

Preparation of oxide, salt, metal and carbon nanoparticles in flames:

Safety precautions for everyday work with nanoparticles and sustainable product development

Wide range of applications in

- biomaterials, medicine
- degradable polymers, plastics
- catalysis, chemical industry
- sensors, electronics
- metals, alloys

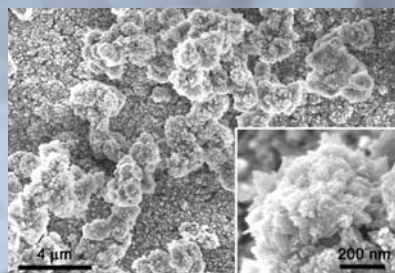
Safety concept

- everyday contact with possible hazardous nano-materials
- classification of material hazards and safety precautions
- Training, monitoring

Nanoparticle production

- e.g. by flame synthesis
- Metals
 - Salts
 - Metal oxides

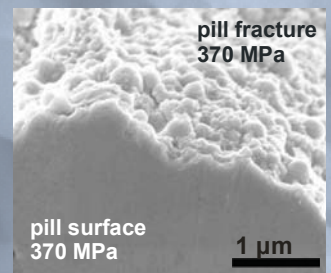
Is there a safe and sustainable route to nanotechnology development?



Nano-bioglass forming hydroxyapatite in simulated body fluid.



Bulk, nanocrystalline bismuth pill and scanning electron image showing pill surface and pill fracture site.



Two fundamental classes of nano-materials:

- biocompatible elements
- biodegradable
- no toxic elements



open reactors for substances such as lime, calciumphosphate, gypsum...

- unknown materials
- non biodegradable
- toxic elements



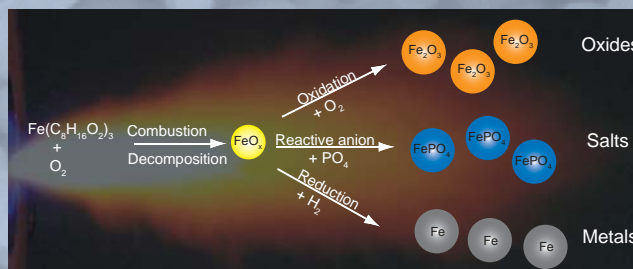
production and handling only in fully closed systems



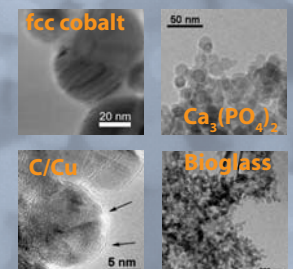
In depth physical, chemical material characterization and cytotoxicological assays

Training of employees in personal safety, discipline, responsibility

24h / 7d / 365d Particle concentration monitoring (ISO 12103-1)



Schematic of flame-spray process showing the variability of the process and products obtainable.



Transmission electron images of flame-synthesized nanoparticles

References:

- Nanoparticle toxicology and uptake:* Limbach, L. K.; Li, Y. C.; Grass, R. N.; Brunner, T. J.; Hintermann, M. A.; Muller, M.; Gunther, D.; Stark, W. J. *Environ. Sci. Technol.* 2005, 39, 9370. Brunner, T. J.; Wick, P.; Manser, P.; Spohn, P.; Grass, R. N.; Limbach, L. K.; Bruinink, A.; Stark, W. J. *Environ. Sci. Technol.* 2006, 40, 4374.
- Biomaterials: calciumphosphates, calciumcarbonate, gypsum and halides:* Huber, M.; Stark, W. J.; Loher, S.; Maciejewski, M.; Krumeich, F.; Baiker, A. *Chem. Commun.* 2005, 648. Loher, S.; Stark, W. J.; Maciejewski, M.; Baiker, A.; Pratsinis, S. E.; Reichardt, D.; Maspero, F.; Krumeich, F.; Gunther, D. *Chem. Mater.* 2005, 17, 36. Grass, R. N.; Stark, W. J. *Chem. Commun.* 2005, 1767. Loher, S.; Reboul, V.; Brunner, T. J.; Simonet, M.; Dora, C.; Neuenschwander, P.; Stark, W. J. *Nanotechnology* 2006, 17, 2054. Brunner, T. J.; Grass, R. N.; Stark, W. J. *Chem. Commun.* 2006, 1384.
- Metal nanoparticles:* Athanassiou, E. K.; Grass, R. N.; Stark, W. J. *Nanotechnology* 2006, 17, 1668; Grass, R. N.; Stark, W. J. *J. Mater. Chem.* 2006, 16, 1825; Grass, R. N.; Stark, W. J. *J. Nanoparticle Res.* 2006, DOI 10.1007/s11051. Grass, R. N.; Athanassiou, E. K.; Stark, W. J. EP Patent application 05 019287.1, 2005.