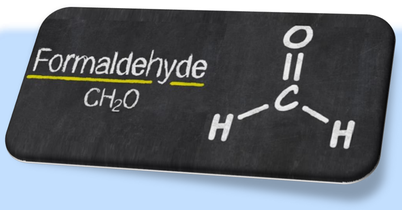
Formaldehyde Dehydrogenase Synthesis by *Pseudomonas putida* Under Different Fermentation Conditions

Cristiana C. Castro[1,*], Marie-Eve Duprez[1], Tangi Senechal[2], Noureddine Rhazi[3], Anne-Lise Hantson[1]

[1] Applied Chemistry and Biochemistry Department, Faculty of Engineering, University of Mons Rue de l'Epargne, 56, 7000 Mons, Belgique
[2] Materia Nova Research and Development Centre, University of Mons, Mons, Belgium
[3] Centre of Protein Engineering, University of Liège, Liège, Belgium
***E-mail:** cristiana.cordeirodecastro@umons.uc.be

INTRODUCTION

Indoor pollution in buildings and structures is creating some health and comfort concerns. Volatile organic compounds (VOCs) released by consume household products, adhesives and building materials, or combustion processes, are some of pollutants usually present in residential units and workplaces indoor air. Formaldehyde (FA) is one of the most representative oxygenated-VOCs, and a widespread chemical pollutant of water, air and soil [1]. It is known by its mutagenic, immunogenic, allergenic and carcinogenic effects [2]. Understanding and controlling this pollutant can help reducing the illness risks associated. Biological degradation strategies of FA through biomolecules transformation is being more and more explored. Formaldehyde dehydrogenase (FDH) is an enzyme known to degrade FA. In the present work, the ability of a wild *Pseudomonas putida* strain to produce FDH under distinct carbon and energy sources is evaluated. Selecting the fermentation conditions able to induce FDH overproduction by *P. putida*, cells will be incorporated into a coating to be further used as an innovative solution for indoor FA-depollution.



Used in different industries and consumer products, widely used in construction materials, wood processing, furniture, textiles, carpeting, and chemical industries

Time Exposure & Concentration
\- +

FA exposure symptoms:

- Irritation of eyes, nose and throat
- Breathing difficulties
- Serious injuries at the respiratory level and chronic pulmonary obstruction
- Pulmonary cancer

Indoor air pollution

Attic
- Asbestos
- Dust
- Fiberglass
- Insulation

Bedroom
- Allergen
- Carbon dioxide (CO_2)
- Carpet
- Curtains
- Dust
- Pet hair

Home Office
- Printers, photocopiers
- Furniture

Bathroom
- Excess humidity
- Mold spores
- Hygiene consumables

Kitchen
- Bacteria
- Cooking pollutants

Living room
- Allergens
- Carpet
- Curtains
- Dust
- Pet hair and dander

Basement
- Carbon monoxide (CO)
- Combustion system
- Dust
- Fireplace/smoke
- Firewood
- Household cleaners
- Mold
- Paint and chemicals
- Radon
- Solvents
- Unpleased odors

Garage
- Carbon monoxide (CO)
- Cleaning agents
- Dust
- Gas
- Pesticides and herbicides
- Paint
- Chemicals
- Solvents

FA degradation methods

Physical
- Adsorption to a carrier
- Photocatalysis

Chemical
- Oxidation
- Combustion

Biological
- Biofilter
- Trickling biofilter
- Bioscrubber

- Development of a selective, highly sensitive, reliable and simple method for fast and inexpensive detection and degradation of FA from the indoor air
- **Biological degradation**: flexible, low-cost and efficient strategy, respecting health and environmental procedure

Formaldehyde dehydrogenase (FDH)

- ✓ Enzyme able to transform FA into less toxic compounds, as formic acid, naturally oxidized to CO_2 and H_2O
- ✓ Synthetized by different bacteria, cyanobacteria, fungi or yeasts
- ✓ *Pseudomonas putida* is a FDH-producing bacteria, commonly used for the biodegradation of FA [3,4]
- ✓ The ability to synthetize the FDH can be improved in the presence of co-substrates, used as carbon and energy sources

Enzymatic degradation of FA:

$$FA + NAD^+ \xrightarrow{FDH} \text{Formic acid} + NADH$$

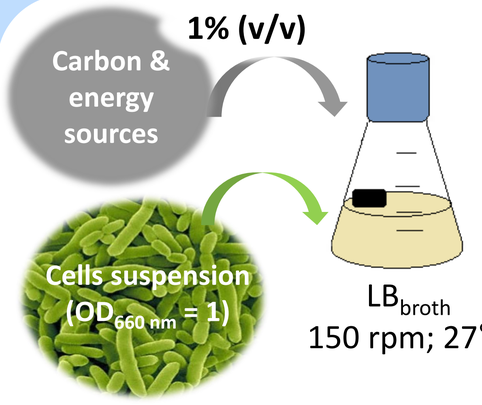
MATERIALS AND METHODS

Carbon / energy sources

1 – Glucose
2 – Mannitol
3 – Sorbitol
4 – Glycerol
5 – Ethanol
6 - Methanol
7 - Alanine
8 - Ribose
9 - Lactose
10 - Control

Pseudomonas putida
LMG 24210 (BCCM)

FDH Overproduction strategy

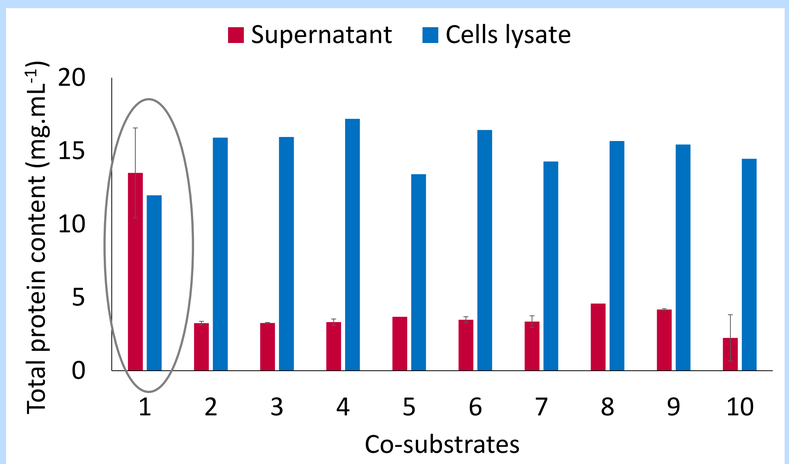


Parameters determined

- Biomass
- Total protein
- FDH activity

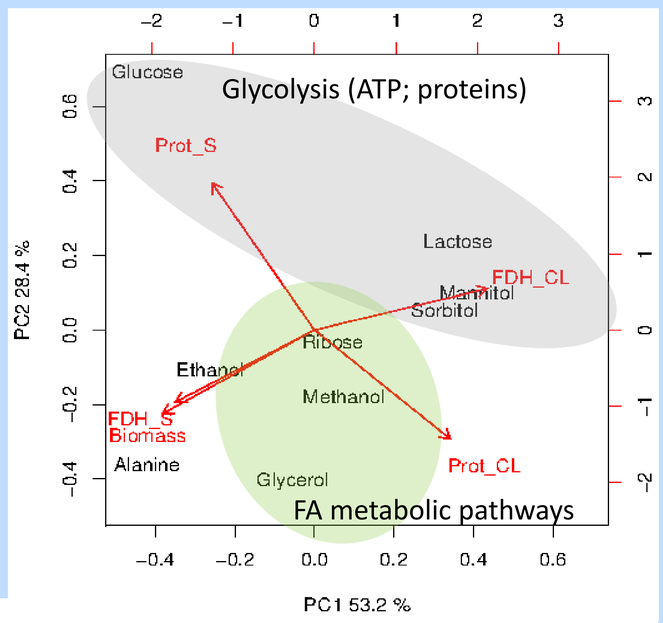
RESULTS AND DISCUSSION

Total protein content



➢ Protein content in cells lysate is higher than in supernatant, **except** in the presence of glucose

Multivariate analysis



➢ Glucose induces protein secretion to the supernatant
➢ Co-substrates (Ethanol, Alanine) which promote biomass growth, improve FDH release to the supernatant
➢ Lactose, Mannitol and Sorbitol induced higher enzymatic activity of FDH in cells lysate

CONCLUSIONS

- ❑ Depending on the substrate used in the fermentation medium, distinct metabolic pathways, associated either to cells growth or FDH production, could be activated.
- ❑ Sequential fermentations where, in a first fermentation, cells growth is induced, followed by a second fermentation where, FDH production is promoted, can increase FDH activity.
- ❑ In future work, the incorporation of these biomolecules coated on solid surfaces, can be presented as an innovative solution for FA degradation from indoor air.

References

[1] Guieysse B. et al. (2008), Biotechnol. Adv., 26, 398–410.
[2] Salthammer T. et al. (2010), Chem. Rev., 110.
[3] Roca A. et al. (2008), Microb. Biotechnol., 1,158–169.
[4] Fujii T. et al. (1975), Agric. Biol. Chem. 39, 2325–2330.

The work presented had the financial support of the FEDER and Wallonie/FWB (Project FILMS MULTIFONCTIONNELS)