Physico-chemicals (particles and fibers) Assessment

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Sampling

- Sampling on filter
  - Different geometries

    Particle size fraction, sampling rate (1-10 l/min)
  - Type of filter

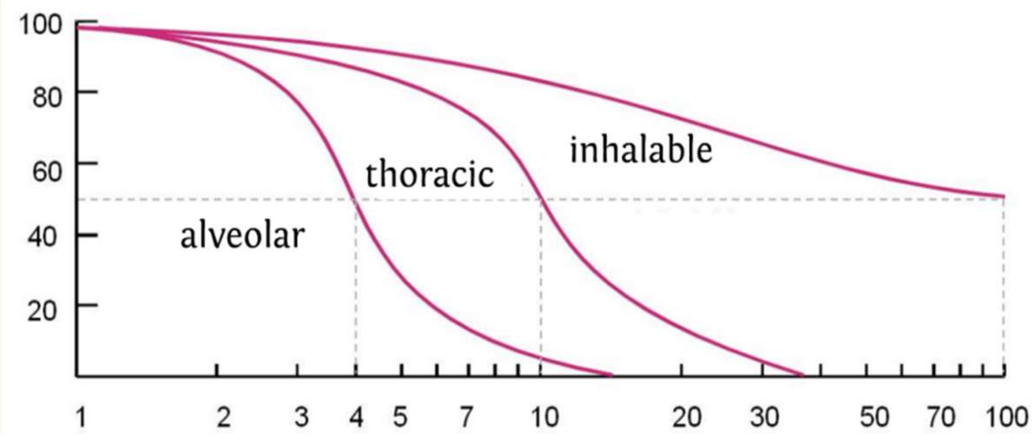
    cellulose ester, teflon, fiberglass, quartz...
- Special features
  - Individual measure
  - Easy to implement
  - Dosimetry, Allows for subsequent analysis

    gravimetry, atomic absorption, GC-ionic, microscopy...

Sampling (particles)

– Selection sampler

- The right granulometric fraction
- Aerodynamic diameter
- Mass fraction

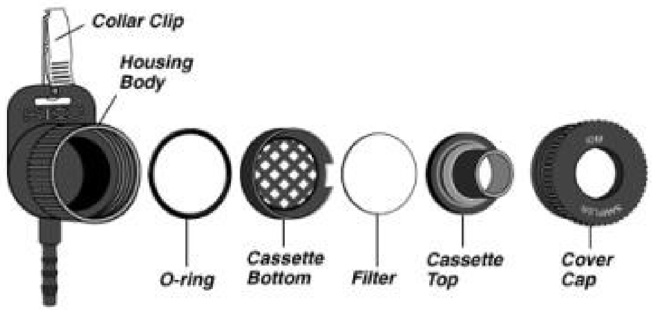


*For a number of pollutants, the measurement metric is a **Proxy** of the relevant toxicological measure.*

Sampling of inhalable dusts

IOM head

- sampling of the inhalable fraction
- 2.0 l/min
- personal sampling
- physicochemical analysis
- gravimetric analysis

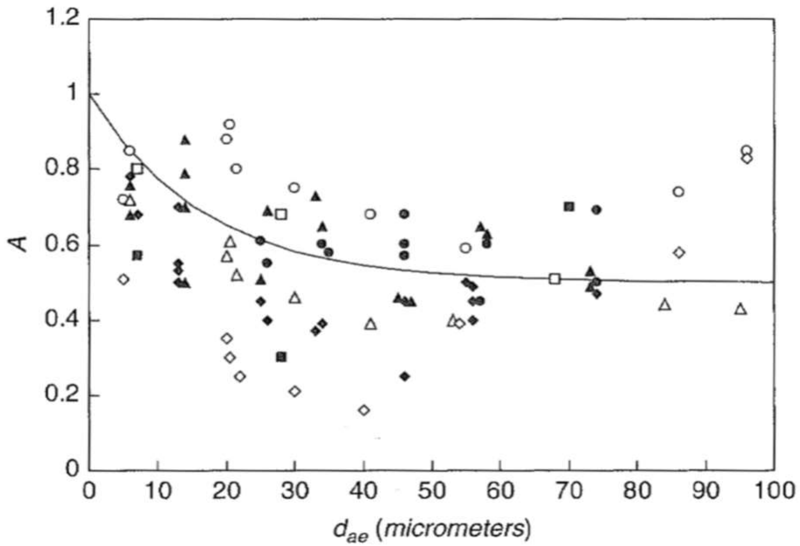


Sampling of inhalable dusts

Relative efficiency of the IOM sampling head

- close to the inhalation curve

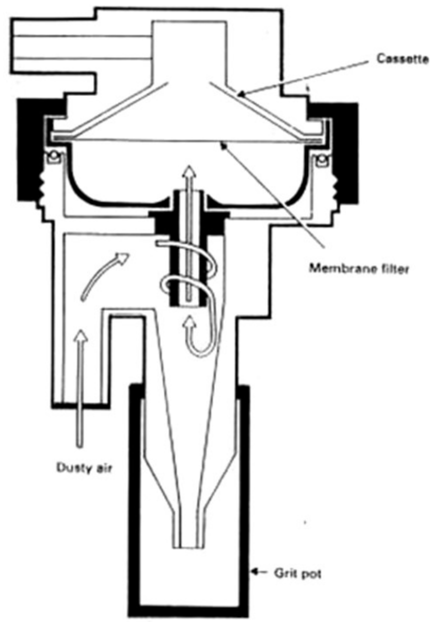
- variability due to ambient air crurent



Respiratory dust sampling

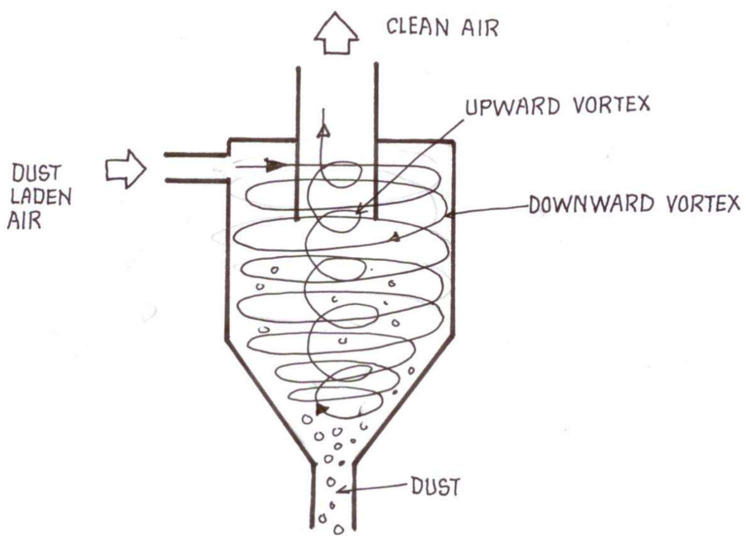
Cyclone

- sampling of the alveolar fraction
- inertial dust separation
- ~2.0 l/min
- personal sampling
- physicochemical analysis
- gravimetric analysis



Respiratory dust sampling

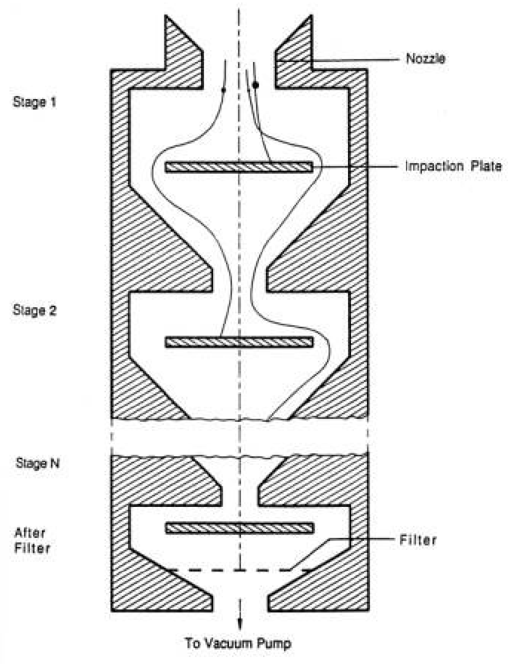
Separation by sedimentation and impaction



The rotation is initiated by the geometry of the inlet.

- the large particles are pushed out of the vortex by the centripetal force
- performance depending on the geometry of the cyclone

Impaction sampling



Schematic Diagram of Cascade Impactor.

Key parameters:

- flow width
- spacing between plates
- geometry of the openings
- air speed

Impaction in **descending** order of particle size

Example:

Personal environmental monitor (PEM) SKC

Case study

Assembling aluminum frames

The presence of a quasi-permanent cloud has generated complaints and concerns among the personnel of a metal construction workshop. The workshop is dedicated to the work on aluminum frames. Most of the work consists in assembling the frames, though welding and flame cutting are also carried out in the hall (about twenty people are working in the hall).

Question (3.2a)

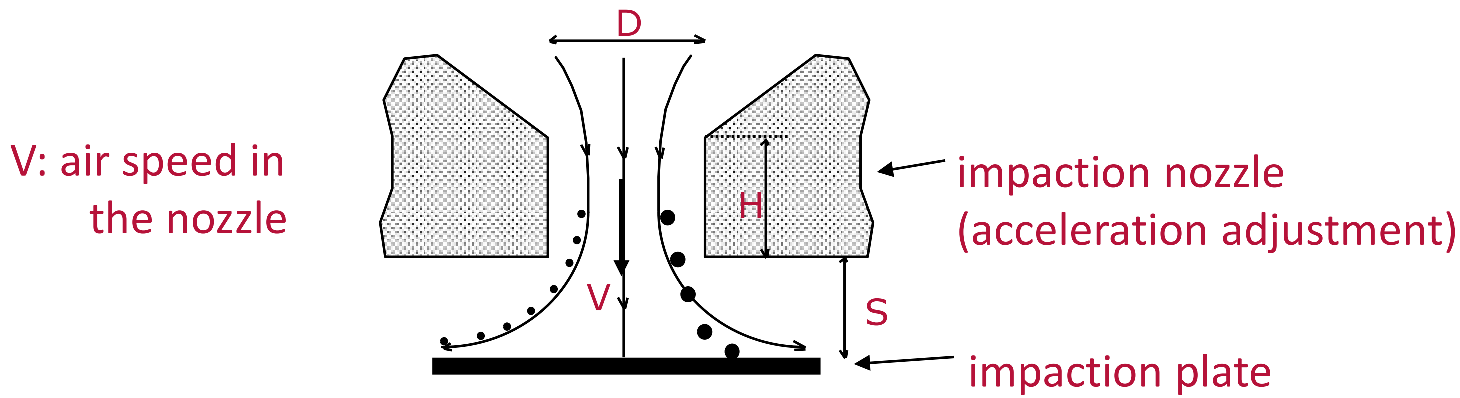
Which measurement strategy (and for what reason) would you prioritize to assess the situation?

Case-study solution

Question 3.2.a

- The information given by the company suggests that the emission of dust is related to thermal processes (welding, cutting) and that this is mainly due to the working of aluminum (which must be verified during a preliminary visit). Thermal processes are emitters of fine dust.
- Aluminum and aluminum oxide dusts are considered as inert dusts from the toxicological point of view (without short term effects, nor specific effect). The OEL-8h values applicable 3 mg/m^3 in respirable dust or 10 mg/m^3 in inhalable dust:
  - 8-hour sampling (individual sampling) using a cyclone and a sampling filter is preferred. In the absence of other pollutants, the filters can then be weighed, without resorting to speciation.
  - Use a 3x3 sampling strategy, alternatively 15 measurements should be taken to ensure, with relative confidence (95%), that at least 1 of the samples taken is in the most exposed situations.
  - in the absence of other sources of pollutants, a direct reading (nephelometry) will allow the identification of the most exposed activities in order to advise the company on targeted prevention measures.

Inertial impaction



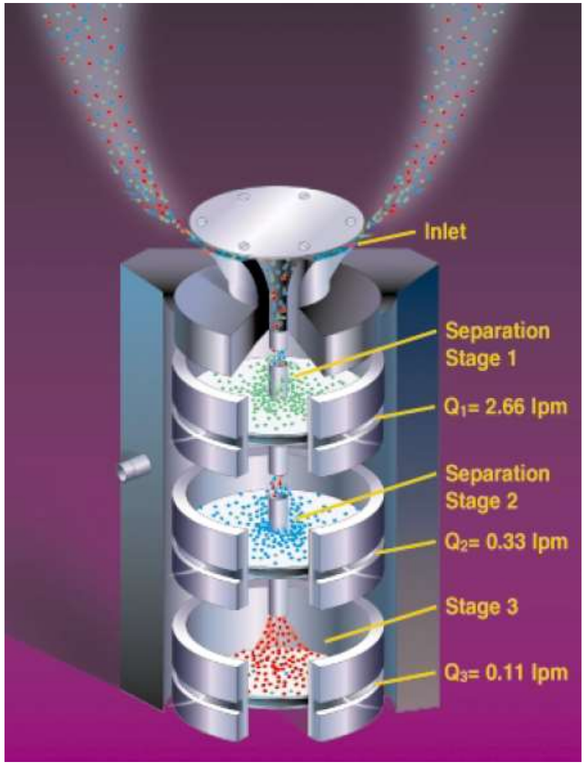
- The air velocity (V), the particle size and the obstacle dimension (D, S, H) are the parameters that determine whether a particle impacts or not.

- The impaction parameters are related to the geometry and the aerosol.

Virtual impactors

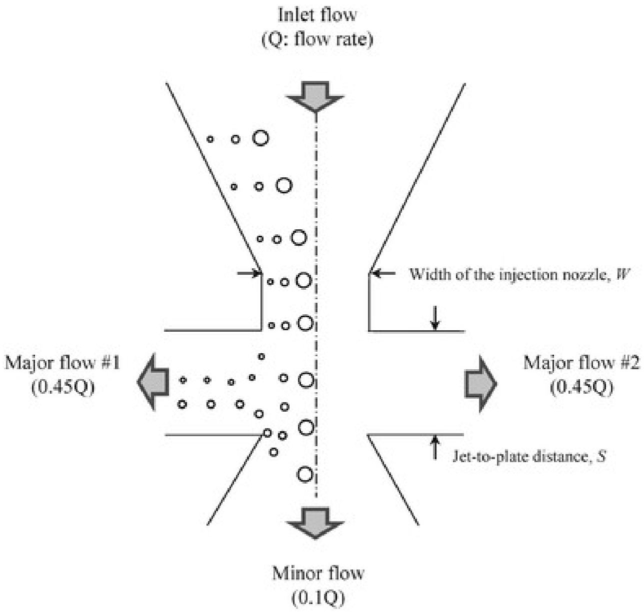
- Cascade impactor
  - sampling of several particle size fractions
  - dust separation by impaction

  - personal sampling
  - physicochemical analysis
  - gravimetric analysis



Virtual impactors

Same principle as the classic impactor, but the collection surface is replaced by an active zone.



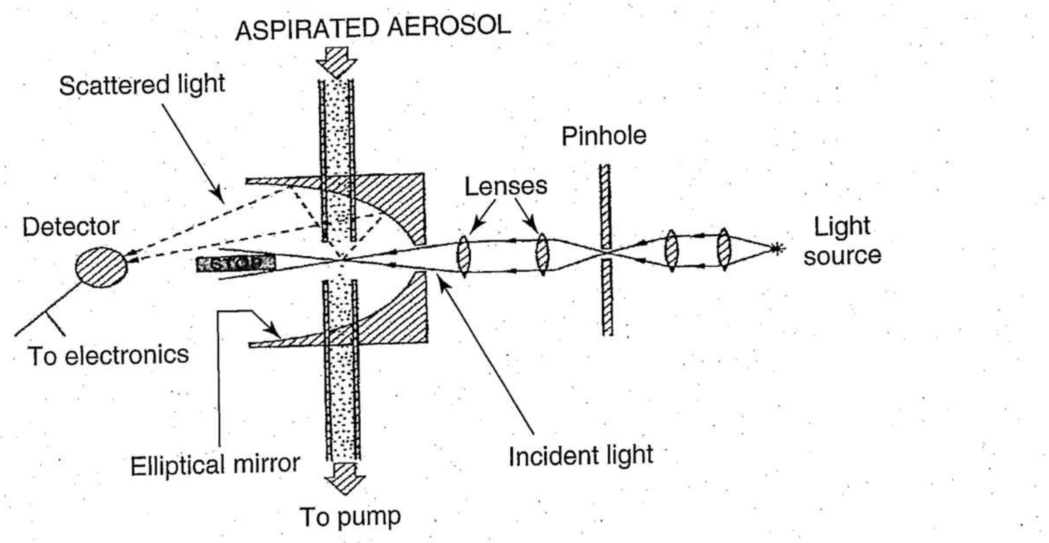
Impaction in order of **increasing** particle size

Continuous measurements

- Nephelometric detector
  - With or without sampling head
- Special features
  - Instantaneous results, continuous measurements
  - Allows for subsequent analysis
  - Pre-calibration

Continuous measurements

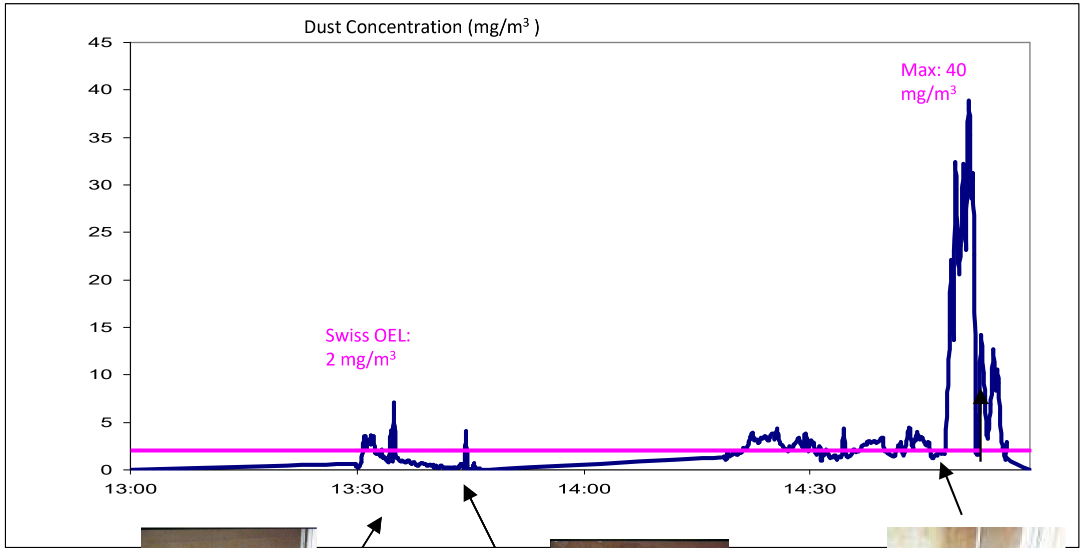
- Nephelometric measurement
  - Particle concentration
  - Particle size fractions

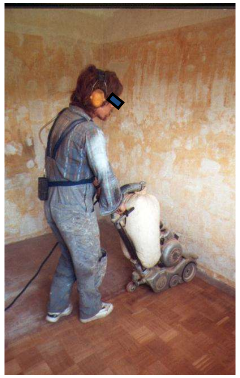


  - Other techniques

    Specific surface, particle counter...

Example, sanding dust

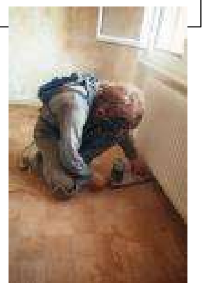




Sanding (standing)

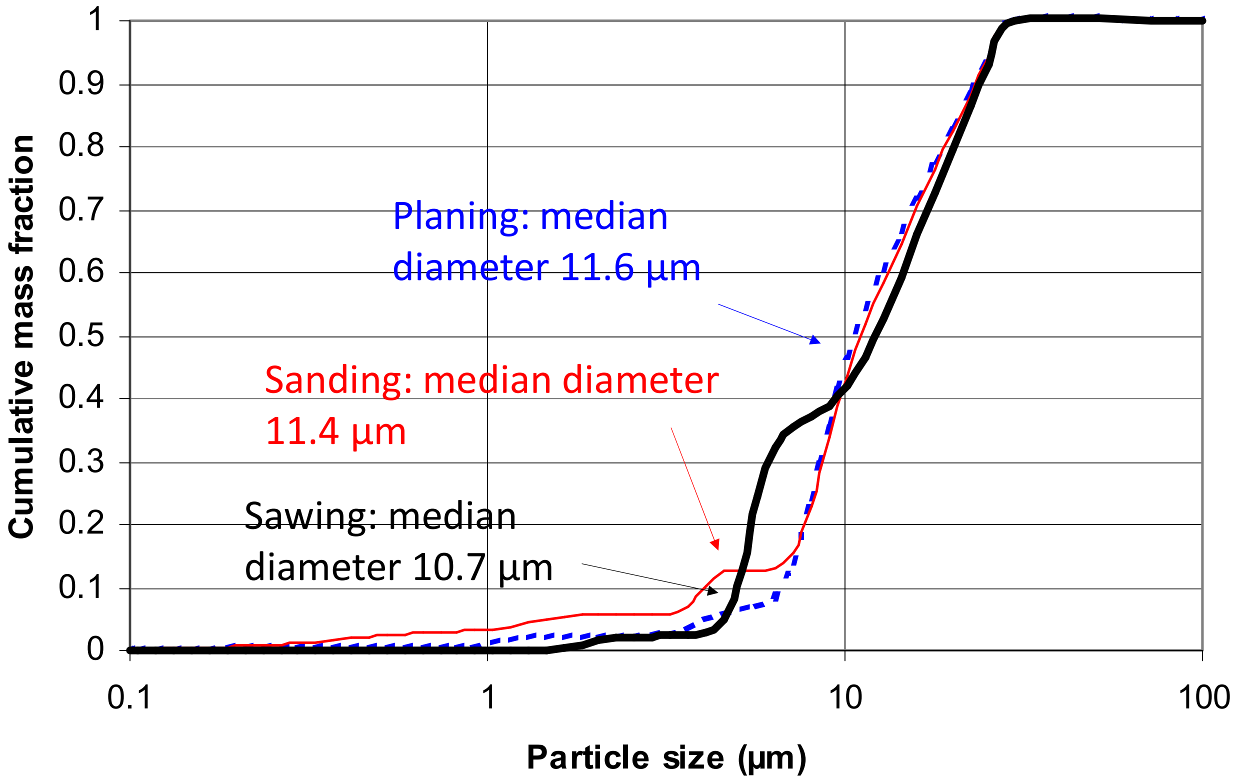
vacuum cleaner

scan



Manual sanding (squatting)

Example: wood dust



Case study

Assembling aluminum frames

A workshop is dedicated to the work on aluminum frames. Most of the work consists in assembling the frames, though welding and flame cutting are also carried out in the hall.

Question (3.2a)

The limit of quantification for aluminum by flame atomic absorption is about 2.5 µg. Calculate the minimum sampling time required to be able to assess exposure (relatively to the OEL of 3 mg/m^3 (a)) with a personal filter sample at a flow rate of 2 l/min.

Case-study solution

Question 3.2.a

- Taking into account the sample variability, you should be able to measure concentrations <1/10 of the OEL (0.3 mg/m³)
- The amount collected on the filter m is

$$m = Conc.\left[\frac{mg}{m^3}\right] \cdot \mathrm{Vol.}\,[\mathrm{m}^3] = Conc\left[\frac{mg}{m^3}\right] \cdot Time[min] \cdot \mathrm{Flow\ rate}\left[\frac{m^3}{min}\right]$$

- The time required is > 4 min
- The measurement limit is not an issue, however longer sampling time are required in order to get a representative sampling (typically a few hours)

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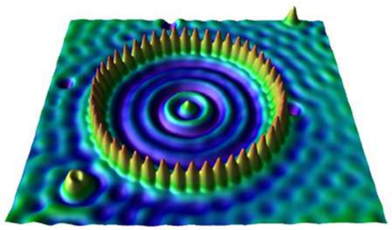
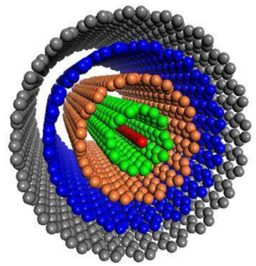
Physico-chemicals (particles and fibers)

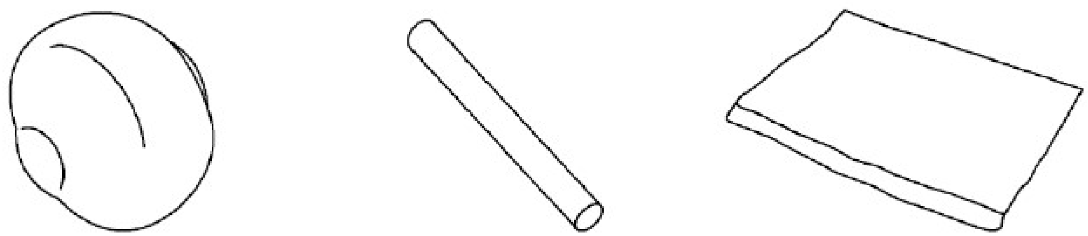
Nanomaterials





Typology

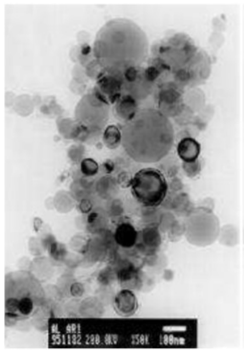
- ➪ materials in the order of magnitude of viruses
- ➪ sometimes used for several decades
- ➪ ISO/TS definition of nanoparticles (September 26, 2008)



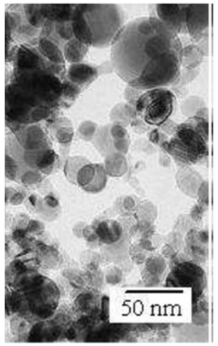
a) particle b) rod c) plate

Typology

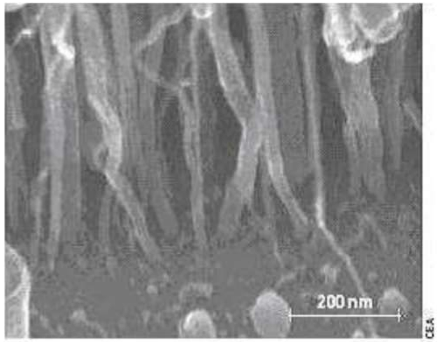
- **Nanomaterials:** materials consisting of manufactured nanoparticles with a size of less than 100 nm



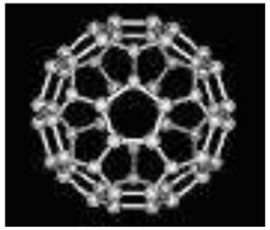
Aluminium nanoparticles (Champion and Bigot, 1998)



Copper nanoparticles (CNRS)



Carbon nanotubes (CEA)



Fullerene (CNRS)

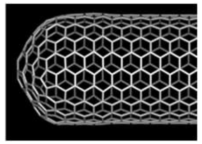
Properties

- Description of the main families of nanomaterials

New properties: mechanical, electrical, optical, thermal, magnetic, chemical, barrier, surface, etc.

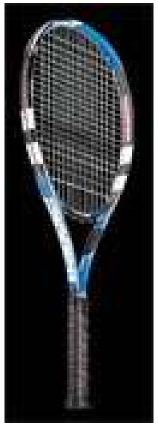
Examples:

- Gold: Gold nanoparticles have particular catalytic properties, especially for CO.



- Carbon nanotubes: the structure of carbon nanotubes is one hundred times stronger and six times lighter than steel, very good thermal conductivity, electrical conductor or semiconductor, etc.

Areas of use



Carbon nanotubes: improving the performance of rackets, manufacturing ultra-resistant textiles, etc.

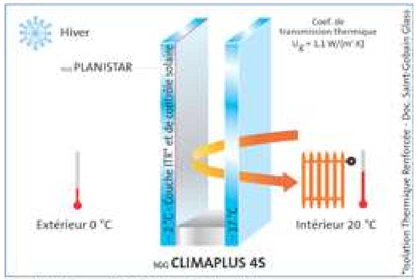
Silicon oxide: anti-graffiti paint (anti-adhesive function)

Silica: improving tire performance

Areas of use

TiO_2 : solar cream (improvement of anti-UV properties)
Self-cleaning glazing

Silver : anti-bacterial cushions
Anti-cold glazing



Double vitrage ITR et de contrôle solaire.*
Plus de confort en hiver et en été, moins de dépenses de chauffage.

Production methods

- Bottom up" methods
  - *construction of structures atom by atom or molecule by molecule*

    Examples: metals, oxides, carbon nanotubes, fullerenes, etc.
  - *production 10^5 to/year*

- Top Down" methods
  - *production from successive fractions of a microstructured material*

    Concerns all types of materials (ceramics, metals, polymers, semiconductors)
  - *production 10^{2-3} to/year*

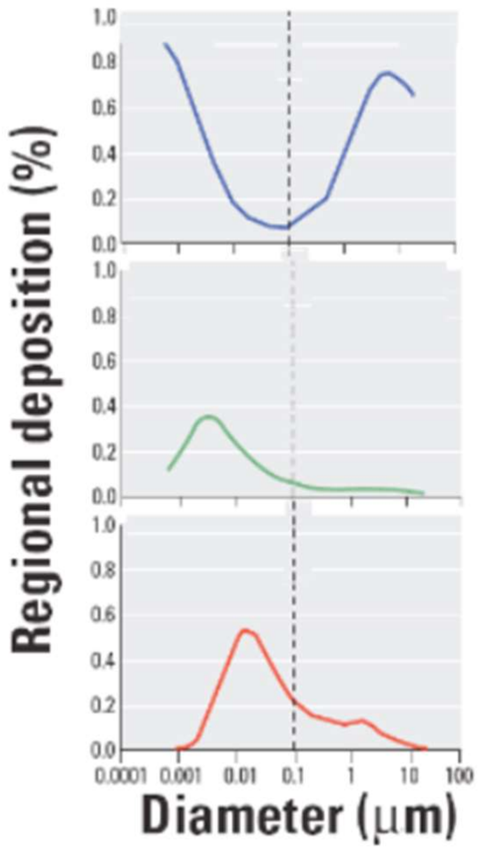
The manufacturing process determines the type of impurities found in the final material

Toxicity to humans

- Toxicology of ultrafine particles
- Toxicology of manufactured nanoparticles

Potential factors: size, air and surface reactivity, chemical composition, shape, number, agglomeration capacity, presence of process-related impurities, etc.

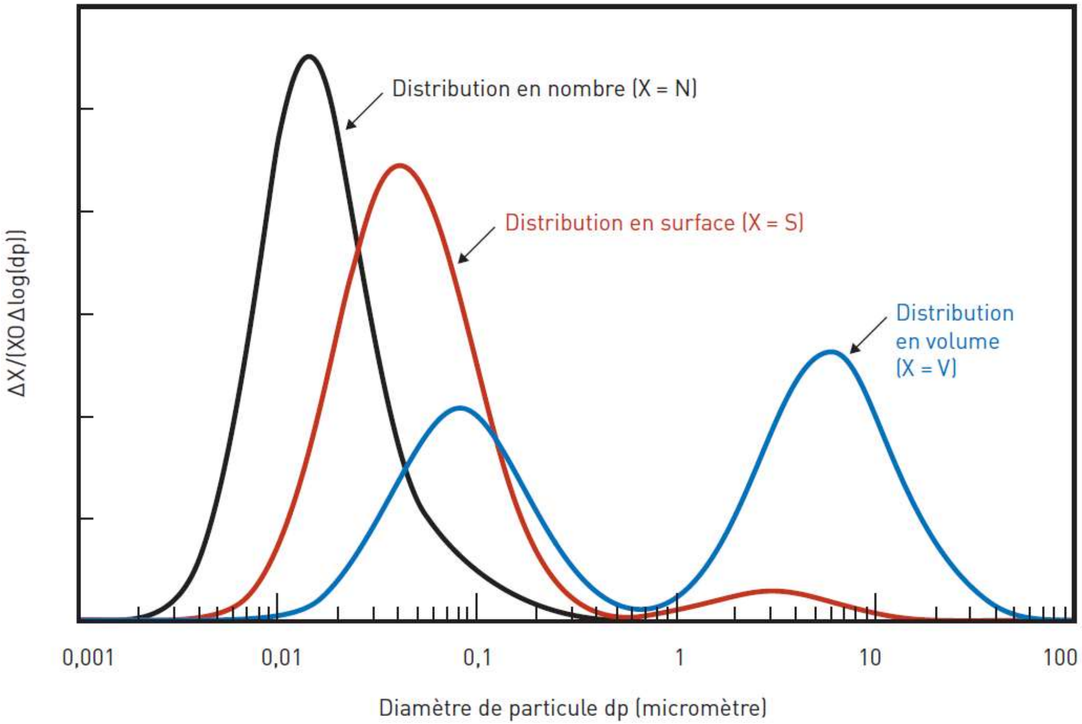
Routes of exposure: inhalation (predominant), skin contact and ingestion



Nanoparticle deposition sites
(Oberdörster et al., 2005)

Fine and ultrafine particles (UF)

Almost all aerosols are expressed in mass concentrations (exception: asbestos, radioactive aerosols)

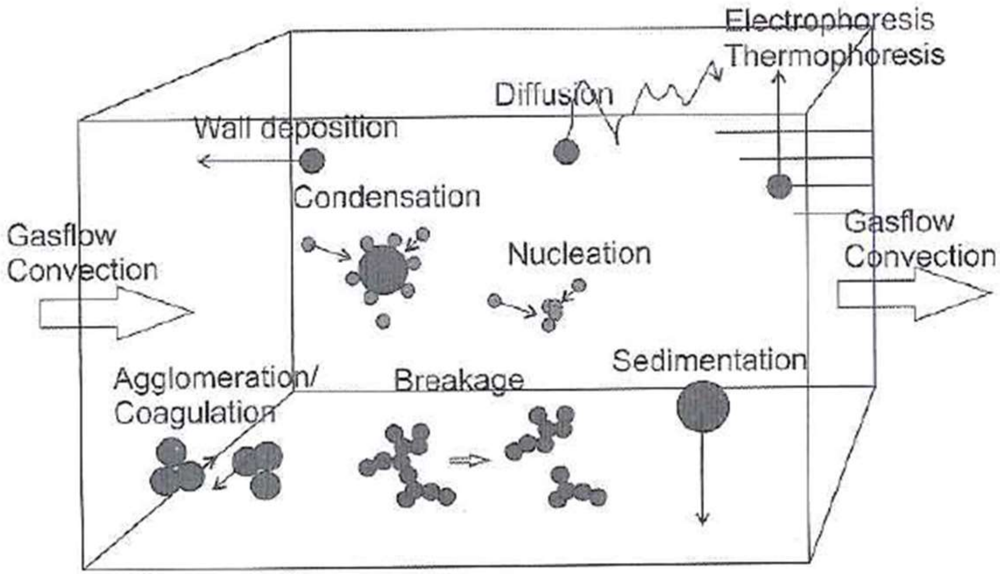


UF represent almost always a very small mass fraction of the aerosol

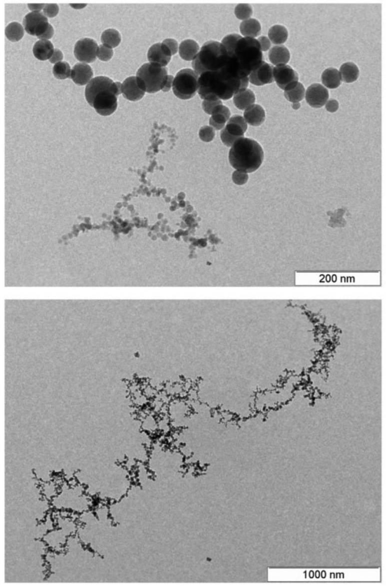
INRS. ND 228-199-05.Note documentaire. Ultrafine particles and occupational health - Sources and characterization of exposure. 2005

Fine and ultrafine particles (UF)

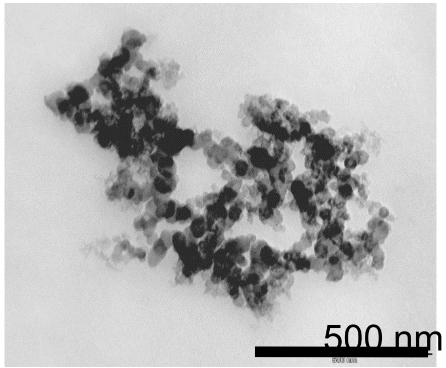
Behavior of ultrafine particles



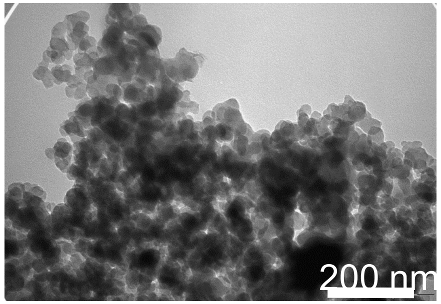
Examples, nucleation & condensation



Stainless steel welding



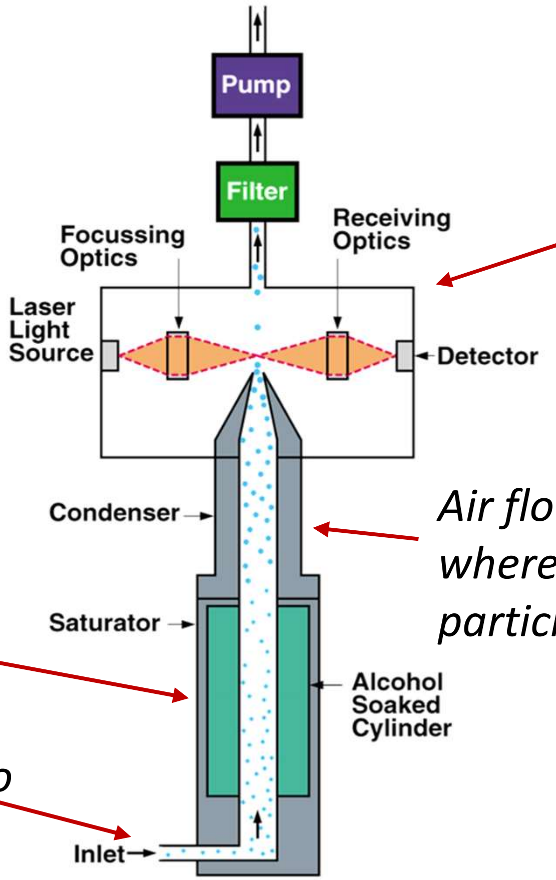
Diesel particle



Hexane soot

Measurement of UF particles

CPC Number Concentration



Particles scatter laser light which is detected by a photo-detector

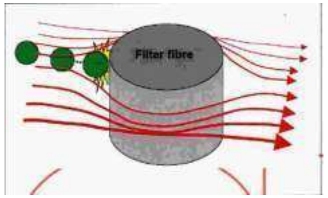
Air flows through a condenser where vapor condenses onto the particles

Particles pass through a saturator chamber mixing with vapor

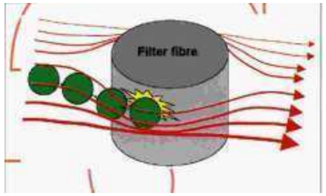
Particles drawn into instrument

Prevention of exposure

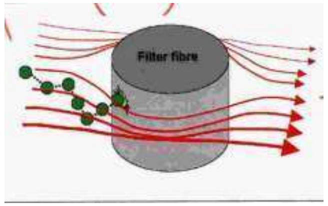
- Efficiency of "classic" filtration
  - Inertial deposition

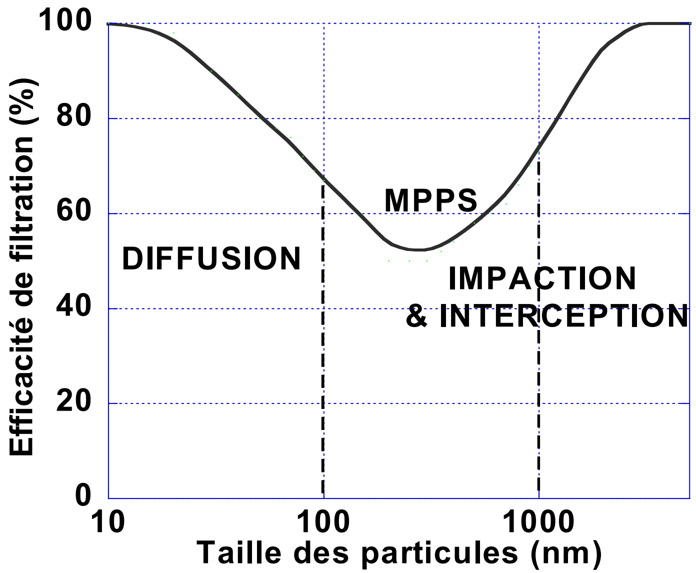


  - Interception



  - Diffusion





Case study

Surprise spraying

During the winter of 2002-2003, the toxzentrum (reference toxicology center) in Zurich noted an upsurge in hospitalizations (about 200 cases) related to acute respiratory problems following the use of waterproofing sprays.

A quick investigation showed that all the incriminated products (several brands) had in common the same waterproofing agent (a fluorinated resin) and that the German company which put it on the market had just changed its composition.
The producing company supplied many wholesalers in Europe with the mother product.
They added it to preparations and repackaged it for different uses (waterproofing spray for leather, for textile...)

Question (3.2c)

Although the product is widely distributed, the "epidemic" of respiratory problems has affected only a fraction of the countries concerned. Can you hypothesize why this is so?

Case-study solution

Question 3.2.c

- The increase in cases may not have been identified (e.g. due to the lack of a sufficient alert structure).
- Differences in the formulations used could have led to undesirable chemical reactions (unlikely as this has happened with products of different formulation and the polymer used is in principle chemically stable).
- The differences in packaging (geometry of the spray nozzles differing from one country to another) generated granulometric modifications of the aerosol. Only the finest aerosols are likely to reach the alveoli and generate a toxic effect.