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Systematic Downstream Development, Optimization, and Equipment Design for Biobased Products and Processes

Andreas Bednarz, Bettina Rüngeler, Peter Scherübel, Markus Schmidt, Andreas Pfennig
andreas.pfennig@ulg.ac.be
Products, Environment, and Processes (PEPs)
Department of Chemical Engineering
Université de Liège
www.chimapp.ulg.ac.be

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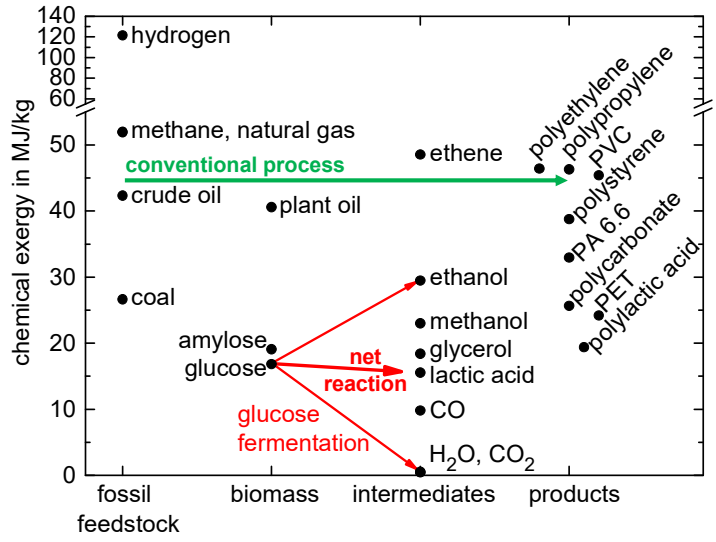
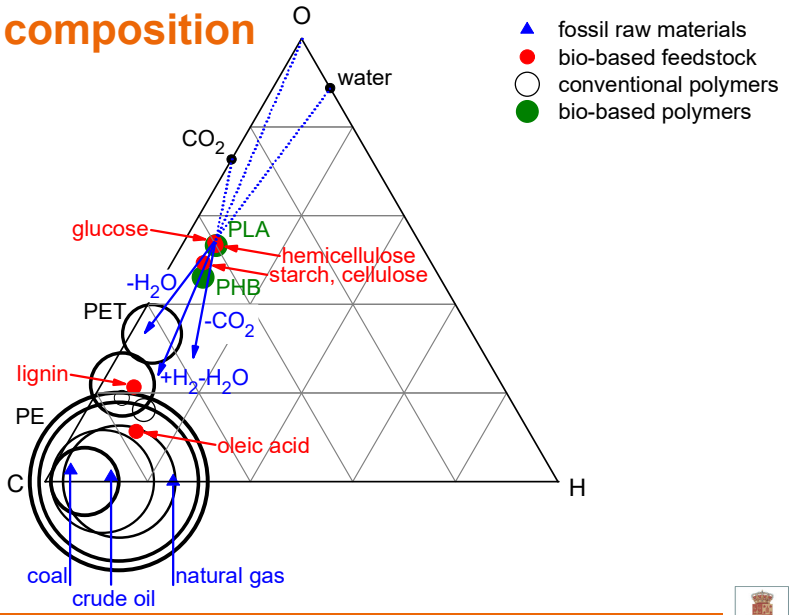
outline

- challenges for biomass as feedstock
- cascaded option trees
- problems in downstream processing
- example
- conclusions

exergy as measure sorting the options



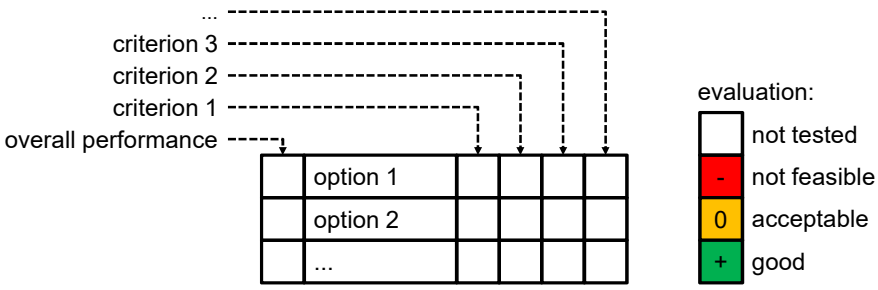
COH composition



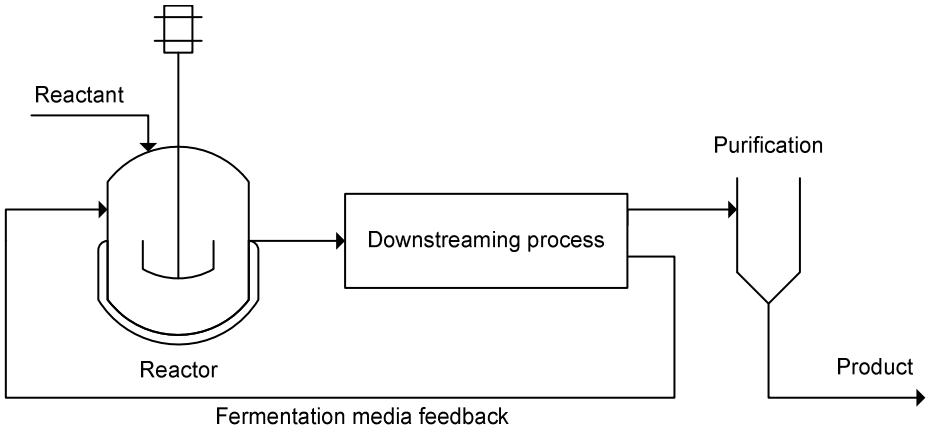
challenges for biomass as feedstock

- new processes, new chemistry
- higher oxygen content
  - lower vapor pressure
  - higher viscosity
  - solids content
- new thermodynamics
- biotechnological steps
  - separate hydrophilic components from water
  - microbes act as solids

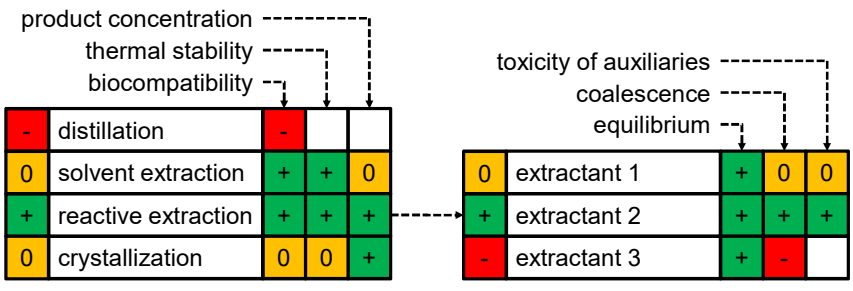
characterizing options



general process flow sheet



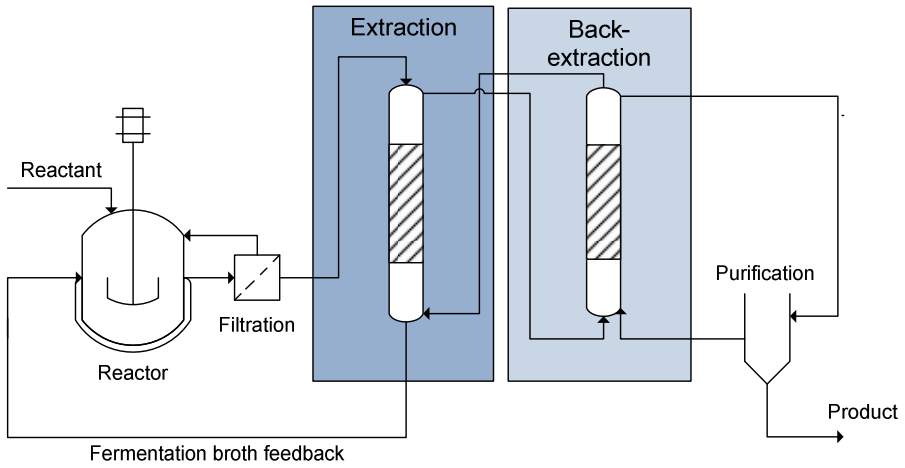
cascading the tree



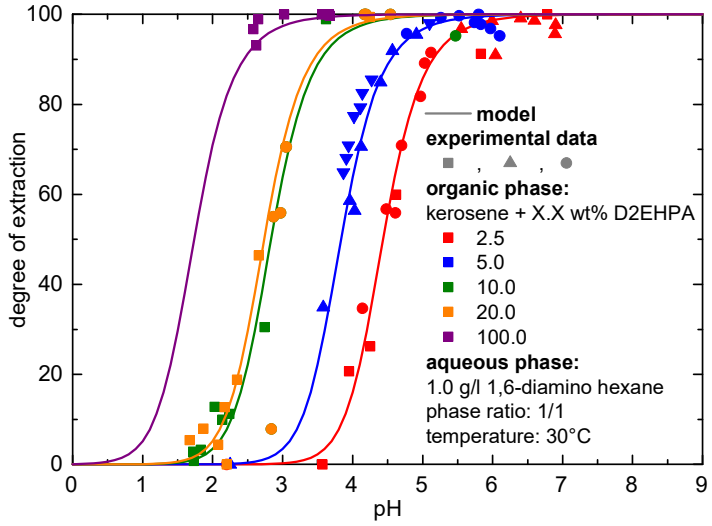
evaluation of criteria

- expert knowledge
- literature information
- modelling, simulation
- experiment
- ... you name it

process flow sheet



basics of reactive extraction



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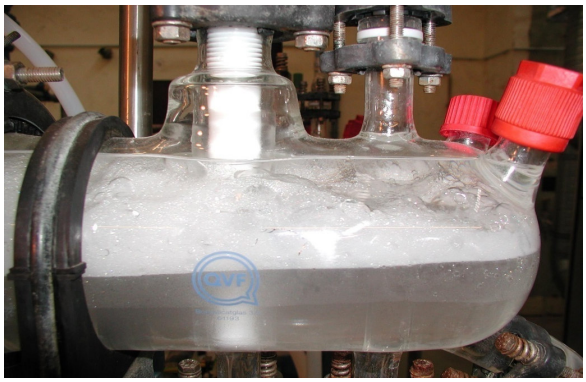
crud basics



Crud:
Chalk River Undefined Deposit
corrosion residual unidentified deposit

S. Ruckes, A. Pfennig, 2010: Untersuchungen zum Einfluss von Mulm auf das Abscheideverhalten organisch-wässriger Stoffsysteme. AiF-Abschlussbericht zu Projekt 14997 N

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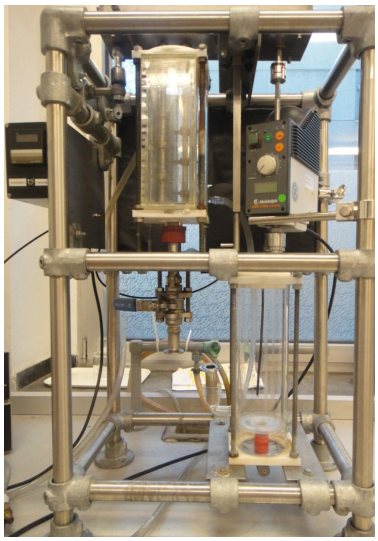
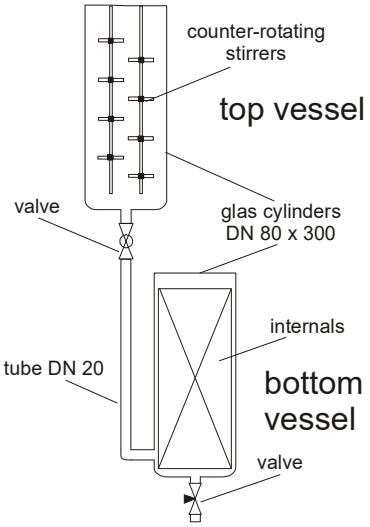
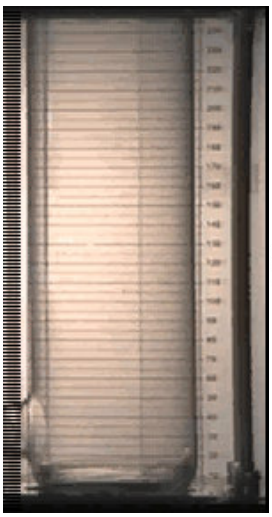
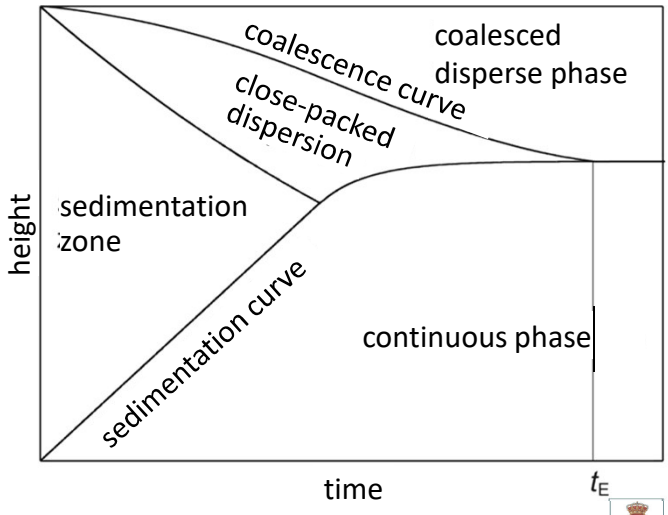
standardized lab experiment for settling



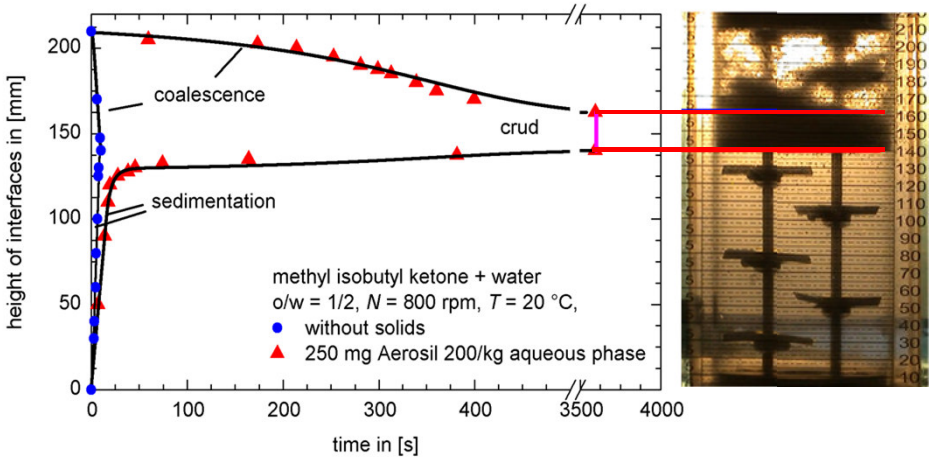


principles of settling





influence of solids in settling experiment



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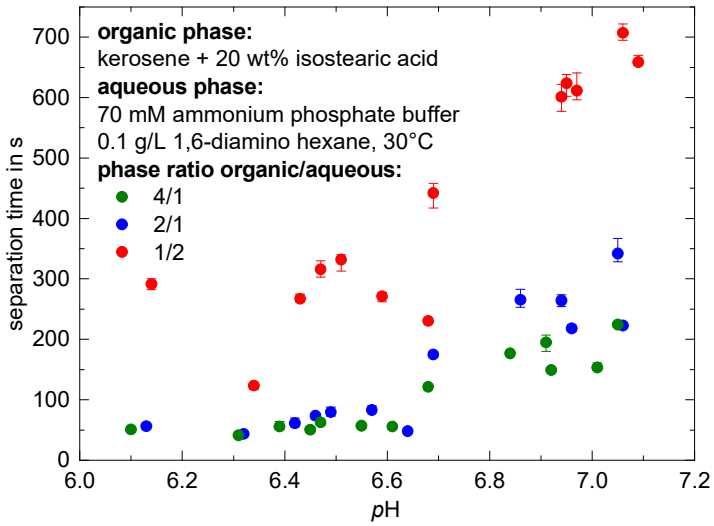
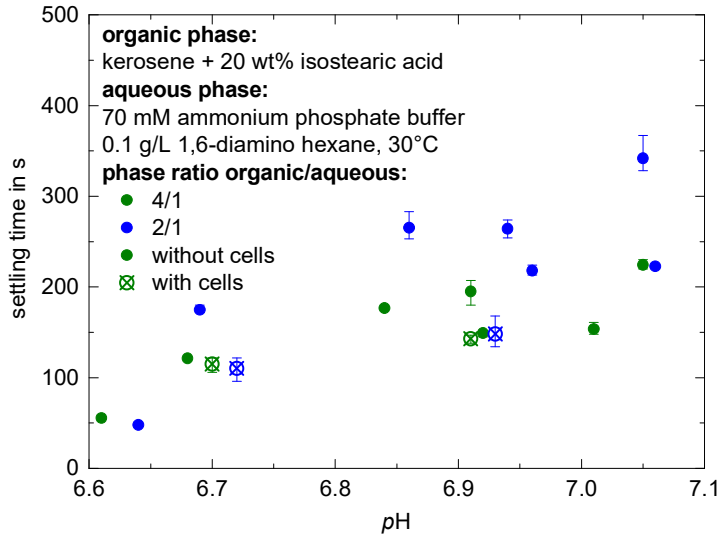
phase separation



phase separation with cells



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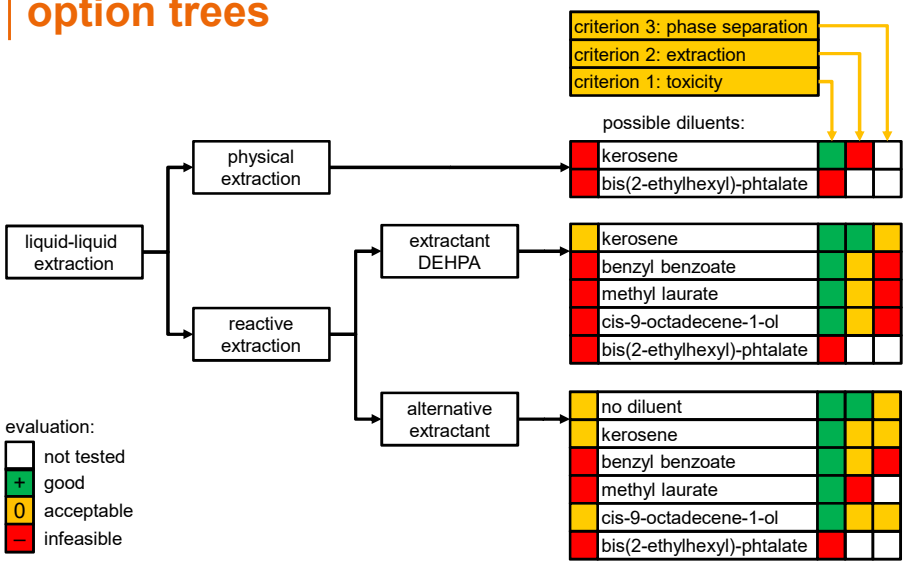
option trees



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optimization criteria

- bio-compatible *p*H
- extractant concentration
  - capacity
  - *p*H-shift between extraction and reextraction
  - phase separation

examples for different levels

- overall process options
- principal downstream options
- unit operations
- solvent selection
- direction of dispersion
- operating conditions like *p*H, phase ratio, etc.
- type of equipment
- ...
- also: modelling approaches, model contributions

cascaded option trees

- clear book-keeping of options
  - cascading through levels
  - allows very different character of evaluations
  - documentation
- clear view of status also for communication
- clear view of second-best alternatives
- creates prototypes of procedures
- intuitive to use

A. Bednarz, B. Rüngeler, A. Pfennig:
Use of Cascaded Option Trees in Chemical-Engineering Process Development
Chem. Ing. Tech. 2014, 86(5), 611–620

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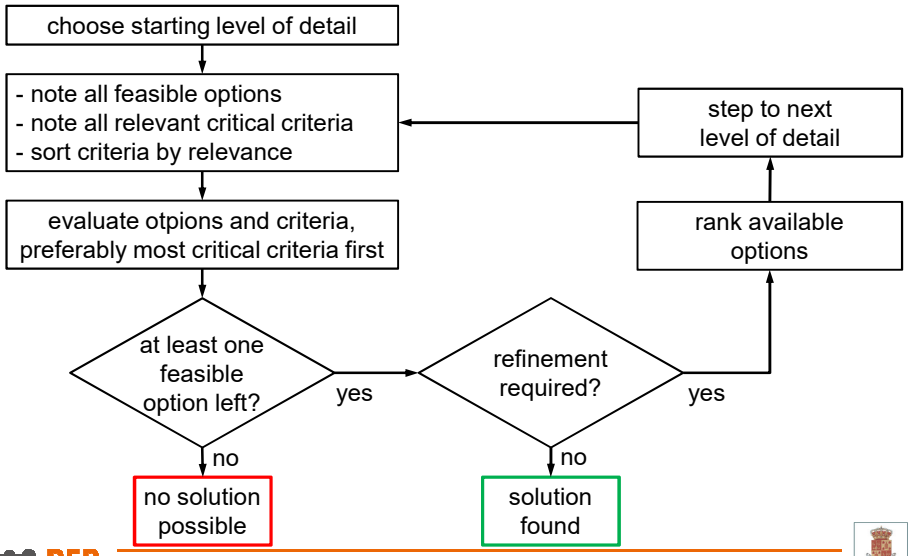
option tree method



some criteria for bio-downstream design

- extractant selection
  - biocompatible physical-extraction system?
  - partition coefficient in physical extraction
  - biocompatible reactive extraction system. reactive extractant, diluent/solvent, modifyer
  - equilibrium without cells
  - equilibrium with cells
  - extraction kinetics
  - ease of phase separation (column or mixer-settler or none)
  - phase separation with cells
  - ease of re-extraction (T or pH shift?)
  - fate of reactants, minor components, impurities
  - ...crud, choice of nutrient system, buffer system,...
- equipment design