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Increasing the safety and performance of lithium-ion batteries by new materials and new approaches

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Abstract: Lithium-ion batteries (LIBs) are today indispensable energy storage devices in the world of laptops, smartphones, for mobile communication and entertainment devices, for many applications in stationary energy storage and for electromobility [1]. LIBs have seen a continuous improvement in performance in recent years, both in terms of capacity, power and reliability, as well as in view of their safety. This latter aspect has become more important, as the increase in power and capacity of LIBs has led to the construction of aggregates of larger size which, by their dimensions and the amount of highly reactive components contained therein, represent a potentially very significant safety hazard [2,3].

Various safety features have therefore been designed and implemented in LIBs in order to prevent their catastrophic failure with the associated safety hazard. These include internal electronics to limit current and voltage, fuses, or separators that, upon exceedance of the allowable temperature range start melting and thereby inhibit further current flow between the electrodes. A central point of consideration remains, however, the electrolyte itself that is exposed to extreme potentials (both oxidizing and reducing), high temperature, and the presence of radicals and other reactive species and intermediates. Under these conditions a great variety of degradation and also condensation products can be formed which alter the electrolyte's properties and thus the characteristics of the entire electrochemical cell, or lead to the formation of volatile, highly flammable and thus hazardous emissions which either remain in the cell until discharged abruptly in an explosion, or are continuously vented.

Devices and strategies for the measurement of these emissions – both on-line and off-line – must be devised and tested. We report in this presentation on the various approaches that have proven successful in

characterizing the degradation of the LIB electrolyte and also the associated changes in the entire battery. Conclusions are drawn on possible routes of development in the future that will lead to increased safety in the operation of lithium ion batteries, as well as improved battery performance in terms of power, capacity and lifetime.

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