BIOPROCESS DESIGN FOR GREEN ETHYL LACTATE II: ETHANOL FERMENTATION

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OBJECTIVES

INITIAL PLANT

Ethanol production → High Equipment and Utilities Costs

Ethanol production → need of coordination → Ethyl lactate production

Lactic acid production → need of coordination → Ethyl lactate production

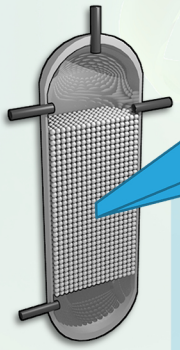
FINAL OBJECTIVES

- Decoupling the two sections and convert the Ethanol from discontinuous to continuous fermentation.
- Improve the strain yield and productivity:
  - · Cells immobilization
  - · Strain genetic improvement

IMPROVEMENTS

BIOREACTOR

- Continuous PFR.
- PBR (packed bed reactor) with immobilized cells in loofah-reinforced alginate matrix (ALM). Cells immobilization leads to increase productivity and to improve purification.
- ALM dimensions will be 20x20x3 mm³. These occupy 32% (v/v) of the PBR bed volume.

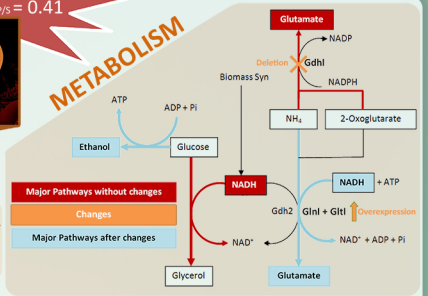


$Y_{P/S}$ = 0.373

Yield increase: 10%

Total $Y_{P/S}$ = 0.41

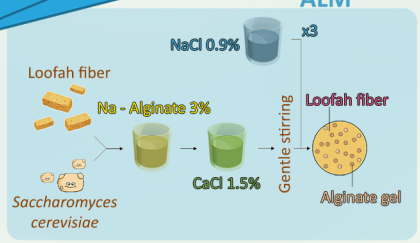
METABOLISM



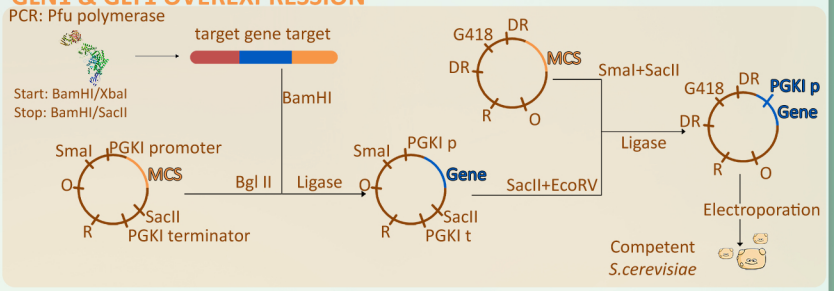
GDH1 DELETION

A plasmid is obtained, in which one fragment of gdh1 gene with 1.0 Kb has been replaced with another fragment of ura3 ORF (genetic marker) with 1.1 Kb. This plasmid is transformed into Uracil or uridine auxotrophic *S. cerevisiae* to do positive selection with the marker.

ALM



GLN1 & GLT1 OVEREXPRESSION



DESIGN

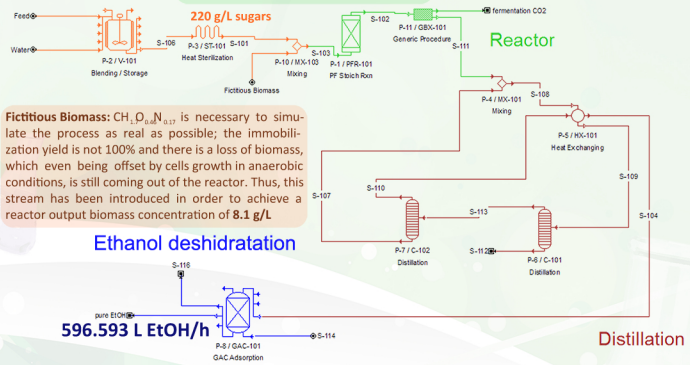
Pretreatment

Feed: Mixture composed by Molasses (defined as glucose) and Others

Reactor: Molasses ($C_6H_{12}O_6$) → 2 CH_3OH + 2 CO_2

- Vs = 4.8 cm/h
- Ethanol concentration achieved: **90.266 g/L**
- θ = 9.10h
- V = 46.62 m³
- Continuously anaerobic conditions at 32ºC

A **Black box** has been added necessarily to separate CO_2, which actually comes out of reactor, because SuperPro Designer did not allow this output to be directly entered in it.



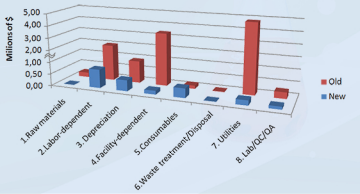
Fictitious Biomass: $CH_{1.8}O_{0.5}N_{0.17}$ is necessary to simulate the process as real as possible; the immobilization yield is not 100% and there is a loss of biomass, which even being offset by cells growth in anaerobic conditions, is still coming out of the reactor. Thus, this stream has been introduced in order to achieve a reactor output biomass concentration of **8.1 g/L**

This ethanol is needed to load the esterification section to produce ethyl lactate, it has been established that the purity is 100% in order to simplify the simulation process.

RESULTS

The importance of Equipment and Utilities costs has been reduced, but the importance of labor-dependent costs has been outweighed.

All the costs are lower than in the initial fermentation, having a big impact on the final plant cost, except for consumables costs. These are higher because of the alginate needed at the immobilization. But consumables costs rise is not comparable to the other costs reduction.



	PREVIOUS DESIGN	MODIFIED DESIGN
Bioreactor used	3 x 268 m³ STRC	1 x 46.62 m³ PFR
Inoculums' Tank	2 x 76 m³ STRC	Not needed
Use of consumables	No consumables	Alginate
Total annual costs	11 million dollars	2 million dollars

CONCLUSIONS

Equipment costs have been dramatically reduced, as a consequence utilities and facility-dependent costs have been reduced too.

→ The improvements have solved all the problems previously identified, and contribute to improve the overall process.

→ A non-viable process will be transformed in a profitable one due to this new section and improvements done in other sections (lactic acid fermentation and esterification).

REFERENCES

[1] - Bangrak.P, Limtong. S, Phisalaphong.M, "Continuous ethanol production in yeast cells entrapped in loofa-reinforced alginated carriers," 2011.

[2] - Torben.L, Morten.C, Kielland-Brandt et al., "Optimization in Saccharomyces cereviseae by Metabolic Engineering of the Ammonium Assimilation," Siencedirect, 2000.