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THERMAL STABILITY AND MATERIAL BALANCE OF NANOMATERIALS IN WASTE INCINERATION

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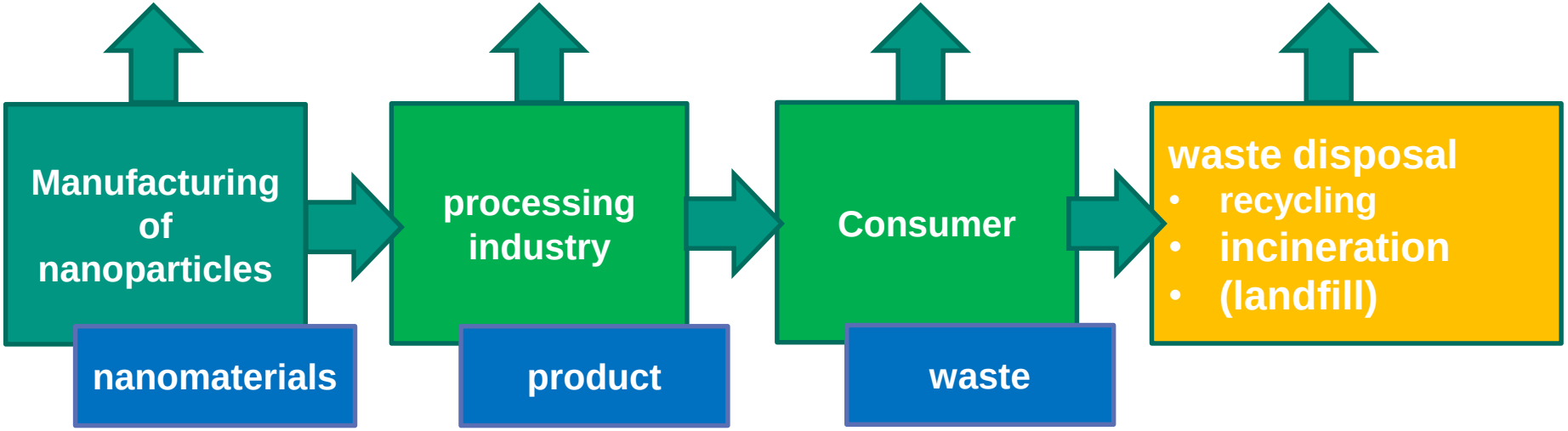
Life cycle of products containing nanoparticles

Possibility of NP release into the environmental compartments air, water and soil

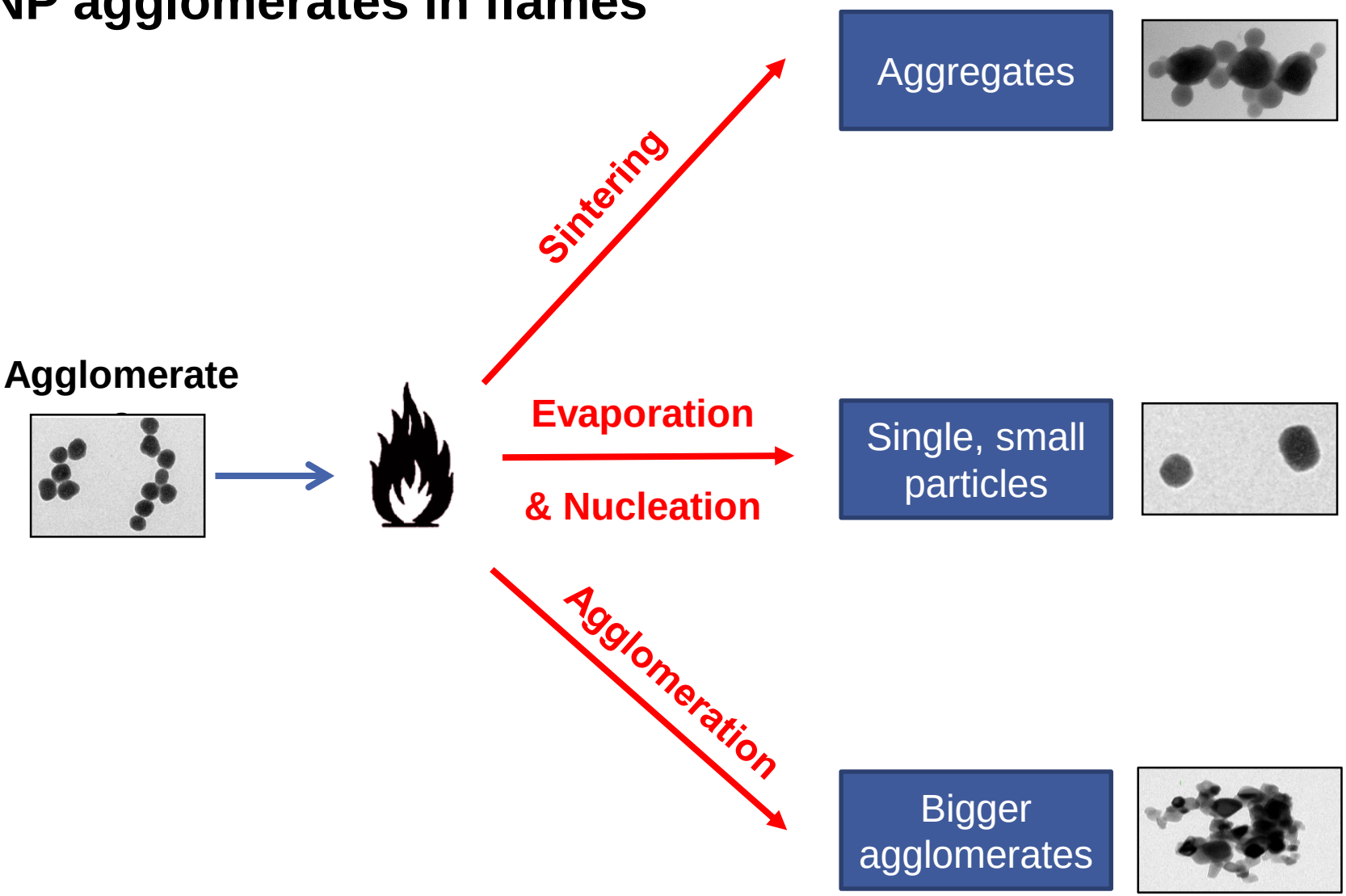


BMBF 2011

Project overview

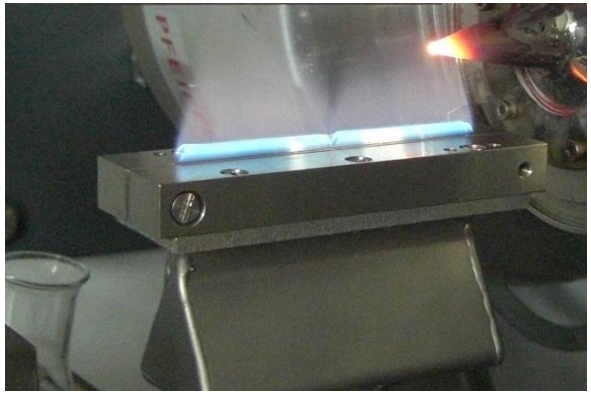
basic lab-scale investigations	Nanoparticle release in incineration plants	ProCycle (NanoCare) Thermoplastic Nanocomposites
behaviour of nanoparticles	Thermal waste treatment	Recycling and thermal disposal
• Lab-scale flame • Tube furnace	• BRENDA • Hazardous waste incinerator	• KLEAA • Lab-scale flame

Mechanistic hypothesis on the behaviour of NP agglomerates in flames



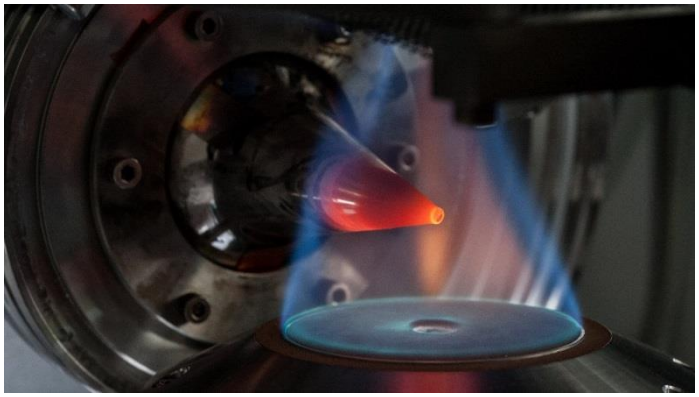
Stability of NP agglomerates in flames

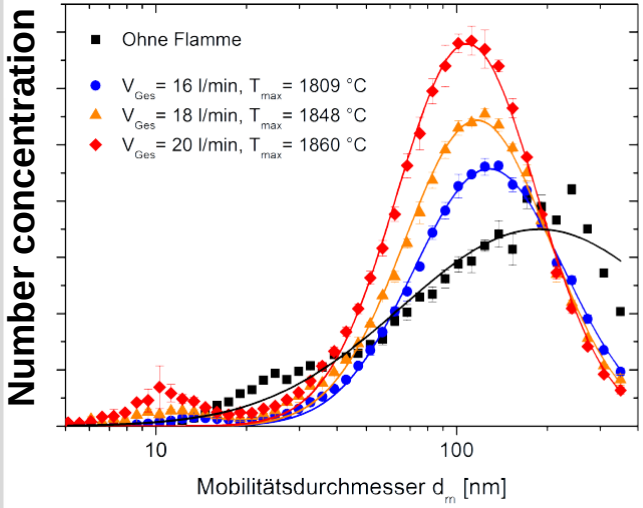
Slit burner
(Atomic absorption spectroscopy)

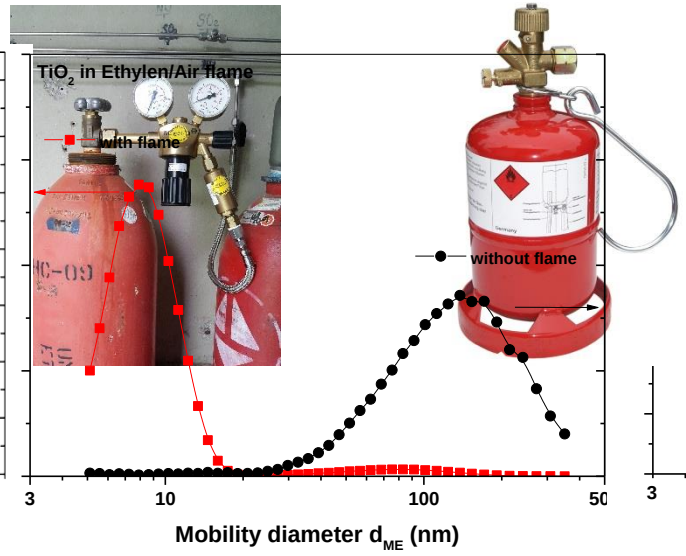


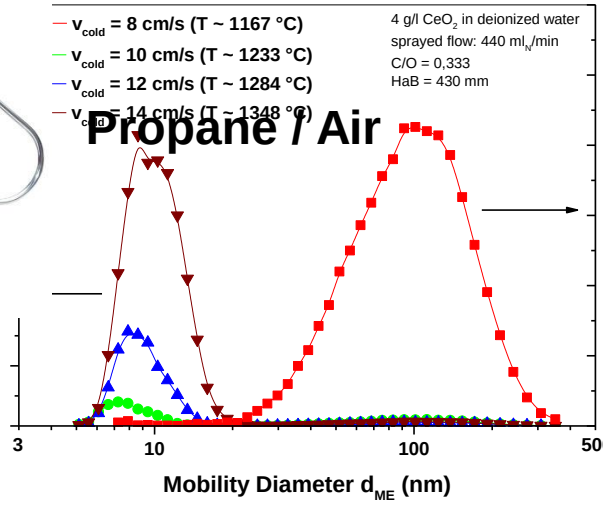
Tube burner

McKenna burner



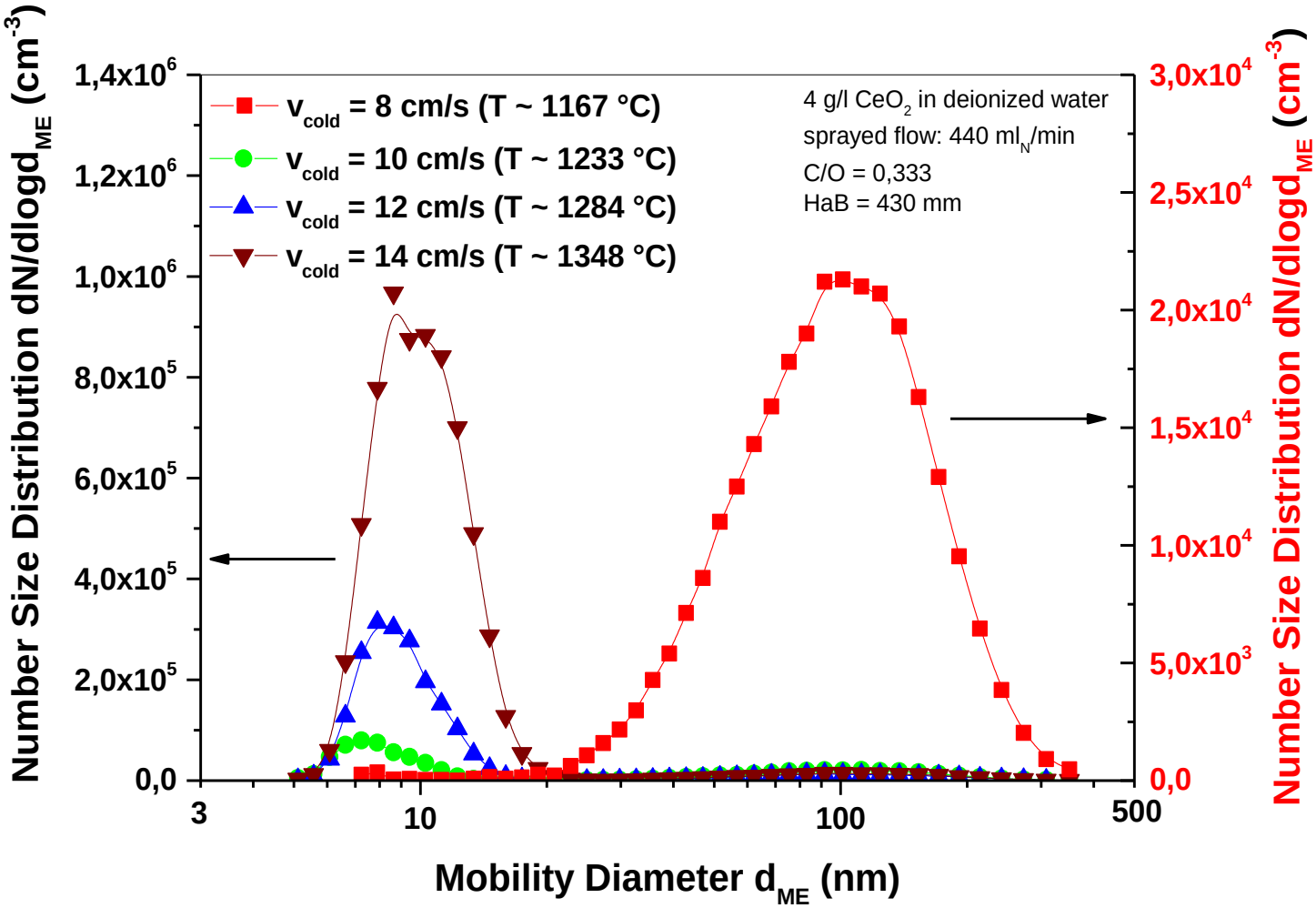




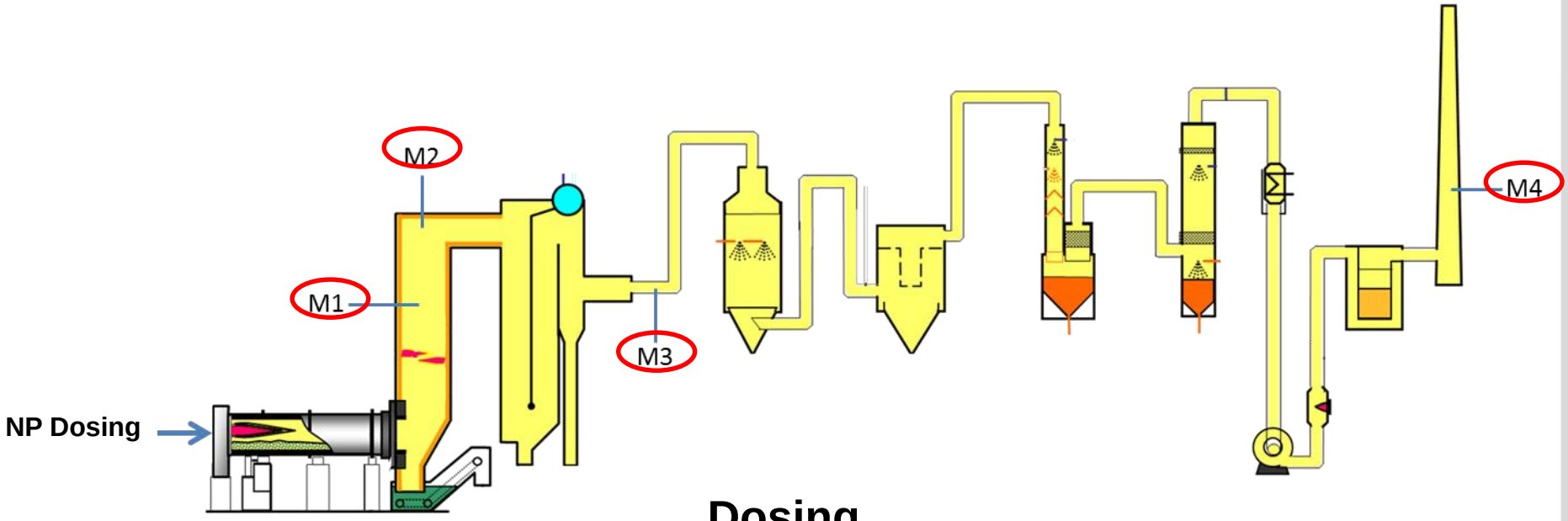


SiO_2 **TiO_2** **CeO_2**

Ceria-particles added to a flame



Tracer experiments at BRENDA pilot scale plant



Pilot scale incineration plant:

- Rotary kiln with burning camber
- 3.5 MW
- Flue gas flow: 3 000 m³/h
- 4 flue gas measuring points

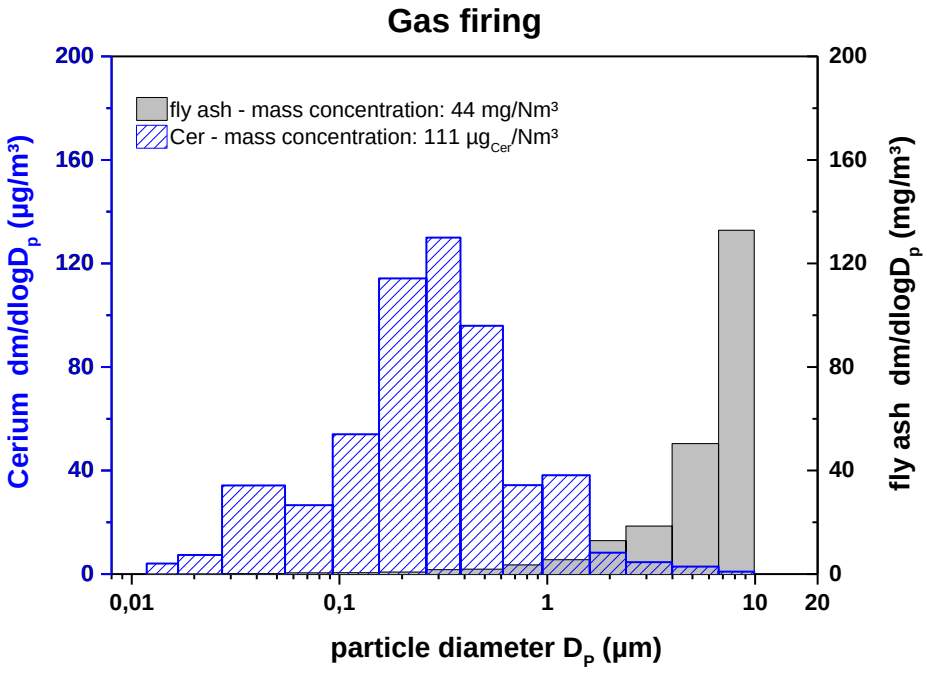
Dosing

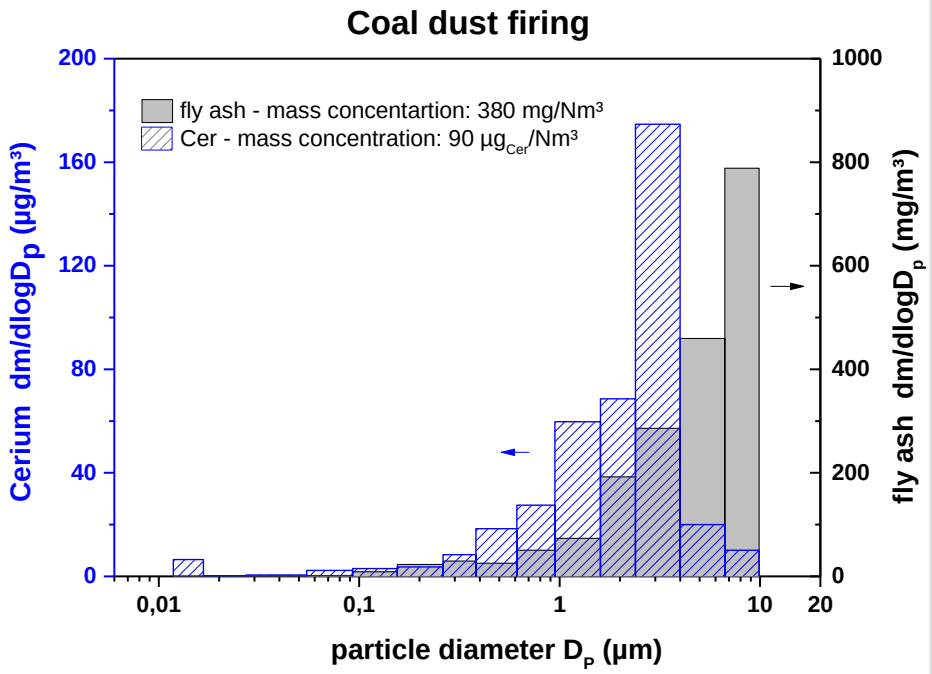
- Concentration of CeO_2 suspension: 1 g/l
- Suspension dosing rate: 10 l/h
- Flue gas CeO_2 concentration: 2.5 mg/m³

Operation

- Gas firing
- Coal dust firing

ELPI measurement behind boiler with ceria dosing



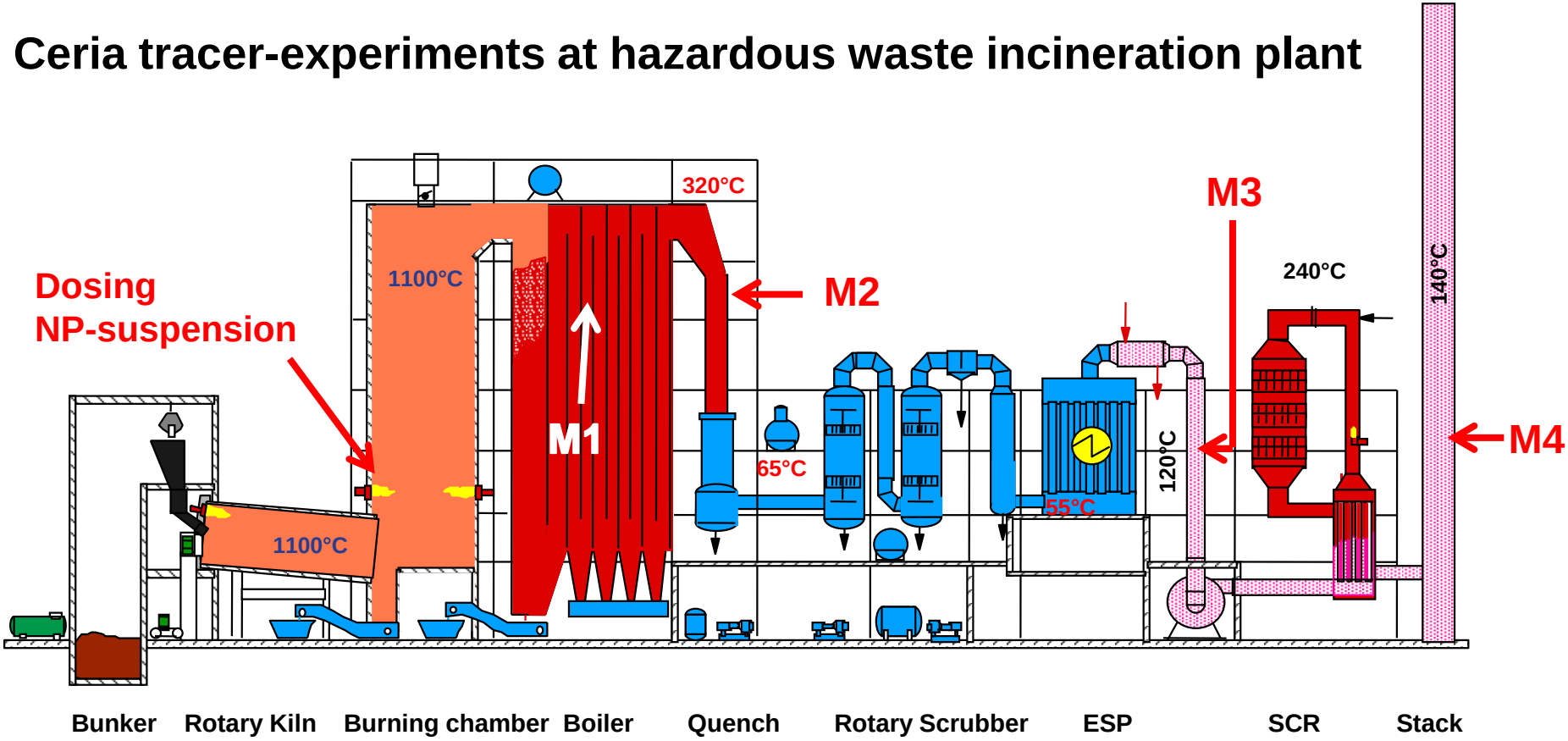


Gas firing: low fly ash concentration

Coal dust firing: high fly ash concentration

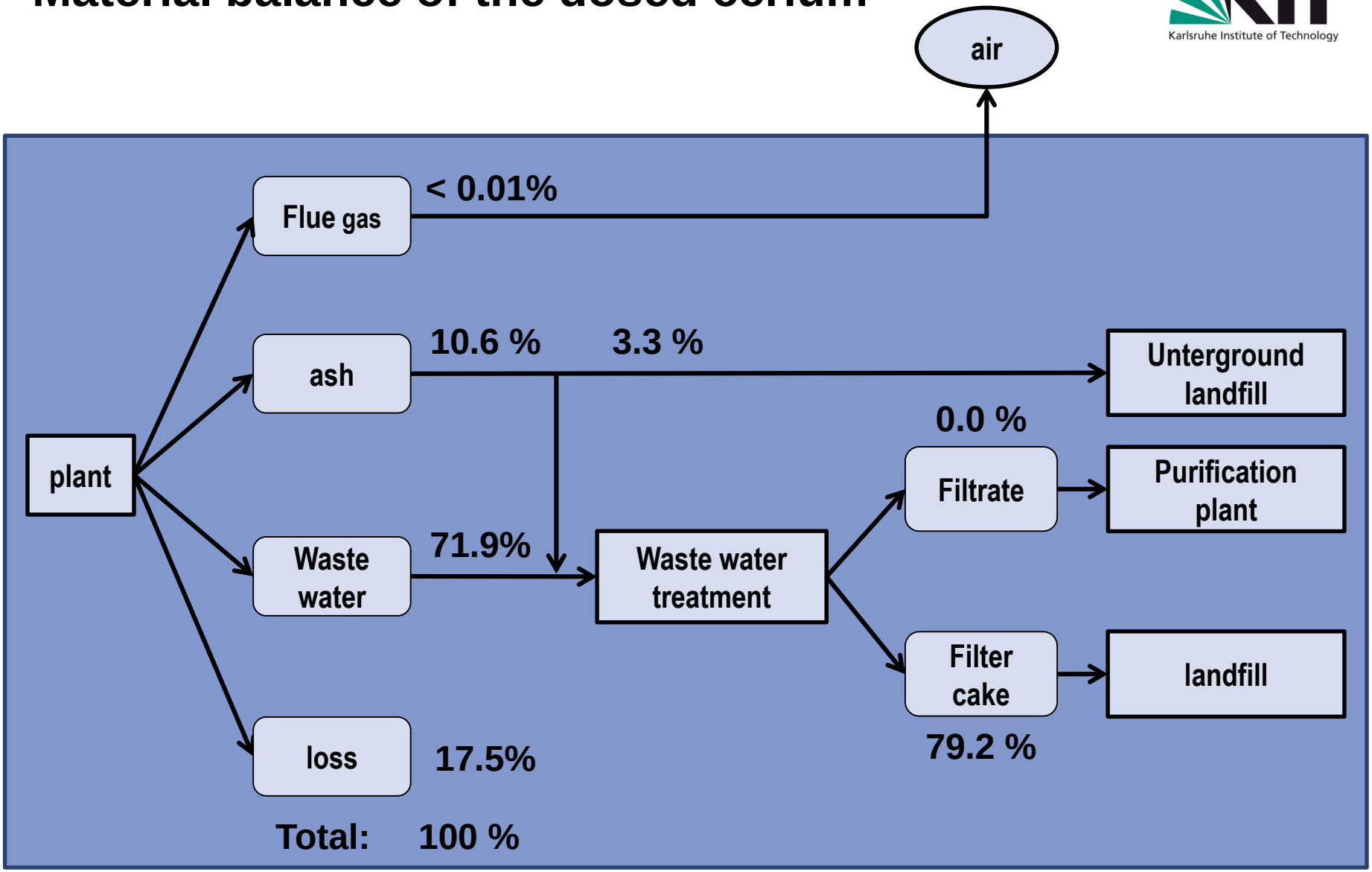
ceria nanoparticles agglomerate with fly ash

Ceria tracer-experiments at hazardous waste incineration plant



Measurement point	Position	Temperature
Dosing	After burner chamber	max. 1.100 °C
M1	Boiler pass 4	530 °C - 580 °C
M2	Behind boiler	300 °C - 350 °C
M3	Behind electrostatic precipitator	120 °C
M4	Stack	150 °C

Material balance of the dosed cerium



Results of current research projects

Incineration type	Fuel / Nanoparticle	Tracer Recovery [%]			Tracer at Stack	
		Bottom ash	Boiler ash	Filtration / Scrubber	Concentration [µg/m³]	Fraction [%]
KLEAA (KIT) lab-scale fixed bed combustion facility	Thermoplastic Nanocomposite with 2 % TiO_2	99	--	--	< 0,1	< 0,01
100 kW wood boiler * (grate)	Wood pellets with 1% TiO_2	approx. 98		without filtration	< 5.000 (boiler outlet)	< 2
Sewage sludge incineration plant * ZVK Neu-Ulm (fluidised bed)	sewage sludge 0,8 % TiO_2	approx. 50		approx. 5	< 20	< 0,01
Municipal waste incineration plant* MVA-Schweinfurt (grate)	Municipal waste 1% TiO_2	92	5	0,2	5	< 0,01
Municipal waste incinerater ** MVA-Solothurn (grate)	Municipal waste a) 10 kg CeO_2 b) 1 kg CeO_2	 32 18	 7 15	 < 0,1 0,6	 < 0,1 < 0,1	 < 0,01 < 0,01
BRENDA (KIT) 2 MW combustion chamber	coal dust with 25 g/h CeO2 6,5 mg/m³	without grate	3	64	< 0,1	< 0,01
Industrial hazardous waste incineration plant	Hazardous waste with 100 g/h CeO_2	without grate	10	72	< 0,1	< 0,01

* UBA-Texte 37/2016 (UFOPLAN-Project 3712 33 327)
** Walser et. al (2012)

Thermal treatment of thermoplastic nanocomposites and toxicological investigations with air/liquid interface

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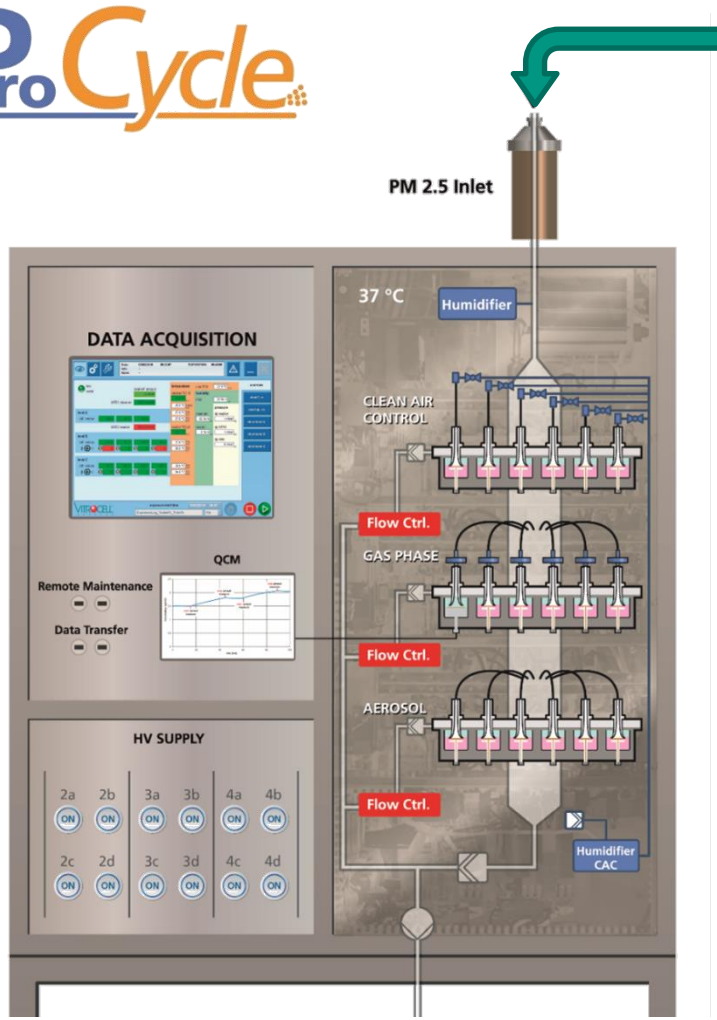
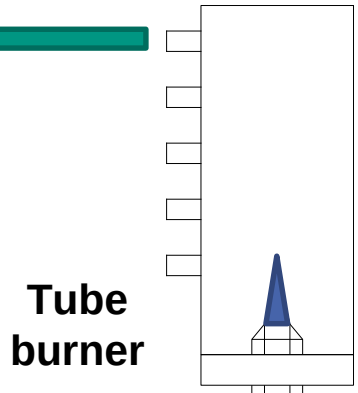
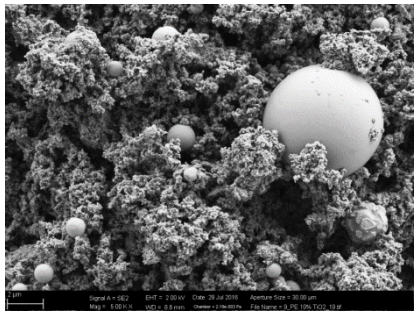
ProCycle



Vitrocell Air/Liquid Interface





Ethylene / Air

Air

Aerosol Generator

Conclusion

- Ceria is a useful tracer
- Lab-scale experiments in flames show a new particle mode
- Agglomeration of the ceria nanoparticles with fly ash
- Retention of the ceria particles in the flue gas cleaning > 99.99 %
- Recovery of the dosed cerium > 80% by balancing the mass flows
- Quantitative recovery of cerium in the filter cake

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Thank you for your attention!

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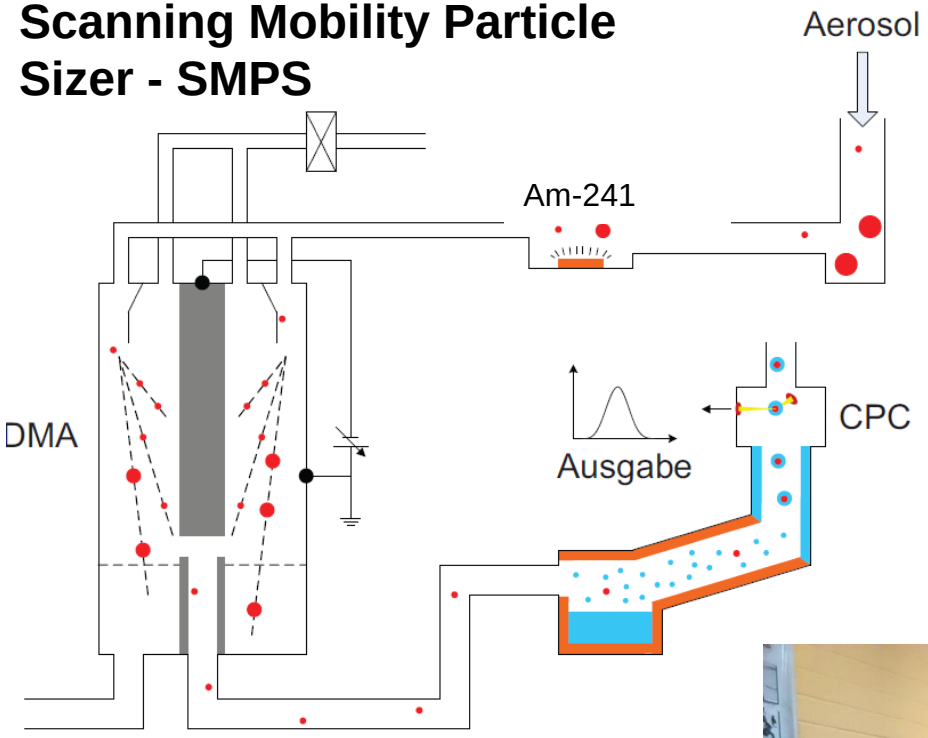
Measurement techniques

Scanning Mobility Particle Sizer - SMPS



Electrical Low Pressure Impactor - ELPI

Transmission Electron Microscopy - TEM

Particle number concentration at a combustion plant downstream of the boiler

Calculation based on half-value period of coagulation of monodispersed aerosols with D_P < 500 nm