White Paper

Supramolecular Interactions Technology: A Game-Changer for the Lithium Industry.

Technology description – Performance and Environmental Proofs.

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Abstract

This white paper presents Adionics' **Direct Lithium Extraction (DLE) technology, based on an innovative supramolecular chemistry applied to liquid-liquid extraction**. After outlining the context, technological foundations, and economic challenges in the lithium field, we introduce the Flionex® — our proprietary formulation that selectively captures lithium salts through supramolecular chemistry – and our **simplified engineering process that consists of three simple steps**, each **optimized for minimal energy and water consumptions.**

The technology validation is supported by a **predictive modeling tool and real-world testing at a demonstration plant**. Key performance indicators — **lithium recovery yield, purity, low water and energy consumptions — are benchmarked across a completed range of brine types**. Parametric studies, modeling comparisons and demo plants results confirm the robustness, adaptability and environmental respectfulness of the solution in terms of **product quality (battery grade-ready lithium) and respect of environmental challenges**.

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PART 1 – DLE overview and ADIONICS

1.1 Introduction: Lithium and DLE, a Game Changer in the Energy Transition

The transition to clean energy is significantly increasing the demand for minerals, which raises geopolitical challenges and environmental issues, requiring a climate-smart approach for sustainable resource development[1].

Lithium, a critical element in the energy transition, is now at the heart of the value chains for energy storage tech, driven by EV and ESS (90% of lithium usage today)[2,3]. Indeed the surge in global lithium demand is putting the entire sector under pressure, with projections indicating a threefold increase in needs by 2035[4].

Two industrial primary supply chains currently coexist: extraction from hard rock (lithiated mineral ores) and the exploitation of salar lithiated brines. While conventional methods remain widely used, innovative Direct Lithium Extraction (DLE) technologies have recently emerged[5] aiming to provide cost effective innovative technologies to fully harness natural resources while offering more environmentally respectful extraction conditions.

Within the category of Direct Lithium Extraction (DLE), several technological approaches exist.Today, Adionics is the first and only company offering a liquid-based DLE solution for LiCl extraction through Salt Absorption- Desorption. This process for capturing lithium as a salt within a liquid phase provides multiple advantages, including higher capacity, superior selectivity, greater durability and stability and adaptability to each client needs.

1.2 The Genesis of a Revolutionary DLE Concept

In 2008, the founder Guillaume de Souza reviewed a wide variety of desalination concepts and technology via a large bibliographic study. It appeared that only salt removal by liquid-liquid extraction could allow very low energy levels. Even if R&D work had been done in 1969-1975 by Dow Chemical Co scientists, none allowed massive NaCl extraction from sea water.

1.3 Adionics' History

In 2011, the historical project "AquaOmnes®" won a Startup competition, allowing the launch of Adionics® in March 2012, with a team of 6 people at the Ecole Centrale Engineering School Campus.

Adionics then joined ex-Merck chemical labs able in May 2013 to support chemical engineering R&D and raised € 1 million from a business angel (06/2013). Adionics synthesis, formulation and analytical Labs became operational in September 2013. The first liter of Flionex, allowing NaCl extraction (up to 75%), was produced in January 2014.

In January 2017, a pivot to lithium brine mining was chosen due to its unique ability to extract selectively salt from a Lithium Salt Brine.

Through the course of 2021/2024, Adionics launched 3 demo plants, one CL250 and two CL15 units. Since 2024, Adionics has opened a subsidiary in Argentina with the inauguration of their demo plant in Güemes, to showcase Adionics' DLE effectiveness on real brines from prospects and clients. It is also a test facility for the implementation of improved practices in operation and safety with more than 4000 hours 24/7 continuous operation on or offsite with natural brines.

PART 2 Supramolecular Technology and Process

2.1 At the Heart of Technology: Flionex

As mentioned previously, Adionics has pioneered a unique liquid-liquid approach based on supramolecular chemistry with low interaction, enabling the selective absorption of salts within a liquid phase.

Currently, Adionics is the only company offering a direct lithium salt extraction solution via a liquid-liquid process. This technology stands out not only for its innovative nature but also for its exclusive ability to regenerate solvents for lithium salt desorption using hot fresh water.

At the core of this process, **Flionex** plays a key role by selectively capturing lithium as a salt, within the liquid-liquid system.

Flionex is a unique patented liquid medium[6] composed of several components:

- **A cationic extractant**, specifically designed to capture selectively lithium ions,
- **An anionic solvating agent**, responsible for binding anions such as chloride in natural brines,
- **A solvent** with optimized physicochemical properties for efficient salt extraction.

Unlike conventional ion-exchange processes, Flionex operates through weak supramolecular interactions which allows gentle, selective, and reversible lithium salt extraction.

The cationic extractant used in Flionex exhibits a strong preference for lithium, ensuring efficient capture and minimal freshwater use for regeneration w/o any pH adjustment requirement.

The anionic solvating agent facilitates phase transfer of targeted anion and can be adapted according to lithium source chemistry. Anions, such as chlorides, nitrates, bromide or sulfates, are key in Adionics process and allow for salt extraction into the organic phase, neutral species, therefore not requiring ion-exchange.

Thanks to the weak supramolecular interactions between Flionex and lithium salts, regeneration is simple using a temperature swing and requires very little water.

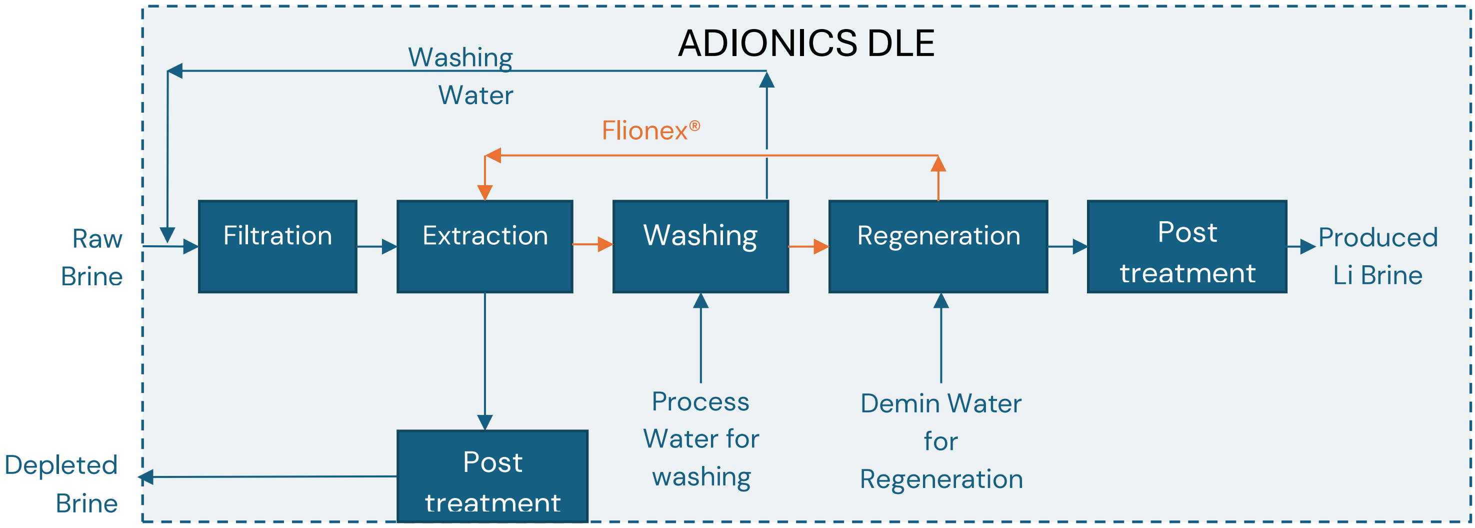
Our mission is to design highly selective molecules while maintaining weak interactions — like magnetic forces — to ensure optimal selectivity for lithium salts within a temperature driven process.

Each component of Flionex has a specific function and can be adjusted according to the characteristics of the brine or resource being processed. This adaptability is one of the key strengths of our technology, allowing for precise customization based on the application.

To date, Adionics offers several Flionex formulations, capable of extracting lithium as a salt, regardless of the source, and adapted to the brine composition.

2.2 Adionics' Process Description

Adionics' process can be represented in a simplified Block Flow Diagram such as:



The only pre-treatment required by Adionics technology is filtration to remove solids & bio (algae…).

Indeed, small solids and colloids are known in liquid-liquid extraction to prevent efficient settling, impacting the size and performances of later equipment. Therefore, the brine, after being pumped through solid removal filtration equipment, is injected into the liquid-liquid extraction system, and goes through the extraction system.

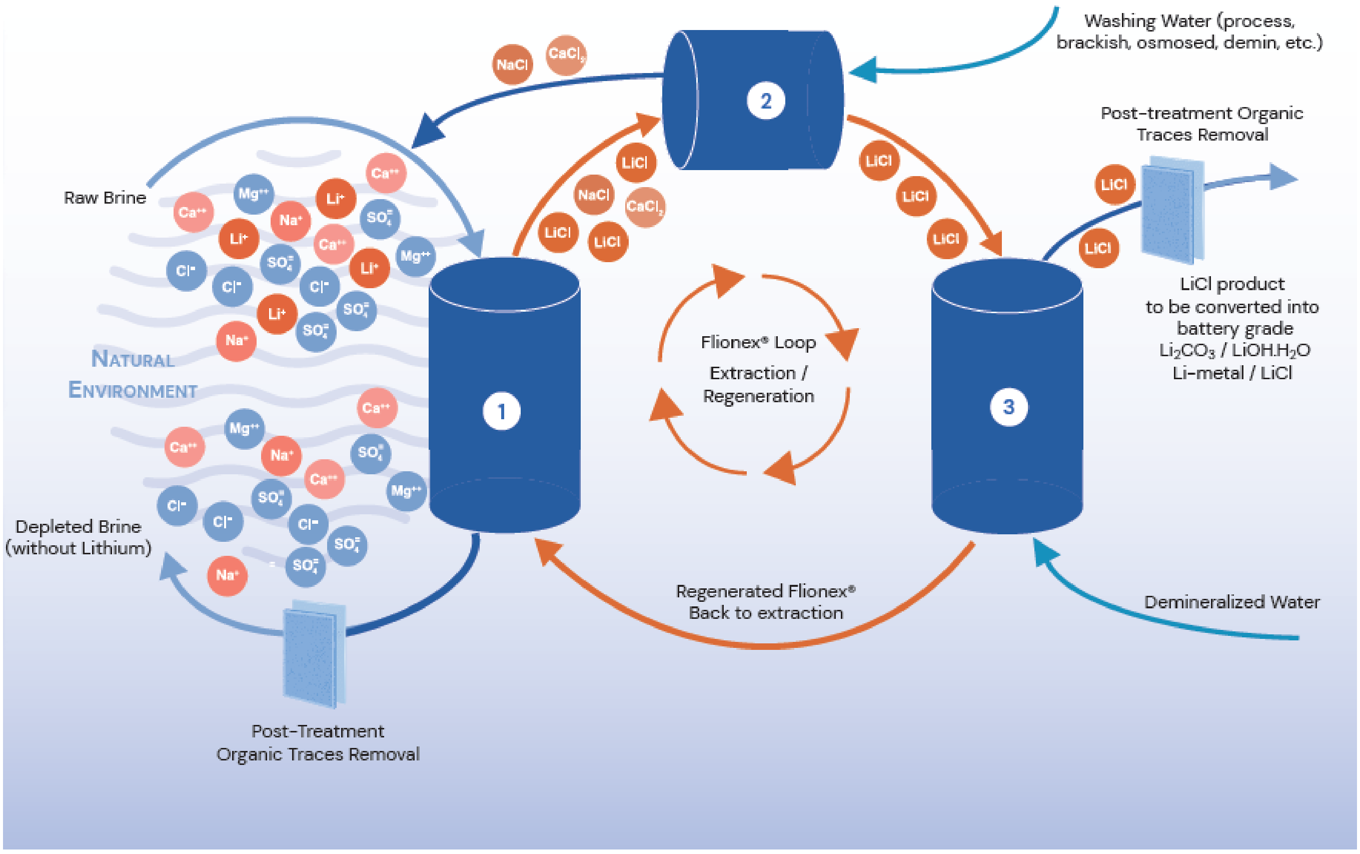
2.2.1 Three Major Process Steps

- **Step 1: Extraction**
  The extraction process involves mixing and separating two phases in a counter-current flow at ambient pressure and temperature. Separation technology is chosen based on the brine and Flionex physico-chemical properties. Lithium, along with its counter-ions and some co-extractable cations like sodium or calcium, are selectively recovered, while potassium, magnesium, sulfate and boron remain in the brine. The lithium-depleted brine is then treated to remove residual organics and can be safely released or reinjected underground.

- **Step 2: Washing**
  The loaded Flionex is then pumped through the washing step, where a very limited amount of water (process or freshwater) is used to wash out the co-extracted ions from the organic phase, therefore increasing the produced brine LiCl purity. This step works at ambient temperature and pressure, and mixer-centrifuge has been identified as the most suitable for this step. The resulting aqueous stream is recovered and mixed with the brine to be treated to prevent any lithium loss.

- **Step 3: Regeneration and Lithium reconcentration**
  The lithium loaded purified Flionex is then processed through the regeneration step, which is the only step conducted at a higher temperature (80°C) and ambient pressure.The ionic species are subsequently released from the high-density organic phase into the demineralized water, and the organic phase is recovered and cooled to be sent back to the extraction step. The produced LiCl brine is collected and processed through a post-treatment chain to remove the remaining traces of organic traces from the aqueous phase and then can be processed to a conversion unit downstream. Throughout Adionics process, various heat-exchangers are implemented to recover heat from the different parts of the process and ensure a very low thermal consumption requirement at an industrial scale.

The post-treatment chains implemented on both aqueous outlets are designed to prevent organic compounds of Flionex from remaining in those effluents. This post treatment chain is split into two distinct sections. The first one, non-destructive for the organic compounds, allows nearly 100% extractant and solvatant recovery for a vast majority of Flionex recuperation and recycling in the process without alteration. A second part, destructive, aims to reduce the remaining organic traces down to a non-measurable level.



2.2.2 Technology Selection Depending on Brines Physico-Chemical Properties

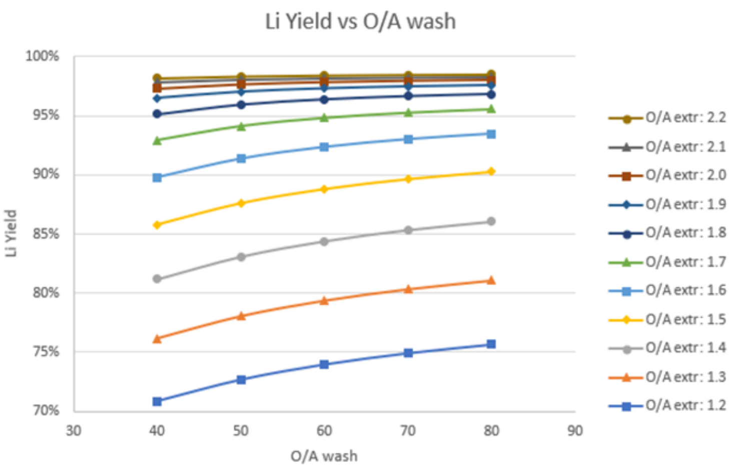
Adionics technology is based on liquid-liquid extraction principles. Adionics process being based on liquid-liquid extraction principles, the implemented technologies to be applied are carefully selected to comply with raw brines' physics-chemical properties.

One key parameter to adjust the process performances is the O/A ratio (or A/O ratio), which is the ratio of volumetric flow rates between the organic phase (O) and the aqueous phase (A).

- The extraction step is conducted with mixer-settler or mixer-centrifuges, the latter being used when gravitational settling is not economically feasible.
- The washing step is conducted with mixer-centrifuges, as the amount of water mixed with the organic phase is very small, resulting in an O/A ratio over 20.
- The regeneration step is conducted using agitated columns, which has been determined to be the most efficient way to maintain a temperature in this section of about 80°C and ensure good contact between the ascending aqueous and the descending organic phases.

2.2.3 A Predictive Internal Model for Ion Balance Chemical Equilibria

- Specific indicators have been studied to establish a database of performances that have been used to develop an internal mathematical modeling tool able to predict process performance indicators from feed brine composition with a high level of precision and certainty, confirmed by different tests on various pilot sizes.
- This mathematical tool not only can predict the evolution of lithium concentration through each stage of the plant, but also its counter-ion and each co-extracted species, key points to ensure the accuracy of the modeling and assess the quality of the produced brine.
- This tool is used to perform parametrical studies, where different key process parameters (such as number of stages, O/A ratio, water consumption, etc.) are incremented to assess their impact on the key performance indicators to establish trends and an optimized answer to the client's targets, both technically and economically.



Example of a parametrical study showing the impact on yield of the amount of consumed wash water in the washing step for different O/A ratios in extraction for a given process cycle on brine 3.

2.3 Adionics' Experience in Brines and Piloting

In Adionics' experience on lithium extraction, a wide range of brine compositions from over 15 countries and various sources (salar, ponds, aquifers, geothermal plants, industrial plants, recycling effluents, ...) have been studied during more than 4,000 hours through the following:

Modeling
About 230 brine compositions from all over the word have been registered and worked on at a modeling and simulation level.

CL1 Lab Pilot
About 65 brines have been studied at a laboratory level, with a laboratory pilot demonstration using Adionics' CL1 lab pilot for a total of over 700h of continuous operation.
The CL1 pilot plant is a lab-size pilot plant, able to process all types of brines from 100mg Li/L to over 60g Li/L. The different technologies can be tested depending on the brine physico-chemical characteristics. The equipment is mainly glassware, to allow for easy visualization and understanding. Clients are welcome during the CL1 operation. The flowrate of treated brine is established between 0.35L/h to 15L/h, depending on the lithium concentration in the brine to be treated. The CL1 plant footprint is about 5m².

CL15 Demo Plant
About 20 brines have been processed through an intermediate pilot plant, one of the two sister units CL15 from Adionics, for a total of over 4,000 hours of continuous operations. The two sister units CL15 pilot plants are small-size pilot plants, able to process all types of brines from 100mg Li/L to over 60g Li/L. The different extraction technologies can be tested depending on the brine physico-chemical characteristics. The CL15 equipment is larger than the CL1, but technologies are identical. The flowrate of treated brine is established between 10L/h to 125L/h, depending on the lithium concentration in the brine to be treated. The standard length of operation is set to 100 hours of continuous operation, which

represents a collected produced brine of 1 to 1.5 m^3, but a longer trial of 1000+ hours has already been conducted. The CL15 plant footprint is about 50m².

CL 250 Demo Plant

Two brines have been processed through Adionics' demonstrator plant, the CL250 plant. The CL250 pilot plant is a demonstrator-size pilot plant, able to process all types of brines from 100mg Li/L to over 3g Li/L. Mixer-settlers are installed for the extraction steps, a mixer-centrifuge for the washing step and an agitated column for the regeneration step. The equipment is the smallest industrial size of each equipment type, available on standards of Adionics selected providers. The flowrate of treated brine is established between 500L/h to 1500L/h, depending on the lithium concentration in the brine to be treated. The CL250 plant footprint is about 450m².

PART 3 Adionics Expertise – A Proven Process & Technology

3.1 KPI Selected

3.1.1 Client's Product KPIs: Lithium Recovery Yield, Purity / Type of Co-extracted Impurities, Lithium Concentration in Product

Throughout Adionics history, a lot of clients came asking for the same three key performance indicators:

- The **lithium recovery yield**, describing the performance of the process to extract lithium from the brine to be treated.

- The **produced brine purity**, which can take different forms: weight fraction, ratios of impurities vs Lithium, impurity content, etc. This describes the produced brine purity level against specifications that may come from the downstream processes or further clients' targets.

- The **produced brine lithium concentration**, which has a direct impact on the overall downstream processes required before transformation of lithium to the final targeted product, being LiCl, Li_2CO_3, $LiOH.H_2O$, etc.

These indicators are common for any client assessing DLEs and are key to determining the process performances regarding lithium extraction, purification and plant production.

3.1.2 Client's Process KPIs : Water Consumption, Electrical Consumption and Economics

Adionics clients usually have different objectives and special requirements which are specific to each plant's location. Nonetheless, the most common are the following ones:

- Water consumption: DLE and downstream lithium processing can require significant water, which can challenge projects in water-scarce regions and raise social concerns. If general thinking is that water based regeneration DLEs require significant water needs, it is not the case with Adionics' thermally regenerated DLE, which has show cased minimal water need

- Energy consumption: High electricity and thermal needs may pose issues in remote areas with limited infrastructure or rising energy costs; natural gas access can also be constrained.

- Water and Energy consumption: CAPEX and OPEX are key to assessing project viability over the plant's lifespan.

3.2 Process Technical Expertise / Case Studies

3.2.1 Brines Studied: ID

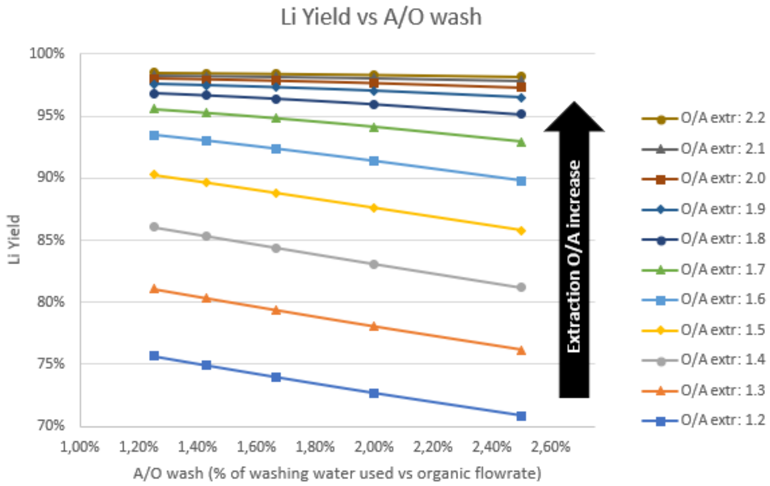
In this white paper, the following generic brines will be studied to demonstrate Adionics' performance through modeling, lab testing and pilot demonstration results:

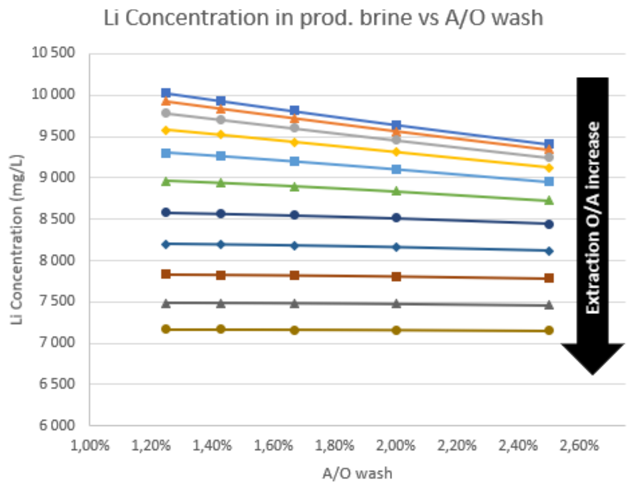
	Brine 1	**Brine 2**	**Brine 3**
Brine type	Preconcentrated	Preconcentrated	Well
Li (wt%)	1,15%	0,51%	0,13%
Composition	[mg/L]	[mg/L]	[mg/L]
Li	**15 000**	**6 500**	**1 600**
Na	3 000	40 000	90 000
K	3 000	30 000	25 000
Mg	90 000	35 000	10 000
Ca	750	100	500
Cl	330 000	200 000	185 000
SO4	1 500	60 000	17 500
TDS	443 250	371 600	329 600

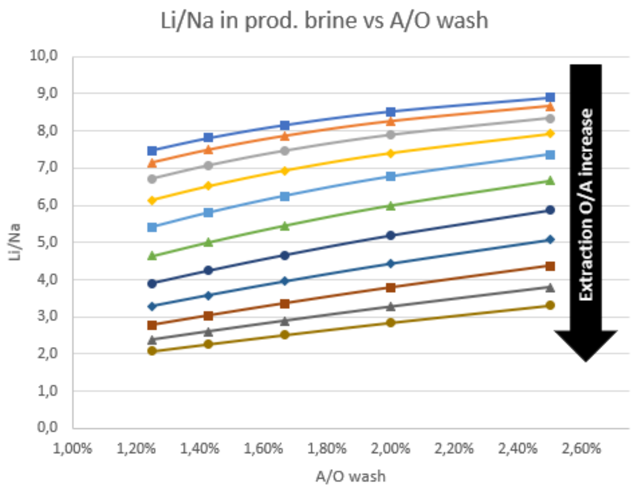
	Brine 4	**Brine 5**	**Brine 6**
Brine type	Well	Well	Well
Li (wt%)	0,07%	0,06%	0,03%
Composition	[mg/L]	[mg/L]	[mg/L]
Li	**800**	**700**	**350**
Na	90 000	100 000	90 000
K	6 000	7 500	5 000
Mg	5 500	2 500	3 000
Ca	11 000	600	40 000
Cl	190 000	170 000	210 000
SO4	1 100	15 000	150
TDS	304 400	296 300	348 500

3.2.2 Parametrical Study Mapping – Brine 3 Example

The following parametrical study has been performed for brine 3 and designed cycle 4-1-3 (four extraction stages, one washing stage and three equivalent regeneration stages). The principle remains the same for each studied case of each studied brine.







Top left graphic describes that the higher the O/A of extraction, the higher the lithium recovery yield and the lower the washing A/O ratio, the lesser the impact on the lithium recovery yield.

Top right graphic describes that the lower the O/A of extraction, the higher the lithium concentration in the LiCl produced brine, and the A/O washing ratio has little impact on Li concentration.

A specificity of Adionics DLE technology is its ability to reach high concentration factor between the inlet brine lithium concentration and the produce brine one. Indeed, depending on the inlet brine lithium concentration, concentration factors up to 12 or 13 have already been demonstrated both at modeling and experimental scales. This confirms Adionics technology limited water consumption.

Botton graphic describes that the higher the washing A/O ratio, the higher Li/Na ratio in the lithium produced brine for higher lithium purity with a similar trend whatever extraction O/A ratio. Similar trends are observed for other co-extracted species, such as Calcium. Maximum Li/Na ratio is obtained for minimum O/A extraction ratio.

3.2.3 CL1/Modeling Compared Results

All the data collected during tests have been used to improve the accuracy of Adionics' internal modeling tool and predictability of chemical equilibrium for each species ions contained in the brine. Thanks to this work, Adionics can predict with accuracy the performance obtained on a brine using different plant configurations (number of stages, O/A ratios, etc.).

Hereafter are presented the results for the 6 brines, both by modeling and experimentally, to demonstrate the accuracy of prediction or the main process KPIs

Design CL1 – Duration: 7 hours Brine type and initial Lithium wt%	**Brine 1** *Preconcentrated 1,15%*		**Brine 2** *Preconcentrated 0,51%*		**Brine 3** *Well 0,13%*	
Number of extraction steps	3		2		4	
Number of washing steps	1		1		1	
Number of regeneration steps	3		3		3	
O/A extraction	10,1		6,8		1,5	
O/A washing	100		100		70	
O/A regeneration	12		10		10	
Flionex	A		A		A	
Performances	**Modeling**	**Experiment**	**Modeling**	**Experiment**	**Modeling**	**Experiment**
Li recovery yield (%)	97,2	99,9	90	89,7	90,3	90,2
Li concentration produced brine (mg/L)	17 090	17 250	9 710	10 110	9 430	9 390
Li/Na (mass ratio)	34,2	38,3	12,8	7,5	6,9	6,4
Li/Ca (mass ratio)	>400	>400	285,6	>200	93,4	74,5

Design CL1 – Duration : 7 hours Brine type and initial Lithium wt%	**Brine 4** *Well 0,07%*		**Brine 5** *Well 0,06%*		**Brine 6** *Well 0,03%*	
Number of extraction steps	4		4		4	
Number of washing steps	1		1		1	
Number of striping steps	3		3		3	
O/A extraction	1,6		1,3		1,5	
O/A washing	40		40		20	
O/A Regeneration	10		10		10	
Flionex	A		A		B	
Performances	**Modeling**	**Experiment**	**Modeling**	**Experiment**	**Modeling**	**Experiment**
Li recovery yield (%)	96	98,3	94,3	94,7	92,1	94
Li concentration produced brine (mg/L)	4 940	5 000	6 420	6 270	2 210	1 870
Li/Na (mass ratio)	1,7	1,4	1,7	1,2	1,2	1,2
Li/Ca (mass ratio)	2,6	2,4	32,9	28,4	0,3	0,3

3.2.4 CL15 Results (Brines 1, 2 &3)

The CL15 unit run length is usually 100 hours or more of continuous flow, allowing for establishment of the hydrodynamics and equilibria in the plant, and stabilized operation. Representative effluents of Li-depleted brine and Li-produced brine are analyzed on-site to ensure operations. The lithium produced brine can be shipped to the client for further testing or discussion, as well as the lithium depleted brine.

Tests have been performed in various places thanks to the mobility of the CL15 units. Clients have been invited to witness the tests in a partner site located in Germany or in Adionics' facility of Güemes, Salta region, Argentina, or on a client's site, such as Atacama salar, Chile in 2024. Tests have been conducted on Brines 2, 3 and 5 typicity, with the following results:

Design CL15 - Duration: >100 hours Brine type and initial Lithium wt%	**Brine 2** *Preconc. 0.51%*	**Brine 3** *Well 0.13%*	**Brine 5** *Well 0.06%*
Lithium recovery yield %	92,1	94,8	95,6
Lithium conc. in produced brine (mg/L)	11 300	10 500	4 800
Li/Na mass ratio in produced brine	36	4,2	9,2
Li/Ca mass ration in produced brine	>1 000	>200	>400
Rejection rates %			
Na	99,4	99,5	99,8
K	99,8	99,9	99,9
Mg	99,9	99,9	99,9
Ca	99,8	97,1	99,6
SO_4	99,9	99,9	99,9
B	99,9	99,9	99,9

For the CL15 trials, the plant configuration tested is selected with the client to ensure the trial is representative in terms of DLE performances. During those trials, samples are collected to ensure no deviation in the performances during the trial, where the following are analyzed:

- Ionic composition of the brine, lithium-depleted brine and lithium produced brine.
- Density measurement on aqueous and organic phases.
- UV-visible measurement to evaluate the traces of organic remaining after the different post-treatment steps are incorporated in Adionics' process. This measurement is validated through stabilized samples analyzed by High Performance Liquid Chromatography in our Argentina demo plant or, if appropriate, in our French laboratory.

Any operational events or comments during operation are recorded hourly to ease any deviation explanation in the final reports.

3.3 Environmental Expertise : Water Consumption

3.3.1 Water Consumption Purpose

Adionics DLE has two water inlets other than the feed brine, and an optional one:

- The washing step uses a very limited amount of aqueous phase to desorb the impurities co-extracted by the Flionex and limit the entrainment of aqueous phase from the extraction to the

- regeneration steps. This water can be demineralized water, but process water, surface water, or lightly salted water can be used for this step.
- The regeneration step uses a controlled amount of water to regenerate the Flionex and produce the lithium chloride brine. For this step, the purer the water, the purer the produced brine, because the Flionex will not extract at 80°C, meaning that anything found in the inlet regeneration water will end up mixed in the lithium produced brine, affecting the product purity. For its CL15 trials, Adionics used double pass reverse osmosis water as an inlet for this step.

Adionics' process can implement adjusted O/A ratios within its different steps, which will allow for modulation of the overall process performances. The impact of water consumption modification on the process can be multiple factors:

- On the washing step, increasing the water flowrate results in an increase of A/O ratio in this step. Washing performance increases for higher LiCl purity in the produced brine. The opposite effect will be observed by decreasing the water flowrate for this step.

- On the regeneration step, lowering the water flowrate results in an increase of the O/A ratio in this step. The impact will be an increased concentration of the ionic species in the aqueous phase and a decrease of the regeneration step efficiency, which can lead to a lowered lithium extraction yield. The opposite effect will be observed by increasing the water flowrate for this step.

By combining these trends, via parametric studies, Adionics sets with its client the best overall design to fit DLE performance, water use and economics.

Water recycling opportunities exist thanks to Adionics selectivity towards lithium and high rejection of other species. Indeed, the produced LiCl brine has relatively low level of other salts minimizing its osmotic pressure for best potential use of downstream reverse osmosis systems, OARO systems or similar other salt reconcentration systems. This concentration step can though result in an efficient recycling of water for its reused within Adionics' DLE. The recycling rate will be dependent on the lithium concentration reached in the produced brine and the targeted inlet LiCl concentration of the carbonation reactor.

3.3.2 Water Consumption

Compared to alumina-based adsorption processes, which require large volumes of wash water to elute lithium chloride, to pre/post treat brine and polish eluate, Adionics' technology achieves comparable or superior lithium recovery with up to 10× lower water consumption, since the desorption relies on temperature-driven LiCl release rather than extensive water washing. This is a major advantage compared to all other DLE technologies in locations where water scarcity is critical such as in South American salars.

It also allows lower Opex & Capex for potential downstream LiCl brine purification and reconcentration

The following table describes the freshwater consumption of the 3 brines:

	Brine 2	**Brine 3**	**Brine 5**
Adonics DLE water consumption w/o recycling (m^3/t_{LCE}) – considering only DLE yield	10.1	15.1	23.6
Adionics DLE water consumption (m^3/t_{LCE}) with concentration up to 15g/L Li after Advanced Reverse Osmosis	7.6	11.0	7.6
Adionics DLE water consumption (m^3/t_{LCE}) with concentration up to 75g/L Li after Forced Evaporation	<2	<2.5	<2

3.3 Energy Consumption and Reagent Control

Our technology enables significant savings on energy expenses. While various parameters must be considered to estimate energy costs—such as the country's energy sources or the type of brine—we can already highlight the areas where our technology guarantees a reasonable energy usage. The exclusive principle of our technology not only delivers tangible benefits for lithium quality and environmental sustainability, but it also provides significant operational cost advantages at both the pre-treatment and post-treatment stages.
Our process incorporates two fundamental innovations that have a direct impact on OPEX.

3.3.1 Mechanical & Thermal Energy Consumption Control

Our process is based on a basic industrial process at atmospheric pressure that allows very low energy consumption. The process minimizes mechanical energy requirements through a simple design for fluid transfer, agitation, and separation, ensuring efficient and sustainable operation.

The supramolecular chemistry-based organic medium with fully reversible host–guest interactions leverage low-energy consumption. Therefore, our technology does not need use of acid or bases to release extracted lithium as required in ion exchanges-based technology. The usage of this reagent generates an important CO2 footprint, and we allow for avoiding this additional footprint.

The thermal regeneration process - which desorbs lithium as a salt from the Flionex – at 80°C / 175F requires low thermal energy consumption, as 90 to 95% of the heat is recycled within the process by two heat exchangers, one on the in/out Flionex, the other on the in/out water. Thermal energy input only compensates the 2-5°C thermal loss at the cold end of the two heat exchangers

3.3.2 Intrant Consumption Control in Pretreatment

We are limiting the use of major's intrant which have a direct impact on cost and on footprint impact.

- **Immunity to brine impurities**

Our supramolecular organic medium exhibits high chemical robustness. It is insensitive to typical brine contaminants and exhibits no irreversible binding or poisoning by ions such as transition metal elements, or anions. As a result, there is no requirement for pre-treatment steps to remove these elements, unlike:

- Ion-exchange systems, which generally necessitate pre-removal of iron and manganese to prevent fouling or oxidation of resins.
- Alumina-based adsorbents, which require extensive sulfate, arsenic, lead, and carbonate management to prevent competitive adsorption or precipitation.

- **No pH dependence**

The extraction mechanism based on supramolecular interactions is insensitive to the brines' pH and obviates the need for acidification or alkalization. It gives a clear benefit when compared to processes relying on H^+/Li^+ ion exchange or pH-dependent adsorption equilibria, which typically requires tight pH control. Adionics pH operation range expands from 3 to 10.

3.3.3 Post-Treatment Simplification Due to High Selectivity

As mentioned before, our supramolecular medium displays exceptional selectivity for lithium chloride (in case of salar brine with no co-extraction of Mg^{2+}, SO_4^{2-}, $B(OH)_4^-$, or K^+.

This high selectivity translates into eluates that contain predominantly lithium chloride with only trace impurities, allowing for an easy polishing step (e.g., ion polishing or polishing crystallization) to meet battery-grade specifications.

This sharply contrasts with other DLE technologies that often produce eluates requiring extensive downstream purification (e.g., magnesium-lithium separation, sulfate polishing, and/or boron removal), all of which incur significant reagent, water and energy costs.

Conclusion

The solution we have presented demonstrates the disruptive advantages of Adionics' technology for the future of lithium production. Beyond lithium extraction from saline water, our approach is versatile and can be applied to alternative sources such as battery recycling and carbonation mother liquor purge.

Adionics is proud to deliver an efficient, scalable, and responsible solution, dedicated to unlocking the full potential of this vital resource, lithium, through the implementation of a sustainable lithium mining process. Our technology is continuously evolving to adapt to the diversity of salts, ensuring optimal performance across a wide range of brine compositions.

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