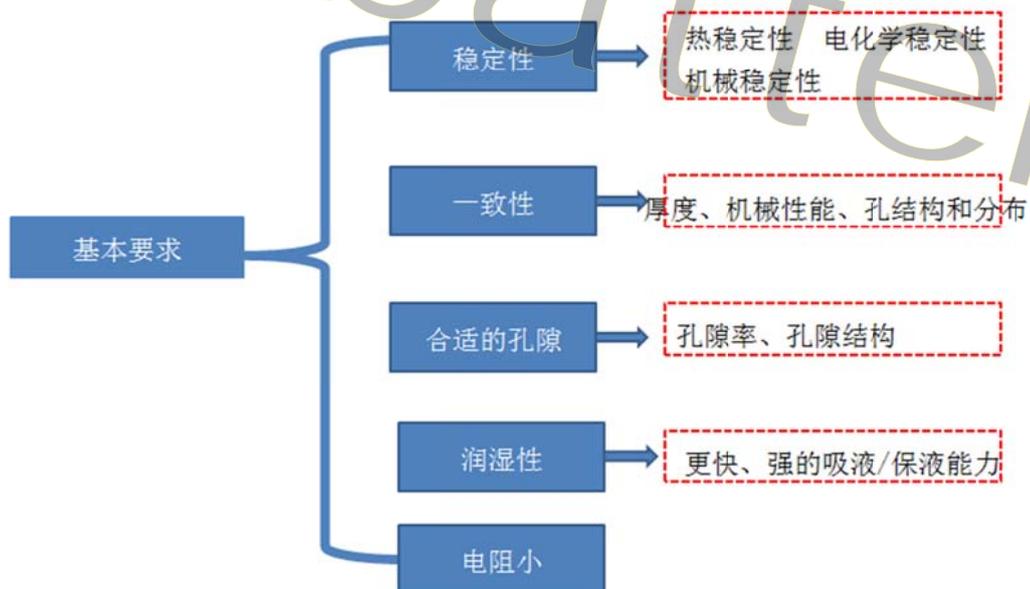


锂离子动力电池用新材质 隔膜发展应用及评测

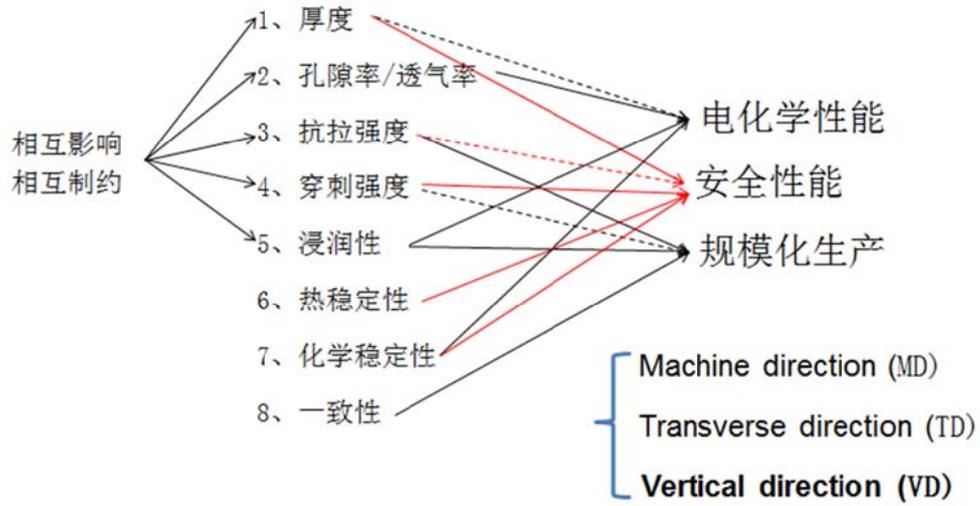


第三届新型电池隔膜材料与电解质技术国际论坛
天津力神电池股份有限公司
力神动力电池系统有限公司

动力电池隔膜



隔膜性能指标对锂电池性能影响



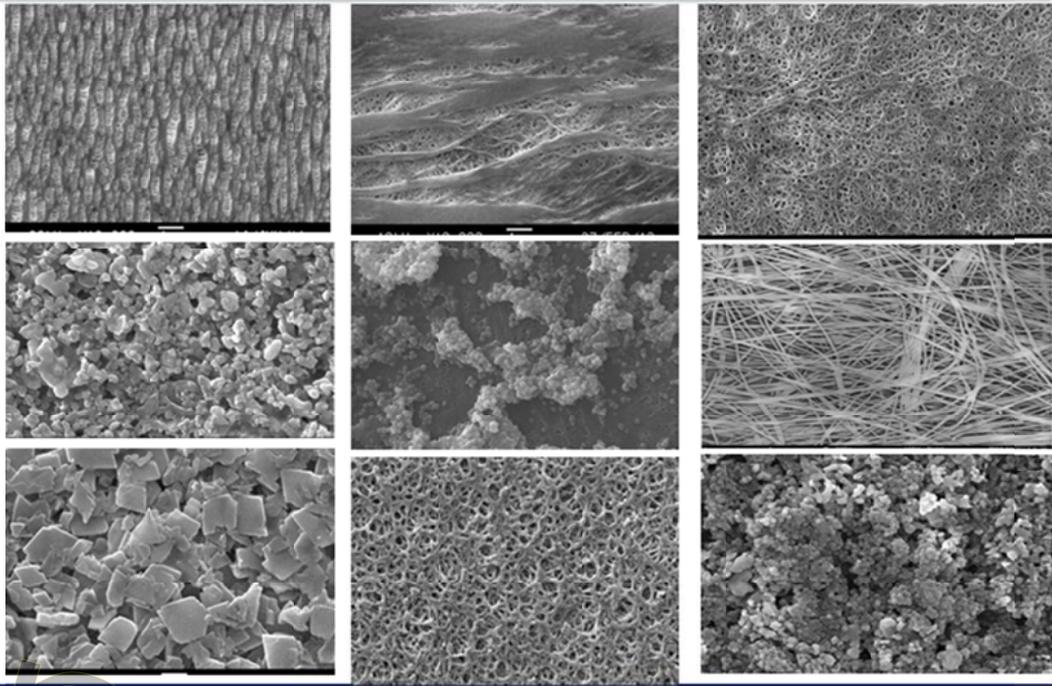
2

隔膜分类



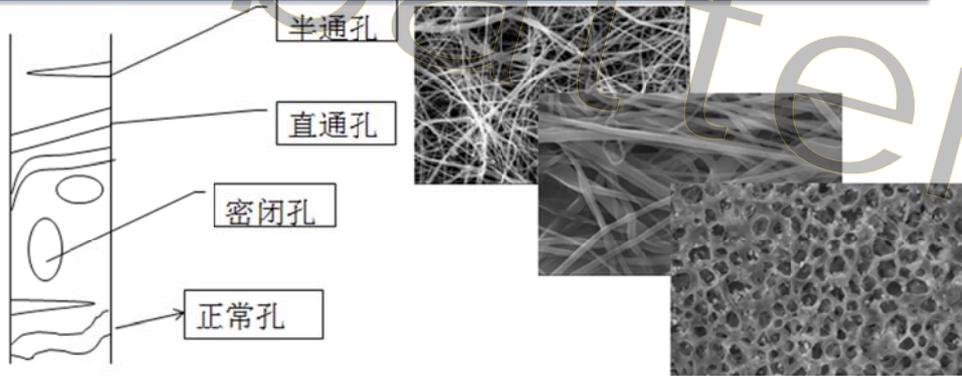
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聚烯烃隔膜和各种涂层隔膜、新材质隔膜



4

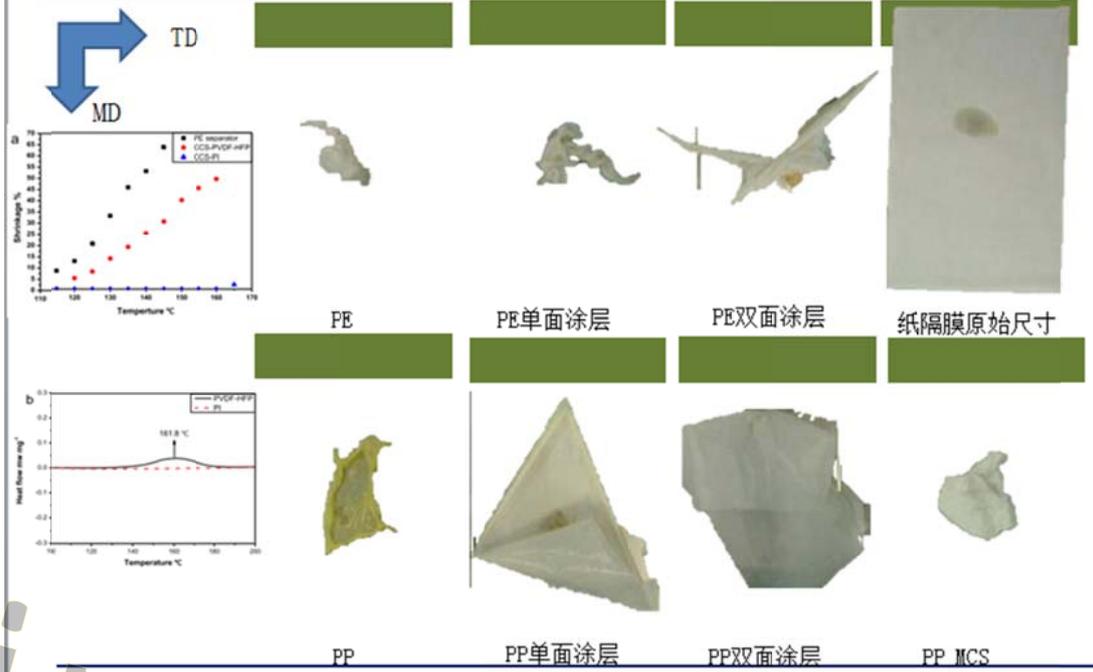
部分指标差异大，对生产工艺的挑战



材质	抗拉强度 kaf/cm ²		空气渗透性 sec/100cc	穿刺强度gf
PP	>1100	>100	380±100	>350
PE	>850	>800	270±100	>480
PP/PE/PP	>700	>70	509~778	>380
纤维素涂层	287	114	极低	>75
无纺布涂层	307	8.1	40	103

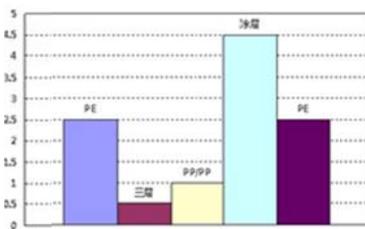
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180度10分钟热收缩



6

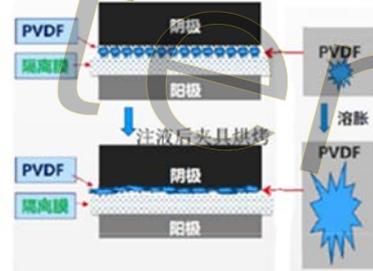
涂层隔膜性能优势



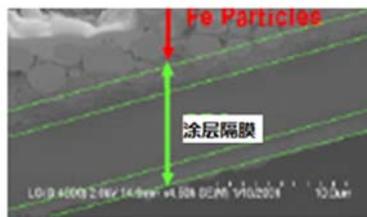
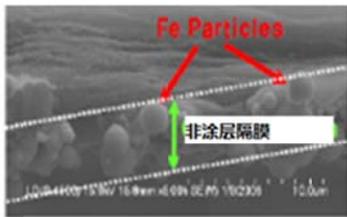
均有较高的吸液/保液特性



提高抗氧化性



抑制极组形变



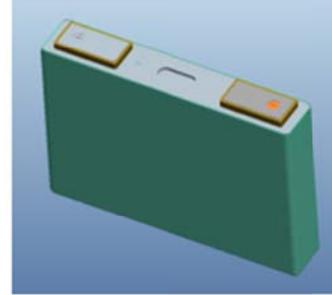
抵抗正极杂质金属析出刺穿隔膜;

改善极片边缘拉丝现象;

7

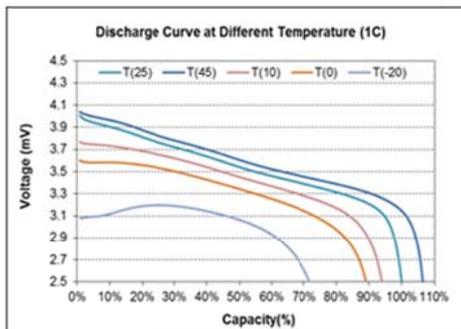
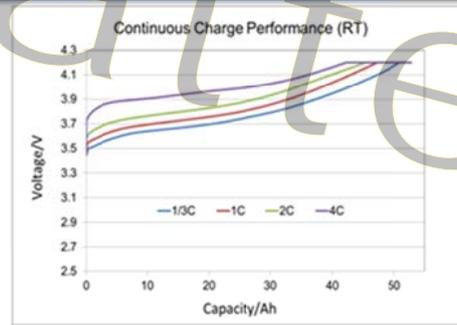
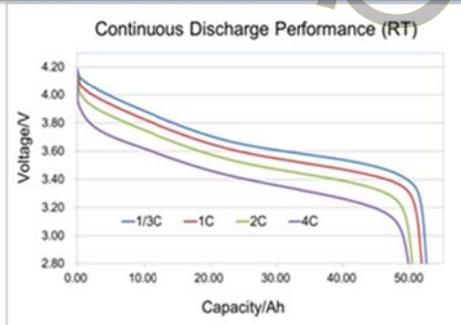
PET隔膜开发应用

	Item	Actual Value
1	Nominal Capacity (1C)	51.68Ah
2	Energy (1C)	187Wh
3	Energy Density (1C)	215.6Wh/kg
4	ACIR (100%SOC)	0.692m Ω
5	DCIR (50%SOC, 6C, 10s)	1.48m Ω
6	Weight	867g
7	Thickness	26.73mm
8	Continuous charge	3C
9	Max Pulse charge	4C(30s)
10	Continuous discharge	4C
11	Max Pulse discharge	6C(30s)



8

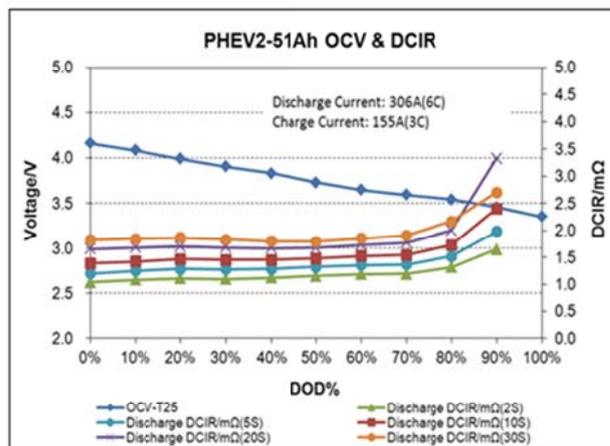
PET隔膜开发应用—倍率和温度性能



Items	Voltage platform/V	Capacity/Ah	Cv/C(T25)
T(25)	3.54	50.26	100.00%
T(45)	3.58	53.50	106.45%
T(10)	3.48	47.24	93.99%
T(0)	3.39	44.78	89.10%
T(-20)	3.21	36.11	71.85%

9

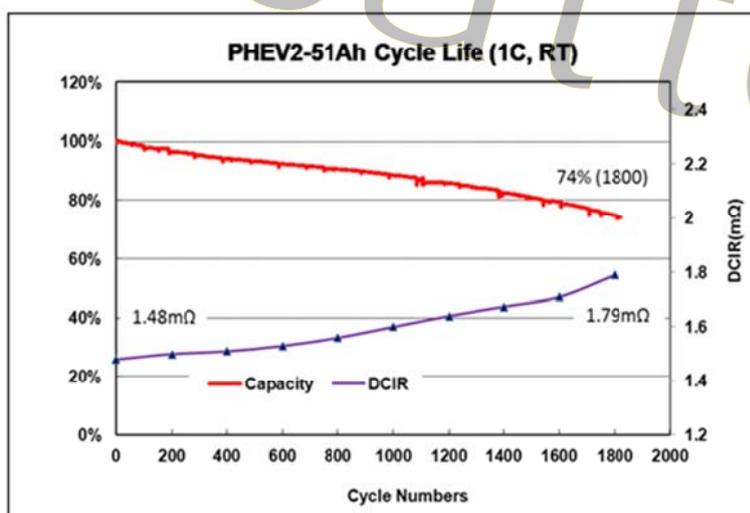
PET隔膜开发应用—DCIR



DOD%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
OCV/V	4.162	4.083	3.990	3.904	3.831	3.728	3.648	3.593	3.541	3.456
Discharge DCIR/mΩ(2S)	1.034	1.08	1.108	1.097	1.119	1.155	1.183	1.192	1.318	1.648
Discharge DCIR/mΩ(5S)	1.197	1.247	1.282	1.273	1.284	1.324	1.355	1.37	1.518	1.977
Discharge DCIR/mΩ(10S)	1.388	1.42	1.465	1.454	1.454	1.48	1.522	1.542	1.724	2.398
Discharge DCIR/mΩ(20S)	1.65	1.677	1.698	1.678	1.665	1.672	1.731	1.77	1.997	3.321
Discharge DCIR/mΩ(30S)	1.819	1.843	1.861	1.83	1.799	1.792	1.85	1.907	2.169	2.717

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PET隔膜开发应用—循环性能



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PET隔膜开发应用—安全性能

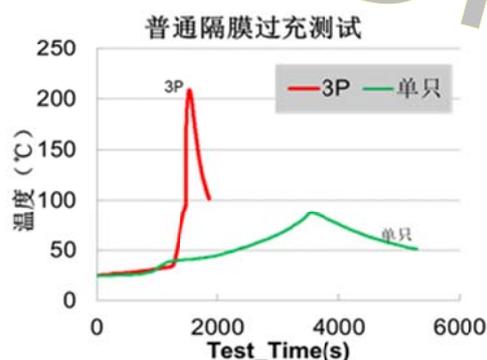
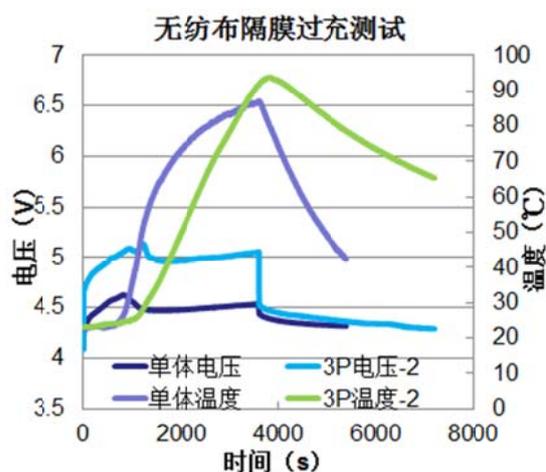
项目	Test Criteria (GB/T 31486-2015)	Requirements	Outcome
Short-circuit	External resistance $\leq 5\text{m}\Omega$ Stay 10 minutes	EUCAR \leq Level 4	Level 2
Over discharge	1C discharge 1.5h	EUCAR \leq Level 4	Level 3
Thermal stability	$(130 \pm 2)^\circ\text{C}$, 30min	EUCAR \leq Level 4	Level 3
Overcharge	Charge at 1C(A) to 8.4V or 200%SOC	EUCAR \leq Level 4	Level 2
Nail penetration	Nail: $\Phi 3\text{-}8\text{mm}$, speed: 10-40mm/s, Penetrate through the center	EUCAR \leq Level 4	Level 5

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涂胶隔膜的性能—安全性能差异

因PET涂层隔膜的耐高温特性，使用该隔膜的电池单体及3P模块的过充测试都可以通过。

而同一款电池使用另两种涂层隔膜的单体过充可以通过，但3P模块却不能通过。温度比PET涂层隔膜高很多。



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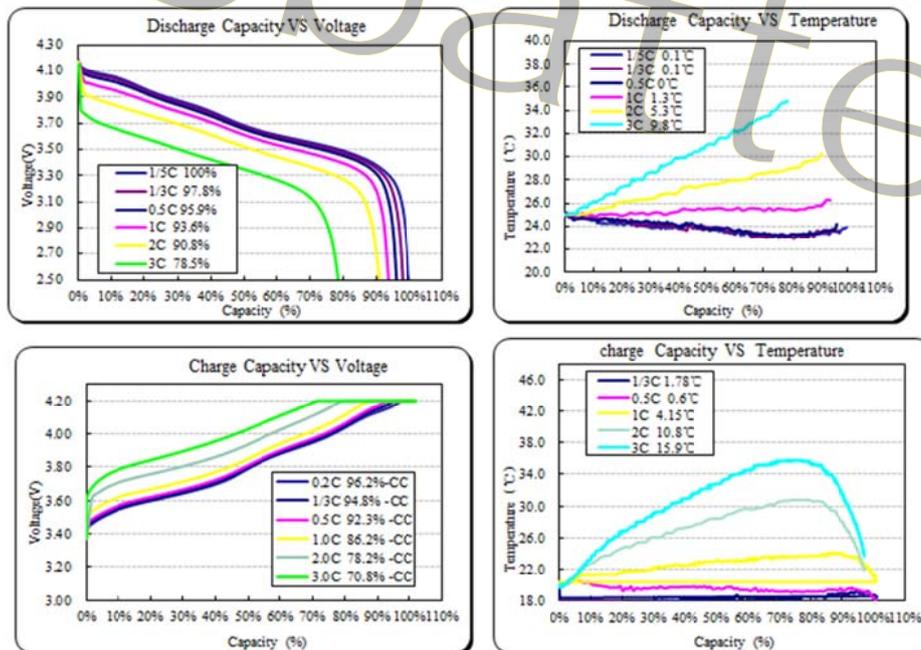
PET隔膜开发应用—240Wh/kg软包电池

No	Item	Spec
1	Capacity★	≥42Ah
2	Energy	≥153Wh
3	Weight★	~640g
4	DC-IR★(50%SOC, 10s)	≤1.8mΩ
5	Max Charge Current★	2C (30s)
		1C (Continuous)
6	Max Discharge Current★	3C (30s)
		2C (Continuous)
7	Specific energy	240Wh/kg
8	Specific power	800W/kg
9	Cycle(1C, 100%DOD)	2000@80%



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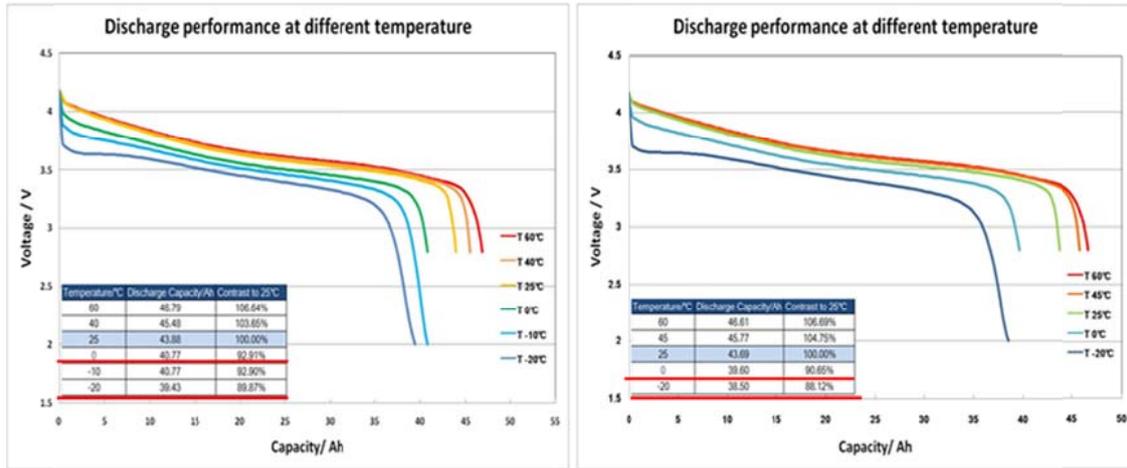
PET隔膜开发应用—240Wh/kg软包电池



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PET隔膜开发应用—低温放电容量略高

高温放电容量几乎没差异，但0℃、-20℃PET涂层隔膜放电容量比氧化物涂层隔膜高约2个百分点。



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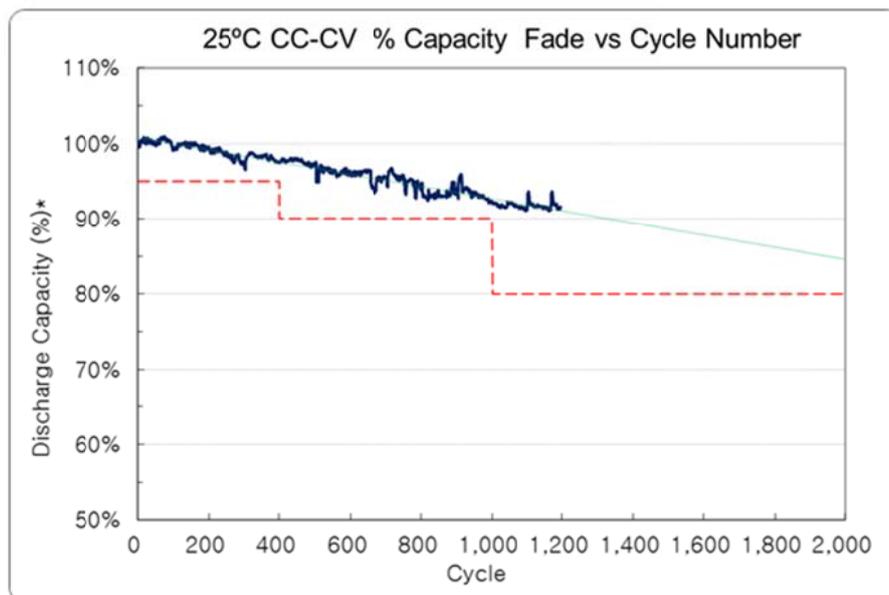
PET隔膜开发应用—高温存储略差

	IR	Residual	Recover	Residual	Recover
	/ mΩ	Cap./%	Cap./%	Ene./%	Ene./%
Initial	0.62				
final	0.623	94.01%	99.43%	92.54%	99.07%
Δ	0.003				
Initial	0.703				
final	0.677	91.62%	97.61%	90.64%	97.49%
Δ	-0.026				

Storage Time: 7d Storage Temp: 60°C

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PET隔膜开发应用—240Wh/kg软包电池



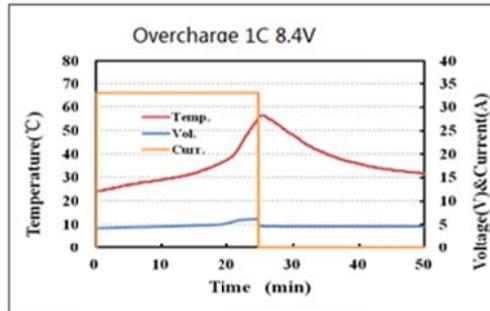
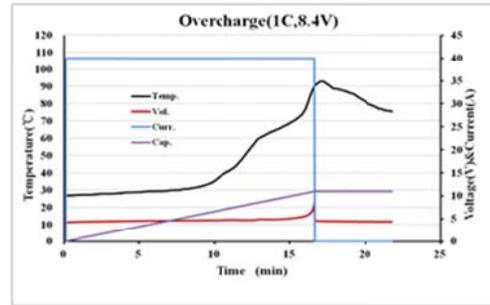
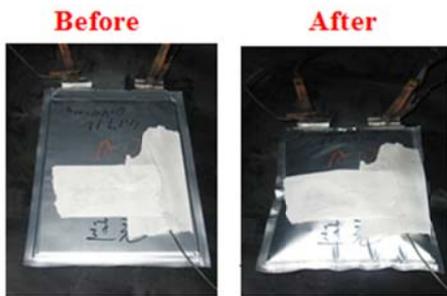
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PET隔膜开发应用—240Wh/kg安全性能

Item	Standard	PE CS	PET CS
Overcharge	1C/8.4V	PASS	PASS
Overdischarge	1C/0V	PASS	PASS
Short-circuit	External resistance $\leq 5m\Omega$	PASS	PASS
Thermal Stability	150°C/30min	Failed	PASS
Crush	50% Dimension	PASS	PASS
Nail	3-8mm, 10-40mm/min	Failed	PASS

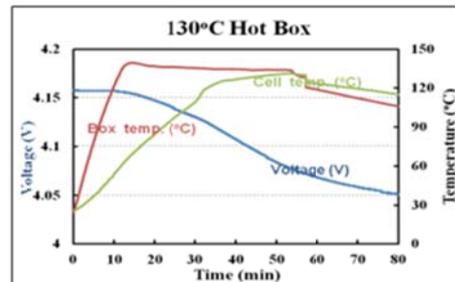
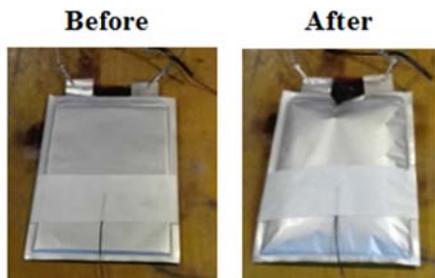
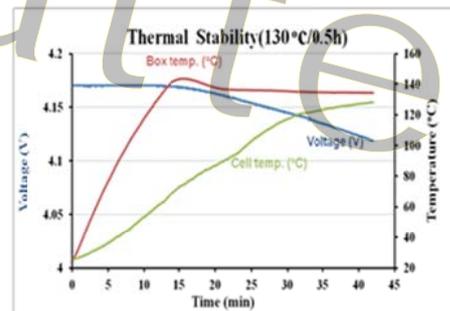
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PET隔膜开发应用—过充



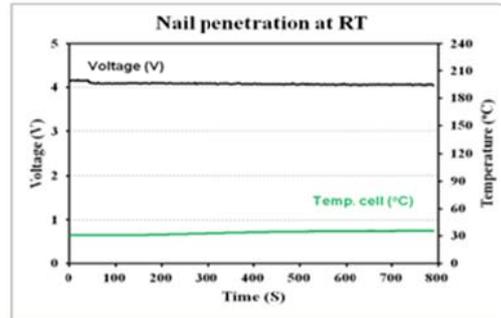
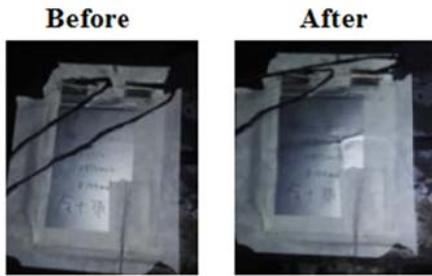
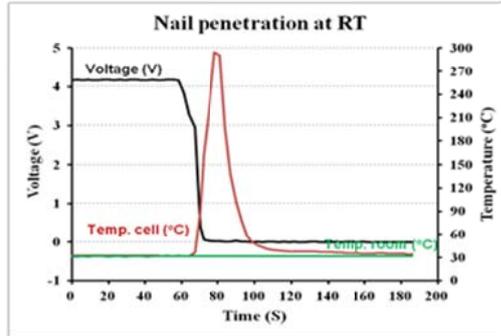
20

PET隔膜开发应用—热箱



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PET隔膜开发应用—针刺



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油性混涂隔膜优势

油性混涂隔膜优势:

- 1、相比于水性混涂隔膜，油性隔膜更易粘接，且粘结力更高；
- 2、能有效抑制循环过程中极组变形与膨胀；

样品编号	A		B		C		D			
涂覆类型	Mg(OH) ₂ +PVDF		Mg(OH) ₂ +PVDF		Mg(OH) ₂ +PVDF		Al ₂ O ₃ +PVDF			
总厚度	1.5+6+1.5		1+5.5+1		1.5+6+1.5		1.5+5.5+1.5			
规格	实际厚度 um	基重 (g/m ²)	Gurley (s/10)	针刺 (gf)	拉伸强度 (kgf/cm ²)		延伸率 (%)		热收缩 (105°C 1h) %	
6+1.5+1.5	6.94	5.3	196	263	1292	1066	41	110	6	-1.06
6+1.5+1.5	7.46	5.4	127	276	1080	1247	95	111	8	1.06
6+1.5+1.5	6.96	4.9	115	273	1201	1317	60	77	8	0.53
5.5+1.5+1.5	8	8	175	316	1095	1218	87	126	6	2

安全测试	短路	冲击	150度热箱
A	OK	OK	NG
B	OK	OK	OK
C	OK	OK	NG
D	OK	OK	NG

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PET隔膜规模化应用会遇到的问题

优势明显：

高的机械稳定性、热稳定性和电化学稳定性；

高孔隙，容易做好一致性；

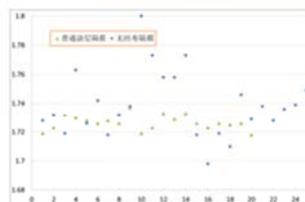
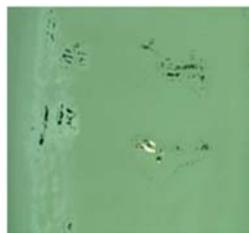
吸液保液性好；

1、较低的机械强度和脆弱的涂层粘结性—> 卷绕设备

2、较大的孔径和高的孔隙率—> 生产工艺

3、过程短路电池的筛选—> 质量控制

4、太贵—> 成本问题；



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总结建议

一、新材质涂层隔膜各种材料本身价格不高、材料易得，不同的配比和材料有不同的物理和化学性能。尽快产业化，降低到合理的成本。

二、随着电池容量增大，安全性也越差。能量密度200wh/kg左右产品的安全性可以通过材料体系和结构改善实现。但再高能量密度的产品，隔膜对安全性并没有明显的影响，高能量密度动力电池用的高安全低成本隔膜如何开发？

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