CASE STUDY: FIRST COMMERCIAL MDLE PLANT

December 2024
Salt Lake City, Utah

international battery metals

Contents

Executive Summary

IBAT deployed and operated their proprietary Modular Direct Lithium Extraction Plant (MDLE Plant) at their customer's facility located near Salt Lake City Utah. This deployment represents the first commercial DLE operation in North America and the only modular DLE plant in the world. Operations commenced June 20th, 2024, and ran for 83 days ending on September 11th, 2024.

- IBAT's MDLE Plant extracted enough lithium to produce **>25 tons of battery grade** lithium carbonate (+99.9% purity) and an additional similar quantity for testing and analysis.
- IBAT & Customer's operational plan initially targeted 8-12 hours of production per day
    - Average production of lithium chloride eluent of 8,000-9,000 (11,000 peak) gpd

IBAT's MDLE plant started mobilization in the first week of February 2024 in Lake Charles, Louisiana and took less than 4 weeks to deliver all 36 shipments to Customer's facility outside of Salt Lake City, Utah. The next 8 weeks were used to modify ~35% of the facility to accommodate the Customer's unique feed stock. The MDLE plant was then commissioned and ready to commence operations in mid-June 2024.

Feedstock to the MDLE Plant was the sole responsibility of the Customer. Using their proprietary batch process they recycled their 40+ years of accumulated stockpile ore to create a lithium rich feedstock with Li concentrations between ~3000 to 5300 mg/L (ppm) (Average ~4000 ppm).

Feedstock composition varied with each batch of ore processed. The IBAT MDLE plant was able to process this brine despite seeing lithium concentrations swinging by an average of 16% per sample (1-5 samples/day).

IBAT's MDLE plant went through ~8,400 total cycles of operation. Analytical laboratory testing has confirmed that the sorbent saw no measurable loss in capacity between the start and end of operations despite being exposed to heavy contamination.

Introduction

Meeting the global demand for lithium will require the identification and development of multiple lithium resources. It is important that lithium can be derived in consistent quantities, with high degrees of purity in a cost effective and environmentally favorable manner. One underappreciated asset may be the recycling of lithium containing industrial waste.

IBAT has designed and fabricated a Modular Direct Lithium Extraction (MDLE) technology which can be rapidly deployed to job sites with minimal site prep required (pilings, foundations etc. not required). The MDLE plant has been designed to work on a wide variety of lithium resources with different lithium and contaminant profiles.

The Customer identified the potential of developing a lithium extraction project from the waste materials generated at their magnesium production facility in Utah. The Customer has produced magnesium from the Great Salt Lake for over 40 years which has produced a significant amount of waste ore.

In January 2024 IBAT and this Customer formed a collaboration to extract lithium from their accumulated stockpile of ore located outside of Salt Lake City by repurposing IBAT's MDLE Extraction plant.

Figure 1. Project Site

Process Overview

The process to take Customer's spent ore through to lithium carbonate can be summarized in the following stages:

1. Feed Stock Production (Customer's responsibly)
2. Extraction (IBAT responsibly)
3. Lithium Carbonate Production (Customer's responsibly)

The following is a summary of the each of these stages specific for this Customer's project.

Feed Stock Production

Customer's waste ore has been maintained in concentrated solid form piled on location at Customer's facilities. The waste ore is ground, treated with HCl acid and water to create a leachate solution high in concentration of lithium (4000 - 5000 ppm).

Initially the leachate solution was produced using predominately hydrochloric acid (HCl) which created a very consistent leachate solution. To increase cost effectiveness the Customer needed to reduce the amount of HCl used. They began testing reduced amounts of HCl with increased water dilution to produce a less expensive leachate solution. The leachate solutions produced using reduced HCl, had higher total suspended solids (TSS) and reduced lithium concentration. This experimentation on the feed stock was performed during live operation of IBAT's MDLE Plant and increased the variability between the lithium and contaminant ratios creating an increase in operational complexity.

Extraction

The leachate solution is transferred to the extraction columns containing IBAT's proprietary double selective absorbent which captures lithium and chloride ions. Once the absorbent media is saturated with lithium the loading cycle is complete. The lithium depleted leachate solution exiting the bottom of the extraction columns is referred to as "Spent Leachate Solution" and is returned to Customer for disposal. Once this process has completed the column is ready for the strip cycle.

The strip cycle consists of three processes, the transition, the product and the strip recycle. Strip solution is pumped into the extraction column as the Spent Leachate solution continues to exit. The

following process starts the Transition cycle which is captured and reprocessed due to the amount of Lithium contained in solution. Next is the Product cut consisting of high quality LiCl which is sent forward for concentration and final polishing. The final stage is the strip recycle which is used to maintain balance of the strip solution.

Lithium Carbonate Production

The Customer used their proprietary lithium carbonate production facility to produce lithium carbonate achieving a desired **battery grade 99.9% purity**. Customer's certified laboratory provided the weekly average analytical data in the below Table 1.

Table 1 – Customer's Carbonate Containment Data

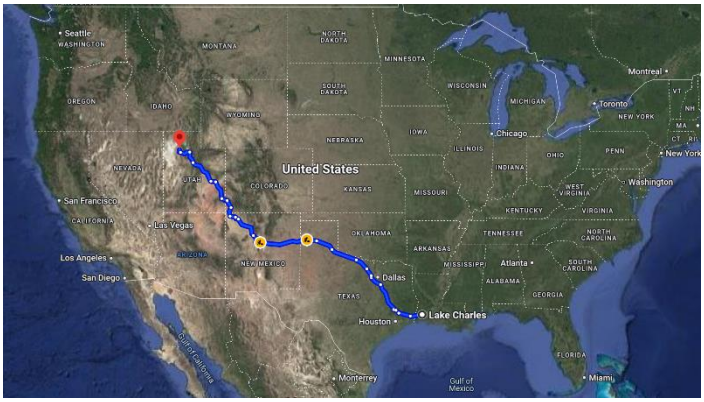
Date	Ca (PPM)	K (PPM)	Li (PPM)	Mg (PPM)	Na (PPM)
Jul 1-7	40	2	OL	53	46
Jul 8-14	11	4	OL	19	51
Jul 29 - Aug 4	18	64	OL	17	100
Aug 5-11	9	4	OL	14	46
Aug 12-18	9	3	OL	7	34
Aug 19-25	6	8	OL	11	66
Aug 26 - Sep 1	11	11	OL	39	77
Sep 2-8	7	10	OL	16	77

(OL – Over Limit)

Modular Plant Mobilization

Mobilization of IBAT's Modular Direct Lithium Extraction Plant started in February 2024. It took less than 4 weeks to move the 36 plant modules across 1,600 miles to the Customer's job site located outside of Salt Lake City, Utah.

Figure 2. MDLE Plant Mobilization



Plant Modifications

The MDLE plant needed to be adapted to the unique operating conditions at the Customer's job site. Customer's feedstock contained lithium in concentrations between ~3000 to 5300 mg/L (ppm) (Average ~4000 mg/L). The MDLE Plant's original design basis was designed for processing brines with approximate lithium concentrations around 300-1500 mg/L. The significantly higher lithium concentration necessitated modifications to the MDLE plant. Approximately 35% of the equipment needed alterations.

Most of the modifications were required for pieces of equipment in the Strip Process.

- Higher lithium feed rate (same flow rate with ~10x the lithium) reduced load cycle time by a factor of 10, which resulted in more production per hour, which means more strip cycles per hour. Due to the increase in strip cycles the capacity of the strip being processed needed to be increased. This required modifications to equipment listed below:

- Vessels
- Piping
- Pumps
- Heat Exchangers
- RO Units

The modular design provided easy access to implement the system modification. It took ~8 weeks to implement the modifications. In addition, the Cause & Effect diagrams, along with the Control Narrative also required updating to reflect new system arrangements.

Due to 2 years of cold storage, the IBAT MDLE plant needed to be reactivated which involved function testing of electrical equipment, replacing seals and bearings in rotating equipment, pipe and vessel leak testing etc. This took ~6 weeks, at which point the MDLE plant went into full operation.

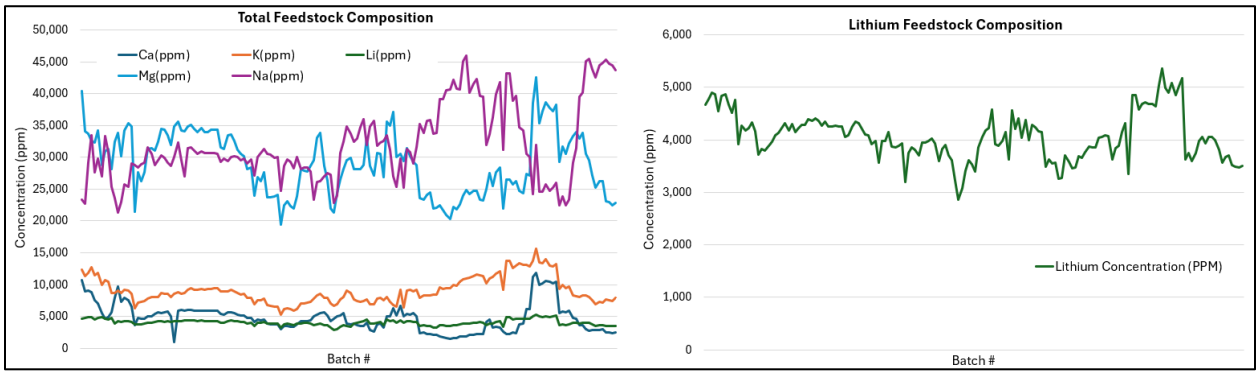
Customer was eager to bring the MDLE plant into full production. However, there were still some outstanding pieces of equipment and instrumentation that had not yet been fully commissioned. Customer moved forward with the startup, as they had production targets, and wanted to commission the remaining equipment while operating the live plant.

Operation

Feedstock

Production of the feedstock for IBAT's MDLE plant was prepared in batches, with each batch containing swings in both lithium and contaminant concentrations. See Figure 2.

Figure 2. Feedstock Concentration Fluctuations per batch



As can be seen there was substantial fluctuation in the lithium and contaminant concentrations for every batch of feedstock prepared by the Customer's process. Lithium concentrations routinely swung by several hundred PPM's per batch. Contaminate concentrations, particularly magnesium and sodium, would swing by several tens of thousands of PPM between batches.

It was challenging to keep the plant in balance under the dynamic loading conditions. Initially operations sampled stream conditions across the plant hourly, the sample results would provide an indicator to the operations team if they were staying within tolerances to the predetermined concentrations for each part of the process. If the sample results indicated that the plant performance was drifting outside of tolerance, then the Plant operator would adjust column sequence parameters bringing the process back into balance.

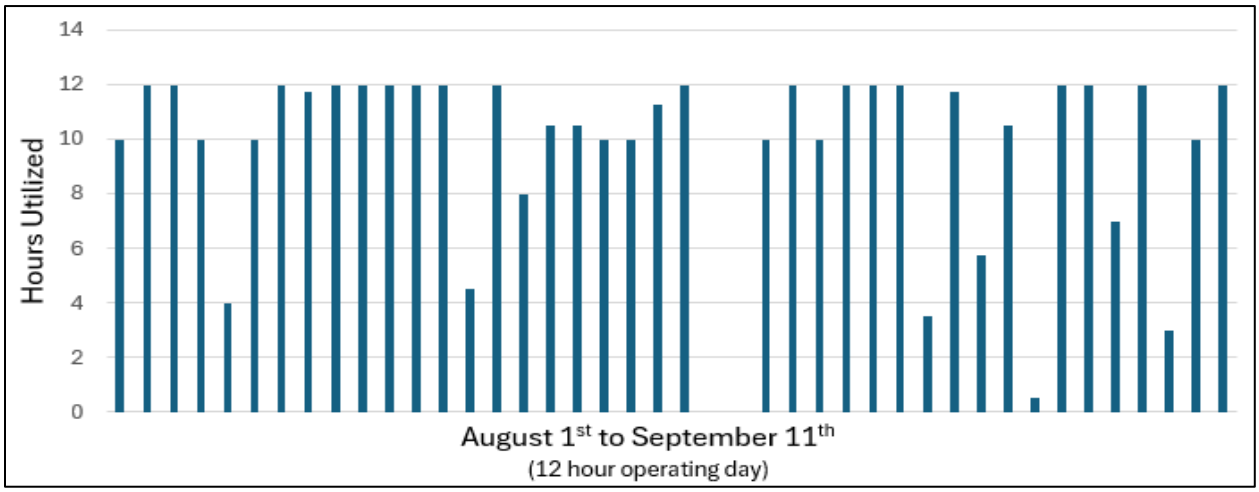
After a few weeks of operation, the sampling frequency was reduced to once every two hours as Operations had gained a better understanding of the responses required to keep the plant performance within tolerances.

Downtime

Customer's Feedstock Production at the time could initially support an ~12-hour operating shift. The IBAT MDLE plant was designed to operate on a continuous 24/7 basis, which lead to a greater than 50% loss in production as the MDLE plant had to go through full thermal cycles at the beginning and end of each shift. This additional thermal cycling caused other challenges in the process such as, extra stress on the sorbent and precipitation of unwanted salts/contaminates in the media bed.

Given the short operating time frame, the nascent nature of IBAT's DLE technology, and Customer's Feedstock Production process, production downtime is not unusual or unexpected. In the second half of the total plant operating period (last 42 days) plant availability was ~80%. See Figure 3 for details.

Figure 3 – Plant Utilization- August 1st to September 11th



Sorbent Performance

IBAT's MDLE plant underwent 8,423 cycles of operation. On average each column went through ~700 cycles (1086 cycles max) using the same sorbent batch.

Analytical testing on sorbent capacity, selectivity and kinetics were performed before and after the project's operations. Results indicate that IBAT's proprietary double selective absorbent has not experienced any loss of performance/capacity.

Conclusion

IBAT began mobilizing their Modular Direct Lithium Extraction (MDLE) plant on February 1st and ended lithium chloride production on September 11th, 2024. During this timeframe IBAT's MDLE plant was:

- Taken out of cold storage and moved ~1600 miles to Customer's facility in Salt Lake City Utah
- Modified to operate on a feedstock containing greater than 10x the amount of lithium than the originally design basis
- Feedstock contaminants included 35k-65k ppm magnesium
- Fully commissioned
- Started up and operated for a time period of 83 days
    - Produced a lithium chloride eluent which was converted by Customer into battery grade lithium carbonate
    - 25tn of battery grade lithium carbonate produced

In this short project lifecycle IBAT demonstrated that their technology is:

- Quickly deployable
- Versatile for a wide range of DLE operations
- Capable of extracting lithium at commercial scale

The deployment of IBAT's Modular Direct Lithium Extraction (MDLE) plant at Customer's facility marked a significant milestone in North America's lithium production landscape. This project successfully demonstrated the operational capabilities of IBAT's innovative MDLE technology, extracting lithium chloride from Customer's 40-year-old waste ore and achieved consistent results despite the challenges posed by variable feedstock quality. Over the course of 83 days, the plant processed thousands of liters of brine, producing over 30 tons of lithium chloride, which was then further refined into battery-grade lithium carbonate.

While the project encountered certain challenges— particularly the fluctuations in feedstock composition, including lithium and contaminant levels— the MDLE plant proved to be resilient. The flexibility of the modular design enabled quick adjustments to the system, and the plant's performance improved as the operational team gained familiarity with the dynamic conditions of the

feedstock. Additionally, the control system played a pivotal role in optimizing operations, enhancing overall efficiency and output.

Despite the operational success, Customer decided to suspend the project due to a lower lithium carbonate pricing environment and until they complete their additional experimentation for a more economic process to produce feed brine. This decision underscores the importance of considering market conditions in the feasibility of lithium extraction projects when analyzing technologies. The operations demonstrated in this project proved that even in challenging market conditions, our technology remains a sound and cost-effective solution for lithium extraction, demonstrating its resilience and economic viability despite external economic factors.

In summary, the IBAT and this Customer collaboration demonstrated the potential of modular DLE technology to revolutionize the lithium extraction process, providing a flexible, efficient, and scalable solution for tapping into non-traditional lithium sources. The insights gained from this project will be invaluable for future deployments of our plants to advance the development of lithium extraction from industrial waste and natural brines.

Note: Should you require any additional information or wish to connect with our customer for further insights, please feel free to contact us. We will be pleased to facilitate your request and provide the necessary details.