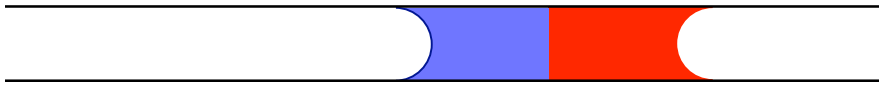
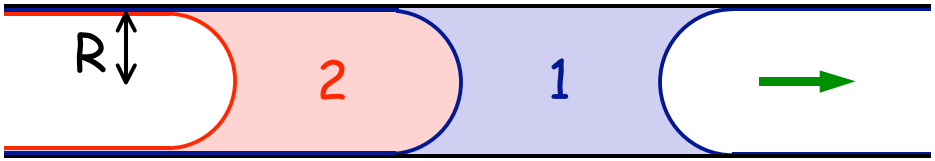
Self-Propelling Slugs in Capillary Tubes

José Bico & David Quéré



Liquid trains



$$f = 2\pi R(\gamma_1 - \gamma_{12} - \gamma_2) = 2\pi R\,\Delta\gamma$$

ethylene glycol / silicone oil

γ_1 = 47,7 mN/m
γ_2 = 20,3 mN/m
γ_{12} = 18 mN/m

$\Delta\gamma$ = 9,3 mN/m

$f/2\pi R$ = 10 mN/m

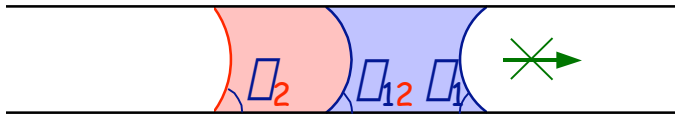
water / ether

$\Delta\gamma_{max} \approx$ 45 mN/m

Marangoni (1871)

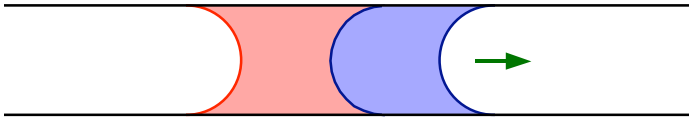
Some different systems

Partial wetting



$\Delta\sigma = \sigma_1\cos\theta_1 - \sigma_{12}\cos\theta_{12} - \sigma_2\cos\theta_2 = 0!$

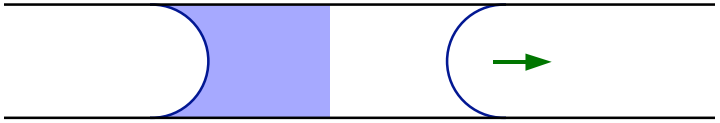
Inversed Meniscus



ethyl alcohol / silicone oil (PE tube)

$\Delta\sigma = \sigma_1 + \sigma_{12} - \sigma_2$

Miscible liquids

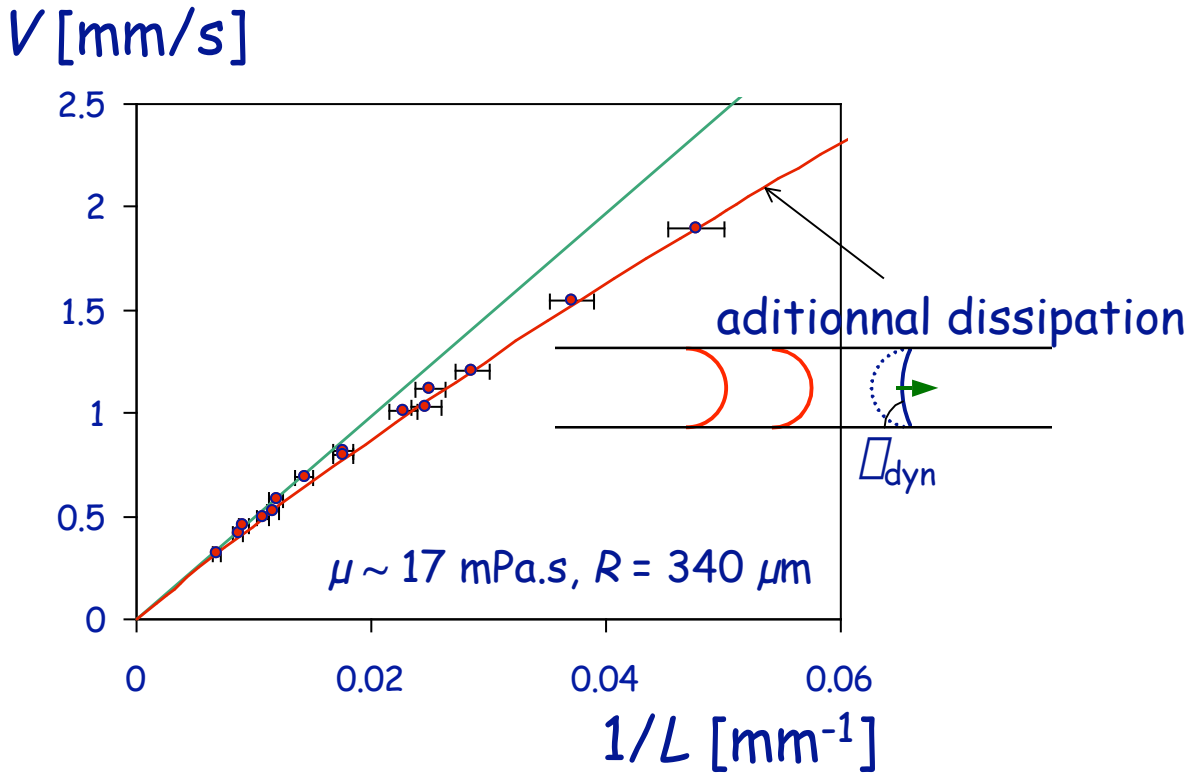


water / alcohol

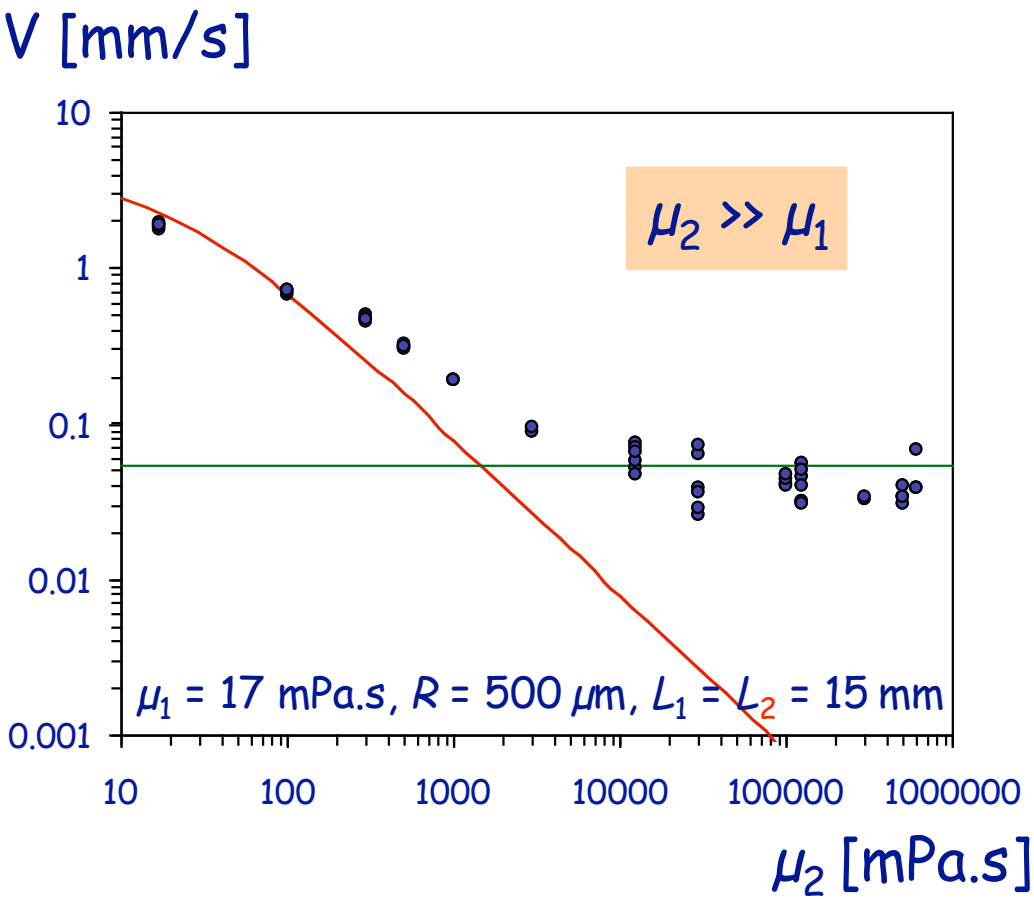
$\Delta\sigma_{start} = \sigma_1 - \sigma_2$

Dynamics

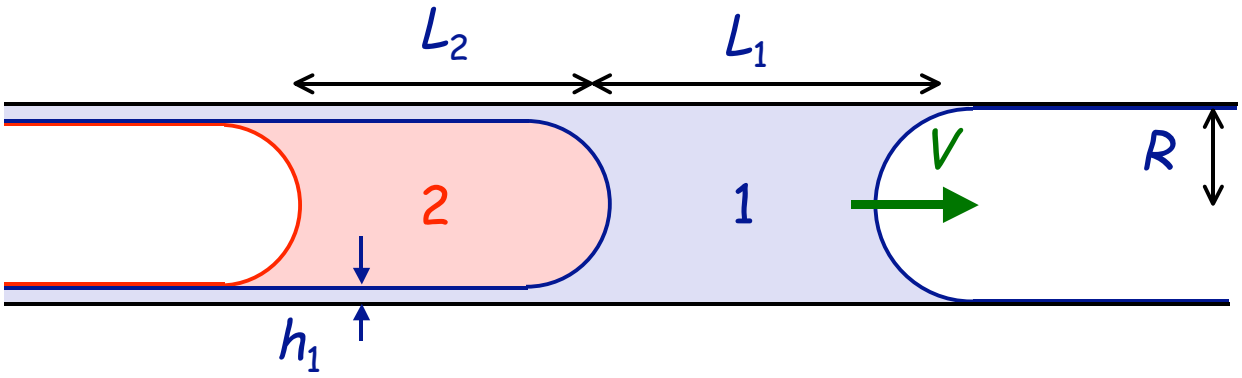
$\mu_1 \sim \mu_2$ □ $V = \frac{R \square \square}{4 \mu L}$



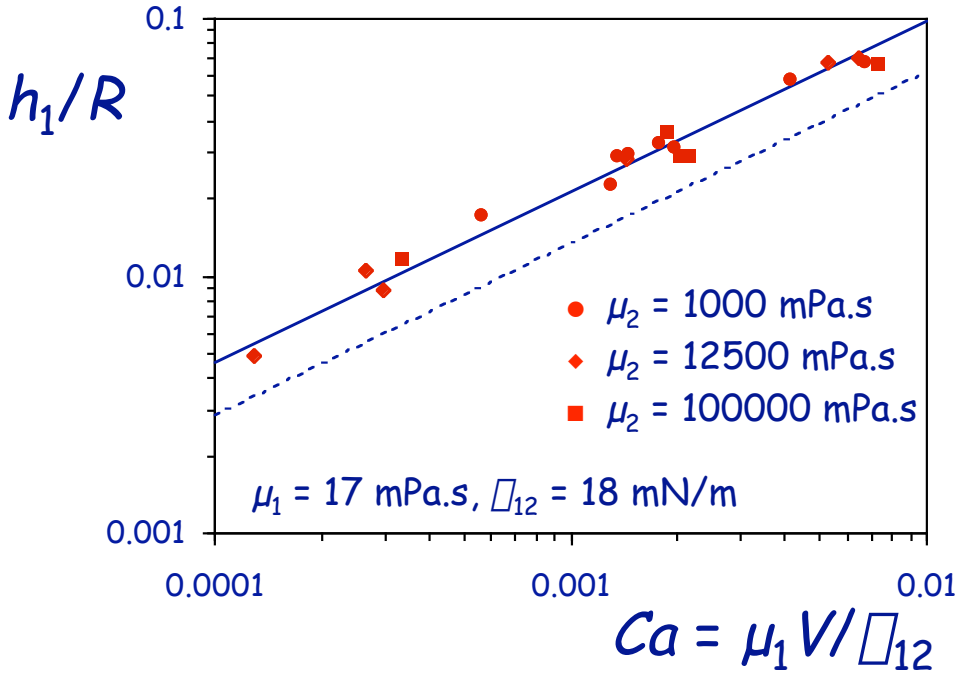
Viscous wagon



Self-lubrication



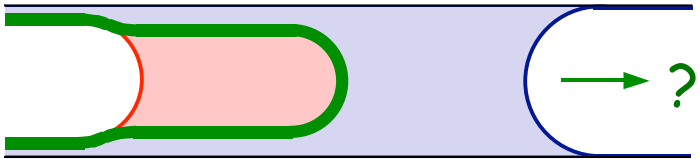
$$V = \frac{h_1 \Delta\gamma}{\mu_1 L_2}$$



$$h_1/R \sim (\mu_1 V/\Delta\gamma_{12})^{2/3}$$

Landau, Levich (1942)

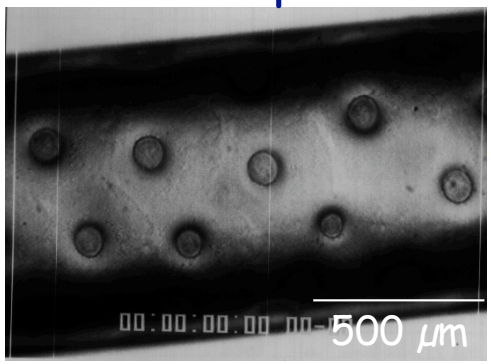
Chemical reactions



1. hexanediamine
2. adipoyl chloride

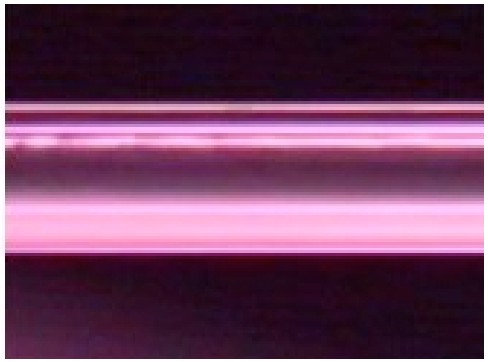
} → nylon film?

Lumps

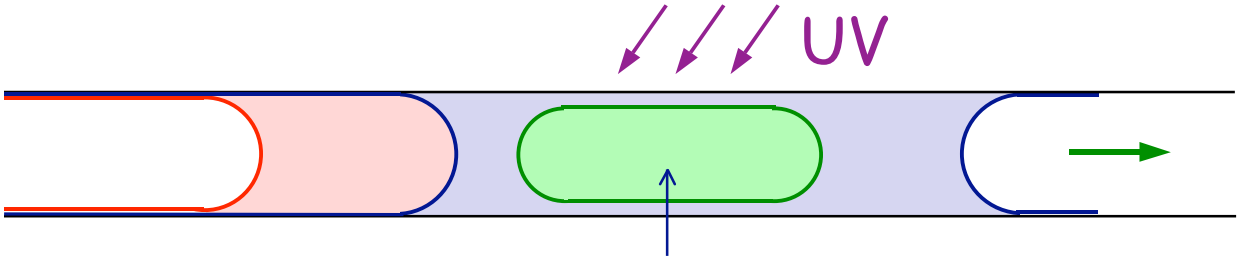


or

Film

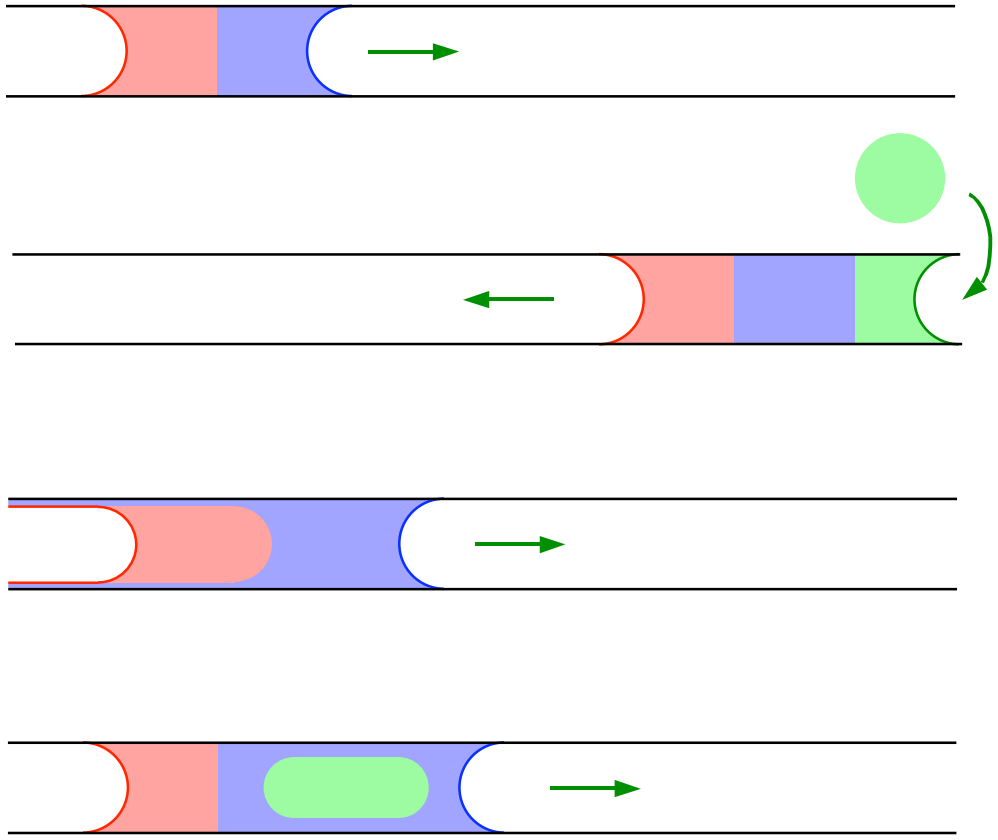


Micropistons



- perfect adjustment
- mobility

Conclusion



Acknowledgements

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for more details:

J.Bico & D.Quéré, *J. Fluid Mech.*, **467**, 101 (2002)