Detection of Mold Release Agent

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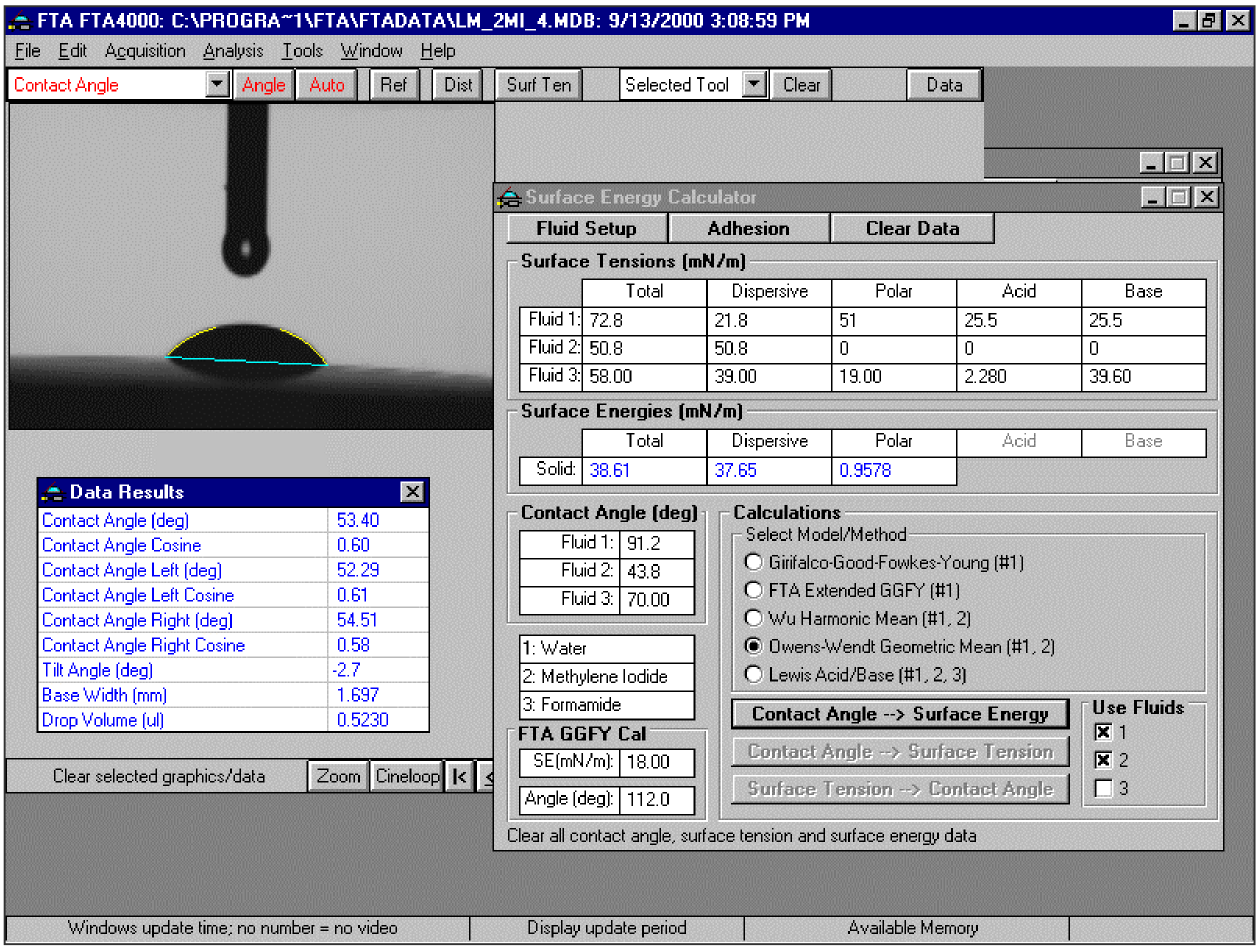
Two injection molded plastic samples were tested for mold release agent. The samples were hemispherical in shape. Contact angles were measured using water and methylene iodide (diiodomethane). The samples had been handled somewhat, so it was not surprising there was some variation in measurements at different locations. Because of this, five measurements of each fluid were made on each sample. The figure below shows a typical drop, in this case methylene iodide on sample #2.



Screen image show frame from movie and surface energy calculator.

The movie image shows the drop is placed on the curved surface, rather than exactly on top. The software accounts for the slope of the substrate; in this case, the right hand side, 54.51°, is the advancing contact angle because it is on the downhill side. The surface energy calculator, also present on the screen, is used to convert averaged contact angles into equivalent surface energies.

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Wetting tensions can also be used to characterize surfaces from contact angle data; these will be described in more detail below.

Two separate drop deposition methods were evaluated on these samples. One method is to form a pendant drop on the dispense tip and then lower the tip until the drop touches off on the substrate from the greater adhesion it has to the surface below. This is what was used in the illustration above. The alternative method is to place the needle lower and continuously expand a sessile drop on the surface. This method was use with water because these surfaces had significant static electricity and this prematurely pulled the water drops off the needle when the touch-off method was attempted. With the expanding drop (needle in drop) method, static electricity is discharged through the slight conductivity of water to the needle and the instrument.

The table summarizes the averaged data and the surface energy and wetting tension data. Wetting tension is the product of the surface tension of the test fluid multiplied by the cosine of the contact angle. It expresses the relative adhesion of the liquid to the substrate versus its own cohesion. A contact angle of 90° gives a zero wetting tension, or a balance between adhesion and cohesion.

Measured or calculated data	Sample #1	Sample #2
Water contact angle (degrees average)	89.8	91.2
Methylene iodide contact angle (degrees average)	32.5	43.8
Water wetting tension (mN/m)	0.25	-1.52
Methylene iodide wetting tension (mN/m)	42.8	36.7
Total surface energy (Owens-Wendt, mN/m)	43.8	38.6
Dispersive surface energy (mN/m)	43.2	37.6
Polar surface energy (mN/m)	0.6	1.0

Sample #2 has the lower surface energy and lower wetting tension. The mold release agent can be expected to have low energy (low adhesion is desired) and be dispersive in nature. Methylene iodide is entirely dispersive (it has no polar component), hence it is an excellent probe for dispersive contaminants. While there is no significant difference between the two samples for the water contact angle (the average contact angle standard deviation for the surface was 4.5°), the methylene iodide angles and energies are significantly different.

The surface energy results also show there is no significant polar energy component to either surface; this is another reason to probe the surface with a largely dispersive liquid rather than a highly polar liquid like water. While methylene iodide is an acceptable liquid to use under laboratory conditions, there are other more benign test liquids to use on the shop floor for surface energy or wetting tension testing. Squalene is one example and there are others. Finally, contact angle results can be calibrated for percent coverage of a contaminant such as a mold release agent by measuring a completely clean and a completely saturated surface. A simple, but useable, model of the surface then has a linear coverage from zero to two monolayers for complete response. A more sophisticated model fits and exponential response with asymptotic full coverage at three monolayers.

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