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Thema	**Electrochemical-calorimetric studies on safety fundamentals of 40 Ah NMC lithium ion pouch cells**
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Kurzfassung

One of the most urgent tasks for the extensive introduction of stationary storage technologies and electric mobility is to provide safe and reliable lithium-ion cells and batteries. During the charging and discharging of lithium ion cells there are numerous chemical, electrochemical processes and transport processes going on that can lead to strongly exothermic reactions. In case of insufficient heat transfer to the environment, this can lead to a loss of battery power but also to uncontrolled reactions (thermal runaway) and ignition to cause an explosion.

In this study, commercial 40 Ah lithium ion pouch cells with $Li[Ni_{1/3}Co_{1/3}Mn_{1/3}]O_2$ (NMC) cathodes from different manufacturers were tested under isothermal and adiabatic conditions to investigate their performance and their thermal behavior. The measurements have been performed in an accelerating rate calorimeter (ES-ARC, Thermal Hazard technology with an integrated battery cycler).

The isothermal investigations were performed at specific temperatures in the range from 30 to 60°C. The results show that the applied environmental temperature did not largely influence the battery thermal behavior. Generally, an overall exothermic behavior for discharging half cycles and an overall endothermic behavior for charging half cycles was observed. At C/8 rate the maximum temperature increase over 5 cycles was 1.5 °C, at C/2 rate it increased to 3 °C. To investigate how the cells react if they are exposed to higher temperatures than they are specified for, they were hold at 100 °C for 3 hours. At C/2 rate this lead to a doubling of the maximum temperature increase to 6 °C and to a large capacity loss of 85 % probably due to the decomposition of the liquid electrolyte.

Tests under adiabatic conditions are important as they more accurately simulate the actual operating environment if several cells are put in a battery pack and the neighboring cells hinder or prevent the heat transfer. As worst case scenario the cells were studied in the adiabatic mode of the calorimeter under conditions of negligible heat loss at starting temperatures between 30 °C and 70 °C. In this case already at C/8 rate the surface temperature was largely increasing over 3 cycles by 15 °C. Additionally by measuring the overall heat capacity of the cells, by using potentiometric measurements and by current interruption technique it was possible to separate the reversible and irreversible parts of the heat.

The data extracted from these studies can be used both as input data for modeling and simulation and for the adaption of a thermal management system.