GREENLION
Advanced Manufacturing Processes for Low Cost GREENer Li-ION Batteries

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Advanced Manufacturing Processes for Low Cost Greener Li-ion Batteries

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Call: FP7-2011-GC-ELECTROCHEMICAL-STORAGE
Topic: Advanced eco-design and manufacturing processes for batteries and electrical components
Grant Agreement #285268

Total budget: 8.6 M€
EC contribution: 5.6 M€

Starting date: 1/11/11
Duration: 4 years
Actions at 3 key levels of the battery value chain:

i) more environmentally friendly production of the battery components

ii) substantial shortening of the battery assembly procedure

iii) easier and more effective disassembly and end-of-life recycling
Aqueous Electrode Processing

Advantages

- NMP 0.9 €/L (1.8 €/L pure)
- Water 0.20 €/L

- Initial investment in explosion-proof system
- Solvent recovery system
- Purification of NMP

- Fluorine binders (State of the art)
  - Polyvinylidenfluoride (PVdF)
  - 15-18 €/kg

- Fluorine-free binders (Future)
  - Carboxymethylcellulose (CMC)
  - 1-2 €/kg

- Non-aqueous processing solvent
  - Special caution during electrode processing
  - Difficulties to recycle components

- Aqueous processing solvent
  - Water is not polluting
  - Possibility of recycling: Easy separation of electrode components by dissolving the binder
i. Electrode Processing

- Aqueous Processing of Natural Binders
  (independent of active materials chemistry – starting selection: C/LFP)

- Slot-die coating process adjustment on pilot line
ii. Cell Assembly

**GREENLION Improvements**

- Laser cutting instead of die notching **COST**
- Stack-Winding process **COST**
- Eco-friendly bonding process **ECO**
- Pre-drying for lower dry room requirements **COST**
- More efficient and long-life cell sealing **ECO**
- Adjusted formation step time **COST**
iii. Module Design & Assembly

- **Lighter module design through air cooled solutions:**
  Electrical and thermal simulation of GREENLION cells to develop a module including BMS (SOC, SOH algorithms, equalization) and Thermal Management System.

- **Eco-designed bonding techniques to improve sealing and disassembly:**
  Degreasing and activation/primering of surfaces for structural bonding. Adhesives/glues with additives to activate easier disassembly for maintenance/reuse/recycling.

- **3D design of automatic battery module/pack assembly line:**
  Pilot line in 3D (validation of a prototype for Key-Processes) as a turn-key production line for Li-ion module manufacturing (Cycle time: 3 sec/cell → production capacity 880MWh/year)
Through a step by step approach:

<table>
<thead>
<tr>
<th>GEN1</th>
<th>GEN2</th>
<th>GEN3</th>
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</thead>
<tbody>
<tr>
<td>Electrodes (0.5 m², s.s.)</td>
<td>Electrodes (m², d.s)</td>
<td></td>
</tr>
<tr>
<td>Laboratory coater</td>
<td>Industrial pilot plant coater</td>
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<tr>
<td>Cells (ca. 5 Ah)</td>
<td>Cells (ca. 20 Ah)</td>
<td></td>
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<tr>
<td></td>
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<td>Modules (5-10 kWh)</td>
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</tbody>
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GREENLION Consortium

16 partners from 7 member states:

- 10 Industries (8 Large, 2 SME)
- 3 Research Institutes
- 3 Universities
GREENLION Partnership and Roles

CIDETEC
Management
Li-ion module development (+BMS,+TMS)
Testing of cells (incl. thermal)

WWU
Electrode formulation
Optimization of cell assembly
Testing of cells
Recycling

AIT
Procedure development
Testing (incl. Abuse)
Equalization development
HIL Validation

UL
Silicon Nanowire/CMC and recyclable anodes

POLIMI
Natural binder choice
Characterization of components
Ionic liquid electrolytes
Testing of cells and modules

ENEA
Characterization of electrodes & components
Ionic liquid electrolytes
Testing of cells and modules

RESCOLL
Bonding and sealing for cells and modules
Regulatory issues & LCA assessment

CEGASA
Manufacturing of Li-ion cells and module
Battery module demonstrator

SOLVAY
Cathode material developer for aqueous electrode processing

TIMCAL
Development of a negative electrode material and conductive additives

MASS
Automated assembly line for the battery modules

PCF
Develop and optimize coating methods
Electrode Coatings in pilot lane

KEMET
Cell assembly
Laser notching of electrodes
Manufacture of cells

TECNICAS REUNIDAS
Reuse/ recycling of cells or battery components
Recovery of materials
Validation of battery module

SEAT
EV specifications for module development
Validation of materials

VOLKSWAGEN
Design of cell, module and system. Efficiency and geometry issues.
Evaluation of materials
GREENLION Partnership and Roles

NOTE: attribution of roles to partners not exhaustive
WorkPackage structure

WP1 Management

WP5 Manufacturing of electrodes, cells & modules in pilot-line

WP2 Advanced electrode development & testing

WP3 Cell design, development & testing

WP4 Battery module eco-design, assembly & testing

WP7 Demonstration of battery module & validation

WP6 Eco-design (Life Cycle Assessment & Reuse/Recycling Strategies)

WP8 Dissemination, Exploitation & Training
WP2 Advanced electrode development & testing

- Optimized formulation for aqueous coating using CMC as binder:
  - Anode: Graphite (SLP30)
  - Cathode: NMC
- Transfer to pilot line (electrodes for GEN2 cells)

Selection of components for GEN1 cells (≈ 5Ah):
- Graphite / NMC
- CMC binder

0.5 m² negative and positive electrodes for GEN1 cell: DELIVERED

Optimized formulation of positive and negative electrodes with CMC Pre-pilot
• GEN1 manufactured cell: testing and evaluation:

• GEN2 cell preliminary design:

- Cell thickness: 8.5-9mm

MAIN ACHIEVEMENTS SO FAR

Manufacture of GEN1 cells from fluorine-free binders, small area electrodes
DELIVERED

Design of the initial GREENLION cell (≈ 20Ah)
GEN2
WP4 Battery module eco-design, assembly & testing

• Mod1 design:

Design of the GREENLION battery modules
UNDER DISCUSSION
→ COUPLED WITH CELL DESIGN & ECODESIGN
WP5 Manufacturing of electrodes, cells & modules in pilot-line

• Electrode manufacturing options:
  ✓ Gen2 coated with 2 passes (4a)
  ✓ Gen3 goal: 1 coating pass (4b)

• Plant layout options

Electrode manufacturing: transference from lab-coater to industrial pilot line
ABOUT TO MANUFACTURE

Production process defined
PRELIMINARY

Figure 4a: One-sided coating and drying of the metal foil.

Figure 4b: Simultaneous double-sided coating with subsequent drying of the metal foil.
WP6 Eco-design (LCA & Reuse/Recycling Strategies)

- Baseline battery LCA boundaries:

**MAIN ACHIEVEMENTS SO FAR**

**Benchmarking on recycling processes done:**
ALREADY STARTED

**LCA & ecodesign:**
gathering of inputs from partners
- reference cell & module
- Greenlion cells & modules
Thank you!!

GreenLion Project Coordination:

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