Technological solutions for recycling various Li-ion battery components

Summary

The main objective of this Ph.D. project is to develop new technological pathways for recycling spent Li-ion batteries (SLIBs). As LIBs production keeps increasing, the amount of SLIBs is also growing rapidly. SLIBs recycling has environmental and economic benefits as they contain various valuable metals (Li, Co, Ni, Mn etc.) and graphite, which is critical strategic mineral. However, to take the full advantage of the recycling potential, there is a great need for finding new recycling strategy. In this project various recycling possibilities will be studied. The final goal is to develop cost-effective recycling methods for SLIBs and propose various new applications for the recycled materials/components.

Research field:	Chemical and Materials Technology
Supervisors:	Ivar Kruusenberg Kerli Liivand
Availability:	This position is available.
Offered by:	National Institute Of Chemical Physics And Biophysics
Application deadline:	Applications are accepted between November 16, 2020 00:00 and December 16, 2020 23:59 (Europe/Zurich)

Description

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Lithium-ion batteries (LIBs) show excellent electrochemical performance and this is the reason they are extensively used in different applications, such as portable electronics and electric vehicles. As the production keeps increasing, the number of spent LIBs (SLIBs) is also growing rapidly. According to statistics, the lifetime of LIBs in digital products is only one to three years, and in power vehicles it is five to eight years. LIBs consist of cathode, anode, electrolyte, and separator. The cathode is an aluminium plate coated with a mixture of active cathode material (LiNiO2, LiMn2O4, LiCoO2, LiFePO4, LiNixCoyMn1-x-yO2, etc.), binder polyvinylidene fluoride (PVDF), and additives. The anode is a copper plate coated with a mixture of graphite and PVDF binder. The electrolyte of a LIB usually includes solvents (mixtures of one or more of the reagents DMSO, PC, and DEC, etc.) and solutes (LiClO4, LiPF6, LiBF4, etc.). LIB separators are usually a single layer or multi-layer of polyethylene or polypropylene. Materials used in LIBs, such as heavy metals and toxic electrolytes, pose a special threat to ecosystems and human health. If the SLIB is disposed of by landfilling the pollution of underground waterbodies can arise. As well, if the SLIB is burned considerable amount of poisonous gases (like HF) emerge, thereby polluting the environment and atmosphere occurs if traditional waste management procedures are applied. In addition, SLIBs have a high economic value because they contain a significant amount of valuable metals. SLIBs usually contain 5%–20% cobalt (Co), 5%–10% nickel (Ni), 5%–7% lithium (Li), 5%–10% other metals (copper (Cu), aluminium (Al), iron (Fe), etc.), 15% organic compounds, and 7% plastic, although their compositions differ depending on the manufacturers. Valuable metals such as Li, Co, Ni, and Mn from SLIBs bring significant economic benefits if they can be recycled.

State-of-the-art processes for metal recycling from SLIBs can be divided into three types of processes: pre-treatment processes, metal-extraction processes, and product preparation processes. Metal-extraction process focuses on changing the solid metals in SLIBs into their alloy form or solution state, which facilitates the subsequent separation and recovery of metal components. The common approaches include hydrometallurgy and pyrometallurgy. Hydrometallurgical method involves leaching, which dissolves the metallic fraction and recycled metal solutions for subsequent separation and recovery. Pyrometallurgical method involves high-temperature smelting reduction, where valuable metals are reduced and then recovered in the form of alloys. At the last stage of a battery recycling process, the valuable metals from SLIBs are transferred into other substances, such as alloys, slags, solutions and precipitates. Metal salts can be recovered if the valuable metals are separated and then respectively recovered by solvent extraction, chemical precipitation, and crystallization. Based on the literature, various recycling processes aiming to recover the valuable metals from SLIBs have been developed. However, an ideal recycling process that can recover all valuable components of SLIBs with low energy consumption and minimum environmental pollution is still unachieved. Therefore, many efforts are still needed for the development of more suitable recycling options and more knowledge needs to be gained to complete the circular economy aspect.

During this project various technological solutions for recycling SLIB different components will be studied and optimized. The final goal is to establish technological pathway for recycling all SLIB components. Additionally, new potential application fields for recycled materials will be explored, mainly focusing on the energy storage and conversion applications.

Responsibilities and tasks:

- Pre-treatment of SLIBs
- Recycling and extraction of various components from SLIB
- Physical characterization of the extracted materials
- Synthesis of new materials from recycled components
- Electrochemical testing of synthesised materials
- Publishing of the results and reporting activities, evaluation of the results

Qualifications

The applicants should fulfill the following requirements:

- background in electrochemistry
- working experiences with energy storage or conversion systems

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