Journal of Colloid and Interface Science 487 (2017) 60–67

Contents lists available at ScienceDirect

Journal of Colloid and Interface Science

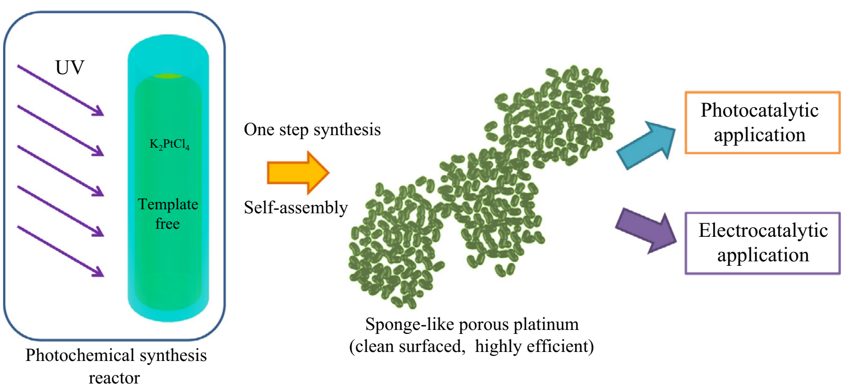
journal homepage: www.elsevier.com/locate/jcis

One step photochemical synthesis of clean surfaced sponge-like porous platinum with high catalytic performances

Xing Kong [a], Hongliang Cao [a,b,*], Chang Li [a], Xin Chen [a,c,*]

[a] Key Laboratory for Ultrafine Materials of Ministry of Education, and Shanghai Key Laboratory of Advanced Polymeric Materials, School of Materials Science and Engineering, East China University of Science and Technology, Shanghai 200237, PR China
[b] State Key Laboratory of Bioreactor Engineering, Biomedical Nanotechnology Center, East China University of Science and Technology, Shanghai 200237, PR China
[c] State Key Laboratory of Functional Materials for Informatics, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, 865 Changning Road, Shanghai 200050, PR China

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 1 August 2016
Revised 2 October 2016
Accepted 3 October 2016
Available online 5 October 2016

Keywords:
Photochemical synthesis
Platinum
Nanomaterial
Catalyst
Self-assembly

ABSTRACT

Hypothesis: Template-free and surfactant-free strategies are highly desirable, which might be used for high efficient platinum catalyst developments.
Experiments: In this work, a facile one step photochemical synthesis method was developed to prepare sponge-like porous platinum. The present synthesis was performed via ultraviolet light irradiation on a K_2PtCl_4 aqueous solution at ambient condition. The final pore sizes were in the range of 1–3 nm. The walls of the pores were formed with platinum nanoparticles of 3–5 nm average diameters. For comparisons, pluronic F127 was introduced into the reaction solutions as a surfactant, and sponge-like and dendritic-like platinum nanostructures were obtained. The catalytic activities of these platinum nanomaterials were studied with both menthol oxidation and 4-nitrophenol reduction.
Findings: The sponge-like platinum synthesized without surfactant exhibited higher catalytic activities than the porous platinum with surfactant and the commercial platinum black.

* Corresponding authors at: Key Laboratory for Ultrafine Materials of Ministry of Education, and Shanghai Key Laboratory of Advanced Polymeric Materials, School of Materials Science and Engineering, East China University of Science and Technology, Shanghai 200237, PR China.
E-mail addresses: caohl@ecust.edu.cn (H. Cao), xinchen73@hotmail.com, xinchen73@ecust.edu.cn (X. Chen).

http://dx.doi.org/10.1016/j.jcis.2016.10.005
0021-9797/

1. Introduction

Platinum (Pt) has been widely used as a high efficient catalyst for chemical reactions, including hydrogen oxidation [1], methanol oxidation [2,3], formic acid oxidation [4] and the oxidation of a variety of other materials, such as glucose [5] and ethanol [6]. However, the price of Pt is relatively high and the supply is quite limited, which has brought about significant limitations to its further applications. An effective approach to deal with such a problem is to improve the catalytic activity of the Pt material, in order to reduce its consumption. Many studies have shown that the catalytic efficiency of Pt is closely related to its morphology and size. Developing nanostructures, including nanoparticles [7], nanowires [8], nanocubes [9], nanosheets [10] and nanodendrites [11,12], is an important strategy to increase Pt surface area and achieve excellent catalytic activity. Among the various nanostructures, nano-porous Pt has attracted extensive attention because of its high surface area, high porosity and low density, which can significantly reduce Pt consumptions [13–20]. Moreover, the interconnected structure of the nano-porous Pt can offer different reaction sites for various reactants in adjacent locations, and help to facilitate the access of different reactants to enhance the catalytic activity [13].

The traditional porous Pt preparations have been largely relied on templates, including hard template, soft template and multiple templates. In the hard-template approach, certain porous materials, such as silica [14] and anodized aluminum oxide (AAO) membranes[15], have been used for the porous Pt preparation. This method often involves many steps, and requires the removal of the template by alkali or hydrofluoric acid, making it complex and costly for large-scale production. In the soft-template approach, lyotropic liquid crystals (LLCs), e.g. high concentration

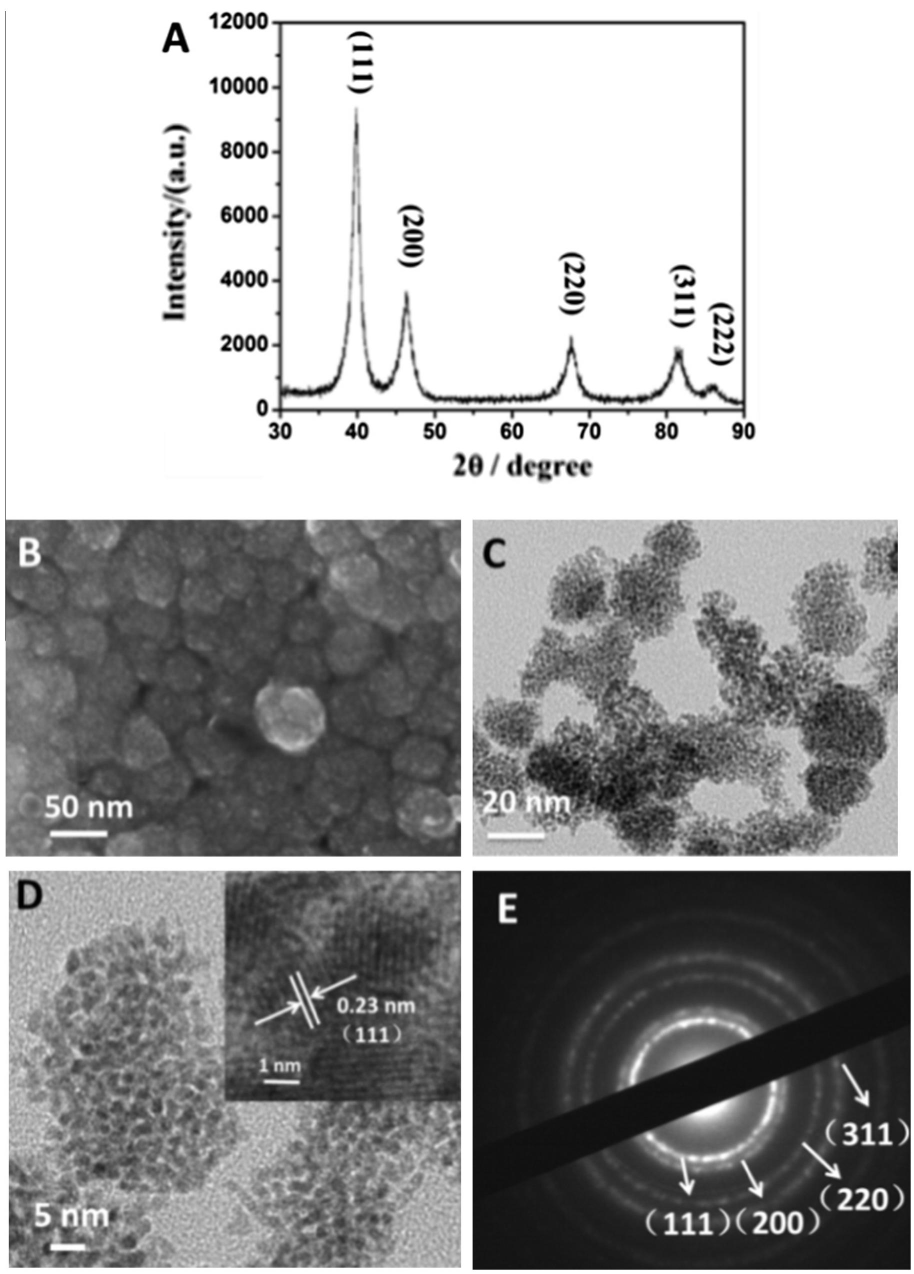


Fig. 1. (A) XRD pattern, (B) SEM image, and (C) TEM image of the sponge-like Pt; and (D) insets are HRTEM images of the sponge-like Pt; (E) SAED pattern of the sample. The UV irradiation time was 15 h.