EMPIR Call 2020 – Fundamental, Industry and Normative

Selected Research Topic number: **SRT-i14**
Version: 1.0

Metrology for the recycling of Technology Critical Elements to support Europe's circular economy agenda

Abstract

Technology critical elements (TCE), are a group of naturally occurring chemical elements increasingly used in high technology for their unique properties (conductive, magnetic, material properties). These critical elements are widely present in energy-efficient devices and in alternatives to fossil fuel energy. As such, TCE have gained much interest due to their economic importance and increasing scarcity. The European Commission has also identified recycling as a priority of the circular economy agenda and the amended Waste Framework Directive (2018/851/EU) has been updated with targets for the recycling of TCE-containing waste. However, progress toward this goal is currently limited predominantly due to a lack of accurate quantification of TCE. Harmonised methods for quantification of TCE will accelerate the knowledge of recycling strategies and new technology development. Therefore, new and improved reference methods and reference materials for TCE analysis in waste are needed.

Keywords

Technology Critical Elements, Circular Economy, Recycling, Electronic waste, Urban mining waste,

Background to the Metrological Challenges

TCE are used in many key industries such as solar panels (In, Ga, Ta), wind turbines (Nd, Dy, Ge, Gd), energy-efficient lighting (La), batteries for electric cars (Co) and electronic devices (Au, Pt, Pd, Rh, Pr), e.g. mobile phones, computers and sensors. What makes these elements critical is the lack of replacement for these materials and in 2017, the EU issued an updated list of Critical Raw Materials containing 17 chemical elements in addition to elements from the platinum group elements and all rare-earth elements.

Urban mine waste from Electrical and Electronic Equipment (WEEE) such as printed circuit boards and electric batteries is expected to grow to more than 12 million tonnes by 2020 in the EU. The total value of all raw materials present in WEEE was estimated at approximately 55 billion Euros in 2016. In order to secure the TCE supply, the EU has promoted more efficient recycling and waste collection through the amended Waste Framework Directive (2018/851/EU).

Accurate, traceable identification and evaluation of TCE concentrations in urban mine waste would allow the recycling industry to: (i) estimate the economic value of the waste, (ii) decide on a recycling route, (iii) engage in new R&D for recycling, and (iv) estimate the economic value of the final product. However, there is currently a lack of certified reference materials as well as analytical methodology for the analysis of TCE in waste matrices. The only reference material on electronic scraps currently available is BAM M-505a, but this is only certified for elements such as Au, Pt, Pd. Primary reference methods as well as certified reference materials are also needed in order to comply with ISO/IEC 17025. Inductively coupled plasma mass spectrometry (ICP-MS) and instrumental neutron activation analysis (INAA) represent the current state of the art for trace metal analysis. But whilst ICP-MS is available in many analytical laboratories, INAA is only available in a few research laboratories with access to a neutron source.

Additional analytical complexity comes from the engineered and heterogeneous matrix of urban mine wastes. Currently, TCE analysis on wastes can be performed by two types of techniques: (i) wet chemistry methods, requiring sample digestion, such as ICP-MS or inductively coupled plasma optical emission spectrometry (ICP-OES); and (ii) those used on a routine basis such as wavelength dispersive x-ray fluorescence (WD-XRF), glow discharge optical emission spectroscopy (GD-OES) or laser induced breakdown spectroscopy (LIBS). The latter do not require dissolution as analysis is performed directly on a solid sample. However, measurements performed on-site on the solid waste by non-destructive or quasi non-destructive techniques (losses of the order of micrograms) such as XRF, GD-OES, or LIBS are often semi-quantitative due to the challenging calibration and sensitivity to other factors such as particle size and smoothness of the surface.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the traceable measurement and characterisation of TCE in urban mine waste.

The specific objectives are:

1. To develop validated SI-traceable reference methods (e.g. ICP-MS, INAA) to determine mass fractions at µg/g levels in urban waste materials with a target combined uncertainty below 10 % for the TCEs Co, Ga, Ge, In, Ta, Nd, Pr, Dy, Gd, La, Au, Pt, Pd, Rh. In addition, sampling and digestion strategies for the reference methods should be optimised specifically for TCE in urban waste matrices.
2. To develop traceable and validated reference materials for the TCE selected in Objective 1 and to use them to validate TCE mass fraction measurements in urban mine wastes with a target combined uncertainty below 20 %.
3. To validate the use of the methods and reference materials from Objectives 1 & 2 using inter-laboratory comparisons involving at least 10 industrial laboratories using both destructive methods (e.g. ICP-MS, ICP-OES) and non-destructive or quasi non-destructive analysis (e.g. WD-XRF, GD-OES, LIBS).
4. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain, standards developing organisations (i.e. those associated with the Waste Framework Directive (2018/851/EU) and ISO/IEC 17025) and end users (recycling industry, analytical laboratories).

Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.5 M€, and has defined an upper limit of 1.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the recycling, electronics, energy and industrial sectors.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Time-scale

The project should be of up to 3 years duration.