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Sol-gel synthesis of silver/titanium dioxide (Ag/TiO_2) core-shell nanowires for photocatalytic applications

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ABSTRACT

Silver/titanium dioxide (Ag/TiO_2) core-shell nanowires were synthesized by direct coating of TiO_2 shells on the surface of silver nanowires (AgNWs) through a simple sol-gel process. TEM image and EDX elemental analysis had confirmed the presence of TiO_2 coating on the surface of AgNWs. The thickness of titanium dioxide coating was about 10 nm. These Ag/TiO_2 core-shell nanowires showed good photocatalytic activities in the decomposition of methylene blue as a model organic dye in aqueous solution under UV light irradiation. Ag/TiO_2 core-shell nanowires are potentially useful in photocatalytic applications.

1. Introduction

Ag/TiO_2 core-shell nanostructures have received great interest and attention due to the interesting properties of Ag and TiO_2 nanomaterials. Nanoparticulate Ag demonstrates unique activities in catalytic, chemical and biological sensing, whereas TiO_2 nanoparticles have been recognized as promising materials in photocatalytic devices [1,2], gas sensors [3], and electrochromic display devices [4]. Ag/TiO_2 core-shell nanostructures showed enhanced optical and catalytic properties due to electron transfer reactions between the Ag core and photoexcited TiO_2 shell [5]. Synthesis approaches that have been used by researchers to synthesize Ag/TiO_2 core-shell nanoparticles include one-step organic solution method [6] and water-in-oil emulsion method [7]. Spherical nanoparticles exhibited lower photocatalytic quantum yields due to increased probability of e^-/h^+ recombination at nanoparticles surface trapping sites. In contrast, increased delocalization of charge carriers in one dimensional Ag/TiO_2 nanowires would reduce the probability of $e^-/h+$ recombination and hence higher photocatalytic activities [8,9]. Du et al. reported a one-step thermal solution route to synthesize Ag/TiO_2 nanowires [10]. However, a major setback of their synthesis method was the sensitive effect of reaction temperature on the morphology of Ag/TiO_2 nanowires. Without proper control of reaction temperatures, Ag/TiO_2 nanowires with bristled surfaces would be produced.

In this paper, we have reported the preparation of Ag/TiO_2 nanowires using a sol-gel process by coating TiO_2 nanoparticles directly onto AgNWs surfaces. The sol-gel approach is a simple and convenient synthesis approach which has been extensively used to form uniform coatings on various metal oxide nanoparticles [11–13]. The photocatalytic properties of these Ag/TiO_2 nanowires were evaluated by photocatalytic decomposition of methylene blue dye in aqueous solution.

2. Experimental

2.1. Materials

All chemicals were of reagent grade purchased from Sigma-Aldrich and Merck, and used without further purification. Ultra pure water (18 MΩ cm) was obtained from a Water Purifying System (ELGA, Model Ultra Genetic).

2.2. Synthesis of Ag/TiO_2 nanowires

Silver nanowires (AgNWs) were synthesized based on the polyol method reported by Sun et al.[14]. These AgNWs were isolated by centrifugation, and then washed 3 times with ethanol to remove ethylene glycol. Purified AgNWs were redispersed in a mixture of ultrapure water and ethanol. Upon adding a measured amount of titanium tetraisopropoxide (TTIP), the mixture was stirred for 24 h at room temperature to allow complete hydrolysis and condensation of TTIP. The pH of the mixture was maintained at 6–7 throughout the reaction. Ag/TiO_2 nanowires were isolated by centrifugation, and then washed 3 times with ethanol to remove excess of TTIP and free TiO_2.

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