Chemical Characteristics of Lithium-Ion Battery Combustion Emissions

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Poster Abstract

Lithium-ion battery (LIB) cells are a ubiquitous component in modern consumable products. They pose a considerable safety risk due to their high energy density and toxic ingredients. Furthermore, the cells are at risk of thermal runaway, when much of the energy contained is released over a short period of time. LIB fires pose a catastrophic risk to the spacecraft and crew of any space mission as concentrations of toxics can increase rapidly and mitigation options are limited. These risks will increase as access to space widens, LIB use becomes more prevalent, and the length of space missions increases. It is therefore necessary to properly characterize the emissions of LIB cell combustion to understand health risks to crew, physical risks to spacecraft components, and determine the best methods to detect and recover from a combustion event.

The goal of this project is to characterize the chemical composition of $PM_{2.5}$ emissions from thermal runaway driven combustion of LIB cells. The effect of LIB state of charge (SOC) will also be considered as this determines the energy stored in each cell. Two types of battery cells were tested, cylindrical “18650” lithium-iron-phosphate (LFP) cells and pouch-type lithium-polymer (LiPo) cells. These cell types differed in both chemical makeup and structure, with the cylindrical cells having a rigid case with overpressure vents, and the pouch cells having only a thin, flexible, wrapper. Each cell was individually triggered into thermal runaway by external heating, at which point the cell was allowed to combust autogenously. Depending on the SOC, cell combustion behavior ranged from smoking to rigorous flaming.

The resulting emissions were delivered to three particulate filter types by sampling lines connected to the exhaust duct of the burn chamber. Measurements of total chamber airflow also allowed total emitted masses per battery cell to be calculated. Filter types included quartz-fiber filters (for carbon and ion analysis), Teflon filters (for mass and elemental analysis), and impregnated cellulose filters (for chemical analysis of hydrogen fluoride).

The results of these experiments have been analyzed to characterize $PM_{2.5}$ emissions and correlation to battery SOC. These data will help with LIB fire safety, suppression, and cleanup in future space missions.