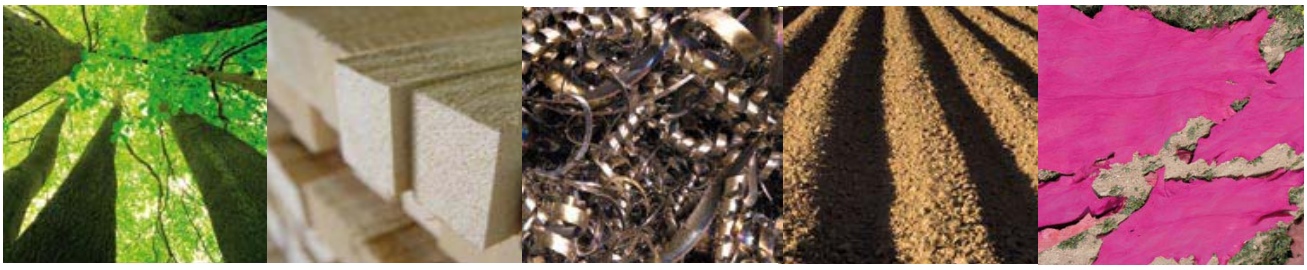

CIP Eco-innovation
First application and market replication projects
Call Identifier: CIP-EIP-Eco-Innovation-2008

Final Report

Project acronym

Contract ECO/11/304532

Covering the reporting period from
01/12/2012 to 30/11/2015
Reporting Date
<29/01/2016>

Project coordinator: Best Wool Carpets B.V.

Project website: www.ERUTAN.eu

1 Achievements of the action

1.1 General progress

Due to general economic conditions in Europe there was a problem with the initial found external financial party for the upscaling of the wool scouring process, which forced the consortium to look for a new partner in the first period of the project. The partnership with Dawson was enhanced from wool supplier to full Erutan partner and the scourer Ariete was found willing to adjust their machinery for industrial production according to the new Erutan scouring process.
During this phase a discussion started about the size of air bubbles in order to further enhance process effectiveness, energy consumption and lead-time. In the beginning of 2014 this led to the introduction of aeration generating tiny air bubbles and turbulence in the process. The trials on production scale with ordinary air bubbles were planned for March 2014, but the further development of the bubbles into micro air bubbles led to the postponing of the upscaling productions. An extra set of trials on lab scale in order to optimize production variables came apparent and these were performed in September, October and November 2014. During these trials the different variables such as temperature, process time and amount of natural degreasing agent, for the three different scouring stages in production were optimized and the process was released for production. In February 2015 a series of production scale tests was performed in collaboration with Dawson at Ariete in Gambino, Italy. These tests showed that the quality of the wool was comparable with the quality of conventionally scoured wool, the process used less energy, only the process times were longer and a problem with the wetting of the wool on industrial scale became apparent. This problem doesn't occur in conventional scouring as soap is added to the process which breaks the surface tension.
Unfortunately, in the last years, the price of lanoline has devaluated in such a way that it became less interesting to harvest and sell lanoline from the process. Besides that, the negative environmental impact of peroxide that is used in conventional scouring processes is no longer an issue; water cleaning companies now use the peroxide in fact in order to clean water. Based on these developments, the consortium has come to the unfortunate conclusion that at this moment it's not viable to invest in the reconstruction of a conventional plant into an ERUTAN production plant. An investor is now sought together with Dawson, for the realization of a smaller, cheaper ERUTAN scouring plant that can be built up close to (a group of) farmer(s). In this way farmers can scour wool themselves and can earn more with their wool.

One thing that came very apparent during the project was the process enhancing capacity of the micro air bubbles. This process enhancing capacity will further be investigated in the dyeing processes of yarn, in collaboration with Dawson and Danspin. For this, a Non Disclosure Agreement was signed between Danspin A/S and ERUTAN.

Trials with regard to the upscaling of the adhesive composition carried out on the pilot line at the beginning of the project using a roll-based method for paste deposition revealed brittleness in the carpet backing. This problem was masked at a lab scale; the manual dosing of the lignin-based paste alone on the carpets lead to thick coatings that didn't show this problem. It became apparent the paste needed further optimization. With regards to this optimization, two different approaches developed in parallel by UPC and James (JMS) have been explored. Advantages and drawbacks of both adhesive pastes – lignin-based and linseed oil-based led to the strategy to combine both approaches and improve the formulations and consequently the adhesive performance. By means of these investigations the developed adhesive paste, a

combination of both approaches, meets the quality requirements. Unfortunately the price of the paste (€ 8,- per kilo) was too high for market uptake of the product.
In the last 7 months of the project new tests were performed with the paste based on linseed oil and in collaboration with Hobum, another stakeholder and supplier of the ERUTAN-paste, a cheaper thixotrope agent was introduced in the paste realizing a paste that meets the quality requirements at a price that is finally more suitable (€ 3,- per kilo). In November 2015 a patent was filed for this paste composition. Hobum is the shared owner on a 50/50 basis together with ERUTAN.
In the meantime BWC has continued the extension of her premises and has created a production area for the backing line as such.
Partner James has built up a new collaboration with DSM; DSM/NIAGA. In the last year DSM/NIAGA also developed a new backing paste, a totally PES based, reversible polymer adhesive, which can be applied to the carpet using a short backing line, which consumes very little energy. The PES adhesive is reversible in a way that it can be separated from the wool carpet by washing it out at a specific temperature, making it possible to fully retrieve all yarn that is processed in the carpet and recycle it. A carpet backing line for this new PES paste is now being built in Zwolle at DSM.

Based on the above mentioned developments the consortium has decided to perform an extra series of tests on the new backing line of DSM/NIAGA; it's possible to perform tests with the ERUTAN paste on this line. After the new series of tests all parameters for the backing line for Best will be clear and the backing-line in Best will be developed and built.

1.2 Results achieved as compared to what was planned in the project proposal

WP1: Management

Project coordination was carried out by Best Wool Carpets BV. Best Wool Carpets BV has monitored and facilitated the overall progress of the project work. For this several consortium meeting were held in order to discuss technical progress and plan ahead. In between the meetings progress was reported to the coordinator by the Work Package leaders on a regular basis. As Christine Kempchen has left James BV the management tasks she performed were taken over by Annemarie Severijn of Best Wool Carpets BV.
As the coordinator, Best Wool Carpets BV wrote the Progress Report after 10 months (D 1.8), the Interim report (D 1.3) and the Final Report (D 1.6). The Interim Report after 18 months (D 1.3) was in time but not approved by the Commission, because of delay in realization of deliverables. A request for amendment was done by the consortium, which led to the postponing of the Interim Report to M25, reporting progress until M24. Again the Interim report was not approved by the Commission because of delays in deliverables.
The Progress Report after 24 months (D 1.4) was skipped after approval of the commission.
A Project Management Guide was completed in M6 (D 1.2). A project website and Project Information Sheet (D 1.1) was set up in M3 of the project. Last updates have taken place in M19 (D 1.1). The next web-site update (planned M27 and M36) will take place when the backing-line in Best will de ordered or an investor for the wool scouring plant will be found.
The monitoring of the performance indicators (D1.5 and D 1.7) hasn't taken place yet as there isn't enough information available at this moment. Performance Indicators will be monitored as soon as processes are operational.

WP2: Up-scaling of the enzymatic wool scouring

Due to general economic conditions in Europe there was a problem with the initial found external financial party for the upscaling of the wool scouring process, which forced the consortium to look for a new partner in the first period of the project. In the summer of 2013 the consortium contacted H. Dawson Sons & Co Wool Ltd. (Dawson). Dawson showed interest in ERUTAN's scouring process and through Dawson the consortium was introduced to Manufattura Ariete (Gambino, Italy) – an independent commission wool scouring company. James, BWC and Dawson visited the production-side in November 2013 in order to analyse whether their scouring line would be suitable for carrying out large-scale trials and easily adaptable to the ERUTAN process. During the visit it was determined that the scouring machine of Ariete is suitable for the intended use and large scale trials were agreed.

In the meanwhile the scouring process was further optimized for production. During various in-depth discussions between James, BWC and Dawson the size of the air bubbles used in the process was challenged. Especially since the size of the air bubbles could enhance process effectiveness and production time.

In March 2014 this led to the introduction of aeration generating tiny air bubbles and turbulence in the process. For this purpose a small aeration air generator was rent from the supplier performing small scale trials in Grubbenvorst. The results were that much encouraging that further trials were scheduled and executed.

In March 2014 the wool scoured on lab-scale according to the process with the initially introduced air bubbles and enzymes was tested at AgResearch. The wool was whiter than conventionally scoured wool with detergents and bleaching agents at high temperatures.

It was planned to perform trials with the air bubbles on production scale in March/April 2014. These trials, however, were delayed due to further time needed for discussions between the consortium and Dawson about the size and amount of air bubbles for scouring. This discussion and further research led to the development of micro air bubbles, with better performance in terms of process time as well as cleanness and whiteness of the scoured wool.
This refined technology was checked with the patent lawyer and confirmation was received that fell within the existing patent position ERUTAN has.

To produce the right size and amount of micro air bubbles for the scouring plant in Italy three pumps as well as other material to adjust the machinery were ordered. The pumps arrived in Grubbenvorst early July 2014 to do larger scale trials before planning the trials in Italy.
To optimize all production variables many additional trials were performed in September, October and November 2014 all in close partnership with Dawson.
During these trials the different variables such as temperature, process time and amount of natural degreasing agent, for the three different scouring stages were optimized and the process was released for production.

In February 2015 a series of production scale tests were performed in collaboration with Dawson at Ariete in Gambino, Italy. These tests showed that the resulting quality of the wool was comparable with the quality of conventionally washed wool, the process used less energy, but the process times were longer than expected and a problem with the wetting of the wool became apparent. The production tests showed that it's possible to scour 400 kilograms of wool in 1 hour, resulting in 3.200 kilogram in 8 hours. With this D 2.1, D 2.2 and D 2.3 were achieved.

Unfortunately, in the last years, the price of lanoline has devaluated in such a way that it became less interesting to harvest and sell lanoline from the process. Besides that, the negative environmental impact of peroxide that is used in conventional scouring processes is no longer an issue; water cleaning companies now use the peroxide in fact in order to clean water. Peroxide is used in conventional scouring in order to obtain whiter wool, as the price for whiter wool is higher. On white wool all colors can be applied in the dyeing process.
Based on these developments, the consortium has come to the unfortunate conclusion that at this moment it's not viable to invest in the reconstruction of a conventional plant into an ERUTAN production plant. Together with Dawson we are searching for an investor for the realization of a smaller, cheaper ERUTAN scouring plant that can be built up close to (a group of) farmers. In this way farmers could scour wool themselves and earn more with their wool.

One thing that came very apparent during the project was the process enhancing capacity of the micro air bubbles. This process enhancing capacity will further be investigated in the dyeing processes of yarn, in collaboration with Dawson and Danspin. For this, a Non Disclosure Agreement was signed between Danspin A/S and ERUTAN. The planning of these trials is April/May 2016.

A film of the scouring process using micro bubbles is up-loaded to the ERUTAN web-site.

During this process Qualizyme was responsible for the supply of appropriate amount of the enzyme product QZ 2002 for the wool scouring pilot trials. QZ 2002 – a formulation of alkaline proteases for the bio-bleaching of sheep wool was produced in larger batches with improved protocols.
In April 2014 new and faster immobilization method for the enzymes used in the formulation was developed, providing good results on wool, and making it possible to reduce the steps during the immobilization process down to the finished enzyme end product.
For the improved formulation protocol a carrier that is an anionic copolymer based on methacrylic acid and methyl methacrylate was applied. This solid substance in form of a white powder is also used in pharmaceutical products as well as food industry and was consequently well suited to be applied in wool without any health risks for the customers. In lab trials we worked with this carrier and alkaline proteases. In a stepwise reconstruction of the old process with an acidic and an alkaline buffer system we were able to bring the process to a one-step immobilization method using only a neutral buffer system with pH 7.
This one-step immobilization procedure for the creation of the QZ 2002 enzyme product was applied in three subsequent batch production cycles and proved to be reproducible. With this method the required time for immobilization was reduced by more than 50% and chemical consumption for buffer production by roughly 12 % leading also to reduced costs of protease immobilization. With this new procedure the production of QZ 2002 in amounts suitable for industrial application was achieved.

Purchase of equipment

James purchased 3 Nikuni pumps KTM32N of 2.2Kw. with Rotary Trading company for use at the trial plant in Grubbenvorst and at the scouring line in Gambino, Italy. More small parts as well as pressure vessels were ordered in order to be able to install the pumps.

Subcontractors/stakeholders

We are pleased that H. Dawson Sons & Co Wool Ltd has become a partner of the ERUTAN process. We signed a non-disclosure agreement as well as a joint development agreement to protect the interest of ERUTAN's IP. The persons involved are Jo Dawson (CEO/Owner) and David Halley (Global Product Director).
Dawson performed many tests on the scoured wool which were graded by an expert panel.

We are pleased that Manifattura ArieteS.r.l. has become a partner for ERUTAN through Dawson's, providing the ability to use their equipment for industrial scale up. The person involved is Claudio Pasini (CEO/Owner).

We are pleased that we found AgResearch Limited available to do testing on scoured wool as well as comparison with current scouring results. The person involved is Steve Ranford (Senior Scientist).

We are pleased that Danspin has now shown interest in the process again and this has lead to the signing of a Non Disclosure Agreement between ERUTAN and Danspin A/S.

WP3: Up-scaling of the adhesive composition and enzymatic bonding of carpet layers

Achievements

The objective of WP3 is the up-scaling of an enzymatic process transforming natural based compounds (e.g. plant phenolics) into an adhesive capable to replace synthetic latex and to make wool carpets 100 % recyclable.

Providers for the adhesive precursors and enzymes have been identified and their supply guaranteed (D3.1 and D3.2). The paste composition has been defined for carrying out pilot scale trials. The consortium has focused its efforts on combining two approaches simultaneously developed at UPC (adhesive generation from lignin and natural phenolics cross-linked with laccase enzyme) and JMS (cross-linking of epoxidized linseed oil). The combination of both approaches was aimed at overcoming the intrinsic brittleness of lignin relying on the flexibility of the linseed resin. At lab scale, the manual dosing of the lignin-based paste alone on the carpets lead to thick coatings that initially masked the brittleness problem. However, the trials carried out in the pilot line at the beginning of the project using a roll-based method for paste deposition revealed the necessity of a natural plasticizer, though the bonding strength of the adhesive was satisfactory. The work carried out under tasks 3.3 and 3.4 brought about a natural-based plasticizer solution consisting in the use of linseed oil. Combination of both approaches using the pilot line located at JMS facilities led to carpets with improved flexibility, reduced powder release upon extensive carpet use and a bonding strength above 35 N (the minimum bonding strength accepted for tufted carpets is 30 N). In this lignin-linseed oil-enzyme formulation, the enzyme activates and phenolates the lignin before mixing with the rest of the ingredients and is still active when the paste is applied on the carpet (the paste composition is detailed in D3.3). Consequently, the step necessary to carry out the enzymatic reaction on the pilot line was eliminated, shortening the whole process. The paste is applied to the carpet and the carpet goes directly to a short 15 min drying step at 95 ºC where the activity of the enzyme is boosted to a maximum.
The price of this formulation was reduced from ca. 7,- €/m^2 to ca. 4,25 €/m^2 after the removal of some expensive components present in the initial paste composition – implying a variation

of the ratio of the rest of the ingredients. Though reduced, this price was still substantially higher than latex and not market competitive.

During the last year of the project, partner UPC continued working on the optimization of the paste composition to overcome the intrinsic brittleness of the lignin-based adhesive using natural-based compounds, according to the original ERUTAN concept. This paste optimization has been carried out without the collaboration of the industrial partners BWC and JMS that adopted an approach based on epoxidised linseed oil supplied by HOBUM Oleochemicals. Although UPC developed a combined lignin-linseed oil (50:50) paste with reduced brittleness, and also advanced the work on a natural phenolics-based hardener for epoxidised linseed oil resins, the company HOBUM couldn't supply UPC with linseed oil and hardeners, as they wanted to protect their knowledge and therefore couldn't share it with UPC. Therefore, UPC continued with the original lignin-based ERUTAN concept, practically without interaction with the industrial partners until the end of the project.

Besides for wool carpets, UPC extended the efficiency of the lignin-based adhesive also to synthetic floor covering, e.g. polyamide tufted carpets with polyester/cotton primary backing.

In order to minimize the brittleness and at the same time improve the economic feasibility of the adhesive, certain components have been replaced with cheaper alternatives. In the previous reported period, dopamine was discarded as a component of the adhesive due to its high price and lack of significant change of the loop withdrawal force when dopamine has been omitted in the formulation. During the last year, the concept for necessity of a compound rich in amino groups (nucleophiles), which will react with the oxidized by the laccase polyphenols, was followed. Compounds with multiple amino groups and long flexible carbon chain between them would provide additional crosslinking to improve the adhesive strength of the paste, lower the brittleness and eliminate the powder release during use. These will be referred to as "internal plasticizers". By adjusting the concentrations of the amino-providers adhesive pastes with appropriate viscosity for large-scale production were obtained.

Alternatively, different low-cost polysaccharides, which do not react chemically with the polyphenolics from the paste, were included in the composition. These polysaccharides will be referred as to "external plasticizers". Additionally, three new natural-based plasticisers were synthesized using environmentally friendly enzymatic reactions.

Another objective was to lower the price of the paste, however, the price was not possible to be reduced below 3€/m^2 without addition of natural/synthetic plasticiser. The basis composition that was used was the initial formulation from D3.3, where dopamine was replaced by another amino-provider. Amino-providers from natural or synthetic origin were used for the preparation of the paste, namely: 4-arm-NH_2-PEG, melamine, fish collagen, gelatin and keratin from hydrolysed chicken feathers. The viscosity of the paste formulation increased significantly after the addition of each amino-provider, which confirms that the cross-linking process has occurred. Varying the concentration of each compound, paste compositions with different degree of cross-linking were obtained. The brittleness and powder release of the adhesive was overcome only in the case when 4-arm-NH_2-PEG was added to the adhesive on both wool and polyamide carpets. Additionally, the initial paste composition with dopamine was applied on both type of carpets and the results showed that the adhesive remained stable on the polyamide carpet and neither brittleness nor powder release were observed. The difference in the efficiency of the adhesive on synthetic and wool carpets comes from the rougher structure of the backside of the wool carpet.

Additionally, the flavonol quercetin or $FeCl_3$ were added to the initial paste formulation detailed in D3.3. The addition of quercetin resulted in a higher phenolation degree of lignin,

and the obtained paste adhesive showed good adhesiveness onto the backing of the polyamide carpet, while the addition of $FeCl_3$, which is capable of non-covalent complexation with polyphenolics, resulted in more brittle adhesive.

The addition of "external plasticisers", such as potatoe starch, chitosan and carboxymethylcellulose in the paste lead to adhesives with unsatisfactory flexibility and thus the obtained adhesives were not considered feasible for large-scale production.

The newly synthesized plasticisers, namely: lignin-based plasticiser (oleate ester of lignin), gallate-based plasticiser (oleate ester of octyl gallate) and galloyl oleate were introduced in the paste composition and good results were obtained in terms of flexibility. These new products were synthesised by enzymatic esterification, catalysed by lipase.

The best results in terms of bonding strength were obtained by introducing in the initial paste composition the following components: epoxidised linseed oil, hardener and silica. The obtained adhesive showed high bonding strength (91 N).

The most adhesive and flexible paste formulation was obtained by the addition of 4-arm-NH_2-PEG. However, the high price of that component (300$ per 1 g, from Creative PEGWorks) makes the paste adhesive economically infeasible. In the cases where amino-providers from natural or synthetic origin without long amino-terminating chains were added, the resulting adhesive was still too brittle.

In order to realize a more realistic price new tests were performed with the 100% linseed oil based paste. In collaboration with Hobum a competive and natural thixotrope agent was introduced in the paste. The thixitrope agent is very important in the paste, as it prevents the paste from going up to the carpets surface. For this six different trials were performed realizing a paste that meets the quality requirements at a price is more suitable (€ 3,- per kilo). In November 2015 a patent was filed for this paste composition. Hobum is shared owner on a 50/50 basis together with ERUTAN. With this D 3.3 was achieved.

In the meantime BWC has continued the extension of her premises and has created a production area for the backing line as such.

Partner James has built up a new collaboration with DSM; DSM/NIAGA. In the last year DSM/NIAGA also developed a new backing paste, a reversible PES Polymer adhesive, which can be applied to the carpet using a short backing line, which consumes very little energy. The adhesive can be washed out of the carpet totally after its lifespan, making it possible to fully retrieve all yarn that is processed in the carpet and recycle it into yarn that can be used in new carpet again. A carpet backing line for this new paste is now being built in Zwolle at DSM.

Based on the above mentioned developments the consortium has decided to perform an extra series of tests on the new backing line of DSM/NIAGA; it will be possible to perform tests with the ERUTAN paste on this line. After the new series of tests all parameters for the backing line will be clear and the backing-line in Best will be developed and built. The aim is to order the for ERUTAN adjusted backing line latest in the first quarter of 2017.

D 3.4 (M24) isn't realized yet, nor is D 3.5, D 3.6, D 3.7 and D 3.8.

Purchase of equipment

So far no equipment has been purchased since all larger trials were done at the pilot line in Grubbenvorst, which was available at the start of the program.

Other trials have been done at a trial production line from Lacom Vertriebs GmbH. Lacom is our partner to co-develop and build the full width backing machine. First trials on their line were done in August 2014. The results of these trails were disappointing compared with the trials done at the pilot line in Grubbenvorst. There wasn't enough pressure on the paste while applying it to the carpet. This lead to the uneven application of the paste.
This has led to further discussions with Lacom about the production line and the decision to first perform production scale tests on the backing-line of DSM/NIAGA.

First costs are expected when the design for the backing-line of Best Wool Carpets is completed, then the machine will be ordered. Planning is to finish the design of the backing-line before the end of 2016 and then order the parts for the new line.

Involved partners and their roles:

The project partners BWC, JMS and UPC are involved in this work package. Whereas BWC will take care of the production of ERUTAN-backing and carpets, JMS and UPC are working on the optimization of the adhesive on the pilot line at JMS facilities.

Subcontractors/stakeholders

BWC has subcontracted IM-aces instead of TNO, who was mentioned as a subcontractor in the Grant, in order to contribute to the development and up-scaling of the paste. IM-aces is a technology and innovation acceleration centre. Its added value can be found in different segments of technology and at any stage of innovation. We work together with Kees Weterings, a retired expert with proven references during his career, in his own field of expertise. Kees Weterings advises the group in how to extract lignin from potato peels and to mix the right components together in order to achieve the best results.

One of the stakeholders within WP3 is Duynie from the Netherlands. At Duynie Holding, part of the international group Cosun, everything revolves around the processing of organic by-products from the food industry in the best possible way. It is a continuous challenge to find new, better and smarter applications for the raw materials. Duynie's approach has proven its success and the company has grown into a versatile group with a wide range of activities operating under their own brand names in specialised market segments. Consequently, Duynie Holding evolves in a different way to its primary competitors. Duynie developed an extraction method for lignin from potato peels together with JMS and IM-aces. Persons involved are Ir. Derk van Manen (Manager QNR), Dr. Ir. Mike Litjens (Manager R&D) and Eric Bals (Sales and Marketing Manager).

Another stakeholder and supplier of the ERUTAN-paste is Hobum from Germany: HOBUM Oleochemicals was founded 1959 as Hamburger Fettchemie Brinckmann and Mergell GmbH. As former subsidiary of an oil mining and refining plant, the basic idea of this company was to develop new products based on vegetable oils and fatty acids for technical applications. Until today the company is processing renewable raw materials into very specialized oleochemicals and additives for the chemical industry. Top quality products from HOBUM Oleochemicals are the basis for further developments and successful applications in various fields of the chemical industry world-wide. HOBUM supported JMS in the development of the paste based on epoxidised linseed oil and provides not only the linseed oil but also the hardener. Persons involved are Dipl. -Kfm. Arnold G. Mergell (Geschäftsführer), Renate Polster (Geschäftsführerin), Dipl.-Chem. Dr. Michael Blumenstein (Forschung und

Entwicklung), Dipl. -Chem Dr. Jens Lüttke (Forschung und Entwicklung), Lutz Kämpfer (Anwendungstechnik).

Supplier of the backing machinery will be LacomVertriebs GmbH. This company is specialized in the most modern laminating machinery. The special way of laminating the paste as developed by ERUTAN can be built by Lacom in existing laminating technology.
Persons involved are Dipl.-Kfm. Techn. Jürgen Kiener (General Manager), Dipl.-Ing. Achim Schalle (Sales Director) and Steffen Kühn (Project Manager).

WP4: Life Cycle Analysis of ERUTAN

No activities have taken place for this work package yet.

WP5: Exploitation and Business Plan

D 5.1 – Business Plan version (M3) was finalized in M16. D 5.2 – Business Plan version 2.0 (M6) was finalized in M19. Version 2.0 isn't approved by the commission, to many questions remain unanswered. As these questions are still open, the business plan can't be adjusted in the proper way yet.
D 5.3 – Exploitation report version 1.0 (M18) and D 5.3 – Exploitation report version 2.0 (M30) can't be drawn up at this moment either.
Negotiations with the New Zealand Merino Company Limited are in process in order to come up with a long-term, 12 month stable and transparent pricing structure for wool (D 5.4). Goal is to finalise the negotiations before the end of May 2016 and set up a contract.
D 5.6 – Supply of ERUTAN treated wool into the supply chain hasn't been realized yet.
D 5.7 – Post-consumer waste management hasn't been taken care of yet.

WP6: Dissemination Activities

Project Information was updated in M19 of the project and made available on the web-site. This was originally planned in M12 (D 6.1). The next project information update will take place when the backing-line in Best will de ordered or an investor for the wool scouring plant will be found.
There was input requested by the Commission regarding additional common information material related to eco-innovation actions (D 6.2).
Several external Project Presentations were given by Chris Reutelingsperger of James (D 6.3).
The consortium decided that it's too early to draw up a Layman report (D 6.4) in this phase of the project.
Regarding D 6.6 – Publication of scientific and technological papers, the following progress can be reported:

- Aracri E, Diaz Blanco C, Tzanov T. An enzymatic approach to develop a lignin-based adhesive for wool floor coverings, Green Chemistry. 2014, 16 (5), 2597 - 2603.
- Article in Chemistry World Magazine - edited by the Royal Society of Chemistry http://www.rsc.org/chemistryworld/2014/02/carpet-lignin-adhesive-soil-fertiliser
- Article in C&EN News edited by the American Chemical Society:

http://www.cendigital.org/cendigital/20140303?sub_id=BFRUFsfr4EGaH#pg41

Besides scientific papers the following oral contribution to international congresses has been done:

- Aracri E, Diaz Blanco C, Tzanov T.
  Development of a lignin-based adhesive for wool floor coverings using laccase and natural phenols
  IPFB2014 - 8th International Conference on Polymer and Fiber Biotechnology
  25-27 May 2014
  Braga, Portugal

- Aracri E, Diaz Blanco C, Tzanov T.
  Laccase-catalysed functionalization of lignin to produce a novel, bio-based adhesive for wool floor coverings.
  International Conference on Biobased Materials and Composites, ICBMC'14
  13 – 16 May 2014
  Montréal, Canada

D 6.7 – Preparation of (commercial) brochures and flyers
One ERUTAN brochure was issued. The second planned brochure wasn't issued as the ERUTAN products are not market ready yet.

During the project the European fair Domotex was visited every year (total 3 times) in order to bring the ERUTAN philosophy to the market and find future partners (D 6.8).

Deliverables

Del. N°[1]	**Deliverable name[1]**	**Type[1]**	**WP N°[1]**	**Delivery date from Annex I [1]**	**Delivered (yes/no) and status (draft/final)**	**Sub-mission with report[2]**	**Forecas-ted deli-very date**	**Comments on progress**
D1.1	Project website and up-dates	Website	1	M3, M15, M27,M36	Yes (final, with regular up-dates)	PR1	M19	Web-site is up-dated continuously, last up-date M 19
D1.2	Project Management Guide	Report	1	M6	Yes (final)	PR1	M6	
D1.3	Interim report after 18 months	Report	1	M10	Yes (final)	PR1	M10	
Del. N°[1]	**Deliverable name[1]**	**Type[1]**	**WP N°[1]**	**Delivery date from Annex I [1]**	**Delivered (yes/no) and status (draft/final)**	**Sub-mission with report[2]**	**Forecas-ted deli-very date**	**Comments on progress**
D1.4	Progress Report after 24 months incl. monitoring performance indicators	Report	1	M24	No		-	Not executed with approval of commission

D1.5	Monitoring of the performance indicators	Report	1	M24	No			
D1.6	Final Report incl monitoring of the performance indicators	Report	1	M36	Yes	FR	M38	
D1.7	Monitoring of the performance indicators	Report	1	M36	No			
D1.8	Progress Report after 10 months	Report	1	M10	Yes		M10	
D2.1	100 kg of wool washed in 1 day	Report and test	2	M10	Yes			
D2.2	1.000 kg of wool washed in 1 day	Report and test	2	M15	Yes			
D2.3	1.000 kg of wool washed in 8 hours	Report and test	2	M25	Yes			
D2.4	10.000 kg of wool washed in 8 hours	Report and test	2	M30	No	-		
D3.1	At least 3adhesive precursors as per yarn and backing material selected	Technical description	3	M6	Yes (final)	PR1	M6	-
D3.2	Supply of adhesive precursors and enzymes guaranteed	Report	3	M6	Yes (final)	PR1	M6	-
D3.3	Optimized for industrial production paste composition	Technical description	3	M12	Yes (final)	FR	M38	Paste optimized for production, price at € 3,-/ kg
D3.4	Industrial scale-up of the pilot-backing line	An assembly line	3	M24	No			
D3.5	Optimized and reproducible enzymatic process	Implementation new process	3	M30	No			
D3.6	Guidelines for paste composition and its application depending on the yarn and backing material	Technical description	3	M30	No			
Del. N°[1]	**Deliverable name[1]**	**Type[1]**	**WP N°[1]**	**Delivery date from Annex I [1]**	**Delivered (yes/no) and status (draft/final)**	**Submission with report[2]**	**Forecasted delivery date**	**Comments on progress**
D3.7	Reproducible at industrial scale product quality	Production of the innovative material	3	M32	No			

D3.8	Report describing the production of the ERU-TAN-carpet and its sales by the end of the project	Report	3	M36	No			
D4.1	Goal and scope definition	Milestone	4	M30	No			
D4.2	Life Cycle Inventory Analysis	Report	4	M31	No			
D4.3	Life Cycle Impact Assessment	Milestone	4	M33	No			
D4.4	Report on LCAs	Report	4	M34	No			
D4.5	Critical review of the LCAs by an external expert panel	Report	4	M35	No			
D5.1	Business Plan version 1.0	Report	5	M3	Yes (final)	IR1	M17	
D5.2	Business Plan version 2.0	Report	5	M6	Yes (final)	IR1	M19	Not approved by commission
D5.3	Exploitation Plan version 1.0	Report	5	M18	No			
D5.4	Long-term stable pricing structure for wool	Report	5	M18	No			Negotiations are in process
D5.5	Exploitation Report Version 2.0	Report	5	M30	No			
D5.6	Supply of ERUTAN treated wool into the supply chain	Milestone	5	M32	No			
D5.7	Post-consumer waste management including a detailed description of the take-back system of ERUTAN-carpets to recycle	Report	5	M36	No			
D6.1	Project Information Updates (pre-defined)	Text, ppt	6	M1, M12, M24,M36	Yes (final)	IR1	M19	
Del. N°[1]	**Deliverable name[1]**	**Type[1]**	**WP N°[1]**	**Delivery date from Annex I [1]**	**Delivered (yes/no) and status (draft/final)**	**Sub-mission with report[2]**	**Forecas-ted deli-very date**	**Comments on progress**
D6.2	Inputs to additional common information material related to eco-innovation actions	Input to posters, articles for newsletters, visuals, interviews	6	On request by EASME	No	-	-	

D6.3	Project-presentations (pre-defined)	Ppt, presentation, participation in events	6	Upon request	No	-		
D6.4	Layman's Report	Brochure	6	M36	No			
D6.5	Evaluation Report	Report	6	M60	No			
D6.6	Publication of scientific and technological papers	Publications	6	Upon request	Yes (final)	IR1	M18	
D6.7	Preparation of (commercial) brochures and flyers	Flyers	6	Upon request	No	IR1	M28	New flyers and brochures will be issued when ERUTAN products are market ready
D6.8	Communication and or visiting of international fairs (addressing target group)	Visits	6	M2, M14, M26	Yes (final)			

[1] This information must be identical with your List of Deliverables in Annex I of your Grant Agreement.

[2]Please indicate the report with which you have submitted the deliverable (PR1, IR, PR2,…).

1.3 Deviations, problems and corrective actions taken in the whole project period

WP	Deviations and encountered problems	Mitigation of the problem
2	No new scouring machine was built due to financial difficulties with the external financial party, due to general economic conditions in Europe.	The partnership with Dawson was enhanced from wool supplier to full Erutan partner. Together we found the scourer Ariete willing to adjust their machinery for industrial production according to the new Erutan scouring process.
2	The price of lanoline has devaluated in such a way that it's no longer interesting to harvest and sell lanoline from the process. Besides that, the negative environmental impact of peroxide that is used in conventional scouring processes is no longer an issue; water cleaning companies now use the peroxide in fact in order to clean water.	It's therefore decided that it's not viable to invest in the reconstruction of a conventional plant into an ERUTAN production plant. An investor is now sought for the realization of a smaller, cheaper ERUTAN scouring plant that can be built up close to (a group of) farmer(s).
3	Pilot scale trials with the enzymatically-generated adhesive demonstrated its brittleness upon extensive usage of the carpet. The brittleness of the adhesive translates into unacceptable powder generation. Such effect is caused by the intrinsic brittleness of the lignin adhesive precursors additionally cross-linked by	To overcome the intrinsic brittleness of the lignin-based adhesive, the inclusion of external (not reacting with lignin) and internal (reacting with lignin) plasticisers have been exploited. Additionally, enzymatic pre-treatment for pre-activation of lignin introducing in its structure of smaller size natural phenolics expected to induce flexibility was assayed. Although, improving the flexibility the phenolation of lignin was still not

	the oxidative enzymes. Normally, excessive crosslinking, although providing high bonding strength (2-3 fold higher that the standard), results in higher brittleness.	sufficient to overcome the brittleness. In a second approach, natural-based epoxidized linseed oil plasticizer has been used. The combination of lignin and epoxidised linseed oil led to high bonding strength and lack of brittleness. Unfortunately it wasn't possible to reduce the price of this formulation to a market competitive level. Therefore, the linseed oil adhesive has been also further developed as a back-up, low-cost approach for carpet backing. This formulation now meets the quality restrictions and is market competitive with a price of € 3,- per kilo.
3	High price for large-scale production of the natural adhesive	Eliminating some of the most expensive ingredients of the lignin-based adhesive. Incorporation in the adhesive formulation of up to 50 % low-cost epoxidized linseed oil. Alternatively, development of a low-cost adhesive based on 100 % epoxidized linseed oil. Shortening of the backing process by 30 min, translated in lower energy costs.
3	Deliverable 3.3 was delayed due to the above problems	D3.3 is achieved using 100 % epoxidized linseed oil optimized for performance and price.

1.4 Progress regarding performance indicators

As no ERUTAN products are produced yet and the definitive parameters for the backing-line have not been set yet it's too early to determine the results on the performance indicators.

2 Evaluation of results

2.1 Results regarding market uptake and exploitation

Uptake of the scouring process

As it's not economical viable to invest in the turnaround of a conventional scouring plant in an ERUTAN scouring plant the consortium, together with Dawson, will investigate the opportunity to build small, low costs scour lines made out of plastic instead of steel that can be used in farming communities around the world.
Sheep farmers currently are getting a low price for their wool because it is a raw product that further needs to be processed.
When these communities are able to offer an end product through the sales network of H. Dawson they will enable to get better prices and ERUTAN will get more traceable wool.
To protect the interest of ERUTRAN we have secured the patent in the most important wool markets.
Our partner Danspin has lately invested a lot in their hank- and stock-dying facilities. Now this is finished they are interested to further investigate the process enhancing capacity of the micro air bubbles in their dyeing processes.

Uptake of the backing process

ERUTAN's carpet backing process will be operational in 2017.
The installation of the backing line is scheduled for summer 2017 and at the latest by the end of 2017, after which Best Wool Carpets can start producing carpet.
In 2017 Best Wool Carpets intends to produce 250.000m² carpet finished with the ERUTAN backing technology.
Once the machinery is operational partners intend to starts with its first 100.000 m² carpet finished with the ERUTAN backing technology.
In 2018 the planning is to produce 2.0 million m² of ERUTAN carpet by Best Wool Carpets and partners, who will join as soon as the machine is operational and all small changes have been done.
In 2019 it is planned that these manufacturers produce 5.0 million m² of ERUTAN carpet together.

2.2 Environmental benefits

Concerning the scouring process it the following environmental benefits can be addressed:

- There is an energy reduction in the production process as the temperatures required in the scouring baths are substantially lower than conventionally used temperatures.
- No chemicals are used in the process.

Concerning the backing process the following environmental benefits can be addressed:

- There is an energy reduction in the process as the ERUTAN paste doesn't need the long ovens that are used for conventional carpet backing.
- No waste; the yarn that is processed in the carpet backing can be retrieved and reprocessed into yarn that can be processed in new carpets again.
- No use of latex; latex needs vulcanisation and curing time in the oven which requires a lot of energy consumption.

Environmental benefits can't be quantified at this moment as figures aren't known yet.

ERUTAN is in line with environmental principled concerning waste reduction.

2.3 Economic benefits

It's too early to determine this.

2.4 Measures taken to ensure the autonomous economic viability of the business programme established in the project, beyond project lifetime and therefore after the EACI financial support has ended.

After the official project term has ended the consortium will continue with the project as before. All consortium partners are financial independent organisations. The backing line in Best will be built as intended.

3 Other issues (max 1 page)

4 Overview on hours spent

Please see the attached report.

5 Financial report

Please see the attached report.