

Synthesis of Au stabilized Cu nanoparticles by gamma-ray irradiation reduction method

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1 Introduction

It is well known that metal nanoparticles (NPs) have some specific properties, which are not appeared in bulk materials such as catalytic activities, magnetic properties, electric conductivity and light absorption. In general, most metal nanoparticles are fabricated by chemical reduction method. We have been trying to synthesize various kinds of metal nanoparticles in water solution by gamma-ray irradiation reduction method. On the other hand, Copper nanoparticles are key materials for various industrial fields, because of its electrical and optical properties. Generally, copper particles of microns have been synthesized using chemical reduction methods. However, they are easy to oxidize and re-dissolved since their high surface activity, so that it is difficult to fabricate copper particles below nanometer size without surface oxidation. Previously, we have successfully synthesized pure copper particles with an average size of about 20 nm diameter by gamma-ray irradiation reduction method [1]. In this study, we been trying to synthesize copper nanoparticles stabilized by addition of gold in aqueous solution under gamma-ray irradiation reduction field with various conditions. These nanoparticles were characterized by transmission electron microscope (TEM), UV-vis, X-ray diffraction (XRD) and X-ray Photoelectron Spectroscopy (XPS).

2 Experiment

Aqueous solutions of Cu²⁺ ion of copper complex ((CH₃COO)₂Cu·H₂O) with a cationic surfactant of sodium dodecyl sulfate (SDS) and a radical scavenger of 8.5 and 42.5 vol.% ethylene glycol (EG) were prepared. An aqueous solution was poured into a polystyrene container and was purged with argon gas for 10 minutes. After degassing, they were irradiated with gamma-ray from ⁶⁰Co in a gamma irradiation facility at Kyoto University Research Reactor Institute. Total dose of gamma-ray irradiation was 20 kGy with the dose rate of 2.0 kGy/h. After irradiation, gold complex (NaAuCl₄·2H₂O) was added into irradiated solutions in nitrogen atmosphere with the concentration ratio of Cu:Au=1:1, 4:1 and 9:1. All of these solutions were examined by using an UV/vis absorption spectrophotometer (Shimadzu UV-2550) in the wavelength range of 200-800nm. Synthesized particles were characterized by TEM on JEOL JEM-2000FX and XPS at KEK-PF BL-27A. The samples for TEM were prepared by dispersing the all products on carbon films

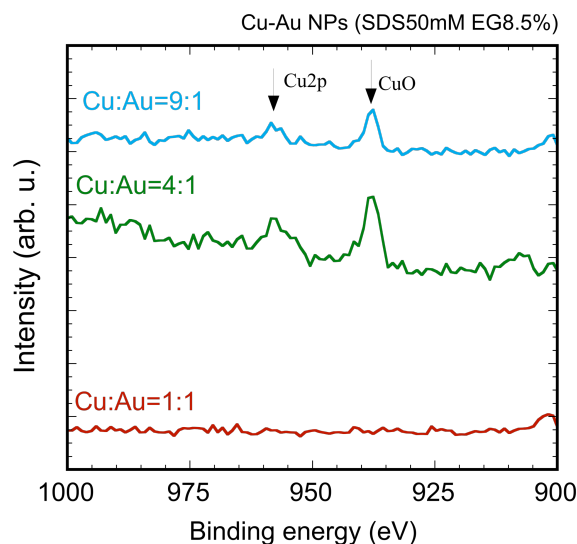


Fig.1 XPS spectra of synthesized nanoparticles in solutions with different concentration ratio of Cu and Au.

with a molybdenum mesh by dropping the solutions and were dried in vacuum. Also the samples for XPS were prepared by dropping samples on germanium and dried in vacuum.

3 Results and Discussion

Figure 1 shows XPS spectra of gamma-ray irradiation reduced solutions including different concentration ratio of Au and Cu. In this figure, a peak around 955 eV, which is originated from pure Cu metal, was found for Cu:Au=4:1 and 9:1 samples together with other peaks correspond to copper oxyde. In case of Cu:Au=1:1 sample, however, no clear peak characteristic of pure Cu metal was appeared. On the other hand, surface plasmon resonance (SPR) of Au (520 nm) was observed for all samples and weak peak of Cu SPR (560 nm) was confirmed. However, these 560 nm and 520 nm peaks combined and becomes one broad peak with increase of Cu concentration ratio. These results show that added Au ions are reduced by reacting with Cu nanoparticles but Cu nanoparticles can be retained more than four times larger Cu concentration than that of Au in a solution.

References

[1] T. Hori et al., Jap. J. Appl. Phys. 53 (2014) 05FC05.

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