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Synthesis of Pt/Ru bimetallic nanoparticles in high-temperature and high-pressure fluids

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Introduction

A primary goal of the synthesis of nanometer-sized particles is the regulation of function and structure, together with the establishment of the efficient and effective synthetic methods. In this study the high-temperature and high-pressure synthetic method has been applied to the production of monometallic ruthenium (Ru) nanoparticles and Pt/Ru bimetallic nanoparticles. EXAFS measurements have been carried out to analyze their structure, and the Pt/Ru bimetallic nanoparticles are found to have a core-shell structure [1].

Experimental

The colloidal dispersions of Ru and Pt/Ru bimetallic particles were synthesized by the following procedure [1]. In the case of Ru particles, the solutions of a 1:1 mixture of $RuCl_3$•nH_2O ethanol solution and PVP aqueous solution were introduced into a high-temperature and high-pressure flow reactor system (30 MPa, 473-573 K). The concentration of $RuCl_3$•nH_2O and PVP were 30 mM and 30 g/L in the reactant solutions, respectively. The colloidal dispersions of Pt/Ru bimetallic particles were prepared by the same method. EXAFS measurements of Pt-L_3 and Ru-K edge of the colloidal dispersions were carried out in a transmission mode at BL-7C and NW10A, respectively. The obtained colloidal dispersions were poured into glass cells for EXAFS measurements. In order to estimate the accurate coordination numbers, measurements of Pt foil, Pt/Ru(1/9) alloyed powder, Ru powder and Ru/Pt(1/9) alloyed foil were performed as reference compounds to extract the phase shifts and amplitude functions [2].

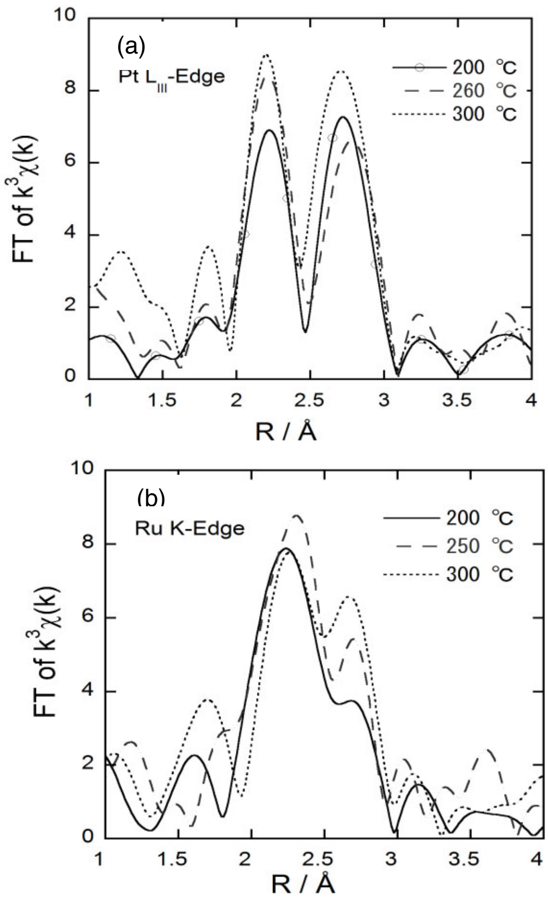

Fig. 1. Fourier transforms of the (a) Pt-L_3 edge and (b) Ru-K edge EXAFS spectra of the colloidal dispersions of Pt/Ru(1/1) bimetallic nanoparticles produced at different temperatures

Results and Discussion

Figures 1(a) and 1(b) show the temperature-dependence of Fourier-transforms of EXAFS oscillation of Pt-L_3 and Ru-K edge for the colloidal dispersions of Pt/Ru(1/1) bimetallic nanoparticles prepared at various temperatures and 30 MPa, respectively. For the Pt-L_3 edge, the spectra of the Pt/Ru colloidal dispersions show double peaks of nearly equal intensities at the R range between 2 and 3 Å, indicating that both the Pt-Pt and Pt-Ru bonds exist in a Pt/Ru nanoparticle.

Almost the same story is true to the case of Ru-K edge for the colloidal dispersions of Pt/Ru(1/1) bimetallic nanoparticles (Fig. 1(b)). The present results indicate that there are Pt-Ru bonds in individual nanoparticles in contrast to the case of nanoparticles synthesized under ambient pressure at 373 K [2]. From the curve-fitting, Pt/Ru(1/1) bimetallic nanoparticles produced here are found to have the structure mostly like the Pt-core/Ru-shell structure [1].

References

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