

Behavior of Nanoparticles and Polymer Nanocomposites during Lab-scale Combustion within the Project 'ProCycle'

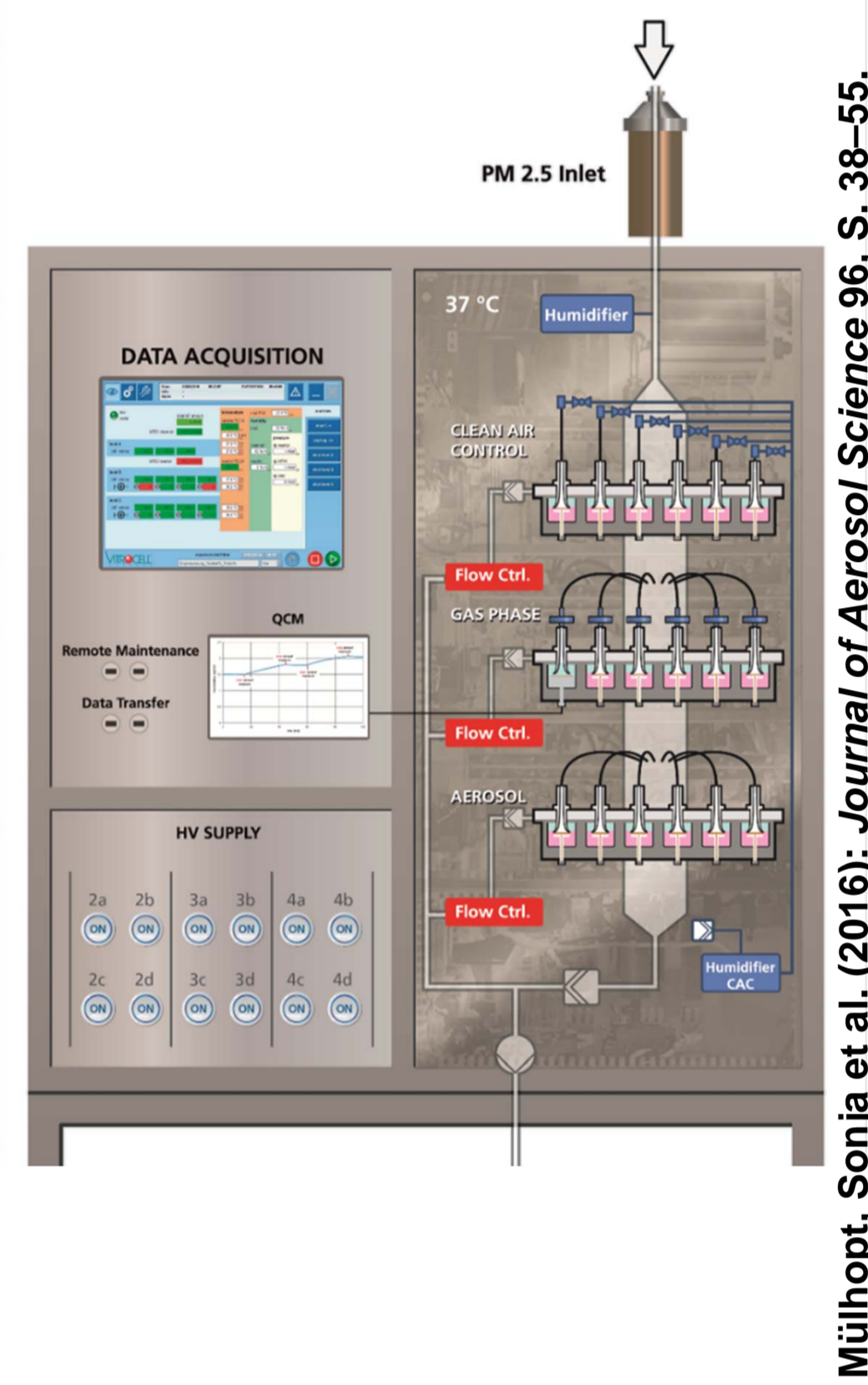
Nadine Teuscher*, Werner Baumann, Manuela Hauser, Sonja Mühlhopt, Hanns-Rudolf Paur, Dieter Stapf Further ProCycle Posters
Institute for Technical Chemistry / Karlsruhe Institute of Technology / Eggenstein-Leopoldshafen / Germany 09.06, 15.03, 15.33
*Corresponding author: nadine.teuscher@kit.edu

Background

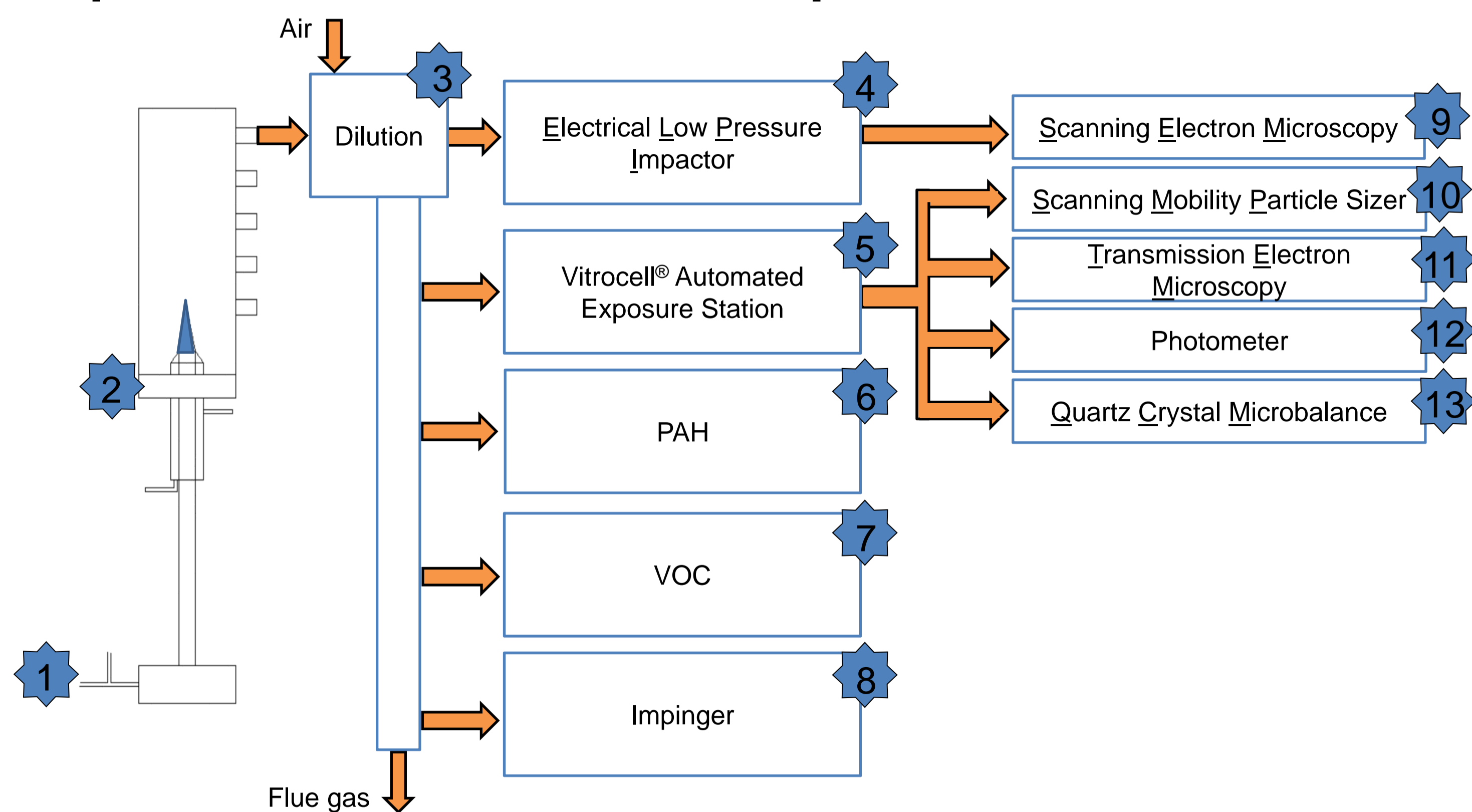
- Nano-enabled thermoplastics are widely used and their end of life potentially constitutes a risk for human health and the environment by release of engineered nanomaterials (ENMs)
- The possible end of life scenarios, recycling and thermal treatment, are investigated
- Comparison of the combustion products of nano-enabled thermoplastics, ENMs and pure thermoplastic matrices

Vitrocell® Automated Exposure Station

Specification	
Cell exposure	3 x VITROCELL® 6/4 CF stainless steel modules of 6 well format, 1 x 6/3 CF stainless steel modules of 6 well format (Clean Air Control)
Aerosol	<ul style="list-style-type: none"> Direct aerosol sampling via size selective inlet: PM_{2.5} inlet with 1 m³/h Aerosol conditioning to 37 °C and 85 % relative humidity.
Negative control	Humidified synthetic air
Dose enhancement	Electrostatic deposition by applying a potential of up to 1500 Volts is optional for each cell culture separately
Dose monitoring	<ul style="list-style-type: none"> Online surface dose monitoring by a Quartz Crystal Microbalance (QCM) in µg/cm². Integrated sampling probes in the reactor for aerosol measurements a for example SMPS, FTIR, filter ...
Automation / Quality insurance	Integrated standard routines for leak tests, exposure experiments and more with comprehensive data acquisition
Dimensions	1923 x 1855 x 649 (H x W x D in mm) / 480 kg



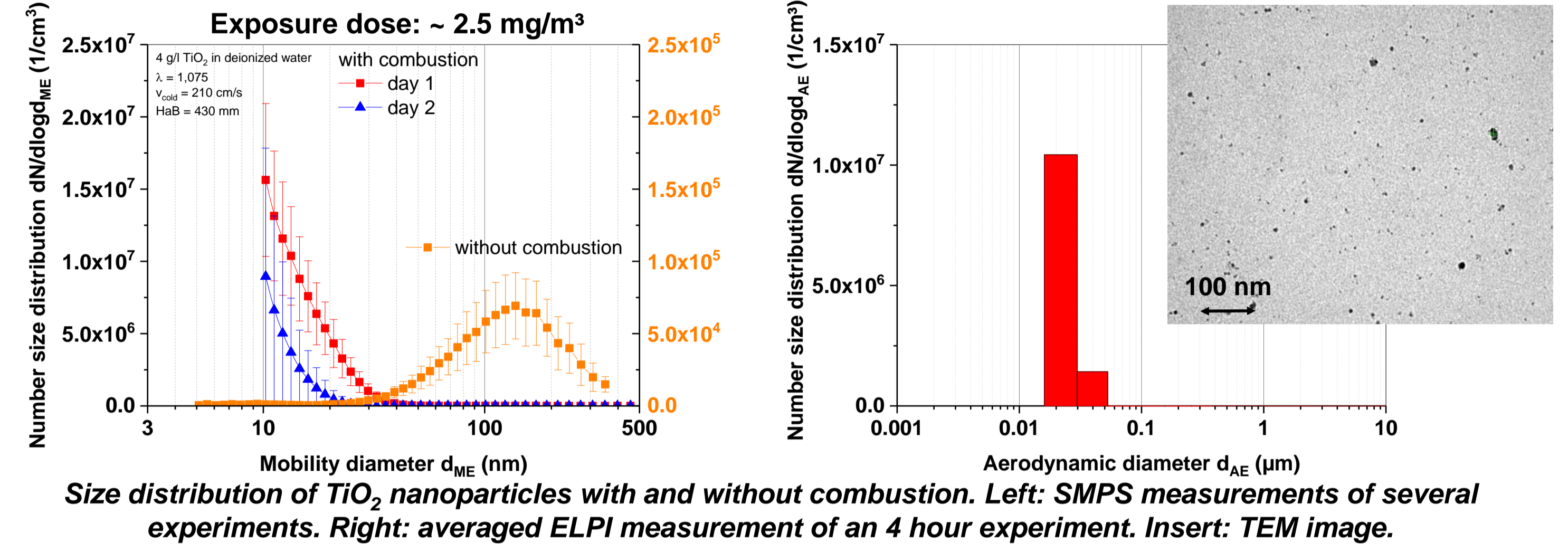
Setup and Measurement Techniques



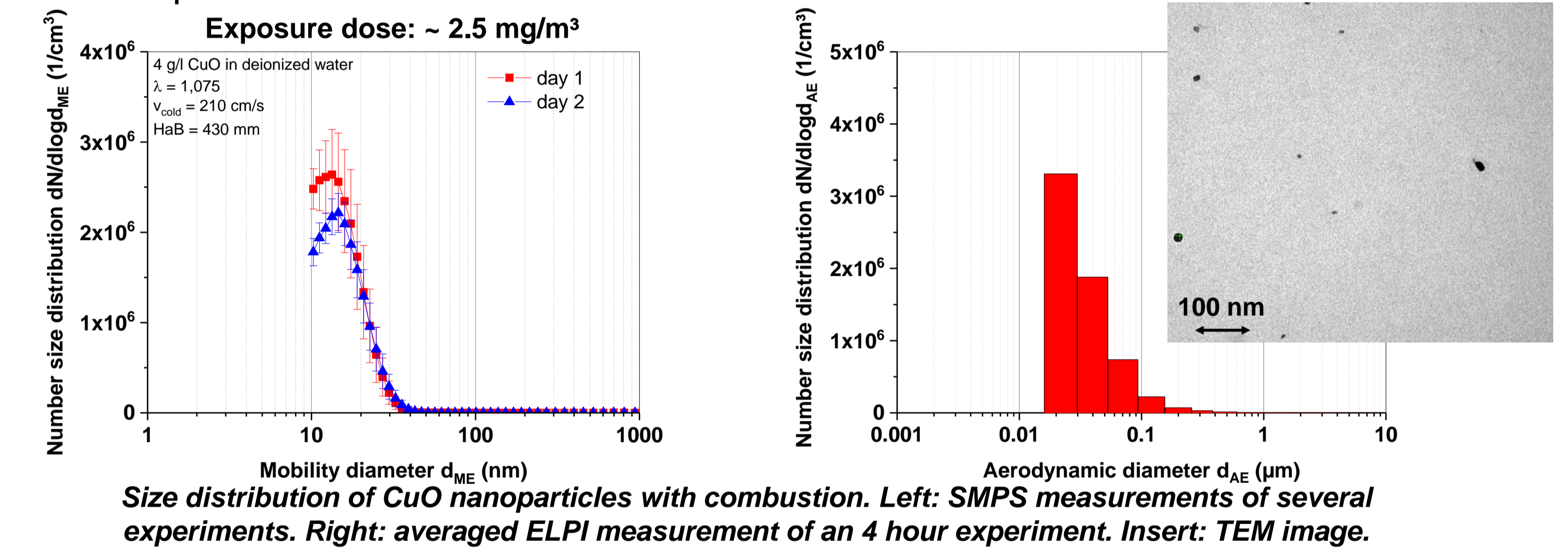
- Polymer nanocomposite powders (< 315 µm) or suspensions of pure nanoparticles are aerosolized and added to an Ethylene / Air mixture ($\lambda = 1,075$)
- Tube burner: Combustion of the gas/particle mixture
- Dilution of combustion products and comprehensive characterization via physical, chemical and biological measurement techniques
- ELPI: number size distribution between 10 nm and 10 µm
- Vitrocell® Automated Exposure Station: exposure of human lung cells at the Air/Liquid-Interface
- PAH: Analysis of the polycyclic aromatic hydrocarbons by HPLC and fluorescence detection
- VOC: Analysis of the volatile organic compounds via TD-GC-MS
- Impinger: subsequent ecotoxicological studies
- SMPS: number size distribution between 10 nm and 1000 nm; measurement inside the reactor of the exposure station
- TEM: image analysis of grids in an exposure chamber
- Photometer: inline measurement of number concentration upstream of each exposure chamber
- QCM: Online dose monitoring

Measurement of Combustion Aerosols

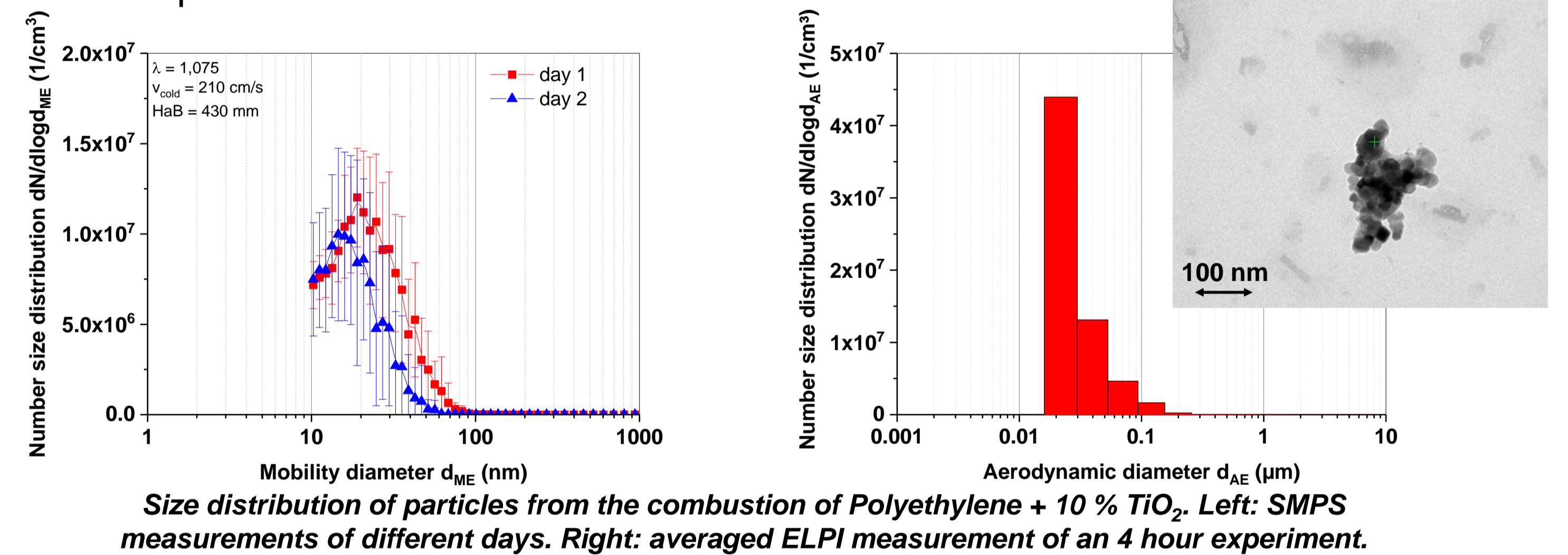
- TiO₂ nanoparticles are used as a negative control for the experiments with A549 cells
- Ultrafine particles < 10 nm are formed due to the influence of the flame



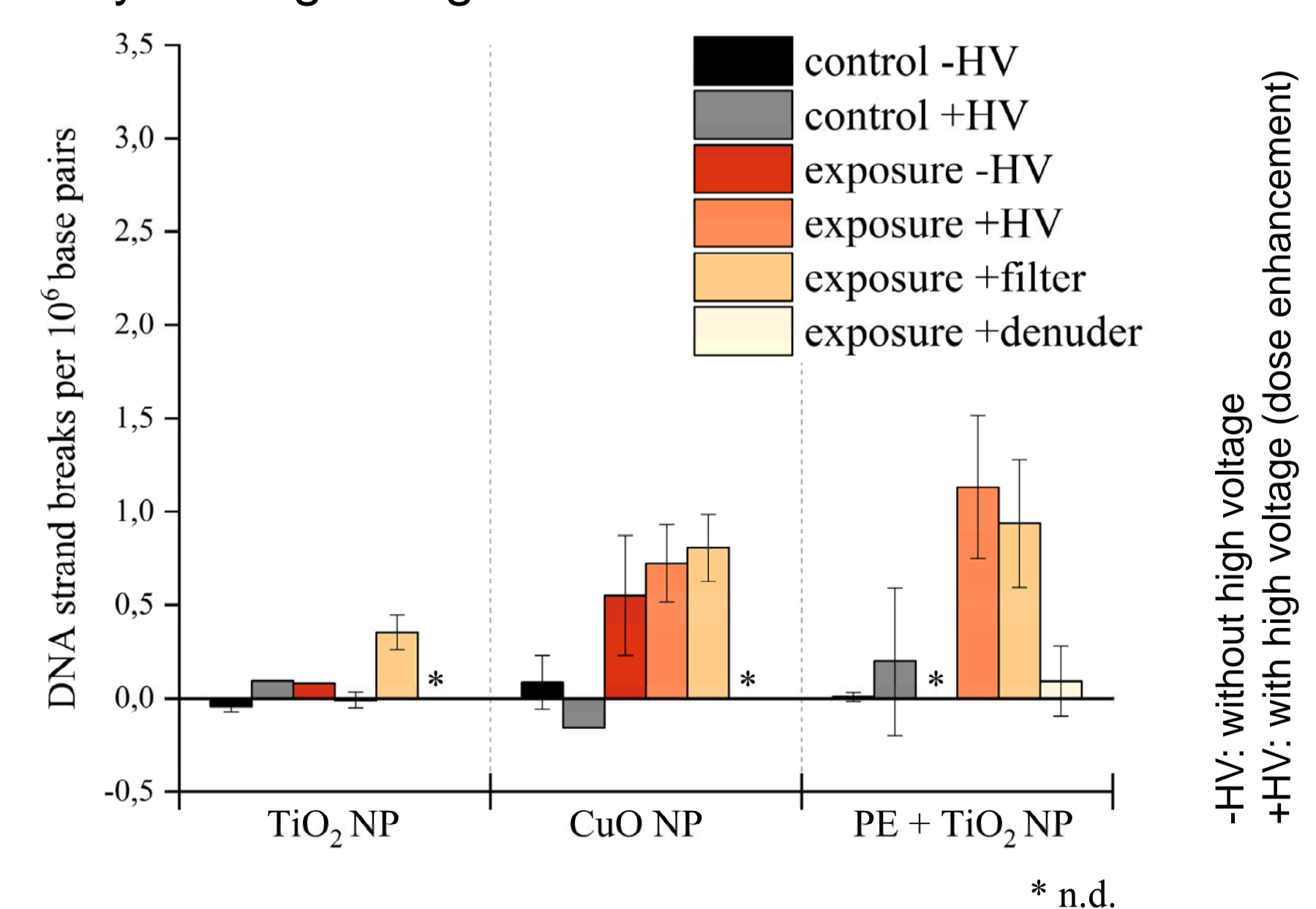
- CuO nanoparticles are used as a positive control for the experiments with A549 cells
- Ultrafine particles of 15 nm downstream of the tube burner



- The Polyethylene + 10 % TiO₂ nanocomposite is tested in comparison to the pure nanoparticles and pure matrix
- Ultrafine particles < 30 nm downstream of the tube burner



- After 4 h exposure to the combustion aerosol and 20 h post-incubation the A549 human lung cells were analysed regarding DNA strand breaks



DNA strand breaks in A549 cells induced by released aerosols from incinerated thermoplastics and related ENMs (Control: Humidified synthetic air, filter: precipitation of particles, denuder: precipitation of volatile organic compounds).

Conclusions

- Successful application of the illustrated measurement chain
- Comprehensive characterization of the combustion aerosol of nano-enabled thermoplastic
- Pure nano metal oxides and nano-enabled thermoplastics form ultrafine nanoparticles with high number concentrations in an Ethylene / Air flame
- Combustion aerosols of nano-enabled thermoplastics induce DNA strand breaks in A549 cells
- For PE + 10 % TiO₂ the toxicity is due to gaseous species