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Thermal Dynamics of 18650 Li-ion Batteries

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The failure of 18650 Li-ion batteries is examined under thermal runaway due to constant power heating. An experiment is designed to measure power input, power absorbed, battery temperature and mass loss rate. The effect of initial charge and power input is examined on runaway time. Analysis of the time response data allow the computation of an effective specific heat of the entire battery considered as a lumped thermal system. The power generated in thermal runaway is estimated, and the combustion dynamics of existing gases and particulate matter is observed. An electric arc igniter allows for piloted ignition of the gases. For a power input of 28 +/- 1 W, thermal runaway occurs at about 230ºC +/- 15 ºC. Thermal runaway is defined here as the onset of a sharp change in the slope of the temperature over time. At times the entire contents of a battery can be expelled after thermal runaway; however, in most cases gases are expelled slowly or as a sudden jet with particulates. Auto as well as piloted ignition can occur. The mass of the contents expelled increases with initial charge, with preliminary data indicating nearly half of the initial mass (44 g) expelled for 100 % charge. The internal energy stored in the battery during runaway increases nearly linearly with charge to about 100 kJ at 100 %. The electrochemical energy stored at 100 % charge is 36 kJ. So an increase in energy is due to the exothermic behavior of the battery components. If all of the gases expelled burn, that energy could reach over 400 kJ at 100 % charge. Experiments are continuing with refinements to measure these effects more accurately, and over a range of power input and charge. The output of these results can be used as input conditions to predict the performance of the thermal runaway potential in a packaged array of batteries. The ultimate outcome is to provide information on the thermal runaway potential in the transportation of cargo.