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Direct recycling of Li-ion battery positive electrodes assisted by supercritical CO₂

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The ecological transition is at the center of our daily life and the issue of energy production and its storage are now the focus of many research projects. With the increasing electrification of our everyday life devices, in particular with the rise of electric vehicles, the question of the batteries' end-of-life, particularly the lithium-ion batteries (LIBs), becomes a real challenge. Indeed, the building elements of this type of batteries, such as copper, aluminum but especially cobalt or nickel are not only expensive, but also present in very localized areas and in limited quantities on earth. It is therefore essential to implement recycling processes for these batteries to reclaim these metals and meet the growing demand of the market. Recycling techniques such as pyro- and hydrometallurgy are already employed to recover elements of economic interest. However, these destructive processes have limitations: i) the purity of the recovered elements is not high enough to reuse them to make new batteries, and also, ii) they require either high-energy inputs or massive use of acids. On the other hand, the direct recycling strategy, which aims to separate the different parts of a battery and recycle them independently, therefore, becomes the most credible alternative to achieve this goal.

In this communication, we will focus on the use of supercritical carbon dioxide (scCO₂) process for the direct recycling of LIBs positive electrodes production scraps [1]. Indeed, scraps can represent from 5 up to 30 wt.% of the electrode production [2,3]. With the increased LIBs production rate, their recovery becomes a priority. As shown in Figure 1, the objective aims to separate all the electrode components while preserving their properties and integrity. For this, we use a technology based on supercritical CO₂. We will first highlight the influence of several optimized parameters including the temperature, time, co-solvent ratio and dosages to successfully delaminate 100% of the active material. Multiple characterization techniques will then be combined to qualify the structure, chemical composition and physical properties of the recycled active material LiNi_{0.6}Mn_{0.2}Co_{0.2}O₂ (NMC622) and current collector (Al foil). Lastly, the performance of the recycled NMC622 electrode material in new batteries will be highlighted.

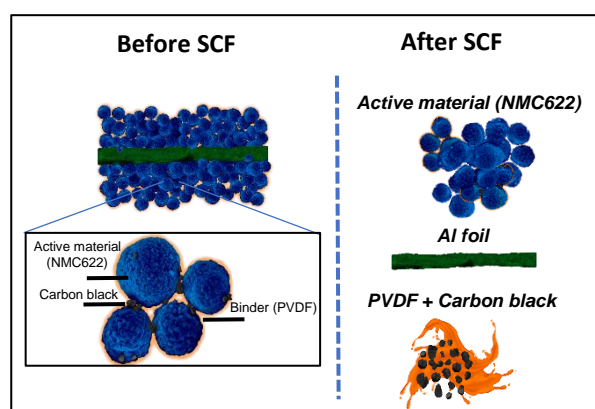


Figure 1. Separation of components in LIB positive electrode before and after scCO₂ treatment.

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