FISCH Thematic Workgroup "Petroleum replacement"

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To : Core team FISCH

CC : K. Van Aken

Subject: **Thematic workgroup on "petroleum replacement" dd. 19/02/09**

Attach. :

On February, 19th, 2009, a Thematic Workgroup (TWG) Meeting was organized by essenscia in the framework of the FISCH IWT Feasibility Study at GUGA, Diegem (Brussels). Four different TWGs on 1) Catalysis, 2) Novel process technologies, 3) Petroleum replacement, and 4) Product design/intensification individually discussed possible breakthrough projects for their technical theme and built roadmaps for these breakthrough projects. In this Technical Report, the findings of the TWG on "petroleum replacement" are summarized.

The major outcome of the Thematic Workgroup Meeting was that a visionary project for "petroleum replacement" could be a:

***Flemish Biomass-biogasification-algae cultivation project** to sustain a closed loop of chemicals and energy, induce an efficient interaction between business within the chemical industry and other stakeholders, by delivering and use of each others input and output stream of chemicals, materials and energy. Both a SWOT-analysis and a preliminary Roadmap were developed.*

1. Attendees

Industry

Evonik Degussa:	Rudolf Vanheertum
Ineos:	Sarah De Caluwé
Tessenderlo Chemie :	Dirk Van Deynse
Oleon :	
Proviron :	Mark Michiels

Fevia:	An Nachtergaele
Value for Technology:	Philippe Willems (FISCH Core team member)
Value for Technology:	Bôke Tjeerdsma (FISCH Core team member)

Knowledge-based Centers

Artesis:	Iris Cornet
Denayer Instituut:	Anke Brems
Denayer Instituut:	Bart Janssens
Universiteit Gent:	Marijke Van der Steen
Universiteit Gent:	Magriet Drouillon
Universiteit Hasselt:	Koen Smets
VITO:	Bert Lemmers
VUB:	Frank Delattin
VUB :	Gert Desmet
Universiteit Antwerpen:	

Facilitator

BECO:

2. Introduction

On the basis of initial response, gained by a written questionnaire among all FISCH participants, a compilation of relevant research themes and breakthrough domains in the field of sustainable chemistry was made by Carl Van der Auwera (essenscia). The outcome of this compilation was presented at the Start Event of FISCH on December, 17th, 2008. On the basis of this compilation, four different major ***breakthrough domains*** could be identified, more specific:

1. Catalysis
2. Novel process technologies
3. Petroleum replacement (using biomass feedstock)
4. Product design/intensification.

For each of these major breakthrough domains, a Thematic Workgroup (TWG) was organized to further elaborate on these themes. For the breakthrough domain/TWG on "***petroleum replacement***", the following ***relevant research themes*** were identified on the basis of the questionnaire:

- Waste and/or biomass --> oil or syngas (flash pyrolysis)
- (bio)waste or non-food/non-live biomass (wood, straw, cellulose, lignin, paper, oils and fatty acids) --> existing or new renewable platform chemicals (succinic acids, C2-C3-C4-alcohols (a.o.1,3-propanediol), glycerine, fatty acids, amino acids, biomonomers, biopolymers)
- New chemistry with these new renewable platform chemicals
- (Intercompany) valorisation of products and/or side streams and waste streams (from agriculture, forestry, food, paper, (oleo)chemistry)
- New non-food / non-wildlife biomass (a.o. micro- and macro-algae)
- On-site producible (non-carrying) reactants (O2, N2,NOx, SO2, H2, CO2) and their chemical reactions

In addition, on the basis of these relevant research themes, some possible ***breakthrough projects*** were identified and compiled by Carl Van der Auwera (essenscia) before the TWG came together. For the TWG on "Novel process technologies", the following possible breakthrough projects were already identified:

- An integrated algaefarm-biorefinery in Flanders
- A CO_2- en NO_x – neutral gasification installation (equivalent of 5000 T/y biomass)
- 5de generation biofuels
- Valorisation of (bio)waste

3. Identification of one visionary breakthrough project

The aim of the first part of the TWG session was to define one major (visionary) breakthrough project in the field of "Petroleum replacement".

The meeting was started by Bôke Tjeerdsma (VFT), who gave a presentation on Chemistry from Biomass. This presentation is given in Appendix 1. Following a presentation on "Biomass streams for potential use as green feedstock" was given by Philipe Willems (VFT). This presentation is given in Appendix 2. Magriet Drouillon of the University of Gent gave a presentation on "Biobased Chemicals: Dream or Reality" prepared by Prof. Chris Stevens. This presentation is given in Appendix 3. Anke Brems of Denayer Institute gave a presentation on "chemicals from non-biomass" and the potential of recycled plastics as feedstock for the chemical industry. This presentation was prepared by Raf de Wil of Denayer Institute and can be found in Appendix 4.

After the presentations, the attendees discussed about the possibilities of integrated or visionary projects for Flanders within the breakthrough domain "Petroleum replacement"".
Many open questions regarding the (industrial) production and downstream processing of algae were discussed and answered by the attendees.

Some aspects mentioned by the attendees in the discussion on possible projects for Flanders were:

- Direct available (bio)chemicals are only a fraction of the total need; however it is regarded as a good start (EV)
- The preference is on a "Pull system" (rather than "Push"): which products can be best replaced by green feedstock or bio-products? (EV)
- There is a direct need for (durable) energy, new and cheaper feedstock; waste treatment and processing (TC)
- Waste: is that large/substantial enough for a 'visionary project'? (PRO)
- Important is a long-term-input of reliable feedstock.
- Not the focus on energy; rather a higher added value, as for instance additives (PRO)
- (fossil) Oil is best suited for alkanes en alkenes, biomass could be best suited for, oxygen containing molecules or products (VITO)
- Oxygen an Nitrogen containing feedstock/platform chemicals offer the best possibilities compared to fossil oil based feedstock chemicals (VITO)
- Waste streams are difficult to capture in long term contracts (VITO)
- C3 chemistry from glycerine (TC)

After this general discussion two projects were defined as potential for Flanders and within this breakthrough domain "petroleum replacement" The two proposed project were described as:

1. waste paper
2. integrated biomass-biogasification-algae processing

1. Waste paper:

Central idea: waste paper stream (collection) is being cleaned for further fermentation into glucose. The produced glucose can be further fermented into:

1. Ethanol for biofuel, or
2. Platform chemicals and further conversion into building blocks and base chemicals.

- Advantage, paper is pre-pulped, low lignin content, high ratio of cellulose
- No competition with food
- No competition with land-use; no fertile grounds needed
- Up-cycling (alteration) of waste stream, increase of one to several steps on the (value) ladder
- An increase of the recycle ratio is needed (in Belgium)
- Only use that part of old paper that no longer suitable is for application in paper; because of this no competition with the main application (paper); improvement of the main stream by valorising of a not useful fraction; quality of the main stream becomes better by selective disposal of inferior part
- The estimate of this side stream of low value waste paper in Belgium on an annual basis = 1 million metric tons of cellulose

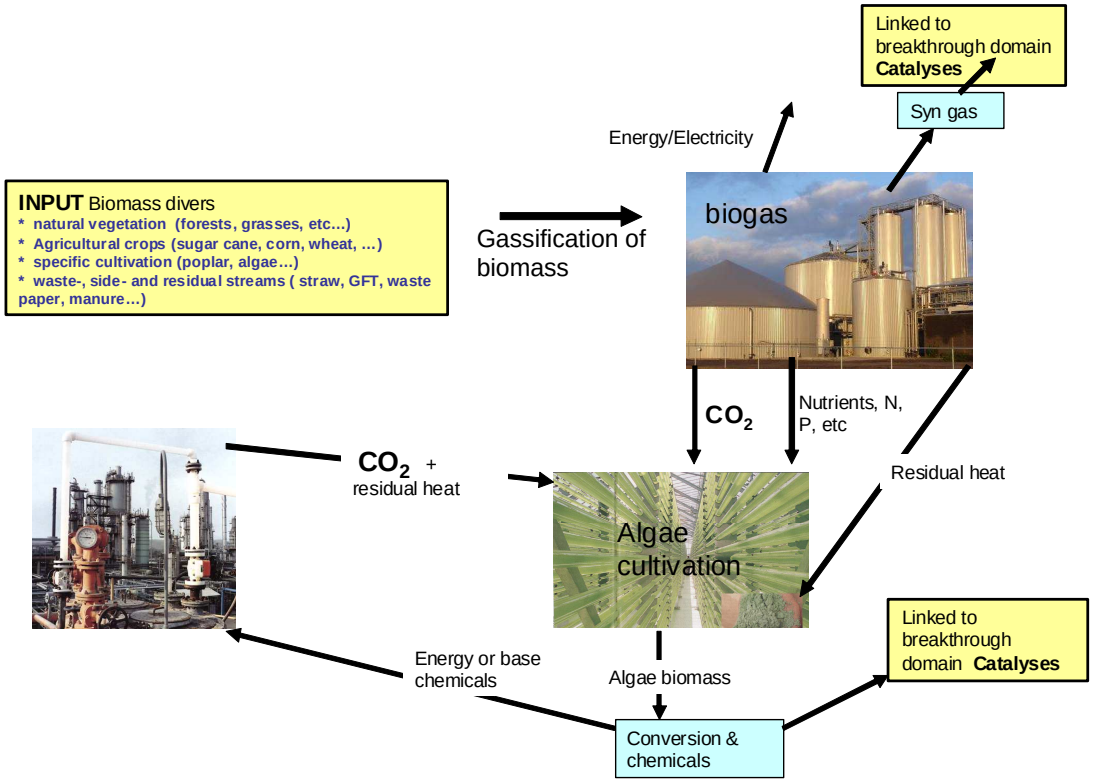
2. Integrated biomass-biogasification-algae processing:

A schematic overview of this plan is shown in the figure below.

Start aspects were:
* closed loop of chemicals and energy
* efficient interaction between business and stakeholders
* delivering and use of each others input and output stream (of chemicals, materials and energy)

- Choice for a broad input of feedstock (biomass), therefore not dependant on one type of biomass as for instance only algae
- The gasification step will cause a decrease of the divers and fluctuating stream of biomass and will result in less dependency of further downstream processing
- Syn gas production is selected as one of the most promising options for converting a divers biomass stream into a valuable new stream. This corresponds perfectly with the C1 chemistry defined as a breakthrough domain in platform "**Catalyses**"
- Algae cultivation will cause a high efficiency of the up-cycling of: energy, chemicals, side-products and chemicals and waste streams within the complete cycle (loop). Also production of high value bio-molecules

- Breakthrough domain "Catalyses" plays an important role in the conversion of the produced algae biomass into base molecules, building blocks and chemicals.
- The (chemical) industry will be supplied with a valuable stream of (durable) energy and chemicals. Residual heat and CO2 of the industry can be used efficiently in algae production.



4. SWOT-analysis and Roadmap

In the afternoon session of the TWG Meeting, SWOT analyses were developed for the "waste paper" and the "biomass-biogasification-algae" project were made by the attendees. A preliminary Roadmap was made for the "biomass-biogasification-algae" project only. This preliminary Roadmap is the starting point for future activities, including regular updates to the Roadmap itself, and the programming of activities to prepare and enable biobased feedstock in the Flemish chemical industry.

The results of the two SWOT analyses are shown in the figures below.

SWOT - Waste paper

STRENGTH

- Certainty of purchase, supply
- Bulk
- Logistic of collecting system existing
- Glucose to several applications
- Pretreated material, therefore rather simple process
- Fermentationcluster in Flanders
- Image builder
- Environment-friendly
- Saving usage of natural raw materials and feedstock
- No competition with food

WEAKNESS

- No IP
- 1 product: glucose
- scale impact for cost-effectiveness?
- Added value limited
- Limits number of replacement products
- What with rest waste ?
- Logistical of collecting system
- Press ink (detoxicate): limits markets
- Benchmark with other waste-based glucose

OPPORTUNITIES

- Known technology for glucose to chemicals
- Public acceptance (no agricultural grounds); No competition with food
- Cheap raw material
- Current flow to Asia
- Legislative framework (biofuel directive)
- High density of paper
- Increased value of old paper for recycling
- Restriction of rest waste (improvement of collecting system)
- Several products based on glucose possible
- Applications develop with customers

THREATS

- Decrease of use of paper
- Pollution of raw material with chemicals
- Cost raw material; fluctuation on markets
- Paper lobby: resistance against change

SWOT - Biogas-Algen

STRENGTH

- Functioning with available CO2, heat, nutrients
- Algae rests to methanisation
- Fermentation = mature
- Flexible with respect to end product by means of algae strains
- High productivity
- Broad product-port folio
- Waste streams to biogas
- New technology: jump on “running” train jump; innovative
- Other approach compared to the US: focus on chemicals, not on biofuels
- No fertile ground needed
- High added value products
- Research performed at universities

WEAKNESS

- Quality of nutrient stream
- Cultivation technology still in premature phase
- Linking (integration) of processes (?)
- Variation in composition of algae
- No knowledge of biology at the CO2 producers
- Competition between biomass cultivation on land use
- Season dependency
- Several/different type of players in the value chain
- Costs of downstream processing
- Cultivation costs; automation of the cultivation; economic feasibility
- Competition with sunnier/warmer climate zones
- Available surface area limited in Belgium
- Complex biomass; technology development necessary
- Not yet delay in technology development, but urgent action necessary (with regard to. US investments)

OPPORTUNITIES

- Potential of billions of € added value
- Cooperation with the Netherlands: quality of knowledge
- Image, eco-products, no fertile ground, little water
- Possible with waste water treatments; purifying ability
- New base of raw material
- Less dependent on fossil raw materials
- Use of residual heat
- Reduction of CO2 (to €100/T!), NOx credits
- Start molecule for polymers
- Use of non-productive ground (safety buffer around chemical complexes)
- Use of higher CO2 concentration
- Sufficient sun in Flanders
- Feed & food applications

THREATS

- No uniform technology
- Transformation from “technology push” to “market pull”
- Spatial structure plan
- Still dependent on petroleum for energy
- Dependant on a concentrated CO2 source
- Selection of competent algae technology provider (be aware of clowns)
- Acceptance of food/feed products on the basis of exhaust gases
- Difficulties in supply of biomass for gasification into biogas
- Competition with foreign expertise
- Legislation concerning CO2

Conclusion for the "waste paper" project after the swot analyses was that:

The waste paper project is not considered as a large incorporated visionary project with which Flanders and its chemical industry can distinguish. This idea has been labelled as an opportunity which at this stage does not require a high tech investments, however entrepreneurship to put it in the market. This project is further taken along as side-project.

Conclusion for the discussion in the workshop was that one visionary project is selected; a biomass-biogasification-algae project. In the second part of the after noon the Roadmap analysis is done for this selected project..

An outline of the preliminary road map is given in the table below.

Roadmap : Biomass-Biogasification- Algae

	Now	2010	2015 - 2020	2020 - 2025
Markets	- Aqua products - market figures - application list	- Feed & Food	- Chemicals	- Biofuels
Products	- choose products - existing = aqua, specialties, pharma	- existing products in food and feed	- Algae fine chemicals - Algae bulk chemicals	- Algae fine chemicals - Algae bulk chemicals - Biofuels: biodiesel, biogas, rest… - conversion of products; HTU, pyrolyses oil….
Techno-logy	- research composition of biomass - research composition of Algae -High throughput screening -Analyses of biomass -Pilot -CO2 source; nutrient source -Downstream processing -Application research	- Pilot plant - optimisation of reactor - downstream development - downstream pilot - Application research - Cultivation and genetic modification of Algae for fast grown/ fast cultivation and specific composition of the components	- Production plant -Selective generation of algae chemicals - Diversification (cultivation, biorefinery) -Algae conversion (hydrolyses, substitution, selective (defunctionalisation,…)	- Mega plant -(location, although maybe not in Flanders IP and royalties to Flanders)
People & means	- Strat. cooperation - Flanders platform or algae consortium - Educations of algologists - Flemish platform - investments	- Formation of Alliances - Investments - Flemish chemistry-algae project	- Refineries	- Refineries