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ANALYSIS AND TOXICOLOGICAL EVALUATION OF DUSTS FROM RECYCLING AND THERMAL DECOMPOSITION OF NANOCOMPOSITES AND STRATEGIES FOR RISK MINIMIZATION - PROCYCLE

ProCycle

# NANOPARTICLE RELEASE FROM THERMAL DECOMPOSITION OF POLYMER NANOCOMPOSITES AND THE BIOLOGICAL POTENTIAL OF THE EMISSIONS

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## Objectives

- Nanoparticle behavior in combustion processes of nanocomposites
- Health effects of nanoparticle emissions from combustion processes of nanocomposites materials

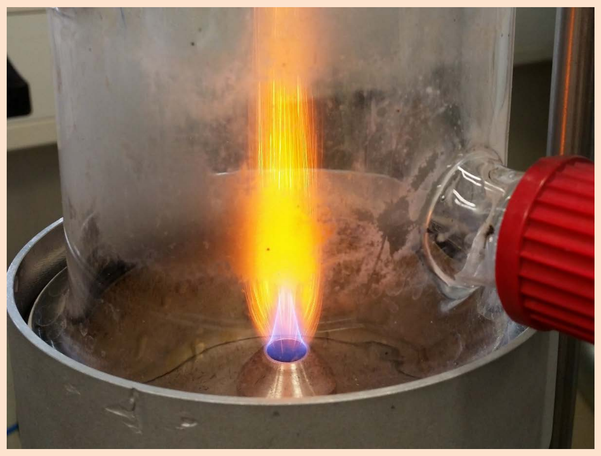
## Challenges

- Combustion of Nanomaterials (NM) and Nanocomposites
- Nanoparticle detection
- Realistic exposure of human lung cells towards the combustion aerosols
- Dose determination at the Air-Liquid-Interface of human lung cells
- Dose-Response relationships from combustion aerosols in ALI exposed human lung cells

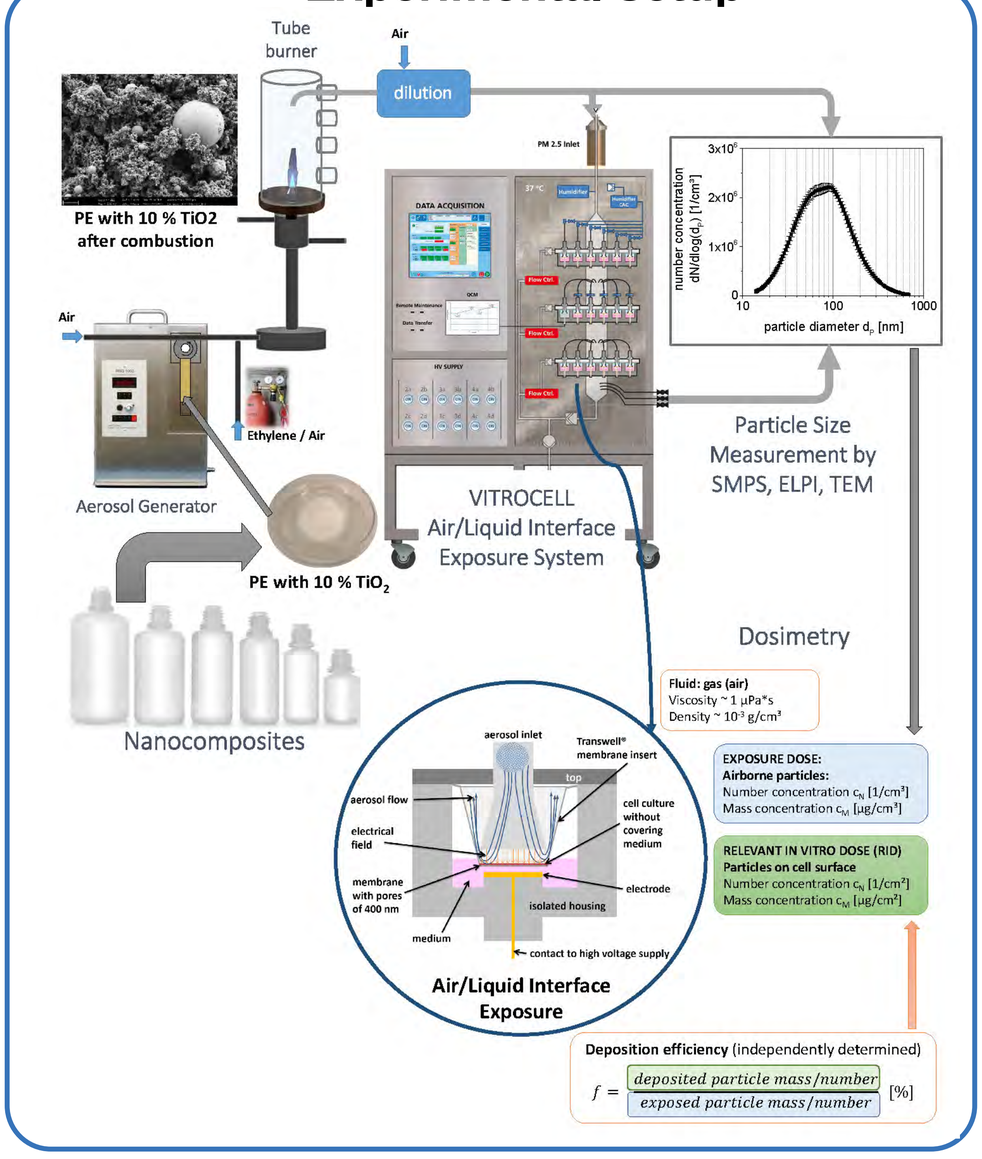
## Combustion of nanocomposites emits high numbers of ultrafine particles

**Tube burner**

- Laminar premixed Ethylene / Air flame
- Stoichiometry: 0.8 < l < 1.2
- Adiabatic flame temperature: ~ 2100 °C
- Addition of suspensions or dusts possible
  - Nano metal oxides
  - ground nano-enabled thermoplastics
  - carbon fibres
- Sampling at different heights above the burner
- Adaption of a dilution stage allows the installation of various measurement systems

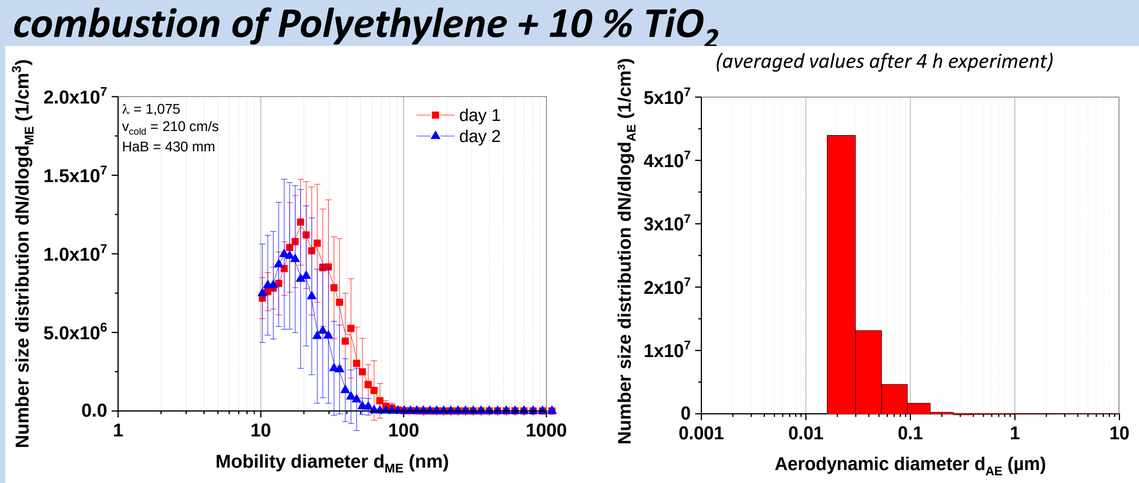


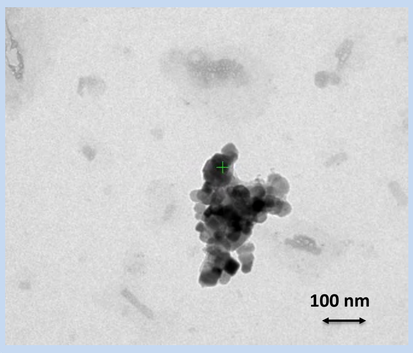
## Experimental setup

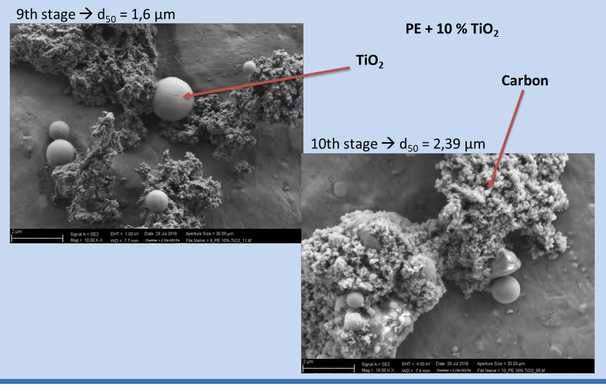



## Combustion aerosols of nano-enabled thermoplastics induce DNA strand breaks in A549 cells

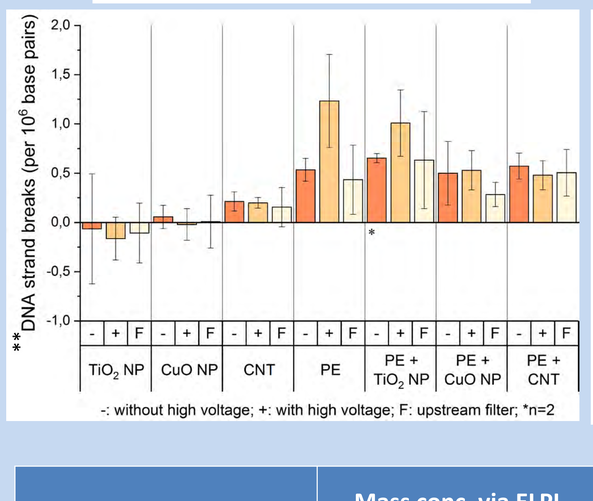
***Size distributions (left: SMPS, right: ELPI) of particles from the combustion of Polyethylene + 10 % $TiO_2$***



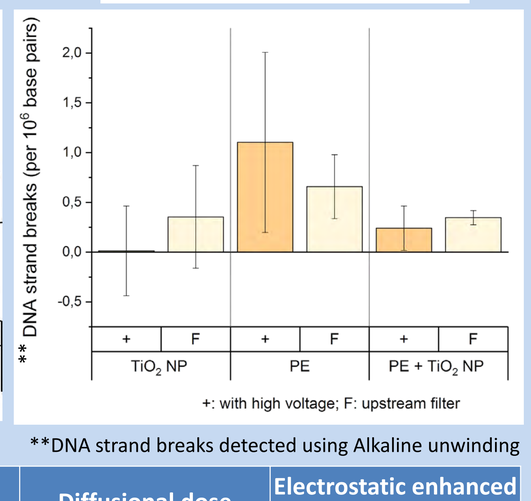




**Human carcinogenic lung cell line A549**




**Human 3D lung tissue *MucilAir™***




**DNA strand breaks detected using Alkaline unwinding

| Material | Mass conc. via ELPI [µg/m³] | Diffusional dose [ng/cm²] | Electrostatic enhanced dose [ng/cm²] |
|---|---|---|---|
| PE | 505 ± 8 | 54 ± 1 | 268 ± 4 |
| $TiO_2$ | 137 ± 20 | 15 ± 2 | 73 ± 11 |
| CuO | 256 ± 151 | 27 ± 16 | 136 ± 80 |
| CNT (+ gum arabicum) | 44 ± 7 | 5 ± 1 | 23 ± 4 |
| PE + $TiO_2$ | 527 ± 317 | 56 ± 34 | 280 ± 168 |
| PE + CuO | 235 ± 18 | 25 ± 2 | 125 ± 10 |
| PE + CNTs | 106 ± 16 | 11 ± 2 | 54 ± 8 |

**References**
Baumann et al., Energy Procedia 120 (2017), 705
Dilger et al., Archives of Toxicology 90 (2016), 3029
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**Abbreviations**
CNT: carbon nanotubes
DNA: deoxyribonucleic acid
ELPI: electrostatic low pressure impactor
NP: nanoparticles
PE: polyethylene
SMPS: scanning mobility particle sizer
TEM: transmission electron microscopy

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