The influence of temperature and humidity on the thermal stability of nanoparticles

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Nanoparticles are used in everyday products like sunscreen, wall colours, textiles or polymer composites. As the products reach their end of life they will usually end up in the waste. Since the untreated deposition of waste is prohibited in Germany and many other countries, it's quite usual to use a thermal treatment (municipal and hazard waste incineration) on certain types of waste. Few work has been published on the behaviour and possible release of these nanoparticles during incineration (Lang et al., 2015).

Basic investigations on the thermal stability of the pure nanoagglomerates are executed as well as the combustion behaviour of nanoparticles embedded in matrixes like polymers.

The basic investigations are carried out at different burner types (McKenna burner, tube burner) where a suspension of nanoparticles, like Ceria or Titania, is added to the flame (Propane/Air, Ethylene/Air). With the flame parameters cold gas velocity and stoichiometry the flame temperature can be changed and their influence on the morphology, size distribution, sintering behaviour, or new particle formation is investigated in different heights above the burner (HAB). In addition to the investigation above the flame measurements were carried out downstream of a tube furnace (T_{max} = 1800 °C) with air or nitrogen as carrier gas. By comparison of the results it's possible to differentiate between a mere temperature effect (tube furnace) and an influence of the flame chemistry (burner).

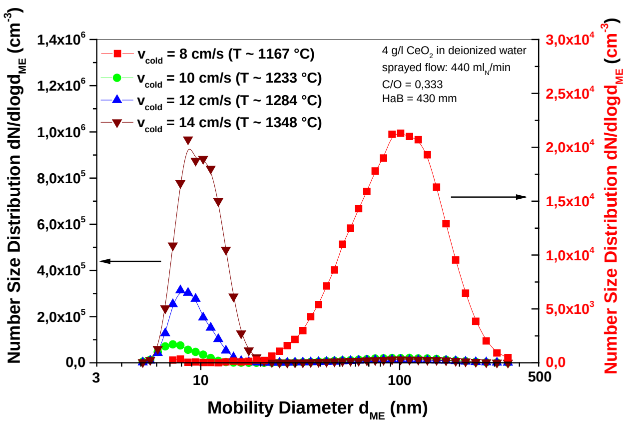

Figure 1. SMPS measurement of a ceria suspension added to the McKenna burner via center tube. The red curve belongs to the right axis and the other curves to the left axis.

By using different burning gases like Propane and Ethylene mixed with diluent gases (N_2 or Ar) a wide temperature variation is possible. With SMPS measurements and TEM images the morphology and number size distribution was studied. At first the original aerosol (without flame) was characterized. It was found that with a certain temperature of the flame the original size distribution starts to build a new peak at small particle sizes. The starting temperature is material dependent and this effect was interpreted as an evaporation and nucleation of the nano-material and was also found by other authors (Goertz et al., 2011).

Investigations in the tube furnace with similar temperature showed no new particle formation. In the tube furnace it was possible to add water via a bubbler system to the carrier gas (N_2 or Air) so that the same humidity is adjustable in the tube furnace as in the flue gas of the burner. With this change in the experimental set up a new particle formation was observed.

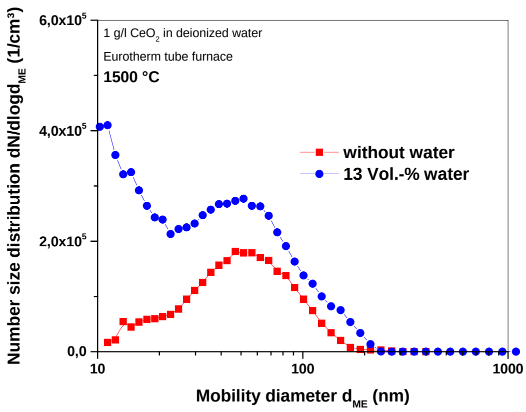

Figure 2. SMPS measurements of a ceria suspension at 1500 °C. The red curve is measured under dry condition and the blue curve is measured with 13 Vol.-% water in air.

Therefore the present components in the flame (radicals, reaction zone) or the flue gas (H_2O, CO_2, N_2) are assumed to be responsible for the observed effect in the flame.

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