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Techno-Economic Optimization and Evaluation of an Integrated Industrial Scale NMC811 Cathode Active Material Manufacturing Process

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Abstract : As part of the transition to electric vehicles, there has been a recent increase in demand for battery manufacturing. Cathodes typically account for approximately 50% of the total lithium-ion battery cell cost and are a pivotal factor in determining the viability of new industrial infrastructure. Cathodes which offer lower costs whilst maintaining or increasing performance, such as nickel-rich layered cathodes, have a significant competitive advantage when scaling up the manufacturing process. This project evaluates the techno-economic value proposition of an integrated industrial scale cathode active material (CAM) production process, closing the mass and energy balances, and optimizing the operation conditions using a sensitivity analysis. This is done by developing a process model of a co-precipitation synthesis route using Aspen Plus software and validated based on experimental data. The mechanism chemistry and equilibrium conditions were established based on previous literature and HSC-Chemistry software. This is then followed by integrating the energy streams, adding waste recovery and treatment processes, as well as testing the effect of key parameters (temperature, pH, reaction time, etc.) on CAM production yield and emissions. Finally, an economic analysis estimating the fixed and variable costs (including capital expenditure, labor costs, raw materials, etc.) to calculate the cost of CAM ($/kg and $/kWh), total plant cost ($) and net present value (NPV). This work sets the foundational blueprint for future research into sustainable industrial scale processes for CAM manufacturing.

Keywords : cathodes, industrial production, nickel-rich layered cathodes, process modelling, techno-economic analysis
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