

Contact Angles on Human Skin

Keyphrases □ Contact angles—human skin, previously developed equations discussed □ Skin, human—determination of contact angles, equations

To the Editor:

Several reports of contact angle measurements of various liquids on human skin have appeared in recent years (1–4). Although these papers differed in the reported values of the contact angles, especially for water, there was general agreement that human skin behaves as a low energy solid. Rosenberg *et al.* (3) made their measurements on specially cleaned viable and excised skin and calculated the surface energy of skin due to dispersion forces (γ_S^D) using Eq. 1:

$$\cos \theta = \frac{-\gamma_L + 2\sqrt{\gamma_S^D \gamma_L^D} - \pi_S}{\gamma_L - \pi_L} \quad (\text{Eq. 1})$$

where θ is the contact angle, γ_L is the surface tension of the liquid, γ_L^D is the dispersion force component of the surface tension of the liquid, π_S is the reduction in surface energy of the solid due to adsorption of vapor from the liquid drop, and π_L is the reduction in surface tension of the liquid due to spreading of the solid. The investigators assumed π_S and π_L to be negligible, as is often done when dealing with low energy surfaces.

Similarly, El-Shimi and Goddard (4) neglected these spreading terms in their analysis of the dispersion force (γ_S^D) and polar (γ_S^P) contributions to the surface energy of skin, using Eq. 2:

$$\cos \theta = \frac{-\gamma_L + \frac{4\gamma_S^D \gamma_L^D}{\gamma_S^D + \gamma_L^D} + \frac{4\gamma_S^P \gamma_L^P}{\gamma_S^P + \gamma_L^P}}{\gamma_L} \quad (\text{Eq. 2})$$

In addition to the symbols previously defined, γ_L^P is the polar contribution to the surface tension of the liquid.

Skin presents a complex surface whose properties are influenced by a variety of endogenous, secreted, and excreted substances. Mono-, di-, and triglycerides and free fatty acids are among the lipids found most abundantly on the skin (5); these substances are known to spread on water, lowering its surface tension significantly (6). According to a recent report, sweat collected from thermally stimulated subjects had surface tension values lower than that of water by about 13–19 dynes/cm, depending on the skin region used (7).

There is, therefore, good reason to think that π_L may have a value other than zero in many cases. The value of π_L will be a function of the liquid, the nature of the skin area, the history (or pretreatment) of the skin sample, and the area of contact between the liquid drop and the skin. If the spreading process is time dependent, then the contact angle will decrease with time, an effect observed by one investigator (1). The large variation found in the contact angle of water on skin (1–4) is probably related to differences

in lipid adsorption at both the water–air and skin–water interfaces.

Unfortunately, neither Eq. 1 nor 2 is adequate for quantitating the effect of skin surface lipids on the contact angle. Equation 2 does not contain π_L . Equation 1 does contain π_L , but no provision is made for changes in adsorption at the solid–liquid interface. For liquids whose contact angles are greater than 90°, Eq. 1 predicts that a rise in π_L will cause an increase in the value of the contact angle. Actually, the opposite takes place (8).

Thus, it appears that approaches that have been successful in characterizing other low energy surfaces are of only limited usefulness when applied to skin. More data on the adsorption of surface lipids would be helpful in understanding wetting and spreading on skin.

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Received March 3, 1975.

Accepted for publication April 4, 1975.

Variability in System for Automated Determination of Dissolution Rate

Keyphrases □ Dissolution rates—automated determination, analysis of data, variability □ Automated analysis—dissolution rates, analysis of data, variability

To the Editor:

Recently, Johnson *et al.* (1) described a continuous-flow system for the automated determination of dissolution rates. The major obstacle encountered in any continuous system, *i.e.*, assuring the measurement of a clear solution free of extraneous particles which cause turbidity in the solution and cloud the surfaces of the flow cells, was overcome by the incorporation of filter units into the system, utilizing disposable Teflon or polyvinyl inserts.

The authors (1) reported excellent agreement between the dissolution rates obtained by an automated system and by manual measurements. According to these investigators, their instrumentation can