Effects of hydrogen partial pressure on fermentative biohydrogen production by a chemotropic *Clostridium* bacterium in a new horizontal rotating cylinder reactor

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As a clean renewable energy resource

H_2 is considered as the fuel of the future…

Two microbial pathways for biohydrogen production

Photo fermentation — Dark fermentation

Carbon source ($C_6H_{12}O_6$)
Anaerobiosis & nutrients

Phototrophic microorganisms
- Low production rate
- High yield
- Light energy consumption

Chemotrophic microorganisms
- High production rate
- Lower yield
- Low temperature (30 °C)

Light

Hydrogen production + CO_2

Alcohols, acids, … in aqueous solution
… → $2CH_3COOH + 2CO_2 + 4H_2$

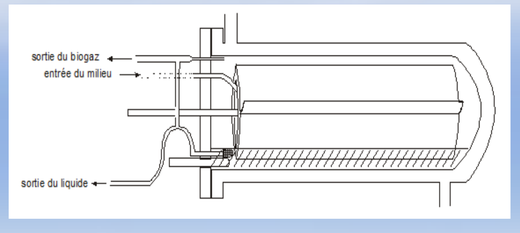
Valorisation (methanisation)

Dark fermentation is more adapted for industrial H_2 production from wastewater and biomass (no light, higher production rate, effluent valorisation, …).

- Pollution reduction
- Energy generation

Methods

Horizontal rotative cylinder bioreactor (2.3L)
Continuous culture

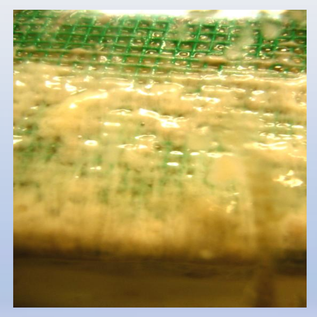


Hydrogen content in biogas determined by GC-TCD and ABB EL 1020 gas analyzer
Soluble metabolites concentration determined by HPLC-RID

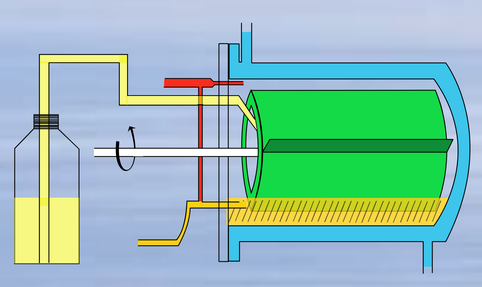
Advantages

The bioreactor shows good performances compared to classical reactor… due to three factors:

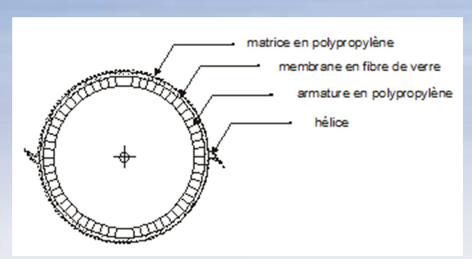
- Continuous fermentation mode and biomass fixation on the cylinder.
  Biomass and liquid retention time are different, promoting a biomass concentration and achieving very good production rates.



- Low liquid volume (300mL) compared to reactor volume (2.3L).
  While the biomass stays fixed on the cylinder, there is no risk of wash out effect working with low HRT.



- The rotational cylinder enhanced hydrogen gas transfer from liquid to gas phase, as a mixing of liquid media.
  A thin layer of liquid constantly renewed with the rotation permit a rapid hydrogen degassing, reducing its inhibitory effect on its own production and enhancing production yields.



Results 1

pH and pressure influence on hydrogen production

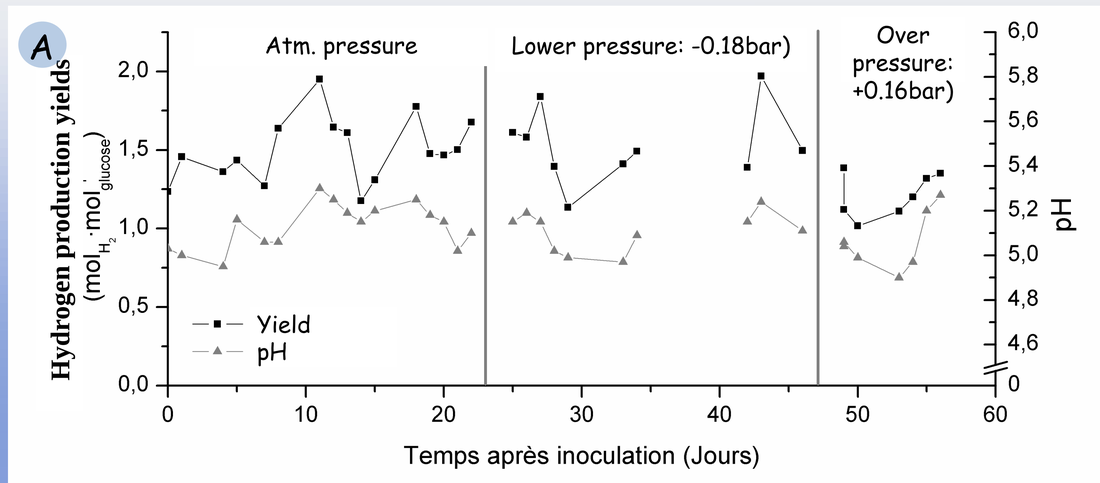


Fig 1: ***A*** :H_2 production yields and pH versus time in the horizontal cylinder bioreactor; **B** : Comparison of the hydrogen production yield (mol H_2/mol glucose) at different pH and total pressure conditions.

Results 2

Self pH regulation adjusting glucose concentration in the feeding media.

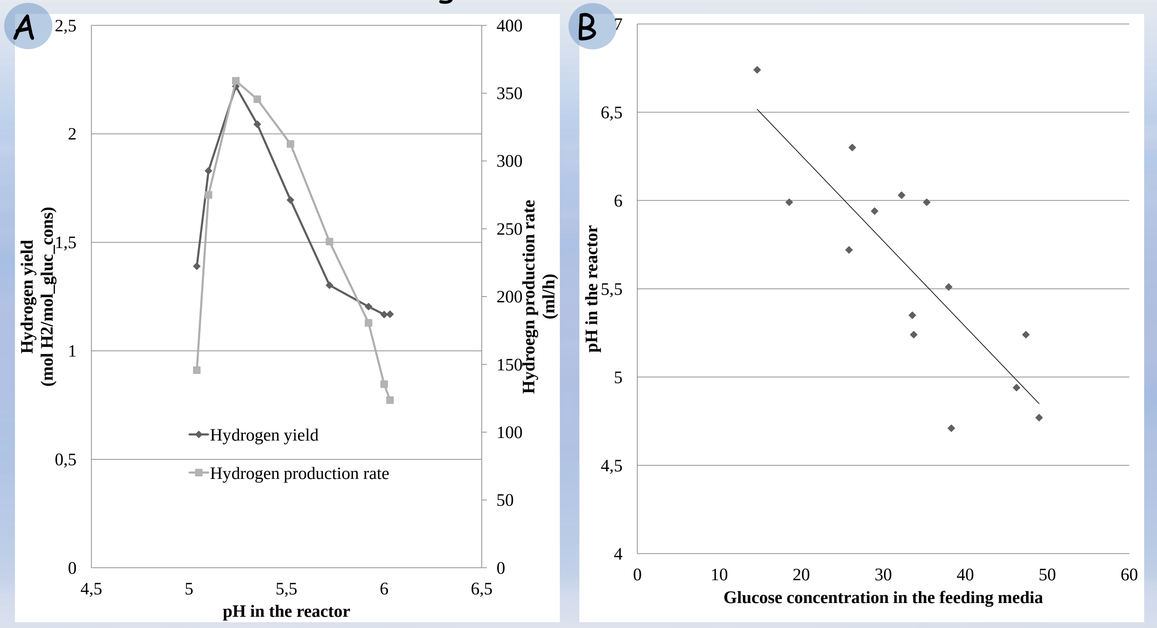


Fig 2: ***A*** : Performances, in terms of hydrogen production yields (mol H_2/mol glucose) and production rates (ml H_2/h) with the pH in the bioreactor. **B** : pH measured inside the reactor for different glucose concentration adjusted in the feeding media. This shows the feasibility of a indirect pH regulation, very important for optimal hydrogen production (see fig. 2.A) by a dilution more or less important of the feeding media.

Conclusions

- **The maximum hydrogen yield was obtained at pH 5.2** while acetate and butyrate are the major sub-products (typical of *Clostridium* fermentation).
- **Hydrogen partial pressure needs to be reduced** by removing the gas from the liquid, in order to limit the inhibition on hydrogen production. The measure of the hydrogen concentration in the media needs to be investigated in order to quantify the effects.
- **pH may be efficiently controlled** at optimal level **by adjusting glucose concentration** in the fed media, without other pH regulation system.

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