

Dyne Solution Equivalents

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There are many commercial kits available for determining wettability by applying a sequence of solutions to a surface and observing whether they "bead up" or not. This is a common shop-floor test. A typical set might have solutions with the following surface tensions: 50, 48, 46, 44, etc. The user purchases a set with the desired range of tensions. Starting with a higher tension fluid, the user spreads solution on the surface under test. If the solution beads up, i.e., does not maintain a continuous film over the surface, then the process is repeated (at another spot on the surface!) until a film remains continuous. The surface tension of this solution is called the *critical wetting tension* for the surface. An industrial short-hand is to say the surface has a "dyne value" equal to the surface tension of the solution which maintained a continuous film. While there are limitations of the technique, such as the operator judgement of whether the film remained continuous (remained continuous for how long?), dyne solutions are widely used.

Surface Energy and Critical Wetting Tension

Surface energy is another way of characterizing a surface. Surface energy is to a solid as surface tension is to a liquid. From a thermodynamic point of view, the critical wetting tension of a surface is not identical to its surface energy, but from a practical point of view, the numbers are very similar. Therefore many workers use critical wetting tension as a usable approximation to surface energy.

Surface Energy and Contact Angles

Contact angles are a classical method of describing the adhesion of a liquid to a solid. Young's equation relates contact angle to interfacial forces. Strictly speaking, surface energy can not be determined from contact angle measurements *alone*, because there are too many variables in Young's equation. We remove these extra variables by employing a theory which explains their interactions. There are several theories in use, from the Girifalco-Good-Fowkes-Young equation to the Lewis acid/base theory. They vary in complexity and accuracy, and different users have their own favorites. Nevertheless, let us have a contact angle θ , surface energy γ_{SV} , and critical wetting tension γ_{CWT} . The following computations are possible:

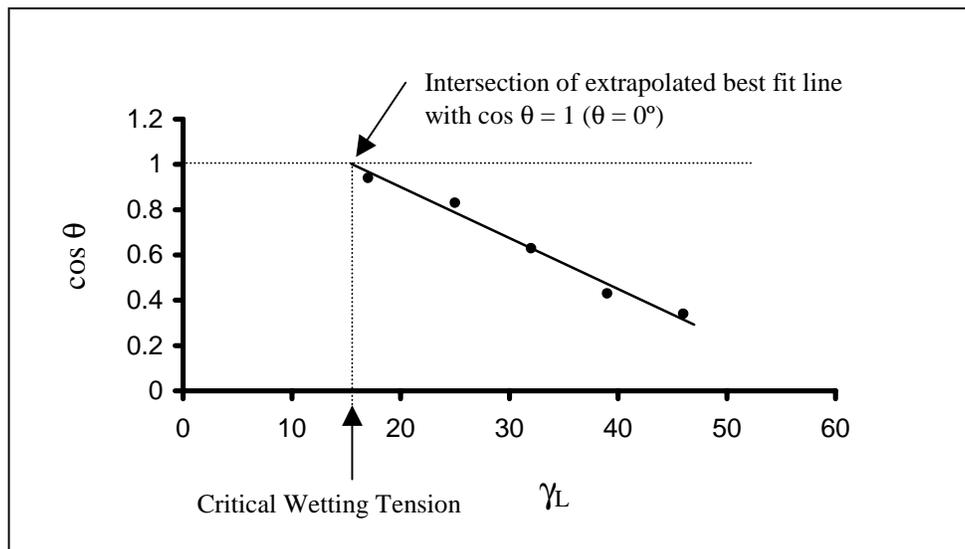
$$\begin{aligned}\theta &\Rightarrow \gamma_{SV} \quad (\text{using additional surface energy theory}) \\ \gamma_{CWT} &\approx \gamma_{SV} \quad (\text{close enough for engineers}) \\ \text{dyne value} &= \gamma_{CWT}\end{aligned}$$

Zisman's Critical Wetting Tension

Zisman developed the following technique, described completely in Arthur Adamson's *Physical Chemistry of Surfaces*, ISBN 0-471-61019-4. Zisman measured the contact angle θ for a set of solutions of differing surface tensions γ_{LV} . When the cosine of the contact angles is plotted against the surface tensions, a more-or-less straight line is formed. This line is extrapolated to the point of

$$\theta = 0$$

which is where $\cos(\theta) = 1$.



Why would he want to do this? When the contact angle just goes to zero, the liquid film will spread and remain continuous, so this is the critical wetting tension, or the "dyne value."

Therefore Zisman's plot lets you compute γ_{CWT} (by extrapolation) from a set of non-zero θ 's. In fact, you can actually use kit solutions with Zisman plots, but you measure the contact angle for several solutions and then make the plot, rather than trying to observe which solution just remains continuous.

FTÅ Software Capabilities

The software offers all of the computations discussed here:

- contact angle θ measurement
- surface tension γ_{LV} measurement
- surface energy γ_{SV} calculation via the theories
- critical wetting tension γ_{CWT} extrapolation from contact angle measurements