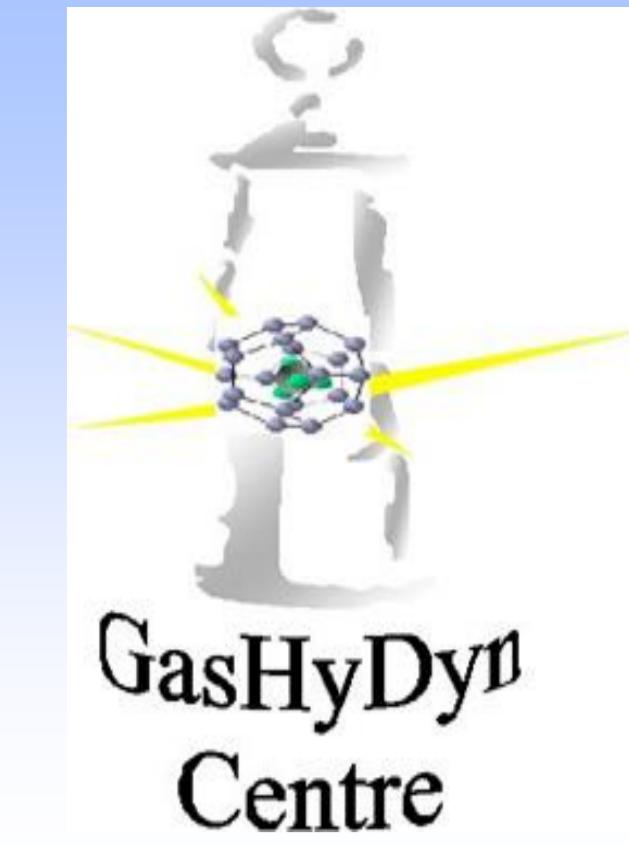


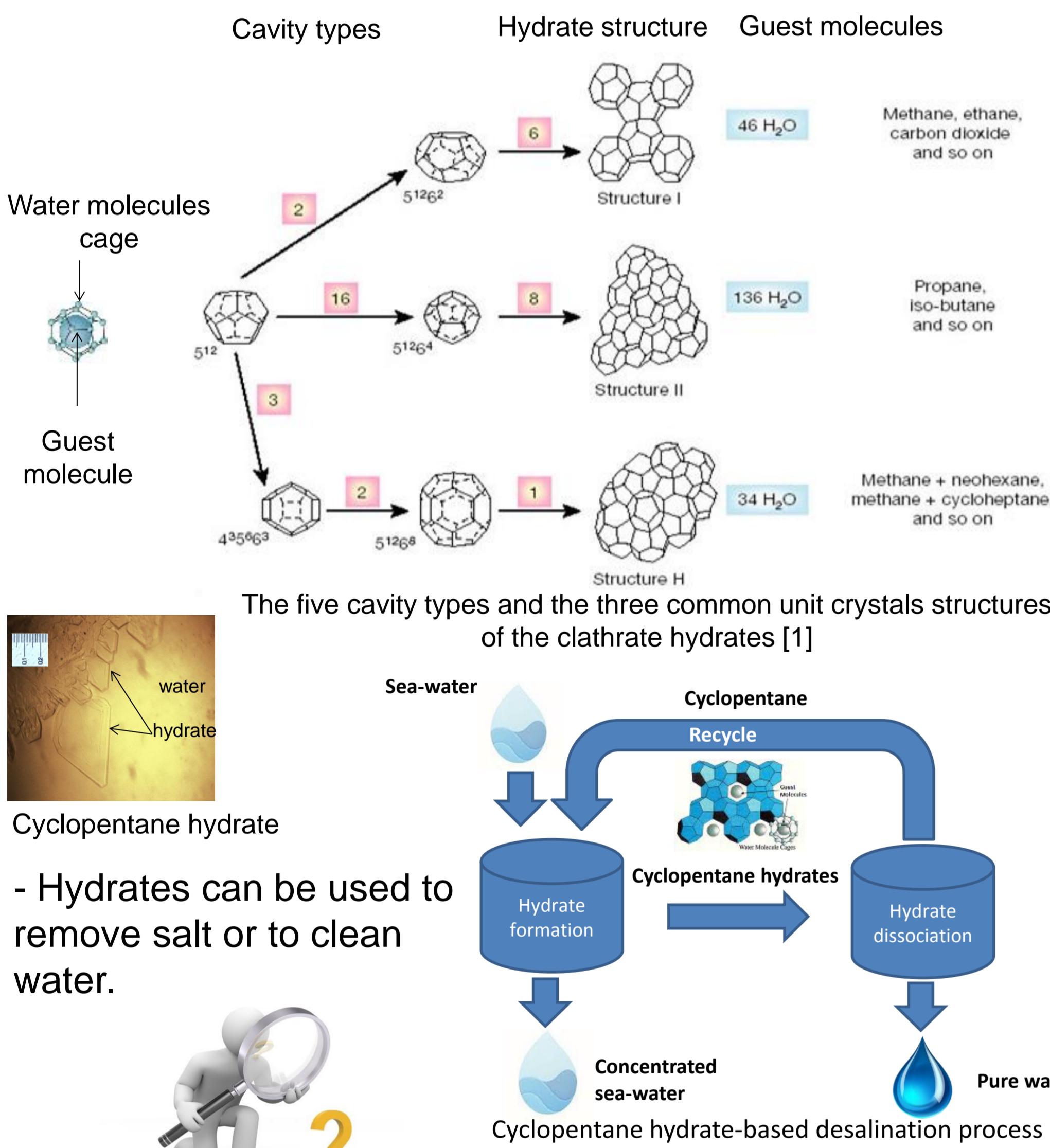
Experimental Study and Modelling of Cyclopentane Hydrates in the presence of NaCl, KCl, a mixture of NaCl – KCl and CaCl₂

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Introduction

- Clathrate hydrates are ice-like crystalline compounds consisting of cage-like structures formed by hydrogen-bonded water molecules that enclose guest molecules stabilizing the lattice structure.

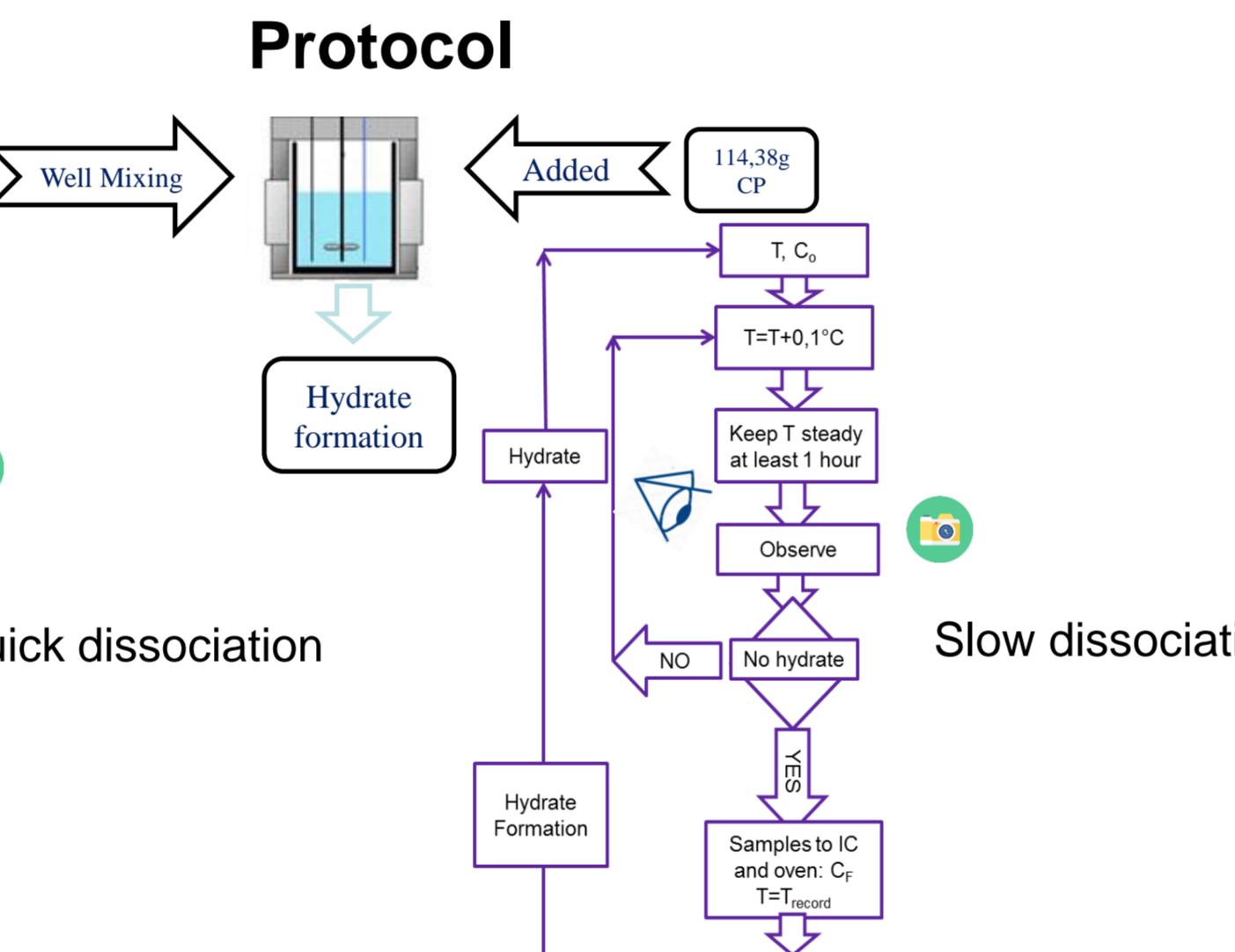
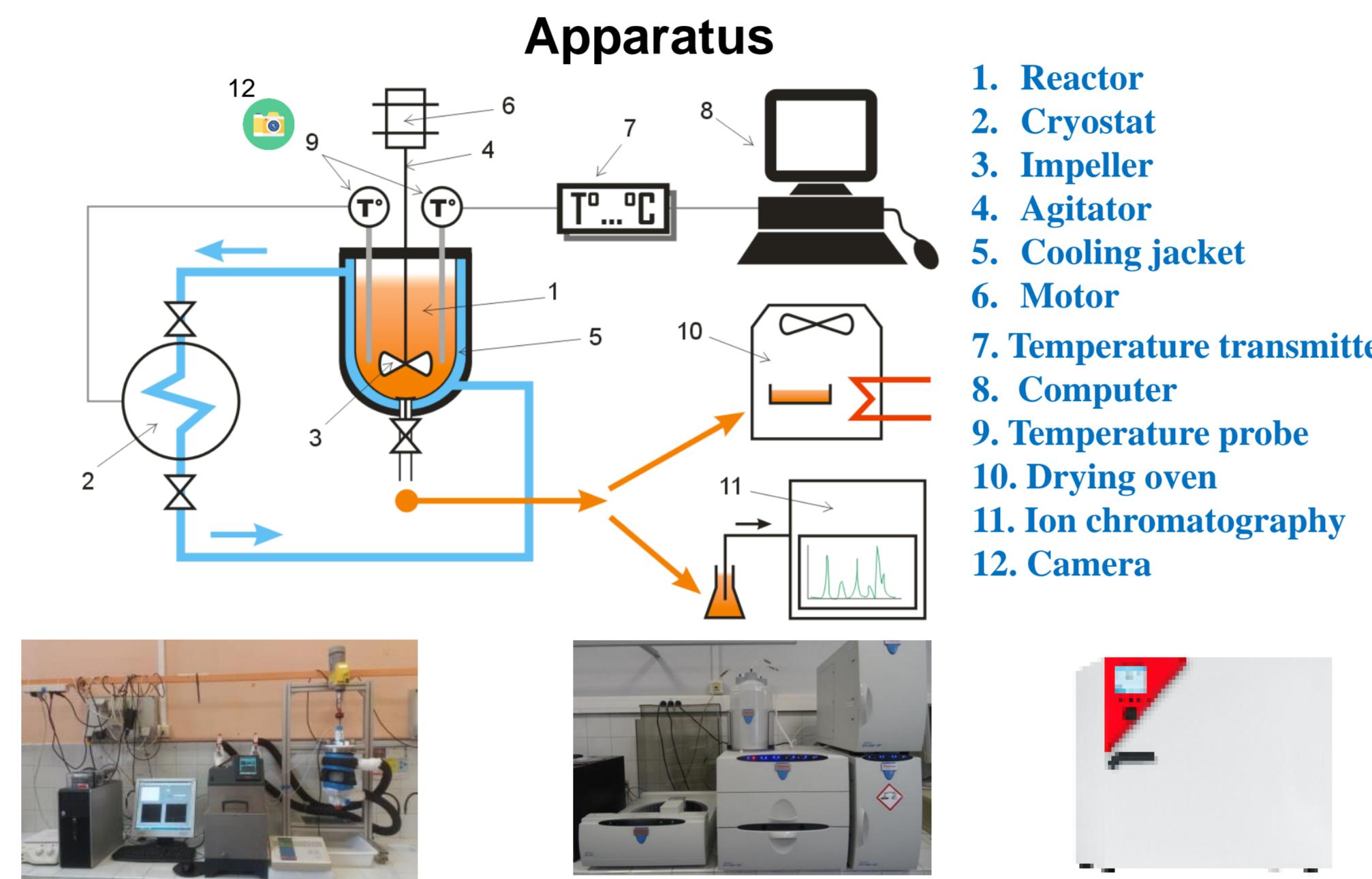


- Phase equilibria data in the presence of different salts is needed. Unfortunately, there are still few studies in the literature

Objectives

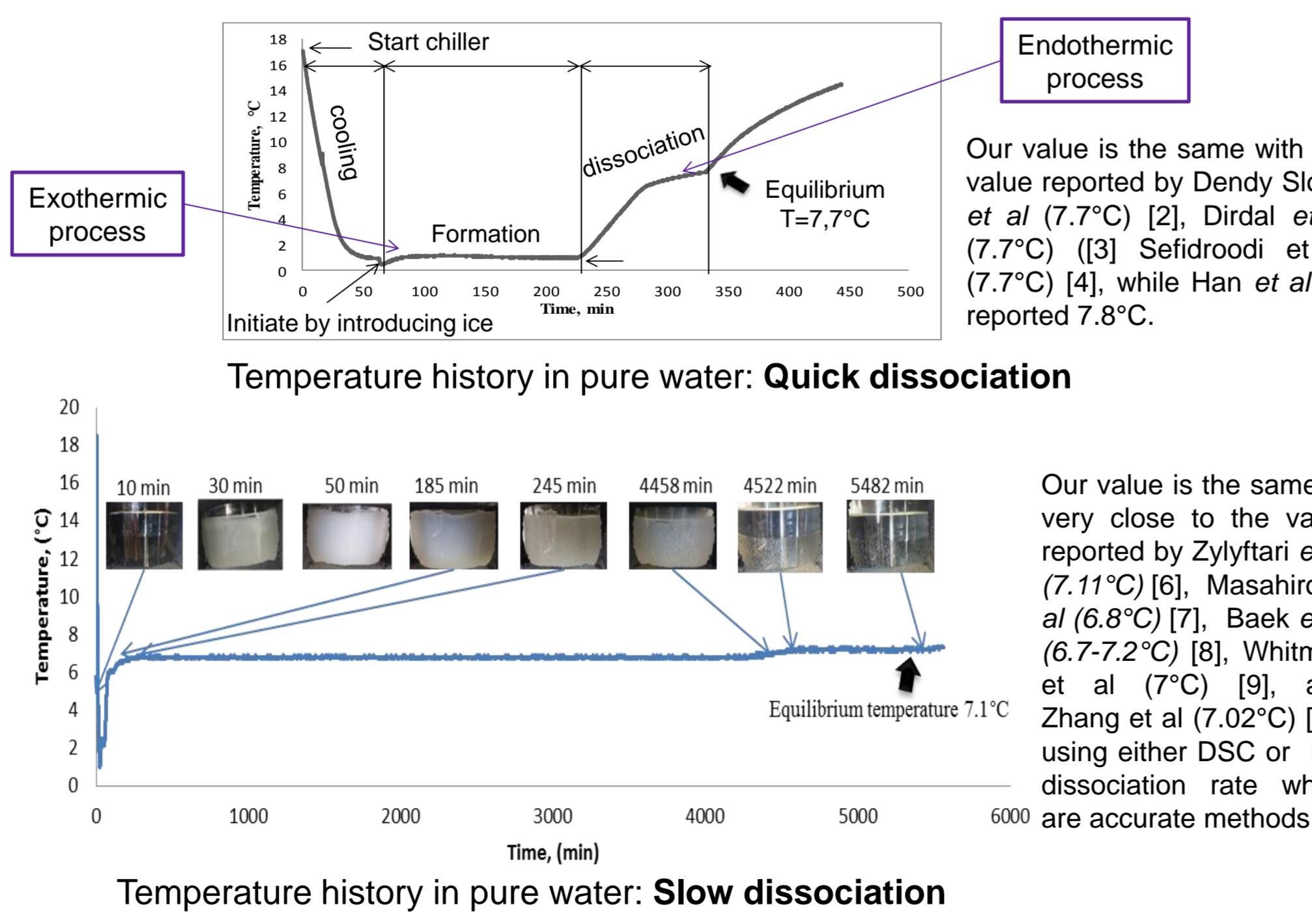
- Comparison between the quick and the slow procedure.
- Determine the equilibrium temperatures of cyclopentane hydrates in the presence of NaCl, KCl, an equal-mass mixture NaCl-KCl, and CaCl₂.
- Developing three thermodynamic models to model cyclopentane hydrates in the presence of salts. One is based on standard liquid-solid water equations; another is based on Kihara parameters in van der Waals and Platteeuw approach, while the third is based on cage occupancy correlation.

Experimental



Results

Comparison of two procedures in pure water



The slow procedure provided a more accurate data than the quick dissociation

Experimental equilibrium temperatures in the presence of salts

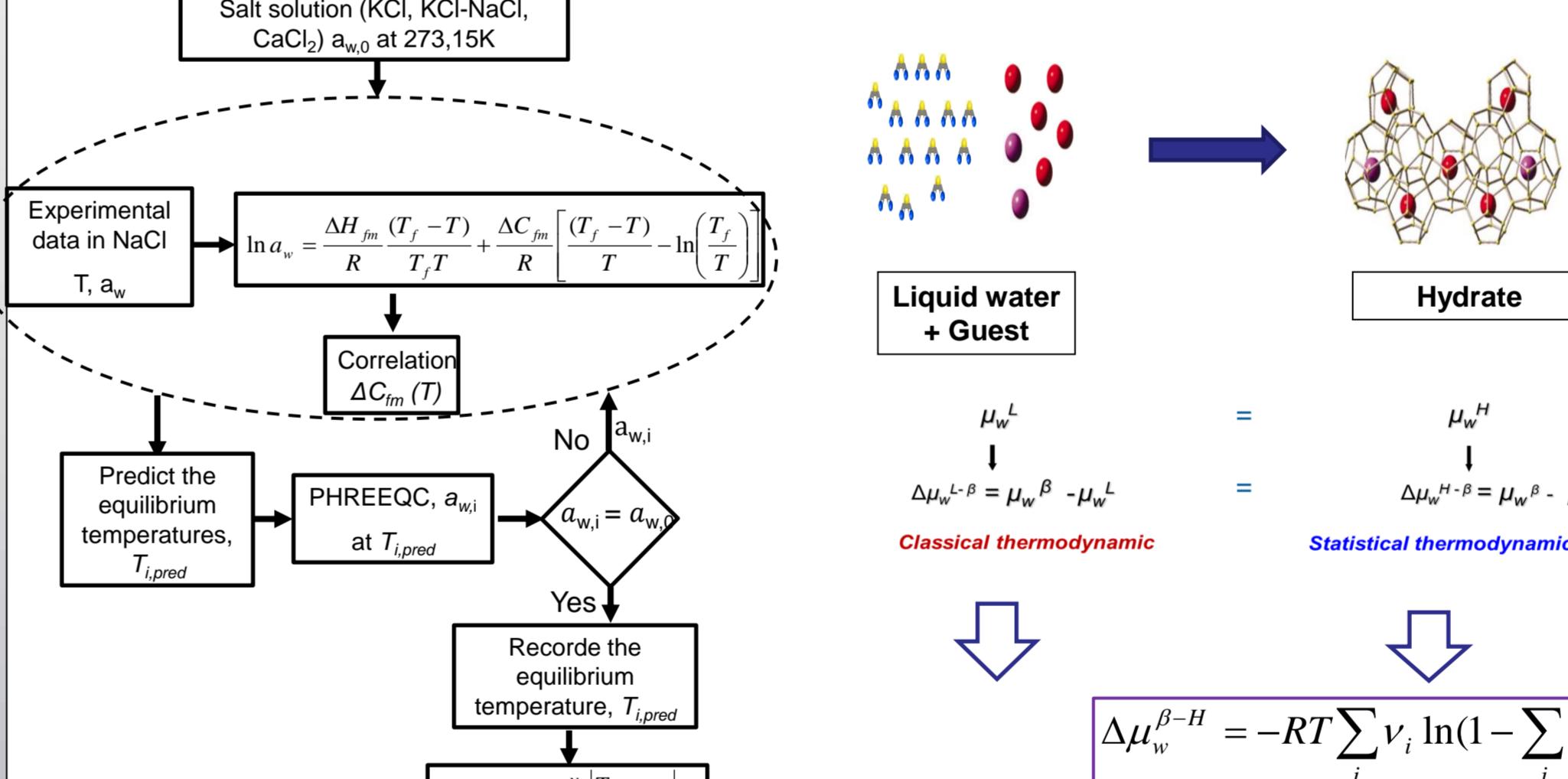
Salinity, % w/w	T _e quick in NaCl, °C	T _e slow in NaCl, °C	T _e in NaCl, °C [6]	T _e quick in KCl, °C	T _e slow in KCl, °C	T _e quick in a mixture of NaCl-KCl, °C	T _e slow in a mixture of NaCl-KCl, °C	T _e quick in CaCl ₂ , °C	T _e slow in CaCl ₂ , °C
0	7.7	7.1	7.11	-	-	7.7	7.1	7.7	7.1
1	6.9	6.4	-	-	-	7.2	6.9	7	6.7
2	6.3	5.9	-	-	-	6.6	6.1	6.5	6.8
3	5.7	5	-	-	-	6	5.5	5.9	5.4
5	4.9	4.1	-	-	-	5.4	4.9	5.1	4.6
8	3.5	2.4	-	-	-	4.2	3.6	3.6	3.0
10	0.9	-0.4	-	-	-	2.3	1.4	1.5	0.6
14	-1	-1.8	-	-	-	1.2	0.4	-0.2	-0.6
16	-2.7	-3.8	-	-	-	0.6	-0.5	-1.2	-2.1
20	-7.2	-7.8	-8.00	-	-	-2.1	-3	-4.6	-5.4
22	-9.7	-10.2	-	-	-	-6.1	-	-12.0	-13.2
23	-11	-11.6	-11.66	-	-	-	-	-13.0	-15.1
25	-	-	-	-	-	-	-	-16.0	-19.0

- The equilibrium temperatures following the quick procedure are systematically higher than the ones following the slow procedure.
- The equilibrium temperatures dropped strongly with an increase in salt concentration, whatever the kinds of salts

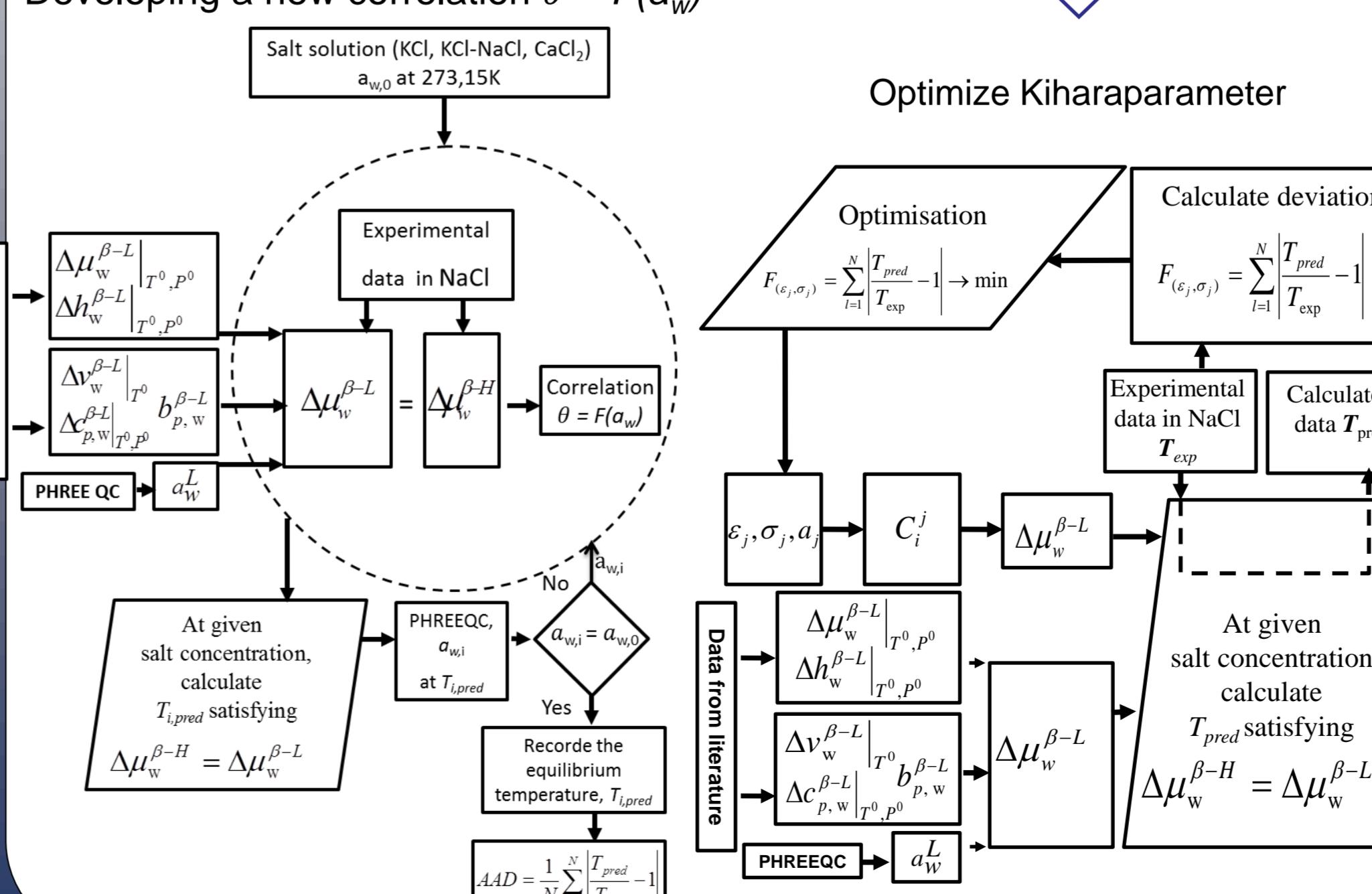
Modelling

Approach n°1: Developing a new correlation $\Delta C_{fm}(T)$

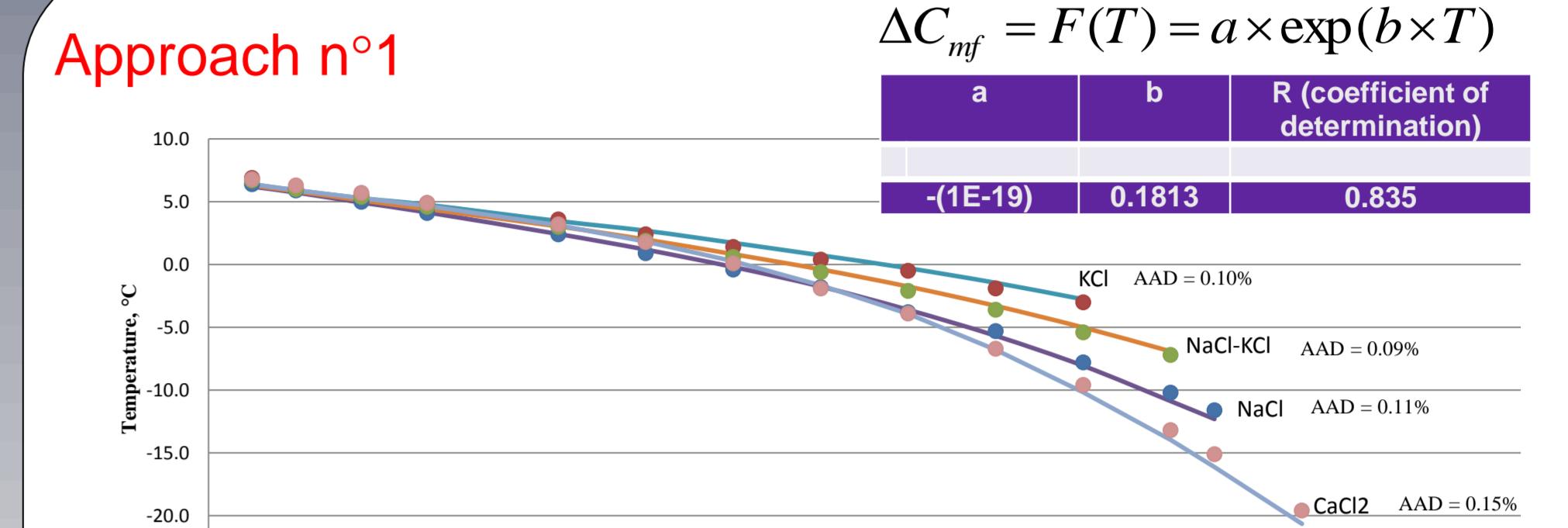
Approach n°2: Statistical thermodynamic



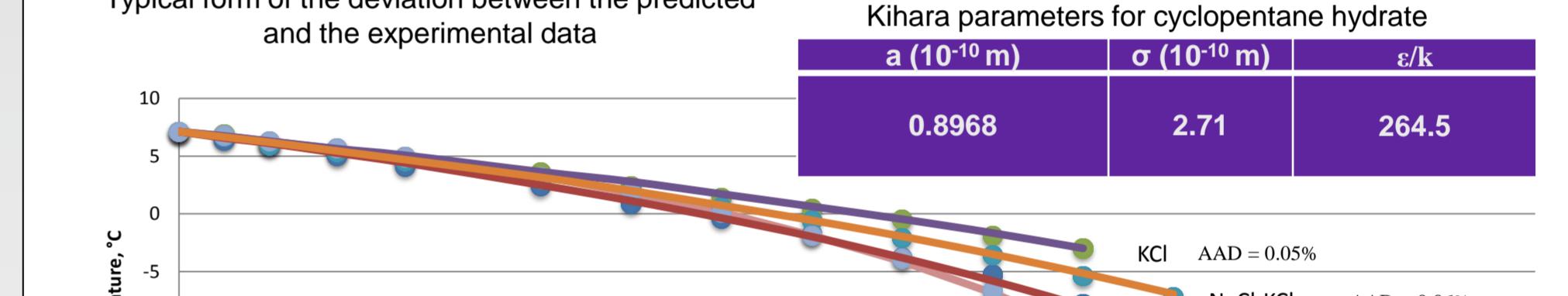
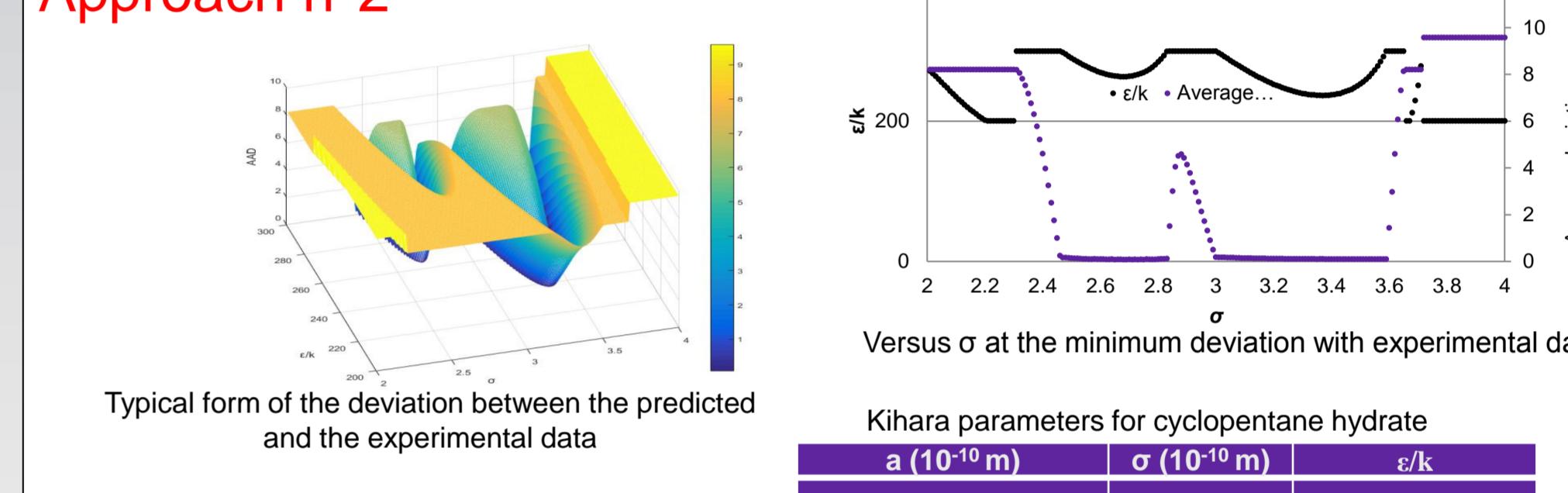
Approach n°3: Developing a new correlation $\theta = F(a_w)$



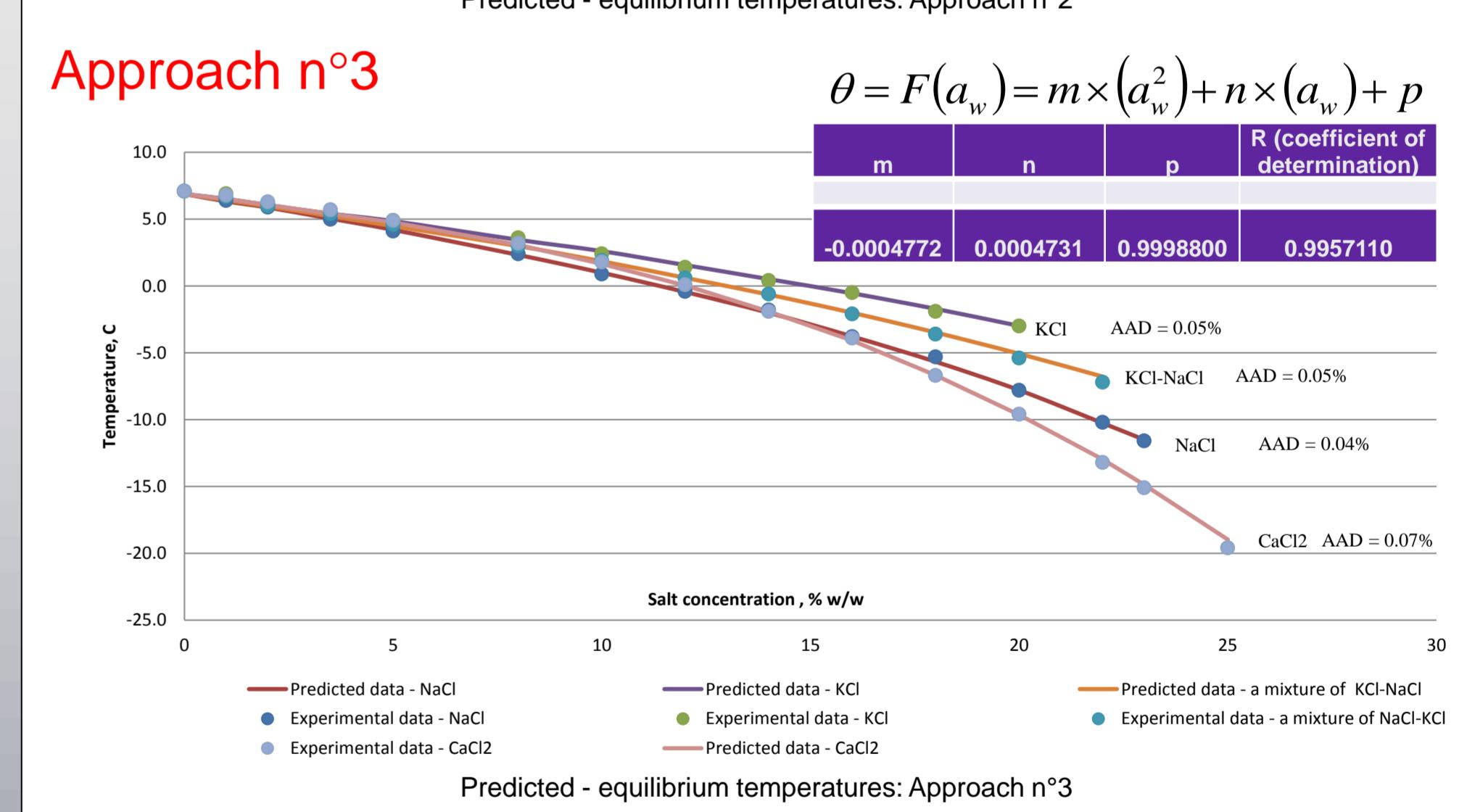
Approach n°1



Approach n°2



Approach n°3



Conclusions

- The equilibrium temperatures were determined following both the quick and the slow dissociation procedure.
- The equilibrium temperatures following the quick procedure are systematically higher than the ones from the slow procedure.
- Three approach have a good capacity to predict the equilibrium temperature, while the third can be a good suggestion as the deviation is almost zero for all kinds of salts.

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