Wenzel Model

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Young’s equation is an oversimplified expression, and is only valid for ideally flat surfaces that are atomically smooth and chemically homogeneous. Conversely, very few solids are atomically flat. Wetting on rough surfaces was first considered by Wenzel (1936). In the Wenzel state, where the roughness grooves are completely filled with liquid, the contact angle ($\theta_w$) can be described by

$$\cos \theta_w = R_f \left[ \frac{\gamma_{SV} - \gamma_{SL}}{\gamma_{LV}} \right]$$

where $R_f$ is the surface roughness factor, which is defined as

$$R_f = \frac{\text{Actual area}}{\text{Projected area}}$$

Combining Wenzel equation with Young’s equation yields

$$\cos \theta_w = R_f \cos \theta_C$$

Since the roughness factor is always larger than unity in practical situations, it is obvious that the apparent angle on a roughened surface will become smaller if its intrinsic contact angle on a smooth surface is less than 90°. Similarly, the apparent contact angle will be larger, if its intrinsic contact angle is larger than 90° (Fig. 1).

References

Wenzel RN (1936) Resistance of solid surfaces to wetting by water. Ind Eng Chem 28:988–994
**Wenzel Model, Fig. 1** Liquid droplet on a rough surface. The contact angle can be predicted by Wenzel model (Hsu 2010)