Enhancement of thermophillic anaerobic digestion of methane by metal nanoparticles encapsulated in porous silica

Alaaeddin Alahmad
Promotor: Philippe Thonart

- Improvement of anaerobic digestion of CH₄
- Metal NP encapsulated in SiO₂ matrix 10⁻⁵ mol/L
- Acetate 5 g/L

- Ni, Co and Fe NPs at different concentrations
- Glucose 5g/L

Maximum methane production rates:
Ni 70% higher than the control without NPs
Co 48% higher than the control
Fe 7% higher than the control
Pt 6%
Synthesis in one-step by the sol-gel process of supported metallic catalysts and their use for biohydrogen production

Julien Mahy
Promotor : Stéphanie Lambert-Jamouille

- Now, hydrogen is used as reactive rather than as an energy carrier and is produced mainly from fossil energy

- Hydrogen production from bioglycerol: $\text{C}_3\text{H}_8\text{O}_3 + 3 \text{H}_2\text{O} \rightarrow 3 \text{CO}_2 + 7 \text{H}_2$

- Need a resistant catalyst towards sintering and coke $\rightarrow \text{Ni-Co/Al}_2\text{O}_3\text{-ZrO}_2$ by sol-gel process

- 2 main objectives : efficient catalyst and kinetic of hydrogen production
Ni/Al2O3 xerogel catalysts for biogas cleaning

Vincent CLAUDE
Promotor: Stephanie LAMBERT

Synthesis of biomass gasifiers catalysts for tars reforming at 750°C
- Resistance against coke
- Resistance against sintering
- Resistance against H₂S

Ni/Al₂O₃ synthesis by sol-gel method

Improvement of catalysts properties thanks to:
- Preparation parameters (Temperature, time ...)
- Surfactants effects
- Ni encapsulation and dispersion by EDAS
Study of the polymerization kinetics of micropollutant during a degradation process in water using biocatalysts

Catherine Hautphenne
Promotor: Frédéric Debaste

- Use of biocatalysts in a packed bed reactor to remove micropollutants in wastewater

- Problem:
  - Decrease of degradation efficiency with time
  - Due to polymers deposition on biocatalysts

- Challenge:
  - Understanding the polymerization kinetics
    - Experiments & modelisation
  - Reduction of polymer formation to enhance the performance of the reactor
Catalytic layer for Proton Exchange Membrane Fuel Cell based on carbon xerogels.

Fabien Deschamps
Promotor: Nathalie Job

- PEMFC are promising candidates for applications in mobile devices and transportations
- Nanostructured carbons: improve the mass transport in catalytic layers
- **Objective:** elaboration of catalytic layers based on carbon xerogels:
  - Synthesis and grinding of carbon xerogels
  - Coatings and characterizations
Synthesis of Pt/Carbon Xerogel Electro catalysts for PEM Fuel Cells by the Multiple SEA Method

Anthony Zubiaur
Promotor: Nathalie Job

- Structure of the catalytic layer in PEM Fuel Cells not optimal
  - Incomplete utilization of the Pt \(ightarrow\) Expensive!
- Cost reduction without any performance decrease
  - Support \(\rightarrow\) Carbon Xerogel
  - Synthesis of Pt nanoparticles \(\rightarrow\) SEA Method

Pt/Carbon Xerogel using the Multiple SEA Method

- Threefold decrease in the Pt consumption with same performance
Production of high value compounds by encapsulation of microalgae in hybrid material (FOTOBIOMAT)

Marie-Eve Duprez
Promoters: A.-L. Hantson, D. Thomas

- Encapsulation of microalgae in a photosynthetic hybrid material (alginate/silica beads)
  - Microalgae alive for long periods (> 6 months)
  - “Continuous” production of metabolites
- Photobioreactor containing beads (fluidized bed)
- Crucial points
  - Recovery of metabolites (out of the algae to the bead; out of the bead; out of the culture medium)
  - Use of green and biocompatible solvents
Manufacturing process of a photo-synthetic material obtained by encapsulation of micro-algae in a synthetic matrix (Polysilicate – Alginate)

Frédéric LOX
Promotors : D. TOYE, M.CRINE

- Design of a pilot device for the large-scale manufacturing MHPS with a predefined geometry
  - Laboratory process (manual) → Industrial process (automatic)

- Challenge
  - $t_{\text{manufacturing}} << t_{\text{gel}}$ (Silicic acid)

- Technical solution
  - Pumps and static mixer
  - Coaxial airflow

- More informations : Poster
Ag and SiO₂ doped TiO₂ thin films and powders to modify their photocatalytic activity and photoinduced superhydrophilicity

Géraldine Léonard
Promotor Benoît Heinrichs

- TiO₂ under UV:
  - Photocatalytic activity
  - Superhydrophilicity

- Use of EDAS:
  - Nanodispersion of silver
  - SiO₂ incorporation

- Two sorts of catalysts:
  - Powders
  - Films on sodalime glass

- Main results:
  - Photocatalytic activity: Difference between powders and films
  - Superhydrophilicity (only for films): Improvement with the dopant content

Improvement by metallic silver incorporation
Simulate commercial-scale a-CLR process using detailed microkinetic model

- Reoxidation catalyst reaction & CPOM, SMR, WGS reactions
- State of catalyst – link between the 2 fluidized beds

Optimize reactor design and operating conditions
Destruction of Volatile Organic Compounds (VOCs) by catalytic oxidation at pilot scale

Remy Bonnemann
Promotors: D. Thomas, G. De Weireld, A. Decroly

- The emission of volatile organic compounds is an environmental & health problem.
- The principle of catalytic destruction is economical & promising. → study of VOCs oxidation on palladium supported catalysts.
- Originality:
  - Catalytic oxidation at pilot scale;
  - Development of catalytic materials & shaping of supports;
  - Oxidation of single component, binary and ternary mixtures.
- The results are interpreted through VOC conversion & CO₂ yield vs temperature. → Decrease temperatures & by-products.
Study of hybrid solvents potential for CO\textsubscript{2} capture in post-combustion process

Irr Julien Gervasi
Promotor: Prof. Diane Thomas
Dr Lionel Dubois

- Challenge for CO\textsubscript{2} capture in post-combustion process with sorbents
  - Reduction of the operating costs/energy requirement
- Hybrid solvents
  - Mixing between a chemical and a physical solvent
  - Combining the advantages of each component
  - Innovative use of acetals as physical solvents
- Absorption/regeneration tests
  - Promoting effect in terms of absorption and regeneration efficiencies
  - Demixing phenomenon observed
  - Complex interactions
  - ➔ Still under investigations...

Chemical Engineering Department
CO\textsubscript{2} capture in cement production and re-use: optimization of the overall process

Nicolas Meunier
Promotors: Prof. Guy De Weireld
Prof. Diane Thomas

- Catalytic conversion of CO\textsubscript{2} from cement plant flue gases into methane/methanol
- Two combustion modes considered:
  - Classical combustion ➔ Post-combustion CO\textsubscript{2} capture
  - Oxyfuel combustion ➔ CO\textsubscript{2} purification
- Researches on hydrogen production technologies
- Technico-economical optimization of the process
- AspenPlus\textsuperscript{®} simulations of the post-combustion CO\textsubscript{2} capture unit with monoethanolamine (MEA) 30%

[Diagram showing the process flow]

Cement plant → Flue gas → Pre-treatments (de-NO\textsubscript{x}, de-SO\textsubscript{2}, de-dust, …) → CO\textsubscript{2} to conversion reactor
Use of Life Cycle Assessment to support in the Eco-Design of a glass-wool process

Saïcha Gerbinet
Promotor : Angélique Léonard

Reduce the Global Warming Potential (GWP)
- Use Life Cycle Assessment (LCA)
- Quantify the impact of each process step
  - 2 possibilities:
    - Less waste generated
    - Change energy mix for electricity production
- Impact on other impact categories (ex: acidification, etc.)
L’objectif de cette thèse est la mise en œuvre de techniques d’assainissements pour la dépollution des eaux résiduaires polluées à l’arsenic via l’utilisation de matériaux latéritiques naturels locaux au profit des populations locales (Burkina Faso).

Quelques échantillons ont été prélevés et ont été caractérisés physiquement et chimiquement dont nous présentons ici les résultats d’un échantillon référencé BN, qui sont les premiers résultats en début de thèse.

L’analyse chimique de BN montre qu’elle est riche en $\text{Fe}_2\text{O}_3$ (14,4%) et $\text{Al}_2\text{O}_3$ (7,44%).

BN est composé de Goethite, de Kaolinite, d’Hématite et du Quartz.

La latérite BN a une surface spécifique au B.E.T de 34,895 (m²/g) et une C.E.C de 67,77 (méq/100g).
Influence de la durée de stockage des boues de station d'épuration sur la déshydratation mécanique et le séchage convectif

Yvon-Bert PAMBOU
Promoteurs: A. Léonard & M. Crine

Filtre presse (AFNOR 1979)

✓ Variabilité de la boue durant le stockage:
  ➔ Répétabilité des essais?
✓ Conception d’un plan d’expériences

MS gâteau : 17 %

Laboratoire de Génie Chimique

Pilote de séchage:
- T = 130 °C
- V = 1 m/s
- Y = 0.005 kg eau / kg air sec
« Product-oriented engineering » applied to the development of porous scaffolds for tissue engineering

Charlotte DE BIEN
Promotors : A. Léonard & D. Toye

- Determine the elaboration conditions of a porous scaffold having *a priori* defined end-use properties
- Establish **quantitative** relationships:

![Diagram of the research process](Diagram.png)

- Part 1: Scaffolds fabrication
- Part 2: Microstructure characterization
- Part 3: End-use properties characterization
- Part 4: Determine quantitative relationships between parts 1, 2 et 3
Study of hydrodynamics and liquid-gas transfer in a stirred tank bioreactor

Anne de Lamotte
Promotors: Michel Crine Dominique Toye

- Biohydrogen production by dark fermentation
  - Key factor = $H_2$ liquid-gas mass transfer rate $\Rightarrow K_La$ criterion
    
    $K_La = \begin{cases} 
    \text{Nature of the gas} \\
    \text{Physicochemical properties of the liquid} \\
    \text{Hydrodynamics} \\
    \text{Operating conditions} 
    \end{cases}$

- Characterization of $H_2$ liquid-gas mass transfer according to agitation conditions
  - Distribution of hydrodynamic quantities
  - Distribution of dissolved $H_2$ concentrations

- Simulation of the global performance of the process
  - Physiological and Transfer Kinetics + Hydrodynamic Model
Study of the interactions between liquid-gas transfer and microbial physiology in a stirred tank anaerobic bioreactor producing hydrogen

Jonathan Baert
Promotor: Frank Delvigne

Bioprocess approach
- Bicompartimented system including an hydrogen accumulation zone (CSTR) and an optimize liquid-gaz transfer zone (Falling Film Micro Reactor; FFMR)

Physiological characterization approach
- On-line single cell analysis using flow cytometry
- Proteomics analysis to indentify proteins expressions associate to hydrogen stress physiological responses
Use of on-line flow cytometry for the characterization of physiological behavior in stress conditions during the bioprocess

Alison Brognaux
Promotor: Frank Delvigne

Microbial cell population heterogeneity is now recognized as a major source of issues for the development and optimization of bioprocesses.

Flow cytometry is a very powerful tool for the follow up of physiological properties of microbial cells in process-related conditions. Response “cell by cell”. Simple interface with two dilution pumps.

Follow up the fis::gfpAAV activity (biocaptor of the nutritional status of the cells) and propidium iodide uptake by automated flow cytometry.
Enhancement of recombinant protein excretion with *Aspergillus oryzae* fermentation in semi-solid conditions

**Quentin Zune**  Promotor: Frank Delvigne

**Unité des Bioindustries**

**Poster 22**

- **Solid state culture**
  - (+) high productivity, solid substrate, etc.
  - (-) heat removal, substrate/metabolite diffusion, downstream process

- **Submerged culture**
  - (+) simple implementation
  - (-) high viscosity, shear stress

**Semi solid culture**

- Metal structured packing (high $A_{spec}$)
- Liquid medium recirculation
  - (+) low viscosity, metabolites recovery, heat transfer, similar productivity, etc.
  - (-) liquid distribution, clogging
Title: Characterization of fengycin homologues produced by *B. amyloliquefaciens* (ET) strain isolated from a salt lake (Eastern Algeria)

Asma Ait Kaki
Promotor: Pr. Philippe Thonart

**Organic agriculture:** *Bacillus* genus bacteria

**Antimicrobial compounds:** Cyclic Lipopeptides (C-LPs)

**C-LPs:** surfactin, iturin and fengycin

**Table 1:** Fengycin variants produced by *B. amyloliquefaciens* (SWI) strain, isolated from a salt lake in Eastern Algeria

<table>
<thead>
<tr>
<th>Retention time</th>
<th>MH⁺⁺</th>
<th>MH⁺</th>
<th>FA length Tag</th>
<th>Sequence tag +1 (A)</th>
<th>Sequence tag +1 (B)</th>
<th>Fengycin homologues</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.5 min</td>
<td>732.46</td>
<td>1463.9</td>
<td>384.4</td>
<td>966.9</td>
<td>1080, 9</td>
<td>C16 feng A</td>
</tr>
<tr>
<td>32.5 min</td>
<td>46.48</td>
<td>1491.9</td>
<td>370.4</td>
<td>994.9</td>
<td>1108, 9</td>
<td>C15 feng B</td>
</tr>
<tr>
<td>33.7 min</td>
<td>724.5</td>
<td>1447.8</td>
<td>363.4</td>
<td>966.9</td>
<td>1080, 9</td>
<td>Unsat. C15 feng A</td>
</tr>
<tr>
<td>38.3 min</td>
<td>759.5</td>
<td>1518.4</td>
<td>410.3</td>
<td>966.9/994.9</td>
<td>1080, 9/1108, 9</td>
<td>Unsat. C20 feng A / Unsat. C18 feng B</td>
</tr>
</tbody>
</table>

**Scheme A:** Primary structures of fengycins: (1) CID fragmentation scheme, (2) list of identified fengycin, including new variants detected in this study
Stochastic exposure to sub-lethal temperature improves *Bifidobacterium bifidum* THT 0101 cell survival to freeze-drying by enhances exopolysaccharides (EPS) excretion

Huu-Thanh Nguyen
Promotor: Frank Delvigne, Philippe Thonart

- Set up new strategies to increase the viability of *Bifidobacterium bifidum* THT 0101.
- With the heat shock stress, the viability was significantly improved by the comparison cold shock or standards conditions.
- Related with the coating of microbial cells with Exopolysaccharide (EPS) and viability of *Bifidobacterium bifidum* THT 0101.
Development of an anaerobic, thermophilic and cellulolytic consortium to improve anaerobic digestion of lignocellulosic biomass

Romain KINET
Promotor: Philippe THONART

- Anaerobic digestion of lignocellulosic biomass
  - Hydrolysis step = first and limiting step of the process

- Study of cellulosic biomass digestibility
  - Highlighting of limiting factors
    - Biomass structure (lignin, crystallinity, ...)
    - Biochemical parameters (bacteria, enzymes, ...)

- Definition of different means to improve anaerobic biodigestion
  - Isolation of high cellulolytic, anaerobic microbial consortium
  - Improvement of cellulose anaerobic digestion
  - Characterization of isolated consortium
    - Degradation capacity (cellulose degradation kinetics, cellulose degradation products, ...)
    - Microbial community structure
Wastes of banana’s lignocellulosic biomass: a sustainable and renewable source of biogas production
Comparative anaerobic digestion of six morphological parts of Williams Cavendish banana (Triploid *Musa* AAA group) plants

Irénée KAMDEM
Promotor: Ph. Thonart - S Hiligsmann

Worldwide annual production

- Banana fruits: 125 million tons
- Discarded annual plant: 250 million tons

= balicebiom = “banana’s lignocellulosic biomass”
- High potential for anaerobic digestion
- 316 m³ CH₄/ton of balicebiom DW

Annual electricity estimation from an agro-industrial banana plantations (*CDC–Del Monte in Cameroon*)

- About 10 million kWh
  = 0.8–1.6 million €
  (current market)
Using a thermotolerant bacterial strain in production of gluconate: An approach towards sustainable development

Raziyeh Zarmehrkhoshid
Promotor: Philippe Thonart

Applications of gluconate: Food, pharmaceutical and construction industries

Method of production: Biochemical, chemical and electrochemical
  - Fermentation: An efficient and dominant technique

Recent restriction: High cost of its production

Objective: Reduction in cooling cost during fermentation
  - Use of a thermotolerant Acetobacter sp.
  - Semi-continuous production of gluconate using recycled cells

Results: Gluconate was produced with the yield of 85% through batch and semi-continuous mode of fermentation
Enzymes of Oenological Interest from Wine Lactic Acid Bacteria

Guilhem JAMIN
Promotor : Philippe THONART

- Role of *Oenococcus oeni* in the wine-making process:
  - Malolactic Fermentation (MLF)
  - Enzymatic transformations of the must (hydrolytic enzymes as β-glucanases)

- β-glucanases applications in the wine-making process:
  - Inhibition of spoilage microorganisms and improvement of must clarification/wine filtration
  - control of the alcoholic fermentation and improvement of wine aging (*yeasts autolysis*)

- Isolation and selection of relevant *lactic acid bacteria*:
  - Malolactic
  - β-glucanases producers
  - adapted to wine physiological conditions

- Production of bacteria and enzymes
  - bacteria production by batch bioreactor
  - One-step (batch with/without pulse) or two-step culture
INFLUENCE DES COEFFICIENTS DE TRANSFERT DE CHALEUR ET DE MASS SUR LE COMPORTEMENT AU SECHAGE D’UN MILIEU POREUX

Loubna Kahlerras
Promotor : Angélique Léonard
Azzedine Belhamri

Cement production has undergone a tremendous development from its beginnings some 2000 years ago. Today’s annual global cement production has reached 3.6 billion tones.

- Their good mechanical resistance properties and durability justifies having a resort
- From macroscopic aspects transfer coefficients have a direct influence on the mechanical behavior and the durability of the structure, bound to the drying of cementitious materials.
- In the process of drying many problems are encountered such as high energy consumption, kinetic of drying and the final shape of the product. In fact, the improvement of drying system is becoming a necessity.
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