FROM RESEARCH TO INDUSTRY

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Stationary instrument vs personal devices to assess occupational exposure to engineered nanomaterials in pilot plants

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November 7th, 2018

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PLATE-FORME NANO SÉCURITÉ

NANOCOMPOSITES FOR THE CONSTRUCTION INDUSTRY
NANOLEAP PROJECT

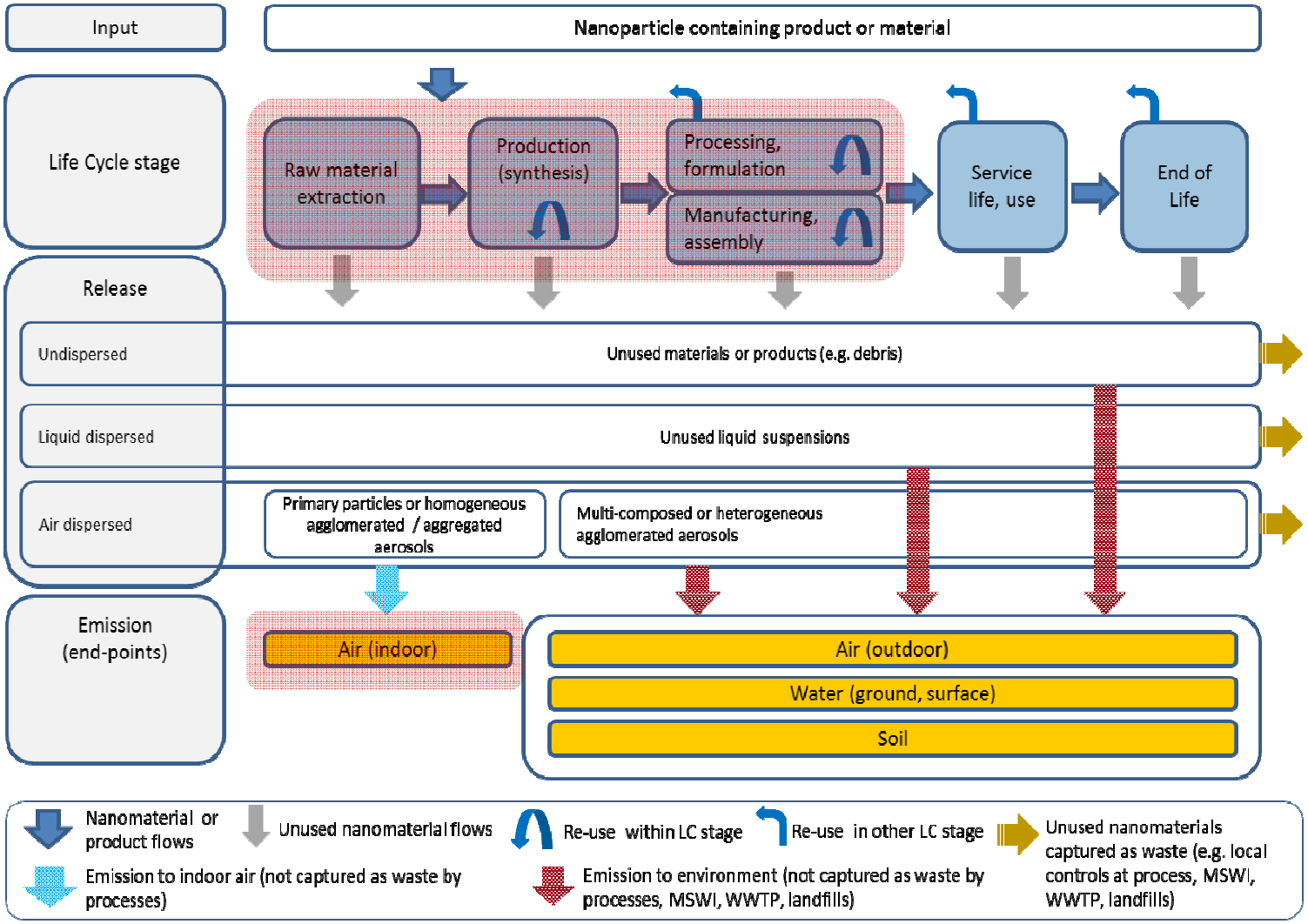
NANOLEAP project brings together a **European Network of pilot production facilities focused on scaling up nanocomposite processing methods** to enable the leap from laboratory-scale developments to industrial production.

This Network of pilot plants, properly equipped and skilled to incorporate nanoparticles or nanoadditives in the process, will effectively support the research activities of the industrial stakeholders across the European Construction value chain, **specially manufacturing SMEs,** which are not able to assume the technological risk and associated investments for developing new technologies . **The goal of this infrastructure is enable the progress of the product to next steps of technology deployment such as installation of industrial lines and enter in the commercialization stage.**

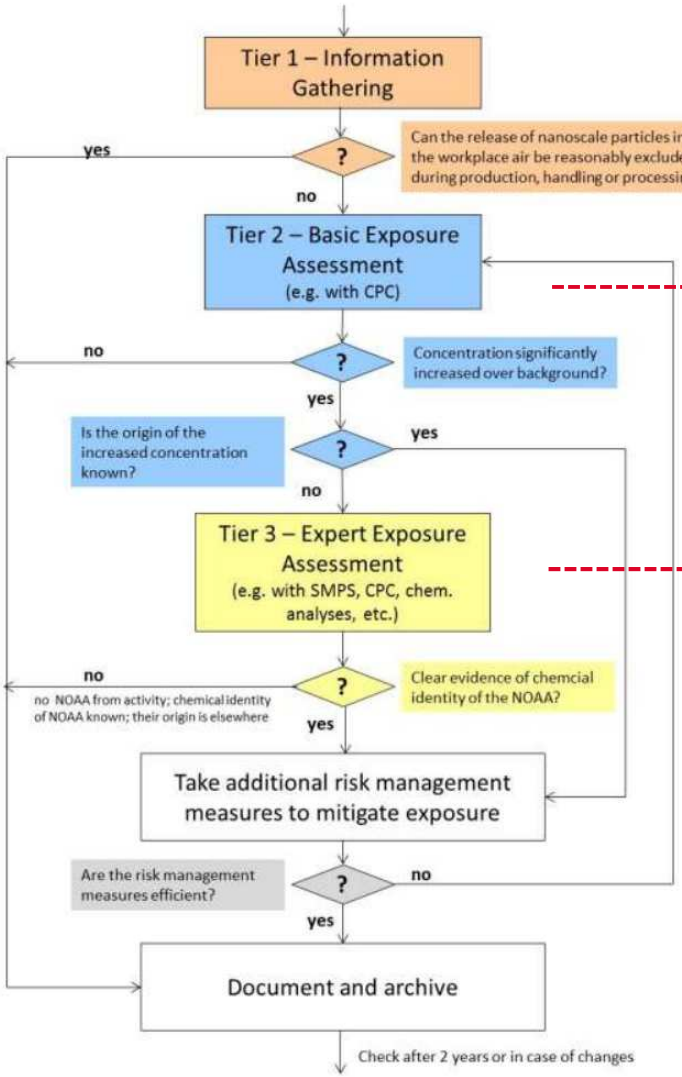
OVERALL STRATEGY FOLLOWED TO MITIGATE RISKS

- Our goal is to ensure the **lowest possible exposure** to nanomaterials for workers, consumers and the environment
- An initial release of material is a prerequisite to exposure

FRAMEWORK WITH NANOMATERIAL RELEASES AND EMISSIONS ALONG DIFFERENT LIFE CYCLE STAGES



STRATEGY TO CONDUCT EXPOSURE ASSESSMENT: OECD HARMONIZED TIERED APPROACH



OECD report, ENV/JM/MONO(2015)19

Particlever sampler[1] (NanoBadge)

Handheld CPC TSI 3007

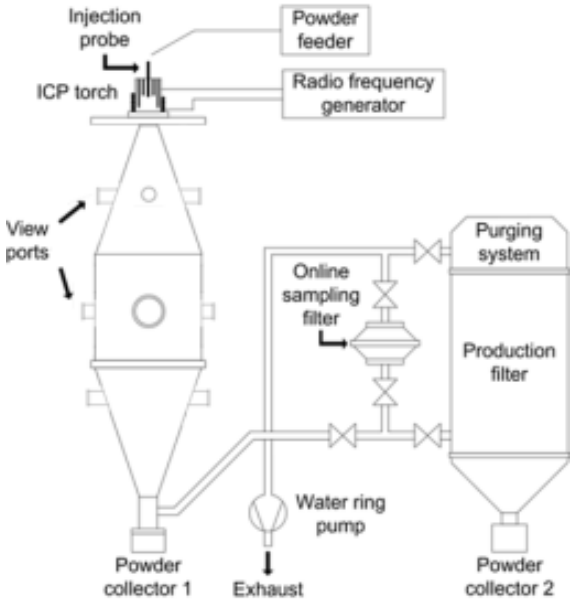
DiSCmini[2]

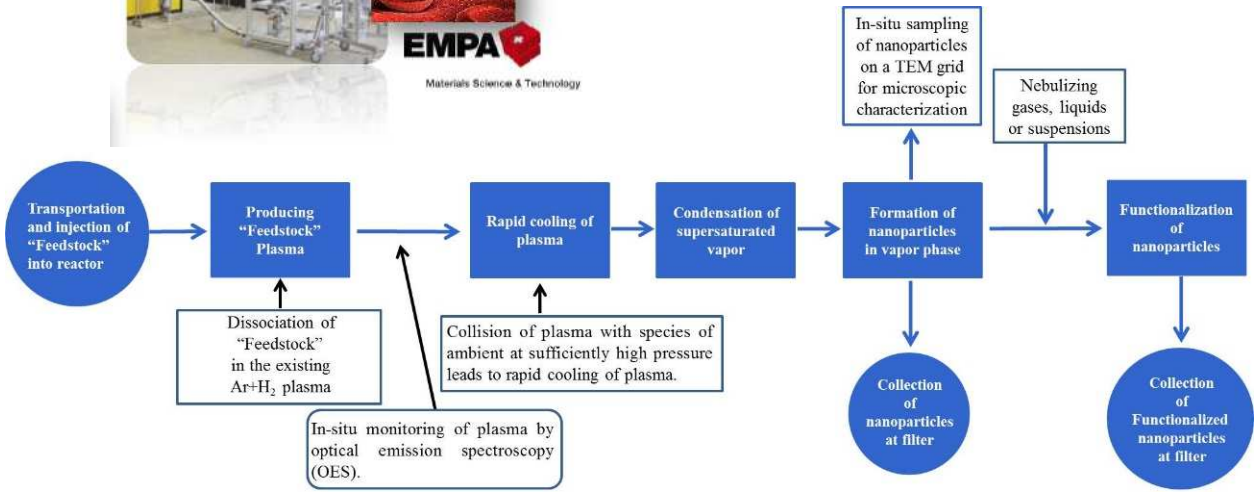
CEA's equipped mobile cart (CPCs, NSAM, FMPS, ELPI …)

NANOINDEX

[1] *Journal of Physics: Conference Series, 2017, 838, 012006*
[2] *Science of the Total Environment, 2017, 603-604, 793-806*
Science of the Total Environment, 2017, 605-606, 929-945

CASE STUDY: NANOLEAP PILOT LINE 1
INDUCTIVELY COUPLED THERMAL PLASMA PILOT LINE





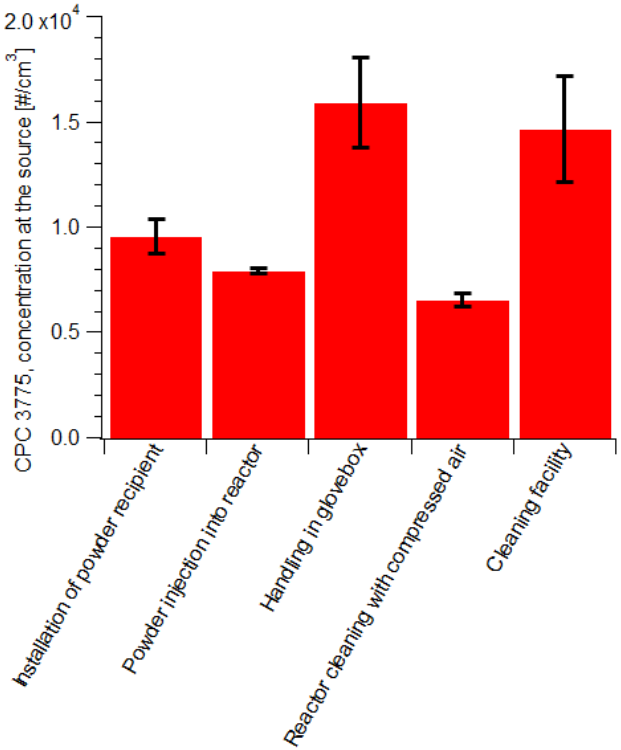
Start – End	Activities
10h00 – 11h00	Raw material handling, transferring and weighing
11h00 – 11h30	Powder injection into reactor and operation of the sealed and depressurized IPC reactor
11h40 – 12h20	Disconnection of the recovering filter unit from the production line Transfer of the filter unit to the glove box and operation of the glove box
14h00 – 16h05	Cleaning and maintenance operation on the ICP reactor
16h05 – 16h40	Cleaning of the filter in the dedicated booth

CASE STUDY: NANOLEAP PILOT LINE 1
LIST OF INSTRUMENTS

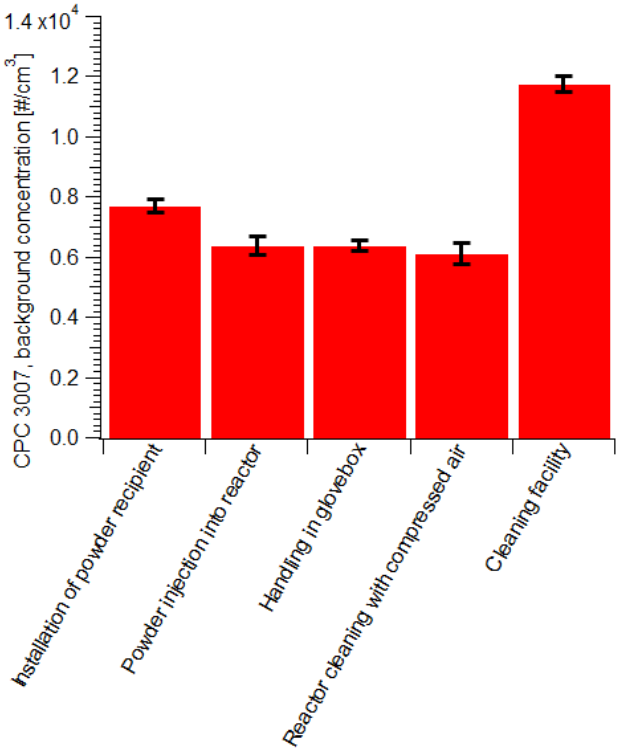
Instrument	Parameter	Time resolution	Location
CPC, TSI 3775 (condensation particle counter)	Particle number concentration, 4 nm – 3 µm	1 sec	As close as possible to the source
CPC, TSI 3007 (condensation particle counter)	Particle number concentration, 10 – 1000 nm	1 sec	Background, and various locations as close as possible to the source
FMPS, TSI 3091 (fast mobility particle sizer)	Particle number size distribution, 5.6 - 560 nm	1 sec	As close as possible to the source
APS, TSI 3321 (aerodynamic particle sizer)	Particle number size distribution, 0.5 – 20 µm	Set to 20 sec	As close as possible to the source
NSAM, TSI 3550 (nanoparticle surface area monitor)	human lung-deposited surface area (LDSA) of particles corresponding to tracheobronchial and alveolar regions, 10 – 1000 nm	Set to 10 sec	As close as possible to the source
2 DiSCmini	Particle number concentration, LDSA, 20 – 400 nm	1 sec	Source, worker personal breathing zone and background
3 Particlever Samplers (NanoBadge)	Elemental mass concentration averaged over the total sampling time	/	Source, worker personal breathing zone and background

CASE STUDY: NANOLEAP PILOT LINE 1

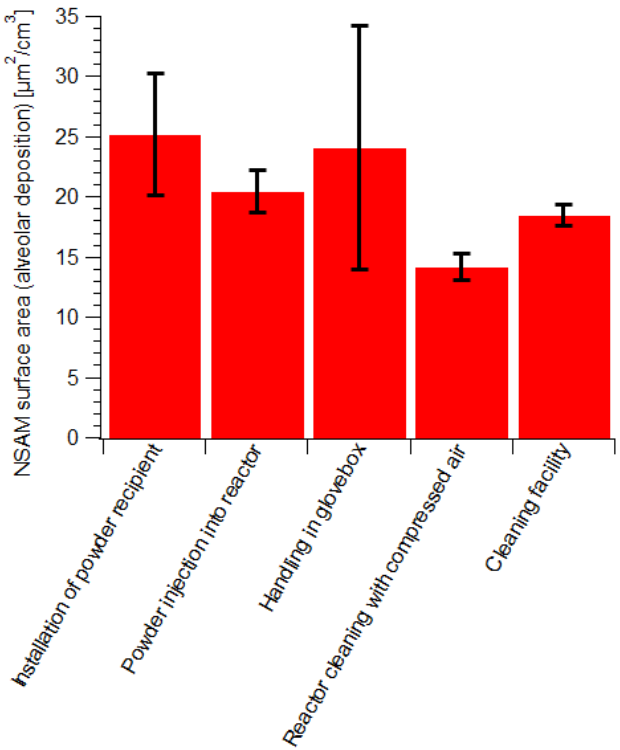
Particle number concentration Source



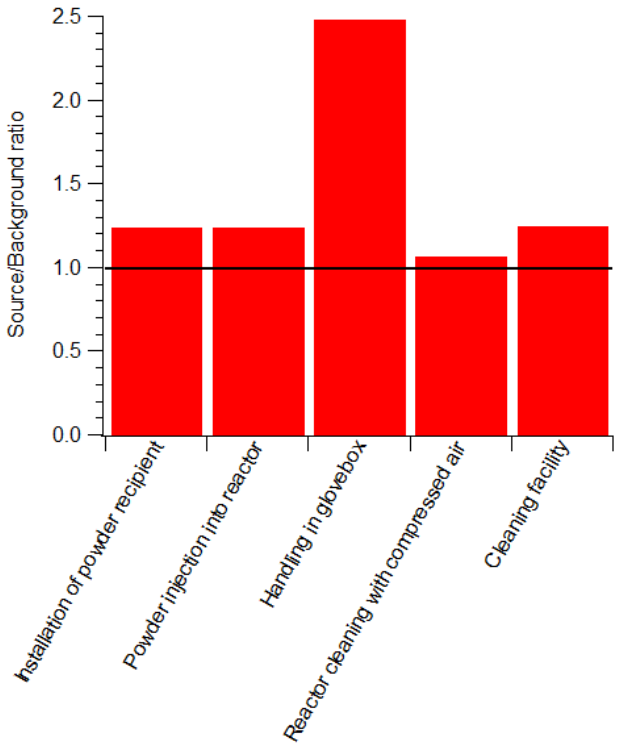
Particle number concentration Background

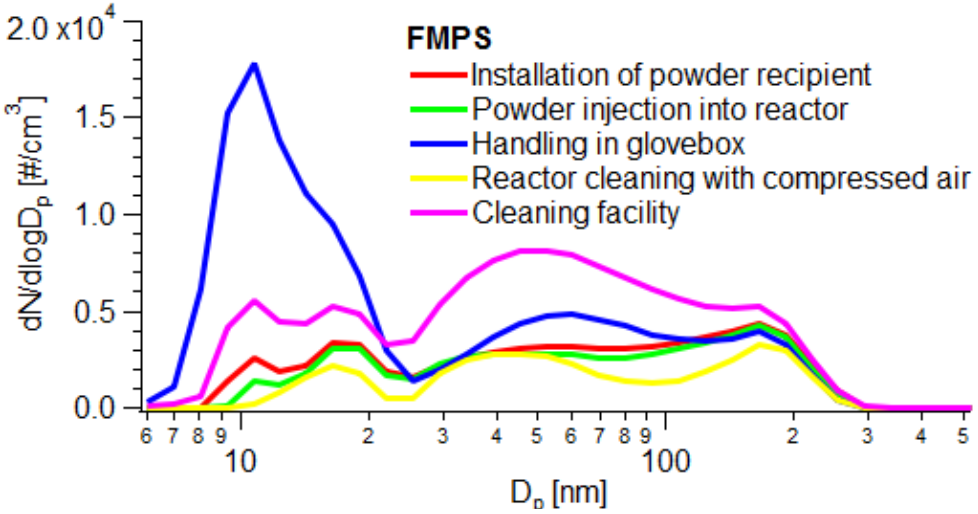


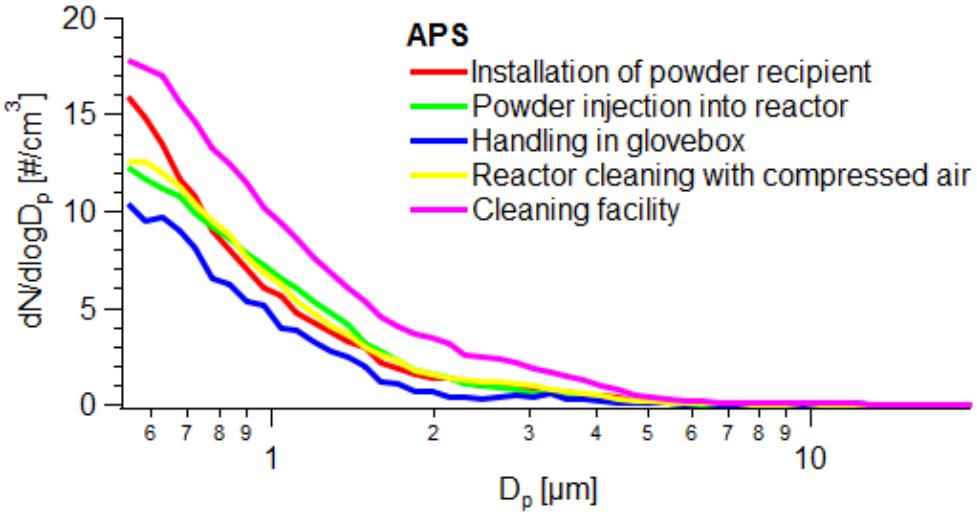
LDSA concentration Source



CASE STUDY: NANOLEAP PILOT LINE 1

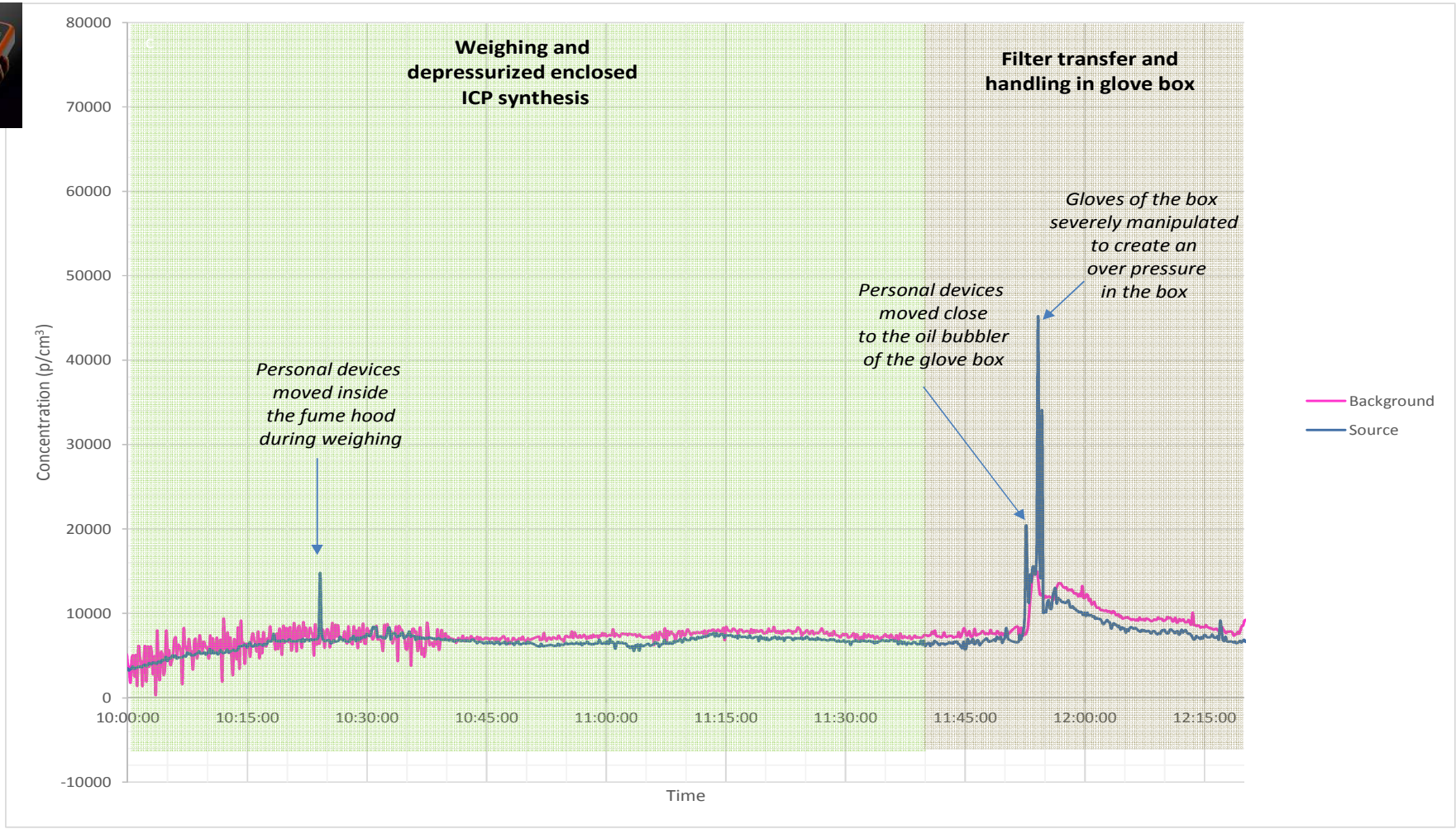






The increase of the particle concentration during the handling in the glovebox could be due to nucleated oil droplets.

CASE STUDY: NANOLEAP PILOT LINE 1



CASE STUDY: NANOLEAP PILOT LINE 1

Personal sampling – NANOBADGE
XRF analysis (quantification of Si)

Background Measurement

A254

[Si] = 0.9 µg/m³

Time

10:00

11:40

12:20

14:00

16:05

16:40

Source

A255 = 2.4 µg/m³

A256 = 5.2 µg/m³

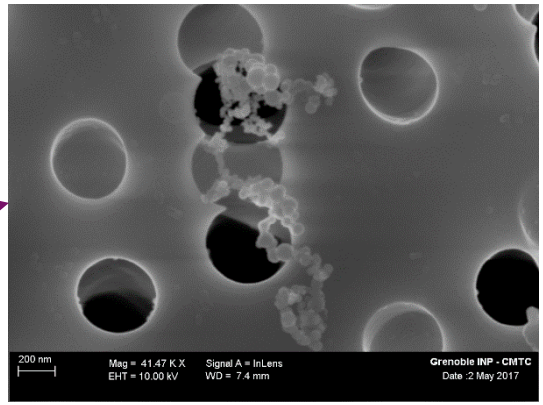
A257 = 3.5 µg/m³

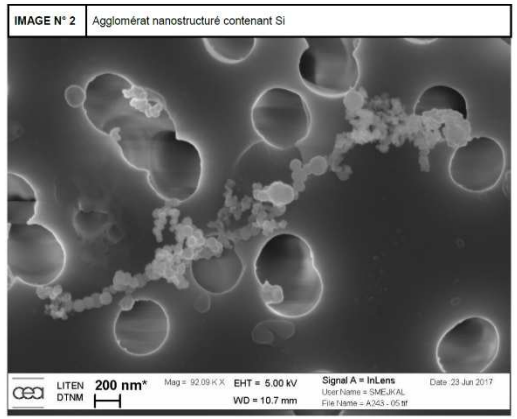
A262 = 8.9 µg/m³

Operator A

A243

[Si] = 1.3 µg/m³





A manual counting of particles of interest from 60 different SEM field views on the sample A254 was performed. A total of 61 objects were counted over a 500 nm to 2 µm size range which gives a concentration of particle of interest of about 9.5 objects per cm³ of ambient air.

KEY FINDINGS FROM THE FIELD MEASUREMENTS CONDUCTED IN EUROPE

Harmonization of the measurement strategy, promotion and implementation of good practices along with effective risk management measures:

- Measurement strategy should be **adapted** to pilot lines and small businesses (i.e. practical and affordable).
- The **diagnostic step** to prioritize measurement campaigns and define the appropriate tier is of most importance with a constraint budget
- For this particular case study, a **combination of samping and monitoring in a Tier 2 assessment** appeared to be the **best compromise** to determine the time-averaged elemental mass concentration and particle morphology along with time resolved number or LDSA concentrations.
- **Short-term exposure monitoring** should be promoted for brief operations.
- **Training** sessions and guidelines should be promoted to make **aware workers of the risks** associated to NOAA in particular for cleaning and maintenance activities.

Identification of the remaining experimental challenges:

- Many factors should be considered for the **positioning** of **instruments** (NF/FF). In particular **air flows** need to be determined during scoping visits using anemometer.
- Adress the **speciation of the emitted particles** (pristine Vs aged and transformed)

KEY FINDINGS FROM THE FIELD MEASUREMENTS CONDUCTED IN EUROPE

Increased understanding of critical exposure scenarios along the early stages of the life-cycle of nano-enabled products is used to provide inputs for practical and cost-effective risk management measures

- Production is usually performed under full containment and release generally occurs when dry materials are handled.
- **Weighing**, **transferring** and **mixing** are short activities (<15 min) that releases airborne NOAA
- High energy mechanical processes: **wet processes** or **integrated suction** to the tool used as close as possible to the source are **preferred**
- The presence of **organic vapors** (use of solvents, heating of polymers …) **interfere** with particle counters and made difficult the interpretation of data.
- **Cleaning and maintenance activities** generates particles over a large size range. Control measures to mitigate emissions should be maintained at all time.
- **Encapsulation strategies** and **sintering steps** when relevant reduces the potential release of NOAA and their subsequent emission

The research leading to these results has received funding from the European Research Council under the European Union's H2020 Grant Agreement n.646397 (NanoLeap project).

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Thank you for your attention !

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