supercritical-co2-recycling-solvent

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Cruising Review

Supercritical CO2 as Processing Solvent for the Recycling and Sample Preparation of Lithium Ion Battery Electrolytes

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This article investigates the potential for Sub and Supercritical CO_2 to be used to extract specific constituents of lithium ion batteries (LIB).

PDF Version of the webpage (first pages)

Supercritical CO2 as Processing Solvent for the Recycling and Sample Preparation of Lithium Ion Battery Electrolytes

The Role of Sub- and Supercritical CO2 as Processing Solvent for the Recycling and Sample Preparation of Lithium Ion Battery Electrolytes

1) This article investigates the potential for Sub and Supercritical CO2 to be used to extract specific constituents of lithium ion batteries (LIB).
2) Lithium ion batteries are quickly becoming the standard power source for a wide array of consumer electronics, including cell phones, laptops, cordless power tools, and most importantly hybrid and electric vehicles.
3) The lithium in lithium ion batteries, quote – has no actual substitute – unquote, and its, quote – demand might exceed the global production by the 2020s – unquote.
4) Besides being a valuable material, better recycling processes must be developed to better utilize limited lithium resources to support future electronic production and advancement.
5) To further incentivize the development of advanced recycling methods, the EU parliament recently introduced strictest LIB recycling requirements to date: quote - Each Eu member state has to meet a collection rate of 45 percent and at least a recycling efficiency of 50 wt percent – unquote.

6) Most LIBs taken out of service have experienced cell failure due to aging. This has lead to a need for better post mortem analysis to better understand the cell aging process.
7) Quote – decomposition of the electrolyte is challenging to investigate due to its complex composition – unquote. Processes do exist to perform post mortem analysis, but none are ideal.
8) The need for better LIB constituent recycling and electrolyte analysis both have the potential to be improved through sub- and supercritical CO2 extraction.
9) Current recycling programs focus on, quote – the recover of heavy metals ... and lithium itself... on the current collectors – unquote, but not the electrolyte which represents 10-15 wt percent of a typical LIB. The new EU directive will necessitate electrolyte reclamation.
10) In its supercritical state (above 31C and 74 bar), quote - CO2 has the density of liquid CO2 and the viscosity of gaseous CO2 – unquote. The physical properties exhibited are a combination of those characteristic of the gas and liquid phases, but most importantly, the supercritical state has, quote – greatly enhanced dissolution characteristics – unquote.

11) Supercritical CO2 is, quote – the most applied supercritical medium for extraction – unquote, often used in the food industry and other industrial manufacturing applications.
12) In most instances Supercritical CO2 is created by pumping a liquid or gaseous CO2 supply up to its critical pressure while applying heat to raise the temperature up to its critical temperature. The supercritical state is not reached until both the critical pressure and critical temperature are achieved.
13) Helium head pressure carbon dioxide (HHPCO2) is another method for achieving SC CO2. Quote – liquid carbon dioxide is compressed with a helium head pressure to 120 bar – unquote, to reach the critical pressure. Depending on the setup, additional heat application may also be required.
14) HHPCO2 allows for similar SC CO2 extractions, but may have some slight differences in efficacy due to the small concentration of helium dissolved in the CO2.
15) The authors describe a proposed method of introducing SC CO2 extraction into the standard LIB recycling process so that the electrolyte currently being destroyed or disposed of can be recaptured.
16) The article also details proof of concept trials that successfully demonstrated the ability to extract Lithium from LIB waste.

17) After proving the concept, the trail went on to investigate what aspects of the SC CO2 extraction were the most influential in increasing recovery. Their results indicated that increased pressure and increased extraction time were the two primary means of improving extraction yield.
18) As an analytical tool, it was also shown that SC CO2 could be used to extract quantitative samples from LIBs undergoing aging testing to better understand how test parameters were impacting the aging process. The SC CO2 derived samples offered greater purity than previous solvent extraction methods and avoided some of the potentially toxic exposure inherent in other methods.
19) The authors conclude that SC CO2 extraction is a promising method for improving the recyclability of LIBs, leading to a more sustainable LIB market in the future.
20) SC CO2 also offers a better analytical approach to post mortem LIB failure investigations which may ultimately lead to better LIB design.

Publication: "The Role of Sub- and Supercritical CO2 as Processing Solvent for the Recycling and Sample Preparation of Lithium Ion Battery Electrolytes." Nowak, Sascha, and Winter, Martin. PDF. 2017.

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