BIOREFINERY: A solution for a sustainable future

Part I. Introduction to biorefinery; context, products and alternatives

Clapés M., Golobardes A., Portell M., **Portell L.**, Prat C.

INTRODUCTION

Nowadays, the shortage of fossil fuels and the irreparable damage done to the environment has induced an increase in biofuels production. The most common biofuel in Europe is **biodiesel**. During this chemical process **crude glycerol** is been produced as a by-product; it has a negative influence on the price of biodiesel because the current market is unable to absorb the large increase of crude glycerol production due to the level of impurities. The production of pure glycerol from this residual glycerol involves high costs and requires complex purification methods. Thus, the process is not economically viable and other alternatives have been found. One of the strongest alternatives is to ferment the crude glycerol with a bacterial strain which is able to tolerate impurities and produce valuable products like **1,3-Propanediol**.

OBJECTIVES

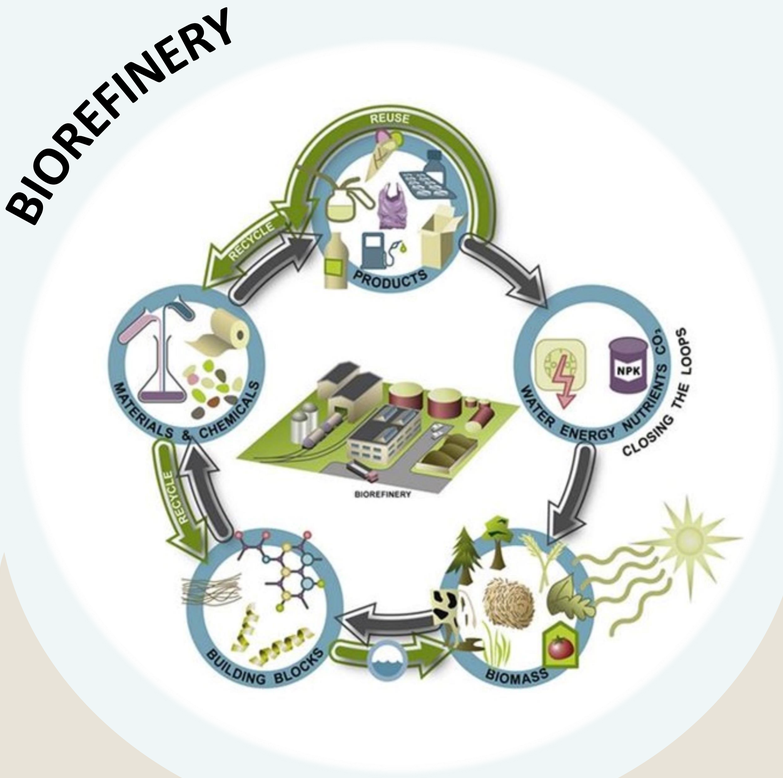
Find a way to use crude glycerol as a carbon source for bacteria and obtain 1,3-Propanediol.

CRUDE GLYCEROL → **1,3-PDO**

Understand basics of biorefinery.

Discuss which strain is the optimal for the process.

BIOREFINERY



Biorefinery is a broad term referring to the conversion of different biobased feedstock to a wide range of products, including food, feed, chemicals, materials and energy. Biorefineries exploit all of the elements of biomass, recycling secondary products and wastes of the reactions into valuable products; in our case, crude glycerol into 1,3-PDO.

MICROORGANISMS

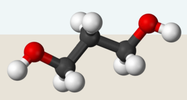
	Citrobacter	Clostridium	Klebsiella	Enterobacter	Lactobacillus
Productivity [g/Lh]	0,58	1,96	1,22	NF	0,33
Yield [PDO/s]	0,66	0,53	0,5	0,51	0,29

Klebsiella pneumoniae

$$1\ \text{Glycerol} + 0,02\ NH_4OH \rightarrow 0,5\ \text{PDO} + 0,18\ \text{Biomass} + 0,01\ \text{BDO} + 0,03\ \text{Acetic acid} + 0,04\ CO_2 + 0,04\ \text{EtOH} + 0,19\ \text{Lactic acid} + 0,03\ \text{Succinic acid}$$

PRODUCTS

1,3-PROPANEDIOL



1,3-PDO

CHEMICAL SYNTHESIS

Hard operation conditions

Environmental effect

→ BIO-BASED PDO PRODUCTION (DUPONT)

Applications of PDO vary from polymers production, such as polyether and polyurethanes as PTT, to **cosmetic and pharmaceutical uses**.

60$/kg Price

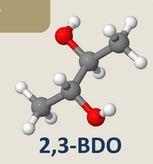
GLOBAL MARKET

PTT	→	80% of total market	→ 50800 T/year
Pharmaceutical and cosmetic use	→	20% of total market	→ 12700 T/year

Higher purity

2,3-BUTANEDIOL

One of its well-known applications is the formation of methyl ethyl ketone, by dehydration, which can be used as a liquid fuel additive.



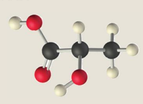
2,3-BDO

40$/kg Price

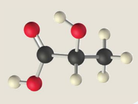
LACTIC ACID

Lactic acid is used as a monomer for the production of polylactic acid (PLA). Recently, there has been an increased focus on the poly D-lacticacid (PDLA) because of its better biodegradability properties. *Klebsiella Pneumoniae* is able to produce highly pure D-lactate.

60$/g Price



L-lactic acid



D-lactic acid

PLANT LOCATION

Wesseling, Cologne, Germany

It is an industrial city where **KFS**, an important biodiesel company, is also located. It is also important to remark the near existence of the river Rhein as well as an efficient communication by train and plane.

This company produces 12.000 tons of crude glycerol every year.

- Crude glycerol is 70% of pure glycerol
- Conversion yield is 50%

→ **4.000 tones/year of PDO are going to be produced.**

CONCLUSIONS

In this project, biorefinery has been discussed as a good alternative to use this waste glycerol as a carbon source for bacteria to obtain 1,3-propanediol. There are different bacterial strains that can use it as a substrate to produce 1,3-propanediol. To go through our process and trying to achieve an optimal final product concentration, taking into account the productivity of each strain, we finally decided to use the microorganism *Klebsiella pneumoniae* which can produce not only 1,3-propanediol, but also other products such as 2,3-butanediol or lactic acid.

What is next? Analyze different operation procedures to select the best process to produce 1,3-PDO with high productivity and benefits in an eco-friendly way.

SELECTED REFERENCES

1. Bio-based economy, *Today's applications: Biorefinery* [Consultation: 25/02/2015] Available in: http://www.bio-economy.net/applications/applications_biorefinery.html

2. Cho MH., Joen SI., Pyo SH., Mun S., Kim JH. "A novel separation and purification process for 1,3-propanediol". Process biochemistry, 41, (2006), p. 739 – 744.

3. Green chemicals blog. [Consultation: 09/01/2015]. Available in: http://greenchemicalsblog.com/2013/03/18/bio-pdo-market-update/

4. Xiao Y., Xiao G., Varma A., "A Universal Procedure for Crude Glycerol Purification from Different Feedstocks in Biodiesel Production: Experimental and Simulation Study". Industrial Engineering Chemical, 52 (2013), p.14291−14296.