2nd International Conference on Sustainability Transitions
Diversity, plurality and change: breaking new grounds in sustainability transition research
June 13-15, 2011
Lund University, Sweden

Diversity in biorefinery: an interdisciplinary approach on Science, Business and "doubly green" Chemistry

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Ce travail qui n'engage que l'auteur,
a bénéficié d'une aide de l'Agence Nationale de la Recherche
portant la référence ANR-09-CP2D-01-01

CP2D

AGENCE NATIONALE DE LA RECHERCHE ANR

Transition in chemistry ?

An evidence : There is no other solution to replace Fossil carbon in chemistry, than using biomass carbon

Development of « biobased » chemistry

A problem : biobased chemistry can be very non-environmentally friendly and very unsustainable

Chemistry must therefore be « doubly green »

which transition to a new doubly green chemistry sociotechnical regime ?

transition management
ici schéma transition

we must know the « beginning of history »
we can organize the transition
science can overcome the problems
green technologies can be created
we just need to know the « right one »…

but there are no green technologies *per se* yet

Our discussion

No niches to new …

But

« two world technologies » from « productive heritages »

And a diversity of trajectories competing to « draw the future »

Sustained diversity or increasing convergence in a new sociotechnical regime ?

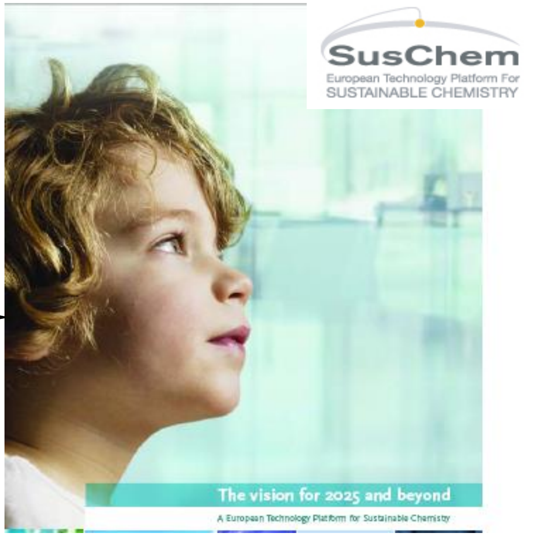
Our methodology

- Observations at the level of scientific programs
  - devoted to transition (e.g. French anr program chemistry and processes to sustainable chemistry)
  - Interdisciplinary long term focus group (2009-2013) economists, biochemists, physicochemists, microbiologists and chemists)
  - Review of literature
- The multilevel perspective of scientists
  - Their responsibility : variability and complexity of raw materials from biomass, biomass recalcitrance
  - Economics and sustainability questions : transportability, local production or integration in global supply chains

How scientists are engaged
in
productive heritages and their commodity chains

how scientists manage to integrate the question of sustainable future ?

1a. Institutional Construction of Knowledge Based Bio-Economy:



- A vision for the future **+**
- Economic stakeholders **+**
- Technological roadmaps

- The scientist considered as productive force
  - to create a new intersectorial linking
  - to bridge agriculture and chemistry
- What happens in the « scientist black-box »?
  - an holistic view dealing with technological complementarities, economic patterns, and social acceptability
  - a multi-level approach from the molecular level, -application of the principle of atom economy-, to the macro-social level

1b. But...

Diversity of scientific communities working at exploring different paths of transition:

- what can we learn from a review of existing scientific literature (biochemistry, chemistry and engineering..)

Diversity of economic strategies influencing the research agendas:

- what can we learn from entrepreneurial behaviours?

Diversity in the implementation of principles of green chemistry

- normalization, but into a **non constraint method**! the 12 US principle of Anastas
- **greenwashing of labs**? Actually green chemistry when at least 2 principles are applied!
- biotechs: the **miraculous technological solution** to the problem of green chemistry?

«green technology bubbles » and diversity?

Productive heritage 1

Breaking biomass into very small molecules

[C_1 or C_2] carbon of as in the petrochemistry

Thermochemistry to transform biomass into syngas and reforming fuels and chemical commodities

The fischer tropsch Process of German industry in the second world war

Only improved by the use of new catalysts

Productive heritage 2

Old fermentation processes to produce agrofuels

Breaking biomass into small C_3 and C_4 Carbon molecules

BIOCHEMISTRY

Improved by biotech revolution : GMO Enzymes (niches ?), but also improvement of existing traditional bacterial transformations

Productive heritage 3

A limited breaking strategy

- Finding in the plant-based material complex polymeric structures possessing interesting functionalities
- Using long-chains natural polymers Cxxxxxx and macromolecules in chemical reactions
- Processes are derived from natural product chemistry, perfumes, food processes, traditional construction

MODIFIED STARCHES

COMPOSITES, FIBERS

- Improved by photochemistry, reactive extrusion,

Heritages

- can offer new opportunities and solutions in the transition to the use of renewable resources in chemistry
  - Assets to the future
- But also constraint the future
  - (Condemn to) sentenced to integrate « the New » into « the Old »
  - Transport the sustainability problems of traditional chemistry in the future

constraints

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  - Transport the sustainability problems of traditional chemistry in the future

Thermochemistry

- Opportunities : can be easily integrated in the petrochemistry scheme
  - No change in the supply chain (e;g ; biosourced ethylene is the same as petrochemcal ethylene)
- Constraints
  - Condemned to very large scale process
  - Processes need very large quantities of raw materials
  - Transportation and world business of biomass commodities competing with food uses and natural forests
- Biorefineries in petrochemical harbours (Rotterdam, Ghent, Singapore...)

Biochemistry

Opportunities :

can be easily integrated in the existing food industries or paper, pulp and fibre complexes

Constraints

Condemned to large scale in order to compete with thermochemistry

Processes need to be economically balanced

- integration with agro-alimentary co-products
- Valorisation of all co-products in fine chemicals

Logistics and costs of transportation of biomass determine the pertinent scale,

Biorefineries are found in territorial complexes using the « Kalenborg symbiosis »

No breaking processes

Opportunities :

- Transformation using the existing structure in the biomass
- Low energy costs
- Solvent-free
- Low water use...

Constraints

- Condemned to contest traditional petrochemistry supply chains

Small Scale production Units ?

Why diversity will not disappear?

In each technological trajectory

Scientists search to overpass look-in in economic and sustainability domains

e.g. New catalysts in thermochemistry

e.g. Solid-state fermentation processes in biochemistry to preserve water

e.g. One pot processes in limited-breaking paradigm ; processes saving energy and water

Why diversity will not disappear?

Thermochemistry will be maintained because aircraft biofuels are very difficult to produce with biochemistry processes (water residues in aircraft fuels can be very dangerous)

Biochemistry carries very strong technological promises (enzymes are the new workers of theses processes)

Limited breaking processes can save energy and water and help economic actors to escape the basic chemistry dominant actors

Technological and economic competition but complementarities in markets

Must institutions enforce or reduce diversity ?

Competition laws promote technological convergence to higher productivity technologies and support traditional supply chains

The changes can only happen in the beginning of the chemistry supply chain and does Not create a new sociotechnical regime in the sense of transition management theory (changing in both consumption patterns and production solutions)

Should diversity be promoted and developed

or should institutions support technological convergence towards a single trajectory to help scale-up growth ?

Vielen Dank für Ihre Aufmerksamkeit
thank you for your attention