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1. What is BioTex

EURATEX, the European Apparel and Textile Organisation and EuropaBIO, the European Association for Bioindustries have formulated their future visions in the form of Strategic Research Agendas for the “European Technology Platform for the Future of Textiles and Clothing” (Textile ETP) and the Industrial or White Biotechnology section of the “Sustainable Chemistry Technology Platform (SusChem – White Biotech)”. In both documents sustainable development R&D strategies for the period up to 2020-2025 are described including clear identifications of biotech based applications. Their potential however will only be fully realised when systematic multisectorial interdisciplinary scientific and industrial collaboration occurs. Therefore the BioTex initiative has been jointly launched by the two European Technology Platforms in order to initiate collaborative action in pre-competitive research and development at European level between the Textile / Clothing and related Industrial Biotechnology sectors.

2. Rationale

The textile and clothing sector remains one of the key manufacturing branches in a significant number of countries of the European Union. The Textile and Clothing sector has an annual turnover of more than 200 billion Euros and employs some 2.5 million people in over 150 000 companies across the EU-27. The EU is the world’s second biggest exporter of textiles and world’s third biggest exporter of clothing. Faced with fierce global competition from low-wage countries its sustainability strongly depends on a new multidisciplinary approach based on innovative high quality products and flexible, environmentally-friendly production systems. In addition, new initiatives to develop new attractive end-use markets for textiles need to be stimulated.

Biotechnology, as one of the modern dynamic disciplines, has an important role for the future knowledge-based economy. The European association for Bioindustries has some 81 corporate and 5 associate members operating worldwide, 6 Bioregions and 25 national biotechnology associations, representing 1800 small and medium sized biotech companies in Europe.
The Industrial (white) biotechnology sector is characterized by tremendous R&D activities and learning from nature. Supported by the European Commission, it has worked out a set of concrete steps to realize the vision of a Knowledge-Based Bio-Economy (KBBE), where new, clean, energy-efficient bio-processes and innovative biobased products will create a sustainable industrial base to ensure Europe’s future prosperity. To highlight the great potential of industrial biotechnology, the European Commission decided to stimulate the development, production and uptake of bio-based products in Europe using one of the specific Lead Market initiatives targeted at these products. Industrial, or also called “white” biotechnology has a major potential to drive the textile sector into employing new possibilities of selective enzymatic catalysis (as an alternative to harsh chemical processing); new bio-based materials can be expected to lead to the launch of textiles with new functional properties (being an alternative source of textile auxiliary agents, creating new functional properties for technical, medical, wellness textiles). Natural and artificial (bio-fermented) fibrous polymers and biotechnologies will develop cleaner production processes assisted by much greater utilization of natural renewable fibre sources and as an instrument of new surface architecture of hybridised fibrous matrices. Additionally, the minimization of the environmental impact of industries is of increasing relevance to protect and preserve the environment and the health of citizens. The other major trend that will influence the global market is the oil price. Because it influences many textile industry factors (energy cost, textile fibres costs, the dyes used, chemicals etc.) it is expected that this situation will favour the use of more sustainable technologies (biotechnology and other environmentally friendly technologies) and bio-based materials. Also due to the fact that the textile industry was historically one of the first areas of industrial biotech applications (after production of foods and drinks), both EURATEX and EuropaBio decided to highlight textile biotechnology within their strategic programmes of the current European technology platforms, i.e. EURATEX for future of textile and clothing and CEFIC-EuropaBio Industrial Biotech sub-platform, supporting Sustainable Chemistry.
3. Objectives

The objectives of the BioTex initiative are:

- the establishment of a permanent collaboration forum between textile manufacturers and developers and manufacturers of new bio-based products to exchange information on major technological trends, developments in bio-based innovation and evolving users needs;
- the combination of complementary elements of the Strategic Research agendas of the SusChem (White Biotech) and Textile European Technology platforms into a joint Research Road map;
- the initiation of strategic, radically break through – oriented collaborative research projects between the two sectors bringing together the best available competences and capacities for mutual benefit and to speed maturity of emerging biotechnologies for industrial implementation within the European textile and clothing industry;
- to strengthen the sustainability of the European textile and clothing manufacturing sector by use of the Bio-based products in Lead Market Initiatives.

4. Stakeholders & Working Structure

The stakeholders of the BioTex initiative are:

- the European textile & clothing industry and their representative organisations
- the European industrial (white) biotechnology and their representative organisations
- the European textile and industrial (white) biotechnology research communities
- the European Commission

The implementation of BioTex initiative is coordinated and facilitated by a Coordination Committee which is composed of representatives of all stakeholders groups. The Coordination Committee is chaired by Jan Marek, Inotex, Czech Republic.
5. R&D Priorities

R&D priorities for BioTex were developed on the basis of research priorities of the Textile ETP covering:

- New speciality fibres and fibre-composites for innovative textile products
- Functionalisation of textile materials and related processes
- Bio-based materials, biotechnologies and environmentally friendly textile processing
- New textile products for improved human performance (health care, protection, sports)
- New textile products for innovative technical applications (transport, construction, energy & environment etc.)

and the research priorities of the Industrial (White) Biotechnology sub-platform of SusChem European technology platform for sustainable chemistry, which aims to promote the exploitation of renewable resources from non-food biomass by use of new bio/chemical technologies and to convert them into bio-based building blocks which can be utilised in production of advanced biodegradable commodities. The key research objectives are:

- Novel enzymes and micro-organisms
- Biocatalysts function and optimization
- Biocatalytic process design
- Innovative downstream processing

These key objectives of Industrial (White) Biotechnology foster the development and introduction of novel, innovative products and process in a cost- and eco-efficient manner, preferably using renewable raw materials. An inherent great significance of industrial process sustainability also contributes to the attractiveness of biotechnologies.

On the basis of a survey among European textile and clothing manufactures organised by EURATEX the European Apparel and Textile organisation in 2006, in correspondence with existing key topics of the SusChem Industrial (White) Biotech sub-platform, identified three main textile related domains:

- Smart textiles and clothing (textile integrated electronics)
- Mass customisation and new design and product development concepts for clothing and fashion
- Integrated quality and life cycle management concepts

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Novel biocatalysts:

**Target oriented screening methodologies:**
- *Novel biocatalysts for specific applications*

Developing biocatalysts that are more effective and the engineering of efficient biocatalytic processes (e.g. textile pretreatments, synthetic fibre modification (hybridisation), and functionalisation. Improved biocatalysts for processing (“bio-retting”) of bast fibres (flax, hemp) and emerging natural fibres to minimize influence of climate changes by use of biocatalysts (e.g. for higher yields natural fibres, waste-reduction for natural fibres, selective extraction of different natural compounds). Extremozymes with improved resistance to the technology conditions of fibre spinning and conventional textile wet processing (high temperatures, pH, oxidative conditions etc.). Novel biocatalysts with specific control (on-off switch) for future processes and products based on functionalized textile materials (or functionalisation of surfaces of textile membranes). Biocatalysts for future processes of new biomaterials (e.g. bio-based polymers from fermentation).

**Biocatalytic process design:**
- *Integration of chemo- and biocatalysis, either in subsequent steps or in heterogeneous catalysis*

New system of cotton (also for bast fibres, emerging natural and man-made cellulosics) treatment based on enzymatic single-step desizing and scouring, followed by chemo-catalytic bleaching as an industrial show-case for intelligent (bio)-catalytic technology. Combination of chemical, physical and biotechnological treatments (substrate activation by plasma, ultrasound etc., followed by subsequent enzymatic reactions) as a new tool for integrated pretreatment and functionalization, including improved dyeability (e.g. better exhaustion of dye bath and better dyestuff fixation).

Enzyme recovery and immobilization of enzymes for textile applications avoiding losses of biocatalysts to further increase process effectiveness. Utilization of textile substrates as carrier for enzymatic catalysis. Enzyme initiated graft copolymerization of functional monomers onto fibres. Key issue in support of design and development of biocatalytic processes (as the clean alternative to traditional chemical processes) will be savings in energy, water and environmental costs. In addition, the incidence of REACH and IPPC implementation must be taken into account.

**Improved fermentation and downstream processes**

**Improved Fermentation process**
- *New synthetic pathway engineering for improved fermentation*

New pathway engineering for improved fermentation processes that lead to new bio-based polymers as a renewable sources for the textile industry become are a fundamental area for the textile sector since availability of oil-based synthetic fibres will become more and more complicated due to the limited oil availability. The cost-effective production of degradable polymers to replace the currently used synthetic polymers is important. Also the development of totally new bio-based fibres, production of fibres by microorganisms, genetically engineered techniques to produce (bio)functionalised or naturally coloured biopolymers etc will offer exciting innovations. Fermentation process improvement is essential to reach quality and cost effectiveness. Contrary to existing synthetic fibres, new bio-based fibres can be fully biodegradable.
Surface coating as a specific tool of biofunctionalization of the existing (limited) range of European synthetic and natural fibre substrates will speed the maturity time of new, customised functionalities (bringing new material qualities e.g. moisture management and thermo-regulation, breathability, stain removal, self cleaning, wellness and health care etc.) – based upon regenerated protein, silk-wool protein based systems.

**Biorefinery Concept**

**Improvement of biorefining technologies**

- **Valorisation of co-products or residues from main stream production**

A broad range of bio-refinable fibres exist e.g. waste material from bast fibres (flax, hemp) and emerging technical plants (e.g. Spartium – Spanish broom, straw, wooden chips). These co-products have potentially a high value as new materials for composite reinforcement, new qualities of construction materials and fibrous additives in building materials etc.

Not only fibres but also bio-resins, essential oils, surface-active bio-substances etc. can be extracted from the biomass. They can be potentially introduced as a new source of functional finishing auxiliary agents (e.g. FR, UV absorbers, antimicrobials, health and body care). Biotechnologies “bio retting” can be part of tailor – made processing technology to enhance the effective, reduced waste utilization of biomass used in (rural) bio-refinery. This can be likened to the utilization of local renewable sources in textile manufacturing which was one key element of European textile industry genesis, which could provide new opportunities for fashion garments and technical textile applications, too. Direct use of extracted fibres as such followed by special surface (bio)modification (elementarisation, resin adhesion improvement, fibre fineness, cottonization etc.) as well as the extrusion (co-extrusion) of natural fibres and extracted polymers can be studied.

On the other hand, textile wastes could be studied as one of the larger sources of feedstock for biorefineries within a biofuel program. The synthetic part of textile blend products will be recycled separately (with the natural, cellulosic, part being utilized as fermentation feedstock).
6. Conclusions

From the major innovation priorities identified by the Textile ETP and in the industrial biotechnology section of the SusChem ETP can be concluded that numerous opportunities for multidisciplinary joint research efforts between the two sectors exist. Both innovative textile and clothing products as well as advanced enzymes and emerging white biotechnology solutions made in Europe should have a dominant role within the global economy. Systematic improvement of a joint multidisciplinary approach should focus both groups on near-term targets facilitating the efficient use of novel biotechnologies – namely enzymatically catalysed processes as a clean production sustainable alternatives. New bio-based products, efficiently using natural renewable resources will open doors for totally new high added value textile materials which will significantly widen the new market positions and new end-use possibilities. As a local alternative raw material source, bio-based products and biotechnologies can reduce (in the short and mid term perspective) and completely eliminate (in the longer term) the dependence on non-renewable fossil-based feedstock for many textile applications.

The following research priorities offer significant industrial potential in the short, medium and long term:

- Development of improved, environmentally friendly textile wet processings based on use of selective enzymatic catalysis as an alternative of harsh conventional chemistry
- New (multi)functional and hybridised fibres made by use of enzymatic modification
- Improvement of reproducibility and zero-waste utilization of renewable natural fibre resources based on bio-processing. Extensive use of bio-based materials as by-products of bio-refineries.
- Bio-polymers for new fibres and textile auxiliary agents as a tool for new (bio) functionalised fibrous materials
- Utilization of textile substrates (garments, technical textiles) as a widely used support for bioactive materials and investigation of textiles wastes as alternative large volume feedstocks for biorefinery

The existing BioTEX Coordination Committee supported by both European Technology Platforms will continue its work towards implementation of the present research roadmap seeking to exploit opportunities offered by European research funding programmes such as the 7th Framework Programme, COST actions or EUREKA as well as any other funding opportunities at national or regional level. Existing initiatives like the International Network of Textile Biotechnology (INTB) or COST Actions (COST 868 at present) will be used as broad interdisciplinary communication platforms. Stakeholders will be informed about major advances in exploring biotechnology and textile innovations and any relevant funding opportunities through events and other information channels of the two European Technology Platforms.
• About the SusChem ETP (Industrial Biotech section):

SusChem brings together a wide spectrum of organisations and individuals looking to boost sustainable chemistry, industrial biotechnology and chemical engineering research, development and innovation in Europe. Our fundamental goal is to contribute to a sustainable quality of life for all Europe’s citizens. As part of this goal SusChem is working to build a supportive environment in Europe for innovation and research in partnership with society. The research topics brought forward by SusChem address the great challenges and needs faced by our society today including energy use, transport, health, and communication technology. The industrial biotechnology section focuses more specifically on the development on a bio-economy through the technological development and industrial uptake of biocatalysis, fermentation technologies and the implementation of the biorefinery concept.

www.suschem.org

• About the Textile ETP:

The European Technology Platform for the Future of Textiles and Clothing launched in December 2004 is an industry-led initiative which brings together all interested stakeholders: the textile and clothing industry, related industrial and service sectors, the research and education community and public authorities at all levels. The platform’s main goal is the development and implementation out of a common long term vision and related strategic research agenda to support the transformation of this industry into a more knowledge – intensive and innovation driven sector. Bio-based materials, biotechnology and environmental friendly processes have been identified as one of the focus areas of the strategic research agenda.

www.textile-platform.eu