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Behaviour of engineered nanoparticles in a lab-scale flame and combustion chamber

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Abstract

Nanostructured materials are widely used to improve the properties of consumer products such as tires, cosmetics, light weight equipment etc. Due to their complex composition these products are hardly recycled and thermal treatment is preferred. In this study we investigated the thermal stability and material balance of nanostructured metal oxides in flames, in a pilot scale combustion plant and an industrial hazardous waste incinerator. We studied the size distribution of nanostructured metal oxides (CeO_2, TiO_2, SiO_2) in a flame reactor and in a heated reaction tube. In the premixed ethylene/air flame, nano-structured CeO_2 partly evaporates forming a new particle mode. This is probably due to chemical reactions in the flame. In addition sintering of agglomerates takes place in the flame. In the electrically heated reaction tube however only sintering of the agglomerated nanomaterials is observed. Ceria has a low background in waste incinerators and is therefore a suitable tracer for investigating the fate of nanostructured materials. Low concentrations of Ceria were introduced by a two-phase nozzle into the post-combustion zone of a waste incinerator. By the incineration of coal dust in a burning chamber the Ceria nanoparticles are mainly found in the size range of the fly ash (1 – 10 µm) because of agglomeration. With gas as a fuel less agglomeration was observed and the Ceria nanoparticles were in the particle size range below 1 µm.

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Keywords: engineered nanoparticles; combustion chamber; waste incineration

1. Introduction

The amount of consumer products containing engineered nanomaterials is constantly growing. Cosmetics, plastics, paints, fuel catalysts, UV-coatings, textiles and electronics are only a few product groups in which nanoparticles like

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Titania, Ceria and CNTs are used to improve their properties [1]. As these products reach their end of life they often end up in the waste incineration (Figure 1). Till now only few data are published concerning a possible release of nanoparticles (NP) into the environment [2, 3, 4]. In the Institute for Technical Chemistry (ITC) at the Karlsruhe Institute of Technology (KIT) this topic is analysed in fundamental investigations of NP behaviour in lab-scale flames [5, 6], in technical investigations at a 2.5 MW combustion chamber at the KIT [7] and in large-scale investigations at an industrial hazardous waste incineration plant in the chemical industry. Since 2005, landfilling of municipal waste is no longer allowed in Germany and the only possible disposal routes are therefore recycling or thermal waste treatment (Figure 1). With every recycle step the product quality is decreasing and a thermal process is always the last possible treatment.

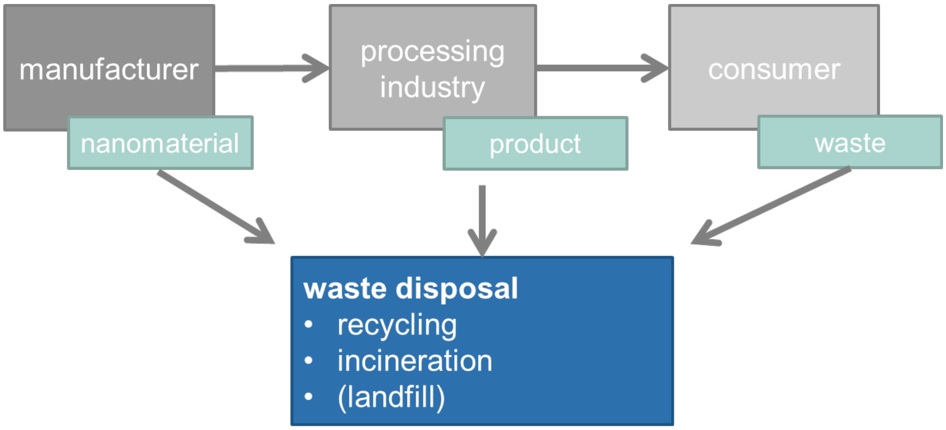

Figure 1: Life cycle of products including nanoparticles.

Figure 2 illustrates the flow sheet of a municipal waste incineration plant with possible paths of nanoparticle release. These can be the exhaust gas, the waste water or the solid residues. First investigations were concentrated on the release via the exhaust path and afterwards also other paths were studied including a mass balance of the incineration plant.

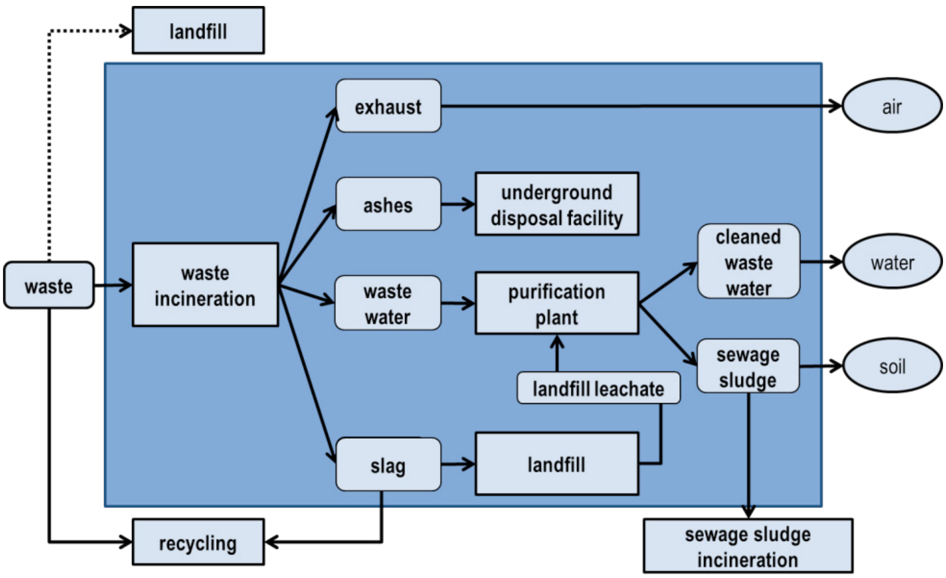

Figure 2: Flow sheet of a municipal waste incineration plant with possible paths of release of nanoparticles.