Electro-assisted extraction of critical raw materials from coal ashes

V. Lopes[1], N. Couto[1], A.R. Ferreira[1], E.P. Mateus[1], S. Pamukcu[2], A.B. Ribeiro[1]

[1] CENSE, Departamento de Ciências e Engenharia do Ambiente, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal
[2] Department of Civil and Environmental Engineering, Lehigh University, Bethlehem, PA 18015, USA
Keywords: electrodialytic process, rare earth elements, recovery
Presenting author email: abr@fct.unl.pt

Over the past decade, the importance of resource efficiency and sustainable management of natural resources has increased considerably, culminating in the historic adoption of the 17 Sustainable Development Goals and in the decision by the leaders of the Group of Seven (G7) nations to promote ambitious actions to improve resource efficiency as a core element of sustainable development [1]. Resource efficiency is the big driver for the demographic growth of the global middle-class, and urbanisation will drive the demand. Over 50% of the world's population lives in urban areas and this is set to increase to 70% by 2050.

Raw materials (RM) are essential to Europe's economy, growth and jobs, as they are key for maintaining and improving our quality of life. Securing reliable, sustainable and undistorted access of certain RM is of growing concern within the EU and across the globe. At a policy level, the Europe 2020 Strategy recognises the need for broad scale economic changes and includes a resource efficient flagship initiative, which aims to build a smart, inclusive and sustainable economy – a circular economy [3]. This means increasing the share of renewable or recyclable resources while reducing the consumption of RM and energy, and at the same time cutting emissions and material losses [3]. The RM Initiative, created to manage responses to RM issues at an EU level, is also defining the critical raw materials (CRM) for the EU's economy. In 2017, the revised list presented 27 CRMs (COM(2017) 490) [4], which have both a high economic importance and high risk of supply interruption. This list of CRMs should help to implement the EU's industrial policy and strengthen industrial competitiveness, stimulate the production of CRMs and the launch of new mining activities in the EU, as well as to prioritise actions, negotiate trade agreements, challenge trade distortion measures, and promote research and innovation. Trust and acceptability particularly from industrial associations is also key. CRMs are hugely important in three main fields: i) Link to industry; ii) Modern technology and iii) Environment, and their importance has to be understood all along the supply chain.

The electrodialytic process (ED) is an electro-based technology that has proved to be efficient for heavy metals removal from porous matrices, with removal rates > 80% and low energy consumptions (< 0.05 kWh/kg) [5, 6, 7]. ED consists on the application of a low level current density, either direct current or alternate current, of a few mA/cm and a low potential gradient of V/cm, between suitably located electrodes [8] in a matrix. Due to the applied electrical field, the target elements/compounds will concentrate close to an electrode from where they can be removed.

The present work aimed to develop an electro-based technology to recover rare earth elements from coal ashes, never studied before. A two-compartment cell design is being tested with the matrix placed in the anode compartment during 3 and 7 days and using two different current intensities. The use of this cell design is expected to be a promising extraction technique for rare earth elements recover from coal ashes, taking advantage of inherent pH changes and avoiding the use of reagents for its adjustment.

The various parameters affecting the efficiency of the process for by-product valorisation should be further studied.

Acknowledgements

This work has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 778045; and from FCT/MEC through grants UID/AMB/04085/2013, Research unit CENSE "Center for Environmental and Sustainability Research".

References

[1] UNEP (2016). Resource Efficiency: Potential and Economic Implications. A report of the International Resource Panel. Ekins, P., Hughes, N., et al., http://www.resourcepanel.org/reports/resourceefficiency, accessed 12-01-2018.

[2] Commission's Communication *'Europe 2020 - A strategy for smart, sustainable and inclusive growth'* (COM(2010) 2020).

[3] EEA, Circular economy in Europe - Developing the knowledge base, European Environmental Agency, 2016.

[4] Commission's Communication *'on the 2017 list of Critical Raw Materials for the EU'* (COM(2017) 490).

[5] E. Velizarova, A.B. Ribeiro, A.M. Castro, L.M. Ottosen, Electrodialytic Removal of Heavy Metal (Cu, Cr and As) from Treated Timber Waste. In: Susana Luque e José R. Álvarez (Eds.), Proceedings of Engineering with Membranes, Granada, Spain, 2(2001) 3-19.

[6] H. K. Hansen, A. Rojo, L.M. Ottosen, Electrodialytic Remediation of Copper Mine Tailings. J. Hazard. Mater. 117(2004) 179-183, https://doi.org/10.1016/j.jhzmat.2004.09.014

[7] K.B. Pedersen, P.E. Jensen, L.M. Ottosen, A. Evenset, G.N. Christensen, M. Frantzen, Metal Speciation of Historic and New Copper Mine Tailings from Repparfjorden, Northern Norway, Before and After Acid, Base and Electrodialytic Extraction. Miner. Eng. 107(2017) 100–111, https://doi.org/10.1016/j.mineng.2016.10.009

[8] Y.B. Acar, A.N. Alshawabkeh, Principles of Electrokinetic Remediation. Environ Sci Technol, 27(1993) 2638–2647, https://doi.org/10.1021/es00049a002