

FTA DCA-100 Resolution

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The force exerted by a liquid on a fiber (or any round object perpendicular to the liquid) is

$$F = \pi D \gamma_{LV} \cos \theta$$

where

D = diameter of fiber (assumed constant)

γ_{LV} = surface tension of liquid

θ = contact angle of liquid against fiber

The balance's resolution is specified in micrograms (μg). This is the mass that it will reliably resolve. For the DCA-100, this is $10\mu\text{g}$. Using

$$F = mg$$

with $g = 9.8\text{m/s}^2$, this $10\mu\text{g}$ resolution figure converts to $9.8 \times 10^{-8}\text{N} = 9.8 \times 10^{-5}\text{mN}$ (approximately $.0001\text{mN}$), which is a convenient choice of units since surface tensions are in mN.

10 Micron Fiber Example

The actual force, and therefore the actual contact angle resolution, will vary with the angle via the cosine function. At zero degrees the force will be its maximum and at 90° there will be no force. To make things easy, we consider the extremes and linearly interpolate. At zero angle, the cosine function is 1. Force on the balance is

$$F = \pi D \gamma_{LV}$$

10 microns is 10^{-5} meters. Letting our forces be measured in mN (rather than N),

$$F = \pi \times 10^{-5} \times 72.8 = 229 \times 10^{-5} \text{ mN}$$

Dividing the maximum force by the useable resolution of the balance,

$$229 \times 10^{-5} \text{ mN} / 9.8 \times 10^{-5} \text{ mN} = 23.3$$

so our theoretical resolution is 1 part in 23.3 ($\approx 4\%$) of the maximum angle (90°).

Other Fiber Diameters

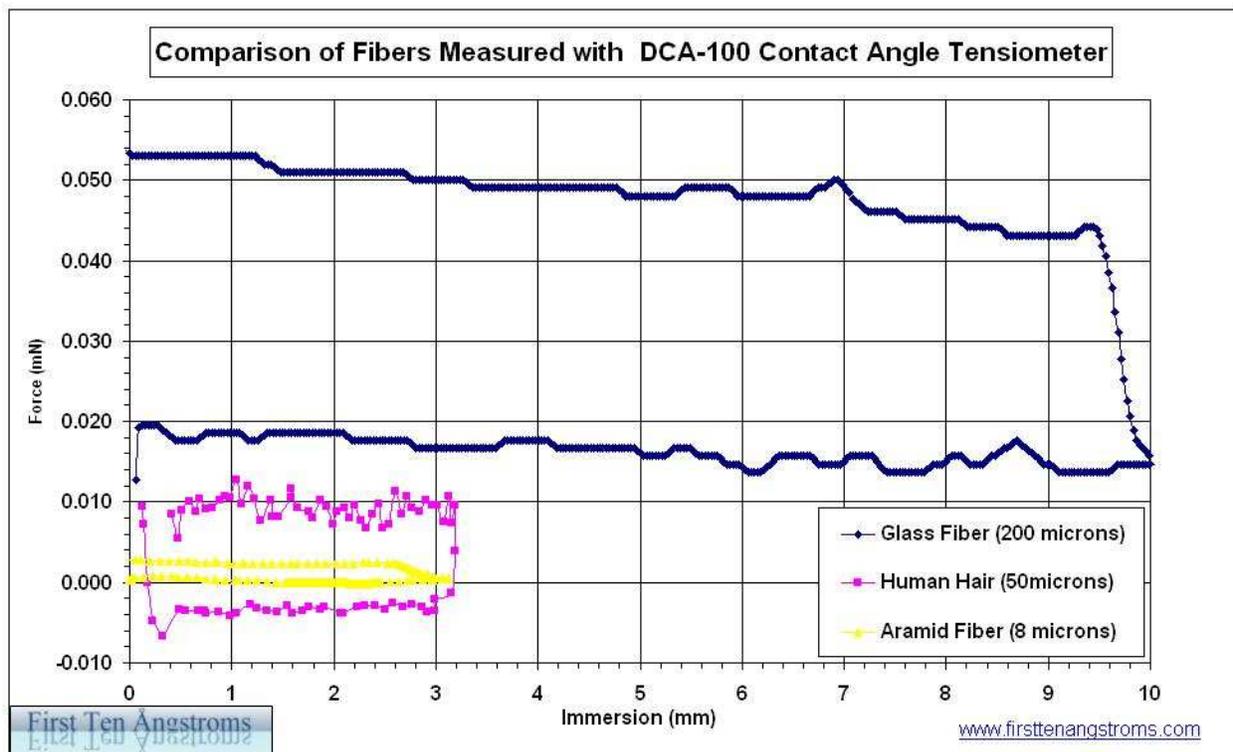
The percentage resolution scales inversely with the diameter: if the fiber is twice as large, the resolution is one half, or 2%. If the fiber is only one half as large (5 microns), it is twice as large or 8%.

Other Surface Tensions

The percentage resolution scales with the liquid's surface tension the same way it does with diameter: larger surface tensions make for better resolution and smaller tensions make for worse (larger) resolutions.

Example Immersion Plots

The following plots show force versus immersion depth for three materials. The lower horizontal portion of the loop is the immersion (measuring the advancing angle) and the upper portion is the withdrawal (measuring the receding angle).



The human hair is porous and not smooth, so requires special consideration (the job of the cosmetics industry!). Glass fiber advancing = 64° and receding angle = 11° . Aramid fiber advancing = 74° , receding angle = 0° . Accuracy depends on diameter accuracy.

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