SCIENTIFIC SUPPORT PLAN FOR A SUSTAINABLE DEVELOPMENT POLICY
(SPSD II)

Part 1:
Sustainable production and consumption patterns

FINAL REPORT
SYNTHESIS

SUSTAINABILITY THROUGH RENEWABILITY

CP/45

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Research contracts n°
CP/16/451
CP/13/452
CP/14/453

January 2006

Belgian Science Policy

gembloux faculté universitaire des sciences agronomiques

FACULTÉS UNIVERSITAIRES NOTRE-DAME DE LA PAIX - NAMUR

UMH

D/2005/XXXX/XX *[Field reserved to the Belgian Science Policy]*
Published in 2006 by the Belgian Science Policy
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The project "Sustainability through Renewability" has been dedicated to the feasibility study of the replacement of fossil-based raw materials by renewable ones.
We have focused our analysis on surfactants and polymers. The originality of our study is to include both a technological approach and a socio-economic approach.

The first aim of this research project was to identify obstacles to the development of bio-products linked to their production and transformation technologies.
The second aim of this project was to evaluate the environmental impacts of the production and consumption of bio-products considering waste management and renewable resources management through an evaluation of the needed surfaces. The third aim was to analyse the impact, the advantages and the obstacles of a substitution on all concerned actors in the supply chains: cultivators, raw material producers, transformation industry, distributors and consumers.
Finally, on the basis of both technological and socio-economic conclusions, we have proposed measures that could be implemented in Belgium, well-suited to its particularities, in order to understand, develop and promote such renewable resources.

Results are presented in view of the successive steps of the bio-product life cycle. In this way, it allows the reader to have a global view of the actors involved in the supply chain i.e. farmers, industrials and consumers. The end of life and waste management step is also considered. The multidisciplinary approach highlights the interaction between different actors and helps to understand the barriers and opportunities linked to the use of renewable raw materials.

1. Production and extraction of raw materials

The main obstacles we have shown up at this level are linked to land management and agricultural practices. Our assessments show that Belgian cropland areas cannot supply a great capacity company producing commodity products in polymer field for example. On the contrary, in the case of surfactant, our study showed that a great scale surfactant production from the local agricultural feedstock would be feasible and would need only a small part of it.

Besides the availability of land areas, the quality of crops is another problem. In fact, if biodiversity encourages the use of various plant resources, it is difficult to obtain uniform raw materials from various sources as they can change with the crop species. In addition, short chain length fatty acids (C12-C14) are not available from local oil crops.

In order to tackle these problems various solutions are proposed. Variety selection permits to resolve the problem of standard quality of required raw materials. The development of appropriate extraction technologies will also be needed.
The availability of crop areas can be resolved by adopting a more productive agricultural practice. However, we are faced here with the ethic issue of GMOs and the use on a large scale of fertilisers and pesticides.
Agricultural by-products (straw, bran...), available in large amounts, can also help to solve the problem of agricultural crop shortage. However, it will be essential to develop a cracking technology for these materials that are largely composed of lignocelluloses.

Another important obstacle to the development of the production and the extraction of these raw materials is the price. The present inflicted quotas and prices do not push the farmers to invest in an emergent sector. For example, in the case of sugar beets, the crop cost is based, according to the sugar content, on a fixed price that will guarantee an equitable income and limit the overproduction. If we want to develop non-food applications, it is necessary to review this practice in order to integrate new production possibilities, to unfreeze quotas, and to determine a price that will ensure an income to the farmers and profitability to the industrial sector.
This measure will avoid focusing too much on resources from other agricultural crops having more competitive prices and offering sometimes additional technological advantages.

Concerning the extraction of raw materials, the production of by-products during the harvesting and the extraction is another point to deal. Commonly, by-products are lignocellulosic materials with potential valorisation as source of renewable raw materials. To exploit these by-products, it will be necessary to develop the bio-refinery concept. The agricultural by-products are for example rich in C5 molecule and fibres. From this point of view, technologies of extraction and conversion of these sugars should be controlled. They could be widened for the biomass in general. Biotechnology is another production technology of raw materials from renewable resources by use of microorganisms. The disadvantage of this way is related to the low yields that would have to be improved.

2. Production and transformation of bio-products

The difficulty in production technologies of renewable based surfactants lies in the complexity to get homogenous products mainly with chemical ways.
The biotechnological way is more specific but it is more expensive owing to its lower yield. The hydrophobic part of surfactants is mostly constituted by C12-C14 alkyl chain coming from tropical oil plants principally in detergent field where they are used as co-surfactants. Therefore local oil plants are not valorized. They provide C16-C18 chain length with more applications in technical fields like agriculture or industrial cleaning.

In the case of polymers, biopolymers are processable with conventional equipments.
Some thermo-mechanical properties of biopolymers limit their applications. The weak thermal stability of Polylactides (PLA) and the mechanical properties of starch-based polymers are their two main drawbacks.
The price has an important impact in the polymer field (with less impact in the surfactant field). At now, in this sector, renewable based manufacturing is more expensive than the fossil-based one.
Reasons are linked mainly to the scale factor (the biopolymer market is still a niche market and represents only 0.1% of global market), biopolymer technologies are in their infancy and may be upgraded (some production methods have too low yields).

3. Use of bio-products

Many factors influence the consumer's buying behaviour. The performance of the product is an important criterion especially in the detergency sector. Now the analysis has demonstrated that the performance of bio-products depends on the chosen applications.
In the surfactant field, the detergent capacity of vegetable-based surfactants (with both parts of them being vegetable-based) is less performing than the fossil-based ones. These surfactants are better used as co-surfactants or emulsifiers in the household detergents.

In the cosmetic field, softening and emulsifying properties of the vegetable-based surfactant are interesting because they determine the consumer's choice. The development of new products including standard detergency criteria could be a major asset.
But in order to develop the vegetable-based surfactant market, it is necessary to "educate" the consumer because he is often prejudiced against renewable raw materials. Indeed our consumption study shows that regardless of the price, nearly one third of the interviewed consumers think that these raw materials have an unpleasant smell. And nearly half of them consider they are less efficient.

In the polymer field, insufficient thermo-mechanical properties have been observed. Current research should quickly bring solutions to this drawback. The biopolymer market is a niche limited one. Applications are mainly dependent on the intrinsic properties of biopolymers. Applications are well targeted.
For example, these biopolymers are very interesting for medical and pharmaceutical applications, as well as in the commodity domain, for the packaging of electronic stuff for example, the antistatic properties being particularly interesting in this field. In addition to the difficulties linked to the performance of the products, others come from the consumer. Most of the time, he is not aware of the advantages of the use of renewable resources. Our study enhances however an increasing sensitivity for environmental issues.

Costs also are to be considered because renewable material products are more expensive than their fossil counterparts. In a low added value sector like packaging, even a weak increase in the price is not acceptable. It is also the case in other domains like detergency. Only products, as cosmetics, presenting high added value could afford a rise in their raw materials prices.

4. End of life of products

The end of life of the products has to be taken into account. In the surfactant sector, available life cycle analysis shows that oleochemical and renewable ways use 30 to 70% less fossil energy than the petroleum-based surfactants. In the polymer field, the use of renewable resources reduces the use of fossil energies up to 25 to 50 % (at least for the 2 biopolymers chosen in our study) and greenhouse gas emissions. An evaluation of greenhouse gas emissions based on a realistic scenario replacement for both fields concludes to a weak gain (0.1 to 0.3% of the Kyoto goals). These reductions are not the most important ones to reach the Kyoto objectives.

Concerning the biodegradation of vegetable based surfactants (alkylpolyglycosides and alkylglucamides) a complete mineralization is observed. On the contrary, ultimate biodegradation under some conditions (anaerobic) of fossil-based surfactant (i.e. LAS) is not achieved. There is a release of intermediary molecules that could be toxic for the environment.
In fact, environmental conditions are not always optimum in vivo and even in aerobic condition some surfactants will not be totally mineralised. During an on-site measure campaign in waters and Walloon rivers, we measured out 3,5 to 14 ppm concentration of surfactants (LAS).
Legislation and norms have to be reviewed in order to specify surfactant biodegradation rates and conditions. Indeed, the new directive requires 60% of ultimate biodegradation but does not specify the effect of the 40% left.
In the case of polymers, there is a lack of adequate waste treatment for compostable polymers. On the packaging field, the main interesting property of biopolymers is their

biodegradability/compostability. But the absence of legislation and waste management system does not enhance this property. The development of such a system will also require clear labelling in order to help consumers during waste sorting.

5. Impacts of policies

Throughout of our studies, we highlighted obstacles to the development of renewable raw material use into non-food ends. An intervention of the government is necessary to favour the emergency of eco-innovations.

Concerning the production of bio-products and transformation into end-products, the promotion of a spread of the use of renewable resources through a partial obligation seems necessary. The law of December 21, 1998 relating to the standards of products makes it possible to implement measures. This law entitles the King to adopt standards with regard to the products that are marketed. "Under the terms of art. 5, the King can take diverse measures concerning these products in order to protect the environment and to promote sustainable production and consumption patterns. The application of this law would make it possible to divide products into categories according to their effects on the environment and to determine specific rules for the labelling of a product ".
Moreover price differences between renewable and fossil polymers could be reduced through a suppression of ecotaxes on renewable packaging.
Currently the end of life of biopolymers is the same as that of their fossil counterparts. A composting chain should be implemented. In order to succeed, labelization should be developed.

According to our study, several key strategic recommendations are interesting to develop in order to set up a sustainable policy.

1. Research and Development

1.1. To encourage the research projects between universities and industries
To support collaboration between the universities and the industries in the research projects by the installation of various helps dedicated to research dealing with the renewable raw materials is of primary importance.

1.2. To develop the cheap renewable resources like agricultural and industrial by-products. Lignocelluloses are available in huge amounts, but a technology of fractionation and conversion of these materials are still little developed. The current tracks are the thermal cracking (pyrolysis) and biotechnology.

1.3. To develop the bio-refinery concept for an optimum valorisation of agricultural resources including the by-products.

1.4. To improve the extraction and purification of bio-molecules particularly in the case of biotechnology processes. The specificity and the mild conditions (solvent free) of reactional medium of biotechnology are interesting. On the other hand yields are relatively low. The search for new producing strains of more powerful enzymes is a priority. The track of "biomimetism" which consists in imitating and reproducing in natural condition (aqueous medium, ambient temperature...) biomaterials which exhibit particular performances in well defined applications is also interesting to explore.

1.5. Research to improve bio-product performances

1.5.1. Surfactants

- To improve the detergent capacity of vegetable based surfactants by increasing their hydrophilicity, for example.

- To valorize temperate oils in detergent applications.

- To use and explore the biotechnology way for the synthesis of surfactants in order to resolve the problem of none-specificity.

- To exploit, when they exist, the multifunctional properties of vegetable based surfactants in product formulation (for example they are at the same time emulsifying, wetting and softening) and to develop potential molecules for the synthesis of surfactants like sterols and other polysaccharides.

1.5.2. Polymers

- To improve the mechanical properties and thermal stability of some biopolymers

- To develop well defined applications of biopolymers in order to valorize their intrinsic properties.

- To develop technologies using raw materials available in great quantity like lignocellulosic by-products or glycerol as a monomer for biopolymer production.

- To develop and exploit white biotechnology in order to produce intermediary chemicals in biopolymer synthesis. The search for new strains using various agricultural by-products available in great quantity with reduced cost for the production of monomers is a crenel to be developed.

1.6. To increase biodegradation of surfactant knowledge in particular on the effect of the products during the kinetics of degradation and on their toxic effects in water.

1.7. To develop and use (Life Cycle Assessment) LCA tool and the functional analysis of the processes in order to determine the limiting stages during the production in order to improve the output and to minimize the environmental impacts at the same time.

1.8. To develop determination and control methods of surfactant origins in end-products mainly during the acquisition of a label certifying the use of renewable raw materials.

1.9. To develop fast biopolymer sorting technology in order to avoid contamination during waste treatment (recycling or composting)

1.10. *To support demonstration projects and to encourage the research of SME launching out in these crenels.* The Implementation of advisers dividing itself between several companies would enable them to have information, of aides... at little cost.

1.11. *To develop Research in the legal field in order to integrate innovations and issues related to the development and the expansion of renewable resources.*

2. Market and price

2.1. *To stimulate investors interested in renewable raw materials because the scale economy will determine the prices.* The investors could benefit from the assistances to the investment proposed by the Marshall plan for example. This plan envisages setting up the budgets for the branches of industry in which Wallonia is likely to become a leader at the European level.

2.2. *To set up incentives in order to promote the use of the renewable raw materials.* Legal solutions for the consumers such as a reduction in the VAT could allow a reduction of the costs to be implemented. According to a European directive on the VAT, the Member States are free to apply one or two reduced rates provided that the rate is equal to or higher than 5%. However, it would be necessary to be further decreasing the VAT only on certain types of matters, which is currently not envisaged. Belgium cannot grant assistances as it wishes: the capacity of the Community legislation weighs on it, these legal solutions are thus to treat with much precaution. However, the various Convention countries agree with the difficulty on the subject of the VAT.

2.3. *To develop the market by launching "green" purchases in the public services by integrating the criteria "renewable origin" in the schedule of conditions.* A sustainable policy in the public supply contracts is launched by the capacities adjudicators of the federal authority (Belgian Monitor 04-02-2005). Concerning the detergents, in the guide of the sustainable purchases, the ecological criteria include the ecolabel. The criterion "renewable raw materials" may be integrated for example in this guide.

2.4. *To set up constraining actions in order to motivate non users of renewable raw materials if a valuable renewable solution exist.* For example, thanks to an expansion of the principle of the pollutant payer to the companies which would use only fossil matters. According to this principle the companies whose activities are harmful to the environment must support the cost of measurements that are necessary to the reduction of the harmful effects of which they are the cause. It is a question of imposing obligations to them...

3. Legislation

3.1. *To promote the acquisition implication of farmers in the new industrial initiatives by the implementation of an partnership agreements between companies and the farmers.* This would be facilitated by the creation of an organization which would centralise the contracts and would put the parts in the contact. This organization would make it possible to protect the farmers, to offer information and councils to them while facilitating the task of search for suppliers of the companies.

3.2. *To determine the price for non-food applications in order to allow a profit for the farmers and a benefit for the manufacturers.* The ideal thing would be in a first step to set up a temporary program of assistance to the farmers. For example the LIFE program suggested by the European Union in order to support the innovative actions respecting the environment. Once the system is launched, this program could be reviewed according to the needs.

3.3. To set up well defined norms for the environmental criteria of the products.

3.3.1. *To reinforce biodegradation norms*

- Surfactants
  The new directive on the surfactant biodegradation in detergents fixes the final biodegradadtion of molecules at 60% in 28 days. Nevertheless, the directive does not take into account intermediaries which can be toxic in particular for certain petrochemical surfactants like alkyl benzene sulphonate.

- To create legislation with regard to end-product labelling in order to avoid terminological confusions between the product contents of plant extracts in small quantity and the content of renewable origin surfactants.
  One could for example widen the European directive n°648/2004 on the labelling of the detergent products by informing the consumers about the origins of the surfactants.

3.3.2. Polymers

- Biodegradation norms
  To establish a general consensus and standardized definitions of some terms like biodegradation, and biopolymers. A voluntary agreement between some companies and organisations working in the field of renewable already exists for example to define the criteria that are necessary for the production and marketing of "biodegradable polymers" by respecting standard EN13432.

- To work out a directive prohibiting the use of "oxo-biodegradable" of petrochemical origin which contains heavy metals likely to have negative effects on the environment and by classifying them neither as "biodegradable" nor as "compostable" according to a precise standard.

3.4. *To abolish or to reduce the ecotaxes in the case of certified "compostable" biopolymers.* Compostable packaging could benefit from at least a lower taxation like those of paperboard packaging.

3.5. *To develop well defined criteria for the installation of a clear label of the plastics.*

3.6. *To set up legislation that imposes the use of renewable raw materials in certain products.*

4. Agriculture

4.1. *To develop an information structure on the possibilities of non-food valorisation that will establish the link between the farmers and the*

manufacturers. The asbl Valbiom already plays a significant role for the promotion of the cultures in non-food applications. Such initiatives are to be encouraged.

4.2. To improve the practices of the cultures
If cultures are widened towards non-food destinations, their environmental impact will be increased. This would require re-examination of the practices of the cultures. The "integrated farming" which consists in minimizing the use of chemicals (fertilizing, pesticides...) is a system to explore. There are already currently codes of good control which propose recommendations in this field. However they are only recommendations but not obligations.

4.3. *To promote the special and little developed cultures which could bean interesting source of raw materials.* It could be oleaginous or proteaginous crops which contain significant molecules for the synthesis of surfactant and polymers.

4.4. To improve the cultures furnishing the main raw materials for surfactants and polymers.
The lack of availability of some renewable raw materials (in the detergent field for example, the tempered plants do not furnish the necessary oily short chains) could be solved through varietal selection.

5. Education and advocacy campaign

5.1. To launch campaign advocacy targeting the consumers so that they become aware of the existence of products containing renewable raw materials, their advantages and the positive impact which they have on the environment.

5.2. On the level of the school textbooks, to integrate courses in relation to the renewable raw materials

5.3. *To work out educational tools dedicated to children and teenagers as we initiated by financing an educational play thanks to SPSD II program.*

5.4. To make people aware, via an information campaign of the consumers, of the recognition of the various labels for an effective sorting of waste during composting.

5.5. *To launch demonstration programs dedicated to the consumers to inform them about the interests of renewable raw materials but also studies of marketing of the bio-products.*

These recommendations require reflection in a European optic (by contacts with Environment and Agriculture Direction for example). Precise propositions in the form of legal text will allow implementing these tasks. **Table 1** summarizes recommendations.

Table 1: Principal tracks of recommendations

Short term	Research and Development (to encourage research projects between universities and companies, to develop the cheap renewable resources like agricultural and industrial by-products, to develop the concept of bio-refinery, to improve the properties and performances of bio-products, to develop Research in the legal matters...)
	Stimulation of investors by investment aids and incentives
	Creation of a structure supporting a partnership between farmers and companies
	Fixing of acceptable price for non-food goods in the interest of all actors
	Improvement of agricultural practices
	Campaign advocacy targeting consumers so that they become aware of the existence of products containing renewable raw materials
	Integration of courses in relation to the renewable raw materials
	Elaboration of educational tools dedicated to children and teenagers
Medium term	To develop the market by launching "green" purchases in the public services by integrating the criteria "renewable origin" in the schedule of conditions
	Development of well defined criteria for the installation of a clear label of plastics
	Improvement and promotion of cultures providing principal renewable raw materials for surfactants and polymers
	Launching demonstration programs dedicated to the consumers of the interests of the renewable raw materials
Long term	Setting up constraining actions in order to motivate non users of renewable raw materials
	Setting up well-defined norms for environmental criteria of products
	To abolish or reduce ecotaxes in the case of certified "compostable" biopolymers
	Setting up a legislation which imposes the use of renewable raw materials in some products