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# NMP-Free Li-ion for Sustainable Manufacturing in Silent-Watch Applications

Samuel L. Esarey\*, Austin Kizzie, Christopher Woodley, Ian Matts, Stuart Hellring, Zhilian Zhou, & Gina Terrago



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# 6T specifications & PPG goals



Test	Description	Pass/Fail Criteria
Cold Crank, -18 °C	Charge 4.2 V, Discharge @ 12C 30 seconds	<i>V</i> <sub>cell</sub> ≥ 2.06 V
Cold Crank, -40 °C	Charge 4.2 V, Discharge @ 4C 30 seconds	<i>V</i> <sub>cell</sub> ≥ 2.06 V
Cycle Life, 38 °C	Charge/Discharge 1C/1C x 1000	≥80% capacity retention
Cycle Life, 50 °C	Charge/Discharge 1C/1C x 500	≥80% capacity retention
Elevated Temperature Storage Test, 60 °C	Charge 4.2 V, Store 60 °C for 28 days, monitor V weekly	V <sub>cell</sub> ≥ 3.8 V

<u>Project Goal</u>: Develop Li-ion batteries within 6T specification using NMP-Free Li-ion battery cathode binder formulation to reduce cost of cell manufacturing



### Full-cell coin & DLP cells show favorable results



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PPG's NMP-Free Binder increases high-power performance over commercial control in small formats

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# Small vs. Large Pouch Formats in Cold Crank



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- Increasing energy density increases cold crank performance
  - Likely due to internal heating from rapid discharge
- Preliminary SLP/DLP cold crank data difficult to interpret





### DLP cold crank consistent with commercial control







### **Cell parameters:**

- 90/5/5 NMC 532/Carbon Black/PPG-B7
- Cathode areal coat weight: 8.00 ± 0.02 mg cm<sup>-2</sup>
- 0.1 Ah, single-sided back-to-back
- Electrolyte, separator, balanced anode, and cell assembly provided by Navitas

### **Cycling parameters:**

- Charge: CCCV @ RT
- Discharge: 12C (-18°C), 4C (-40°C)

NMP-Free binder has promising cold-crank performance in DLP cell

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### Impact of Formulation Procedure on Power & Mobility (P&M)







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# Strong High-Voltage Stability in Elevated (P&M)

**Temperature Storage** 

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• Cells charged to 4.2 V at RT, then stored at 60 °C over 4 weeks

Cells w/ PPG cathode binder yield voltage loss within specification for high temperature storage



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# 3 Ah Cells Show Strong Power

### rformance



#### **PPG Cell parameters**

3 Ah, 8.00  $\pm$  0.02 mg cm<sup>-2</sup> cathode coat weight

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#### **Navitas Cell parameters**

3 Ah, 8.50  $\pm$  0.08 mg cm<sup>-2</sup> cathode coat weight

Large format cells comparable to historical commercial products



# Summary of Results & Conclusions

 PPG's NMP-Free cathode binder system provides <u>manufacturing benefits</u> over PVDF/NMP system with <u>similar or better performance</u> under 6T specifications.

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- Higher solids/lower solvent, NMP-free, longer pot life, faster line speeds
- DLP cell and MLP cell data consistent with 6T specifications for given formats.
- Scale up from DLP to MLP revealed similar rate performance that met many 6T specifications.
  - Cold crank data for commercial DLP cell formats known to fail when MLP cell format passes, PPG DLP data similar to commercial.
  - Lack of cell heating during discharge in DLP
- Overall expected manufacturing cost savings expected with continued scale-up.

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