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Large-Scale Synthesis of Nanoparticles by Thermal Plasma

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Thermal plasma is a powerful tool for synthesizing well-dispersed nanoparticles in a continuous and scalable way. By its means of high temperature (up to 1.0×10^4 K) and high active radicals, fast quenching rate (10^5-10^6 K/s), it becomes easy to obtain nano-scale products.

Optical emission spectroscopy diagnosis of the RF thermal plasma was carried out to characterize the active radicals in the plasma and the reaction process. It shows that plasma active radicals can enhance the reaction, which can help to synthesize nanoparticles with a short process.

Metal nanoparticles, such as W, Mo, Ni, Cu, are synthesized via a single-step pathway with hydrogen plasma enhancement by the RF thermal plasma process using the metal precursor. The crystallized product is well dispersed spherical nano-particles with a particle size of 30-100 nm. Compared with the conventional reduction process, the plasma hydrogen reduction from a metal precursor to metallic particles is completed in one step.

ZnO, SnO_2, MoO_3, WO_3, NiO, CoO, Co_3O_4, MnO, Mn_2O_3, Mn_3O_4, TiO_2, SiO_2 and Al_2O_3 by one-step oxidation of corresponding spherical metal powders are carried out in an RF thermal plasma system under atmospheric pressure with oxygen plasma. It is found that oxidization process in the thermal plasma can give oxides nanoparticles with special structure, such as sphere, nanowire, octahedral.

In addition to the synthesis of nanoparticles with chemical reaction in the thermal plasma, physical vapor deposition is also a very important process in the thermal plasma to produce nanoparticles in large scale. Herein, the high temperature in thermal plasma is the key factor. Precursor powders with size in micrometers are delivered into the plasma flame by the carrier gas in a continuous way, and the evaporation reaction occurred in the plasma jet and is cooled down by the quenching gas to get nanoparticles. Nanoparticles with size in 50-100nm, such as Si, Fe, Co, Ni, Sb_2O_3 can be synthesized, and this technique gives a short process without pollution.

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