Neuron-shaped Au nanocrystals fabricated using a long-chain amidoamine derivative

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Controlling the morphology of metal nano-materials is essential to develop modern material chemistry because their physical and chemical properties can be easily and widely tuned by tailoring the size and shape. Among the unique shaped Au nanocrystals, one- and two-dimensional nanocrystals such as single crystal ultrathin Au nanowires (Au NWs) and highly branched dendritic Au nanowires (Au DNWs) have attracted considerable interest. In previous works, we reported that a long-chain amidoamine derivative (C18AA) can selectively adsorb on Au surface, namely preferably adsorb on (100) and (110) facets than (111) facet [1,2]. In addition, we also demonstrated that ultrathin Au NWs with diameters less than 2 nm can be prepared using the lamellar structure in an organogel of C18AA and its selective adsorption for specific gold surface [3]. In this paper, we show the preparation of 2-dimensional dendritic Au NWs (2D Au DNWs) with diameters of 100-200 nm in an aqueous solution of C18AA, and they can be used as a seed to synthesize larger 2D Au DNWs with size 400-700 nm. Further, we also demonstrate that seeded growth method can be applied to fabricate neuron-shaped Au NWs consisting of two DNWs dangling from the both ends of ultrathin Au NWs.

For a typical synthesis protocol of 2D dendric Au NWs dispersed in water, 1.0 g of 1wt% HAuCl₄ aqueous solution was added to 4.0 g of 0.5, 2.0, or 10 wt% C18AA aqueous solution and the mixture was then heated at 55 °C for 8 hours without stirring. The molar ratios of [C18AA]/[HAuCl4] of 0.5, 2.0 and 10 wt% were 1.67, 6.67 and 33.5, respectively. In case of 2.0 wt% C18AA, i.e., [C18AA]/[HAuCl4] = 6.67 system, Au DNWs comprising of 4~7 nm branches were successfully obtained as shown in Fig. 1. However, spherical and 2-D plate-like Au nanocrystals were obtained at a lower ratio of [C18AA] / [HAuCl4] = 1.67 and a higher ratio of [C18AA] / [HAuCl4] = 33.5, respectively. Further, it was found that the formation of the dendritic Au NWs was affected mainly by [C18AA]/[HAuCl4], but not by the reaction temperature.

HR-TEM observation of various branches revealed that the dendric Au NWs were grown in the (111) direction. This conclusion is consistent with the observation that a strong peak of (111) at 38.3° and a weak peak of (200) at 44.4° appeared in the X-ray diffraction (XRD) pattern of 2D dendric Au NWs.

Seeded growth method using the selective adsorption property of C18AA is very useful for the preferential growth of Au from the (111) crystal facet. Here, since the both ends of ultrathin Au NWs prepared in the toluene gel of C18AA have (111) crystal facet, thus, it is expected that the application of the seeded growth method to ultrathin Au NWs would be useful to obtain a hybrid nanostructure of straight NWs and dendritic NWs. In order to apply the seeded growth method to ultrathin Au NWs, 2wt% C18AA-water (4.0 g) and HAuCl₄ aq (1 g) were added to the resulting aqueous dispersion of the ultrathin Au NWs (1.0 g) and the mixed solution was left at room temperature (26 °C) for 3 day. We successfully obtained novel neuron-shaped Au nanocrystal consisting of two DNWs dangling from the both ends of the ultrathin Au NWs, as shown in Fig.1.

References