QUALITY RECYCLES.

Selective Lewatit® ion exchange resins for extracting, refining, and recycling battery metals

Lewatit®

QUALITY WORKS.

LANXESS
Energizing Chemistry

ABOUT LANXESS

We are a leading specialty chemicals company based in Cologne, Germany, well established on the global market. Our primary expertise lies in producing, developing, and marketing chemical intermediates, additives, specialty chemicals, and plastics. As a specialist and efficient partner, we offer solutions to all kinds of challenges faced by our customers. We focus on our customers' requirements in order to drive progress and reliably provide innovative product, material, and service solutions. Our manufacturing, administration, and logistics processes are designed for efficiency and performance.

We offer a broad range of technologies and solutions for the treatment of water and other liquid media and are one of the leading manufacturers of ion exchange resins, with production sites in Germany and India. Our **Lewatit®** ion exchange resins and adsorbers are used in many different industries and applications to treat water and other liquid media.

With our sustainably produced **Lewatit® Scopeblue** ion exchange resins, we offer products that have a carbon footprint up to 61 percent smaller than products manufactured from conventional fossil sources and consist of more than 90 percent renewable raw materials. In accordance with the mass balance approach, they are chemically identical to conventional products and produced in the same plants using the same processes.

In addition, we also offer a range of **Bayoxide®** iron oxide adsorbers for various water treatment applications. Furthermore, our unique calculation and design software **LewaPlus®** is used for modeling and dimensioning diverse ion exchange systems, including process configurations only available with **Lewatit®** product technology.

High-quality products
Providing high-quality products is crucial for our business success. Our global production sites are carefully controlled in order to ensure the highest quality possible, no matter where our products are manufactured.

Reliable service
We provide a high level of technical expertise and do our best to support you however we can. Our global technical sales team will help you find the best product for your needs.

Innovative solutions
We are continuously investing in research and development in order to optimize our products and discover innovative uses for our ion exchange resins, adsorbers, and iron oxide adsorbers.

BATTERY METALS VALUE CHAIN: LEWATIT® ION EXCHANGE RESINS PLAY A CRUCIAL ROLE

Technologies for generating renewable energy from wind and solar power are expected to be key for the transition of the energy sector towards climate neutrality. Lithium-ion ion batteries (LIBs) can store electrical energy very efficiently with high gravimetric and volumetric energy densities, short charging times, and long life cycles. Especially in the field of electromobility, LIBs are expected to play a crucial role in the transition from fossil-driven combustion engines to battery-powered motors.

As a result, the demand forecast for lithium-ion batteries is strong. To obtain the batteries needed for the green energy transition, it has to be ensured that they can be manufactured in sufficient quantities at a low CO_2 footprint. Therefore, there is a high demand for raw materials produced using sustainable techniques. Additionally, to secure market acceptance, a recycling process with a low CO_2 footprint has to be established. For all these challenges Lewatit® chelating resins play a crucial role in extracting and refining raw materials as well as recycling (Figure 1).

The fascinating properties of Lewatit® ion exchange resins for the sustainable extraction, refining, and recycling of lithium, nickel, cobalt, manganese, and copper are described in this brochure.

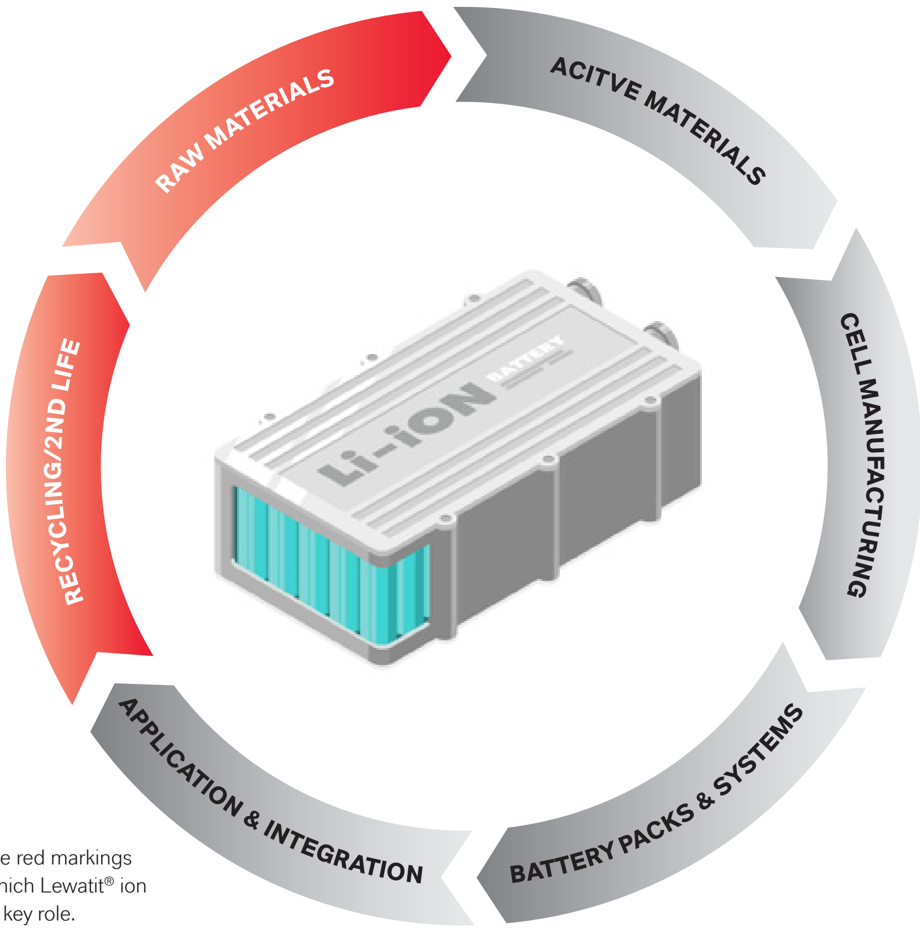


Figure 1:
Value chain of LIBs. The red markings denote processes in which Lewatit® ion exchange resins play a key role.

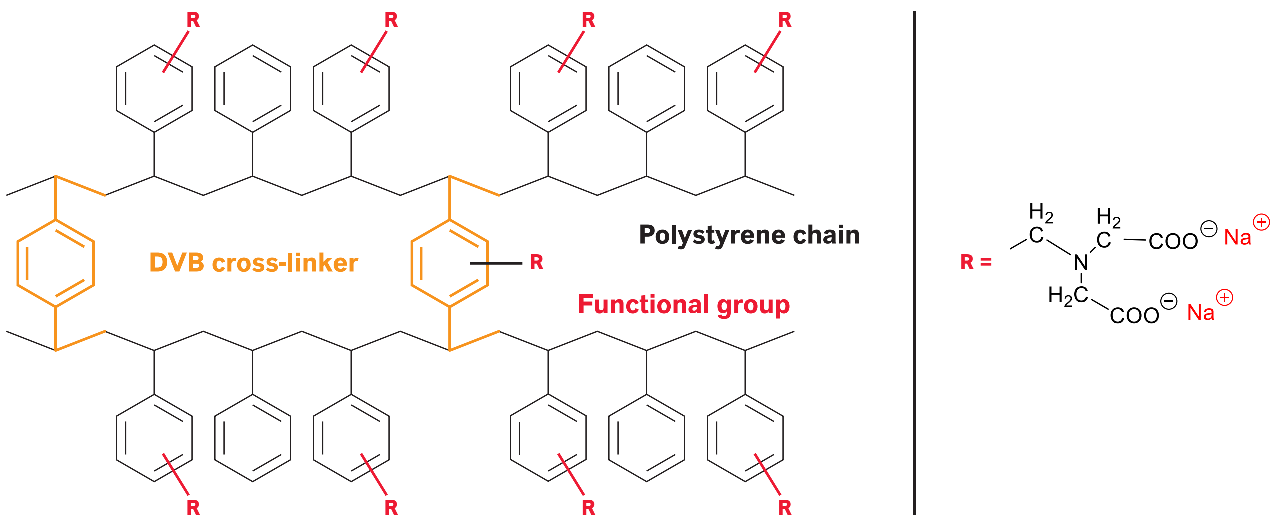
UNIQUE FEATURES OF LEWATIT® LEAD TO SAVINGS ON CAPEX AND OPEX

Ion exchange resins are cross-linked polymer networks equipped with ion exchange groups that are utilized to load and concentrate target ions onto a solid separation medium. These resins typically possess a spherical bead shape with a mean size between 0.3–1.1 mm. When filled into a vessel, the resin beads organize into close packing, generating defined interstitial void spaces between the beads. These void spaces enable the treated fluids to flow homogeneously. In contrast to other non-spherical separation media, the homogeneous flow allows more efficient usage of total capacity and improves separation efficiency.

The porosity of ion exchange resins can be fine-tuned over a wide range, generating microspores (gel-type, < 2 nm), mesopores (2 nm–50 nm), and macropores (50 nm–1 µm). Choosing the right porosity for a specific application in hydrometallurgy is crucial because the pores enable the battery metals to access the ion exchange site. Therefore the ion exchange kinetics can be optimized and high loading capacities as well as pure battery metal concentrates are obtained.

Ion exchange resins are prepared by the free radical polymer-ization of organic monomers such as styrene in emulsion drops. Since ion exchange resins exhibit charged polar groups as active sites, the polymers need to be chemically cross-linked, e.g. by divinyl benzene, in order to prevent the beads from dissolving. The degree of cross-linking is a crucial parameter for the selectivity of the resin beads and it provides the required accessibility to the functional group. Traditionally, ion exchange resins are prepared by suspension polymerization, which yields a broad bead size distribution. As a result, very often low operating capacities and low mechanical and osmotic stability due to inhomogeneous cross-linking are obtained. LANXESS has therefore developed a unique technology to produce monodisperse beads that is based on encapsulation of monodisperse drops. Interestingly, these resins have superior mechanical and osmotic stability and excellent exchange kinetics due to the homogeneous polymerization within monodisperse drops.

Scheme 1: Schematic representation of the chemical structure of an ion exchange resin; black linear polystyrene, yellow cross-linker, red ion exchange groups.



UNIQUE LEWATIT® PROPERTIES OF HYDROMETALLURGICAL APPLICATIONS

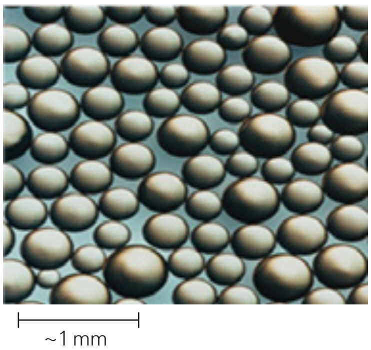
Lewatit®

Tailored bead size distribution enables savings in CAPEX and OPEX and generates high-quality battery metals

The size of the resin beads plays a key role in hydrometallurgy applications. At LANXESS, the particle size of monodisperse resins – those with a uniform bead size – is adjusted with high precision by means of continuous droplet formation through a perforated plate. In aqueous suspensions containing monomer droplets of uniform size, the resin beads are then formed by polymerization (Figure 3). This method allows beads of different sizes to be created in a flexible and reproducible manner – a vital prerequisite for their large-scale application. The polymer beads in standard types measure between 0.5 mm and 0.7 mm. In addition to the type of ion exchange groups in the polymer (Figure 7), their suitability for a specific separation task depends on their number and a range of other properties and characteristics. Process parameters such as the pH value, temperature, and flow rate also influence the separation performance. The ion exchange process usually takes place in single columns or in a series of columns that are filled with the resin and through which the solutions to be treated flow. "Resin in pulp" (RIP) processes have also been developed, whereby the resins in the solution or suspension to be treated are suspended and then separated before regeneration.

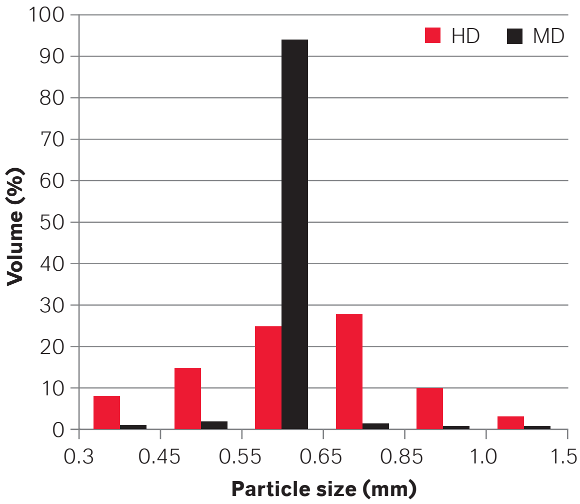
Figure 2: Optical microscope micrograph of heterodisperse ion exchange resins (left), size distribution of heterodisperse and monodisperse ion exchange resins (middle), optical microscope micrograph of monodisperse ion exchange resins (right).

Heterodisperse (HD) beads

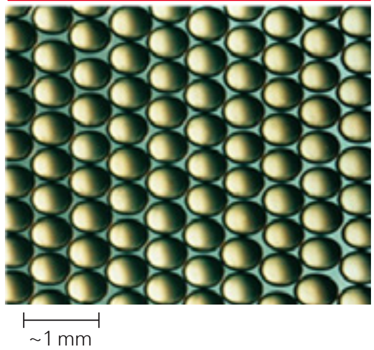


- Polymerization in conventional reactors during stirring

Particle size distribution



Monodisperse (MD) beads



- Polymer manufactured in jetting columns
- Advantages in stability and operating capacity

Small resin beads with a diameter of just 0.3 mm to 0.4 mm – also known as MDS (monodisperse small) resins – exhibit very different properties and characteristics compared with standard sized beads. Thanks to their smaller size and, in turn, shorter diffusion paths, they exhibit faster kinetics during exchange and regeneration. Not only does their homogeneous packing density (Figure 2) make them ideal for chromatographic separation, they also have a higher capacity utilization and, in turn, longer service lives with lower requirements for regeneration chemicals. However, the smaller bead size also results in higher pressure loss, a factor that has to be taken into account when the plant is designed. A comparison of the loading performance (Figure 6) of an iminodiacetic acid (IDA) chelate resin of MDS-type (left) with copper ions (blue) shows clear differences with respect to standard monodisperse resin (MD, middle) and heterodisperse resin (HD, right) with a wider bead size distribution. In addition to superior retention, MDS resin exhibits a sharp, precisely defined mass transfer zone of adsorption. This prevents the premature breakthrough observed especially with HD resin as a result of a fuzzier adsorption mass transfer zone.

On the other hand, the RIP process imposes quite different requirements. An ion-containing suspension of ore slurry is mixed with the resin beads. After a contact period during which the resin absorbs the ions, the resin is separated again. To increase efficiency, multiple vessels are positioned in a cascade arrangement and the ore suspension is treated with the exchange resin in counterflow (scheme 2) (continuous RIP). During this process, the majority of metal ions from the slurry are captured by the resin and can be recovered when the resin is regenerated. In the field of hydrometallurgy, ion exchange processes such as these are increasingly replacing the decanting of suspensions in large water tanks because this not only requires a great deal of space, but is also time- and cost-intensive. Mechanically robust ion exchange resins are needed for separating and transferring the resin as efficiently as possible. This helps to prevent premature resin breakage during extraction. A sufficient size difference between resin and ore slurry particles is also essential for efficient separation. Because of this, LANXESS has developed two highly stable Lewatit® TP 209 types: a monodisperse resin with a particle diameter of 0.85 mm (XL) and a heterodisperse resin with an average particle diameter of 1.1 mm (± 0.1) (XXL).

Figure 3: Two-stage production of monodisperse ion exchange resins through continuous drop formation and subsequent batch polymerization.

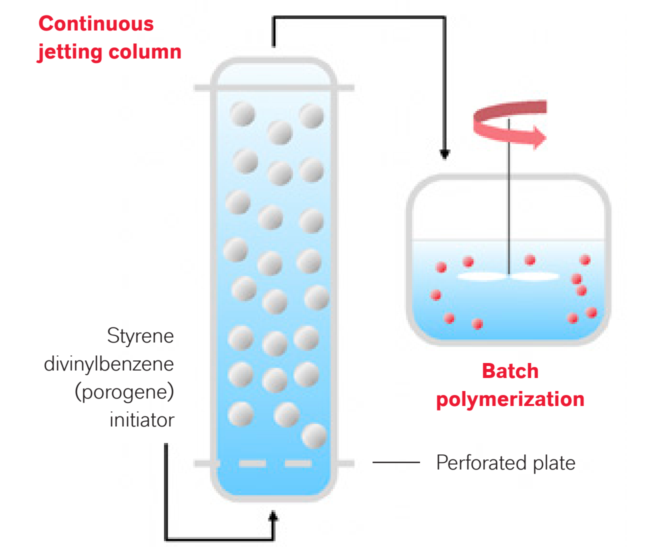


Figure 4: Comparison of MDS and MD resins for the softening of lithium brine (60°C; flow 10 BV/h; breakthrough at 100 ppb Ca). The Y-axis shows the calcium concentration (ppb) in the effluent of a fixed bed column. The X-axis shows the throughput (BVs). Lewatit® MDS TP 208 is plotted in red circles and Lewatit® MonoPlus TP 208 is plotted in black squares.

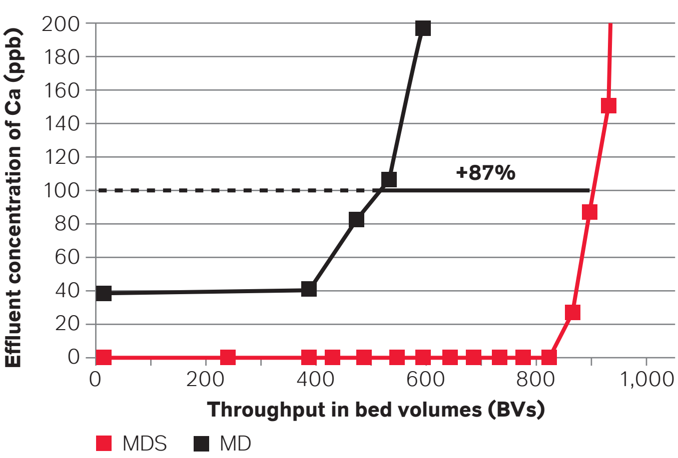


Figure 5: Mechanical resilience of Lewatit® MonoPlus TP 209 XL and XXL compared with two competitor products (W 1/W 2) in the Chatillon and roller tests.

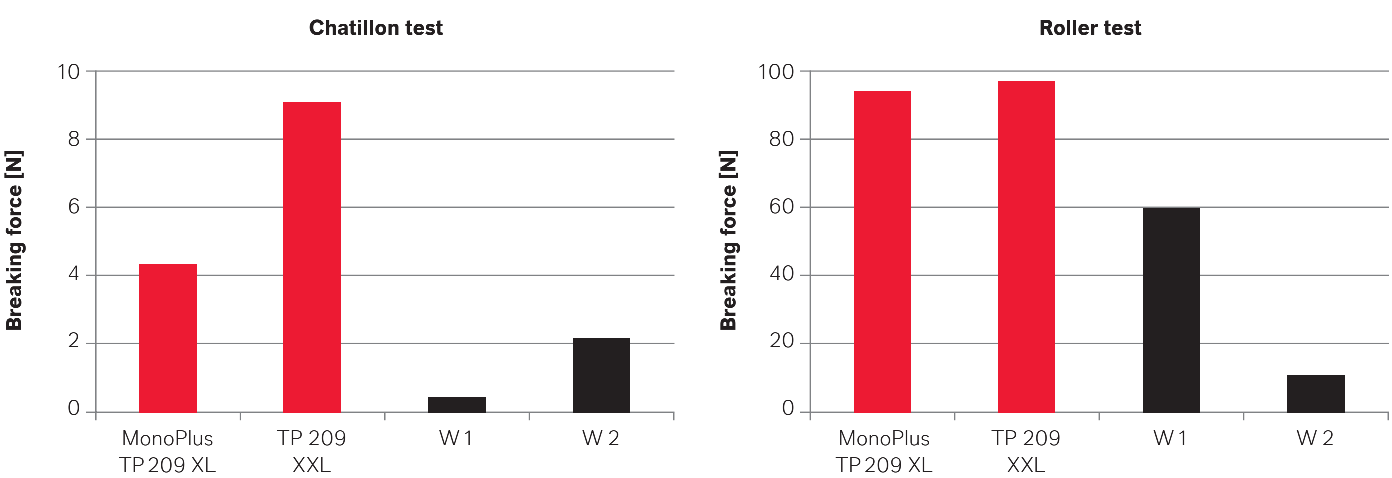
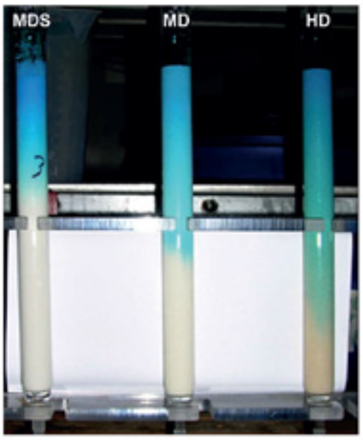
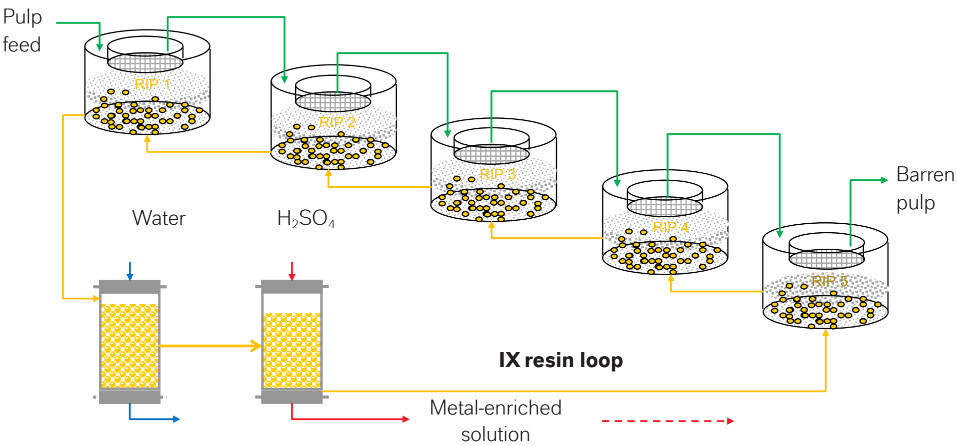


Figure 6: Loading performance of MDS, MD, and HD ion exchange resins with copper ions under identical operating conditions.



Scheme 2: Diagram showing a continuous "resin in pulp" (cRIP) process with Lewatit® MonoPlus TP 209 XL.



High osmotic and mechanical stability ensure long resin lifetime

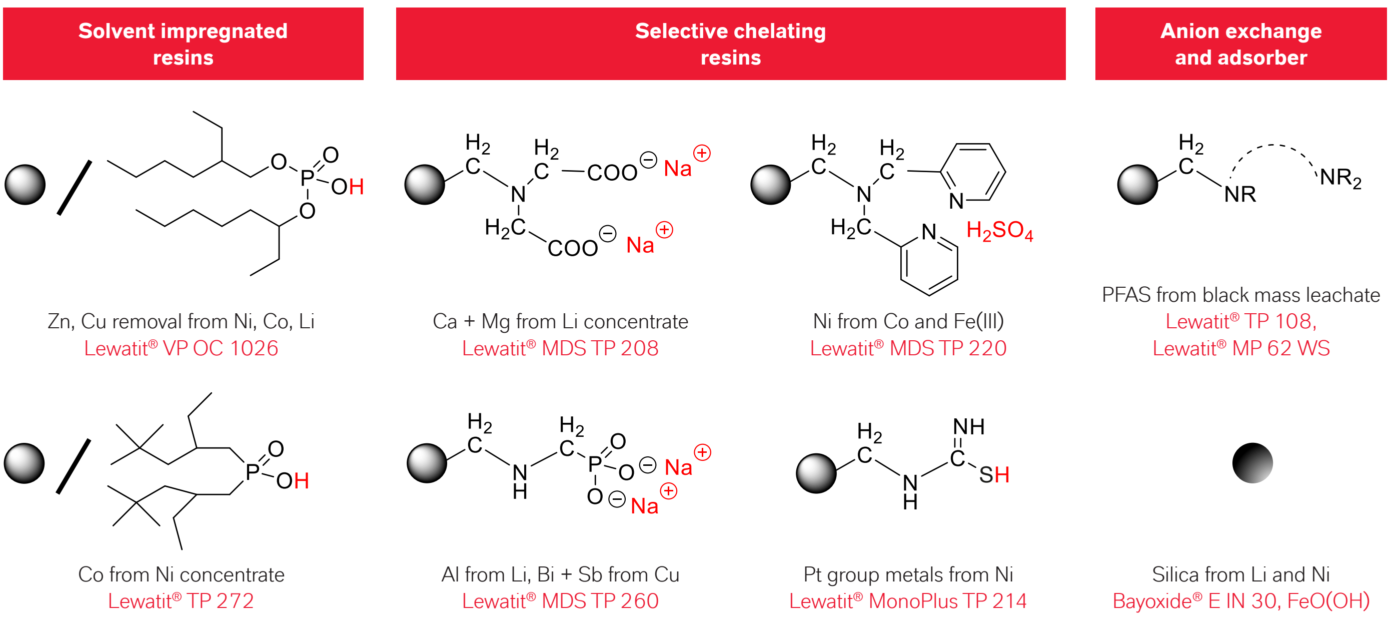
Due to the requirements of the RIP process regarding the mechanical stability and elasticity of the resin beads, these properties were examined in detail in the laboratory. Comparative measurements with competitor products revealed superior performance profiles for both the Lewatit® MonoPlus TP 209 XL and XXL types. These were demonstrated in the Chatillon test, for example, which helps to determine the stability and elasticity of resin beads by applying a defined force on individual beads until they break. The roller test, in which a metal roller is passed over a single layer of thousands of resin beads twenty times (Figure 5) is well suited to obtain information about mechanical stability with good statistics. The number of beads still intact after the test serves as a relative measure of their stability and resilience. The potential applications of RIP processes are as manifold as the selectivity coefficients of the resins suitable for these processes.

Ion exchange groups – selectivity is the key for challenging separations

High-purity metal concentrates can be produced by the use of selective Lewatit® resins. Battery metal concentrates pass through the ion exchange resin bed, while impurities are loaded onto the resin, yielding pure concentrates that are needed for high-quality batteries. If the concentration of battery metals is high, co-loaded battery metals can be recovered from the resin by selective elution with low-concentrated eluting agents.

Additionally, the extraction and recovery of battery metals relies on the concept of selectively loading valuable metals onto the ion exchange resin. Non-valuable constituents such as calcium and iron pass through the resin not exchanged and can be disposed of safely. The elution of battery metals loaded onto the resin yields metal concentrates. Because many battery metals and impurities are involved, LANXESS has developed a smart chemical toolbox approach to manufacture ion exchange resins with unique selectivity properties. The concept of selectivity makes it possible to introduce efficient processes in the field of battery metals (Figure 7).

Figure 7: Selectivity overview of Lewatit® ion exchange resins and Bayoxide® adsorber for battery metals and contaminants that need to be removed from metal concentrates.

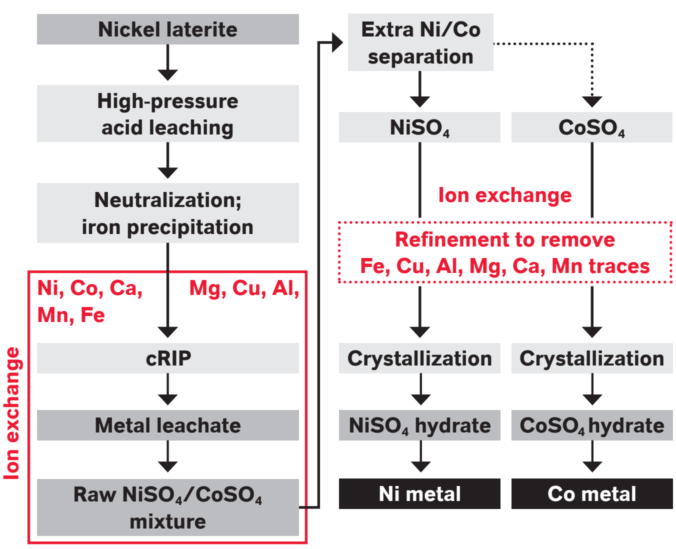


Extraction

Large quantities of water are used in ore processing – from cleaning the raw ores to isolating the pure metals. Obtaining and, if applicable, separating the metal ions from this water is indispensable for both economic and ecological reasons. With the aid of special ion exchange resins, metals can be obtained from ore leachates by means of direct extraction. The Lewatit® grades specially adapted for applications in hydrometallurgy possess chelating functional groups that very efficiently and highly selectively bind specific metal ions (Figure 7). Thus, using resin-in-pulp (RIP) technology, for example, metals such as copper, nickel, and also cobalt can be extracted more efficiently and ecologically than with conventional methods. Similarly, ion exchange resins for the final polishing of nickel and cobalt concentrates are used to produce high-purity cobalt and nickel. The metals are constituent parts of active materials for cell cathodes in the lithium-ion batteries.

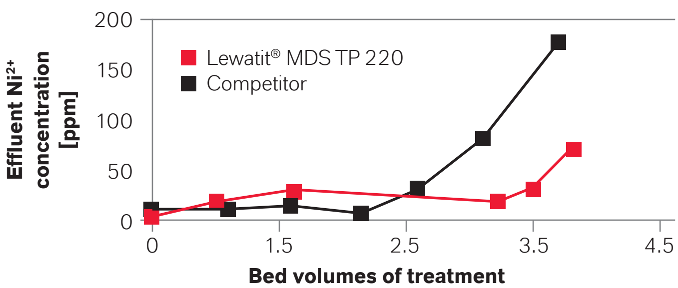
Lewatit® MonoPlus TP 209 XL has already demonstrated its suitability during several years of operation at an ore processing plant in Kazakhstan, to recover copper. Another plant designed for the large-scale separation of divalent ions – primarily of nickel and cobalt – following the high-pressure acid leaching (HPAL) of nickel laterite ore deposits is currently being planned in Australia. In this process, following neutralization, iron is first separated by means of precipitation. Once the divalent ions have been isolated by means of cRIP, a raw mixture of Ni and Co sulfate is obtained from the leachate. This mixture is separated by means of liquid extraction. Next – again in an ion exchange process – trace impurities are removed. The crystallization process finally results in pure nickel and cobalt sulfate hydrates, which can be used for recovering the metals by electrochemical means. This process, too, illustrates the huge and far-from-exhausted potential of the ion exchange technology in hydrometallurgy.

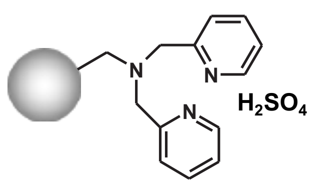
Figure 8: Flow sheet for nickel and cobalt extraction and refining.



Around 73% of continental nickel is present in nickel laterite ore and will therefore be the main resource for battery-grade nickel. However, the nickel content in laterite ore is low and efficient recovery processes need to be developed. One of the main challenges is the separation of nickel from ferric (Fe^{3+}). Lewatit® MDS TP 220 shows excellent selectivity towards nickel, even in the presence of high concentrations of Fe^{3+} and is therefore ideal for the extraction of nickel. Excellent resin properties allow an approximately 40% longer cycle time, resulting in significant savings in regeneration chemicals and a higher nickel upgrade (Figure 9).

Figure 9: Nickel (2.6 g/L) extraction in the presence of high-concentration ferric (17 g/L) at room temperature, pH 1.8 and a specific flow of 10 bed volumes/h (BV/h). The Y-axis shows the nickel concentration in the effluent of the fixed bed column (ppm). The X-axis shows the throughput in BVs. Lewatit® MDS TP 220 is plotted in red squares. An equivalent resin from competitor is plotted in black squares.





Refining

The beneficial properties of MDS resins can be leveraged for various tasks such as lithium brine purification. This is a vital process step in the production of battery-grade lithium carbonate, a raw material used to manufacture lithium-ion batteries. Even in the presence of large quantities of lithium chloride and sodium chloride (61.1 g/L / 60 g/L), the resin – Lewatit® MDS TP 208 in this case – helps to remove almost all traces of calcium from 10 ppm. Remarkably, MDS resins significantly reduce calcium slip to residual levels of less than 1 ppb. Ultrapure lithium brine obtained in this way is needed mainly for electrolysis in order to protect cell membranes. In addition, the operating capacity exceeds that of the equivalent MD type by 87% (Figure 4).

Earth alkaline metals including Ca, Mg, Sr, and Ba can be removed efficiently from various lithium concentrates including LiCl, LiOH, Li_2SO_4 and $LiHCO_3$. Additionally, lithium recovery requires calcium-free Na_2CO_3 that is also obtained by using Lewatit® MDS TP 208.

We recently developed our new resin Lewatit® TP 308 for removing earth alkaline contaminants from lithium concentrates generated by direct lithium extraction. These brines are generated by the elution of selective lithium materials and contain high concentrations of earth alkaline and heavy metals (>100 mg/L) and dilute lithium brines of less than 2 g/L. It is a perfect addition to Lewatit® MDS TP 208 that removes smaller concentrations (1–100 ppm) of Ca^{2+}, Mg^{2+}, Sr^{2+}, Ba^{2+} from more concentrated lithium brines (>10 g/L) of Li.

Lewatit® MDS TP 260 has a high aluminum selectivity even at elevated pH and can efficiently load aluminum present as both Al^{3+} and $Al(OH)^{4-}$. Our selective elution process for aluminum with NaOH and co-loaded lithium elution with HCl or H_2SO_4 makes it possible to reuse the resin for many cycles.

Lithium concentrates from hard-rock mining or black mass leachate recycling can also contain fluoride as a contaminant. Our aluminum-doped Lewatit® MDS TP 260 is highly fluoride-selective, even in the presence of high concentrations of chloride or sulfate, and efficiently purifies the concentrates to high grades.

Figure 11: Overview of refining applications

Battery metal concentrate	Contaminant	Lewatit® type	Regeneration
LiCl, Li_2SO_4, LiOH	Mg, Ca, Sr, Ba	MDS TP 208	HCl, H_2SO_4 and NaOH
	Al	MDS TP 260	NaOH
	F	MDS TP 260	$AlCl_3$
	F, Silica	Bayoxide® E IN 30	NaOH
$LiHCO_3$	Mg, Ca, Sr, Ba	MDS TP 208	HCl
$NiSO_4$	Co	TP 272	H_2SO_4
	Zn	VP OC 1026	H_2SO_4
$CoSO_4$	Ni	MDS TP 220	H_2SO_4
	Zn	VP OC 1026	H_2SO_4
$MnSO_4$	Cu	MonoPlus TP 207	H_2SO_4
$CuSO_4$	Sb, Bi	MDS TP 260	HCl, Thiourea

We recently also introduced our Bayoxide® E IN 30 as an efficient adsorber for selectively removing silica from lithium concentrates. The adsorber can be regenerated and recycled by using an NaOH elution procedure.

Nickel and cobalt concentrates often contain impurities such as Zn, which can be efficiently removed by the use of selective Lewatit® resins. The solvent-impregnated resins (SIR) Lewatit® TP 272 and Lewatit® VP OC 1026 are especially suited for this separation task, because of their high selectivity and loading capacity regarding impurities, which ensures efficient removal below the specification limit. At the same time SIR show a low interaction with valuable and concentrated battery metals nickel and cobalt, which pass the resin at high yield and recovery. SIR are composed of special macroporous, cross-linked polymeric beads with a solvent extractant entrained within the pores and immobilized on the surface. The special production procedure of Lewatit® SIR allows the formation of homogeneously distributed extractant, leading to higher operating capacities and faster exchange kinetics than for conventional SIR resins. SIR combine the advantages of ion exchange resins (low capital cost and plant footprint, simple maintenance) with the unique and enhanced metal selectivity of solvent extraction.

During the industrial extraction of cobalt – another essential metal in the production of lithium-ion batteries – MDS resins can capably perform yet another separation task. With Lewatit® MDS TP 220, which carries bis-picolylamine groups, around 300 ppm of nickel can be almost completely removed from a concentrated cobalt salt solution in a highly acidic environment.

In copper electrolyte purification, a copper anode containing impurities such as Bi and Sb is introduced into an electrolysis cell, containing a copper concentrate disolved in sulfuric acid. At the cathode, pure copper is recovered by electrochemical reduction, while the impurities remain in the electrolyte. Lewatit® MDS TP 260 has a very high Bi and Sb selectivity and can load these impurities even in concentrated sulfuric acid. The resin can be regenerated and reused by using concentrated HCl. Under these conditions Sb and Bi form anionic chloro-complexes and are eluted. By the selective removal of contaminants, high-purity copper can be obtained and value is generated.

Recycling

The growing demand for high-purity battery lithium, nickel, cobalt, and copper requires access to new raw material resources. The most economical and eco-friendly approach is to recycle end-of-life batteries. Due to their high concentration of battery metals, they can be extracted and recycled with a low carbon footprint and at low cost. For this reason, the European Union has established strictly regulated recycling targets and a minimum content of recycled battery metals for manufacturing new batteries. As a result, processes truly in line with the circular economy principle are developed. A significant amount of off-spec material is already available from cathode producers and more end-of-life batteries will become available within the next few years. Lewatit® ion exchange resins are crucial for many process steps in the hydrometallurgical recycling flow sheets. We describe three of the most important applications and the benefits of our resins in the field of battery recycling.

Purifying black mass leachate

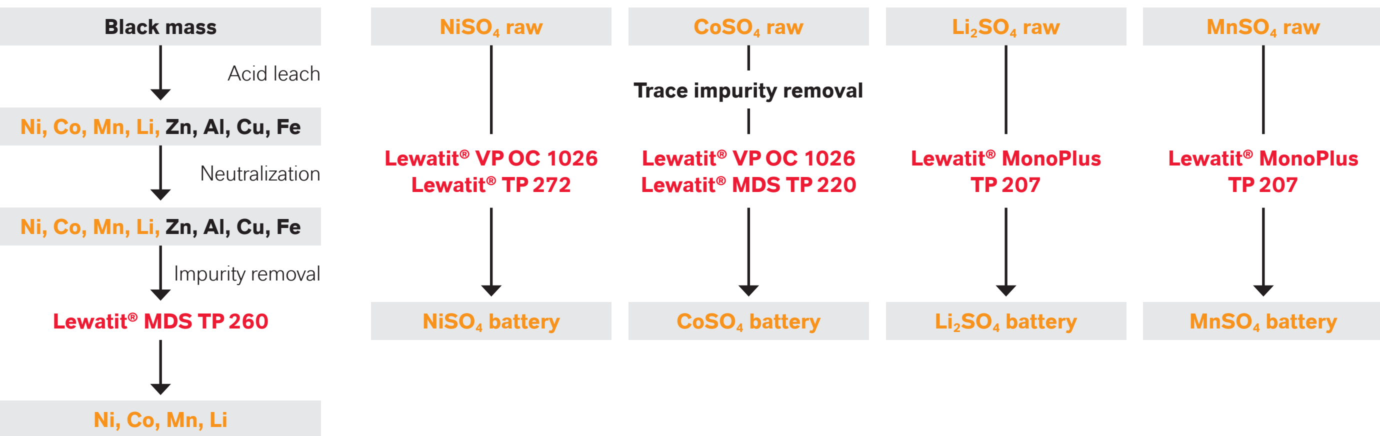
Recycling usually starts by discharging, dismantling, and shredding lithium-ion batteries. In hydrometallurgical operations the solid black mass powder is separated by filtration because it contains the valuable metals lithium, nickel, cobalt, and manganese. Leaching the black mass with acid dissolves the valuable metals Li, Ni, Co, and Mn. However, impurities such as Cu, Al, Zn, and Fe are also usually contained in the concentrates, because mechanical separation cannot be performed perfectly. These impurities can be efficiently removed with selective chelating resin Lewatit® MDS TP 260. We have especially developed a new, efficient Al regeneration technology with the use of NaOH and the elution of the $Al(OH)_{4-}$ anionic complex. Thanks to the smaller size of our monodisperse small (MDS) resins and, in turn, shorter diffusion paths, they exhibit faster kinetics during exchange and regeneration. Not only does their high packing density make them ideal for chromatographic separation, they also have higher capacity utilization and, in turn, longer service lives with lower requirements for regeneration chemicals.

Per- and polyfluorinated alkyl substances (PFAS) is a family of highly efficient surface-active agents used in various applications including lithium-ion batteries. They are present as cathode binders and in the semipermeable ion exchange membrane. However, when they are not handled and disposed of thoroughly, they can leach into the groundwater and surface water, where they persist as a result of their high chemical stability. Due to their hazardous potential, water limits have been strictly set. Standard technologies such as activated carbon and reverse osmosis cannot usually comply with the low effluent limits. Especially in hydrometallurgy applications these technologies fail, due to challenging operating conditions such as high ionic strength.

We therefore applied our PFAS selective resins Lewatit® TP 108 and Lewatit® MP 62 WS, which are already used for water-related applications as well as for purifying black mass leachate. Lewatit® MP 62 WS is a weakly basic resin and becomes selective for anionic PFAS when conditioned with mineralic acids such as HCl or H_2SO_4. After exhaustion with PFAS the anion exchange resin is regenerated and recycled with NaOH. Because PFAS need to be removed to low ppt levels (ng/l) a PFAS polisher, i.e., Lewatit® TP 108 with high selectivity is used to remove PFAS to very low levels.

In LIBs a frequently used electrolyte is $LiPF_6$ dissolved in a carbonate solvent, e.g., methyl ethyl carbonate. When the LIBs are dismantled and shredded the electrolyte comes into contact with moisture from the air, which causes the hydrolysis of $LiPF_6$ to HF, HPO_2F_2 and LiF. Because HF is detrimental to the ion exchange membrane, it needs to be removed for the production of high-quality LIBs. Lewatit® MP 62 WS Dried efficiently absorbs HF from the electrolyte and ensures a long lifetime for LIBs. Because Lewatit® MP 62 WS Dried has a very low water content due to the absence of permanently charged strongly basic groups, this resin is best suited for the purification process. The ion exchange resin is regenerated with NaOH.

Scheme 3: Schematic representation of the usage of Lewatit® resins (red) in the most common black mass leachate flow sheet.



Purifying individual metal concentrates

Since black mass contains a high concentration of battery metals, the individual metals is usually separated by solvent extraction. The generated metal concentrates are most efficiently purified by our selective chelating resins, e.g., Ni with Lewatit® TP 272 and Lewatit® VP OC 1026, Co with Lewatit® VP OC 1026 and Lewatit® MDS TP 220, Li and Mn with Lewatit® MonoPlus TP 207 (Scheme 3).

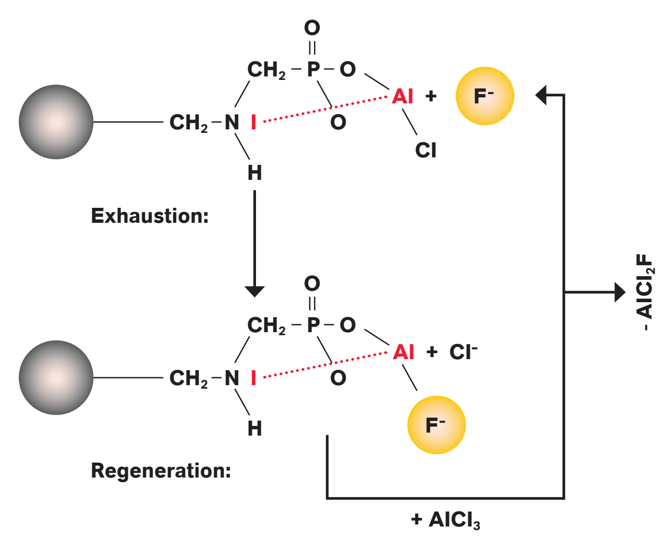
Our selective chelating resins are especially suited for this separation task because of their high selectivity and capacity to load impurities, which ensures efficient removal below the specification limit. At the same time they show low interaction with the valuable and concentrated battery metals nickel and cobalt, which pass the resin at high yield and recovery levels.

Wastewater treatment

Wastewater streams generated by battery metals recycling plants can be efficiently treated by Lewatit® MonoPlus TP 207. This resin selectively removes harmful heavy metals in the presence of high concentrations of other constituents of the wastewater, e.g. hardness. Valuable battery metals can additionally be recovered and recycled from the resin by selective regeneration.

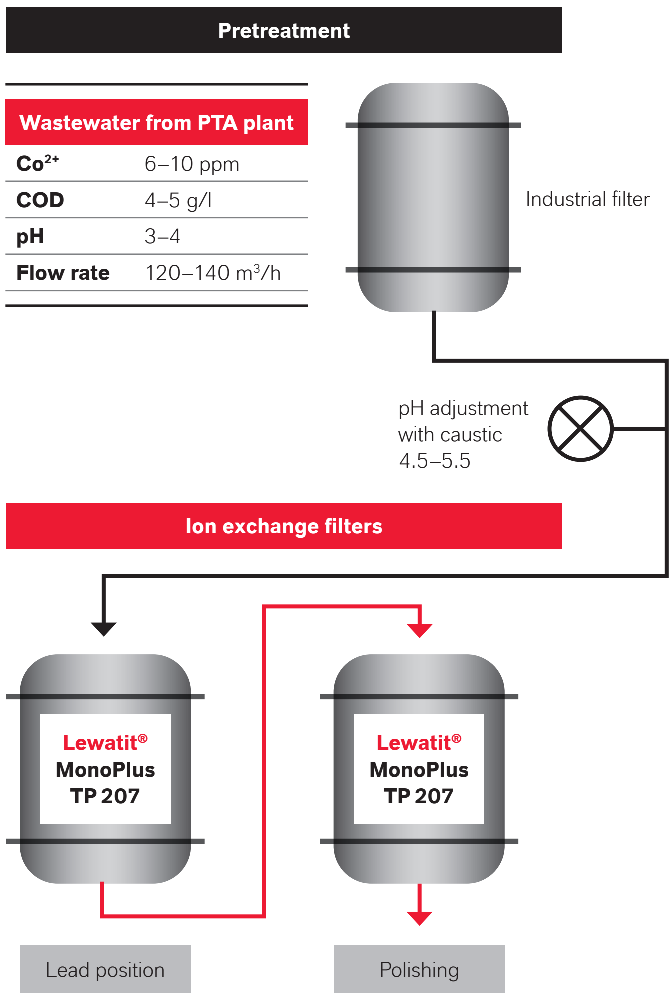
Many industries, such as the solar, glass, microprocessor, and metal finishing industries, generate water containing fluoride, which can be purified by Lewatit® MonoPlus TP 260 below the wastewater limit of 1 ppm. This resin is selective even in the presence of high concentrations of chloride, sulfate, etc. and is a reliable and safe method for removing fluoride. Our first reference plant in Gujarat, India, has been operating successfully for several years.

Scheme 4: Scheme for fluoride removal by the use of aluminum-doped Lewatit® MDS TP 260.



Ion exchange resins recover catalysts such as cobalt and manganese from the wash water generated by terephthalic acid production and therefore help to save operational costs and preserve value by recycling catalysts. The high selectivity and operating capacities of Lewatit® MonoPlus TP 207 for cobalt and manganese preserve value by recovering and reusing catalysts. Heavy metals are removed from wastewater to (i) protect the environment and (ii) to avoid potential penalties associated with violating discharge limits.

Scheme 5: Flow sheet of a heavy metal removal unit from wastewater in an LIB refining or recycling plant: pretreatment, removal of battery metals by Lewatit® MonoPlus TP 207.



In conclusion, Lewatit® ion exchange resins provide benefits including up to two times longer cycle times compared to conventional resins as well as savings on regeneration chemical costs. Excellent exchange kinetics ensure contaminant removal down to trace levels and yield pure battery metal concentrates. Additionally, Lewatit® chelating resins are highly resilient towards osmotic and mechanical stress and ensure long resin lifetimes.

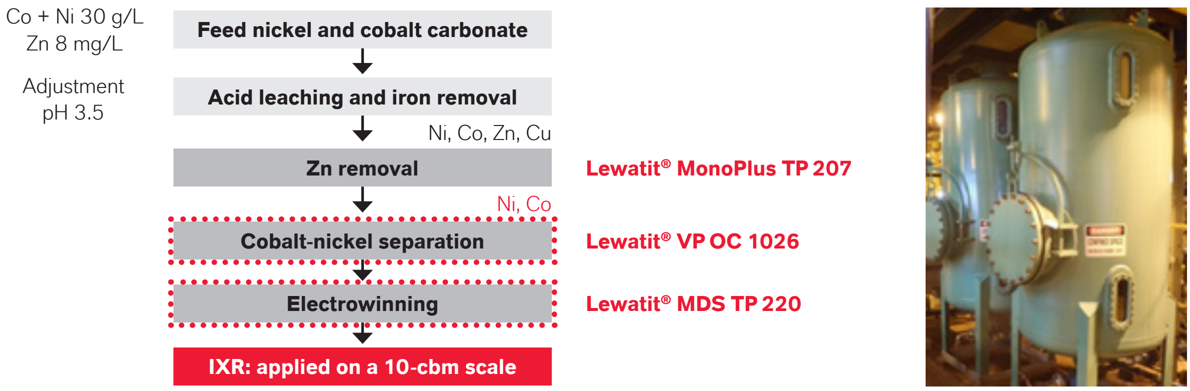
CASE STUDIES

Nickel and cobalt concentrate purification by solvent-impregnated ion exchange resins

The cobalt-nickel concentrate at the Vale Canada Ltd. Port Colborne site has been purified with Lewatit® ion exchange resins for many years. Copper impurities are removed by Lewatit® MonoPlus TP 207 in the H-form at pH 3.5 (Scheme 6). The selective removal of Zn and other contaminants from Ni and Co concentrates is done by the use of Lewatit® VP OC 1026. Interestingly, an optimization project has been identified to eliminate zinc's breakthrough that originated in the increase of zinc impurities in the cobalt feed.

Finally, cobalt and nickel are separated by the use of Lewatit® MDS TP 220. Nickel is selectively loaded onto the ion exchange resin while cobalt is passing through. The resin can be regenerated by the use of 10% sulfuric acid.

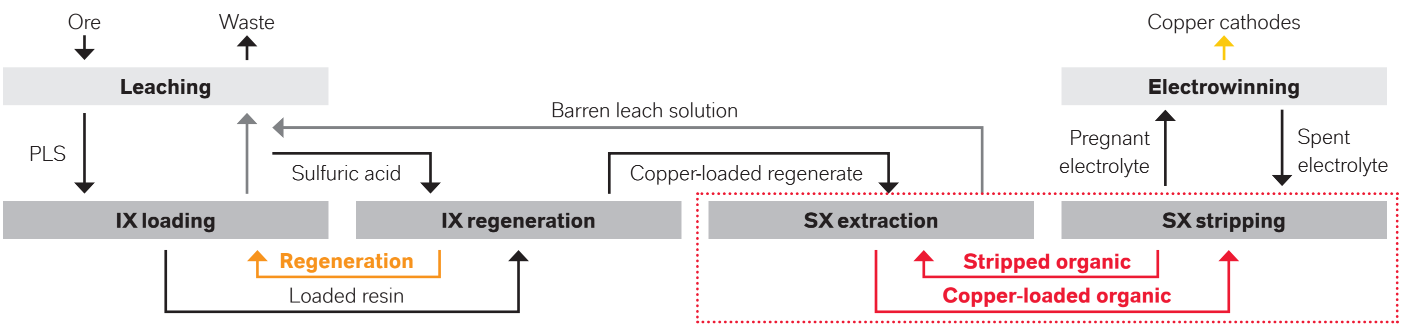
Scheme 6: Flow sheet for battery metal processing in the nickel and cobalt refinery plant at Vale, Port Colborne (Canada).



The complementary aspects of Lewatit® ion exchange resins and solvent extraction in copper recovery processes

A complementary ion exchange/solvent extraction process for the recovery of copper from low-grade ores is described. It has successfully been implemented on a full-scale plant level at the Buchim Copper Mine in Macedonia, yielding a maximum copper cathode production of 2,400 tonnes per year. Compared with conventional SX/EW operations, this technology makes the exploitation of low-grade copper ores economically viable due to reduced operational and capital expenditure. Furthermore, the additional Lewatit® ion exchange installations diminish the volumes of harmful organic substances in the following SX step and minimize the risks associated with the handling and usage of these chemicals, such as environmental pollution or fires. Finally, the significantly diminished quantities of liquids for the SX operation have a tremendous effect on the footprint of the plant (ca. 50% less) thereby reducing capital expenditure.

Scheme 7: Flow scheme of the Buchim Mine copper recovery plant. The combined IX/SX process has been running successfully for several years.



LEWATIT® PRODUCT PORTFOLIO
FOR BATTERY METALS APPLICATIONS

	Nickel and cobalt						Copper				Lithium		$LiPF_6$
	Recycling	Fixed-bed recovery	Resin-in-pulp recovery	Concentrate purification	Separation	Wastewater	Resin-in-pulp recovery	Fixed-bed recovery	Wastewater	Concentrate purification	Brine purification	Recycling	Purification
Lewatit® MonoPlus TP 209 XL		■	■			■	■						
Lewatit® MonoPlus TP 207	■	■		■		■		■	■			■	
Lewatit® VP OC 1026	■			■									
Lewatit® TP 272	■			■	■								
Lewatit® MDS TP 220				■	■			■	■				
Lewatit® MDS TP 260	■			■		■		■		■	■	■	
Lewatit® MDS TP 208											■		
Lewatit® MonoPlus TP 214				■									
Lewatit® TP 308											■		
Lewatit® MP 62 WS				■									■
Lewatit® TP 108	■												
Lewatit® MK 51											■		
Bayoxide® E IN 30											■		

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Edition: November 2024

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