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Effect of surfactants on the stability of Rh–Pd–Pt alloy nanoparticles produced by femtosecond laser irradiation in aqueous solution

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Studies on alloy NPs are of great importance because of the optical and catalytic properties, which are usually depend on the composition and size of NPs. Formation of alloy NPs is based on the reduction of metal ions, which could take place by transient species through the photo-decomposition of water molecules caused by a high intensity optical field. This method is not only one of green routes to the synthesis of pure metal and/or alloy NPs but also possible to produce multimetallic NPs with desired compositions. The use of surfactants, which will immediately cover the particles during their formation, improves size uniformity as well as their stability. In this context, the addition of surfactants is an appropriate choice for catalytic use. In this study, we demonstrate that the use of surfactants in femtosecond laser irradiation makes it possible to reduce the mean diameter as well as the size distribution of produced alloy NPs.

Sample solutions of Rh, Pd and Pt ions with 2.5×10^{-4} M concentration were separately prepared with dispersants polyvinylpyrrolidone (PVP) and citrate and then mixed. A 3 ml of the mixed solution was kept in a quartz glass cuvette and irradiated for 30 minutes by tightly focused laser pulses at the intensity of 2.1×10^{14} W/cm^2. Figure 1 shows the TEM images and XRD profiles of NPs fabricated in the mixed ion solutions with PVP after irradiation. The fabricated NPs were well dispersed and stable, and the average sizes of the NPs are 3 nm. The XRD peaks for (111) and (200) planes of fcc structure are in the range of those of pure Rh, Pd and Pt. Crystalline nature of alloy NPs is also confirmed by HR-TEM measurements. The elemental compositions of NPs measured by EDS analysis showed the particles are Pt rich Rh–Pd–Pt alloy.

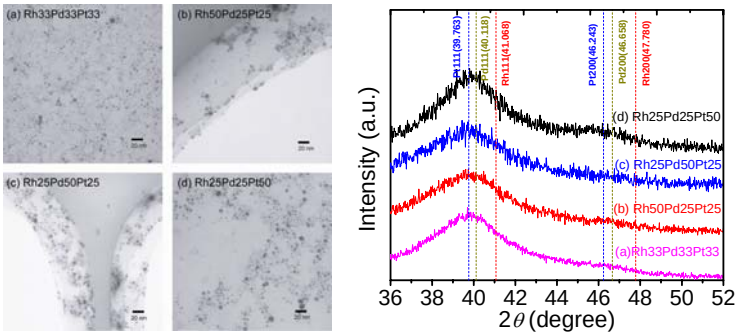

Fig. 1. TEM images (left) and XRD patterns (right) of the NPs fabricated by the laser irradiation of solutions with different mixing ratio of ions, (a) Rh33Pd33Pt33, (b) Rh50Pd25Pt25, (c) Rh25Pd50Pt25 and (d) Rh25Pd25Pt50. The dotted straight lines in XRD profile correspond to peak positions of pure Rh, Pd and Pt obtained from JCPDS card.