

LITHIUM RESOURCE EXTRACTION AND PURIFICATION

- Extracting lithium from salt lakes and recovering associated resources such as rubidium, cesium, boron, etc

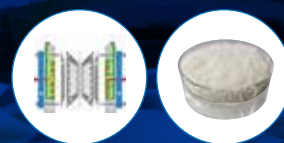
- Extraction and purification of lithium from geothermal brine

- Lithium extraction from lithium ores and recovery of associated resources

- Extracting lithium from fly ash for resource recovery

- Lithium extraction and purification from oil and gas field brine

- Resource recovery of lithium from electrolytic aluminum waste residue

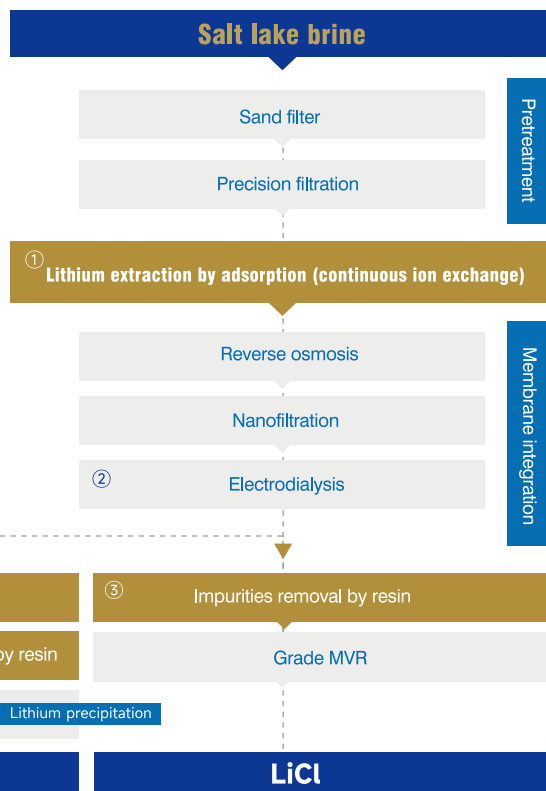
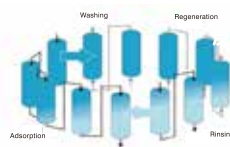


Haipu Relying on the core adsorbent, ionic membrane and supporting equipment R & D and manufacturing system combined with the provincial brine extraction engineering research center to provide technical and engineering support, can be for the brine lithium resource extraction needs to provide a full range of customized solutions, and to provide the construction and housekeeping operation services.

① Continuous Ion exchange

Continuous Ion Exchange technology is a completely innovative separation technology, which is different from the traditional fixed bed, pulsed bed, simulated moving bed and other processes. The continuous ion exchange system consists of resin column series and porous distribution rotary valve. According to the process design, the resin column series can be divided into several functional areas.

After the material enter the system, each resin column passes through each functional area in turn by swithing the rotary valve to realize all the processes of simultaneous adsorption,water washing, desorption and regeneration, thus turning the traditional intermittent process into a continuous process.



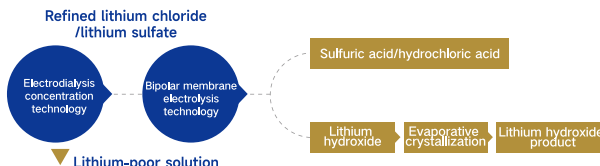
② Electrodialysis and bipolar membrane products

Preparation of lithium hydroxide by Haipu bipolar membrane electrodialysis

Bipolar membrane electrodialysis technology has a bright future in preparing lithium hydroxide from lithium-containing solution. Bipolar membrane is introduced into common electrodialysis system to promote the process of water dissociation into H^+ and OH^- ions under electric field. Driven by DC electric field, OH^- can migrate from lithium-containing raw material solution into lithium hydroxide formed by the combination of Li^+ in alkali chamber. In view of the characteristics of high magnesium-lithium ratio in salt lakes in China, bipolar membrane electrodialysis can be combined with adsorption lithium extraction to prepare high purity lithium hydroxide products. Compared with the traditional preparation technology of lithium hydroxide in salt lake, this method has the characteristics of low energy consumption, environmental protection and high product quality, and has certain advantages in improving the quality of lithium salt products in salt lake and enriching the types of lithium products.

Boron removal by Haipu electrodialysis concentration

The electrodialysis process can remove boron from the concentrated water of nanofiltration and reverse osmosis system in the middle stage of brine extraction, and at the same time, the highest concentration of lithium can be more than 20g/L. Compared with the membrane method and chemical method, the electrodialysis process can reduce the consumption of alkali and save 80% of the evaporation and concentration cost.



③ HAIPU decontamination technology

HP4010 Calcium and magnesium removal from lithium-containing liquid

For the production of lithium carbonate and lithium hydroxide products, calcium and magnesium ions must be removed in advance. Conventional nanofiltration membranes cannot be used as substitutes, and the preferred method is calcium and magnesium removal using chelating resin.

HP3500 Fluorine removal from leaching liquid

Fluoride ions can easily corrode equipment and affect the purity of lithium salts. HP3500 can stably reduce fluoride ions to below 1 mg/L without introducing any new impurities.

HPB119 Boron removal from raffinate

HPB119 can selectively and deeply remove boron while minimizing the loss of metal cations, offering an irreplaceable advantage over traditional chemical methods in this step.

Iterative Innovation of Lithium Extraction Technology in Salt Lake-Lithium Extraction Adsorbent &Technology Core Competitiveness

Haipu's aluminum and titanium -based lithium adsorbents have been developed to the 5th and 3rd generation respectively, and these new generation products have significantly improved in terms of adsorption capacity, selectivity, operational stability and adaptability to extreme conditions.

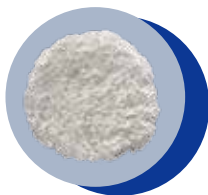
Upgrading and iterating adsorbents to expand usage scenarios

Due to the differentiation of the resource endowment of the salt lake, the 5th generation aluminum and 3rd generation titanium adsorbent products of Haipu have significantly improved the adsorption capacity, adsorption rate, low temperature resistance and other product performance, and are applicable to the scenarios, including direct lithium extraction from high-magnesium old brine, magnesium sulfate subtyped brine of the salt lake, gas field brine, carbonate brine, and selective separation of lithium and sodium from lithium precipitation mother liquor, and so on.

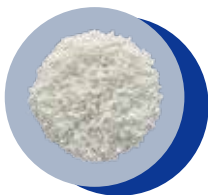
Lithium extraction from high magnesium old brine to effectively deal with the challenge of high magnesium-lithium ratio;
Direct lithium extraction from raw brines of magnesium sulfate subtype salt lakes, improving resource utilization;
Lithium extraction from gas field brine, opening up a new source of lithium resources;
Lithium extraction from carbonate-type brines, customized for brines with special chemical properties;
Selective separation of lithium and sodium in lithium precipitation mother liquor, enhancing product purity and value

Full-scene coverage of lithium extraction adsorbent category
Haipu has the most complete product category of lithium extraction adsorbent in the industry, with outstanding product research and development ability and strong iterative ability, and can quickly adjust and update the product line according to customer needs to pursue accurate adaptation with customers; In addition, Haipu has the most efficient industrial production ability in the industry, from product technology research and development to pilot trial production to large-scale production to product optimization, and continues to provide high-quality and stable industrial products; In particular, Haipu titanium-based lithium extraction adsorbent is the first large-scale industrial application of titanium-based lithium extraction in the world.

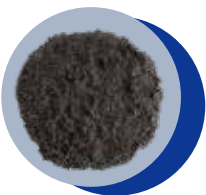
Haipu	Trademark	Exterior	Particle size range ≥95%	pH	Scope of application
Aluminum-series	HPL16X series	Regular particles	0.5-2mm	4-8	Suitable for direct lithium extraction from old brine or original brine, with high adsorption rate, large adsorption volume, excellent low temperature resistance, and guarantee production capacity in all season.
			0.2-0.4mm	4-8	Micro-uniform particle adsorbent is suitable for scenes with high water consumption requirements, has excellent low temperature resistance, and guarantees production capacity in winter.
Titanium-series	HPL91X series	Regular particles	0.5-2mm	7-14	It is suitable for direct lithium extraction from carbonate type brine and lithium precipitation mother liquid, with strong bursting resistance, low dissolution loss, excellent low temperature resistance, and guarantees production capacity in winter.
Manganese-series	HPL180 series	Regular particles	0.5-2mm	6-9	It can be used for low-grade brine, suitable for direct lithium extraction from chlorine type and sulfuric acid type brine, with high selectivity.



Aluminum-series adsorbent for lithium extraction



Titanium-series adsorbent for lithium extraction



Manganese-series adsorbent for lithium extraction

Haipu has a wide range of functional chelating adsorbents with excellent performance in calcium and magnesium removal, boron removal, etc., which can solve the demand for deep calcium and magnesium removal and deep boron removal in the whole process chain of lithium extraction from brine, and provide industrial-grade and electronic-grade lithium salt products.

Core technological breakthrough

The biological embedding and wet spray pelletizing technology was pioneered, and the fifth generation aluminum-series lithium extraction adsorbent products, the third generation titanium-series lithium extraction adsorbent and manganese-series lithium extraction adsorbent were successfully synthesized. During the preparation process, lithium resources in the materials were recycled, which effectively solved the problem of low recovery rate of dry granulation lithium materials, and took the lead in controlling the dissolution rate of titanium-series lithium extraction adsorbent to meet the level of industrial application. The combination technology of low water consumption lithium extraction adsorbent and low bed adsorption process will also greatly improve the water shortage problem in salt lake mining in Xinjiang, South America and other regions, and provide more advanced production tools for domestic lithium battery resource mining and industrial layout.

Lithium extraction technology in low water consumption application scenario

An aluminum-series adsorbent for lithium extraction based on small-particle polystyrene was developed, and $\text{LiCl} \cdot 2\text{Al}(\text{OH})_3 \cdot n\text{H}_2\text{O}$ was grown in-situ inside and on the surface of resin channels.



SEM electron micrograph of effective components of aluminum hydroxide in adsorbent channels

This technology integrates the synthesis of active components with granulation and molding, thereby streamlining the conventional complex process of separate powder synthesis, preparation, and forming. Leveraging its uniformly small spherical structure and nano-scale pores, the adsorbent achieves an extremely high packing density and adsorption exchange rate, with an exchange capacity more than 400% higher than that of traditional adsorbents. The use of Haipu's patented low-bed adsorption device enables high-speed operation, reduces resin consumption, and—through superior exchange kinetics and a counter-current regeneration method—significantly cuts system water usage, making it well-suited for water-scarce salt lake lithium extraction areas such as Xinjiang and other overseas regions.

The low-bed process operates the resin under moderate loading conditions, utilizing primarily the exchange groups on the resin surface layer. When system throughput is not high, a fine-grained resin with high specific surface area is essential to maintain rapid ion exchange kinetics, which in turn supports the device's high processing capacity—this generally requires the adsorption resin particle size to be as small as possible. To date, other manufacturers have not been able to produce aluminum-based adsorbent products within this optimal particle size range, and their irregular granulation forms do not meet the full bed packing requirements of the low-bed process, a challenge that Haipu has successfully overcome.

ITERATIVE INNOVATION OF LITHIUM EXTRACTION TECHNOLOGY IN SALT LAKE -VALVE ARRAY & ROTARY TABLE TYPE CONTINUOUS ION-EXCHANGE DEVICE

Haipu matches and develops special products according to enterprise customers' needs in a targeted manner. With enterprise products as the core, Haipu further designs and develops advanced supporting system devices such as simulated moving beds, continuous ion-exchange systems, continuous chromatography, etc., which constitutes a set of comprehensive and efficient solutions. Combined with the characteristics and advantages of materials and equipment, they are applied in different scenarios and industries. Based on the diversified needs of our customers, Haipu has developed valve array and rotary table type continuous ion-exchange system which have obvious advantages over fixed bed units in terms of increased productivity, cost reduction, flexibility and automation.

“Merry-go-round”Sequence Continuous Ion Exchange System

Continuity and Stability: The carousel-type unit achieves a continuous lithium ion exchange process through a fixed bed on a rotating disk, providing a stable lithium product output.

Multi-Stage Separation: The carousel unit allows for multi-stage separation in a single system, further improving lithium purity.

Reduced Solvent Consumption: Due to its continuous operation nature, the carousel unit reduces eluent and solvent consumption.

Easy to maintain: The relatively simple structure of the carousel unit makes it easy to maintain and clean.

Adaptable: The rotary disk device can be adapted to different operating conditions, such as temperature, pH, etc., and is suitable for many types of lithium extraction processes in salt lakes.



Simulated moving bed

High efficiency: The valve array device can realize continuous operation, improve the extraction efficiency of lithium ion and reduce the production cycle.

Flexibility: By adjusting the switching mode of the valves, it can adapt to different lithium content and characteristics of the salt lake to optimize the extraction process.

Reduced resin usage: Valve array devices typically require less resin volume, thereby reducing material costs.

Improved lithium recovery: By precisely controlling the operating conditions, lithium recovery can be improved, reducing resource waste.

Easy to automate: Valve array devices are easy to automate and control, improving operational accuracy and repeatability and reducing human error.



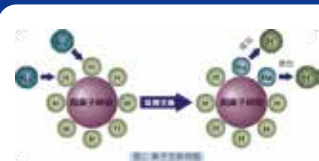
2D AND 3D MATERIALS

Ion exchange membranes and ion exchange resins

Ionic membrane is the core component of many key industrial technologies, and its performance directly affects the efficiency, stability and cost of equipment. Through independent research and development of high-performance ionic membrane, HaiPo can break the monopoly of technology, reduce the production cost and enhance the competitiveness of the market. We provide customized solutions for enterprise customers' applications under complex working conditions to meet their diversified needs and stand out in the fierce market competition.

2D materials - ion exchange membranes

Ion exchange membranes are films that allow selective transmission of ions and are broadly categorized into cation exchange membranes and anion exchange membranes. In cation exchange membranes, only cations are permeable due to a fixed negative charge exchange group, and anions are not permeable due to the rejection of negative charges (as shown in the figure on the left), while anion exchange membranes utilize the opposite effect.



3D materials and ion exchange resins

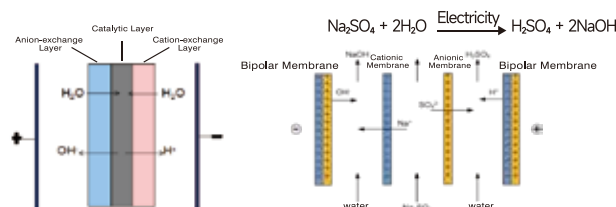
Ion exchange resins contain a large number of functional groups and are roughly divided into two types of resins: anion and cation. The cations in the water are converted with the cation exchange resin, and the cations in the water are adsorbed onto the resin, while the cations on the resin are exchanged into the water, which then passes through the anion resin, which then releases OH⁻ ions, which are combined with the H⁺ in the cation exchange resin, and become harmless substances.

SALT LAKE LITHIUM EXTRACTION TECHNOLOGY ITERATIVE INNOVATION-MEMBRANE DEVICE

Salt lake projects domestic and abroad have a wide demand for electrodialysis concentration and bipolar membrane acid and alkali production technology. In response to the need for cost reduction and efficiency increase in salt lake projects, Haipu organically combines many years of engineering projects and R&D experience in ion exchange materials, quickly launches a series of products of bipolar membrane electrodialysis and completes the construction of a full-cycle service team in the three-point-one-line of supporting R&D laboratories, membrane production factories and engineering assembly and installation workshops.

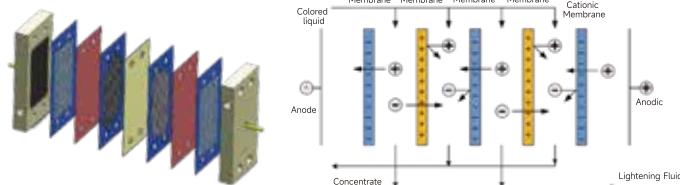
Bipolar Membrane

A new type of ion exchange composite membrane, consisting of a cation exchange layer (N-type membrane), an interfacial hydrophilic layer (catalytic layer) and an anion exchange layer (P-type membrane). Under the action of electric current, it can dissociate water into hydrogen ions and hydroxide ions. When used in conjunction with anion exchange membranes, the Bipolar Membrane Electrodialysis System converts salts in an aqueous solution into the corresponding acids and bases without the introduction of new components.



Electrodialysis

The system consists of alternating stacks of cation and anion exchange membranes separated by spacers and equipped with electrode plates, end plates and other components. Principle of operation: The membrane stack alternates cationic and anionic membranes to form a desalination and concentration system. Under the influence of a DC electric field, when brine is introduced into the compartments, cations migrate toward the cathode only through the cation-exchange membrane, while anions migrate toward the anode only through the anion-exchange membrane. The result of this process is that the brine is desalinated in the dilution zone and the brine is concentrated in the concentration zone.



PRODUCTION CASES

Lop Nor Salt Lake in Xinjiang

The project has an annual production capacity of 5,000 tons of lithium carbonate. In September 2023, Haipu won the bidding for the Aluminum-based Adsorbent Optimization Project of SDIC. The old brine after potassium extraction can be directly passed into the ion exchange device equipped with aluminum-based adsorbent to selectively adsorb lithium. The recovery rate of lithium in the adsorption process reaches more than 85%. Compared with other adsorbents, the performance of HPL151 (third generation) has been improved by more than 10%.



Unit: mg/L						
Projects	Appearances	pH	Li ⁺	Mg ²⁺	Na ⁺	B ³⁺
Raw Brine	Yellow	5	400	124,700	1,800	2,150
Qualified liquid	colorless	7	600	1,000	10	400

Argentina 3Q Salt Lake

In October 2024, Haipu sent technicians to the 3Q Salt Lake in Argentina to carry out the on-site pilot test on the raw brine for cross-linking adsorption, which also obtained excellent experimental data. This salt lake is of chloride type, characterized by high lithium concentration and high calcium content. Under the condition of 95% lithium recovery rate, the adsorption capacity of HIPP aluminum-based adsorbent reaches more than 4.5g/L. The lithium concentration of the qualified solution reaches 1.0g/L, while the sodium concentration is only 0.6g/L and calcium concentration is 0.7g/L.



Unit: mg/L						
Projects	Appearances	pH	Li ⁺	Mg ²⁺	Na ⁺	B ³⁺
Raw Brine	colorless	5	700	80,000	35,000	1,200
Qualified liquid	colorless	7	1,000	600	700	400

Laguo Co Salt Lake in Tibet

The project has an annual production capacity of 20,000 tons of lithium carbonate, from November 2022 to April 2023, Haipu conducted pilot tests on the project and won the bidding for Zijin Mining's titanium-based adsorbent procurement project and has been successfully commissioned. The data shows that the lithium recovery rate in the adsorption process reaches more than 75%. Compared with other adsorbents, the performance of HPL910 has been improved by more than 30%. After nearly 1 year of industrialization, the stability is good.



Unit: mg/L						
Projects	Appearances	pH	Li ⁺	Mg ²⁺	Na ⁺	B ³⁺
Raw Brine	colorless	9	240	760	15,300	2,150
Qualified liquid	colorless	6	1,400	230	700	400

Material purification (except calcium and magnesium)

Haipu's in-depth calcium and magnesium removal technology with adsorption process as the core is a special adsorption material and application process developed specifically for in-depth calcium and magnesium removal, which can ensure that the content of Ca²⁺ and Mg²⁺ in the effluent water is ≤5 ppm, and the adsorbed effluent water can meet the customer's index requirements.

Calcium and magnesium removal from lithium sulfate feed solution

Targets	Water volume (t/d)	Ca ²⁺ , Mg ²⁺ (mg/L)	pH	Note
Adsorption inlet	75-90	< 50	10-12	20% of production capacity reserved
Adsorption effluent	75-90	< 5	10-12	Lithium sulfate material liquid recycling treatment
Acid desorption solution 1	0.75-0.9	/	acidic	Back to front-end acid leaching process
Acid desorption solution 2	7.5-9	500-750	acidity	/

Ginel Salt Lake, Dongtai, Qinghai

HPL162 (fourth generation) has excellent adsorption performance on raw brine of salt lake and high boron electrodialysis tailings. The brine of Qinghai Salt Lake has low lithium concentration and high sulfate concentration, and the experimental data in the field pilot test in June 2024 is excellent. The volumetric adsorption capacity reached 3.5 g/L under the condition of guaranteeing 95% lithium recovery, and the lithium concentration of the qualified liquid reached 0.8 g/L, while the sodium concentration was only 0.4 g/L and the magnesium concentration was 0.1 g/L. The customer ordered 525m³ for production application and put into production in December 2024.

Unit: mg/L						
Projects	Appearances	pH	Li ⁺	Mg ²⁺	Na ⁺	B ³⁺
Raw Brine	light yellow	6	450	105,000	14,000	600
Qualified liquid	colorless	7	800	400	100	100

A Salt Lake in Qinghai

The project has an annual output of 15,000 tons of lithium carbonate. Our pilot production (scale 800 tons/year) lithium recovery rate reached more than 90%. Compared with other adsorbents, the performance has been improved by more than 20%. The brine in the salt lake has a high content of sulfate ions, and the aluminum-based adsorbent on the market will be poisoned during long-term operation, leading to a decline in the performance of the adsorbent. HPL162 has been in operation for more than a year without such a problem. The customer ordered 590m³ for production application and put into production in March 2025.



Unit: mg/L						
Projects	Appearances	pH	Li ⁺	Mg ²⁺	Na ⁺	B ³⁺
Raw Brine	colorless	6	165	28,560	84,580	500
Qualified liquid	colorless	7	650	60	150	150

Material purification (boron removal)

The effective specific surface area of boron removal adsorption resin is large, the adsorption capacity is high, and the adsorption capacity of boron ion per unit volume of adsorption resin exceeds the adsorption capacity of common materials on the market. The overall process design adopts two-stage adsorption tower series mode, cobalt sulfate solution sequentially through the two towers in series adsorption, adsorption of raw water and adsorbent materials with a long contact time, the adsorption of adsorbent quality adsorption rate is high.

Unit: mg/L			
Targets	Water quantity (t/d)	B ³⁺ (mg/L)	pH
Boron adsorption inlet water	20	~40	2.0-3.5
Boron removal adsorption effluent	20	≤2	< 6
Boron-containing desorption solution	0.67	/	Strong Acid
Liquid alkali activation solution	0.67	/	neutral

Removal of calcium and magnesium from nickel and cobalt-containing liquids



Targets	水量 (t/d)	Ca ²⁺ (ppm)	Mg ²⁺ (ppm)	Note
Adsorption inlet	20	≤100	≤50	/
Adsorption effluent	20	≤1	≤0.2	Continue to use
High concentration desorption solution	0.33	/	/	Customer Handling

ONE-STOP SERVICE - PRODUCTION,
TRANSPORTATION, LOADING, COMMISSIONING



SYSTEMS INTEGRATION,
ENGINEERING SERVICES AND DESIGN SUPPORT



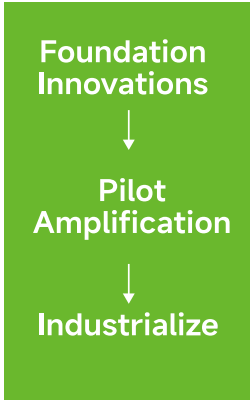
Industrialization transforms efficient production capacity



More than 70% of R&D personnel hold a master's degree or above. Leveraging a solid technological foundation, the company has achieved efficient industrialization of new products, continually driving fresh momentum into the industry.

The production line is designed with a modular and reconfigurable concept, enabling stable yet flexible production capacity. It can deliver thousand-ton-scale products within one month, meeting customer needs for customization and fast delivery.

The company has an annual production capacity of 36,000 cubic meters of adsorbents, 1 million square meters of membranes, and a 20,000-square-meter intelligent equipment manufacturing workshop. In-house production capacity for both materials and equipment ensures high-quality and high-volume delivery for every order.



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