On a Method to Mitigate Thermal Runaway and Propagation in Packages of Lithium-Ion Batteries

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Abstract

Experiments have been conducted on a variety of lithium-ion batteries to measure their energy output in thermal runaway. Experiments were conducted to examine runaway due to puncture as well as heating, and to demonstrate how water could shutoff runaway. Techniques were developed to measure the internal energy release as decomposition of the battery causes runaway, and combustion energy that can arise from ignited battery gases released in runaway. A nitrogen bomb calorimeter was designed, constructed, and utilized to measure the internal energy in runaway. Three techniques were examined for measuring the combustion energy: (1) the Cone Calorimeter, (2) the Oxygen Bomb, and (3) the using a Gas Chromatograph to measure combustion species. The results from these measurement techniques are discussed and compared to the literature for similar batteries. Results generally show for 18650 batteries that the energies in runaway depend on battery chemistry, decomposition energy tends to increase with the SOC and can exceed its electric energy by 2-times, while combustion energy can reach 6-times the stored electric energy. Water is demonstrated as having the best potential means for a safe packaging design. Experiments have been conducted to examine the behavior of capillary flows in a water-saturated cellulosic sponge to mitigate battery runaway. An 18650 battery with the highest decomposition energy from the current study was used as the runaway trigger in the water experiments. It was demonstrated that a prototype package cardboard box containing nine 18650 batteries at 100 % SOC produced violent fire and explosion for a cardboard battery separator matrix, but no propagation of battery damage in a water-saturated sponge matrix. It is suggested, by analysis that the mechanism for water in preventing runaway is it's boiling with a very high coefficient of heat transfer that reduces the temperature during runaway.