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BPTI

SABATLE - Safety Assessment of Flow Battery electrolytes (2021-2022)

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Safera – Meeting

Rome, 19.05.2022

TU Graz

www.tugraz.at

Consortium and Funding

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Graz University of Technology

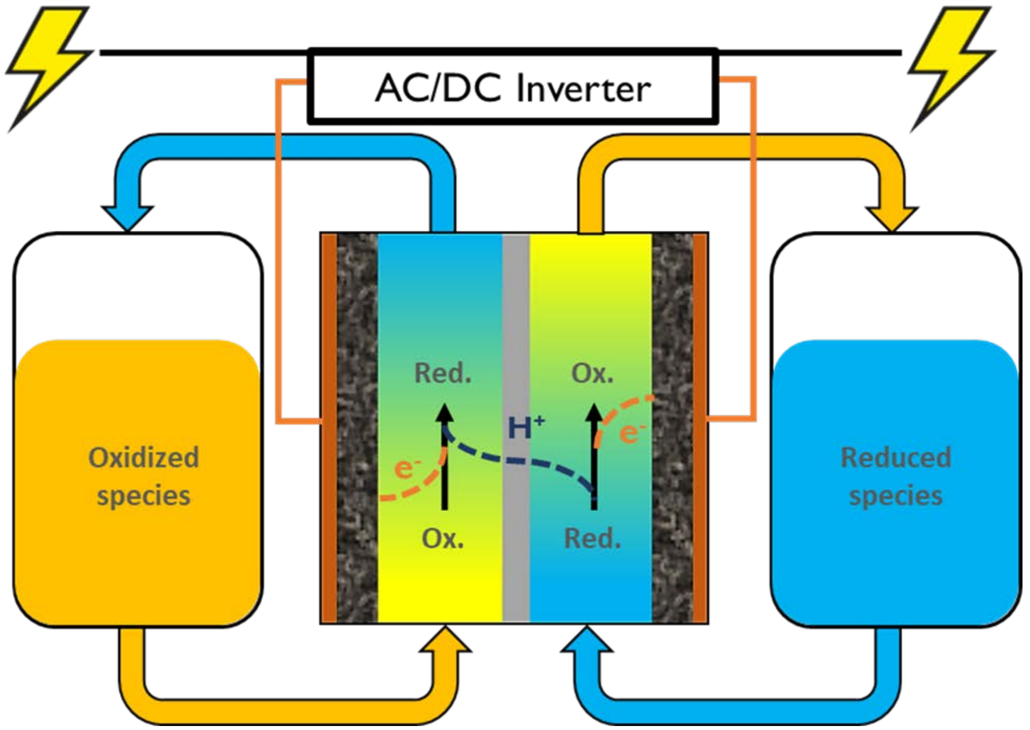
University of Graz

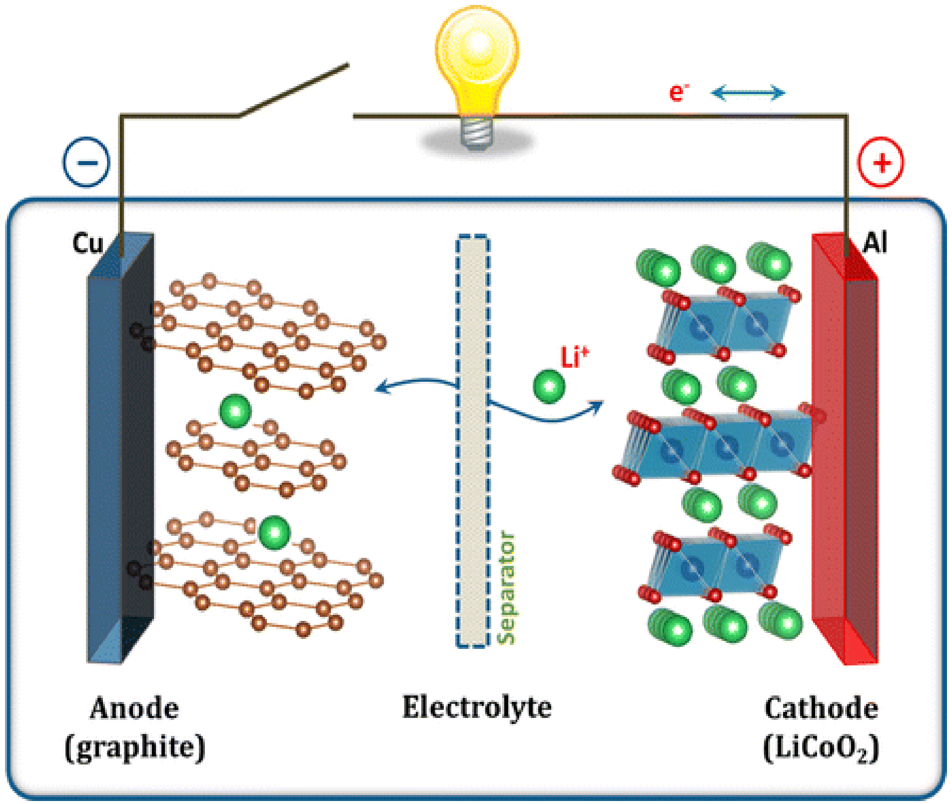
BioNanoNet

Mondi AG

BioBide

Flow Battery vs Li-Ion Battery

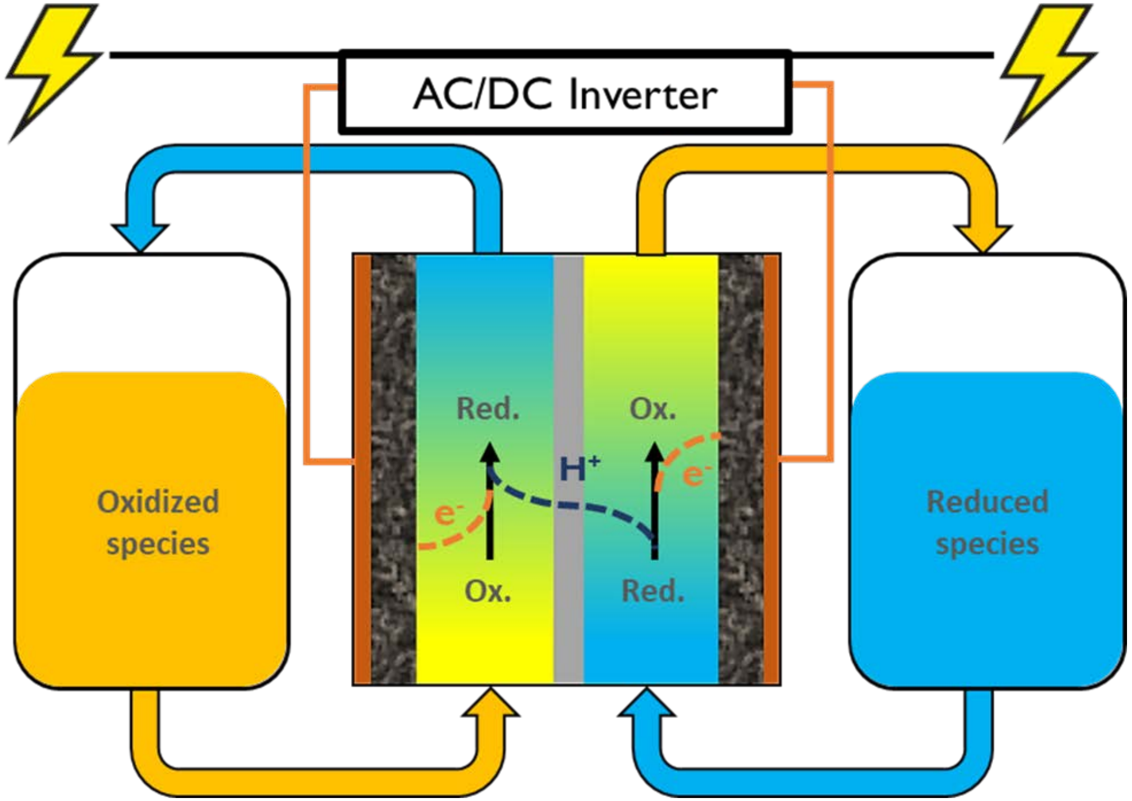




Low energy density, solutions

High energy density, solid electrodes

Assets of Flow Batteries



Advantages:

- Independent design of power & storage capacity
- Easy scalability to MW regime
- No self discharge
- No capacity fading during cycling
- Long lifetime (20 years+)
- Long discharge times (4-8 h)

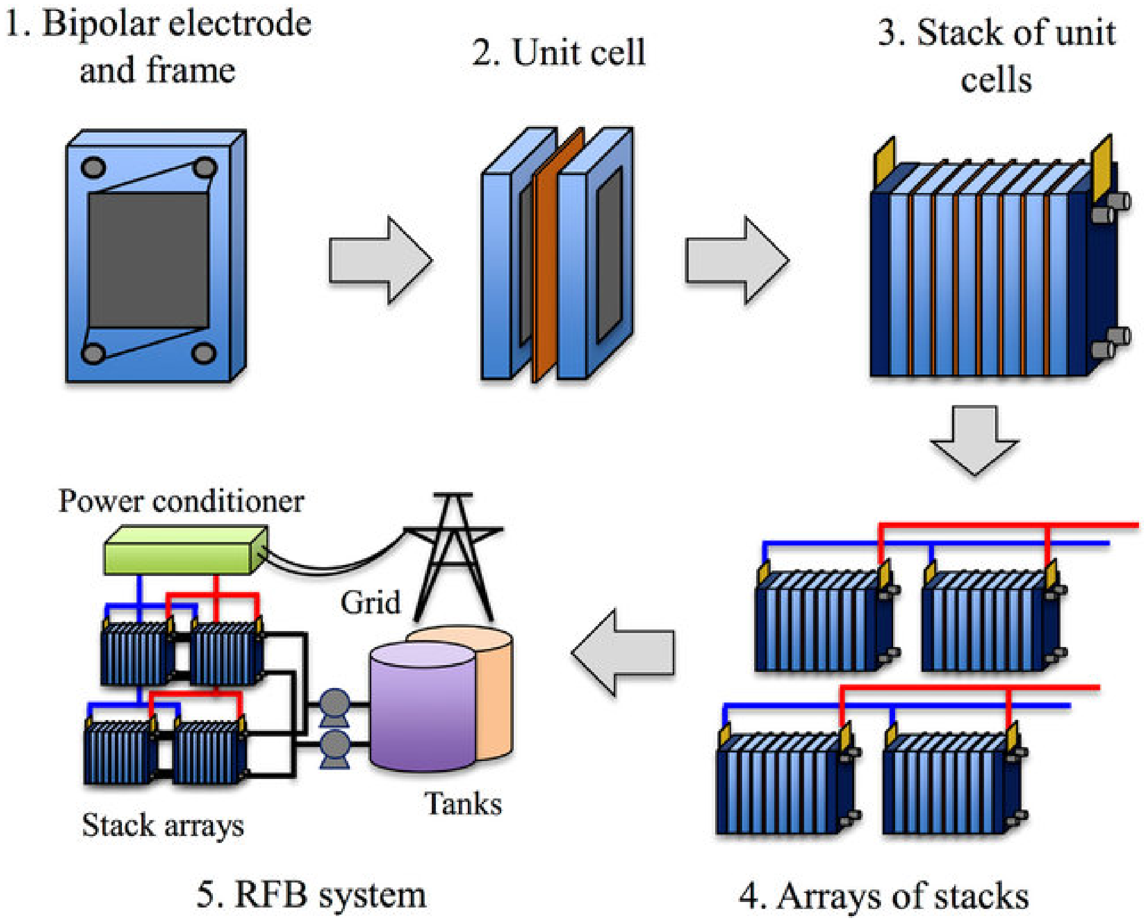
Current technology:

Vanadium flow battery (80%)

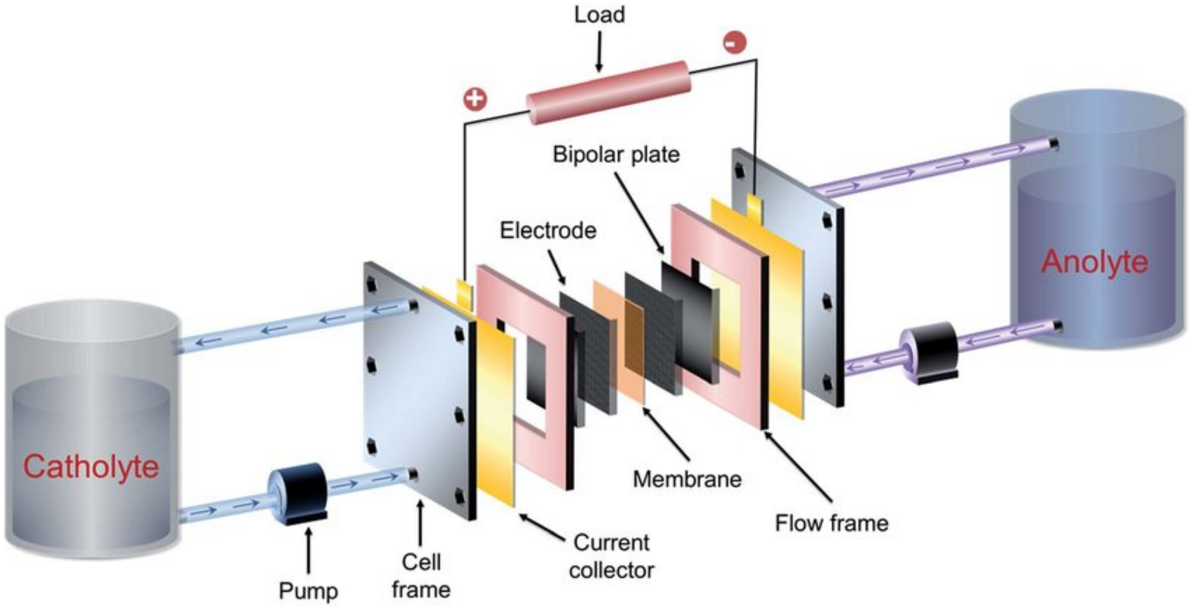
Sizes of Flow Battery Systems

Dalian site China, 200 MW/800 MWh

100-150 kW/400-500 kWh



Our Sustainable Vision



J. Mater. Chem. A, 2015,**3**, 16913-16933

Renewable materials for active elements in flow batteries

Sustainable electrolytes (Raw Materials, Processes, End-of-Life)

Renewable membranes materials

Carbon felts produced from side streams

Frames produced from renewable or recycled feedstock

The patented Lignin/Vanillin based Battery

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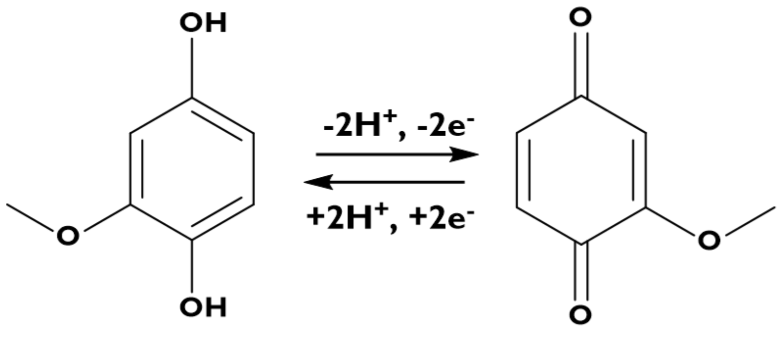
Lignin

Vanillin



2-methoxy-hydroquinone

2-methoxy-quinone

Eur. Pat. Appl. (2021), EP 3828975 A1,
PCT Int. Appl. (2021), WO 2021105322 A1

- Tailor-made continuous flow reactors
- Regionally available and renewable (average pulp mill: 100000 t lignin /year)
- Compatible with existing battery technology
- Different types of synergies of SABATLE with other national projects
- Startup was founded in 2022 to commercialize technology (ECOLYTE)

LIGNOFRACSTORE IONFLOW

Ecolyte

Goals of the project

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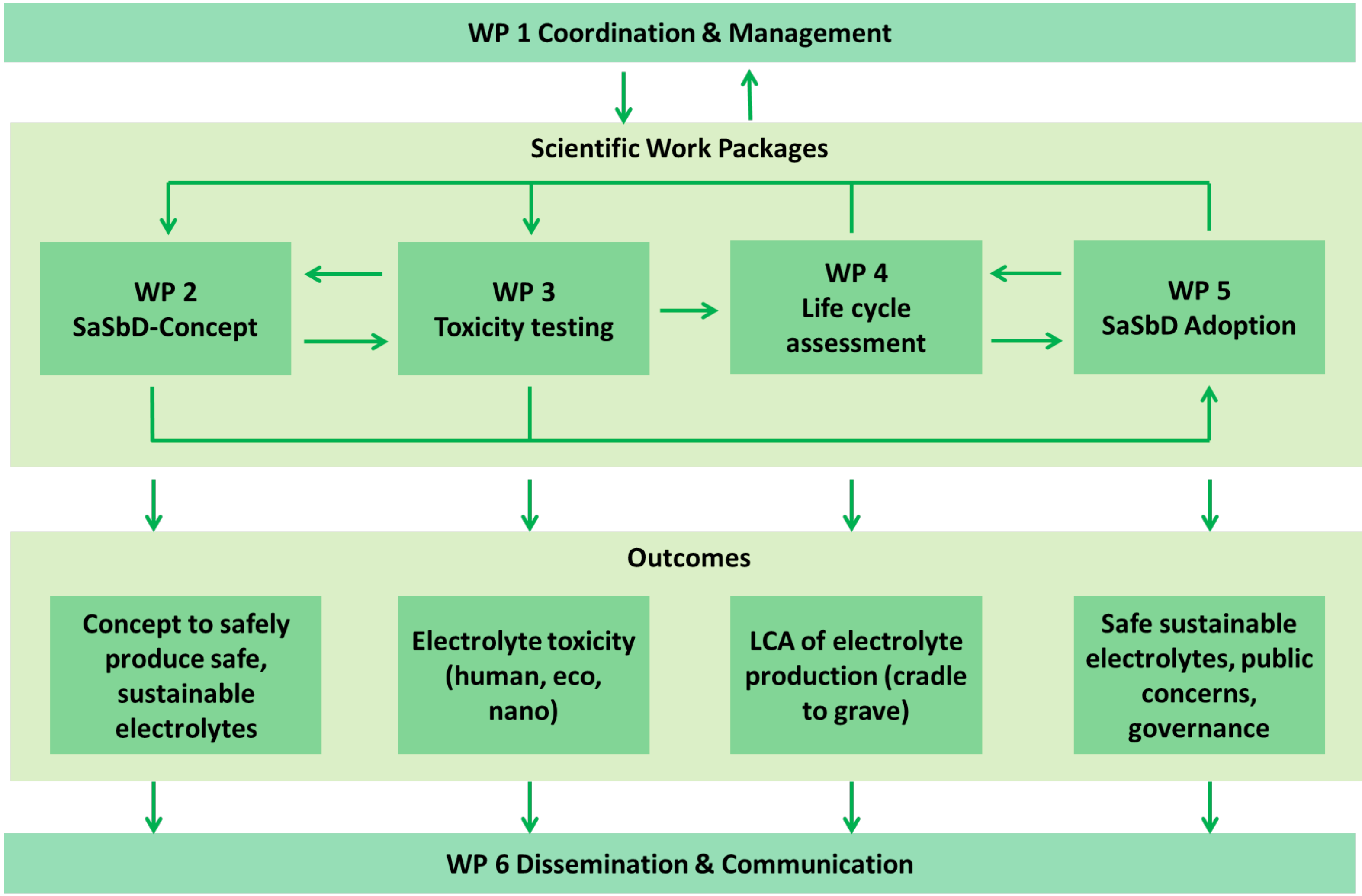
| How safe (or dangerous) are current redox flow battery electrolytes?

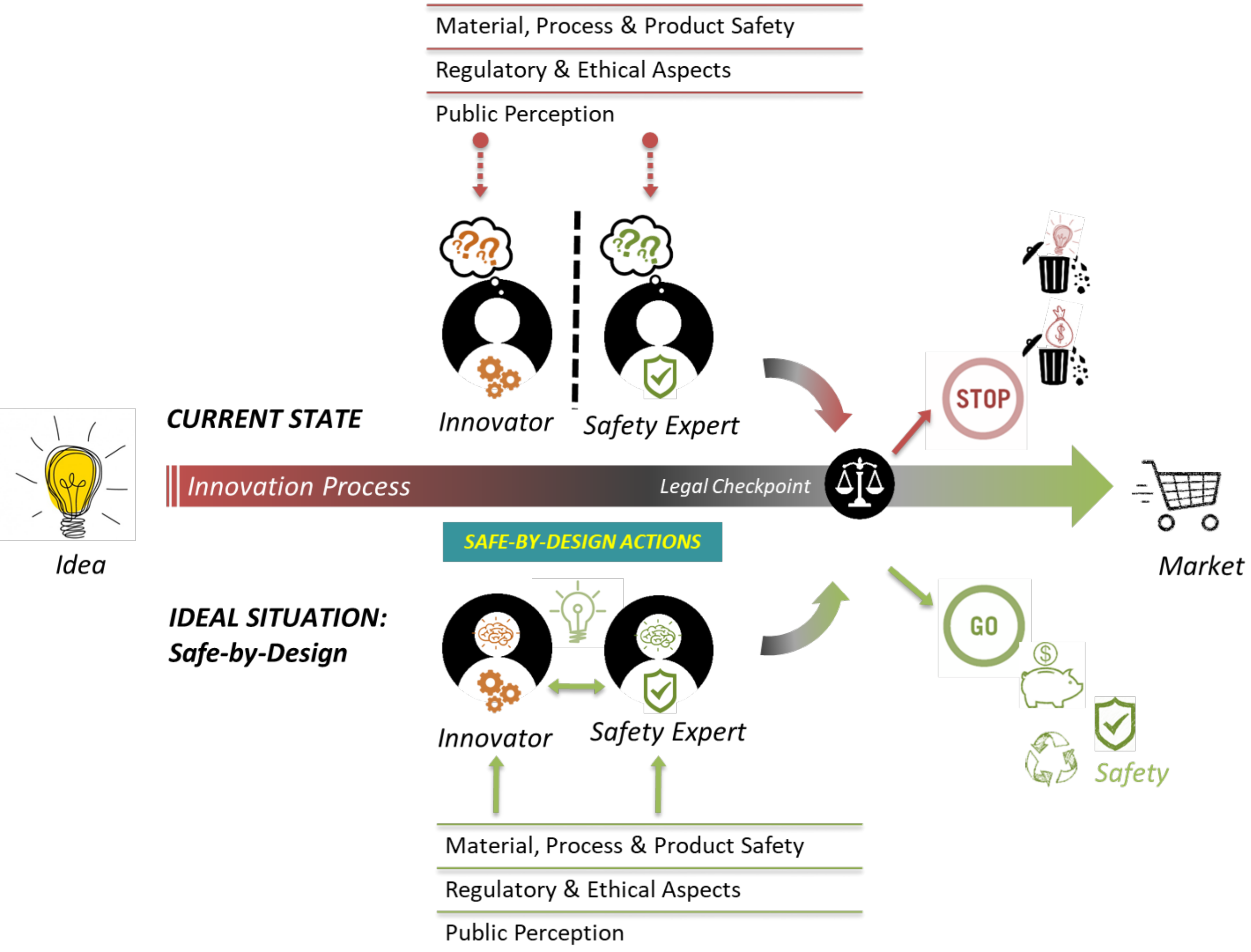
| How safe are emerging organic flow battery electrolytes from lignin?

| Implementation of safe-and-sustainable-by design principles to mitigate environemntal and toxicity impacts

Work Packages and Interrelation



Rational Design of Systems: Safe-by-Design



| Technological innovations present a challenge to health & environmental risk assessment

| Rapid innovation causes a gap between technology and suitable risk assessment tools / frameworks

| Reduce uncertainties and minimize risks to humans & the environment, starting at an early phase of the innovation process and covering the whole innovation value chain

→ **'Safe and sustainable-by-Design' concept**

Rational Design of Systems: Safe-by-Design

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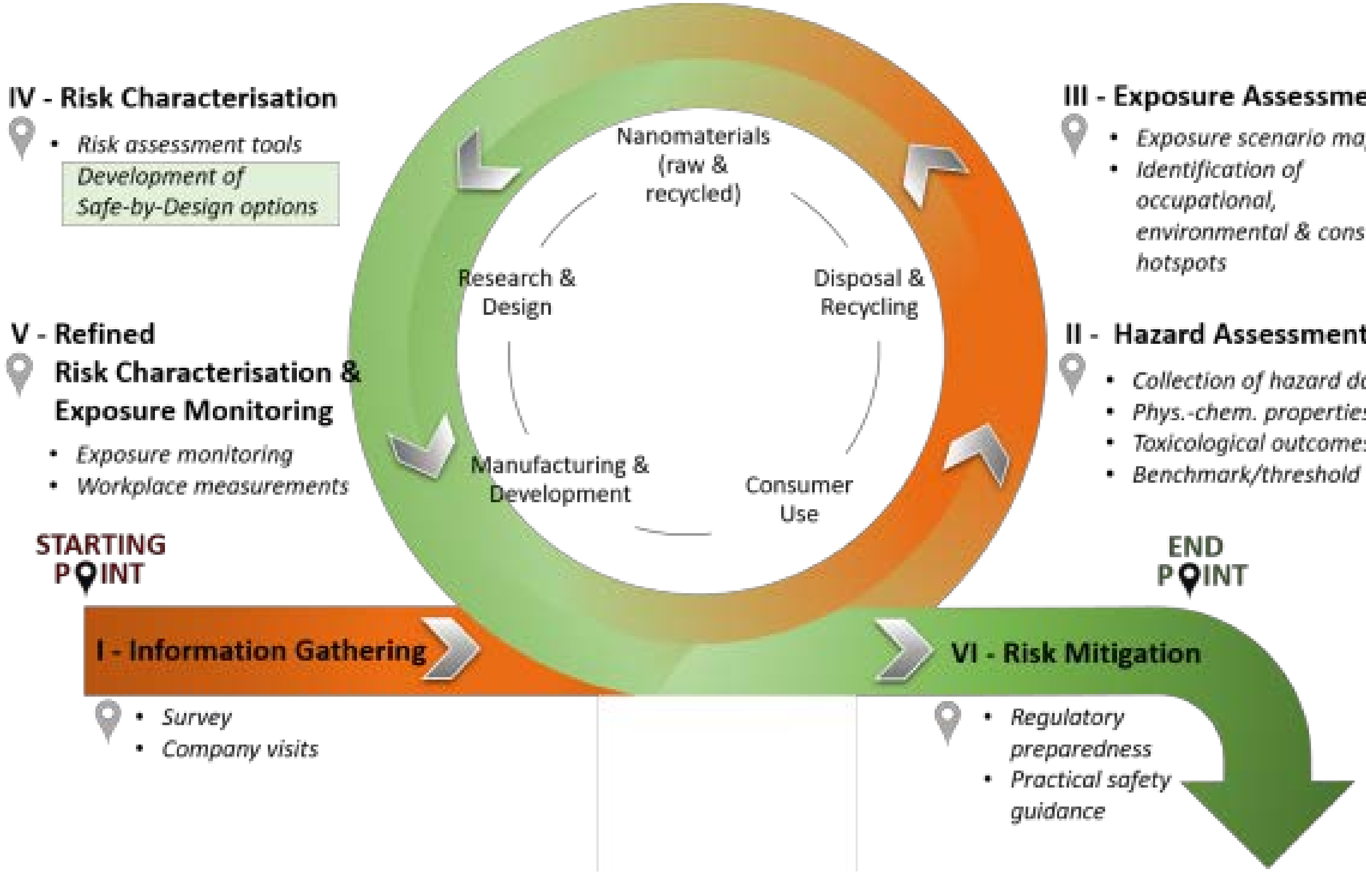

- Information gathering & hazard assessment
- Exposure assessment
- Risk characterisation
- Risk mitigation

SaSbD - Workflow mapping

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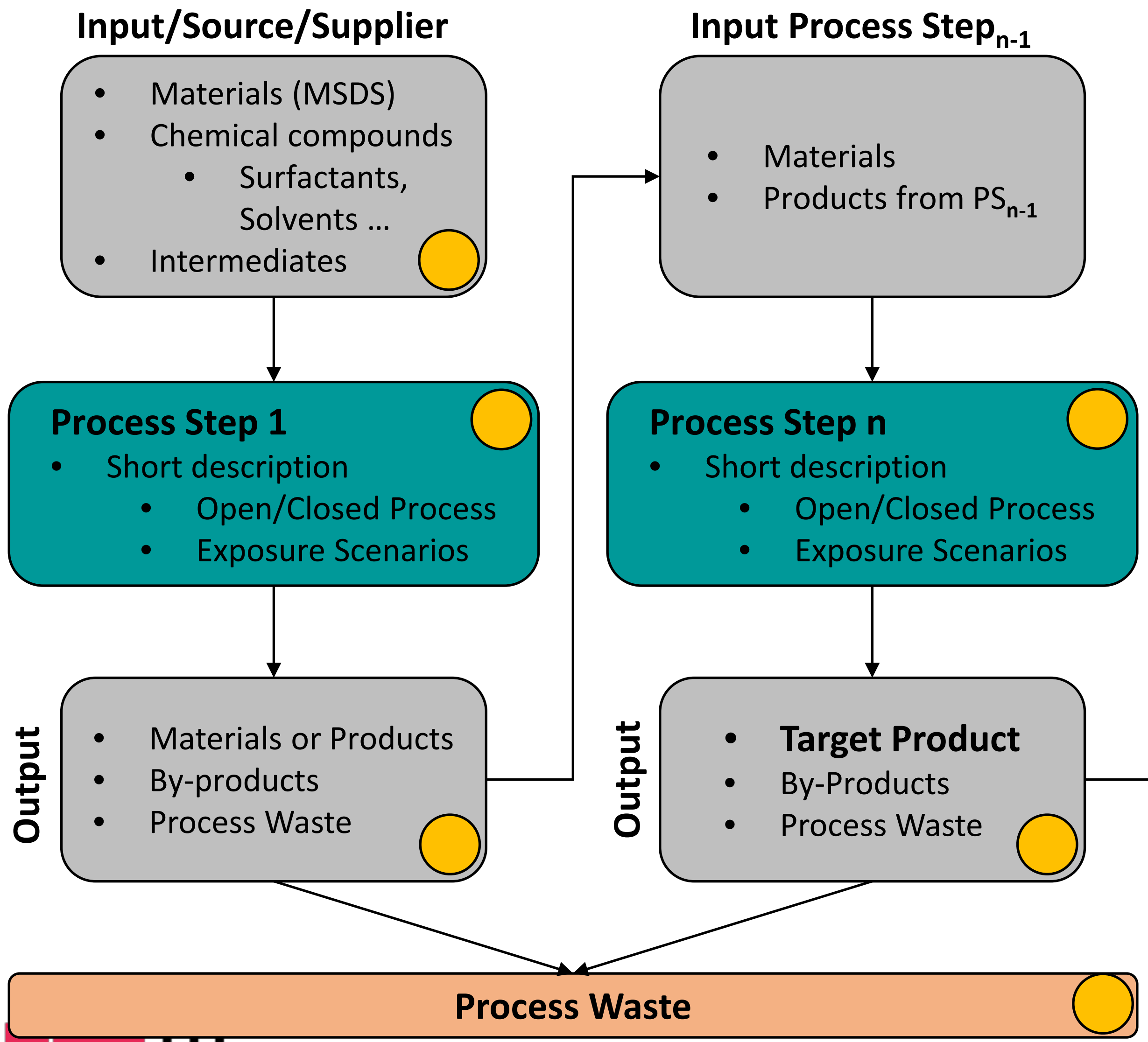
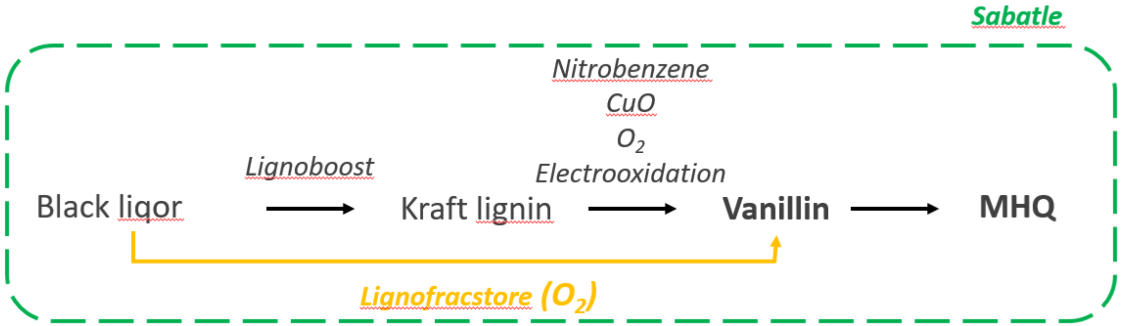




Two improvements provided (solvent, ring structure)

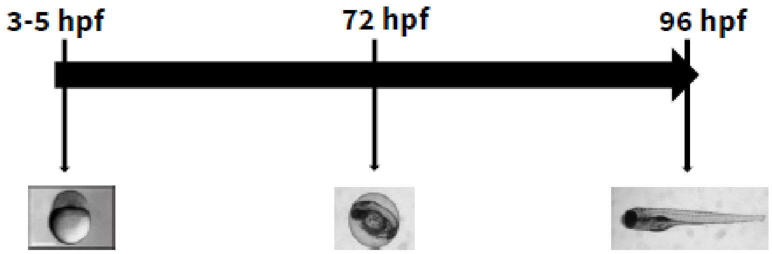
Target product MHQ

● Possible SaSbD actions

Toxicity Testing

Teratotox

1. Dose range finding (5 concentrations)
2. Developmental toxicity (8 concentrations)



Treatment
P24; 5 emb/well

Visual Analysis
(morphology, lethality)

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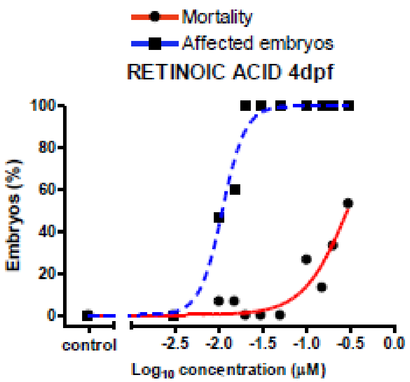


EC50 and LC50 are calculated and a Teratogenic Index (TI) established (ratio between LC50 and EC50)

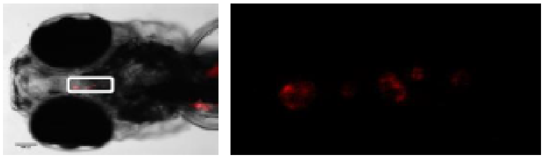
- Likely teratogenic: T(2) ≥ 2
- Toxic but not teratogenic: TI(2) < 2
- Not toxic in zebrafish embryos

Thyroid disruption assay

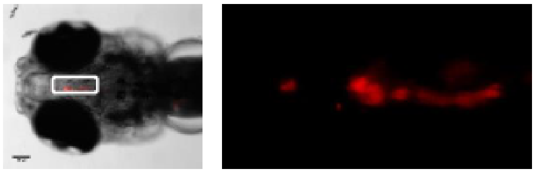
1. Dose range finding (8 concentrations) LC_{50}, EC_{50}, and EC_{10} parameters are calculated to characterize the systemic toxicity profile of the test substance.
2. Fluorescence assay (5 concentrations) The maximal concentration assessed is EC_{10} to avoid interference of systemic toxicity.

Treatment
P24; 5 emb/well

Fluorescent microscopy analysis
(fluorescent variations)



Control tg(tg:mcherry) embryo at 5 dpf



Tg(tg:mcherry) embryo exposed to 25 mg/L $KClO_4$

Human toxicity of MHQ and MQ (zebrafish)

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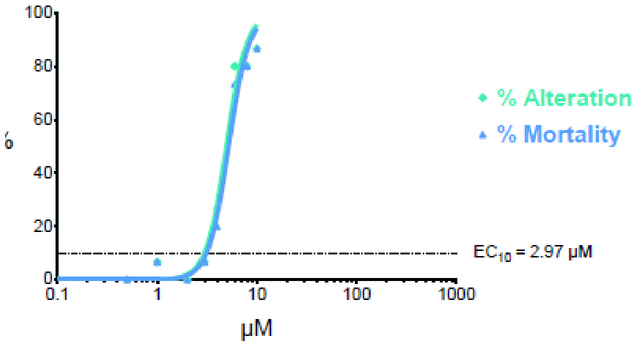
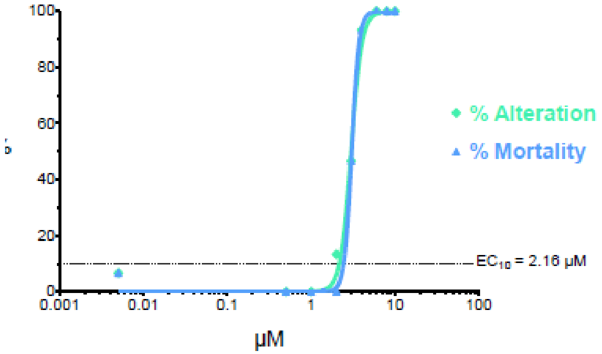
- DRF results

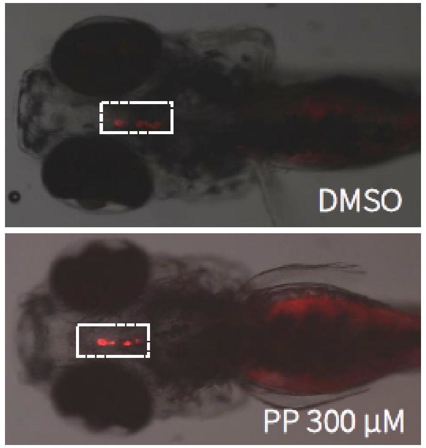
PE-3474 (MHQ)

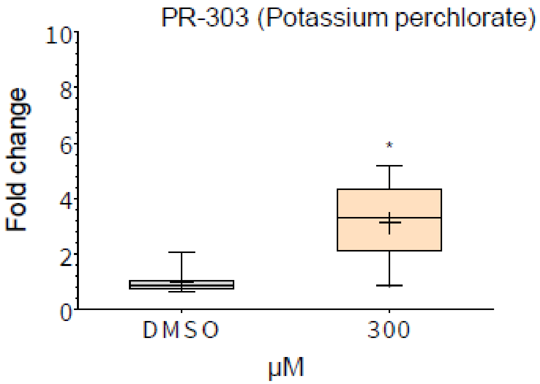


PE-3475 (MQ)

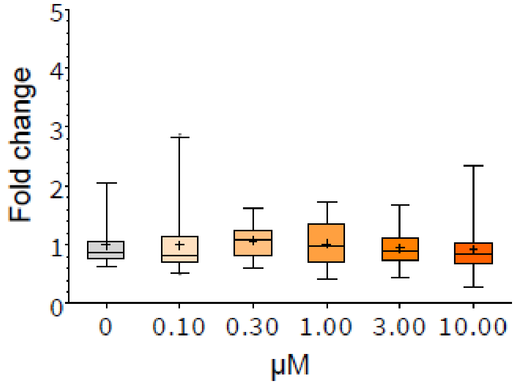


- Fluorescence assay





PE-3474 (MHQ)



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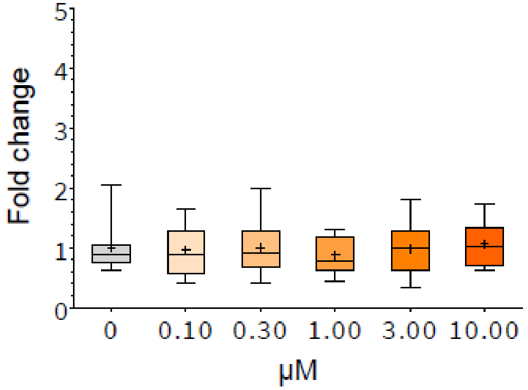
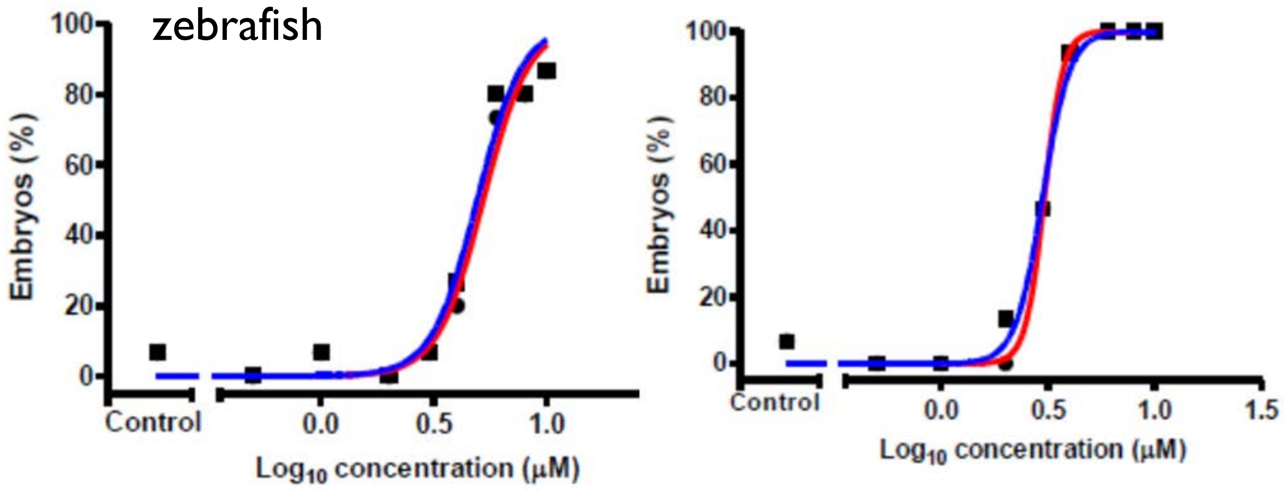
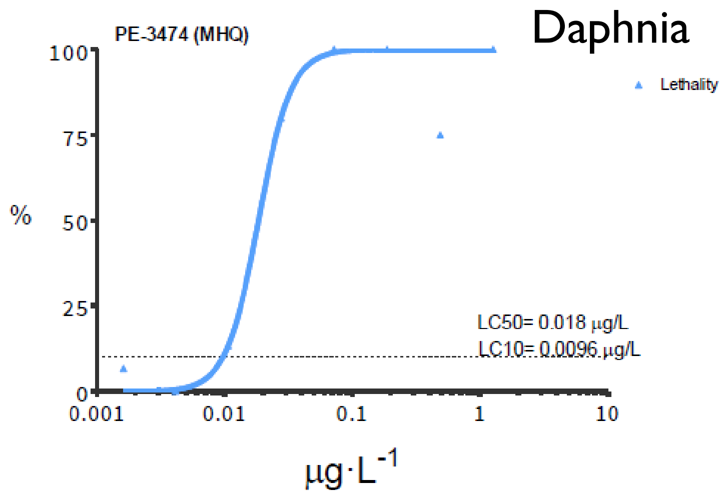


No endocrine disruptors, even at high concentrations

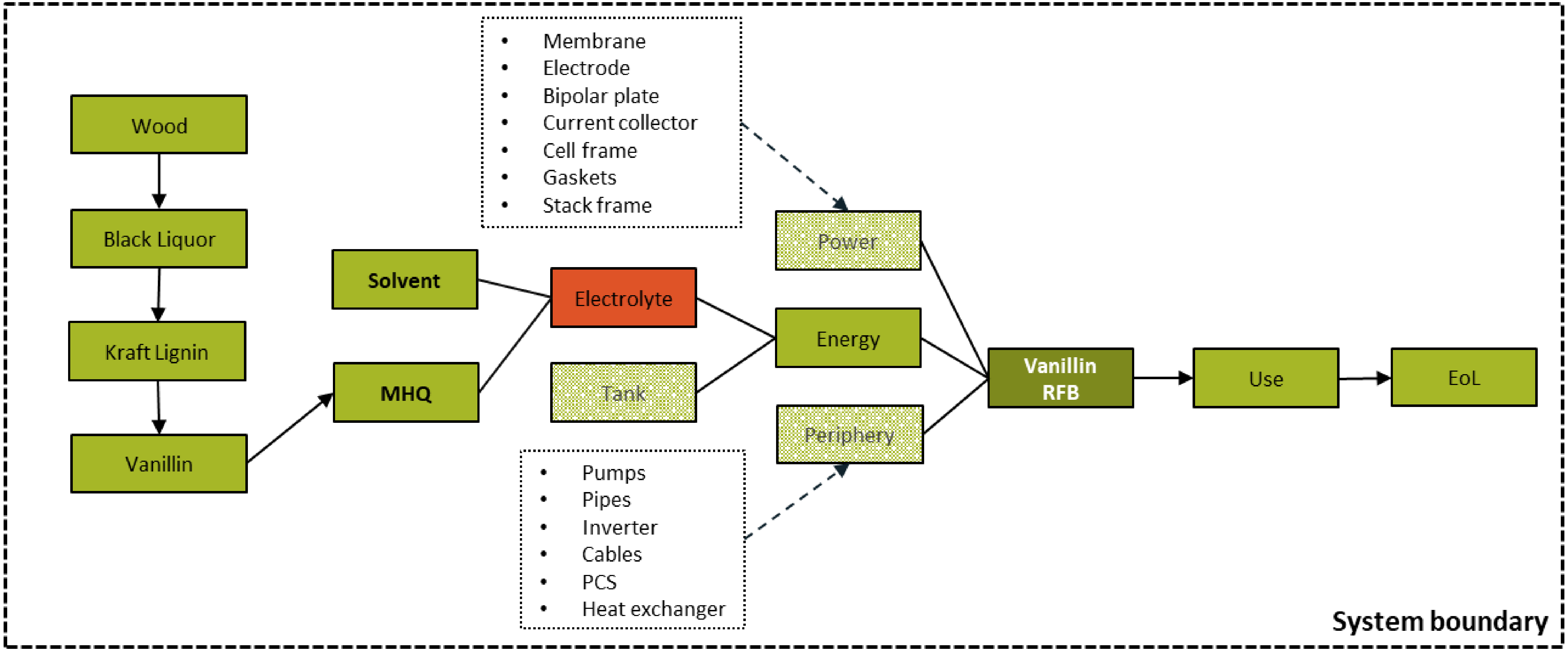
Human and ecotoxicity of MHQ and MQ





- Not teratogenic
- Still toxic but less toxic than vanadium (factor of ca. 30)
- No endocrine disruptors, even at high concentration
- Ecotoxicity similar as for vanadium compounds (EC_{50}: 1.1-2.0 mg/ml), Daphnia seems to be very sensitive towards MHQ and MQ (EC_{50}: 0.02 µg/L)

Life cycle analysis – System Boundary



1 MW power, 20 years lifetime of battery, vanadium vs MHQ, ongoing work

Life cycle analysis – preliminary results

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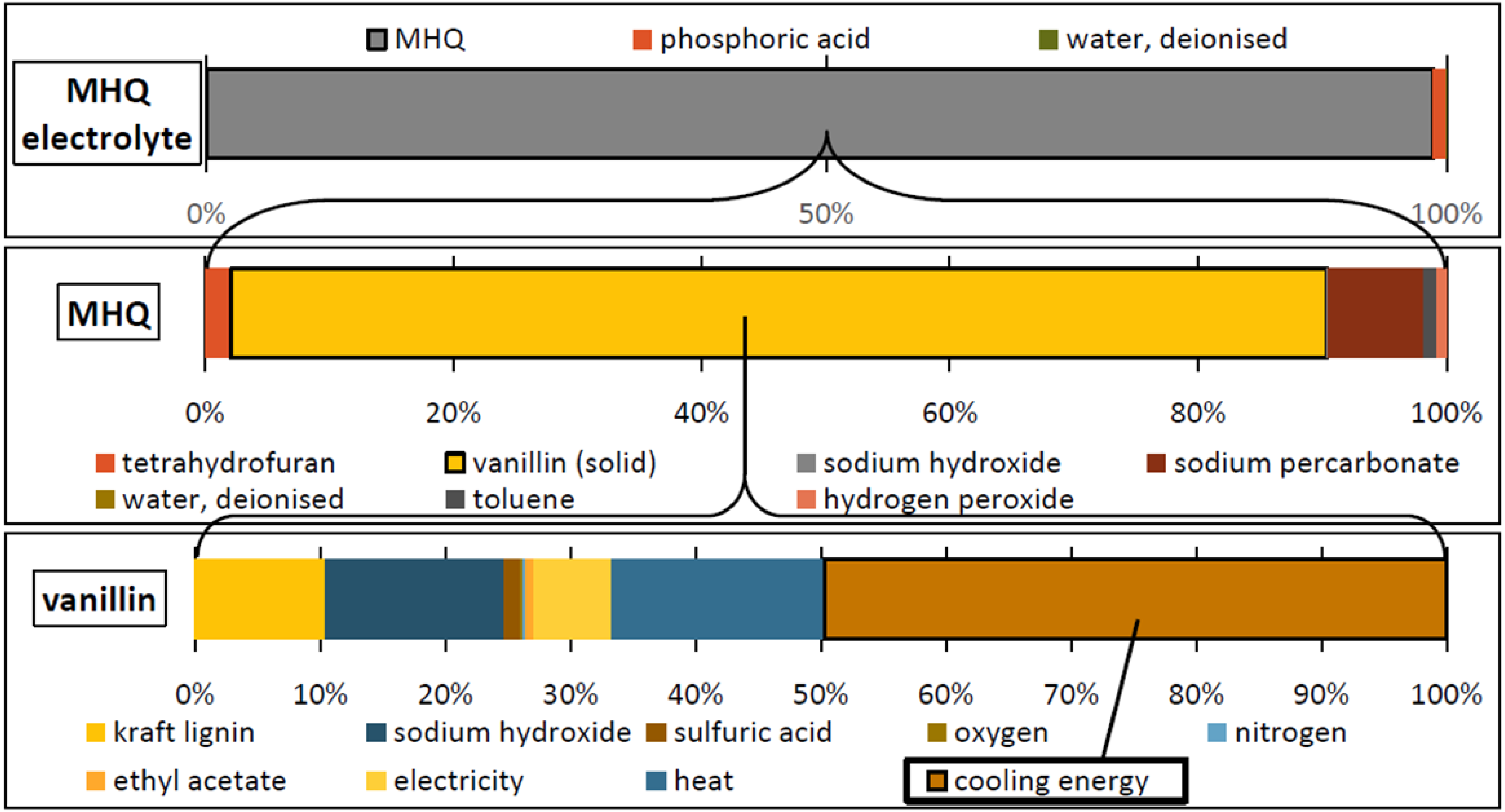
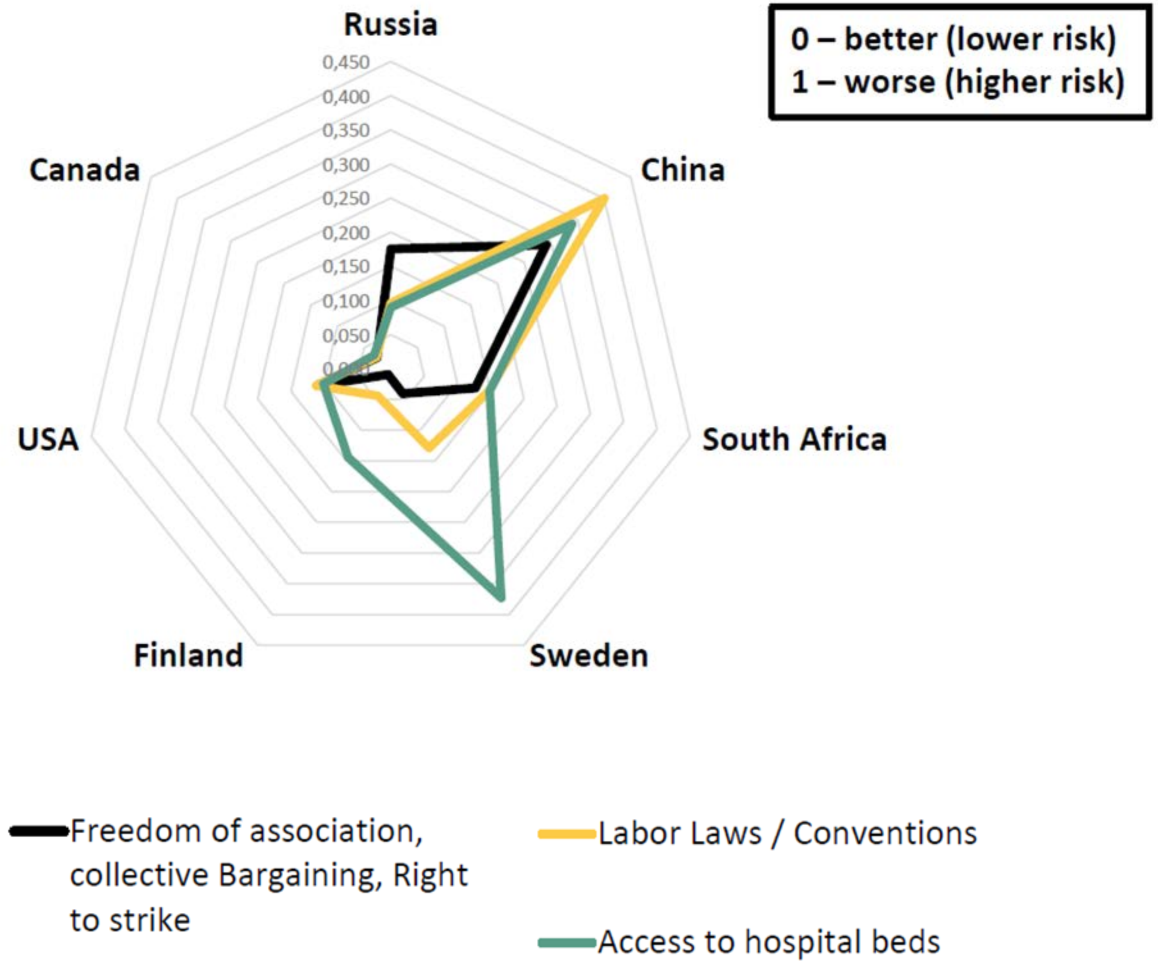
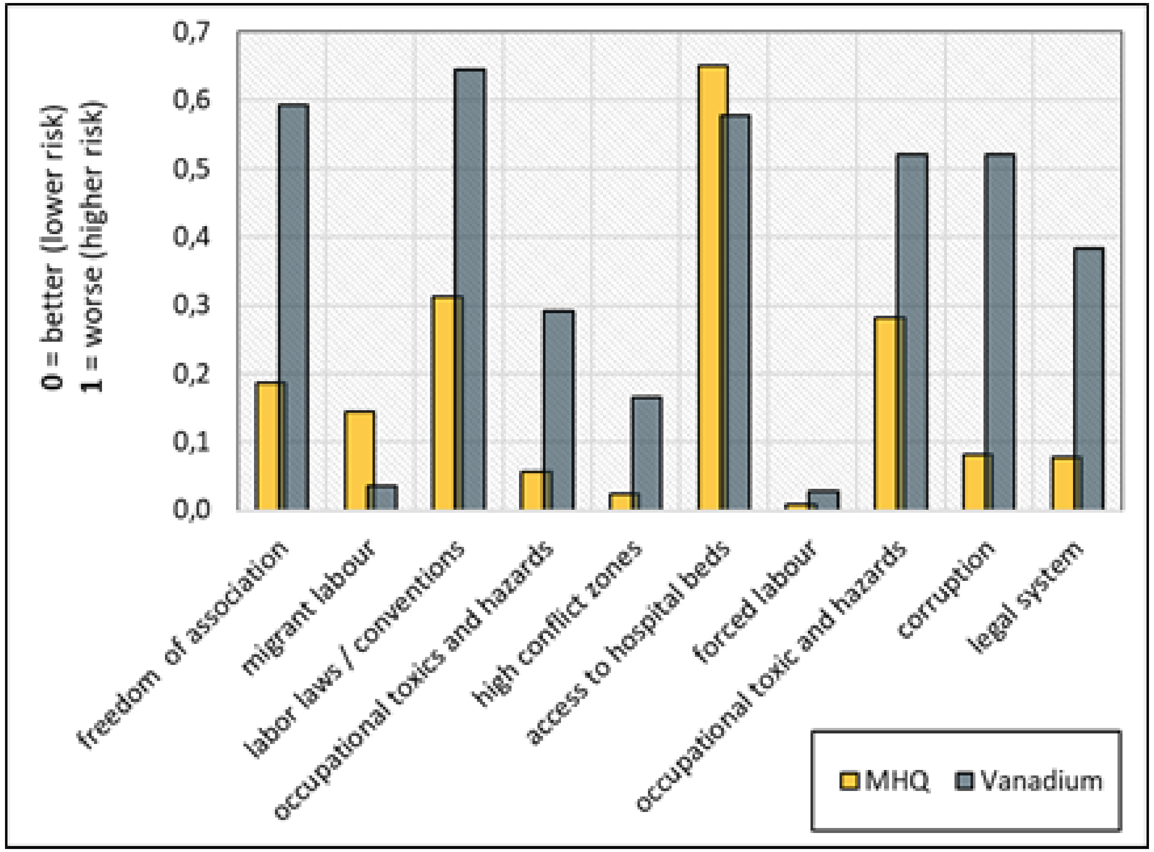


GWP hotspots of the MHQ electrolyte

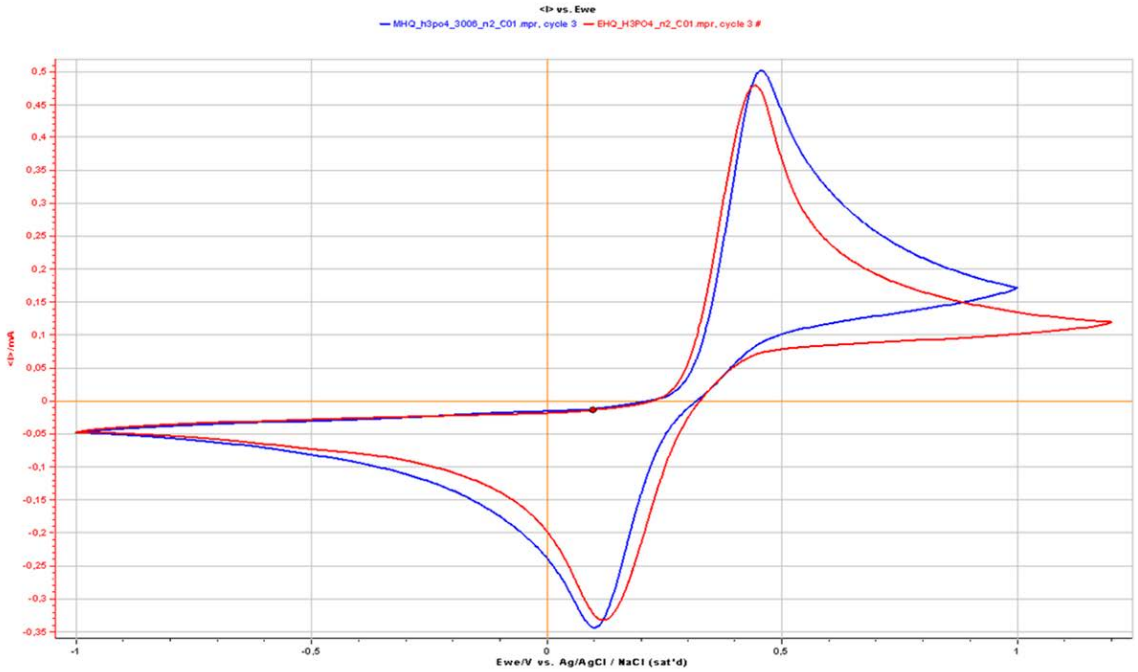
Relative contribution of unit processes to the respective reference flows.

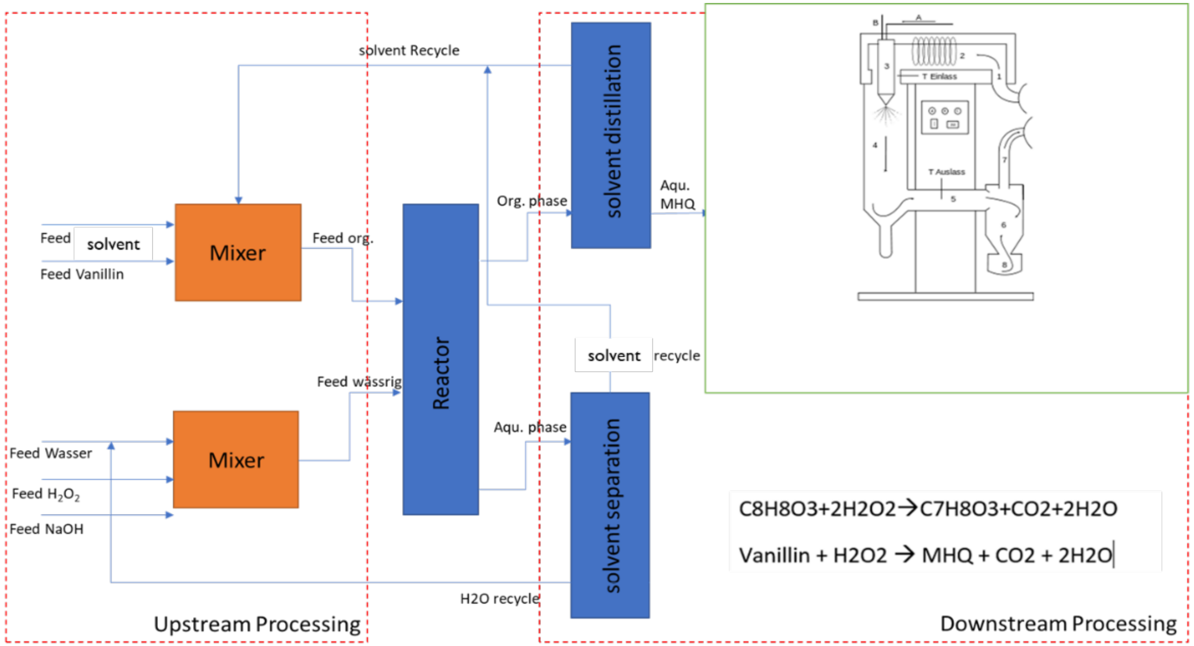
Life cycle analysis – social aspects (in progress)





Outlook and Current Activities





- Implementation of safe-and-sustainable-by-design suggestions in process
- Toxicity testing of modified compounds
- LCA finishing
- Preparation of manuscripts
- Continuation of interaction with stakeholders on national and international level

THANK YOU

Contact me if you have questions!

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