FACULTY OF ENGINEERING SCIENCES

Topic -2nd

Propionic Acid Production

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Introduction

- Propionic acid (propionate) is mainly used in the food industry but it's has applications in the cosmetic, plastics and pharmaceutical industries.
- Propionic acid is fermented by *Propionibacterium freudenreichii.*
- Propionic acid, is a ubiquitous fatty acid present in many processed foods as well as animal feedstocks.
- It's use as a natural intermediate and metabolite in many biological processes, and is a useful intermediate in several chemical reactions, particularly in polymerizations.
- Propionic acid fermentation is carried out by several bacteria that belong to the genus *Propionibacterium* and to the species *Clostridium propionicum*.

History

Propionic acid was first described in 1844 by Johann Gottlieb, found it among the degradation products of sugar, and propionic acid derived from fermentation was first observed by Strecker (1854) and subsequently by Pasteur (1879) and Fitz (1879) on various sugar, alcohol, and organic acid substrates.

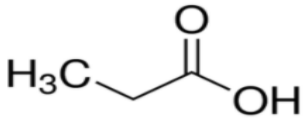
The first works on propionic acid fermentation resulted in the formulation of the Fitz Equation:

3 Lactic Acid----->2Propionic Acid + 1Acetic acid + 1 CO2 + 1H2O

or

1.5 Glucose----> 2Propionic Acid + 1Acetic acid + 1CO2 + 1H2O

(When lactate is the initial substrate, propionic fermentation results in the production of 2 mol of propionic acid, 1 mol of acetic acid, and 1 mol of CO_2).



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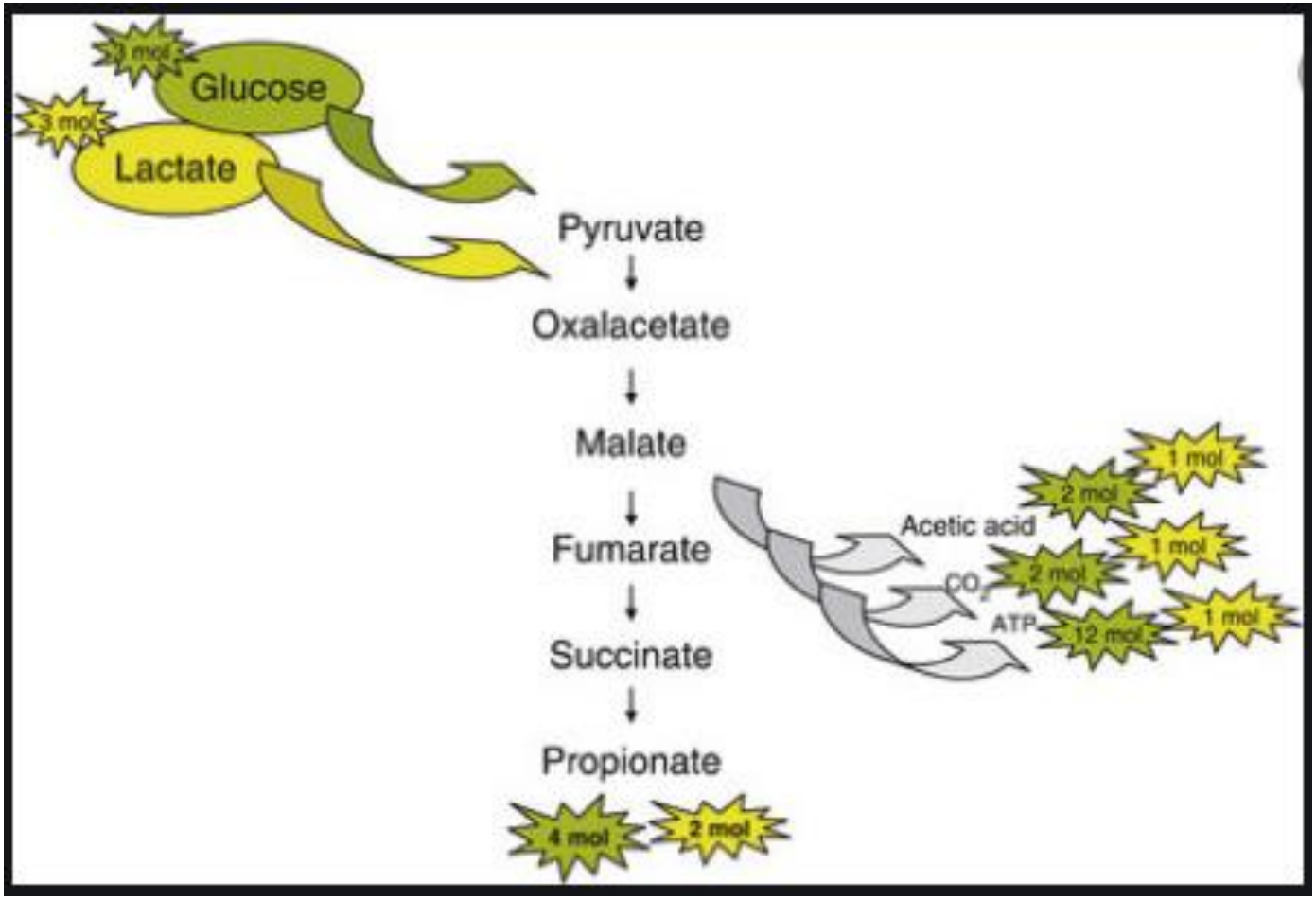


- Propionic acid fermentation is reported by several Propionibacterium species under anaerobic conditions.

- propionic acid fermentation is currently facing a number of challenges including: low growth rate, product inhibition, and expensive downstream processing for high quality products.

- Recently progress has been made in optimising fermentation conditions and in developing genetically-engineered microbes to increase yields and reduce by-product formation.

- Propionic acid production can occur through several pathways and it is important to understand the mechanisms and mode of fermentation in order to select the right fermentation conditions and to optimise them.

- Propionic acid can be produced from a variety of substrates such as glucose, ethanol, lactose, glycerol, and pectin. So, several industrial streams will be suitable to produce propionic acid, if the bacteria are adapted to the inhibitors present in the waste streams and fermentation is optimised to achieve high cell densities and high product concentration.

Cont...

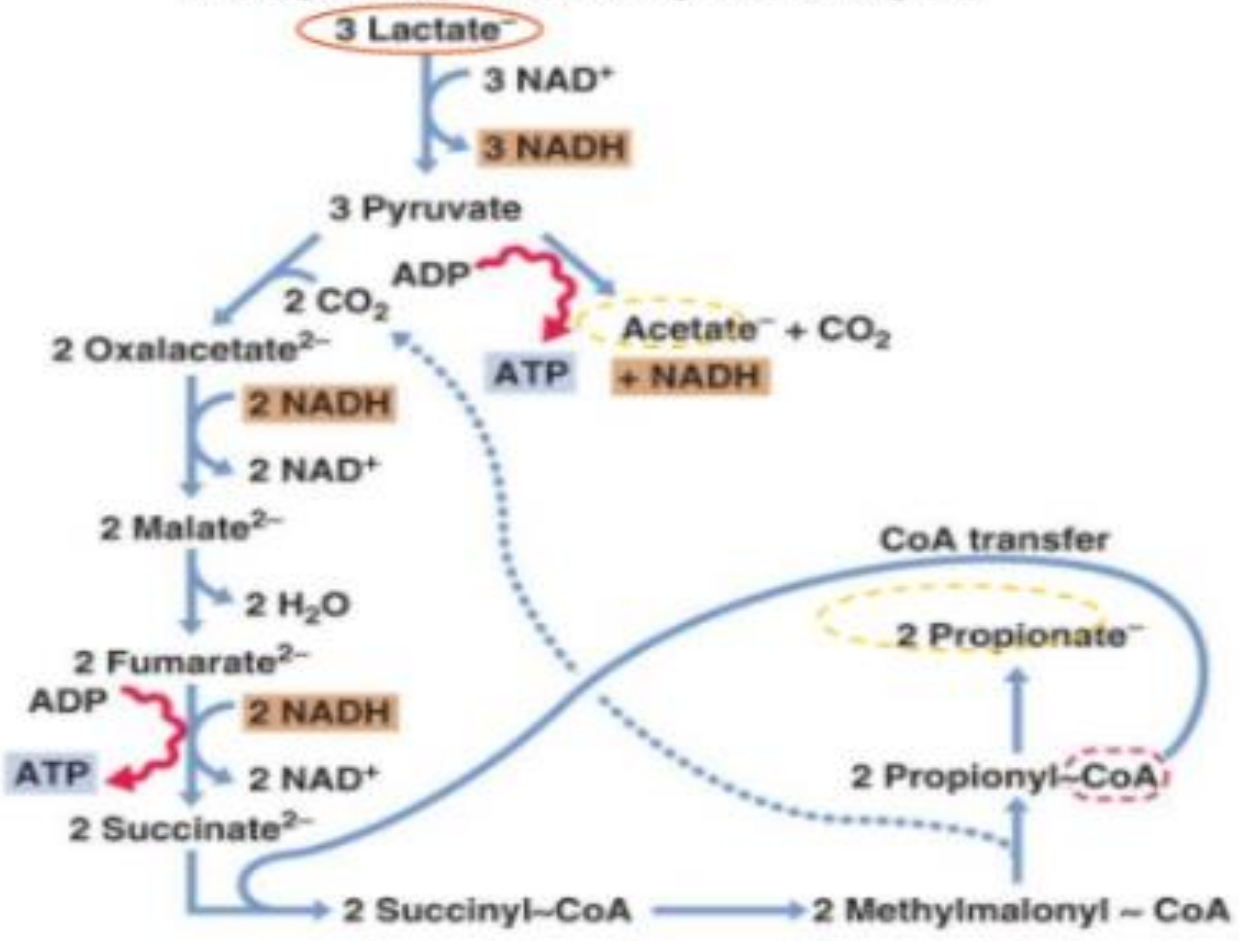
- During propionic acid fermentation, both sugar and lactate can be used as the initial substrate.

- The other end products of propionic fermentation are acetic acid and CO_2. In particular, the propionic acid fermentation of 3 mol of glucose produces 4 mol of propionic acid, 2 mol of acetic acid, 2 mol of CO_2, and 12 mol of ATP.

- When lactate is the initial substrate, propionic fermentation results in the production of 2 mol of propionic acid, 1 mol of acetic acid, and 1 mol of CO_2. In this process, 1 mol of ATP is generated per nine carbons, and because of this, propionic bacteria generally grow very slowly.

(ncbi)

THE PROPIONIC ACID FERMENTATION OF *PROPIONIBACTERIUM*



There are two main pathways for the fermentation of PA from pyruvate: *via* decarboxylation of succinate or conversion of acrylate with lactate.

- **Temperature** optimum temperature for PA production was recorded mostly between 30 and 40 °C.
- **Carbon source** Many different types of carbon sources as the substrate can be considered as the most expensive conventional raw materials in the fermentation process (fructose and 20 g/L glucose, Glycerol).
- **Nitrogen source** *Propionibacterium* spp. can digest nitrogen sources including peptone, corn steep liquor and yeast extract, which can enhance the PA production.

APPLICATION OF PROPIONIC ACID

- ✓ Propionic acid is beneficial to the human body and may play a role in satiety and energy homeostasis by specific mechanisms including activation of free fatty acid receptors, reducing lipogenesis level and glucose homeostasis.
- ✓ Small quantities of propionic acid as a commercial antimicrobial agent are available in many foods such as dairy products.
- ✓ It can be applied to produce characteristic holes and nutty flavour in Swiss-type cheese.
- ✓ The propionic acid in low concentration can slightly promote citric acid production and in combination with acetic acid it improves hydrogen production rates during fermentation.
- ✓ It can be used for enzyme-catalyzed synthesis of esters from alcohols as well as in P ethanol fermentation.

(V Ranaei *et., al* 2020)

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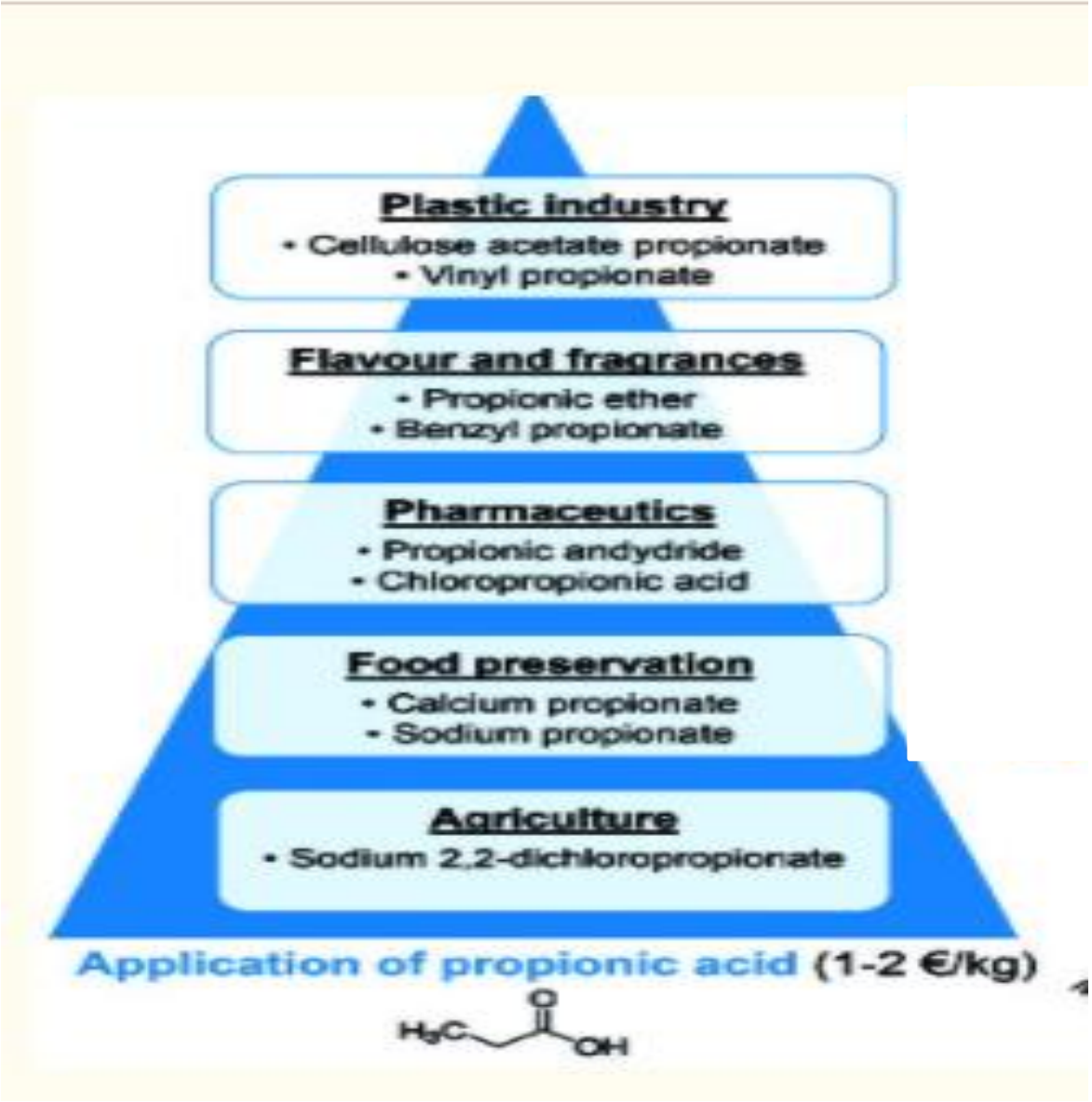
Plastic industry
• Cellulose acetate propionate
• Vinyl propionate
Flavour and fragrances
• Propionic ether
• Benzyl propionate
Pharmaceutics
• Propionic andydride
• Chloropropionic acid
Food preservation
• Calcium propionate
• Sodium propionate
Agriculture
• Sodium 2,2-dichloropropionate
Application of propionic acid (1-2 €/kg)
H3C
O
OH

Properties

- Antimicrobial agent
- Anti-inflammatory agent
- Herbicide
- Preservative and safe food additive

THANK YOU