Surface Tension Measurements by Detachment and Partial Immersion Methods

Teng-Jui Lin
Department of Chemical Engineering, University of Washington
Surface and Colloid Science

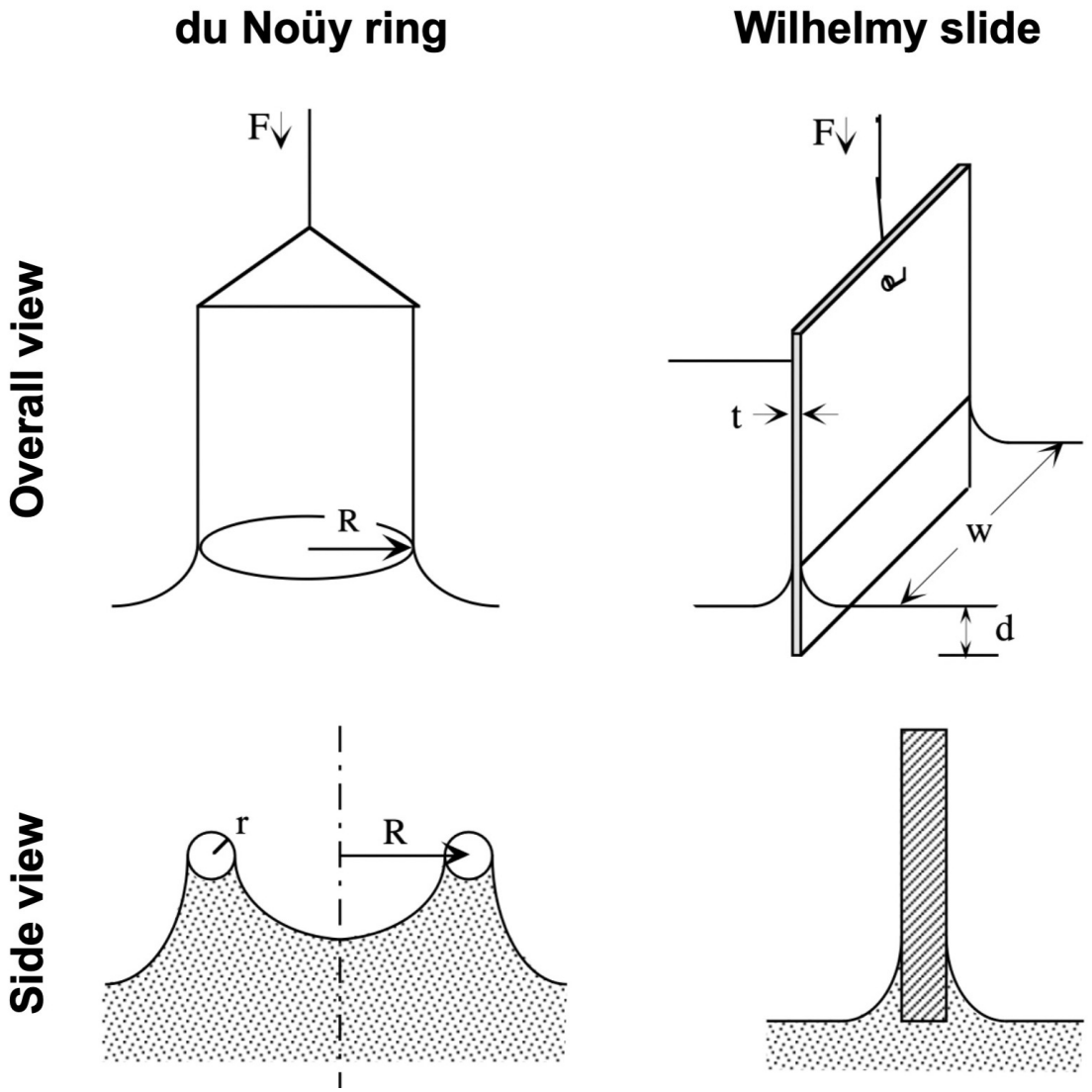
Surface tension can be measured from force methods

- Detachment method (du Noüy ring)
  - Force required to pull a solid completely through a fluid interface
- Partial immersion method (Wilhelmy slide)
  - Force required to maintain the position of a solid which penetrates a fluid interface
- Force balance
  - Down = Weight - Buoyancy + Surf. Tension

$$F_{\downarrow} = F_g - F_b + F_\sigma$$

$$F_{\downarrow} = mg - \rho g V_{\text{disp}} + P\sigma$$

Assumes: uniform σ, fully wetted $\theta = 0$



du Noüy ring can be used to measure σ by the detachment method

- Force balance

$$\begin{aligned} F_{\downarrow} &= mg - \rho g V_{\text{disp}} + P\sigma \\ &= mg - 0 + 2\pi[(R+r)+(R-r)]\sigma \\ &= mg + 4\pi R\sigma \end{aligned}$$

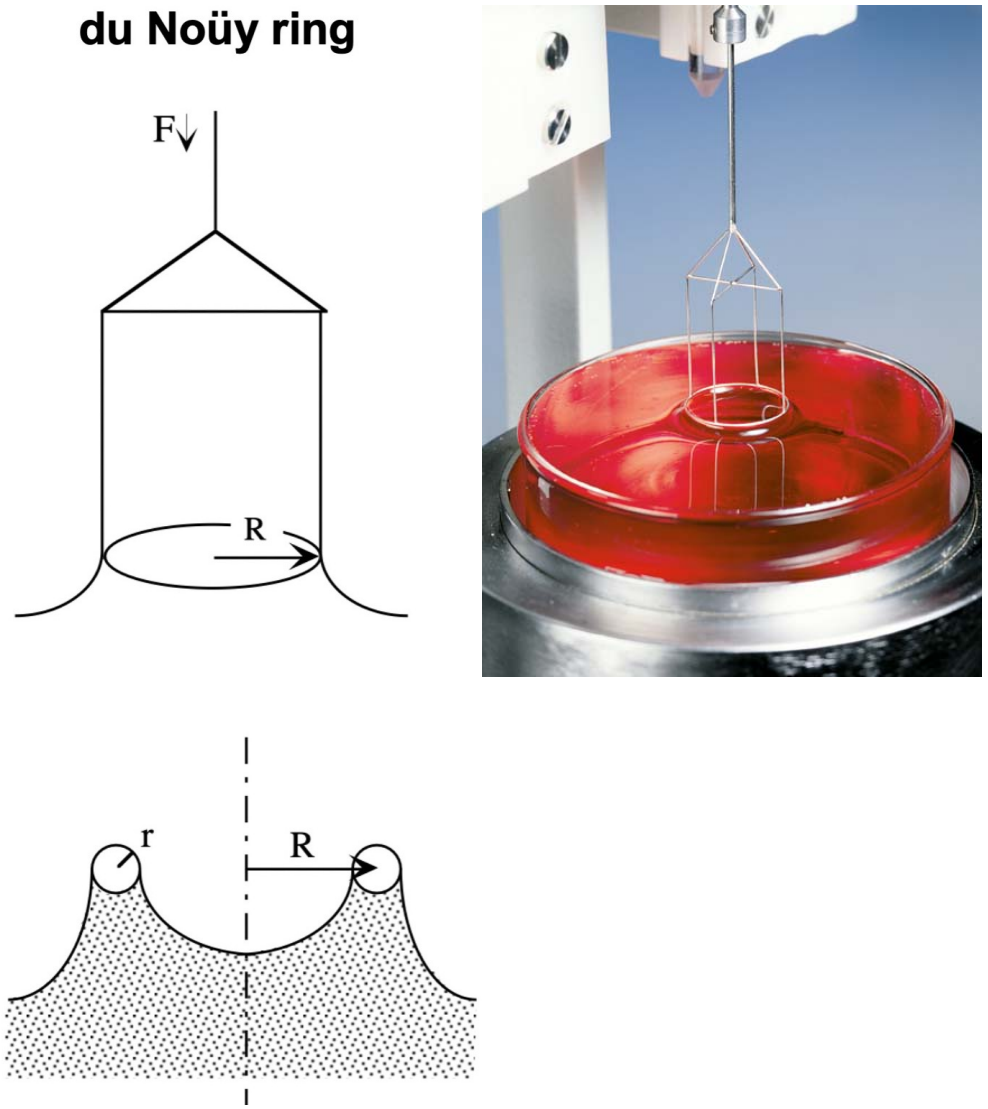
- Uncorrected surface tension σ^*

$$\sigma^* = \frac{F_{\downarrow} - mg}{4\pi R}$$

- Correction factor F [cgs unit]

$$F_{\downarrow} = mg + \frac{4\pi R\sigma}{F}$$

$$F = 0.725 + \sqrt{\frac{0.01425\sigma^*}{(2\pi R)^2(\rho_l - \rho_{\text{air}})} + 0.04534 - \frac{1.679}{R/r}}$$

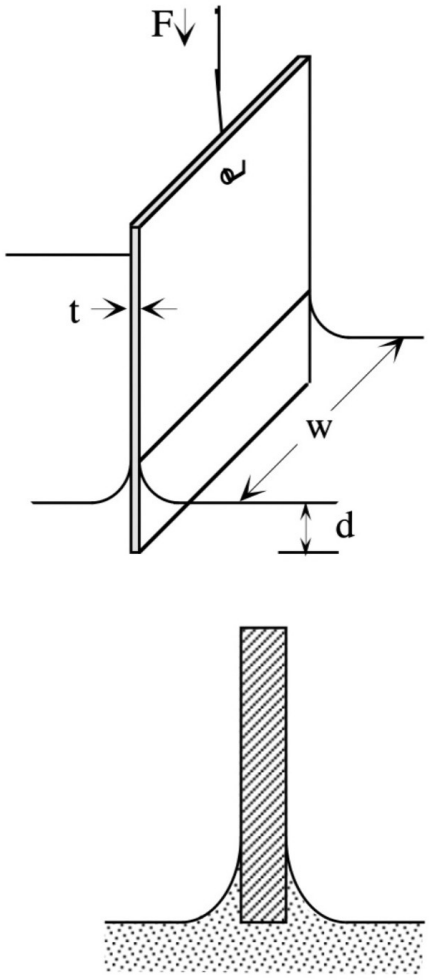


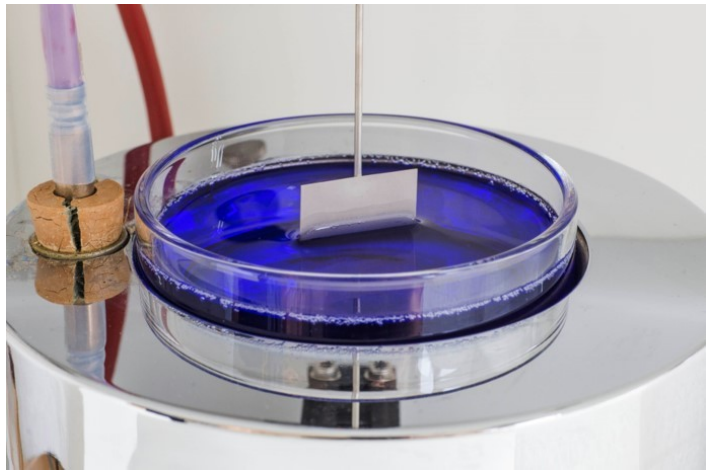
Wilhelmy slide can be used to measure σ by the partial immersion method

- Force balance ($d = 0, t \ll w$)

$$\begin{aligned} F_{\downarrow} &= mg - \rho g V_{\text{disp}} + P\sigma \\ &= mg - \rho g t w d + 2(w + t)\sigma \\ &= mg + 2w\sigma \end{aligned}$$

Wilhelmy slide





Tensiometer is used to measure force on du Noüy rings and Wilhelmy slides