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In-situ loading nano silver on magnetic carbon using Tollen's reagent

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HIGHLIGHTS

- Ag-Fe_3O_4/C was prepared by in-situ reduction of Tollen's reagent.
- Ag-Fe_3O_4/C showed good magnetic separation property.
- The loaded Ag had good crystal quality and catalytic property.
- Tollen's reagent as silver source was more cost-effective than $AgNO_3$.

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ABSTRACT

Composites of nano silver on magnetic carbon (Ag-Fe_3O_4/C) were facilely prepared by in-situ reduction of Tollen's reagent. The prepared sample was characterized and compared with a control sample obtained from $AgNO_3$. The results showed that the Ag-Fe_3O_4/C sample obtained from Tollen's reagent as the silver source had better degree of crystallinity, smaller size and more Ag loading amount than that of the control sample. The reason of these advantages was discussed base on the in-situ loading mechanism. Then the prepared sample and the control sample were used in the reduction of Rhodamine B, the prepared sample also showed better performance in the catalytic application. It was suggested that using Tollen's reagent as the silver source could improve the economics of the Ag nanocomposites on their preparation and further application.

1. Introduction

Silver (Ag) nanomaterials with remarkably different physiochemical and biological characteristics have attracted much intensive research interests due to their wide applications in catalysis, antibacterial, increased optical, electromagnetic and biosensing [1]. However, single phase of Ag nanoparticles are prone to aggregate and difficult to separate from the application system owing to their strong surface effect and small size, which greatly restrict their potential applications [2]. These drawbacks can be partially eliminated by supporting the Ag nanoparticles on a specific matrix and combining them to constitute the Ag nanocomposites [3].

Magnetic carbon materials obtained from hydrothermal biomass process with a relative low temperature has been reflected significant superiority for Ag loading thanks to its outstanding separability and stability [4]. It can greatly improve the recycling of the precious metals and reduce the application cost [5]. Up to now, many efforts have been devoted to the preparation of the silver magnetic carbon nanocomposites with high quality and performance. Most of the preparation processes choose silver nitrate ($AgNO_3$) as the silver source for the synthesis of Ag [6–8], while it does not mean that $AgNO_3$ is the only and the best silver source, and the impacts of other silver source on the product are worthy of study.

Herein, Tollen's reagent was used as the silver source, and an in-situ reduction was taken placed on the magnetite carbon (Fe_3O_4/C) carrier surface for the preparation of nano silver on magnetic carbon (Ag-Fe_3O_4/C) composites. Then comparisons were carried out between the prepared sample and the Ag-Fe_3O_4/C control sample obtained by in-situ reduction of $AgNO_3$. Based on that, the advantages of Tollen's reagent as the silver source were reflected in this article.

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2. Experimental

2.1. Materials

D-glucose and Rhodamine B (RhB) were purchased from Zhongao Scientific Co., Ltd. Ferric chloride ($FeCl_3 \cdot 6H_2O$), sodium acetate (NaAc), silver nitrate ($AgNO_3$), ammonia ($NH_3 \cdot H_2O$), and sodium borohydride ($NaBH_4$) were all of analytical grade and used without further purification.

2.2. Synthesis

The magnetic carrier of Fe_3O_4/C was prepared by one step of hydrothermal D-glucose with $FeCl_3 \cdot 6H_2O$ and NaAc, the reaction conditions were according to our literature [9]. Tollen's reagent was prepared by adding $NH_3 \cdot H_2O$ drop by drop into the $AgNO_3$ solution until the formation of the brown precipitation was not observed [10].

The Ag loading process was as follows: 50 mg of Fe_3O_4/C was dispersed into 10 mL of the Tollen's reagent (1 M) by sonication. The above mixture was incubated at 60 °C with continuous agitation at 130 rpm using an orbital shaker-incubator (SHA-BA, Jieruier Company, China) for 30 min. The final products were purified by magnetic separation, washed with distilled water and ethanol for several times, and then dried in a vacuum atmosphere at 60 °C for 10 h. The Ag loading amount was expressed as the mass of Ag on the per unit mass of Fe_3O_4/C ($mg\ mg^{-1}$), and it was estimated as the weight difference of the solid samples before and after the loading process.

2.3. Characterization

X-ray powder diffraction (XRD) patterns of the samples were performed using a Bruker D8 Focus diffractometer with a Cu Kα radiation ($\lambda = 1.5406$ Å). Raman spectra were recorded by using a Thermo Fisher DXR Raman microscope with a neodymium-doped yttrium aluminum garnet laser at an excitation wavelength of 532 nm and a power of 3.0 mW. Fourier transform infrared (FT-IR) spectra were recorded on a Thermo Nicolet Nexus 670 spectrometer FT-IR spectrophotometer using a KBr pellet. Transmission electron microscope (TEM) images were taken using an FEI Tecnai G^2 F20 field emission gun electron microscope operating at 200 KV. Magnetization studies were performed at room temperature on a LDJ 9600-1 vibrating sample magnetometer (VSM).

2.4. Catalytic application of the Ag-Fe_3O_4/C

The catalytic reduction of Rhodamine B (RhB) was chosen as the

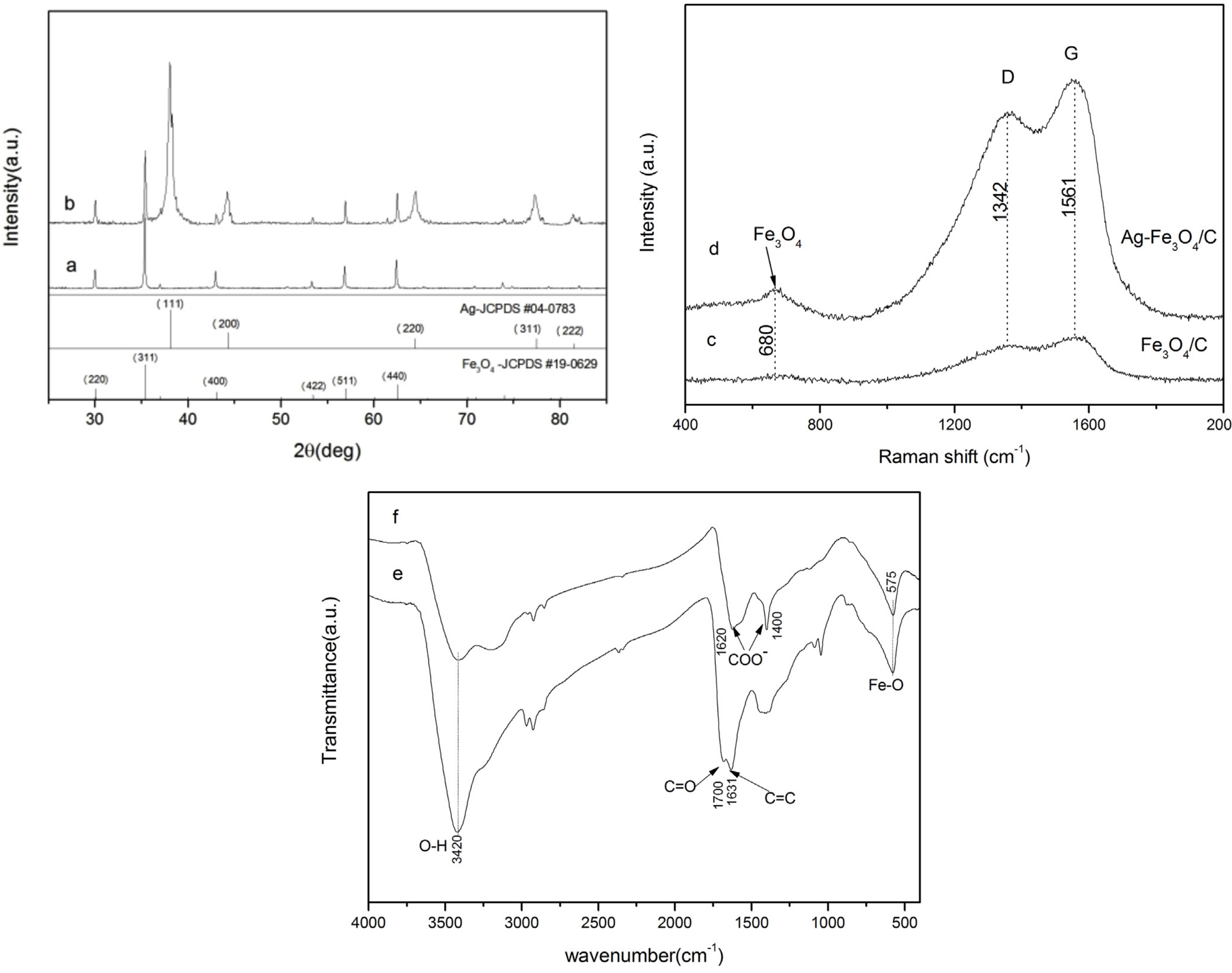

Fig. 1. XRD patterns of the Fe_3O_4/C (a) and the Ag-Fe_3O_4/C (b). Raman spectra of the Fe_3O_4/C (c) and the Ag-Fe_3O_4/C (d). FT-IR spectra of the Fe_3O_4/C (e) and the Ag-Fe_3O_4/C (f).