

Forces d'interactions colloïdales

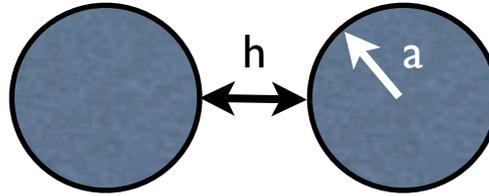
HS40

40wt%

$a = 12 \pm 2 \text{ nm}$

densité silice: 2.2g/ml

pH=9.0



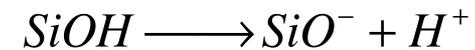
interaction de Van der Waals

origine dipôle-dipôle

$$W = -\frac{A}{6} \left(\frac{2a^2}{r^2 - 4a^2} + \frac{2a^2 + \ln(r^2 - 4a^2)}{r^2} \right)$$

A: constante de Hamaker $A = 0.83 \times 10^{-20} \text{ J}$

interaction électrostatique



$$W_e = 32\pi\epsilon a \left(\frac{kT}{ze} \right) th^2 \left(\frac{ze\Psi_0}{4kT} \right) \exp\left(-\frac{h}{\lambda_D} \right)$$

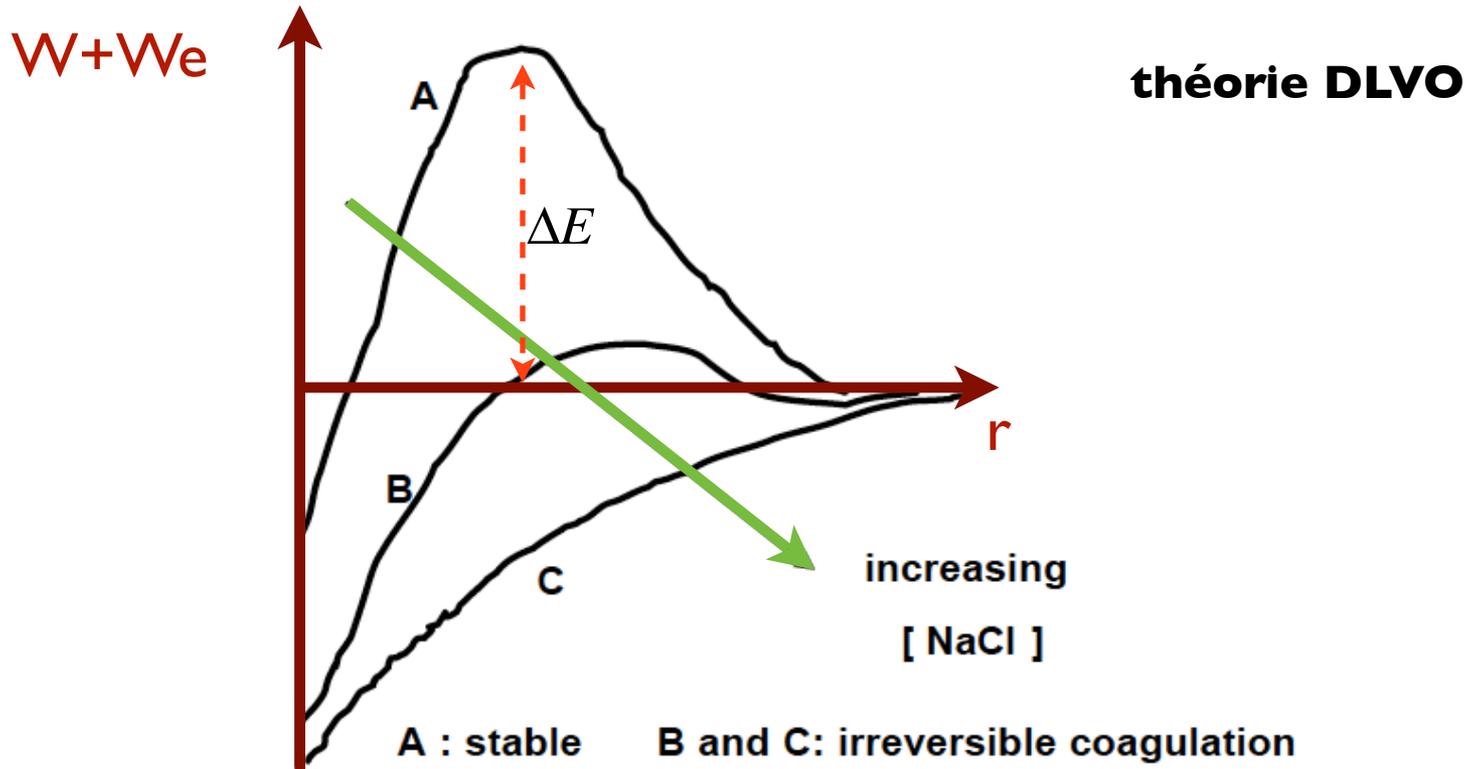
Ψ_0 : potentiel de surface de la particule

longueur de Debye $\lambda_D = \left(\frac{2000e^2NC}{\epsilon\epsilon_0kT} \right)^{-1/2}$

⇒ plus la concentration en sel, C, augmente,
plus la longueur de Debye diminue

écranage des charges de surface

Energie d'interaction en fonction de la distance entre particules

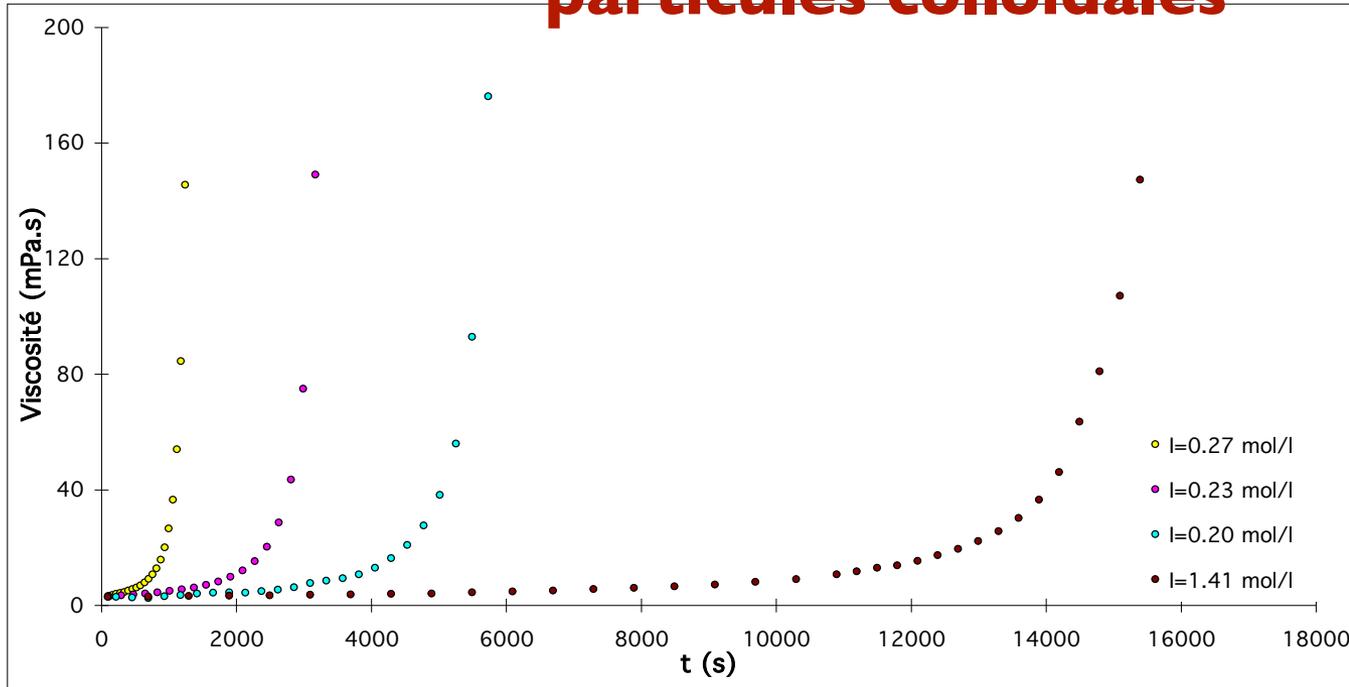


A: $\Delta E \gg kT$ la suspension est stable

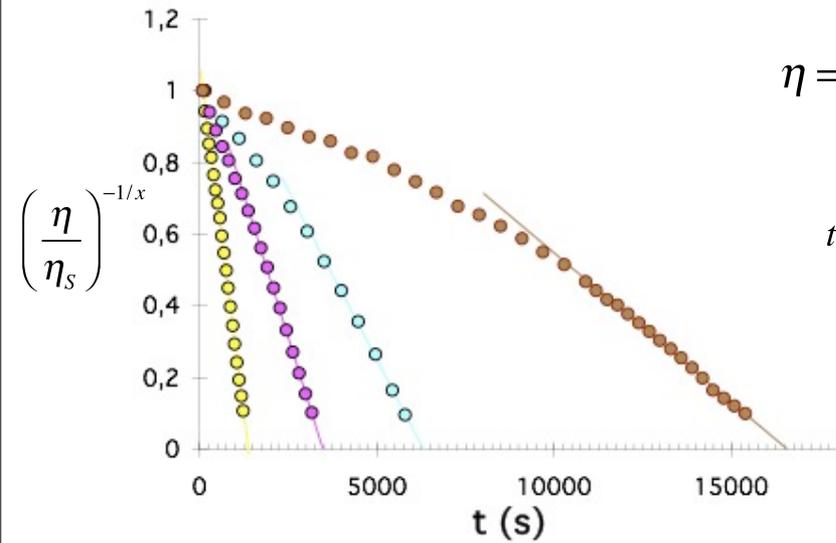
B: $\Delta E \sim kT$: les particules vont s'agréger lentement, la suspension est instable

C: Van des Waals prépondérant système instable

Mesure de la viscosité au cours de l'agrégation de particules colloïdales

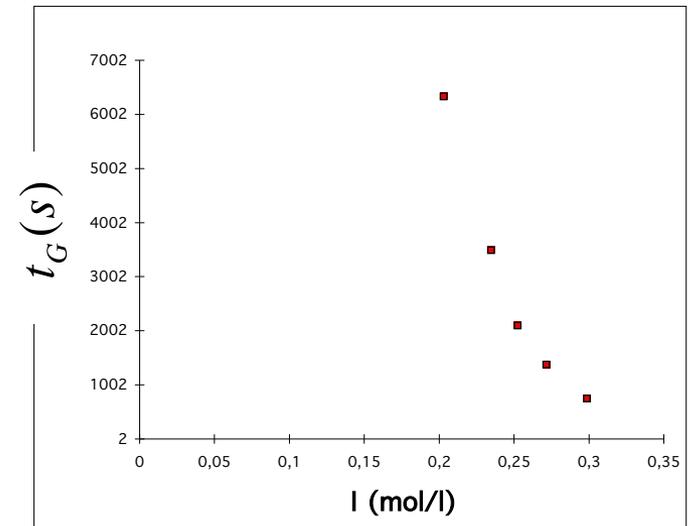


NaCl
 \Downarrow
 force ionique I
 =
 concentration C



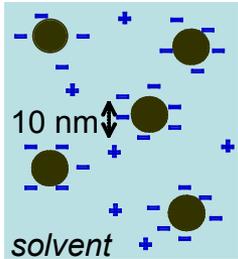
$$\eta = \eta_s \frac{1}{(t - t_G)^x} \Rightarrow t_G$$

$$t_G = t_0 \exp\left(-\frac{\Delta E}{kT}\right)$$



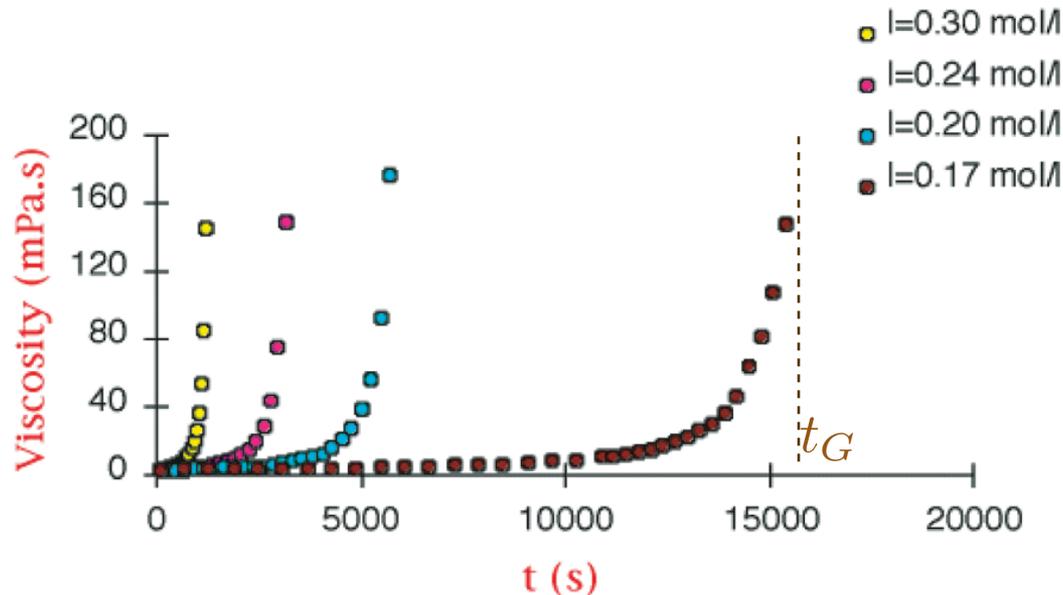
2 coupled effects in the sol-gel transformation

Gelation kinetics



influence of the ionic strength, I :
screening charges borne by particles

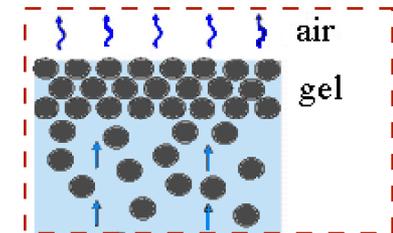
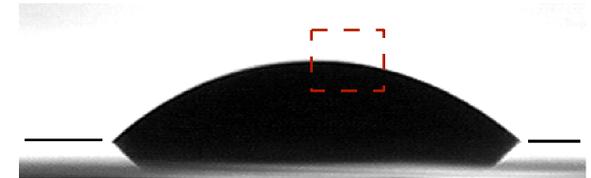
suspension viscosity increases as aggregates form



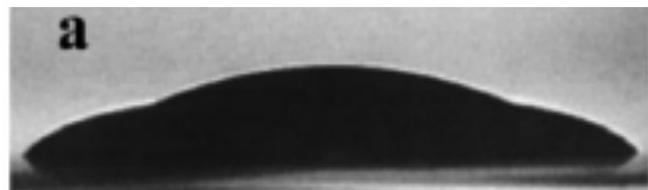
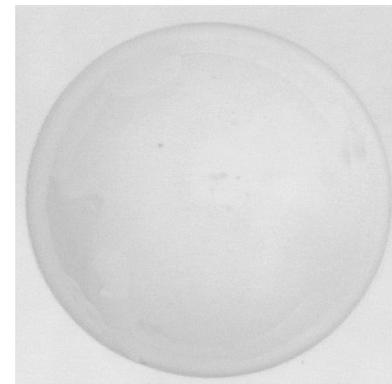
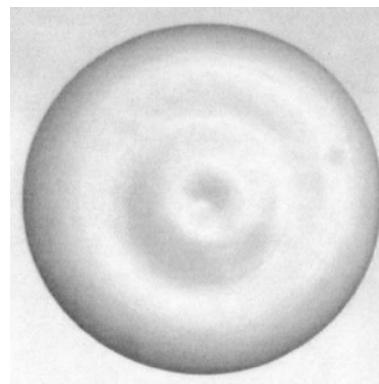
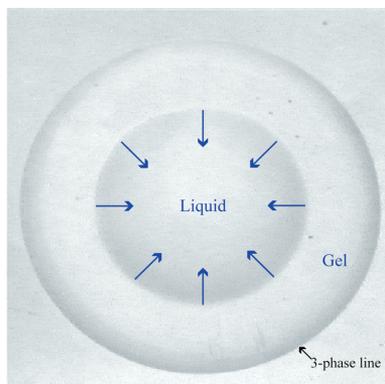
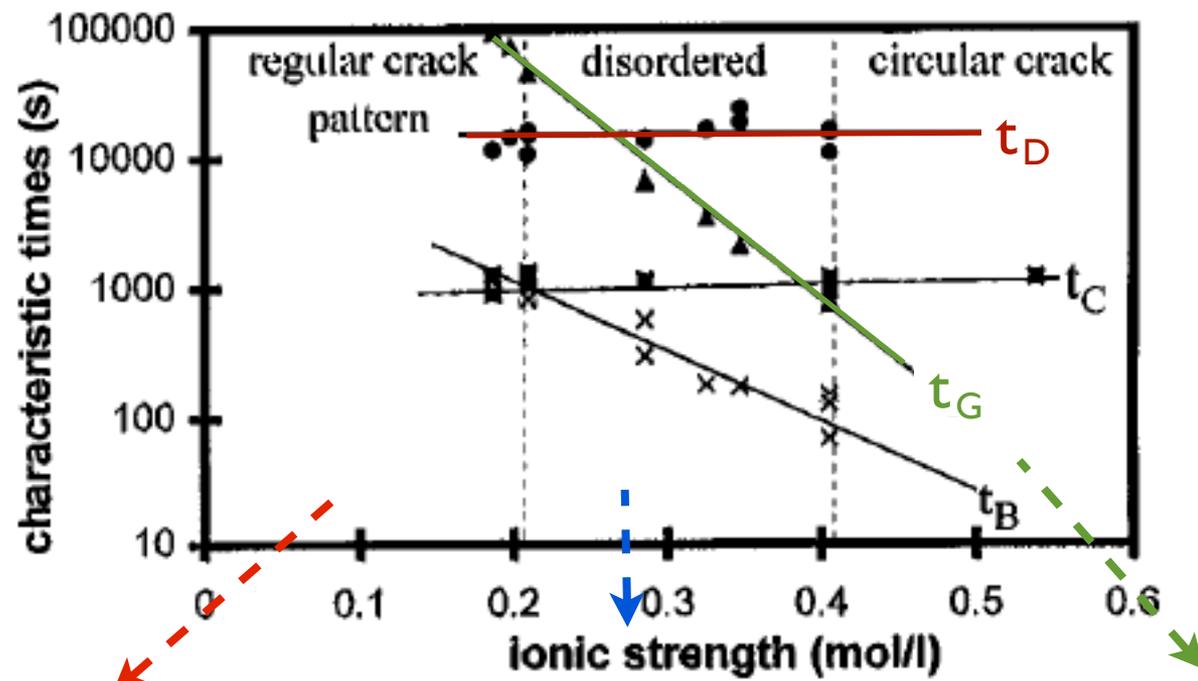
gelation time t_G

Drying kinetics

evaporation of solvent



$$\text{drying time } t_D = \frac{R_0}{\dot{V}_E} \cdot \frac{V_0}{R_0 S_0}$$

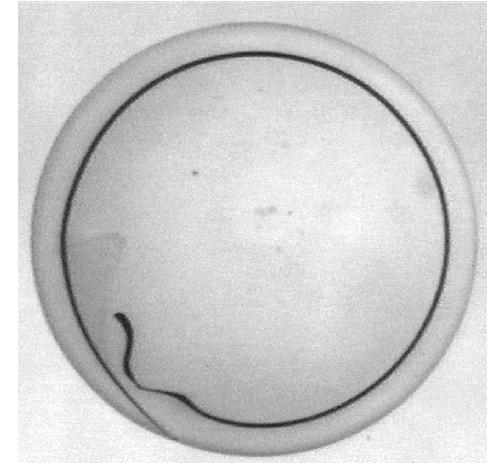
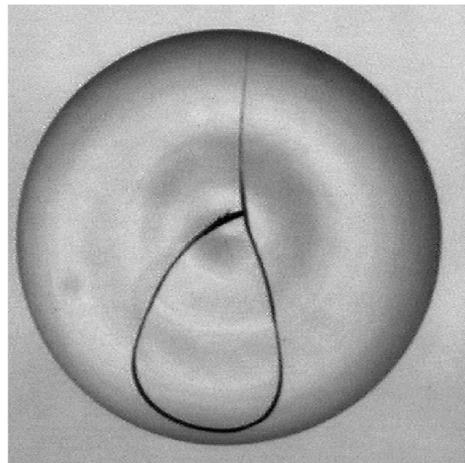
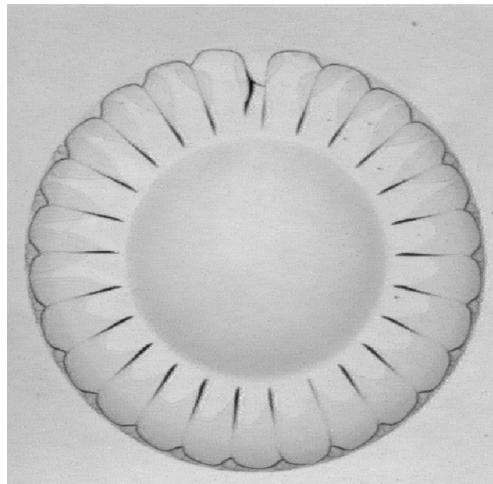
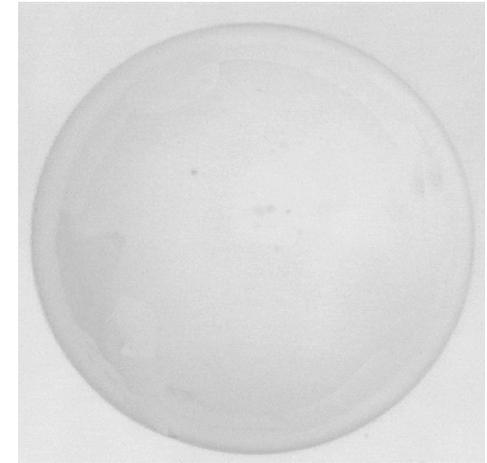
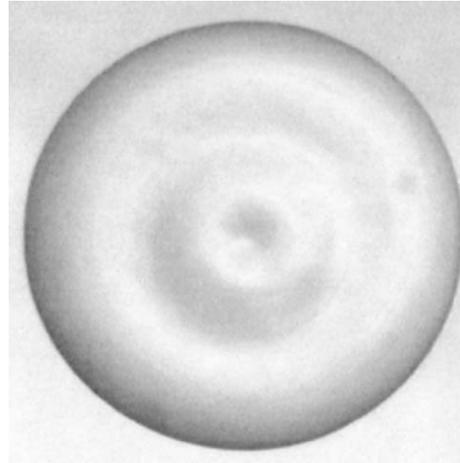
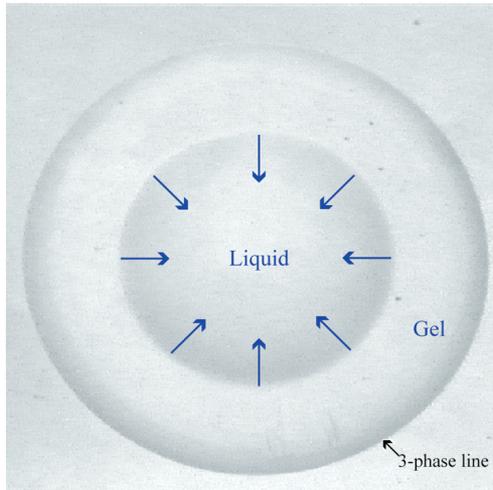


Figures de fractures induites par séchage de gouttes

$$t_G/t_D > 10^2$$

$$10^{-1} < t_G/t_D < 10$$

$$t_G/t_D < 10^{-2} \text{ force ionique}$$



Influence of the salt content on the crack patterns formed by colloidal suspension desiccation
L. Pauchard, F. Parisse, C. Allain Phys. Rev. E, 59, 3737 (1999)

Contraintes mécaniques induites par séchage

évaporation \Rightarrow **contraintes de rétraction d'origine capillaire**

$$p_c = \frac{2\gamma_{air/eau}}{r_{pore}} = \frac{2 \times 73 \cdot 10^{-3}}{20 \cdot 10^{-9}} \approx 10^7 \text{ Pa}$$

influencées par:

- effets de la présence de surfactants (réduction de la pression capillaire)
- perméabilité de la structure poreuse
- rigidité de la structure poreuse
- cinétique du séchage
- de l'adhésion sur le substrat

$$\dot{V}_E = -\frac{\kappa}{\eta} \nabla P \Big|_{z=h} \quad \text{loi de Darcy}$$

κ : perméabilité

$$\kappa = \frac{1}{180} \frac{K^3}{(1-K)^2} (2r_{pore})^2 \quad \text{loi de Carman-Kozeny}$$

K : porosité