

A New Method of Analyzing Electrolyte from Lithium-Ion Cells

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Thompson, D.S. Hall, and J.R. Dahn

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Energy density

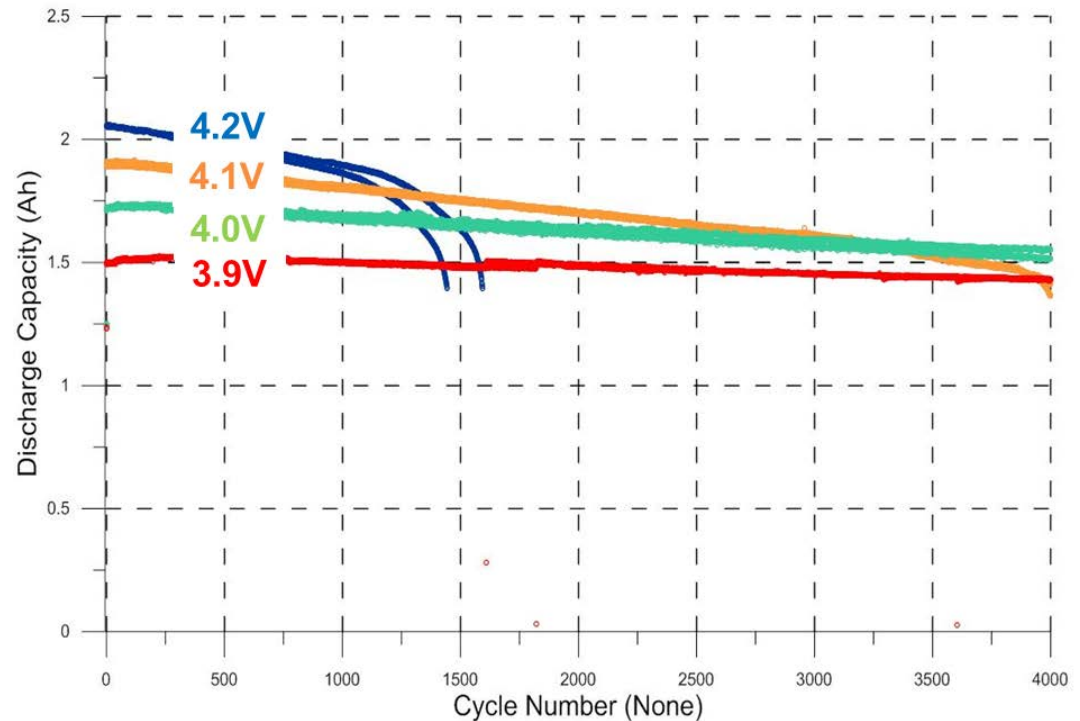
- (250–693 W·h/L)

Cycle life

- (>1000 cycles, ~10 years)

Energy (Wh) =

capacity (Ah)*voltage (V)



E-One Moli for 2200 mAh NMC 18650 power cells. C-rate cycling at 23°C.

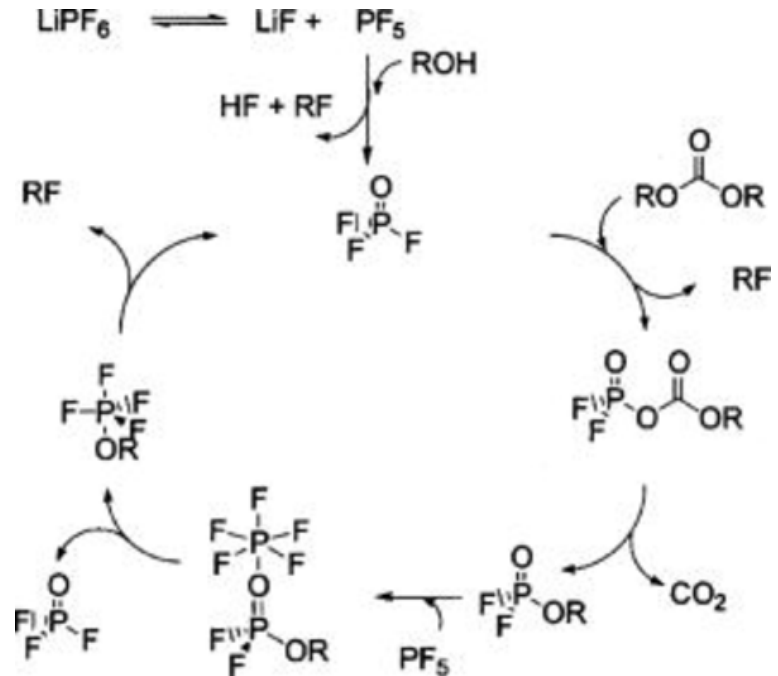
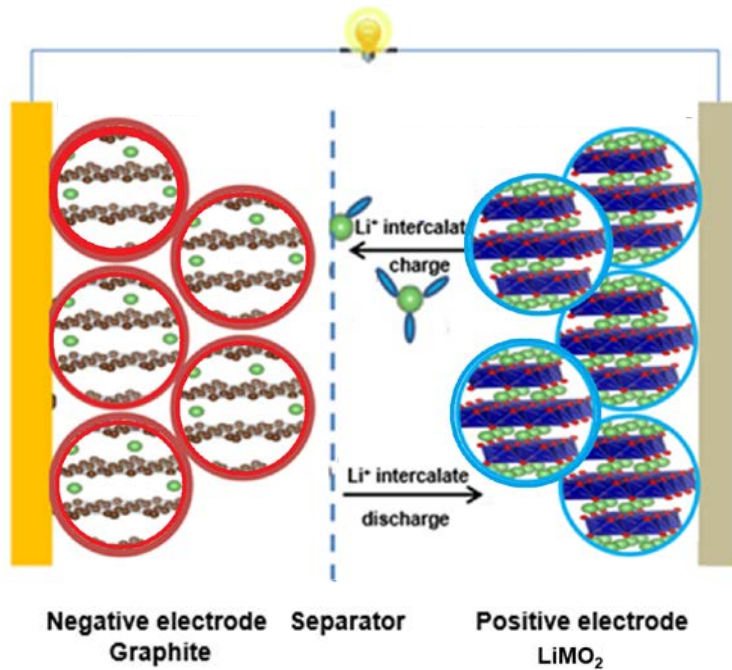
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Solvent oxidization

Solvent reduction

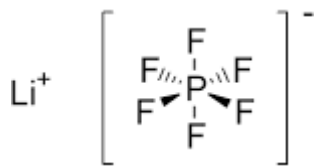
Salt/ solvent decomposition

Campion, et al., *J. Electrochem. Soc.* **2005**, A2327



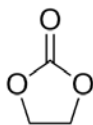
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Salt: LiPF_6

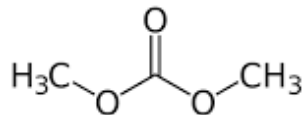


Inductively Coupled
Plasma Optical Emission
Spectroscopy
(ICP-OES)

Solvents:
ethylene carbonate (EC)

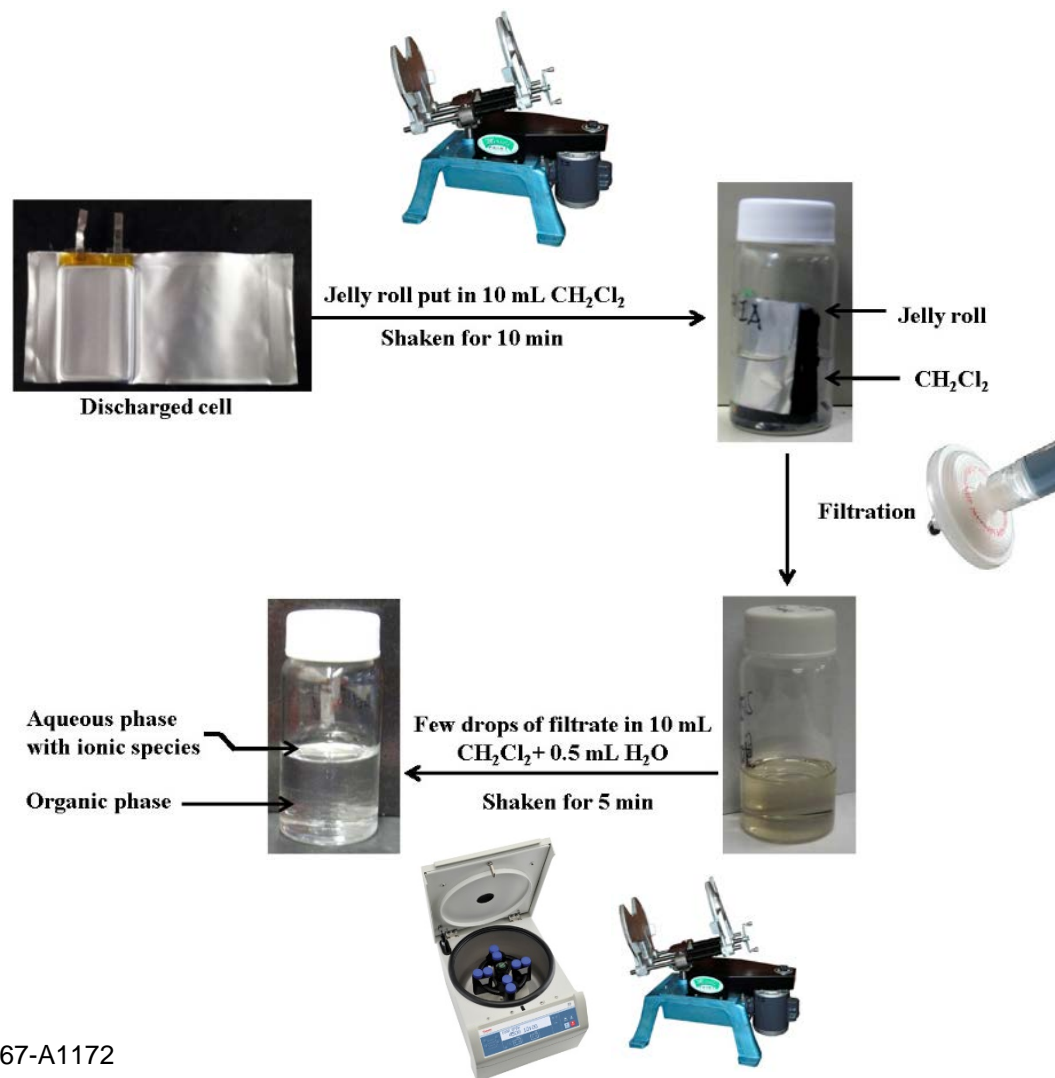


Dimethyl carbonate
(DMC)



Gas Chromatography +
Mass Spectrometry
(GC-MS)

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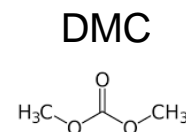
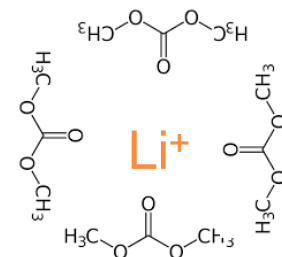
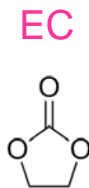
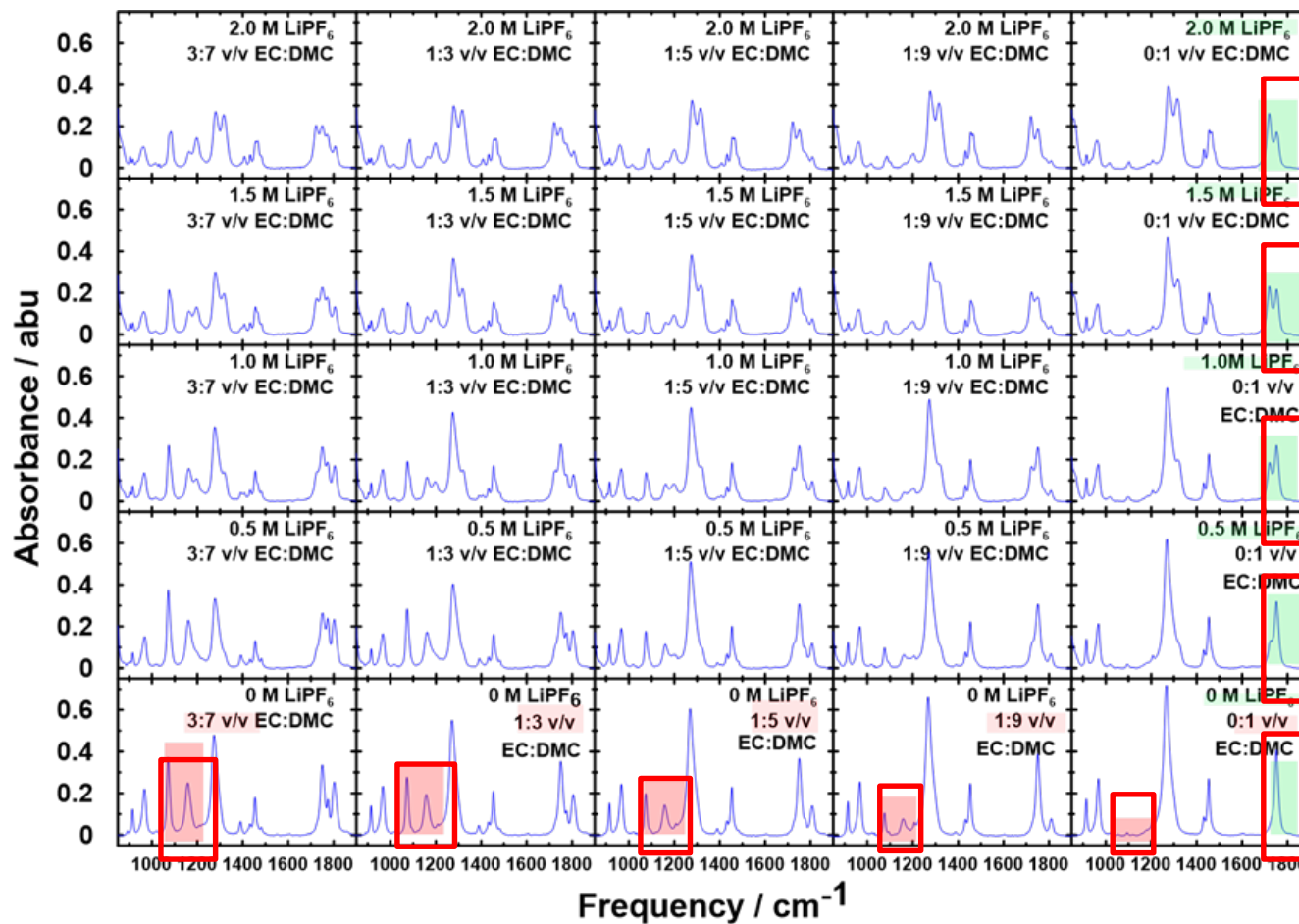


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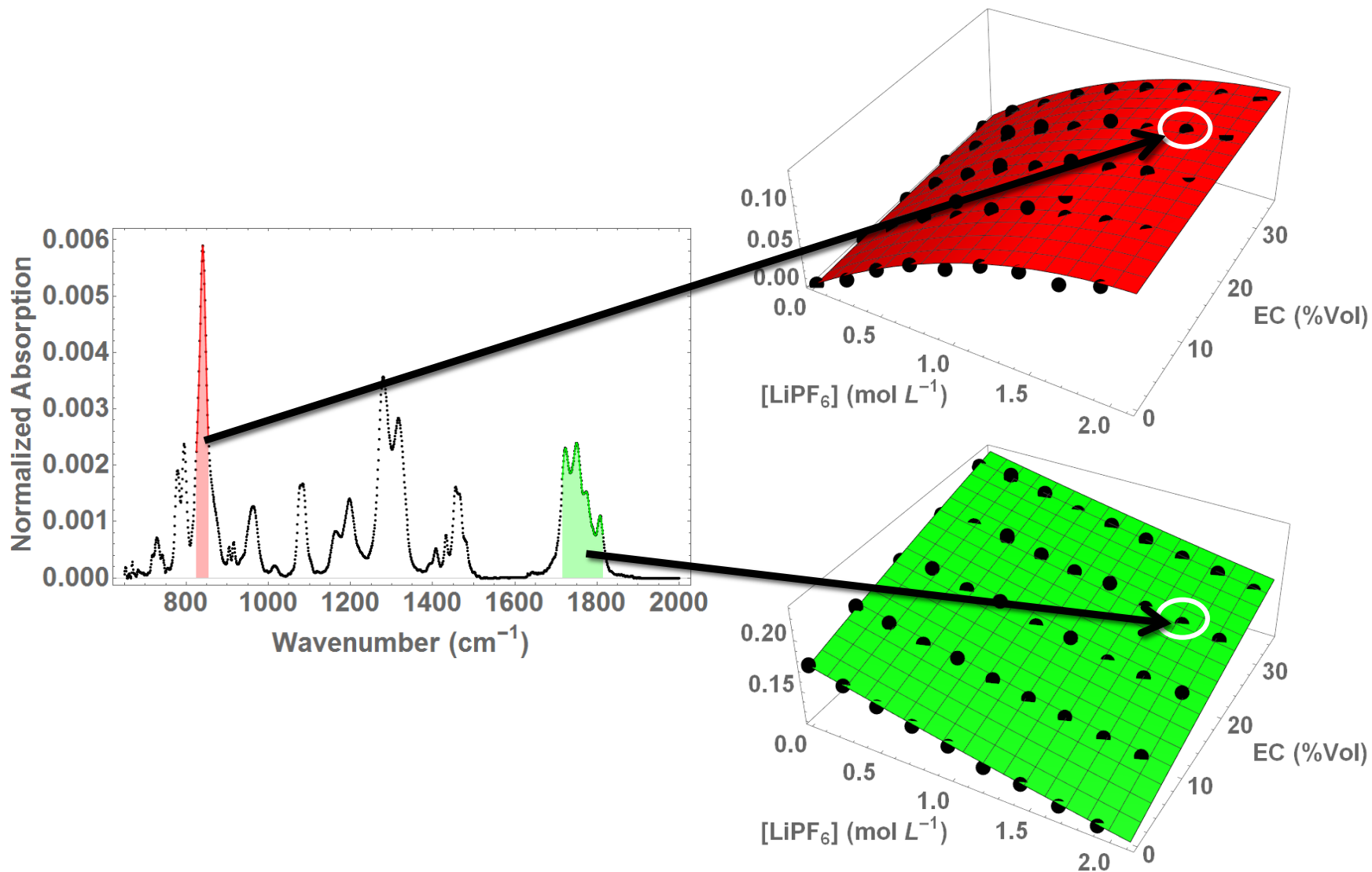


Fourier Transform Infrared Spectroscopy
(FTIR)

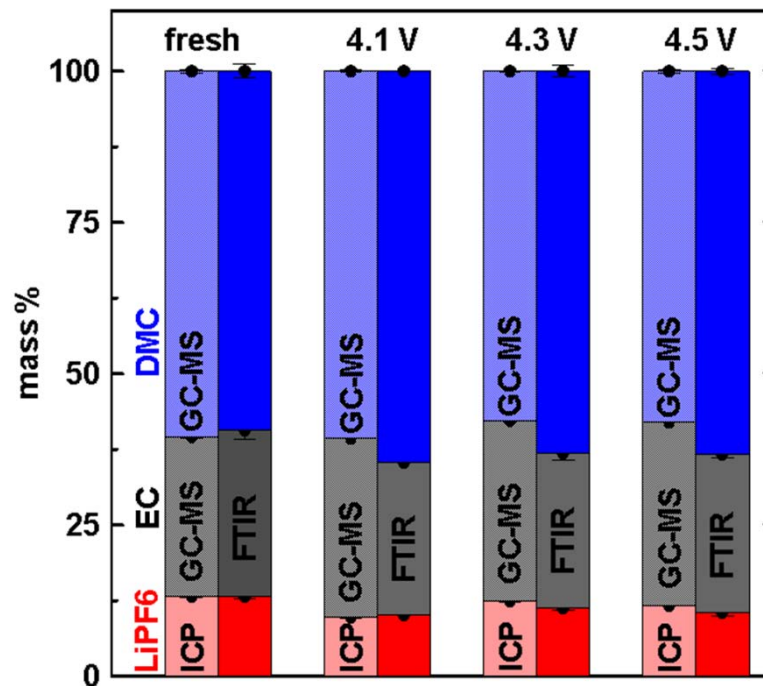
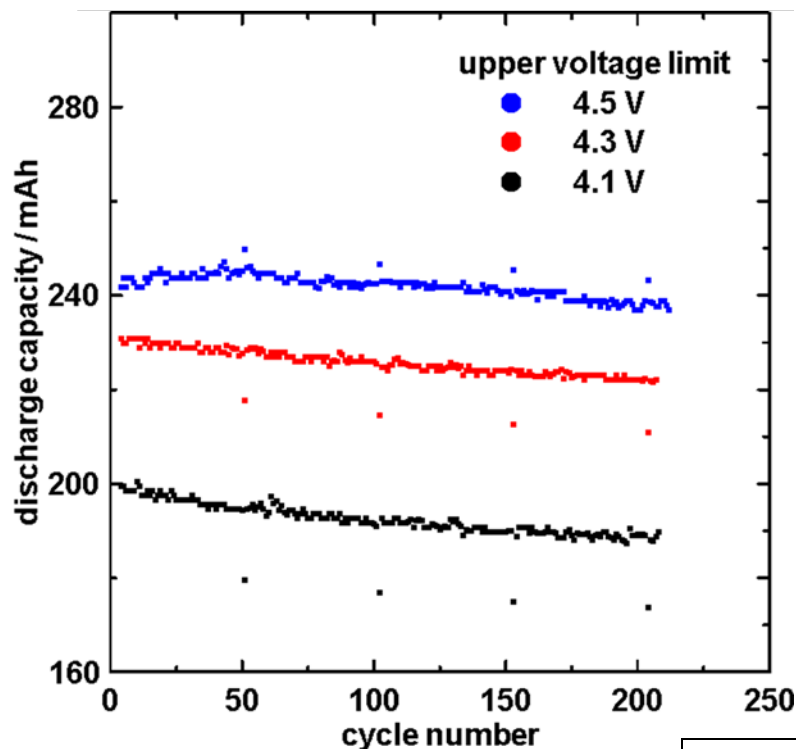
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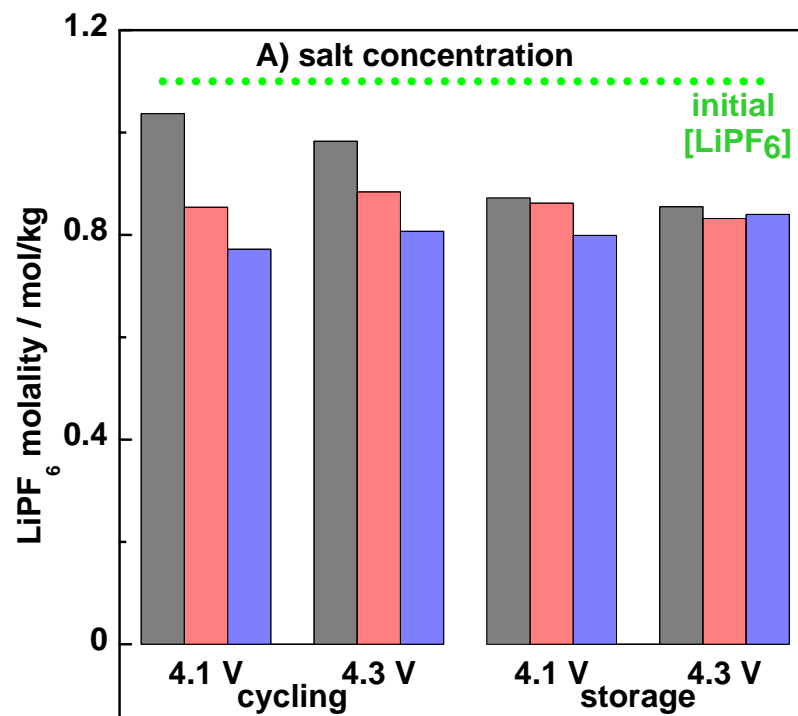


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electrolyte	method	LiPF ₆ / wt. %	EC / wt. %	DMC / wt. %
Fresh	GC-MS/ICP-OES	13.1 ± 0.1	26.5 ± 0.2	60.4 ± 0.3
	FTIR-ML	13.3 ± 0.4	27.5 ± 1.5	59.3 ± 1.2
4.1 V	GC-MS/ICP-OES	9.8 ± 0.2	29.51 ± 0.03	60.7 ± 0.2
	FTIR-ML	10.08 ± 0.02	25.35 ± 0.04	64.57 ± 0.03
4.3 V	GC-MS/ICP-OES	12.5 ± 0.2	29.8 ± 0.1	57.8 ± 0.1
	FTIR-ML	11.4 ± 0.4	25.4 ± 1.1	63.2 ± 0.9
4.5 V	GC-MS/ICP-OES	11.8 ± 0.1	30.22 ± 0.03	58 ± 0.3
	FTIR-ML	10.5 ± 0.6	26.3 ± 0.6	63.3 ± 0.5

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4 months test at:

20°C

40°C

40°C

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<u>method</u>	<u>Analytes</u>	<u>Sensitivity</u>	<u>preparation</u>	<u>Speed</u>	<u>Instrument cost</u>
	Organic solvents LiPF ₆	3-5 wt %	none 	seconds/ sample	~\$18,000 USD
GC-MS 	Organic solvents Trace components	ppm	Extraction, DCM	~ 1h / sample	~\$100,000 USD
ICP-OES	LiPF ₆	ppm	Dilution, HNO ₃	~ 1h / sample	~\$100,000 USD

A New Method of Analyzing Electrolyte from Lithium-ion Cells

- Analyzing electrolyte helps to understand cell failure
- electrolyte analysis with FTIR is
 - ✓ faster
 - ✓ cheaper
 - ✓ “greener”
- The FTIR method can be used for other solutions
 - redox-flow electrolytes

Thank you!

Dahn lab, 2018



Tesla Inc.

Walter C. Sumner
Memorial Fellowship

