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RESET – RESEARCH CENTERS OF EXCELLENCE IN THE TEXTILE SECTOR

GOOD PRACTICE HANDBOOK 2 (GP3 & GP4)

PROJECT NUMBER	RESET - PGI00016
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CONTACT PERSONS	ROMY NAUMANN / STFI romy.naumann@stfi.de PAOLO GUARNIERI / COMUNE DI PRATO p.guarnieri@comune.prato.it
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CONTENT

1. GENERAL INTRODUCTION

1.1 AIM OF THE RESET PROJECT

European textile and clothing sector is the most relevant economical source for the EU, accounting for 4% of the total added value of the manufacturing sector, with 173.000 companies and a turnover of 165 billion €. Its competitiveness is linked to increased investments in innovation and research both public and private which are key drivers for European companies to lead the market in the coming years. Due to its enormous environmental impact, sustainability and environment-friendly production it is emerging as a new driver of textile process and product innovation as well as technology development. The overall objective of the project is to generate a policy change in the implementation of regional policies and programmes of the Structural Funds related to the strengthening of research, technological development and innovation to assure the sustainability of the T&C sector in the partner regions. It will be achieved through policy learning and capacity building activities on public policies supporting innovative, green and sustainable T&C production and processes. The learning potential embedded in an **interregional exchange** will result in the **uptake of new Good Practices and projects by the partner regions** enabling to support excellence in R&D, to promote investments by enterprises, to develop innovative skills of T&C stakeholders, and in a deeper integration between research and innovation policies for the sector's sustainability. Sustainability driven research and innovation will concern primarily the production processes and product development and addresses **six key themes**:

// Recycling in textile and waste disposal
// Water consumption and energy saving, sustainable company organisations
// New sustainable chemistry, including reduction of chemical substances
// Smart textiles and new ways of production
// Eco-creativity, natural fibres, short value chains
// New materials and new applications

1.2 EXCHANGE OF EXPERIENCE VIA GOOD PRACTICE EXAMPLES

The policy learning process and the resulting improvement of policy capacity of partners and regions participating in the INTERREG Europe programme are based on collecting, analysing, disseminating and transferring Good Practices and policy experience (in economic, technological, social and environmental sectors), in order to transfer and implement Good Practices developed by other regions in one's own area. Good Practices are initiatives (e.g. methodologies, projects, processes and techniques) undertaken in one of the programme's thematic priorities. To be considered a Good Practice, an initiative has to fulfil the following conditions:

- to be relevant to the project's objectives
- to provide added value
- to be proved successful and to have tangible and measurable results in achieving a specific objective
- to have the potential to be transferred to a different geographic region, i.e. to be transferred and implemented without any significant adaptations and changes in other regional and/or economic contexts

Following the above mentioned key topics, six thematic seminars were planned within the RESET project (see table below). Each partner prepares a template in advance of the seminars where the proposed thematic Good Practice is explained following a certain scheme. During the seminars, this Good Practice example is presented more in detail to a broad audience from industry and policy.

No.	Title	Venue	Date
1	Recycling in textile and waste disposal	Alcoy (ES)	October 2016
2	Water consumption and energy saving, sustainable company organizations	Vila Nova de Famalicão (PT)	January 2017
3	New sustainable chemistry, including reduction of chemical substances	Bucharest (RO)	April 2017
4	Smart textiles and new ways of production	Chemnitz (DE)	June 2017
5	Eco-creativity, natural fibres, short value chain	Lodz (PL)	October 2017
6	New materials and new applications	Huddersfield (GB)	January 2018

After each seminar, all Good Practice examples are assessed by the project partners together with their regional stakeholders. Hereby, the Good Practice evaluation criteria follow the RESET methodology. The most important evaluation criteria are:

Evaluation criteria	Description
Strategic relevance	long-term impact on the policy theme
Evidence of success	tangibility (concrete results/outputs measured through indicators), durability (potential to become a durable model) and visibility (communication and dissemination activities)
Added value	effectiveness (tangible achievements and results of the practice and the resulting benefits for the different stakeholders), innovativeness, efficiency, (amount of resources required for the implementation of the GP)
Transferability	the potential of the practice to be adapted to and adopted in different contexts and regions (replicability) and transregional or transnational collaboration

To simplify the assessment process, a template for an easy evaluation of the GPs was developed by the partners (see Figure 1). An assessment score from 1 (least relevant) to 5 (most relevant) was introduced and the template is sent out by STFI (Exchange of Experience Manager in RESET) after each Interregional Learning Event (ILE) to be completed by the partners. Each partner has to assess the GPs for each topic concerning the above mentioned criteria.

	Dear partners, please use the present questionnaire to evaluate each GP according to the RESET methodology. *You can score the relevance of the GP for your region on a 1 - 5 scale:* *1 least relevant - 2 less relevant - 3 relevant - 4 very relevant - 5 most relevant*													
Policy Theme	**Title of Seminar**			**Name of project partner**										
	Title of the Good Practice	**Partner**	**Country**	**Municipality of Prato (IT)**	**NTT - Next Technology Tecnotessile (IT)**	**Lodzkie Region (PL)**	**CLUTEX - Cluster Technical Textiles (CZ)**	**AITEX - Textile Research Institute (ES)**	**TCoE - Textile Center of Excellence (GB)**	**STFI - Saxon Textile Research Institute (DE)**	**CITEVE - Technological Center for Textile and Clothing (PT)**	**INCDTP - National Research & Development Institute for Textiles and Leather (RO)**	**CETI - Centre of European Textile Innovation (FR)**	**Total Score for each GP (average)**
GP1														
GP2														
GP3														
GP4														
GP5														
GP6														
GP7														
GP8														
GP9														
GP10														
	Best GP examples (each partner)													

Figure 1: Good Practice evaluation template

A ranking of the scoring results has to be done and the two GP examples with the highest scoring will be presented in the **GOOD PRACTICE HANDBOOK.**

2. GOOD PRACTICE 3 “NEW SUSTAINABLE CHEMISTRY, INCLUDING REDUCTION OF CHEMICAL SUBSTANCES”

THEMATIC INTRODUCTION

The concept of sustainable chemistry encompasses the design, manufacture and use of efficient, effective, safe and more environmentally benign chemical products and processes. Recently, textile companies have been introducing advanced processing technologies to make textile processing greener and to reduce or eliminate water consumption. These include technologies with low process water need, the use of greener fibre and greener dyes and auxiliaries, eco-friendly, optimized and efficient processing and elimination of hazardous chemicals. Examples for sustainable textile processing concepts and related technologies include:

// Replacement of chemical processing by biotechnological processing through use of enzymes or other bio-organisms instead of chemicals

// Water-free textile finishing techniques such as digital printing and nano-coating by physical methods deposition

There will be similar examples of more environmentally friendly/sustainable products and textile processes for finishing, coating and laminating of textiles being developed in the partners’ regions and the RESET project will identify these good practices and their transferability in regional Action Plans.

2.1 SHORT INTRODUCTION OF 10 REGIONAL GOOD PRACTICE EXAMPLES ON “NEW SUSTAINABLE CHEMISTRY, INCLUDING REDUCTION OF CHEMICAL SUBSTANCES”

On 4th April 2017, the 3rd Thematic Seminar of the RESET project took place in Bucharest (RO) organized by RESET partner INCDTP (see Figure 2). Project partners as well as several European experts presented a series of Good Practices and results of actions related to “New sustainable chemistry, including reduction of chemical substances” (see Figure 3).

Figure 2: Impressions of 3rd Thematic Seminar in Bucharest (RO)

Policy Theme 3: "New sustainable chemistry, including reduction of chemical substances”- coordination by INCDTP (RO)			
	Title of the Good Practice	**Partner**	**Short Description**
GP1	**Methodologies and tools for chemicals management -** Maria José Carvalho, Technological Centre for Textile and Clothing of Portugal (CITEVE/PT)	CITEVE (PT)	The implementation of the methodologies and tools presented in this good practice (ZDHC tools, OEKO-TEX® products: STANDARD 100 (appendix 6) and DETOX TO ZERO and GM SUB tool), have no specific funding, so they must be financed by the user. In the case of the ZDHC tools they are available for free. The OEKO-TEX® products: STANDARD 100 and DETOX TO ZERO and GM SUB tool have a cost associated but depends on the type of company and its product or processes. In any of the cases, human resources are required to set up and to run any of the methodologies and tools, and if not yet available, they need to develop the specific skill in chemicals management.
GP2	**Biological exhaust air purification in textile finishing – pilot plant for biological elimination of cyanide -** Marco Sallat, Saxon Textile Research Institute (STFI)	STFI (DE)	Since 2006, STFI and its partners have gradually developed a market-ready technical solution for exhaust air purification for textile finishing processes using flame lamination. The aim of the work was to increase the environmental compatibility of the flame lamination by further developing a novel biological exhaust air purification process, in particular by stabilizing the biological conversion processes.
GP3	**Bicomponent spunbond nonwovens -** Thierry Leblan, Centre of European Textile Innovation (CETI)	CETI (FR)	In the framework of a private contract, our customer wanted to develop a new spunbond nonwovens product for various applications. The objective of this project was to develop a lofty spunbond nonwovens. Presently this kind of nonwovens is produced through the following process : choice of two fibres (one of them will be used as thermofusible fiber in order to consolidate the nonwoven by heating it, opening and preparation to carding); elimination of contaminants, blending, opening of fibers bundles; carding of the blend to obtain a web as even as possible; cross-lapping to get the target weight of the nonwoven; heating in a flat oven to bind the web and got the high loft nonwoven.
GP4	**Sustainable chemistry method to improve the wash-off process of reactive dyes on cotton** – Craig Lawrance, Textile Centre of Excellence (TCoE) Huddersfield	TCoE (GB)	Reactive dyes are extensively used for coloration of cellulosic fibres because of their excellent wash fastness (stability to washing with aqueous detergent solutions), which arises from covalent bond formation between dye and fibre. Existing and developmental Dye Transfer Inhibiting (DTI) polymers were employed to remove unfixed (hydrolysed) dyes. It was found that the use of DTI in the wash-off of reactive dyes enables a much more efficient, economical and sustainable process to be developed, which significantly reduces operation time, water consumption and energy consumption.

Policy Theme 3: "New sustainable chemistry, including reduction of chemical substances"- coordination by INCDTP (RO)			
	Title of the Good Practice	**Partner**	**Short Description**
GP5	**Detox: from threat for brands to opportunity for labs and manufacturers –** Fabio Guenza, Blumine srl	Prato (IT)	Several chemical substances have always been used to make clothes, which through water discharges and household care can be harmful for the environment and toxic for human health. To protect fresh and sea water resources, in 2011 Greenpeace launched the Detox campaign, aimed at having cleaner and toxic-substances-free fashion. The list of substances to be eliminated has grown to around 430 compounds now. In Prato cluster (Tuscany), local business association Confindustria Toscana Nord (CTN) has created a consortium to gathered together and support a group of 27 committed companies since early 2016 and launched CID, a Consortium for Detox Implementation, in October 2016.
GP6	**Medical antibacterial textiles obtained on a pilot line based on sonochemical process** - Daniela Anton, DAVO Star Impex SRL	INCDTP (RO)	The good practice addressed to production of medical antibacterial textiles, in order to prevent, control and reduce the nosocomial infections of patients and personnel in the hospital. Is known as the hospital-acquired infections are a major financial issue in the European healthcare system. The good practice directly addresses the above problems by developing a pilot line for the production of medical antibacterial textiles based on the scale-up of a sonochemical process developed and patented by Bar Ilan University(Israel) laboratories.
GP7	**Antimicrobial surface functionalisation of polylactide fibres** - Dawid Stawski, Lodz University of Technology	Lodzkie region (PL)	This good practise description reports on a barrier-forming compound, poly(2-(N,N-dimethyloamino ethyl) methacrylate)(PDMAEMA), deposited on a polylactide fibres in nonwoven textile. PDMAEMA is a mucoadhesive polymer, that can be cationic in acidified media or quarternized by using an alkylating agent. PDMAEMA can be attached to glass, paper, or textiles. The antimicrobial activity of PDAMA against gram-positive and gram-negative bacteria was reported by us and researchers earlier. Here, PDMAEMA layer was deposited on polylactide nonwoven surface and evaluated for its antimicrobial properties.
GP8	**MUFTEX - textiles for protective clothing and health care sector** - Miloš Beran, Cluster Technical Textiles (CLUTEX)	CLUTEX (CZ)	The main objective of the project is the research and development of textiles with new functional properties (functional samples) based on the combined solution by selecting the material structure and processing methods (proven technology), extend the offer to the specific requirements of the user committee and deepening consortium cooperation within the cluster.

Policy Theme 3: "New sustainable chemistry, including reduction of chemical substances"- coordination by INCDTP (RO)			
	Title of the Good Practice	**Partner**	**Short Description**
GP9	**Sustainable textile finishing using ozone and nanobubble technologies** - Oscar Calvo, AITEX & Victoria Puchol, Jeanologia S.L.	AITEX (ES)	Main problem addressed is the massive consumption of chemicals and water in textile finishing processes applied on fabrics or garments. Processes like desizing, bleaching, washing (roll-to-roll systems on fabrics) and dip-coating functionalization or dyeing (batch systems on garments) are currently developed by wet application systems and chemicals that require huge amounts of water and treatment of the waste-water released.This good practice (use of alternative chemistry like ozone for fabric treatment in a continuous way, and use of nanobubble technology for garment finishing) is able to reduce the chemical consumption -also water consumption- in comparison with traditional systems. The development and first stage implementation of the good practice and the involved technologies has been done through national and EU R&D projects, and last stage is the implementation on companies (direct selling and installation of finishing systems on textile companies).
GP10	**Integrated fashion project for eco-sustainable products** – Daniele Spinelli, Next Technology Tecnotessile	NTT (IT)	PIMECO project aims to realise products with high technological content and low level of environmental impact thanks to the combination of experiences and technology gained in different areas of fashion: textiles, tanning, footwear and furniture. The final goal of the project is to break down the manufacturing systems barriers in order to share the know-how and the various skills of the different sectors that compose the fashion industry. Through the combination of the data from the different sectors, it will be possible to get products that fully meet the market needs in terms of eco-sustainability. Studies carried out by the Research Centers of the Fashion Pole OTIR2020 have highlighted the following possibilities: leather "plus": anti-static, water-repellent and resistant to dirty; non-slip shoe-leather; products with special effects that currently are made only on hides and that are unknown to the textile sector; applications for the modelling footwear that optimizes the thermo-physiological comfort level.

Figure 3: Overview of GP examples on “New sustainable chemistry, including reduction of chemical substances”

Summary and notes of the Brokerage event

After the presentation of the regional GP examples, a Brokerage event and B2B meetings took place. GPs were discussed among the partners and participants. The main issues of this are listed below.

GP2. Biological exhaust air purification in textile finishing – pilot plant for biological elimination of cyanide

Marco Sallat, Saxon Textile Research Institute (STFI)

This GP was contacted by:

a) **Romania**: **Dr. Eng. Mihaela Stoica (Research &Development National Institute for Metals and Radioactive Resources from Bucharest)**: Discussion of possibility of transfer STFIs´ GP "Biological exhaust air purification in textile finishing" to other sectors with contaminated waste water containing cyanides (e.g. from mining recultivation sectors).

b) **Romania: Mihaela Ionescu (Webbing RDA at Autoliv Romania SRL**): Autoliv presented and explained the dyeing and finishing process of safety belts (webbing), question about possibilities of exhaust air treatments and energy saving, STFI proposed information about air treatment methodologies (e.g. scrubbing, oxidation via UV)

c) **Spain: Oscar Calvo (AITEX):** Question from AITEX how Spanish companies could implement the air purification technology presented by STFI. STFI could establish contacts with German plant manufacturers and with the Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB) (isolated bacteria strains); discussion on Spanish legal guidelines with critical values for pollutants.

d) **Czech Republic: Miloš Beran (CLUTEX):** Interest from CLUTEX in the presented GP from STFI, question if the mechanism is also suitable for other pollutants than cyanide, STFI explained that the bacteria strains must be able to decompose the structure of the pollutants

GP4. Sustainable chemistry method to improve the wash-off process of reactive dyes on cotton

Craig Lawrance, Textile Centre of Excellence (TCoE) Huddersfield

Following on from the Presentations of the Good Practices, TCoE had discussions with:

a) **Germany: Marco Sallat and Anna Grosse (STFI).** Marco asked for more details of the DTI Technology and details of the DTIs used. I promised to send him the PDF of the published paper from the Sustainable Chemistry Publication, as well as giving him the contact details of Dr Richard Blackburn at the University of Leeds who carried out the study.

b) **Romania: Doina Toma and Alina Popescu (INCDTP)** asked for more information regarding the use of DTIs in the dyeing process. I gave Doina a copy of the PDF of the published paper from the Sustainable Chemistry Publication, as well as giving her the contact details of Dr Richard Blackburn at the University of Leeds who carried out the study.

c) **Romania**: I had a discussion with representatives of **R&D National Institute in Chemistry and Petrochemistry/ ICECHIM from Bucharest:** regarding the use of DTIs and agreed to send a copy of the PDF of the published paper from the Sustainable Chemistry Publication, as well as giving them the contact details of Dr Richard Blackburn at the University of Leeds who carried out the study.

d) **Romania: Mihaela Ionescu and Bogdan Vasiliu (Autoliv Romania SRL, Brasov)** asked about the possibility of using the DTI Technology in the Disperse Dyeing of at the 1st wash off stage.

I gave them the details of the DTIs in use as well as a copy of the published paper and they were going to carry out experiments to ascertain the suitability of the technology.

e) **Romania: Drd. eng. Ioana Carmen Popescu and Dr.eng Mihaela Stoica** (**R&D National Institute for Metals and Radioactive Resources from Bucharest)** discussed with me the possibilities of fabrics or processes on fabrics for the prevention of exposure to ionizing radiation/sunlight. I agreed to send the details of the paper on the DTI technology and contact details for the MLSE Technology with a view to potential idea transfer.

f) **Spain: Oscar Calvo (AITEX)** was interested in the DTI Technology and whether it could be integrated into the Nano-Bubble Technology. I agreed to send him a copy of the paper surrounding the chemistry and he was going to try it. Oscar was also interested in carrying out a trial on the MLSE Technology and I promised to send him contact details of the MLSE system with a view to arranging the sending of a roll of fabric for treatment. Further, Oscar agreed to send me details of the Nano-Bubble Technology and how it could be used in the wider Textile Finishing Processes, especially regarding polyester, cotton, viscose and the suitability for use on wool.

<u>GP6. Medical antibacterial textiles obtained on a pilot line based on sonochemical process</u>

Daniela Anton, DAVO Star Impex SRL

This GP was contacted by:

a) **Italy: Fabio Guenza (Blumine SRL):** Fabio wanted to know the details about DAVO's business to see if it could be involved in the Detox business line. Our answer focused on a detailed presentation of DAVO's production activity and on the past and current research projects in which we have been involved for the last 10 years. Considering that we produce a wide range of clothing products for export and that a large part of our clients require products made of natural raw materials with "bio" finishes we would be interested in joining the DETOX group. More information on the requirements and steps to be followed are expected from BLUMINE SRL.

b) **Poland: David Stawski(Lodz University of Technology):** During the discussion, David wanted to find out more details about our involvement in the SONO project, given that his presentation was related to a new method of textile surface treatment in order to obtain antibacterial properties. Taking into account DAVO's collaboration with the University of Lodz in the past, the possibility of a future collaboration in textile research projects was discussed.

c) **Romania: Dr.eng Mihaela Stoica** (**R&D National Institute for Metals and Radioactive Resources from Bucharest):** The representatives of this Institute have shown interest in the technology of depositing antibacterial substances with ultrasounds. Starting from the sonochemical equipment at our headquarters and based on the experience of the specialists from the Institute, we discussed the possibility of engaging in a project to investigate the possibility of developing a new technology for textile surface treatment to obtain the necessary properties both on the clothing market and the market of special products (antibacterial; anti-dirt, etc.)

GP7. Antimicrobial surface functionalisation of polylactide fibres

Dawid Stawski, Lodz University of Technology

a) **Germany: Marco Sallat and Anna Grosse (STFI).** Question from STFI how the antimicrobial tests presented by Lodz University of Technology were performed in detail; Lodz University of Technology provided scientifical paper with detailed description; question from STFI if untreated PLA-samples also showed antimicrobial effects

GP8. MUFTEX - textiles for protective clothing and health care sector

Miloš Beran, Cluster Technical Textiles (CLUTEX)

a) **Spain: Oscar Calvo (AITEX)** – discussion about TEXAFLAM (product presented by CLUTEX) – IPR used on TEXAFLAM, possibility to get samples. Discussion about new project proposal based on TEXAFLAM product and finishing technologies presented by Oscar. Results of meeting has been transformed to the representative of INOTEX Company (Czech R&D partner)

b) **Romania**: **Carmen Ghituleasa (INCDTP)** – discussion about possible cooperation on new project

c) **Romania: Cornelia Loti Oproiu (R&D National Institute in Chemistry and Petrochemistry/ ICECHIM from Bucharest):** – discussion about possible cooperation on new project (flame-retardancy)

d) **Italy: Fabio Guenza (Blumine SRL):** Fabio presented „DETOX“ project and asked CLUTEX for "ecological aspects" of TEXAFLAM flame-retardant. It seems that TEXAFLAM meets all environmental requests (based on organic P/N chemistry, formaldehyde-free, VOCs-free (volatile organic compounds) halogen (Cl, Br) and antimony-free, heavy metals-free.

GP10. Integrated fashion project for eco-sustainable products

Daniele Spinelli, Next Technology Tecnotessile

NTT had discussions with:

a) **Romania: Irina Chican (R&D National Institute in Chemistry and Petrochemistry/ ICECHIM Bucharest, Romania):** We discussed about possible collaboration in the next H2020 calls. Interesting opportunities could be related to the following topics: ecological bioprocessing of wool fibers, functionalisation of textile surfaces, formulation of detergents and washing products, synthesis and test of new dyes.

b) **United Kingdom: Bill Macbeth (TCoE):** Discussion about possible applications of plasma technology to increase the properties of textiles. The goal is to explore the technology for smart textiles production.

c) **Germany: Marco Sallat (STFI):** Discussion about the application of plasma pre-treatment as good practice in new sustainable chemistry. The goal is the reduction of traditional chemicals use to increase the material performances according to market requests.

d) **Romania: Mihaela Ionescu (Autolive Romania SRL, Brasov):** was interested about the application of plasma pre-treatment for leather related to automotive sector.

2.2 ANALYSIS AND EVALUATION OF GOOD PRACTICE EXAMPLES ON "NEW SUSTAINABLE CHEMISTRY, INCLUDING REDUCTION OF CHEMICAL SUBSTANCES"

Following the evaluation methodology, the assessment template was sent to all partners for completion. After getting back the templates, the scoring results were calculated and a scoring table created (see Figure 4).

GP	Title	Partner	Total score
9	Sustainable textile finishing using ozone and nanobubble technologies	AITEX (ES)	39
2	Biological exhaust air purification in textile finishing – pilot plant for biological elimination of cyanide	STFI (DE)	36
4	Sustainable chemistry method to improve the wash-off process of reactive dyes on cotton	TCoE	33
6	Medical antibacterial textiles obtained on a pilot line based on sono-chemical process	INCTDP (RO)	29
7	Antimicrobial surface functionalisation of polylactide fibres	Lodzkie Region (PL)	29
8	MUFTEX - textiles for protective clothing and health care sector	CLUTEX (CZ)	27
5	Detox: from threat for brands to opportunity for labs and manufacturers	Prato (IT)	27
10	Integrated fashion project for eco-sustainable products	NTT (IT)	26
1	Methodologies and tools for chemicals management	CITEVE (PT)	24
3	Bicomponent spunbond nonwovens	CETI (FR)	24

Figure 4: "New sustainable chemistry, including reduction of chemical substances"

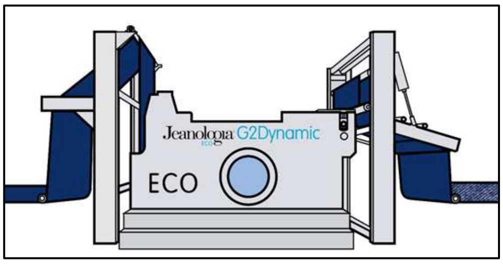
2.3 DETAILED DESCRIPTION OF THE TWO GOOD PRACTICES WITH HIGHEST SCORING

Following the scoring table (see Figure 4), the GP examples presented by project partner AITEX on “Sustainable textile finishing using ozone and nanobubble technologies” and STFI on “Biological exhaust air purification in textile finishing – pilot plant for biological elimination of cyanide” were selected by the partners to be the most relevant GPs. Detailed description of both examples follow below.

1. Sustainable textile finishing using ozone and nanobubble technologies (AITEX/ES)

Short description:

Abstract:



Main problem addressed is the massive consumption of chemicals and water in textile finishing processes applied on fabrics or garments. Processes like desizing, bleaching, washing (roll-to-roll systems on fabrics) and dip-coating functionalization or dyeing (batch systems on garments) are currently developed by wet application systems and chemicals that require huge amounts of water and treatment of the waste-water released. This Good Practice (use of alternative chemistry like ozone for fabric treatment in a continuous way, and use of nanobubble technology for garment finishing) is able to reduce the chemical consumption - also water consumption - in comparison with traditional systems. The development and first stage implementation of the good practice and the involved technologies has been done through national and EU R&D projects, and last stage is the implementation on companies (direct selling and installation of finishing systems on textile companies).

Resources needed:

An estimation of funding for set up and run this ozone technology could be: 350k - 400k €. Nanobubble technology for garment finishing (softening, functionalization, dyeing): 75k - 125k €.
Human resources: mechanical engineers and textile engineers.

Evidence of success (results achieved):

This practice is considered good as the R&D project results have been successfully industrialized and implemented in textile companies. For example: for nanobubble garment finishing technology 3 different processes (softening, functionalization and dyeing) are set-up in the same machine and validated. Quantified savings are:

- Savings up to 50% of chemical products
- Reduction of 86% of water consumption
- Reduction of 44% of energy consumption
- Elimination of 97% of wastewater

Difficulties encountered/lessons learnt:

Main difficulties encountered are: technologies still unknown by textile companies, both technologies require some adjustments/trials in order to find the right operation parameters for each textile substrate, some functional chemicals not set-up yet for nanobubble finishing (e.g. flame retardants).

Potential for learning or transfer:
Key success factors for transferring are: • Technologies/results proven not only at R&D stage but also at industrial level. • Restrictive legislation not applicable. GP fits environmental legislation and policies of different EU countries. • Funding required for implementation, size of the machinery and auxiliary installation devices are not so high. • Easy-to-operate technologies. • Key competitive technologies that provide not only environmental benefits (reduction of chemicals, water saving, less waste-water released, etc.) but also competitive benefits against processes and end-products developed by emerging non-EU countries. • Possibilities to launch R&D and cooperation projects at national/EU level. For nanobubble technology, transferring was done - firstly - in the frame of MNB-ECOFINISHING CIP-Ecoinnovation project: Pizarro S.A. (Portugal) was involved to scale-up the nano-bubble technology to the real industrial processes. Transferring has also been done to AITEX (Spain) few months ago.
Detailed description:
The textile finishing industry gives fabrics and garments their final appearance and properties. It employs traditional processes that are not environmentally friendly. Associated to water disposal, there are different chemicals used in preparation and finishing (desizing, bleaching, mercerizing, washing, etc.). These industrial activities have some environmental, on health and social/cultural consequences: • Chemical emissions, intensive use of water and energy resources, waste-water treatments required, etc. • Some chemicals used are toxic not only for operators (breathing problems, skin irritation/injuries caused by caustic chemicals, etc.) but also for end-users (skin allergies, etc.). • Rights of the working force sometimes not respected, poor working conditions, social gaps between regions/countries. In the case of ozone for fabric treatment and nanobubble for garment finishing (described here as a GP), both technologies promote a new vision of the textile industry: • Ozone 'Dynamic' technology is able to use only electric power and air for fabric finishing. • Nanobubble 'eFlow' technology is able to treat raw garments and apply different chemicals, transferring them employing micro-nanobubbles (MNB) as the vehicle of the chemical products, which can get inside the fibres directly. These technologies, taken as a GP, are not difficult to implement or operate. Skills on textile processes, textile finishing, engineering and chemistry would be required. This GP is focused on fabric and garment finishing, and a specific technology/process applies for each textile format. **Fabric finishing using ozone 'Dynamic' technology** Background of this part of the GP comes from eco-washers of garments that use ozone to soften or reduce colour in clothing producing and 'sun-washing' effect. Significant energy savings of water and the elimination of the need for toxic processes associated with bleaching were found. By upgrading and modification of the technology, it was developed a roll-to-roll ozone treatment for fabrics. It only uses air and electric energy in order to produce ozone (a powerful oxidant gas): vintage effects, fading looks, improved crocking, bleaching, cleaning, crystal-like flat look on denim and colour degradation are the main benefits. Then, it's possible to substitute oxidizing common chemicals (H_2O_2, other bleaching agents, etc.) by a natural oxidizing agent like O_3, with other environmental benefits like less waste-water releasing.

Garment finishing using nanobubble 'eFlow' technology

This part of the GP is referred to garment finishing. Current technologies for garment finishing are based on distributing the chemicals in a bath inside of industrial washing machines. Hence, great amounts of water, chemicals and energy are needed.

Different chemical products, like softeners, wrinkle-free resins, liquid repellants, antimicrobials, dyes, etc., whose functional properties need to be transferred to the garment, are employed. The innovative aspect by using this new technology is that such products get in contact with the garments with a minimal amount of water, being transported to the fibres through micro-nano bubbles by means of a flow of wet air.

Three common processes can be replied by this technology: conditioning processes (softening), functionalization processes (special/technical properties), exhausting processes (dyeing directly on garments).

Stakeholders involved:

Textile companies (weaving/knitting, finishing and garment manufacturers), chemical producers.

Legal framework:

- Directive 2008/105/CE, Water Framework Directive (WFD) and Directive for Integrated Pollution and Prevention Control (IPPC)
- Presence of harmful chemicals: Oekotex Standard 100
- CE marking

Analysis of the Good Practive:

Relevance of the Good Practice to the policy theme:

This GP has a direct impact on the Policy Theme 3 "New sustainable chemistry, including reduction of chemicals" of RESET project, as it promotes the implementation on innovative and eco-friendly finishing technologies for fabrics and garments. The main textile products to be treated with these technologies are mainly focused on denim and apparel, but not restricted, as new R&D projects focused on finishing of textiles for home applications, workwear, automotive, footwear, leather-based products, medical/health sector, etc. could be launched by EU textile companies, in order to develop new textile materials and processes. In this case, collaboration and networking between the technology owner, academic and R&D entities, chemical producers and textile companies will be required.

Evidence of success (tangibility, durability, visibility):

GPs tangibility: results and impacts on the partner's policy (e.g. through measurable indicators)

Results and impacts of the 'Dynamic' ozone technology are still being evaluated as the system could be optimized in terms of productivity, fabrics to be processed, etc. The tangible main results of the previous ozone system (for garments) were:

- Uses no liquid chemicals
- Savings of 67% of water
- Reduction of 85% of chemical consumption (ozone is considered as a chemical product)
- Savings of 62% of energy
- Reduction of 55% in production time

Results and impacts of the 'eFlow' technology are based on the MNB-Ecofinishing project main findings:

- 3 different finishing options (softening/conditioning, functionalization and dyeing)
- Savings up to 50% of chemical products
- Reduction of 86% of water consumption
- Reduction of 44% of energy consumption
- Elimination of 97% of wastewater

Success factors

- Technologies/results proven not only at R&D stage but also at industrial level
- Restrictive legislation not applicable. GP fits environmental legislation and policies of different EU countries
- Funding required for implementation, size of the machinery and auxiliary installation devices are not so high
- Easy-to-operate technologies
- Key competitive technologies that provide not only environmental benefits (reduction of chemicals, water saving, less waste-water released, etc.) but also competitive benefits against processes and end-products developed by emerging non-EU countries
- Possibilities to launch R&D and cooperation projects at national/EU level

Difficulties encountered and lessons learnt from the practice

Technologies still unknown by textile companies, both technologies require some adjustments/trials in order to find the right operation parameters for each textile substrate, some functional chemicals not set-up yet for nanobubble finishing (e.g. flame retardants), textile companies/operators sometimes don't respect the established procedure methodologies and recommendations for a right the machine work.

Remarks on the durability of the GP results and impacts

Proposed GP and technologies are considered as durable in terms of results and impacts, as they are mass-production systems that can also be customized under demand. There is a wide background of results and environmental benefits provided by both technologies (mainly on denim fabrics/garments) and unless opportunities for innovations in other textile end-applications are open: home-textiles, workwear, automotive, footwear, leather, etc. Eco-creativity, creative industries and design/fashion are other fields of the textile sector where this GP directly impacts, in terms of replicability and durability.

Possible leverage effect to trigger further improvements in policies and know-how

New R&D projects focused on new applications of the technologies involved in the GP could be launched, in order to finish/process not only textiles but also non textile-based materials and end-products. Policies focused on promotion of sustainable technologies for traditional manufacturing sectors, and promotion and strengthening of creative industries and their links with the textile sector (mainly finishing/confection subsectors) could act as main drivers of the textile innovation and development next years.

Added-value of the practice in terms of innovativeness, effectiveness and efficiency:

Added value of this GP in terms of regional and EU level is the replicability and the innovation level of the processes and technologies involved. In addition, the industrialization level of each technology promotes effectiveness and efficiency of the further implementation in textile companies around Europe.

Remarks on feasibility and transferability of the GP to other regional/local contexts:

Conditions for transferring the GP to other regions/countries should consider several issues:

- Machinery design, processing parameters, etc. should be fitted for each end-user (on demand)
- Chemical products and resources to be used for each technology should be taken in to account to avoid unexpected results on fabric/garment finishing or processing problems
- Installations and facilities are required, in terms of safety
- Technical skills and training of the people involved are required, in order to operate the machines properly
- Know-how and industrial property of the technology developed by Jeanologia to be taken into account

Long and short terms context impacts on GP feasibility and transferability in terms of economic, political, social and cultural environment, involvement of special competencies and skills Presented technologies are easily transferable and implementable in a short/mid-term because almost every textile finishing company (fabric or garment finishing) could use them. Both technologies present a great number of technical and environmental advantages compared to currently used technologies for fabric and garment finishing. For that reason, an open-minded point of view referred to new materials to be processed and interaction/collaboration with creative industries' partners are very important. Special competencies in chemistry, eco-design, textile finishing, technical textiles and design/fashion should be taken into account.
Further information:
• General information of the good practice (ozone 'Dynamic' and nanobubble 'eFlow' technologies) can be found on the website's manufacturer: **http://www.jeanologia.com** • Specific information about the nanobubble 'eFlow' technology can be found on: **http://www.mnbecofinishing.eu/**
Contact:
Name: Mr. Vicente Albert / Ms. Victoria Puchol **Organisation:** Jeanologia S.L. **Email:** vicente@jeanologia.com ; vpuchol@jeanologia.com

2. Biological exhaust air purification in textile finishing – pilot plant for biological elimination of cyanide (STFI/DE)

Short description:
Abstract:

Since 2006, STFI and its partners have gradually developed a market-ready technical solution for exhaust air purification for textile finishing processes using flame lamination. The aim of the work was to increase the environmental compatibility of the flame lamination by further developing a novel biological exhaust air purification process, in particular by stabilizing the biological conversion processes.

Thus it was shown that the biological elimination of cyanide using a bacterial mixed culture isolated from the Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB), despite the biocidal effect of cyanide, is fundamentally an alternative to the basically available, but cost-intensive chemical / physical elimination methods. In laboratory experiments with synthetic exhaust air, biological HCN elimination efficiencies of 80% could be achieved. Pilot experiments with 1 m³ reactors and real exhaust air confirmed the applicability and functionality of the process under practical conditions.

In 2009, two large plants were put into operation under STFI's scientific supervision at two sites. In the initially experimental mode, further, important influencing factors became apparent to the process stability, e.g. the additionally occurrence of biologically good or poorly usable substances (competing substrates, interfering solids) next to hydrogen cyanide. With the implementation of this exhaust air purification technology also in large scale and under real working conditions a solution for the compliance with the Federal Immission Control Act (limit values for HCN 3 mg/m³) could be provided for textile finishing companies using flame lamination processes.

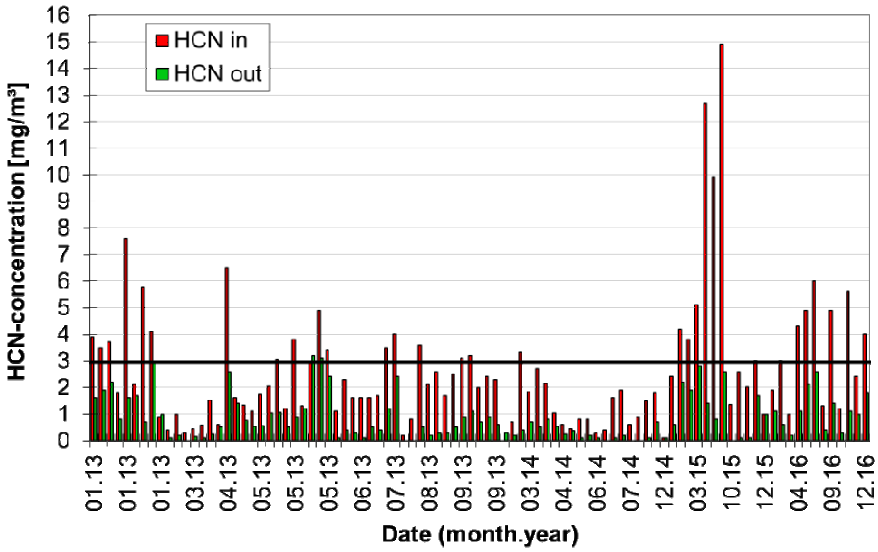
The collaboration with planners, plant and machine operators and licensing authorities ensured the further scientifically sound development of a novel process concept for the biological elimination of highly toxic cyanides from industrial exhaust air. Due to the political and (environmental) legal relevance of the topic, the responsible environmental authority as well as the trade association were involved in the R & D work right from the start.

Resources needed:

The biological air purification plants are custom-made, adapted to exhaust air volumes and load (content of cyanide) of the specific flame lamination plants. Therefore, the financial resources required to set up and run the practice differ from case to case. The maintenance costs are about 3000 to 4000 € / year for maintenance by external contractors. This includes checking and cleaning of measuring probes, valves, stopcocks, filters and pumps and cleaning the reactor interior and the column packing.

Evidence of success (results achieved):

The practice is considered as good since it provides a reliable cleaning of exhaust air from flame lamination processes by biological elimination of hydrogen cyanide / cyanide. The process operates very reliably and effectively when the optimum operating conditions are ensured. Emission limits for hydrogen cyanide in the exhaust air are complied with, see



. With an estimated 5,000 operating hours per year, emissions of 200 kg of hydrogen cyanide and 125 kg of dust per year can be avoided by the biological exhaust air cleaning at the locations examined and monitored by STFI. With an estimated 5,000 operating hours per year, emissions of 200 kg of hydrogen cyanide and 125 kg of dust per year can be avoided by the biological exhaust air cleaning at the locations examined and monitored by STFI.

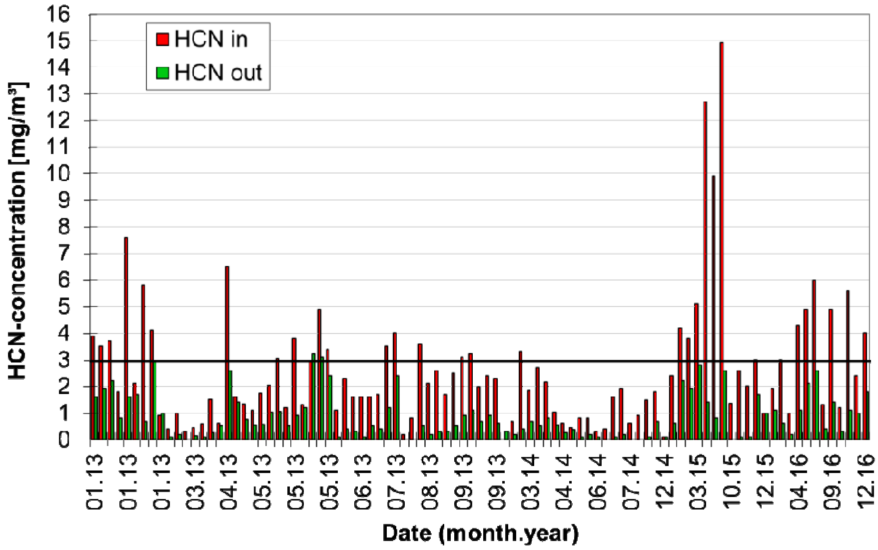


Figure 1: Emission values for a flame lamination plant during the year, emission limits (3 mg/m³) are complied with

Potential for learning or transfer:

The R & D work has created essential prerequisites for a successful market launch of the exhaust air purification process. One of the most important results here is the elaboration and derivation of plant specifications (operating conditions) and operating instructions to ensure high stability and functionality of the process. The plant operators can conclude on the operating state of their plant on the basis of the regular analysis of key parameters and their evaluation and if necessary, take appropriate measures for the problem elimination. The design and construction of the biological trickling filters need to be adapted to the local conditions (ambient temperature, air humidity, etc.)

and the specific flame lamination plant parameters. It is expected that due to the environmental relevance of the topic, the regional pilot character will reach beyond both Saxony and the textile sector. In Germany, currently around 32, in Europe estimated 50 flame lamination plants are operated, which can potentially be supplemented by biological exhaust air purification. In addition, the strategies for problem solving implemented in the project and parts of the developed technical solutions are also transferable to other industrial sectors (e.g. electroplating: detoxification of cyanide-containing sewage). One of the most important results here is the elaboration and derivation of plant specifications (operating conditions) and operating instructions to ensure high stability and functionality.

Detailed description:

Flame lamination is a highly economical and widespread process in the textile industry for the production of textile composites consisting of e.g. textile webs, artificial leather or foils with a foam layer in between. Main application fields for these structures are upholstery materials for the automobile industry (e.g. for car seats, door panels, roof liners), medical technology sector, furniture industry or insulation materials. The foam webs (primary made of polyurethane) are treated with an open flame coming from a gas burner and afterwards connected to the other layers. The resulting thin, sticky layer of the foam is used for bonding with a wide range of materials. The laminates provide a simultaneously achieved cushion effect. The advantages of the flame lamination are that no solvents or glues are needed and hence no outgassing of the materials will take place during their usage, the process is technically easy to control and allows very high production speeds compared to other technologies, e.g. hotmelt process.

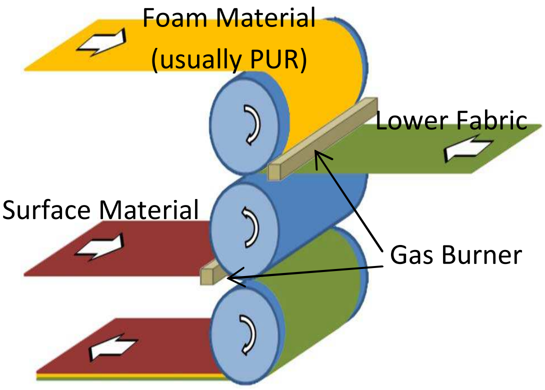


Figure 2: Principle of flame lamination process (left) and flame lamination plant (right)

During the flaming of the foams, exhaust gases are formed, which need to be removed by suctioning. The composition of the exhaust gases is extremely diverse. Nitriles, ethers, diisocyanates, aldehydes, halogenated hydrocarbons (CFCs), amines, chlorinated phosphoric acid esters and benzene and 1,2-dichloroethane can be present. However, special attention is given to the highly toxic hydrogen cyanide (HCN, blue acid) which is released during the processing of polyurethane foams. This makes a treatment of the exhaust air necessary. Released cyanides are highly toxic, soluble in water and classified as highly water-endangering substances. Toxicity is based on the blockade of tissue respiration in living beings by inhibition of enzymes. In order to protect nature and the environment, to safeguard viable working, residential and recreational areas, minimizing or avoiding such harmful biocidal emissions is required.

<u>Currently various methods are known for cleaning exhaust air containing cyanide:</u>

- Thermal treatment
- Oxidation in the low temperature plasma
- Catalytic detoxification using Cu-doped activated carbon

- Absorption of HCN in the basic medium (for example, in sodium hydroxide solution) and subsequent chemical detoxification via oxidation (with hypochlorite or hydrogen peroxide)
- Biological elimination

According to STFI´s own research, technical solutions for exhaust air purification have so far been installed at four of Germany's approximately 13 production sites with flame lamination. Thereof 2 are based on the biological process, one is performed chemically and one with the low temperature plasma technology. The high requirements for a technical exhaust air purification process are regarded as essential reasons for the low implementation of exhaust air cleaning measures for flame lamination.
STFI has developed a biological exhaust air purification process for treating cyanide-containing emissions from the process of flame lamination as a cost-effective and resource-saving alternative to chemical / physical methods. The establishment of a biological exhaust air purification process in the textile industry as an energy-efficient cleaning technology represents an innovation.

The advantages of the biological elimination method compared to the other processes are:

- No use of hazardous substances such as acids, alkalis, oxidation or reducing agents
- Exhaust air purification is performed at ambient temperatures; additional power supply is only needed for sprinkling and, if necessary, frost protection heating → sustainable and energy efficient process
- Real (biological) degradation of the problematic emission of hydrogen cyanide (no transformation into other problematic substances or transfer of the problem into waste water)
- Plant engineering is robust against dusts and accompanying emissions; dusts are separated by the waste gas scrubbing and can be disposed together with the resulting excess biomass
- Potential degradation of (previously) unknown non-target substances possible
- Low maintenance (1-2 plant maintenance per year at 24/7 operation)

Detailed content and working of the Good Practice

The main content of the Good Practice was the development of a novel process concept for the biological elimination of highly toxic cyanides from industrial exhaust air of flame lamination. The process was developed starting from lab scale, over pilot scale up to large scale.

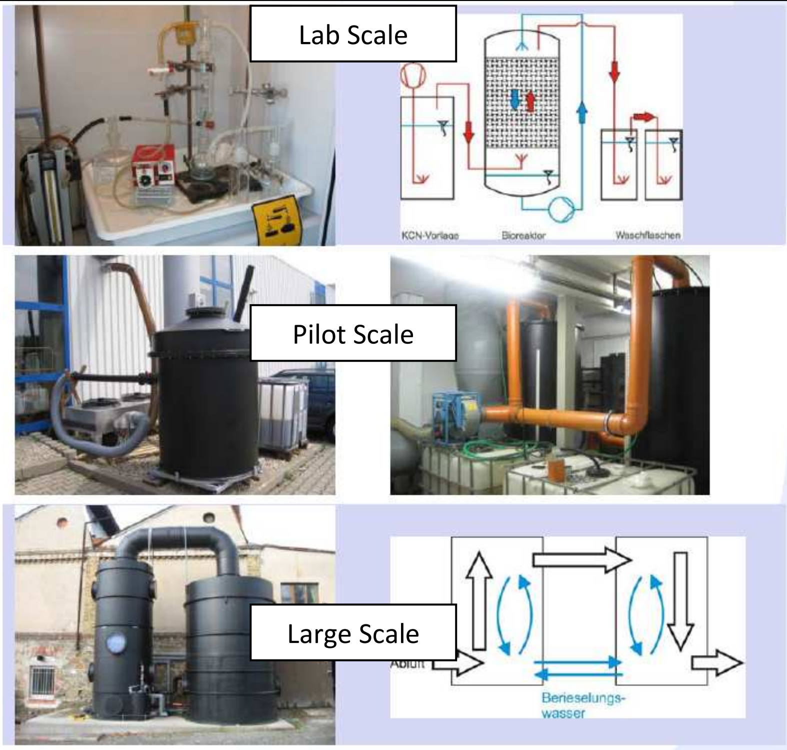


Figure 3: Biological exhaust air purification in lab, pilot and large scale

The exhaust air purification process is based on a biological trickling filter which is a combination of a biofilter and a bioscrubber for biological sewage or waste gas purification. The carrier material in the bioreactor consists of an inert material such as, for example, synthetic materials and is necessary for the absorption of the harmful substances and / or odours originating from the feed stream. The microorganisms immobilized in the filter material are then circulated with the exhaust air and the toxic substances are degraded into non-toxic substances or low-molecular-weight substances and new biomass is formed. The necessary nutrients for the microorganisms and the moisture are supplied via a sprinkling process.

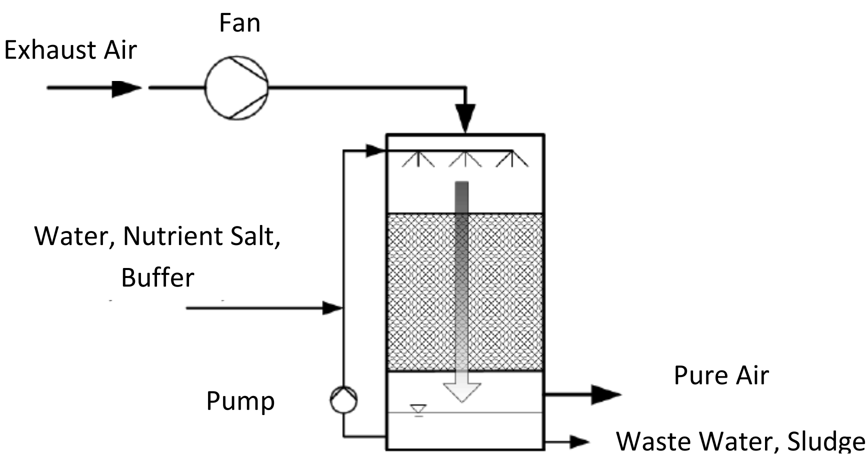


Figure 4: Principle of a biological trickling filter

The bacterial strain KS-7D isolated by scientists at the Fraunhofer Institute, which is a mixed culture of Cupriavidus basilensis and Cupriavidus eutrophus from the Burkholderiaceae family, is able to degrade cyanide and was used as microorganism in the biological trickling filter. The degradation occurs by cleaving cyanide by the enzyme cyanide hydrolase and producing ammonia and formic acid. The isolated strain KS-7D is able to use both products as nitrogen or carbon source. Moreover, this mixed culture is very tolerant to cyanide and can withstand concentrations up to 1.4 g cyanide / liter (55 mM).

After the use of bacterial strains in the biological trickling filter at laboratory scale and testing of their effectiveness in the cyanide decomposition, the process was extended to a pilot plant. There, both relevant process parameters and first optimal operating conditions have been identified: air flow, temperature within the reactor, retention time of exhaust air within the reactor, load of HCN, nutrition supply, pH, humidity. Then, the process was extended into a large plant and controllable conditions were created. The following objectives were achieved: reduction of pH fluctuations, adjustment of the carbon dosage, increasing irrigation water temperature and reactor temperature, regulation of excess biomass, interception of stress peaks.

Stakeholders involved:

Due to the crosslinking of the fields of machine- textile- and process-technology, personal protection, bio-technology and environmental protection an interdisciplinary approach for the problem was needed. In addition to the directly affected textile companies (C. H Müller GmbH, Vowalon® coating GmbH, Kunz-Textil GmbH), companies from the environmental engineering sector (plant and ventilation builders: UGN Umwelttechnik GmbH) and research institutes (textile, biotechnology: Sächsisches Textilforschungsinstitut e.V., Fraunhofer Institute for Interfacial Engineering and Bioprocess Engineering) as well as suppliers (Otto Bock Schaumstoffwerke GmbH) were very actively involved in the problem solving. In addition to financial support, immediate support was provided by material positions as well as an extensive transfer of knowledge through e.g. deep insights and availability of company and production data. Due to the political and (environmental) legal relevance of the topic, the responsible environmental authority as well as the trade association were involved in the R & D work right from the start.

Legal framework:

The "TA Luft" is the "First General Administrative Procedure for the Federal Immission Control Act" of the German Federal Government. It contains, inter alia, calculation rules for essential air pollutants and creates legal requirements for plants which need an approval for installation by the German Ordinance on Installations. The technical manual “TA Luft” existing since 1986, reduced the limit value for hydrogen cyanide in 2002. This substance is currently subject to Class II of the Federal Immission Control Act (for gaseous, inorganic substances) of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety of 24 July 2002. HCN is indicated in this class with a concentration limit value of 3 mg/m³ (formerly 5 mg/m³) and must be observed without condition since 2007.

Analysis of the Good Practive:

Relevance of the Good Practice to the policy theme:

The Good Practice presented by STFI has impact on the policy theme “New sustainable chemistry, including reduction of chemical substances” in terms of providing a resource efficient and energy saving biological exhaust air purification process specifically for cyanide that works without any additionally needed chemicals at relatively low energy supply. At the same time this technology provides companies with flame lamination plants the possibility to comply with legal requirements regarding the cyanide values stated in the “First General Administrative Procedure for the Federal Immission Control Act”. Classical exhaust air purifications as end-of-pipe processes do not interfere directly with the textile finishing process and therefore cannot contribute to the increasing of production or production cost reductions. On the contrary, if it is not possible to reduce the cost of exhaust air purification e.g. through energy saving measures or changes in production, the additional costs must be transferred to the produced goods. These are the reasons why there is a great interest in cost-effective solutions from an economic point of view.

From the point of view of environmental policy, it must be added that the majority of the costs for the cleaning of the exhaust air result from energy and material requirements. The further development of the biological process for cyanide elimination as an alternative to chemical / physical techniques can contribute to the conservation of these resources since biological processes operate at a comparatively low energy level and are natural degradation processes. Moreover, a problem shift like accumulation of contaminants in process-water or in sludge is avoided, since the toxic components are actually decomposed in this case.

Evidence of success (tangibility, durability, visibility):

- **GPs tangibility: results and impacts on the partner's policy (e.g. through measurable indicators)**

The results obtained provide a scientific step towards the development of textile technology, machine and application technology as well as biotechnology and process engineering. They also contribute to a successful acquisition of future R & D projects. This is expected to increase the reputation of the STFI e.V. as a research and testing institute as well as a consultancy service provider. National and international cooperation on industrial level including transfer of knowledge and know-how is one of STFI's main concerns. The innovative character of the developed technology could bring thus benefit to other partners or regions. From a technological point of view, the described Good Practice is transferable to other regions provided that the requested investment for machinery is available.

- **Success factors**
  - Clean air, elimination of toxic cyanide contaminations
  - Environmental friendly process
  - Admission of both the exhaust air treatment plant and the biological treatment process by authorising agency
  - Safeguard of (regional) employment in textile industry (production via flame lamination can be continued)
- **Difficulties encountered and lessons learnt from the practice**

The high requirements for a technical process are regarded as essential reasons for the low implementation of exhaust air cleaning measures for flame lamination plants. In this way, the present conditions, such as discontinuous production regimes and the associated fluctuating emission of pollutants, the content of further harmful and problematic substances (dust and particulate matter attack) as well as the high volumetric flows in the extraction of exhaust air complicated the technical developments. In addition to the strongly fluctuating emission density, the actual biocidal effect of the hydrogen cyanide problem was the particular challenge from a biotechnological point of view.

Difficulties:

- Influence of temperature on biological elimination of HCN
- Diverse composition of the exhaust gases → further nitrogen input due to other combustion products in the exhaust air (too much nitrogen for bacteria strains) → risk that total amount of HCN can´t be decomposed
- Growing biomass
- Enrichment of particles by combustion (→ blocking of trickling filter)

Lessons learnt:

- Avoidance of both drastic variations in temperature and temperatures below 10 °C
- Regular monitoring of nitrogen content and adaption and continuous dosage of carbon source
- Continuous removal of sludge by bypass-sedimentation

- **Remarks on the durability of the GP results and impacts**
  - Process of HCN elimination is stable since process conditions are well-adjusted (→ less extreme situations)

- As the plants are located outside, cold temperatures (<10°C) affect the elimination process (permanent frost is very critical) which has also impact on the reliability of the air purification process • **<u>Possible leverage effect to trigger further improvements in policies and know-how</u>** - Publication/communication between regional authorising agencies (publicity) - Consideration as best available technique (BAT) in European BREF documents should be aspired
Added-value of the practice in terms of innovativeness, effectiveness and efficiency:
• Gaining expertise in a specialized technological field • Establishing innovative technologies • Industrial up-scaling of energy-efficient technologies • Complying with international legal requirements regarding the cyanide values in exhaust air • Saving of energy and processing time → protection of the environment • Transferability of Good Practices to other regions • Improvement and adaption of machinery and equipment for worldwide application
Remarks on feasibility and transferability of the GP to other regional/local contexts:
• Investments for establishing machinery systems and equipment to build up a purification plant and for its connection with existing finishing plants • Availability of needed raw materials (bacterial strains, filling material for the biological trickling filter, etc.) • Existence of a market for functionalized technical products and flame coated laminates • Acquisition of customers and establishment of a customer network • Training, education and know-how transfer by specialists and experts • Long and short terms context impacts on GP feasibility and transferability in terms of economic, political, social and cultural environment, involvement of special competencies and skills.
Contact:
Name Marco Sallat Organisation Sächsisches Textilforschungsinstitut e.V. Email marco.sallat@stfi.de

3. GOOD PRACTICE 4 “SMART TEXTILES AND NEW WAYS OF PRODUCTION”

THEMATIC INTRODUCTION

Smart or intelligent textiles are considered as a new generation of textile products actively providing support in fields like safety or health. One of the main reasons for the fast growing development of smart textiles during the last years is the attention of and the importance for research and industry. Smart textiles can be used for very different applications and under extreme weather conditions. They are able to monitor and to think for themselves and are sensitive towards manifold environmental infl uences. Key areas of development are seen in nano-fibres, hybrid fabrics, further miniaturization of electronic components and the increased application of electronic textiles in innovative wearable products. Furthermore, the focus will be on developments for the health care sector. Biomedical applications have been forecast as one of the fastest growing end-use markets.

3.1 SHORT INTRODUCTION OF 9 REGIONAL GOOD PRACTICE EXAMPLES ON “SMART TEXTILES AND NEW WAYS OF PRODUCTION”

On 20th of June 2017, the fourth Thematic Seminar of the RESET project took place in Chemnitz (DE), organized by RESET partner STFI. Project partners as well as European experts presented a series of Good Practices and results of actions related to the topic smart textiles and their applications carried out in the main textile manufacturing regions of the EU.

Figure 5: Impressions of 4th Thematic Seminar in Chemnitz (DE)

Policy Theme 4: Smart textiles and new ways of production			
	Title of the Good Practice	**Partner**	**Short Description**
GP1	**SmartArmour – new idea of the smart personal protections** – Marcin Struszczyk, Institute of Security Technologies MORATEX	Lodzkie region (PL)	Currently, ballistic body armour consists of inserts of 20-50 layers of para-aramid textiles with optional ceramic, metallic or composite inserts. These structures make the body armour heavy and bulky and uncomfortable. In many scientific and R&D centres, researchers are exploring new technologies to improve soldiers' safety and comfort. One promising technology is "Liquid Body Armour". Research objective was focused on designing modern nanostructural body armour with application of rheological fluids and implementing it into the industrial practice. The designed products are applicable for: end users of the ballistic protections; manufacturers of the ballistic protections responsible for implementation of modern solutions into industrial practice; scientific institution as a user of the new generated knowledge for the commercial utilization of the smart textiles products made of the new generation materials and fibre technologies.
GP2	**Seab2 - Clothing system with integrated inflation** – Gilda Santos, Technological Centre for Textile and Clothing of Portugal (CITEVE)	CITEVE (PT)	The development of SeaB2 (Clothing system with integrated inflation) - a smart protective garment with an inflation device completely unnoticeable and automatically inflated when it hits the water, that combines functionality with an appealing, comfortable and practical design is of high importance for the safety of maritime environment users. As a part of regular clothing (jacket, overalls or vest) allows the user to swim and access the nearest vessel or platform, preventing deaths due to the negligence in the use of uncomfortable and restrictive life jackets existent in the market. SeaB2 promises to revolutionize the security in maritime activities - is used as a part of regular clothing (jacket, overalls or vest) being completely unnoticeable, combining functionality with an appealing, comfortable and practical design.
GP3	**Smart socks for sports and medical applications** – Thomas Lindner, Strumpfwerk Lindner GmbH	STFI (DE)	It looks like a normal sock, feels like a sock and is easily washable in the machine. A Saxon development, the smart sock, has a decisive advantage over conventional socks, it can communicate. Eight ultra-thin pressure sensors, embedded in a gel layer between two textile layers, report pressure distribution and acceleration of the foot to an App. With a mini-computer that can be connected with the sock, it shows the wearer/ patient how he strains his feet using real-time data. If the load is too high or unilateral, the App will be alarming. Researchers and companies see applications fields in medical technology,application in pain and accident therapy and also in performance and recreational sport.

Policy Theme 4: Smart textiles and new ways of production			
	Title of the Good Practice	**Partner**	**Short Description**
GP4	**Smart textiles for wearable technology** – Craig Lawrance, Textile Centre of Excellence (TCoE) Huddersfield	TCoE (GB)	With a growing demand for wearable technologies in many diverse sectors, e.g. leisure, defence, medical applications, assisted living, the need for smart textiles is growing at a rapid rate and requires better, faster and more reliable connectivity to ensure the technology implanted into the textile fabric performs at a premium. As demands for electronic connectivity's grow, new methods of controlling electrical signals or pulses are being developed to meet these requirements. The textile manufacturing process of fabrics, e.g. woven, knitted, non-woven does not always lend itself to ensuring these properties are met and each fabric forming system creates its own challenges in the use of them as communicative technology. As traditional methods of creating fabrics with conductive threads becomes increasingly more difficult to ensure a constant connectivity can be maintained, new methods are required to meet the needs of this rapidly growing sector. The Good Practice of Nano Silver Impregnation/Electro less plating can be one of these new methods that are overcoming the traditional method. The technology works across all fabric formation techniques and can withstand many laundry cycles, overcomes the connectivity issues that plague the normal fabric forms when these are bent, twisted, stretched, pulled etc. out of their normal plane.
GP5	**Nanostructured textiles to promote cell growth in severe burn injuries** – Pilar Sepúlveda, Instituto de Investigación Sanitaria La Fe, Valencia & Òscar Calvo, AITEX	AITEX (ES)	This GP involves electrospinning technology, bio-compatible polymers, cell culture and in-vitro/animal in-vivo modellization and validation. It starts with the development of bio-compatible poly (D,L-lactide-co-glycolide) (DLPLG) nanofiber webs through electrospinning technology (monoaxial). This nanostructured textile biomaterial is used as a scaffold for cells in order to promote their growth. Nanofibers are able to integrate into fibrin matrix and they are permeable to nutrients and cells and, in addition, these new dermal equivalents with nanofibers are optimal for clinical handling. The nanofiber scaffolds are used, then, for cell culture and growing of dermal cells (fibroblasts and autologous keratinocytes) is tested using in-vitro and in-vivo animal models. The biological characterization of these nanotextile-based biomaterials show that new dermal equivalents have angiogenic capacity (it promotes formation of new blood vessels) and they improve scar quality, less tension, smooth surface of the 'new' skin.
GP6	**Kompozitex – Emergency evacuation kit** – Kateřina Bartošová, Nyklíček a spol. s.r.o.	CLUTEX (CZ)	The project Kompozitex followed the previous project Betex, which was focused on fabrics protecting from high frequency electromagnetic radiation. Here the know-how about electromagnetic shielding was gained and it was decided to develop it further in a new project. The well-established consortium ran the project Kompozitex –

Policy Theme 4: Smart textiles and new ways of production			
	Title of the Good Practice	**Partner**	**Short Description**
			Composite textile materials for protection of humans and devices against the effect of electromagnetic and electrostatic fields.
GP7	**Manucoat: Photocatalytic self-cleaning textiles** – Claudia Niculescu, National Research & Development Institute for Textiles and Leather (INCDTP)	INCDTP (RO)	The good practice addresses a new way of production for obtaining textiles and wood surfaces with self-cleaning, antibacterial and antifungal properties. In the MANUCOAT project two new ways for technological manufacturing processes of textile materials with self-cleaning properties in visible solar spectrum, antibacterial and antifungal properties were developed. One of method developed by MGM STAR Construct (Romanian SME), are used vacuum plasma and RF/DC sputtering technology for deposition nanoparticle on the textile and wood surfaces and another method developed by IRIS (Spanish SME) are used atmospheric plasma and electrospray for deposition nanoparticle on the textile surfaces.
GP8	**Smart textiles with odour absorption properties** – Lorenzo Giusti, Next Technology Tecnotessile	NTT (IT)	This research project was focussedon the development of a smart textile able to have a good impact on the market by offering furnishing fabrics with useful and innovative properties. The anti-odour textile should be able to attract costumers belonging to premium market segment by ensuring distinctive characteristics not easily available in other market's products. The development of a functionalization process able to ensure odour absorption properties textiles started from the selection of the active compound. The chemical substance used to give smart properties to the textile was selected considering functionalization process, final cost and odour absorption capabilities.
GP9	**From Wearables to smart textiles - From performance to emotion** – Thierry Le Blan, European Centre of Innovative Textile	CETI (FR)	The GP has been developed In the framework of a French collaborative project and of a private contract. The objective of the collaborative project named AUTONOTEX was to develop first bed sheets for patients with Alzheimer disease and to design some smart work garment autonomous in energy production for the sensors, the data collection and the data transfer. During these R&D works the GP was to begin the development by defining precisely the needs of the "customer" without taking account of the technological possibilities. The goal is to evolve from the research of the performance of captors which drives to a diagnostic to the measurement of the well-being of the person (patient, worker or customer) and its emotions. This is done with the help of a special software which offers a method for this step.

Figure 6: Overview of GP examples on "Smart textiles and new ways of production"

Summary and notes of the Brokerage event

This summary presents the key points retrieved from the brokerage event between the stakeholders and the audience of the seminar. It was compiled by STFI with the contributions from the stakeholders presented the GPs on smart textiles.

GP1: SmartArmour – new idea of the smart personal protections

Marcin Struszczyk, Institute of Security Technologies MORATEX /Lodz (PL)

During the thematic seminar "Smart textiles and new ways on production" which was held in Chemnitz in June 2017, Lodzkie Region was represented by MORATEX with the good practice "SmartArmour - new idea of the smart personal protection equipment". The seminar included **B2B meetings** with **STFI (Germany), CITEVE from Portugal and TCoE - Textile Centre of Excellence (United Kingdom).** The range and possibilities of applying good practices has been specified and discussed with partners potentially interested in the transfer of good practice. Moreover, other potential areas of cooperation, including the area of designing and manufacturing the lightweight structural composites under the ESA or EDA-funded projects were discussed with STFI and CITEVE.
The stakeholders from the Lodzkie Region were also interested in the details of a good practice presented by INCDTP "Photocatalytic self-cleaning textiles" and the materials with TiO_2 nanoparticles were discussed. Authors used two methods of titanium dioxide deposition - sputtering and electro spraying. They obtained material not only with barrier and antibacterial properties, but it is also self-cleaning fabric. It was achieved thanks photocatalytic effect of TiO_2 nanoparticles (see GP 7).

GP2: Seab2 - Clothing system with integrated inflation

Gilda Santos, CITEVE - Technological Centre for the Textile and Clothing Industries of Portugal (PT)

This GP was contacted by:

a) INCDTP (RO) / Doina Toma and Claudia Niculescu

Question 1: How this automated inflation works?
Gilda Santos informed there is a sensor capsule that is dry and when becomes wet, in contact with the water, inflates automatically the life vest.

Question 2: Does the light sensor work in the same way?
Yes. Also, the light is connected with a sensor that in contact with water turn on the light.

Romania suggested that the idea is very interesting because it could be included in different parts of clothing, as also could be transferable, for instance, for parachute that landing in the sea or oil platforms with small changes!

b) AITEX (ES) / Oscar Calvo and Gilda Santos

Question 1: Oscar Calvo asked if the company is commercializing the product. Gilda answered yes, they are starting now, and even the certification of the product is under work.

Question 2: How the system is activated? It is activated automatically in contact with water.

Question 3: Oscar also asked if the company received other type of requests from potential users, for instance improve the suit for heating avoiding hypothermia. Gilda answered yes and it is already developed.

GP3: Smart socks for sports and medical applications

Thomas Lindner, Strumpfwerk Lindner GmbH (DE)

There were no special questions concerning the presented GP, but discussions about potential future cooperation between the project partners.

a) CLUTEX (CZ) / Mr. Miloš Beran and Nyklicek a spol. s.r.o (CZ) / Katerina Bartosova

Discussion about shielding properties of presented woven products for different applications:

- Consumer (electro-smog mobile phones etc.)
- Technical applications (shielding of machinery in carbon fibre processing)

Discussion about combination of fire-resistant and shielding properties for special applications:

- Larger battery bags (Ion-lithium-batteries in flight and other transports)
- Transport of dangerous goods/materials

(IDEA behind: Preparation of a CORNET project for DE-CZ-Cooperation when suitable topic/scientific relevant task could be identified)

b) Lodz University of Technology (PL) / David Stawski and Lodz Region (PL) / Monika Urbaniak
Discussion was done about cooperation concerning a project idea to be submitted in German BMBF call MOEL/SOEL in 2017 (when successful, STFI would be supported by BMBF to prepare an EU proposal with topic RRI (Responsible Research & Innovation) in textile research and industry). Technical University Lodz could be an associated project partner (without budget) and LOI would be needed. STFI will check if it is possible that also Lodzkie Region could be an associated project partner.

c) MORATEX (PL) / Marcin Struszczyk
Anna Große and Romy Naumann discussed with the Polish stakeholder MORATEX about future cooperation in European projects. Different funding schemes (CORNET, IRA-SME, ESA-calls) were explained in detail and project ideas especially on composites for lightweight applications were discussed.

GP4: Smart textiles for wearable technology

Craig Lawrance, TCoE - Textile Centre of Excellence Huddersfield (GB)

Following on the presentation of the Good Practice, TCoE had discussions with:

a) warmX (DE) / Christoph Mueller
Mr. Mueller asked a question about the use of the technology with regards to controlling the resistance of the conductivity and maintaining satisfactory conditions. I explained the way the technology worked and gave him the contact details of the technology company in order to obtain any answers he could have in relation to the technology that I was unable to answer.

b) NTT (IT) / Lorenzo Giusti and Leonardo Marchetti
Questions were asked as to whether other than the silver nano particles could be used. I was asked if it could be used on a yarn rather than a fabric as it was a potential idea for another project they were working on. I explained that the technology is not exclusive to any one area of application but designed to facilitate electrical connectivity and any circuit shape or design and can integrate any type of electronics to give technical functionality.

GP5: Nanostructured textiles to promote cell growth in severe burn injuries

Pilar Sepúlveda, Instituto de Investigación Sanitaria La Fe (ES), Valencia & Òscar Calvo, AITEX (ES)

AITEX has had contact with:

GP5/GP9 CETI (FR) / Thierry Leblan AITEX and its stakeholder IIS La Fe were interested in the possibilities to use polyvinylidene fluoride (PVDF) as a polymeric substrate for cell culture and biomedicine purposes. It was explained by Thierry that PVDF is a kind of material that is able to produce electric current when bending and polarize it (along the presentation of his GP this effect was described as part of new yarns that CETI is currently developing).
Yarn form of PVDF shown by CETI seems not useful for the request of ISS La Fe; however, this PVDF polymer would be interesting for cell culture purposes, as some special human cells like cardiomiocells (cells from heart) need to grow on electro-conductive materials. Pilar Sepúlveda PhD, main researcher of ISS La Fe, explained that electro-conductive material polypyrrole had been tested but successful results haven't been obtained yet. IIS La Fe is currently looking for an electro-conductive/piezoelectric material (even synthetic and not bio-absorbable, as the main goal of this

request is ‘differentiation’ of stem cells, and not to be used as an implant) to promote cardiomiocell culture on it. This material should help these ‘heart’ cells to ‘beat’ and grow.

GP2 CITEVE (PT) / Gilda Santos and Paulo Cadeia
AITEX was interested in the current state of the Seab2 project and the product developed in the GP presented by CITEVE. They explained Damel (company that developed the product) is starting to commercialize the inflatable device to promote safety at sea; it was also explained that some problems were found regarding the standardization process for validation of the product (current standards aren’t adapted to the new structure of the inflatable device). Safety of the device (life vest) is provided by a very quick inflatable system, based on a chemical sensor that acts (under a certain pressure) in contact with water. AITEX asked about it, as some time ago a kind of similar project proposal was addressed to the institute by a company of the North of Spain: in this case the main goal was to provide a heatable system on sea life-vests not based on an electrical solution but in a chemical one (to minimize loss of heat from body after falling into water). If interest of the Spanish company in re-launching this project is shown in a further time, then the experience and background from CITEVE would be very useful and both entities will keep in contact.

GP5/GP6 CLUTEX (CZ) / Milos Beran
A discussion about electrospinning devices and possibilities to cooperate in the field of nano-textiles, scaffolds and biomedicine was performed, in relation with GP5 presented by IIS La Fe / AITEX.
AITEX asked CLUTEX about its GP6 and the electromagnetic (EM) performance of the textile barrier presented by the Czech partner: they said that the EM barrier effect was not measured yet. In addition, they inform all other tests were performed out of CLUTEX but in case AITEX has interest in some of them both entities could keep in touch to promote cooperation.

<u>GP6: Kompozitex – Emergency evacuation kit</u>
Kateřina Bartošová, Nyklíček a spol. s.r.o. (CZ)

This GP was contacted by:

a) STFI (DE) / Petra Franitza
Discussion about Kompozitex project (presented by CLUTEX) was done. The theme focused on textile materials with electromagnetic and electrostatic shielding effect could be used for another common CORNET project (different possibility of application – specific shielding of products, machines, persons). Another possible application of textiles with conductive fibres could be in textile architecture.

b) INCDTP (RO) / Claudia Niculescu and Doina Toma
Deeper introduction of emergency evacuation kit was done by Ms. Bartošová. Discussion followed about MANUCOAT project presented by Claudia and a possible cooperation with some Czech partner on a common project.

c) MORATEX (PL) / Marcin Struszczyk
CLUTEX asked for more information and deeper explanation of the principle of product presented by GP1, because the presented results could be used in some cooperation with Czech partners (CLUTEX’s members) focused on bulletproof vest.

d)) AITEX (ES) / Oscar Calvo and Gilda Santos
Discussion took place about Kompozitex project. Main topic of discussion was the equipment for conductivity testing.

GP7: Manucoat: Photocatalytic self-cleaning textiles

Claudia Niculescu, INCDTP - National Research & Development Institute for Textiles and Leather (RO)

This GP was contacted by and had contacts with:

a) Lodz University of Technology (PL) / David Stawski and Lodz Region (PL) / Monika Urbaniak

David wanted to know more about the self-cleaning mechanism. Claudia explained that the self-cleaning effect is based on the photocatalytic property of TiO_2. The self-cleaning mechanism based on photo-catalysis is different from that of the lotus leaf which is based on hydrophobicity (water rejection and dirt also with it). TiO2 photo-catalyst uses light energy to produce highly reactive intermediates with high oxidation or reduction potential, eliminating dirt. While TiO_2 is irradiated with UV rays, pairs of electrical charges – voids are created in the valence band and electric charges, electrons in the conduction band. Gaps react with water molecules or hydroxyl ions and hydroxyl radicals are formed, which are very potent oxidants of organic molecules.

David also wondered if the treatment could also be applied on the yarns. Claudia mentioned that we did not try but, we think it's possible. It is possible to initiate a collaboration to experiment the treatment of yarns with TiO_2, non-doped or doped. It is important what the destination of treated yarns is. If they are subjected to the weaving process, we assume that much of the treatment is destroyed. The yarns treatment process will be discussed and documented.

b) CETI (FR) / Thierry LE BLAN

Thierry wanted to know if the photocatalytic treatment presented by the GP is available on the market. INCDTP mentioned that the photocatalytic treatment applied by the methods described in GP is applied at the pilot stage. Not available at the industrial stage.

Thierry also asked for more information about MGM. Claudia briefly presented the activity of MGM: a private company specialized in physical and chemical vacuum deposition (PVD and CVD), optical manufacturing, and photolithography technology. We provided information about national and international research projects involving the company and MGM business partners. CETI has shown interest in initiating collaboration with MGM. Direct contact to MGM was made available to Thierry.

c) CITEVE (PT) / Paulo Cadeia and Gilda Santos

Interest from INCDTP in GP2 presented by CITEVE was: automatic operation of inflation system. Paolo and Gilda presented us, in detail the 3 inflating possibilities: manually by pulling a handle that triggers the release of liquefied CO_2 from the gas cylinder; Blowing air inside the jacket through a tube with a head valve; this mode of inflation is used to supplement the pressure in the vest if, for various reasons, the pressure has dropped; Automatically inflated when it came in contact with water.

d) CLUTEX (CZ) / Mr. Miloš Beran and Nyklicek a spol. s.r.o (CZ) / Katerina Bartosova

Question from INCDTP in GP6 presented by CLUTEX was about the component of emergency evacuation kit. Milos and Katerina gave us more information mentioning that in the rescue kit only the suit is produced by company Nyklicek, the rest of the kit products are being developed by other manufacturers. The company Nyklicek delivers the complete kit.

e) NTT (IT) / Lorenzo Giusti and Leonardo Marchetti

Discussion on the GP8 presented by NTT, question from INCDTP: If the treatment for odour absorption can be combined with the self-cleaning treatment to obtain smart fabrics with multiple characteristics. Leonardo mentioned that they have not raised the issue until now, but have shown interest in collaborating in a future research project on the nanoparticle deposition field. In this regard, Lorenzo gave us direct contact with their specialist in this domain.

Also, NTT wanted to know concerning GP7 if they can buy TiO_2 nanoparticles from Romania. INCDTP answer was affirmative. At laboratory level, maximum 1 kg of TiO_2 nanoparticles per month can be produced.

GP8: Smart textiles with odour absorption properties

Lorenzo Giusti, Next Technology Tecnotessile (IT)

NTT has had contact to the following GPs:

a) TCoE (GB) / Craig Lawrance

The Good practice on “Smart textiles for wearable technology” acted by Textile Centre of Excellence describes the process for obtaining conductive fabrics applicable in wearable technology that has been developed by their researchers. The most important questions were related to:

- Technical details of fabric coating technology
- Reasons that lead to prefer coating of the fabric instead of yarns functionalization
- Stakeholders of the technology: Mr. Lawrance explained that the technology was developed in a the R&D center National Physical Laboratory in UK

Mr. Lawrance explained how the National Physical Laboratory has applied a conductive bilayer on a specific area of the fabric. This technology was developed in order to obtain a scalable process to apply conductive properties to the fabrics on a large scale.

Moreover, he told that the company STAR-TEX (an industrial partner of National Physical Laboratory) is trying to develop a commercial product. The main target of the company is to enter in specific markets such as sport, safety, health etc.

b) INCDTP (RO) / Claudia Niculescu and Doina Toma

Claudia Niculescu (National Research & Development Institute for Textiles & Leather) Good Practice “MANUCOAT-Self-cleaning textiles”. Mrs. Niculescu explained the wide range of research activities of the National Research & Development Institute for Textiles & Leather. In particular, they described their experience coming from MANUCOAT project.

The most important questions during the B2B meeting were related to:

- Titanium nano particles production processes
- Techniques of TiO_2 nano particles application on fabrics
- Characterization methods for coated fabrics
- Applicability of Clean-Odour technology on self-cleaning fabrics

The meeting allowed identifying a common interest of both partners in photocatalytic coatings systems.

The production processes proposed by Next Technology (Top-Down approach) and National Research & Development Institute for Textiles & Leather (Bottom-Up approach) have been compared focusing on Pros & Cons of both technologies. At the end of the meeting, it has been proposed a possible follow related to the TiO_2 NP production processes.

GP 9: From wearables to smart textiles - from performance to emotion

Thierry Le Blan, CETI - European Centre of Innovative Textiles (FR)

B2B discussions took place with:

a) MORATEX (PL) / Marcin Struszczyk

Marcin Struszczyk from Institute of Security has presented GP1 on smart armour for personal security based on rheological fluids which are inserted in the clothing. The question was to know how the fluids are maintained in the clothing and if there is a problem of sedimentation of the fluid. Marcin answered that it is a real problem and that they try to tackle this problem by coating directly the STF (Shear Thickening Fluid) on the textile or by an anti-trauma pad containing STF applied behind the hard ballistic insert. This product is at TRL8 and should be used for the miners.

b) NTT (IT) / Lorenzo Giusti and Leonardo Marchetti

CETI was interested in GP8 on “Smart textile with odour absorption properties”. CETI is involved in a French research programme. It could be interesting to exchange GPs on this topic when the programmes will be more advanced.

3.2 ANALYSIS AND EVALUATION OF GOOD PRACTICE EXAMPLES ON "SMART TEXTILES AND NEW WAYS OF PRODUCTION"

Following the evaluation methodology, the assessment template was sent to all partners for completion. After getting back the templates, the scoring results were calculated and a scoring table created (see Figure 7).

GP	Title	Partner	Total score
3	Smart socks for sports and medical application	STFI (DE)	34
5	Nanostructured textiles to promote cell growth in severe burn injuries	AITEX (ES)	32
4	Smart textiles for wearable technology	TCoE	31
1	SmartArmour – new idea of the smart personal protection	Lodzkie Region (PL)	30
8	Smart textiles with odour absorption properties	NTT (IT)	30
2	Seab2 - Clothing system with integrated inflation	CITEVE (PT)	28
6	Kompozitex – Emergency evacuation kit	CLUTEX (CZ)	26
7	Manucoat: Photocatalytic self-cleaning textile	INCDTP (RO)	26
9	From wearables to smart textiles - from performance to emotion	CETI (FR)	19

Figure 7: Scoring table of GP examples on "Smart textiles and new ways of production"

3.3 DETAILED DESCRIPTION OF THE TWO GOOD PRACTICES WITH HIGHEST SCORING

Following the scoring table (see Figure 7), the GP examples presented by project partner STFI on "Smart socks for sports and medical applications" and AITEX on "Nanostructured textiles to promote cell growth in severe burn injuries" were selected by the partners to be the most relevant GPs. Detailed description of both examples follow below.

1. Smart socks for sports and medical applications (STFI/DE)

Short description:
Abstract:
 Smart or intelligent textiles are considered as a new generation of textile products actively providing support in fields like safety or health. They are high-tech and highly specialized products with a high added value. One of the main reasons for the fast growing development of smart textiles during the last years is the attention of and importance for research and industry. Smart textiles can be used for very different applications as shown by the presented example of smart socks for sports and medical applications which was developed by a research team consisting of the Saxon SME Strumpfwerk Lindner® GmbH and Chemnitz University of Technology. The aim of the development was on the one hand the implementation of pressure sensors in a textile and on the other hand the visualization of the measured results after an individual calibration. In addition to that, the product should be easy to take on and off, washable, nice to wear, fashionably looking and with a good durability. The solution is a double sock with a double layer sole. Between the two soles, the pressure sensors are fixed and the user stands on a textile and not directly on the sensors. The fixation secures a wrinkle free fabric while wearing the smart sock. Between the layers of the leg part the cableway is covered at the outside of the sock. An integrated mobile and modular data logger (Dialogg) can be put on and off very easily. The Dialogg, developed by Chemnitz University of Technology, is equipped with additional sensors, a battery, a device for wireless messaging and special software. This device allows data storage and wireless messaging if required. There is a wide range of applications for LINDNER® smart socks in the fields of home care, rehabilitation, medical and sports.
Resources needed:
The smart sock project was financed by the Chemnitz University of Technology and Strumfpwerk LINDNER® GmbH. For the next steps – certification, mass production and marketing – partners and financial sponsorship are searched.
Evidence of success (results achieved):
One of the best examples from technical/medical point of view is the medication after putting off a plaster bandage worn after a fracture. The patient will be asked to stress its broken leg only with 30% of its weight. By using the smart sock the patient gets an optical or acoustic signal if it is more than the recommended stress. It speeds up the healing process and can prevent additional diseases.

Potential for learning or transfer:
Following the current market growth in smart textiles, the development of the intelligent sock has great potential to be launched successfully on the market. On the one hand, the focus in smart textiles will be on developments for the health care sector and biomedical applications which have been forecasted being one of the fastest growing end-use markets. On the other hand no special high-tech equipment is required and the technology is reproducible and can be transferred to other application fields.

Detailed description:

<u>Operational context / background for the implementation of the Good Practice (e.g. economic, political, social and cultural environment, requirement of special competences / skills)</u>

Terms such as "smart textile" and "intelligent textiles" have different meanings for different people. There is, however, a general agreement that these are textiles or textile products which have additional specific and functional characteristics which are not normally associated with traditional textiles.

Textiles are smart

- if the cycle jacket flashes on the side to which the cyclist wants to turn,
- if the carpet (in the retirement home) indicates that someone has fallen and needs help,
- when the fibre wallpaper regulates room temperature and humidity,
- when the rotor blade of the wind turbine indicates that it must be checked,
- when the sock tells you to be more careful with your insured leg or foot.

Smart textiles ensure that sensory impressions are received, transmitted, processed and translated into action. Some of these functions already exist in prototypes, others are still future music.

The standardization of intelligent textiles or intelligent textile products or textile systems is not uncomplicated. There must be an overlap between the standardization of the "traditional" textile product, e.g. a fire brigade work jacket, and the standardization of the additional specific and functional characteristics of the "intelligent product". The technical report DIN CEN / TR 16298 (DIN SPEC 60298):2012-02 provides recommendations and information to be drawn upon the definition of standards for intelligent textiles or the application of existing standards to these products.[1]

The integration of electronic functions into textiles can be achieved by means of e.g. conductive fibres and microchips. Digitization makes possible, which seemed unthinkable ten years ago: technology and textile are growing together. This will also affect the production: The textile and fashion industry 4.0 enables new digital products, processes and also new digital business models.

Today the "Gesamtverband Textil und Mode" (German textile and fashion association) certifies an enormous growth potential for intelligent textiles. Sales in this segment are still below one percent, according to association spokesman Hartmut Spiesecke. By way of comparison, the industry generated sales of around 32 billion Euros. But in the case of technical textiles, German companies are already export world champions; smart textiles would provide further impulses.

<u>Detailed content and working of the Good Practice</u>

It looks like a normal sock, feels like a sock and is easily washable in the machine. A Saxon development, the smart sock, has a decisive advantage over conventional socks, it can communicate. Eight ultra-thin pressure sensors, embedded in a gel layer between two textile layers, report pressure distribution and acceleration of the foot to an App. Thus, after e.g. a cruciate ligament fracture, the leg can be physically loaded to 30% in a controlled way as prescribed by the physician. Without a technical aid, man can only estimate this with difficulty. The research team of the Chair for Sports Equipment Engineering at the Chemnitz University of Technology developed the intelligent sock together with Strumpfwerke Lindner GmbH from Hohenstein-Ernstthal (district of Zwickau). The fourth-generation company has already produced special socks for diabetics or anti-

[1] Textiles and textile products – Smart textiles – Definitions, categorization, applications and standardization needs; German version CEN/TR 16298:2011

tick stockings. The smart sock goes one step further: With a mini-computer that can be connected with the sock, it shows the wearer/ patient how he strains his feet using real-time data. If the load is too high or unilateral, the App will be alarming. Researchers and companies see applications fields in medical technology. Up to now, such measurements have only been carried out in the laboratory via plates embedded in the soil. Natural walking under laboratory conditions, however, is only conditionally natural. With the sock, measurements can be carried out not only on the move, but also in everyday life. In addition, the technique is to be used almost barefoot, a distortion by shoes are thus eliminated. Further possibilities of use are offered by the sports sector, for example within the framework of the training analysis. Painful feet are often caused by a one-sided weight strain. When walking, however, few people notice anything. The integrated electronics of the sock measure the pressure distribution and acceleration at the foot. This allows conclusions to be drawn on parameters such as one-sided loads. The corresponding App has a graphical user interface that displays processed data in real time on mobile devices such as smartphones and tablets. In this way users can see exactly which foot area is stressed too much. If this happens, the App generates an alarm. Sensors also detect humidity and temperature. This opens up areas of application in pain and accident therapy, but also in performance and recreational sport. Medical applications are also possible, for example in the field of rehabilitation and diabetology. A further advantage of the new technology is that the data are comparatively precise and extensive, since they can be recorded continuously over a long period of time, especially in different everyday situations. A stay in a medical facility becomes not necessary. Compared to measuring methods in or on the shoe, the smart sock offers the advantage that the wearer can use the sensor system even barefoot, since shoes are not necessary for the detection. For the functionality of the principle, the electronics must be robust and firmly attached to the foot. For this, the textile manufacturer Strumpfwerk Lindner GmbH developed its own method by which the sensor is embedded like a sandwich between two textile layers. In addition, a gel insert prevents slipping.
Stakeholders involved:
• Chemnitz University of Technology • Medical device producers • Electronic device producers • Orthopedic technology • Sports equipment producers • End-users (patients), e.g. in the field of pain and accident therapy, rehabilitation and diabetology or leisure and sports
Legal framework:
All textile products should comply with the requirements of the General Product Safety Directive, which stipulates that only safe products should be placed on the European market. Certain groups of textile articles, such as protective clothing, geotextiles or textile floor coverings, are also subject to certain national and European laws, and it may even be necessary to address the requirements of more than one EU Directive. A "classic" fire service tool should meet the requirements of the PSA Directive, usually as defined by EN 469, while an "intelligent" fire service tool with built-in electronic features, (e.g. ICT and ATEX regulations) should also be in line with the applicable provisions of Information and Communication Technology. The conformity assessment system must also comply with the conformity assessment systems for both regulations.
Analysis of the Good Practive:
Relevance of the Good Practice to the policy theme:
The Good Practice presented by Strumpfwerk Lindner GmbH has impact on the policy theme “Smart textiles and new ways of production” in terms of presenting a new technology and product in the field of smart textiles. The smart socks combine classical textile technologies (production of socks by

knitting) with additional properties and features (electronic sensors, microchips, analysis and communication via App) which bring the product to a higher level. The developed smart socks are still in the prototype phase and will be further optimized, tested and evaluated to bring them to an industrial production. The concept with its diverse application fields opens up new business models and opportunities for Strumpfwerk Lindner GmbH. For the Chemnitz University of Technology new research fields and follow-up projects are possible.	
Evidence of success (tangibility, durability, visibility):	
<u>GPs tangibility:</u> results and impacts on the partner's policy (e.g. through measurable indicators) The results of the GP are a perfect example how the combination of two technology fields (textile technology, sensor technology with microelectronics) leads to new products and business cases with highly public interest and manifold application fields. **<u>Success factors</u>** - new products with enhanced performance - opening up new markets with innovative smart textiles - solving problems of e.g. patients that need medical help or athletes and create a real benefit for them **<u>Difficulties encountered and lessons learnt from the practice</u>** One of the greatest challenges for Strumpfwerk Lindner GmbH was the implementation of the pressure sensors into a sock. The most difficult task for Chemnitz University of Technology is the minimisation of the data logger Dialogg to make the system easy to wear. It is expected that it will be difficult to sell that product in Germany as a medical device, because it will take a long and bureaucratic way to get all the certificates needed for the required CE certification. **<u>Remarks on the durability of the GP results and impacts</u>** The socks can be used several times and they can be washed like normal socks (electronics can be removed via a clip-on mechanism). The aim is to achieve a life cycle for the socks of approx. 60 washing cycles.	
Added-value of the practice in terms of innovativeness, effectiveness and efficiency	
• Gaining expertise in a specialized technological field • Establishing innovative technologies and new products • Meeting the requirements of the customers, solving their problems with the innovative product • Transferability of Good Practices to other regions • Improvement and adaption of machinery and equipment for worldwide application	
Remarks on feasibility and transferability of the GP to other regional/local contexts:	
Following the current market growth in smart textiles, the development of the intelligent sock has great potential to be launched successfully on the market. On the one hand, the focus in smart textiles will be on developments for the health care sector and biomedical applications which have been forecasted being one of the fastest growing end-use markets. On the other hand no special technical equipment is required and the technology is reproducible and can be transferred to other application fields.	
Contact:	
Name	Thomas Lindner
Organisation	Strumpfwerk Lindner GmbH
Email	lindner@lindner-socks.com

2. Nanostructured textiles to promote cell growth in severe burn injuries (AITEX/ES)

Short description:

Abstract:

In general terms, this good practice (GP) focuses the problem and context in the need of re-industrialization of the Valencian textile industry and how cooperation and technological collaboration between partners and entities from different sectors is required. This GP is an example of novel technology that is currently used for researching but results could be exploited not only by textile companies but also by machine manufacturers. In this specific case, the GP aims for a textile-based media for severe burn injuries, developed by novel electrospinning technology, which promotes cell growth of the skin better than current solutions.This GP reach its objectives starting from a researching work on bio-compatible polymers to be electrospun, the development of suitable nanotextiles (nanofibers) in a web form and the implantation and validation -in a preclinc stage- of these nanowebs for treating some severe injuries on the skin. Final implementation and validation will be done on humans.

Resources needed:

Paying attention to the technology (mono- or multi-axial electrospinning) an estimation of funding for set up and run this equipment could be: 80k - 120k €. Human resources (only for research and development of nanotextiles by electrospinning): textile engineers, chemical engineers. Resources needed for pre- and clinical testing/research are not indicated as they're out of the scope of the project.

Evidence of success (results achieved):

First, successful results in terms of development of nanofibers and webs. Promising nanostructures and nanofiber webs developed with biopolymers have been developed. Possibilities to enhance functionalities of these nanofibers doping them with drugs or growing factors will be considered.On the other hand, results achieved in pre-clinical trials show that implantation of these textile-based biomaterials promotes cell growth, formation of new blood vessels and improves 'quality' of the regenerated skin structure. Next step is the clinical trial and validation of this new dermal equivalent.

Potential for learning or transfer:

Key success factors for transferring are:

- Electrospinning is a mature technology and some EU producers of end-products and machinery can be easily found
- Intensive collaboration between partners with different profiles is required
- Pay attention to legislation
- Specialization of technicians driving electrospinning devices is required. Increasing of knowledge of technicians
- Funding required for implementation, size of the machinery and auxiliary installation devices are not so high
- Easy-to-operate technologies
- Specialization and re-conversion of traditional textile companies that are currently producing sanitary goods, nonwovens or medical textiles
- Final benefits after validation at clinical stage will be transferred to people requiring regenerative medicine or skin dressing
- Possibilities to launch R&D and cooperation projects at national/EU level

Detailed description:
Operational context / background for the implementation of the Good Practice, GP (e.g. economic, political, social and cultural environment, requirement of special competences / skills) The operational context for the implementation of this GP should take into account the specific situation of the Spanish and Valencian textile industry during last 7-10 years. While the Spanish market consumption of textiles has increased almost 20% in the last 7 years, national production has fallen by 29% and employment by 35%. These figures reflect the not only the intensity of production relocation process, but also some lacks in terms of technification of processes/products, re-industrialization needs and a ‘traditional’ production of ‘traditional’ textile products (even for specific markets like nonwovens). Last years some funding instruments have been launched by the Spanish and the Valencian governments, in order to reduce lacks in terms of technology level and diversification of the production in national/Valencian textile companies. REINDUS -national- and CREATEC -Valencia- programmes (co-funded by ERDF EU funds) or the Industrial Modernization Plan -Valencia- are only some examples of these instruments. By the other hand, demand of new bio-materials, novel solutions and tools to increase health and quality life of people is in a constant growth. From the point of view of textiles, more and more textile-based products (socks, t-shirts, mattresses, pillows, bedsheets, bandages, wound dressings…) are produced looking for release of some benefits to the end-user (skin-care, sleep enhancement, etc.). Nanotechnology, new production methods of fibers and new polymers allow researching centres and companies to produce new materials and to develop new technical applications. For specific end-uses like polymeric substrates to promote cell growth to be used as medical bio-materials, a long researching work is required in order to develop, validate and -further- produce successful biomaterials. This GP involves electrospinning technology, bio-compatible polymers, cell culture and in-vitro/animal in-vivo modellization and validation. It starts with the development of bio-compatible poly (D,L-lactide-co-glycolide) (DLPLG) nanofiber webs through electrospinning technology (monoaxial). **Detailed content and working of the Good Practice:** This nanostructured textile biomaterial is used as a scaffold for cells in order to promote their growth. Nanofibers are able to integrate into fibrin matrix and they are permeable to nutrients and cells and, in addition, these new dermal equivalents with nanofibers are optimal for clinical handling. The nanofiber scaffolds are used, then, for cell culture and growing of dermal cells (fibroblasts and autologous keratinocytes) is tested using in-vitro and in-vivo animal models. The biological characterization of these nanotextile-based biomaterials show that new dermal equivalents have angiogenic capacity (it promotes formation of new blood vessels) and they improve scar quality, less tension, smooth surface of the ‘new’ skin. These bio-compatible nanotextiles are currently being produced by AITEX but the final goal is the production at industrial scale by the company manufacturing electrospinning technology or even by textile companies specialized in nonwovens and/or medical products.
Stakeholders involved:
Textile research centre (AITEX - Alcoi, Alacant), Hospital and its researching units (Regenerative Medicine and Heart Transplantation Unit - Instituto de Investigación Sanitaria La Fe - València) and machinery/technology developer (Bioinicia SL - Paterna, València)
Legal framework:
• Medical Devices Directive 93/42/EC: requirements for harmonized standards and requirements for CE marking. It provides definitions, specify general requirements and sets the requirement for certain organizations • Standards: EN ISO 14971:2012 “Medical Devices – Application of risk management to medical devices”; EN ISO 13485:2016 “Medical Devices – Quality management systems – Requirements for regulatory purposes” and EN ISO 14630:2012 “Non-active surgical implants – General requirements”

Analysis of the Good Practive:
Relevance of the Good Practice to the policy theme:
This GP is released by AITEX as an example of smart textiles developed by new ways of production, under a re-industrialization concept. Firstly, bio-responsive textiles are a new market in constant growth due to new requirements and needs in terms of availability of new bio-materials, human health, skin-care or less aggressive clinical treatments for severe burn injuries. The GP promotes research, development, testing and further use of these bio-responsive textile-based materials. Electrospinning is a mature technology that allows development of new textile materials and formats (up to nano-scale) and it has been demonstrated as a valid new production method to develop end-products like filters, bio-materials, acoustic/isolating materials with better performance that current end-products obtained by traditional processes. This is directly linked with a re-industrialization point of view of the textile industry (and other industrial sectors) of the Valencian Region, that has suffered a severe impact of the economic crisis on the working force and number of companies. This GP is relevant in terms of how to find new production processes and creation of new markets for some textile companies.
Evidence of success (tangibility, durability, visibility):
GPs tangibility: results and impacts on the partner's policy Results and impacts are measured in terms of R&D projects launched involving electrospinning for biomedical applications and number or strategic partners. **Success factors** Main results achieved can be considered as successful in two ways: First, successful results in terms of development of nanofibers and webs. Promising nanostructures and nanofiber webs developed with biopolymers have been developed. Possibilities to enhance functionalities of these nanofibers doping them with drugs or growing factors will be considered. On the other hand, results achieved in pre-clinical trials show that implantation of these textile-based biomaterials promotes cell growth, formation of new blood vessels and improves 'quality' of the regenerated skin structure. Next step is the clinical trial and validation of this new dermal equivalent. **Difficulties encountered and lessons learnt from the practice** Main difficulties encountered during development have two origins: first are the problems found in the selection of biocompatible medical grade material and their processing conditions according to the requirements of quality production of the medical devices; the second source of difficulties is the setting up and validation of the test protocols of a novel material both in vitro and in vivo procedures with animal models. The most important lesson learnt with this development is that exploring new ways and disciplines requires to surround with specialized partners. This is the case of IIS LA FE, a reference center for biomedical research and BIOINICIA, a leader in electrospinning equipment production and development of production plants. **Remarks on the durability of the GP results and impacts** Work performed until now shows the possibilities to use new biomaterials and structures for dermal implants and treatment of severe burn injuries. Then, the durability of the GP could be considered as high, as it's expected a further development at industrial scale and use of these new textiles by many Regenerative Medicine Units, at national or even EU level.
Added-value of the practice in terms of innovativeness, effectiveness and efficiency
Added value of this GP in terms of regional and EU level is the potential replicability and the innovation level of the new materials and manufacturing technologies involved. In addition, the final goal of the bio-responsive textiles developed along this project and GP is highly relevant for end-users and people suffering severe burn injuries. Entities beyond RESET partnership (as hospitals, clinical and biomedical researching centres, polymer manufacturers, chemical industry, etc.) could also find some benefits from this GP.

Remarks on feasibility and transferability of the GP to other regional/local contexts:
Conditions and requirements of GPs transferability • Conditions for transferring the GP to other regions/countries should consider several issues: • Machinery design, processing parameters etc. of the electrospinning device should be fitted for each end-application (on demand). • Chemical products and polymers used to develop bio-responsive textiles must be bio-compatible and 'medical grade'. • Installations and facilities to develop biomedical textiles must be considered as 'clean room'. • Technical skills and training of the people involved (for production of biomedical textiles) are required, in order to operate the machines properly and to know the relation between processing parameters and structure/morphology of the nanofiber webs. • Know-how and industrial property of the specific electrospinning technology or the development of specific nanofiber webs to be taken into account. **Long and short terms context impacts on GP feasibility and transferability in terms of economic, political, social and cultural environment, involvement of special competencies and skills.** Presented GP is an example of how technological evolution, re-industrialization, new ways of production and collaboration between partners coming from different sectors can provide new solutions to enhance life quality of people. Development of biomaterials for implants (severe burn injuries, skin-care, etc.) is a long way that requires great efforts in terms of R&D actions, funding and time for final validation of results. Due to this issue, economic exploitation of results by the industry is not so fast. Special competencies in textile engineering, chemistry and machinery/mechanical engineering should be taken into account for textile companies and technicians involved in the development of bio-responsive textile materials for biomedical applications.
Further information:
http://www.bioinicia.com/electrospinning-projects-2/ http://www.iislafe.es/grupos-y-lineas-de-investigacion.aspx http://www.aitex.es/portfolio/resoltex-desarrollo-de-apositos-con-aceites-omega-3-enriquecidos-en-mediadores-lipidicos-encapsulados-para-curar-heridas-cronicas-con-problemas-de-cicatrizacion/
Contact:
Name Ms. María Blanes / Mr. Bruno Marco Organisation AITEX Email mblanes@aitex.es ; bmarco@aitex.es