Theoretical and Practical Aspects of Complex Contact Angles on Rough Surfaces

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ABSTRACT

Perceived as a real number the Young contact angle is simply a complex number with zero imaginary part. A major question is, if there may be a necessity for introducing an imaginary part. Confronted with the inequality $\cos\theta > 1$ in tensiometric measurements on highly wettable rough surfaces, we found that the singular solution to this inequality was indeed a defined imaginary part $\{\lambda i\}$, with λ as the contact angle [1]. Since the occurrence of $\cos\theta > 1$ was accompanied by an *intrinsic* (i.e. Young) contact angle of zero degrees (θ_0) we could formulate *apparent* complex contact angles (Θ) as $\Theta = \{\theta_0\} + \{\lambda i\}$, which for the hyperhydrophilic case reduces to $\Theta = \{\lambda i\}$, i.e. so-called imaginary contact angles. This approach had two consequences: (i) It allowed an expansion of hydrophilicity beyond the zero degree limitation of the Young-Duprey equation into the hyperhydrophilic range, which has proven to be very useful in quantitating high-wettability surfaces e.g. on implants. (ii) It also necessitated the generalization to *apparent* superhydrophobic contact angles on rough surfaces, defining them as complex, in which the *intrinsic* contact angle (Young) of the underlying smooth surface, being the real part, is combined with the calculated imaginary part, characterizing the rough surface, into a single superhydrophobic complex contact angle (Θ). The application of complex contact angles to characterizing the wettability of non-ideal rough surfaces will be shown to deepen our insight and understanding of their wetting behavior. Finally, the mathematical approach of complex contact angles may be a unifying concept in contact angle science in general.

[1] Jennissen H.P. A general mathematical form and description of contact angles. *Materialwissenschaft und Werkstofftechnik. (Materials Science & Engineering Technology)* **45**(11) (2014), 961-969.