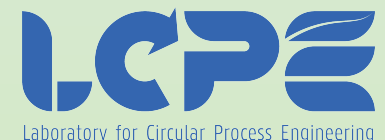


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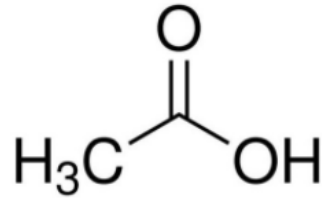
Energy optimization of the evaporation process towards upconcentration of bio-based carboxylic acids

Srija Balachandran; Joël Hogie; Tobias De Somer; Erik Meers; Steven De Meester

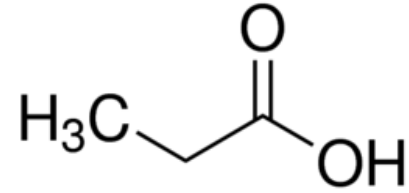
Department of Green Chemistry and Technology, Ghent University, Belgium
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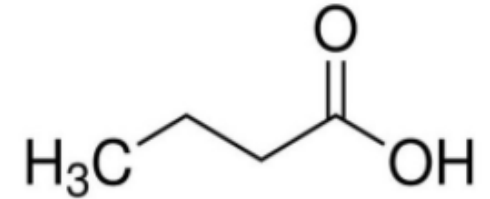
What are volatile fatty acids (VFAs)?



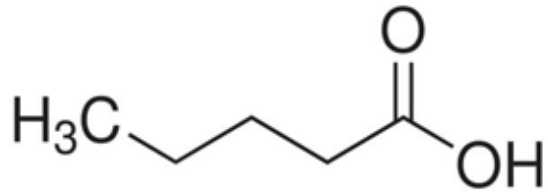
Acetic acid (C2)



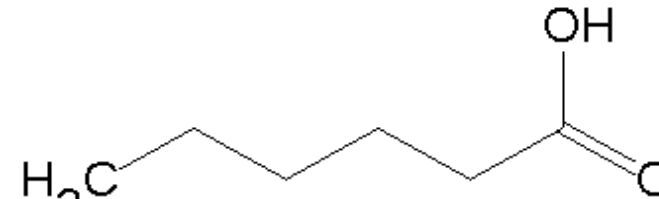
Propionic acid (C3)



Butyric acid (C4)



Valeric acid (C5)



Caproic acid (C6)

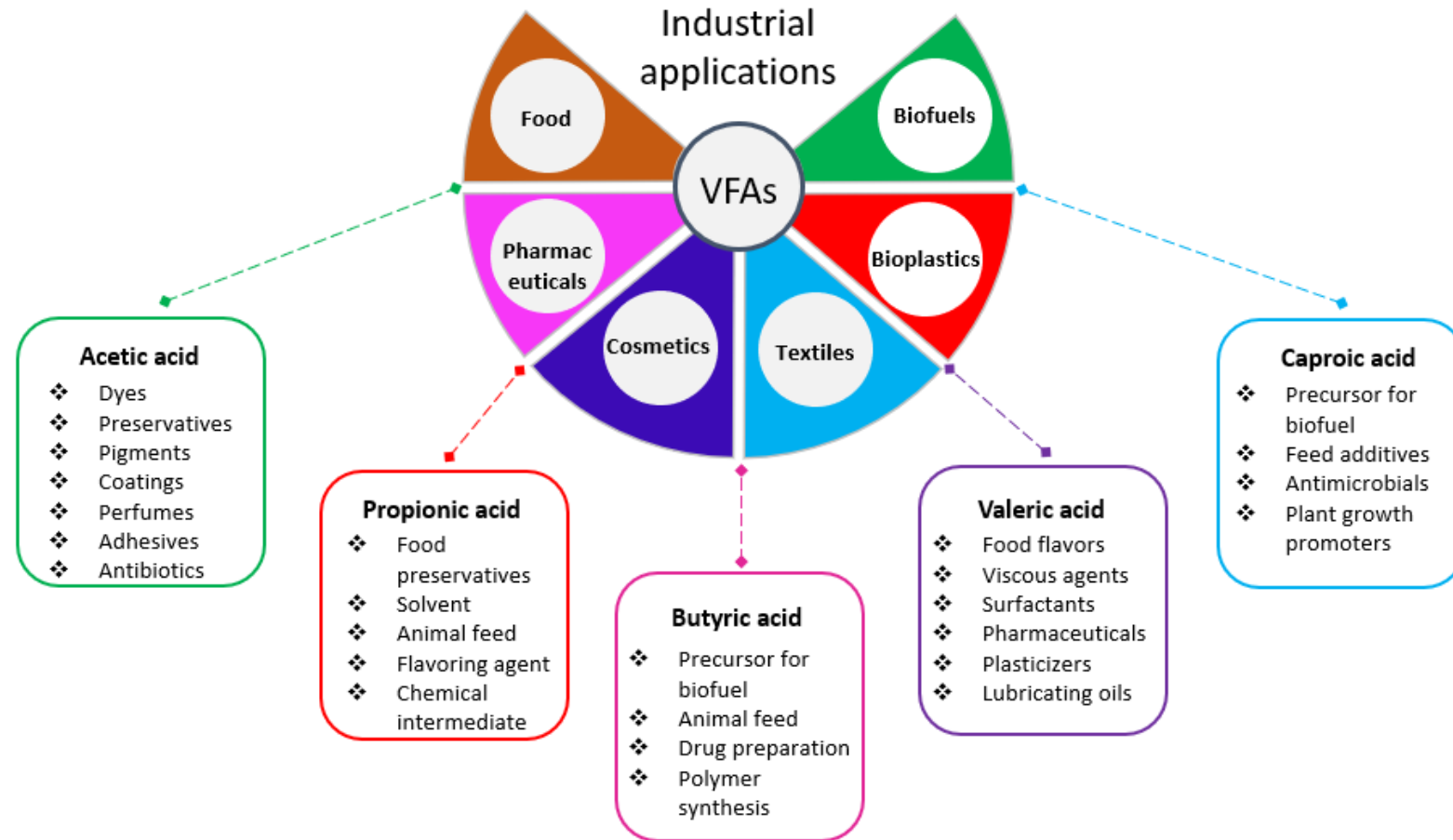
- VFAs, also known as carboxylic acids, are short-chain fatty acids containing two to six carbon.

What is the market price of VFAs?

VFAs	Price (USD/t)
Acetic acid	500-800
Propionic acid	1300-3500
Butyric acid	1600-5000
Valeric acid	4000-7200
Caproic acid	3000-5200

(Adapted from Sukphun et al., 2021)

Why are VFAs important?



By 2031, the global carboxylic acid market is expected to generate a revenue of USD 26.7 billion.

How are VFAs produced?

1. Chemical route

Acetic acid

- Eg.: Methanol carbonylation process

Propionic acid

- Eg.: Reppe's process

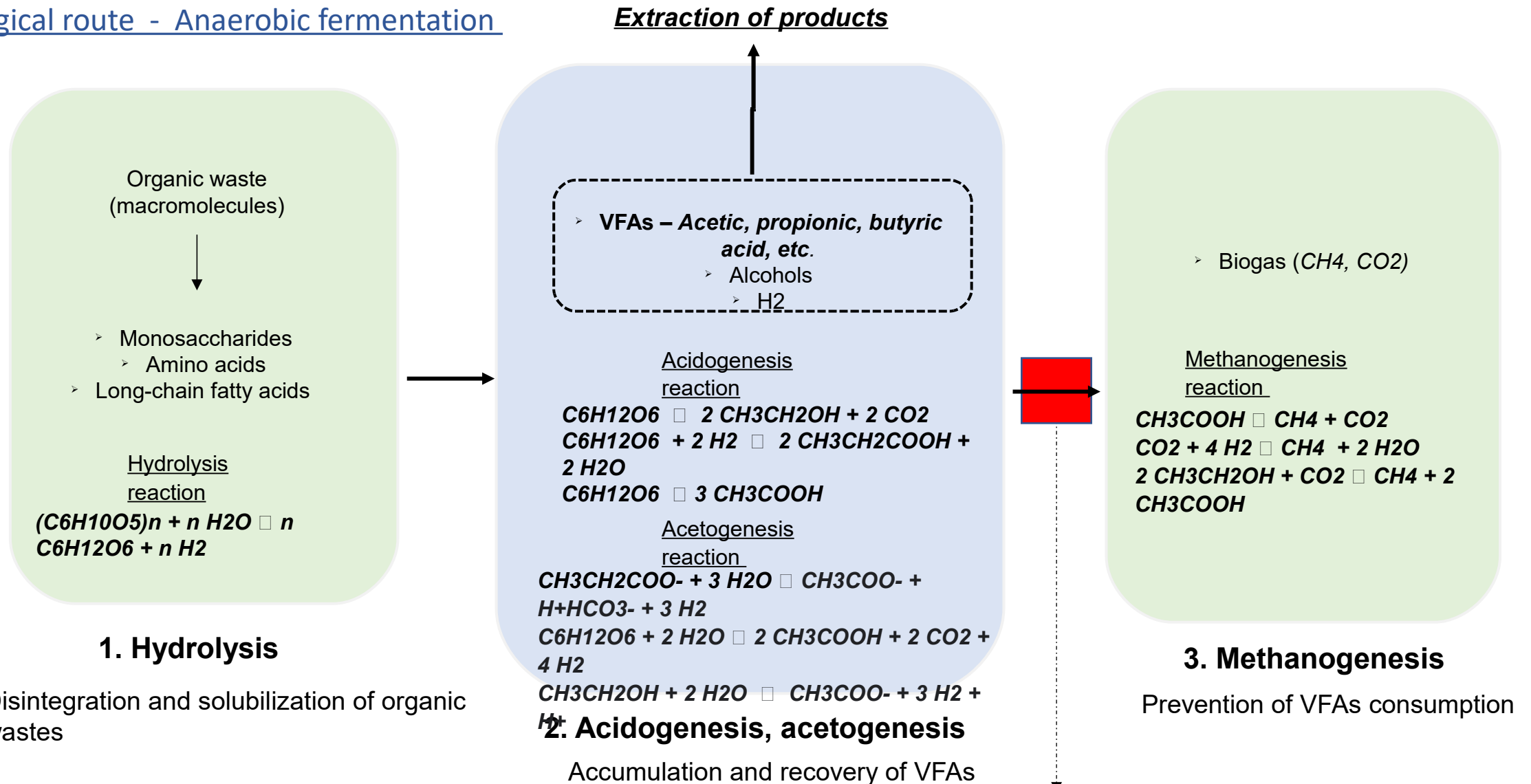
Butyric acid

- Eg.: Oxidation of butyraldehyde

Currently, almost 90% of VFAs are derived from petroleum-based routes.

How are VFAs produced?

2. Biological route - Anaerobic fermentation



Challenges in bio-based VFAs production

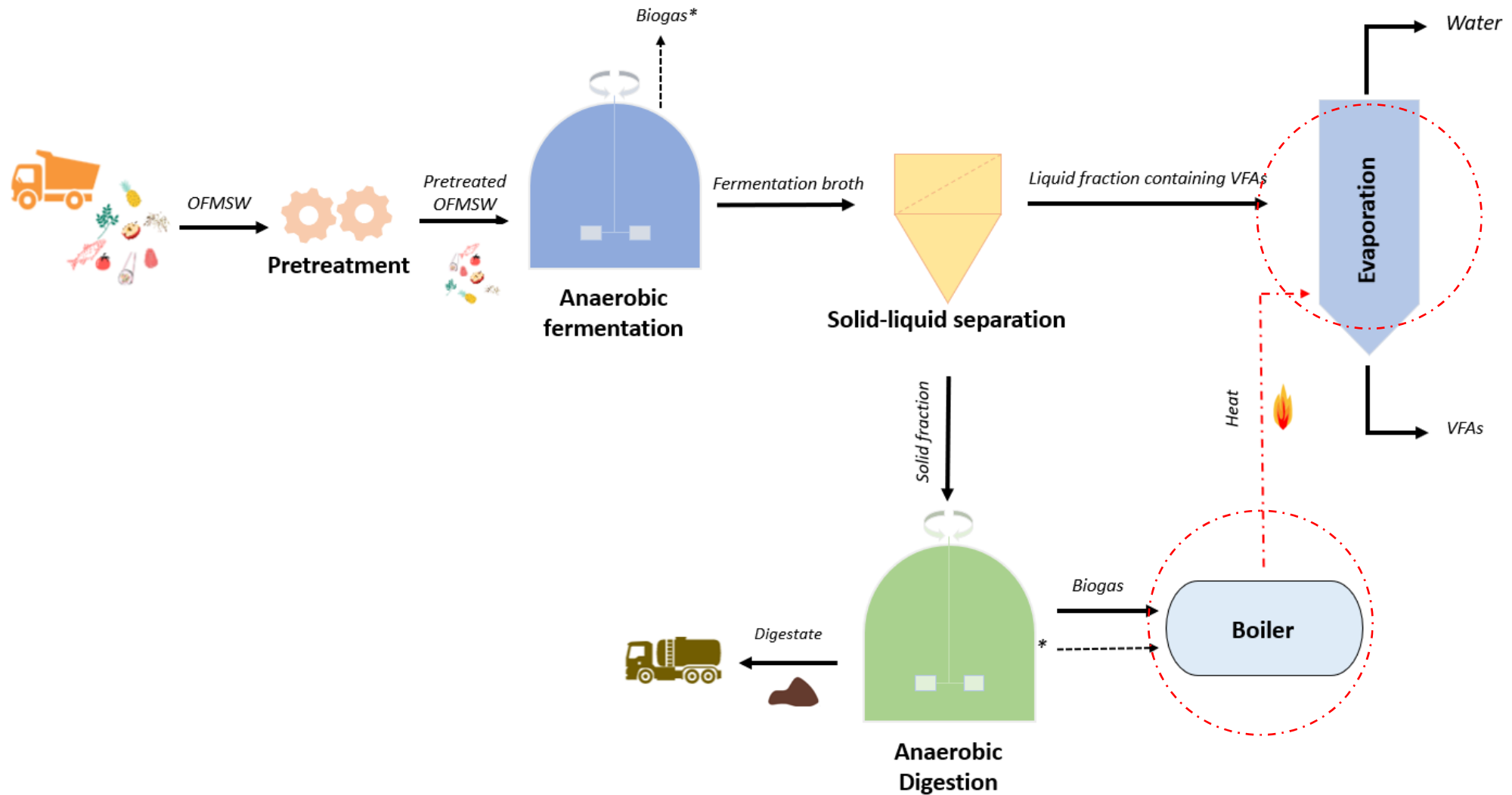
- Presence of mixture of acids.
- Individual acids have higher value than the mixture.
- Acids are in low concentration (1-2 wt%).
- High water solubility.
- The fermentation broth contains solids, salts, trace elements, and other impurities.
- **The cost of VFAs recovery accounts for nearly 50-60% of acid production cost.**

Component	Concentration (g/L)
Acetic acid	2.5 – 10
Propionic acid	2.5 – 10
Butyric acid	2.5 – 10
Lactic acid	2.5 – 10
Sodium (Na ⁺)	1-5
Potassium (K ⁺)	1-5
Chloride (Cl ⁻)	1-10
Phosphate (H ₂ PO ₄ ⁻ / HPO ₄ ²⁻)	1-10
Sulfate (SO ₄ ²⁻)	1-10
Sulfide (S ²⁻)	0.3
Magnesium (Mg ²⁺)	0.3
Calcium (Ca ²⁺)	0.3
Ammonium (NH ₄ ⁺)	0.1
Trace elements (eg. Cobalt (Co), nickel (Ni) and iron (Fe))	10 ⁻⁴
Inert COD (eg. Humic acid and fulvic acid)	1
Microbes	

Composition of fermented wastewater

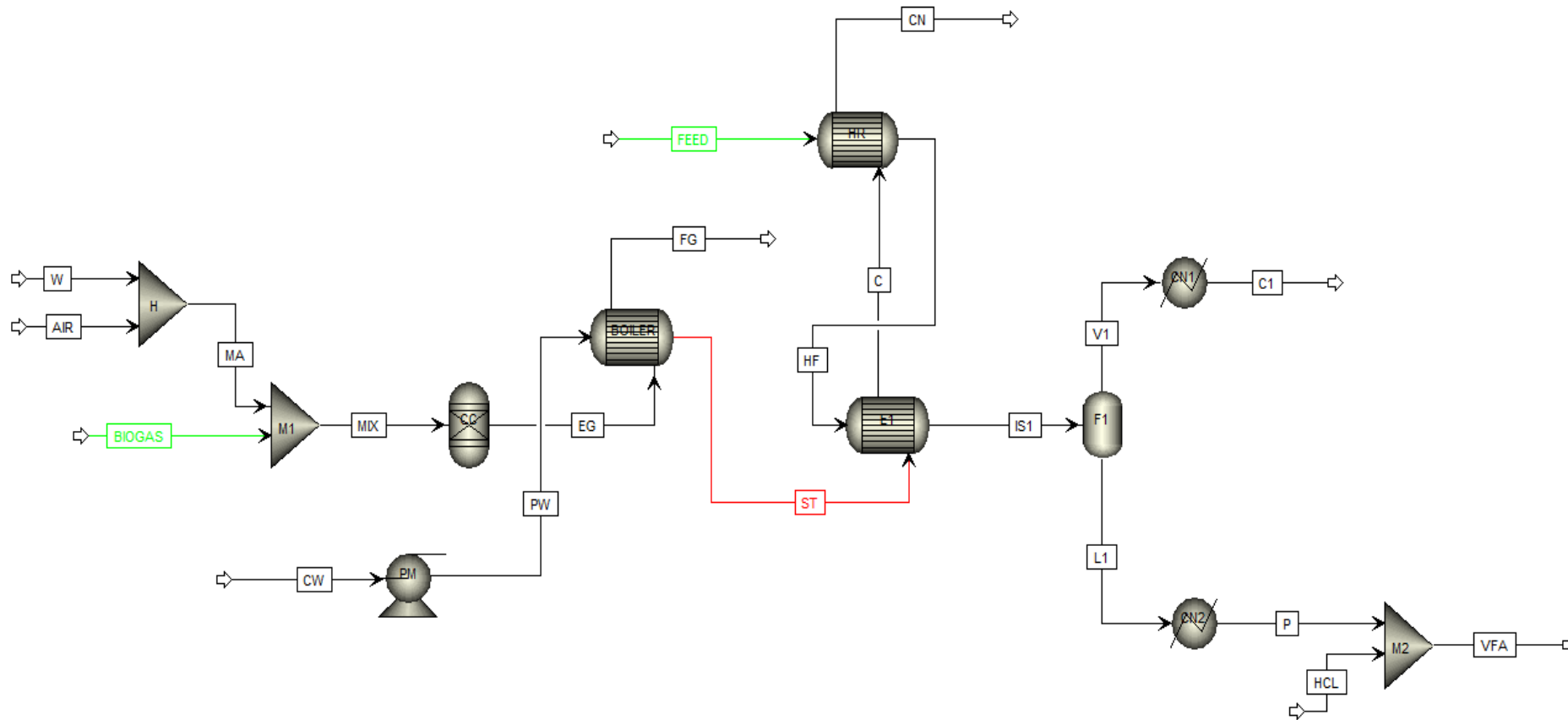
(Adapted from Reyhanitash et al., 2017)

Potential of the evaporation process for VFAs recovery



OFMSW – Organic fraction of municipal solid waste

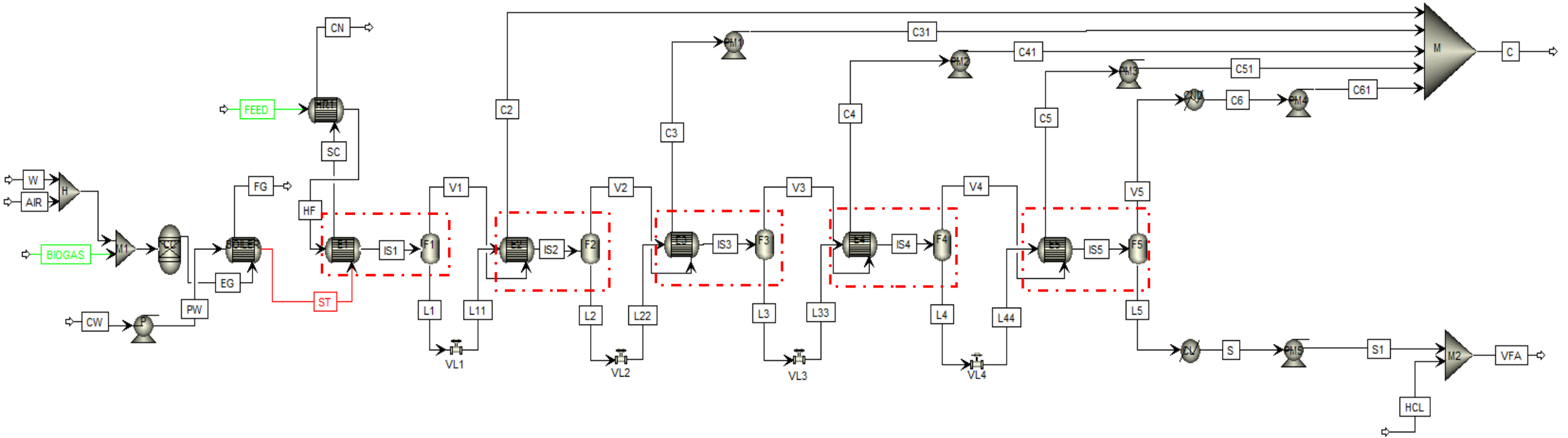
VFAs upconcentration in a single-effect evaporator



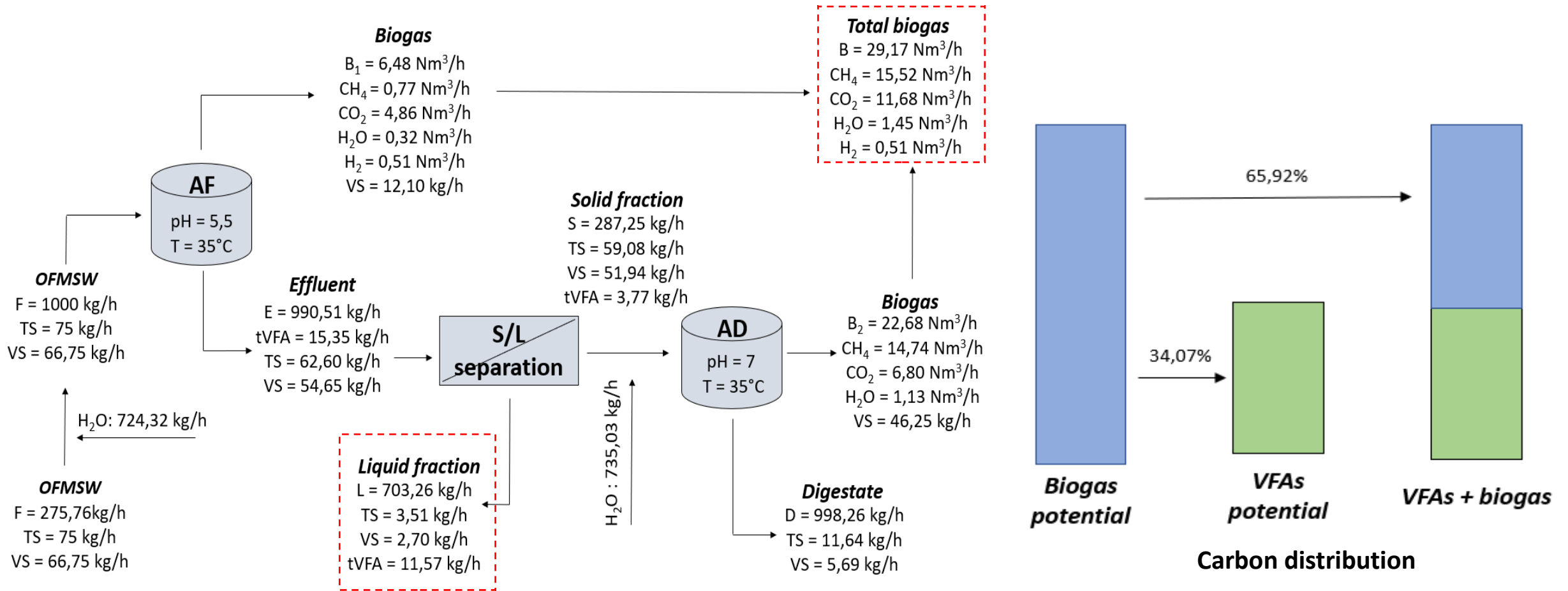
H, M1 and M2 – mixer units
 CC – reactor
 Boiler, HR, and E1 – heat exchangers
 F1 – Flash separators
 CN1 and CN2 - coolers
 PM – pump

FEED – Liquid fraction containing VFAs

VFAs upconcentration in a multiple-effect evaporator



Results – Overall mass balance



Conclusion and future outlook

- The evaporation process shows a great opportunity for VFAs upconcentration by utilizing biogas energy.
- An increase in the concentration of acids from 16 g/L to 180 g/L was achieved.
- Develop a process modelling in Aspen plus by integrating a combined heat and power (CHP) unit with the evaporation process.
- Compare different evaporation systems like single-effect and multiple-effect evaporation, and perform an energy optimization to achieve an economic VFAs upconcentration.

Thank you



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