effiCient mineral processing and Hydrometallurgical ReCovery of by-product Metals from low-grade metal containing seCondary raw materials
The CHROMIC project investigated new and existing technologies to improve the selective recovery process of Chromium (Cr), Vanadium (V), Molybdenum (Mo) and Niobium (Nb) from industrial by-products such as slags. These four metals are crucial for the competitiveness of the manufacturing sector and the innovation potential of high-tech sectors. Ensuring their steady supply is of strategic importance for the European industry. However, the four elements are almost exclusively mined and produced outside Europe - especially in China, Brazil, South Africa, Russia, Kazakhstan and Turkey - making the EU highly dependent on import. Europe, on the other hand, has large stocks of industrial by-products such as steel, stainless steel and ferrochrome slags, which contain a wealth of such metals. These slags are used mainly as aggregates in the construction industry, with small fractions of some slags even being landfilled. In these applications, the entrapped valuable elements are not used to their full value. The CHROMIC project aimed at unlocking the potential of these resources by pioneering the development of new sustainable ways of metal recovery, paving the way for a zero-waste recycling of the entire slag-material.

The CHROMIC project started out knowing that, on the long run, the introduction of novel sustainable processes to recover by-product metals will have important beneficial impacts on our economy, environment, and thus on society as a whole. It will alleviate Europe’s dependence on foreign sources of valuable and critical metals and it will help the European industry to turn waste into products with market value; it will reduce greenhouse gas emissions from metal production as well as the environmental impact of industrial waste; it will further improve the safety of the metal refinement processes.

Keeping in mind the potential for replication to other industrial value chains across Europe, the project focused on carbon steel (CS), stainless steel (SS) and ferrochrome (FeCr) production chains. In these model streams, great amounts of slags are
produced, which contain valuable metal resources at low concentrations that, nowadays, are not recovered from the material. CHROMIC’s first goal was to improve these model streams. Smart combinations of existing and new methods have been implemented, tested and validated for the extraction of valuable and critical raw materials from the slags in the most sustainable way, covering the entire recovery process, composed of three stages: pre-treatment (size reduction, beneficiation), selective leaching and selective metal recovery. This new production system devised by CHROMIC also implies that fractions of primary materials are recovered and can be reused as input flows in production processes, improving sustainability and reducing the environmental impact of the metal industry.

The results

Among the results obtained, it was found that for pre-treatment of the slag magnetic separation yields remarkable 3-fold increase of Cr concentration in the resulting magnetic fraction, and that high carbon FeCr slags treated with gravity separation techniques may have the potential to be used as a replacement for primary Cr ores in FeCr production. At the leaching stage, >95% liberation rates for Cr have been achieved for selected slags with the help of conventional and microwave roasting techniques. As for the final recovery, it was found that a combination of different methods - precipitation with nanofiltration and reduction; sorption, solvent extraction and electrocoagulation - is needed to obtain the target metals from the leachates, and it was shown that the selective recovery of Cr can be achieved through such a combined process. New sorption materials with a high selectivity for vanadium (V) over chromium(VI) were synthesized. Furthermore, flowsheets enabling to choose suitable processes for the recovery of metals from different types of leachates were developed. For Cr recovery, the entire flowsheet gives a >85% overall efficiency. While the materials studied in CHROMIC (CS, SS and FeCr slags) can be used as building materials or fertilizers, the CHROMIC processes can be used for other waste streams which currently cannot be valorized because of environmental constraints due to the presence of residual Cr. The recovery of valuable metals form these materials and removing of the environmental constraints for valorization of the residues would significantly improve the economic and environmental viability of the CHROMIC processes.

Ultimately, from the results of the tests performed during the technology validation stage, it was possible to estimate that (at least) 25000 tonnes of Cr per year can be recovered in Europe through the CHROMIC process. Potentially, thanks to CHROMIC, in a next future the steel slags can be considered as metal deposits.

Photo by Ludger Beninghaus
Beside technology-focused activities, CHROMIC also included an assessment of the impact of these technologies on the economy and – in a broad sense – on society. Through participatory events such as workshops and focus groups, CHROMIC collected the views and expectations of European citizens about the occupational, environmental and health aspects of metal production and recovery. The participatory activities involved citizens, stakeholders linked to the economical, health-related and environmental aspects of the project, civil society organizations and all the other value-chain actors.

We found that non-experts have very poor knowledge of the purposes and uses in the industry of non-common metals. There is little to no awareness of the life cycle of these materials and on how to connect metals to circular economy. In turn, it is expected that the development of new technologies impact positively on local and regional economies, on environmental sustainability, and on resource use efficiency.

Citizens also demand that communication about the development of new metal technologies be transparent. This request is shared by stakeholders, who consider transparency one of the crucial elements for metal technologies to be successful, along with safety (e.g. reduce risks of pollution from the detoxification of slags), economic advantage (e.g. reduce the need of primary raw material) and the involvement of all local actors in the development process.

The societal impact

PRE-TREATMENT METHODS
A combination of magnetic and density separation resulted in a 3-fold increase in Cr concentration (compared to the original material).

Roasting with NaOH followed by water leaching extracted >95% Cr and 33% V into solution.

In order to separate valuable elements from impurities in the solution, several methods have been combined. The entire flowsheet gives a >85% overall efficiency for Cr recovery.
The key contribution

Promising metal recovery techniques have been identified and selected, marking a first important step towards the final long-term objective of creating a circular economy - where all resources are kept at the highest possible level of functionality and value at all times - for the four metals studied in CHROMIC, as well as for other critical raw materials.

On the other hand, the insight collected through the participatory events is meant to support researchers, the metal industry, EU policy makers and regulators in taking future decisions and steering further research, with the aim of increasing citizen’s awareness and gaining societal trust, hence preparing a path for successful market application of the system process and technologies introduced by CHROMIC.

The CHROMIC project has contributed to set the way towards the realization of a circular economy for critical raw materials, which has the potential to bring significant economic and environmental benefit to the European society.

CHROMIC project

CHROMIC project is a coordination and support action financed by the European Commission under the Horizon 2020 Programme. It runs from November 2016 to October 2020.

Project coordination

Liesbeth Horckmans
VITO NV, Mol · Belgium

Consortium members

VITO: Belgium
Vlaamse Instelling voor Technologisch Onderzoek

MEAM: Belgium
Microwave Energy-Energies Applications Management

Orbix: Belgium

formicablu srl: Italy

ARCH: Belgium

TUKE: Slovakia
Technicka Universita v Košiciach

HZDR: Germany
Helmholtz-Zentrum Dresden-Rossendorf EV

BFI – VDEh Betriebsforschungsinstitute GmbH
Germany

FEBh: Germany
Institut für Baustoff-Forschung EV

brgm: France
Bureau de Recherches Géologiques et Minières

EWV: Germany
Elektrowerk Wasseiller GmbH
CHROMIC

efficient mineral processing and Hydrometallurgical
Recovery of by-product Metals from low-grade
metal containing secondary raw materials

www.chromic.eu
info@chromic.eu
#euCHROMIC