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.
Welcome back to GREENLION newsletter!

This issue of the newsletter is focused on the eco-design aspects of GREENLION project.

Eco-design starts from the very beginning with the choice of materials, followed by selection and development of processes and to the very end with the assembly of the different components of the Lithium-Ion battery. Taking into account every single step of a battery module production will lead to increased performance with a lower carbon footprint and environmental impact.

This edition includes technical notes on electrode processing, battery module design and Life Cycle Assessment (LCA) from the environmental impact point of view. Electrode materials are one of the key elements for the performance of the whole system. Development of volatile organic solvent free electrode coating process and the selection of suitable active and inactive materials will impact strongly not only in the performance but also on the environmental friendliness of the final battery.

Module design is also important since it will also influence the manufacturing processes, especially in regards to production time and cost. To build a module respecting the environment while having a competitive process is a main challenge.

Finally, the Eco-design of the battery module product can be supported thanks to different tools such as LCA.
Technical Review

How the inactive electrode materials may influence the battery performance? What is the GREENLION approach and results achieved so far?

Nowadays, conventional electrodes are mainly prepared by using Polyvinylidene fluoride (PVdF) as binder and organic solvents, such as N-Methyl-2-pyrrolidone (NMP). This system is well understood and yields a good and stable cycling performance. But due to the toxicity and volatility of NMP there is a deep interest in replacing PVdF by water soluble binders, which are less expensive than PVdF (0,2€/L vs. 1,2€/L) and avoid the use of toxic and volatile solvents.

Moreover the use of water as solvent results in process cost savings and a decrease of waste produced during the life cycle of the product.

The required contents of binders for Lithium-Ion batteries are good cohesion between active material particles as well as adhesion of particles to current collectors, stable electrochemical properties, good solubility and homogeneity in the solvent.

Aqueous binders, such as sodium carboxymethylcellulose (CMC), show good results for anodes and are already commonly used for their preparation. In contrast to CMC-based anodes which are commercially produced, the cathode preparation in aqueous solutions still causes problems, such as leaching of the active material and therefore irreversible loss of Lithium ions during the aqueous processing. (...
The battery assembly design and process can be optimized in different aspects in order to achieve an environmental friendly final product. The defined goals of the GREENLION project regarding an ecological module design are mainly focused on:

- Design of a light module
- Use of bonding clean processes
- Easy disassembly for both, maintenance and recyclability
- Manufacturing time reduction

All these goals are directly or indirectly linked to a more ecological design. The steps, given in this project to fulfill such characteristics for the module will be next explained.

Moreover the pH value of the cathodic suspension rises, causing corrosion of the aluminum current collector during the coating step. To overcome these issues several approaches are used in GREENLION, such as

- pH adjustment with carboxylic acids
- or protective layer application on the aluminum foil.

So far, investigating the electrochemical performance of aqueous processed cathodes, almost the same capacity compared with those prepared with conventional non-aqueous binders, could be achieved in GREENLION.

Nina Laszczynski, University of Muenster
The module design concept is based on a holistic idea: each part of the module is designed as an integrator of the whole body of the module and finds its best performance stacked with the rest of parts of the module. The summation of light and stiff parts results in a lighter and even stiffer total module.

In order to reach the best assembly among elements, the first step is to reinforce each cell as core of the module, by adding to the cell a surrounding light and thermally effective armor. This armor will be also the key element to pack the whole module. The individual assembly of each cell and the global module assembly will be performed by thermal bonding processes and/or mechanical fit. The use of thermal bonding techniques, together with mechanical fit, facilitates the disassembly and recyclability of the module.

Another important goal of the design is the manufacturing time, which could be optimized thanks to the modularity concept of the design. The automation grade of the process is also very high due to this modularity property.

Although it is not highlighted in the goals of the project, safety is of course an essential characteristic to be fulfilled by any design. That is why a special effort has been done in studying the venting conduction procedure in case of damage and the cells’ swelling absorption during the cycling of the module.

Iosu Cendoya, CIDETEC
An important goal of GREENLION project is to develop a new ecofriendly Lithium-Ion battery. So, it has been planned to work on the whole life cycle of the battery design from raw materials choice (aqueous processing) to recycling of the battery.

There are diverse methodologies and tools available but LCA is the most complete and recognized method of environmental performance assessment. It is standardized by the ISO 14040-44 and some guidelines have been produced by European Commission: the ILCD handbook (International Reference Life Cycle Data System) gives more specific guidance than ISO 14040-44.

Furthermore, LCA allows analyzing several environmental issues, for instance, climate change, atmospheric acidification, eutrophication of water and photochemical oxidation. Since several environmental indicators are chosen, study will be more complete and will permit to avoid shifting of burdens.

In GREENLION context, purpose of the LCA is to validate that the project developments really improve the Eco-profile of the module and also to support the design decision-making process.

At the beginning of the project, the baseline which fits to the cell at the first stage of development was assessed. Improvements will be highlighted. This process will be repeated as many times as necessary to obtain the best possible environmentally friendly product.

Claire Michaud, RESCOLL
The goal of the workshop organized by the European Commission was to promote a good understanding on how projects can address individually and collectively standardization aspects as a mean to enhance the exploitation of research results. GREENLION was selected to be part of a group of 18 EU current projects dealing with manufacturing activities and programs such as "Factories of the Future", with clear potential to contribute towards standards development.

During the workshop, representatives from the EC and standardization bodies such as CEN CENELEC provided an overview of the European standardization system, its major deliverables and the benefits that standardization can bring to research projects, including a review of the support they can provide. Three projects that have successfully integrated project outputs into standards discussed their experiences and issues they had to address. The benefits of standardization were made clear, but also the time and high commitment needed from the project partners.

CEGASA attended this event and during a break out session briefly presented GREENLION goals and the project outputs that could be developed into standards. A few aspects were identified, such as

- Hardware-In-the-Loop methodology to evaluate cells/modules in real application performance,
- Eco-design as real optimization tool for whole process and
- An industrially optimized recycling process for the battery module.

Especially, battery cell test procedures (safety, functional, performance and lifetime; mechanical, electrical, thermal & environmental compatibility), if not already contributing to a standard, are definitely influenced and will be needed to conform and follow standards already in place. In addition, the influence and potential participation on the development of a standard on pouch cell design for electric vehicle applications (format and dimensions) was discussed.

A "Guideline" on design for disassembly and recycling of battery products can be also identified as a possible result of GREENLION Project.
5th Congress on Ionic Liquids (COIL-5),

Ionic Liquids – basically liquid salts at experimentally reachable temperatures in any commonly equipped lab – started gaining scientific relevance about 20 years ago. Research tackling and using these fluids continues to boom, involving investigation in many fields of the exact sciences, natural sciences, technology, as well as the life and health sciences.

This event organized worldwide every two years will be held in Europe this year. Each event attracted circa 400 participants, transforming this gathering into the most important congress on this topic, worldwide.

During this conference, results about GREENLION project were displayed, thanks to the communication of A. Mele from POLIMI who presented an oral communication “Pyrazolium-based ionic liquids: physico-chemical and structural features of imidazolium isomers”.

Furthermore a poster was presented about “Ionic liquids based on diethylmethyl(2-methoxyethyl)ammonium (DEME) and bis(perfluoroalkanesulfonyl)amide: short- and long range structural features”.

Finally, “Room temperature ionic liquids with fluorinated tails: evidences of triphilic behaviour and structural implications” was also presented in collaboration with ENEA.

Consortium Meeting

The partners met for the fourth time on 25-26 April 2013 at the MEET battery institute facilities of the University of Münster to hold the first GREENLION Review Meeting.

The progress for this first 18-month period of the project was presented for each Work Package. Project efforts have been mainly focused on the electrode processing step, with the development and testing of active materials and binders suitable for water-based slurry formulations and electrode coating process. First selected formulations have been used for small-scale GEN1 prototype pouch cell assembly while the optimized module design and assembly process is underway. Together with the module design options, the cell design has been fixed for GEN2 cells that will be produced before the end of the year.

In the evaluation of the EC representatives present at the meeting (Patrice Millet, Project Officer, and Dimitris Karadimas, Project Technical Assistant), objectives and milestones for the relevant period have been mostly fulfilled. The consortium has been encouraged to keep this fruitful exchange and collaboration in order to continue advancing towards the challenging milestones expected for the next period.
2nd International Conference on Materials for Energy (EnMat II)
The second conference will bring together a multi-disciplinary group of internationally recognized researchers and scholars. It will give you a unique opportunity to make contacts for collaboration or commercial exploitation in materials for energy applications and will give you an excellent overview of recent developments in the areas of energy conversion, energy storage, transport and efficiency.
13-16 May 2013, Karlsruhe, Germany
http://events.dechema.de/en/enmat

E-MRS 2013 Spring Meeting
Each year, E-MRS organizes, co-organizes, sponsors or co-sponsors numerous scientific events and meetings. The major society conference, the E-MRS Spring Meeting, is organized every year in May or June and offers on average 25 topical symposia.
27-28 May 2013, Strasbourg, France

AABC Europe 2013
Keep pace with the technology and market development of advanced vehicles and the batteries that will power them! Advanced Automotive Batteries (AAB) hosts two conferences annually, AABC Europe and the International AABC, with both events attracting professionals from the hybrid and electric vehicle world and the three tiers of the battery supply chain
24-26 June 2013, Strasbourg, France
http://www.advancedautobat.com/
**BATTERIES 2013**
The international power supply conference and exhibition remains in Nice Acropolis. Whether you're in R&D, manufacturing, servicing or an end-user, presenting a paper at BATTERIES 2013 lets you share your knowledge and experience with your colleagues in the industry.
14-16 October 2013, Nice, France
http://www.batteriesevent.com/

**Batteries and Fuel Cells**
Attendees will dive into an introduction to batteries and fuel cells modeling at the unit cell level. You learn how simulations can predict the effects of electrode geometry, material properties, and operating conditions on the performance of batteries and fuel cells.
14 November 2013, Burlington, MA
http://www.comsol.com/events/bfc/22549/

**World Electric Vehicle Symposium and Exhibition (EVS)**
The World Electric Vehicle Symposium and Exhibition (EVS) series, organized by World Electric Vehicle Association (WEVA), is recognized as the premier event for academic, government and industry professionals involved in electric drive technologies.
This year a new activity on European and International Projects Dissemination has been opened. The European Commission has been supporting many projects on electric mobility in the last years.
17 -20 November 2013, Barcelona –Spain
http://www.evs27.org/
PARTNERS

16 Partners from 7 members states:
- 10 Industries (8 Large, 2 SME)
- 3 Research Institutes
- 3 Universities

Coordinator of the project:
IK4- CIDETEC
Parque Tecnológico de San Sebastián
2009 Donostia – San Sebastian (Gipuzkoa)
Spain

INFO@GREENLIONPROJECT.EU
WWW.GREENLIONPROJECT.EU