Enhancement of graphite recovery from LIB-NMC black mass using froth flotation

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Abstract

The recycling of end-of-life lithium-ion batteries (LIBs) faces significant technical challenges due to the complex mixture of metals, graphite, cathode-anode, and binders, specifically polyvinylidene fluoride (PVDF). This composition complicates material separation, particularly within the "black mass" derived from cathode and anode powders. Residual PVDF binders on graphite surfaces further resist the efficiency of froth flotation.

This research aims to enhance the concentration of graphite from Nickel-Manganese-Cobalt (NMC) battery black mass by integrating pyrolysis with froth flotation to recover high-purity graphite. Black mass samples went through pyrolysis in a nitrogen atmosphere to investigate the effects of temperature, duration, and heating rate on PVDF decomposition. Statistical analysis via Minitab was utilized to determine optimal parameters. Preliminary results indicate that pyrolysis effectively eliminates PVDF, with temperature identified as the most influential factor, followed by duration and heating rate. The optimal conditions were established at 500°C for 45 minutes with a heating rate of 10°C/min, PVDF elimination 21% approximately.

The pyrolyzed material was further subjected to flotation studies to evaluate the impact of collector types, agitation speeds, and reagents on the separation of cathode and anode materials. This integrated approach aims to optimize cathode grade and total material recovery yield, providing a feasible pathway for high-efficiency LIB component redemption.

Keyword: Black mass, Lithium-ion batteries (LIBs), Graphite, Froth flotation, Pyrolysis