PhD IN MINERAL PROCESS ENGINEERING

Universidad de Antofagasta

Every remarkable innovation and groundbreaking discovery is born from a simple act of curiosity, reflecting our shared human desire to explore and understand the world around us.

PhD in Mineral Process Engineering

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Overview

This program responds to the need to generate knowledge that facilitates the innovation and technological development of the mining industry. For this, our postgraduates are prepared to carry out first-class scientific and technological research, and to apply their knowledge in original and innovative ways within the field of the industrial processes involved in metal mining and industrial minerals.

The objective of the program is to cultivate graduates capable of autonomously proposing, leading, and executing original research. The outcomes of this research are intended to contribute to the body of scientific and technological knowledge within the domain of industrial processes associated with metal mining and industrial minerals.

Our program aims for excellence, offering top qualifications in Chile and ranking first among doctoral programs related to mining in the Chilean accreditation system.

Double graduation agreements

The program has a national and international network of collaborations, including double degree agreements with various universities, such as
Lappeenranta-Lahti University of Technology (Finland),
University of Barcelona (Spain),
University of Valladolid (Spain),
Autonomous University of Madrid (Spain),
University of Granada (Spain),
University of Lleida (Spain),
University of Santiago de Compostela (Spain),
and the Université du Québec en Abitibi-Témiscamingue (Canada).

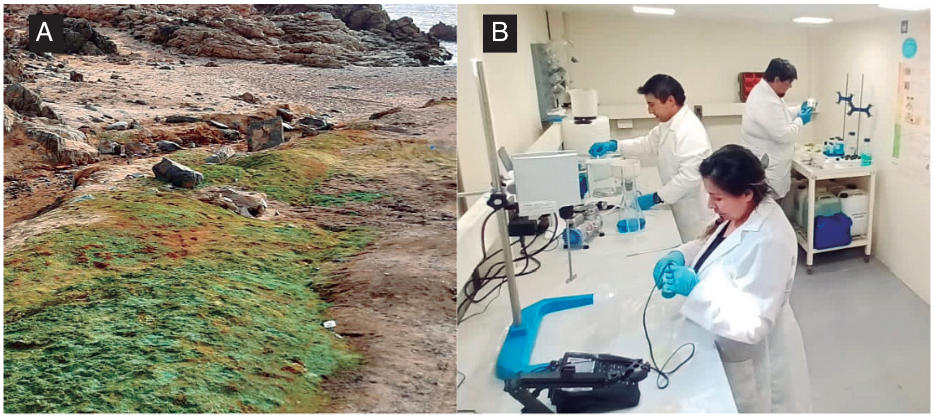
Research Areas

The research areas include Process Engineering Sciences, Separation Systems Engineering, and Process Systems Engineering.

Process Engineering Sciences engages in foundational research encompassing thermodynamics, electrochemistry and corrosion, phase equilibrium, and biotechnology. This research seeks to deepen our understanding of various phenomena that are crucial for the advancement of mining, particularly in the realms of process engineering and the management of water and energy resources.

Separation Systems Engineering explores separation technologies with a focus on methods such as leaching, bioleaching, crystallization, flotation, bio-flotation, and electro-dialysis. The objective is to enhance mineral extraction processes while optimizing the efficient use of energy and water resources.

Process Systems Engineering employs systematic, computer-assisted approaches to process engineering. This discipline emphasizes the design, modeling, analysis, and optimization of processes related to leaching, flotation, and the management of water resources.

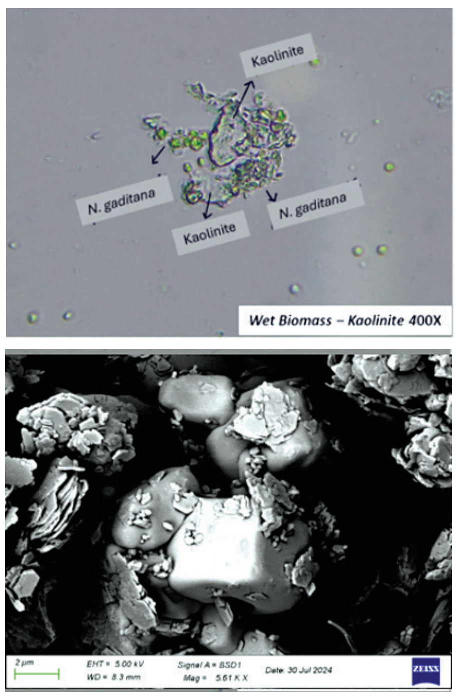


A. Contaminated soils from mining are found on Chañaral's coast and elsewhere.
B. The MBL-UA team working on bioremediation to clean up these wastes.

Getting Metals Back with Seaweed: A Friendly Approach to Mine Tailings reprocessing

The mining industry is essential for human development and must enhance productivity and environmental sustainability. Biotechnology offers safer technologies that positively impact mining practices. This includes biohydrometallurgy and biobeneficiation for extraction, as well as environmental initiatives like bioremediation of mining effluents and water recovery.

Mining is an activity that provides significant benefits to the countries in which it occurs. However, it also negatively impacts the environment, such as the potential contamination of soils and both continental and oceanic waters with heavy metals.
Various physical and chemical methods, including precipitation, ion exchange, filtration, and adsorption, are available to effectively treat or eliminate heavy metals. However, these techniques often suffer from low selectivity, high operating costs, and the generation of secondary waste. In response, new technologies have emerged that aim to remediate contaminated environments in a more environmentally friendly and cost-effective manner. One such method is bioremediation, which utilizes biomass from plant or microbial sources to remove contaminants like heavy metals.
At the Mining Biotechnology Laboratory (MBL) at the Universidad de Antofagasta (UA), which is part of the doctoral program, researchers are studying the application of biotechnology for treating tailings and other mining waste. This laboratory consists of academics, doctoral researchers, and undergraduate students who are exploring the ability of various marine algae to recover copper and other heavy metals from tailings, anodic sludge, and contaminated soils. Their goal is to harness the unique properties of certain polymers found in the tissues of specific marine plant species to interact with these metals.
So far, the algae-based additives developed in the laboratory have significantly reduced the copper and arsenic content in mining effluents, while also creating a seaweed-based adsorbent matrix with a high capacity for reuse and biodegradability.



Kaolinite-type clay floccules with Nannochloropsis gaditana and Chlorella sp. Ch03 microalgae, with surface interactions at the amide and carbonyl bonds.

Enhancing the quality of recirculated water by removing clays using biologically based flocculants.

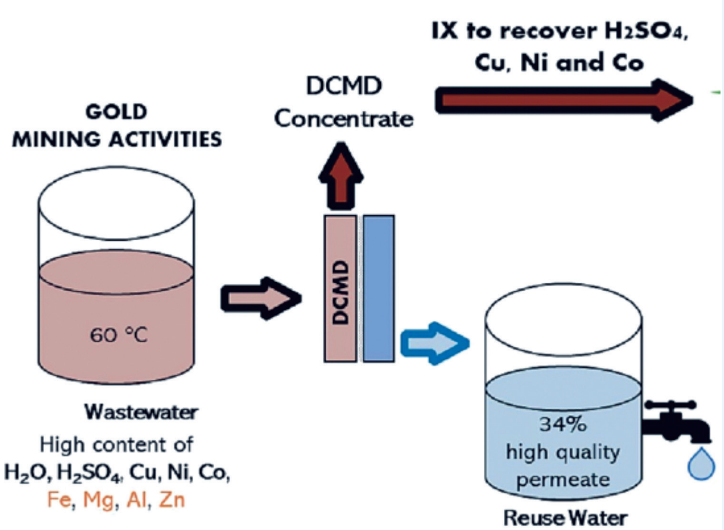
Water is a vital yet complex resource for mining, especially given its scarcity and importance for life. The industry has been innovating ways to improve water management, incorporating seawater and recirculated water into mineral processes by almost 73%. After metal extraction, waste material is transported as slurry to tailings, and while solids consolidate, recovered water can be recycled. However, clays hinder mineral concentration, leading to the use of flocculants for clarification. Our research focuses on bio-based reagents that form flocs with clays spontaneously.
The mining industry is increasingly adopting "green mining" and the "circular economy." Bio-based, biodegradable reagents that are environmentally friendly are crucial to these concepts. While bacteria in bioleaching processes have been used for years, advances are being made in bioflotation and extracting minerals from seawater. Notably, microalgae can spontaneously interact with clays to form rapid flocs in both fresh and seawater.
Microalgae and cyanobacteria are used across various industries due to their bioactive compounds, but they can also cause harmful algal blooms. In Asia, specific clays help microalgae form flocs that settle without resuspension. This knowledge has led to exploring the opposite effect: the settling of colloidal clay in mining recirculated water.
Kaolinite, a common clay, negatively impacts mineral processing, prompting the use of chemical flocculants like polyacrylamide (PAM). However, PAM has environmental drawbacks, including toxicity. In our study, we investigated microalgae such as Nannochloropsis gaditana and native strains from the Atacama Desert. We characterized them and conducted sedimentation tests, revealing that they formed clay-microalgae flocs rapidly and effectively reduced turbidity. This suggests that bio-based reagents from microalgae could offer a sustainable solution for clay removal in mining water management.

Water treatment in mining: Essential for sustainable practices

Water treatment in mining is a vital process that ensures the sustainability and environmental responsibility of mining operations. While mining is essential for resource extraction, it often generates large amounts of wastewater contaminated with pollutants such as heavy metals, suspended solids, and acidic compounds. Key challenges in this process include high concentrations of pollutants (e.g., lead, mercury, and arsenic), large volumes of wastewater, variability in water quality (which can depend on the type of mining operation, ore, and extraction methods), and the remote locations of many mining sites.

Water treatment technologies can be grouped into three main types: 1. Physical Treatments: These include processes like sedimentation, filtration, and flocculation-coagulation. 2. Chemical Treatments: This involves methods such as chemical precipitation, oxidation, and neutralization. 3. Biological Treatments: This method uses microorganisms to break down organic pollutants and remove certain metals. There are also advanced treatment technologies that provide more specialized solutions, including ion exchange, membrane filtration, and electrochemical treatment. Ion exchange removes specific ions using resins, while membrane filtration utilizes membranes to remove many contaminants. Electrochemical treatment employs processes like electrocoagulation and electroflotation to remove suspended solids, organic matter, and metals.

Additionally, a combination of advanced water treatment technologies—such as evaporation, crystallization, and membrane filtration—aims to recover water for reuse. This approach is linked to the concept of Zero Liquid Discharge (ZLD), a water management strategy designed to minimize or eliminate wastewater discharge by recycling and reusing water within mining operations.
By implementing effective water treatment technologies and sustainable water management practices, mining companies can significantly reduce their environmental impact, conserve water resources, and ensure the long-term viability of their operations.



Water is a crucial resource for the mining industry, particularly for mineral processing. However, mining can significantly impact water resources by depleting supplies and causing contamination. To combat water scarcity, the mining industry has adopted new technologies that reduce its reliance on fresh water. Currently, mining operations utilize 38% seawater in their processes and recycle 74% of their water. These initiatives pose challenges that the doctoral program aims to address with advanced knowledge and innovative solutions.

Seawater in Mining

To address water shortages, the mining industry in Chile utilizes 38% of seawater in its processes, whether desalinated or raw seawater. From an environmental perspective, using raw seawater is the preferred option, as the desalination process consumes energy that contributes to greenhouse gas emissions. Additionally, desalination generates brine that is returned to the ocean and produces solid waste associated with used membranes.
Using raw seawater presents both positive and negative effects on the mining industry. Negative effects include increased corrosion and impacts on metallurgical outcomes. On the positive side, it offers chemical stability for tailings and enhances leaching processes as well as certain aspects of flotation.
Our laboratories have conducted several projects to study these aspects, aiming to promote the use of undesalinated seawater. These studies encompass various processes, including transportation, leaching studies, flotation, thickening, and tailings management involving seawater.

Water Recovery and Rheological Management of Tailings in Mining for Arid Regions

Improving water recovery from mining tailings addresses the urgent need to optimize water resource use in mining, especially in arid regions with limited water availability. Given that mining is a key activity for economic development, efficient water management becomes a crucial challenge for the sustainability of this industry. Tailings, as by-products of mineral concentration, contain a mix of solids and water that can be treated through thickening and flocculation techniques, thus enabling water recovery for reuse in the process.

A fundamental aspect of our developments has been enhancing the understanding of particle-flocculant interactions, with a focus on the use of anionic polyacrylamide (A-PAM), which facilitates particle aggregation and sedimentation to produce clarified recyclable water. This flocculant generates larger aggregates in seawater due to its anionic charge and polymer bridging capacity, although its effectiveness is reduced in the presence of divalent cations such as calcium and magnesium, which interfere with flocculation processes. This has led to further exploration of seawater treatments to reduce these cations, optimizing sedimentation and tailings compressibility and lowering viscosity in clay-rich systems.

Thickener paste for optimal water recovery from tailings

Furthermore, the use of molecular simulations has allowed for microscopic-level analysis of interactions between polymers and particles in different water qualities, facilitating the prediction of rheological behaviors and the efficiency of rheological modifiers, such as sodium pyrophosphate, which increases electrostatic repulsion and reduces viscosity in saline suspensions.

These advancements enhance the sustainability of mining in arid regions, where closing water circuits is essential to reduce freshwater consumption. They also improve the safety and stability of tailings management.

Optimizing Water Management in Concentrator Plants

Effective water management in concentrator plants is crucial for improving operational efficiency and sustainability. Current methodologies often involve mixing water from diverse sources, including thickeners and tailings dams, into a singular repository for subsequent recycling. While this practice mitigates the water footprint, it can inadvertently compromise water quality.

The degradation of water quality frequently necessitates increased reagent consumption, underscores the requirement for supplementary treatment processes, and can adversely affect metallurgical performance. Consequently, it is imperative to explore innovative solutions for optimizing water resource management within these facilities. Our research laboratories are actively engaged in investigating methodologies tailored to the unique physicochemical characteristics of available water sources. This targeted approach aims not only to enhance operational efficiency but also to curtail associated costs while minimizing detrimental impacts on processing outcomes.

Embracing of eco-friendly solvents in mining

Currently, the mining industry faces several challenges, including climate change, water scarcity, energy efficiency, stricter legislative regulations, and the increasing complexity of mineral processing. To address these issues, the United Nations' Sustainable Development Goals, the development of green mining practices, and the industrial application of the circular economy model necessitate the creation of new environmentally friendly technologies.

Recent studies are exploring the use of ionic liquids, deep eutectic solvents, organic acids, natural extracts, and amino acids in metallurgical processes. Additionally, reducing water consumption in these processes offers promising alternatives. Solvometallurgy, in particular, presents a significant opportunity for development in local contexts. At the Process Research Laboratory (LIP), researchers have been investigating the use of these "green" solvents for several years.

Their work focuses on dissolving metals from a variety of sources, including minerals, concentrates, mining waste, and electronic waste (known as urban mining). This involves processes such as leaching, solvent extraction, and crystallization. In the next stage, further studies are planned for the electrowinning process to recover metals of interest. So far, successful dissolution of metals like copper (Cu), gold (Au), silver (Ag), and cobalt (Co) has been achieved using solvents without the addition of water. Ongoing research aims to refine the selective extraction of these metals.

Essential topics under investigation include the characterization of these solvents, their life cycle in the process, and their recyclability. The goal is to develop a comprehensive solvometallurgical process that facilitates the selective dissolution of metals and their recovery while also measuring the water and carbon footprints involved.

The mineral and metal industry is dedicated to advancing sustainability by actively reducing the environmental impacts of mining and processing operations. Our PhD program in mineral process engineering offers innovative research projects that play a crucial role in fostering sustainable practices in mineral processing, ultimately leading to a more responsible future for the industry.

Representation of a mining waste that can be treated with an environmentally friendly process

Green Corrosion Inhibitors for Metal and Alloys Protection

The corrosion of metals is a thermodynamically favored process that poses significant challenges in preserving the mechanical integrity of ferrous alloys used in industrial equipment, machinery, and infrastructure exposed to natural environments. One of the most widely used methods for preventing corrosion in metals submerged in liquid is the application of corrosion inhibitors. These additives help slow down the corrosion rate.

Inorganic inhibitors are commonly employed on an industrial scale due to their chemical stability and high effectiveness. However, they can be harmful to the environment, contaminating surface and groundwater and posing varying degrees of toxicity to humans, animals, and plants.

When developing new corrosion inhibitors, it is essential to consider low toxicity, eco-friendliness, and effectiveness. Conventional synthetic inorganic or organic inhibitors, despite their corrosion-inhibiting properties, have significant drawbacks, including high cost, toxicity, and non-biodegradability, which raise environmental concerns.

Recently, scientific publications have reported the use of efficient, eco-friendly corrosion inhibitors derived from plant extracts. However, these studies often overlook important factors such as product stability, reproducibility, and hydrodynamic corrosion effects. In our PhD program, we embrace the challenge of advancing research on organic inhibitors that precisely meet critical service requirements. This focus not only addresses current industry needs but also paves the way for innovative solutions.

E-waste valorization via liquid-liquid extraction with green solvents

E-waste is an increasingly significant global issue, consisting of discarded electronic devices such as computers, smartphones, and televisions. Improper disposal of e-waste poses serious environmental and health risks due to the toxic substances contained within these devices. However, processing e-waste is essential for recovering valuable materials and minimizing environmental impact.

In recent years, Deep Eutectic Solvents (DES) and Ionic Liquids (ILs) have emerged as promising green solvents for extracting valuable metals from e-waste. These solvents offer various advantages over traditional organic solvents, including low volatility, non-flammability, and high solvation capacity.

Liquid-liquid extraction (LLE) involves transferring a solute from one liquid phase to another. In the context of e-waste recycling, LLE using DES or ILs can effectively extract valuable metals such as copper, gold, silver, cobalt, and rare earth elements from leachates derived from e-waste.

DES and ILs have several benefits for the LLE of valuable metals from e-waste. These solvents can be tailored to selectively extract specific metal ions,

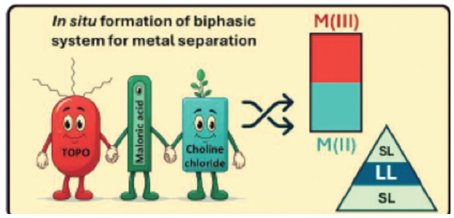
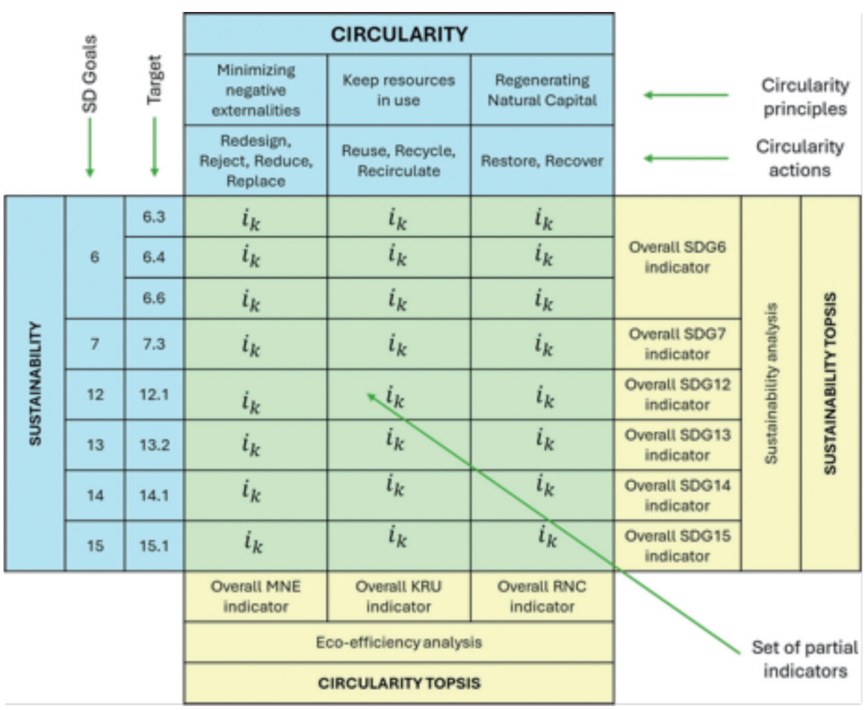


Illustration of in-situ formation of a biphasic system using DES components for metal separation.

simplifying the separation process. They also exhibit high extraction efficiencies, ensuring maximum recovery of valuable metals. Additionally, DES and ILs are generally more environmentally friendly and recyclable than traditional organic solvents, helping to reduce pollution and waste.

The LLE process involves leaching e-waste, extracting metal ions into the DES or IL phase, stripping the ions, and recovering the pure metals. By utilizing these innovative solvents, we can efficiently and sustainably recover valuable metals from e-waste, thereby contributing to a circular economy.



Measuring Circularity in Mineral Processing

The circular economy is an essential framework for various sectors, including mining. It focuses on reducing waste, enhancing resource efficiency, and promoting sustainable practices. Many initiatives at governmental, industrial, and academic levels aim to advance this approach by innovating processes and developing supportive policies.

Despite ongoing efforts, a notable gap remains in standardizing methodologies for assessing circularity across various applications. This lack of universally accepted standards complicates the comparison of different initiatives and technologies, making it difficult to quantify their actual impacts on circularity.

In mineral processing, many proposals focus on valorizing mining waste through end-of-pipe solutions that address waste after it is generated. These strategies prioritize treatment and disposal over waste prevention. In contrast, our doctoral program emphasizes proactively identifying innovative solutions within the production process. We promote methodologies like clean production and industrial ecology to address the root causes of inefficiencies, fostering the development of more circular systems that integrate sustainability into their core operations.

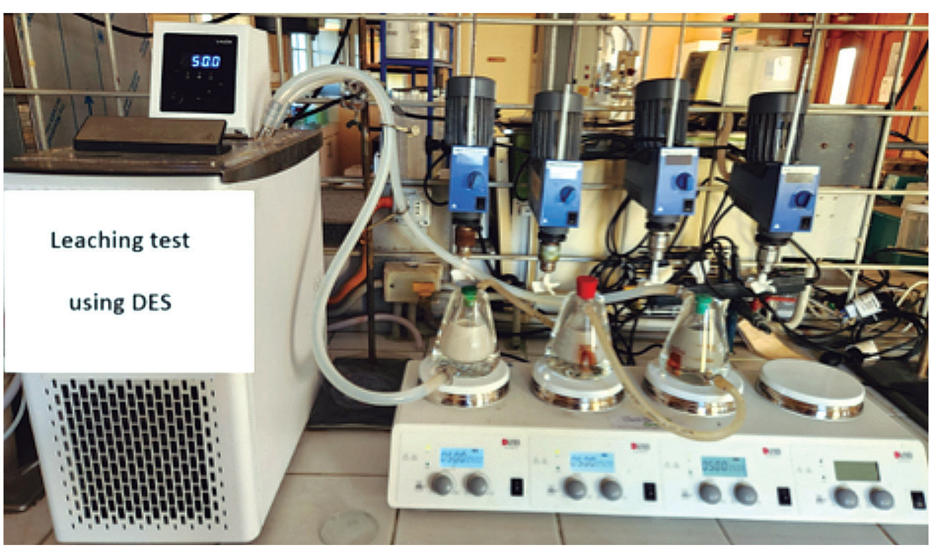
To further these objectives, we are developing robust and versatile tools specifically designed to measure circularity. These tools will facilitate comprehensive comparative analyses of various technologies currently available. By providing essential metrics and insights, our goal is to enhance circularity within the mineral processing sector, ultimately aligning it more closely with the principles of sustainability and resource efficiency that the circular economy espouses.

Reusing mining waste as alternative cement materials

The significant presence of mining waste in Chile, combined with the urgent need to reduce CO_2 emissions, creates considerable challenges both in the Antofagasta region and nationwide. In the medium to long term, mining activities are expected to continue generating waste.

In response, the Mining Waste and New Materials research group is conducting applied research focused on valorizing existing mining waste, using it as a secondary raw material to synthesize alternative construction materials.
For example, the physicochemical properties of tailings make them suitable for producing alkali-activated materials (AAMs), supplementary cementitious materials (SCMs), and hybrid alkali-activated cements (HAACs). These alternatives provide more sustainable options compared to conventional construction materials based on ordinary Portland cement (OPC).

Utilizing mining waste as precursor materials offers an innovative method for recycling industrial byproducts, reducing reliance on natural resources, and promoting a circular economy. This strategy aligns with the global shift towards more sustainable construction practices, which is a key focus in modern construction technologies.



Leaching test at University of Antofagasta

Solid waste valorization via hydrometallurgical and solvometallurgical processes

Solid and liquid waste generated from mining processes includes materials such as tailings, slag, anodic sludge, and waste rock. These solid wastes can still contain valuable elements like copper (Cu), gold (Au), silver (Ag), rare earth elements (REE), cobalt (Co), and vanadium (V), presenting opportunities for developing new metallurgical processes to recover these metals of interest.

Many industries have recently begun incorporating the circular economy model into their production processes. This model promotes the reuse of mining wastes, which aligns with ongoing developments and research in this area. Various methods have been proposed to reprocess these wastes.

The Process Research Laboratory (LIP) is exploring hydrometallurgy and solvometallurgy as potential methods for extracting metals still present in solid waste. This research includes the use of emerging and environmentally friendly solvents. Promising results have been observed in metal dissolution from flotation tailings, anodic sludge, and copper smelting slag, utilizing glycine, organic acids, ionic liquids, and deep eutectic solvents as leaching agents. It is important to note that this metal recovery process results in a solid residue, necessitating the identification of new uses for this material. Collaborative efforts across various disciplines are essential to tackle these complex challenges effectively.

Sustainable Tailings Management: Hydrophobic Flocculants and Seawater Treatment

Research is focused on enhancing management strategies for mining tailings, particularly thickened tailings, in the context of a circular economy and mining sustainability. One promising approach involves using hydrophobic flocculants as an alternative method for increasing the solids concentration (Cp) of deposited tailings. This strategy entails modifying traditional polyacrylamides (PAMs) by incorporating hydrophobic functional groups into the molecule. This modification improves thickening efficiency by reducing electrostatic attraction and promoting the formation of more stable aggregates.

The treatment of highly clayey tailings is of particular interest, as these materials present significant challenges in sedimentation and the management of rheological properties. Clay minerals, their laminar characteristics, and complex electrostatic interactions can negatively impact the thickening and solid-liquid separation processes.

Another important consideration is the use of seawater, especially in mining regions where fresh water is scarce. Utilizing alternative water sources becomes essential. However, divalent cations in seawater, such as magnesium, can adversely affect flocculation and sedimentation processes. To address this issue, researchers have investigated treating seawater with lime to remove magnesium. This treatment enhances the interaction of flocculants with tailings particles and facilitates water clarification in thickeners.

Drenaje ácido de Minas

S.O.S.: Solid without Sulfide

The mining industry produces significant amounts of solid waste, primarily in the form of waste rock (material that is not processed) and tailings. These wastes can lead to the production of acid mine drainage (AMD). AMD occurs when metal disulfides, particularly iron (often found as pyrite), oxidize in the presence of oxygen, water, and bacterial activity. This process significantly damages the quality of surface and groundwater due to its acidity and the presence of heavy metals and other contaminants. As a result, communities may struggle to access clean water.

If acid drainage is not identified promptly, it can lead to severe environmental issues in mining areas. AMD can devastate aquatic ecosystems, harming marine flora and fauna, and making recovery challenging due to the high metal content absorbed by these ecosystems. Current strategies in the mining industry tend to focus on actions taken at the end of the waste management process, such as monitoring or neutralizing waste after it has been generated.

In our doctoral program, we focus on developing proactive solutions to prevent solid waste from containing particles that could potentially lead to AMD. Our slogan is “Solid Waste Without Sulfides.” We have created processes to ensure that waste rocks do not generate AMD, while also adding value to these materials. Additionally, we are exploring new concentration processes that yield tailings free of particles capable of generating AMD. This approach not only reduces the environmental impact of mining operations but also enhances the circularity of the process. In fact, with this method, the tailings can be easily applied in construction, and the recovery of other minor materials is improved through their extraction in the bulk concentrate.

New Lithium Process for direct extraction and lithium hydroxide

This research focuses on innovative methods for separating, concentrating, and extracting lithium compounds. We aim to develop novel separation techniques in electrochemical cells, employing electrodialysis and electrolysis while avoiding contaminating reagents or increasing waste.

Our alternative lithium hydroxide (LiOH) extraction method uses concentrated lithium chloride (LiCl) brines, eliminating the intermediate carbonation stage. This process achieves 86-90% current efficiency and consumes 3-4.5 kWh/kg of LiOH, yielding a 4% LiOH solution that can produce high-purity LiOH-H_2O crystals (over 99.3% purity). Integrating photovoltaic solar panels in the Antofagasta Region will further reduce energy costs and carbon footprint, enhancing sustainability in lithium production.

We are also developing materials for direct extraction of lithium to produce highly pure lithium compounds, addressing extraction challenges in water-limited northern Chile. This research is vital for ensuring a sustainable lithium supply chain, crucial for the energy transition and electric mobility.

Solar energy and H_2 generation

In green hydrogen generation, we investigate new electrodes for membrane electrolysis cells to enhance the production process. This includes studying the electrocrystallization of nanostructured metals and optimizing the kinetics of hydrogen evolution (HER) and oxygen evolution (OER).

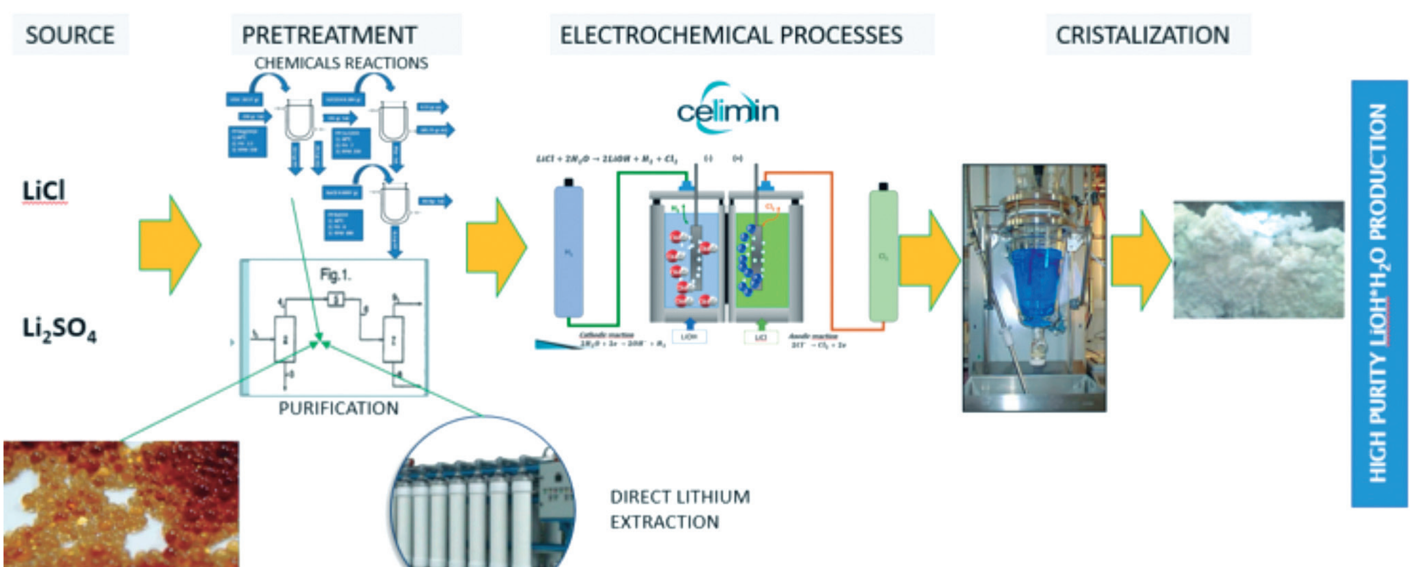
Using low-cost substrates like copper and titanium, we create nanostructures with improved electrocatalytic properties. Optimizing these electrodes in AEM electrolyzers, integrated with photovoltaic energy, aims to produce clean hydrogen efficiently. With minimal waste and a high energy density, hydrogen is a promising energy source, and this research will contribute to developing national technologies for boosting green hydrogen production in Chile.

Electrical Energy Storage Materials for LIBs

This line of research focuses on developing sustainable cathode materials for lithium-ion batteries. The active material is crucial, as it determines the battery's capacity, cycle life, weight, and cost.

The development centers on nanostructured materials for battery electrode fabrication, utilizing elements with abundant resources such as lithium (Li), magnesium (Mg), iron (Fe), and manganese (Mn). This approach aims to address key performance parameters related to energy storage, including energy density, power density, safety, charging rate, cycle life, longevity, and overall cost.

The main research activities in the area of electrical storage include the production of nanostructured cathode materials using methods such as sol-gel synthesis, mechanochemical processing, and coprecipitation. Additionally, optimization of active electrode materials is achieved through methods like particle size reduction, structural doping with anions and cations, the combination of active electrode compounds, and surface modification using conductive and non-conductive coatings.



Sustainable combined system for high purity LiOH□H_2O obtaining

Use of industrial waste and Lithium battery recycling

This area discusses the integration of the circular economy, life cycle analysis (LCA), and waste salts within the context of lithium production and battery manufacturing. LCA allows for an objective evaluation of the environmental impacts associated with the production of lithium precursors, cathode materials, and lithium-ion batteries throughout their life cycles. Additionally, waste salts identified in the lithium extraction process and the production of lithium compounds can be characterized and refined for further use. By transforming this waste into a commercially valuable product, we can extend the life cycle of these materials.
As part of a circular economy approach, we has developed a process to obtain magnesium hydroxide ($Mg(OH)_2$) from industrial waste Bischofite. When combined with high-purity lithium hydroxide ($LiOH\text{-}H_2O$), this compound contributes to the synthesis of a manganese spinel that exhibits superior physical and electrochemical characteristics, achieving a capacity of 121 mAh/g—14% higher than that of commercial spinels.
Furthermore, cutting-edge recycling technologies are currently being developed for the environmentally sustainable and cost-effective recovery of critical materials from spent lithium-ion batteries, including manganese (Mn), nickel (Ni), lithium (Li), and iron (Fe), among others.

Manufacturing of Lithium-Ion Cells

The design and manufacturing of prototypes for “coin” and “pouch” type cells, as well as lithium battery modules, employ various cathode chemistries such as LFP (Lithium Iron Phosphate), LMO (Lithium Manganese Oxide), and LMNO (Lithium Nickel Manganese Oxide). These prototypes are intended for use in backup systems for solar energy storage in the Antofagasta Region.
The main research activities in the area of electrical storage include:

* Preparation of suspensions and deposition onto current collectors.
* Treatment of cathode materials through calendering and heat treatment.
* Characterization of the electrochemical properties of materials, including electrodes in lithium batteries, using experimental button cell batteries.
* Manufacturing of prototypes of pouch-type lithium-ion cells and their electrochemical characterization.
* Techniques utilized in CELiMIN include cyclic voltammetry, chronopotentiometry, and electrochemical impedance spectroscopy in both potentiostatic mode (PEIS) and galvanostatic mode (GEIS).
* Fabrication of battery modules equipped with an intelligent control system (Battery Management System - BMS).
* Optimization and scaling of pastes, along with the production of lithium battery prototypes up to 6 Ah, including post-mortem analysis.

Scaling LIBs from coin cell to prismatic pouch lithium battery

Thermal Energy Storage Materials and Energy Efficiency

Research into thermal storage has revealed significant advancements in the use of Phase Change Materials (PCMs) within the construction and HVAC sectors. These materials can store and release thermal energy, enhancing the energy efficiency of buildings. In this context, we designed and built a plant for Domestic Hot Water (DHW) that utilizes solar thermal energy combined with PCMs developed from local raw materials. This plant not only promotes the use of renewable resources but also contributes to sustainable hot water management.
Additionally, extensive research has been conducted on encapsulation techniques for inorganic PCMs, as well as characterizing materials to optimize their performance. Studies on cyclability, aging, and the design of nucleating and thickening agents have led to improvements in both the efficiency and durability of materials used in thermal storage systems. These efforts are crucial for ensuring that PCMs remain effective over time, even under conditions of intensive use.
Furthermore, the application of commercial PCMs in passive air conditioning for modular buildings in coastal environments has shown substantial reductions in energy consumption. Integrating PCMs into architectural designs not only enhances energy efficiency but also improves the thermal comfort of living spaces. Collectively, these innovations in sustainable thermal storage foster a more efficient and environmentally friendly future for the construction sector.

"Minerals and materials are vital resources that drive the progress of our society. In the Doctorate of Mineral Process Engineering, we are dedicated to uncovering innovative solutions that promote clean energy, water, and air, essential for life. Become part of our mission to develop creative, sustainable solutions that make a real difference for future generations."

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