GTR EVS

'Electrolyte leakage and venting'

JRC Work Update

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JRC.C.1

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Electrolyte leakage/venting verification - Current state of the art

"…visual inspection without disassembling any part of the Tested-Device" is adopted in Phase 1 as a method for verification of the occurrence of electrolyte leakage and venting.

JRC concerns:

- Due to high volatility of some electrolyte components and limited release volume, electrolyte leakage and venting may not always be easily detectable, while potentially creating hazardous environment.
- Special measures may be required to ensure safety of inspecting personnel.
- Release of other substances, e.g. coolant, is currently treated equally to release of electrolyte.

JRC work will focus on the development of more robust method(s) to first verify the occurrence of the electrolyte release and/or venting and, if possible, to quantify such release.

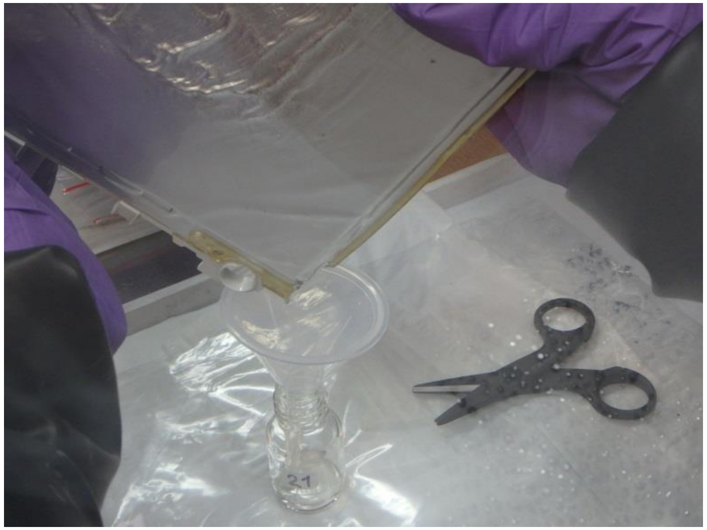
Free liquid electrolyte - amount

JRC has finalised research to quantify the amount of free liquid electrolyte in Li-ion battery (LIB) cells
(continuation of research shown in EVS-07-24e.pdf and EVS1414-503.pdf):

- In addition to the previous 4 cells (EVS-07-24e.pdf), 22 large format cells from 6 different LIB cell manufacturers have been opened, including 3 cells aged in an electric vehicle and 1 calendar aged cell

Free liquid electrolyte - amount

- Fresh cells of 4 manufacturers contained up to 40 ml of free liquid electrolyte.
- Some of the cycle-aged cells investigated contained free liquid electrolyte.
- Calendar ageing does not seem to have any effect on the amount of free liquid electrolyte.



Free liquid electrolyte - toxicity

Solvent	Volume of evaporated solvent*, ml	
	PAC-2 level	PAC-3 level
Diethyl carbonate (DEC), CAS # 105-58-8	1.4	21.5
Dimethyl carbonate (DMC), CAS # 616-38-6	25	149
Acetonitrile (AN), CAS # 75-05-8	42	86

** Volume, solvent evaporates into, is defined as vehicle + 1-m clearance; 61.5 m^3 in this study*

PAC stands for **Protective Action Criteria**
PAC-2: Irreversible or other serious health effects that could impair the ability to take protective action
PAC-3: Life-threatening health effects

N.P. Lebedeva, L. Boon-Brett, Considerations on the Chemical Toxicity of Contemporary Li-Ion Battery Electrolytes and Their Components, Journal of the Electrochemical Society 163 (2016) A821

Free liquid electrolyte - toxicity

- Li-ion battery cells can contain free liquid electrolyte in amounts sufficient for the formation of potentially toxic atmosphere in enclosed spaces after a release of electrolyte from a single battery cell.
- Release of the contained free liquid electrolyte represents the best case scenario as its amount corresponds to the minimum amount of electrolyte that can be released from a battery cell when the integrity of the cell casing is compromised.

Field data

iPad battery 'explodes' at Amsterdam Apple store, three treated for breathing problems

" Three people developed breathing difficulties after the battery of an iPad 'exploded' in the Apple store... Fire officers suspect that the battery began to leak, and then exploded but said no smoke was released. 'It is likely that a substance was released in the explosion which caused irritation to the lungs and airways,' a spokesman told broadcaster RTL."

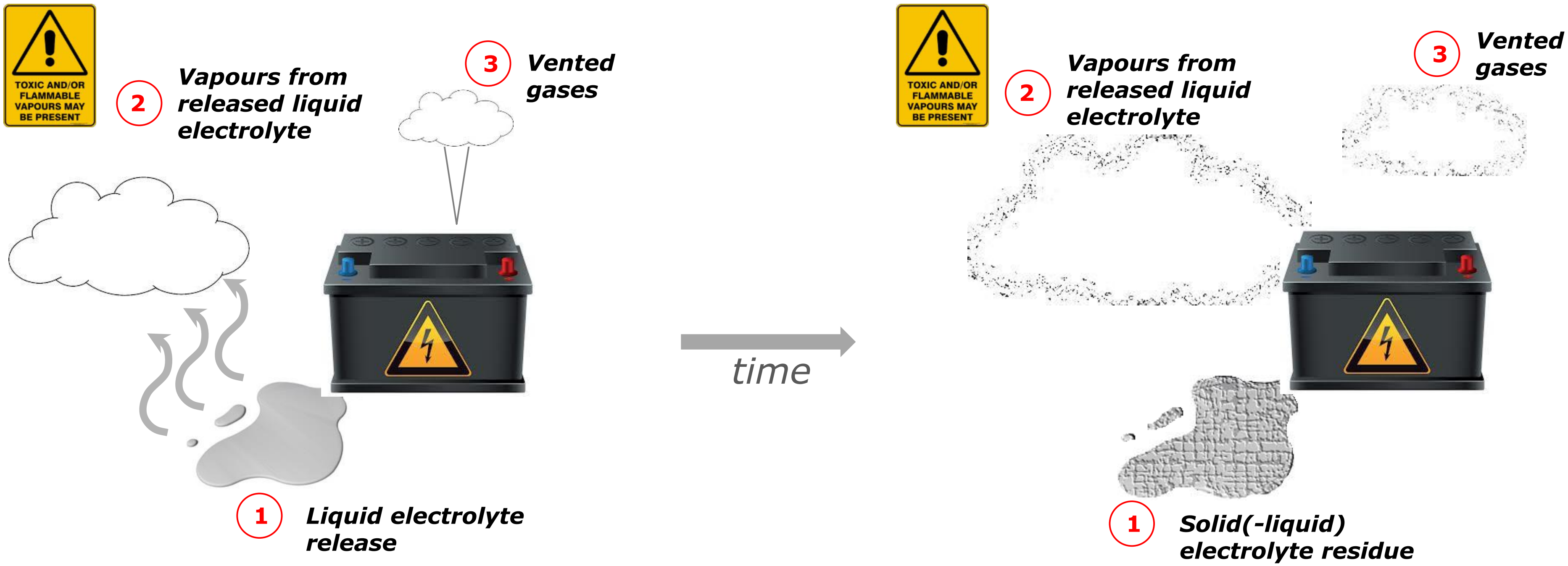
https://www.dutchnews.nl/news/2018/08/ipad-battery-explodes-at-amsterdam-apple-store-three-treated-for-breathing-problems/

Objective

Method development for detection and quantification of potentially toxic release associated with electrolyte leakage and venting

The aim is to develop a robust and practical method, suitable for use within regulatory environment, for detection and quantification of the emissions from traction batteries upon electrolyte leakage and/or venting that delivers reproducible and repeatable results.

Ongoing Work



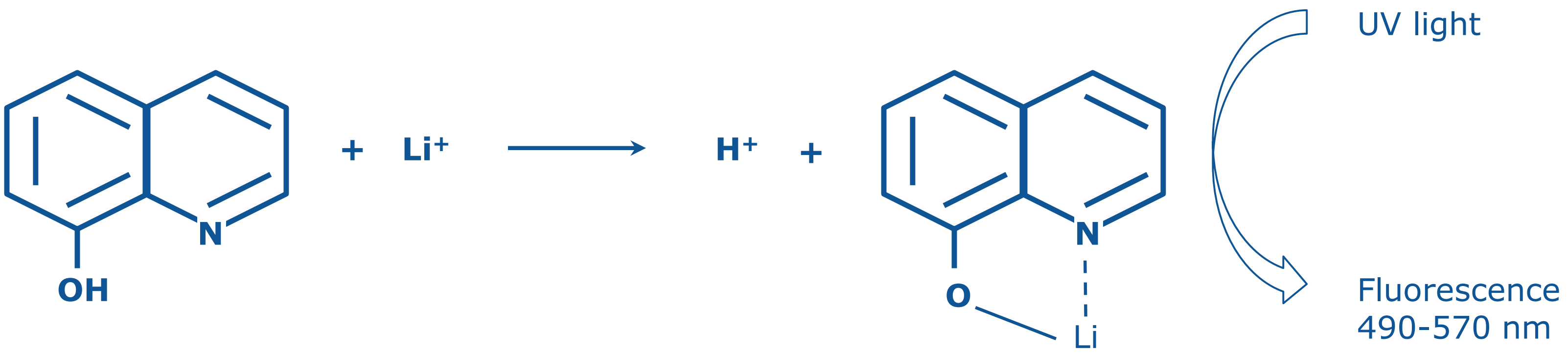
Possible approaches for detection of electrolyte release

1 Detection of Li-ion presence

2 + 3 Gas detection

Approaches to release detection

(1) Detection of Li-ion presence



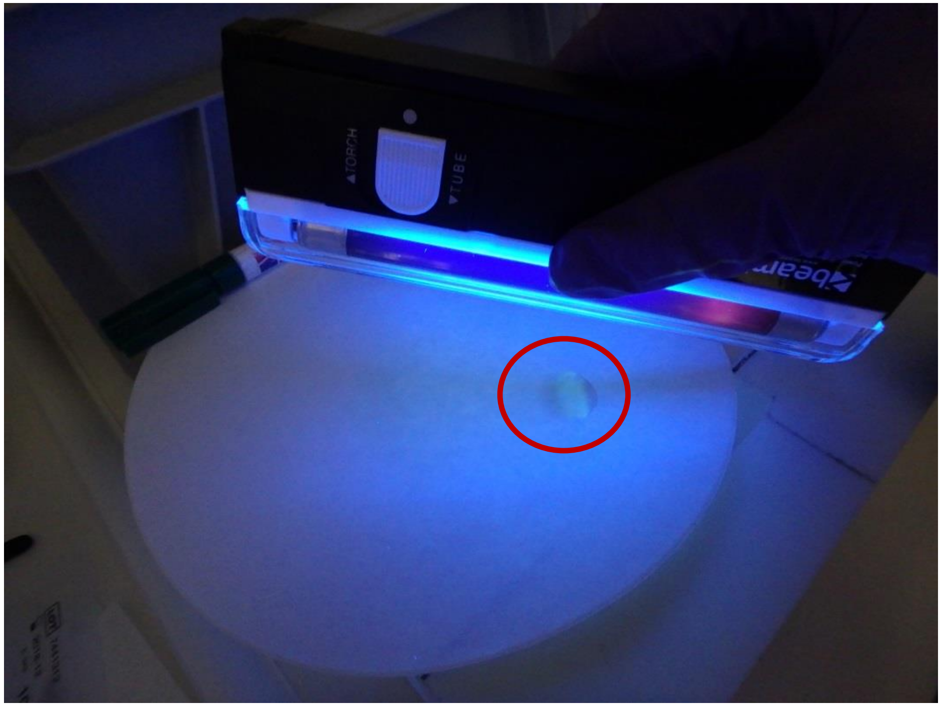
8-hydroxyquinoline

For more information see, for example, N.B. Hansen, Mikrochimica Acta, 1983, II, 277-285

First results – Li ion presence detection

Proof of concept

- Droplet of electrolyte was placed on a paper filter
- Droplet of 8-HQ was added to the same spot
- After ca. 5 min green fluorescence was visible upon exposure of the spot to UV light
- Reactants alone did not produce any fluorescence



First results – Li ion presence detection

Currently 'an appropriate coating' is indicated as technique for electrolyte leakage detection:

6.1.6.2.6. Electrolyte leakage.
An appropriate coating, if necessary, may be applied to the physical protection (casing) in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. Unless the manufacturer provides a means to differentiate between the leakage of different liquids, all liquid leakage shall be considered as the electrolyte.

Following this line JRC research on detection of Li ion presence will also investigate and potentially provide guidance on the characteristics an appropriate coating could have.

First results – Li ion presence detection

Proof of concept

- Filter paper was pre-treated with 8-HQ and allowed to dry at RT overnight
- Droplet of electrolyte was added to the 8-HQ pre-treated paper
- After ca. 5 min green fluorescence was visible upon exposure of the spot to UV light
- Reactants alone did not produce any fluorescence

Work plan – Li ion presence detection

	Test details	Finalisation (expected)
1	Proof-of-concept: model electrolyte	Q3 2018
2	Influence of test parameters, e.g.: - temperature - time - coolant, casing (plastic, metal) - Li^+ concentration	Q4 2019
3	Tests with real electrolytes	Q2 2020

Work plan – gas detection

	Test details	Finalisation (expected)
1	Method requirements	Q4 2018
2	Review analytical methods	Q1 2019
3	Method selection	Q1 2019
4	Tests with individual model compounds	Q3 2019
5	Tests with model mixtures and feasibility check	Q2 2020
6	Tests with real-world mixtures in an enclosed environment	Q4 2020
7	Tests with real-world mixtures in open air environment	Q2 2021