Surface Tension of Paint Pigment Paste

November 15, 2000

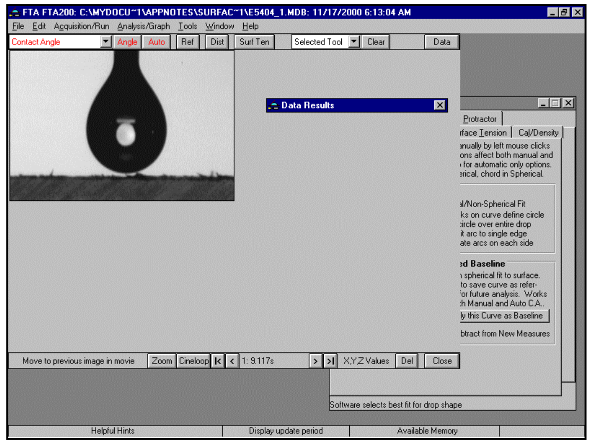
The interfacial tension of paint pigment in paste form is important industrially but can not be measured with traditional methods (Wilhelmy plate or Du Nouy ring tensiometers) because the sample is not a liquid. The drop shape method is practical however.

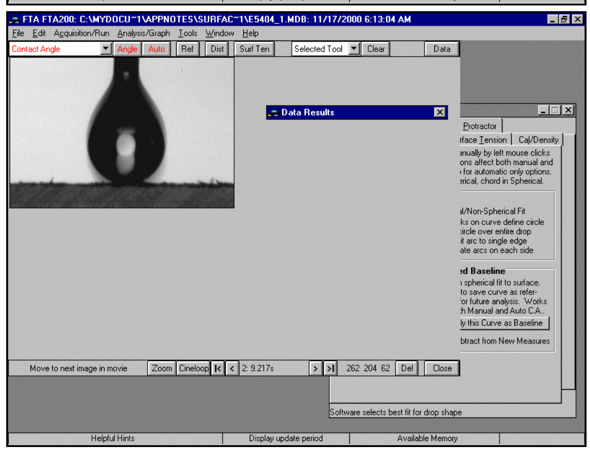
Sample Preparation

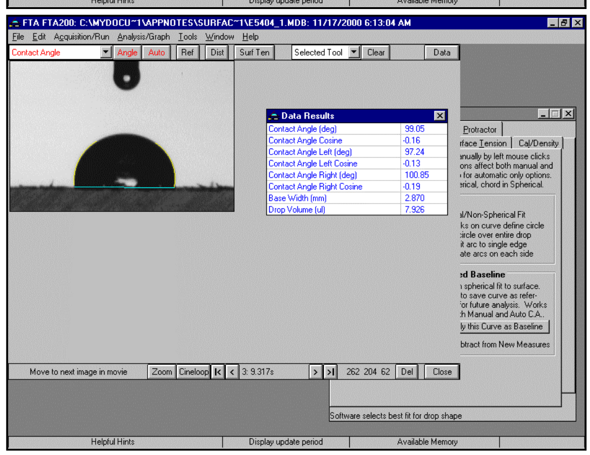
The paste is spread smoothly onto a carrier. We used glass microscope slides (3" × 1" × 1mm) because they offer good adhesion to the paste and are smooth, reasonably sized, and economical. The slides are disposable; it would be expensive to clean them to the degree necessary to guarantee no cross-contamination. The slides were used as-is from the box. A technical knife was used to spread a uniform sample coating on the slide. Approximately 5mm^3 (equivalent to 5μl volume) is required per sample. The results do not seem to be influenced by the normal variations in spreading the sample.

Measurement Protocol

Sessile drop contact angle measurements were made using an FTÅ200. Because water reacted with these pigments, ethylene glycol was used as the test fluid. Formamide would have worked well also. The ethylene glycol was placed in a disposable plastic 10cc syringe and dispensed with a 22GA stainless steel needle. The surface tension of the ethylene glycol was verified with the same instrument, since contact angle measurements are dependent on both the substrate *and* the test fluid. The needle tip was placed 3mm above the surface so the pendant drop would grow into the surface — when the bottom touches the surface the drop will detach. The three images below, 100ms apart, illustrate the touch-off process.

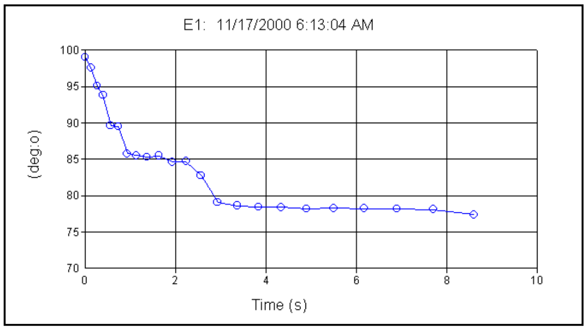




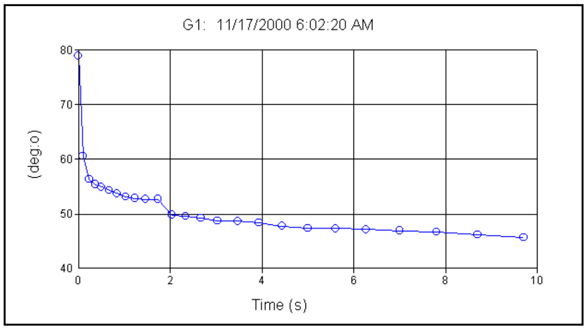


Samples

Two different pastes, "E" and "G", were tested to find any wettability difference. The contact angles was measured over the ten seconds after the drop touched off. The following graphs of contact angle versus time show two characteristics: a decreasing angle in time (the drop spreads), and, often, a "stick-slip" wetting. The viscosity of ethylene glycol, ≈16 times that of water, limits how fast the drop can spread on the surface. The first one second is dominated by viscosity-limited spreading. In the graph immediately below, the plateau from 1-3s shows stick-slip wetting. The equilibrium angle from 4-8s in this graph is 78.2°.



A representative contact angle graph for G is next; the equilibrium angle (4-8s) is 46.6°.



The G sample is more wettable than the E sample, as its contact angle is much lower. Three drops were placed on each type material (a more thorough study would use a larger number of drops for better statistics). The following table summarizes the data.

Sample	Contact Angle
E, #1	78.2°
E, #2	74.3°
E, #3	70.7°
E Mean (average)	74.4°
G, #1	46.6°
G, #2	48.5°
G, #3	40.3°
G Mean (average)	45.1°

The standard deviation σ of the data is ≈4°, but the means of the two materials are separated by ≈30°, or 7.5σ, which is substantial.

Surface Tensions

Surface tension (or, equivalently, surface energy) can be calculated from contact angle data using one of several available theories. The simplest is the Girifalco, et al, theory (all of the commonly used theories are included in FTÅ software), used here.

Sample	Contact Angle	Surface Tension
E	74.4°	19.3mN/m
G	45.1°	34.9mN/m

Surface tensions are sometimes specified with units of dynes per centimeter, but this is numerically equal to milli Newtons per meter.

Summary

Surface tension, ordinarily used to describe the cohesiveness of liquids, can be determined by contact angle measurements followed by conversion to surface tension units using surface energy theory.