FP7-SME-2013 / 606517-BETITEX / SME-AG

Development of sustainable textiles against bugs

FINAL PUBLISHABLE SUMMARY REPORT

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1. Executive summary

BETITEX is a research and development project, cofounded by the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement nº 606517, starting on November 2013 and lasting 36 months.

Its aim is to obtain textile materials capable of providing protection against ticks and bedbugs, arthropods of medical and veterinary importance all over the world, in order to solve the current lack of protective solutions.

It is coordinated by GREMI TÈXTIL DE TERRASSA, a non-profit Catalan organization which joins more than 120 companies in the textile sector. In BETITEX, GREMI leads a consortium of 10 partners: 3 textile associations (ATEVAL from Spain, CLUTEX from Czech Republic and TEXCLUBTEC from Italy); 3 technological centers (INOTEX from Czech Republic and LEITAT and TECNALIA both from Spain; 4 SMEs (GEM'INNOV from France, NILKA from Turkey and SILK&PROGRESS from Czech Republic and LIASA from Spain).

The research and development activities carried out are focused on:

1. Study and selection of the biocides and the textile materials where to be applied.

2. Study and define the incorporation of the biocides to the textile materials. The selected technologies are: microencapsulation and application of microcapsules by finishing processes, during the extrusion and sol-gel technology.

3. Develop and validate test methods of biological effectiveness

4. Application of the biocides to textile materials

5. Determination of the durability of the biocide effect

6. Industrialization of the optimal solution

These tasks have been structured in a work plan consisting on five R&D Work Packages and one Demonstration Work Package.

In order to assure the communication of the project and its results to the general public, scientific community and other stakeholders and the correct management of the Project, two transversal Work Packages have been carried out during the whole project: Dissemination and Management.

The final BETITEX result is a prototype of a textile material: efficient, environmentally friendly and with a slow release of biocide. This prototype will be the base for new final products such as mattress covers or other home textiles protecting against bedbugs and also garments for outdoor activities protecting against ticks.

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2. Project context and objectives

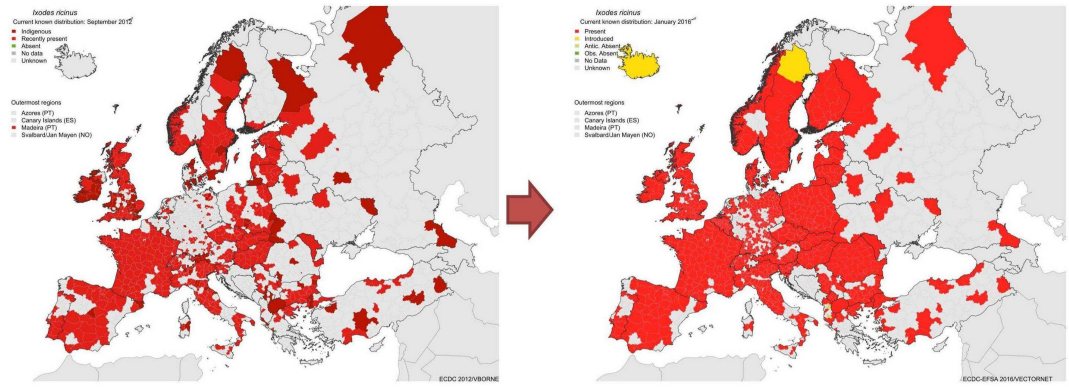
The recent increase in vectors is associated with increased resistance to chemicals of insects and other arthropods, increased restrictions on the use of pesticides, climate change and other anthropogenic factors (e.g. changes in agricultural practices).

Vectors are living beings which carry and transmit infectious pathogens to other living organisms.

According to the WHO - World Health Organization, vector-borne diseases account for over 17% of all infectious diseases, and cause every year more than 1 million deaths.

Some of the resurging vectors are mosquitoes, lice, ticks and fleas.

Figure 1 shows the presence of *Ixodes ricinus* (common tick) in Europe. An increase is observed from 2012 to 2016, especially in the countries of Central Europe.



September 2012 January 2016

Figure 1: Presence of Ixodes ricinus in Europe
Source: European Center for Disease Prevention and Control (ECDP)

Ticks are small arachnids that feed on blood. They are found mainly in habitats with vegetation, maintaining high humidity, such as woodlands.

They are involved in the transmission of a variety of pathogens of major medical and veterinary importance. Two of the major diseases transmitted by the common tick are:

- *Lyme Borrellosis* (Lyme disease): is the main tick-borne disease in Europe. It can affect the nervous system. 10% of infected people may develop disorders in the central nervous system.

- *Tick-Borne Encephalitis* (TBE): is a viral infection that causes brain inflammation in 25% of infected people. Russia and Europe report between 10,000 and 12,000 cases of infections in humans each year.

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Other arthropods in resurgence are bedbugs, insect parasites of the *Cimicidae* family that feed exclusively on blood. The common bedbug is the *Cimex lectularius*.

The increased presence of bedbugs is attributed to increased international travel, climate change, mismanagement of insecticides and the development of insect resistance to insecticides (mainly pyrethroids).

Bedbugs are suspected of transmitting infectious agents. There is international concern about their vectorial capacity (about 40-45 pathogens have been detected in wild bedbugs and/or lab bedbugs), some as important as Chagas disease or hepatitis B. However, no data exists demonstrating their efficient transmission under natural conditions.

Bedbugs can reduce the quality of life, causing anxiety, discomfort, skin disorders, insomnia, anaemia (when many) and may even cause anaphylaxis. They have a great negative impact on tourism at world level.

The habitats of the bedbugs are especially sofas, mattresses and other furniture.

In Spain, the most demanded bedbug pest control services are distributed as shown in **Figure 2**.

An example of the resurgence of bedbugs in the United States is shown in **Figure 3**. Since 2000 until today, the presence of bedbugs has increased up to 70%.

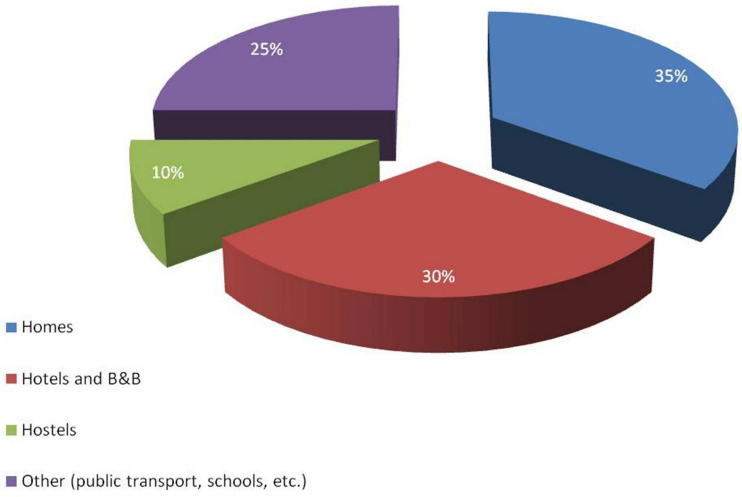

Figure 2: Distribution of services required for bedbugs pest control
Source: National Association of Pest Control (ANECPLA)

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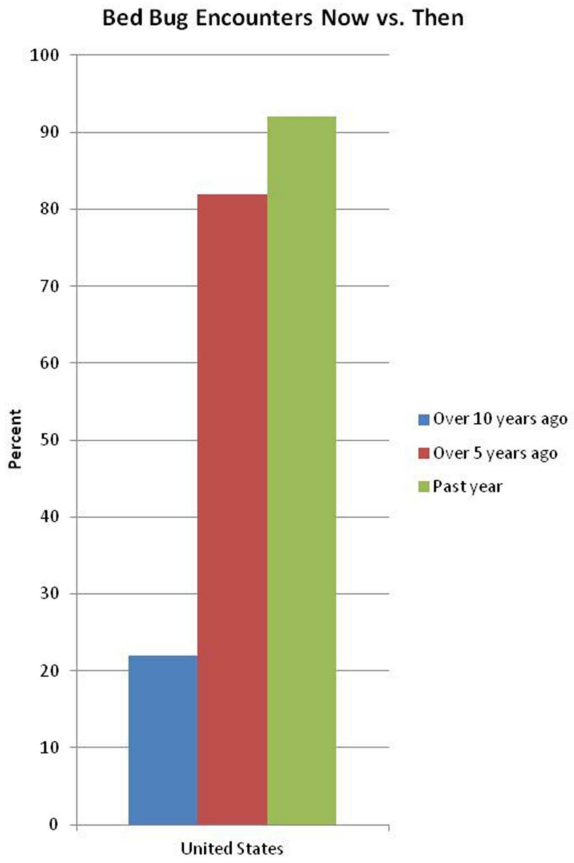

Figure 3: Evolution of the presence of bedbugs in the United States
Source: Hilton Head Exterminators

Bedbugs and ticks, despite being present in different habitats, have similar behavior and are affected by the same type of biocide.

Nowadays the most used method to fight them is using a repellent-spray. These sprays contain the biocides responsible of providing protection to the user. There are not too many authorized repellents by the Regulation (EU) No 528/2012. Many known active substances are not accepted in the European market due to their toxicity and/or their environmental impact.

To solve the current lack of protection against bites of these two types of arthropods, the BETITEX project was conceived.

Main BETITEX objectives are:

- To develop functional textiles with protection against ticks and bedbugs, mainly for outdoor garments and home textiles.

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- To develop and research on environmentally friendly biocides offering protection against ticks and bedbugs and accepted by the Regulation (EU) No 528/2012.

- To develop innovative finishing technologies (sol-gel, microencapsulation and extrusion) in order to control the repellent effect and so contributing to a longer lifespan (control-release of the biocide).

- To obtain high durability of the finishing (maintaining the repellence property at least up to 50 washings) by biocide control release (long-lasting biocide treated textiles)

- To reduce the use of repellent sprays that are used nowadays (spreading them on the human body).

- To promote the BETITEX results by the SME-Associations involved in the project to their SMEs associated companies, in the textile sector.

- To offer solutions to the SMEs and improve their competitiveness by getting protective textiles against ticks and bedbugs in the field of outdoor garments and home textiles.

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3. Main S&T results

BETITEX project research activities have been structured in five R&D work packages and one Demonstration Work Package. Figure 4 shows the Project workplan.

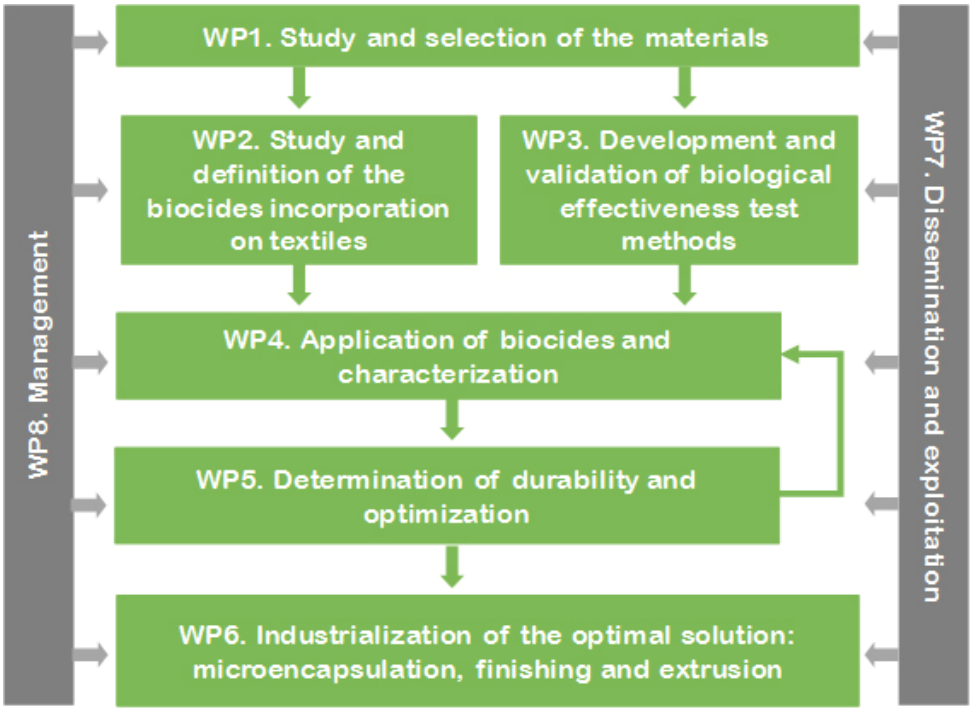

Figure 4. BETITEX workplan

WP1. Study and selection of the materials

1. Study and selection of biocides

There are a wide variety of biocide products all over the world. Environmental disturbances and Public Health risks derived from abuse of pesticides and constant alerts that demand innovative researches. In this sense, this task had the aim to select the biocides between accepted ones, by Regulation (EU) No 528/2012.

The selection has been divided in two main tasks: an initial selection of biocides in which a bibliographic review of selected chemicals known to have repellent and/or insecticidal effects on ticks /bedbugs all over the world has been done. For the final selection, the bibliographically pre-selected biocides (with repellent effect (PT19) and insecticidal effect (PT18)) have been evaluated against bedbugs and ticks in the laboratory, though in vitro feed screening tests.

Three repellents and three insecticides were selected.

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2. Study and selection of textile raw materials

In this task, the textile materials to be used as raw materials in the following work packages have been selected.

The selection process has begun with a study on the presence, habitat, hazards, etc. of bedbugs and ticks.

As a result of this study the major application sectors have been selected: clothing for outdoor activities and personal protective clothing (protection against ticks) and home textiles (protection against bedbugs).

From these sectors, the most commonly used textile materials have been studied, in terms of raw materials and structures, with a final selection of four substrates.

WP2. Study and definition of the biocides incorporation on textiles

In this WP, different methodologies for including the previously selected biocides into the selected fabrics have been studied.

These technologies include:

1. Embedding technologies of the biocide: Sol-gel coating and micro and nanoencapsulation of the biocide.

The sol-gel technology consists of a series of hydrolysis and condensation reactions, whereby one solution (sol-gel) containing the biocide inside is obtained. It is a method well known to provide new functionalities to materials.

The main advantage of insecticide/repellent textiles by sol-gel coatings is the control over the amount of insecticide/repellent into the silica coating and the excellent adhesion of sol-gel coating to the textile fibres due to the nanoparticulate size of the sol particles.

The micro/nano encapsulation (depending on the size of the capsule) is a process by which the active ingredient (in this case the biocide) is wrapped with a protective layer (shell) that allows a controlled release.

The need for biocides encapsulation is mainly based on their toxicity for both human or animals and the environment. Although isolation of the insecticide is required regarding health issues, proper and controlled release in the target has to be performed to achieve the active effect. Thereby, the main challenge for selected polymer matrix or shell is the matching of compromise between a good protection of biocide and an appropriate liberation of product at the correct dosage. Additionally, controlled release of biocides may result in a reduction in resistance of bugs or ticks, providing an added value.

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The concern of minimizing the contact between biocides and human skin or environment has been growing in the last years and different encapsulation approaches have been studied and evaluated.

2. Application of the embedded biocide onto textile materials. Two different technologies have been studied: finishing technologies and extrusion.

The finishing technologies selected are: padding, coating and exhaustion. The extrusion process consists on the incorporation of the micro or nanoencapsulated biocide in a polypropylene yarn during its extrusion.

The usual problem in the application of biocides on the fabrics is low durability of their biological efficacy after washing. For that reason, the efforts have been focused on finding new methodologies characterized by a slow release of the biocide from the textile and a high resistance to washing.

As final result, a definition and description of the potential processes to be followed according to the biocides and fabrics selected has been obtained.

WP3. Development and validation of biological effectiveness test methods

The goal of this workpackage is to study and define the methodology for testing fabrics with effect against ticks and bedbugs.

First task of the WP was the laboratory in-vitro cultures (*Ixodidae* and *Cimicidae*). Second task was the development of the methodology to assess antitick and antibedbug properties of the biocide treated textile materials.

Cimex lectularius L. was selected as the *cimicid* target of the BETITEX project for its worldwide distribution and its high signification as man´s parasite because of its strong semisynanthropic habits. *C. lectularius* is a hemimetabolous insect that requires vertebrate blood in all five nymphal instars as well as in the adult stage. Original hosts of bed-bugs are bats, but they have evolved switching to other vertebrate species, including man.

Figure 5. *Cimex lectularius L.*

Ixodes ricinus was selected as it is the most widespread and abundant *ixodid* tick in Western Europe and frequently bites humans. It is an important vector of zoonotic diseases, including Lyme disease, tick borne encephalitis, ehrlichiosis and babesiosis (Bonnet et al, 2007).

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Figure 6. *Ixodes ricinus*

WP4. Application of biocides and characterization

This WP consists on the application of the selected biocide onto the selected textile materials by using the selected methodologies, at laboratory scale.

The WP is divided in three main tasks:

1. Sol-gel formulation and application: Development of a sol-gel formulation containing a repellent and/or insecticide: studying type of precursor, pH, water/alkoxide ratio, type of catalyst, solvent, time and temperature and amount of insecticide/repellent.

The sol-gel formulation has been applied onto the textile material by padding.

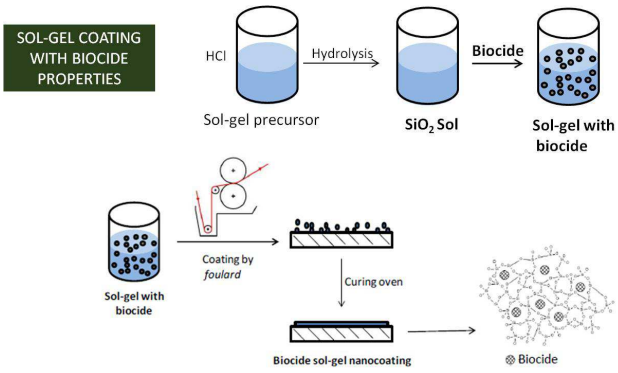

Figure 7. Sol-gel process

1. Microcapsules development and application on textiles

The micro/nanoencapsulation process avoids the degradation of the core, masks odours, protects the core during the processing and allows controlled-release of the active substance.

The three types of encapsulation used are: sol-gel nanocapsules, in-situ polymerization and interfacial polymerization.

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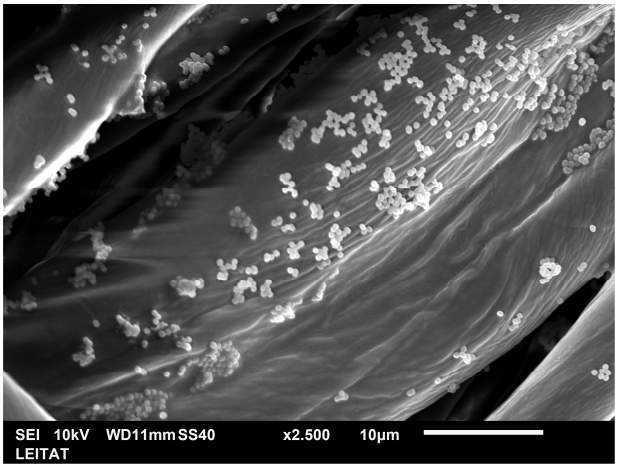

Figure 8. Microcapsules on cotton fibers

The obtained micro and/or nanocapsules have been incorporated onto textiles by: padding, exhaustion and coating, and within a polypropylene yarn.

Once introducing microcapsules in a formulation, different parameters have to be studied such as the dispersion level, the stability of the dispersion, the concentration of microcapsules and the concentration of the binder.

The concentration of the microcapsules applied on the fabric has also to be controlled in order to employ the minimum quantity of microcapsules necessary to obtain a good effectiveness and a good washing fastness of the effect.

The padding process consists of introducing the solution containing the insecticide inside the padding machine and the fabric is squeezed between the machine rolls after being impregnated in the solution. Then the textiles are dried and cured in a stenter.

The coating process can be done by foaming or not the solution. In foam coating the application on the fabric is done by a knife coating machine. After application on the fabric, the textile is dried and cured to fix the finishing layer on its surface.

The exhaustion process consists in immersing the fabric inside a solution containing the insecticide during a specific period of time and at a specific temperature profile, until exhausting the bath. The fabric is also submitted to agitation to enhance its impregnation into the bath. Then, the textiles are finally dried.

The process of applying the micro/nanocapsules within the polypropylene yarn is shown at Figure 9.

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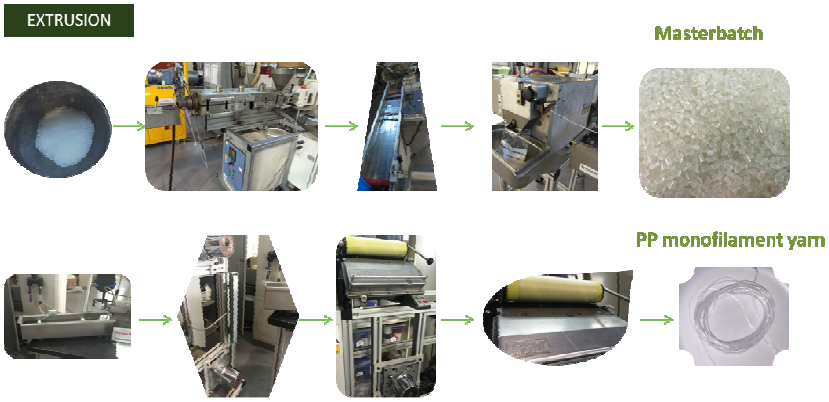

Figure 9. Incorporation of micro/nanocapsules containing biocide on a polypropylene yarn

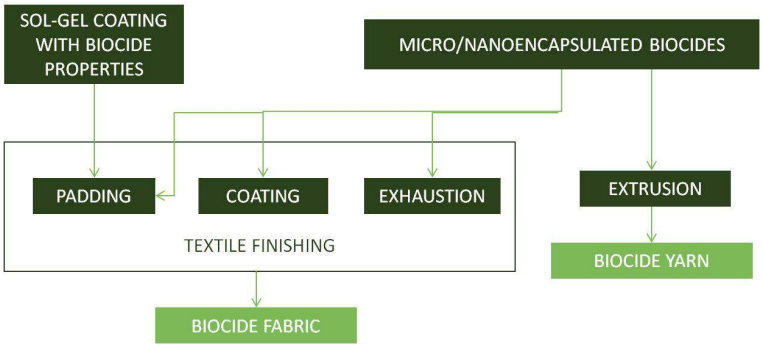

Figure 10. Diagram of the application processes which have been carried out in WP4

3. Characterization

The obtained fabrics and yarns have been characterized according to the tests shown in Figure 11, in order to determine the biocide content on the micro/nanocapsules, once they have been applied onto the textile materials, their structure and also the main properties of the fabrics to confirm they maintain their initial properties (before being treated).

Technology	Test	Determination
Microcapsule/yarn characterization	High-performance liquid chromatography (HPLC) Thermogravimetric analysis (TGA)	Biocide content in the capsule
	Scanning Electron microscopy (SEM)	Capsules shell, spherical form, size, etc.
	Laser diffraction particle size analysis instrument	Capsules size
Fabric characterization (mechanical/physical properties)	EN ISO 13934-1	Tensile strength & elongation
	EN ISO 9237	Air permeability
	EN ISO 15496	Water vapor permeability
	ISO 6330	Washing fastness

Figure 11. Characterization tests

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WP5. Determination of durability and optimization

The objective of this WP is to determine the effectiveness of biocide by means of repellency and mortality tests (according to the biocide used) conducted adapting methodologies to BETITEX project (previously defined in WP3).

Effectiveness has been determined without washing and then with 1, 5, 25 and 51 washes, as this is one of the weaknesses of the technologies used.

Moreover, a complete characterization of the fabrics according final fabric application has been done in order to define if the optimum fabric is capable of providing biocide effect without reducing common and usual characteristics.

The different research lines studied in WP4 have been further evaluated aiming to determine the most feasible options to be transferred to industrial scale in WP6.

Figure 12. Mortality tests

Figure 13. Repellence tests

On the other hand, due to the different end uses of the products developed, it is necessary to determine the complementarity of the biocide application processes with other necessary finishes depending on application.

Functional clothing is relatively new and a growing segment of the textile clothing group. The field of functional clothing is wide and diverse with each functionality having its own specification, material requirements, consequent technologies and processes. All clothing is known to perform multiple functions from aesthetic to basic protection from the external environment elements and respect of users comfort.

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Functional clothing can therefore be defined as a generic term related to both - clothing or assemblies that are specifically engineered to deliver various predefined performances or functionality to end user who goes over its normal function. Standard classification used for technical textiles divides the textiles to the three basic groups: protective, medical, sports/outdoor textiles. The protective – functional presents the largest segment of functional clothing (PPE) – one of highlighted. More and more the (multi)functional textiles penetrate in o the B2B (barrier) textiles for technical uses as well.

The textile industry is constantly striving for innovative production techniques to improve product quality. Besides the traditional function by dressing people, textiles now provide wear comfort and protection in dangerous environments. Textile finishing chemicals are used to convert a textile material into a technical textile with functional properties. In the textile industry, finishing is usually carried out in the final stage of textile processing, as a result of which the textiles gain several functional characteristics. Novel finishes providing high value addition to textile fabrics are greatly appreciated by a more demanding consumer market. The functional finishes can also be applied to apparel fabrics, household textiles and technical textiles to increase their attractiveness to the consumer and to stimulate growth at the niche markets.

There are different types of functional finishes and the right type of finish should be decided depending on the fibre type of the textile substrate and the desired end use. The additional costs of the multifunctional textiles must be compensated by durability of functional effects. More and more the (multi)functional finishing processes work together with the maintenance service processing.

The multi-functionalization has been tested with hydrophobic finish and antibacterial finish.

Finishes that repel water are important in all categories of the textile market. Hydrophobic finishes give additional properties on fabrics to realize higher value textile products. Repellence properties also enable easier cleaning of fabrics.

The growth of microorganisms on textiles leads to the generation of unpleasant odour, discoloration of the fabric and reduction in the fabric strength and other useful properties. For these reasons, it is highly desirable that the growth of microorganisms on textiles is minimised during their storage and use.

After the application of the multifunctional treatments, effectiveness tests have been carried out in order to determine which is the final effect.

WP6. Industrialization of the optimal solution: microencapsulation, finishing and extrusion

The last stage of the project involves the industrialization of the optimal solution obtained in the previous WP, at the premises of the participating SMEs in the project.

Various microcapsules' types have been developed and characterized (particle size and spherical form). The capsules prepared have been compared to the capsules obtained at laboratory scale. The presence of the biocide has been determined as well after the microencapsulation process.

From one side, these microcapsules have been used for the production of a biocide yarn and, from the other side, they have been applied onto textiles by the mentioned finishing processes.

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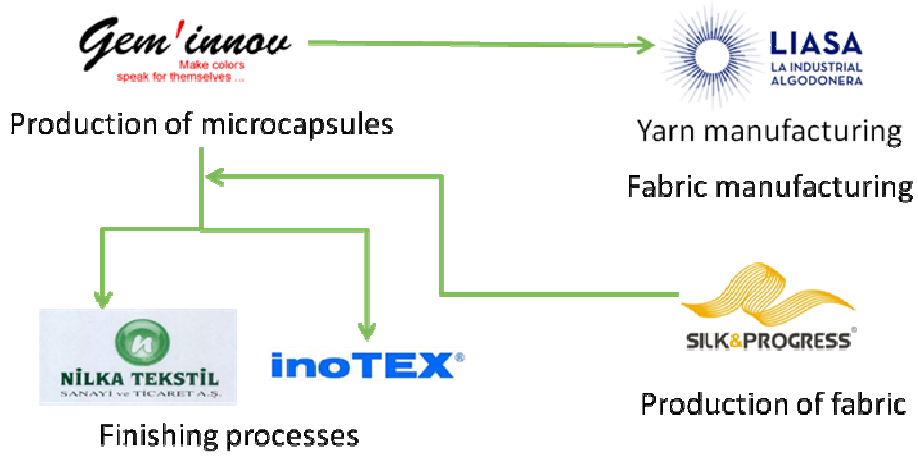

Figure 14. Industrialization scheme

Final results of the BETITEX can be summarized as follows:

- Functional textile material with protection against ticks and bedbugs for PPE – Personal Protective Equipment and Home Textiles applications.

- Use of environmentally friendly biocides offering protection against ticks and bedbugs which are accepted by the Regulation (EU) No 528/2012 of the European Parliament and of the Council of 22 May 2012 concerning the making available on the market and use of biocidal products.

- Use of innovative finishing technologies (sol-gel, microencapsulation and extrusion) in order to control the repellent effect and so contributing to a longer lifespan (control-release of the biocide).

- Obtaining high durability of the biocide effect (maintaining the biocide property at least up to 50 washings) by biocide control release (long-lasting biocide treated textiles).

In general terms, and according to the market research on available similar products on the market, results of effectiveness achieved are considered as satisfactory.

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4. Potential impact

Socio-economic Impact

BETITEX has been carried out by a consortium mainly set up of textile organizations: textile trade associations, technological centers and SMEs.

In that sense, BETITEX results will have direct socio-economic impact in the textile industry.

The textile and clothing industry plays an important role to the European economy and well-being. According to Euratex (The European Apparel and Textile Confederation): In 2015, the overall size of the Textile & Clothing industry in the EU-28 represented a turnover of 169 billion € and investments of around 4 billion €, employing over 1.7 million workers. EU external trade was more dynamic than the previous year with 45 billion € of T&C products exported and 109 billion € imported from Third markets".

After China, the EU is the world´s second largest exporter of textile products with 31% including intra- EU trade.

According to the European Commission "The EU textile and clothing sector is a SMEs based industrial sector as companies of less of 50 employees account for more than 90% of the workforce and produce almost 60% of the value added."

The largest activity within the textile and clothing sector (at NACE Division level) is the manufacturing of textiles which accounted for a little under one half (49 %) of sectorial turnover in 2013.

The textile and clothing sector in Europe has been subject to a series of radical transformations over the last years, due to a combination of technological changes, evolution of production costs, the emergence of important international competitors and the elimination of import quotas after 2004. In response to competitive challenges, the textile and clothing industry in Europe has improved its competitiveness by ceasing mass production and simple fashion products and concentrating instead on sustainable products with higher added value.

The textile and clothing industry is highly interconnected, which means that changes in the trade and production of textiles and clothing can have significant positive or negative impacts on national economies, and/or the growth or subsidence of the industry. In general, the textile and clothing industry can be considered as a catalyst for economic growth in developing countries, due to its suitability for people with limited skills and education. Despite the health risks and low income, it is often the most economically viable source of employment in areas where other occupations are either not available or do not provide sufficient income.

General BETITEX project benefits for SMEs and SMEs' trade associations on the textile sector at European and/or International level can be summarized as follows:

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- Increasing their productivity, opening new market and extending their product range by manufacturing an innovative product.

- Bringing to the market cost-efficient and long lasting products responding to the consumer need.

- Bringing to the market ready-to-use and odourless ticks and bedbugs protecting fabrics avoiding the application of repellents sprays on clothes.

By strengthening the role of high technology in the textile industry, SMEs would be re-launched in the European and international market; foreign direct investment will be attract to reinvest in an area of high quality and with high technological potential; scientific research will be incentivized; European market will tend more and more to products that comply with European environmental policies encouraging foreign competitors to conform to the same rules in order to be competitive; as well as it would be an advantage for the labour market and local economies.

Given the high potential market opportunities of BETITEX outcomes, the results of the project will improve the competitiveness of the SME participants by providing them with a valuable know-how.

In parallel, by stimulating traditional textiles companies to develop innovative and sustainable products with a high and important social protective function, the project will introduce to the market an innovative product with health benefits and low environmental impact. Moreover, thanks to the environmental friendly biocides used (accepted by the Regulation (EU) No 528/2012), the SMEs will gain a high added value in a European (but also international) market that becomes more and more environmental sensitive, in sectors where there is a high interest and every time more needs of this protective function due to the high presence of bugs. All these factors will have an impact also at economic level (growth, production, labour market).

There is a need of offering to the market innovative and technical fabrics to cover some lacks and then, being capable to differenciate from the competence in order to contribute to a growth economy.

BETITEX project has not only been focused on final fabric finishing, but also on the extrusion process in order to get a wide range of application possibilities and so, offering solutions for more diverse SMEs (not only finishing sector but also extrusion and spinning sectors). The potential growth of these SMEs may have an automatic impact on the labour demand and so on employment rate in the nearly future.

In line with the Europe 2020 strategy and the related European Employment Strategy, BETITEX project seeks to create more and better jobs on textile sector throughout the EU.

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Impact - Societal implications

As it has been shown, ticks and bedbugs are in resurgence and this directly affects human health.

Especially the presence of ticks is of higher concern as it transmits infectious pathogens.

Approximately 820 species of ticks have been identified worldwide. Of these, 100 are capable of transmitting pathogens such as bacteria, viruses and protozoa, and some tick even poisons, to humans. In Europe it is almost always Ixodes ricinus (http://www.lymeneteurope.org/info/ticks).

Main common infections are: Crimean-Congo haemorrhagic fever, Lyme disease, Relapsing fever (borreliosis), Rickettsial diseases (spotted fever and Q fever), Tick-borne encephalitis and Tularaemia.

According to the World Health Organization (WHO) (http://www.who.int/mediacentre/factsheets/fs208/en/) Crimean-Congo haemorrhagic fever (CCHF) is a widespread disease caused by a tick-borne virus (Nairovirus) of the Bunyaviridae family. The CCHF virus causes severe viral haemorrhagic fever outbreaks, with a case fatality rate of 10–40%.

CCHF is endemic in Africa, the Balkans, the Middle East and Asian countries south of the 50th parallel north – the geographical limit of the principal tick vector.

The hosts of the CCHF virus include a wide range of wild and domestic animals such as cattle, sheep and goats. Many birds are resistant to infection, but ostriches are susceptible and may show a high prevalence of infection in endemic areas, where they have been at the origin of human cases.

Animals become infected by the bite of infected ticks and the virus remains in their bloodstream for about one week after infection, allowing the tick-animal-tick cycle to continue when another tick bites.

The CCHF virus is transmitted to people either by tick bites or through contact with infected animal blood or tissues during and immediately after slaughter. The majority of cases have occurred in people involved in the livestock industry, such as agricultural workers, slaughterhouse workers and veterinarians.

Although an inactivated, mouse brain-derived vaccine against CCHF has been developed and used on a small scale in Eastern Europe, there is currently no safe and effective vaccine widely available for human use.

In the absence of a vaccine, the only way to reduce infection in people is by raising awareness of the risk factors and educating people about the measures they can take to reduce exposure to the virus.

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According to the European Center for Disease Prevention and Control, (http://ecdc.europa.eu/en/healthtopics/vectors/infographics/Pages/infographic-tick-borne-diseases-in-Europe.aspx) Lyme disease is the most prevalent Tick-Borne-Disease in Europe. The main European vector is *Ixodes ricinus*.

An article from *LymeNet Europe (*http://www.lymeneteurope.org/info/) states that Lyme disease is predominant on the northern hemisphere in temperate climates, which goes together with the spread of ticks. On a world map it is a band going over the Unites States, Europe, and across central Asia all the way to Japan.

In order to reduce the risk of tick-to-human transmission, amongst all the proposed measures by the WHO, there are some in which BETITEX can have direct impact: wear protective clothing (long sleeves, long trousers) or to use approved repellent on the skin and clothing.

Concerning the reduction of risk in animal-to-human transmission, BETITEX can have impact on: wear gloves and other protective clothing while handling animals or their tissues in endemic areas, notably during slaughtering, butchering and culling procedures in slaughterhouses or at home.

BETITEX prototypes can be turned into marketable products which can help to avoid ticks and bedbug bites on humans.

Dissemination and exploitation

BETITEX had a Work Package exclusively dedicated to dissemination. The objective was to elaborate and implement a dissemination plan agreed by all members of the Consortium, to attract the interest of the public, investors, research sector, SMEs and associations of SMEs through the publication of articles and advertisements in dedicated technical press, to elaborate and exploitation plan agreed by all members of the Consortium and to ensure that the achievement of the project results are made available to the targeted potential clients and (or) market segments and to provide key information for the feasibility demonstration of SMEs solutions for getting protective textiles for ticks and bedbugs attack mainly focused on two sectors: protective garments for outdoor activities and home textiles.

Main dissemination activities include:

- Elaboration and updating of a project website: www.betitex.eu
- Creation of a project video: https://vimeo.com/181630794
- Distribution of press releases to textile and general media in the project partners' countries.
- Distribution of project leaflets and exhibition of the project poster or roll-up in several international events related to the textile sector, such as: Techtextil Frankfurt, Heimtextil, Medica, Milano Unica, ITMA, ISPO, etc.

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- Project presentations in scientific or congresses: BETITEX partners have done 4 presentations at 3 international events: TEXCHEM'14 and IFATCC'16 (Pardubice, Czech Republic) and the conference of the European Textile Technology Platform: European Textiles: Going Digital, Going High-Tech on October'16 (Brussels, Belgium).

Besides, other activities have been carried out in order to help pushing the project results towards the market. These activities include:

1. A report on technical, economical and environmental aspects containing the results of a techno-economic analysis to show the innovative character and the environmental impact of the textile materials protecting against ticks and bedbugs which have been obtained.

The technical viability of the project results is detailed, considering, for the optimal solution: the technical explanation of its selection, its technical key points and the proved durability of the biocidal effect, as a summary of R&D and Demonstration WPs' results.

The industrialization of the optimal solutions, has allowed analysing the manufacturing costs of all stages to obtain the final textile materials. Together with the estimated retail price, obtained as result of a market research, it has been possible to estimate the economic viability of the final products.

The environmental viability of the final products is justified, considering that a biocidal product is used.

The environmental viability of the resulted biocidal textiles of BETITEX has been ensured from the beginning when the initial selection of the active substances for the whole project was based on the efficacy (mortality and/or repellence) but only for those active substances approved according with the Regulation (EU) 528/2009.

Insecticides (excluded those used for plant protection) and insect-repellents are included as biocides on the Biocidal Product Regulation of the European Union (Regulation (EU) 528/2012). Although biocidal products play an important role in EU citizens' daily lives, for example, when these are used to prevent bites of hematophagous arthropod-vectors, because of their intrinsic properties, biocidal products can be a serious risk for the health of people, animals and ecosystems. As a result, the EU has set up strict rules and procedures to ensure a high level of protection. All EU countries must follow these harmonised rules to ensure that risks are properly assessed before commercialization. Any biocidal product cannot be placed on the European market or used unless it:

1) only contains approved active substances and

2) has been authorised. For this authorization, companies must demonstrate the product efficacy and that it does not have unacceptable risks to: a A-human health, B-animal health and C-the environment.

Biocide treated products (as the BETITEX core products or Biocidal Treated Textiles) are also included on the Regulation (EU) 528/2012.

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Furthermore, the sustainability of the final product is evident as the biocides are integrated into a polymeric or ceramic matrix, reducing in this way the toxicology for the final users and the environment. This has been confirmed by Thermo gravimetric and Scanning Electron Microscopy analyses carried out in WP4.

Moreover, for all the tested biocides, the concentration added on the textile is much lower than the established by the safety data sheet of the products.

The higher durability of the insecticide effect in the treated fabrics, which confirms also their sustainability, has been proved during WP4, WP5 and WP6 through the washing cycles and the effectiveness tests.

2. A market research has been performed for the final expected products in order to define marketing opportunities and strategies.

Initially, BETITEX project's objective was to obtain a textile material capable of providing protection against ticks and bedbugs in personal protective equipment and home textile applications.

At the end of the project not only has this objective been achieved but there are other intermediate products that can also be, on their own, subject of marketing actions. In this sense, the report explores the business opportunities for the different sub-products and establishes strategies in order to engage marketing actions that will lead to the exploitation of these results.

The main objective is to take the results of the research of the BETITEX project one step ahead, closer to achieving a market-ready product. Being the specific objectives of the report, the following:

- Provide a market benchmark for anti-tick and anti-bedbug applications
- Identify all possible market applications for the final products
- Define the target market
- Identify main stakeholders
- Specify the marketing strategies that will allow the products to reach the market

3. A Plan for the Use and Dissemination of Knowledge (PUDK) has been prepared. It contains:

- A description of the key exploitable results
- Priority map per exploitation of results
- The exploitation plan
- Knowledge Management and IPR protection: IPR Framework, Technology watch, IPR protection strategy and Access rights
- Exploitation Agreement

All information related to exploitation of project results is considered as confidential by project partners.

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5. Project website and contact details

Project website: www.betitex.eu

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