PROCESS DESIGN FOR THE CO-PRODUCTION OF 3-HYDROXYPROPIONIC ACID AND 1,3-PROPANEDIOL

Tereza Kolaiti, John M. Woodley, Rafiqul Gani

KT-Consortium, Department of Chemical and Biochemical Engineering, Technical University of Denmark, Denmark

Research Motivation

- Develop innovative sustainable technologies, able to exploit the excessive amount of Glycerol that derives from the biodiesel production so that by-products become raw materials
- Investigate and research the production of 3-Hydroxypropionic acid (3HP) and 1,3-Propanediol (1,3PDO) using metabolic engineered microorganisms as well as achieving high yields
- Research the activity of *Lactobacillus reuteri* resting cells in the biotransformation of Glycerol, since it cannot be used as a carbon source by it
- Encourage the biorefineries concept so that the shift to the sustainable economy based on biomass is performed

Objectives

- Design the optimal production process towards simultaneous and equimolar amounts of 3HP and 1,3PDO
- Compare to the existing methods that are producing the two products separately
- Investigate how the toxic intermediate 3-Hydroxypropanal (3HPA) can assist the production or else sold separately pure
- Perform an economic evaluation and a sustainability check of the process

The products

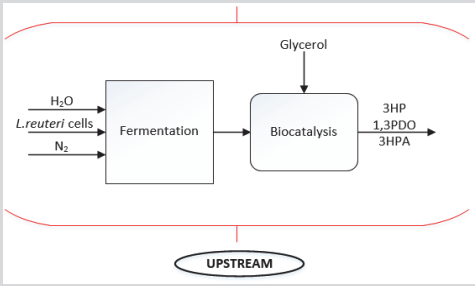
3-Hydroxypropionic acid

- Wide range of industrial applications, precursor of the acrylic acid
- Can be converted to acrylic esters, enabling the sustainable production of polymers

1,3-Propanediol

- Bulk chemical used in the manufacture of polymers, cosmetics, medicine, lubricants
- Flexible properties, can be used as chemical additive in food

Process Methodology



REACTIONS

Glycerol dehydration: $C_3H_8O_3 \xrightarrow{\text{Glycerol dehydratase}} C_3H_6O_2 + H_2O$

Conversion of 3HPA to 1,3PDO: $C_3H_6O_2 + H_2O \xrightarrow{\text{1,3 propanediol oxidoreutase}} C_3H_8O_2 + \frac{1}{2}O_2$

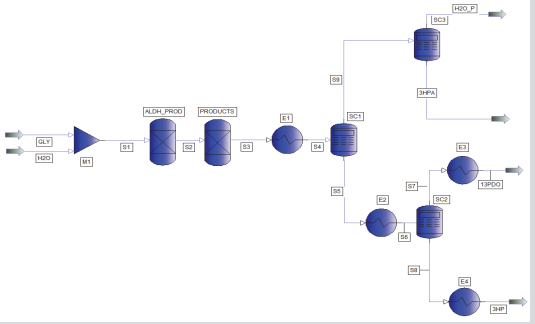
Oxidation of 3HPA to 3HP: $C_3H_6O_2 + \frac{1}{2}O_2 \xrightarrow{\text{i. propionaldehyde dehydrogenase, ii. phosphotransacylase, iii. propionate kinase}} C_3H_6O_3$

Steps

- Growth of the *L.reuteri* cells in a stirred fermenter at 37°C , 1 bar, pH 5.5, 200 rpm and anaerobic conditions
- Biotransformation of Glycerol by the *L.reuteri* cells, at 37°C , 1 bar, pH 7, 500 rpm and anaerobic conditions
- Products' separation

The challenge

Perform 2 azeotropic separations between the four compounds of the process, namely between 3HP - 1,3PDO and 3HPA - water



Benchmarks – Existing processes

The benchmark processes that have achieved the highest yields are:

- Wilkens et al., "High level production of 1,3-Propanediol from crude Glycerol by *Clostridium butyricum* AKR102a", Applied Microbial Biotechnology, 2014, 93:1057-1063

  1,3PDO concentration of 93.7 g/L and a productivity of 3.3 g/(L·h)

- Sankaranarayanan et al., "Production of 3-Hydroxypropionic acid from Glycerol by acid tolerant *Escherichia coli*, Journal of Industrial and Microbial Biotechnology, 2014, 41:1039-1050

  3HP concentration of 41.37 g/L and a productivity of 0.86 g/(L·h)

Expected results

- The development of a sustainable, economically feasible process able to produce simultaneously both 3HP and 1,3PDO achieving high yields and total conversion of the feed
- The 3HPA that is produced as an intermediate is expected to assist the simultaneous production, so it will be recycled back to the biocatalysis reactor
- 1,3PDO is expected to be produced with a concentration of minimum 4.7 g/L and 3HP is expected with a concentration of minimum 5 g/L, so the equimolar production is expected to be successful