Alloys and Intermetallics

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Characterization of Ag-TiO_2 and Au-TiO_2 nanoparticles by means of transmission electron microscopy

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Silver (Ag) and gold (Au) nanoparticles (NPs) typically have dimensions ranging from 1 nm to 100 nm. These dimensions are similar to cellular objects and because of their high stability, biological compatibility, controllable morphology and size dispersion, and easy surface functionalization, Ag and AuNPs are of high interest. Both NPs have many potential applications in electrochemistry and medicine, as well as for the production of nanodevices.

There are many different methods for synthesis of Ag and AuNPs. We report on the synthesis by means of ultrasonic spray pyrolysis (USP), which is a simple aerosol synthetic technique [1]. USP enables synthesis of Ag and AuNPs of various sizes and shapes, including nanoparticles contaminated with metals from alloys [2, 3].

A chemically dissolved pure Ag ($HAgCl_4$) or Au ($HAuCl_4$) and ortotitanate ($Ti(OC_4H_9)_4$) were used as a precursor for the synthesis of Ag- and Au-TiO_2 NPs by means of USP, using an ultrasonic atomizer. A water solution of $HAgCl_4$ or $HAuCl_4$ and $Ti(OC_4H_9)_4$ was used for an aerosol production. The solution was then passed over to the ultrasonic atomizer at 2.5 MHz. The aerosol produced was transported by hydrogen gas into a hot reactor, where the aerosol droplets underwent drying, droplet shrinkage, solution precipitation, thermolysis, and sintering to form nanoparticles. Thermal decomposition of the resulting solution was performed at 300 °C. NPs were collected in a reactor tube and in a bottle with water.

The study focused on the transmission electron microscopy (TEM) analysis of Ag-TiO_2 (Ag/Ti-NPs) and Au-TiO_2 (Au/Ti-NPs) nanoparticles synthesized by means of USP: their size, shape, and morphology, which are associated with the key parameters of growth.

The average size of Ag/Ti-NPs ranged from around 20 nm to 80 nm (Figure 1). AgNPs were present in a matrix of TiO_2, so called 'micelle' (mixture of AgNPs and TiO_2). Micelles were spherical and varied in size between 150 nm to 300 nm. The NPs were or spherical, hexagonal or polygonal form.

The Au/Ti-NPs contained 'micelles', the mixture of AuNPs and TiO_2, as well (Figure 2). Micelles were present as bigger and smaller agglomerates and their average size was between 50 nm to 700 nm. On their surfaces, individual AuNPs were present (attached), with their size of around 7 nm to 50 nm in spherical, hexagonal or polygonal form. Some bigger nanoparticles of around 100 nm were also present. Most of the particles were around 10 nm in size. The lattice fringes were nicely observed using high-resolution TEM (HRTEM), and the growth of individual particles in the contact surfaces as well.

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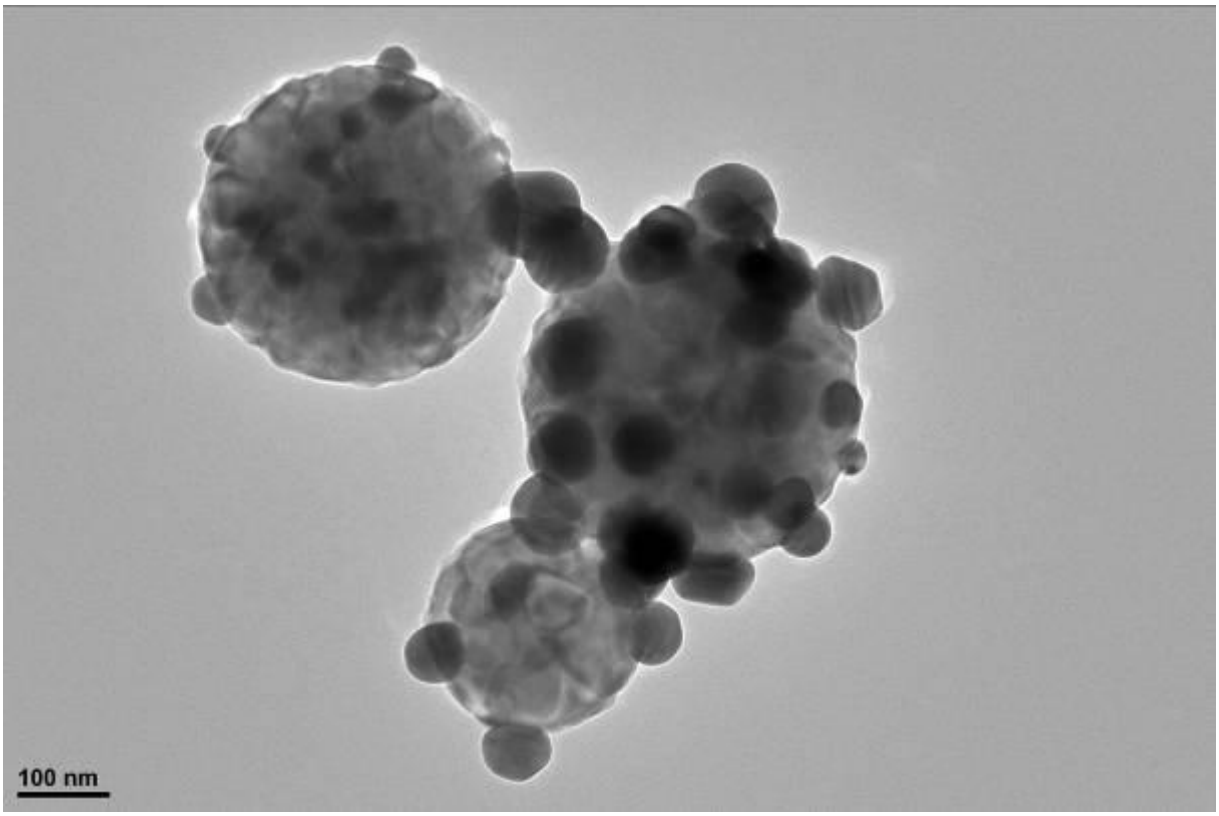

Figure 1. TEM image of Ag-TiO_2 nanoparticles.

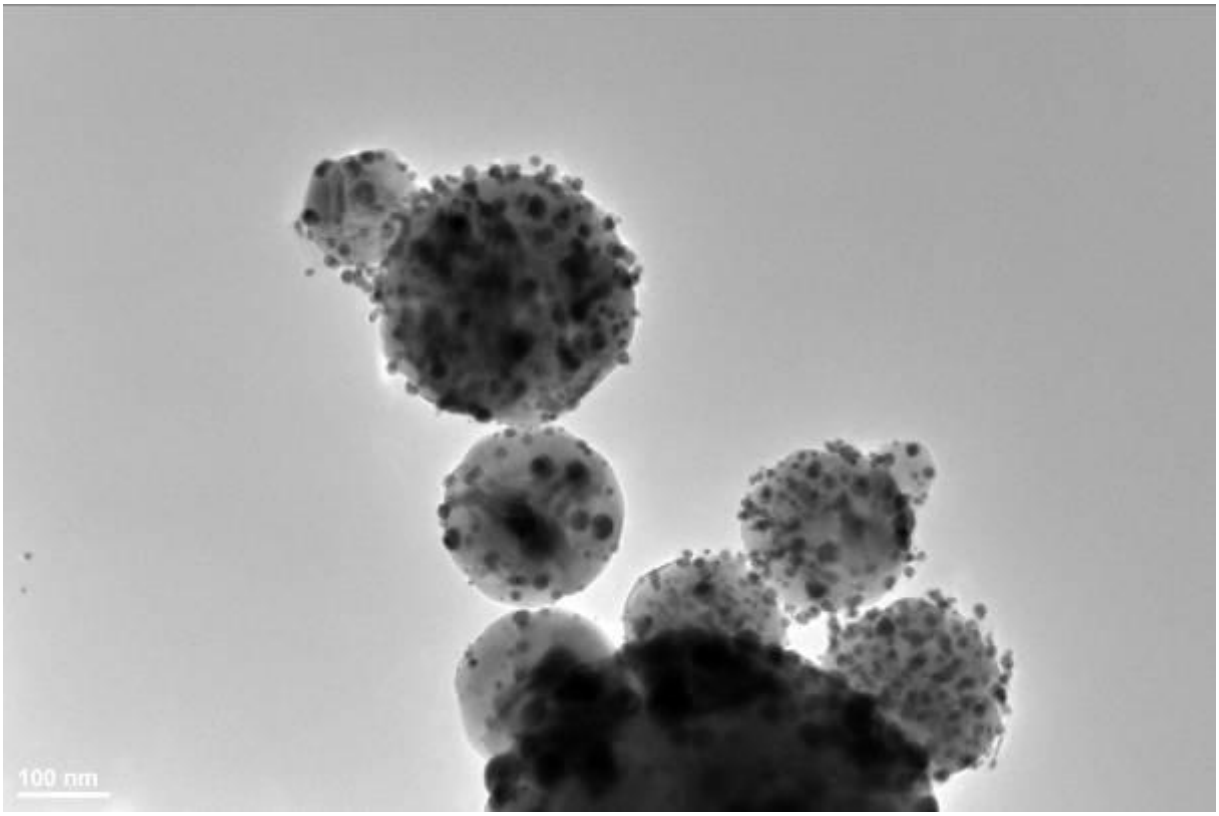

Figure 2. TEM image of Au-TiO_2 nanoparticles.