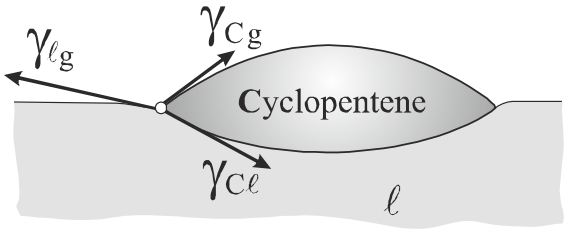
Problem 15-05 Spreading of a liquid on liquid surface

Estimate what is the minimal value of the interfacial tension between cyclopentene (C) and another liquid (ℓ), immiscible with cyclopentene, at which the cyclopentene would still spread on this liquid surface. The surface tension of the liquid was measured by the capillary rise method: at the temperature of 20 °C the level of the studied liquid in the glass capillary of inner diameter of 0.8 mm climbed to the height of 2.5 cm above the horizontal level of the liquid in the wide beaker. The liquid density is 1.06 g cm^{-3} and it wets the material of the capillary completely. The density of cyclopentene is 0.762 g cm^{-3}, molar mass 68 g mol^{-1}, and its surface tension 21.6 mN m^{-1}.



[$\gamma_{C/\ell} < 30.4$ mN m^{-1} ($\gamma_{\ell g} = 52$ mN m^{-1})]

Solution:

C ≡ C_5H_8

Cyclopentene will spread on the surface of the liquid ℓ, if $S_{C/\ell} = \gamma_{\ell g} - \gamma_{Cg} - \gamma_{C\ell} > 0$

Calculation of $\gamma_{\ell g}$ from capillary rise data:

h = 2.5 cm = 0.025 m

$\mathcal{D}$ = 0.8 mm = 0.0008 m , $\mathcal{R}$ = 0.0004 m

ρ_ℓ = 1.06 g cm^{-3} = 1060 kg m^{-3}

cos θ = 1

$$\gamma_{\ell g} = \frac{h\,\rho_\ell\,g\,\mathcal{R}}{2} = \frac{0.025 \cdot 1060 \cdot 9.81 \cdot 0.0004}{2} = 0.051993 \text{ N m}^{-1} = 52 \text{ mN m}^{-1}$$

From Harkins spreading coefficient: the cyclopentene will spread if

$$\boxed{\gamma_{C\ell} < \gamma_{\ell g} - \gamma_{Cg}}$$

then $\gamma_{C\ell} < 52 - 21.6 = 30.4$ mN m^{-1}