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Proposal for a new COST Action**

COST ACTION 868

**Biotechnical Functionalisation of Renewable
Polymeric Materials**

Proposer:

Prof. Georg Guebitz
Graz University of Technology
Petersgasse 12
8010 Graz
Austria
Tel + 43 316 873 8312
Fax + 43 316 873 8399
E-mail: guebitz@tugraz.at

COST National Coordinator:

Dr. Helga Mieling
Bundesministerium für Verkehr, Innovation und
Technologie
Radetzkystrasse 2
1030 Vienna
Austria
Tel + 43 1 71162 1300
Fax + 43 1 71162 1399
E-mail: helga.mieling@bmvit.gv.at

**TC Agriculture, Biotechnology
and Food Sciences
Rapporteur:**

To be appointed

DRAFT
MEMORANDUM OF UNDERSTANDING
For the implementation of a European Concerted Research Action
designated as

COST Action 868

“Biotechnical Functionalisation Of Renewable Polymeric Materials”

The Signatories to this ‘Memorandum of Understanding’, declaring their common intention to participate in the concerted Action referred to above and described in the ‘Technical Annex to the Memorandum’, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 400/01 ‘Rules and Procedures for Implementing COST Actions’, the contents of which the Signatories are fully aware of.
2. The main objective of the Action is to generate a synergistic approach for utilisation and upgrading of different biomaterials; to assess the potential of enzymes for surface functionalisation as well as the production of recombinant biopolymers with special functions and together with advanced and sustainable clean processing technologies generate new added-value polymer products with a broad application range.
3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at Euro 240 million in 2005 prices.
4. The Memorandum of Understanding will take effect on being signed by at least five Signatories.
5. The Memorandum of Understanding will remain in force for a period of four years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of Chapter 6 of the document referred to in Point 1 above.

COST ACTION 868

“Biotechnical Functionalisation of Renewable Polymeric Materials”

A. Abstract

Renewable polymeric materials from agricultural origin such as proteins, polyesters, polysaccharides and lignin are currently under-utilised because of the high cost and difficulties in their processing (that is, further functionalisation). This Action aims at the development of new highly sophisticated technologies to introduce new functionalities to the surface of polymer materials in order to design smart products with applications in medicine, cosmetics, the construction industry or technical textiles. Two approaches for the production of smart renewable materials will be investigated in this COST Action. First, sophisticated surface modification techniques using enzymes to specifically form cross-linkages or novel functionalities to polymer surfaces will be used. Second, the production of recombinant functional/hybrid biopolymers will be a tool to obtain smart renewable materials.

B. Background

State-of-the-art

Biopolymers to be studied in this COST Action are of agricultural origin and in many cases their origin is important (pre-treatment, processing, etc.). The major aim is the upgrading of these agricultural materials; however, in terms of application there will also be a focus on materials science. In this COST Action, mainly biotechnical tools for their functionalisation will be studied.

Biomass is a clearly under-exploited resource that has nevertheless a big potential for replacement of fossil oil-based products. Renewable polymeric materials such as proteins, polyesters, polysaccharides and lignin are currently under-used because of the high cost and difficulties in their processing (that is, further functionalisation). Chemical and physical technologies to add new functionalities to these materials or to exploit their interesting properties as coatings have had limited success. Similarly, in the production of blends/composites of biopolymers and synthetic materials for medical devices and other applications, current cross-linking or coating processes were inefficient. Therefore, new highly sophisticated technologies are required to introduce new functionalities to the surface of polymer materials in order to design smart products with applications in medicine, cosmetics, construction or technical textiles. Two approaches for the production of smart renewable materials will be investigated in this COST Action. First, sophisticated surface modification techniques using enzymes to specifically form cross-linkages or novel functionalities to polymer surfaces targeting hydroxyl, amine, amide, phenol, carboxyl, sulphhydryl, etc. groups present in the polymers will be used. Second, the production of recombinant functional/hybrid biopolymers will be a tool to obtain smart renewable materials.

Interaction of polymers with living cells or microorganisms is an important factor in many polymer applications ranging from protective antimicrobial materials to biomedical devices. Interestingly, surface properties of polymers have a strong influence on cells which attach to them. **Smart coatings** have a substantial effect on the **phenotypic and genotypic response of cells**. By controlling the hydrophobicity polymers, it is possible to alter the protein layer deposited, and thus the cell-signalling pathways and gene expression of cells.

The enormous potential of bioprocessing of polymers and production of recombinant biopolymers comprised production of **'active' photo-, thermal-, and chemical-sensitive**, conductive, signal transmitting, etc. fibrous materials has been assessed in the last few years. Such materials could display variable insulation properties, be water resistant or change colour on certain conditions.

Biomaterial-derived biopolymers display many interesting characteristics such as for example, antimicrobial properties (chitosan, lignin), which can be exploited as coatings for or composites with other natural materials, with applications in the medical and textile area and composites production. Although several promising applications of biopolymers as coatings or films have been reported there is a strong need for a systematic multidisciplinary approach investigating the potential of advanced techniques for biopolymer modification or coating applications. For example, films and coatings prepared from polysaccharides or proteins have shown to be excellent oxygen and oil barriers. The major drawback of these biopolymer coatings has been their hydrophilic nature, which results in low moisture tolerance. Thus, further functionalisation is necessary to overcome such shortcomings.

For several biomedical applications natural polymers alone will not comply with all the requirements especially in terms of mechanical properties. A promising approach is to **combine** (coatings, composites) the good biocompatibility of natural materials with the good and tuneable mechanical properties of synthetic polymers (**'bioartificial materials'**). The compatibility with cells and tissues of a material is determined by the interactions at a molecular level between the material and the constituents of the host living tissue. Through these interactions, the molecules of the living tissues can change their biological functionality, for example by changing the molecular configuration and/or the activity of the functional groups that link or interact with the synthetic material. The higher the compatibility of the synthetic material, the lower is the number of variations of the biological functionality of the living tissues that are induced by the material. In particular, since the key properties expected from the synthetic materials are mainly bulk properties, while those deriving from the natural one are exploited at the surface or the interphase, the realisation of 'multilayer' bioartificial material could result in significant benefits for several prospective applications in the biomedical sector. For example, coating of biomedical devices or implants with silk fibroin solutions (a protein) or hyaluronic acid (a polysaccharide) can improve the interaction of the biomaterial with the living body and favour its integration, avoiding adverse inflammatory reactions.

However, because of the chemical structure of synthetic polymers, their modification/coating requires drastic conditions in order to obtain the desired end-product properties. Furthermore, functional substances are often released from the end-products arising from weak bonding. In the recent years, enzymes have been discovered capable of modifying polymer surfaces. Both surface enzymatic oxidation and hydrolysis have been described for synthetic polymers such as polyethyleneterephthalate, polyamides and polyacrylonitriles. This enzymatic activation can per se

improve polymer properties such as hydrophilicity but can also facilitate coating with other materials to produce, for example, biocompatible materials.

The development of advanced functional materials based on macromolecules is often limited by the randomness associated with polymer synthesis and the exponential increase in technical difficulties caused by attempting to reach a sufficient degree of complexity in the molecular design. Evolution has produced materials showing a level of mechanical properties and functionality which is significantly higher than those reached in synthetic materials. This amazing functionality relies on the absolute control of the amino-acid sequence in protein biosynthesis by living cells. Based on current developments in molecular biology the required technology to use genetically modified cells as factories to produce **functional recombinant protein-based polymers** with the following advantages is available.

By genetic engineering, systems and devices exhibiting a function not displayed in living organisms but of a particular **technological interest** can be obtained while the degree of control and complexity attained in the designed polymers is clearly superior to chemical synthesis. Single amino acids are grouped within functional domains. In their turn, those domains are arranged along the polymer chain in a well-defined molecular architecture in which there is no space for randomness. There is no direct relationship between producing yield-cost and complexity of recombinant polymers. Once the genetically modified (micro)-organism is obtained, the fast, robust and cheap production readily compensates for the costs associated with the molecular biology steps. The raw materials employed in biosynthesis of these materials are not the amino acids themselves but **many simple, renewable and cheap sources of carbon and nitrogen** can be converted into the needed amino acids by the microorganisms and, finally, to the desired polymers. Examples of **recombinant protein-based polymers** can be found from bulk materials and fibres with extraordinary mechanical performance to the most advanced, functional, self-assembling and smart materials for biomedical and high-tech uses.

Polyhydroxyalkanoates (PHAs) have been used for several years to replace plastics as biodegradable polymers made from renewable resources. Technologies have been developed to alter the properties of these materials for special applications such as antifouling surfaces, in medicine (tissue engineering, wound treatment, resorbable implants for complicated fractures and sutures), and in pharmacy (drug release). For example, the covalent linkage of polyhedral oligomeric silsesquioxane systems (POSS) to PHA resulted in a new bioglass. On the other hand, bioengineering of PHA synthesis can lead to co- and terpolyesters with varying side chains with functional properties. Only recent advances in microbial physiology combined with new downstream-processing technologies make the targeted biosynthesis of polyhydroxyalkanoates with special composition and function/properties possible.

In the last few years sophisticated **technologies for surface functionalisation** such as **micro contact printing** have been developed mainly in the USA. However, some existing European activities which should be strengthened within this Action have also demonstrated the potential of this technology. Soft lithography allows **functionalising** materials to have **surfaces** by stamping functional 'links' ,– for example containing enzymes – on them. A number of other new techniques will be assessed in this project as described below.

The availability of a **sophisticated analysis tool** is essential for the development of processes for functionalisation of renewable polymers. Expensive machines for surface analysis are not available in single institutions; therefore good cooperation is necessary. A number of new instruments have become available in recent years and numerous advanced methods such as surface tension, adhesion, AFM, FTIR, ESCA, REM-EDX, and other spectroscopic methods will be compared in this COST Action. Through Short-term Scientific Missions (STSMs) access to and experience of certain analysis techniques/instruments currently available in only a few places in Europe will be possible and thus synergies will be established.

Need for a COST Action

The state-of-the-art on the functionalisation of different renewable polymers only rarely considers **combinations/composites of these materials** in order to obtain the best product properties. Similarly, common functionalisation and analysis strategies can be exploited for different materials while for certain requested properties (e.g. antimicrobial) the best functional biomaterial of a combination thereof could be selected from a number of compared materials. Such a combination of materials and **synergistic approaches** could nevertheless turn out to be a key success factor for the increased use of such products and is thus a major aim of this Action.

Despite the tremendous potential of smart biomass-based polymers, this sector has not been widely supported in Europe. For example the EU FP6 calls for proposals have mainly concentrated on energy and chemical raw materials rather than on renewable polymeric materials and, in addition, were incorporated within several separate sectors (nanomaterials, health, feedstuffs and food). This has led to a fragmentation of the research within the European Research Area (ERA). There is a need for coordination of such activities. The only exception where a good coordination existed in the field of lignin was the FP5 thematic network Eurolignin which has led to a multitude of new lignin projects and induced a significant advance for Europe in that field. However, there are many other biomaterials that are of interest to the industry, such as polysaccharides (cellulose, starch, chitosan), proteins and biopolyesters. A coordinated COST network is necessary for two reasons:

- Fundamental problems appearing in this field are always similar and cross-fertilisation effects between the different types of raw materials are expected to be very important: methods and processes of production and functionalisation, analytical challenges, similar markets and therefore testing methods in many of these products.
- All these raw materials and new sophisticated production processes need a new impact to promote their implementation: this will be achieved by this common Action focusing on high added-value applications of functionalised materials.

To realise the above objectives a COST Action is the most appropriate instrument. Based on a cross-cutting focus of this Action, synergies can be developed only by a bottom-up network. Both the planned meetings and workshops and the exchange of young scientists will lead to exchange of knowledge (from simple working procedures to highly sophisticated analysis) and the development of new strategies and ideas for individual projects within the Action. The state-of-the-art clearly shows that a wide European network is needed in this area. Also, an important feature should be the open access for new participants, clearly a characteristic of the COST programme. Even some current European research projects do not have the critical mass to consider all aspects of biotechnical functionalisation of biopolymers.

C. 1 Objectives

Main objective

The main objective of the COST Action is to generate a synergistic approach for utilisation and upgrading of different biomaterials; to assess the potential of enzymes for surface functionalisation as well as the production of recombinant biopolymers with special functions and, together with advanced and sustainable clean processing technologies, generate new added-value polymer products with a broad application range.

To reach this objective the following goals have been defined:

- Common strategies for functionalisation of different renewable polymers (e.g. polysaccharides, proteins, lignin) will be identified.
- New enzyme tools will be developed for surface functionalisation and mechanisms will be elucidated.
- Enzyme-based processes for durable (covalent) coating processes will be investigated.
- The potential of 'smart' recombinant biopolymers will be assessed.
- Properties of microbial biopolymers (PHA) will be engineered based on directing biosynthesis towards desired polymer backbone composition and side chains.
- Bioartificial materials and systems for medical applications will be developed.
- A pool of analysis techniques including advanced analytical instrumentation as well as standard technical characterisation methods relevant to the analysis of all biomaterials will be set up (surface analysis, special effects such as antimicrobial or biocompatible properties, characterisation at the nano-scale).
- The performance of functionalised materials and their combinations for specialty applications (biomedical, cosmetics, etc.) will be evaluated.

C.2 Benefits

The technical benefits from this COST Action are the generation of multifunctional polymer materials and their combinations through environmentally friendly processing technologies. Underused biomass resources will be converted into high value materials. Implementation and promotion of such technology by this COST Action will thus have a strong economic impact for participating European countries. This will increase competitiveness with respect to other leading countries such as Japan and the USA. Smart materials such as biocompatible medical devices, intelligent sensor-performing fibres or durably grafted finishing agents will also contribute to the health and safety of European citizens.

The major strategic benefit of this Action is the generation of a synergistic approach for use and upgrading of different biomaterials (proteins, polysaccharides, lignins). Only this combination will lead to breakthroughs and future implementation. An important benefit of the Action is also to bring together experts from different areas and countries with expertise ranging from molecular biotechnology, polymer processing to analysis which is required for the interdisciplinary objectives of this Action. Through short term scientific missions this interchange of knowledge will be promoted, especially among young scientists.

The incorporation of small and medium enterprises (SMEs) and leading European companies will benefit the European economy by implementing new technologies and thus increase competitiveness.

D. Scientific programme

The scientific programme of this COST Action comprises coordination of research activities in the fields of enzyme technology, genetic engineering, materials science, fermentation and processing technology. The potential of enzymes for targeted attachment of functional molecules to the surface of polymeric materials will be exploited. Similarly, enzymatic cross-linking/grafting (tyrosinases, laccases, transglutaminases) will be investigated with special focus on functional coatings and composites. As an alternative approach recombinant and natural microbial biopolymers (for example polypeptides) with special functional groups or anchor groups for further functionalisation will be produced. In this way a broad range of products can be engineered.

The scientific programme of the Action is structured into three Working Groups:

- WG1 will investigate functional natural and bioartificial materials obtained by new technologies such as with enzymes.
- WG2 will focus on tailored microbial biopolymers designed genetically (recombinant proteins) or by directing biosynthesis.
- WG3 will evaluate several speciality applications of these materials.

WG1: Functional Natural and Bioartificial Materials

Biopolymers display many interesting characteristics which will be exploited in coatings. Furthermore, because of the reactivity of the polymers, additional functionalities can be inserted into the matrix via enzymatic techniques. Although several promising applications of biopolymers as coatings or films have been reported, there is a strong need for a systematic multidisciplinary approach investigating the potential of advanced techniques for biopolymer modification for coating and composites applications. For example, films and coatings prepared from polysaccharides or proteins have shown to be excellent oxygen and oil barriers. The major drawback of these biopolymer coatings has been their hydrophilic nature, which results in low moisture tolerance. Cross-linking polymers via chemical or physical methods (UV, temperature, γ -ray) or dehydrothermal cross-linking has been attempted, especially with proteins to increase their stability in humidity or aqueous environments, improve their mechanical properties, processability or swelling behaviour. The most important result of cross-linking is the decrease of solubility and swelling in an aqueous environment. By modifying cross-linked proteins with hydrophobic additives such as oils or waxes the hydrophilicity of proteins materials can be strongly reduced. Similar approaches can be used for polysaccharide modification.

Enzyme-based functionalisation techniques rely on the use of novel enzyme systems. On the one hand, novel reactions/substrate specificities for polymeric substrate are continuously being discovered and on the other hand enzyme treatment of polymers requires certain enzyme stabilities. A close cooperation between enzymologists, molecular biotechnologists and experts on polymer chemistry and engineering is required. Within this WG, enzymology will mainly cover new oxidative enzymes, hydrolases and transferases. In particular, the potential of bacterial polyphenol oxidases which are investigated for only a few years (in contrast with fungal enzymes), peroxidases from microorganisms and plants (for example the palm tree) and various tyrosinases for polymer functionalisation will be assessed among other oxidases. Tyrosinases form reactive quinone precursors on the side chain of the tyrosine residue in proteins, which can further react with nucleophiles, such as amino-groups in chitosan or to undergo direct cross-linking. Laccases or peroxidases can cross-link both feruloylated arabinoxylans and proteins. Among hydrolases,

polysaccharide modifying enzymes such as esterases, α -galactosidases, sucrases will be included while proteins will be modified with oxidative enzymes (such as tyrosinases), proteases and transglutaminases. The latter enzymes catalyse the formation of an intra- or intermolecular isopeptide bonds between lysyl and glutamyl residues in different types of proteins.

Material preparation with biotools at bulk or surface modification on the meso or nanoscale will be eventually assisted by advanced physico-chemical modification tools (plasma treatment, molecular imprinting, template polymerisation). Production and fabrication techniques able to produce devices with nano or microstructuration will be applied, such as microfabrication techniques (e.g. soft lithography) or electrospinning.

Starting materials for the production of functional natural and bioartificial materials will include proteins (gelatine, silk), polysaccharides (starch, hemicelluloses), lignocellulose and lignins. In detail, materials to be investigated for medical devices will be based on resorbable materials such as glycolic and lactic acid (PGA, PLLA) and copolymers, block copolymers based on degradable (bio)polyester segments, tailor-made thermoplastic materials using starch and other natural polymers (proteins, polysaccharides, etc.), collagen, gelatine and related materials obtained by recombinant techniques, of new origin such as marine sources modified or cross-linked by enzymatic treatments, combined to produce bioartificial blends from proteins or polysaccharides and degradable synthetic or bacterial polymers.

Biotechnical methods for bulk and surface modification will be compared with the performance of chemical processes (e.g. carbodiimide chemistry, chemical cross-linking) and physical processes (e.g. e-beam, plasma, dehydrothermal cross-linking).

An important part of the WG will be the establishment of analysis methods both for mechanistic studies (such as enzymatic radical formation on polymer surface for activation for coating) and to access final physicochemical, biological and mechanical parameters. State-of-the-art techniques will be discussed and should lead to a more cooperative approach in terms of making expensive machinery available to the participants (for example through STSMs). Tools for analysis of surface properties of the coatings include surface tension, adhesion, AFM, FTIR, ESCA, REM-EDX and other spectroscopic methods in order to get information about the coatings and the interfaces between coating and substrate. Similarly, technical properties relevant for specific applications assessed in WG3 will be determined. In addition to physicochemical and mechanical parameters antimicrobial activity of biocoatings will be tested using standards methods.

Thus, from coordination of research and exchange of knowledge the deliverables of WG1 will be a set of new methods (e.g. involving enzymes) allowing the production of new functional natural and bioartificial materials. New biotechnical coating techniques will result in materials with special properties such as for medical devices.

WG 2 Recombinant and Microbial Biopolymers

In this Working Group, European research activities in the field of functional microbial polymers (protein and polyester based) will be coordinated. Two approaches will be compared: recombinant protein-based polymers will be constructed containing functional groups in their backbone. The second approach will investigate biosynthesis of biopolyesters (polyalkanoates) to allow production of co- and terpolyesters with different functional side chains.

The task of genetic engineering of protein-based polymers will be carried out in cooperation with biotechnologists and polymer scientists and engineers. To exploit the potential of nature, a portfolio of possible functionalities of protein-based polymers will be created (e.g. environmental sensing, specific surface attachment, self-assembling, specific bioactivities, etc.). Already determined and potential properties (physical, chemical, biological) of such functional material designs will be included. In turn, shortcomings of existing polymers will be listed to identify further targets for genetically engineered protein-based polymers.

While the production of advanced functional materials based on macromolecules is often limited by the randomness associated with polymer synthesis, evolution has produced materials showing a level of mechanical properties and functionality which is significantly higher than that which has been reached in synthetic materials. Even the newest concepts in materials science, such as hierarchical organisation, mesoscale self-assembly or smartness are common to many natural macromolecules. In WG2 new functional protein-based polymers will be studied. Relationships between amino acid sequences and resulting polymer properties will be established. Functional groups will be inserted into the backbone of the polymers. Besides the design of new self-assembling and smart materials their production on a large enough scale will be necessary in order to evaluate product properties under realistic conditions. Thus, production and downstream processing of these recombinant protein-based materials will be a major issue for WG2.

Functionalisation of polyhydroxyalkanoates (PHA) will be studied by engineering biosynthesis to yield co- and terpolyesters with varying side chains with functional properties. These will include applications for antifouling surfaces, in medicine (tissue engineering, wound treatment, and sutures), and in pharmacy (drug release). Furthermore, the potential of various enzymes will be assessed to modify the surface of PHAs. These techniques will be compared with chemical approaches such as covalent linkage of polyhedral oligomeric silsequioxane systems (POSS) to PHA which resulted in a new bioglass.

For microbial production of both PHA and recombinant protein-based polymers the spectrum of renewable carbon and nitrogen sources will be assessed.

As a result of coordination activities within WG2 the development of functional materials based on tailored microbial biopolymers with novel properties obtained by genetic and biotechnical engineering will be strengthened.

WG 3 Smart Polymers

Within WG 3 a platform will be established to connect the enormous potential of functional materials (possible with new technologies) to the increasing complexity requirements to polymeric materials. The establishment of this new technological platform on smart polymers (with presence of end-users and industry) within this WG3 will be based on the combination of modern biotechnology and traditional polymer science. As a main outcome, this platform will be the source of truly advanced polymers for biomedical applications (tissue engineering, controlled drug delivery), smart systems and materials (sensors, actuators) and nano-related products. In addition, commodity materials, matching and outperforming the properties of oil-derived plastics, composite materials, elastomers and fibres are also being targeted. Life cycle assessments will be performed in addition to technical evaluation of new materials. In all cases, the materials are produced exclusively from renewable biomass, and use only truly environmental clean technologies.

The three main industrial sectors where the functional materials will be applied at high value are: life

science-related fields (cosmetics, nutraceuticals, health care), high performance polymers and technical textiles. In all these sectors complex performance characteristics are necessary like they can be achieved by high complexity molecules available in the biosphere. Among such characteristics are: anti-bacterial, anti-viral, anti-fungi, anti-algae, anti-oxidant, ad- and absorbing, biocatalyst (improving the general well-being and performance of the organisms), complexing, emulsifying, dispersing, photon scavenging, flame retardant. Many of these characteristics are of importance in several of the abovementioned three industrial sectors. For example anti-oxidant effects are important in life sciences as well as in materials science. For **implants** the prepared materials can include active molecules to enhance biocompatibility, to suppress inflammation, infection, bacterial adhesion, or other adverse responses resulting from contact with body fluids. Therefore surface modification procedures to create ultrathin nanostructured and biologically functionalised interfaces at the implant surfaces will be investigated. For **drug delivery**, degradable polymers coated with polysaccharides or proteins showing enhanced properties in terms of delivery of specific drugs to the target will be studied. One aim of the WG with regard to **tissue engineering** is to explore the abovementioned approaches to functionalise biologically scaffold surfaces which interact with the body so that the biological system will not be disturbed and at the same time the correct adhesion and differentiation of the cells will be stimulated. For all these activities, this WG will have a **strong involvement of industry/end-users** and special meetings will be organised.

E. Organisation

The COST Action will consist of a Management Committee (MC) and three Working Groups (WG) and a Short-Term Scientific Mission (STSM) programme.

The responsibilities of the Management Committee are to:

- appoint the chairperson, the vice-chair person and the Working Group leaders during the kick-off meeting;
- plan the MC, WG meetings and workshops;
- evaluate and monitor the progress of the Action;
- report the progress annually;
- compare the original objectives with the actual results;
- ensure networking between all participants and Working Groups;
- appoint an STSM manager and assist with evaluation of applications;
- up-date the Website;
- perform other duties as specified in the COST implementation rules and procedures.

The responsibilities of the Working Group leaders are to:

- organise the Working Group meetings and appoint national organisers;
- coordinate the activities within the WGs in the framework of the objectives;
- promote the set-up of joint research and the writing of common publications;
- report on the WG progress to the chairperson and Management Committee.

Short-Term Scientific Missions

Short-term Scientific Missions will be organised to enhance cooperation between different participating countries and institutions. STSMs can also cut across different Working Groups. The research will be strengthened and intensified by the exchange of young scientists between different organisations.

Working Groups

All practical work will be carried out within a large number of projects at the participating institutions while the coordination of this work by this COST Action will increase the impact of these individual activities. The COST Action will be structured in three Working Groups (WGs): WG1 will investigate functional natural and bioartificial materials obtained by new technologies such as with enzymes. WG2 will focus on tailored microbial biopolymers designed genetically (recombinant proteins) or by directing biosynthesis. WG3 will evaluate several speciality applications of these materials.

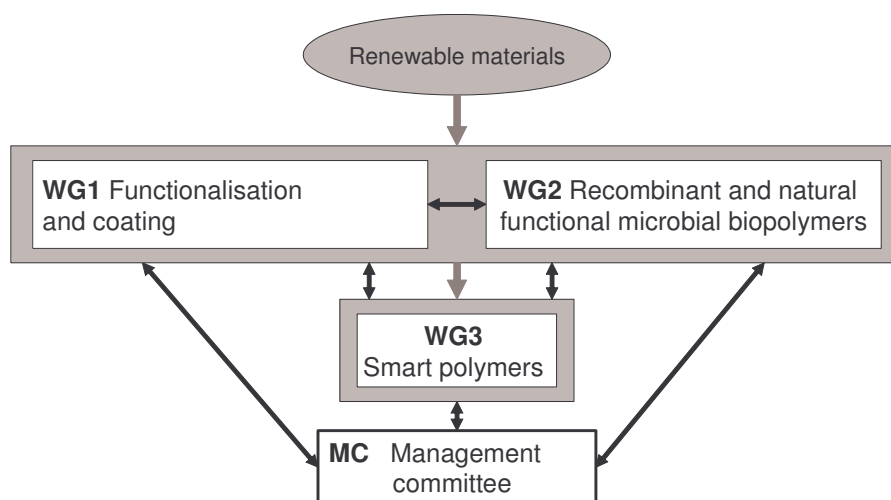


Figure 1. Schematic presentation of the interaction of Working Groups of this COST Action.

F. Timetable

This Action will last for four years. For several reasons this time frame seems appropriate. First, most projects incorporated in this COST Action will have a duration of between three and five years. Second, the cross-cutting cooperation between specific areas of bio/enzyme-technology and polymer functionalisation (coating) also require a transfer of basic knowledge between experts from these different areas.

The activities to be organised during the course of the Action are shown in Table 1. During the first MC meeting, WG leaders will be selected. WG meetings form the basis of the Action and are usually organised twice a year. Meetings of two different Working Groups (changing the combinations) will usually be held in conjunction. During the annual workshop, special topics will be discussed in various sessions relevant to the Working Groups. Outside experts will be invited to this workshop while special sessions will be organised for the industry and SMEs. Also, young scientists will be given the opportunity to present their results while participants of the STSM programme will present the results of the missions.

Table 1. Overall timetable

Year	1	2	3	4
First MC	■			
Annual workshop		■	■	■
Annual MC meeting	■		■	■
WG meetings*	■	■	■	■
Final workshop				■

Reporting each year

* Meetings will be organised simultaneously with alternating combinations of two WGs at the time.

G. Economic dimension

A total of 77 institutions from 22 countries including 16 companies have shown an interest in participating in this Action. However, a substantial increase in this number is expected after the first year of the Action. It should especially be noted that this Action cuts across different areas (bio/enzyme technology, coating and functionalisation of polymers) for the first time. The Action will thus enhance cooperation between experts from different areas leading to new technologies with economic potential. Participants from Russia and Egypt are anticipated, based on their special expertise related to polymer processing and the economic opportunities for European companies in these countries.

The following 20 COST countries have actively participated in the preparation of the Action or have otherwise indicated their interest: Austria, Belgium, Czech Republic, Denmark, Spain, Finland, France, Germany, Italy, Lithuania, Latvia, Netherlands, Poland, Portugal, Romania, Sweden, Slovakia, Slovenia Switzerland and the United Kingdom. On the basis of national estimates provided by the representatives of these countries, the economic dimension of the activities to be carried out under the Action has been estimated, in 2005 prices, at roughly EUR 240 million in total. This estimate is valid on the assumption that all the countries mentioned above, but no other countries, will participate in the Action. Any departure from this will change the total cost accordingly.

H. Dissemination plan

The results obtained in this Action will be disseminated through the routes described in Table 2. An important tool in the dissemination of the results of the COST Action will be a Website platform. Both information for the public, industry, academics, policy makers and stakeholders will be made available on this Website, while a restricted area will be generated with access for the participants of the Action only. Research results generated within this Action will be published in international peer-reviewed journals and books. Similarly, review articles will be published in cooperation with several Action participants as multi-author papers. Presentations will be given at international scientific conferences. Participants of the STSM-programme will be especially encouraged to present the outcome of the missions at conferences and workshops. On the one hand European technological excellence will be promoted while on the other hand IPR aspects will be considered.

This COST Action will also disseminate new strategies through teaching activities at universities. Participation in the STSM programme will be offered to PhD students to promote transfer of knowledge.

The major communication tool between the participants of the Action will be the annual workshops and Working Group meetings. Keynote speakers will be invited to the annual workshop. Also, special sessions with industrial relevance will be organised. This is especially important to prepare implementation of new processes and attract representatives of industry.

Besides the Website, flyers will be used to target special groups in the public to enhance public awareness of new biotechnical tools in biopolymer functionalisation. Results will be presented in different forms to make them understandable to those with and without a technical background in the area. Economic and European strategic data will be included for targeted dissemination of results and goals of the Action to policy makers and stakeholders.

Interaction of the COST Action with other European and national networks and initiatives (for example Europabio) will be established at the first MC meeting. Manuals for testing procedures will be developed based both on theoretical discussions and interlaboratory analysis projects.

This dissemination strategy will be continuously updated during the lifetime of the Action.

Table 2. Dissemination methods of the COST Action

<i>Type of dissemination</i>	<i>Main target groups</i>	<i>Quantity</i>
Website	Public, industry, academics, policy makers and stakeholders	1
Website/limited access	Participants	1
Newsletters	Industry, academia, public	1 per WG
Working Group meetings	Participants	several
Presentations at scientific conferences	Academia	several
Workshops (yearly)	Participants, invited speakers, others	4
Flyers	Public, industry, academics, policy makers and stakeholders	1
Proceedings	Public, industry, academics	1 per workshop and conference
Review article	Scientific community	1 per WG
Teaching	Graduate students	
Book (final proceedings)	Public, industry, academics	1
Interaction with other networks	Network members	various
Manuals	End-users, researchers	various

COST Action 868

**“Biotechnical Functionalisation of Renewable Polymeric
Materials”**

**ADDITIONAL INFORMATION
NOT PART OF THE MoU**

History of the Proposal

The idea of this Action was born within the framework of several European projects focusing e.g. on enzymatic polymer functionalisation or on biotechnical improvement of natural fibres. A core group for the preparation of this proposal has been formed in November 2004. From this point on, discussions have been performed with further experts. While the proposer was a WG leader in the previous COST Action 847 on textile biotechnology, the current Action goes in a different direction focusing on high value functionalised biomaterials and in the textile area only technical materials (e.g. for medical or construction) will be considered not included in the previous Action. Expertise acquired in the previous Action will be helpful for the management of the new COST Action. Various finished, running and planned COST Actions in different domains have been evaluated to identify possible overlaps. Although there have no overlaps been identified, contacts could be established to some Actions (e.g. via organisation of a joint workshop) to D29 green chemistry or E34/E49 on wood materials (bonding timber; wood based panels). It was the scope of this new Action from the beginning on to create a network cross-cutting over different disciplines ranging from biotechnology to polymer processing to bring all experts together needed to reach the common objective to develop smart functional materials from renewable sources. Thus, this Action is not the continuation of existing activities but a new strategic tool to form a critical mass to promote use and upgrading of bio-based materials. Especially synergies between different areas (e.g. analytical tools, enzyme functionalisation) were considered during formation of the network. **All** listed participants for this action have provided information which was collected in especially designed forms.

List of Experts

All experts of this list have been contacted and they have provided information for the draft of this COST action. Experts marked with an asterisk, have actively participated in this COST Action proposal.

Austria

Georg Gübitz *

Department of Environmental
Biotechnology
Graz University of Technology
Petersgasse 12
A - 8010 Graz

tel + 43 316 873 8312
fax + 43 316 873 8815
email guebitz@tugraz.at

Gerhart Braunegg

Walter Steiner

Institute of Biotechnology and
Bioprocess Engineering
Graz University of Technology
Petersgasse 12
A - 8010 Graz

tel + 43 316 873 8412
fax + 43 316 873 8434
email g.braunegg@tugraz.at
Walter.steiner@tugraz.at

Ewald Srebotnik *

Kurt Messner

Institute of Chemical Engineering
Vienna University of Technology
Getreidemarkt 9
A – 1060 Wien

tel +43 1 588 011 7242
fax +43 1 586 281 6
email esrebot@mail.zserv.tuwien.ac.at

	Andreas Kandelbauer Funder Industrie G.m.b.H. Klagenfurter Strasse 87 A-9300 St. Veit an der Glan	tel +43/(0)4212/494/374 fax +43/(0)4212/494/477 email andreas.kandelbauer@funder.at
	Hedda Weber Lenzing AG Werkstrasse 2 A-4860 Lenzing	tel +43-7672 701-3181 fax +43-7672 918-3181 email h.weber@lenzing.com
Belgium	Sandrine Gautier * KitoZymes S.A. Parc Industriel des Hauts-Sarts Zone 2 Rue Hauteclair B – 44040 Herstal	tel + 32 425 985 02 fax + 32 425 985 09 email s.gautier@kitozyme.com
	Paul Kiekens * Textile Department Universiteit Gent Technologiepark 907 B – 9052 Gent	tel + 32 9 264 5735 fax + 32 9 264 5846 email Paul.Kiekens@ugent.be
Czech Republic	Ludmila Martinkova * Laboratory of Biotransformation Institute of Microbiology Vdenska 1083 CZ – 142 20 Prague 4	tel + 420 296 442 569 fax + 420 296 442 509 email martinko@biomed.cas.cz
Denmark	Knud Allermann * Ib Schneider BioLocus A/S Agern Allé 3 DK – 2970 Horsholm	tel + 45 4442 7022 fax + 45 4442 1258 email info@biolocus.com
	Alexander Nikolov * Novozymes A/S Krogshøjvej 36, Byg. 1DS.28 DK – 2880 Bagsvaerd	tel + 45 40505 521 fax + 45 4576 5708 email anik@novozymes.com
Egypt	Ahmed Awad Haroun * Dept. of chemistry of tanning and leather technology National Research Center El-Bohoth street, Dokki Cairo	tel + 202 337 0931 fax + 202 337 0931 email Haroun68_2000@yahoo.com

Finland**Bo Hortling**
Tiina PursulaKCL
PB 70
FI - 02151 Espootel + 358 9 43711
fax + 358 9 43711
email bo.hortling@kcl.fi**Kristina Kruus**
Arja Miettinen-Oinonen *VTT Biotechnology
P.O. Box 1500
FI – 02044 VTTtel + 35820 7225143
fax +358207227071
email kristiina.kruus@vtt.fi
arja.miettinen-oinonen@vtt.fi**Annele Hatakka ***
Maija TenkanenDpt. Applied Chemistry and
Microbiology
University of Helsinki
POB 27
FI-00014 Helsinkitel +358-9-19158410
fax +358-9-19158475
email Annele.Hatakka@helsinki.fi
maija.tenkanen@helsinki.fi**France****M. Bourgeois**Institut Francais du Textile et de
l'Habillement (IFTH)
Avenue Guy de Colongue
F - 69134 ECULLYtel + 33 472861 635
fax
email mbourgeois@ifth.org**Stéphane Guilbert ***INRA / ENSAM
2, place P. Viala
F - 34060 Montpelliertel + 33 499 61 28 31
fax + 33 467 52 20 94
email guilbert@ensam.inra.fr**Simon Hawkins**Laboratoire de Physiologie des Parois
Végétales
Université des Sciences et
Technologies de Lille
UFR Biologie, Cité Scientifique
F - 59655 Villeneuve d'Ascq cedextel + 33 3 20 43 40 30
fax + 33 3 20 33 63 02
email simon.hawkins@univ-lille1.fr**Günter Reiter ***Institut de Chimie des Surfaces et
Interfaces (ICSI)
CNRS
15, rue Jean Starcky
F - 68057 Mulhousetel + 33 3 89 60 87 66
fax + +33 3 89 60 87 99
email G.Reiter@uha.fr

Germany

Micheal Doser

Deutsche Institute f. Textil- u.
Faserforschung (DITF)
Koerschtalstr. 26
D – 73770 Denkendorf

tel + 49 711 9340 263
fax + 49 711 9340 416
email michael.doser@itv-denkendorf.de

Klaus D. Jandt

Institute of Materials Science and
Technology
Meissner Ring 1-5
D -09599 Freiburg

tel + 49 3641 947730
fax + 49 3641 947732
email K.Jandt@uni-jena.de

Doris Klee

DWI at the RWTH
Aachen University
Veltmanplatz 8
D - 52056 Aachen

tel + 49 241 802 3335
fax + 49 241 802 3301
email klee@dwi.rwth-aachen.de

Michael Meyer *

FILK (Forschungsinstitut für Leder und
Kunststoffbahnen)
Friedrich-Schiller University Jena
Loebdergraben 32
D - 07743 Jena

tel + 49 3731 366 165
fax + 49 3731 366 130
email michael.meyer@filkfreiberg.de

Helmuth Möhwald

Max-Planck Institute of Colloids and
Interfaces
D – 14424 Potsdam /Golm

tel + 49 331 567 9201
fax + 49 331 567 9202
email moehwald@mpukg-golm.mpg.de

Holger Notbohm

Institut für Med. Molekularbiologie
University of Lübeck
Ratzeburger Allee 160
D - 23538 Lübeck

tel + 451-5004083
fax + 451-5004919
email Notbohm@molbio.uni-luebeck.de

Bodo Saake

Institute for wood chemistry and
chemical technology of wood
BFH
Leuschnerstr. 91
D – 21031 Hamburg

tel + 49 40 73962 510
fax + 49 40 73962 502
email b.saake@holz.uni-hamburg.de

Hartmut Seliger

Universität Ulm
Albert Einstein Allee 11
Johannisallee 21
D - 89081 Ulm

tel +49 731 50-23161
fax +49 731 50-23159
email hartmut.seliger@
uni-ulm.de

Wolfgang Zimmermann *

Dept. of Microbiology & Bioprocess
Technology

University of Leipzig

Johannisallee 21

D - 04103 Leipzig

tel +49 371 5311581

fax +49 371 5311790

email wolfgang.zimmermann@uni-
leipzig.de

Italy**Carlo Bonini**

Department of Chemistry

University of Basilicata

Via N. Sauro 85

I – 851000 Potenza

tel +39 0971 202254

fax +39 0971 202223

email bonini@unibas.it

Simona Bronco

PolyLab

INFM

Largo Pontecorvo 3 56127 Pisa

I – 56127 Pisa

tel +39 050 2219447

fax +39 050 2219320

email simona@dcci.unipi.it

Sergio Casella

Dipartimento di Biotecnologie Agrarie

University of Padova

Agripolis

Viale dell'Università, 16

I – 35020 Legnaro, Padova

tel + 39 049 827 2922

fax + 39 049 827 2929

email Sergio.casella@unipd.it

Emo Chiellini

Department of Chemistry & Industrial
Chemistry

University of Pisa

Via Risorgimento 35

I – 56126 Pisa

tel + 39 049 827 2922

fax + 39 049 827 2929

email Sergio.casella@unipd.it

Gianluca Ciardelli *

Politecnico in Turin

Corso Duca degli Abruzzi, 24

10126 Torino

tel + 39 050 511 271 (277)

fax + 39 050 511 266 (273)

email gianluca.ciardelli@ing.unipi.it

Enrico Fatarellá

TECNOTESSILE Società Nazionale di
Ricerca Tecnologica r.l.

Via del Gelso, 13

I – 59100 Prato

tel + 39 574 634 040

fax + 39 574 634 045

email chemtech@tecnotex.it

Guiliano Freddi *
 Stazione spermintale per la seta
 (SSPS)
 Via Guiseppe Colombo 83
 I – 20133 Milano
 tel +39 02 2665990
 fax +39 02 2362788
 email freddi@ssiseta.it

Marco Orlandi
 Department of Enviromental Science
 Piazza della Scienza 1
 I – 20126 Milano
 tel + 39 02 644 828 12
 fax + 39 02 644 828 90
 email marco.orlandi@unimib.it

Latvia

Janis Gravitis *
Galia Shulga *
Galina Telysheva
 Latvian State Institute of Wool
 Chemistry
 Dzerbenes St. 27
 LV – 1006 Riga
 tel + 371 755 3137
 fax + 371 755 0635
 email jgravit@edi.lv
 shulga@junik.lv
 ligno@edi.lv

Lithuania

Jolanta Liesiene *
 Kaunas University of Technology
 Radvilenu pl. 19
 50254 Kaunas
 tel +37037 68559292
 fax +37037 300152
 email jolanta.liesiene@ktu.lt

Netherlands

H.B.M. Lenting *
 TNO Industry and Technology
 Ariensplein 3
 NL - 7511 JX Enschede
 tel + 31 35 486 0490
 fax + 31 35 486 0487
 email herman.lenting@tno.nl

Dr.Ir.Jan Klugkist *
 Unilever
 Olivier van Noortlaan 120
 NL - 3133 AT Vlaardingen
 tel .+31 10 460 5605
 fax
 email jan.klugkist@unilever.com

Marc J.E.C. van der Maarel
 TNO Quality of Life/Centre for
 Carbohydrate Bioprocessing
 TNO-University of Groningen
 Rouaanstraat 27
 NL - 9723 CC Groningen
 tel + 31 503 694 631
 fax + 31 503 128 891
 email maarel@voeding.tno.nl

Jost Maas
 TNO Industry and Technology
 De Rondom 1
 NL - 5600 HE Eindhoven
 tel + 31 40 265 03 41
 fax + 31 40 265 03 02
 email Jost.maas@tno.nl

Jos M. van der Meer
 AVEBE Group
 P.O. Box 15
 NL - 9640AA Veendam
 tel + 31 598 662084
 fax + 31 598 664230
 email meerj@avebe.com

G.F.J. (Ad) Schasfoort

TNO Industry and Technology
De Rondom 1
NL - 5600 HE Eindhoven

tel + 31 40 265 0457
fax + 31 40 265 0???
email ???@tno.nl

Jeff Thornton

Glycanex BV
Koninginneweg 11-13
NL - 1217 KP Hilversum

tel + 31 35 625 0628
fax + 31 35 625 0627
email Thornton@glycanex.com

V.A. Nierstrasz**M.M.C.G. Warmoeskerken**

University of Twente
P.O. box 217
NL – 7500 AE Enschede

tel + 31 53 489 2899
fax + 31 53 4893849
email v.a.nierstrasz@utwente.nl

Dr.ir. Alfons Wegdam

Ten Cate Advanced Textiles
p.o. Box 360 Campbellweg 30
NL - 7443 PV Nijverdal

tel + 31 548 633 640
fax + 31 548 633 256
email Alfons.wegdam@tencate.com

Poland**Marek Kowalczyk ***

Centre of Polymer Chemistry
Polish Academy of Sciences
34 M. Curie-Sklodowskiej St.
P - 41-800 Zabrze

tel +48 322 716 077
fax +48 322 712 969
email cchpmk@bachus.ck.gliwice.pl

Stansilaw Slomkowski *

Center of Molecular and
Macromolecular Studies
Polish Academy of Sciences
Sienkiewicza 112
PL - 90-363 Lodz

tel +48 42 682 6537
fax +48 52 684 7126
email staslomk@bilbo.cbmm.lodz.pl

Portugal**Rui L. Reis ***

3B's Research Group, Biomaterials,
Biodegradables and Biomimetics,
Department of Polymer Engineering
University of Minho
Campus de Gualtar
PL – 4710-057 Braga

tel +351253604781
fax +351253604492
email rgreis@dep.uminho.pt

Artur Cavaco-Paulo *

Departamento de Engenharia Têxtil
University of Minho
P - 4800 Guimarães

tel +351-253-510280
fax +351-253-510293
email artur@det.uminho.pt

- Lígia O. Martins**
 Instituto de Tecnologia Química e
 Biológica
 Av. da República
 P - 2785-804 Oeiras
 tel + 35 121 446 954
 fax + 35 121 446 954
 email lmartins@itqb.unl.pt
- Romania** **Bogdan Simionescu ***
C. Vasile *
 P.Poni Institute of Macromolecular
 Chemistry
 41A Gr. Ghica Voda Alley, Ro
 RO - 700487, IASI, Romania
 tel + 40 232 217 454
 fax + 40232 211 299
 email cvasile@icmpp.ro
- Russia** **Ivan Sakharov ***
 Chemical Department, the
 M.V.Lomonosov
 Moscow State University
 Lenin's Hill
 GUS - 119992 Moscow
 tel + 7 095 939 3407
 fax + 7 095 939 5417
 email sakharov@enz.chem.msu.ru
- Sergey Shleev**
 Institute of Macromolecular Chemistry
 Russian Academy of Sciences
 Leninsky pr-t, 33, build. 2
 GUS - 119071 Moscow
 tel + 7 095 954 4477
 fax + 7 095 954 2732
 email shleev@hotmail.com
- Chavdar Pavlov ***
 Moscow Medical Academy
 Pogodinskaja 1/1
 GUS - 119881 Moscow
 tel +79166829954
 fax +70952487515
 email chavdar@newmail.ru
- Slovakia** **Peter Biely ***
 Institute of Chemistry
 Slovak Academy of Sciences
 Dubravska cesta 9
 SK - 845 38 Bratislava
 tel + 4212 5941 0275
 fax + 4212 5941 0222
 email chempbsa@savba.sk
- Slovenia** **Adrej Krzan ***
 National Institute of Chemistry
 Hajdrihova 19
 SLO - 1000 Ljubljana
 tel + 386 1 4760 200
 fax + 386 1 4760 300
 email andrej.krzan@ki.si
- Lidija Fras**
Vanja Kokol *
Bojana Vončina
 University of Maribor
 Smetanova ul. 17
 SI – 2000 Maribor
 tel +386 2 220 7909
 fax +386 2 220 7990
 email lidija.fras@uni-mb.si
 vanja.kokol@uni-mb.si
 bojana.voncina@uni-mb.si

Spain

Pere Garriga

Tzanko Tzanov *

Technical University of Catalonia
Colom, 1
E – 08222 Terrassa (Barcelona)

tel + 34 937 398 998
fax + 34 937 398 225
email pere.garriga @upe.edu
tzanko.tzanov@upe.edu

José Carlos Rodríguez-Cabello *

Dpto. Física Materia Condensada
E.T.I.I.
University of Valladolid
Paseo del Cauce s/n
E - 47011 Valladolid

tel + 34 983 184585
fax + 34 983 423192
email cabello@eis.uva.es

Almerinda Domingo Roura

BDF Ingredients
Estacio S/N
La Selva (Girona)

tel + 34 972 477 162
fax + 34 972 477 162
email jbosch@bdfingredients.com

J.M. Lagaron

CSIC
IATA, CSIC
Apdo. Correos 73
E - 46100 Burjassot

tel + 34 96 3900022
fax + 34 96 3636301
email lagaron@iata.csic.es

Ignacio Aramendia Moliner

F. Marti

AIMPLAS
Valencia Parc Tecnologic
c/ Gustave Eiffel, 4.
E - 46980 Paterna (Valencia)

tel + 34 961 366 040
fax + 34 961 366 041
email fmarti@aimplas.es

César Fernández-Sánchez

CSIC
CNM-IMB
Campus UAB, Bellaterra,
E - 08193 Barcelona

tel + 34 935 947 700
fax + 34 935 801 496
email cesar.fernandez@cnm.es

Antonio Sánchez-Amat

Faculty of Biology
University of Murcia
Campus de Espinardo
E – 30003 Murcia

tel + 34 968 364 955
fax + 34 968 363 963
email antonio@um.es

Xavier Valera

La Seda de Barcelona
Avda Remolar 2
E – 08820 El Prat de Lobregat

tel + 34 934 017 613
fax + 34 934 017 544
email valera@laseda.es

Sweden**Peter Axegard**

STFI Packforsk AB
Box 5604
SE – 114 86 Stockholm

tel + 46 8 616 72 21
fax + 46 8 411 55 18
email Peter.axegard@stfi.se

Leif J. Jönssen *

Div. for Chemistry
Karlstad University
SE – 651 88 Karlstad

tel + 46 54 700 180
fax + 46 54 700 145
email Leif.Jonsson@kau.se

Björn Lindman**Iseult Lynch**

Physical Chemistry 1
Lund University
PO Box 124
SE – 22100 Lund

tel + 46 46 222 81 63
fax + 46 46 222 44 13
email Iseult.lynch@fkem1.lu.se

Henrik Stålbrand *

Biochemistry
Lund University
PO Box 124
SE – 651 88 Karlstad

tel + 46 46 222 8202
fax + 46 46 222 4534
email henrik.stalbrand@biokem.lu.se

Switzerland**Alfred Abaecherli ***

International Lignin Institute (ILI)
Granit Rechere Develepoment SA
Rue du Grand-Chene 5
CH – 1003 Lausanne

tel + 41 21 318 75 15
fax + 41 21 318 75 11
email Alfred.abaecherli@granit.net

Manfred Zinn *

Material Science and Technology
Empa
Lerchenfeldstrasse 5
CH – 9014 St. Gallen

tel + 41 71 274 7698
fax + 41 72 274 7788
email Manfred.zinn@empa.ch

United Kingdom**Tony Covington ***

University College Northampton
Empa
Boughton Green Road
UK - NN2 7AL Northampton

tel + 44 160 489 2219
fax + 44 160 471 1183
email tony.covington@northampton.ac.uk

Amanda Long

BLC Leather Technology Center
Leather Trade House
Kings Park Road Moulton Park
UK - NN3 6JD Northampton

tel + 44 160 467 99 61
fax + 44 160 467 99 98
email amanda_l@blcleathertech.com

Gleb Sukhorukov *

Dept. of Materials
University of London
Mile End Road
UK – E1 4NS London

tel + 44 20 7882 5508
fax + 44 20 8983 1799
email g.sukorukov@qml.ac.uk

Tajalli Keshavarz

University of Westminster
115 New Cavendish Street
UK - W1W 6UW London

tel +44 20 791 150 00
fax +44 20 791 150 87
email T.Keshavarz@westminster.ac.uk