European Metrology Programme for Innovation and Research

Delivering Impact

Improving the detection of technology critical elements in urban e-waste

Urban waste contains computers, mobile phones, and televisions. These discarded electronic items hold many elements essential for modern technology applications. Whilst a range of European directives and acts are in place to recover these, the generation of electronic waste is rising five times faster than documented "e-waste" recycling and new metrology is required to halt this trend.

Europe's National Measurement Institutes working together

The European Metrology Programme for Innovation and Research (EMPIR) has been developed as part of Horizon 2020, the EU Framework Programme for Research and Innovation. EMPIR funding is drawn from 28 participating EURAMET member states to support collaborative research between Measurement Institutes, academia and industry both within and outside Europe to address key metrology challenges and ensure that measurement science meets the future.

Challenge

Urban electronic waste (e-waste) contains elements critical to both modern technology and the European economy. Many of these, such as lithium used in batteries, or samarium used in permanent magnets, are produced outside of Europe. As these elements are responsible for the functionality of a technology, they are often referred to as "Technology Critical Elements" (TCE).

The EU has targets in place to improve the recycling of TCE, including the Waste Framework Directive and the Critical Raw Materials Act, which sets a 25% recycling target by 2030. However, a 2024 UN report highlighted severe shortcomings. This stated that 62 million tonnes of e-waste was generated in 2022, up 82% from 2010. This would fill 1.55 million 40-tonne trucks, enough to encircle the equator, and e-waste is set to reach 83 million tonnes by 2030. The same report projected a drop in e-waste recycling from 22.3% in 2022 to only 20% by 2030.

A major hurdle is a lack of reference materials and sensitive analysis methods. These are vital to determine the amount of TCE present in waste and reassure recycling agencies about the efficacy of the process, which can incur high costs. In addition, these elements can also leach out, posing dangers to the environment and human health.

Solution

As no traceable analytic methods or reference materials existed for TCE, in MetroCycleEU, Montanuniversität Leoben assessed TCE detection using one of the most sensitive measurement instruments available, a PerkinElmer NexION 5000 inductively coupled plasma mass spectrometer (ICP-MS). In ICP-MS, analytes can be forced to react or collide with a gas, often oxygen (O_2), to change the target's mass, which is then measured with a mass spectrometer without a disturbing interference. During MetroCycleEU, a new reaction gas, nitrous oxide (N_2O) was assessed on 73 elements, showing an improvement in ICP-MS sensitivity for 59 of these.

An intercomparison was then performed on printed circuit board (PCB) reference material generated in the project with 10 participants from the recycling industry and analytical and academic laboratories, including many members of the MetroCycleEU consortium. Using ICP-MS or neutron activation, 20 relevant TCEs, including platinum and lithium, were analysed down to the microgram level. All but one method produced data with ± 20% in agreement of each other.

Impact

PerkinElmer are world leaders in developing analytical instruments for applications including atomic spectroscopy, chromatography, and molecular and mass spectroscopy. The company has a strong commitment in safeguarding the environment, partnering with customers, equipping them with technologies to enable development of environmentally friendly materials, products, and services. PerkinElmer produced the first commercial ICP-MS in 1983 and provided their award winning NexION 5000 to Montanuniversität Leoben, a member of the MetroCycleEU consortium – industry's first and only four-quadrupole ICP-MS instrument. It is the most sensitive on the market – a sensitivity that has improved using N_2O, information they can pass onto their customers.

MetroCycleEU has demonstrated the first SI traceable methods and materials for TCE analysis in e-waste, with reference materials for Lithium-Ion batteries and LEDs developed alongside the PCB used with the NexION 5000. In another project, this instrument was also used in the first investigation into contamination from e-waste in plants and aerosols in the city of Vienna, Austria, providing valuable insights for managing environmental risks.

Validated methods and materials now exist for TCE in urban waste. This will provide recycling industries with vital knowledge on potential retrieval amounts, support EU goals in this area, and help remove Europe's dependence on imports of vital elements.

Developing the metrology for technologically critical elements

The MetroCycleEU project:

- Produced three reference materials for TCEs in urban mine wastes in compliance with quality standards (ISO/IEC 17025): Printed circuit board (PCB), Lithium Battery (Li-B) and Light emitting diodes (LED).
- Performed an analysis on the PCB material developed using ICP-MS, demonstrating measurement uncertainties of < 10% for Au, Co, Dy, Ga, La, Li, Nd, Pd, Pr, Pt and Sm.
- Investigated the use of instruments that don't require predigestion of e-waste, neutron activation and laser ablation.
- Performed an interlaboratory comparison with users demonstrating the applicability of the methods and the use of the reference materials in real-world industrial settings.
- Evaluated the use of X-ray fluorescence spectroscopy for the analysis of TCE and other additional major chemical elements in waste materials.

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