

## Nanoparticles: Synthesis, characterisation and cellular effects- The NANO-SYNCC- Project

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### Introduction

Metal-oxide nanoparticles are widely used in industry, food technology, personal hygiene and are expected to find major applications in medicine in the future. Although there is clear experimental and epidemiological evidence that particles can induce inflammation and cancer in some instances, little is known about the underlying mechanisms. Biological effects of particles depend on their chemical composition, their size which is correlated with the specific surface area (Oberdörster et al., 1994), reactivity of the surface, and other parameters (Nel et al. 2006). In order to predict the biological activity of new nanoparticles, it is necessary to know which parameters induce which effects. For this purpose, in-vitro experiments have been started to screen defined nanoparticles with different sizes and surface properties for their biological effects. Here we discuss the synthesis of metal oxide nanoparticles by flame synthesis and microwave plasma, their physico-chemical characterization and the first assessment of their toxicity by bioassays.

### Experimental

Low Pressure Flame Synthesis (LPF) was carried out by combustion of iron pentacarbonyl at 30 mbar in a premixed hydrogen/oxygen flame in argon under carefully controlled flow conditions. The particles were collected on a teflon-membrane filter.

Microwave plasma synthesis (MWP) is a low-temperature process, which was previously described by Vollath et.al. (1992). Silane (SiH<sub>4</sub>) in Argon/Oxygen was oxidized in the microwave plasma at temperatures of about 500 K at p = 20 mbar. The nanoparticles were characterized on-line by Particle Mass Spectroscopy (PMS). The particles were collected thermophoretically by impingers.

The nanoparticles collected were characterised by transmission electron microscopy (TEM) and by dynamic light scattering (DLS, Horiba). Nanoparticle suspensions were prepared and dispersed by electrospray (TSI) and the airborne size distributions were measured by mobility sizing (SMPS, TSI).

Bioassays were conducted by suspending the collected iron and silicon oxide nanoparticles in medium and applying the suspensions to cell cultures. The effects on viability and production of intracellular reactive oxygen species (ROS) were analyzed and compared to those of commercial iron

and silicon oxide NPs. Primary particle sizes are 12 and 40 nm for SiO<sub>2</sub> and 20-40 nm for Fe<sub>2</sub>O<sub>3</sub> NPs.

### Results

Tab. 1 summarizes the primary size of silicon and iron oxide nanoparticles measured downstream of the microwave plasma by PMS and by electron microscopy. These particles when suspended in water show significantly higher particle sizes in DLS-measurement. As the particles were produced at low temperature the agglomeration is probably not due to sintering of the primary particles. IR-spectra of the iron oxide particles show strong OH-bonds, which may indicate agglomeration of primary particles by hydrogen bridge induced bonding.

Particle Source	Precursor	Primary Part.size	Agglomerate size
MWP	200 ppm SiH <sub>4</sub>	10 nm <sup>a</sup>	53 nm <sup>d</sup>
MWP	2000 ppm SiH <sub>4</sub>	25 nm <sup>b</sup>	150 nm <sup>c</sup> /126 nm <sup>d</sup>
LPF	800-2500ppm Fe(CO) <sub>5</sub>	11 nm <sup>b</sup>	208 nm <sup>c</sup>

Table 1. Size of primary metal-oxide nanoparticles measured by <sup>a</sup>PMS and <sup>b</sup>TEM as well as agglomerate sizes in liquid suspension measured with <sup>c</sup>DLS and by <sup>d</sup>SMPS.

The first results of the bioassays using commercial silicon and iron oxide NPs are summarized as follows:

- Toxicity in human lung epithelial cells was found for silicon and iron oxide NPs at high concentrations only.
- Silicon dioxide NPs showed high toxicity in mouse macrophages, however iron oxide was not toxic in this test system.
- No ROS formation was detected for both particle species. Iron oxide NPs synthesized by LPF showed similar effects as commercial iron oxide NPs.

Further work will concentrate on the influence of particle size, agglomeration state and chemical composition on biological effects. Furthermore, the response of cells exposed to NPs at the air-liquid interface and under submerged conditions will be compared.

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