Stability of nanoparticle agglomerates in flames
First results of investigations on the release during waste incineration

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Background:

Currently, several nanostructured materials are applied widely in products sold to customers, but there is a lack of information about what happens to engineered nanoparticles during waste incineration.

The focus of the project is the thermal stability of engineered nanoparticle agglomerates in flames.

The objective of the fundamental investigation is to identify the influence of thermal energy to the stability of nanoparticle agglomerates. These findings are implemented in an experiment at a pilot scale incineration plant (BRENDA).

Material and methods:

Laboratory experiments:

A dispersion of engineered nanoparticles is atomized by a two-component jet using air. For flame investigations the aerosol is introduced into the fresh gas of a propane flame. The flame is a laminar premixed flame which is not insulated by a sheath air stream, so that oxygen has the possibility to diffuse into the flame. The aerosol size distribution is measured before and after flame ignition, far downstream of the flame front (T ≈200 °C).

In the experiments, different metal oxides (titanium dioxide, silica, cerium oxide and zinc oxide) are investigated.

Pilot plant experiments:

To test the behavior of engineered nanoparticles in waste incineration plants, a nanoparticle dispersion will be introduced into the pilot incineration plant BRENDA which consists of a combustion chamber with steam boiler and flue gas cleaning. Measurements will be realized for detecting the introduced nanoparticles in the afterburning chamber, behind the boiler and in the stack. The results will give information about the release of nanoparticles during the incineration process.

Measurement technique:

The size distribution is measured by scanning mobility particle sizer SMPS+C (Grimm, Austria) which uses the electrical mobility as equivalent diameter. Comparative measurements are done with an Electrical Low Pressure Impactor ELPI+ (DEKATI, Finland) using the aerodynamic equivalent diameter. The results in the laboratory are verified by Transmission Electron Microscopy (TEM). For detecting the introduced nanoparticles in the pilot plant the mass concentration is determined using the Dekati Low Pressure Impactor DLPI (DEKATI, Finland). Then the impactor stages are chemically analyzed by inductively coupled plasma mass spectrometry ICP MS recovering the introduced substance.

Results:

First results of the laboratory experiments show that the size distribution is influenced by the flame.

An example is given in figure 1, where a cerium dioxide aerosol at flame conditions and without flame is shown. The plotted particle size distribution is measured with SMPS+C (Grimm, Austria). At room temperature (without flame ignition), the measured modal diameter is about 60 nm at a total concentration of $2*10^5$ particles per cm³ and a size distribution width of log σ_g = 0,3. After flame ignition, the modal diameter decreased to 23 nm and the total concentration increased to $5*10^6$ particles per cm³ with a size distribution width of log σ_g = 0,2.

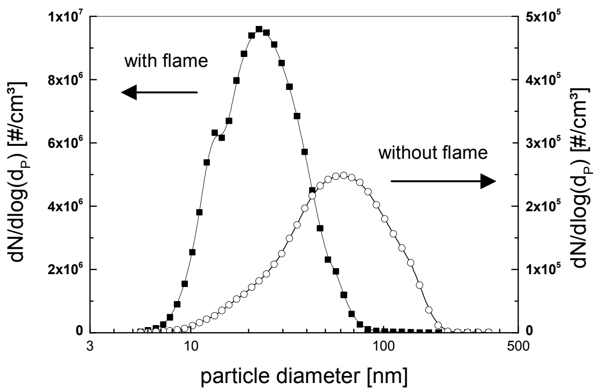

Figure 1: Comparison of the size distribution of a cerium oxide before and after flame ignition.

References:

Paur, H-R.; Baumann W.; Mätzing, H.; Seifert, H. (2005): *Formation of nanoparticles in flames; measurement by particle mass spectrometry and numerical simulation.* Nanotechnology 16 (7), S. 354.

Mätzing, H.; Baumann, W.; Bockhorn, H.; Paur, H-R.; Seifert, H. (2012): *Detection of electrically charged soot particles in laminar premixed flames.* Combustion and Flame 159 (3), S. 1082–1089.