

From bio-oil to cosmetics

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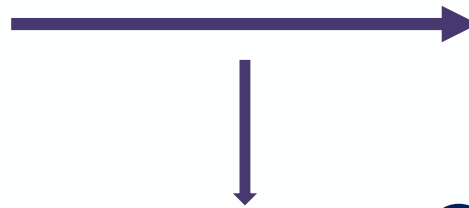
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Mentor(s): dr. ir. Kenneth Toch, ir. Alexandra Bouriakova

The way to SUCCeSS

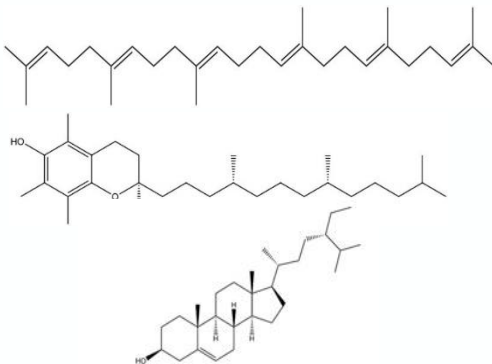
valorisation of waste stream

SUCCeSS: SUperCritiCal solutions for SideStream valorisation



waste stream: ODD

- squalene 2,00 wt%
- tocopherols 3,00 wt%
- sterols 0,05 wt%
- FAME 1,00 wt%
- FFA 43,0 wt%



applications & current source

squalene



current source



tocopherols & sterols



current source



applications & current source

squalene



current source



alternative source?



tocopherols & sterols



current source

✓ ODD



How to extract the
minor components?

principle of supercritical CO₂-extraction

Distinct liquid and gas phases do not exist

CO₂: critical temperature: 31°C
critical pressure: 7,4 MPa

Why supercritical CO₂?



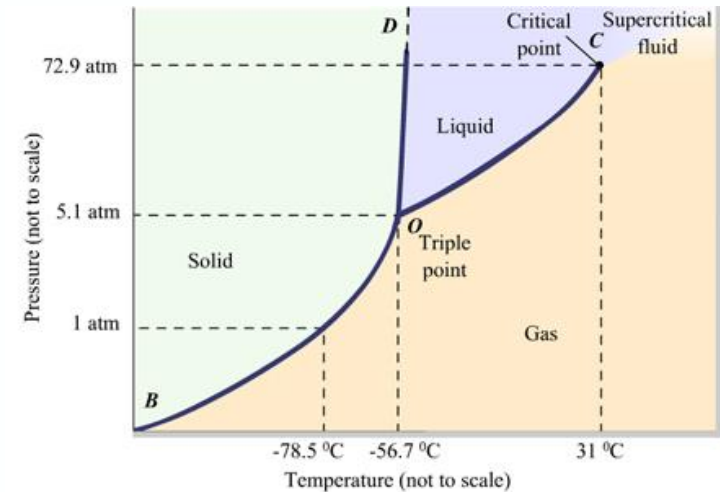
inert



lower temperature



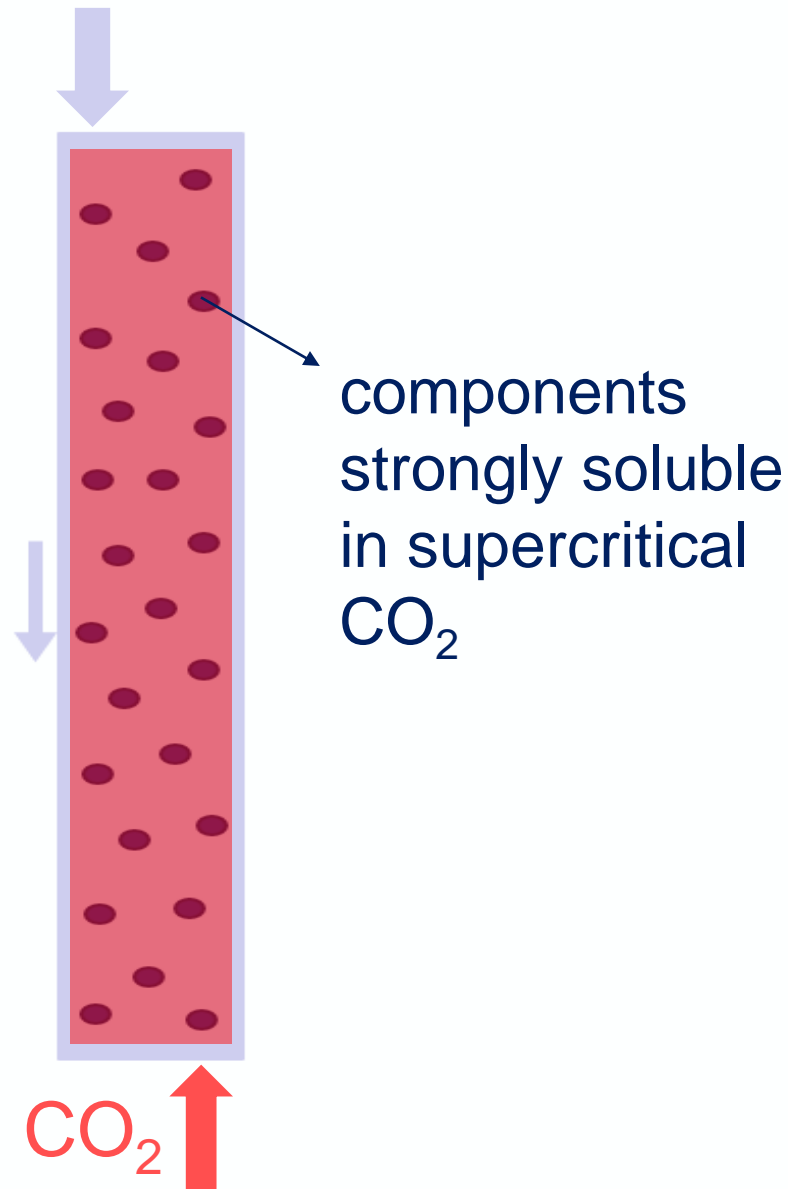
high affinity



principle of supercritical CO₂-extraction

feed (ODD)

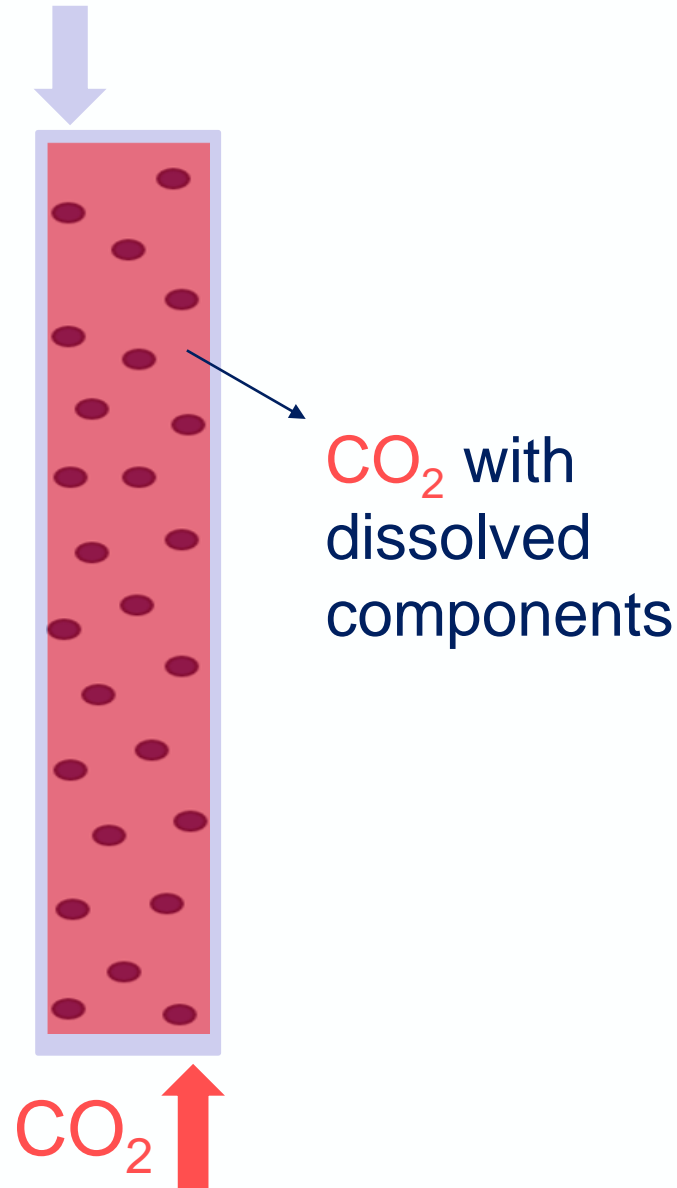
- minor components
- FFA
(free fatty acids)
- FAME
(fatty acid methyl esters)



principle of supercritical CO₂-extraction

feed (ODD)

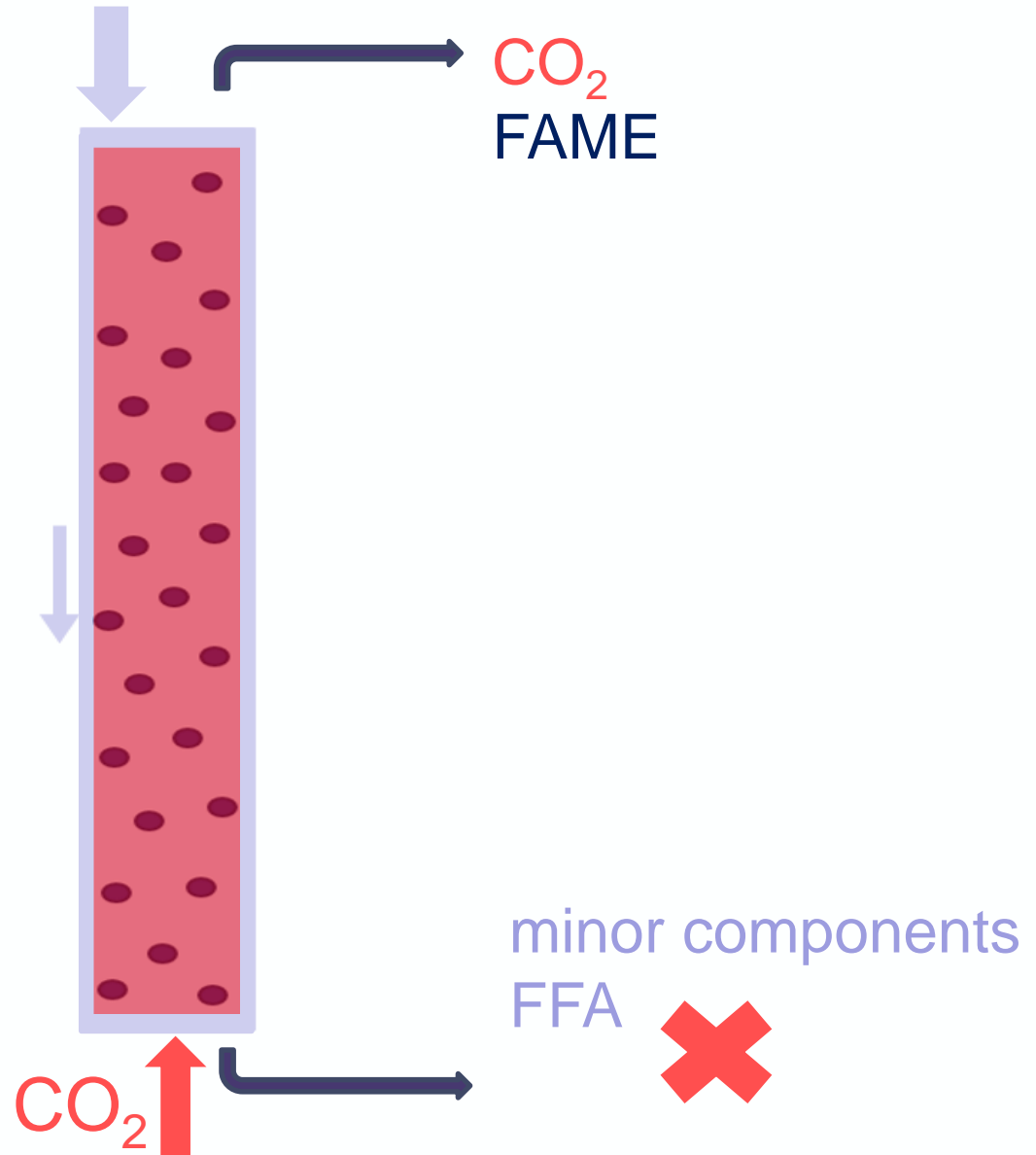
- minor components
- FFA
(free fatty acids)
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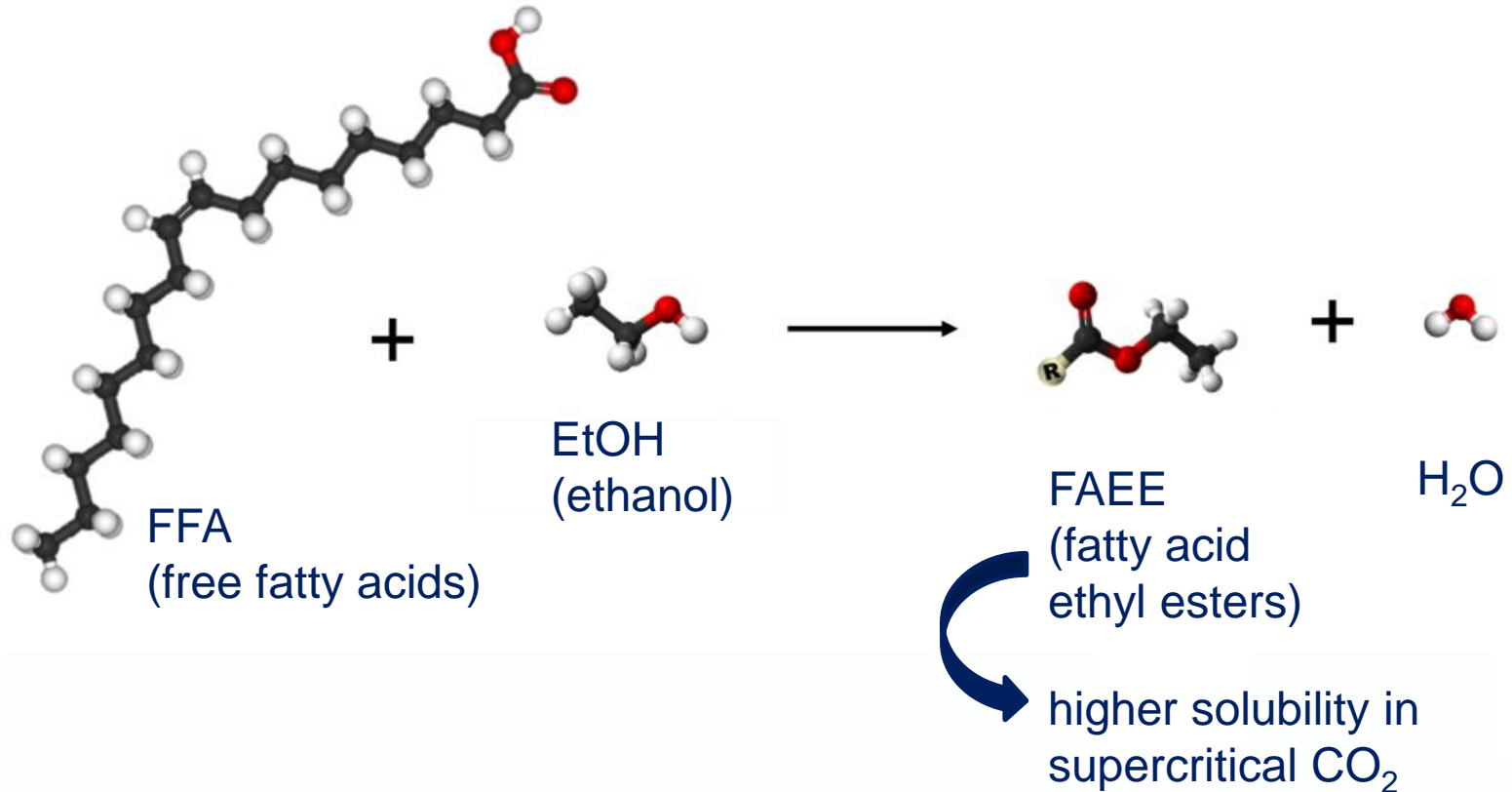
principle of supercritical CO₂-extraction

feed (ODD)

- minor components
- FFA
(free fatty acids)
- FAME
(fatty acid methyl esters)



benefit of supercritical esterification



EtOH: critical temperature: 241°C
critical pressure: 6,14 MPa

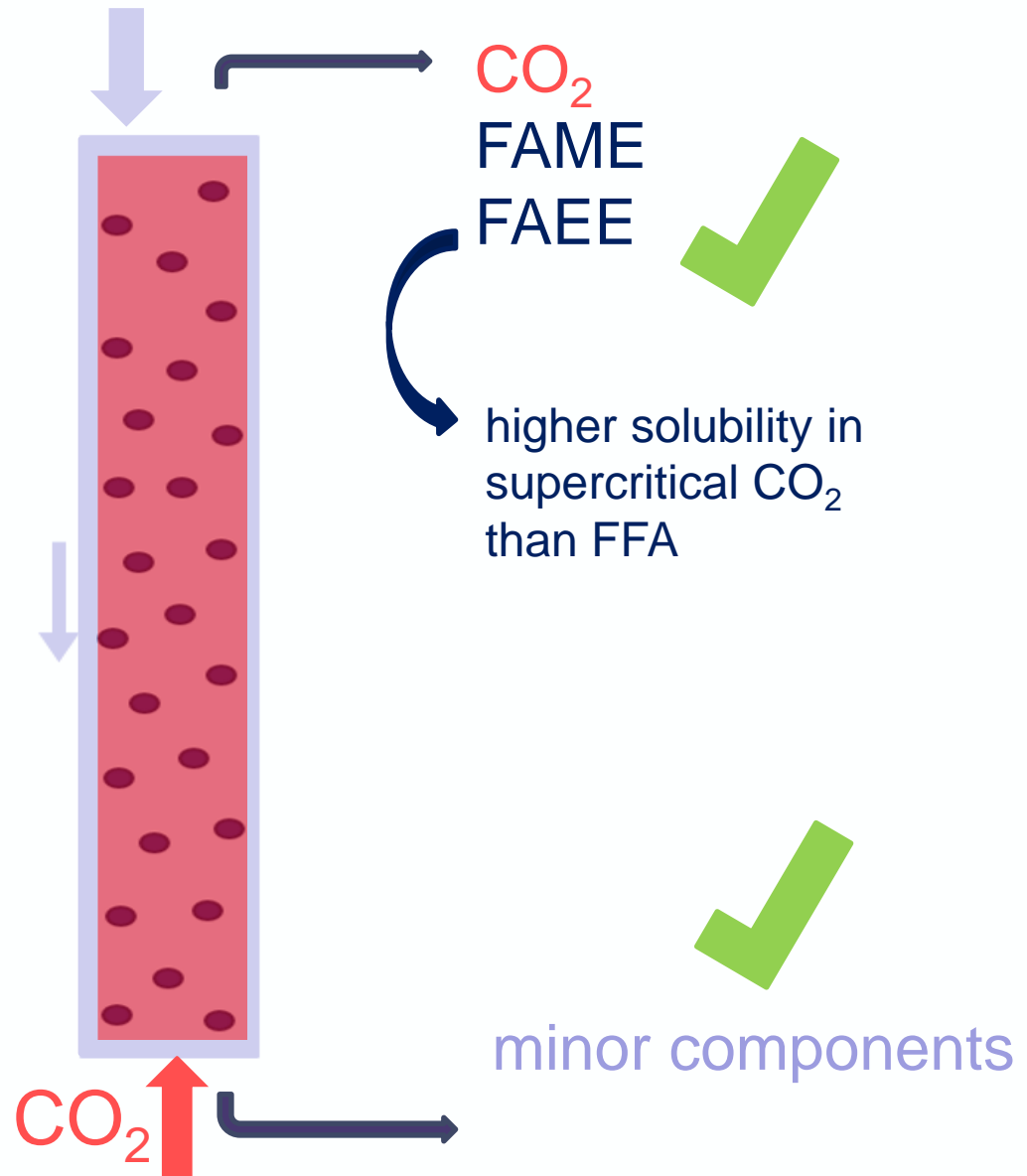


no catalyst needed

desirable supercritical CO₂-extraction

feed

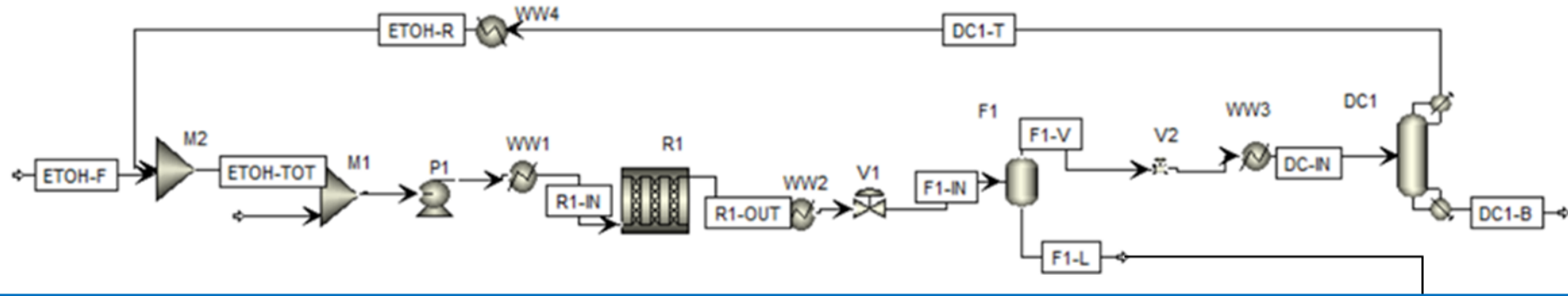
- minor components
- FAEE
(fatty acid ethyl esters)
- FAME
(fatty acid methyl esters)



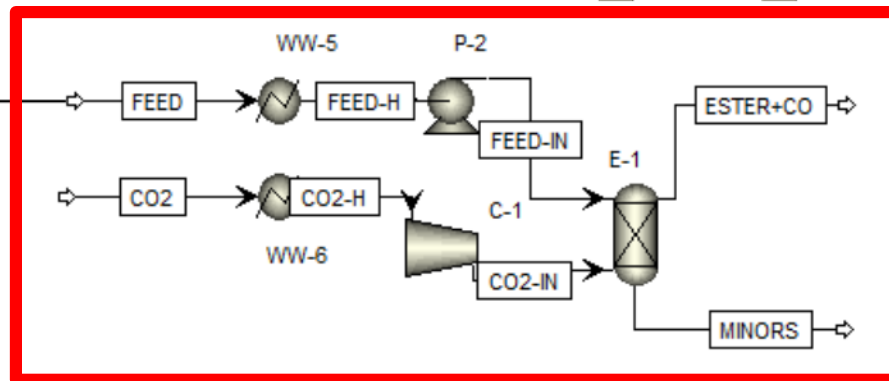
Overall process

overall process

esterification section

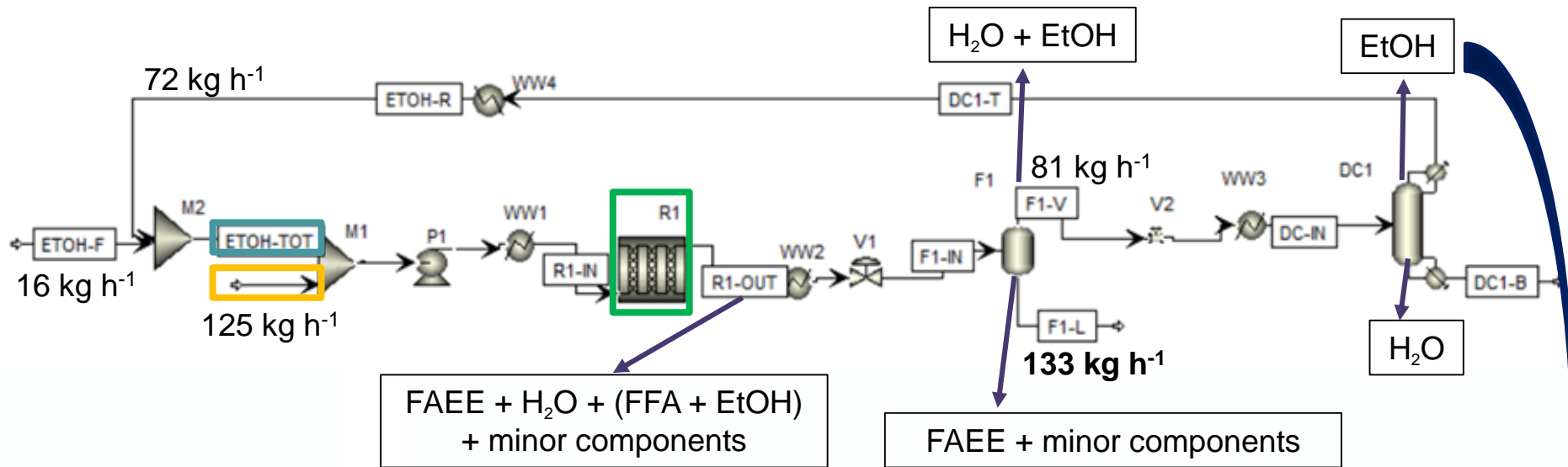


extraction section

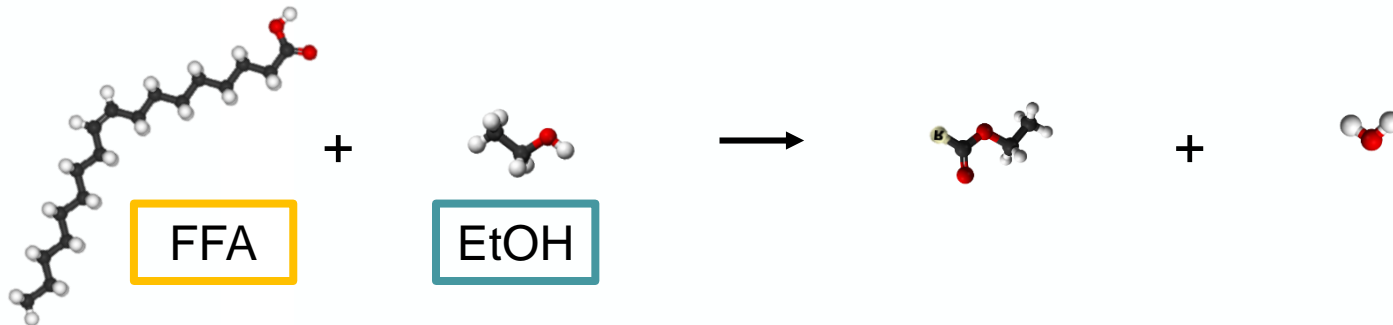


Supercritical esterification

esterification section



plugflow reactor:



conversion of 96 mol%



recycled!



Supercritical CO₂-extraction

extraction section



composition after extraction section

extract

component	amount (kg h ⁻¹)
CO ₂	0,004
FAEE	0,877
FAME	0,025
squalene	0,024
tocopherols	0,041
sterols	0,083

raffinate

component	amount (kg h ⁻¹)
CO ₂	0,023
FAEE	0,102
FAME	< 0,001
squalene	0,027
tocopherols	0,026
sterols	0,108

90% esters in top, > 50% minors recovered in bottom

optimization? → additional experimental research



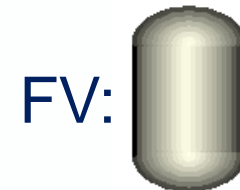
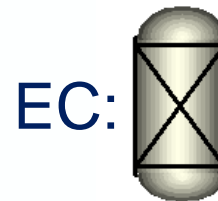
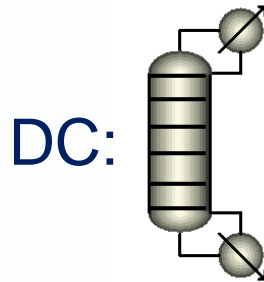
Sizing and
cost analysis of the
overall process

dimensioning of the separation units

Why?

- length and diameter (tray distance) of columns depend on process and process conditions
- dimensions determine the capital expenditures (CAPEX) of units

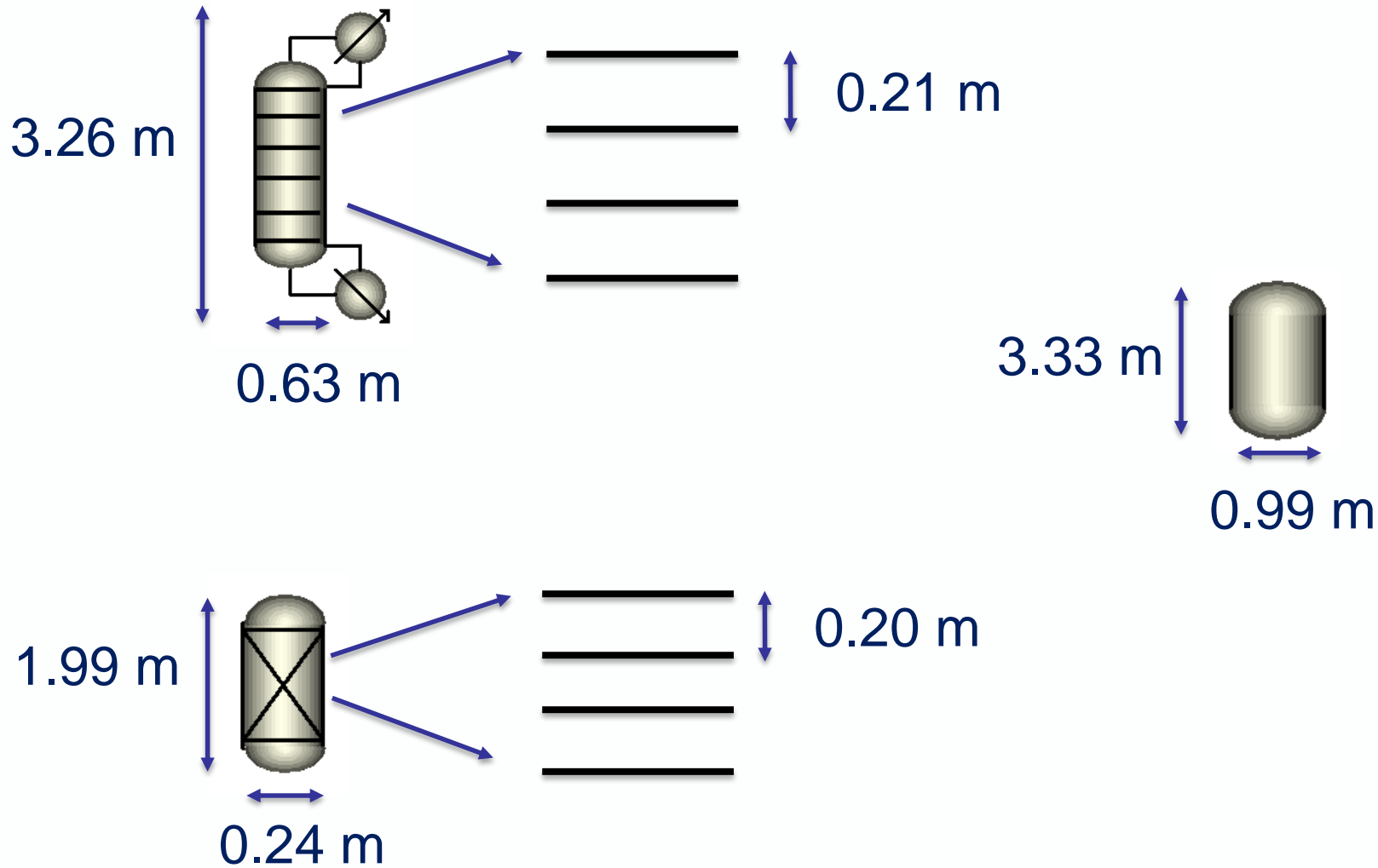
Which?



How?

- Aspen Plus
- Correlations

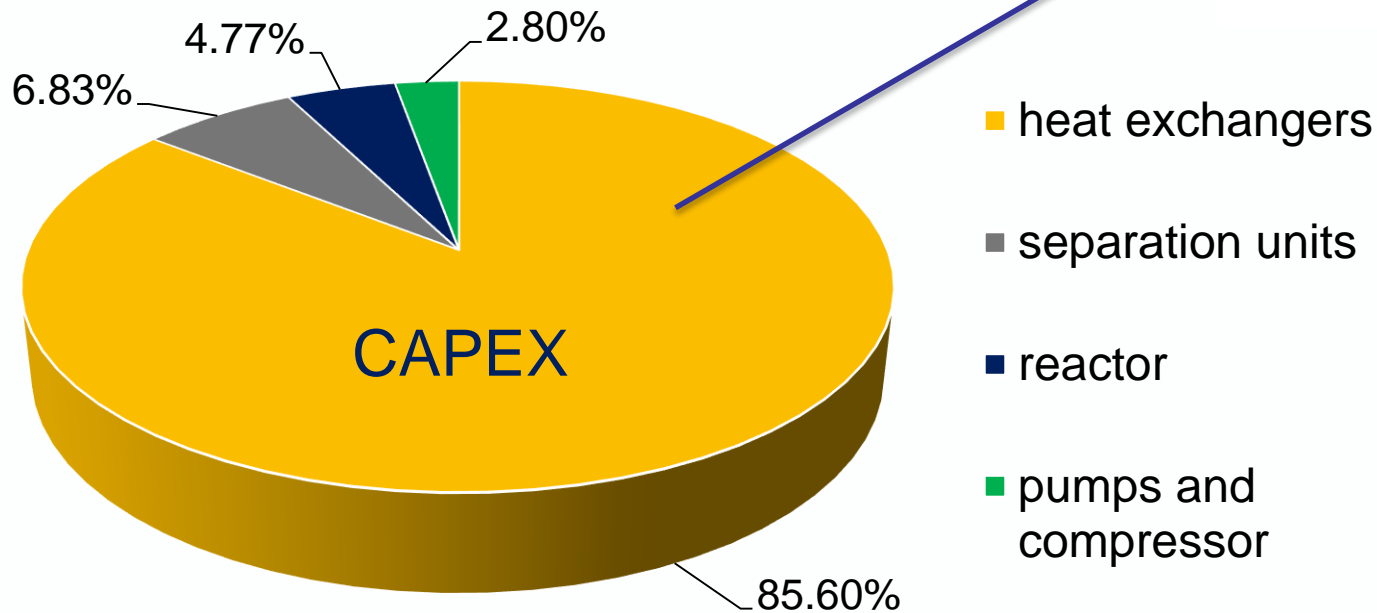
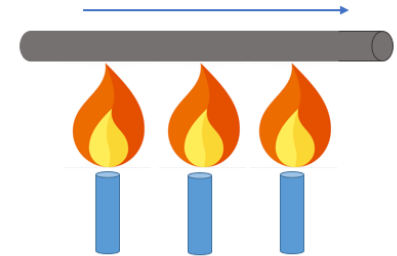
dimensioning of the separation units



capital and operating expenditures

CAPEX = 1 130 000 € (Method of Guthrie)

OPEX = 14 500 € each year (energy required



raw materials	price (€ kg ⁻¹)
ODD	0,56
EtOH	1,00

products	price (€ kg ⁻¹)
squalene	17,50
tocopherols	40,00
sterols	32,50
ethylesters	1,75

- break-even at 2,37 kg_{ODD} h⁻¹
- total profit at optimal conditions: 6 042 000 € each year
(if minor components are fully separated)



Conclusion

conclusion



Waste stream valorization



Sustainable solution



Economically feasible



Further research on supercritical extraction needed



