# The Lithium Crisis for the Grease Industry

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**Lithium End Uses**

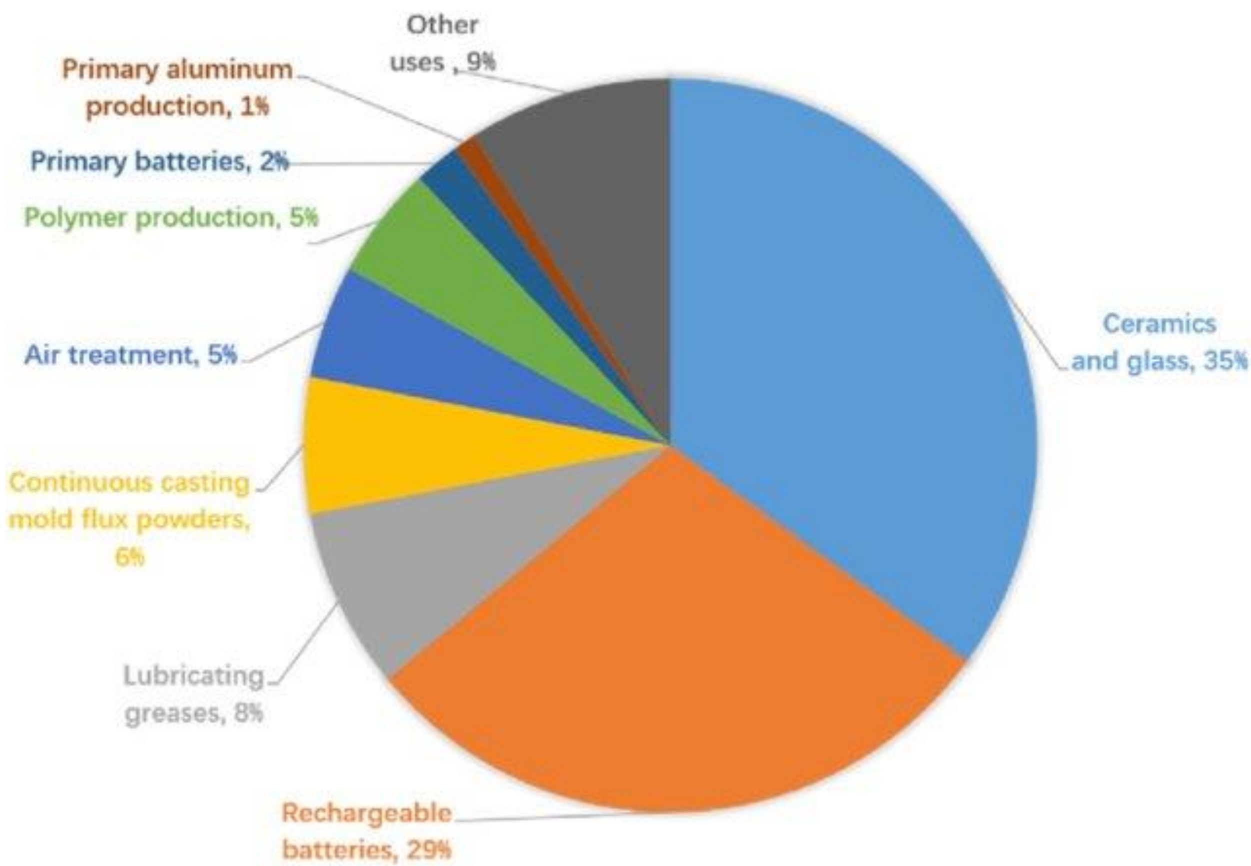


Figure 1 Source Ding Weng, et al., Progress in Natural Science: Materials International, https://doi.org/10.1016/j.pnsc.2020.01.017

Usage in greases is declining as a percent of the total due in part to a decline in lithium and lithium complex grease production, and also as a result of growth in the rechargeable battery demand.

The grease industry is challenged by the recent increases in price and decreases in availability of lithium hydroxide, driven by the growing demand for lithium for batteries for mobile electronics and *especially, electrified vehicles*


Many countries are mandating and supporting with tax incentives minimum EV market share.

US EPA has just approved increased auto maker MPG requirements, expected to drive EV sales to 17% of new vehicles.

**Where is the lithium?**

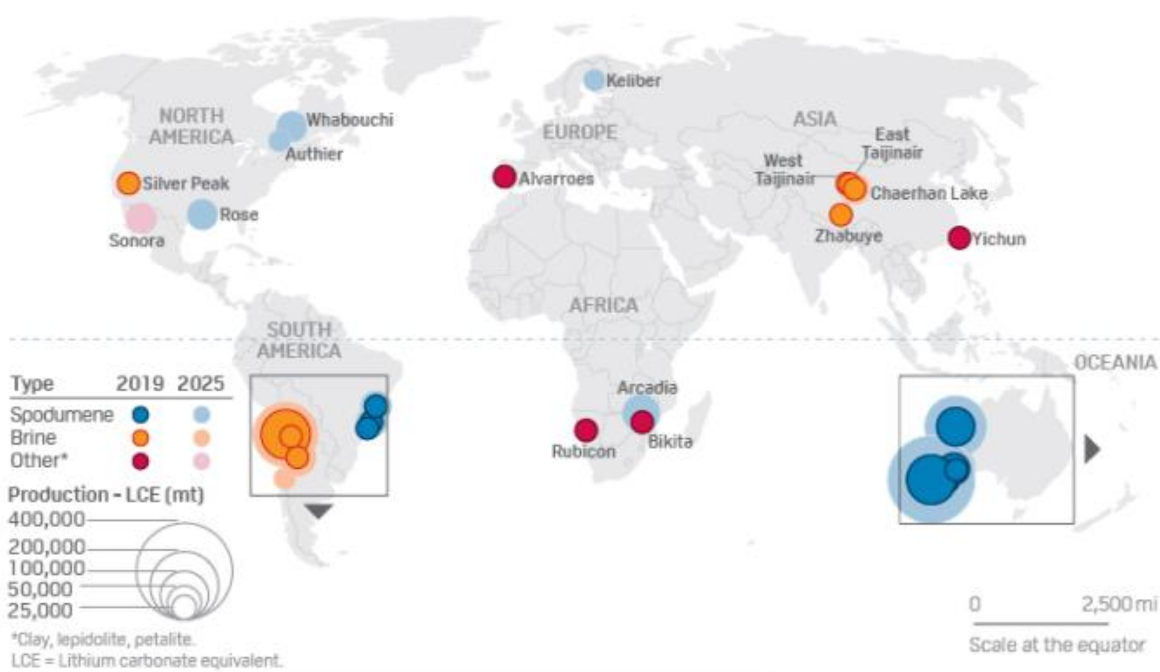

Figure 2 Source: S&P Global Market Intelligence, S&P Global Platts

US is hard rock and brine; Argentina, Chile, and Bolivia are brine; Australia is hard rock; Brazil is hard rock; Portugal is hard rock; Zimbabwe is hard rock; China is hard rock and brine.

**Supply/Demand Outlook**

- Lithium demand growth is expected to outpace supply growth through 2025 and beyond → widening the deficit between supply and demand
- Ongoing pandemic related restrictions on deployment of people, resources are impacting the ability to bring on new sources
- ongoing supply chain challenges restricting movement of equipment, product, significantly increasing labor, logistics, raw material costs
- long timelines and high capital slowing the development of new resources
- pandemic-related restrictions on expansion projects' schedules (DELAYS) as well as capex, opex and investment economics

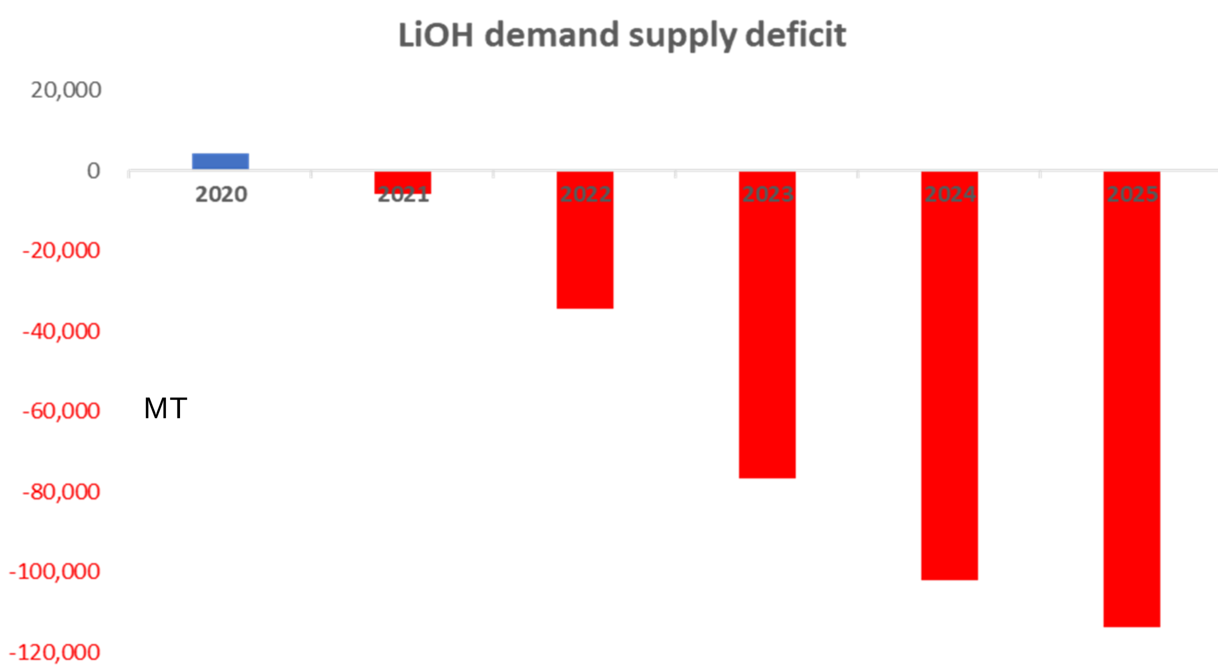


Figure 3 Source: Livent market update December 2021

**Lithium Hydroxide Monohydrate Price Trends**

| | Q4 2020 | 1Q 2021 | 2Q 2021 | 3Q 2021 | 4Q 2021 |
|---|---|---|---|---|---|
| *Quarter-on-Quarter change, %* | *1%* | *31%* | *42%* | *37%* | *>60%* |

Table 1 Source Livent market update December 2021

**Lithium in Grease**

Lithium plus lithium complex account for nearly 70% of global production:

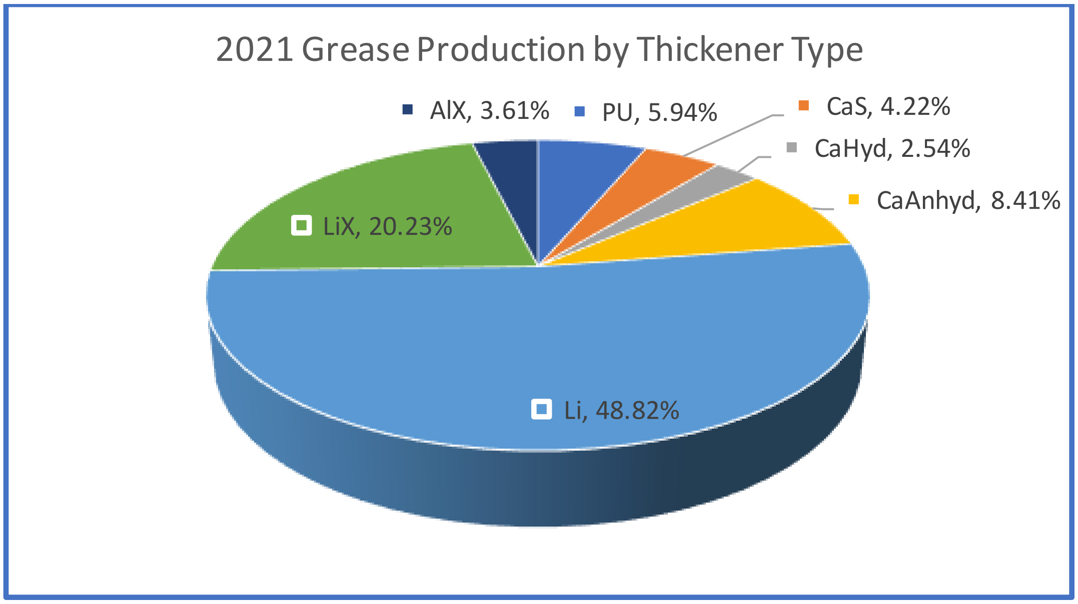


Figure 4

Based on 0.12% LiOHoH$_2$O in Li and 0.20% LiOHoH$_2$O in LiX

## Estimated NA LiOH consumption

| | Lbs | MT | Kg | 30 $/Kg | |
|---|---|---|---|---|---|
| Li soap | 1,857,380 | 842 | 842,489 | $25,274,675 | 25 million dollars |
| Li complex | 4,557,830 | 2,067 | 2,067,386 | $62,021,583 | 62 million dollars |
| | | | | $87,296,258 | 87 M$ |

## Estimated global LiOH consumption

| | Lbs | MT | Kg | 30 $/Kg | |
|---|---|---|---|---|---|
| Li soap | 15,019,770 | 6,813 | 6,812,818 | $204,384,528 | 200 million dollars |
| Li complex | 9,823,617 | 4,456 | 4,455,894 | $133,676,828 | 130 million dollars |
| | | | | $338,061,356 | 330 million $ |

Table 2 Source: 2020 NLGI Global Grease Production Survey

**Trends in lithium grease production versus alternative thickeners**

Simple lithium grease production has been declining for years, probably largely driven by a shift to lithium complex and other thickeners for higher performance, is now also being driven by increasing lithium hydroxide monohydrate prices.

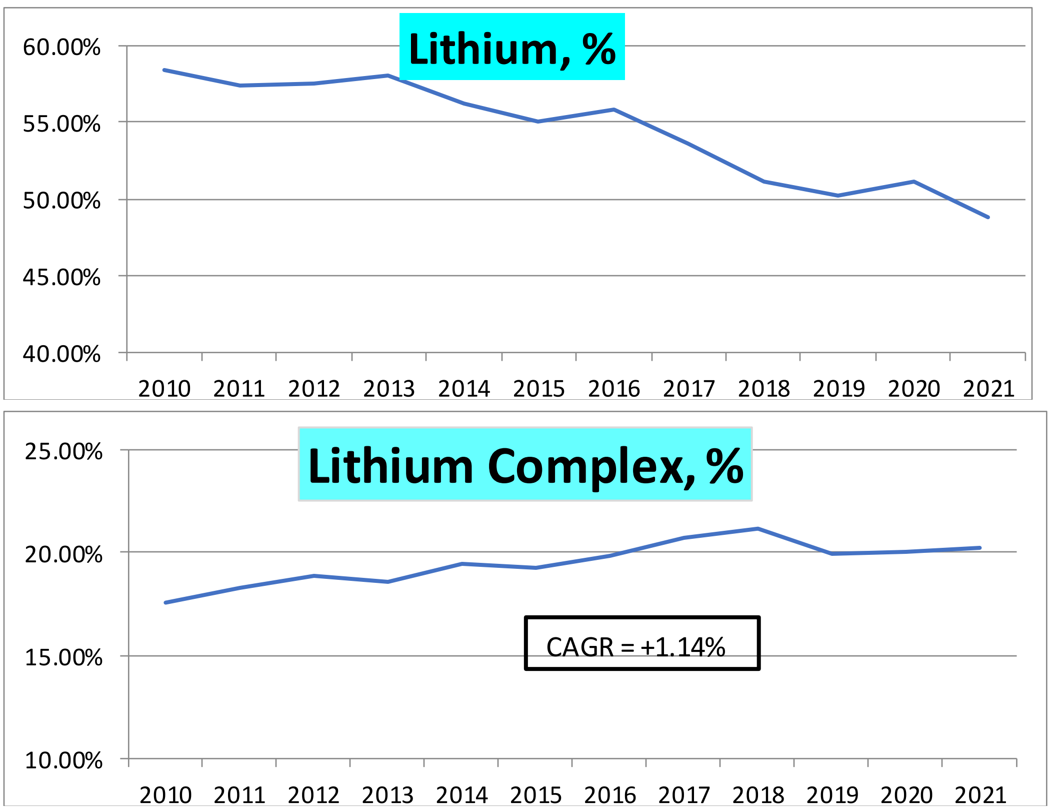


Figure 5 Source: NLGI Global Grease Production Surveys 2010 - 2021

At the same time, polyurea and calcium sulfonate grease production are both increasing, while aluminum complex grease production is not showing the same consistent growth. These three thickeners can be viable replacements for lithium complex thickeners, depending on the application.

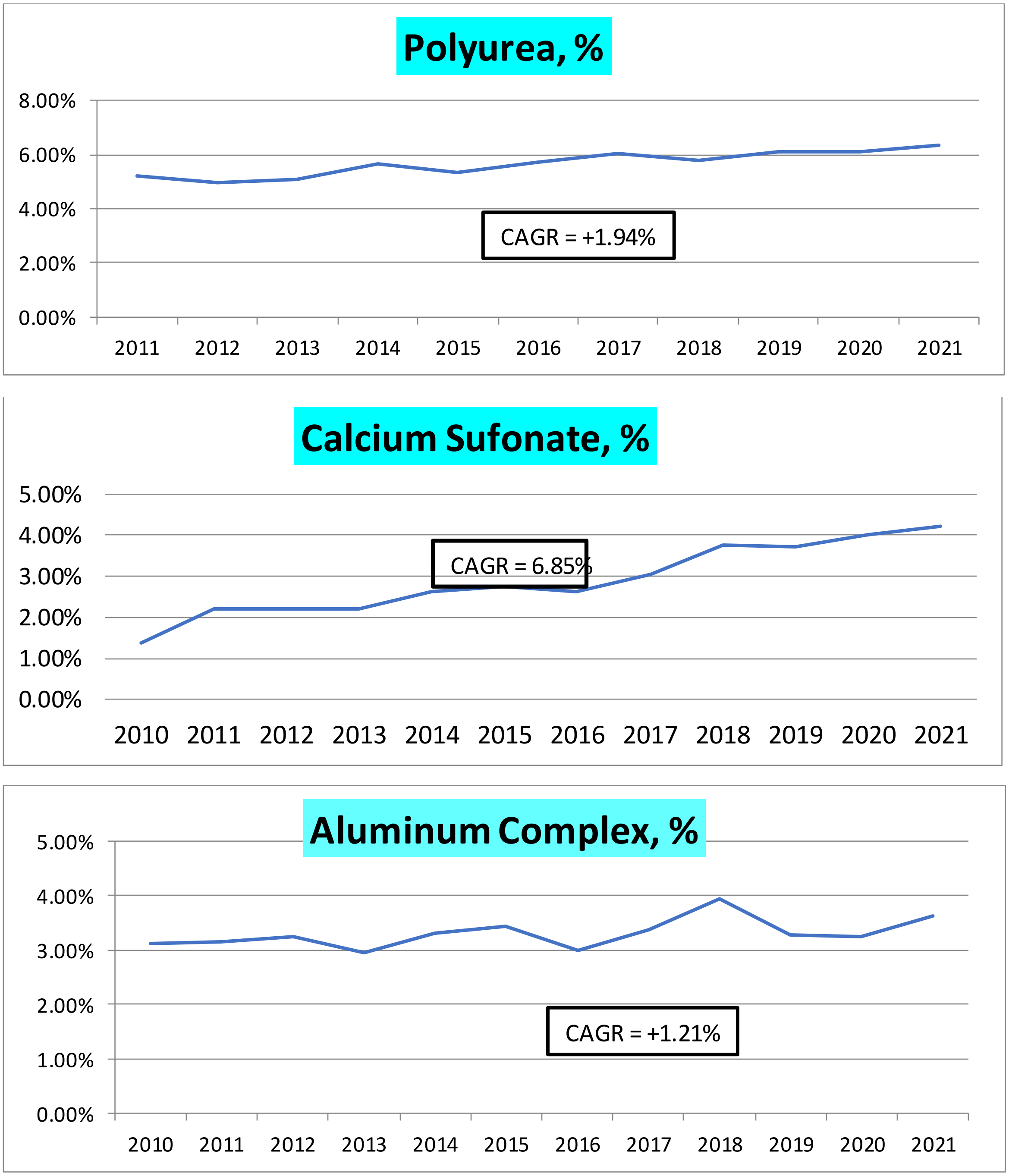


Figure 6 Source: NLGI Lubricating Grease Production Surveys 2010 - 2021

**Comparison of lithium grease properties to other thickeners**

Lithium complex thickeners provide high dropping points, good mechanical stability, water stability, storage stability and pumpability. They do usually require additives to enhance wear resistance, load carrying, water and corrosion resistance and oxidation stability. They can be fine-tuned to a certain extent by choice of complexing agent and varying the ratio of complexing agent to lithium 12-hydroxy stearate thickener.

Aluminum complex thickeners also provide high dropping points, good mechanical stability, good pumpability, and excellent water resistance. They also generally require additives to improve corrosion resistance, oxidation stability, wear resistance and load carrying ability. They can be fine-tuned by varying the molar ratio of Benzoic Acid to Fatty Acid (BA:FA), and/or Total Acids to Aluminum (TA:Al). This is to manipulate thickening efficiency (yield), dropping point, and mechanical stability.

Calcium sulfonate complex thickeners also provide high dropping points, good mechanical stability, inherent water resistance, rust protection, and load carrying performance. They require only minimal additives, especially antioxidants. Their formulation and manufacture must be carefully controlled to provide the best pumpability possible, given the typically high thickener contents.

Polyurea thickeners provide high dropping points, fairly good mechanical stability (diureas), and inherent oxidation stability. Multiple variations of components and ratios provide the ability to customize performance to specific applications. The main challenges are a tendency towards poor compatibility with other thickener types as well as safety concerns with raw material handling.

All of these thickener types are suitable for a wide range of applications, as shown in Table 3.

| **Lithium Complex** | **Aluminum Complex** | **Calcium Sulfonate Complex** | **Polyurea** |
|---|---|---|---|
| Automotive - GC/LB | Automotive | Automotive | Under-the-hood applications |
| General Industrial - HPM | Steel Mills | Construction & Mining | Constant Velocity Joints |
| Construction & Mining | Construction & Mining | Open Gears | Industrial |
| Steel Mills | Open Gears | Steel Mills | Steel Mills – Continuous Casting |
| Paper Mills | Slow, Heavily Loaded Bearings | Paper Mills | Electric Motor Bearings |
| Electric Motor Bearings | Thread Compounds | Marine | Fill-for-life applications |
| *new development* – HX1 | Food grade - HX1 | Food Grade - HX1 | Food Grade - HX1 |
| | Anti-Seize Compounds | Power Generation | |

Table 3 Source: NLGI Advanced Grease Course 2021

**So how do we reduce lithium usage in greases?**

The options fall into one of two categories:

1. Reduce LiOH usage in Li Complex greases

   Or

2. Switch to a different thickener type

*First let's look at three options for reducing LiOH usage in Li Complex greases*:

1. Replace LiOH monohydrate + water with dehydrated LiOH dispersion [1]

- Higher raw material cost at typical 2:1 acid ratio (12 HSA : diacid)
- Faster reaction
- Allows reduction in diacid content (to 5:1 acid ratio), resulting in lower net formulation cost
- Reduces amount of lithium equivalents needed

2. Add overbased (400 TBN) magnesium sulfonate at beginning of saponification and complexing reaction [2]

- Facilitates more intimate co-crystallization of lithium complex thickener salts
- Overbased calcium sulfonate (400 TBN) can also be used
- Acid ratios can be decreased from about 2:1 to 3-5.8:1 (12 HSA : azelaic acid), greatly reducing lithium equivalents needed
- Grease properties are equivalent to typical Li azelate complex grease

3. Replace dicarboxylic acid complexing agent with a borated ester [1]

- Reduces lithium equivalent requirement by a factor of nearly 3x
- Simplifies manufacturing, with borated ester addition occurring towards the end of the batch cycle, when typical performance additives are incorporated
- Provides equivalent performance to dicarboxylate acid complexed grease, including dropping point, high temperature rheology, wear and life testing
- Due to reduced thickener content (no lithium-dicarboxylate salt), improved low temperature pumpability is realized

*Now let's look at switching to a different thickener type*

1. From the end user's perspective there are several considerations
   - Cost
   - Compatibility
   - Performance

2. From the manufacturer's perspective there are also several considerations
   - Raw material handling
   - Equipment requirements
   - Processing changes

*From the end user's perspective*:

Cost

- The three primary alternative high-performance thickeners to replace Li complex are all more costly

Compatibility

- When switching greases end users must be extremely careful about compatibility
- Polyurea and Aluminum complex are frequently incompatible with Lithium complex thickeners

Performance

- The specific application must be considered in order to define needed water resistance, load-carrying, pumpability, mechanical stability, long life, etc. in order to choose the best thickener type.

*From the manufacturer's perspective*:

Raw material handling

- Polyurea raw materials are hazardous and require special handling and storage

Equipment requirements

- Polyurea, Aluminum complex and Calcium sulfonate complex typically require kettles, not contactors or continuous units
- Filters are frequently needed for polyurea greases

Processing changes

- Alternative thickeners require careful sequencing and cleaning of equipment
- Operators must be educated about new procedures and raw material handling
- Managing volatile, hazardous by products both handling and storage may be required

**Regulatory issues**

Proposed harmonization and classification of lithium hydroxide

In 2019, ANSES (French Agency for Food, Environmental and Occupational Health & Safety) submitted a proposal to the European Chemicals Agency (ECHA) for harmonized classification of lithium carbonate, lithium chloride and lithium hydroxide under the CLP Regulation (Classification, Labelling and Packaging of products).

ATIEL (Technical Association of the European Lubricants Industry), UEIL (Union of the European Lubricants Industry) and ELGI (European Lubricating Grease Institute) jointly opposed the proposal.

If the proposal is accepted *(which is very likely)*, the lithium salts in question will have to be labelled as follows: "May damage fertility or the unborn child: Category 1A (H360FD)"

The proposed classification for LiOH is to be classified as Toxic to Reproduction for effects on fertility and development in category 1A H360FD. This effectively means that any concentration of this substance in lithium salts (soaps) greater than 0.1% (in the U.S.) would lead to the classification of the whole product. Since the grease industry does not generally sell the salts (soaps), one must assume that the same limits would apply to the greases which incorporate the soaps. During the manufacture of lithium soap greases, the alkalinity (free LiOH) in the soap concentrate is typically 0.02 to 0.05%, and of course, that number gets smaller (due to dilution) as additional oil and additives are added to make the finished grease. Therefore, this classification should not have a negative impact on lithium grease manufacturers or marketers.

However, the labeling requirement should impact the LiOH-H2O suppliers who will need to label as noted. It might impact safety rules for LiOH-H2O handling for manufacturers, but not labelling of the grease.

Note that 0.3% is the general concentration limit for classification in EU.

**The future: a shortage is possible through 2030**

According to Fitch Solutions:

- Well established lithium producing countries will record further growth
- New lithium-producing countries will emerge, amid rising interest, government support and increasing capital dedicated towards lithium projects
- Technological advancements in extraction make progress, posing upside risks to supply
- Actual supply could rise faster than expected, as a host of new players are developing new extraction techniques, namely geothermal brines and sedimentary (clay) deposits, which could upend primary supply of lithium
- Lithium reserves are ample and keep on growing, suggesting plenty of potential to boost supply in the long term

According to Green Authority's article "10 alternatives to lithium-ion batteries: Which new tech will power the future?":

- Emerging technologies are expected to begin to replace lithium-ion batteries – magnesium, sodium, and others.

According to my assessment based on considerable reading of the available literature, there are so many unknowns in the supply side that forecasting is highly challenging to say the least. Additionally, shortages of LiOH in the near term may reduce the EV demand below what is currently promised by the auto industry. And there is the elephant in the room: EV charging infrastructure is slow in coming and consumers continue to be hesitant to purchase EVs due to range and charging concerns. So, the supply shortfall may somewhat resolve itself over the next decade or so.

References

1 NLGI paper 2018 G.Fish: Lubricating Grease Thickeners: How to Navigate you Way through the Lithium Crisis

2 NLGI paper 2020 A.Waynick: A Fresh Look at Lithium Complex Greases Part 2: One Possible Path Forward