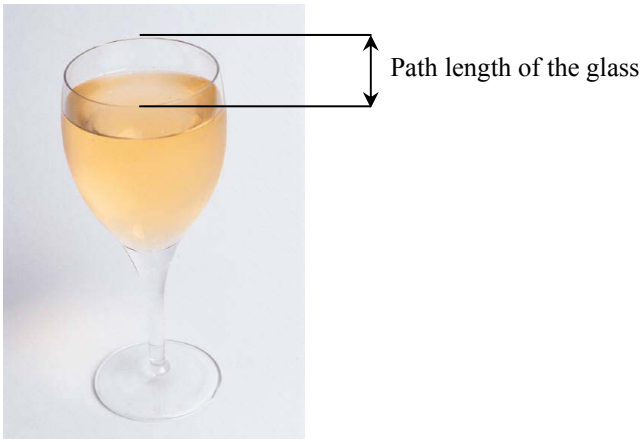
Applications Note

Insight on Color **Vol. 14, No. 8**

Path Length and the Measurement of Transparent Liquids

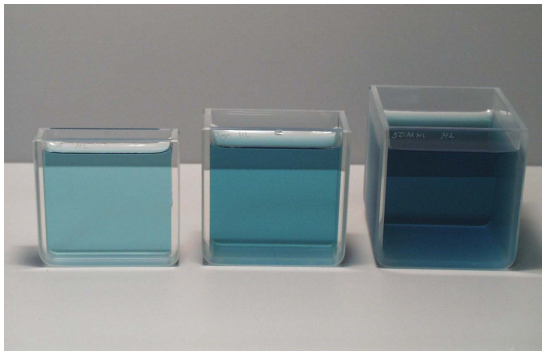
If you were to hold a glass of colored liquid up to a lamp and look at its color as the light shines through it from behind, you would be viewing its transmitted color. Transmitted color of a liquid is determined the same way with your instrument (ColorQuest XE, ColorQuest XT, UltraScan PRO, or UltraScan VIS). When you place the liquid into the transmission compartment, the instrument lamp shines through the sample and the detector measures the color of the light that passes through the liquid to the detector.

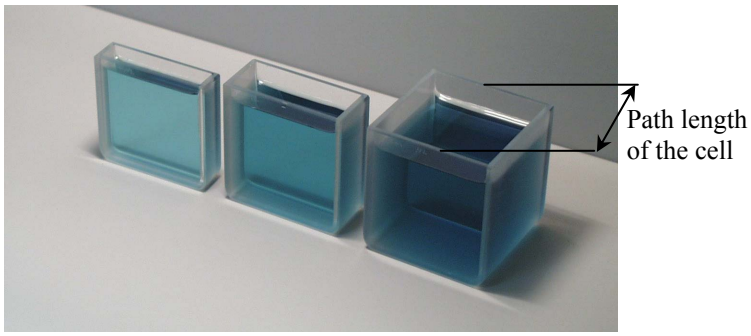
In either case, the path length of the liquid is determined by its container. The distance from the front edge of your glass (where you are looking) to the back edge of the glass (where the light is entering) is the path length. For a typical transmission cell, the path length is the distance from the clear side of the cell where the light enters the sample to the opposite clear side of the cell where the light exits and goes to the instrument's detector.



When measuring transmitted color of a liquid in any container, it is ESSENTIAL that the appropriate sample path length be selected and used consistently. Why is that? Well, let's take a look.

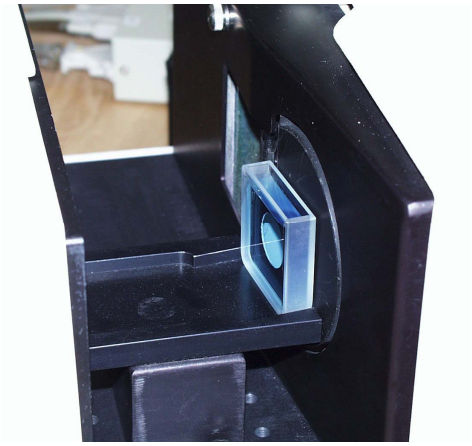
Below are pictures of transmission cells with three different path lengths that have been filled with the **same** colored liquid.



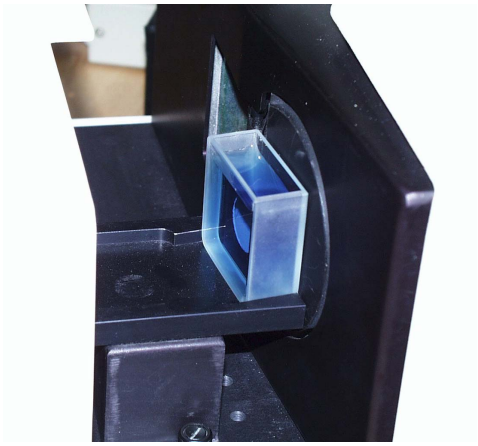


Do they look the same? No! In the front view, you can see that the liquid in the cell on the left looks lighter and less saturated than the liquid in the other two cells. The sample on the right looks very dark and saturated. In the angled view, you can see the differences in the cell path lengths. The cell on the left has a 10-mm path length, the middle one has a 20-mm path length, and the cell on the right has a 50-mm path length. The samples look different to your eye with different path lengths. Is the same thing true when you measure with an instrument? You bet.

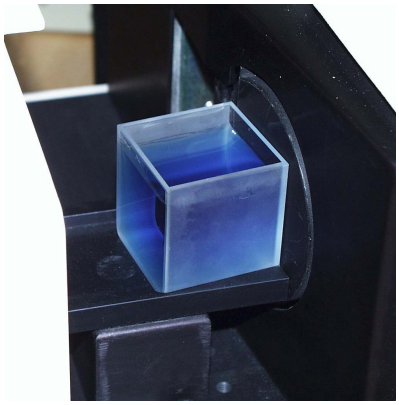
Each of the above samples was measured on an UltraScan XE in TTRAN mode as shown in the pictures below.



10-mm cell



20-mm cell

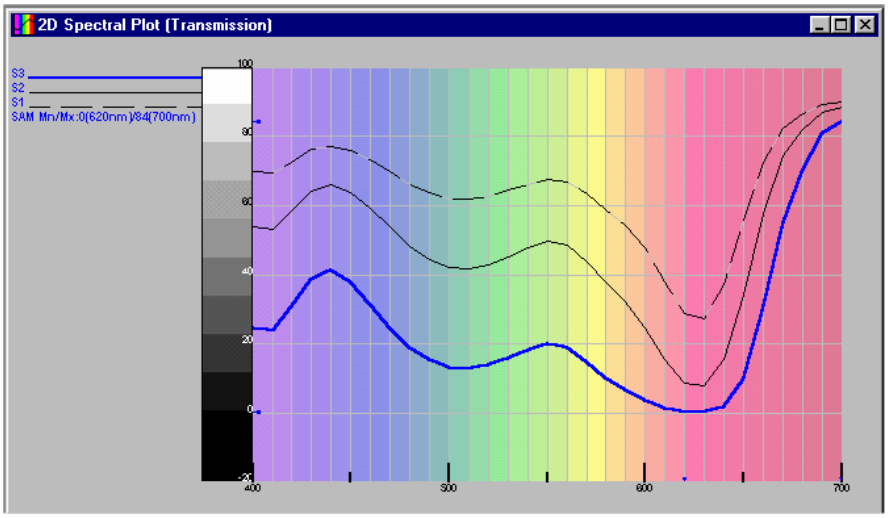


50-mm cell

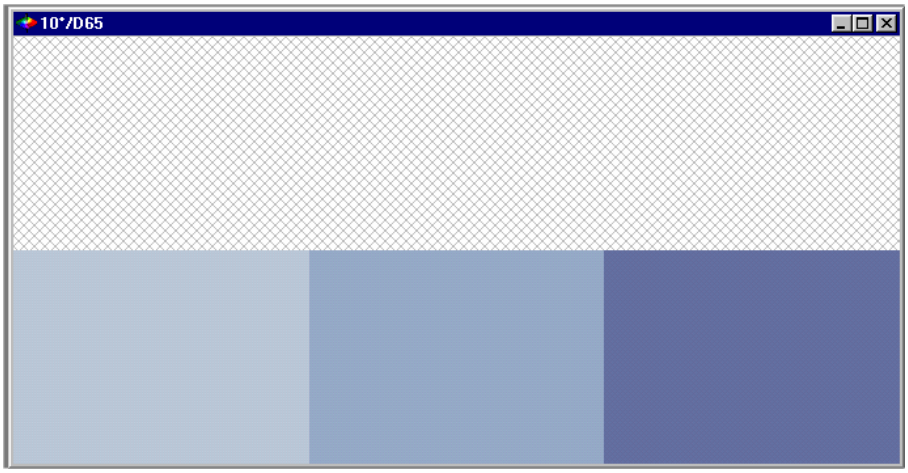
The following color values were received (D65/10°).

Cell Path Length	L*	a*	b*
10-mm	81.82	-8.77	-11.34
20-mm	69.88	-10.18	-19.59
50-mm	44.54	0.79	-32.26

Just as we had noted visually, the sample in the 10-mm cell appears lighter (higher L*) and less saturated (particularly for the blue; b* is less negative) than the samples in the cells with longer path lengths. The spectral plot and color rendering view shown below also illustrate the differences detected instrumentally.



The spectral transmission plot for the samples. The top curve is the 10-mm path length and the bottom curve the 50-mm path length. The curves have the same shape.



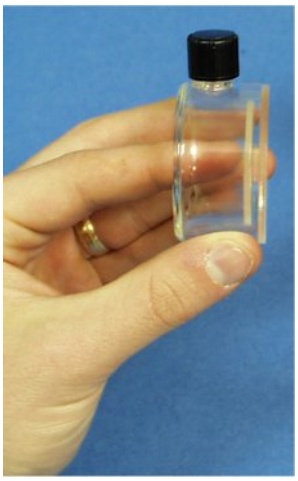
The color rendering (approximation of what the instrument sees) for the samples. The left box on the bottom is the 10-mm path length and the right box on the bottom is the 50-mm path length.

So, what does all this mean? It means that for each type of liquid you measure and compare, you need to choose one path length, record that path length as part of your measurement method, and stick with it.

If you measure some samples in a 10-mm cell and others in a 20-mm cell, you will not be able to compare the measurements. So, what is the proper path length for your samples? That depends.

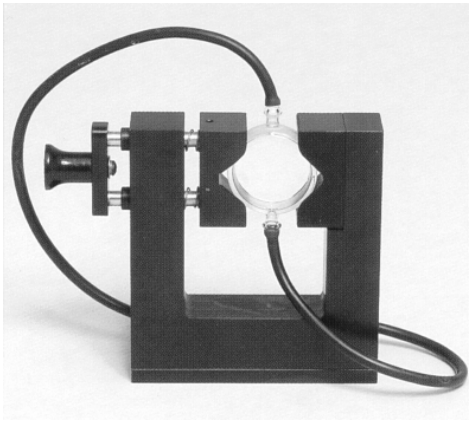
Sometimes the path length may be specified by your measurement method. For instance, ASTM D1500 requires that measurements of samples for which the ASTM D1500 Index will be calculated be made in a 33-mm transmission cell. This kind of specific requirement makes your decision easy.

In other cases you may have limited quantities of sample available or it may be an expensive product that you'd like to use sparingly. You might choose to use a special small path length cell that requires only a very small amount of sample.



For hazardous or volatile liquids, you may wish to use a screw-top transmission cell rather than an open one. A 20-mm screw-top cell is shown below.

If you would like to bleed sample from a process line and/or pump liquid directly into and out of the transmission cell while it is situated in the instrument, you may wish to use a flow-through transmission cell like the one shown below.



If none of these conditions apply, then your path length should be chosen based on the color of your sample. If you're measuring a colorless or near-colorless liquid, a 50-mm cell should be used, if possible, to maximize the difference the instrument will see between samples. The longer path length means more liquid is being viewed and any color there is will be amplified. If your sample is a dark or very saturated color, you will want to use a cell with a smaller path length (such as 10-mm) so that as much light as possible can pass through the sample and get to the detector. A shorter path length and less liquid means that less light will be lost in the sample and the amount of light making it to the detector will be adequate for an accurate measurement. For moderately-chromatic liquids or when a variety of colors will be measured, a 20-mm cell can be used by default.

All the transmission cells currently available through HunterLab are listed in the table below. Each transmission cell requires a special cell holder for proper placement. These holders are also listed in the table, grouped with the cells they support. More information on these items can be found in your User's Manual or CMR addendum.

Catalog Number	Item	Path Length
D02-1011-568	Transmission Spill Tray and Cell Holder	
C02-1005-481	Transmission Cell Holder	
13-8573-20	Transmission Cell	50 mm
B04-1003-801	Transmission Cell	33 mm
04-4592-00	Transmission Cell	20 mm
13-8573-40	Transmission Cell	10 mm
D12-1011-892	Transmission Cell with Two Screw Tops	50 mm
D12-1011-891	Transmission Cell with Two Screw Tops	33 mm
D12-1011-890	Transmission Cell with Two Screw Tops	20 mm
D12-1011-893	Transmission Cell with Two Screw Tops	10 mm
B04-1002-672	Tall Transmission Cell	20-mm
D02-1009-960	Flow-through Cell Holder	
C04-1001-960	Flow-through Cell	50 mm

Catalog Number	Item	Path Length
C04-1001-959	Flow-through Cell	20 mm
C04-1001-958	Flow-through Cell	10 mm
CMR 2581	Small Volume Top-Loading Transmission Cell	2 mm
L02-1012-202	Semi-micro Cell Holder and Optical Assembly for 10-mm or 20-mm standard or semi-micro cuvettes (not available through HunterLab)	
D02-1011-550	Cylindrical Cell Holder for 27-mm to 30-mm OD Tubes (not available through HunterLab)	
CMR 2751	Spill Tray and Cylindrical Cell Holder for 27-mm to 30-mm OD Tubes (not available through HunterLab)	
D02-1011-886	Holder for Small Volume Transmission Cells	
A13-1011-613	Screw Cap and Injectable Cylindrical Small Volume Transmission Cell	10 mm
CMR 2375	Transmission Cell Holder for Narrow (1-cm wide) 10-mm, 20-mm, and 50-mm Cuvettes (not available through HunterLab) in RTRAN	
CMR 2608	Insulated Holder for Hot Liquids	
B04-1002-672	Tall Transmission Cell	20-mm
CMR 2865	Holder for 20-mm OD Nessler Tall Form Color Comparison Tubes (not available through HunterLab)	

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