

27 July 2017

## BATTERY GRADE LITHIUM CARBONATE AND HYDROXIDE MADE FROM WOLFSBERG SPODUMENE CONCENTRATE

### Highlights

- **Battery grade lithium carbonate (>99.9%) with 86.8% lithium recovery**
- **Battery grade lithium hydroxide (>56.5%) with 82.6% lithium recovery**

European Lithium Limited (ASX:EUR, FRA:PF8) (the **Company**) is pleased to report results from the recently completed hydrometallurgical testwork programme at its advanced Wolfsberg Lithium Project (**Wolfsberg**) in Austria.

Steve Kesler, CEO, commented "This work has confirmed that the spodumene concentrate from Wolfsberg can be successfully processed to battery grade lithium carbonate and lithium hydroxide. The Wolfsberg project is well placed to be a strategic supplier to the lithium battery plants that are now being developed in Europe."

The hydrometallurgical testwork was conducted by leading German independent consultant in lithium, Dorfner Anzaplan (**Dorfner**). Dorfner had previously undertaken the physical processing test work which demonstrated that Wolfsberg ore can be processed by flotation to produce a spodumene concentrate of 6.2% Li<sub>2</sub>O.

The hydrometallurgical testwork was specified to use only commercially proven technology. Currently the only commercial scale conversion plants use the acid roast-carbonate precipitation process.

The testwork showed that battery grade lithium carbonate (>99.9% Li<sub>2</sub>O<sub>3</sub>) can be made from the flotation concentrate. Unit processes included calcination, acid roasting and lithium dissolution, solution purification by neutralization and ion exchange followed by carbonate precipitation and bicarbonatation. The purity of the lithium carbonate meets the common specifications for battery grade lithium carbonate. The recovery of lithium from the spodumene concentrate as lithium carbonate was estimated as 86.8% for a continuous operation.

The battery grade lithium carbonate can be reacted with lime to form soluble lithium hydroxide. A 2 stage crystallization is used to obtain lithium hydroxide which is then vacuum dried to form the monohydrate. Elemental analysis showed that the lithium hydroxide product (>56.5% LiOH) met the common specifications for battery grade lithium hydroxide. The recovery of lithium from spodumene concentrate as lithium hydroxide was estimated as 82.6% for a continuous operation.

More detail of the testwork undertaken is given in Appendix 1

Dr Steve Kesler  
Chief Executive Officer  
European Lithium Limited

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Visit the Company's website to find out more about the advanced Wolfsberg Lithium Project located in Austria.

**Competent Person's Statement**

The information in this announcement pertaining to the Wolfsberg Lithium Project, and to which this statement is attached, relates to Project Development and Metallurgical Studies and is based on and fairly represents information and supporting documentation provided by the Company and its Consultants and summarized by Dr Steve Kesler who is a Qualified Person and is a Fellow of the Institute of Materials, Minerals and Mining and a Chartered Engineer with over 40 years' experience in the mining and resource development industry. Dr Kesler has sufficient experience, as to qualify as a Competent Person as defined in the 2012 edition of the "Australian Code for Reporting of Mineral Resources and Ore reserves". Dr Kesler consents to the inclusion in the report of the matters based on information in the form and context in which it appears. The company is reporting progress on project development and metallurgical results under the 2012 edition of the Australasian Code for the Reporting of Results, Minerals Resources and Ore reserves (JORC code 2012).

## **Appendix 1 - Hydrometallurgical testwork to produce battery grade lithium carbonate and lithium hydroxide**

### **Lithium Carbonate**

The first stage of the process is calcination to transform the spodumene concentrate from the insoluble alpha to the soluble beta form. Testwork showed that complete transformation is achieved from flotation and DMS concentrates by calcination at 1100°C for 60 minutes. The concentrates are then roasted at 250°C for 60 minutes with sulphuric acid. A higher acid/sample ratio of 0.4 was required for flotation concentrate than for DMS concentrate (0.35) but the lithium recovery in solution was significantly higher at 96% compared to the 92.9% from DMS concentrate.

Impurities are removed from the leach solution by neutralization with sodium hydroxide or lime. The precipitates formed after neutralization of the DMS concentrate leach solution with sodium hydroxide were very voluminous and proved difficult to filter or centrifuge such that lithium recovery was only about 50%. The precipitates formed after neutralization of the flotation concentrate leach solution were significantly less in volume and relatively easily filtered and resulted in a lithium recovery of 96.4%. Lithium extraction from DMS concentrate was not pursued further.

Neutralisation with lime has the advantage over sodium hydroxide in that it is of significantly lower cost. Whilst the use of sodium hydroxide yields a soluble sodium sulphate product the use of lime results in a hardly soluble gypsum that is filtered off with the other precipitates. It also reduces the amount of Glauber salt which must be separated in downstream processing and typically lithium losses in filtration of gypsum are lower than in filtration of Glauber salt. The efficiency of precipitation is independent of the neutralization agent and the key parameter is pH. Most impurities are removed at pH9 apart from magnesium which requires pH10 to reduce to 2mg/l. Lime is slightly soluble in water and calcium is reduced from 400-500mg/l to 10-45mg/l by the addition of sodium carbonate to produce the hardly soluble calcium carbonate which is filtered off.

Ion exchange is a polishing step to reduce the content of polyvalent ions such as Mg, Ca and Al. The calcium content was reduced from 13 to 0.5mg/l.

After impurity removal the liquor contains only lithium and sodium with traces of potassium and rubidium. The lithium concentration is between 6 and 9 g/l. When sodium hydroxide is used for neutralization the sodium concentration is about 20g/l but when lime is used the sodium concentration is much lower at about 1 g/l. When sodium hydroxide is applied for neutralization then evaporation is used to reduce the liquor volume until sodium sulphate starts to crystallise which then forms Glauber salt on cooling. There is a significant reduction in sodium content but there is also a 4% loss of lithium with the salt. When lime is used for neutralization such a crystallization step is not required.

Since lithium carbonate has a residual solubility of 7.2g/l at 100°C it is necessary to increase the lithium content in solution as far as possible by evaporation. A sodium carbonate solution is used to precipitate lithium carbonate from the liquor to eliminate the risk of sodium carbonate particles being included in the precipitate and contaminating the product. Lithium carbonate precipitated from liquors following sodium hydroxide neutralization yielded a rather pure product with 0.1% sodium and only minor amounts of other impurities and with a lithium step recovery of 82%. For liquors neutralized with lime there is no Glauber salt crystallization and the liquor can be concentrated to a higher extent. A concentration factor of 6.7 was achieved using lime compared to a factor of 4.4 using sodium hydroxide

whilst a higher lithium step recovery of 89.7% was also obtained. The overall hydrometallurgical recovery in batch tests is summarized in Table 1 as 74.2% mainly determined by the step recovery of the carbonate precipitation which is limited by the lithium carbonate solubility.

Step	Li recovery
	[wt.-%]
Acid baking & leaching	96.0
Neutralization	98.2
Ca-precipitation	99.8
Glauber Salt precipitation	96.0
Li <sub>2</sub> CO <sub>3</sub> -Precipitation	82.2
Total	74.2

**Table 1:** Step recoveries for the batch precipitation of lithium carbonate

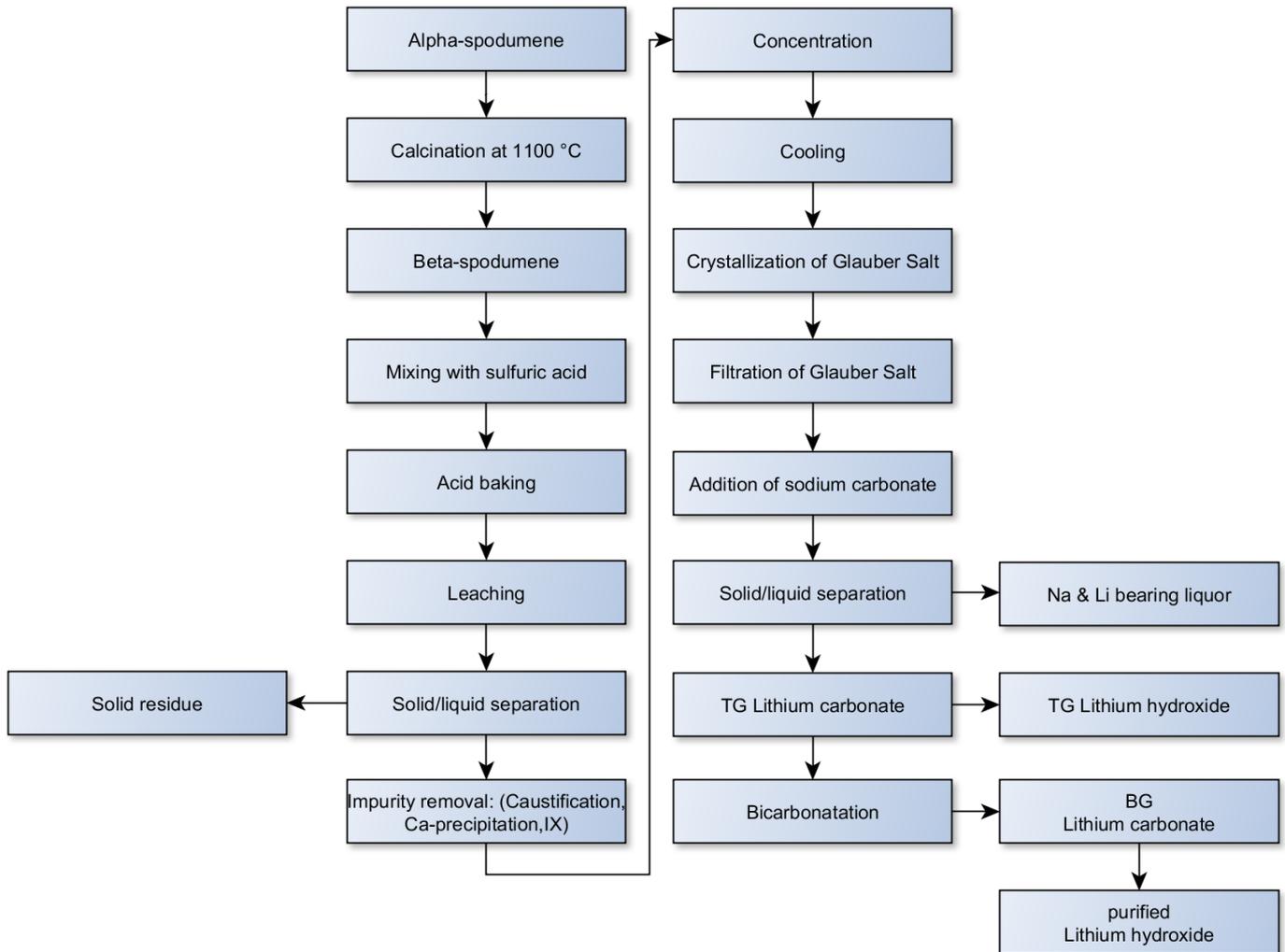
In a continuous process the liquor from precipitation is recycled to leaching thus minor losses of lithium will occur with the subsequent purification steps. A bleed stream is required to prevent a build-up of sodium and other impurities. The overall hydrometallurgical lithium recovery for a continuous process is estimated to increase from 74.2% to 86.8% for battery grade lithium carbonate.

Bicarbonatation is a purification step to remove residual impurities from the raw lithium carbonate. Lithium bicarbonate is formed by the addition of carbon dioxide at pressure which is then heated to boiling temperature and lithium carbonate re-precipitated in a much purer form. Purity exceeds 99.9% lithium carbonate with sodium at 65mg/kg thus meeting common specifications for battery grade lithium carbonate as shown in Table 2.

		Li	Na	Mg	Al	P	K	Ca	Mn	Fe	Rb
solid	[mg/kg]	188,000	65	<1	3.1	7	16	<1	<1	1	60

**Table 2:** Elemental analysis of lithium carbonate after bicarbonatation

The flowsheet for production of lithium carbonate is shown in Figure 1.



**Figure 1:** Flowsheet for the production of battery grade lithium carbonate from spodumene concentrate

### Lithium Hydroxide

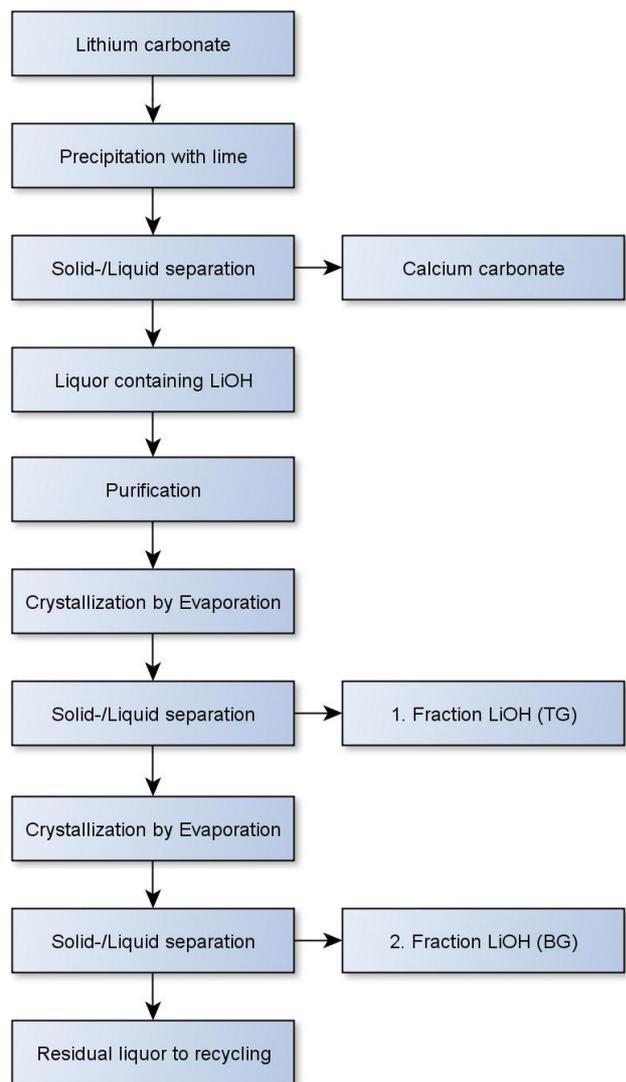
Lithium hydroxide is produced by reaction of lithium carbonate with lime to form calcium carbonate and soluble lithium hydroxide. The calcium carbonate is filtered off and the solution is crystallised to obtain lithium hydroxide. The use of technical grade lime yielded only technical grade lithium hydroxide. Purer lime was synthesised by precipitation of calcium carbonate from a calcium chloride solution with sodium carbonate followed by calcination and addition of water. Use of the purer lime resulted in calcium being the main impurity element. A two step crystallization was applied to the solution with the first fraction containing more calcium being recycled to process or used as technical grade product and the second fraction taken as battery grade product.

Lithium hydroxide is very sensitive to carbon dioxide in air after filtration and it is dried under vacuum to minimize air contact and obtain the monohydrate product. The finally obtained element levels in the lithium hydroxide are compared in Table 3 with commonly specified elements of battery grade lithium products in the market.

			Obtained Values	Typical values of BG products
LiOH	min.	[wt.-%]	>56.5	56.5
Na	max.	[mg/kg]	16	20-150
Sulfate	max.	[mg/kg]	<12	50-300
Cl	max.	[mg/kg]	<12	15-30
K	max.	[mg/kg]	<1	10-100
Ca	max.	[mg/kg]	25	10-70
Fe	max.	[mg/kg]	<1	5-10

**Table 3:** Elemental analysis of lithium hydroxide product compared to typical battery grade products

Recovery of lithium in lithium hydroxide product resulting from reaction of lithium carbonate and lime was 95.2%. Residual solution from crystallization can be fully recycled to process so this is the only process step in lithium hydroxide production from lithium carbonate where lithium losses can appear. Thus, full recovery of lithium in a continuous process for lithium hydroxide production is estimated at 82.6%. The flowsheet for production of battery grade lithium hydroxide from lithium carbonate is shown in Figure 2.



**Figure 2:** Flowsheet for production of battery grade lithium hydroxide from lithium carbonate