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Transport of hydrate slurry at high water cut

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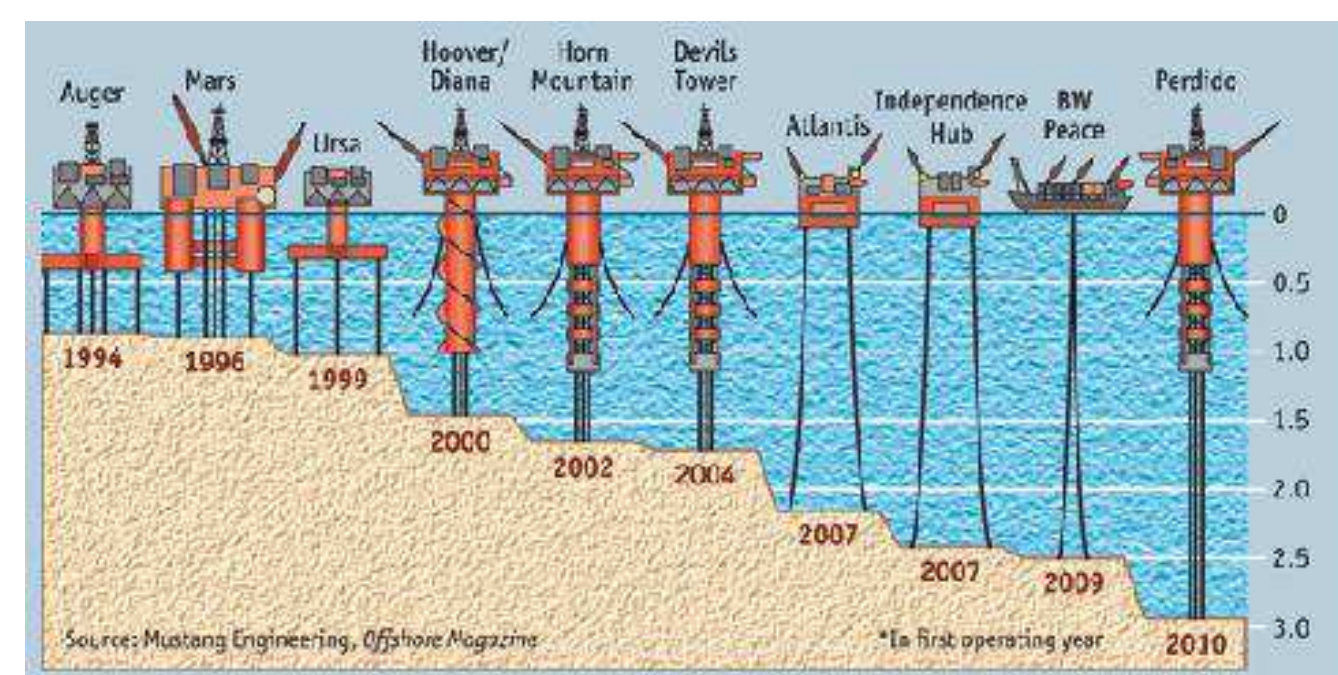
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Context

The increase on the offshore extraction of petroleum in deeper conditions represents a great concern in flow assurance, as it favors the conditions of hydrate formation (low temperature and high pressure).

Nowadays, another concern appears; as the oil/gas fields matures and the fraction of water increases.



Objective

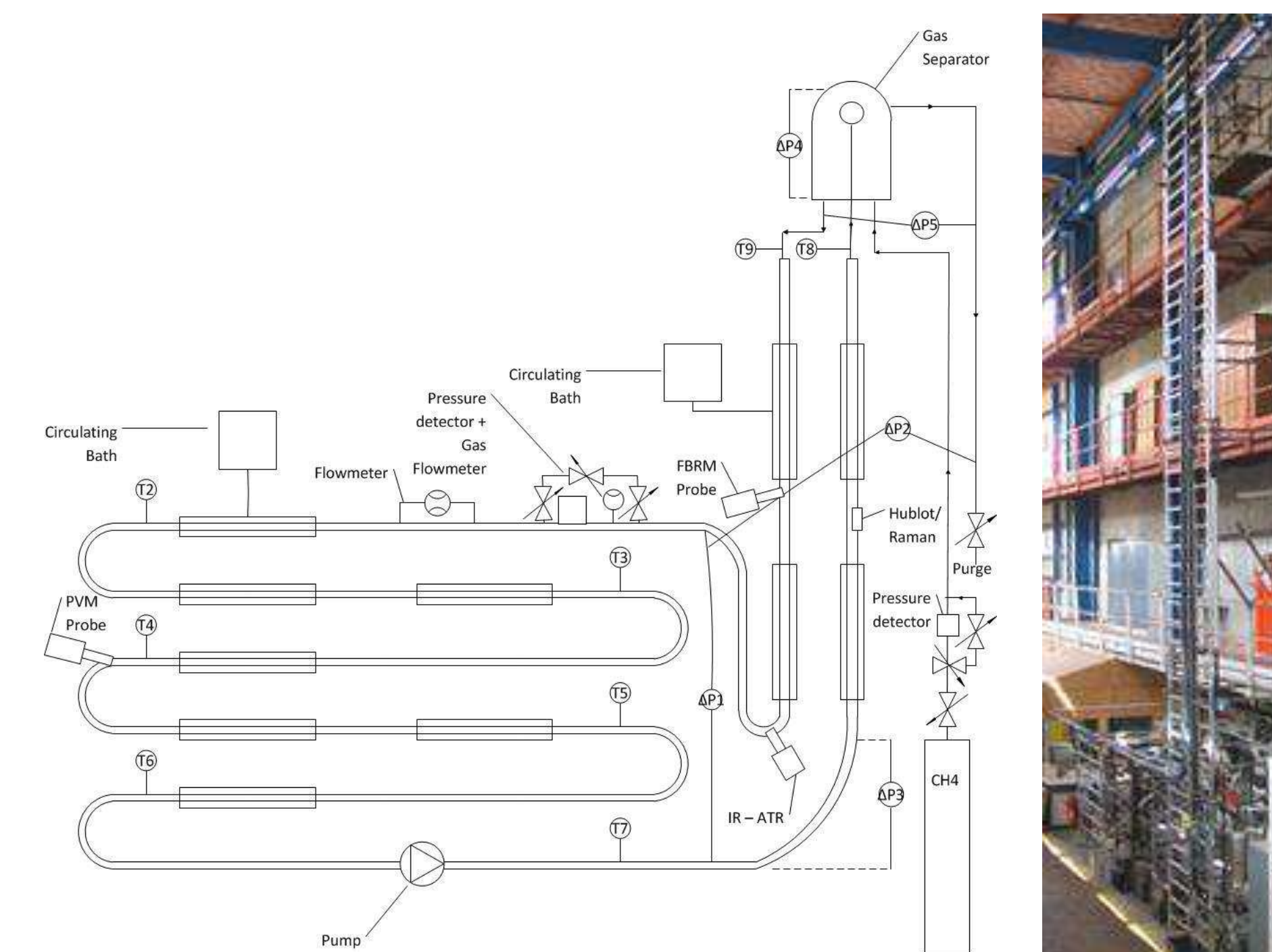
- To present the preliminary results of a experimental study of methane hydrate formation at high water cut.
- To observe the influence of a dispersant additive (anti-agglomerant – AA) in this kind of system.

Experimental Method

Experimental Conditions

Without AA	Flow Rate (L/h)	With AA	Flow Rate (L/h)	Additive (% vs. w)
Water Cut (%)		Water Cut (%)		
90	200	90	200	0.005
	400		400	0.005
80	200	80	200	0.01
	400		400	0.01
70	200	70	200	0.01
	400		400	0.01
60	200	60	200	0.01
	400		400	0.01

Experimental Apparatus



Experimental Results

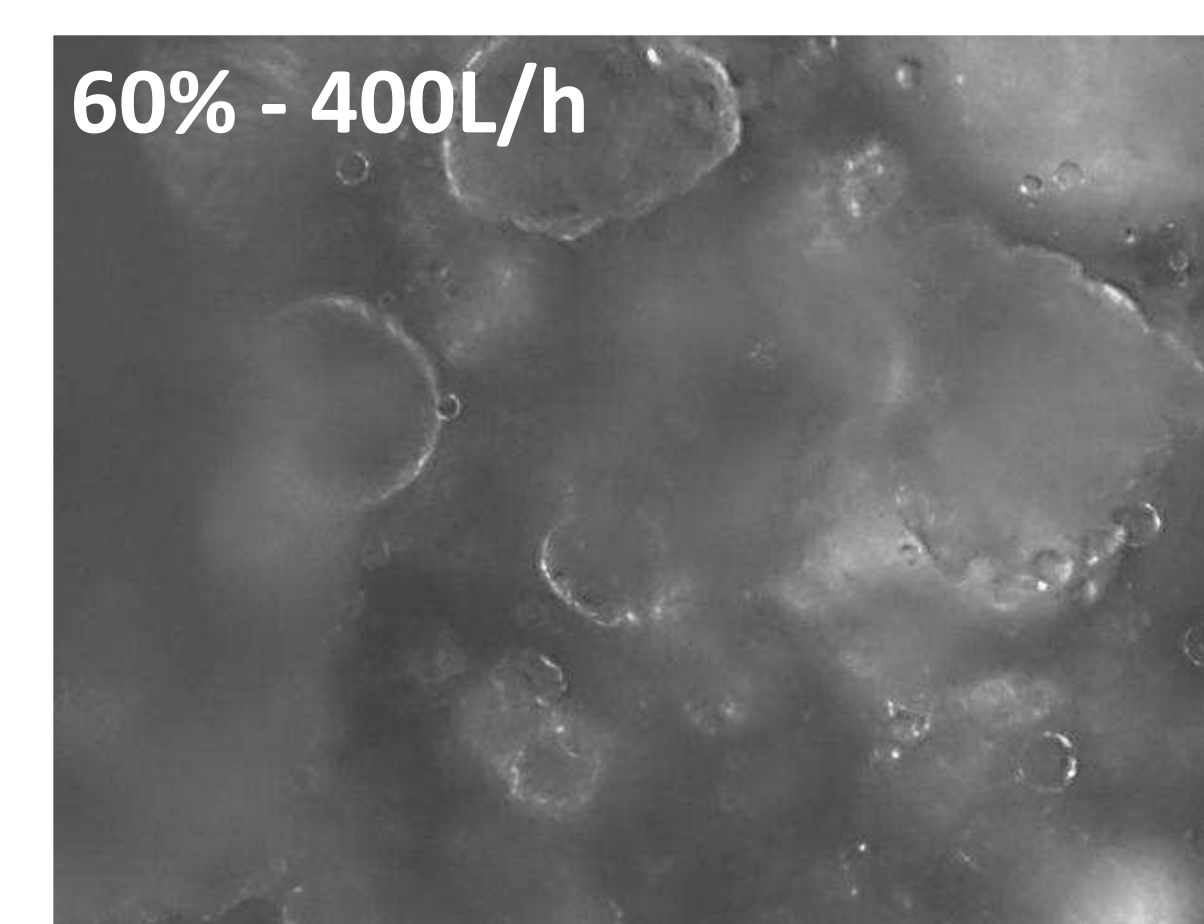
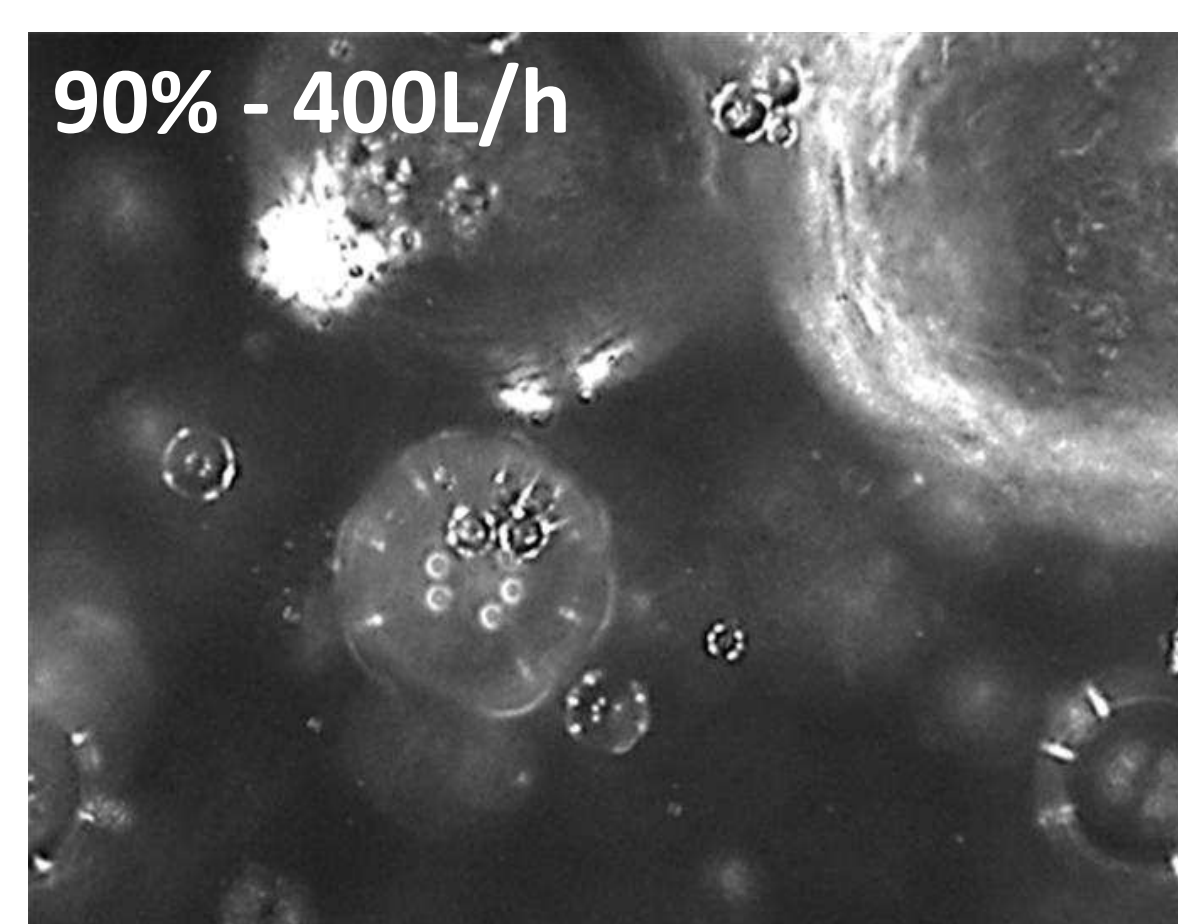
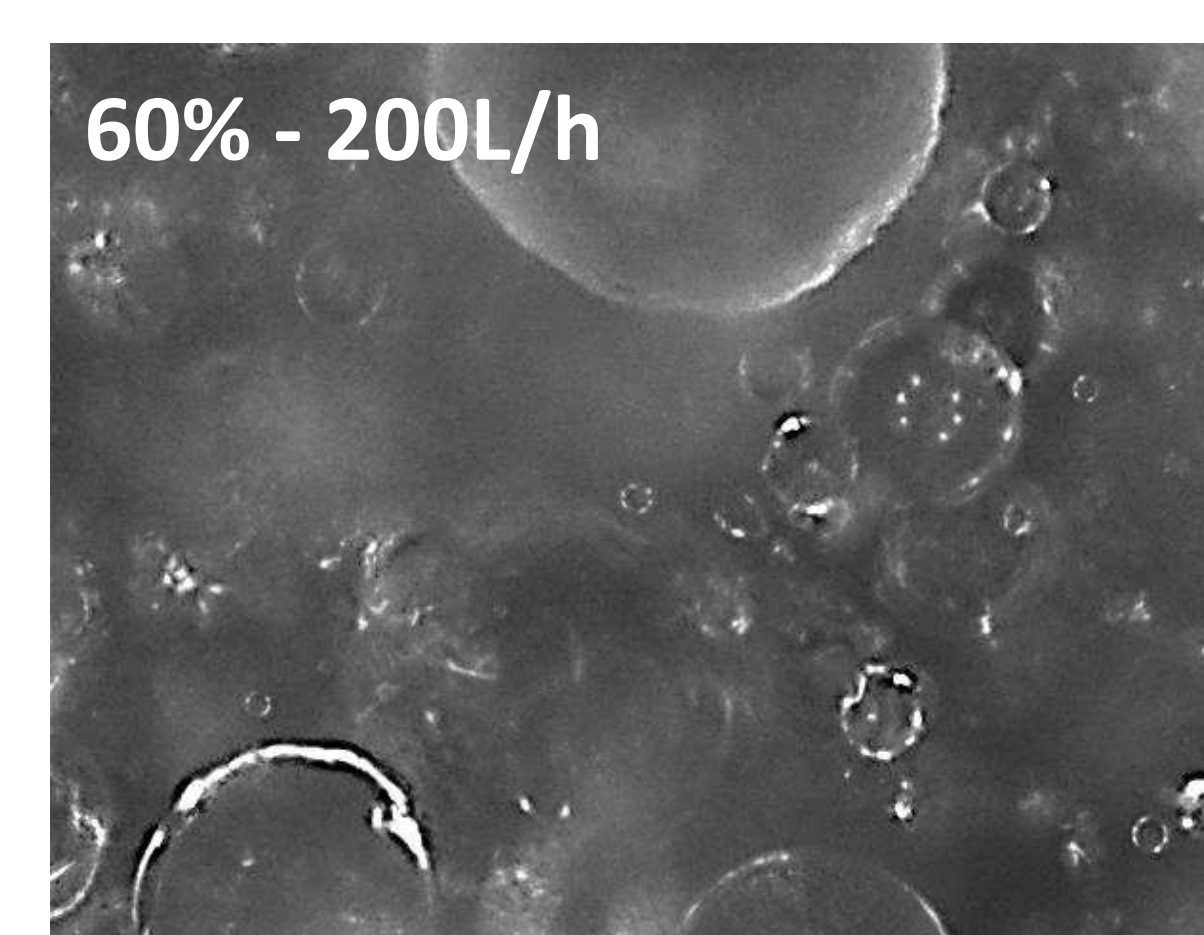
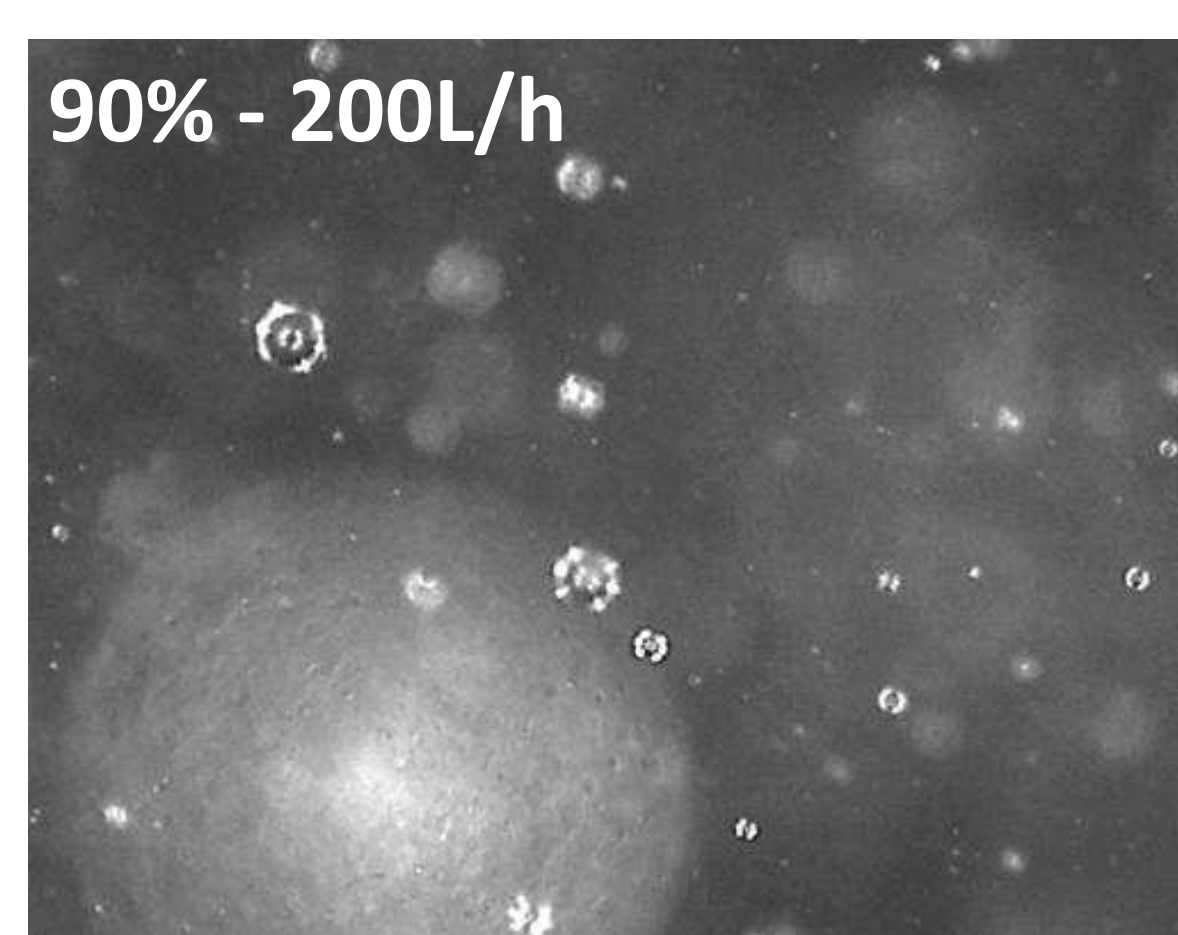
Emulsification and Rheological Study

Water Cut (%)	Flow Rate (L/h)	Without AA	With AA
		Average Chord Length (µm)	Average Chord Length (µm)
90	200	25	8
	400	26	9
80	200	22	10
	400	19	9
70	200	28	8
	400	23	10
60	200	27	9
	400	23	9

Without AA	Viscosity (mPa.s)
90	4.61
80	4.83
70	4.58
60	4.46

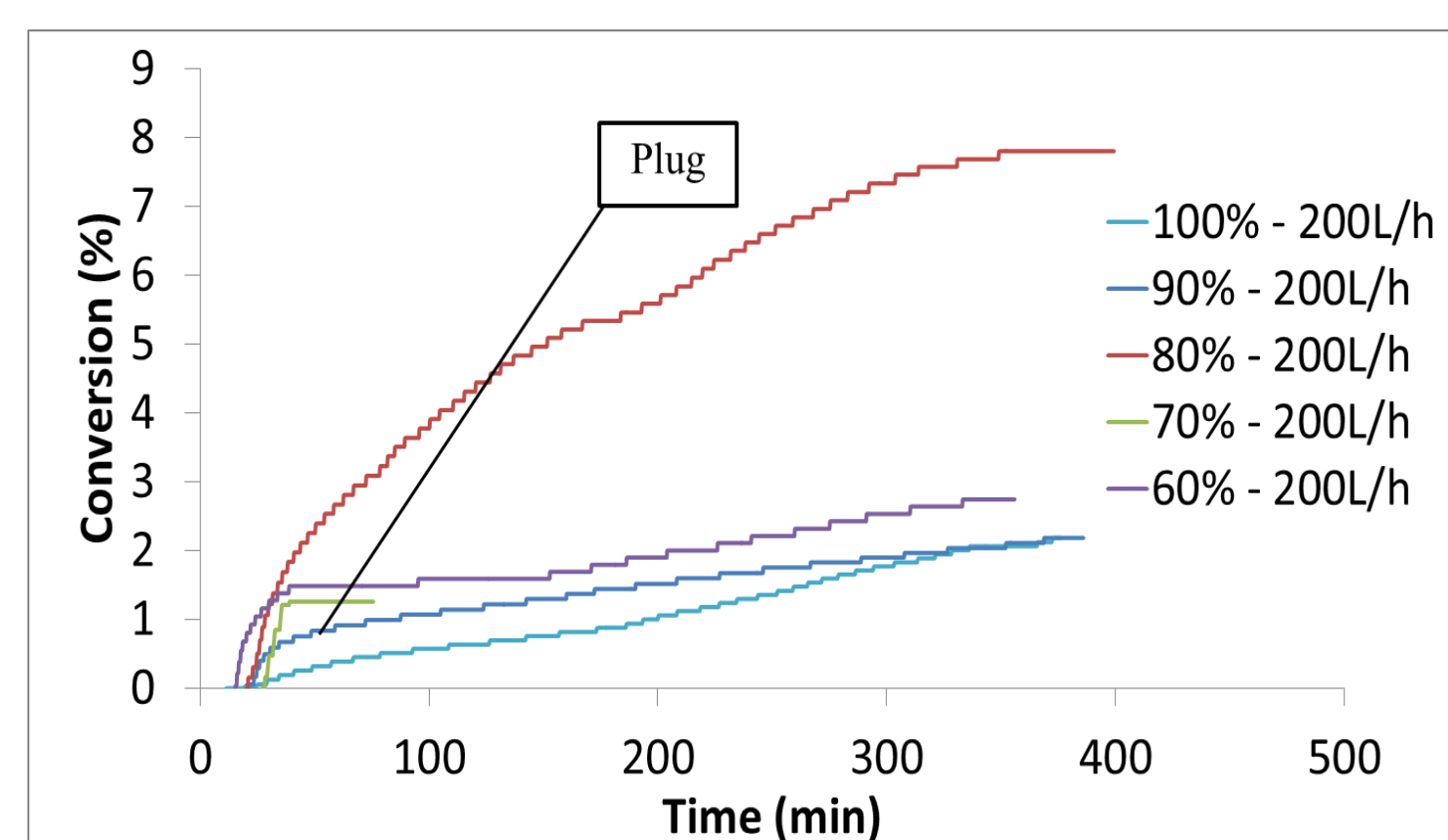
With AA	Viscosity (mPa.s)	Additive (% vs. w)
90	4.03	0.005
80	3.76	0.01
70	5.28	0.01
60	5.83	0.01

PVM Images from Crystallization (1050 x 800µm)

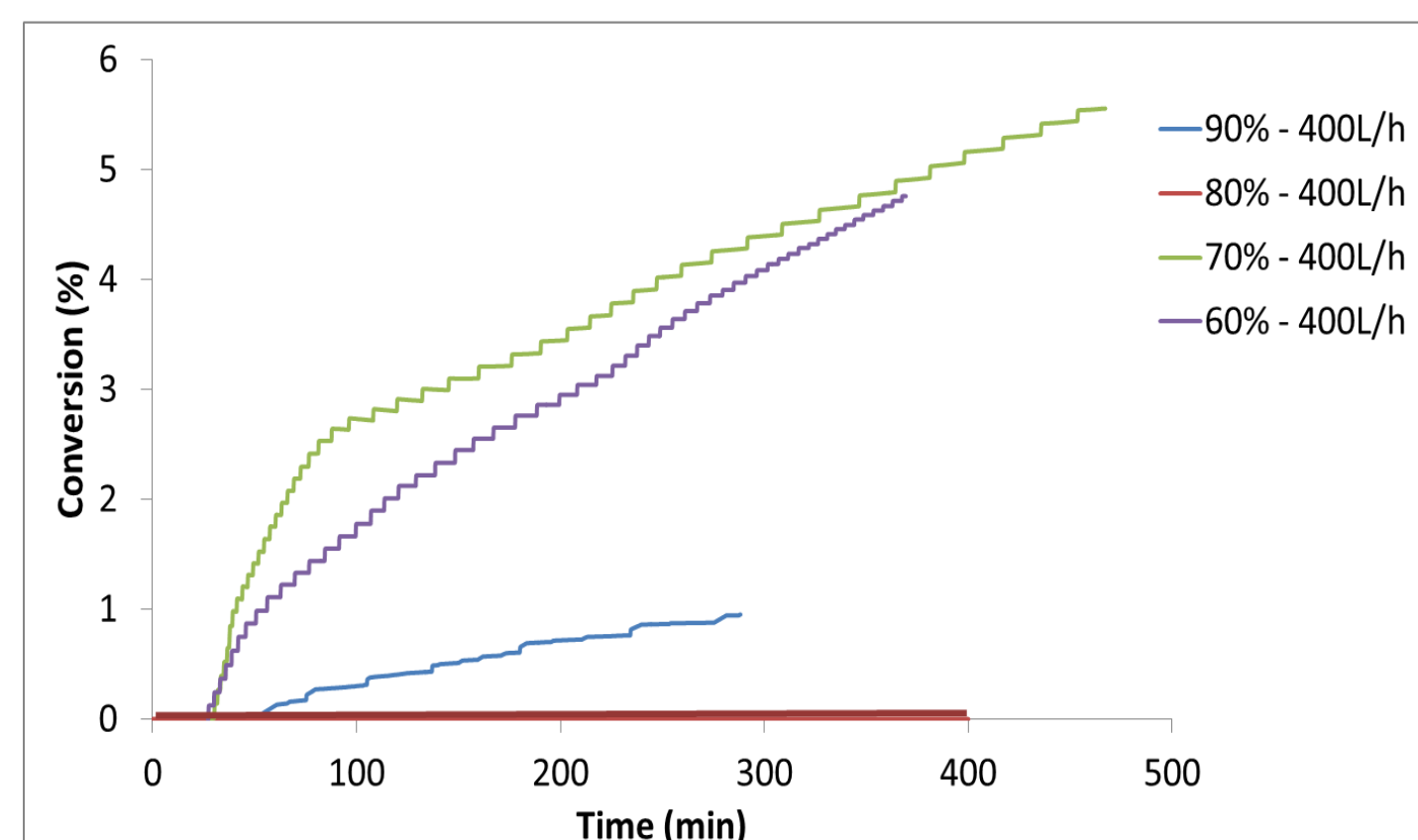
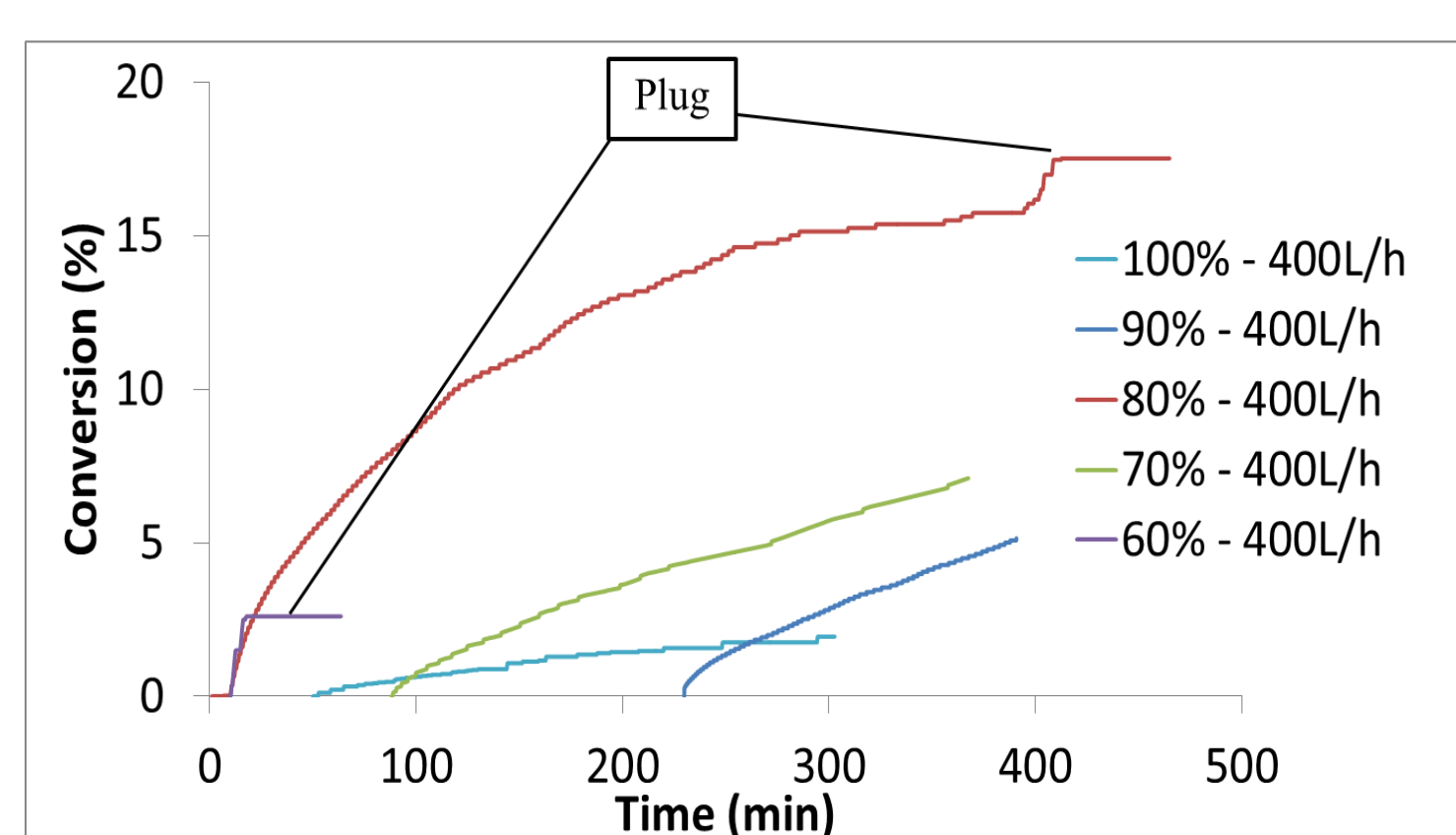
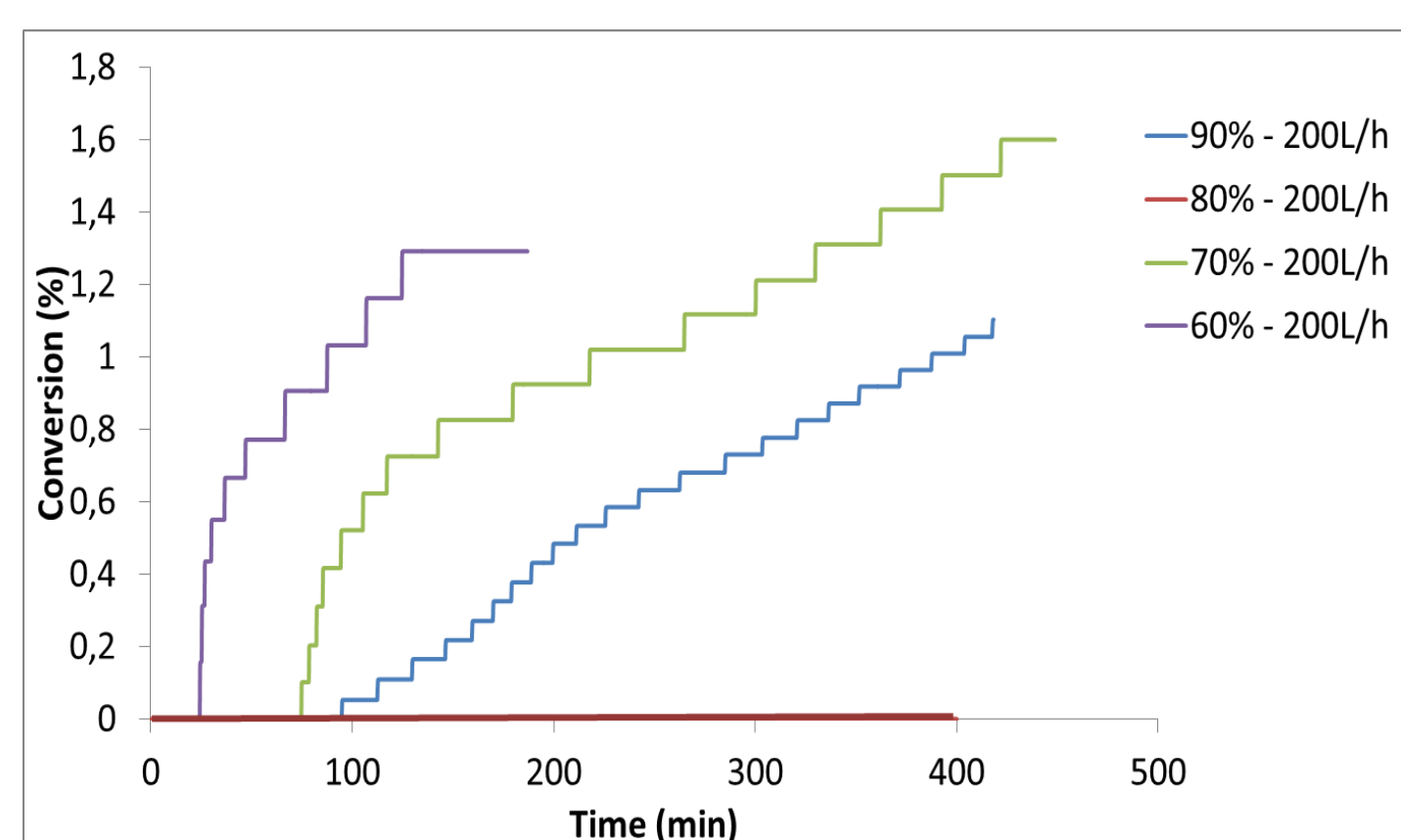


Crystallization

Without AA

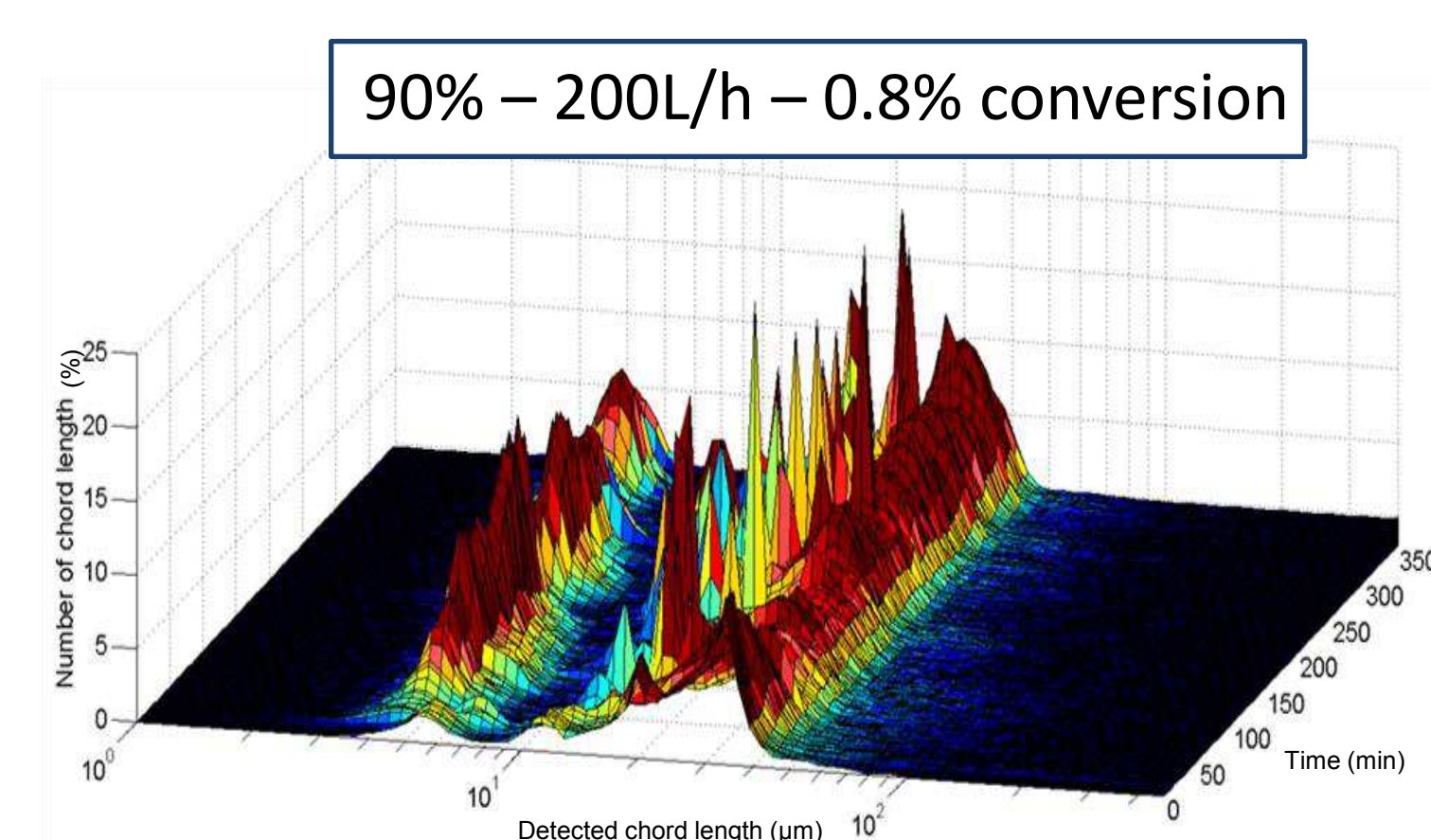


With AA

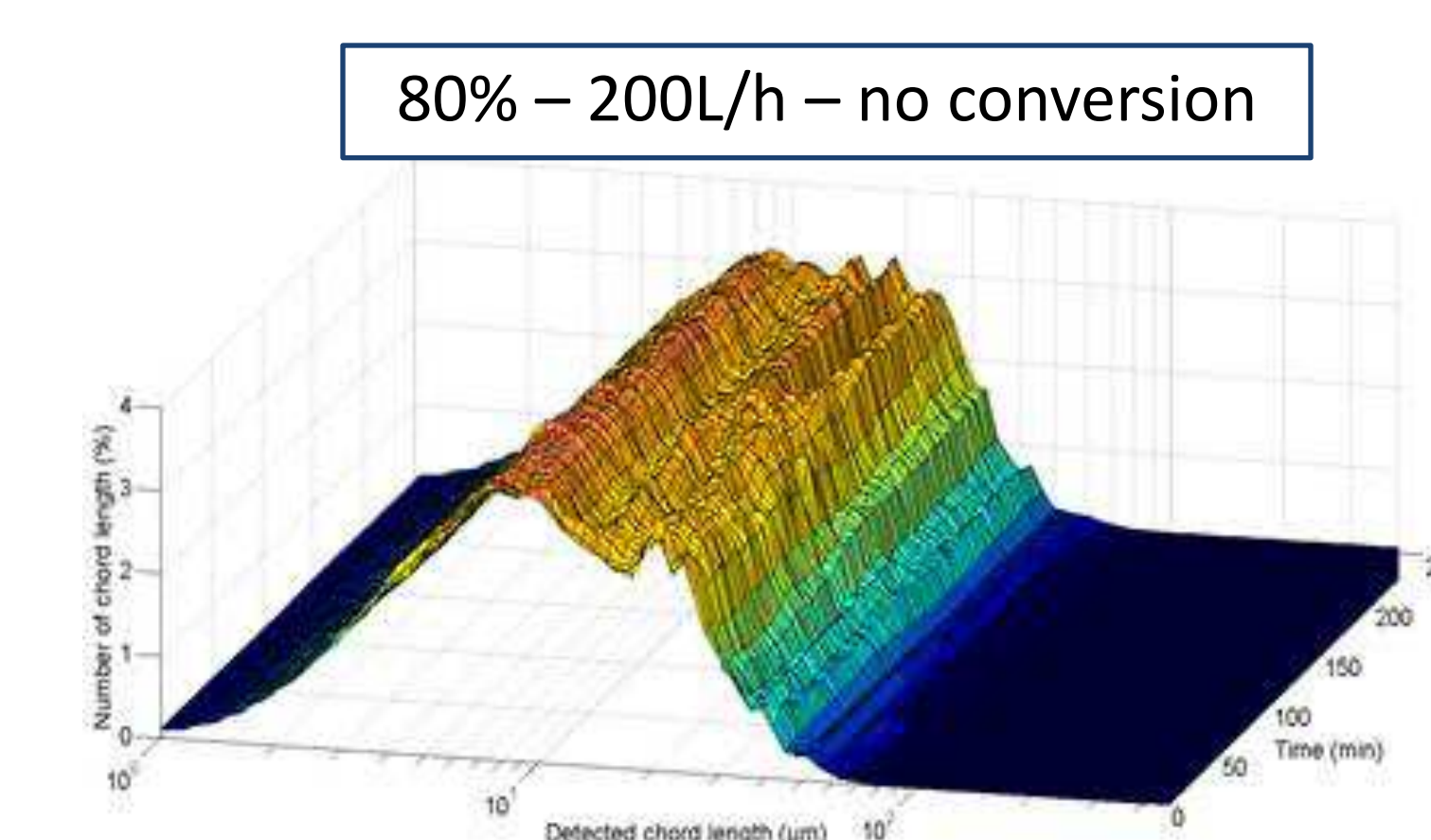


Chord Length Distribution

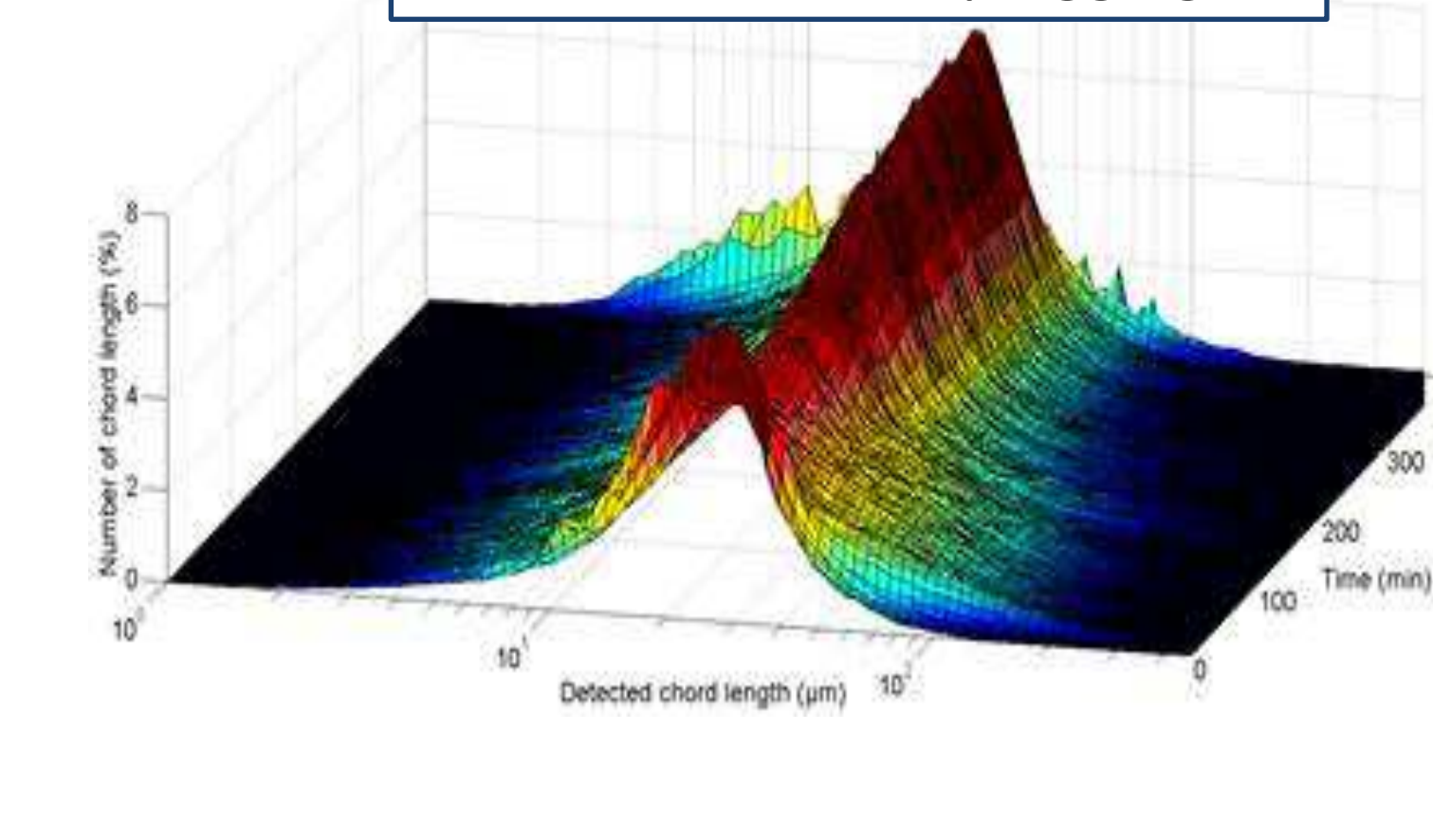
Without AA



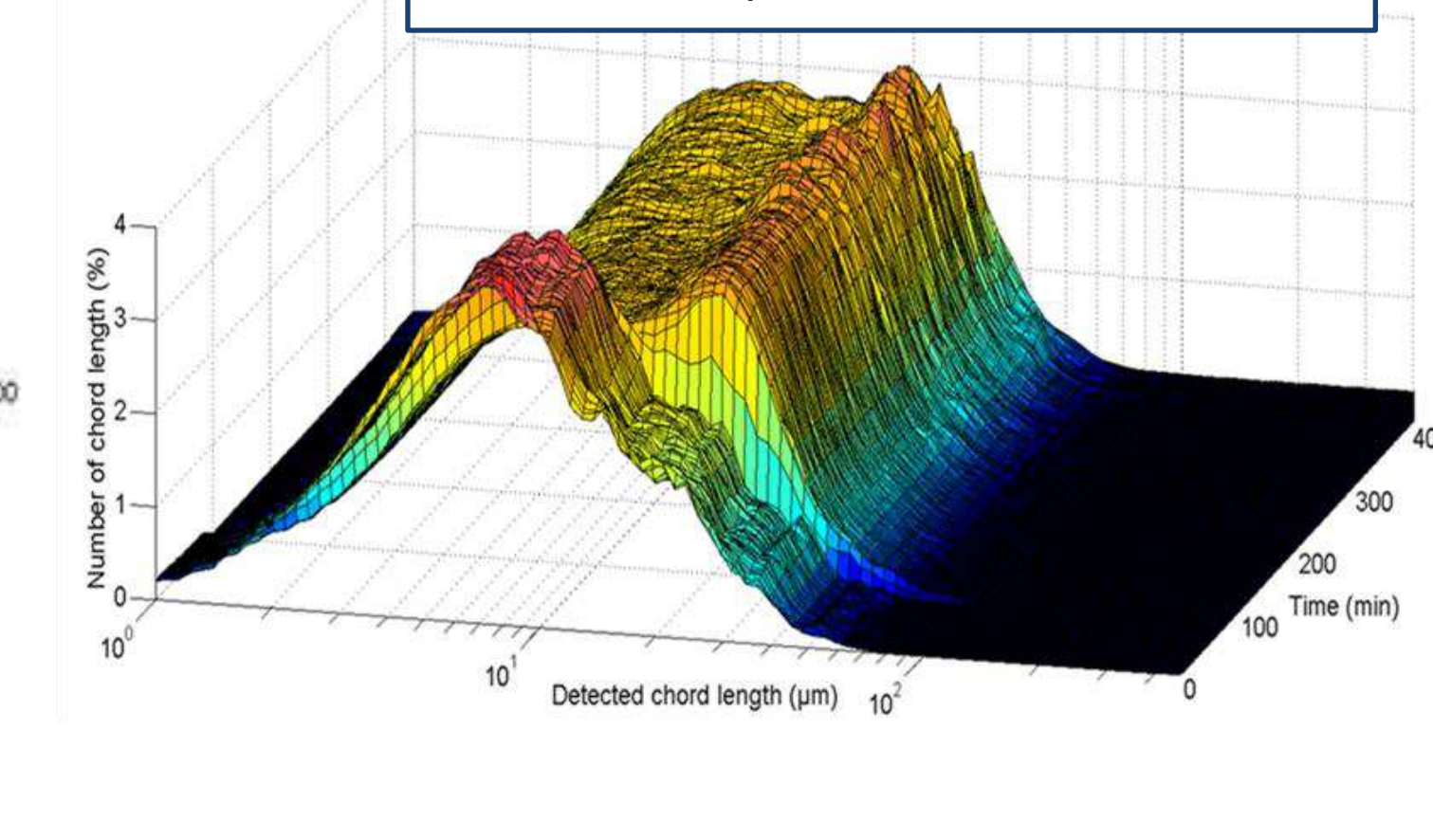
With AA



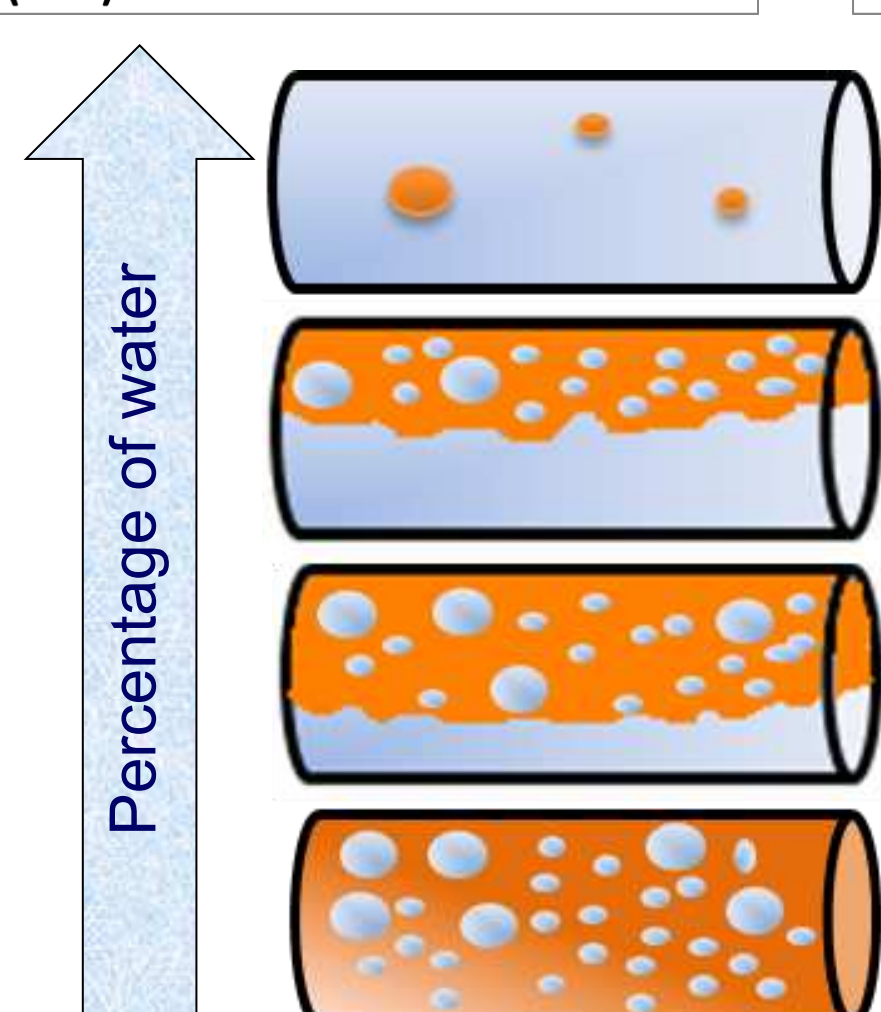
80% - 400L/h - plugging



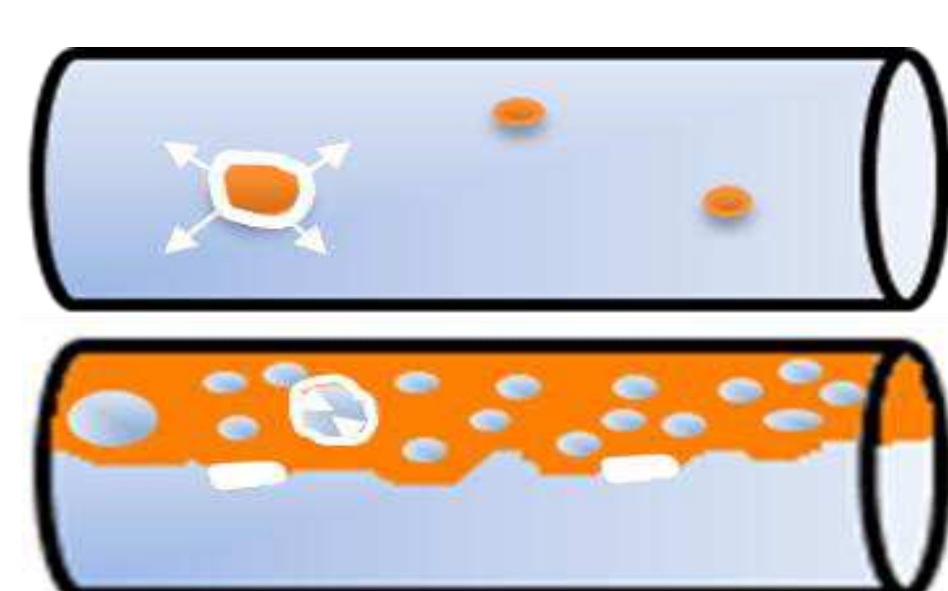
70% - 200L/h - 1.3% conversion



- Emulsion Model:



- Crystallization Model:



Conclusions

- The higher is water cut, the slower & less important is the hydrate formation.
- The percentage of additive seems to be more important at low water cut.
- The FBRM probe allows to differentiate between experimental results with and without AA.
- The PVM probe allows the observation of the emulsions and crystallizations without AA.

References:

Joshi SV, Grasso GA, Lafond PG, Rao I, Webb E, Zerpa LE, Sloan ED, Koh CA, Sum AK. *Experimental flow loop investigations of gas hydrate formation in high water cut systems*. Chemical Engineering Science. vol. 97. 2013. p. 198-209.

Greaves D, Boxall J, Mulligan J, Sloan ED, Koh CA. *Hydrate Formation from High Water Content-Crude Oil Emulsions*. Chemical Engineering Science. vol. 63. 2008. p. 4570-4579.