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One-step Synthesis of Core-Shell Porous Nanoparticles by an Aerosol Route

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Nanostructured composite particles, exhibiting high surface area, well-defined pore sizes and pore connectivity are of great interest for multiway catalytic processes such as in the automotive catalytic converter. One multifunctional nanoparticle, through different pore sizes and doped layer structures can act as a gaseous and particulate (soot) catalyst performing adsorption and oxidation processes. The short procedure of Aerosol Spray Pyrolysis (ASP) (Messing, 1993; Karadimitra, 2001) can begin from a primary solution and end up in building multiple structures at the nanoscale, which can be used for automotive applications.

Primary structures of core-shell nanoparticles were synthesized by ASP. An aqueous solution containing surfactant, tetraorthosilicate (TEOS) and appropriate salt ions is atomized into nano-sized droplets by an air assisted atomizer. The droplets are carried via air inside a heated (400^0C) tubular reactor and the produced particles are collected on a glass fiber filter located at the exit of the reactor. In the silica droplet, the surfactant is located towards the external surface (Ward, 2003) forming micelles, which self assemble into ordered structures, while the water-ion solution is captured in the core undergoing crystallization of the ions when the concentration reaches saturation point. Calcination of the synthesized particles at 450^0C for 5hrs removes the surfactant leaving the final product particles with a porous shell behind.

Further investigation involves synthesis of silica porous particles enriched with catalytic agents by mixing their precursor compounds together in an aqueous solution with surfactant, achieving high dispersion of the dopant and large surface area on each particle. Various combinations of oxides and surfactants are tested, in order to improve nanoparticles durability towards thermal treatment and soot oxidation performance, as well as create complex structures able to shield precious metals from undesirable reactions in the exhaust.

The nanoparticles are tested for soot oxidation efficiency at a Thermogravimetric Analysis device (TGA, Pyris 6), for the determination of surface area and the pore size distribution by BET analysis (Autosorb-1) and particle size distribution by an Aerosizer (TSI 3603) and are morphologically characterized by Transmitting Electron Microscopy (TEM, JEOL JEM 2010).

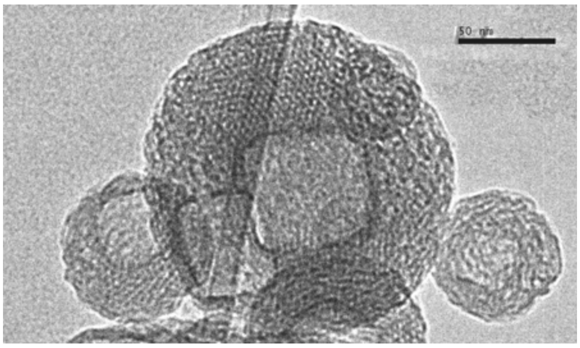

Figure 1. Crystalline core and 2.9 nm porous shell nanoparticle

In the preliminary experiments successful synthesis of crystal core porous shell particles was achieved. The BET analysis measures high surface area (78-326 m^2/g) and continuous pore connectivity while the pore size varies from 2-8 nm depending on the surfactant/s used, while in the case of the oxides the dopant was highly dispersed on the whole particle area exhibiting even higher particle surface areas (289-1115 m^2/g)

Porous silica nanoparticles having multiple morphology and composition are synthesized from one primary solution by ASP. The particles have a well defined pore size shell exhibiting high surface area and are applicable in catalytic processes.

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