

Autumn School
Galician Network of Ionic Liquids (REGALIs)
Santiago de Compostela, 7-8 November 2018



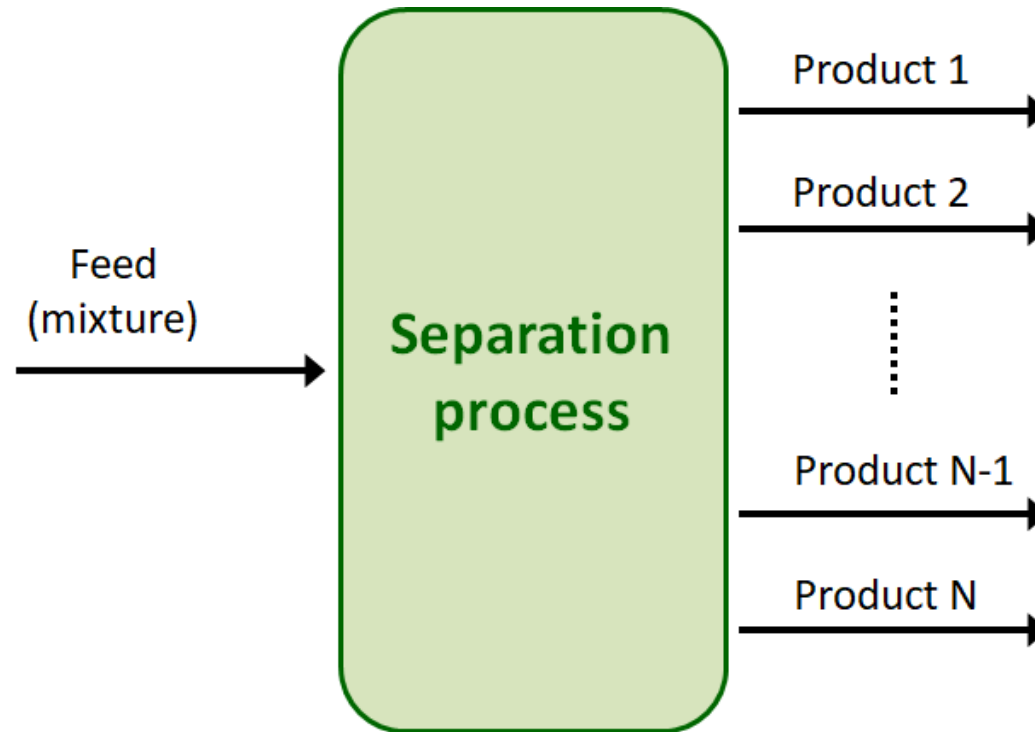
Ionic liquids in separation processes of industrial interest

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Research Group on Sustainable Separation Processes

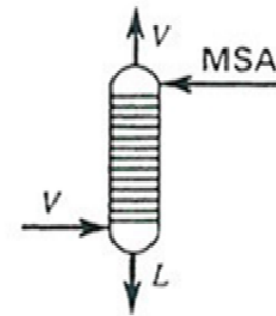
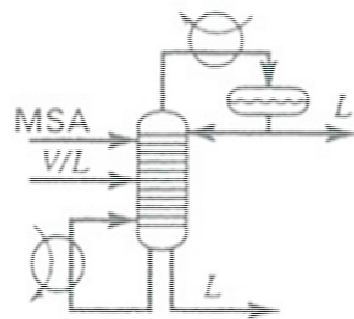
Department of Chemical Engineering, Universidade de Santiago de Compostela

Separating...

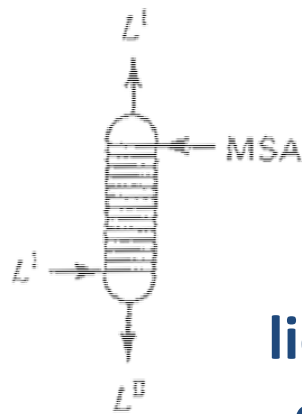


Separation processes involving liquid mass separation agents

extractive distillation

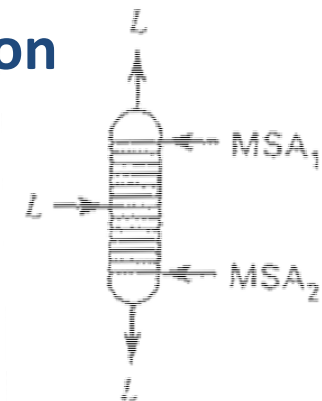


absorption

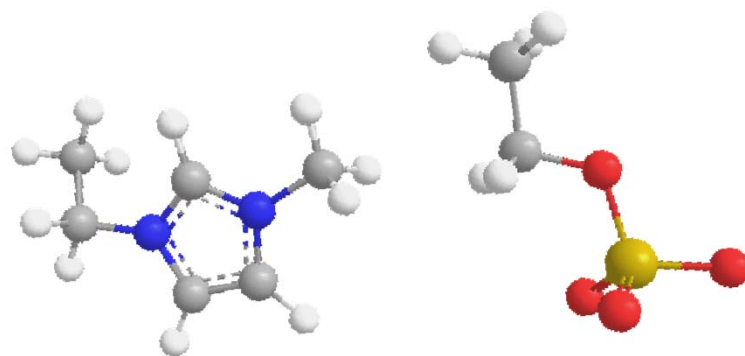


liquid-liquid extraction

**liquid-liquid extraction
(two solvents)**



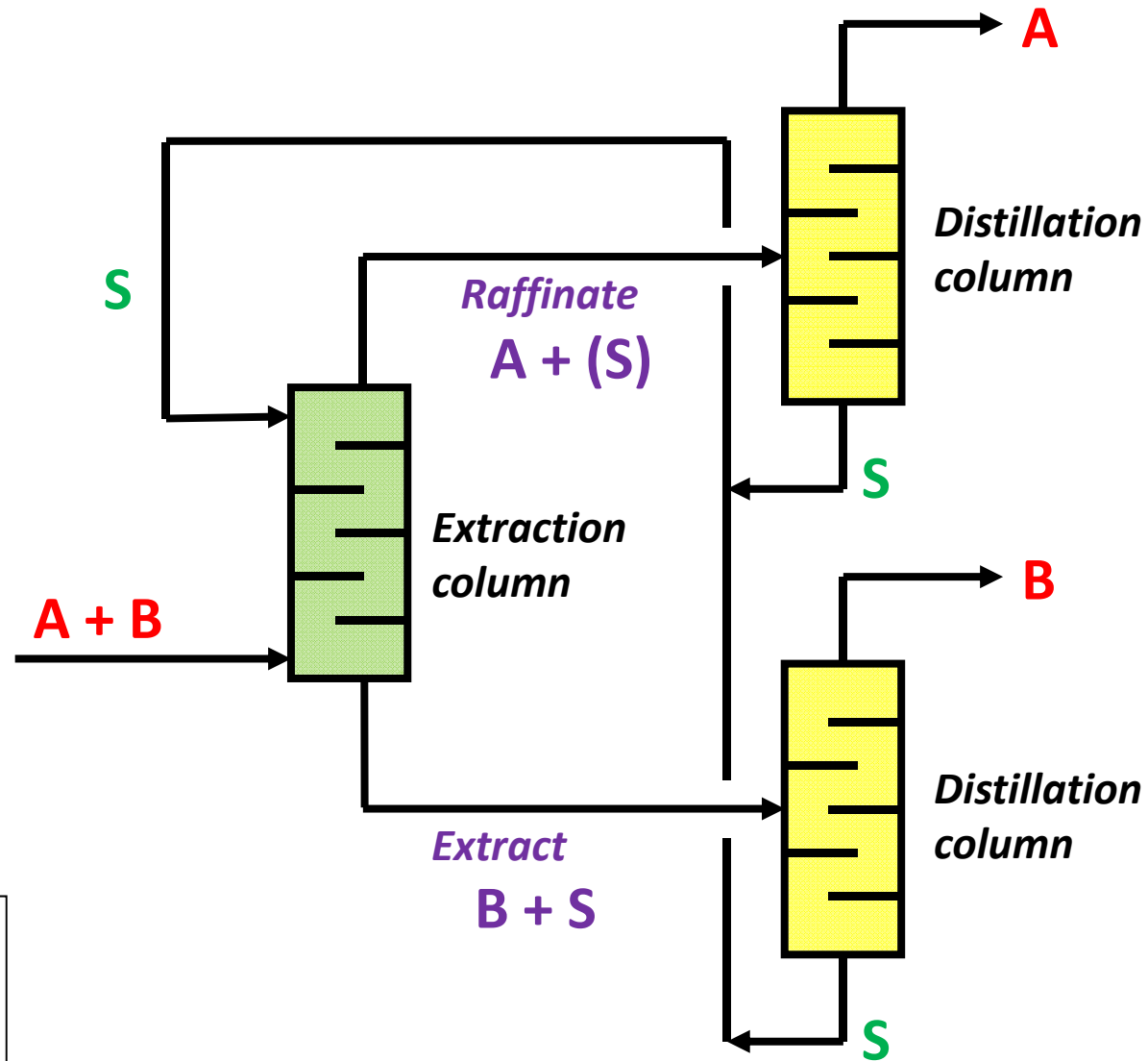
Ionic liquids as mass separating agents



➤ A set of very interesting properties for their use as MSAs in separation processes:

- Practically negligible vapour pressure
- In general, good thermal and chemical stability
- Great solvation ability
- Tunability of properties by judicious choice of the constituent ions

Liquid-liquid extraction unit: scheme



A: inert/carrier
B: solute
S: solvent

The solvent for liquid-liquid extraction

Ideal solvent:

- High solute distribution ratio
- High selectivity
- Large difference in volatility with the solute
- Low vapour pressure
- Chemically stable
- Non-flammable
- Large difference in density relative to inert
- Low viscosity
- Moderate interfacial tension
- Freezing point sufficiently low
- Non-corrosive, non-toxic
- Cheap

Ionic liquids

?

- Extremely low volatility
- In general, chemically and thermally stable, as well as non-flammable
- Tunability:
 - ✓ Physical properties
 - ✓ Cost
 - ✓ Toxicity
 - ✓ Corrosive character

Solute distribution ratio and selectivity

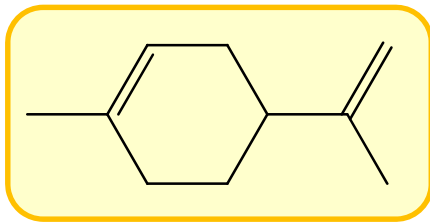
- Solute distribution ratio (β)
 - Ratio of the solute concentrations in the extract and the raffinate: $\beta = x_{s,extr} / x_{s,raff}$
 - Related to the **amount of solvent** needed.
- Selectivity (S)
 - Ratio of the solute distribution ratio and the inert distribution ratio: $S = \beta_s / \beta_i$
 - Related to the **separating power** of the solvent.

Ionic liquids as replacing solvents in liquid-liquid extraction

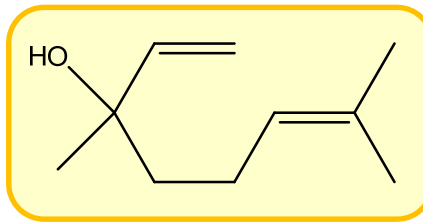


❖ Deterpenation of **citrus essential oil**:

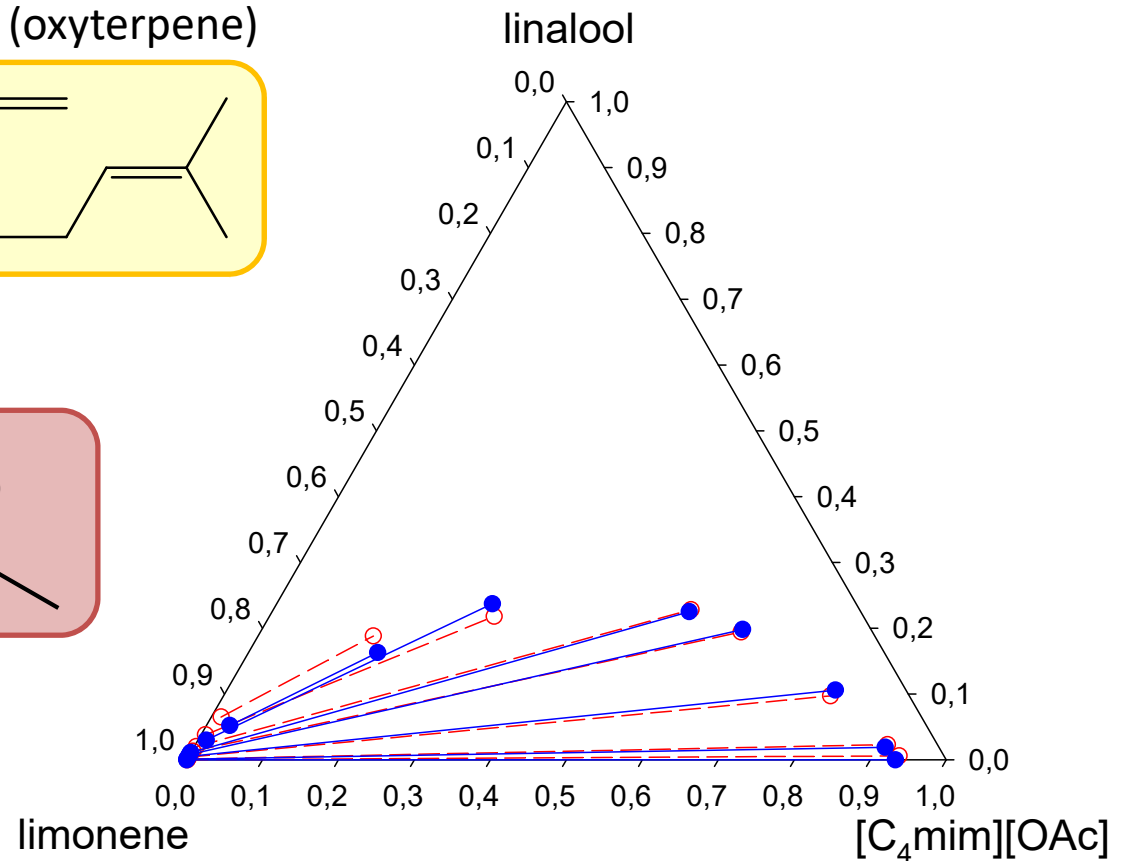
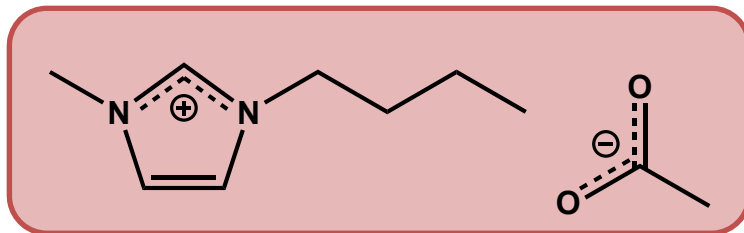
Limonene (terpene)



Linalool (oxyterpene)



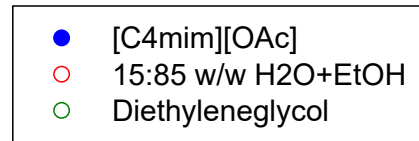
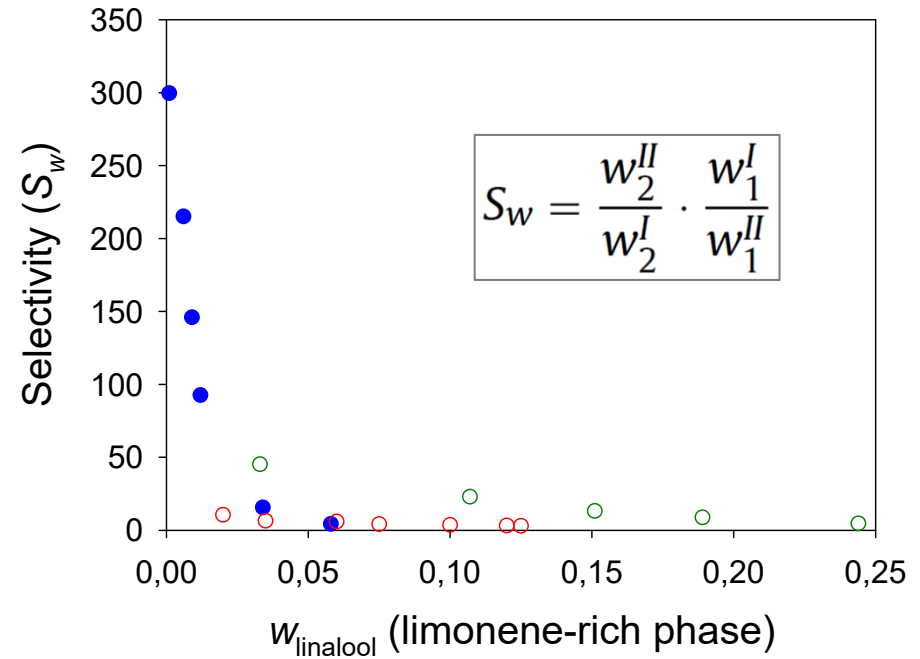
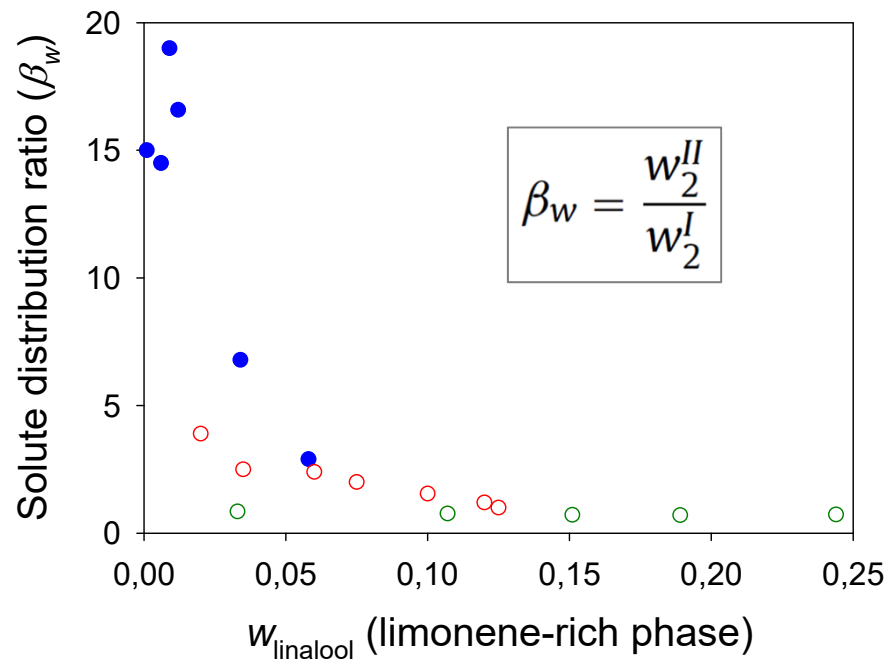
Ionic liquid: $[C_4mim][OAc]$



Ionic liquids as replacing solvents in liquid-liquid extraction

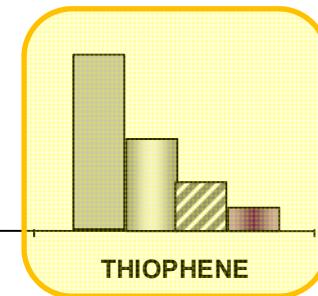
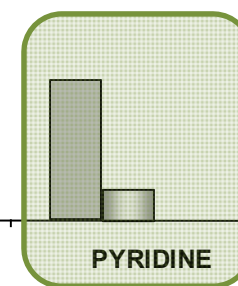
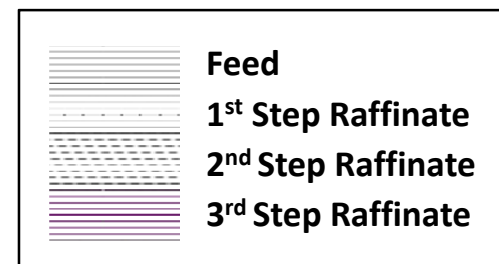
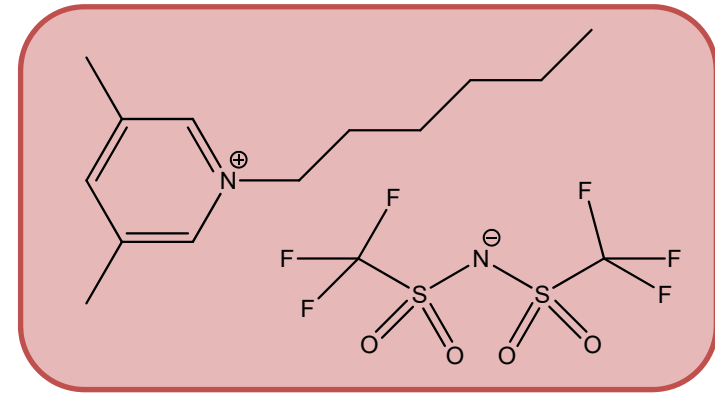
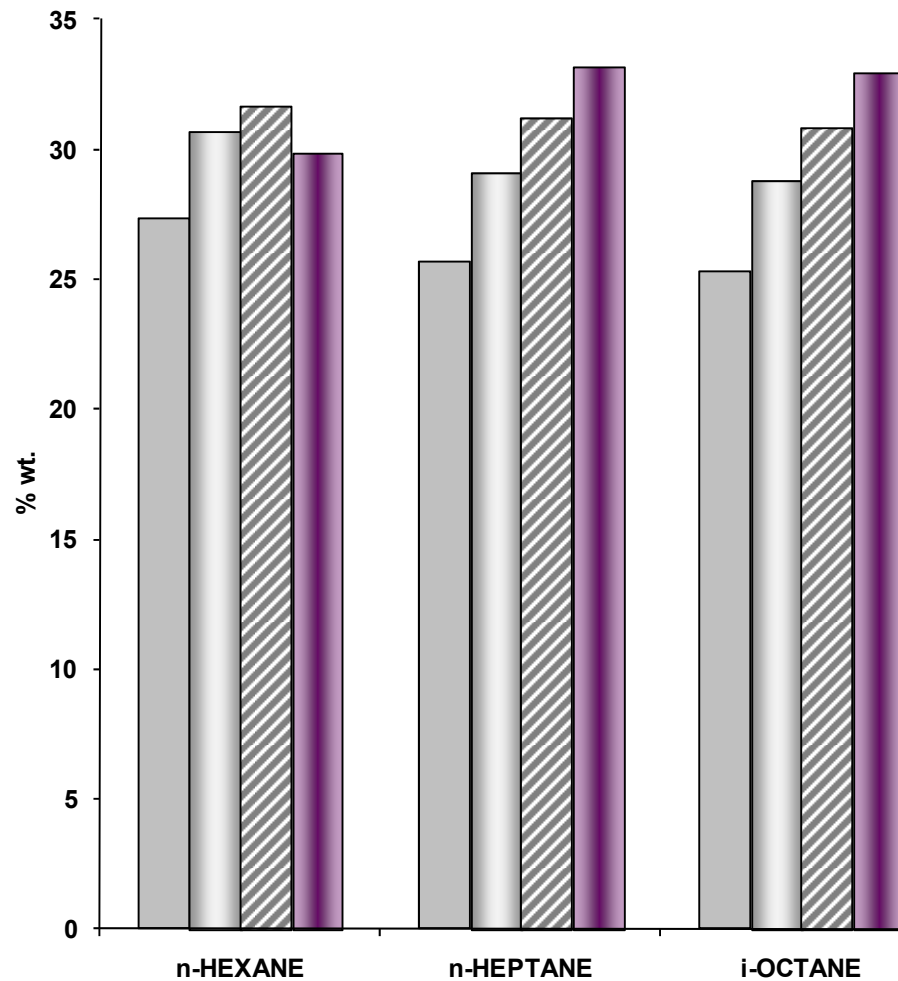


❖ Deterpenation of **citrus essential oil**:



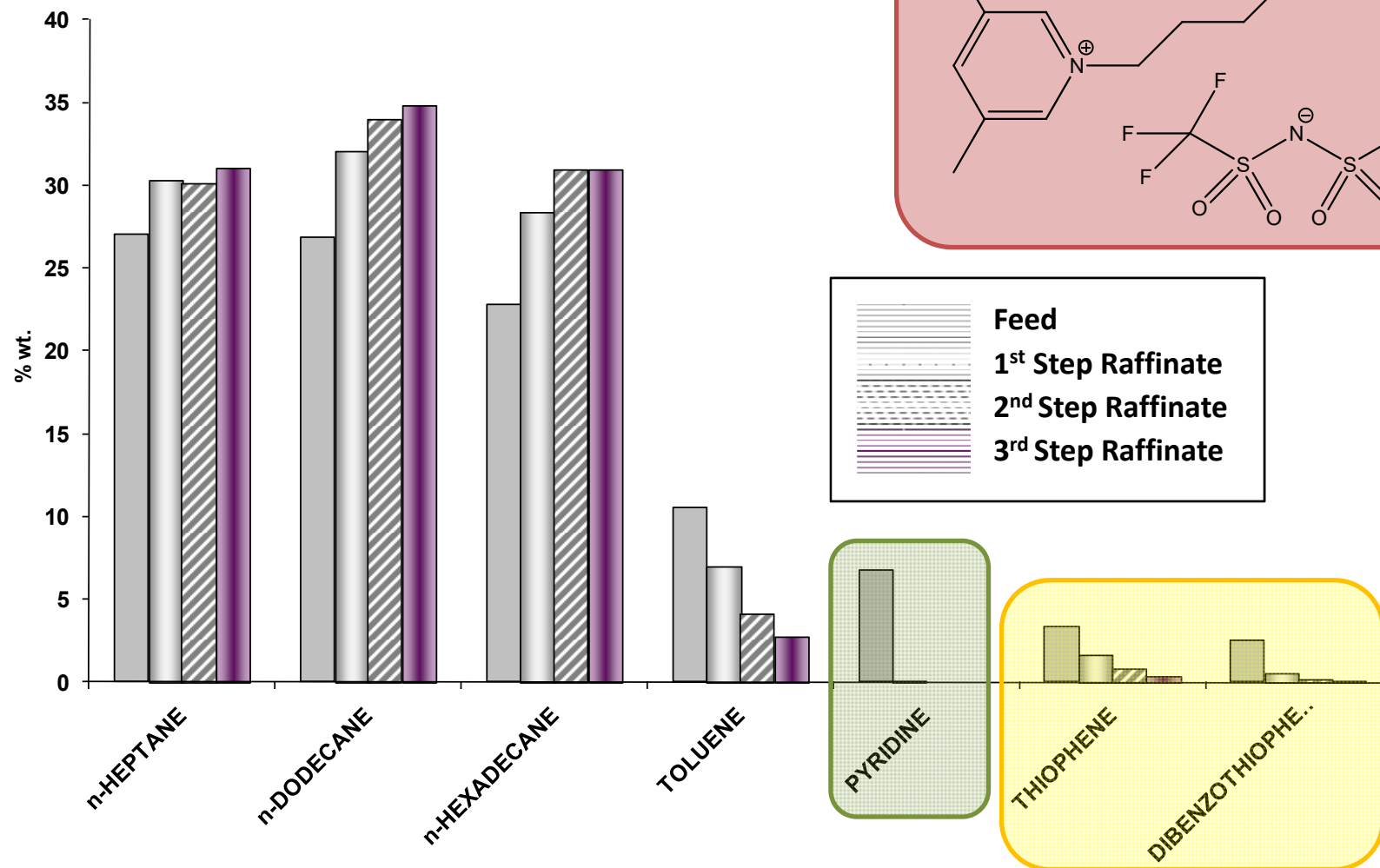
Ionic liquids as solvents in new liquid-liquid extraction processes

❖ Desulfurisation of fuels (gasoline):



Ionic liquids as solvents in new liquid-liquid extraction processes

❖ Desulfurisation of fuels (gasoil):



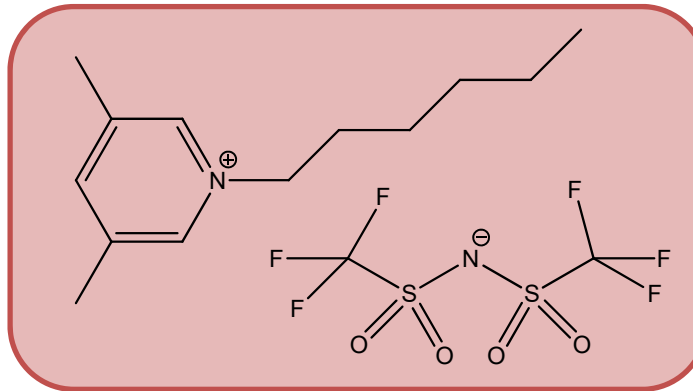
Ionic liquids as solvents in new liquid-liquid extraction processes

❖ Desulfurisation of fuels:

➤ Deep desulfurisation experiments with **real** samples

- Starting sulfur content: 50 ppm

- Ionic liquid:

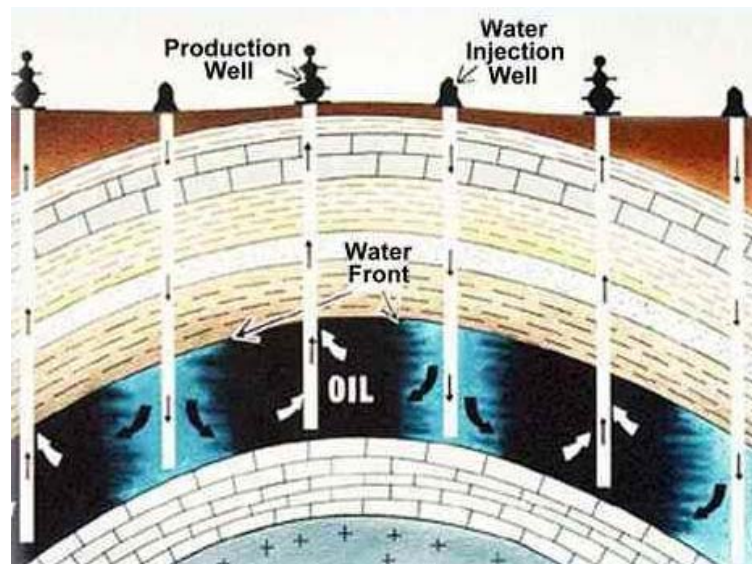


Sulfur content below the 10 ppm limit in 3 batch stages

Enhanced oil recovery

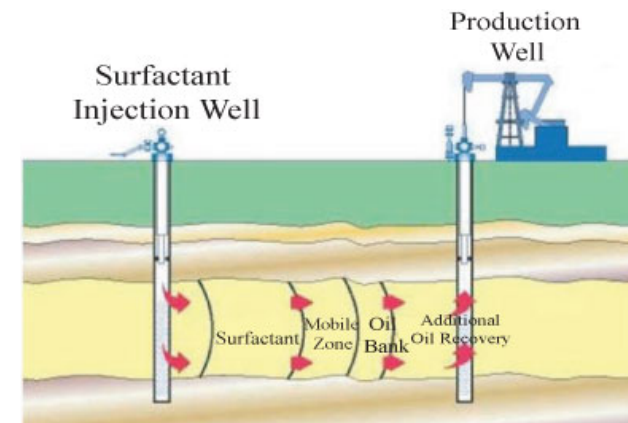


- Primary recovery:
 - Production of 10-15 % of the original oil
- Secondary recovery:
 - Production of 15-20 % of the original oil
 - Water flooding



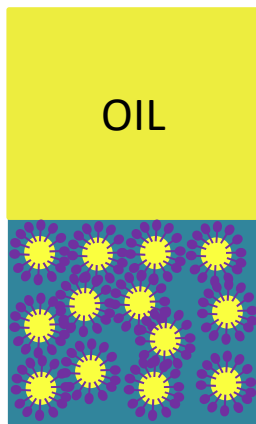
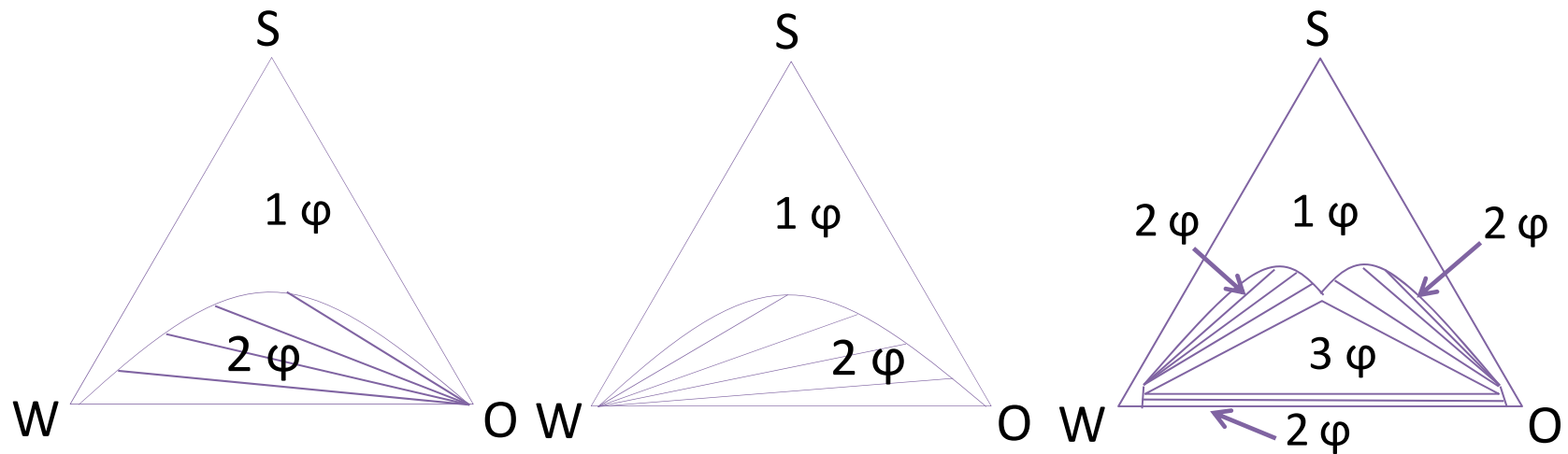
- **Tertiary recovery:**

- Injection of other fluids (e.g. surfactants)

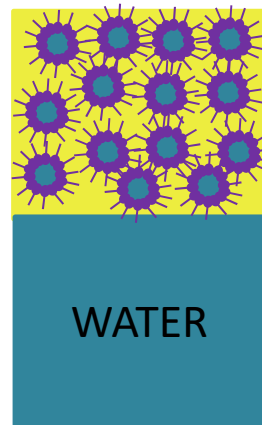


Enhanced oil recovery

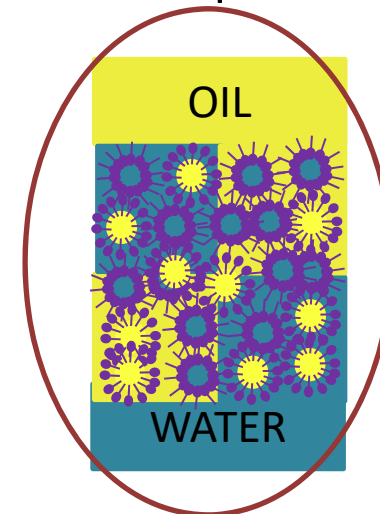
➤ Winsor diagrams: water + oil + surfactant



Type I



Type II

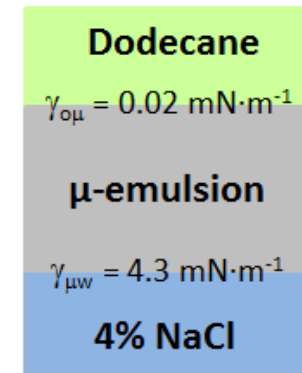
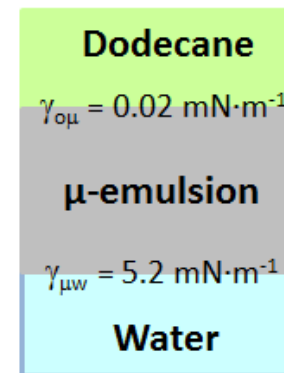
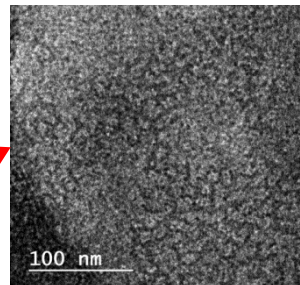
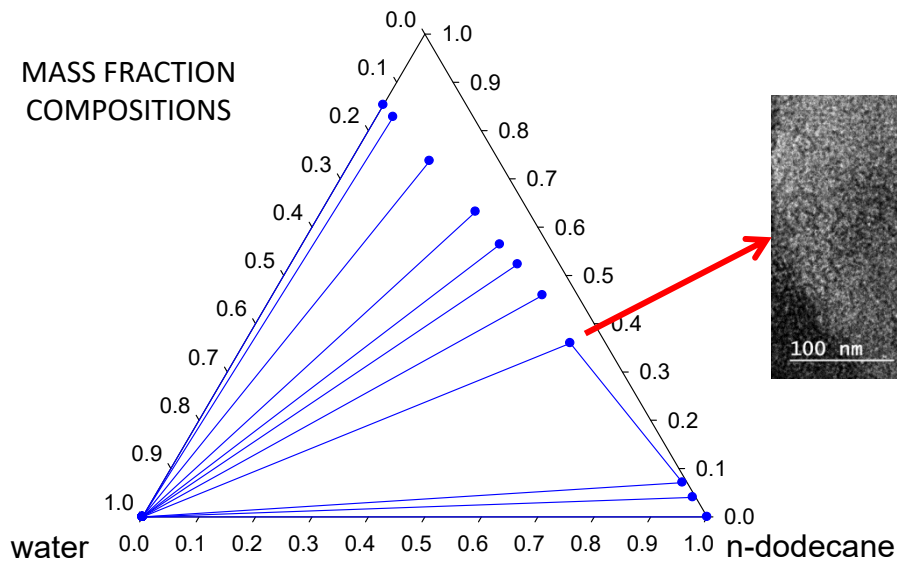
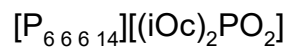
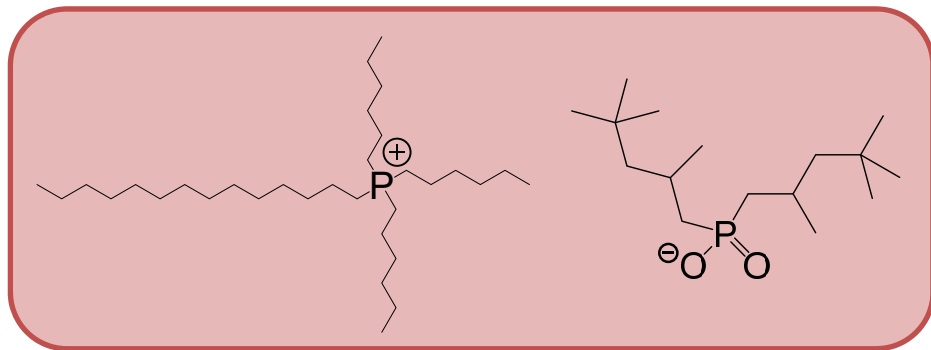


Type III

Min. γ

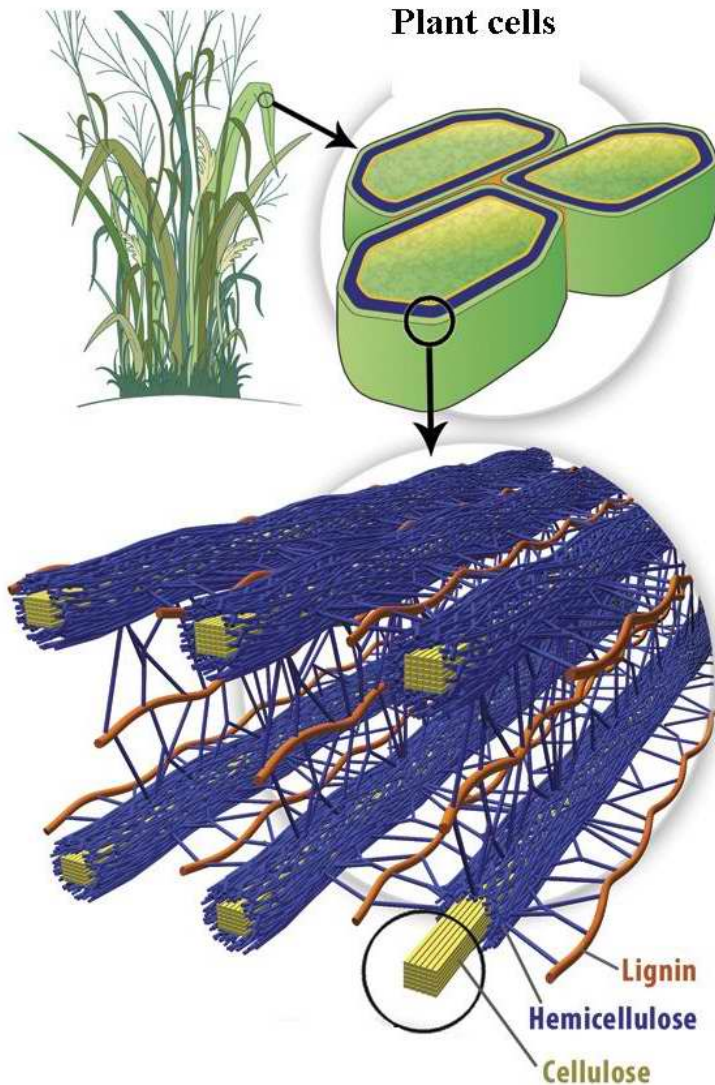
Enhanced oil recovery

- ❖ Surfactant ionic liquids – Phase behaviour and interfacial tension analyses:

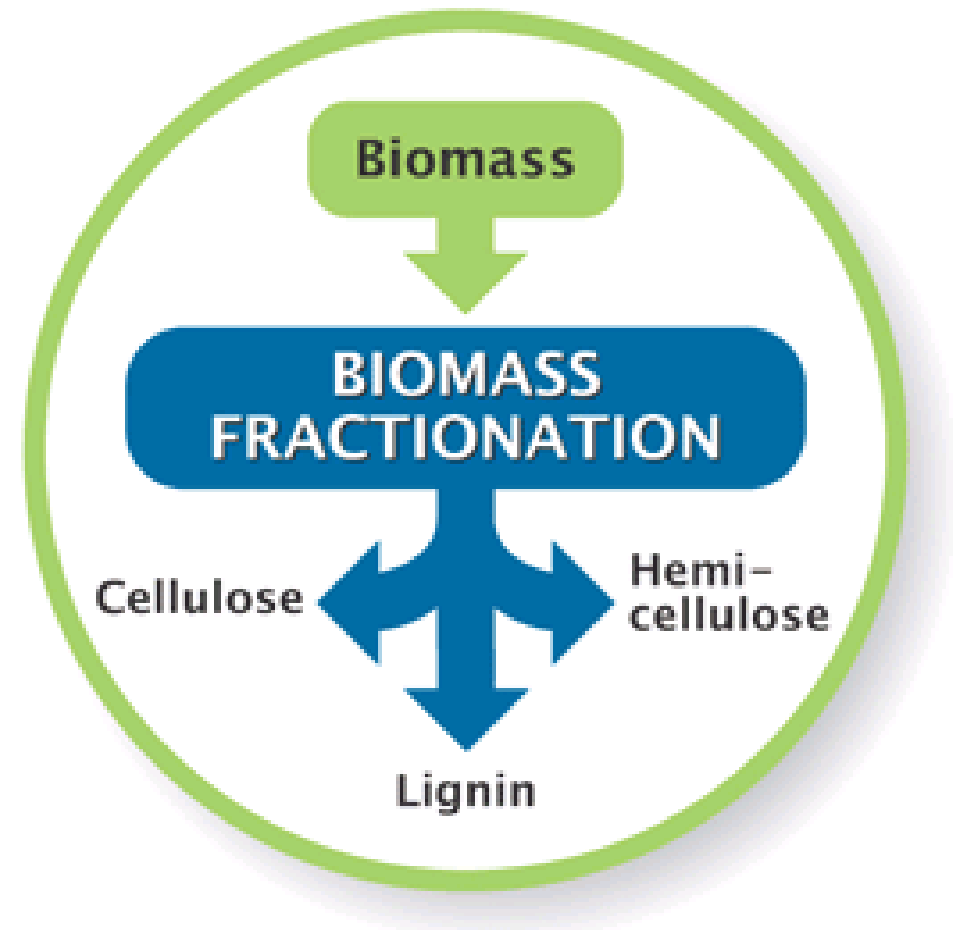


Fractionation of lignocellulosic biomass

Biomass

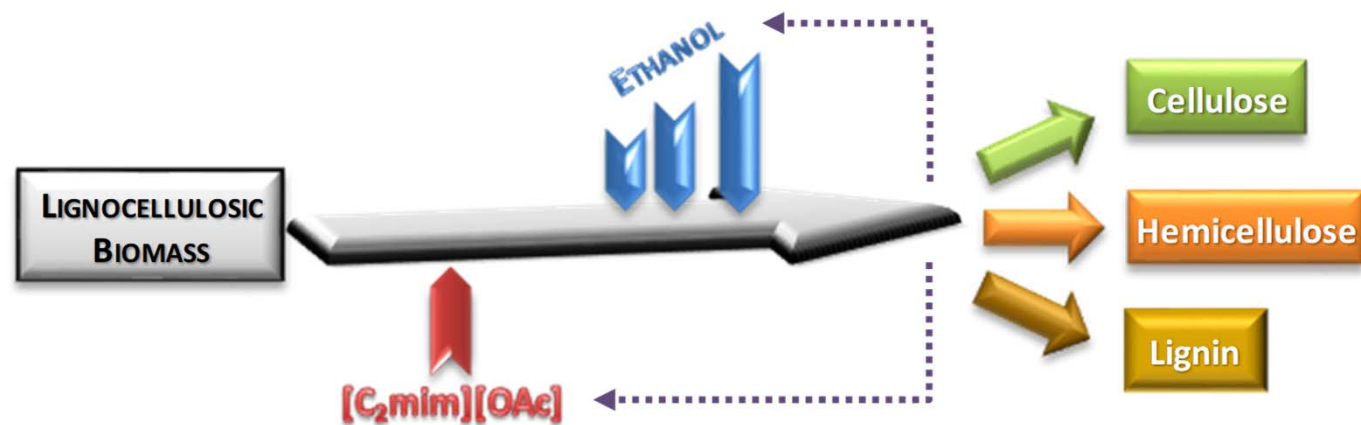
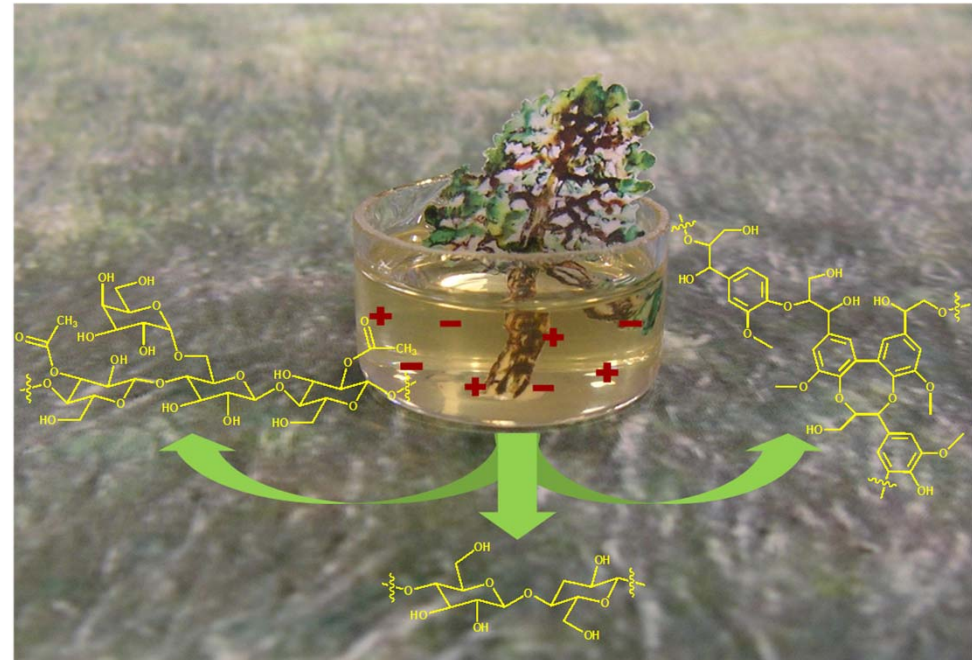


➤ The big challenge:



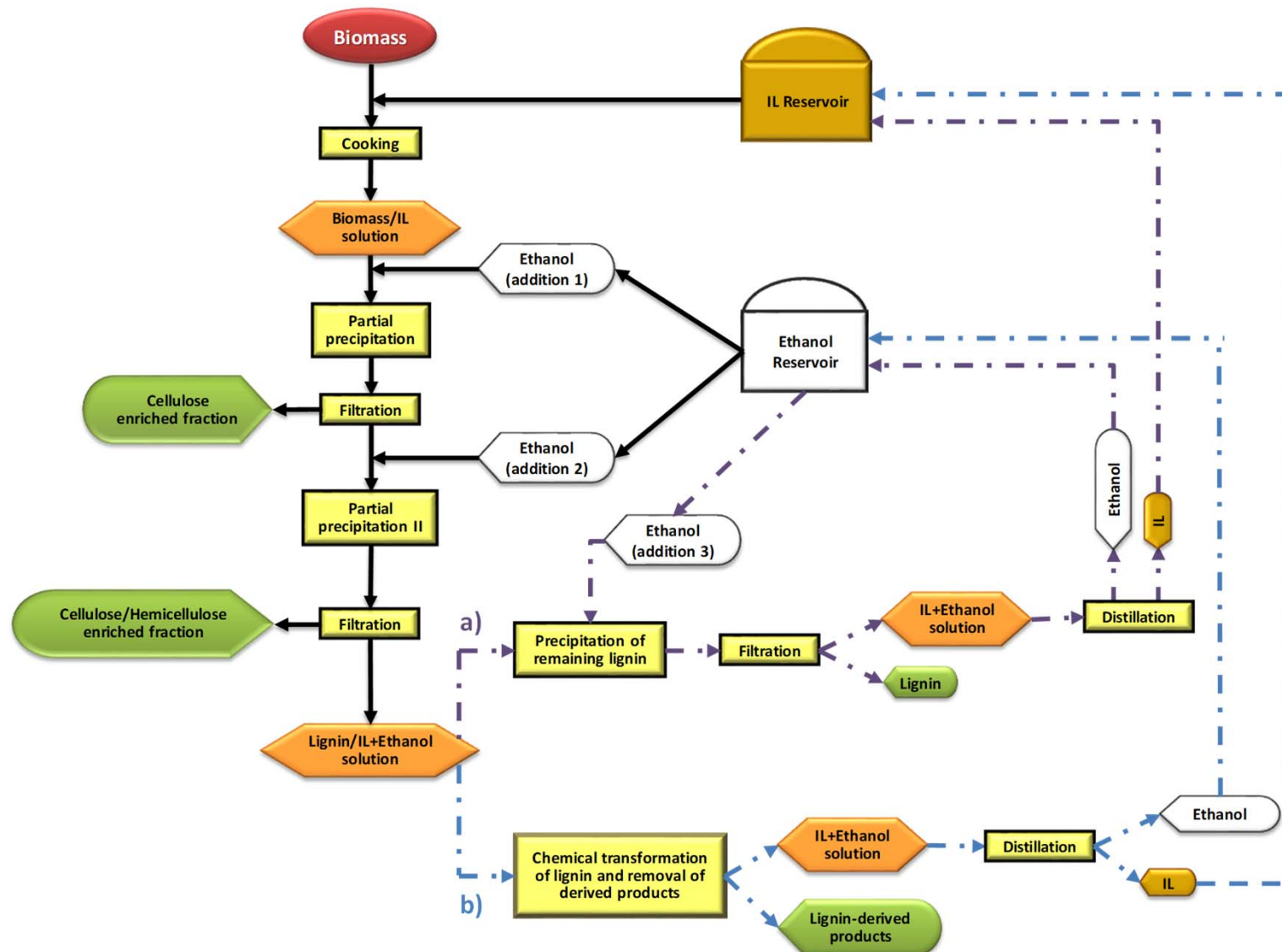
Fractionation of lignocellulosic biomass

Ionic liquids at the cornerstone of the biorefinery?



Fractionation of lignocellulosic biomass

- ❖ Development of suitable solvent + antisolvent schemes:





Take home notes

- ✓ Consideration of the potential mismatch in formula weights when comparing performances of ionic liquids and molecular solvents in an applied context.
- ✓ Deeper attention needed on the recovery of the ionic liquid when used as mass separating agent in separation processes
- ✓ Non-conventional 'separations' to be much largely explored...



Thank you!

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