

Amperex Technology Limited / Phostech Lithium Inc.



Phosphate for high rate application

Presented at:

THE 25TH INTERNATIONAL BATTERY SEMINAR & EXHIBIT



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Outline

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- LiFePO_4/C powder by Phostech
- ATL IFR18650 performance
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 - Temperature rise at different rate
 - Ragone plot
 - 1C discharge at different temperature
 - 4A/6C cycle performance
- Conclusion



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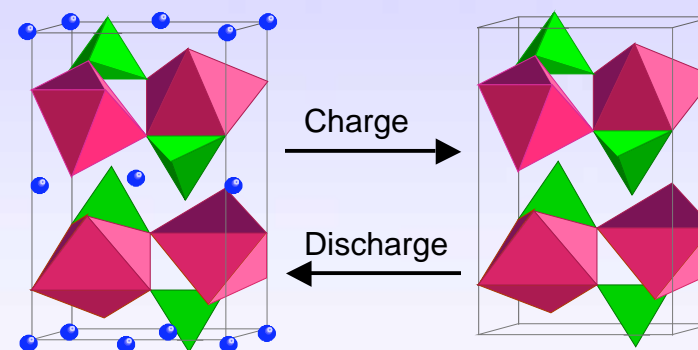
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LiFePO₄ characteristics

- Thermal stability of FePO₄ phase after full charge
 - Covalent P-O bonding makes the skeleton of LiFePO₄ and shows less effects by Li ions.
 - No O₂ release for overcharge and overheat, much safer than other commercial cathode materials.
 - Possibility to decrease costs associated to external safety devices
- Good electrochemical characteristics
 - Long Calendar Life for the stable olivine structure
 - High tolerance to high and low-voltage abuse
 - Lower thickness change of full cell during charge and discharge provides stable performance for negative swelling rate of cathode.
- Abundant resource of basic elements
 - Fe and P are common components
- Environmentally friendly
 - No toxic elements

Compound	a(Å)	b(Å)	c(Å)	V(Å ³)
LiFePO ₄	10.3449	6.0137	4.6990	292.33
FePO ₄	9.8213	5.7927	4.7886	272.43



The olivine structure is stable during Li-ions insertion and extraction.



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LiFePO₄ characteristics

➤ Some physical parameters of cathode materials

Cathode	Electric conductivity	Solid diffusion co-efficient
• LiCoO ₂	10 ⁻³ ~10 ⁻⁴ S/cm	10 ⁻⁷ ~10 ⁻⁹ cm ² /s
• LiMn ₂ O ₄	10 ⁻⁵ ~10 ⁻⁶ S/cm	10 ⁻⁹ ~10 ⁻¹² cm ² /s
• LiFePO ₄	10 ⁻⁹ ~10 ⁻¹⁰ S/cm	10 ⁻¹² ~10 ⁻¹⁴ cm ² /s

Pure LiFePO₄ shows lower conductivity for the one-dimensional model of Li⁺ diffusion among 3D structure. Lower solid diffusion co-efficient and electron conductivity, are major problems before it can be applied in power cell.

➤ How to improve conductivity and rate performance

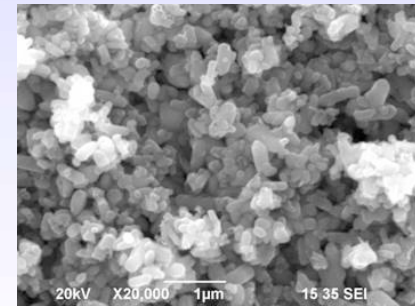
- Carbon coating

Drs. M.Armand and N. Ravet, of University de Montréal Introduced and patented nano-painting of LiFePO₄ with a Carbon electronic conductor in 1998

- Nano-structured

Decrease the distance of Li⁺ insertion/extraction in particle

Phostech C-LiFePO₄, P2



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ATL IFR18650 performance

➤ Cell information

ATL-IFR18650	
Cathode material	Phostech P2 LiFePO ₄
Nominal voltage	3.2V
Nominal discharge capacity at 1C	1.2Ah
Nominal Impedance	20m!
Cell weight	39±1g
Maximum continuous discharge current	30A
Energy density	100Wh/kg
	240Wh/L
Power density	1800W/Kg
	3800W/L

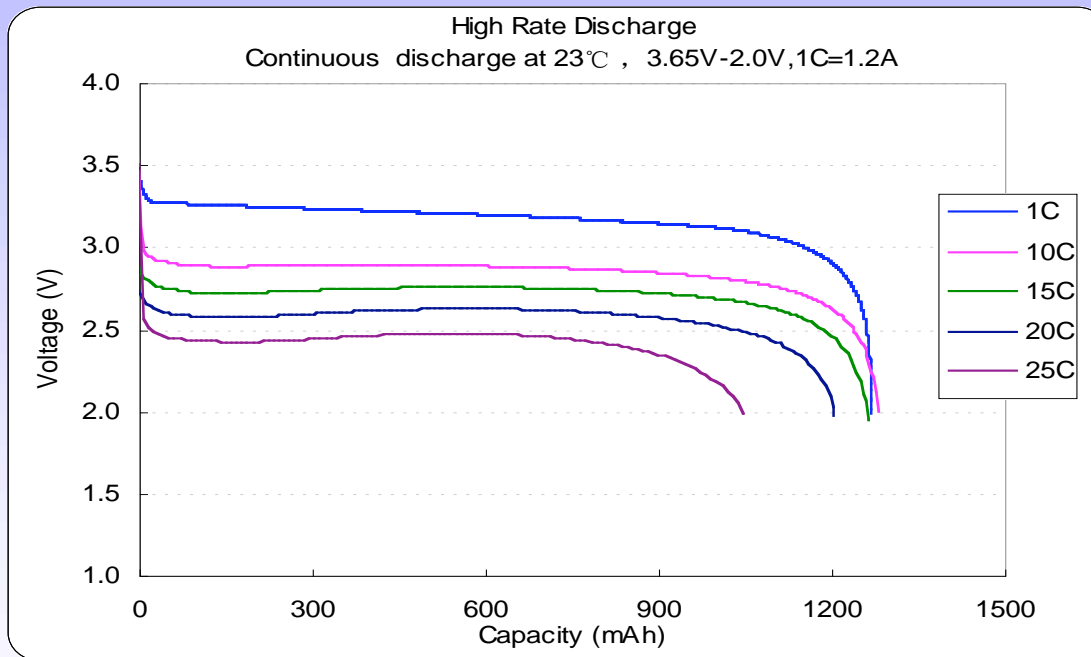


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ATL IFR18650 performance

- Continuous discharge at different rate
Charge: 1C CC to 3.65V, CV to 60mA



Rate	1C	10C	15C	20C	25C
Power (W)	3.84	34.6	49.5	62.9	73.5
Energy (Wh)	4.03	3.69	3.47	3.14	2.46



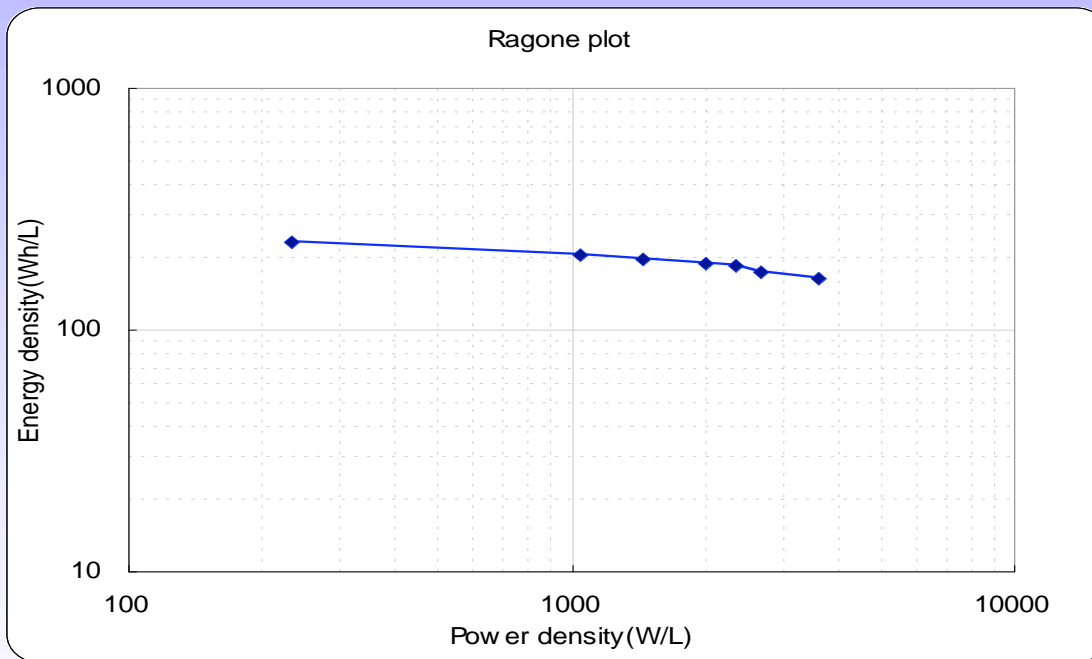
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ATL-IFR18650 performance

➤ Ragone plot



- Increase in power density hasn't led to obvious decrease in energy density.



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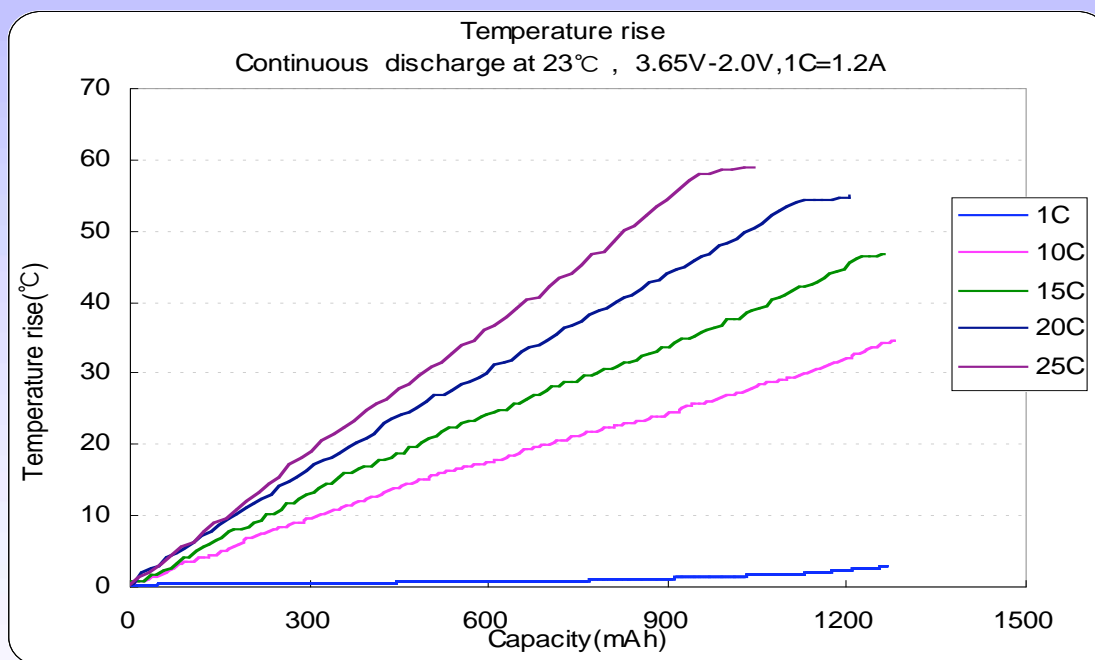
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ATL IFR18650 performance

- Temperature rise at different rate
Charge: 1C CC to 3.65V, CV to 60mA



- Temperature rise is below 60 °C even after 25C continuous discharge to 2.0V



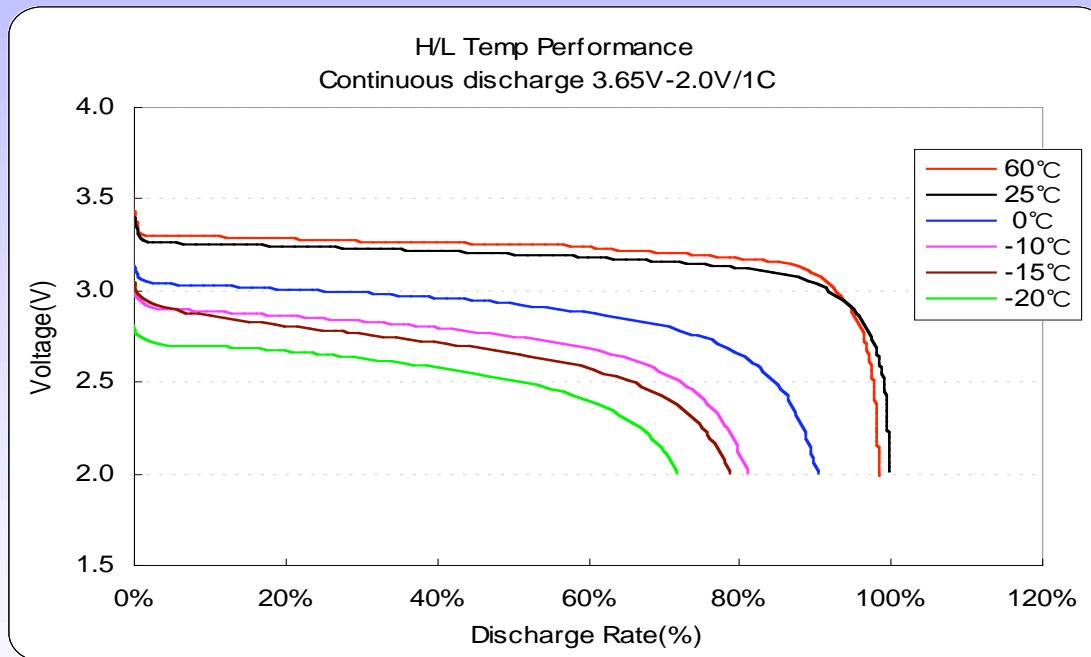
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ATL-IFR18650 performance

➤ 1C discharge at different temperature

Charge: 23°C, 1C CC to 3.65V, CV to 60mA



- 80% capacity retention even at -15°C



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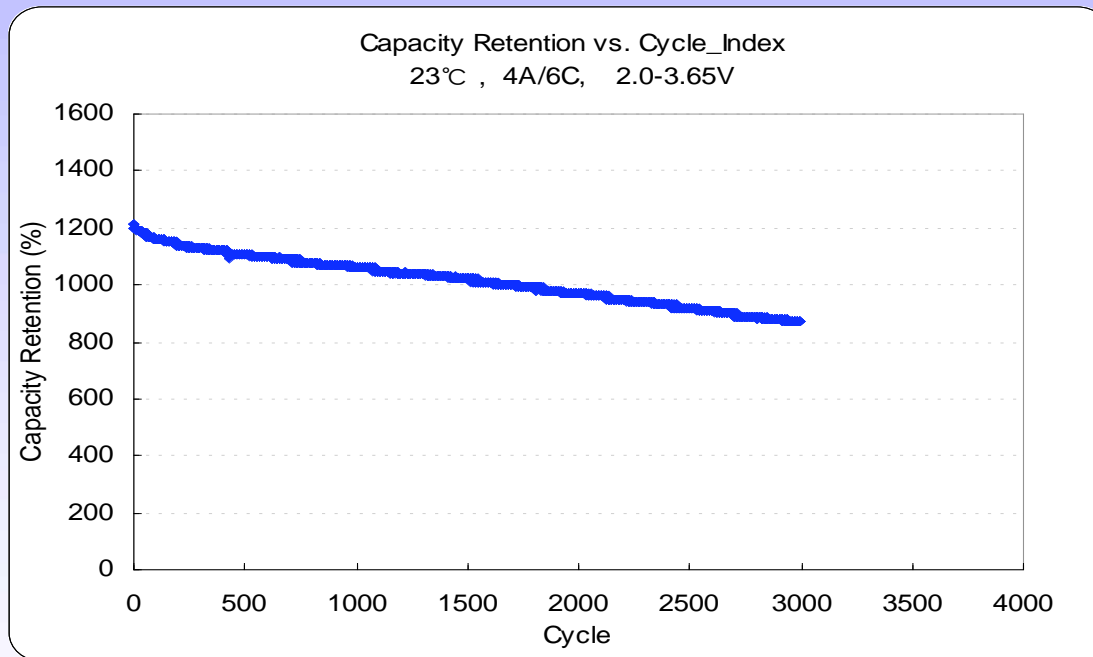
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ATL-IFR18650 performance

➤ 4A/6C cycle

Charge: 4A CC to 3.65V, CV to 60mA, Discharge: 6C to 2.0V.



- Excellent 4A/6C cycle performance



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Conclusion

- LiFePO₄ as one promising cathode material displays significant advantages of low cost, environmentally benign and reliability. The limitation of poor rate performance has been solved by carbon coating and nano-structured in Phostech P2 Powder.
- ATL IFR18650 with Phostech LiFePO₄ demonstrates excellent rate performance and reliability, which has been employed in power tools.



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