Metrology and metrics for exposure assessment throughout the life cycle

ECHA Topical Scientific Workshop
Regulatory Challenges in Risk Assessment of Nanomaterials
Helsinki, 23 - 24 October 2014
Release – Exposure - Hazard?

Release

- No release
- Release with no link to exposure

Exposure

- No exposure
- Exposure with no link to hazard

Hazard

- No hazard potential
- Hazard with no link to exposure

Risk

Diagram illustrating the relationship between release, exposure, hazard, and risk.
- Metrics for exposure
- Tiered approach for exposure assessment
- Release
Which metric?

- Mass?
- Number?
- Surface?
- Reactivity?
Which metric to be used in exposure assessment?

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Tiered Approach for exposure assessment

OECD Guidance Document

Harmonized tiered approach to measure and assess the potential exposure to airborne emissions of engineered nano-objects (<100nm) and their agglomerates and aggregates (>/= 100nm) at workplaces

Michele L. Ostraat, Thomas A.J. Kuhlbusch, Christof Asbach
Release / Exposure scenarios along the life cycle

- Production
- Processing
- Use phase
- End of Life

Releases:
- Soil
- Air
- Water

Processes:
- Re
- lea
- se
Similar release mechanisms for different life cycle stages possible

- Heat stress – processing / use / end of use phases
- Abrasion – processing / use / end of use phases
- Wash off – use / end of use phases
- ............

➢ Separation into release mechanisms?
### Release processes / mechanisms

**mechanical processes**
- sanding
- milling
- mechanical shock
- drilling
- cutting
- wash off
- sawing
- dustiness
- ..........

**thermal processes**
- thermal stress
- combustion
- incineration
- .....  

**chemical processes**
- reactive liquids / gases
- dissolution
- ...... 

**mixed processes**
- sanding (mechanical and thermal processes)
- wash out (dissolution and wash off)
- weathering (degradation and abrasion)
- ......

**Based on Kuhlbusch et al., 2014**
Release process - Sanding

Sanding is a process describing the dynamic friction between two surfaces.

Life Cycle Stage: Manufacturing (e.g. surface treatment, grid blasting), Consumer Use (e.g. surface treatment, …)

Process properties
- Sandpaper grid size
- Contact force
- Sanding speed
- Sanding duration
- Heat production
- Other properties

Material properties
- Properties of NanoObjects
- Properties of matrix material (rigidity,…)
- Matrix material, NanoObjects in matrix material, free NanoObjects?
Improved sanding test stand – set-up

Flow chamber

Sanding unit

Air inlet

Sampling positions

for MARINA round robin test
CEA, BASF, IUTA
Defining parameters!

Extract MARINA

- Sandpaper size: 32 mm diameter
- Sandpaper grid size: 80
- Speed between paper & material: 1.8 m/s
- Weight: 1 kg (+/- 5%)
- Size of sample disc: 11 cm diameter x 1.0 cm thickness,
- Disc time of contact: depending on material (~2-4 min)
- Air flow: 21 l/min
- ........
Set up

CEA

Weight
Flow splitter
Abrasive paper
Sample

BASF

IUTA
Average of four experiments:

→ Observed variability between experiments of mostly up to ± 50% observed within one laboratory
Release processes / mechanisms

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Based on Kuhlbusch et al., 2014
Spatial distribution of exposure

Number
Concentration

Mean Particle Size

Prediction of possible release and exposure
OECD Guidance Document

Harmonized tiered approach to measure and assess the potential exposure to airborne emissions of engineered nano-objects (<100nm) and their agglomerates and aggregates (>/= 100nm) at workplaces

Michele L. Ostraat, Thomas A.J. Kuhlbusch, Christof Asbach
Exposure Assessment

Tier 2a: Screening

Simultaneous or consecutive measurement of background concentration
Tier 2b: Monitoring

Simultaneous or consecutive measurement of background concentration
Field measurements according to the Tiered Approach

- Measurements were carried out at the IUTA pilot plant
Monitoring

- Monitors (miniDiSCs) were mounted under the ceiling (mesh floor) above potential leaks as well as in the closest ventilation inlet.

Bagging
Later moved to 1st floor for tube cleaning

Reactor

Ventilation
Results from monitoring (miniDiSC)

- 13.11. 08:45 – 10:30
- 13.11. 12:15 – 16:00
- 14.11. 11:10 – 12:45
Results from monitoring (miniDiSC) and background (FMPS)

- 13.11. 08:45 – 10:30
- 13.11. 12:15 – 16:00
- 14.11. 11:10 – 12:45
Results from monitoring (miniDiSC)

- Start of work day
- Heating up of reactor
- Nanoparticle production
- Bagging
- „Artificial“ leak
- Tube Cleaning
- Background measurement
- Background measurement
Artificial Leak

- It was expected that no particles would be emitted from pilot plant.
- Therefore, a "leak" was simulated by dispersing harmless particles (PSL and NaCl) into the workplace to test the measurement strategy.

- 12:09 – 13:14: 143 nm PSL; 16,000 #/cm³
- 13:14 – 14:10: Atomizer off
- 14:10 – 15:12: NaCl, mode 195 nm, 3.6*10⁶ #/cm³

"Leak"
Evaluation based on reactor miniDiSC

Background before PSL: 32,794 ± 1120 #/cm³
Concentration during PSL: 37,437 ± 2025 #/cm³
Background after PSL/before NaCl: 40,897 ± 1420 #/cm³
Concentration during NaCl: 46,435 ± 4270 #/cm³
Background after NaCl: 40,244 ± 1549 #/cm³

![Graph showing number concentration over time with markers for ventilation, reactor, bagging, and NaCl addition.]

- PSL 143 nm
- Atomizer off
- NaCl

- Background before PSL: 32,794 ± 1120 #/cm³
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## Evaluation based on reactor miniDiSC

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### Average background
- **PSL**: 36,845 ± 4331 #/cm³
- **NaCl**: 40,556 ± 1493 #/cm³

### Net Emission
- **NaCl**: 5,879 #/cm³ >3*σ ➔ Significant

⇒ Not significant
Tier 3: „Expert Assessment“

Simultaneous or consecutive measurement of background concentration/size distribution
Which metric to be used in exposure assessment?

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Assessment of Individual Exposure to manufactured nanomaterials by means of personal monitors and samplers

Funded in the framework of the SIINN Era-Net program in EU-FP7

Start: 01. Juni 2013
Duration: 36 Months
Total funding: 1.439.395 €
Coordinator: Christof Asbach
Thanks to C. Asbach, J. Meyer, H. Kaminski...........

and

to you for your attention