NEW MATERIALS
Development of new active and inactive battery materials viable for water processing

INNOVATIVE ELECTRODE PROCESSES
Innovative processes leading to reduce electrode production cost and avoid environmental pollution

NEW ASSEMBLY PROCEDURE
Development of new assembly procedures capable of substantially reducing time and cost of cell fabrication

ECO-DESIGN BONDING TECHNIQUES
Lighter battery modules with air cooling and easier disassembly through eco-designed bonding techniques

AUTOMATED MODULE ASSEMBLY
Development of an automated module and battery pack assembly line for increased production output and reduced cost

WASTE REDUCTION
The use of the water solubility of the binders, allow an extensive recovery of the active and inactive battery materials with a waste and pollution reduction.
Introduction

GREENLION is a 8.6 M€ project supported by the 7th framework Program of the European Commission that officially concluded on the 31st of October. The main objective of the project has been to develop several lithium-ion cell and module design and manufacturing technologies for HEV application.

The goals of the project have been fully achieved and the most significant ones could be briefly highlighted:

- Water based electrode formulation and industrial manufacturing, without organic solvents have been achieved.
- More than 150 cells (17 Ah) and 6 modules have been manufactured.
- Module design followed eco-design rules and easy (dis)assembly concept.
- Developed LCA analysis proofs the minimal environmental impact of the used technologies.

As a result of the developed work 7 patents were produced within the project lifetime, 20 scientific publications were published as well as more than 50 communications to different events.

Editorial from the coordinator, IK4-CIDETEC

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Regarding the electrode/separator stacking/winding step, the traditional approach is Stacking. This process however presents a low manufacturing throughput, and improvements are needed to make the product more cost-effective. The Stack Winding process is an innovative solution that incorporates continuous process of winding with volumetric efficiency and energy density of Stacking and will be developed in GREENLION for the aqueous-based electrodes.

### Electrode industrial manufacturing
- Optimized formulation of positive and negative electrodes with new binders: PATENTED.
- Scalable synthesis of high-capacity anodes: Sn-seeded Ge nanowires: PATENTED.
- Development of high temperature stable separator membranes based on water soluble polymers: PATENTED.

Electrode industrial manufacturing

- Development of simultaneous electrode double side coating to decrease production time.
- Electrode laser cutting.
- Manufacture of cells free from fluorine-free binders.
- Cell tab industrial laser welding.
- Cell performance and abuse testing.

Manufacturing of 150 cells (>150 Wh/kg & >390 Wh/l) with the developed technology

- LCA & eco-design: GREENLION cells & modules
- Module and cells recycling strategies
- Module industrial production steps validation: tab folding and laser welding
- Module validation in laboratory: performance testing.

Manufacturing of 6 modules (>90 Wh/kg & >125 Wh/l)

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Project financially supported by 7th Framework Program of the European Commission under Grant Agreement no. 285268
Together with the project final review meeting, a public workshop was organized to celebrate the closing of GREENLION. The one day public workshop on the 29th of October included a poster session and several talks on EV batteries.

As gathered in the workshop agenda, the event covered both the research and the industrial perspective. GREENLION is a quite multidisciplinary project, in which there have been developments at electrode, cell and battery module level. Therefore, almost every step of the value chain of lithium or post-lithium based battery technology was shown during the poster session.

<table>
<thead>
<tr>
<th>Time</th>
<th>Duration</th>
<th>Name</th>
<th>Presentation Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00</td>
<td>30’</td>
<td>Oscar Miguel (IK4-CIDETEC)</td>
<td>Arrival &amp; Registration</td>
</tr>
<tr>
<td>9:30</td>
<td>05’</td>
<td>Welcome &amp; Opening</td>
<td></td>
</tr>
<tr>
<td>9:35</td>
<td>20’</td>
<td>Enrique Monasterio (IBIL)</td>
<td>Electric vehicle as a key element in the electricity demand side management</td>
</tr>
<tr>
<td>9:55</td>
<td>20’</td>
<td>Hector Olabegogeaskoetxea (IRIZAR)</td>
<td>E-bus application</td>
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<tr>
<td>10:15</td>
<td>45’</td>
<td>Prof. Stefano Passerini (KIT-HIU)</td>
<td>New developments on advanced battery materials</td>
</tr>
<tr>
<td>11:00</td>
<td>30’</td>
<td>Coffee break + Posters + Expo Greenlion</td>
<td></td>
</tr>
<tr>
<td>11:30</td>
<td>25’</td>
<td>Iosu Cendoya (Greenlion Project Coordinator, IK4-CIDETEC)</td>
<td>Greenlion project overview</td>
</tr>
<tr>
<td>11:55</td>
<td>25’</td>
<td>Karl-Heinz Kampmann (SOLVAY)</td>
<td>Fluorinated materials for improved lithium ion battery performance</td>
</tr>
<tr>
<td>12:20</td>
<td>25’</td>
<td>Flavio Mornaghini (IMERYS)</td>
<td>Carbon materials for energy storage and conversion</td>
</tr>
<tr>
<td>12:45</td>
<td>25’</td>
<td>Antonio Merino (SEAT)</td>
<td>Electromobility according to SEAT: current projects</td>
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<tr>
<td>13:10</td>
<td>15’</td>
<td>Roundtable / Q&amp;A</td>
<td></td>
</tr>
<tr>
<td>13:25</td>
<td>5’</td>
<td>Closing</td>
<td></td>
</tr>
</tbody>
</table>
IK4-CIDETEC, as coordinator, organized this closure workshop titled “Towards Advanced Green Batteries” in San Sebastian (Spain). The event was open to all public with an attendance of around 50 participants. The workshop included talks and posters related to GREENLION topics. Some partners of the project participated as speakers, together with other invited external participants.
It must be highlighted the lecture of Professor Stefano Passerini, member of GREENLION project, who focused his talk on the Na-ion technology as a future alternative to lithium based ones.

The rapid growth of the worldwide demand of lithium for batteries (LIBs) can possibly lead to a shortage of its reserves. Sodium batteries represent a promising alternative since they enable high energy densities and are not limited by sodium availability. SOLVAY and IMERYS, members of GREENLION, focused their talks on their respective companies work in cathode, anode and binders for lithium ion cells. Another GREENLION member, who shared their view about EVs business, was SEAT, who summarized the wide experience of the company in EV development.
Regarding guest speakers, IRIZAR, one of the most important Basque bus manufacturers, presented their e-bus product and explained their involvement in several e-bus integration projects through Europe. On the other hand, the Basque EV charging management company IBIL, shared their concerns about the EV charging and the impact of EVs on the grid.

The workshop was useful to disseminate the achieved milestones in the project, with a clear industrial application on energy storage field.
During 3 years (2011-2014), the ELIBAMA partners worked in developing innovative electrodes and cells manufacturing processes from raw materials up to battery recycling. In order to increase the added value of these activities, a White Paper summarizing the key problematic for each process and describing the main breakthroughs achieved has been produced and made available to the batteries’ community (https://elibama.wordpress.com/electrodes-and-cells-manufacturing-white-paper/)

In order to disseminate more deeply the results obtained from GREENLION and widen the work started by ELIBAMA project, it has been agreed a collaboration between both projects. GREENLION will complete the White Paper with significant results obtained during the lifetime of the project. The content of the White Paper is shown below with partial or full contributions from GREENLION underlined. Before the end of 2015, it will be available on both, ELIBAMA and GREENLION websites:

(http://www.greenlionproject.eu/homepage)

INTRODUCTION

II. RAW MATERIAL MANUFACTURING

1. LiTFSi electrolyte
2. Lithium Titanate Oxyde (LTO) anode active material
3. Li-alloying nanomaterials
4. Novel graphite materials for aqueous coating
5. Green and safe electrolytes based on Ionic Liquids
6. Electrodes with water soluble binders

III- ELECTRODES MANUFACTURING

1. 3D structured collector foils manufacturing
2. Electrodes Coating
3. Electrodes calendering
4. Electrodes surface’s inspection
5. Electrodes laser cutting
IV. CELLS’ MANUFACTURING

1. Electrodes stacking and joining
2. Cells filling
3. Electrodes and cells clean manufacturing
4. Non destructive cells testing (NDT)
5. Cell venting system
6. Thermal sealing
7. Performance and abuse tests on cells

V. MODULE MANUFACTURING

1. Module design
2. Cell – frame bonding
3. Thermal simulations on the cooling plate
4. Performance and abuse tests on modules

VI. BATTERIES END OF LIFE MANAGEMENT

1. Used batteries diagnostic, discharge and dismantling
2. Batteries reuse
3. Batteries recycling
4. Hydrometallurgical recycling treatment

VI. OTHERS

1. Eco-design of Lithium-Ion batteries (LCA)
2. Eco-design of GREENLION module
3. Comparative LCA of baseline and GREENLION module

PS: since chapter V has been fully created by GREENLION and included in the logical order according to the existing index, chapters VI and VII have been renumbered with respect to the original ones.
15 Partners from 7 members states:
- 9 Industries (7 Large, 2 SME)
- 3 Research Institutes
- 3 Universities

Coordinator of the project:
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