

Editorial

Presenting *Materials Today Nano* to the nanotechnology community!

Nanotechnology has been bringing tremendous innovations and pushing the boundaries of our knowledge. The newest technological advancements will allow a much broader and deeper study of the materials structures/functions at the nanoscale. For example,



Review Article

Palladium-based nanoelectrocatalysts for renewable energy generation and conversion

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Replacing platinum (Pt) with palladium (Pd) as the electrocatalytic materials is essential to address the technical barriers of unaffordable Pt usage in numerous renewable energy technologies, such as fuel cells, metal-air batteries, and water electrolyzers. In the past decades, both theoretical and experimental progresses have been made in advancing the Pd-based nanocatalysts, leading to catalytic activity comparable to or even exceeding that of Pt. In the present review, we overview the recently important breakthroughs in the development of promising Pd-based nanoelectrocatalysts. We begin with the brief introduction of current knowledge in fundamental electrocatalytic behavior of Pd-based electrodes and some reaction mechanism, aiming to rationalize the general guidelines of structural design for more promising nanocatalysts. Then, we demonstrate the representative examples of high-performance Pd-based nanoelectrocatalysts in terms of catalytic reactions, including hydrogen evolution/oxidation reaction, oxygen reduction reaction, and liquid fuels oxidation reaction. Finally, we provide a short conclusion and personal perspective in this research field.

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1. Introduction

Energy generation and conversion represent the essential processes in renewable energy innovations based on electrochemistry, which aim to solve the global crisis of energy shortage and environmental pollution [1–3]. Lying at the heart of these processes is a phenomenon called electrocatalysis, the efficiency of which critically relies on the applied electrocatalytic nanomaterials [4,5]. Owing to its unique chemical, physical, and electronic properties, platinum (Pt) seems to be the natural choice for catalyzing a wide range of reactions that are associated with the renewable energy technologies, such as fuel cells, metal-air batteries, water electrolyzers, and so on. However, the high cost and low abundance of Pt greatly hinder the wide adoption of these technologies, which has thus stimulated considerable efforts being devoted to reducing the Pt usages in electrocatalyst or even replacing it with less expensive materials [6,7].

As one of the most promising replacements to Pt, palladium (Pd) has received extensive attention in the past decades [8–10]. First, Pd is located in the same group and shares similar physicochemical properties with Pt. This explains why Pd lies among the most active elements for hydrogen evolution/oxidation reaction (HER/HOR), oxygen reduction reaction (ORR), and liquid fuels oxidation reactions. Second, in comparison with other transition metals, Pd possesses relatively high oxidation potential, thus ensuring fairly good stability during the long-term electrochemical operation. Finally, the average cost of Pd in history is only 1/3 to 1/2 of Pt, which might considerably decrease the overall cost of nanoelectrocatalysts.

In spite of these attractive advantages, a gap in catalytic performance (in terms of both activity and stability) between Pd and Pt still exists. In the past decade, various strategies have been proposed to fill this gap, including alloying or doping with other cheap transition metals, controlling the morphology or architecture, tuning the crystalline phases, searching for the optimized support materials, and so on. The present review aims to summarize recent progresses on advancing Pd-based electrocatalysts based on the abovementioned strategies. We first overview the fundamental studies of electrocatalysis toward various reactions using well-

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Full Length Article

PdPt nanoalloy transformation pathways at the atomic scale ^{*}

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abstract

Nanoalloys have attracted considerable attention for their wide applications in materials, optics, catalysis, and biomedicine, which largely rely on their composition-, size-, and shape-dependent properties. Because these properties change dynamically with working conditions, the knowledge of the complex transformation pathway of nanoalloys is highly demanded. Herein, we combined the in-situ aberration-corrected scanning transmission electron microscopy and multiscale modeling to fully resolve the whole transformation trajectory of a bimetallic nanoalloy (PdPt) at the atomic level. The transformation from core-shell to solid-solution structure is a multistep and temperature-dependent pathway, which includes monometallic-surface refacetting, bimetallic-surface refacetting, and alloy mixing, owing to the different atomic activation barriers of surface diffusion and bulk migration. The critical role of shell thickness in determining the transformation pathway was also revealed and explained. In particular, a unique partial core-shell structure with an anisotropic surface pattern was observed in the annealing process of ultrathin core-shell nanoparticles. This study offers a fundamental insight into the structure evolution of nanoalloys, which is beneficial for the development of functionalized nanoparticles with kinetic stability.

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Nanoalloys have attracted extensive attention for their potential applications in nanocatalysis, nano-engineering, and nanomedicine [1,2]. The unique properties of nanoalloys are determined not only by their morphologies and sizes, as for other nanomaterials, but also by their unique chemical compositions and atomic distributions [1e9]. For Pt-based bimetallic alloys, the solid solution structures and core-shell structures exhibit distinct properties. The PdPt solid-solution alloy nanoparticles (NPs) have a higher hydrogen-storage capacity than the core-shell-type NPs [10], and their core-shell NPs have been widely employed as model catalysts for oxygen reduction reaction in fuel cells [11e15]. In particular, the core-shell PdPt NPs with controlled shell thickness and morphology have attracted great interests because of their distinct catalytic properties [16e18]. Interestingly, recent in-situ

experiments have shown that both structures and compositions of nanoalloys may considerably transform during thermal treatment and under real reaction conditions [19e26]. For instance, Vara et al. recently reported that both the shape and the mixing pattern of PdPt core shell NPs change at a high temperature, consequently changing their catalytic activities [27]. As a result, understanding how the structure of a controlled core-shell nanoalloy changes under a given condition is crucial for the effective tuning of properties, which requires detailed information about the complex transformation pathways.

In the past decade, much effort has been contributed to study the complex pathways of formation [28], transformation [29e32]

Review Article

Non-fullerene acceptors for large-open-circuit-voltage and high-efficiency organic solar cells

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abstract

The development of fused ring-based non-fullerene acceptors has established a great competitiveness of solution-processed organic solar cells (OSCs) beyond other emerging solar photovoltaics. In this review, we highlight the recent progresses in non-fullerene OSCs that have shown high power conversion ef-
