Lithium – Many metallurgical challenges

About 40 years ago lithium was a metal of curiosity. Its production was limited due to limited demand. Lithium was only produced from spodumene concentrate. Then, of course, along came lithium-ion batteries. As the demand for lithium-ion batteries has grown exponentially, so has the need to extract lithium from different sources.

Lithium is the only metal for which production from naturally-occuring solutions is as important as production from hard rock deposits. Dissolved lithium occurs in brines across many parts of the world, in the form of lithium chloride, which has an extremely high solubility. The primary source is salar (salt lake) deposits in South America. Dissolved lithium also occurs in oil and gas field brines as well as geothermal brines. The most important form of hard rock lithium is spodumene (lithium aluminium silicate), with Australia being the leading producer.

The metallurgical extraction of lithium from these different sources poses many challenges. The most important point to remember, is that purity is king! Battery-grade lithium carbonate and lithium hydroxide require purities of >99.8% and >99.9% respectively. This places enormous demands on selectivity and purification during the processing of the various sources of lithium.

Let us start with lithum in brine. It is easy to imagine that because the lithium is already dissolved, a large part of the metallurgical work has already been done. Well, you would be mistaken. Unfortunately, all the various brines contain many impurities. When production of lithium from brine started in South America, evaporation ponds were (and still are) used to concentrate the lithium. The concentrated brine then reports to a lithium carbonate plant where a long sequence of purification steps leads to the production of battery-grade lithium carbonate.

The location and lower lithium concentration of oil and gas field brines as well as geothermal brines means that evaporation ponds are a non-starter. Over the last 5 years there has been a significant development of direct lithium extraction (DLE) technologies, using ion-sieve, ion exchange, or solvent extraction. These techniques allow the selective extraction of the lithium from the brine, and are followed also by a sequence of purification steps. DLE plants are in operation in China and there is one in Argentina. There are many DLE projects in development and its application looks promising.

The issue with extracting lithium from hard rock deposits is that it is very energy intensive. Crushing and grinding are required, followed by DMS and/or flotation, to produce a spodumene concentrate. The concentrate then requires calcining and roasting steps before leaching and purification. Alternative less energy-intensive options are being studied but their possible application is still on the horizon.

Production of waste streams is also an issue for lithium extraction. In the case of salars, the evaporation ponds produce huge stockpiles of sodium, potassium, magnesium, and calcium salts. There are no markets close enough for these salts. Hard rock lithium extraction produces DMS or flotation tailings, which require tailings dams. It also produces a sodium sulphate by-product for which there is not always a market. The beauty of DLE is that the waste product, brine minus most of the lithium, can be reinjected back into the brine reservoir.

Given the very stringent purity requirements for battery -lithium hydroxide, many lithium projects are considering the electrolytic production of lithium hydroxide from purified lithium chloride, which is based on the chlor-alkali process used for producing sodium hydroxide from sodium chloride. The problems with this approach are the significant energy consumption and the large volumes of concentrated hydrochloric acid by-product, for which there is not always a market.

In summary, lithium metallurgical extraction faces many challenges in terms of producing the required product purities for lithium batteries, reducing waste production, and also the reduction of carbon footprints.

M. Dworzanowski