PROPERTIES OF MERCURY IN GYPSUM STUDIED BY MASS SPECTROMETRY TECHNIQUE IN DEVELOPMENT OF METHODOLOGIES FOR SAFE SECONDARY USE OR DISPOSAL OF GYPSUM

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Introduction

The Šoštanj Thermal Power Plant (ŠTPP) is the biggest power plant in Slovenia and burns lignite which is extracted from the nearby Velenje Coal Mine. During coal combustion variety of different chemical and physical processes occur. Different air pollution control devices (APCD) such as electrostatic precipitators (ESP) and a wet flue gas desulphurization system (WFGD) have been installed along the system with the purpose of reducing emissions (trace elements, particles, gases) into the environment (Pavlish et al., 2003). The final partitioning of (trace) elements in the by-products is a consequence of several factors including type of coal and its mineral content, coal particle size, and other factors (such as emission control devices, temperature profile, turbulences) (Meij, 1994; Xu et al., 2004). The aim of this study was mainly focused on distribution of mercury and identification of mercury compounds in by-products of coal combustion, particularly in gypsum samples.

Methods

Samples of different by-products (coal, fly and bottom ash, gypsum) were collected in order to obtain the distribution profile of elements in each waste material. To access the importance of particle size gypsum samples were separated into finer and coarser fraction. Concentration of elements in all samples were measured by neutron activation analysis (k_0-INAA). Our special focus was mercury and mercury compounds present/formed in gypsum samples. Gypsum sample (1-10 mg) was loaded into a quartz tube, heated to 650 °C at 10 °C/min and analyzed by quadrupole mass spectrometer (QMS) to get thermal decomposition/desorption profile of Hg (thermograms).

Results

Basically, the partitioning of elements in fly and bottom ash corresponding to the literature data, except for Hg and Se that are highly enriched in gypsum samples with respect to the coal samples. In general, the concentrations of elements present in the coarser and finer fractions of gypsum varied, demonstrating the importance of particle size (Sedlar et al., 2015; Stergaršek et al., 2008). Further accumulation of mercury and most other elements is significantly higher in finer fraction compared to the coarse fraction. There are small differences between different blocks in ŠTPP using the same coal that might be the cause of the combustion regime, variations in APCDs or it is an error of sampling itself. Small differences between gypsum samples from two different FGD systems, coupled with the fact that all blocks use the same coal, may reflect the importance of coal rank.

Coarse and finer fraction show similar position of the released peak but the shape and intensity are not the same. In general identification of mercury compounds present in gypsum samples are under investigation since none of standards (mixture of various mercury compounds and pure chemical $CaSO_4 \cdot 2H_2O$) fits with the peak released in the real samples. Real gypsum samples are very complex matrices and elements/compounds present in gypsum may act as a surface for adsorption or catalysts which can shift the peak to higher or lower temperatures. QMS allows measuring of more ions at the same time that help in identifying of decomposition products and envisaging of the mercury compounds.

Conclusion

The stability of mercury compounds is important in determining whether or not waste material needs to be treated before being landfilled since the conditions of disposal can affect the release of Hg. In the production of the new materials, such as wallboard, where FGD gypsum is used as raw material, knowledge of the temperature at which Hg is released can aid in the design of the whole production process. Further investigations are required where interaction between different mercury species, various particles (surfaces) and compounds with catalytically role/adsorption affinity will explain the decomposition/desorption behavior of mercury (mercury compounds) from gypsum and other solid matrices.

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