Assessment of the emission behavior of nanomaterial-containing waste in thermal treatment plants

Scientific Stakeholder Meeting on Nanomaterials in the Environment

10-10-2017
UBA, Dessau

Jürgen Oischinger
Martin Meiller
Dr.-Ing. Robert Daschner
Fraunhofer UMSICHT

© GKS Schweinfurt
Nano-TiO₂
Agenda

- Introduction
- Project “Assessment of the emission behavior of nanomaterial-containing waste in thermal treatment plants” (UFOPLAN FKZ: 3712 33 327)
- Project “NanoEmission”
- Overview of other research projects
- Project “Investigations on the possible release of nanoparticles during the deposition and soil-related application of mineral waste” (UFOPLAN FKZ 3716 34 319 0)
- Discussion / Further points of interest
Introduction

Emission pathways of ENM during disposal

Products containing engineered nanomaterial (ENM) e.g. cosmetics, paints

Waste containing nanomaterial

End-of-life

Disposal

Release by flue gas?

Fate in the bottom ash?

© Fraunhofer UMSICHT

© GKS Schweinfurt

© MEV

[BOE16]
## Project UFOPLAN FKZ: 3712 33 327

**Examined waste streams**

<table>
<thead>
<tr>
<th>Different forms of application of ENM to different fuels</th>
<th>Sewage sludge</th>
<th>Municipal waste</th>
</tr>
</thead>
</table>

- Pilot plant at Fraunhofer UMSICHT
- Sewage sludge incineration plant ZVK Steinhäule
- Municipal waste incineration plant GKS Schweinfurt

© GKS Schweinfurt
Selection of ENM

- Nano silver
- Nano zinc oxide
- Nano cerium oxide
- Nano aluminium...
- Nano iron oxide
- CNT (carbon...)
- **Nano titanium dioxide**
- Nano silica

**Advantages:** inert, chemical stable, melting point > 1800 °C

**Product:** Hombicat UV 100 WP (slurry for large-scale plants experiments)
**Project UFOPLAN FKZ: 3712 33 327**

**Measurement technique / analytics**

<table>
<thead>
<tr>
<th>Pilot plant</th>
<th>Sewage sludge incineration plant</th>
<th>Municipal waste incineration plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference measurement</td>
<td>Measurement with incorporation of nano TiO₂</td>
<td></td>
</tr>
</tbody>
</table>

### Measuring points

**Sampling solid residues**
- Combustion residues
- Filter residues
- Washing water

**Sampling along the flue gas path**
- Total dust measurements (VDI 2066-1)
- Particle size selective measurements (13 stages, low pressure cascade impactor)

### Analytics

- SEM/EDX
- ICP/MS
Project UFOPLAN FKZ: 3712 33 327
Measurement instrumentation / analytics
Cascade impactor

Dekati® Low Pressure Impactor

- Operation in low pressure range
- 13 stages + filter
- Determination of particle size distribution in the range of 30 nm up to 10 µm (10 nm with filter stage)
- 3 stages in the nm scale
Project UFOPLAN FKZ: 3712 33 327
Measurement instrumentation / analytics
Cascade impactor

- Aerosol passes through the nozzles with high speed and makes a sharp turn to flow between the plates → Particles larger than a certain size impact on the collection plate
- Nozzle diameter reduces in the impactor cascade → Classification by particle size
- Collection of aerosol on aluminium foils → Gravimetric analysis
  → Following: SEM/EDX or ICP/MS

Functional principle of impactor [DEK10]
Project UFOPLAN FKZ: 3712 33 327
Experiments in sewage sludge incineration plant

Total dust- and impactor measurement (flue gas)

Solid sampling

Wash water sampling

Source: www.klaerwerk-steinhaeule.de
Project UFOPLAN FKZ: 3712 33 327
Experiments in sewage sludge incineration plant

- Fate of titanium: Particularly in solid combustion residues
- Emission of titanium by purified exhaust gas is hardly to be expected.
Project UFOPLAN FKZ: 3712 33 327
Experiments in municipal waste incineration plant

<table>
<thead>
<tr>
<th>Number</th>
<th>Position</th>
<th>Sample matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>After boiler</td>
<td>Dust</td>
</tr>
<tr>
<td>2</td>
<td>After cyclone</td>
<td>Dust</td>
</tr>
<tr>
<td>3</td>
<td>Before scrubber</td>
<td>Dust</td>
</tr>
<tr>
<td>4</td>
<td>Before stack</td>
<td>Dust</td>
</tr>
<tr>
<td>5</td>
<td>Boiler ash</td>
<td>Ash</td>
</tr>
<tr>
<td>6</td>
<td>Cyclone dust</td>
<td>Dust</td>
</tr>
<tr>
<td>7</td>
<td>Bottom ash</td>
<td>Ash</td>
</tr>
<tr>
<td>8</td>
<td>Spray dryer</td>
<td>Solid matter</td>
</tr>
<tr>
<td>9</td>
<td>Wash water</td>
<td>Water sample</td>
</tr>
<tr>
<td>10</td>
<td>Fabric filter</td>
<td>Ash</td>
</tr>
</tbody>
</table>
Project UFOPLAN FKZ: 3712 33 327

Experiments in municipal waste incineration plant

- Fate of titanium: Particularly in solid combustion residues
- Emission of titanium by purified exhaust gas is hardly to be expected.
Project NanoEmission
Experiments in municipal waste incineration plant

- Joint research project:
- Funded by BMBF
- Project duration: 2013 - 2016
- Objective of the project: Investigation of the emission behavior of nanoparticles in waste incineration
- Detailed investigation along the whole pathway considering the waste, combustion, filtering and a possible release of ENM as well as human toxicity studies
- Experiments in pilot plants as well as in the municipal waste incineration plant MVA Weisweiler
- Bariumsulfate as tracer in the MVA Weisweiler

Reports available: https://www.tib.eu/de/, keyword: NanoEmission
Project NanoEmission
Experiments in a municipal waste incineration plant

- Fate of barium: Particularly in solid combustion residues
- Emission of barium by purified exhaust gas is hardly to be expected.

Source: [BAR16]
## Overview of other research projects

### Experiments in thermal treatment plants

<table>
<thead>
<tr>
<th>Plant/Combustion system</th>
<th>Fuel / ENM</th>
<th>Tracer recovery rate in [%]</th>
<th>Tracer at stack</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bottom ash</td>
<td>Boiler ash</td>
</tr>
<tr>
<td>100 kW Boiler* Grate</td>
<td>Wood chips with 1% TiO₂</td>
<td>ca. 98</td>
<td>No precipitator</td>
</tr>
<tr>
<td>MWIP Schweinfurt* Grate</td>
<td>Waste with 1% TiO₂</td>
<td>92</td>
<td>5</td>
</tr>
<tr>
<td>Sewage sludge incinerator* ZVK Neu-Ulm / Fluidised bed</td>
<td>Sewage sludge with 0,8 % TiO₂</td>
<td>ca. 50</td>
<td>ca. 5</td>
</tr>
</tbody>
</table>
| MWIP-Solithurn** Grate                 | Waste with a) 10 kg CeO₂  
  b) 1 kg CeO₂                                      | 32          | 7          | < 0,1        | < 0,1             | < 0,01          |
| KLEAA (KIT) Labor shaft furnace        | PMMA-composite with 2 % TiO₂                     | 99 Residue  | --         | --           | < 0,1             | < 0,01          |
| BRENSA (KIT) 2 MW burning chamber      | Coal dust with 25 g/h CeO₂ /  
  6,5 mg/Nm³                                            | No grate    | 3          | 64           | < 0,1             | < 0,01          |
| RVA in chemical industry/rotary kiln with afterburner chamber | Residues with 100 g/h CeO₂                       | No grate    | 10         | 72           | < 0,1             | < 0,01          |

Source: [PAU16]

* UBA-Texte 37/2016 (UFOPLAN-Projekt 3712 33 327) [BÖR16]
** Walser et. al (2012) [WAL12]
*** At boiler outlet with no further flue gas cleaning
Project UFOPLAN FKZ 3716 34 319 0

- Partner:
- Funded by UBA
- Project duration: 2016 – 2019
- Objective of the project: Investigations on the possible release of nanoparticles during the deposition and soil-related application of mineral waste (UFOPLAN FKZ 3716 34 319 0)
- Production of nanomaterial containing ashes/slags from municipal waste and sewage sludge (Fraunhofer UMSICHT)
- Leaching tests with the nanomaterial containing ashes/slags in large-scale lysimeters (Fraunhofer IME)
Discussion
Further points of interest

- Summary
  - Nano-TiO$_2$, nano-CeO$_2$, nano-BaSO$_4$ show similar behaviour during combustion in thermal treatment plants
  - Fate of examined ENM: Particularly in solid combustion residues
  - The examined incineration and flue gas treatment plants comply with the requirements of the best available techniques.

- Further points of interest:
  - How behaves a carbon tracer like CNT during combustion?
  - How behave CeO$_2$, BaSO$_4$ and CNT in mineral waste streams?
Assessment of the emission behavior of nanomaterial-containing waste in thermal treatment plants

Scientific Stakeholder Meeting on Nanomaterials in the Environment

Thank you!

Contact:

Jürgen Oischinger
Research assistant
Group energy from biomass and waste

Fraunhofer UMSICHT
Institute branch Sulzbach-Rosenberg
An der Maxhütte 1
92237 Sulzbach-Rosenberg
Phone: 09661-908 448
E-Mail: juergen.oischinger@umsicht.fraunhofer.de
Internet: http://www.umsicht-suro.fraunhofer.de

Thanks to:

Umwelt Bundesamt

© Fraunhofer UMSICHT
Literaturverzeichnis


