Fabrication of high dispersion Pd/MWNTs nanocomposite and its electrocatalytic performance for bromate determination

Dan-dan Zhou, Liang Ding, Hao Cui, Hao An, Jian-ping Zhai, Qin Li *  
State Key Laboratory of Pollution Control and Resource Reuse, School of the Environment, Nanjing University, Nanjing 210046, PR China

HIGHLIGHTS

- The Pd/MWNTs nanocomposite with good activity and stability was synthesized.
- The application of Pd/MWNTs for the determination of BrO₃⁻ was investigated.
- A BrO₃⁻ reduction peak between 0.15 and −0.25 V was obtained by CV measurement.
- Linear correlation between the peak intensity and C_bromate (0.1–40 mM) is good.
- The Pd/MWNTs electrode could be employed as an amperometric sensor for BrO₃⁻.

ARTICLE INFO

Article history:
Received 23 March 2012
Received in revised form 31 May 2012
Accepted 6 June 2012
Available online 15 June 2012

Keywords:
Palladium nanoparticles  
Electroreduction  
Multiwall carbon nanotubes  
Bromate sensor

ABSTRACT

Pd nanoparticles decorated multiwall carbon nanotubes (Pd/MWNTs) catalyst was synthesized by in situ chemical method and its application for the determination of bromate was investigated. The morphology and composition of the Pd/MWNTs catalyst was characterized by Transmission electron microscopy (TEM), Energy dispersive X-ray spectroscopy (EDX) and X-ray photoelectron spectroscopy (XPS). The analyses indicate that Pd nanoparticles in metallic-state were homogeneously deposited on MWNTs with an average diameter of 4.5 nm. The electrocatalytic activity of Pd/MWNTs for the reduction of bromate was investigated by cyclic voltammetry (CV). An obvious peak corresponding to the bromate reduction was obtained between 0.15 and −0.25 V. Effects of different factors including scan rate, temperature and initial concentration of bromate ions on bromate determination were studied as well. A good linear relationship between the values of reduction peak and bromate concentration was obtained. Chronoamperometric measurement showed that the Pd/MWNTs modified electrode could be successfully employed as an amperometric sensor for bromate in a wide concentration range (0.1–40 mM) within a short response time (5 s), and the sensitivity of this sensor is 768.08 μA mM⁻¹ cm⁻². The results reported herein indicate that the Pd/MWNTs have a potential application in fabrication of bromate detector. © 2012 Elsevier B.V. All rights reserved.

1. Introduction

Bromate, used as a food additive in the production of fermented beverages and fish pastes, has been found in drinking water as disinfection by-products (DBPs) [1]. It has been published that bromate ion can cause renal cell tumors [2]. The International Agency for Research on Cancer has classified it as 2B carcinogen [3]. Bromate is very stable and difficult to be removed from aquatic system. Various kinds of methods have been developed to determine and eliminate bromate ion in water system [4]. However, second pollution and high consumption of reagents inevitably followed the removal process. Among all those treatment methods, the electrochemical method requires only electricity in operation, and no second pollution companied. Moreover, catalysts modified electrode can be recycled and thus make it an economic way for disposing bromated wastewater [5].

Utilizing of metal nanoparticles as modified electrode materials has aroused great attentions in recent years [6,7]. Palladium (Pd) is an important part of noble metal group with powerful electrocatalytic activity, which is widely applied as catalyst in heterogeneous reactions [8]. For example, there have been reports of Pd nanoparticles modified electrode for the electoreduction of pentachlorophenol [9], monochloroacetic acid [10], oxygen [11], nitrogen [12], hydrogen [13]. It is reasonable to believe that Pd catalyst is a favorable candidate for bromate determination in water system.

However, naked palladium nanoparticles are prone to agglomerate, which greatly restrains their catalytic activity. In order to overcome this technical bottleneck, solid supports which are stable and difficult to react with catalyst are needed, carbon, conducting...