



**European Cooperation  
in the field of Scientific  
and Technical Research  
- COST -**

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**Secretariat**

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**Brussels, 11 June 2009**

**COST 222/09**

**MEMORANDUM OF UNDERSTANDING**

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Subject : Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action FP0901: Analytical Techniques for Biorefineries

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Delegations will find attached the Memorandum of Understanding for COST Action FP0901 as approved by the COST Committee of Senior Officials (CSO) at its 174th meeting on 26-27 May 2009.

## **MEMORANDUM OF UNDERSTANDING**

**For the implementation of a European Concerted Research Action designated as**

**COST Action FP0901**

### **ANALYTICAL TECHNIQUES FOR BIOREFINERIES**

The Parties 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 270/07 “Rules and Procedures for Implementing COST Actions”, or in any new document amending or replacing it, the contents of which the Parties are fully aware of.
2. The main objective is to develop new and evaluate existing sufficient analytical methods related to forest-based and agroindustrial Biorefineries that eventually will be applied within novel and existing sustainable Biorefining processes and for products, as well as in state-of-the-art academic research and innovations.
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 EUR 76 million in 2009 prices.
4. The Memorandum of Understanding will take effect on being accepted by at least five Parties.
5. The Memorandum of Understanding will remain in force for a period of 4 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 V of the document referred to in Point 1 above.

## **A. ABSTRACT AND KEYWORDS**

Trees, annual and perennial plants, recycled fibres, and lignocellulosic side streams from forest and agroindustry are renewable resources for the development of natural materials, biochemicals, and bioenergy. The chemical complexity of plant materials, the feed material of Biorefineries, renders the analyses of the feed constituents, processes, and valorised products challenging. The main objective of the Action is to develop new and evaluate existing analytical methods related to forest-based and agroindustrial Biorefineries. Thus, the Action covers the analytical methods for the Biorefinery feed material and for processed biochemicals, biomaterials, and process residues. Especially analytical pretreatments will be evaluated. Critical steps are the representativeness of the sampling and samples, the extraction, fractionation, and sample storage methods applied. New methods will be applied and evaluated for their relevance. Other emphasised areas will be development of analytical on-line applications, hyphenated techniques, and applying statistical multicomponent analyses to sort out the relevant data from the main data stream. The European forest-based, bioenergy-based and agroindustrial industries will benefit from the Action in receiving relevant information on their developments of sustainable and environmentally benign solutions for novel utilisation of renewable resources. The development of analytical tools will lead to cost effective and sustainable processes and products.

**Keywords:** Biorefinery, analytical methods, biochemicals, biomaterials, bioenergy

## **B. BACKGROUND**

### **B.1 General background**

The progressive increase in environmental awareness and in petroleum cost has raised the interest in the development of materials, chemicals, and fuels from renewable raw material sources. The lignocellulosic materials from forest and agroindustry contain some of the most abundant polymers present in Nature, lignin and cellulose, in addition to hemicelluloses, extractives, and a number of minor constituents with potential for special applications.

The valorisation of biomass components constitutes a new frontier of economically sustainable and environmentally friendly processes. Trees, annual and perennial plants, recycled fibres, and lignocellulosic side streams from various industries are a renewable source for the development of new chemical and biotechnological production methods for materials, bioenergy, and fine chemicals. The design of such processes benefits from fundamental knowledge, such as new analytical techniques and new biotechnological tools; the raw materials and products being unconventional in many cases.

A large number of European, national, and industrial projects and researchers deal with analytical problems for biomasses and their processing, but the knowledge is scattered and not easy to survey. The COST Framework (European Cooperation in the field of Scientific and Technical Research) offers ideal support for networking and bringing both experienced and young researchers together and hence strengthening the European knowledge and hence also the economic dimension in the Biorefinery area. The possibility of exchange of experiences and key and spearhead technologies and analytical methods will certainly enhance the leading expertise needed for future Biorefineries.

## **B.2 Current state of knowledge**

There is a wide variety of different research and standard methods applied in the forest and agricultural fields. However, the chemical complexity of plant materials, and hence the feed material of different Biorefineries, renders the analyses of the feed constituents, processes, and valorised products difficult. Results obtained using different methods are not always equivalent and their interpretation is a challenge. Especially pretreatments need to be evaluated and standardised. Critical steps are the representativeness of the samples, as well as the extraction, fractionation, and sample storage methods applied. The wide range of feed materials is also a challenge for a proper calibration of each analytical method. In recent research, a number of chemistry-related problems have emerged, which require development of new analytical techniques. It is also credible that analytical tools already applied in other scientific fields could be applied in the Biorefinery research, either as such or after modifications.

The research in Europe concerning Biorefineries and analytics used therein is strong but scattered within EU Framework or national projects. It is evident that the outcome of the Action and the future of the Biorefineries very much depend on researchers and networks with a strong basic and also applied knowledge of chemistry. The Action will thus gather the best researchers and capabilities into one network and that way also achieve important synergies and innovative solutions to both the analytics and the processes and products from the Biorefinery area.

### **B.3 Reasons for the Action**

The Action aims at developing and evaluating sufficient analytical methods related to forest-based and agroindustrial Biorefineries, which eventually will be applied within novel and existing sustainable Biorefining processes and for products, as well as in state-of-the-art academic research and innovations.

The Action will thus strengthen the European state-of-the-art knowledge and hence also the economic dimension in the Biorefinery area. The European forest-based, bioenergy-based and agroindustrial industries will benefit from the Action through the development of sustainable and environmentally benign solutions for novel utilisation of forest and agroindustrial resources and the development of tools for cost effective and sustainable processes and products. The ultimate outcome will thus include novel, environmentally sound, and efficient processes and products from renewable waste materials. Eventually the environment will also benefit from these sound solutions.

### **B.4 Complementarity with other research programmes**

Several EU research agendas and the 7<sup>th</sup> Framework Program have lately dealt with Biorefineries and biofuel in order to upgrade and valorise biomass. The Action is related to, but not overlapping with, COST Actions FP0602 (Biotechnology for lignocellulose biorefineries), E50 (Cell wall macromolecules and reaction wood), E54 (Characterisation of the fine structure and properties of papermaking fibres using new technologies), and the recently finished E41 (Analytical tools with applications for wood and pulping chemistry) and D29 (Sustainable/Green Chemistry and Chemical Technology).

Furthermore, the topic of the Action is represented in several European/international conferences: Italic 5, 15<sup>th</sup> International Symposium on Wood, Fibre and Pulping Chemistry 2009, Fourth International Symposium on Separation and Characterization of Natural and Synthetic Macromolecules, and the 2008 Nordic Wood Biorefinery Conference. The strategic research agendas of the Forest-Based Sector Technology Platform and the European Biofuels Technology Platform also strongly coincide with and strengthen the objectives of the Action.

## **C. OBJECTIVES AND BENEFITS**

### **C.1 Main/primary objectives**

The main objective of the Action is to develop new and evaluate existing sufficient analytical methods related to forest-based and agroindustrial Biorefineries that eventually will be applied within novel and existing sustainable Biorefining processes and for products, as well as in state-of-the-art academic research and innovations.

### **C.2 Secondary objectives**

More specific objectives are:

- Create an interdisciplinary platform for interaction between scientists in Europe to provide a good transfer of knowledge
- Develop new and evaluate new and existing analytical methods for Biorefineries
- Apply and evaluate presently available analytical methods from different research areas
- Intensify the cooperation between Industry and Academia to motivate the research and to create ideas and innovations of new, useful analytical methods
- Develop and evaluate standardized, rapid, non-destructive on-line methods applicable in the industry
- Stimulate the use of reliable statistical methods in the analytics
- Identify the needs for new ERA-NET (Networking of the European Research Area) or ERA-NET Plus Actions within the Biorefinery analytics area

### **C.3 How will the objectives be achieved?**

The exchange of information in the form of reports, publications, and experimental procedures and hence the development and evaluation of novel analytical methods will be achieved through state-of-the-art conferences, workshops, and seminars. These means will bring the researchers from both academia and industry together and thus broaden the views of the researchers and fortify their problem solving capabilities. Furthermore, the exchange of experts, scientists, and graduate students for training, especially through Short-Term Scientific Missions (STSMs), will facilitate the Action to achieve its objectives. Additionally, at least three Training Schools concerning state-of-the-art techniques will be arranged in conjunction with European or national courses and graduate schools.

### **C.4 Benefits of the Action**

The expected benefits to the European forest-based and bioenergy-based industries and to the agroindustry will be promotion of:

- the development of sustainable and environmentally benign solutions for the utilisation of forest and agroindustrial resources
- the development of tools for cost effective and sustainable processes in Biorefineries
- the development of new raw material sources and novel, sustainable products for Biorefineries and bioenergy

### **C.5 Target groups/end users**

The European forest-based, bioenergy-based and agroindustrial industries will benefit from the Action through the development of sustainable and environmentally benign solutions for novel utilisation of forest and agroindustrial resources and the development of tools for cost effective and sustainable processes and products. Furthermore, the European Scientific Community will find excellent opportunity to strengthen their key technologies and analytical methods for different Biorefineries within the course of the Action.

## **D. SCIENTIFIC PROGRAMME**

### **D.1 Scientific focus**

The Action will be in compliance with the general rules of the COST Framework and will include:

- State-of-the-art conferences, workshops and seminars
- Exchange of experts, scientists, and graduate students for training, especially in the form of short-term scientific missions
- Exchange of reports, publications, and experimental procedures

The scientific areas will be those focusing on methods for characterisation of lignocellulosic materials from forest and agroindustry and their processing to renewable materials, biochemicals, and bioenergy.

### **D.2 Scientific work plan - methods and means**

#### *Biorefinery feed material sampling and characterization*

The feed material of a Biorefinery may cover a wide range depending on the source; from forest to agroindustry and from fresh plants to industrial waste or recycled fibres. Therefore, necessary pretreatments will be evaluated and standardised. Comparison of isolation methods, and evaluation of their advantages and disadvantages, including the representativeness of the obtained sample, will hence be part of the Action. The isolation and analysis of specific compounds are also critical steps to understand the process chemistry.

The isolation and analysis of intact polymers is a challenge for the Biorefineries. Plant polysaccharides or lignin can be the starting material for advanced natural materials or a potential source for sustainable bioenergy production. The molar mass, polymer structure, physico-chemical properties, as well as the molecular building blocks are critical factors offering analytical challenges. Inorganic compounds may be a problem especially in Biorefineries using feed material from the agroindustry. Their analysis is critical for the outcome of the process or to control the quality of, e.g. biofuels. Extractives represent an interesting source of bioactive compounds, specialty chemicals, and biofuels, where the analytical methods also are extremely challenging.



### *Characterization of processed biochemicals and biomaterials*

The representativeness of the analytical samples, as well as the pretreatments, and sample storage methods, and a proper calibration of each analytical method will be in focus also for the processes and products. The sampling methods and pretreatments used in the process and for the products may differ significantly from those used for the feed material, since the sample matrix and environment are dissimilar.

An increasing amount of analysis data is needed directly from the processes. Therefore, one emphasis of the Action will be put to the development of analytical on-line applications, hyphenated techniques (i.e. combination of several techniques) and statistical multicomponent analyses to sort out the relevant data from the main data stream.

### *Characterization and fate of process residues*

The ultimate aim of a Biorefinery is to utilize 100% of the feed material. However, this may yet be difficult to achieve in practice and there will hence be a varying amount of process residues. Such residues may originate from process chemicals, inorganic compounds, or high-molar-mass natural polymers that have undergone chemical reactions during the processing which have rendered them unsuitable for further processing. The sampling, pretreatment, characterization, and fate of these process residues will be challenging but necessary to achieve the ultimate goal of total utilisation of the feed material. The utilisation of such residues for bioenergy (i.e. burning the residues) places high demands on a thorough characterization and deep understanding of the material to be able to avoid problems of corrosion, fouling, and low performance.

Useful analytical techniques for characterisation of lignocellulosic materials and Biorefinery processes will be at least:

- Isolation and fractionation methods (pre-treatments, preparative techniques)
- Chromatographic techniques (e.g. SEC, IEC)
- Spectroscopic methods (e.g. FTIR, Raman, UV, MS)
- Capillary electrophoresis (e.g. mobility, charge)
- Analytical pyrolysis
- Structural and compositional analysis (e.g. NMR, cleavage methods)
- Elemental composition (e.g. LA-ICP)

- Radical analysis (e.g. ESR)
- X-ray based methods
- Durable ion selective sensors
- Hyphenated analytical techniques (e.g. GC-MS, LC-NMR)

## **E. ORGANISATION**

### **E.1 Coordination and organisation**

The Management Committee (MC) will manage the Action in compliance with the existing COST regulations. The MC will organise bi-annual meetings to monitor the progress of the Action. Seminars and workshops with all WGs will be organized in conjunction with these meetings. Working Group leaders, a Steering Group (SG), and an STSM Manager may be elected by the MC to assist with the management. Preferentially, the Steering Group could consist of the Chairperson, the Vice Chairperson, the Working Group leaders, and the STSM Manager. The STSM Manager would also manage the organisation of the Training Schools, so that existing national (or international) graduate courses could be integrated with the Training Schools. One of the tasks of the SG would be to coordinate the publication of reports and proceedings from the Action, as well as to manage the publication of reports through the public Action website.

The establishment and publicity of the STSM system during the first year of operation will be an important milestone. Another important milestone is the establishment of the system for Training schools and thus the integration or upgrading of state-of-the-art national graduate courses to serve the participants of the Action. The establishment of a working public Action website with up-to-date information of the Action is another important milestone, which should be achieved during the first year of operation. The arrangement of seminars, workshops, and WG meetings, according to the timetable depicted in the F section, is the fourth important milestone that the MC will be responsible of.

## **E.2 Working Groups**

This Action will have three Working Groups:

WG 1: Biorefinery feed material sampling and characterization

WG 2: Characterization of processed biochemicals and biomaterials

WG 3: Characterization and fate of process residues

The Action will encourage the exchange of scientists between the participating partners through short-term scientific missions. The outcome of the STSMs will be presented at the annual seminars. The Action will be carried out in cooperation with existing national and international research programs related to Biorefineries. Scientists from related fields are promoted to take part in the Action to provide input of new ideas and an exchange of information. A website for the Action will be created and maintained to enhance the communication within the Action and to inform the external scientific community and disseminate the results.

## **E.3 Liaison and interaction with other research programmes**

The Action is related to several COST Actions: FP0602 (Biotechnology for lignocellulose biorefineries), E50 (Cell wall macromolecules and reaction wood), E54 (Characterisation of the fine structure and properties of papermaking fibres using new technologies). Whenever possible, joint meetings and workshops will be arranged with these Actions to further allow the exchange of research experiences and methods and to deepen the contact between researchers from related areas. Furthermore, representatives from the Forest-Based Sector Technology Platform and the European Biofuels Technology Platform will be encouraged to participate in the Action seminars and workshops.

## **E.4 Gender balance and involvement of early-stage researchers**

This COST Action will respect an appropriate gender balance in all its activities and the Management Committee will place this as a standard item on all its MC agendas. The Action will also be committed to considerably involve early-stage researchers. This item will also be placed as a standard item on all MC agendas.

## F. TIMETABLE

The total duration of the Action will be four years, calculated from the date of the first meeting of the Management Committee. Meetings and seminars in the Working Groups will be held according to the plan below. The seminars will be common for the three Working Groups. The MC meetings and the seminars will be held at the same time. Additionally, at least three Training Schools concerning state-of-the-art techniques will be arranged in conjunction with European or national courses and graduate schools.

Year 1	Year 2	Year 3	Year 4
Start			
Plan	Seminar	Seminar	Workshop
WG1/WG2/WG3	WG1/WG2/WG3	WG1/WG2/WG3	Training School
	Training School	Training School	Final report
			End

## G. ECONOMIC DIMENSION

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest:

AT,CZ,FI,FR,DE,GR,HU,IT,LV,NL,PL,PT,RO,SK,SI,ES,SE,CH,UK. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at 76 Million € for the total duration of the Action. This estimate is valid under 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.

The valorisation of biomass components constitutes a novel frontier of economically sustainable and environmentally friendly processes. The European forest-based, bioenergy-based and agroindustrial industries will most certainly benefit from the Action through the eventual development of cost effective and sustainable processes and products. The outcomes of the Action will eventually also strengthen the competitiveness of the European Biorefinery industries towards the rest of the world. The potential economic impact for companies involved in utilising renewable biomass resources may thus be substantial through the introduction of reliable state-of-the-art analytical methods developed within the Action.

## **H. DISSEMINATION PLAN**

### **H.1 Who?**

The most important results from this Action will be new and improved chemical characterisation methods for various Biorefinery processes and products and eventually improved and environmentally friendly processes. Main target groups for dissemination of information of such results are the forest and agroindustrial industries. Persons working with environmental and energy issues, as well as the general scientific community are also important target groups for the Action. The MC will also maintain an active contact to the COST Forests, their Products and Services (FPS) and the Food and Agriculture (FA) Domains.

### **H.2 What?**

The participating partners (mainly national research institutes and universities) will distribute interim and state-of-the-art reports, as well as proceedings and presentations from the COST Action to the national industry. These papers will also be available through the public Action website. Industry people will be invited to participate in the seminars and workshop of the Action. The general scientific community will be informed through participation in national and international conferences and symposia and through publications. The Action will also aim at setting up an e-mail network for new information that includes related national research institutes and universities, in conjunction to those participating in the Action.

The Action will encourage researchers to publish their findings and the most outstanding results from the final report in peer-reviewed scientific and technical Journals. Furthermore, efforts will be put to also publish selected results in non-technical, popular science, publications to reach outside the scientific community.

The MC contact to the Domain FPS will be maintained by:

- Establishing close contact with the appointed liaison officer of the Domain Committee
- *Via* the appointed rapporteur, by inviting him/her to the events organised by the Action and providing him/her all relevant reports and memorandums

- *Via* attendance of the Chairperson or his/her representative at the meetings of the FPS DC when appropriate
- *Via* annual progress reports

In addition, the MC will inform Domain FA about its activities related to that Domain. The most feasible procedure for this communication will be decided together with the FPS liaison officer.

### **H.3 How?**

The dissemination methods listed in part H.2 aims at reaching as wide an audience as possible concerning the European Scientific Community and the forest and agricultural industries.

Eventually, improved analytical methods will lead to enhanced, environmentally sound, and energy-efficient solutions for novel Biorefineries. The Action also aims at raising the awareness of the general European Community, as well as the industry, towards the utilisation of renewable forest and agroindustrial resources.

Especially young researchers will benefit from strengthening their future networks as well as their scientific capabilities. The Short Term Scientific Missions and Training Schools offered within the Action will certainly contribute to this.

The dissemination plans will be evaluated by the MC on a yearly basis and revised at the end of the penultimate year of operations. The MC will also take into account any novel sufficient means of dissemination that may occur during the course of the Action.