# NANOTRANSPORT -

## *Transport of Engineered Nanoparticle (ENP) Aerosols in the Workplace Environment and its Consequences*

**Recommendations to European Commission regarding**

- *Test aerosols for nano-toxicology studies*
- *Testing of filters and protective equipment in the workplace*
- *Metrology of nano-aerosols*
- *Open questions: Research priorities*

# Essential constraints of the study

- *Study limited to airborne NP („nano-aerosols“)*
- *Study concentrated only on the aspect of NP size as a key metric,*
- *the evolution of „size“ with time spent in the aerosol phase („history“) between source and receptor (i.e. target organism), and its implications for measurement, testing, abatement, hazard evaluation.*

# Key conclusions from the study

- *Nano-aerosols evolve considerably with time: their average size increases while concentration decreases*
- *Natural background aerosols are effective scavengers for NP*
- *Thus, NP will (usually) be physically/chemically present in size classes other than the one in which they were originally emitted.*
- *Time scale for size evolution depends on concentration - on the order of a few min.*
- *Filtration efficiency for „true“ NP not an issue - focus on filter performance at MPPS.*

# *Test aerosols for nano-toxicology studies*

- *„Aged“ NP aerosols and primary sources of (unagglomerated) NP equally relevant for risk assessment in workplace environments*
- ***Scenario I:** direct exposure to primary NP aerosol*
  - only for people standing **very close to source**
- ***Scenario II:** indirect exposure via inhalation of aged/attached NP*
  - Includes secondary NP aerosols due to re-suspension from surfaces, which are always agglomerated

# *Test aerosols for nano-toxicology studies (2)*

***Characteristics** of „aged“ nano-aerosols:*

- Typical size range for auto-agglomeration: (20) - 200 nm
- Typical size range for attachment to background aerosol: 0.1 < d <1 µm
  (number concentration in the coarse aerosol mode usually too low)
- „Aging“ in the aerosol phase by Brownian collisions
  usually leads to relatively weak agglomerate structures
- ***Consequences:***
  - Strongly recommend generating test particles via aerosol phase (incl. aging, scavenging), rather than instillation of powders or liquid dispersions
  - Control of particle structure (as well as surface chemistry) critical for toxicological studies (not only size), because influence of agglomerate strength, structure, etc. on toxicity not well understood
  - Control of structure, “history” of particles much better done via aerosol processes involve aerosol technologists in these studies!

# *Testing of filters & protective equipment in the workplace*

- *Filtration efficiency for "true" NP (2-10 nm) generally sufficient*
- *Need to consider effective protection against scavenged NP*
- *Most critical size range around filter MPPS: 80 - 200 nm*
- *Effective testing equipment and aerosol generation in this range most important (SMPS+CPC)*
- *Physical/chemical composition of test aerosol not relevant for filtration, only equivalent size*

# *Metrology of nano-aerosols in workplace*

- *Aged NP aerosols not recognizable by a specific particle size range (e.g. "<20 nm")*
- *Not sufficient to look for NP in the "nano size range" where they may have originally been generated/emitted*
- *Not sufficient to assess workplace situation via simple size distribution measurements - additional ENP concentrations are often marginal*
- *... unless an analytical technique is highly selective*
- *Alternative: aerosol dynamic models to predict ENP hazard in spec. scenarios*
  - characterize emission sources (strength, primary size range)
  - identify release mechanisms for each specific ENP
- *Need capability for species-specific tracing of scavenged/agglom. NP*
- *Need to validate (existing!) aerosol dynamic models for workplace scenarios*
- *Need technique for measuring agglomerate strength*

# Open questions & Research priorities

- *Characterize **release mechanisms and sources** of hazardous ENP types (source strength, size range, particle structure) for specific scenarios*
- *Develop **aerosol generators** for relevant classes of release mechanisms and species for use in toxicological studies*
  - incl. controlled/variable NP structure, surface chemistry
- *Validate & refine **aerosol dynamic models** for predicting ENP evolution between source & receptor for specific scenarios*
- *Develop **species-specific real-time** **detection methods***
  - real-time chemical detection of attached NP aerosols
  - agglomerate strength
  - Surface composition
  - ...
- *Involve more aerosol technologists and their tools in toxicology studies!*