Electrical Discharge Interaction with Lithium-Ion Battery Vent Gases: ***Investigations using High-Speed Imaging and Breakdown Analysis***

Popular Science Summary

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Due to the increasing motivation for sustainable and clean transportation, the electrification of cars has become a top priority in the energy and transportation sectors. As the prevalence of batteries continues to increase, safety becomes more important than ever. The work done in the scope of thesis research is performed in collaboration with Volvo Cars and focuses on optimizing battery safety in regards to electric vehicle battery fires. This research consisted of designing, performing and analyzing two different experiments to further investigate the ignition of battery vent gases due to electrical discharge occuring within the system.

Minimum breakdown voltage is the voltage value at which electrical discharge will occur in a gas. This electrical discharge contains extremely concentrated heat, and in the presence of combustible gases, can provide the ignition source required for combustion to begin. Consequently, the lower the minimum breakdown voltage, the more likely it is that electrical discharge will form. The first experiment done in this research investigated the effect of a number of variables on this minimum breakdown voltage, including: gas flow rate, gas temperature, gas composition, and electrode distance. The results of this experiment indicated a strong dependency on synergistic effects within the gas molecules. The dependence on this phenomena provides a stepping stone into further research and design surrounding electrical vehicle battery design systems. Specifically, further research into battery geometry designs can limit the occurrence of electrical discharge occuring due to geometric constraints, while considering battery vent gases can limit the tendency for certain battery chemistries to produce combustible battery vent gases.

The second experiment performed used high-speed imaging and laser diagnostics to investigate the interaction between the electrical discharge and the battery vent gases, as well as the flame behavior after ignition. This experiment was designed to better understand the risk associated with battery fires that were caused by different gas compositions. As a result of this experiment, it was determined that it is possible to analyze the electrical discharge-vent gas interaction, but it would require a higher frame rate. Additionally, and most importantly, it was determined using laser diagnostics that the combustion behavior of one of the gases analyzed (NCA gas) was driven primarily by OH (hydroxide) radicals. This is significant because most venting systems and extinguising methods consider oxygen driven combustion as the main reason for a flame. Considering this information, it provides electrical vehicle battery manufacturers with an incentive to further investigate the different factors that drive combustion for specific battery chemistries.