PtRu–C (Pt 30 wt% and Ru 15 wt%) and Pt black.

1. Introduction

Recently, gold (Au) nanostructures have received significant attention because of their fascinating intrinsic optical, chemical, and electrical properties [1,2]. And diverse morphologies of Au nanostructures have been synthesized [3,4] such as spheres [5], chains [6], plates [7], rods [8], dendrites [9,10], and flowers [11,12]. However, Au nanoparticles display much lower catalytic activity in comparison with other noble metals [13,14], albeit with their superior durability in catalysis.

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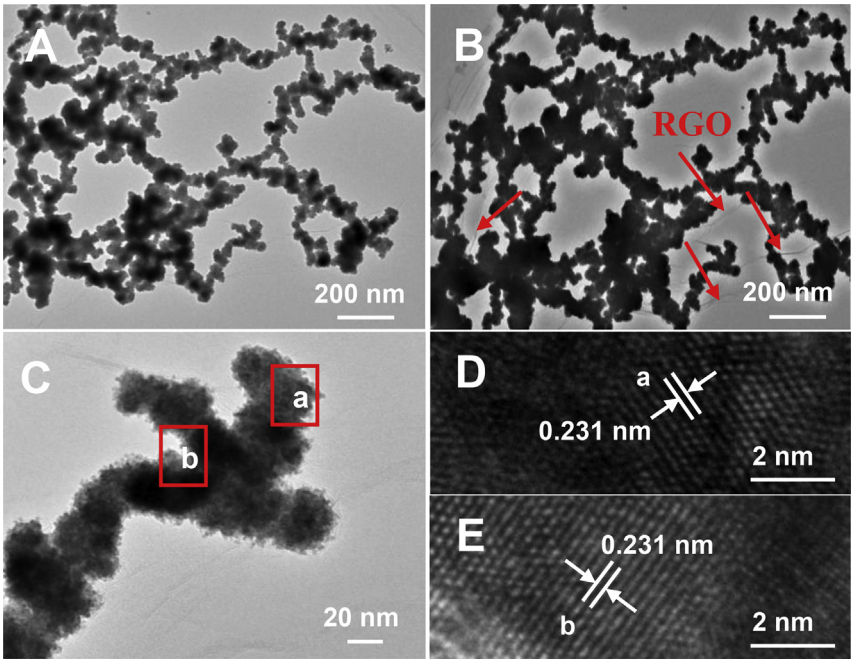

Fig. 1. Representative TEM images of Au–Pt NCs/RGO taken by the normal-focus (A) and under-focus (B) models (red arrows indicate the wrinkles of RGO). HRTEM images (C–E) of Au–Pt NCs/RGO. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

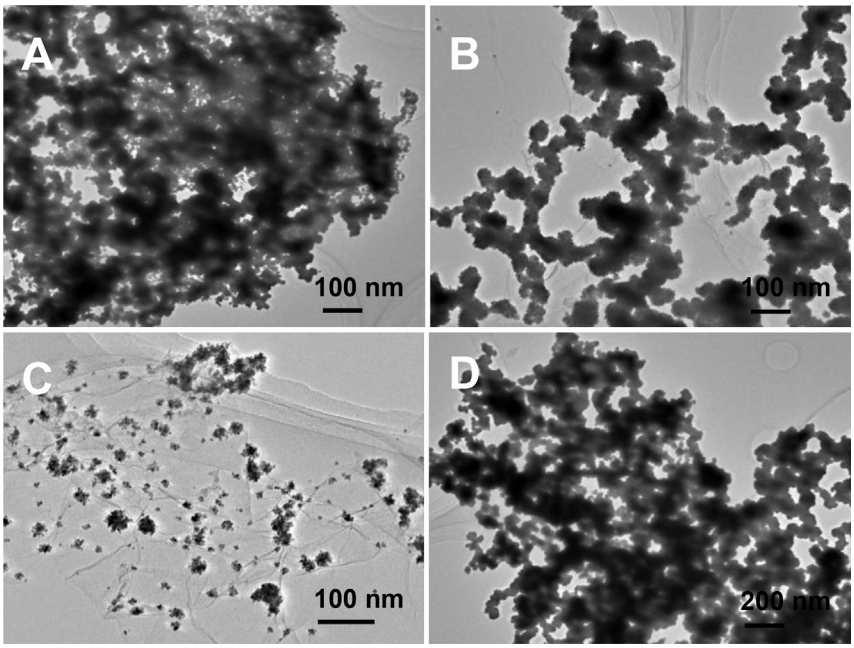

Fig. 2. TEM images of Au–Pt NCs/RGO prepared without (A), and with 10 mM (B) and 50 mM (C) caffeine. TEM images (D) of Au–Pt NCs prepared without RGO.

Alternatively, platinum (Pt) is one of the most common catalysts in heterogeneous catalytic processes including petroleum cracking, CO/NO_x oxidation, environmental protection, and especially in direct fuel cells [15]. Nevertheless, it is still a long way to realize the commercialization of Pt catalysts thanks to its high cost, limited supply, sluggish kinetics, and easy poisoning of CO-like intermediate species [16]. Therefore, it is necessary to introduce a second metal in bimetallic systems to improve the catalytic activity and/or durability of individual counterparts. For example, Au–Pt bimetallic nanoparticles exhibited improved electrocatalysis as compared to pure Pt in fuel cells, owing to their synergistic and electronic effects between Au and Pt [17–21]. In another example, core-shell Au@Pt nanoparticles showed enhanced specific activity for methanol oxidation reaction [19].

In addition, the catalytic performance of catalysts is tightly associated with the support. Recently, reduced graphene oxide nanosheets ((R)GO) have drawn considerable attention for their convenient preparation on a large scale, enhanced specific surface area, good electrical and thermal properties [22,23]. They have been demonstrated as promising candidates to support bimetallic