

Conversion of lithium chloride into battery-grade lithium hydroxide by solvent extraction

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Background

Driven by ambitious climate targets, there is an exponentially growing demand for Li-ion batteries (LIBs), which are key enablers for e-mobility and stationary renewable energy storage. To fulfil this demand for LIBs in Europe and the rest of the world, a secure, affordable and sustainable supply of battery-grade lithium salts is key. At present, the need for lithium hydroxide monohydrate, $\text{LiOH}\cdot\text{H}_2\text{O}$, is rapidly increasing due to the growing importance of Ni-rich NMC cathode materials. Production of LiOH has typically been an expensive two-step process, using LiCl brines to first produce Li_2CO_3 by precipitation with Na_2CO_3 , then converting Li_2CO_3 into LiOH. Therefore, a versatile process that can directly produce $\text{LiOH}\cdot\text{H}_2\text{O}$ from LiCl, bypassing the Li_2CO_3 intermediate, would be advantageous from an economical and environmental point of view, because this reduces the number of process steps, consumes less chemicals and generates less waste.

Method

A solvent extraction (SX) process was developed to convert lithium chloride in solution directly to lithium hydroxide by a two-step SX process. The first test were done at lab scale in vials (5 mL), followed by batch countercurrent extraction and finally by continuous countercurrent extraction experiments with mixer-settlers. The first SX step (SX1) involves contacting an aqueous NaOH phase with an organic phase containing the quaternary ammonium chloride Aliquat 336, an alcohol/phenol and a diluent. In the second SX step (SX2), the organic phase, residing from the 1st step, is contacted with an aqueous LiCl solution. The batch extraction experiments were used to optimise the chemical composition of the organic phase and the extraction conditions. The yield of each SX step was determined by titration.

Results

In general, the total conversion (SX1 and SX2 combined) for alcohols was very low compared to those for phenols. Among all the phenols tested, 2,6-di-*tert*-butylphenol is the most promising one with the highest conversion rate. Besides the choice of alcohol/phenol, also the diluent was found to have an influence on the extraction. Although aromatic diluents lead to a slightly higher conversion rate, the more environmentally friendly aliphatic diluents were preferred, such as Shellsol D70, which consists predominantly of C₁₁–C₁₄ paraffins and naphthenes. Due to the limited base stability of Aliquat 336, it is not recommended to increase the NaOH concentration in the aqueous phase of the first SX step above 10 M. Simultaneous operation of a 2-stage countercurrent process for SX2 and a 6-stage process for SX2 in mixer-settlers showed that at equilibrium, more than 87.1% of the phenolate [A336][OR] was formed in SX1 and 98.5% LiCl was converted to LiOH in SX2.

Conclusions

A solvent extraction process was developed to efficiently convert LiCl in solution directly to LiOH by a two-step solvent extraction process, by using an organic phase containing Aliquat 336, 2,6-di-*tert*-butylphenol and Shellsol D70.

Acknowledgements

The research leading to this manuscript received funding from the European Union's EU Framework Programme for Research and Innovation Horizon 2020 under grant agreement no. 963281 (SOLVOLI).