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Tuning crystal structure of iridium-incorporated titanium dioxide nanosupport and its influence on platinum catalytic performance in direct ethanol fuel cells

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ABSTRACT

Titanium dioxide (TiO_2) has recently been used as a promising support for platinum (Pt)-based catalysts; however, its very low electrical conductivity and understanding the effect of the TiO_2 structure on Pt electrocatalytic performance for ethanol electro-oxidation reaction (EOR) are major challenges in direct ethanol fuel cells. This study reports an easy and green approach to control the crystal structures of a robust iridium-incorporated TiO_2 nanomaterial and its effect on the Pt electrocatalytic performance for EOR. A green hydrothermal route is used to fabricate iridium-modified TiO_2 nanosupports with different structures by controlling the reaction temperature and time as well as solution pH without using further calcination, followed by the anchoring of Pt nanoparticles (NPs) via a surfactant-free modified reduction route. The experimental results indicate that the pure structure of the iridium-modified TiO_2 nanosupport can easily be obtained by controlling the solution pH. In terms of EOR, all prepared catalysts show more effective performance than the commercial Pt/C catalyst. Among the prepared catalysts, the Pt anchored on the rutile iridium-incorporated TiO_2 exhibits higher EOR performance than on the anatase iridium-incorporated TiO_2 nanosupport, with negative onset potential, high current density, and electrochemical stability. The enhancement is assigned to the great adsorption and desorption ability as well as the high natural resistance to metal NPs ripening on (110) facets of the rutile structure compared with the (101) facets of the anatase structure. This exploration can offer an efficient route for tuning the structure of metal oxides and understanding the effect of the structure of the TiO_2-based support on the Pt catalytic performance.

1. Introduction

Direct ethanol fuel cells (DEFCs) have gained attention as green power sources for portable and transportation applications because of their simple infrastructure, facile storage, and conveyance [1,2]. Pt loaded on high-surface-area carbon is widely used as an electrocatalyst in DEFCs, with the carbon support allowing for good distribution of Pt nanoparticles (NPs) and relatively high performance for both anodic and cathodic reactions [3]. However, several challenges remain concerning the electrocatalytic performance of the Pt/C catalyst, hindering large-scale DEFCs. For instance, the Pt active-site surfaces are easily poisoned by the strong adsorption of carbonaceous intermediates during ethanol electro-oxidation reaction (EOR), which is assigned to charge donation from the lone-pair orbital of the adsorbed CO to the Pt atom 5 d orbital and black donation from the 5 d orbital of the Pt atom to the

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