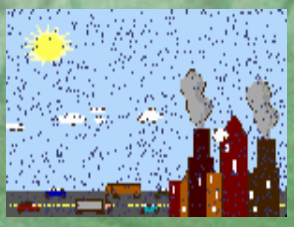
European Strategy for Nanosafety

nanoSAFE

Safe production and use of nanomaterials

Is it possible to easily measure the engineered nanoparticles at workplaces?



An essential step for exposure evaluation in case of potential nanotoxicity

Dissemination report
June 2008
DR115/121 June 200806-3

Project ID NMP2-CT-2005-515843

A European Integrated Project Supported through the Sixth Framework Programme for Research and Technological Development

Dissemination reports from Nanosafe2 project are designed to highlight and present in a simplified way the main results obtained in the studies carried out during this project. These reports mainly deal with one question which is of general concern for whom is interested in the safe production and use of nanomaterials. The full results are summarized in the corresponding Technical reports.
All the Dissemination reports and Technical reports are publicly available from Nanosafe2 project website**: **http://www.nanosafe.org

Refer to Nanosafe2 deliverables:

D115: Measurement methodologies for nanoparticle detection
D121: Nanoparticle measurements with different types of on-line and off-line monitoring instruments

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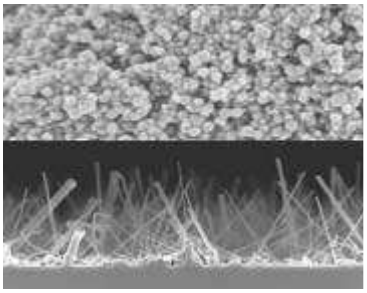
Natural, Incidental and Engineered particles

Nanoaerosols are composed of nanoparticles which may originate from different sources. Already about 10 000 ***natural*** *nanoparticles per cubic centimetre of air are present even in the "pure" atmosphere of our mountains. This very high level may be enhanced by anthropogenic activities: unwanted production of nanoparticles in combustion processes called* ***Incidental*** *particles and* ***Engineered*** *particles produced intentionally in laboratories and in the industry.*
The detection sensitivity for engineered nanoparticles is limited by the high background noise due to Natural and Incidental nanoparticles.

Volcanic eruptions, sea spray, sand erosion, etc. produce natural nanoparticles

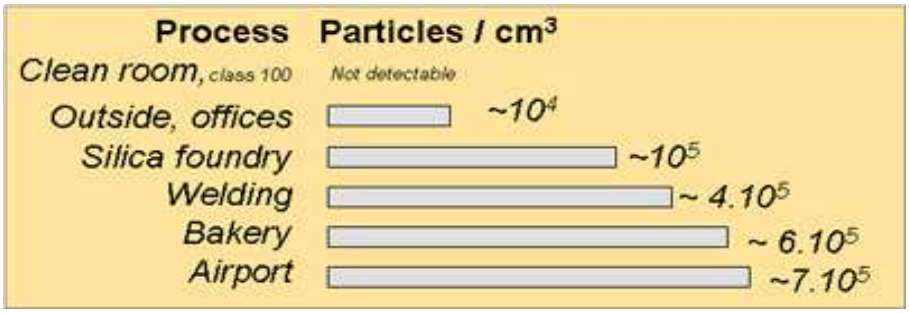
Different combustion processes emit incidental particles

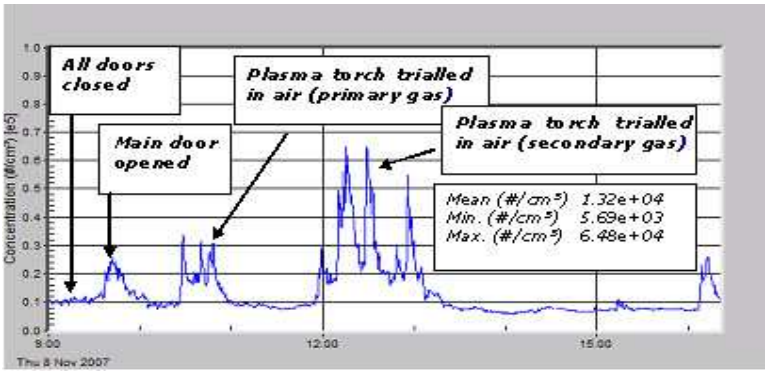


Engineered particles and tubes

What are the concentrations of already existing nanoaerosols without engineered nanoparticle production?

According to the activities the levels of total particle concentrations are very different.





In addition to the very high level of nanoparticle concentration, the background noise is often fluctuating with a large dynamic: a variation of one decade in a few minutes is possible.

← QNL source: Particle concentrations measured in production facility during plasma torch trials.

➔ The detection sensitivity of engineered nanoparticles is handicapped by the very high and fluctuating levels of already existing particles (10 000particles/mL > 10 nm). Therefore the detection limit of engineered particles in conventional environments is in the 10^5 – 10^6 particles/mL range!
➔ It is easier to detect engineered nanoparticles in controlled environments (clean room, portable filtering canopy, etc.)

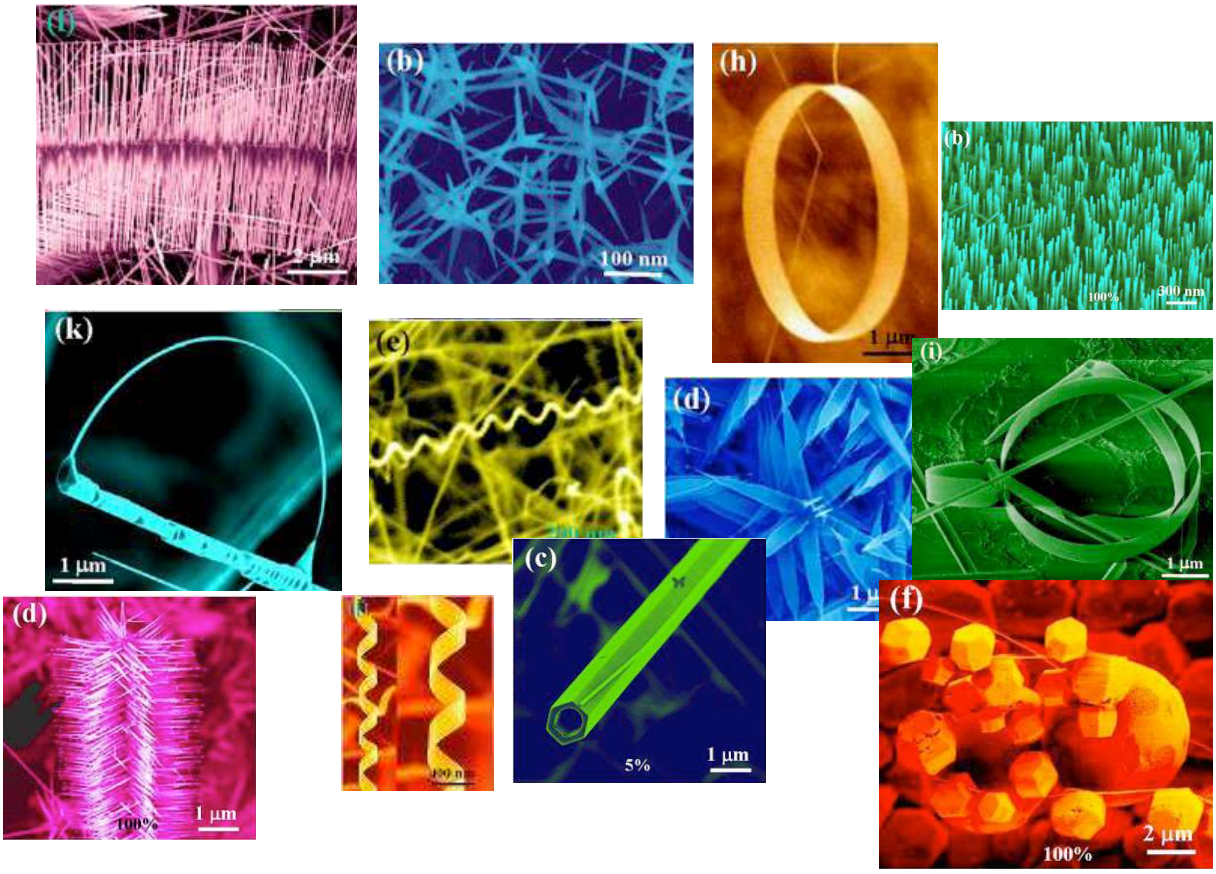
In order to be more sensitive, detection methods based on a specific property of the engineered nanoparticles have to be used: shape recognition, elemental analysis…. These approaches are not treated in this document.

What are the physical principles to measure nanoaerosols?

The principles of nanoparticle measurements in air are based on the measurement of very different physical units:

- *Total **mass***
- *Electrical charges carried by the particles, proportional to the particle **surface***
- *Light scattering which gives **the number** of particles*

The mass of nanoparticles is measured by microbalances, surface acoustic waves, etc.
The electrical charges can be measured with an electrometer.
The light scattering effect is used in optical counters and in Condensation Particle Counters, in which particles are previously grown in a supersaturated vapour.



Nano-ZnO: One chemistry, many shapes! Courtesy of Prof. Z.L. Wang, Georgia Tech

The results obtained in NanoSafe2 project show that:
➔ It is necessary to standardize the chosen measurement method according to the nanoparticle types to be measured
➔ It is often difficult to compare measurements performed with equipment using so different principles!

Are easy-to-use equipments for nanoaerosol measurements available?

A large number of equipments able to measure nanoaerosols are available on the market, the majority is designed for laboratory use, but newly developed equipments are easily transportable and easy to use.
Some typical equipments are shown below. At this moment the comparative tests performed do not allow advising one particular technology.

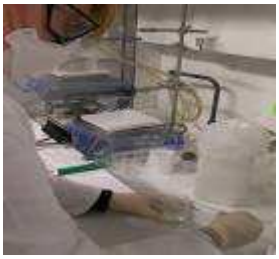
Portable Particle	***Condensation Counter***	***Scanning Particle***	***Mobility Sizer***	***Electrostatic Pressure***	***Low Impactor***
	*15 – 500 nm* *Maxi 5^5* *particles/mL* *Price: 7 k€*		*10 – 500 nm* *Maxi* *1^7particles/mL* *Caution: contains a radioactive source* *Price : 50 k€*		*6-10 000 nm* *Maxi10^8* *particles/mL* *Price: 75 k€*

Some particle detectors. The given prices are indicative only.

	***➔ A large variety of equipment can be already used to measure the nanoaerosols at workplaces.*** ***➔ Their use is quite simple, but the interpretation of the results requires a rigorous analysis to quantify the engineered nanoparticles. It is often necessary to take into account the background noise, the specific response of the measurement tool to the engineered nanoparticles of interest, the agglomeration kinetics, etc.***

Is it possible to evaluate the exposure to nanoparticles?

The evaluation of worker exposure to nanoparticles is a bit more complex than a rough particle measurement. This as the way of measurement has to be pertinent with the potential effects on the health: sampling representative of the respiratory area, sampling of the toxic form of the particles, use of the most appropriate metric in relation with biological effects, etc.
As both the route of entry and the mechanisms of health alteration are not very well known, we are not today able to measure, stricto sensus, the exposure to nanoparticles.



Preparation with Individual Protection Equipments (IPE)

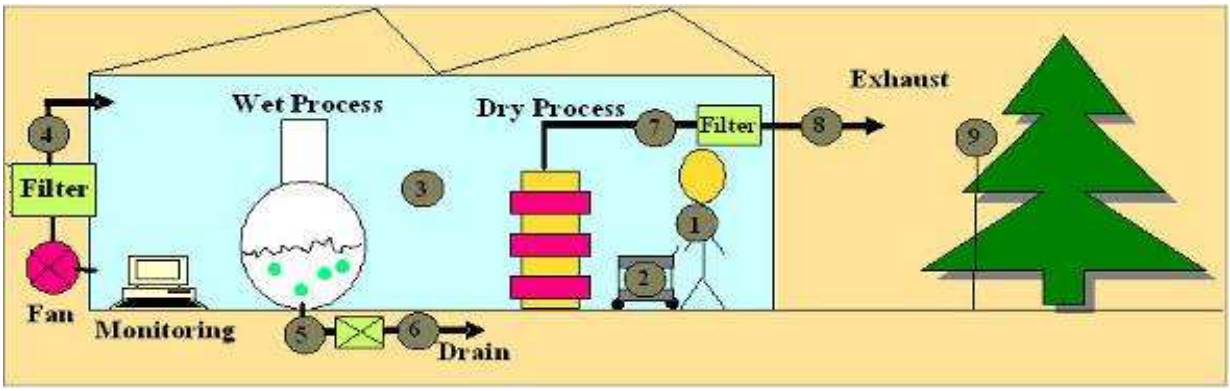
Wet "nano" process under sorbonne

Transfer after cooling (wet workshop)

	***➔ At this time, we can only characterize the exposure at our best. But even a not perfect nanoaerosol measurement may be of prime importance for the future occupational health issues of the workers.*** ***➔ It is also necessary to conserve the characterization data (shape, size, material, crystalline structure, electrical charges, etc.) of the handled nanoparticles to know in the future the hazard factors seen by the workers.***

Is it possible to continuously monitor the workplaces?

A continuous nanoparticle monitoring at workplaces would be of great interest for the early detection of leaks and for a more effective occupational hygiene. A device able to monitor nanoparticles at workplace require specific characteristics such as robustness, reliability, long maintenance interval, no clogging effect, etc.



Particle measurement at workplaces is a multidimensional task

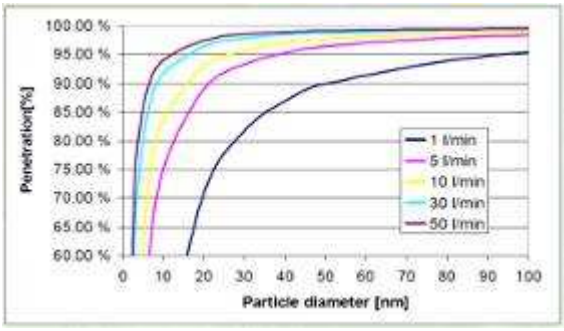
1- Personal sampling: Exposure integration or alarm for personal use. Daily to monthly analysis.
2- Mobile device: New operations, maintenance. Response time: 5 min
3- Work places: Monitoring tool for data collection and alarm. Response time: 5-30 min.
4- Efficiency of collective protective equipments. Qualification after new filter installation.
5-6 - Drain: Environment protection in the liquid drain. Spot measuring or continuous
7-8 - Extraction: Environment protection in the air. Spot measuring or continuous
9- External: 2 different needs ➢ *Monthly survey of the impact of the fabrication site on the environment (routine and accidental situations).* ➢ *Real time determination of the fluctuation of the external background noise in order to correct inside measurements*

Is it possible to sample nanoparticles at distance?

Multi-point sampling and analysis by one tool seems to be a convenient solution to multiply economically the sampling points, but what is the deposition rate of nanoparticles in the sampling pipes?

Calculation shows that deposition in pipes by diffusion is relatively slow for nanoparticles greater than 10 nm. If the pipes are electrically conductive, even a length of 20 m is acceptable as long as the flow rate is greater than 10L/min (whatever the pipe dimension). However, the losses need to be taken into account when analysing the measurement data.

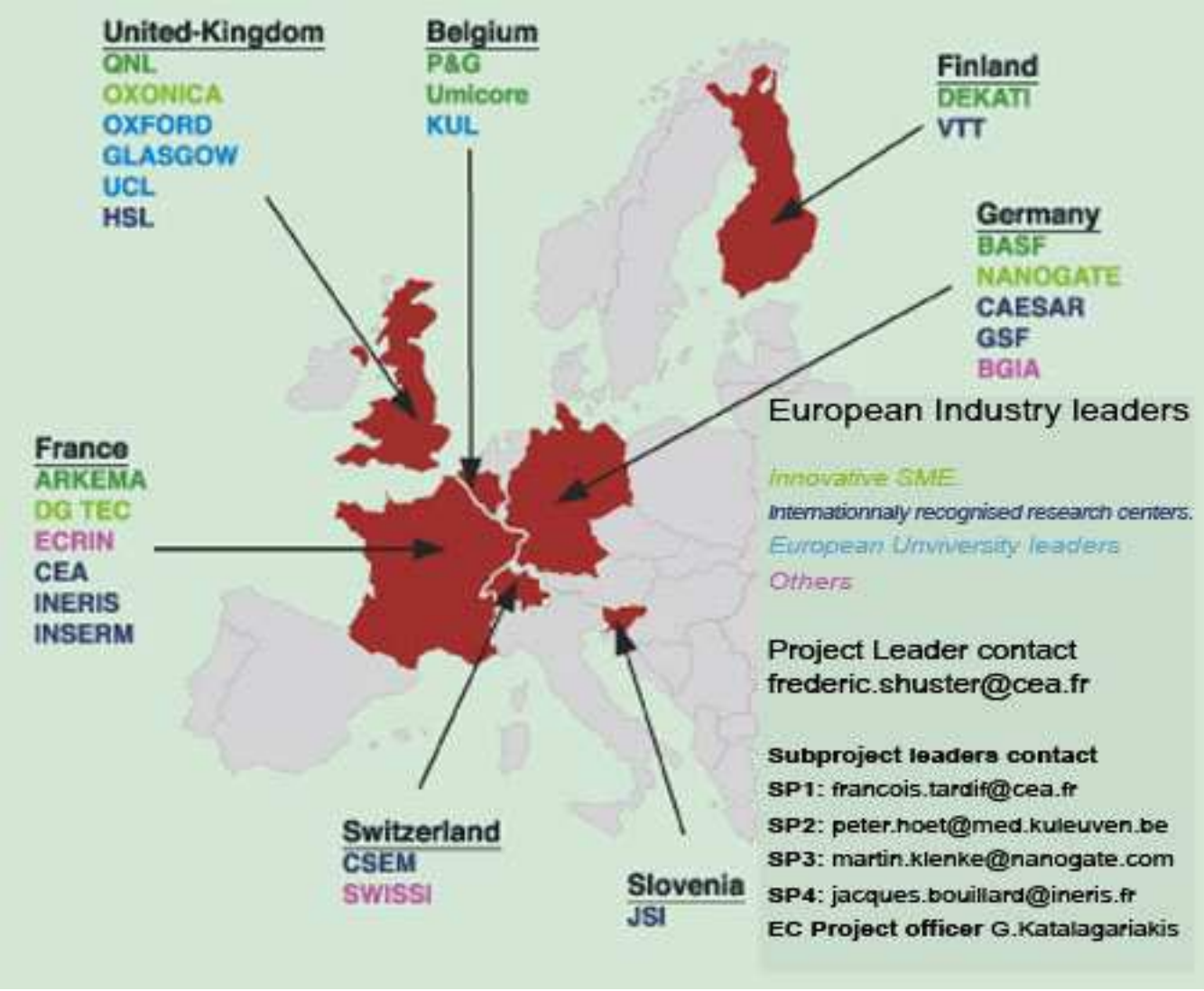
Penetration through a 20 m long pipe



➔ Unfortunately no equipment is commercially available today for long term monitoring.
Characteristics and performances of the future monitoring devices are being defined.
➔ It is possible to sample nanoparticles with an electrically conductive pipe of 20m as long as the flow rate is greater than 10L/min.

Nanosafe2 brings together twenty five partners from seven countries of the European Union, mainly small, medium and large enterprises and public research laboratories. The project is supported through the Sixth Framework Programme for Research and technological Development of the European Commission and addresses the thematic priority3.43.2-1: Hazard reduction in production plant and storage sites. The project started in April 2005 and will end in March 2009.
Nanosafe2 main objective is to develop risk assessment and management for secure industrial production of nanoparticles. It focuses on four areas: detection and characterisation techniques, Health hazard assessment, development of secure industrial production systems and safe applications, societal and environmental aspects.

Partners



http://www.nanosafe.org

Engineered aerosol and exposure evaluation – DR-115/121- 2008
Nanosafe-June 2008

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Measurement principles

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Easy-to-use equipments

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Monitoring and Sampling

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