

Conversion of lithium chloride into lithium hydroxide using a two-step solvent extraction process in an agitated Kühni column

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It is well-known that lithium-ion batteries (LIBs) are currently crucial for the green transition. A commonly used class of cathode materials for these LIBs are called lithium nickel manganese cobalt oxides (NMC). Lithium carbonate is a common precursor for the synthesis of most NMC cathodes. However, NMC cathodes with higher nickel contents (NMC 811 or NMC 622) are nowadays increasingly used. Here, lithium hydroxide monohydrate is preferred as a precursor over lithium carbonate. Currently, lithium hydroxide is produced by precipitation methods, making use of consumables and generating solid waste residues. For example, lithium chloride is often first treated with soda ash to precipitate lithium as lithium carbonate. This precipitate is then treated with lime milk ($\text{Ca}(\text{OH})_2$) to produce lithium hydroxide and precipitate calcium carbonate. Lithium hydroxide is eventually crystallized from the filtrate into lithium hydroxide monohydrate. However, this method requires big amounts of consumables like lime milk and generates in turn big amounts of solid waste. Furthermore, lithium chloride has to be converted first into lithium carbonate and losses of lithium are observed in further downstream processing due to the adsorption of lithium hydroxide particles onto calcium carbonate. As a response, SOLVOMET has developed a two-step solvent extraction (SX) process that converts lithium chloride directly into lithium hydroxide. SX enables here more circularity as it makes use of recyclable reagents, that could be used for multiple successive cycles, and prevents the generation of solid waste. Here, the organic phases consists of a combination of Aliquat 336 with a phenol, which are diluted in an organic diluent (Binnemans, 2021). The organic phase is contacted with sodium hydroxide in the first SX step, causing deprotonation of the phenol and transfer of the chloride anion from the organic phase to the aqueous phase. The phenolate anion then recombines with the quaternary ammonium cation of Aliquat 336. The converted organic phase is subsequently contacted with lithium chloride in the second SX step. Water transferred to the organic phase protonates the phenolate to phenol, and the formed hydroxide ions undergo an anion exchange with chloride ions in the aqueous phase. The result is that the chloride ions in the aqueous phase are replaced by hydroxide ions, causing the formation of lithium hydroxide. This approach was upscaled in mixer-settlers (Nguyen et al., 2023) and a Kühni agitated extraction column (Peeters et al., 2024). Compared to mixer-settlers, the Kühni agitated column could prevent losses of lithium hydroxide into lithium carbonate by CO_2 -uptake from the air. Lithium hydroxide monohydrate could be recovered from the aqueous solution via antisolvent crystallization by addition of isopropanol.

- Binnemans, K. (2021). Method for producing battery grade lithium hydroxide monohydrate (Patent No. WO 2021/228936 A1).
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- Peeters, N., Riaño, S., & Binnemans, K. (2024). Conversion of lithium chloride into lithium hydroxide using a two-step solvent extraction process in an agitated Kühni column. *Journal of Sustainable Metallurgy*, 10(1), 637–645.