



Workshop on Choline Chloride based IL's

# **Recycling and Waste Management**

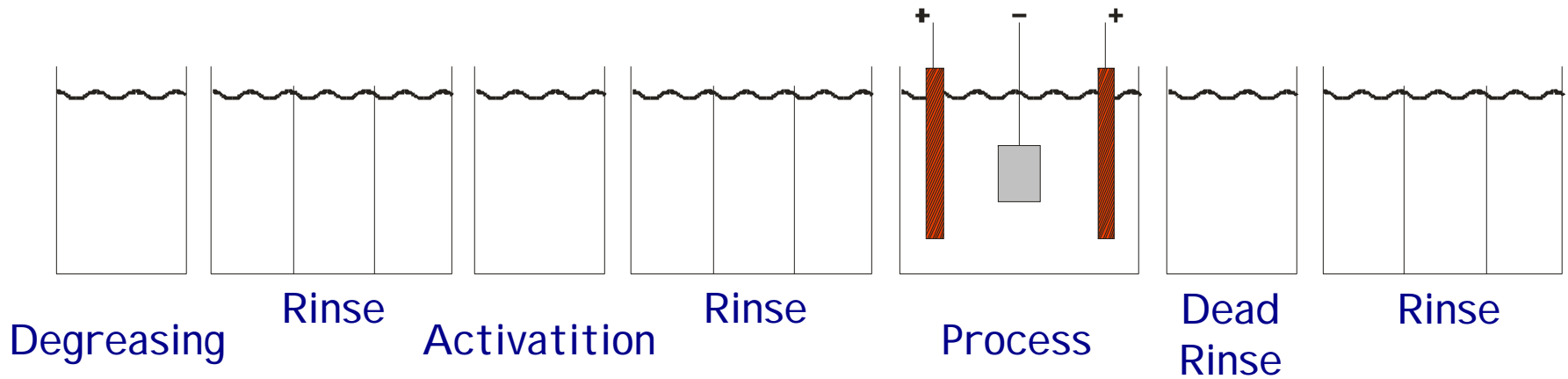
München : 24 March 2009



1. Electrodepositions from IL's on a larger scale
2. Adequate recycling techniques
3. Waste management of choline based ionic liquids



# 1. Electrodepositions from IL's on a larger scale



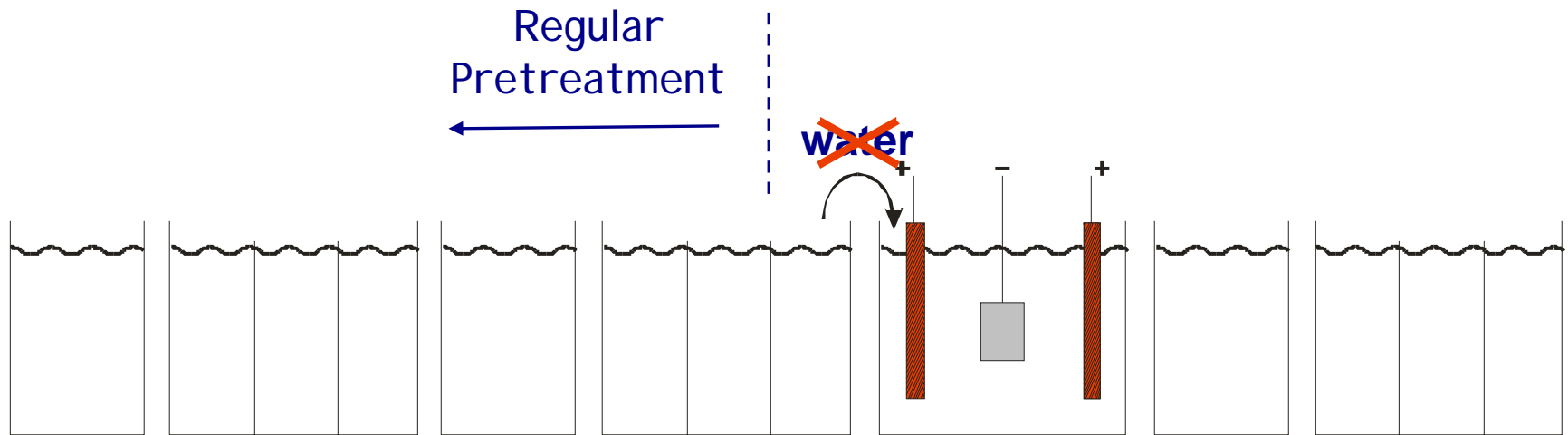


Specific problems with ionic liquids :

- 1.1. Contamination with rinse solution
- 1.2. Drag-out of process solution
- 1.3. Reactions at anode (and side-reactions at cathode)



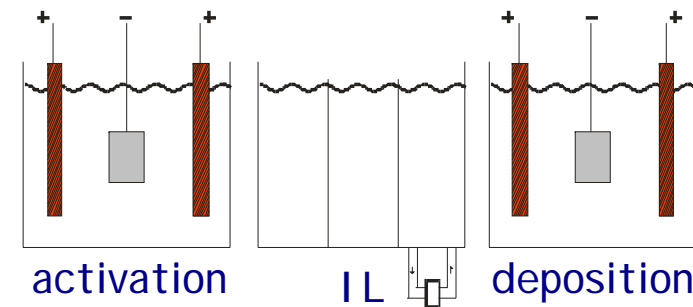
## 1.1. Contamination with rinse solution





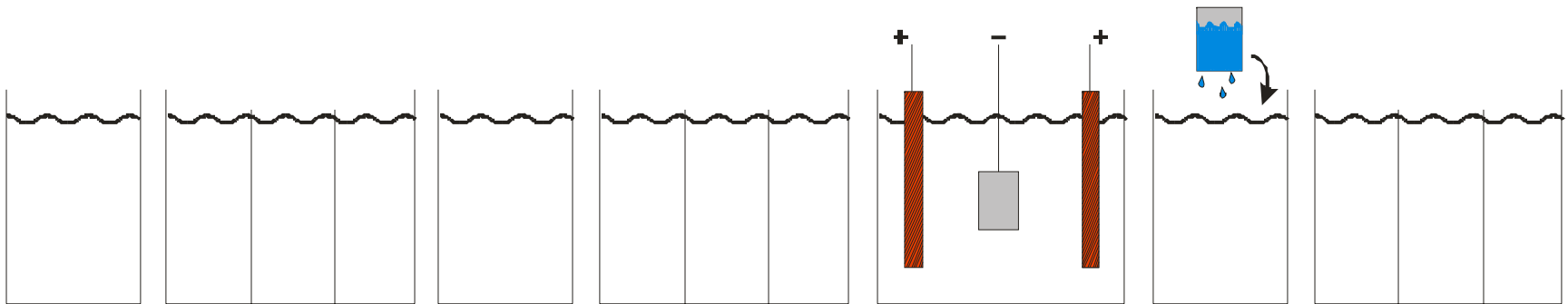
## 1.1. Contamination with rinse solution

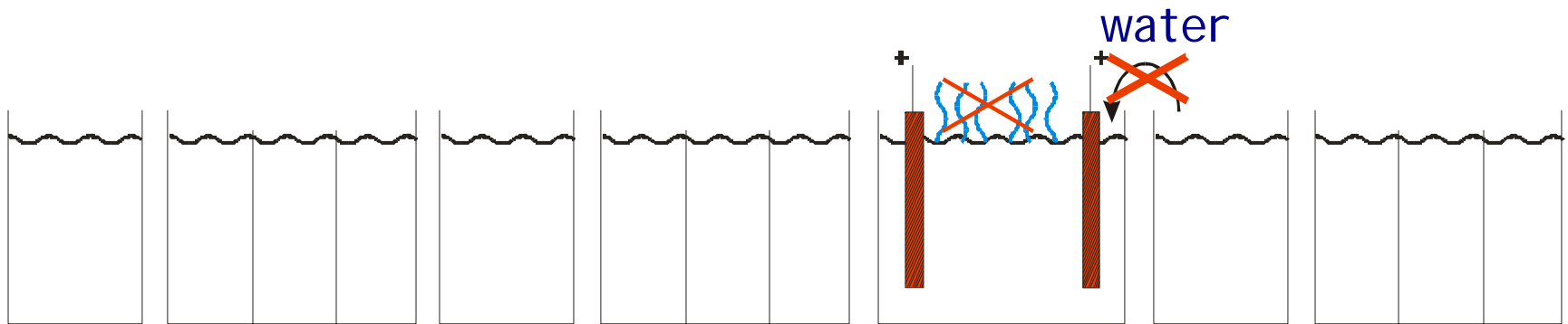
- ◆ drying the object after pretreatment is not an option
- ◆ activation in the same ionic liquid
  - cfr. electropolishing
  - online purification necessary
- ◆ when water does not disturb the process, water can be used as well in the pretreatment; in many cases low concentrations of water are even advantageous





## 1.2. Drag-out of process solution



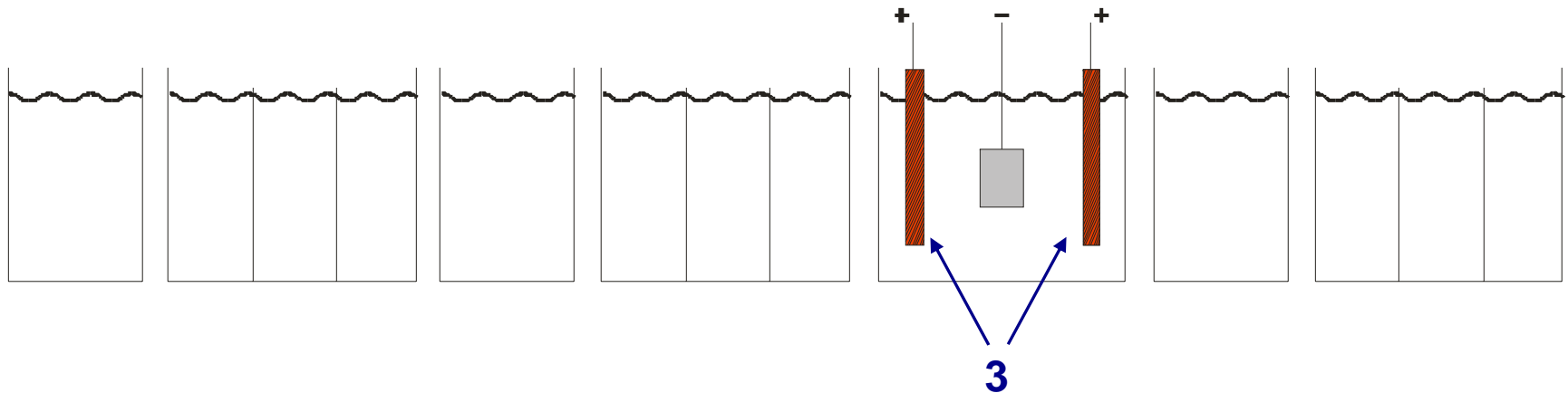




## 1.2. Drag-out of process solution

- ◆ when rinsed with water after process and no water is allowed in the I L, then the rinse solution cannot be returned in the process solution
  - minimize drag-out
  - dead-rinse with I L
  - recycling of the I L from the rinse solution
- ◆ when small amounts of water do not disturb the process, rinsing with water is possible

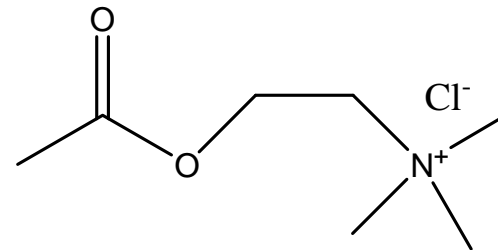
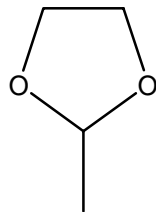
### 1.3. Reactions at anode (and side-reactions at cathode)





## 1.3. Reactions at anode (and side-reactions at cathode)

- ◆ suppose the deposition at the cathode occurs at 100%,  
what reaction occurs at the anode?  
→ complex organic reactions

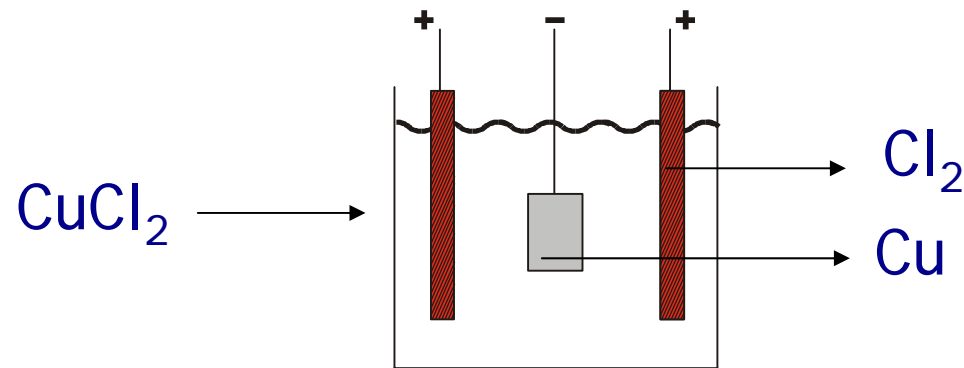


→ because of the transformation of the solvent,  
these reactions must be avoided

- ◆  $\text{Cl}_2$ ? not observed excessively →  $\text{Cl}_3^-$ , chlorinated products



- ◆ soluble anodes
  - less transformation of ionic liquid
  - replenishment without piling up of anions



- not always available
- not always compatible with I L

- ◆ addition of easily oxidizable components



## 2. Adequate recycling techniques

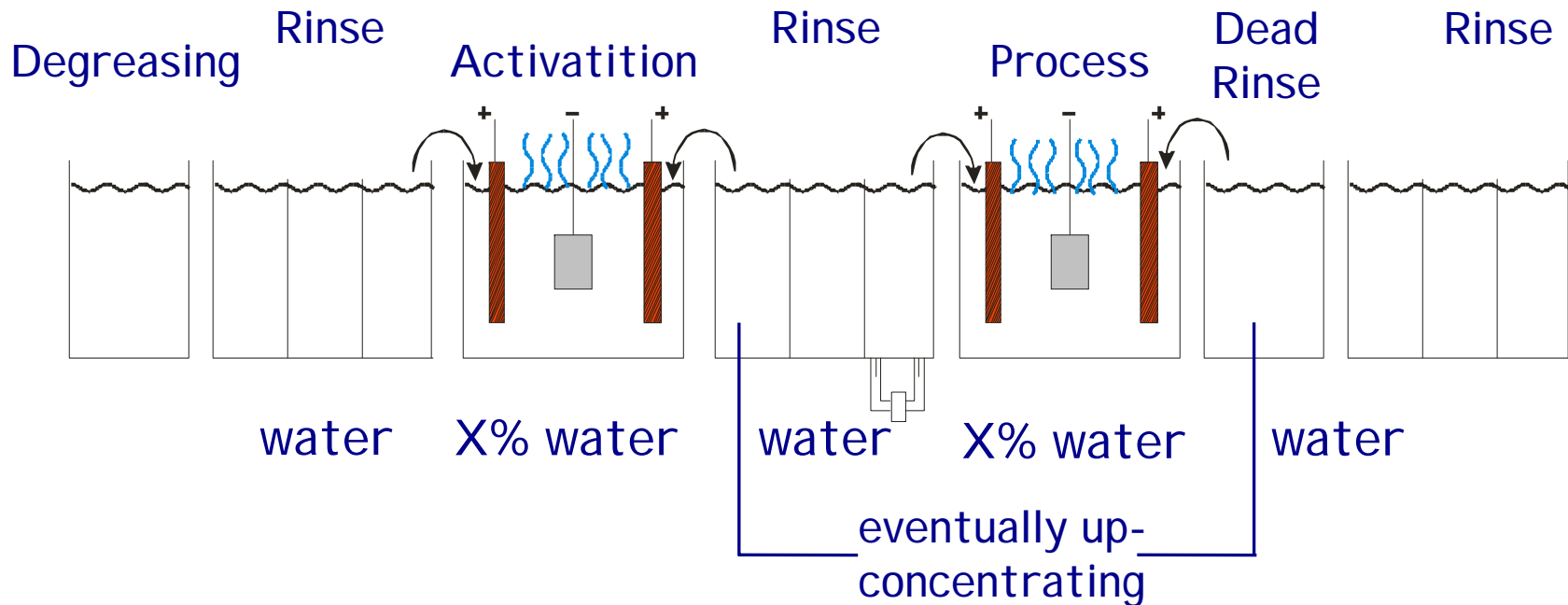
- closed loops e.g. when soluble anodes can be used
- large-scale processes are in reach when small quantities of water are allowed in the IL
- non-volatility of IL's
  - ⇒ separation of water from rinse solutions with vacuum distillation



- in some cases the situation is not different from aqueous systems

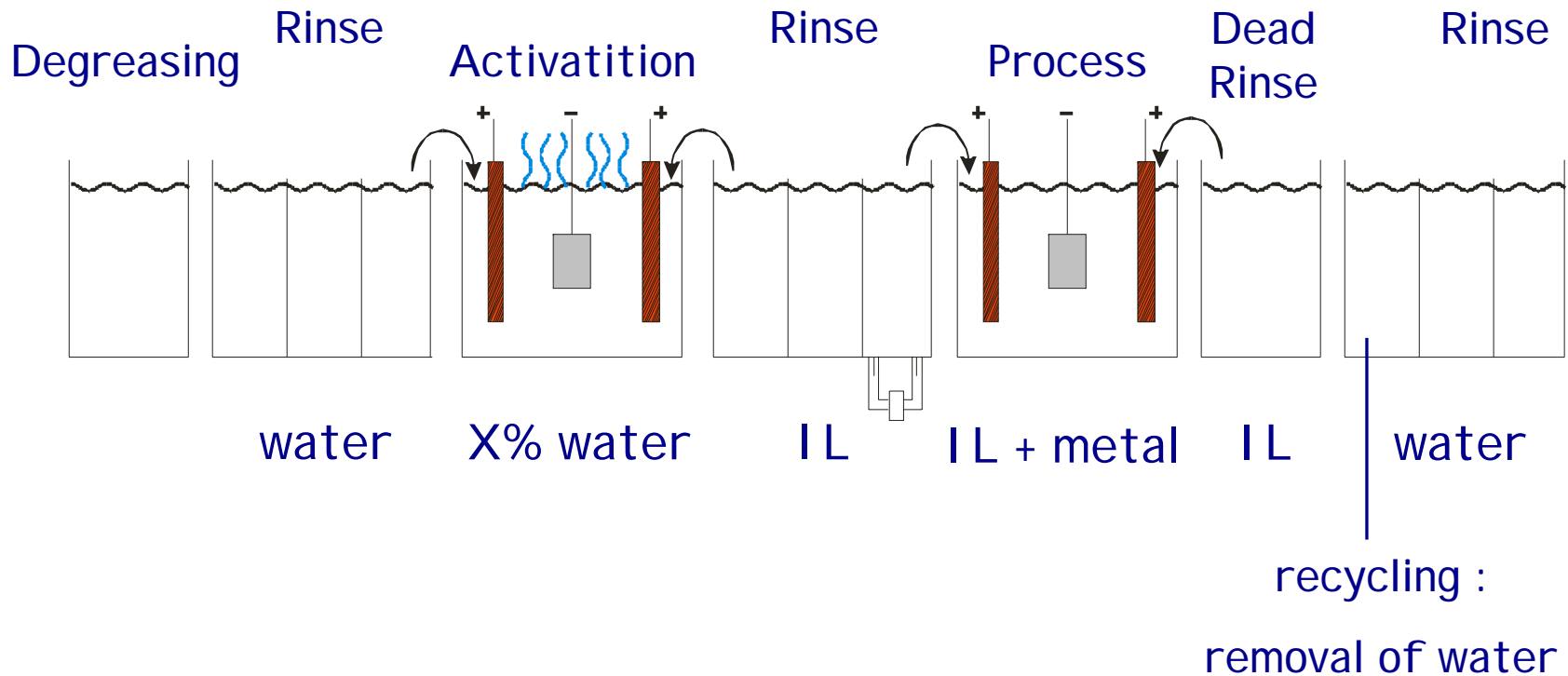


- ◆ if small amounts (10 - 70 %) of water are present and soluble anodes at 100 % efficiency





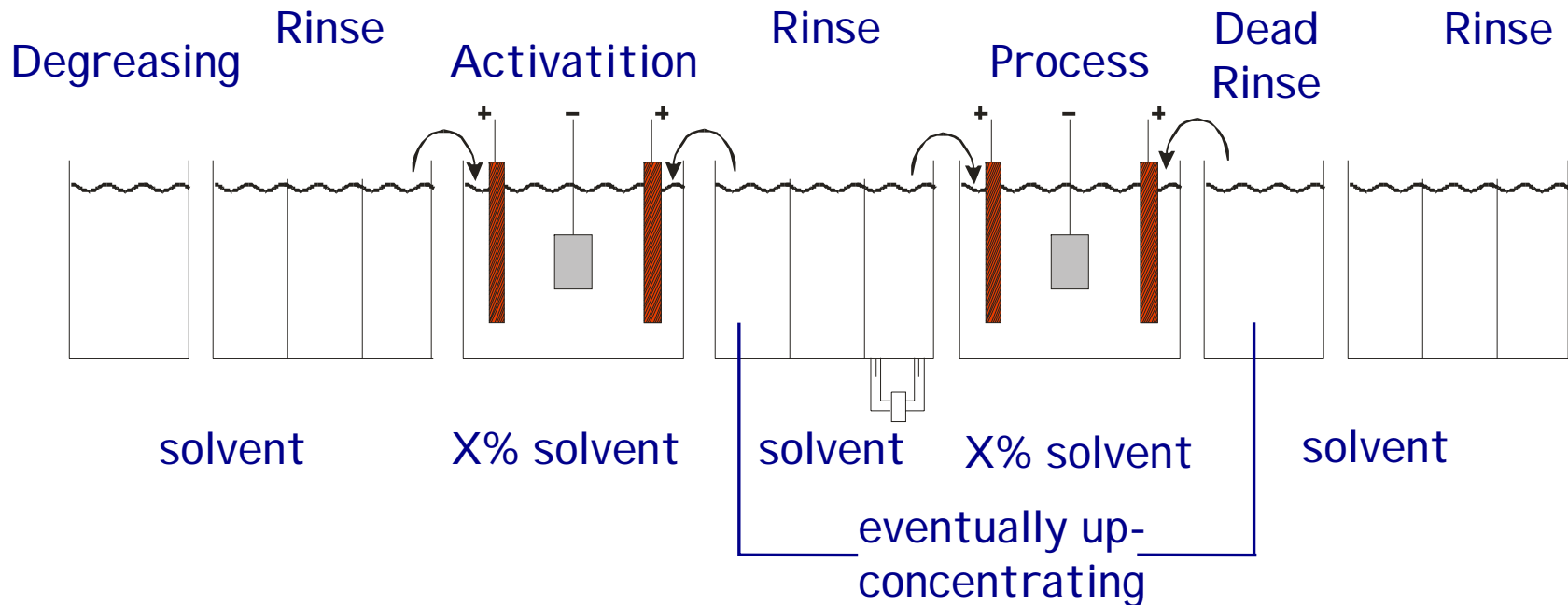
- ◆ if water is not allowed and soluble anodes are used at 100 % efficiency





◆ if water is not allowed at all

⇒ the use of acceptable solvents for pretreatment and rinsing should be considered





### 3. Waste Management of choline based IL's

- in comparison with other IL's
- electrochemical window rather narrow
- not toxic
- biodegradable (ethylene glycol, urea, malic acid etc.)
- cheap
- easy to prepare
- in several processes addition of water does not disturb the process or is even beneficial, when compared to the situation in the water-free ionic liquid



### 3. Waste Management of choline based IL's

→ strategies

- longevity of concentrated process solution must be high
- treatment of rejected solutions quite similar to the treatment of aqueous solutions after addition of water
- online recycling in several process steps preferred



## Conclusion

- extended process control; looking for alternatives to rinse, replenish, minimize drag-out and online recycling/purification of the solutions is challenging but not impossible
  - ⇒ for applications with high added value
- 'hybride' processes with low concentrations of water seem most reachable at this moment



**Thank you for your attention**