Preparation of Pt metal nanosheets using graphene oxide powder as template

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Abstract: Single crystalline Pt metal nanosheets could be prepared by adding dried graphene oxide and aqueous H_2PtCl_6 solution into cyclohexane, followed by heating at 180 °C in the autoclave. In addition, size of Pt nanosheets could be controlled from 20 to 100 nm by the amount of aqueous H_2PtCl_6 added into cyclohexane.

Keywords: Pt nanosheet, Graphene oxide, Template

1. Introduction

Two-dimensional materials have attracted attention since the discovery of graphene[1]. Recently, preparation methods for nanosheet of various compounds such as metals and metal oxides have been developed[2]. Most of these nanosheets have been synthesized by top-down method using layered compounds as starting materials. Nanosheets of single crystalline metal oxides can be synthesized by exfoliation of the layered compounds. However, every metal oxide nanosheets could not be prepared by the top-down methods because the methods require layered compounds as starting materials. Therefore, development of bottom-up methods for the preparation of nanosheets is required by arranging constituent atoms two-dimensionally. However, it is difficult that atoms composed of the nanosheets are spontaneously arranged two-dimensionally. Thus, templates with a two-dimensional structure are usually used in the bottom-up method[3].

We have succeeded in the preparation of metal oxide nanosheets by using graphene oxide (GO) as a two dimensional template[4]. In this method, a metal oxide nanosheet can be formed on GO by adsorbing the metal alkoxides on the oxygen-containing functional groups on GO. In this study, we tried to prepare Pt nanosheets using GO as a template.

2. Experimental

GO was prepared using Hummers method[5]. Firstly GO was dispersed into cyclohexane. Then aqueous H_2PtCl_6 solution was added to the suspension and stirred at room temperature for 3 days. After washing the sample with cyclohexane, the sample thus obtained was heated in the autoclave at 180°C. The morphology of the sample was observed with a transmission electron microscope (TEM).

3. Results and discussion

Pt specie should be densely adsorbed on the GO surface in order to prepare Pt metal nanosheets using GO as a template. Adsorption of Pt species onto GO was examined by impregnation of GO in various solutions containing different Pt salts. Water, ethanol, cyclohexane, dimethylformamide and so on were used as solutions for the impregnation. H_2PtCl_6, Pt(II) acetylacetonate, $Pt(NH_3)_2(NO_3)_2$ and so on were used as Pt metal precursors. However, any Pt species cannot be densely adsorbed on GO. Therefore, we could not obtain Pt metal nanosheets by this method. Thus, we developed a new method for the preparation of Pt nanosheets as follows. First, GO powder was added into cyclohexane, and then little amount of aqueous H_2PtCl_6 solution was added into the suspension. When the suspension was stirred at room temperature, GO powder was transferred into the drop of aqueous H_2PtCl_6, because of hydrophilicity of GO. Finally, the suspension was treated at 180° C in the autoclave. The morphology of the sample thus obtained was observed by the TEM image (Figure 1). Thin materials were observed in the TEM images. The select area electron diffraction (SAED) patterns were measured in order to clarify the structure of the thin material. The diffraction patterns were consistent with that of single crystalline Pt metal. The thickness of Pt nanosheet was estimated from the contrast of Pt nanosheet in the TEM image. The thickness of Pt nanosheets was evaluated to ca. 1.3 nm. These results indicates that single crystalline Pt metal nanosheets can be prepared using GO from H_2PtCl_6.

In addition, we found that the size of Pt metal nanosheets could be controlled by the amount of H_2PtCl_6 added into cyclohexane. Fig. 2 showed TEM images of the sample prepared by addition of 2.8 µL and 7.0 µL of aqueous H_2PtCl_6. The size of Pt nanosheet prepared at 2.8 µL was distributed in the range of 20 to 30 nm, while the size of Pt nanosheet prepared at 7.0 µL was about 100 nm. These results suggested that the size of Pt nanosheets could be controlled from 20 to 100 nm by the amount of H_2PtCl_6 added into cyclohexane.

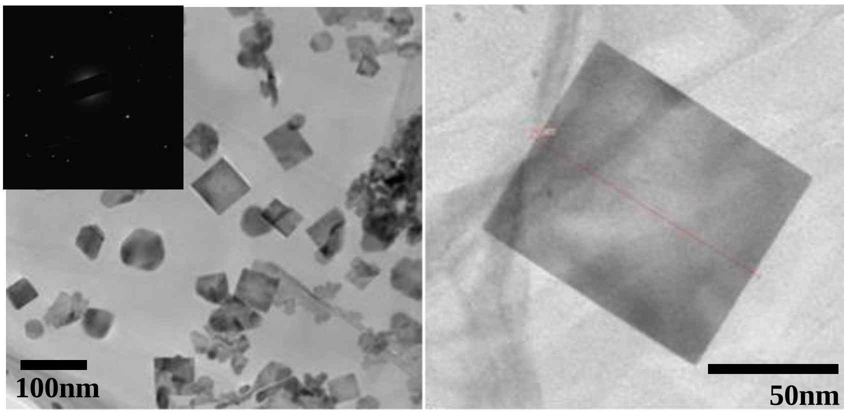

Figure 1. TEM images of Pt nanosheets.

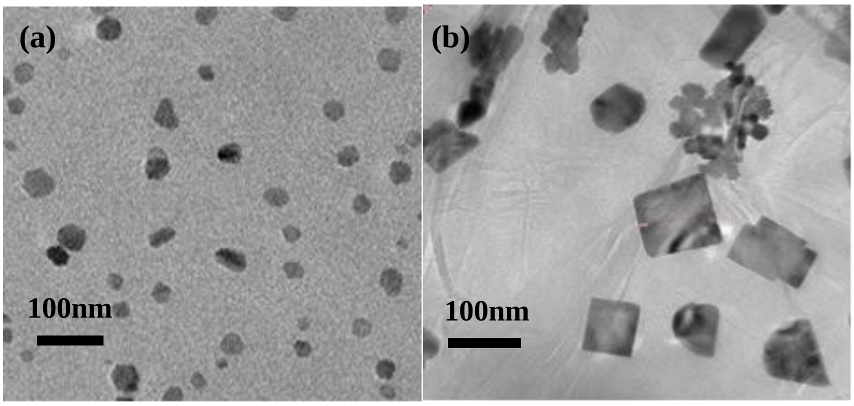

Figure 2. TEM images of Pt nanosheet prepared at (a) 5.6 µL and (b) 7.0 µL of the amount of H_2PtCl_6.

4. Conclusions

In this study, we succeeded in the preparation of single crystalline Pt metal nanosheets using GO from H_2PtCl_6. The size of Pt nanosheets could be controlled from 20 to 100 nm by the amount of H_2PtCl_6 added into cyclohexane.

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