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new world of textiles

Superhydrophobic and oleophobic surfaces for sustainable medical textiles

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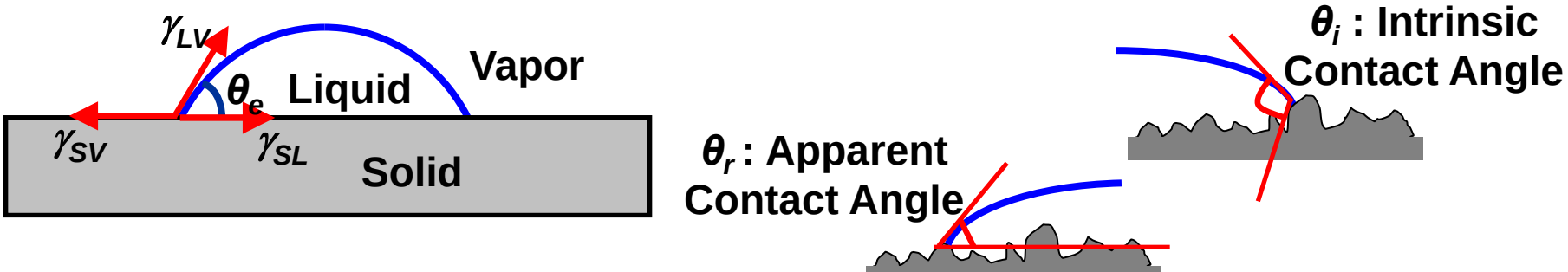
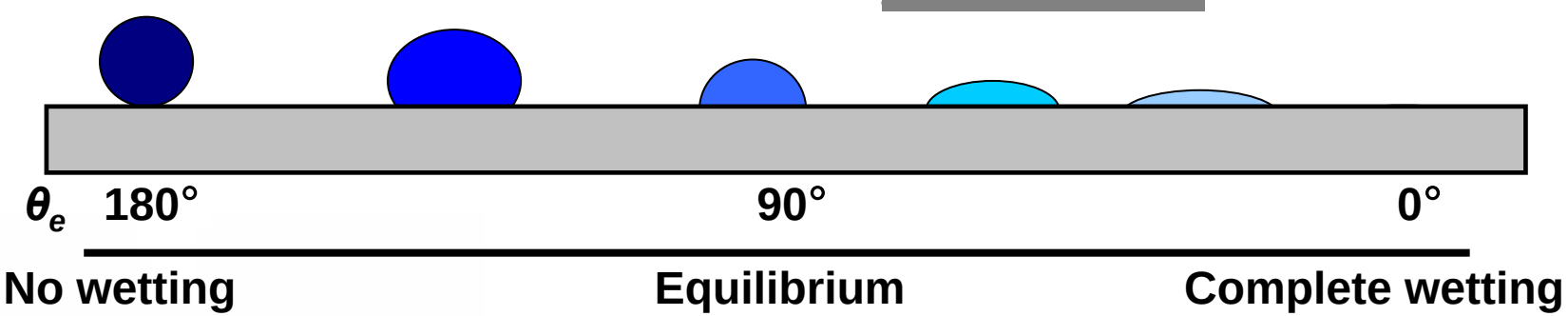
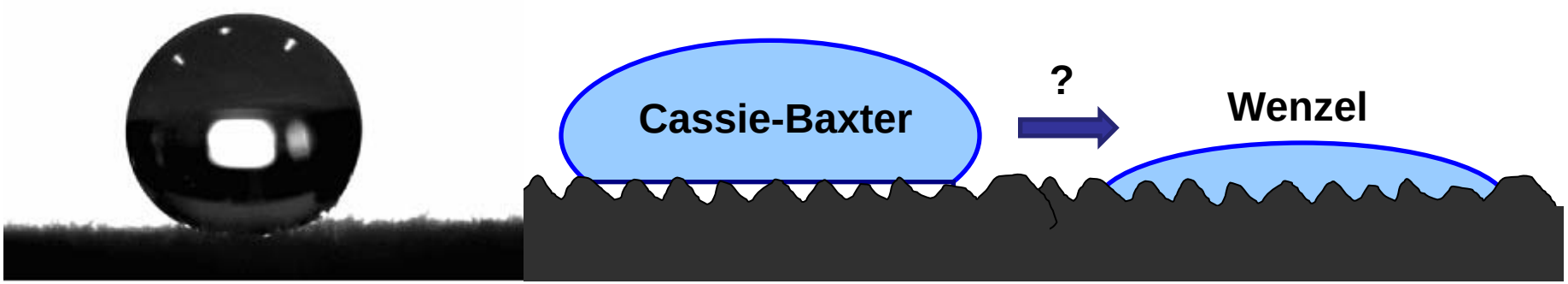
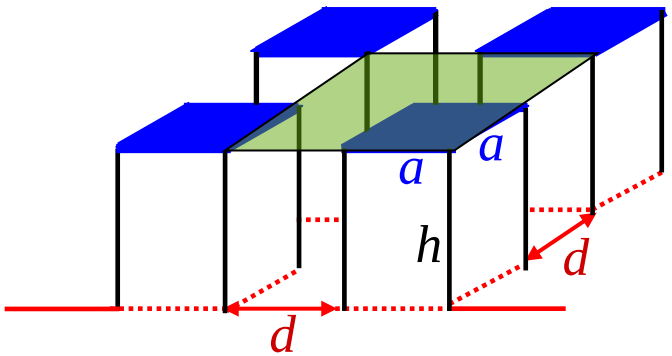
Contact Angle and Wetting Behavior

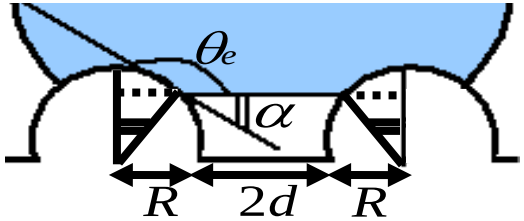


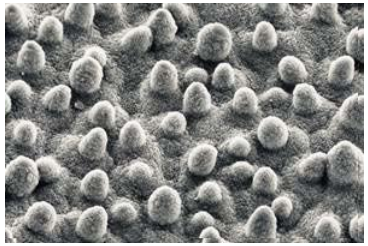




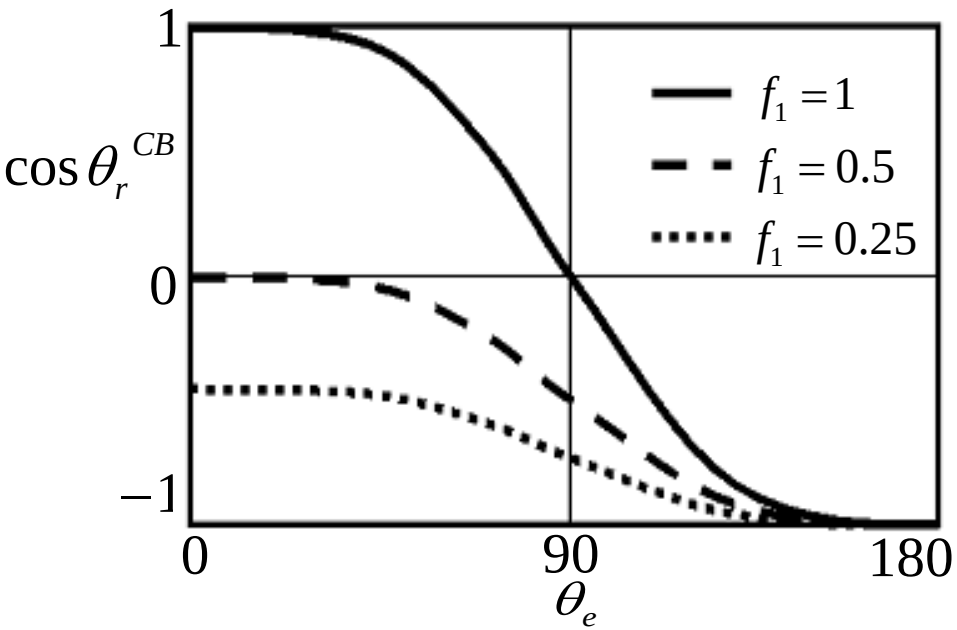
Design of Cassie Baxter Surface





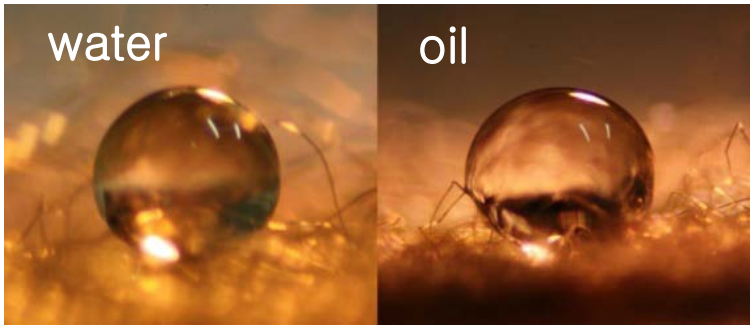


$$\cos\theta_r^{CB} = f_1 \cos\theta_e - f_2$$

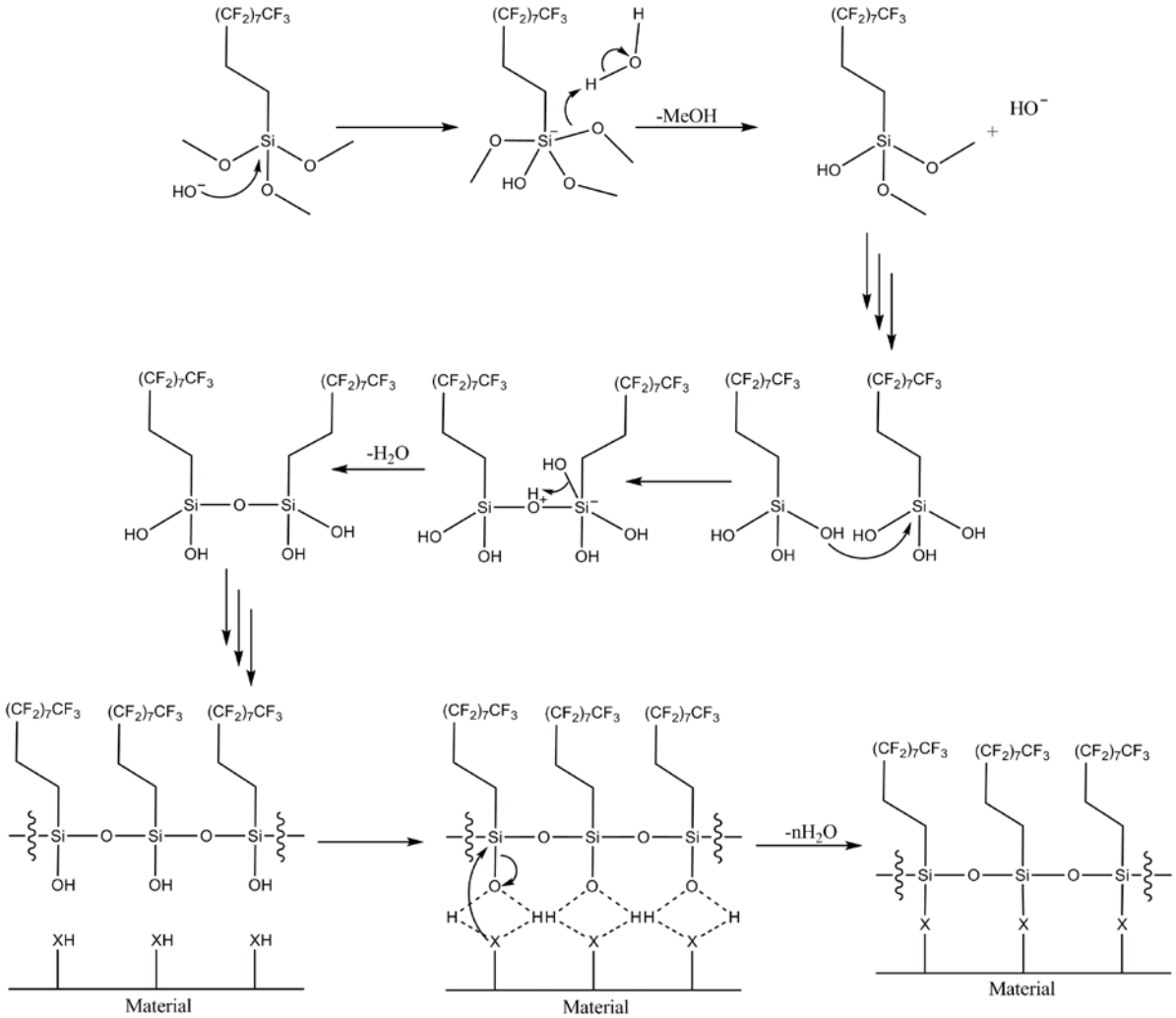


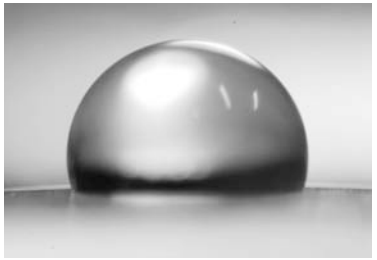
$$f_1 = \frac{\text{Area in contact with liquid}}{\text{Projected area}} = \frac{R\alpha}{R+d}$$

$$f_2 = \frac{\text{Area in contact with air}}{\text{Projected area}} = \frac{(R+d) - R\sin\alpha}{(R+d)}$$

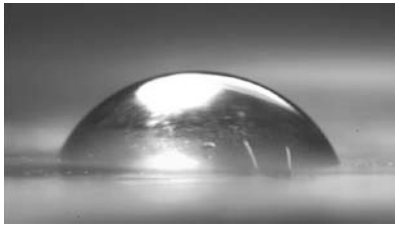


Chemical Modification with F-silane through Microwave Reaction



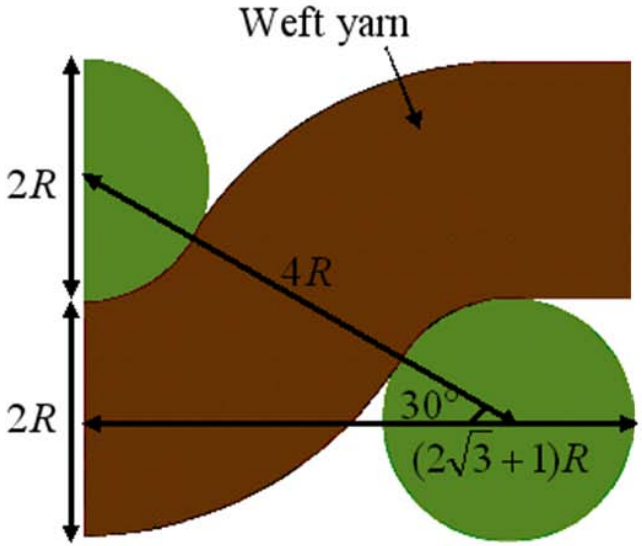


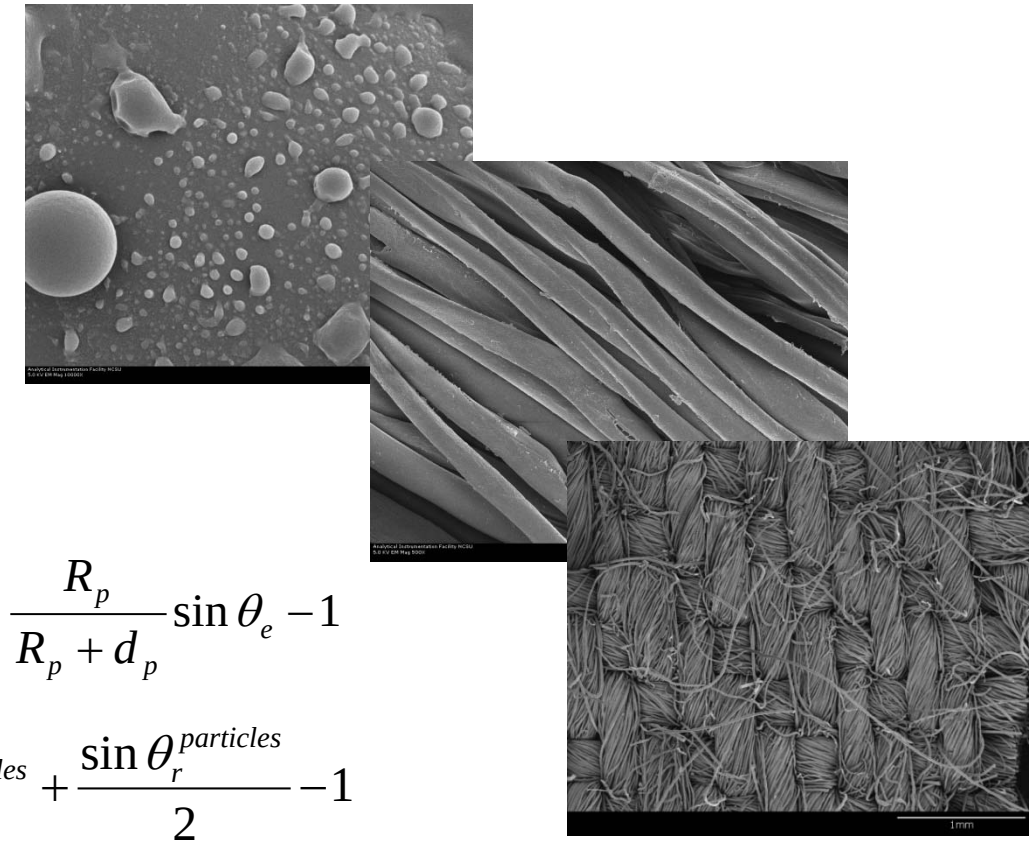
Water on modified nylon



Dodecane on modified nylon

Geographical Modification I – NyCo Multifilament Woven Fabric



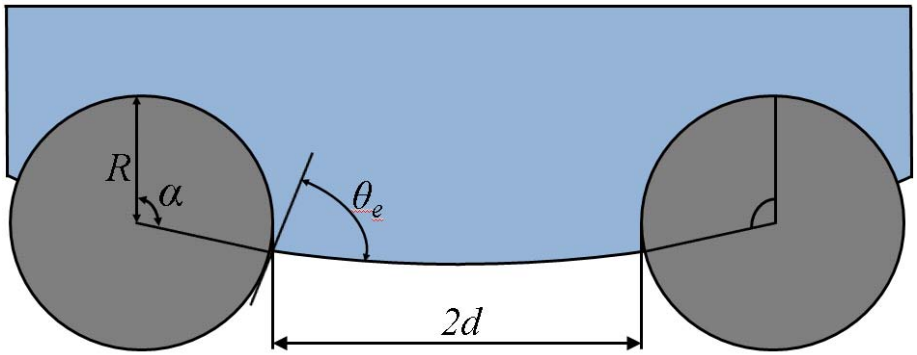


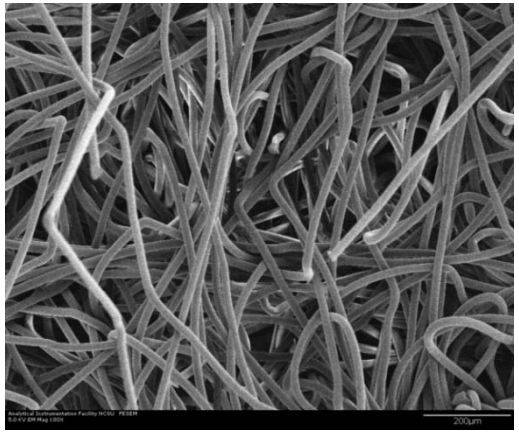
$$\cos\theta_r^{particles} = \frac{R_p}{R_p + d_p}(\pi - \theta_e)\cos\theta_e + \frac{R_p}{R_p + d_p}\sin\theta_e - 1$$

$$\cos\theta_r^{multifilament} = \frac{\pi - \theta_r^{particles}}{2}\cos\theta_r^{particles} + \frac{\sin\theta_r^{particles}}{2} - 1$$

$$\cos\theta_r^{NyCo} = \frac{4(\pi - \theta_r^{Multifilament}) + 1}{2\sqrt{3}+1}\cos\theta_r^{Multifilament} + \frac{1 + 4\sin\theta_r^{Multifilament}}{2\sqrt{3}+1} - 1$$

Geographical Modification II – Nylon Hydroentangled Nonwoven Fabric





$f_2 \approx 0.93$

$$\cos\theta_r^{CB} = f_1 \cos\theta_e - f_2$$

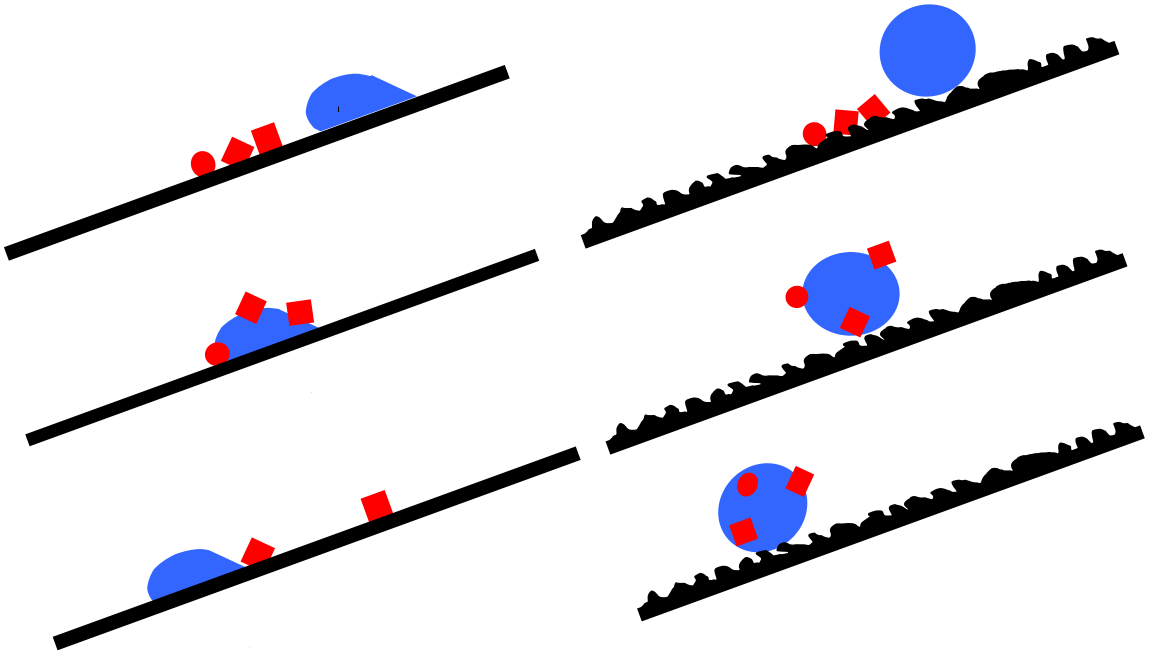
$$\cos\theta_r^{CB} = \frac{R(\pi - \theta_e)}{d + R}\cos\theta_e + \frac{R}{d + R}\sin\theta_e - 1 \xrightarrow[78^o \le \theta_{e\text{-}dodecane} \le 81^o]{R \approx 10\ \mu m}$$

$d \le 131\ \mu m$

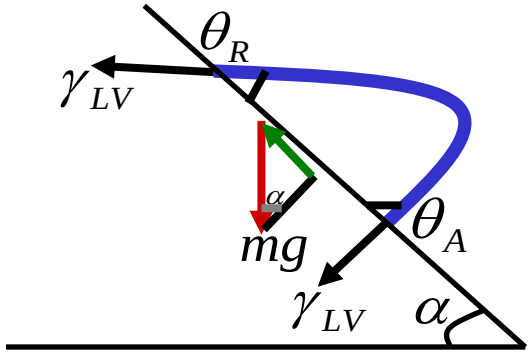
$155^o \le \theta_{r\text{-}dodecane} \le 156^o$

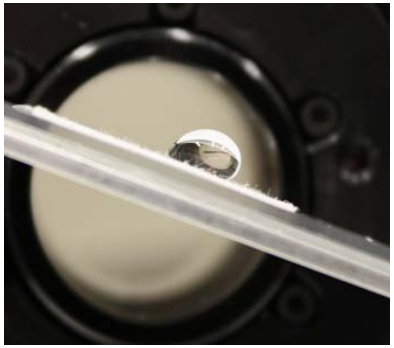
Superhydrophobicity vs Superoleophobicity

$$mg\sin\alpha = \gamma_{LV}(\cos\theta_R - \cos\theta_A)$$



Self-cleaning effect by superhydrophobicity.
(Source: Barthlott, W., Neihuis, C., *Planta*, 1997, *202*, 1.)





Roll-off Angles and Contact Angle Hysteresis

- **Wenzel Model**

$$\cos\theta_e^{\,W} = r\cos\theta_e$$

$$G_e^W = \frac{r\sin\theta_e}{\sin\theta_e^W}$$

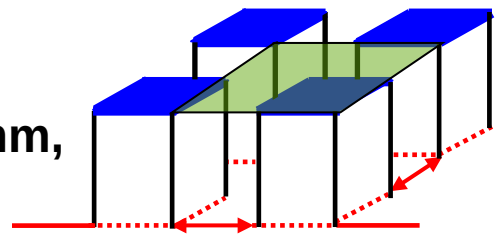
$$\Delta\theta_H^W = G_e^W \Delta\theta_H$$

- **Cassie-Baxter Model**

$$\cos\theta_e^{\,CB} = \Phi_S(\cos\theta_e + 1) - 1$$

$$G_e^{CB} = \frac{\Phi_S \sin\theta_e}{\sin\theta_e^{CB}}$$

$$\Delta\theta_H^{CB} = G_e^{CB}\Delta\theta_H$$

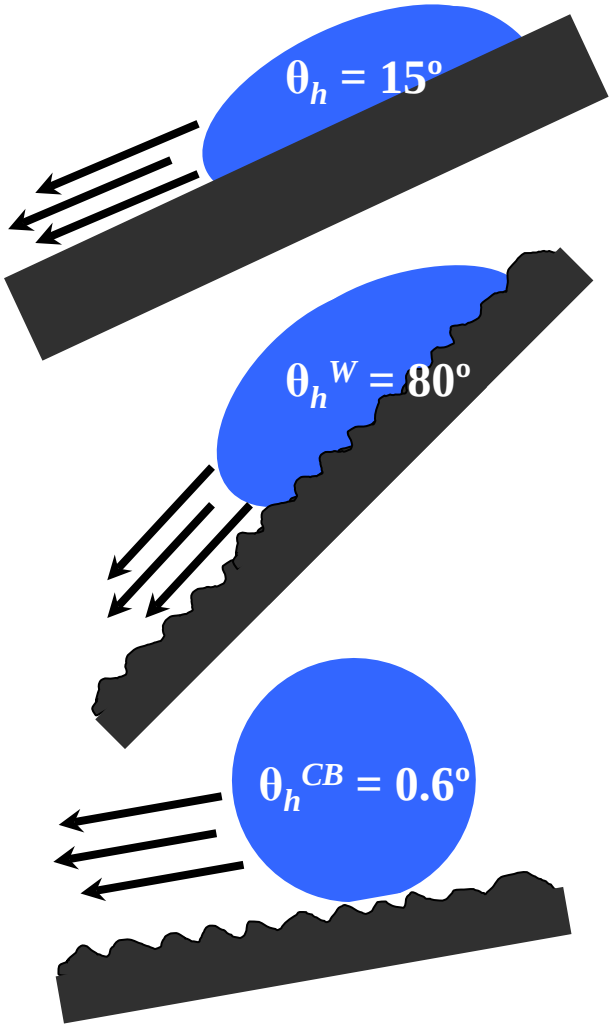


- **Numerical Example**

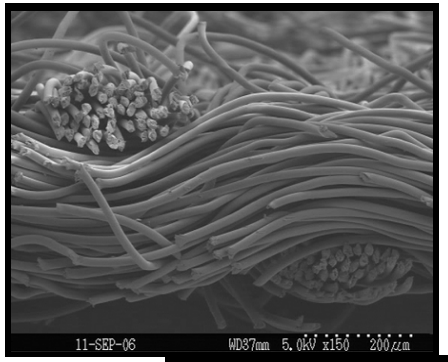
θ_e = 120º, θ_h = 15º, a = 0.01mm, d = 0.2mm, and h = 1mm

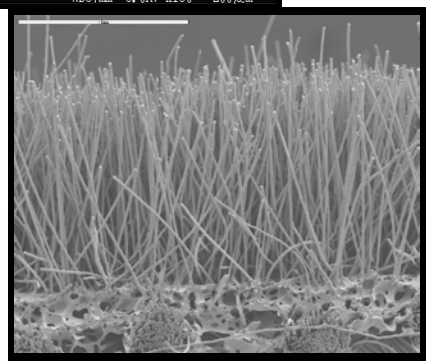
In Wenzel model,
r = 1.9
$\theta_e^{\,W}$ = 162º,
$G_e^{\,W}$ = 5.32,
and $\theta_h^{\,W}$ = 80º

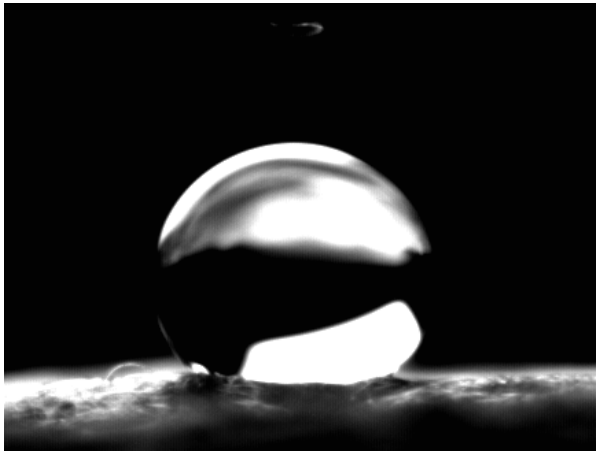
In Cassie-Baxter model,
Φ_s = 0.0023
$\theta_e^{\,CB}$ = 177º,
$G_e^{\,CB}$ = 0.04,
and $\theta_h^{\,CB}$= 0.6º

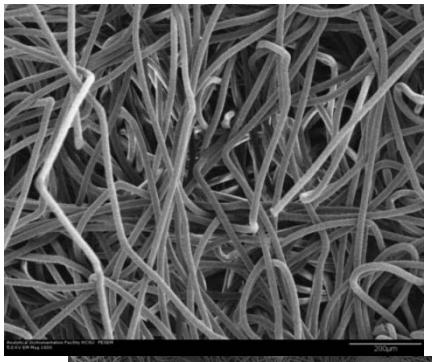


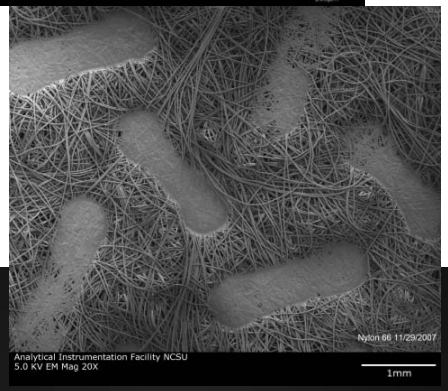
Conclusion

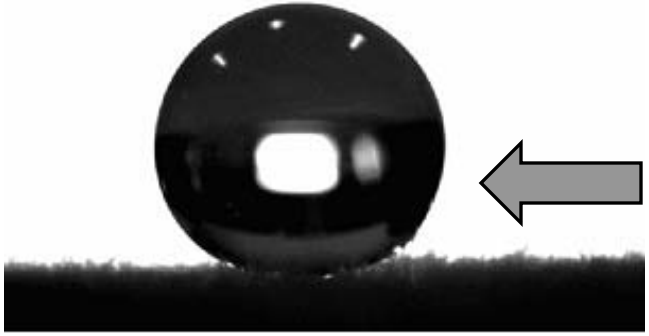

11-SEP-06
WD37mm 5.0kV x150 200µm

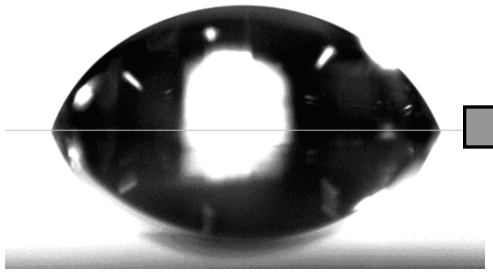


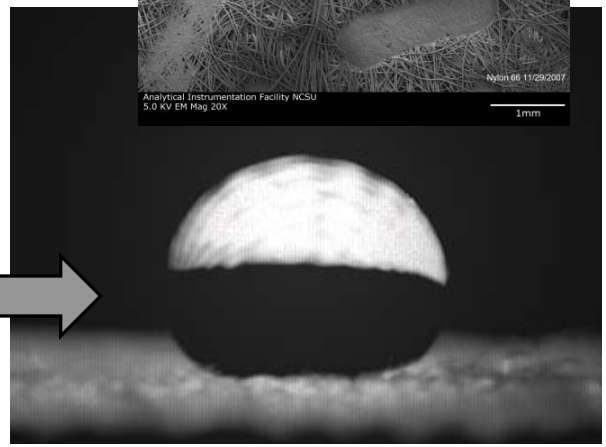





Nylon 66 11/29/2007
Analytical Instrumentation Facility NCSU
5.0 KV EM Mag 20X
1mm







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- NCSU Nonwoven Institute

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Thank you.