

FISCH Thematic Workgroup “Novel process technologies”

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To : Core team FISCH

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*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 “Novel process technologies” are summarized. The major outcome of the Thematic Workgroup Meeting was that a visionary project for “Novel process technologies” could be a **Flemish knowledge-based and implementation Center for Process Intensification (PI)** to accelerate the introduction of PI in the Flemish chemical process industry. For this initiative, tentatively named as **“Vlaams Instituut voor Proces Intensificatie (viPI)**, both a SWOT-analysis and a preliminary Roadmap were developed.*

1. Attendees

Industry

Agfa-Gevaert:	René De Keyzer
Bayer:	Gabriel Denecker
Janssen Pharmaceutica :	Emile Siaens
Janssen Pharmaceutica :	Peter Van Broeck
Proviron :	Gilbert Devos
Umicore :	Maarten Schurmans

Knowledge-based Centers

Hogeschool West-VL :	Charlotte Boeckeaert
KULeuven :	Tom Van Gerven (afternoon session)
VITO :	Ludo Diels
VITO :	Luc Van Ginneken (FISCH Core team member)
VUB :	Gert Desmet

Facilitator

BECO:	Maikel van Putten
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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 feedstocks)
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 "Novel process technologies", the following **relevant research themes** were identified on the basis of the questionnaire:

- (Super)adsorption (CO₂, H₂, etc.) as an energy-efficient separation process;
- Solventless reactions;
- Ionic liquids, supercritical fluids;
- Coupling of chemistry and energy production;
- (Bio)electrochemistry;
- Miniaturization;
- In-situ product recovery (ISPR);
- Reactive extraction;
- Membrane technology/membrane catalysis;
- Greening of existing chemical processes;
- Water recuperation;
- Click chemistry (novel way of functionalizing).

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:

- Oxidation reactions with co-generation of electricity;
- Specific, reversible superabsorbers for capture, separation and sequestration of gasses;
- Bringing together existing Flemish expertise in relation to production and use of multifunctional, selfcleaning smart membranes;

- Greening of chemical production processes;
- A Flemish F³ (Future, Fast, Flexible) demonstration factory;
- Water re-use for industrial applications.

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 "Novel process technologies". Because a lot of the relevant research themes (identified in the domain of "novel process technologies") are quite closely related to what is known as "Process Intensification (PI), the Meeting was started by Luc Van Ginneken, who gave a presentation on PI, which was made by Tom Van Gerven (KULeuven) and supplemented with additional info by Ludo Diels (VITO). This presentation is given in Appendix 1. PI presents a set of often radically innovative principles ("paradigm shift") in process and equipment design, which can bring significant benefits in terms of process and chain efficiency, capital and operating expenses, quality, wastes, process safety, and more (European Roadmap for Process intensification, 2007¹). PI is driven by four generic principles (Van Gerven and Stankiewicz, 2009²):

- Maximize the effectiveness of intra and intermolecular events;
- Give each molecule the same processing experience;
- Optimize the driving forces on every scale and maximize the specific areas to which those driving forces apply;
- Maximize the synergistic effects from events and partial processes.

PI is scientifically founded on four areas:

- STRUCTURE (spatial domain);
- ENERGY (thermodynamic domain);
- SYNERGY (functional domain);
- TIME (temporal domain).

PI is not only about miniaturization and safety. It also has sustainability-related dimensions: reducing costs, energy consumption, material usage and waste generation. Producing much more with less – a drastic efficiency increase – is the key to PI. As such, PI is often named as key to reaching the long term sustainability objectives of the chemical industry.

It was agreed upon by the attendees that PI excellently covered all the relevant research themes in the field of "novel process technologies", and, hence, PI was used as a starting point for the brainstorm/discussion. After the presentation, the attendees discussed what was missing in the already identified breakthrough projects, and this from a PI point of view. Concerning "reversible superabsorbers for capture, separation and sequestration of gasses", it was felt by the attendees that the scope of this project was too narrow, and needs to be broadened by including (new) CO₂ chemistry (i.e., using CO₂ as a reagent). It was also strongly felt by the attendees that miniaturisation (as an important research theme) was completely lacking in the already summarized research projects, and needs to be included as well. Also the use of low-temperature process streams for energy recuperation should be included.

¹ European Roadmap for Process Intensification. 2007.

<http://www.senternovem.nl/mmfiles/Report%20'European%20Roadmap%20for%20Process%20Intensificatio n' tcm24-258503.pdf>

² Van Gerven T, Stankiewicz A. 2009. Structure, Energy, Synergy, Time – The fundamentals of Process Intensification. Ind. Eng. Chem. Res., in press.

It was also recognized by the participants that the following enabling technologies need to be included:

- Process analytical technology (PAT): (In-situ) measurement and analytical methods to better understanding of kinetic and thermodynamic characteristics of chemical processes at the molecular level;
- Process control systems that can cope with the incorporation of (often continuous) PI modules in (often batch) processes.

After some discussion and brainstorming, the attendees agreed that almost all of these breakthrough projects could be clustered around one major research theme, namely Process Intensification. Therefore, it was concluded that a visionary project for “Novel process technologies” could be a **Flemish knowledge-based and implementation Center for Process Intensification** to accelerate the introduction of PI in the Flemish chemical process industry. The aim of such a Flemish Center, tentatively named as “**Vlaams Instituut voor Proces Intensificatie (viPI)**”, would be:

- To keep the Flemish (bio-)chemical industry at its current high level (from a European point of view);
- To lift the already existing Flemish knowledge on process technology to a higher level;
- To offer important opportunities to modernize the Flemish process industry (oil refinery, petrochemicals, bulk chemicals, specialty chemicals, pharmaceuticals);
- To initiate, bundle and coordinate activities, involving all stakeholders that can contribute and/or benefit from PI;
- To act as a facilitator to ease implementation of PI in both large-scale companies as well as in SMEs (stimulating the third and fourth “O” in O&O&O&O, namely “Ondernemen” en “Open”);
- To develop a strategy to incorporate long-term development of new products and processes.

Fast start-up of demonstration projects will be crucial for the Institute to be successful. Its success will also largely depend on careful bundling of activities in **cross-sector programs**, and on strong **coordination along the innovation value chain**.

When the business plan for the initiative is finalized, and sufficient commitment gathered, financing requests need to be submitted to the most appropriate financing sources depending on the character of each activity — ranging from government subsidies and European grants to bank loans and venture capital funds.

4. SWOT-analysis and Roadmap

In the afternoon session of the TWG Meeting, a SWOT analysis and a preliminary Roadmap were developed for viPI (Appendix 2 and 3). 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 PI implementation in the Flemish chemical process industry.

End of Report

Roadmap: Vlaams Instituut voor Proces Intensificatie (vPI)

	Now	2010	2015	2020
Markets	<ul style="list-style-type: none"> - Mapping of expectations of SMEs with regard to Process Intensification. 	<ul style="list-style-type: none"> - Participation of large chemical companies + interest of SMEs to participate. 	<ul style="list-style-type: none"> - Large participation of (high-tech) SMEs (apart from participation of large chemical companies). - Participation of other (non-chemical) industrial sectors. 	
Products	<ul style="list-style-type: none"> - Stimulating interaction/connection between knowledge-based Centers and industry. 	<ul style="list-style-type: none"> - (Small-scale) demonstration projects (prioritizing list of start projects), with results expected end 2012. - "Peterschap": stimulating interaction between large companies and SMEs. - Development of relevant knowledge. - Development of a strategy to incorporate long-term development of new products and processes. 	<ul style="list-style-type: none"> - Large-scale (demonstration) projects. - Multi-sector projects. - Job creation. 	<ul style="list-style-type: none"> - Large-scale (multi-sector) projects - Job creation.
Technology	<p>Assessing applicability in Flanders of 47 existing Technology Reports, developed within the European Roadmap for PI.</p> <ul style="list-style-type: none"> - Selection of relevant technologies in a Flemish context. - Matching of demand and offer to define (small-scale) demonstration projects, relevant for Flanders. 	<ul style="list-style-type: none"> - Continuous interaction: available knowledge, available technology, generated results in demonstration projects. - Matching of demand and offer to define large-scale (demonstration) projects, relevant for Flanders. 	<ul style="list-style-type: none"> - Continuous interaction: available knowledge, available technology, generated results in (demonstration) projects. - Matching of demand and offer to define large-scale and multi-sector projects, relevant for Flanders. 	<ul style="list-style-type: none"> - Continuous interaction: available knowledge, available technology, generated results in projects.
People and means	<ul style="list-style-type: none"> - Virtual network. - Mapping of other existing initiatives with regard to PI. - Participants of FISCH. - Stimulating "open innovation", and assessing how to deal with IPR. - Start writing a Business and Communication Plan. - Start looking for location of physical part of the Center + location of test facilities. 	<ul style="list-style-type: none"> - Operational Center, with both a physical and virtual counterpart, that coordinates all activities and involves all stakeholders. - Submitting financing requests to the most appropriate financing sources. - Test locations available at company sites 	<ul style="list-style-type: none"> - Bundling of activities in cross-sector programs and inducing strong coordination along the innovation value chain. - Submitting financing requests to the most appropriate financing sources. - Test locations available at company sites 	<ul style="list-style-type: none"> - Bundling of activities in cross-sector programs and inducing strong coordination along the innovation value chain. - Submitting financing requests to the most appropriate financing sources. - Test locations available at company sites