Primary Gushing by “Gushing Task Force” (GTF)

Christina Schönberger
Guy Derdelinckx
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In collaboration with:
Sylvie Deckers
Tuija Sarlin

Overview

- Gushing and carbonated beverages
  - CO_2 properties
  - Hydrophobin properties
  - Mechanism
- Gushing Task Force consortium
  - Targets
  - How to join
  - Next activities

Definition : Gushing

- = overfoaming at bottle opening of a **carbonated** beverage without any shaking



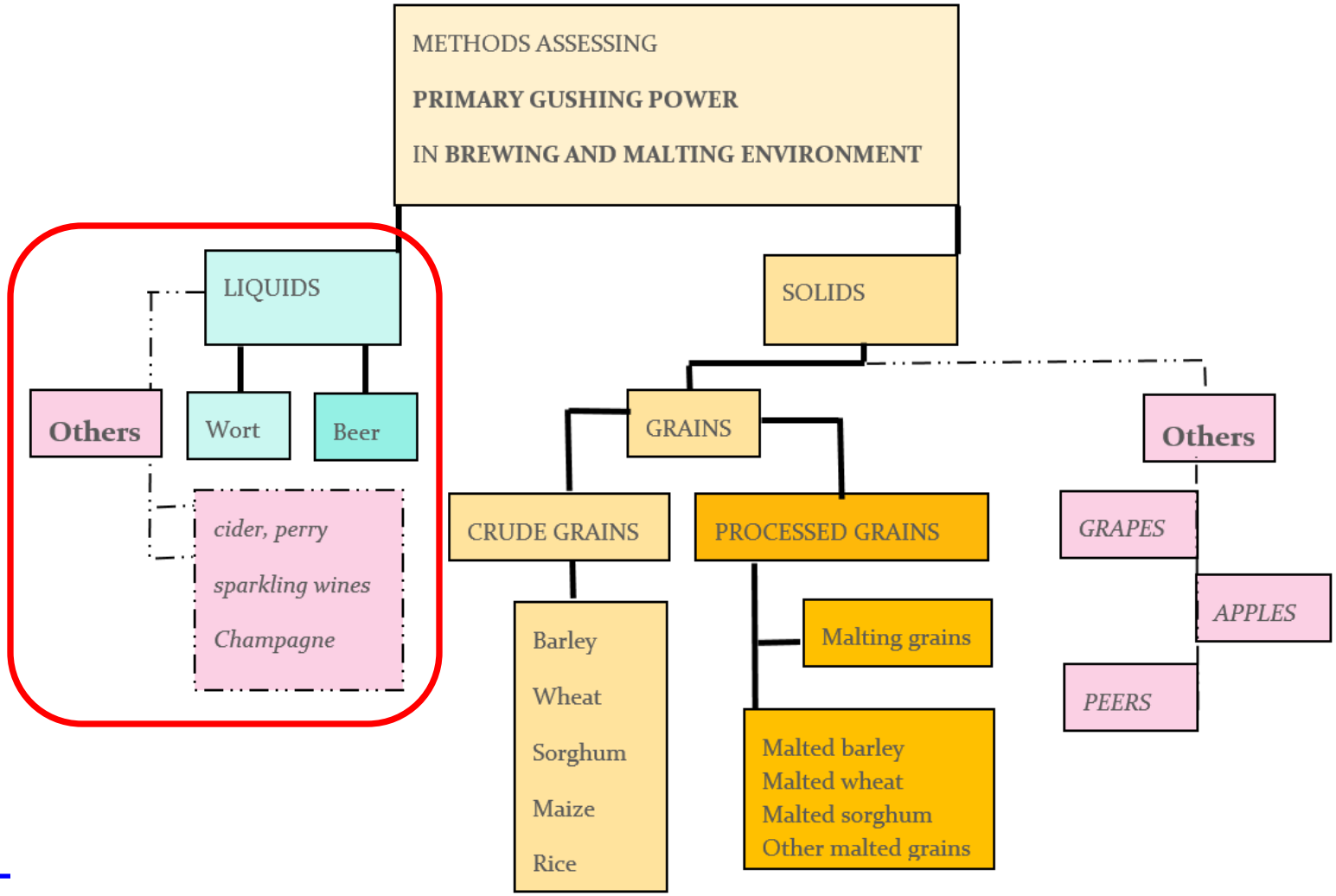




Carbonated beverages

= beverages containing dissolved CO_2

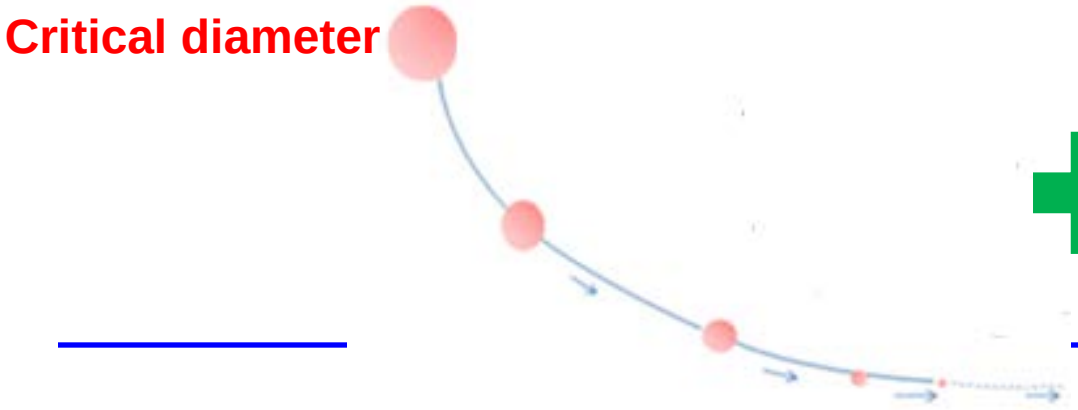
Work frame of GTF



Properties of CO_2

- Hydrophobic gas
- Solubility : 1,66 g/L (P_{atm}, 25°C)

  ⇨ 8-9 g/L (carbonated beverages)
- Injection and dissolution of gaseous CO_2 and/or production by refermentation



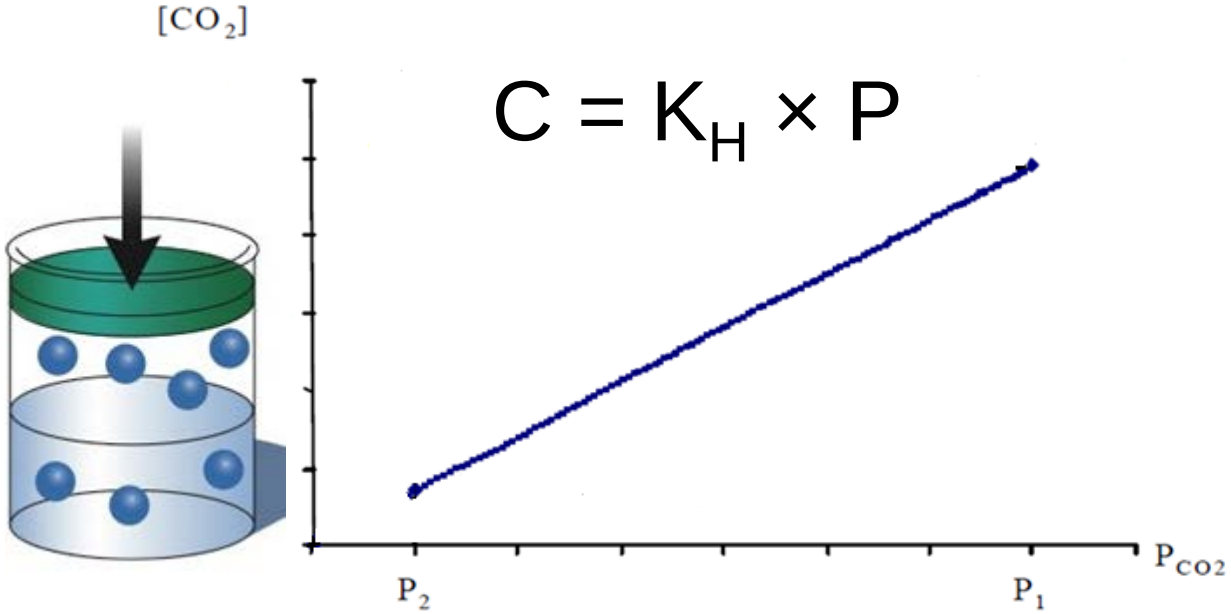
+ Pressure (Henry's Law)

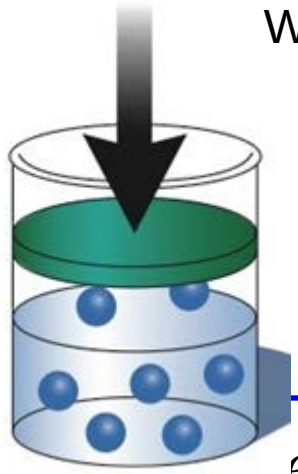
CO_2 properties: Henry's Law

The solubility of a pure gas into a liquid is directly proportional to the partial pressure of that gas above the liquid

William Henry

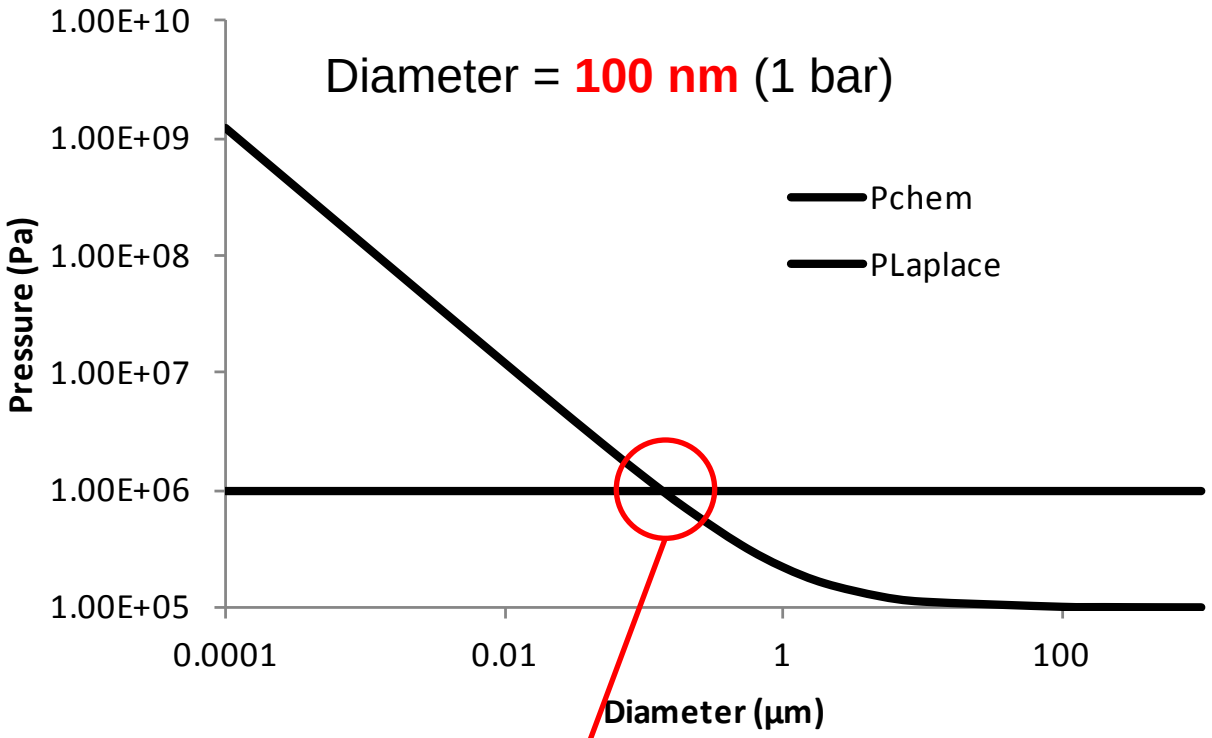
$$C = K_H \times P$$





e of Beer

CO_2 properties: Critical diameter



$K_H \times C = P_{ambient} + 2\gamma/r$

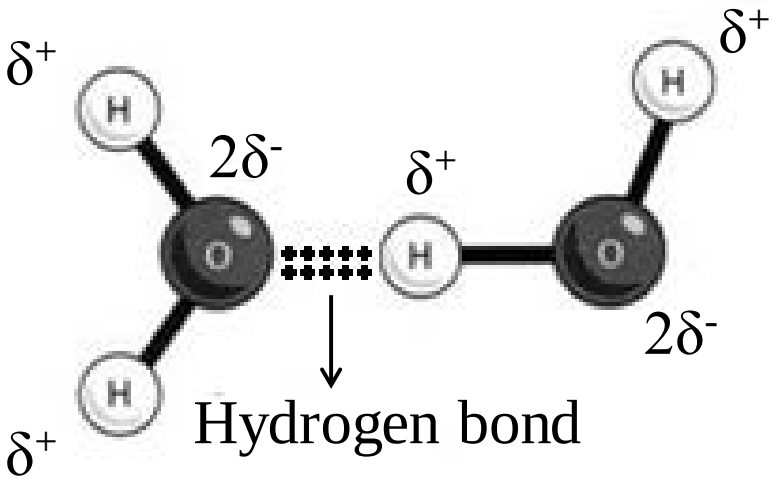
Henry's Law

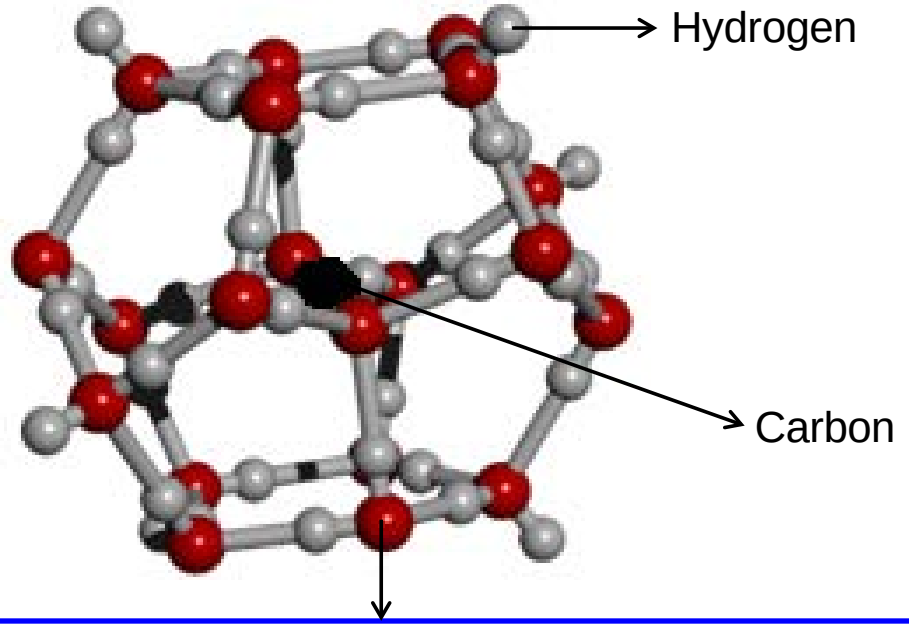
Young-Laplace's Law

CO_2 properties: Hydrogen bond

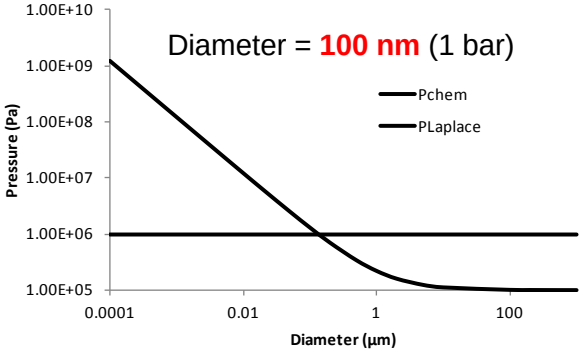
$$CO_2\,(g) \underset{}{\overset{K_H}{\rightleftharpoons}} CO_2\,(d) + H_2O \overset{K_s}{\rightleftharpoons} H_2CO_3 \overset{K_{a1}}{\rightleftharpoons} HCO_3^- + H^+ \overset{K_{a2}}{\rightleftharpoons} CO_3^{2-} + 2H^+$$

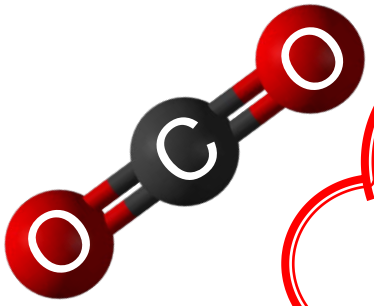
Henry's Law



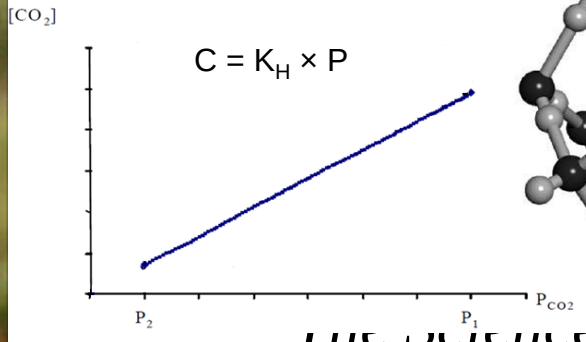


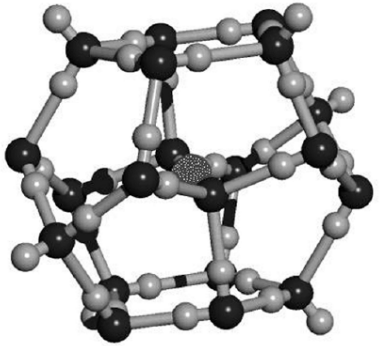
CO_2 properties : Summary





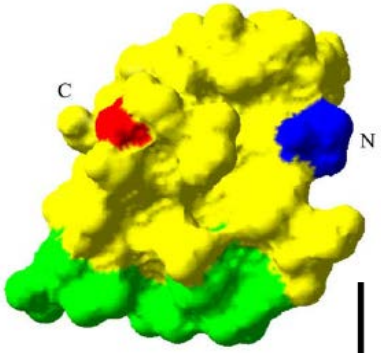
- **Hydrophobic**
- **Critical diameter**
- **Pressure**
- **Hydrogen bond**



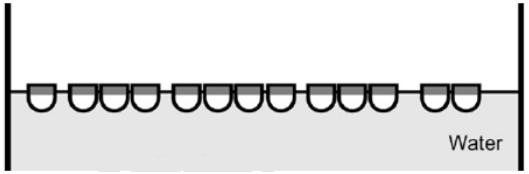


The Science of Beer

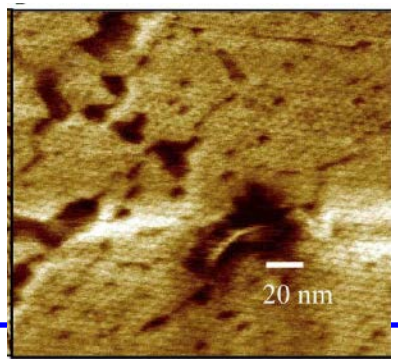
Properties of hydrophobins : Summary

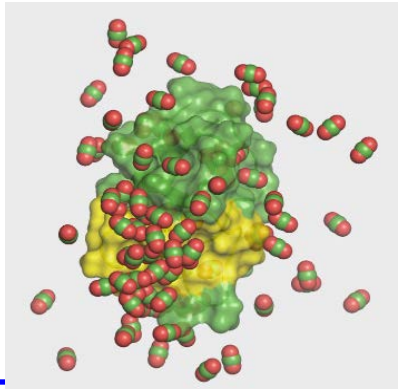


Rath (EBC 2015): « *Fungal hydrophobins are present in detectable quantities in beers with gushing potential* »



- **Hydrophobic patch**
- **Surfactant**
- **Elastic structure**
- **CO_2 interaction**





The Science of Beer

EBC 2015 – Euromalt Gushing Project

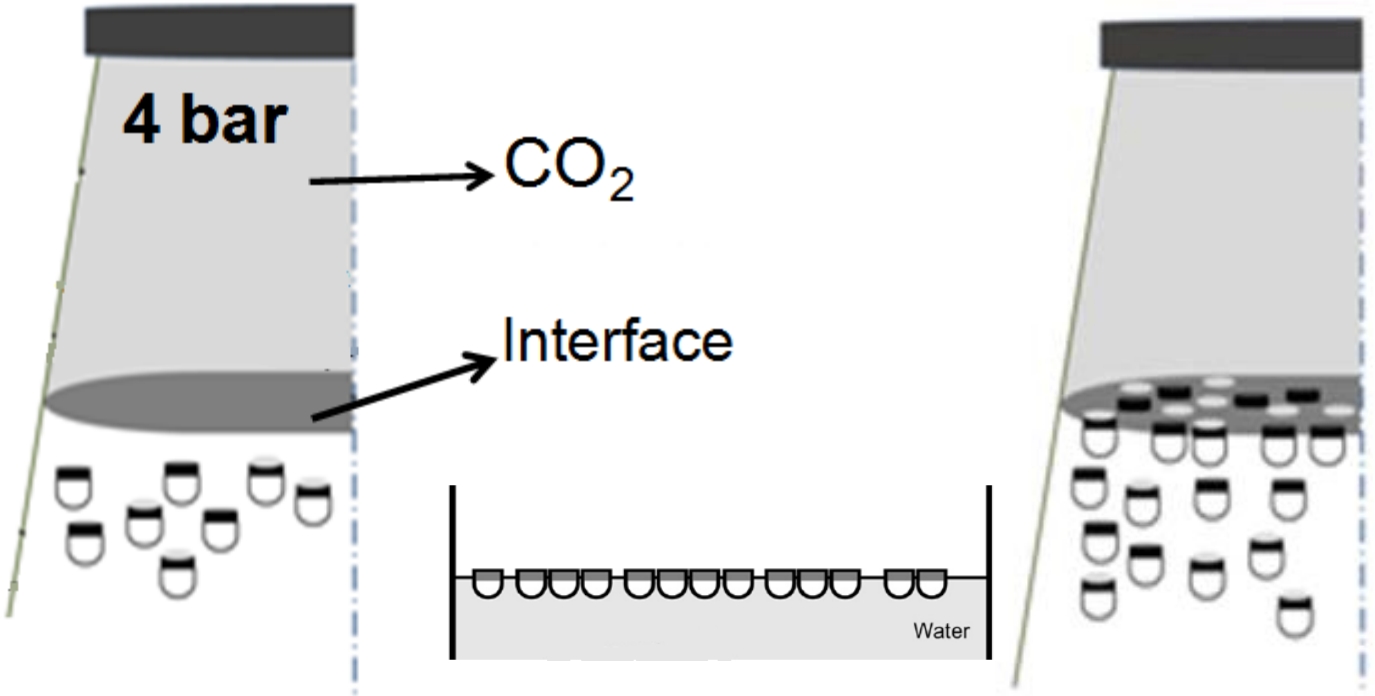
- « *No clear correlation between the concentration of fungal hydrophobins and overfoaming could be observed. It is unlikely that fungal hydrophobins are the sole cause of gushing. It was not possible to define an applicable hydrophobin threshold* »

Amount of hydrophobin µg/0.33 L beer	Amount of beer gushed (g)			
	T. reesei HFBI	*T. reesei* HFBII	*F. poae*	*Nigrospora* sp.
0.01	0	0	nd	nd
0.1	0	0	nd	nd
1	10	12	0	0
10	189	192	0	66
45	nd	nd	27	183
60	nd	nd	80	nd

nd = not determined.

Sarlin et al., 2005

Mechanism

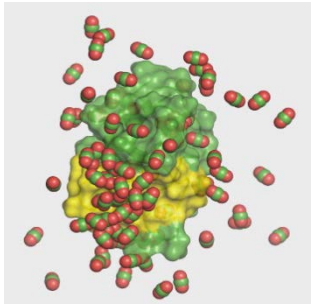


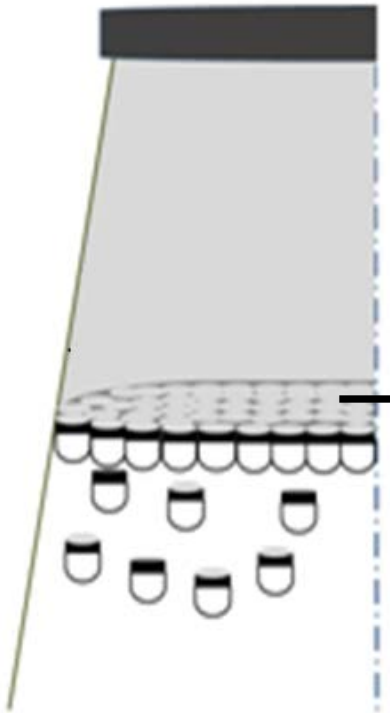
Surface Tension
45-72 mJ/m² (beer-water)

Hydrophobins migrate to the interface

Mechanism

Contamination and concentration
⇨ Self-assembly

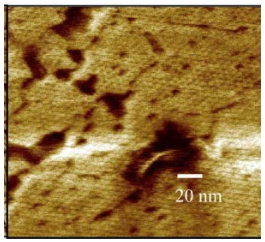




Shaking

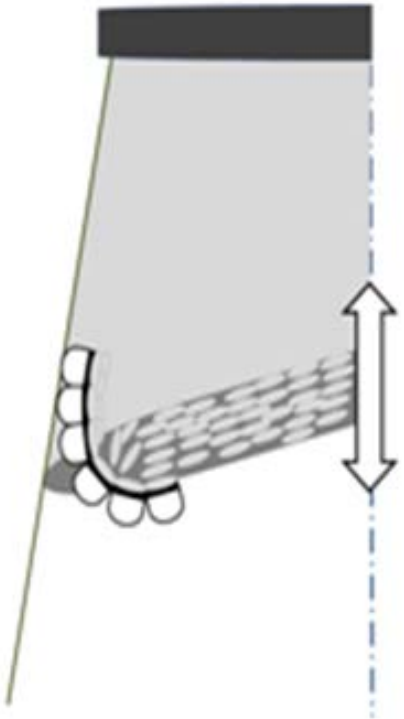
structure

Vertical movement



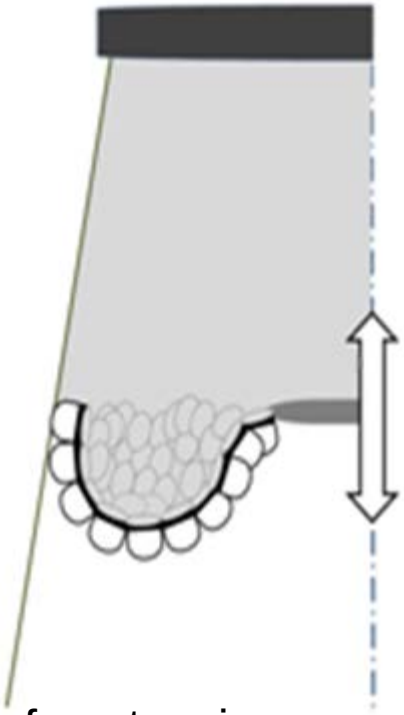
Surface tension
30 mJ/m²

Orverpressure in the bottle neck
Interaction hydrophobin - glass



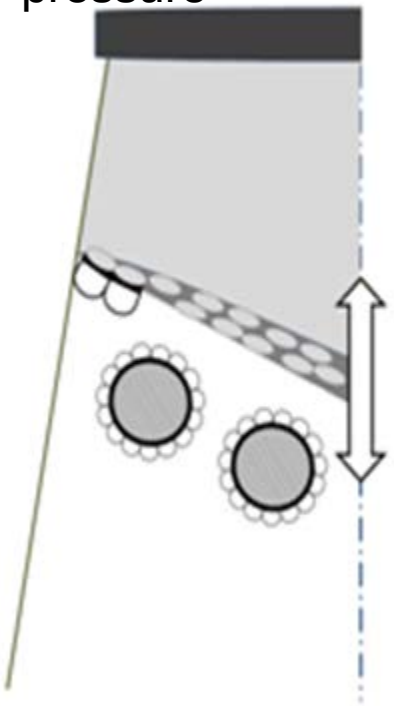
Mechanism

Formation of the nanobubble
Return to Henry's equilibrium

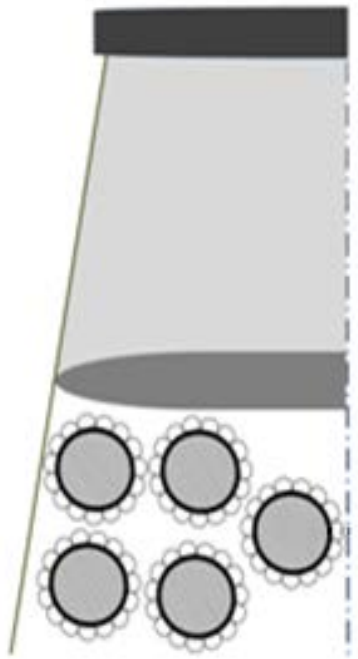


Surface tension
45-72 mJ/m² (beer-water)
30 mJ/m² with hydrophobin

Closing of the nanobubble by Young-Laplace's pressure

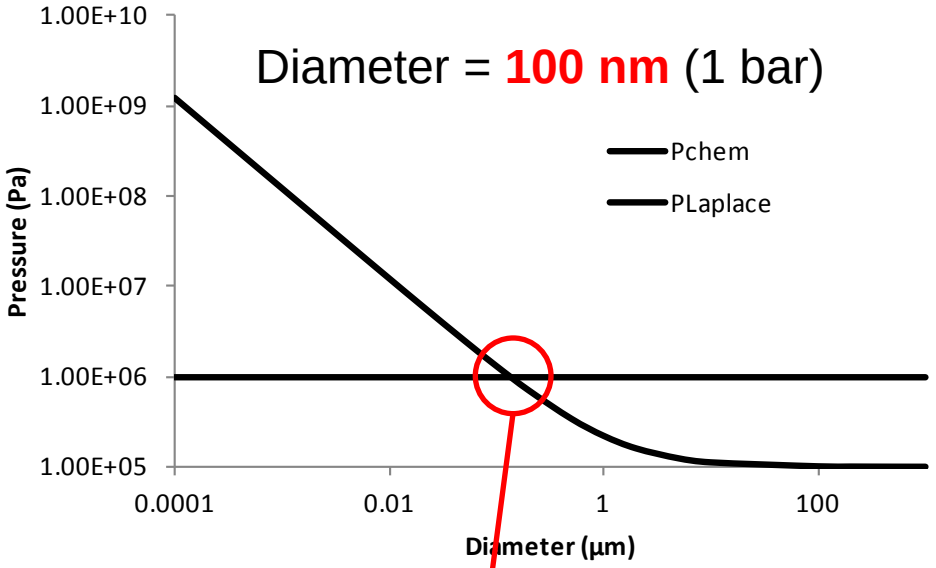


Mechanism



Diameter = 63 nm (4 bar)

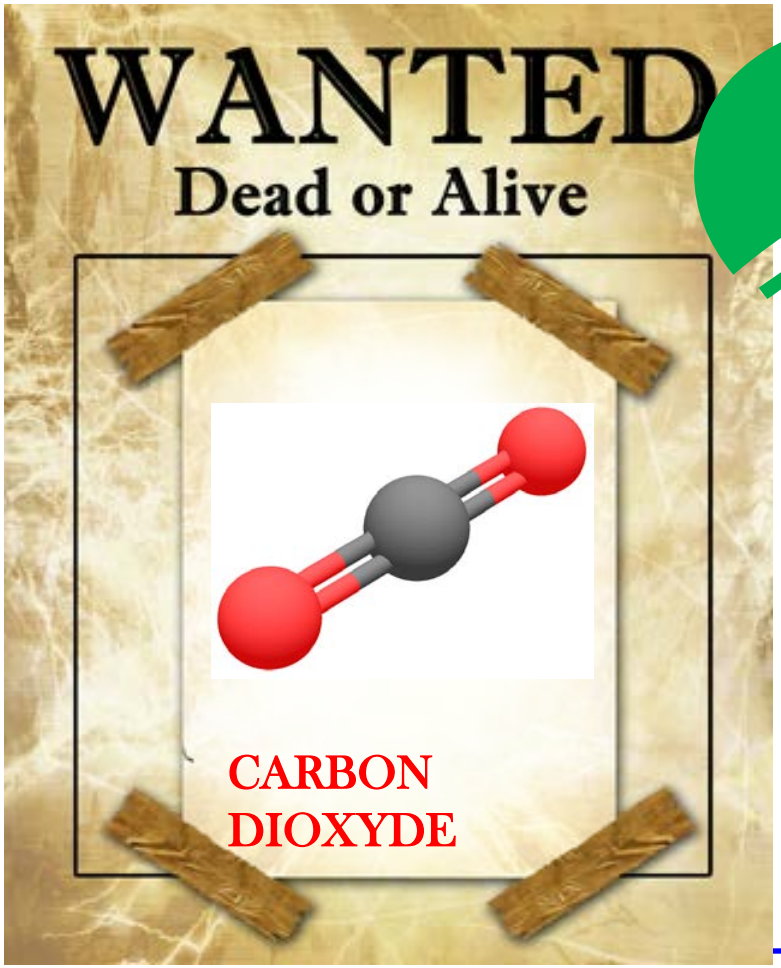
Boyle-Mariotte's Law
(PV = cst)

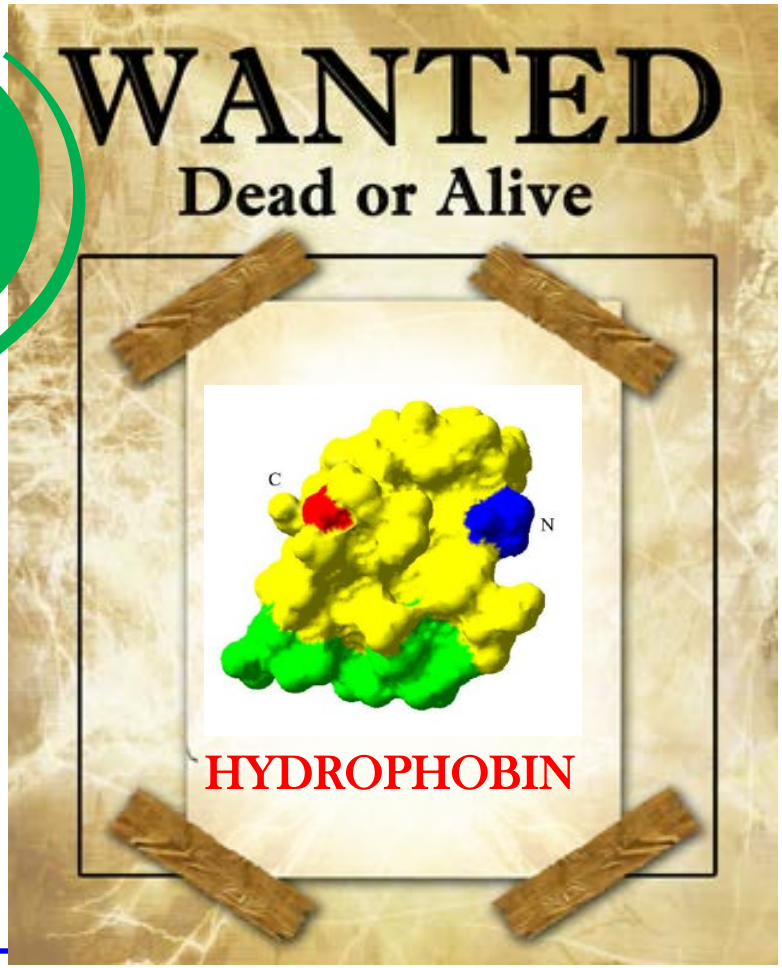


$K_H \times C = P_{ambient} + 2\gamma/r$

Henry's Law Young-Laplace's Law

Who is the true responsible



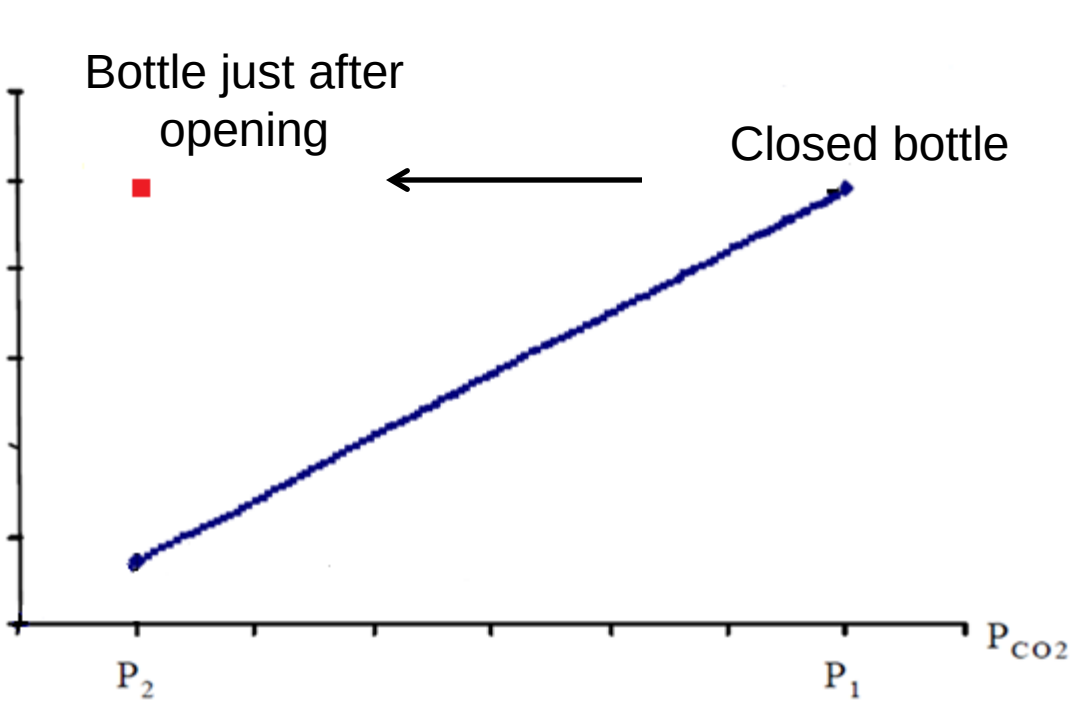


Precision of the definition

- Gushing = ~~overbarrin~~

= nucleation problem

Henry's Law : Supersaturation



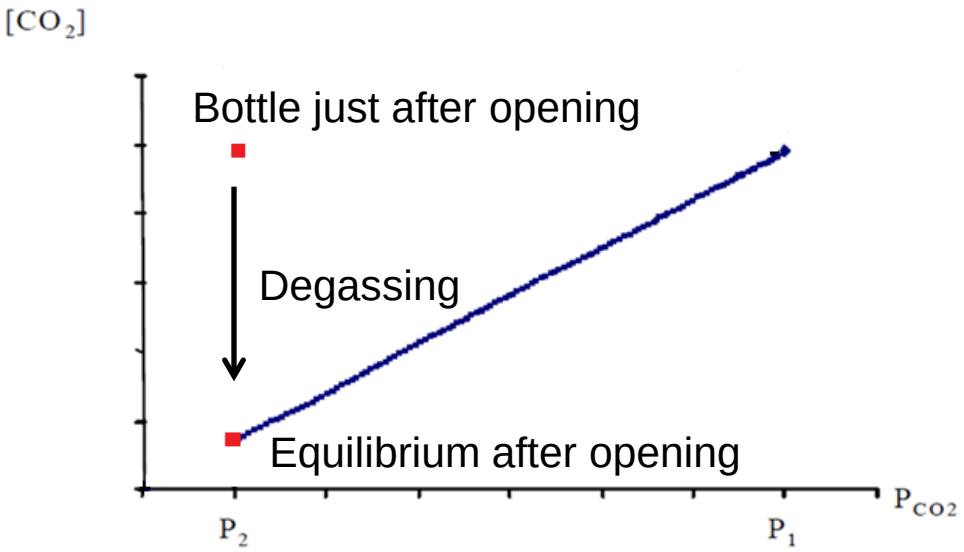
– $P_1 \rightarrow P_2$

– Concentration $\approx$

} Supersaturation
(concentration at P_1 is higher than the concentration at equilibrium P_2)

Henry's Law : Degassing

- Diffusion : Long

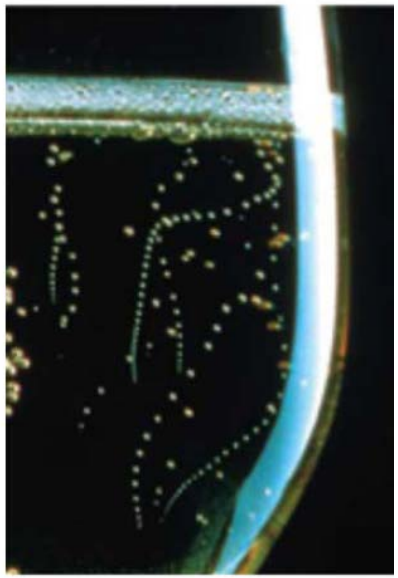


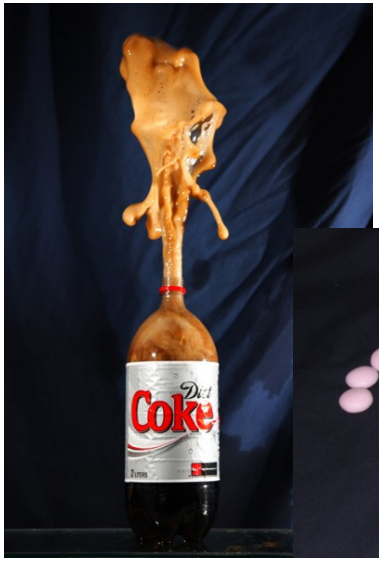
Overcarbonated beverage

Degassed beverage

- Nucleation ⇨ Nucleation sites

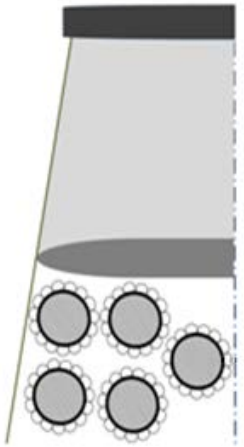
Nucleation





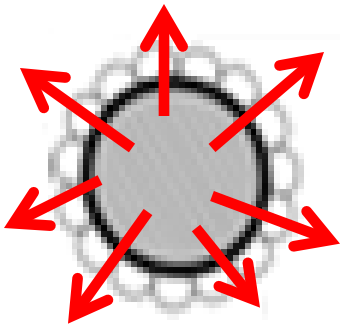
The Sci

Primary Gushing : bottle opening



Depressurisation
4 bar ⇨ 1 bar

Explosion of nanobubbles



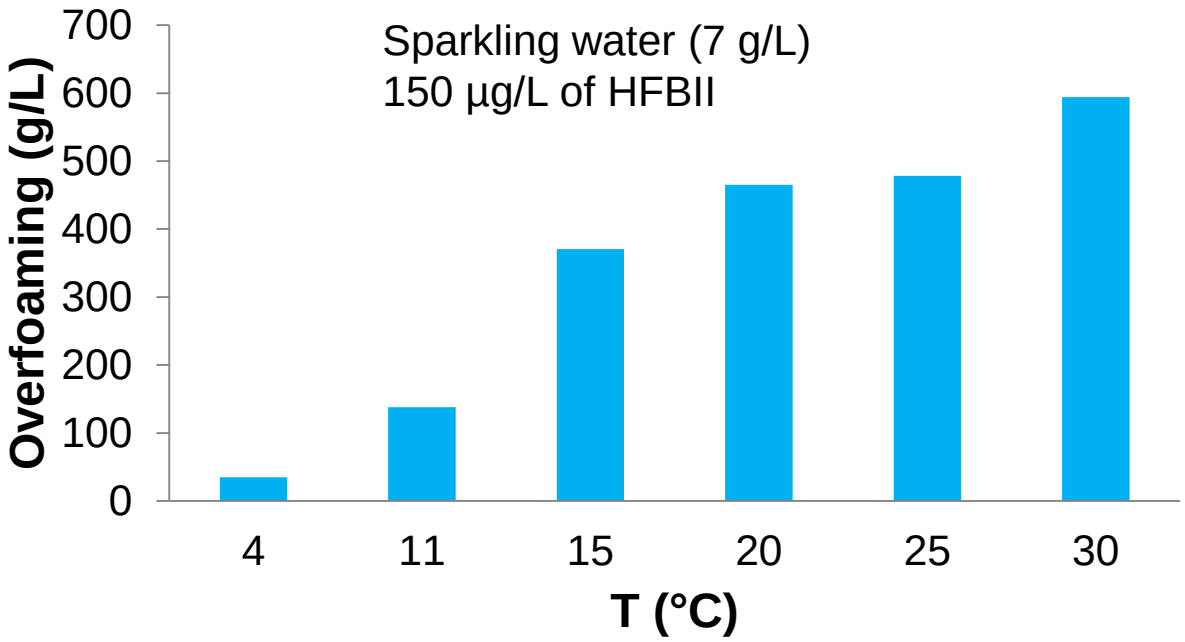
or

=

Breaking of the hydrogen bonds between water and CO_2 and liberation of CO_2

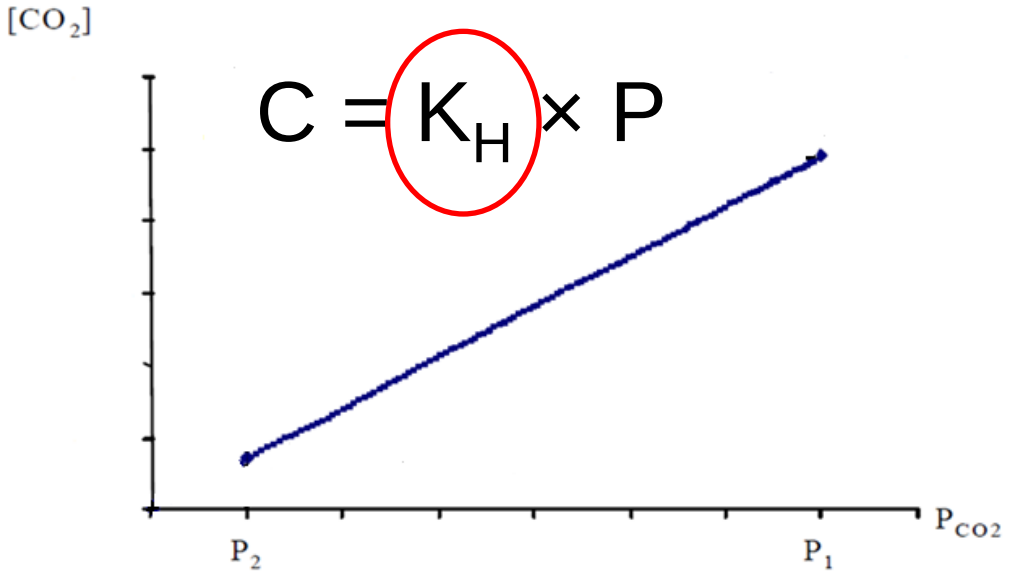
Effect of the temperature

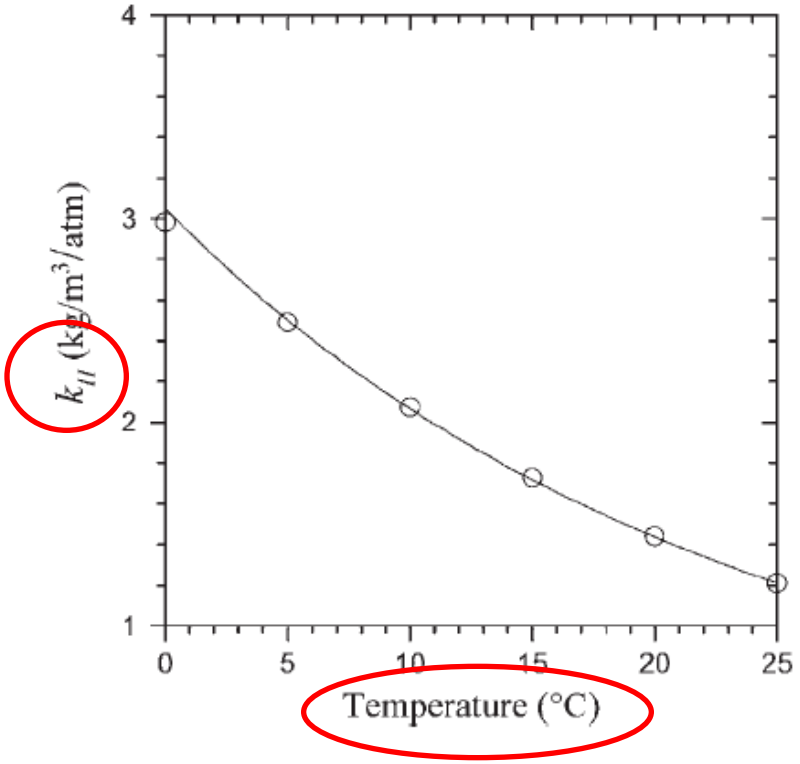
2°C



25°C

Henry's Law : Temperature





See also Poster 40

Targets of GTF

- Creation of a scientific forum of experts on “Primary Gushing”

Institutes involved : TUM, VLB, KULeuven, VTT, BLQ, IFBM, ICPF,…

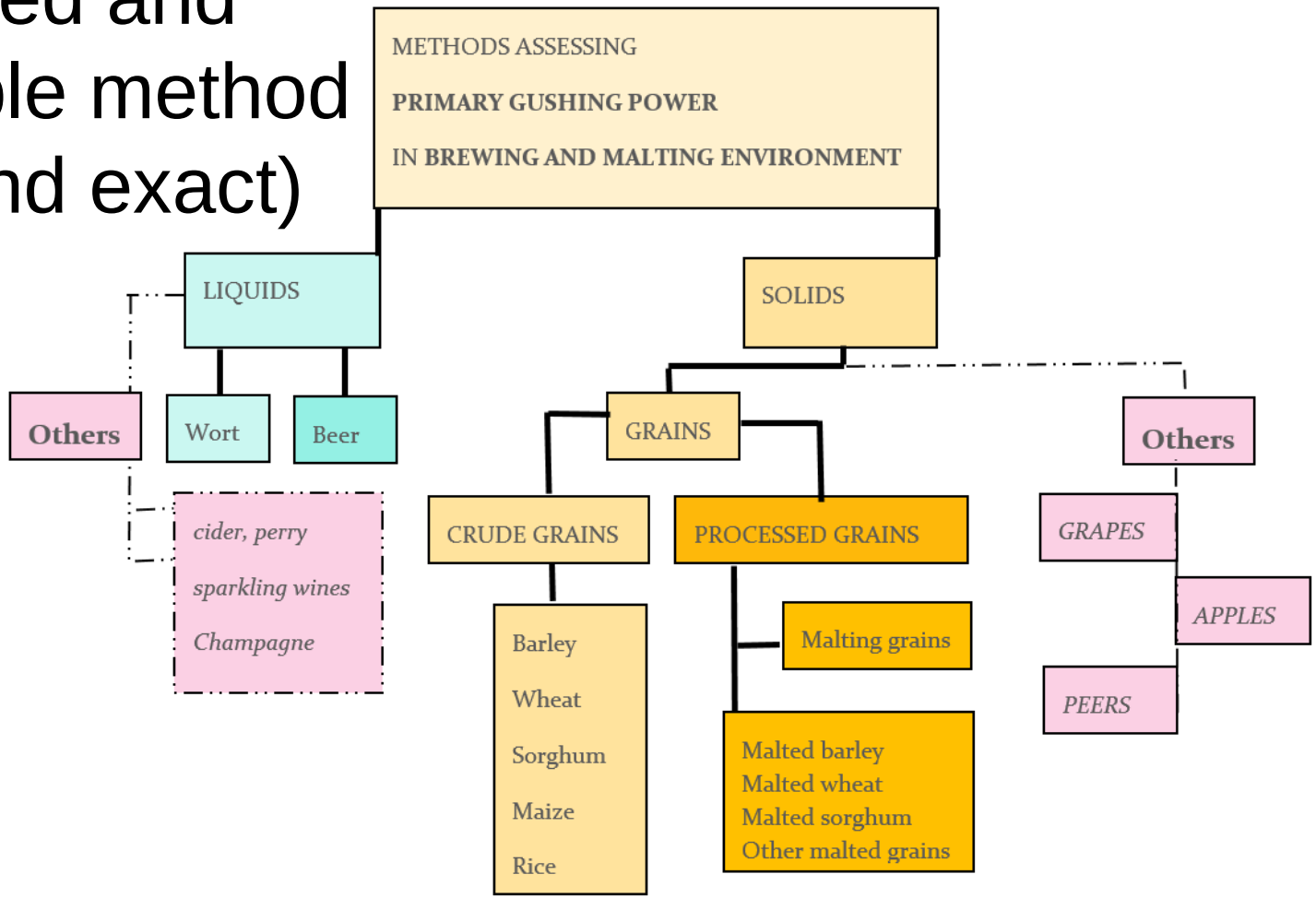
YOU ARE WELCOME

Targets of GTF

- Consensus about the scientific causes of “Primary Gushing” :
  - Physical
  - Chemical
  - Biochemical
  - Microbial

Targets of GTF

- Development of a standardized and reproducible method (precise and exact)



Rath (EBC 2015): *Further research will be required in order to arrive at a validated gushing predictive analytical method*

How to join

- Everybody is welcome :

Scientific institutes, industries, individual gushing aficionados,…

- No registration fee
- Just send an email to :
  - Christina.Schoenberger@johbarth.de
  - Guy.Derdelinckx@biw.kuleuven.be

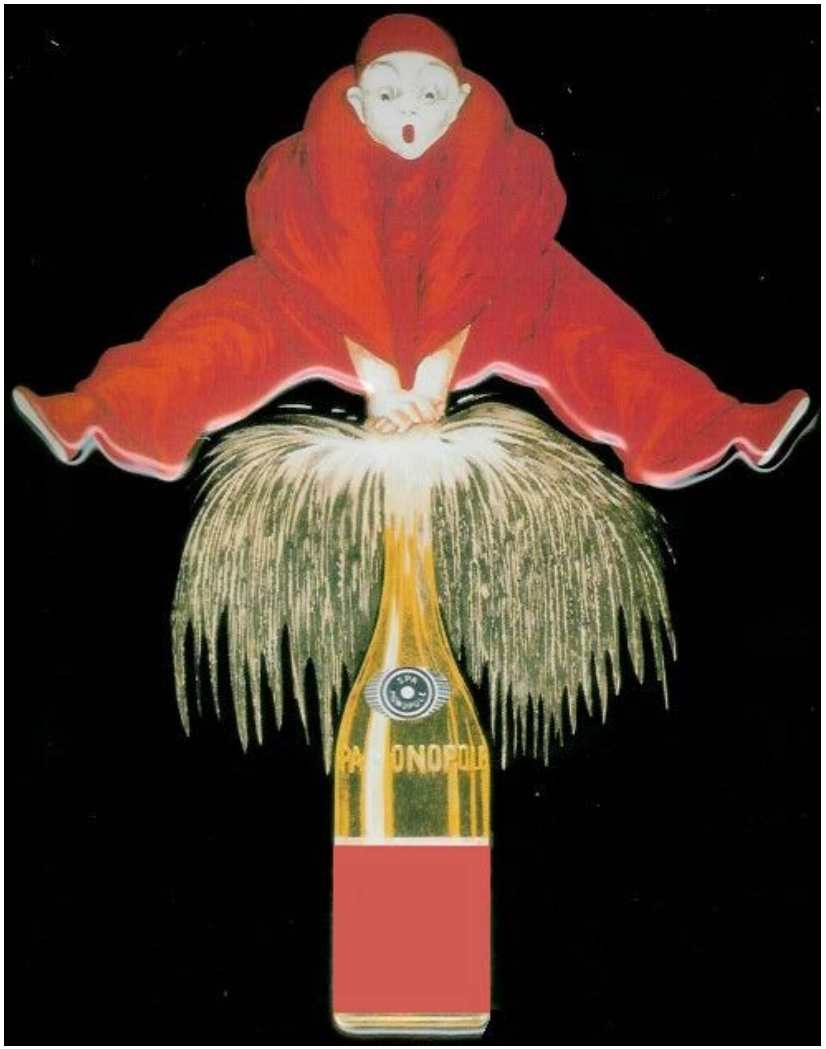
Next activities of GTF

- Invitation letter of GTF will be sent out by end of July 2015
- 1st Convention with Technical Program is planned for early December 2015 (Date not fixed yet)

Next activities of GTF

- Long term objectives :
  - Establish (inform about) methods (predictive and curative) for affected industries
  - Exchange scientific data that helps to understand better primary gushing

Thank you for your attention



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