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Toward the decoration of Pt nanoparticles supported on carbon nanotubes with Fe oxides and its effect on the catalytic reaction

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ABSTRACT

Deposition of metallic oxides on noble metal catalysts improves their catalytic performance dramatically due to the highly active sites formed at the interface of two metals (nano-contact). In this work, Fe oxides were deposited on preformed Pt nanoparticles by using a novel microwave assisted polyol reduction method. The facile synthesis is performed in liquid phase at 438 K, which preserves the growth of large Pt nanoparticles and precludes the formation of Pt–Fe alloy. The Fe promoted Pt catalyst exhibited high activity (6340 h^{-1} in turnover frequency) and selectivity (89.1% for cinnamal alcohol) in the hydrogenation of cinnamaldehyde, which was attributed to the uniform distribution of Fe promoters on Pt surfaces. The characteristics of Fe oxides on Pt nanoparticles were identified by employing electrochemical analysis and X-ray photoelectron spectroscopy.

1. Introduction

Metallic oxides, such as Al_2O_3 [1], TiO_2 [2], CeO_x [3] and ZrO_2 [4], have been wildly used as supporting materials in the preparation of heterogeneous catalysts. Their catalytic performances are remarkably affected by the strong interactions between metal and support. Acid support, such as Al_2O_3, is prone to extract electrons from metal particles, leading to the electron-deficient active centers. As a result, the reaction rate in aromatics hydrogenation is increased due to the enhanced interaction between substrates and metal particles [5]. Strong metal–support interaction (SMSI) also contributes to the formation of active sites at the interface of metal particle and metallic oxide support [6]. For example, the activation of carbonyl group in the selective hydrogenation can be associated with simultaneous adsorption of carbon atom on metal particle and oxygen atom on the Lewis site of support [5]. In Cu/ZnO catalyzed hydrogenation of CO to methanol, the metallic oxide carrier involves in the hydrogenation directly and serves as a hydrogen reservoir, as hydrogen molecules dissociate over ZnO surface, giving OH and ZnH [7].

The promoting effect of metallic oxides on noble metal catalyst is mainly due to the interaction between them or/and their synergistic effect. Usually, promoting effect is studied with noble metal supported on metal oxides. An alternative route to understand this effect is to fabricate active sites by decorating noble metal particles with metallic oxides as promoters. Recently, Fu et al. discovered that Fe oxide nano-islands are stabilized by the strong interaction between interfacial Fe and Pt atoms [8]. The elaborately prepared Pt–Fe bimetallic catalysts exhibited significantly high efficiency in CO oxidation at room temperature, which was ascribed to unsaturated metal sites at the peripheries of Fe oxide nano-islands on Pt nanoparticles [8]. Both carbon materials [9] and metallic oxides [10] have been investigated as supports for these types of metal oxides modified noble metal nano-particles.

The metallic oxides promoted bimetallic catalysts can be prepared simply by co-impregnation method [11], as well as carefully designed reductive deposition precipitation (RDP) technique [12]. In the later approach, promoters are preferably deposited on the noble metal surface *via* reduction of their precursors by the adsorbed hydrogen on noble metals [12]. Bimetallic catalysts obtained from RDP method showed prominent activity and selectivity in the hydrogenation of α,β-unsaturated aldehydes, which was attributed to the close contact of promoters and active centers [12]. We have also demonstrated Fe oxides doped Pt catalysts prepared by RDP method exhibited outstanding catalytic performance in aerobic oxidation of benzyl alcohol [13]. In our previous report of selective hydrogenation of cinnamaldehyde (CALD) to cinnamal alcohol (CALC), microwave-assisted polyol reduction was developed as a facile and effective approach to synthesize

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