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CORDIS Results Pack on

sustainable processing of mineral resources

A thematic collection of innovative EU-funded research results

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Safety, sustainability and security for Europe's mineral processing industry

Research and Innovation

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Editorial

Dependence on mineral resources is rooted in their use in a plethora of devices and everyday applications: mobile phones, flat screen televisions, automobiles, solar panels, space guidance systems, jet engines and pacemakers. Even a smartphone contains more than 50 metals, including rare earth elements, that are in huge demand with limited supply. This Results Pack showcases seven EU-funded projects spearheading research to improve processing of these materials with emphasis on sustainability.

To achieve the objectives of the European Green Deal, there is a need for the supply and use of raw materials to meet the needs of a growing population that stays within the sustainable limits of our planet's natural resources and ecosystems.

Raw materials, in particular critical raw materials (CRMs), are crucial to Europe's economy. A reliable, uninterrupted supply of CRMs is necessary to enable a strong industrial base to produce the goods and technologies we have come to rely on in daily life.

To address this challenge, the European Commission has created a list of CRMs for the EU. This list is subject to review and update every three years to reflect the dynamic and expanding economy. Fourteen CRMs were identified on the first iteration of the list in 2011; by 2020 that number had grown to 30.

In parallel, as part of its Action Plan on Critical Raw Materials, the European Commission launched in 2020 the European Raw Materials Alliance (ERMA), an industrial alliance dedicated to securing a sustainable supply of raw materials in Europe. Vital to key EU industrial ecosystems such as automotive, renewable energy, defence and aerospace, the alliance will expand to incorporate other CRM issues, supporting the circular economy and addressing the EU Green Deal.

Reducing waste and closing supply chain gaps

The seven projects in this pack address many challenges: CRMs are rare and can be difficult to extract, exposure to them is often hazardous and toxic to the environment and their supply chains are vulnerable to competition from outside Europe.

Covering a wide range of the rare earth elements necessary for high-tech industry, the research also demonstrates that these raw materials and side streams that often end up as waste can be produced or reused sustainably through innovation.

Tapping the full potential of primary and secondary raw materials, these research projects boost the innovation capacity of the EU raw materials sector along the entire value chain.

Contributing to the circular economy in the construction arena, NEMO has demonstrated the potential use of mine tailings in concrete products as well as recovering additional metals from sulfidic residues. Aluminium production yields a vast amount of bauxite residue and the RemovAL project converts this into new products including substrate for road construction and building aggregates.

Many rare earth elements are reluctant to be separated from their rock deposits so optimisation of the extraction model is key. The SecREEts project extracts rare earth elements from phosphate rocks used in fertiliser production. Exotic-sounding metals like praseodymium are extracted that are used in permanent magnets for space exploration and healthcare. Making use of steel waste streams, CHROMIC removes chromium for use in the high-tech sector.

New methods devised by the FineFuture project separate mineral particles as small as 20 μm so that they are not discarded. PLATIRUS may enable the recovery of enough valuable platinum from mining and electronic waste to fill the supply gap up to 30 %, making Europe more competitive. One of the costliest elements on the market is scandium and its supply has been limited to imports from Asia and Russia. The SCALE project aims to establish a closed supply chain for the valuable metal used in high-intensity lighting and 3D printing applications.

Mine tailings to treasure: providing society with sustainable resources

Critical metals are vital to emerging technologies, but their extraction leaves behind a potentially dangerous environmental legacy. An EU-funded project is working towards novel solutions for the treatment of mining waste.

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Sulfidic mining waste residues, from mining and processing sulfidic ores to produce copper (Cu), zinc (Zn), lead (Pb), nickel (Ni) and other critical metals, represents the largest extractive waste in Europe. Approximately 600 Mtonnes are produced a year and there is a historic stockpile of 28 000 Mtonnes deposited in either tailings storage facilities, dry stacked or back-filled in mines.

When poorly managed, this waste can become an environmental hazard, causing problems such as acid-mine drainage or the outflow of acidic water from mine waste. At the same time, this waste represents a new stock of critical metals and minerals needed to move to a green circular society.

Recently, the European Innovation Partnership on Raw Materials launched a 'call to arms' to transform the 'extractive waste problem' into a 'resource recovery opportunity'. Responding to this call is the EU-funded NEMO project.

"Using a 'four pilots – three case studies' concept, NEMO takes up the challenge to develop, demonstrate and exploit new ways to valorise sulfidic tailings," outlines Mika Paajanen, project coordinator. The aim is to recycle up to 95 % of waste. Key to achieving this is increasing the technology readiness level of various innovative technologies within the near-zero waste treatment of sulfidic ores and sulfidic mining waste.

Using a 'four pilots – three case studies' concept, NEMO takes up the challenge to develop, demonstrate and exploit new ways to valorise sulfidic tailings.

The NEMO concept

The project focuses on three cases: the Sotkamo Ni-Cu-Zn-REE/Sc (rare earth element scandium) mine in Finland, Luikonlahti processing facility in Finland and the Tara Zn-Pb mine in Ireland. Through four pilots, using NEMO technologies, the project aims to demonstrate cutting-edge bioleaching processes to recover additional metals from sulfiidic ores/residues and to boost the conversion of sulfides to sulfates – helping to eliminate the risk of acid-mine drainage. It also seeks to 'clean' the residual matrix allowing its use in cement and construction applications.

"Results from the pilots to date include the development and evaluation of novel and innovative unit processes and flowsheets for the hydrometallurgical valorisation of low-grade base metals from processing residues. These include a low-duty bioreactor for cost-efficient hydrometallurgical processing and novel hydrometallurgical flowsheets for production of battery-grade metal concentrates," confirms Paajanen.

Additionally, two bioleaching options have been benchmarked, one in Sotkamo and one in BRGM France. In Sotkamo a bioleaching heap with enhanced operating conditions and in France a bioleaching pond. Metal extraction above 90 % was achieved in the first step of the pond bioleaching pilot.

"NEMO has also developed processes and mixtures that can incorporate a high percentage of mine tailings and has demonstrated the potential use of mine tailings in concrete products. These developments were achieved by project partners Boliden, Thyssenkrupp, VITO and Resourcefull, specifically targeting the tailings from the Tara mine of Boliden," emphasises Paajanen.

A new understanding of the specific nature of the secondary raw materials at each studied mining site has also provided useful information on their suitability for various processing and valorisation methods and on their exploitation potential.

Looking onwards

"It is expected that NEMO's technology will provide the EU with a range of benefits from new resources for the metal and agricultural sectors to a reduction in CO_2 levels in the metal recovery process and the replacement of ordinary Portland cement," concludes Paajanen. It will also be instrumental in eliminating acid-mine drainage and other environmental problems.

The project will continue monitoring the delivery of samples and the performance of the different pilots. It aims to replicate its technologies and concepts in other mines within the EU and beyond.

PROJECT
NEMO - Near-zero-waste recycling of low-grade sulphidic mining waste for critical-metal, mineral and construction raw-material production in a circular economy

COORDINATED BY
VTT Technical Research Centre of Finland Ltd in Finland

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/776846

PROJECT WEBSITE
h2020-nemo.eu/

Aluminium processing takes on new lustre

Researchers are demonstrating technologies to valorise bauxite residue – the by-product of aluminium production – so that it no longer needs to be disposed of as waste.

Practical and highly sought after, aluminium is a common material used in power lines, household appliances, consumer electronics, aircraft components, electric cars and modern buildings. The list of uses for which the material is used keeps growing. Despite its tremendous value, this lightweight yet strong and corrosion-resistant silvery metal presents a major constraint during its production: red mud, formally known as bauxite residue.

How the red mud stockpile increases

Bauxite residue is a caustic blend of different oxide compounds just like silicon, iron, aluminium, calcium, titanium and sodium oxides. Often found with rare earth element fragments, it is the industrial waste generated during processing into alumina using the Bayer process. And it is piling up.

"As its name suggests, bauxite residue is what's left after treating the bauxite ore for alumina extraction. The extracted alumina is then used in primary aluminium production," notes Efthymios Balomenos, senior consultant at Greece-based energy & aluminium company MYTILINEOS. The amount of the waste generated is astounding. "We need about 2 tonnes of alumina to make 1 tonne of metallic aluminium. A tonne of alumina production generates on average 0.8 tonnes of bauxite residue in Europe."

To estimate the accumulated waste, we need to consider that around 4 million tonnes of aluminium are produced each year in Europe, which account for just 8 % of the global production. "It is now evident how bauxite residue piles up since only 3 % of it is reused as a raw material," adds Balomenos.

Technologies to remove the waste streams

Balomenos is coordinating the EU-funded RemovAL project that his company has been running since 2018. RemovAL is designed to pool together certain technologies that help transform bauxite residue into valuable products and raw materials and scale them up at industrial pilots. The next step is to combine them in sustainable flowsheets that can achieve complete bauxite residue valorisation in specific alumina plants with waste generation close to zero.

"What sets us apart from state-of-the-art initiatives is that we do not only help advance the technological readiness of aluminium processing solutions but also take first steps towards designing new industrial ecosystems and value chains around bauxite residue reuse," explains Balomenos.

Researchers' attempts to demonstrate bauxite residue treatment technologies have so far been rewarding. At a MYTILINEOS pilot plant unit and then in another refinery in Ireland, researchers demonstrated a new residue treatment method to decrease the alkaline concentration in bauxite residue, keeping the sodium oxide content below 0.5 % wt.

This opens up a plethora of new applications, with the ability to use processed bauxite residue. Together with other industrial by-products, bauxite residue was used to produce a stable and safe substrate for road construction, as demonstrated in a pilot application in Ireland.

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Lightweight aggregates and high-performance binders for buildings are other exciting application uses of bauxite residue. A pilot plant in Germany demonstrated the production of lightweight aggregates from bauxite residue, while at KU Leuven University, a new high-strength binder has been created. In Norway, researchers aim to scale the production of a ferro–silicon alloy by heating bauxite residue and other industrial by-products from aluminium primary production, such as spent potlining, in an electric arc furnace. The slag from this process is used in hydrometallurgical pilots in the project in Greece and Germany to recover aluminium and titanium oxides as well as critical raw materials like scandium and gallium.

We plan to achieve 100 % reuse of bauxite residue, providing significant gains in environmental and resource preservation. Europe-based production of critical raw materials like scandium and gallium, is an additional bonus.

RemovAL provides a sustainable pathway for valorising bauxite residue along with other industrial by-products from its pilot plants, considering waste characteristics, logistics and the potential for symbiosis with other nearby plants. "In the long term, we plan to achieve 100 % reuse of bauxite residue, providing significant gains in environmental and resource preservation. Europe-based production of critical raw materials like scandium and gallium is an additional bonus," Balomenos concludes.

PROJECT
RemovAL - Removing the waste streams from the primary Aluminium production and other metal sectors in Europe

COORDINATED BY
MYTILINEOS SA in Greece

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/776469

PROJECT WEBSITE
removal-project.com/

Building a European value chain for rare earth elements

Critical raw materials are of high economic and strategic importance to the European economy, but they are associated with high supply risks. One forward-looking team of researchers has set to work to secure Europe's access to these materials.

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Rare earth elements (REEs) are crucial for producing the goods and applications we use every day, including vital green technologies such as computers, TVs, electric vehicles and wind turbines. There is, however, growing concern over reliable and unrestricted access to certain raw materials, particularly in Europe. This is because Europe does not have primary REE sources, and as a result is dependent on imports from mining countries such as Australia, China, Myanmar/Burma and the United States.

The EU-funded SecREEts project seeks to transform the way Europe acquires these elements. "We aim to establish a stable and secure supply of critical REEs based on a sustainable extraction from phosphate rocks used in European production of fertilisers," outlines Arne Petter Ratvik, project coordinator and senior research scientist with SINTEF, one of Europe's largest independent research organisations.

We aim to establish a stable and secure supply of critical REEs based on a sustainable extraction from phosphate rocks used in European production of fertilisers.

Game-changing value chain

To achieve this, the project is working towards the creation of an integrated value chain to produce REEs in Europe, based on process demonstrations in three pilots. "Focus will be on the metals praseodymium (Pr), neodymium (Nd) and dysprosium (Dy) used in permanent magnets, as these are extremely critical for the European economy," notes Ratvik.

The project primarily involves Yara International ASA, a company that aims at extracting a concentrate of rare earths from its fertiliser production. Yara's production uses approximately 650 000 tonnes of phosphate annually. This contains approximately 0.3 % to 1 % rare earths, which are not currently being extracted. "A company working on REE separation technology, REEtec, separates out rare earths that are input to magnet metal maker Less Common Metals (LCM), while returning the non-rare earth products to Yara's fertiliser production line," adds Ratvik. Magnet alloys produced at LCM are validated by magnet producer Vacuumschmelze.

The produced magnets will be supplied to application areas such as automotive (electric vehicles), industrial motors (advanced manufacturing), and potentially, clean energies (wind turbines).

Great potential

"Good progress has been made in all pilot stages," reports Ratvik. Further verification and optimisation activities will continue. It is expected that a successful industrial implementation of the pilots can lead to a supply of at least 600 tonnes annually of neodymium-praseodymium (NdPr) REEs to European industries, with EUR 85 million in estimated value based on current prices.

Ratvik concludes: "Establishing a new value chain in Europe based on already mined ore for fertiliser production represents by far the lowest environmental footprint of rare earth extraction globally." This is due to the fact that new mining waste is not being created. The value chain is also expected to further strengthen Europe as a resource-efficient and environmentally conscious area, and help create and secure existing jobs, reduce import risks and support the growing green technology industry.

PROJECT
SecREEts - Secure European Critical Rare Earth Elements

COORDINATED BY
SINTEF AS in Norway

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/776559

PROJECT WEBSITE
sintef.no/projectweb/secreets/

Revolutionising the recovery process of valuable raw materials from industrial by-products

By combining existing methods and new technological innovations, an EU-funded project has unlocked the potential of critical metals in industrial waste.

Chromium (Cr), vanadium, molybdenum and niobium are pivotal metals for the competitiveness of the manufacturing sector and the innovation potential of high-tech sectors. However, Europe remains exceedingly dependent on their import, risking an inflexible and insecure supply, while such metals are found in abundance in industrial waste or used in applications where their intrinsic value is not fully utilised.

Large amounts of steel and ferrochrome slag, waste after mining or processing, are produced annually. These contain significant amounts of metals, in particular Cr. Currently, the slags are mostly used in construction applications as sand or aggregates for their technical properties. However, the metals contained within do not have a purpose in this application and are therefore lost. Moreover, their presence can seriously harm the environment.

The EU-funded CHROMIC project focused on developing new sustainable technologies for the recovery of critical and valuable metals from steel and ferrochrome slag. "We hoped to find ways to take the metals out of the slag before using them in construction applications," explains project coordinator Liesbeth Horckmans.

Juggling with hazardous substances

Removal of the large (> 2 mm) metallic particles is a common practice and state-of-the-art technology. However, the finer metallic particles and the oxidised forms of the metals are not recovered. CHROMIC was successful in developing a highly efficient hydrometallurgical method, able to recover more than 95 % of Cr present in the slag.

Nonetheless, to get the metals out of the slag, Cr must be changed from its insoluble, non-hazardous form Cr (III) into the soluble, hazardous Cr (VI). Due to the very stringent limits on Cr (VI) leaching, all residual Cr (VI) must be removed from the solid – a major challenge that the project team has not yet been able to solve.

"This proved more difficult than foreseen, and some unexpected reactions occurred. In the project, we only had limited time to investigate, so this is certainly a topic to investigate further," notes Horckmans. "We are looking for new opportunities to continue the research – also looking at other metals. Chromium is a particularly difficult metal because of the highly hazardous nature of Cr (VI) and the resulting very rigorous legislation."

We are looking for new opportunities to continue the research – also looking at other metals. Chromium is a particularly difficult metal because of the highly hazardous nature of Cr (VI) and the resulting very rigorous legislation.

A multi-beneficial solution

Despite the challenges, CHROMIC has reached significant and completely sustainable results. Apart from those related to the technological core of the project,

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there are also those addressing assessments on the impact of the technologies on the economy and society.

The solution will benefit metal-producing companies with high-Cr residues, as the removal of Cr can generate value and increase the application options for the slags. The latter is especially important in the circular economy, to avoid overconcentration of metals in downstream use. Landfill owners with high-Cr waste, such as governments, will also benefit from CHROMIC results, given that the removal of Cr can generate value and can make often-used materials less hazardous.

Moreover, according to an integrated economic and environmental assessment, once the Cr issue is solved, the process can be beneficial compared to landfilling. This led the CHROMIC team to perform a three-step community involvement plan gathering information from laypeople, experts and students about their views on metal recycling.

PROJECT
CHROMIC – effiCient mineral processing and Hydrometallurgical RecOvery of by-product Metals from low-grade metal contaIning seCondary raw materials

COORDINATED BY
Flemish Institute for Technological Research (VITO) in Belgium

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/730471

PROJECT WEBSITE
chromic.eu/

Groundbreaking methods for maximising fine-particle recovery from ores

Researchers are developing new methods to more efficiently separate valuable fine materials measuring less than 20 μm from ores. The process involves attaching the particles of the desired material to air bubbles and recovering them as a froth.

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Treating fine-grained materials poses a great challenge for the mining industry. Ores must first be crushed and ground down to the micrometre range, a process that increases their surface area and liberates the mineral particles from gangue.

At this early stage, froth flotation helps to separate particles based on the ability of minerals and metals, hydrophobised by flotation reagents, to adhere to the surfaces of air bubbles in an aqueous slurry. These bubble-particle aggregates are carried to the surface of the pulp (slurry), where they enter the froth which is then removed. The remaining material from the ore that does not rise to the surface forms the flotation tailings.

The challenge of recovering (ultra)fine particles

Although froth flotation can efficiently handle particles whose size ranges between 20 μm and 200 μm, it has yet to make significant headway in treating smaller particles. Fine and ultrafine particles cannot easily float as they have low collision and attachment efficiencies with air bubbles, leading to the loss of valuable minerals. Furthermore, owing to their relatively high surface area, these smaller particles require more reagents for their processing.

The EU-funded FineFuture project is working on inventive solutions for recovering fine particles of high grade and at high rates, so that valuable ultrafine materials are no longer discarded.

"The ability to recover particles smaller than 20 μm in size is very important since currently no technology exists that can efficiently capture them without spending much energy and water. Our advanced energy-efficient solutions promise significant reductions in resource losses, thereby promoting the competitiveness of the EU mining industry," notes project coordinator Kerstin Eckert.

Going green and staying afloat

FineFuture aims to advance fundamental understanding of fine-particle flotation. Its groundbreaking technological solutions are expected to provide a sustainable pathway for valorising resources through reprocessing tailing deposits, while they could also help unlock new critical raw materials from natural deposits and mining waste.

Researchers are on track to offer methods that demonstrate superior performance, 20 % energy savings and 30 % water savings compared to the state of the art.

Generating electrostatic attraction and smaller bubbles

"A major focus has been on effectively controlling the surface interactions between bubbles and fine particles to selectively enhance their attachment probability," explains Eckert. So far, researchers have been testing methods to describe the interactions between collector reagents, depressants and minerals.

The FineFuture team has also reported methods to enhance the flotation selectivity of carbonate minerals. The use of non-ionic additives led to a significant decrease in the collector consumption. The project developed a new collector causing an electrostatic attraction between bubbles and silica-based particles.

An effective strategy to overcome the problems of fine-particle flotation is to decrease the bubble size and use special types of flotation cells, known as reactor-separator cells that boost particle–bubble interactions. Researchers achieved progress on this front. In particular, they reported different technologies for generating microbubbles, including the use of an air-in-water microdispersion generator. Flotation tests conducted using this generator showed that microbubble addition promoted the recovery of quartz particles.

Towards a new mining paradigm

"FineFuture applies a transdisciplinary and first-of-its-kind research approach that merges colloid and interface science, fluid dynamics, physics, mineral processing, chemical engineering, electrical engineering, computational science and advanced mathematics," notes Eckert. "Our groundbreaking concepts and technologies will shift the current mining paradigm towards exploiting natural mineral deposits consisting of tiny grains in an economic and environmentally friendly way."

Our groundbreaking concepts and technologies will shift the current mining paradigm towards exploiting natural mineral deposits consisting of tiny grains in an economic and environmentally friendly way.

PROJECT
FineFuture - Innovative technologies and concepts for fine particle flotation: unlocking future fine-grained deposits and Critical Raw Materials resources for the EU

COORDINATED BY
The Helmholtz-Zentrum Dresden-Rossendorf (HZDR) in Germany

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/821265

PROJECT WEBSITE
finefuture-h2020.eu/

A sustainable bridge for the gap between supply and demand of valuable metals

Closely linked to green technologies and crucial for a broad spectrum of technological applications, platinum group metals are in demand more than ever. An EU-funded project addresses the challenge of establishing their stable supply in Europe.

Among the scarcest of Earth's elements, the platinum group metals, so-called PGMs, are classified by the European Commission as critical raw materials. The group includes six elements: ruthenium (Ru), rhodium (Rh), palladium (Pd), iridium (Ir), osmium (Os) and platinum (Pt), the last being the most commercially significant as it is extensively used from the automotive and electronics to high-tech industries.

While global demand is disproportionally growing in comparison to the supply potential, even more dramatically within the context of the global geopolitical turmoil, there is an urgent need for effective circular solutions. Apart from traditional mining, PGMs can also be acquired through conventional recycling methods that are, however, highly energy-intensive and harmful for the environment.

Through the joint work of a consortium comprised of 11 recognised and experienced key actors across the value chain representing industry, research and academic organisations, the EU-funded PLATIRUS project developed innovative, cost-efficient and sustainable technologies to recover PGMs from spent autocatalysts, mining and electronic waste.

PLATIRUS will reduce the EU's current dependence on PGMs by filling the supply gap up to 30 %, diversify the supply chain and make Europe competitive while preserving the environment.

Moving forward through trial and selection

PLATIRUS was split into three key phases. Phase 2016-2018 focused on researching innovative technologies in all stages of leaching, separation and recovery.

The period 2018-2019 included the selection of the best technologies for validation supported by economic and environmental assessment. Microwave-assisted leaching (VITO, Belgium), non-conventional liquid extraction (KU Leuven, Belgium) and gas-diffusion electro-crystallisation (VITO, Belgium) technologies have been evaluated with the highest recovery, environmental impact, flexibility, low-cost and compact-size technologies.

Finally, the main objective of phase 2019-2021 was the upscaling of the selected technologies and operation in cascade in an industrially relevant environment. These methods successfully recovered PGMs from secondary resources and demonstrated that it is possible to use these recycled PGMs to manufacture new autocatalysts.

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A green and competitive goal that benefits us all

Deployment of PLATIRUS's solutions will enable optimisation of PGM recycling, increase resource efficiency and production of new sustainable products. PLATIRUS will reduce EU's current dependence on PGMs by filling the supply gap up to 30 %, diversify the supply chain and make Europe competitive while preserving the environment.

The project has been highly successful: four PLATIRUS technologies have been categorised as market-ready innovations in the Innovation Radar, the European Commission initiative to identify high-potential innovations and innovators in EU-funded research and innovation projects.

Moreover, essential information about the developed technologies, as well as the potential exploitation routes for the recovery of PGMs, has been shared with interested stakeholders through a series of seminars, workshops and conferences.

PROJECT
PLATIRUS – PLATInum group metals Recovery Using Secondary raw materials

COORDINATED BY
FUNDACION TECNALIA RESEARCH & INNOVATION in Spain

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/730224

PROJECT WEBSITE
platirus.eu/

Elusive scandium awaits in industrial by-products

Researchers are developing technologies for extracting scandium from metallurgical waste that could provide the EU with a reliable supply of this valuable rare earth elements.

Owing to its scarcity and limited production, scandium (Sc) is currently one of the costliest elements on the market. This soft, silvery transition metal has been used for decades to create high-intensity lighting and solid oxide fuel cells, as well as aluminium-scandium (Al-Sc) alloys used in high-end sporting equipment and 3D printing applications. However, scandium supply has been limited to imports from Asia and Russia.

Bauxite residues from titanium dioxide pigment production contain trace amounts of scandium that could be exploited with a viable extraction technology.

Turning industrial waste into treasure

The EU-funded SCALE project is taking the first steps to establishing a closed supply chain for scandium in Europe. The use of industrial by-products, which now are mostly disposed and stockpiled, contributes to the circular economy approach adopted by the EU.

"Bauxite residues from alumina production and acid waste from titanium dioxide (TiO2) pigment production contain trace amounts of scandium that could be exploited with a viable extraction technology," notes Efthymios Balomenos, senior consultant at Greece-based energy & aluminium company MYTILINEOS and project coordinator. These mineral concentrates are then processed with advanced refining technologies to produce pure scandium compounds. The pure scandium compounds are used, in turn, as feedstock for producing Al-Sc master alloys.

SCALE has been developing breakthrough technologies to overcome both metal extraction and production barriers. It has also been optimising refining technologies to decrease the processing costs and eliminate the use of harmful reagents. So far, significant progress has been achieved in the pilot-scale extraction of scandium from bauxite residue and acid waste from TiO2 production. Using 10 tonnes of bauxite residue and 2 m^3 of acid waste, researchers obtained scandium concentrates with scandium content up to 25 wt %.

A novel scandium-refining flowsheet has also been developed, allowing efficient and flexible scandium(III) oxide (Sc2O3) and scandium(III) fluoride (ScF3) production, circumventing the use of commonly used hazardous chemicals like hydrogen fluoride gas. Furthermore, researchers trialled the production of high-performance Al-Sc master alloys in a pilot plant. Through the aluminothermic reduction of ScF3 or the molten salt co-electrolysis of aluminium and Sc2O3, they eliminated the need for metallic calcium, a highly expensive and difficult to produce reagent.

The work conducted in SCALE will continue in two follow-up projects under EIT RawMaterials, which are likely to bring about the creation of a supply chain for scandium in Europe. The first one aims to create a scandium refinery process obtaining acid waste as primary feedstock and Sc2O3 as a product. The second one will focus on further optimising and scaling up scandium extraction from bauxite residue.

Tapping into the potential of Al-Sc alloys

Al-Sc alloys represent a new generation of high-performance alloys with superior properties compared to all other aluminium alloys. Small amounts of scandium enhance the metal strength, corrosion resistance, grain size and recrystallisation resistance. Importantly, the element provides the highest increment of tensile strength per atomic percentage than any other alloying element when added to aluminium.

"Aircraft manufacturers, for instance, could use it to build planes that have lighter aluminium framing and burn less fuel," notes Balomenos. "Scandium use in bicycle frames has demonstrated a 12 % reduction in weight, a 50 % increase in yield strength and a 25 % improvement in fatigue life compared to the best-selling aluminium bicycle frames."

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PROJECT
SCALE - Production of Scandium compounds and Scandium Aluminum alloys from European metallurgical by-products

COORDINATED BY
MYTILINEOS SA in Greece

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cordis.europa.eu/project/id/730105

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RESULTS PACK ON MINERAL EXPLORATION

This Results Pack focuses on the innovative results developed by eight Horizon 2020-funded projects working on exploration technologies for a sustainable supply of raw materials.

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cordis.europa.eu/article/id/413488

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