First Ten Ångstroms

Instrument Selection

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Instrument selection requires evaluation of a number of factors, including how much flexibility is required in sample handling and whether special chambers are required. These affect the cost and complexity of the instrument. All things being equal, you want the simplest instrument that will do the job. FTA offers a variety of instruments to suit the different needs of different industries and applications. Roughly speaking, these vary over a 10:1 range in price.

Why Do Instruments Vary in Price?

Sample handling and automation (robotics) are the main reasons for cost variations. Optics is a secondary, but not trivial factor.

Does the Software Vary?

The same software is furnished with all instruments. Upgrades are available for download at any time without charge. The only variation is that some instruments will not be able to acquire the data for some measurements because they lack the mechanics to do so. Also, the FTA software may be installed on as many machines at your company as you find convenient.

Does the Accuracy Vary Between Different Models?

The accuracy is similar between all models. The differences which arise are caused by some models having better, or more flexible, optics. The zoom microscope used in the FTA200, 1000, 2000, and 4000 models lets the magnification be varied so the liquid drop fills a significant portion of the screen. The FTA100 series has fixed magnification. Sometimes that can be multiplied by a factor of 2 with an auxiliary lens. Basically it is easier to obtain *fine* results with an FTA200 than with a 100 series instrument because it is easier to obtain an ideal image with the zoom microscope.

465 Dinwiddie Street • Portsmouth, Virginia 23704 • 1.757.393.1584 Fax: 1.757.393.3708
http://www.firsttenangstroms.com

What Affects Accuracy?

Accuracy is primarily determined by the care with which the operator sets up the measurement, not by the instrument itself. These following are under the user's control and are crucial to good results:

- Focus. Bad focus is the primary cause of poor results. A focus "meter" is part of the software and should be used.

- Drop Size. With a zoom microscope, the magnification can be changed to match the drop. With the 100 series, the magnification is fixed so the drop volume must be varied to fit the image size. Ideally, the drop will always occupy 2/3 or more of the image.

- Contrast. Proper lighting and camera adjustment are required for good images.

- Vibration. This affects interfacial tension measurements more than contact angle measurements. An air table may be required in the most difficult cases. You should never see motion in the image caused by external vibration sources.

- Baseline Determination. This is the limitation with contact angle measurements. Good automatic baseline determination requires a well-positioned sample so the baseline is visible.

What Kind of Accuracy Can I Expect?

Specifications are given for FTA instruments in the note, *General Specifications for FTA Drop Shape Instrumentation,* available in the Papers section of www.firsttenangstroms.com:

http://www.firsttenangstroms.com/pdfdocs/GeneralSpecsForVideo.pdf

This note uses the term "practical accuracy," by which we mean the accuracy you can expect with ordinary care. A user can obtain *superior* results with extra care. The issues are those of the above list. The optics are sufficiently good that they are not normally the limiting factor with any of the instruments, but some instruments may require more care and effort as described above.

What Calibration Standards Are Available?

For contact angle work, FTA has available 90 and 39° standards made by embedding a sapphire ball in an aluminum block to the correct depth. These are 3-D objects and require the same setup as a real liquid drop. They should not be confused with 2-D film images which are much less demanding and do not really test the instrument.

You should expect to come within ±1° of the standard's value. In truth, much of the uncertainty is in the standard itself, as it is difficult to manufacture to the precision required to be really better than the instrument.

For interfacial tension work, most people use distilled water. At 25°C ambient, the handbook value is 71.9mN/m. You should be able to come within ±1mN/m and with care, ±0.5mN/m. Vibration becomes the limiting value at this point. It should also be noted that *extreme* care is required to maintain the purity of the water for such measurements. See the FTA website for examples and discussions of this measurement. With good vibration isolation, people do ±0.25mN/m.

How Does Sample Handling Vary?

Sample handling varies from a simple table, positioned by hand on the desktop, for the FTA125 to 3 axis robotic stages for the FTA200 and above systems. The more expensive instruments offer a choice of manual rack-and-pinion stages (so the user turns a knob to move the stage) or stepper motor driven stages under software control.

There are three descriptions that can be applied to stages:

- range of motion (how much can position be varied without a new setup)
- how big a sample can be supported
- over what range on the sample can drops be placed and analyzed.

The real limitation is the *working distance* of the optics. This is the distance from the mechanical end of the lens to the focal plane. Sample motion greater than the working distance requires special considerations. Why not just use a long working distance lens? The answer is that these suffer from poor resolution, so there is a compromise between good optical resolution (good image quality) and space to move the sample around. For reference, most FTA instruments use a working distance of approximately 100mm.

To get around this limitation for really large samples, most FTA instruments provide the flexibility to look down slightly on the sample. A typical angle is 3° above the horizontal. This tilts the optics up just enough that the sample can slide under them and thus be moved around on a larger scale. We presume, of course, that the sample is flat so no "mountains" run into the optics.

The table on the following page compares the various instruments in the FTA line.

Model	Working Distance and approximate Horizontal Field of View	Stage Movement	Sample Size	Comments
FTA125	75mm 8mm or 4mm with opt extender lens	manual X-Y, adjustable Z, completely by hand; limited to 125mm along optical axis; other dimension open	125×125×25mm practical one "125" dimension can be larger if need be	choose either 0° or 3° mirror at time of order; use 0° for small (25×100mm) samples; 2nd mirror at extra cost. FTA125 does not have optional stages or chambers.
FTA135	75mm 8mm	manual R, manual Z, geared theta R-θ-Z stage for wafers	up to 300mm ϕ wafers or 400×400mm panels	specialized for wafers and similar products
FTA136	75mm 12mm	sits on top of transparent glass sample which may be indefinitely large	any size	contact angle measurements by the top view method; particularly good for low angles
FTA137	75mm 8mm	sits on top of non-transparent samples	any size	traditional 3° side-view contact angles from head sitting on large sample
FTA188	65mm 5mm high quality fixed mag microscope	manual rack-and-pinion 44×44×25mm stage standard; rotary and other stages optional	150×150×25mm practical; the FTA188 offers unusually good access to samples and this makes sample handling easy and flexible	The FTA188 is the only model in the 100 series that can use FTA200 chambers and stages; it also has a swinging arm mount to instantly change from 0° to any angle up to 6° lookdown
FTA200	93mm 8→1.4mm zoom	manual rack-and-pinion 44×44×25mm stage standard; rotary and other stages optional	150×150×25mm practical	variety of stages and chambers available
FTA1000	35 to 175mm 8→1.4mm zoom	modular system with a variety of stages	up to 300mm ϕ wafer or 150×150mm general purpose samples	expandable, modular system compatible with automation
FTA2000	175mm 8→1.4mm zoom	150mm radial, 360° theta, 25mm Z stepper driven	up to 300mm ϕ wafer	highly automated, sequencer driven instrument
FTA4000	35mm 1.7→.26mm zoom	25×25×25mm stepper driven	25×25×25mm	specialized for very small drops

What Measurement Techniques Are Possible?

The software to support all measurements is supplied with instruments. The only question is whether the hardware provides the required sample support.

Technique	Instruments ✓ = yes, × = no, ○ = with opt equip	Comments
Contact Angle by		
Sessile drop	✓ All	
Captive bubble	○ FTA125	requires user supplied chamber
	× FTA135, FTA136, FTA137	no space for chamber
	○ FTA188, FTA200	cuvette holder and IFT chamber available
	× FTA2000, FTA4000	no space for chamber
Capillary rise	× FTA125, FTA135, FTA136, FTA137	no space for sample support
	○ FTA188, FTA200	requires kit or user construction to support sample
	× FTA2000, FTA4000	not practical to support sample
Interfacial Tension by		
Pendant drop	✓ All	inverted mode (upside down drop) requires a cuvette or chamber; see notes above for captive bubble for inverted experiments
Sessile drop	✓ All	
Drop volume	× FTA125, FTA135, FTA136, FTA137	no automated pump available
	○ FTA188	requires optional automatic pump
	✓ FTA200, FTA2000, FTA4000	
Dorsey approximation	✓ All	useful only when Laplace-Young cannot be applied
Distance	✓ All	
Absorption by		
Sessile volume	✓ All	
Surface Energy	✓ All	all common approximations (methods) supported
Dilational Stress	× FTA125, FTA135, FTA136, FTA137	requires automated pump
	○ FTA188	requires optional automatic pump
	✓ FTA200, FTA2000, FTA4000	

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