Behaviour of ZnO NPs during combustion processes of waste biomass: On-line, size-resolved elemental analysis

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ENPs (Engineered Nanoparticles) are widely used in many applications like motor- or vehicle-related products, electronics, paints, coatings and adhesives, household products, personal care and cosmetic products. For instance, ZnO is one of the relevant metallic ENPs regarding possible high exposures and it is often used for paints, impregnation and waterproofing sprays.

Increasingly with the interest in reduction of atmospheric particle emission, the release of such nanoparticles from waste incineration processes is of great importance. To date it is not fully clear whether the filtering systems used in waste incinerators can completely remove nanoobjects from the offgasses, and hence avoiding their emissions to the environment (Roes, 2012).

Under incomplete waste combustion mostly carbonaceous particles in the range of aerodynamic diameter of 100-200 nm are generated, however, metallic ultrafine particle emissions are reported (dominated by K, Zn and Ca, Fe, Mg and Na) (Sanderson, 2014).

In this work we aimed to study the behaviour of ZnO during wood combustion as model for a waste biomass, and hence to understand the influence of the different generated species on the redox-sensitive Zn (Ludwig, 2001). For a complete characterization of the ZnO and particles emitted from the combustion process, two important parameters are needed, namely the size distribution and the elemental composition.

Different techniques can be used to determine online particle size distribution and concentration of gas-borne particles; among them the Scanning Mobility Particle Sizer is one the most suitable (SMPS). The chemical composition is often determined off-line with multi elemental techniques (Krystek, 2011), such as Inductively Coupled Plasma Mass Spectrometry (ICPMS), on the previously collected particulate matter, segregated in the different size classes with the use of low pressure impactor. However contamination or morphology alteration of the particles for offline analytical methods must not be neglected.

For all these reasons, we recently developed and validated an analytical method to determine on-line the particle size distribution and elemental composition in aerosols and process gases, coupling a modified SMPS operating with argon instead of air with an ICP-MS (Hess, 2015 a, b). In our previous study we measured on-line different metallic particulate in aerosols emitted by impregnated wood samples, heated in a Thermogravimetric Analyzer (TGA).

In the current study the experimental setup consist on a tubular furnace, used as lab-scale incinerator, connected to the above mentioned SMPS-ICP-MS with a rotating disk diluter (RDD) and a heating tube, allowing an adjustable and high dilution ratio, in order to prevent condensation and introduce a well-defined flow of the aerosol into the SMPS.

The behaviour of Zn is studied considering two relevant situation, i.e. gas-borne NPs and NPs which are present in the feedstock. In the first case a stream of dried nanoparticles, generated by an aerosol generator, is injected in the lab-scale incinerator during the combustion, while in the other a wood sample is impregnated with ZnO nanomaterial. The physical and chemical behaviour of the ZnO in both cases is investigated.

Hess, A., Tarik, M. and Ludwig, C. (2015 a) *J. Aerosol Sci.,* **88**, 109-118.

Hess, A., Tarik, M., Losert, S., Ilari, G., Ludwig, C., (2015 b) *J. Aerosol Sci.***,** in press.

Krystek, P., Ulrich, A., Garcia, C.C., Manohar, S. and Ritsema, R. (2011*), J. Anal. At. Spectrom*., **26**, 170.

Ludwig, C., Lutz, H. and Wochele, J. (2001) *J. Anal. Chem.*, **371**, 1057-1062.

Roes, L., Patel, M. K., Worrell, E. and Ludwig, C., (2012) *Sci. Tot. Environ.*, **417–418**, 76–86.

Sanderson, P., Delgado-Saborit, J.M. and Harrison, R.M., (2014) *Atmos. Environ.*, **94**, 353-365.