ADVANCED MANUFACTURING PROCESSES FOR LOW COST GREENER LI-ION BATTERIES

ELECTRODE MANUFACTURING

Coating Li-ion battery electrodes from aqueous slurries
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Coating Li-ion battery electrodes from aqueous slurries...

... allows a lower environmental impact and reduced cost of cell manufacturing with the removal of organic volatile solvents and fluorinated binders from the electrode formulations.

1 Introduction

Within the Greenlion Project, Task 5.1 was focused on the large area electrode manufacturing on pilot line, with two main aims:

- Coating and drying trials for electrode manufacturing on pilot line for cell assembly in Task 5.2
- Development of an industrial scale machine for coating and drying green Li-ion electrodes

These large anode and cathode surfaces constitute the deliverable corresponding to the electrodes necessary for large format GREENLION pouch cell manufacturing. Work was developed in 2 generations: this document reports on E2 electrodes (only anode aqueous slurry) and the final E3 electrodes expected for cell manufacturing.

The task of manufacturing large areas on the pilot line was shared between PCF and CEGASA. Last electrode rolls were manufactured at lower speeds to overcome de-lamination during drying of aqueous based slurries. The new electrode aqueous formulations (E3) developed in WP2 (2 candidates for cathode and 2 for anode) to overcome the drying issues observed in GEN2 were tested to make a final decision before full scale-up manufacturing.
Figure 1: Overview of manufactured electrode generations in GREENLION

**GEN2**

**ANODE** Aqueous processing

- SLP 30 Graphite (Imerys)  91
- C45 (Imerys)  4
- CMC  5

**CATHODE** Organic processing

- NMC  84
- C45 (Imerys)  8
- PVDF  8

Batches: 3-9kg slurries; >200m coated rolls

**GEN3**

**ANODE** Aqueous processing

- Surface Modified Gr (Imerys)  96.5
- C45 (Imerys)  0.5
- CMC  1
- SBR  2

**CATHODE** Aqueous processing

- NMC  90
- C45 (Imerys)  7
- CMC  2
- Acrylate binder  1

Avoided Al corrosion or active metal leaching
This chapter provides the information on the final selected scaled-up E3 electrode formulations, manufacturing process and final characteristics. These electrodes were then used in the manufacturing of at least 105 GEN3 cells.

The development of simultaneous coating equipment by Wifag-Polytype Technologies (PCF) to increase production output is also included.

2 Work performed on E2 electrodes

Anode coating and drying based on the aqueous slurry of graphite active material and sodium carboxymethyl cellulose (CMC) as only binder -developed by KIT-HIU in WP2- was carried out by Wifag-Polytype Technologies (PCF) using a slot-die pilot line machine. The target dry coat weight was 74.7 g/m² in accordance with the desired battery capacity of 20 Ah corresponding to 1.9 mAh/cm². Coating speed of 5 m/min was used, which was on the low side compared to the current industry standard of 25 – 30 m/min but allowed producing two-side coated anode rolls for cell manufacturing (Figure 2). Cathode aqueous slurry, also formulated with CMC, was also tried but could not be upscaled to the targeted high dry coat weight.
Figure 2: GEN2 anode and cathode coating (organic solvent) on CEGASA pilot equipment: conditions and manufactured roll
Due to the cracking and delamination problems encountered on the cathode drying, in order to avoid further delays in cell manufacturing, the cathode coating was carried out by CEGASA using organic formulation (NMP as solvent) with PVdF as binder (see Figures 2 and 3). Target loading to match with the first anode produced by PCF (1.95mAh/cm²) was achieved.

The electrodes used in GEN2 cells were thus:

- **Anode**, Water-based slurry: 91% SLP 30 Graphite (Imerys); 4% Super C45 (Imerys); 5% Walocel CRT2000 CMC (Dow Wolff Cellulosics) – 7.47 mg/cm²

- **Cathode**, Organic solvent (N-methyl pyrrolidone, NMP) based slurry: 84% NMC (Toda); 8% Super C45 (Timcal); 8% Solef 6020 PVDF (Solvay) – 15.34 mg/cm²

  - Knife coating
  - Single-side coating with 2 passes
  - Gap: 360mm over Al
  - Speed 0.5 m/min
  - Drying, 3m, 100/120/150ºC

*Figure 3: GEN2 NMC cathode coating (organic solvent) on CEGASA pilot equipment: conditions and manufactured roll*

The electrodes, both anode (PCF #1 & #2) and cathode (CEG) were calendered to target densities:

- **Anode** target 1.6-1.7 g/cm³. Achieved: 1.62 (PCF#1) & 1.72 (PCF#2)

- **Cathode** target: 2.1 g/cm³. Achieved: 2.00

- Quality control: adhesion of the coated layer by peeling test conducted by CIDETEC show acceptable values for PCF#1 and CEG electrodes to be used for cell manufacturing.

*Figure 4: Calendering machine and peeling test results to evaluate electrode adhesion*
Prior to cell assembly, the electrode performance was validated by electrochemical testing in full coin cell: PCF#1 anode / CEGASA cathode, 130mAh/g-NMC at 1C/1C cycling, as shown in Figure 5.

**Figure 5:** Full coin cell cycling at 1C of electrodes to be used in GEN2 cells (PCF 1st anode / CEGASA cathode)
3 Work performed on E3 electrodes

3.1 Proposed E3 electrode formulations

Based on GEN2 experience and further developments in WP2, two options for the anode and another two for the cathode were proposed by KIT-HIU as candidates to scale-up for GEN3 cells. Both electrodes are going to be processed in water.

The proposed compositions for the anode with modified graphite from IMERYS (Graphite 01 (SMG) instead of SLP30 in GEN2) are summarized in Table 1.

<table>
<thead>
<tr>
<th>ANODE formulation A</th>
<th>Graphite 01 (SMG)</th>
<th>Super C45</th>
<th>CMC</th>
<th>SBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>96.5%</td>
<td>0.5%</td>
<td>1%</td>
<td>2%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ANODE formulation B</th>
<th>Graphite 01 (SMG)</th>
<th>Super C45</th>
<th>CMC</th>
<th>SBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>95.5%</td>
<td>0.5%</td>
<td>4%</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

To match the aim of GREENLION, electrodes without synthetic binders (formulation B) were successfully prepared at lab-scale by KIT. Nevertheless anode formulation A was prioritized for scale-up trials.

Figure 6: Cycling performance of Graphite 01 (SMG) anodes with different current and electrode densities
In the cathode formulation, the total amount of binder was reduced from 5% to 3% from GEN2 to GEN3. This allows increasing the total amount of active material. The compositions proposed for the cathode electrode were thus 90% NMC active material, 7% Super C45 cabon and 3% of a natural binder. The two options of bio-sourced binders were i-carrageenan polymer and a cationic guar gum derivative (ESAFLOR EC7, Lamberti). Among these, the guar gum formulation was suggested to be prioritized.

### 3.2 Electrode slurry scale-up trials

Before starting the larger scale pilot line trials, the processability of the electrode formulations has been tested at intermediate scale by preparing slurries with 45-60g of solids.

As mentioned in section 3.1, the **anodic formulation selected for trials is A** (detailed in Table 1). When testing the anode formulation processability, it was found that there was good slurry mixing of the materials and that anode electrode coatings could be made without any problem. Electrochemical tests also supported the scaled up formulation, as shown in Figure 7.

![Figure 7: Charge/Discharge capacity of for pre-scaled anode E3a at different C-rates](image)

**Figure 7: Charge/Discharge capacity of for pre-scaled anode E3a at different C-rates**

For the cathode, things were different. The **selected formulation was** the one with EC7 binder. Based on previous experience from KIT-HIU, it was known that slurry viscosity managing could be difficult, so two slurry processing routes were proposed, changing the order of the component addition and mixing steps. However, trials were unsuccessful: in all cases, the phosphoric acid addition, necessary to regulate the slurry pH in order to avoid aluminum corrosion and metal leaching, affected the binder and increased the viscosity irreversibly, converting the slurry into a lacquer that could not be further processed. Since this EC7 and other natural binder based cathode slurry scale-up was not accomplished within the internally set deadline for cell manufacturing (December 2014), they were further studied and optimized in WP2 but were not used for GEN3 cells.

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**Size cell:** Coin cell  
**Cathode:** Li metal 50µm  
**Separator:** Glass microfiber  
**Electrolyte:** 1% VC, EC/DMC LiPF$_6$
In order to go forward with the electrode manufacturing, an *alternative cathode formulation* (*E3_alt*) was investigated in parallel. This was developed taking into account GEN2 cathode formulation, with CMC as binder, and including an additional acrylic-based water-borne binder. This new formulation is processable and showed good electrochemical results (Figure 8). This alternative formulation is reflected in Table 2.

Table 2: Alternative cathode electrode composition (*E3_alt*)

<table>
<thead>
<tr>
<th>ALTERNATIVE CATHODE FORMULATION</th>
<th>Toda NMC</th>
<th>Super C45</th>
<th>CMC</th>
<th>Binder</th>
<th>NMC :H$_3$PO$_4$ ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90%</td>
<td>7%</td>
<td>2%</td>
<td>1%</td>
<td>1:0.005</td>
</tr>
</tbody>
</table>

![Figure 8: Charge/Discharge capacity of pre-scaled alternative cathode at different C-rates](image)

### 3.3 Slurry properties

The rheology of the finally selected trial slurries was measured with an AR2000EX rheometer from TA Instruments, with Peltier plaque and a plate-plate geometry of 40mm.

- The test conditions are:
  - Plate temperature: 25°C
  - Geometry: Parallel plates, 40mm steel plate peltier
  - Shear rate: 1000 - 0.1 s$^{-1}$
  - Duration: 3 minutes
  - Points number: 100

Figure 9 (left) shows the initial shear thickening rheological behavior of *E3a anode slurry*. In spite of this shear thickening behavior, processing of the slurry was carried out without problems. Nevertheless, in
order to achieve shear thinning slurries preferred for electrode coating, the solid/liquid (S/L) ratio has been adjusted by reduction of the solids content from S/L = 1/0.94 to 1/1.17 final ratio.

![Figure 9: Viscosity plot of the E3a anode slurry: S/L = 1/0.94 (left) and S/L = 1/1.17 (right)](image)

The cathode slurry (E3\textunderscore alt) has a shear thinning rheological behavior as can be seen in Figure 10.

![Figure 10: Viscosity plot of the E3 cathode slurry](image)
3.4 Electrode slurry mixing for GEN3 cells

The finally selected E3 electrode slurries were prepared using commercial planetary mixers in CEGASA (scheme shown in Figure 11).

![Figure 11: Scheme of the planetary mixers to prepare slurries in CEGASA](image)

Since the pilot plant mixers have a volume capacity of 5 L (anode) and 15 L (cathode), slurries were mixed in batches of approximately 3kg (anode) and 9 kg (cathode) to prepare the overall quantity needed for the manufacturing of electrodes for at least 105 cells.

Final GEN3 electrode slurry compositions and mixing procedures are summarized and outlined in the following pages.

Anode slurry mixing

The scaled-up GEN3 anode composition and the aqueous slurry mixing process are presented in the following Table 3 and Figure 12:

<table>
<thead>
<tr>
<th>Material</th>
<th>Ratio - Weight %</th>
<th>Solids batch / g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphite 01 (SMG)</td>
<td>96.5</td>
<td>1447.5</td>
</tr>
<tr>
<td>Super C45</td>
<td>0.5</td>
<td>7.5</td>
</tr>
<tr>
<td>CMC (1.4wt% solution)</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>SBR (48wt% sol.)</td>
<td>2</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 3 GEN3 Anode composition
Figure 12: GEN3 Anode slurry mixing procedure

Cathode slurry mixing
The scaled-up GEN3 cathode composition and the aqueous slurry mixing process are presented in the following Table 4 and Figure 13:

Table 4 GEN3 Cathode composition

<table>
<thead>
<tr>
<th>Material</th>
<th>Ratio - Weight %</th>
<th>Solids batch / g</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMC - NM-3100</td>
<td>89</td>
<td>5000</td>
</tr>
<tr>
<td>Super C45</td>
<td>7</td>
<td>393</td>
</tr>
<tr>
<td>CMC (4wt% sol.)</td>
<td>2</td>
<td>112</td>
</tr>
<tr>
<td>BINDER (40wt% sol.)</td>
<td>2</td>
<td>112</td>
</tr>
<tr>
<td>H₃PO₄ (25.5wt%)</td>
<td>1:0.005 (to NMC)</td>
<td>25</td>
</tr>
</tbody>
</table>
Figure 13: GEN3 Cathode slurry mixing procedure

CATHODE MIXER (15 L)

- Add NMC
  - Mix 30 min

- Add H₂O
  - Mix 45 min
  - S/L-ratio=1/0.80

- Add BINDER 40%
  - S/L=1/0.81
  - (61.7%)
  - Mix 20 min
  + Vacuum (20')

- CMC 4% + C45
  - Mix 20 min
  - Add H₃PO₄ 25.5%
  - Mix 15 min
3.5 Coating and drying of the GEN3 electrodes

The electrode coating was carried out on CEGASA modified Coatema Basecoater pilot machine, which is a narrow width machine (up to 300 mm) with a dryer comprising 3 zones of 1 m length each. The pilot coating line characteristics are summarized in Figure 14.

- Knife, Comma-bar or slot-die coating
- Single-side coating with 2 passes for double-side production
- Expected low speed = 0.5 – 2 m/min
- Adjustable GAP over rollers
- Drying 3m (1m/zone)

Other aspects of the coating and drying process that were taken into account are summarized below:

- E3 electrode size and coating pattern: as for GEN2 cells, 275mm width current collectors were used with a continuous coating pattern of 245mm width, as in Figure 15.
- Following the experience in GEN2 electrodes and cell manufacturing (see D5.4), same electrode dimensions were maintained. GEN3 cell capacity target was set at the previously expected 20Ah (1.9 mAh/cm² with optimized electrode density and anode/cathode balancing).
- E3 production was done by single-side coating with two passes in the coating line (see characteristics in Table 5 below).
- Calculated net length double-side coated) for the assembly of at least 105 GEN3 cells = 270/280 m.
The parameters used for the coating and drying of both anode and cathode are presented in Table 6. From GEN2 experience, the aqueous cathode slurry was expected to show the highest difficulty to achieve the targeted loading (>14mg/cm²) without delamination or other drying issues. However, the developed and scaled-up formulation provided homogeneously coated electrodes, as shown at different stages of the coating line in Figure 16.

Table 5 GEN3 electrode coating and drying parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Anode</th>
<th>Cathode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coating width / mm</td>
<td>245</td>
<td>245</td>
</tr>
<tr>
<td>Speed / m.min⁻¹</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>GAP (over head roller) / μm</td>
<td>180</td>
<td>250</td>
</tr>
<tr>
<td>Drying (3m) / ºC</td>
<td>100/120/120</td>
<td>80/90/90</td>
</tr>
</tbody>
</table>

Figure 16: GEN3 cathode coating. Left to right: at coating head, before drying zone and at the end, dry and wound.

3.6 Post-processing of the electrodes

After electrode coating and drying, the electrodes were calendered to compress the coated layers to the target densities shown in Figure 17. Since preliminary testing showed particle damage above 1.7 g/cm³ for the anode, calendering was set below that limit. Porosity on the cathode was also maintained by low densification to allow high pulse power capability for HEV specifications.

Apart from thickness homogeneity and as quality control before cell assembly, the adhesion of the coated layer was measured by peeling test. Peel resistance values above 15 N/m were achieved.

Figure 17: CEGASA calendering machine and density targets

Anode: 1.6-1.7 g/cm³
Cathode: 2.1-2.2 g/cm³
### 3.7 GEN3 electrode specifications

The manufactured electrode rolls with their characteristic parameters, ready for cell manufacturing, are presented below:

<table>
<thead>
<tr>
<th>ANODE</th>
<th>CATHODE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Graphite 01(SMG)/C45/CMC/SBR</strong>&lt;br&gt;96.5/0.5/1/2</td>
<td><strong>NM-3100/C45/CMC/BINDER</strong>&lt;br&gt;89/7/2/2</td>
</tr>
<tr>
<td>Current collector Cu ($W = 275 \text{ mm}; T = 10 \mu m$)</td>
<td>Current collector Al ($W = 275 \text{ mm}; T = 20 \mu m$)</td>
</tr>
<tr>
<td>Double-side coated</td>
<td>Double-side coated</td>
</tr>
<tr>
<td>Coated Width = 245 mm</td>
<td>Coated Width = 245 mm</td>
</tr>
<tr>
<td>Length = 280 m (3 rolls)</td>
<td>Length = 270 m (2 rolls)</td>
</tr>
<tr>
<td>Loading = 8.0 mg/cm$^2$</td>
<td>Loading = 14.7 mg/cm$^2$ ($\sim 2.0 \text{ mAh/cm}^2$)</td>
</tr>
<tr>
<td>Thickness (calendered) = 47 $\mu$m</td>
<td>Thickness (calendered) = 67 $\mu$m</td>
</tr>
<tr>
<td>Density = 1.65 g/cm$^3$</td>
<td>Density = 2.1 g/cm$^3$</td>
</tr>
</tbody>
</table>

**Figure 18:** Manufactured GEN3 anode and cathode characteristics
4 Simultaneous coating development

Introduction

The development of attractive concepts for double-sided coating was performed first with conventional Li-ion electrode slurries to be applied later to new and more suitable formulations (of the type E3) successfully tested by Cegasa for one-sided application, see above.

Concepts for the layout of the coating machine

In battery manufacturing the metal foils of both the anode (copper) and the cathode (aluminum) must be coated on both sides with electrically conductive slurries. Performing this task efficiently and effectively, i.e. at minimized unit costs, is one of the goals of the GREENLION project. As schematically shown in Figure 19, three concepts for the layout of the coating machine are known, and each concept has advantages and disadvantages as discussed below.

The concept shown in Figure 19a uses only one simple machine, which allows one to only coat one side of the foil at a time. Consequently, two coating passes are necessary for coating both sides of the foil, which is inefficient. On the positive side, intermittent coating can easily be implemented with this machine configuration. In this case, however, it may be necessary to rewind the foil between the two coating passes in order to properly align the leading and trailing edges of the coated patches. This increases the number of passes to 3, which is extremely ineffective and costly. Moreover, the slurry on one side of the foil will pass twice through the dryer. This may alter the electrical properties of the electrode, which is undesirable.

The concept shown in Figure 19b uses two simple machines placed in series behind each other. Now, both foil sides can be coated in one pass. Moreover, intermittent coating can easily be implemented, and rewinding the foil is no longer necessary, because the edges of the patches are automatically aligned properly. All these features are very attractive. The drawbacks of this concept are the much higher...
investment costs (two machines instead of one), the higher operating costs (two machines must be staffed), and the fact that one side of the foil will pass twice through the dryer.

The concept shown in Figure 19c uses only one machine. In contrast to Figure 19a, both sides of the foil are coated before the substrate enters the dryer, which is very attractive from a productivity point of view. However, the dryer will be longer than in concept 1, which results in investments costs, which are between the costs of concept 1 and 2. Consequences of this approach are that the second coating process must be carried out in the kiss or tensioned-web operating mode, and that the dryer must be of the flotation type, because both sides of the substrate will be wet. Moreover, intermittent coating, if necessary in the first place, will be more difficult to implement owing to the flexible geometry of the tensioned-web coating process. On the positive side, both coated sides of the metal foil will pass only once through the dryer, thus resulting in equal electrical properties on both foil sides.

From our point of view, simultaneous double-sided coating as depicted in Figure 19c is the most attractive machine concept.

Choice of coating method

As mentioned above, simultaneous double-sided coating requires at least one of the coating stations to be operated in the kiss or tensioned web mode. Tensioned web coating processes can be implemented with slot coating, or with any one of a great number of methods, which use a smooth roller for transferring the liquid to the substrate. The latter version includes indirect gravure coating, indirect comma doctor blade coating or indirect knife-over-roll coating, as well as many versions of multiple roll coating systems.

Our method of choice is slot coating (see Figure 20), because it has significant advantages over all other methods, including all attractive features of the class of premetered coating methods like excellent cross and length profiles, high wall shear stress in the entire liquid feeding system, no excess fluid and hence no problems related to re-circulating the excess fluid, ability to handle highly reactive fluids, etc. In addition, slot coating is capable of stripe and intermittent coating, two features which may be required in connection with battery electrode coatings.

As the tensioned-web operating mode must be mastered when applying simultaneous double-sided coating at least at one of the two coating stations, it might even be advantageous to implement it at both stations in order to keep the work of the operators simpler and easier, because they would only have to master one coating method.
Figure 20a: Slot coating method with a rigid geometry configuration.

Figure 20b: Slot coating method in the tensioned-web operating mode with a flexible geometry.

**Tensioned-web coating**

Tensioned-web slot coating works best, if the flow field in the coating bead, i.e. the flow field between the die lip and the substrate, is optimized according to the optimization criteria known for the rigid geometry slot coating configuration. These criteria include a parallel downstream coating gap, absence of any vortices in the flow field, a downstream die lip, which is neither too long nor too short, and a location of the dynamic wetting line near the exit of the die slot.

In the absence of a back-up roller, the tensioned web must provide a counter force, which is able to equalize the pressure force in the coating gap generated by the flowing liquid. Theoretical considerations show that this counter force depends on the web tension, Z, and on the wrap angle, $\alpha$, of the web around the die lip, see Figure 21.
As the coated web must directly enter the flotation dryer (see Figure 22), the die is best oriented with the die slot being perpendicular to the axis of the dryer. Moreover, the web tension must be set so as to optimize the flotation behavior of the web in the dryer. Consequently, the web tension is not a good parameter to adjust the behavior of the coating bead for the tensioned-web operating mode. Therefore, the wrap angle, $\alpha$, is the main parameter for optimizing the flow field of the coating bead, and $\alpha$ can best be tuned by adjusting the vertical position of the idle roll placed just upstream of the coating point, see Figure 22.
One major challenge of implementing the tensioned-web slot coating mode is the fact that substrate must be perfectly flat when it passes over the die slot. If this not the case, for example due to longitudinal web deformations, then these deformations will immediately translate into equivalent variations of the wet film thickness, which, usually, is not acceptable.

For the configuration depicted in Figure 22, such web deformations may also be generated by web flutter generated in the flotation dryer and propagating upstream from the dryer to the coating point. According to our experience, such effects may successfully be dampened by installing so called disc presses on both dry edges of the web, and in dry stripes in between, if stripe coating is used.

The implementation of this technology is shown in Figure 23. A slot die is used for coating the back side of the aluminum foil. The vertical position of the idle roller just upstream of the coating point can be adjusted in order to optimize the wrap angle of the foil around the slot die. A pair of disc presses is mounted on each dry edge of the foil in order to suppress web flutter and longitudinal web deformations at the coating point.

Figure 23: Tensioned-web slot coating mode for coating the back-side of the aluminum foil. Disc presses mounted in both dry edges of the foil just upstream of the dryer entrance.
Outlook

All process and machine concepts presented above were implemented on the Techma 3 pilot coating machine of Wifag-Polytype Technologies in Fribourg, Switzerland, see Figure 24. Moreover, all concepts have successfully been tested several times, although not with water-based cathode slurry formulations developed in the GREENLION Project.

Figure 24: Techma 3 pilot coating machine at Wifag Polytype Technologies.
5 Conclusions

In summary, the manufacturing of large areas of E2 electrode formulations as well as final E3 battery electrodes -both water-based slurries- for GEN3 cells was accomplished by mid January 2015, including the following steps:

- Sourcing of raw materials for the anode and cathode slurries
- Scaling up the new formulations before pilot plant trials, including alternative aqueous cathode slurry proposal
- Preparation of the electrode slurries (mixing procedure)
- Specification of the coating format for the anodes and cathode, i.e. full-width
- Coating and drying of electrode rolls (two passes) on coating line at low speed for cell manufacturing
- Post-processing of the coated metal foils - calendering for optimum density

The produced anode and cathode rolls were then used on GEN3 cell manufacturing, as well as samples provided for laser cutting by MANZ for a few comparative cells.

In addition, the concepts to simultaneously coat both sides of the metal foils with the slot coating method were developed and are implemented on the Techma 3 pilot coating machine at PCF.

6 References


Contacts and Authors

Contact Person
Iratxe DE MEATZA, IK4-CIDETEC, Pº Miramon 196, Donostia-San Sebastian, Spain.

Authors
Idoia Urdampilleta (CIDETEC): iurdampilleta@cidetec.es
Iratxe de Meatza (CIDETEC): imeatza@cidetec.es
Koldo Ugarte (CEGASA): imeatza@cidetec.es
Peter M. Schweizer (PCF): Peter.Schweizer@wifag-polytype.com
Nicholas Loeffler (KIT-HIU): nicholas.loeffler@kit.edu
Guk-Ta Kim (KIT-HIU): guk-tae.kim@kit.edu
Stefano Passerini (KIT-HIU): stefano.passerini@kit.edu