



Phostech Lithium

Innovative Material

LiFeP₄OWER

PERFORMANCE BATTERY MATERIAL

for Energy Storage

SÜD-CHEMIE
Creating Performance Technology





Phostech Lithium

"We provide innovative and premium-quality materials to make a major contribution to the battery industry"

VISION

LiFePO₄W⁴WER
PERFORMANCE BATTERY MATERIAL

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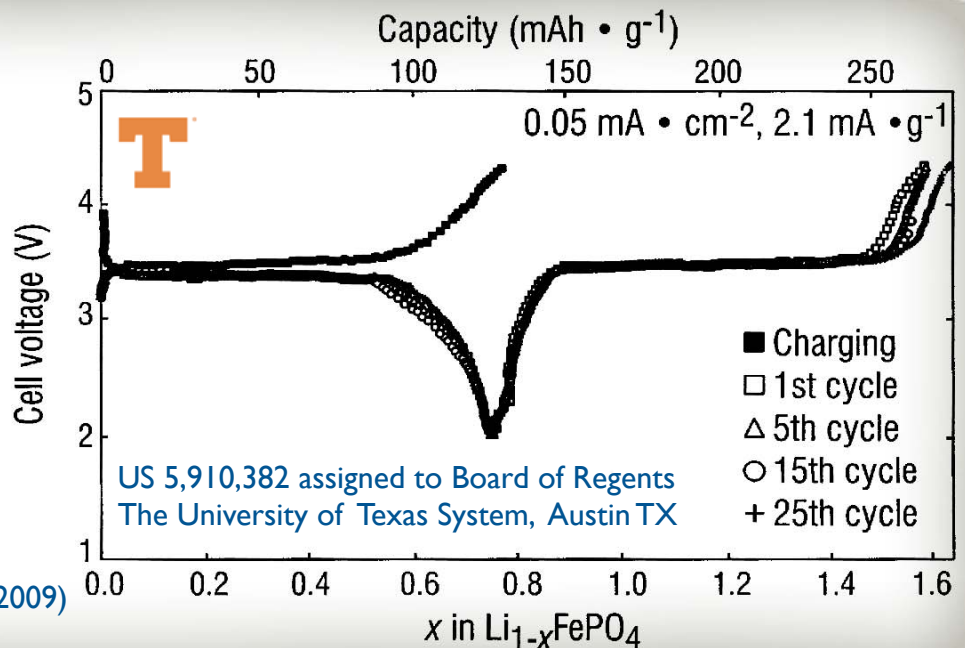




Phostech Lithium

HISTORY

- 1994:** LiCoO₂ inventor John B. Goodenough and his team discover lithium metal phosphate cathode at the University of Texas at Austin (UT)
- 1996:** John B. Goodenough and his team patent lithium metal phosphate cathode at UT
- 1997:** Hydro-Québec (HQ) obtains an exclusive license on Goodenough's invention from UT
- 1999:** UdeM's R&D on C-LiFePO₄ lead to patent co-owned (1/3:1/3:1/3) by Université de Montréal (UdeM), French CNRS and ACEP Inc. (50/50 HQ/Yuasa JV)
- 2000:** UdeM's R&D on C-LiFePO₄ processes lead to patents co-owned (1/3:1/3:1/3) by UdeM, CNRS and HQ
- 2001:** Phostech founded by UdeM researchers following obtention of rights for manufacture/sales of lithium metal phosphate for Li-ion from UT, HQ, UdeM and CNRS
- 2003:** UdeM's R&D on LiMPO₄ synthesis by a melt process lead to patent co-owned by UdeM, CNRS and Phostech
 - Süd-Chemie independent R&D program on LiFePO₄ cathode in Germany (Moosburg R&D center)
- 2004:** Süd-Chemie patents wet-process for LiFePO₄
 - Phostech Lithium starts commercial operation for solid state process in Québec
 - Süd-Chemie starts pilot operation for wet-process in Germany
 - Süd-Chemie initiates relationship with Phostech Lithium
- 2005:** Süd-Chemie initial investment into Phostech Lithium
- 2008:** Phostech Lithium 100% owned subsidiary of Süd-Chemie



Dr. John Bannister Goodenough
 Lithium Metal Phosphate cathode inventor
 Japan Prize (2001) for his works on batteries
 U.S. Presidential Enrico Fermi award winner (2009)
 Professor at the University of Texas at Austin



LiFePO₄ characteristics

1. Thermal stability

- LiFePO₄ is made of a skeleton of PO₄ polyanions that is very stable thermally while favorable to one dimensional Li⁺ ion reversible diffusion
- Covalent P-O bond stabilize the oxide when fully charged and avoid O₂ release making LiFePO₄ the most stable commercial cathode material
- LiFePO₄ stability and tolerance to overcharge make possible cost reduction associated to external safety devices

2. Good electrochemical characteristics

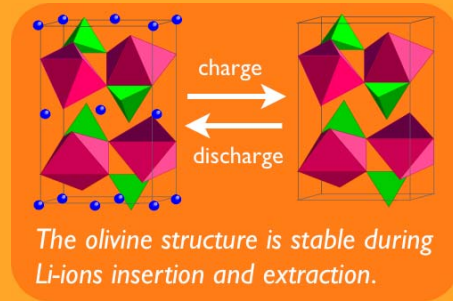
- Long calendar life for the stable olivine structure
- High tolerance to high and low-voltage abuse
- Lower thickness change of full cell during charge/discharge

3. Abundant resource of basic elements

- Fe and P are common components

4. Environmentally friendly

- No toxic elements



Why C-LiFePO₄ ?

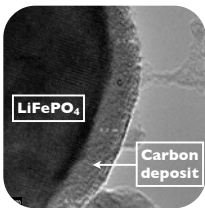
Some physical parameters of cathode materials

Cathode	Electric Conductivity	Solid diffusion coefficient
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 coefficient and electron conductivity, are major problems before it can be applied in power cell

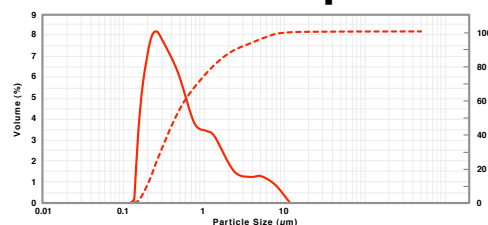
How to improve conductivity and rate performance ?

Pyrolytic carbon deposit !



Ravet et al. invented in 1998 the use of a conductive pyrolytic carbon nano-deposit on LiFePO₄ (US 6,855,273, US 6,962,666 & US 7,344,659)

Submicron-sized particles !



Life Power® C-LiFePO₄





Phostech Lithium

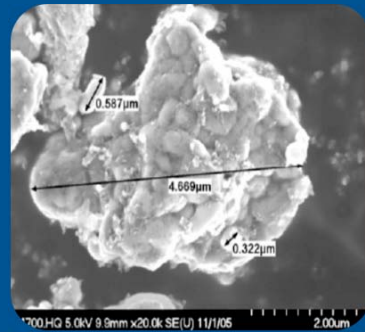
ENERGY

Life Power® PI grade is micro-aggregates C-LiFePO₄ manufactured by solid-state process and designed for cathode formulation in the production of energy lithium batteries

Life Power® PI is ideally suited for lithium batteries used in consumer batteries, as replacement of VRLA batteries, in e-bike, e-scooter, small mobility, UPS, EV's, ...

Technical Information:

- convenient coating processability
- specific electrochemical capacity of ca. 140 mAh/g
- carbon content : 1 to 2 wt.%
- average particle size (D₅₀) : 2 to 4 µm
- surface area (BET) : 10 to 15 m²/g
- water content < 1000 ppm



For More Information:

- info@sud-chemie.com

Life Power® PI

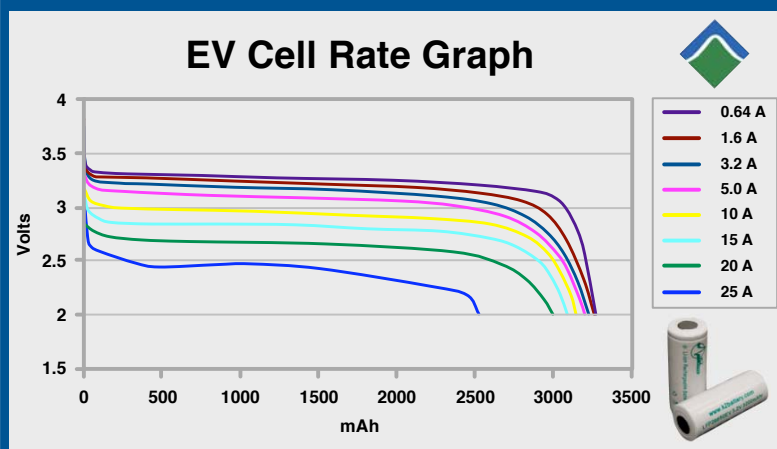
K2 Energy Solutions LFP300ES (90Ah)

300 A continuous and up to 700+ amp pulses



K2 Energy Solutions LFP26650EV

3,200 mAh designed for EV's applications



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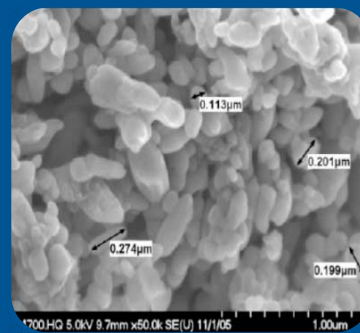
POWER

Life Power® P2 grade is submicron C-LiFePO₄ manufactured by advanced wet-process and designed for cathode formulation in the production of power lithium batteries

Life Power® P2 is ideally suited for lithium batteries used in power tools, SLI batteries, HEV's, PHEV's, EV's, large storage batteries, defence applications, ...

Technical Information:

- specific electrochemical capacity of ca. 150 mAh/g
- carbon content : 2 to 3 wt.%
- nano-sized primary particles
- average particle size (D₅₀) : 0.5 to 1 µm
- surface area (BET) : 12 to 18 m²/g
- water content < 1000 ppm



For More Information:

- info@sud-chemie.com

Life Power® P2

SAFT Space & Defense Division (SDD) Life Power® Lithium Ion cells



Cell	Nominal Capacity	Discharge Power (kW/kg)			Specific Energy (Wh/kg)
		200 ms	2 sec	Continuous	
VL10VFe	10 Ah	7.2	5.5	5	55
VL25PFe	25 Ah	4.6	4.4	3.2	85
VL45EFe	44 Ah	/	/	0.17	156



SAFT Space & Defense Division is the U.S.'s largest supplier of Li-ion batteries for space and for hybrid electric military vehicles.

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ITRI & ExtraEnergy PHET® e-bike battery pack crush test (10 Tons)

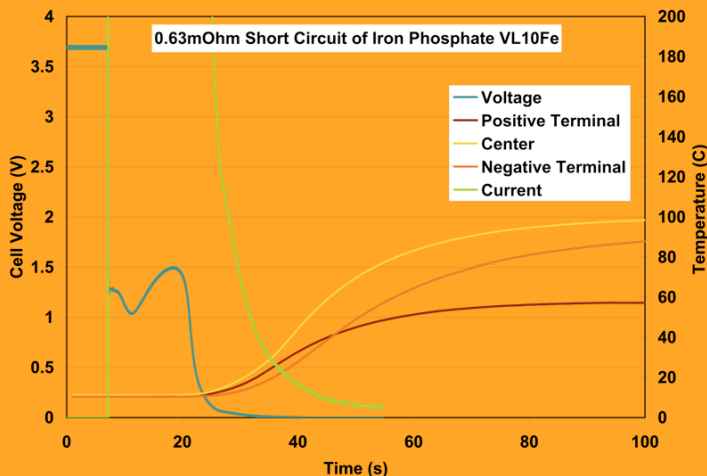
Safety level A (intrinsic pack safety)

Superb { Temperature performance
Over-voltage behavior
Over-charge behavior



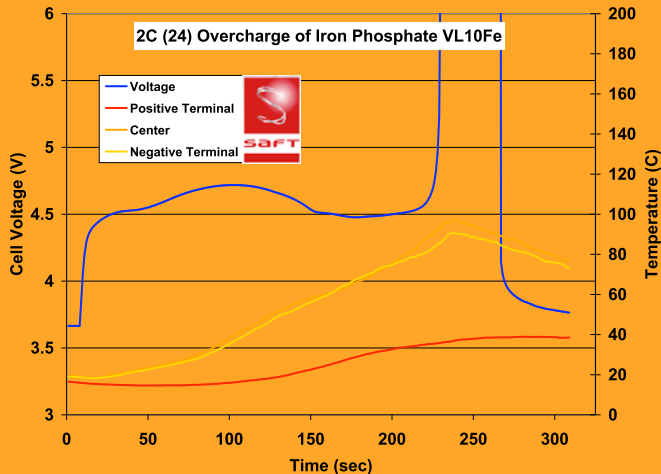
SAFETY

Short Circuit



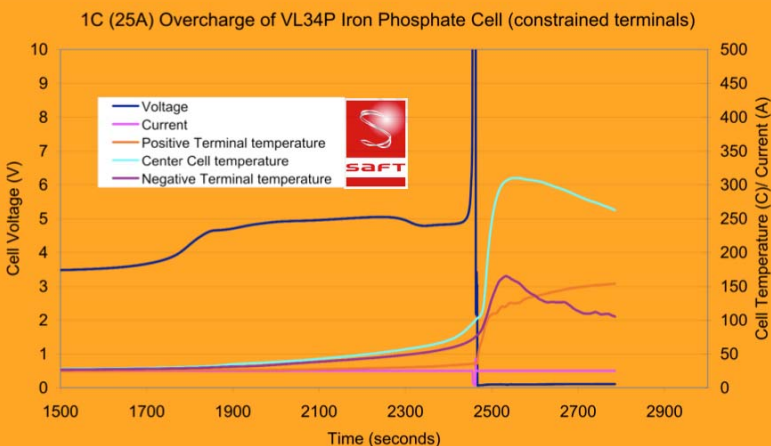
« No Event, T < 100°C »

Overcharge



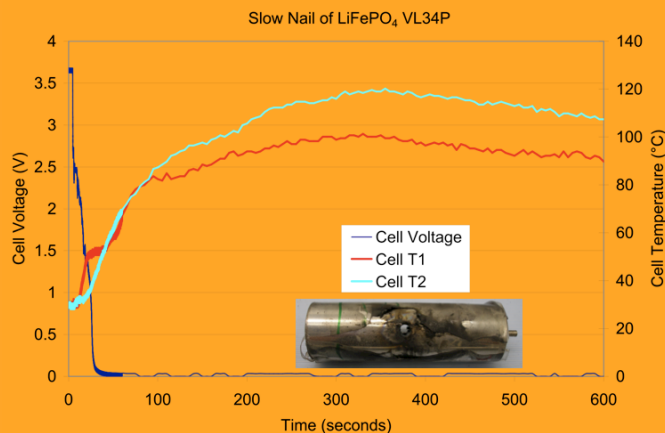
« Vent with No Smoke & No Fire, T < 100°C »

Overcharge



« Smoke, No Flame, Max Temp 310°C »

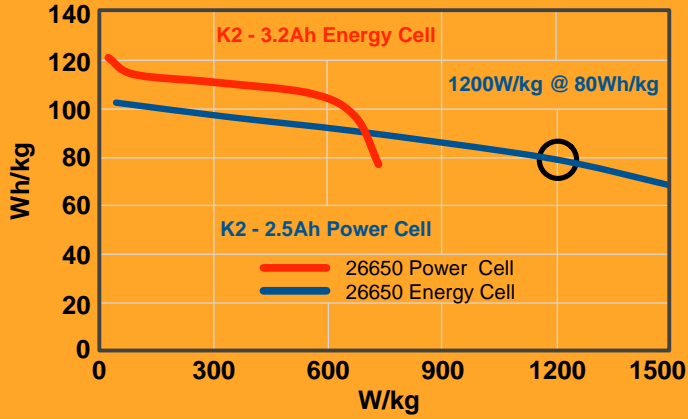
Slow Nail



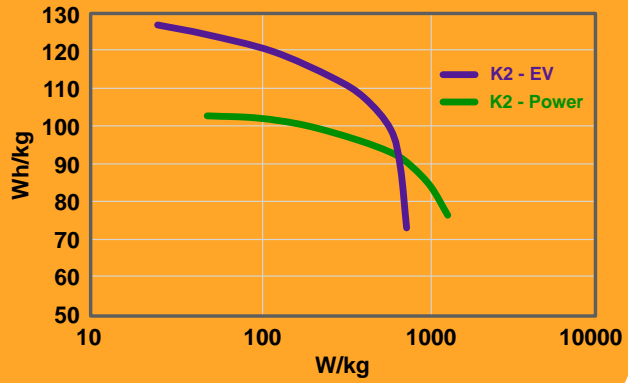
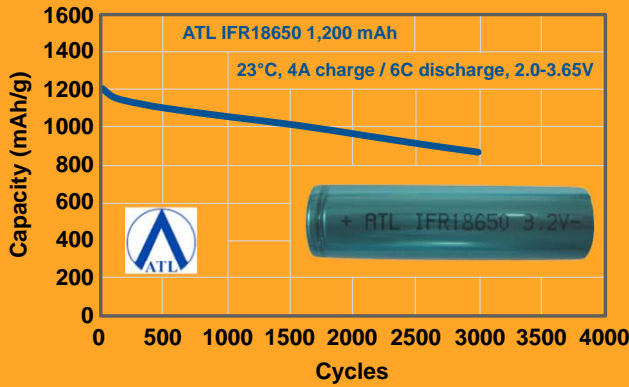
« Smoke, No Flame, Max Temp 120°C »



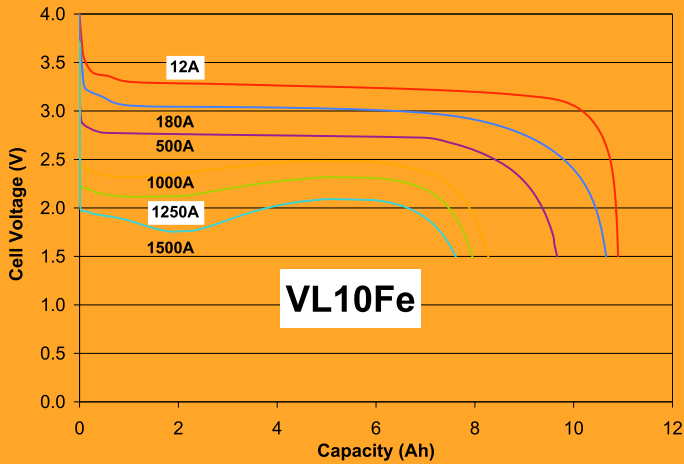
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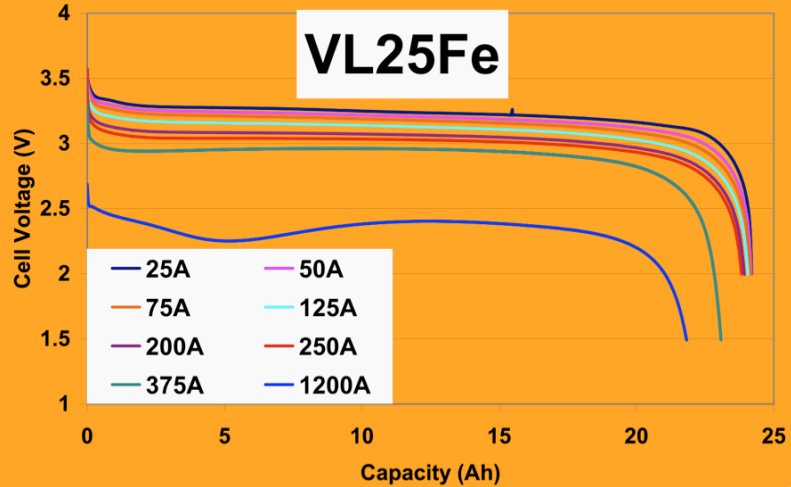
Life Powered



VL10Fe - 10 Ah Very High Power



VL25Fe - 25 Ah Medium Energy / Medium Power



© Microcar

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Life Power® "Material" IP

United States Patent



Canadian
Intellectual Property
Office



Core 1: LiFePO₄ (HQ/UT)

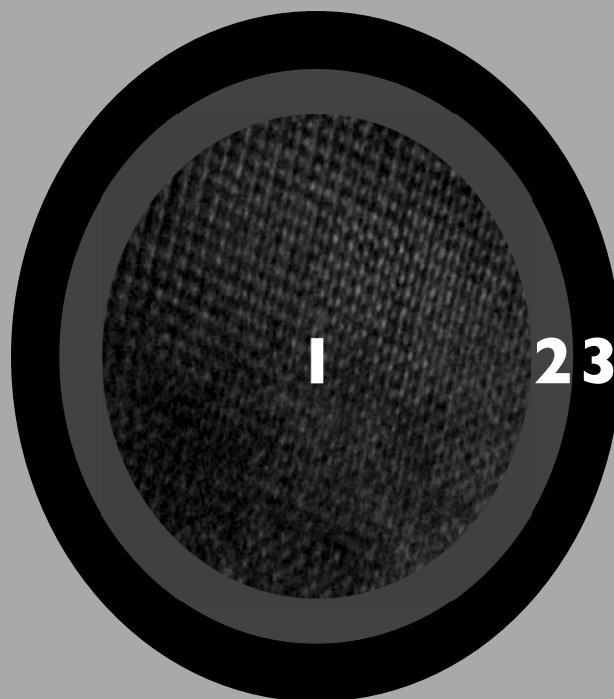
US 5,910,382 CI US 6,514,640 CI
CA 2,251,709 EP 0904607

**Core 2: Carbon deposit 1
(UdeM, CNRS, ACEP co-ownership)**

US 6,962,666 US 7,344,659
EP 1049182 EP 1796189
CA 2,307,119
+ JP examination

**Core 3: Carbon deposit 2
(UdeM, CNRS, HQ co-ownership)**

US 7,457,018
KR 100879839
CN 100421289
+ JP, EP and CA examination



LiFeP₄OWER

PERFORMANCE BATTERY MATERIAL
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"Multicore" Material IP

Worldwide Customers



LiFeP₄OWER

PERFORMANCE BATTERY MATERIAL
PERFORMANCE BATTERY MATERIAL

*Life Power® C-LiFePO₄
is used and evaluated by numerous companies*

Worldwide Customer Service

Worldwide / North America

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E-mail: research@sud-chemie.com

LiFePO₄ POWER
PERFORMANCE BATTERY MATERIAL

To best serve our customers



Phostech Lithium

Süd-Chemie invests 60 M€ to establish a 2,500 t/year Life Power® facility in Québec !

Commercial production will start in 2012



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