Miltec UV International

UV Processing Reduces Electrode and Ceramic Coated Separator Costs

UV Curable Binder Technology to Reduce Manufacturing Cost and Improve Performance of LIB Electrodes

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Project ID # ES265

Project Overview

Timeline:

Start Date: 12/01/2015
End Date: 11/30/2017
Percent Complete: 25%

Budget:

DOE Share	$1,742,560
Cost share	$ 513,640
FY 16	$1,742,560

Barriers to Electric Vehicles addressed in this project :

1. Cost, reducing Electrode Manufacturing Costs, Safety, Energy, …
2. Performance, possible advantages

Partners:

Argonne National Laboratory
Oak Ridge National Laboratory

OAK RIDGE National Laboratory

Argonne NATIONAL LABORATORY

Relevance

Lowering Cathode Manufacturing Costs vs NMP process

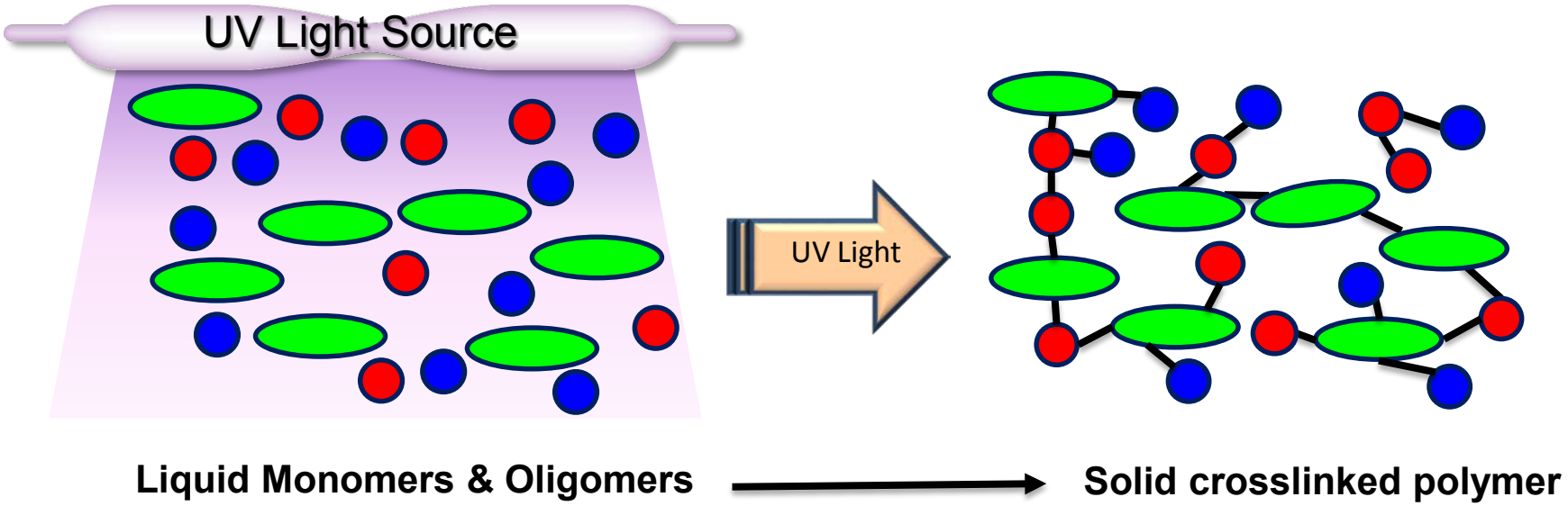
- ✓ **Miltec cost model shows manufacturing savings in capital and operations of at least 80% and likely 95%.**
- ✓ **Total electrode savings (including materials):**
  - **50% for the two single-sided layers in each cell**
  - **25% for each double-sided layer**

Proving It Can Work

- ✓ **Reduce binder (90/5/5 and 90/7/3) in hybrid type batteries**
- ✓ **Achieve reactive impedance and long term cycling equal or better than PVDF**
- ✓ **Proved fast curing (100 m/min) with power cathodes**
- **Demonstrate faster coating technology**
- **Demonstrate layered coating and thicker curing capability for high energy electrodes**

Milestones	Planned Completion	Status
Budget Period 1		
Project Management Plan	12/31/2015	Complete
Confirm binders and coating procedures and testing protocols	12/31/2015	Complete
UV curable Binder Formulation with improved AC Impedance	06/15/2016	Ahead
Complete integration and installation of print coating equipment.	07/24/2016	Ahead
Complete Test to confirm lower AC Impedance and acceptable long term capacity. (Go-No Go)	12/31/2016	
Budget Period 2		
Demonstration of two-sided electrode coating complete	03/31/2017	
Coating on coated cathode evaluation complete	06/30/2017	
Long term cycling evaluation complete	09/30/2017	
Multilayer pouch cell performance evaluation complete	11/30/017	

UV Curing Replaces Polymer Drying



UV Light instantly polymerizes photoreactive mixture into a solid plastic.

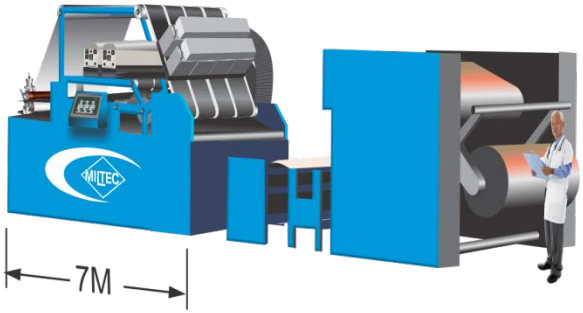
Coating is fully cured and ready to use or test immediately after light exposure.

UV vs Conventional

Conventional Solvent Drying

- Instant UV curing reduces space, capital, and operating costs
- One two-side UV system @ 60 m/m has output of four conventional coating lines @ 30 m/m

UV Curing



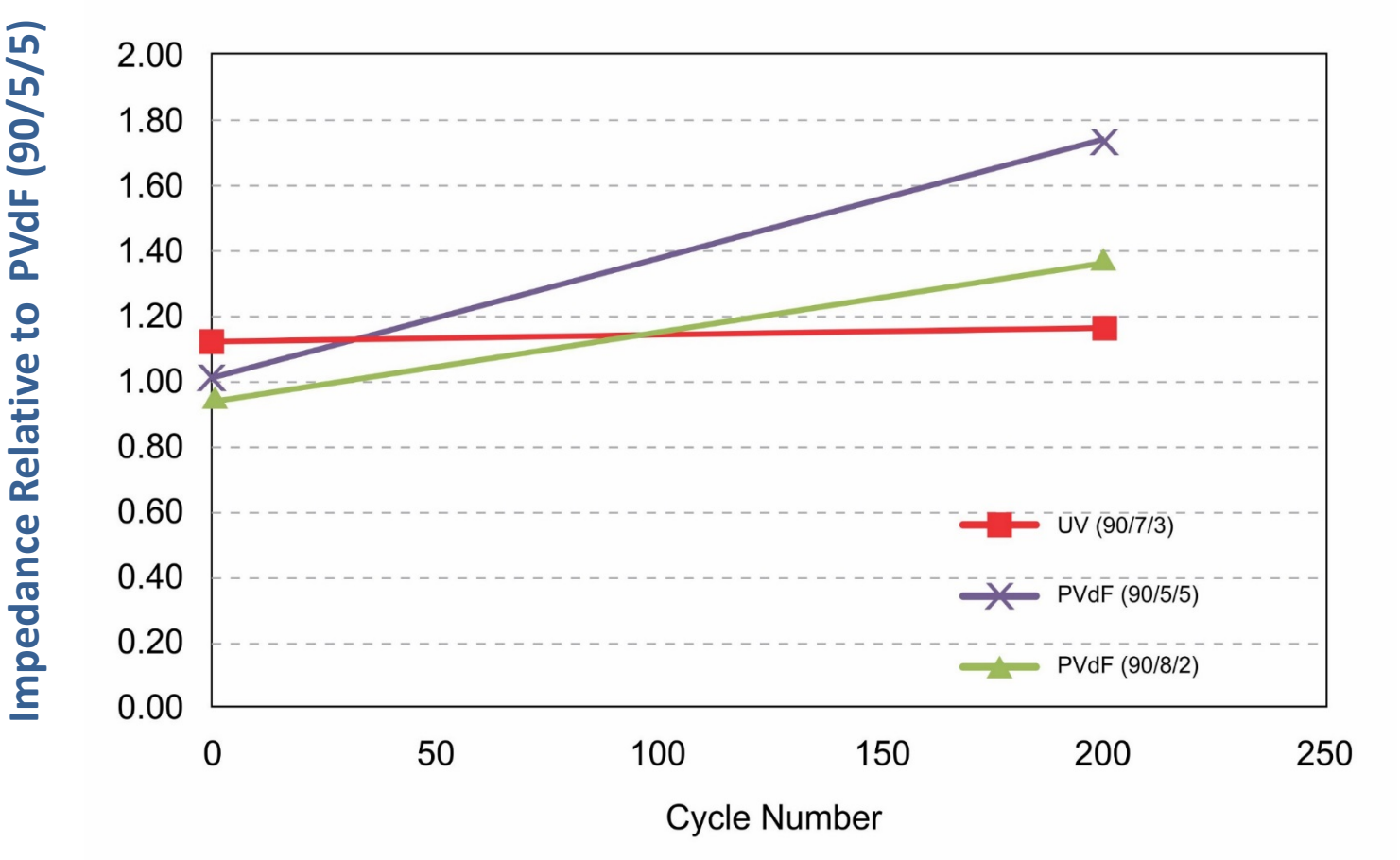
Miltec's UV Electrode Coating Process is smaller, simpler, and can reduce manufacturing expenses by 80%

Approach & Strategy

UV cathode coatings have cured up to 100 m/min

Now focus shifts to see if slot die or printing technologies can equal these speeds as well as the use of thicker layered coatings and superior double-sided coating processes

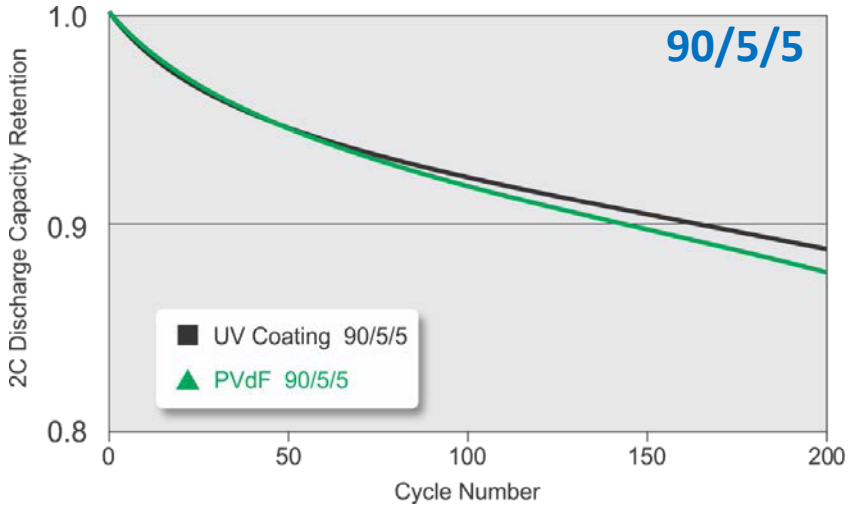
More stable low temperature impedance with UV NMC Cathode (90/7/3) than PVDF (90/5/5 and 90/8/2)

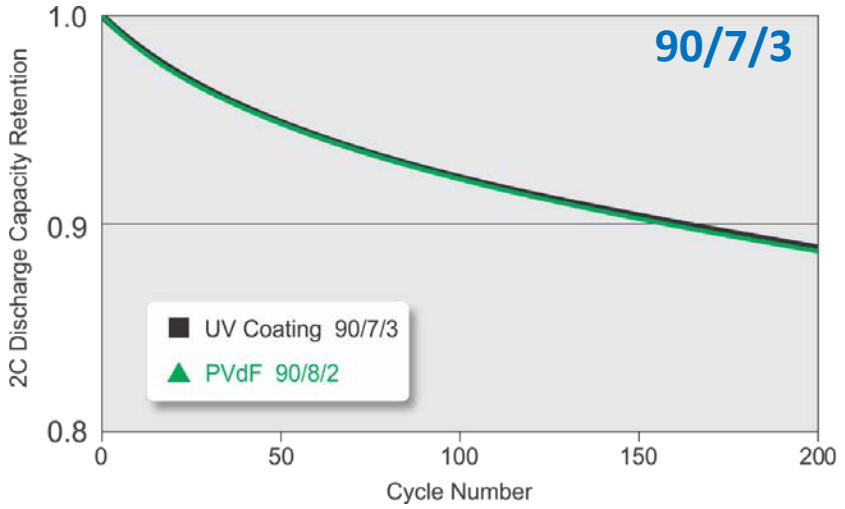


Pouch Cell AC Impedance @-10°C

5.8 mg/cm2, 25 µm thick, NMC 111, carbon, UV binder

UV Cathodes Have Equivalent Accelerated 60°C Cycling Performance as PVDF Cathodes with Similar Loading in Single Layer Pouch Cells





Partners & Collaboration

Testing and analysis of UV cured cathodes in pouch cells and compare performance to PVDF baseline

Dr. Khalil Amine, ANL

Coating and testing of multilayered UV cathode with goals of higher energy density and higher voltage cells

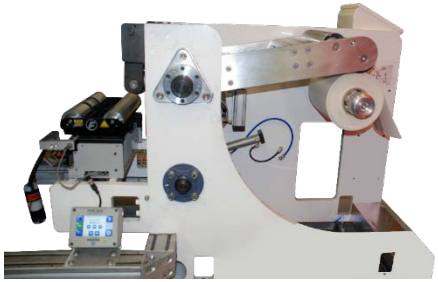
Dr. David Wood, ORNL

Remaining Challenges Future Work

- ✓ **Major challenges of capacity, impedance, and long term cycling have been overcome**

- **Focus now shifts to installation and operation of high speed coating with slot die and printer technology to demonstrate high speed coating and curing; single and double sided.**

- **Confirm ability to make high energy density multi-layered cathode coatings and assessing their performance**



Summary

- **Estimated 80-90% manufacturing cost reduction; 24% cost reduction including materials**
- **Demonstrated capacity, impedance, cycling ≥ PVDF (90/5/5 and 90/7/3)**
- **Confirmed UV curing at 100 m/min of hand drawn samples**
- **Focus now shifts to continuous high speed coating and curing with slot die and printing technology and layered coatings**