Cell Venting System

ADVANCED MANUFACTURING PROCESSES FOR LOW COST GREENER LI-ION BATTERIES

Introduction

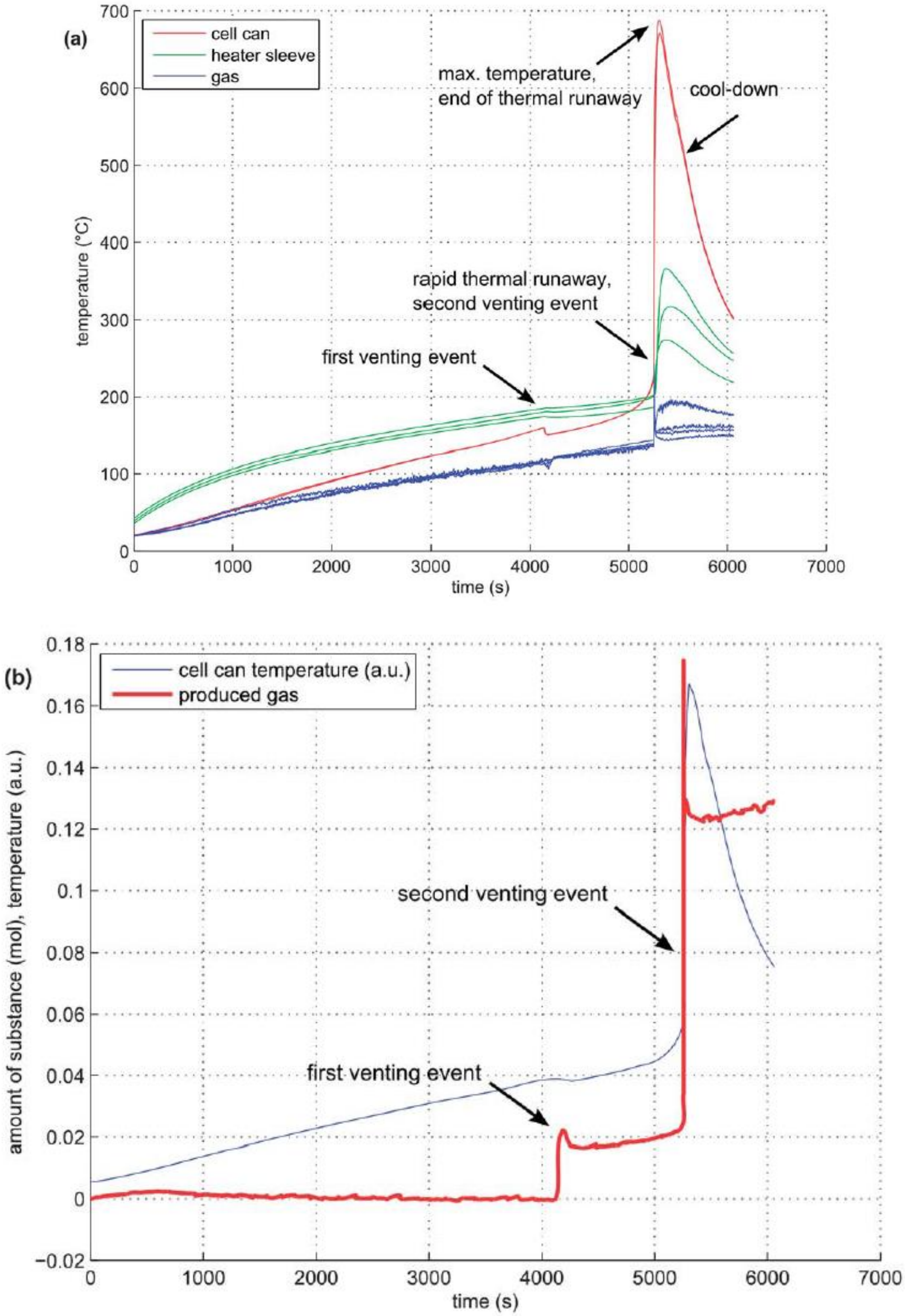
Li Ion cells are one of the most popular types of rechargeable batteries for portable electronics, with a high energy density, small memory effect,[8] and only a slow loss of charge when not in use. Beyond consumer electronics, they are of increasing use in military, battery electric vehicle and aerospace applications.

However like any energetic system, they may show some safety concerns in some specific use or damage conditions and thermal runaway can occur, leading to fast and complete destruction of the battery pack and even worse destruction of the whole powered subsystem (e.g. car, plane) and possible injuries or death. Thus there is an evident need of the safety improvement, in combination to health monitoring of the Li Ion cells.
Work on the prevention of thermal runaway was a specific goal within Greenlion, specially addressed with the development of venting systems.

Thermal runaway: general information

Abuse conditions such as overcharge, over-discharge and internal short-circuits can lead to battery temperatures far beyond the manufacturer ratings. At a critical temperature, a chain of exothermic reactions can be triggered. The reactions lead to a further temperature increase, which in turn accelerates the reaction kinetics. This catastrophic self-accelerated degradation of the Li-ion battery is called thermal runaway.
During thermal runaway, temperatures as high as 900 °C can be reached and the battery can release a significant amount of burnable gas, leading to damages to the powered device and possible injuries (inhalation of the toxic gases, burns), one example of damage is given below (Li Ion battery from All Nippon Airways' Boeing 787).

The curves hereunder show a typical evolution of battery temperature and gas generation under runaway (Source: RSC Adv., 2014, 4, 3633).



These curves clearly highlight the dependence between gas evolution and cell temperature. One evident strategy to prevent thermal runaway is to allow gas exhaust and then limit cell pressure build up and corresponding temperature increase. The introduction of a venting system was thus investigated as a possible solution to work on that issue.

Greenlion venting systems

Two main specifications were set for the development of the venting system within GREENLION:

- Venting pressure: <1.5bar
- Venting system integrated in the cell and compatible with cell manufacturing and formation.

The focus on venting at low pressure is an important point since it allows to exhaust gas in the very early stage of thermal runaway, and subsequently to limit temperature increase within the cell.

The developement of the venting system was carried out in 2 stages:

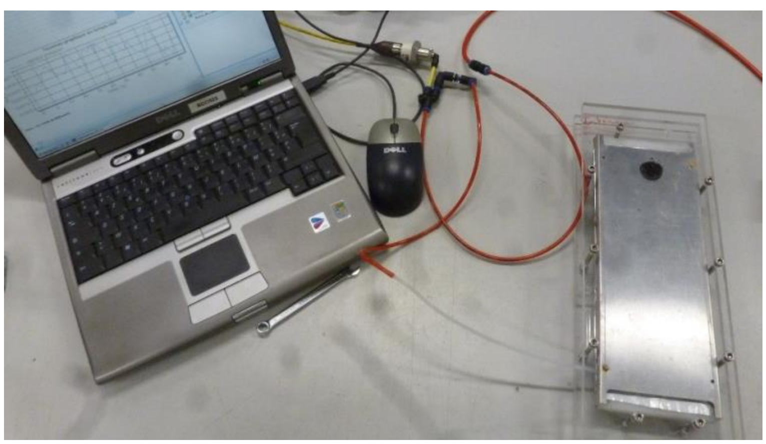
- Assesment of the blow out resistance of the cell in free and stack mode
- Integration of the venting system at the cell level and blow out tests

1. Cell blow out resistance

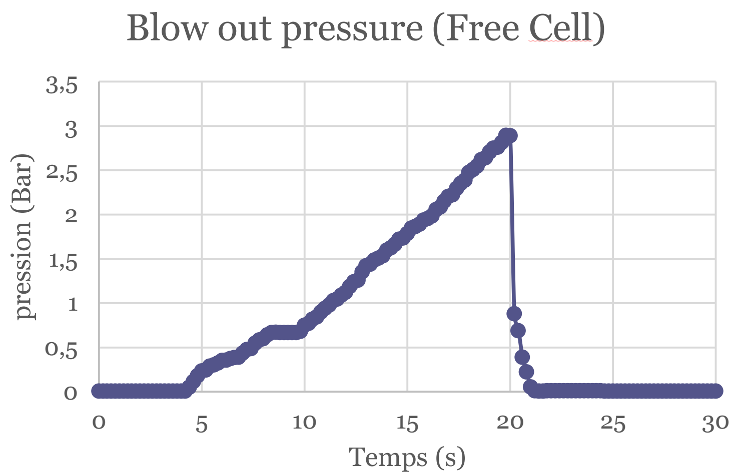
In order to assess cell resistance to blow out, i.e pressure at which cell will explode under inner volume expansion, we carried out a series of cell blowing test on dummy samples.
Two cell configurations were tested:

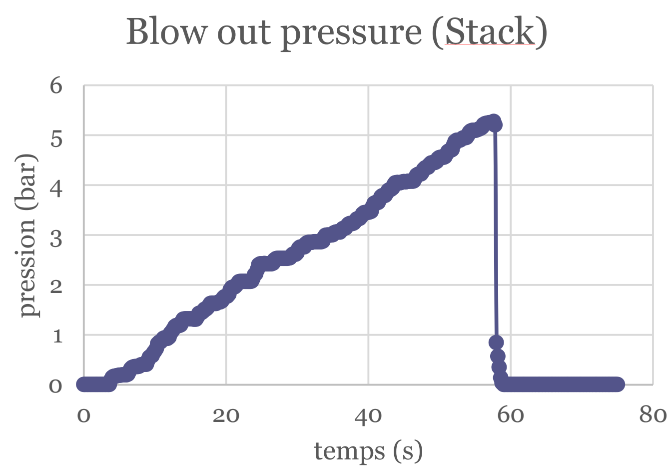
- Free cell (as a self standing element)
- Stacked cell (stacked within a cell pair, constitutive unit of GREENLION module)

The picture below shows the test set-up developed by RESCOLL for the measurement of the cell blow up, in stack configuration (heat sink and frame are visible). The paired cells are stacked between 2 PET plates, tightened under fixed torque values. The computer allows live monitoring of the pressure inside the cell and tracking of the blow out.



The curves hereunder show the different behavior and pressure resistance of the cell in the 2 configurations.





In free cell configuration the cell inflates without external constraints and strong peeling forces appear on the aluminum foil sealing line. At blow out, the sealing line opens quickly on one side of the cell and debonding of the seal spreads on several centimeter, leading to large opening of one side on complete leakage of components.

In stacked configuration, the cell and its sealing line are pressed and their movements and swelling capability strongly reduced compared to free cell. In stacked configuration, surrounding components and pressure applied on the cell act like a kind of armor, which leads to higher pressure resistance of the cell in stacked configuration. After blowing, damage on the cell is similar to what is observed for free cell, with a large opning of the sealing line on one side of the cell.

Conclusion of these tests is that venting at a pressure below 1.5 bar (stacked cell) would strongly reduce the “natural” blowing resistance of the cell and can be seen as a reasonable target.

2. Cell venting systems

Two different approaches were investigated within GREENLION for the venting of the cell:

- Venting sticker on the cell face
- Venting tubing equipped with a venting valve

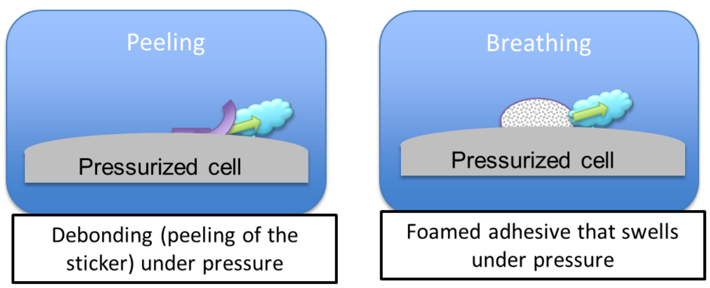
a. Venting sticker

In order to provide an effective weak point for a controlled cell venting in case of failure, the 1st approach investigated consists in the use of a sticker on the surface of the pouch cell (sticker laminated over a hole in the ALF).

Different stickers providing a peeling or breathing solution (as shown below) to cell overpressure were investigated.

Initial testing on dummy cells provided reduced blow out pressure (around 1 bar) that would allow for a controlled venting of the faulty cell.

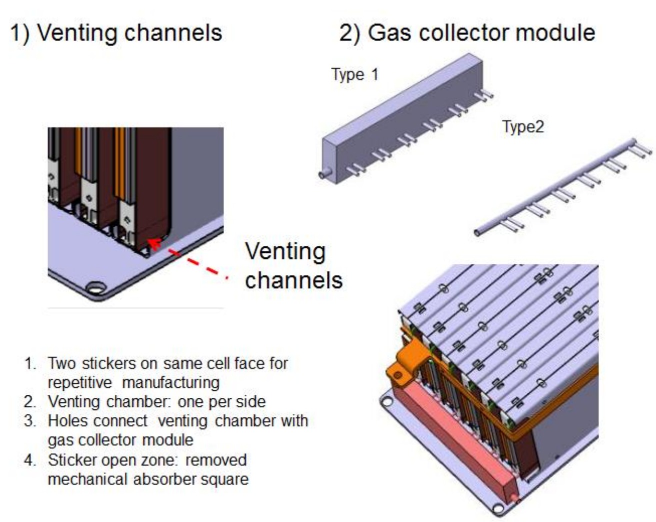
Ageing tests have been carried out in a second step in order to validate the stickers (resistance to the electrolyte, no leakage under vacuum).



Pros and cons of this sticker approach are as follows:

- Efficient venting at low threshold pressure
- Limited impact on cell geometry
- Cheap materials
- Integration of a weak point in the ALF material
- Ageing resistance directly impacted by the adhesive resistance to electrolyte
- Bonding protocol and bonding quality is crucial

A view of the sticker integrated in the cell is given hereunder, with an overview of the venting solution integrated at the different levels of the module.



b. Venting valve

The second approach is based on the combined use of a tube and a valve that enable gas exhaust at a threshold pressure around 1.5 bars.
One example of venting valve can be found in the rupture disk like products, one example given below.

This solution is safer than the sticker but implies work on different point like integration of the disk on mounting jigs in the module and connection to the venting tube. The venting tube itself as to be safely connected to the cell.
In addition, all the materials involved need to be electrolyte resistance and with no impact on the cell service.

Pros and cons of this tube & valve approach are as follows:

- Efficient venting at controlled threshold pressure
- Reliability
- Impact on cell design
- One valve per module and not per cell (to limit impact on design compactness)
- Expensive valve system

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