INDUSTRIAL DEVELOPMENT PROJECT

Investigation of zinc and antimony in waste incineration fly ash using XANES, EXAFS, nano-XANES and nano-XRF techniques

THE INDUSTRIAL CHALLENGE

Ashes from incineration plants contain metals such as zinc (Zn) and antimony (Sb) which currently are lost when the ashes are landfilled. The chemical forms (speciations) of the metals are important when determining the ecotoxicity. Some chemical speciations are regulated and therefore knowledge about the metal speciations in the ash is crucial for a correct classification. Improved knowledge may also lead to higher recycling yields and reduced residual ash for disposal.

WHY USING A LARGE-SCALE FACILITY

The low metal concentrations and complex ash matrix hinders the use of traditional methods for analysing chemical speciation. However, a combination of synchrotron based X-ray Absorption Spectroscopy (XAS) techniques like XANES (X-ray Absorption Near Edge Structure), EXAFS (Extended X-ray Absorption Fine Structure), and the high spatial resolution nano-XANES, provides speciation information of specific elements. Additionally, nano scale X-ray Fluorescence (nano-XRF) provides a high-resolution elemental mapping that displays the metal distribution. The combination of these techniques enables studies of very low concentrations (>0.1%) in complex multi-element matrices.

HOW THE WORK WAS DONE

Samples of fly ash were collected from six Waste to Energy (WtE) facilities: five Swedish and one Norwegian. Fresh and processed (i.e. leached or stabilized with acids) ash samples were homogenised and analysed with XAS at the Balder beamline at MAX IV in Lund. The absorption edges of Zn and Sb were scanned and Linear Combination Fitting (LCF) between spectra of the ash sample and references performed. To get information about the physical distribution of trace metals in the ash particles, samples were analysed with a nano-focused (50 nm) X-ray beam using nano-XRF and nano-XANES at the I14 beamline of Diamond Light Source, UK, and at NanoMax at MAX IV. The samples were also leached sequentially, with the leachates analysed with respect to elemental composition using Inductively Coupled Plasma - Mass Spectrometry (ICP-MS).

THE RESULTS AND EXPECTED IMPACT

The use of combined techniques enabled identification of the most common Zn and Sb speciations in fly ash. The XAS results showed that the Zn condensates were alkali zinc salts, composing 40-65 % of the Zn in the ash. The nano-XRF indicated that smaller and coarser particles had different chemical content. The project results may be used by NOAH to reclassify their treated ash from hazardous to non-hazardous waste. A set of reference materials mimicking ash compounds were added to the XAS library at Balder (17 Zn and 15 Sb containing ash references). Lessons learned were that results from nano-XANES may be used to validate results from XANES, but the data could in this case not lead to stand alone results. The nano-XRF on complex matrices generates large amount of data and requires extensive analysis.

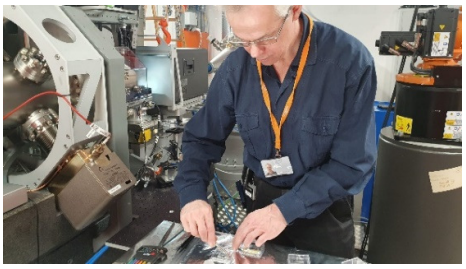

Figure. Mounting of samples at Nanomax, MAX IV.

"Detailed information on speciation of the metals in the ashes is crucial to design processes for recovery of values – information that is uniquely provided by synchrotron-based spectroscopy."
/Charlotte Nilsson, Fortum Waste Solutions AB

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