Spectro 1™ Review[1]

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Have you ever looked at the small color sensors like Nix and Color Muse, wishing that you had one that was more than a simple colorimeter? Poof! Your wish is granted.

Earlier this year a new device appeared on the market. Produced by the same company that makes the Node color sensor, the Spectro 1 has one big difference; it is a spectrometer, not a simple color sensor.

About the size of a C cell battery, this device crams lots of capabilities in a small package. It connects by Bluetooth to an iPhone or Android phone. The rechargeable battery is charged over a supplied USB cable. The top of the Spectro 1 has colored LEDs indicating status, measurement completed and a color simulation of the object measured.

Let's take a closer look at what you get and how it performs.

What's In the Box?

The package I received contained the Spectro 1, three calibration tiles, a USB charging cord, a lanyard and a carry bag.

Notice what is not in the box; a manual. The only instructions provided are printed on one side of the accessory box.

[1]This is a revised review first published in 2019.

Hooking It All Up

The first thing I did was to plug the Spectro 1 into a USB port to charge the battery to full. Then I installed the app in an iPhone. Before testing, the Spectro 1 was calibrated to the three tiles to make sure it would produce its most accurate measurements.

Spectral Testing

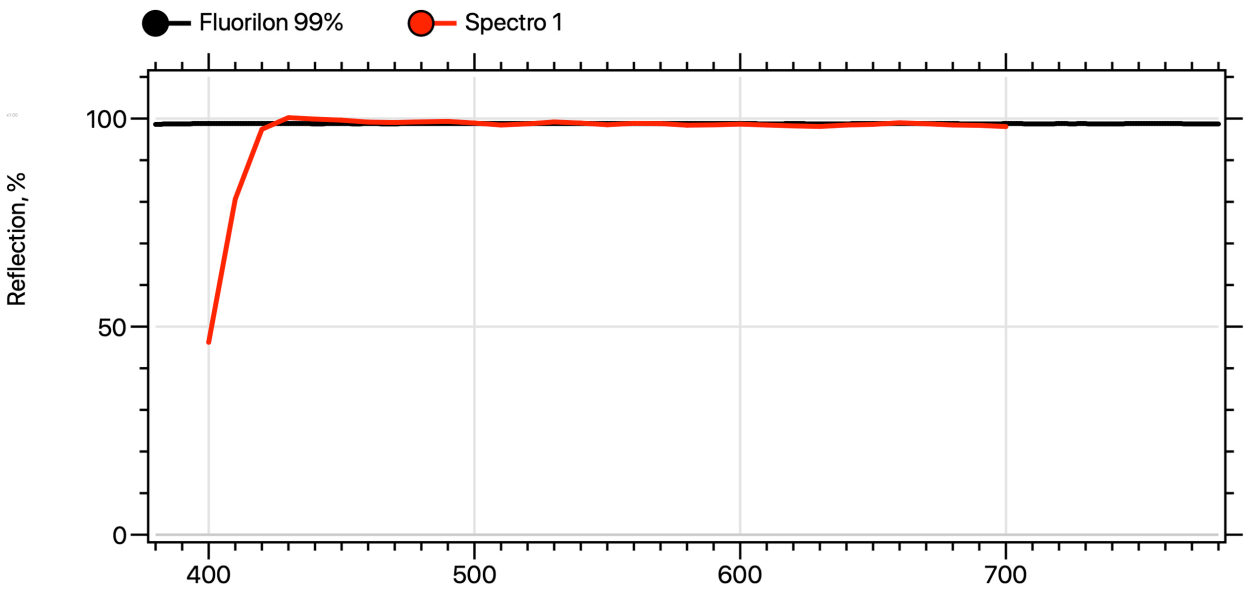
To test the Spectro 1, I assembled a set of materials that would provide information on the sensitivity and accuracy of the unit. In addition, I added some fluorescent materials to test how well the instrument responds for white paper (almost all of them are brightened with fluorescent whitening agents) and to test the illumination for UV emission.

Here is a list of the test materials.

Maximum Scale Accuracy	Fluorilon™ 99% Reflectance Standard.
Fluorescence Response	Fluorescence Reflectance Standard (1 tile)
Reflectance Accuracy	Munsell Gloss Grayscale Inks (3 patches at N9.5, N5.0 and N0.5)
Gloss Reflectance	Lucideon CCSII Standards Gloss (12 tiles)
Matte Reflectance	Lucideon CCSII Standards Matte (12 tiles)
Saturation Response	Day-Glo Pantone Fluorescent Inks

Spectral Range and Maximum Response Test

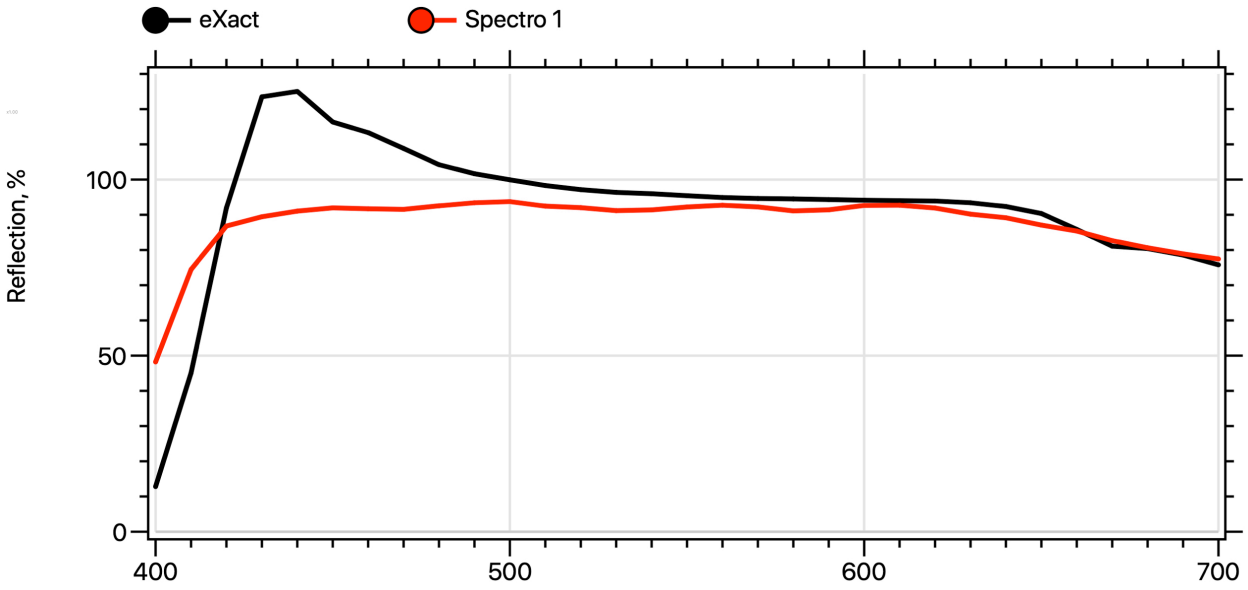
The first thing tested was the full scale accuracy using the Fluorilon 99% reflectance standard. Fluorilon, which is sintered PTFE, has a matte finish and its reflectance of 99% across the visible spectrum makes it about as close to the perfect reflecting diffuser as commercially available.



The results are good from 420 to 700 nm, but below from 400 to 420 nm the instrument is displaying dramatically reduced response.

Fluorescence Response Test

The next test is checking the Spectro 1's light source for UV and deep blue emission and to check the instrument's response to fluorescent emission that should exceed 100% relative reflectance. For this test I used a plastic fluorescent standard. This was a surplus used item which did not come with its spectral reflectance data, so I used an X-Rite eXact spectrometer's response for the reference data.The Spectro 1's light source is provided by a white LED which



does not have any ultraviolet to activate the fluorescent standard. The measurement confirms this, since the expected blue fluorescence peak is absent from the resulting spectrum. Thus the Spectro 1 is always using an M2 measurement condition.

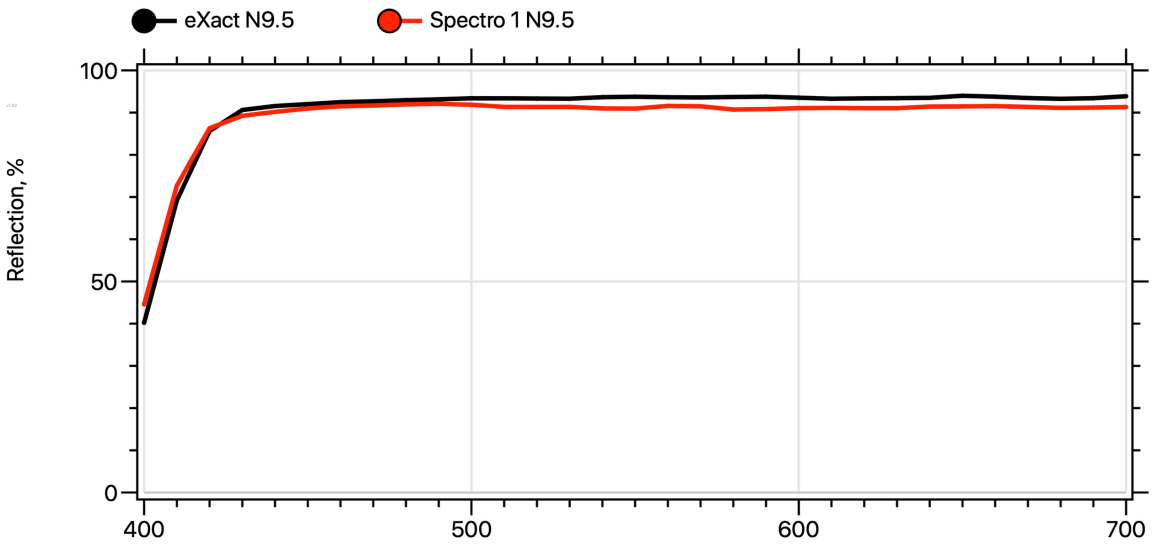
Reflectance Accuracy Test

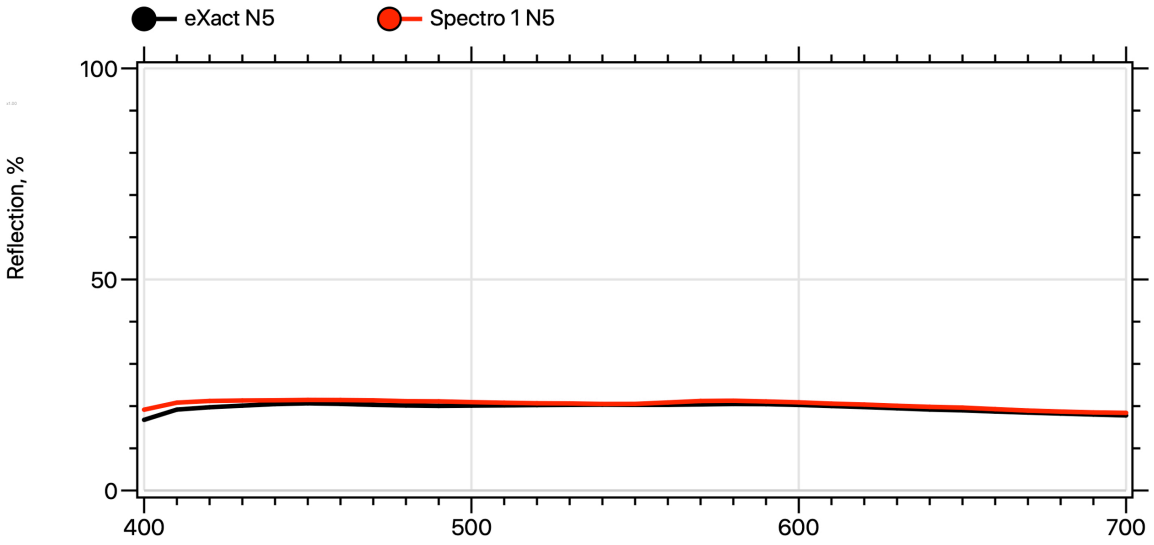
To test the spectral reflectance accuracy I decided to use three Munsell Gray Scale patches, N9.5, N5.0 and N0.5.

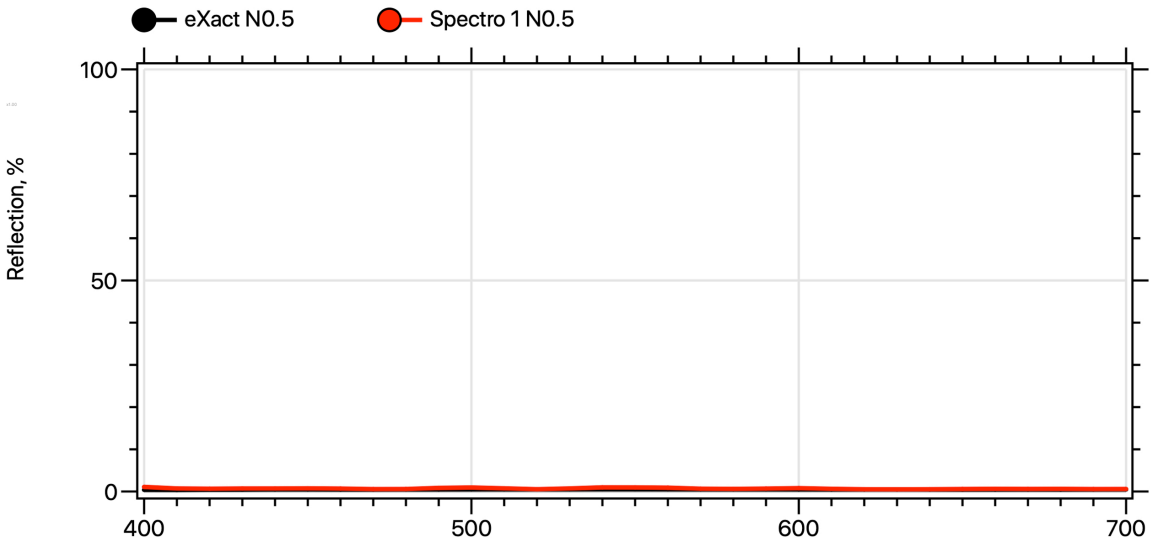
Including the N9.5 patch somewhat duplicates the Fluorilon test, but the Munsell patch has a glossy surface and Fluorilon has a matte surface. The Spectro 1 specifications state that its illumination is diffuse in directionality. This will test if measuring a glossy surface results in specular reflection affecting the measured spectrum.

The N5.0 patch is a middle gray in the human visual range and is often used for calibrating cameras.

The N0.5 specimen is a very dark black and should test the instrument's low-light sensitivity. If the glossy surface produces any specular stray light to the sensor this patch should show it.

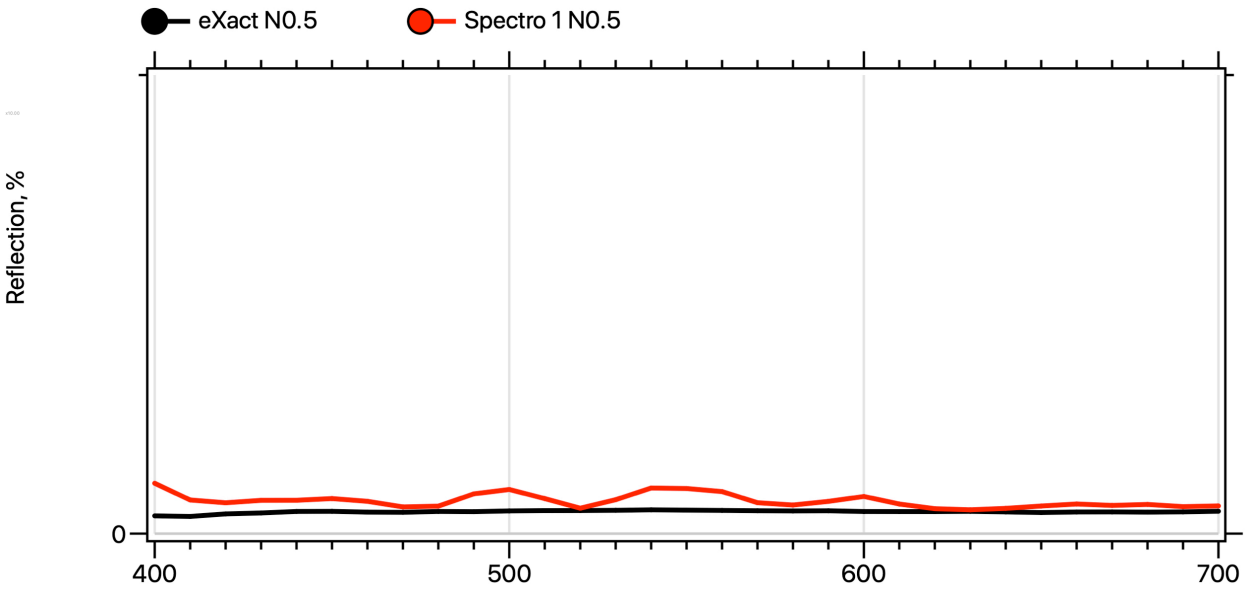






The N9.5 and N5.0 tests show that the Spectro 1 produces a very good result in comparison to the eXact. The N5.0 patch Spectro 1 spectrum shows a tiny bit more reflectance than the eXact. which was expected due to the diffuse illumination and the patch's glossy surface, both of these combining to send a little specular reflection to the sensor. The N9.5 patch does not show this but it does show that there are some full scale differences resulting in a lower relative reflection for the Spectro 1. My suspicion is that the sensor scale factors are set to matte materials so they are lower than they would be for glossy materials, thus producing a slightly lower N9.5 reflectance spectrum.

That leads to the N0.5 patch. Looking at a full scale spectral graph it looks like there is a very slightly higher reflectance for the Spectro 1. A 10X magnification makes the differences more visible (full scale is 10%).

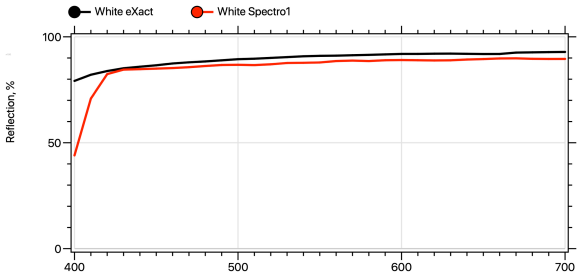


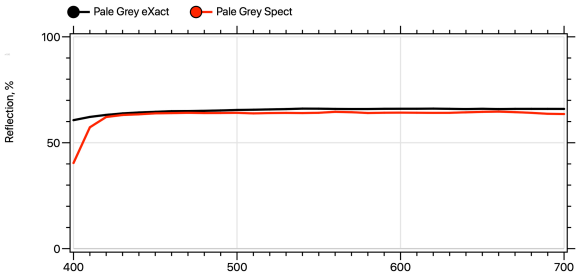
The higher Spectro 1 reflectance differences are below 1%, possibly due to specular reflection, sensor drift, dark noise or all of them.

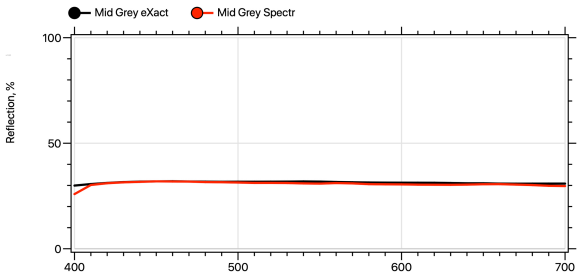
Gloss and Matte Surface Test

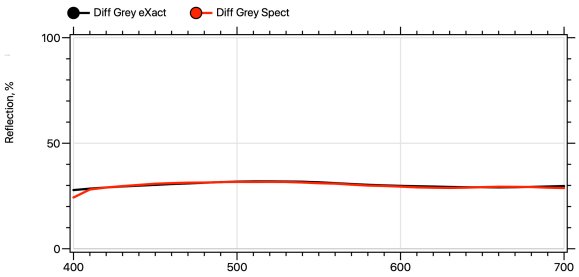
The CCSII standards from Lucideon are the materials used for these tests. These are ceramic standards previously known as the BCRA tiles. These tiles have been used for decades to test spectrometers. Lucideon released a pocket-sized set of tiles on a metal substrate in both matte and glossy finishes.

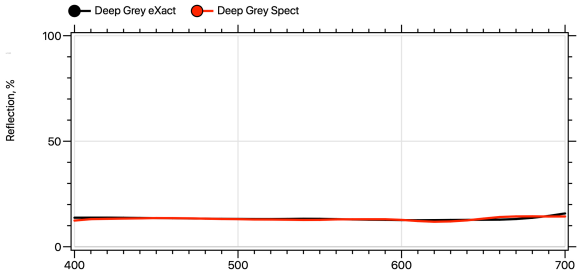
Matte Tiles

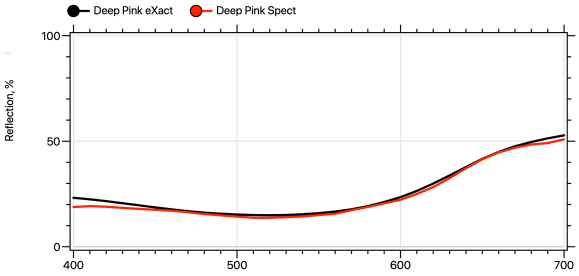


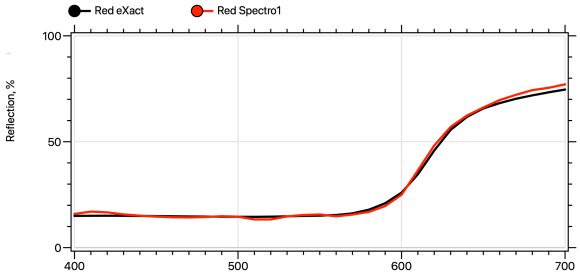


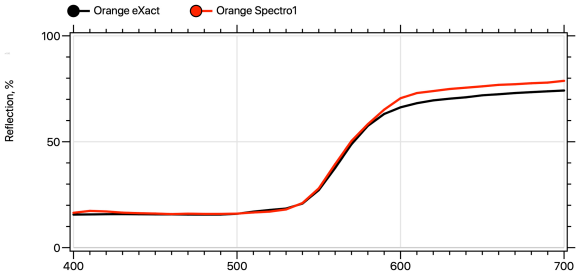


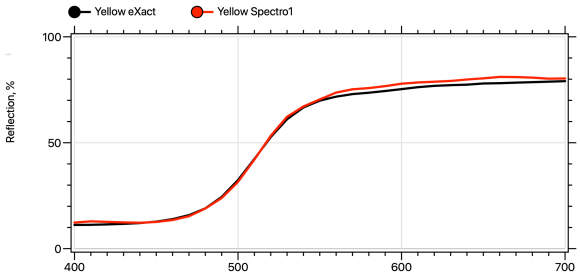


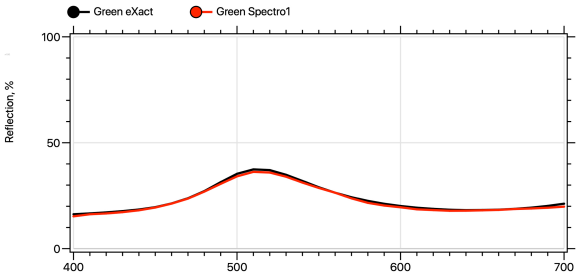


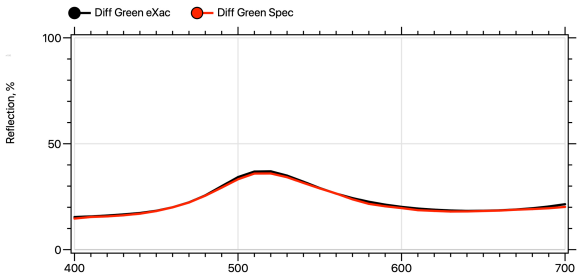


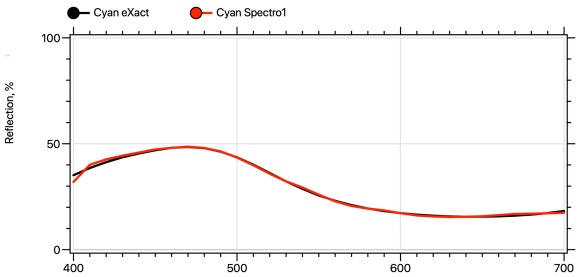


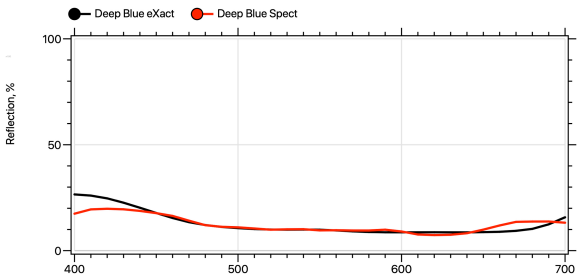


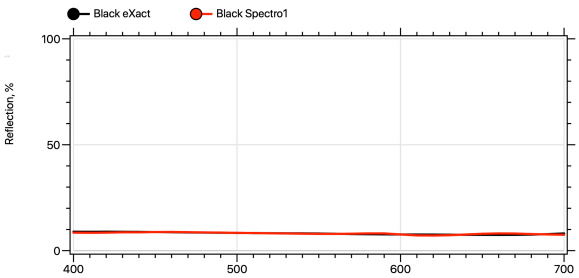








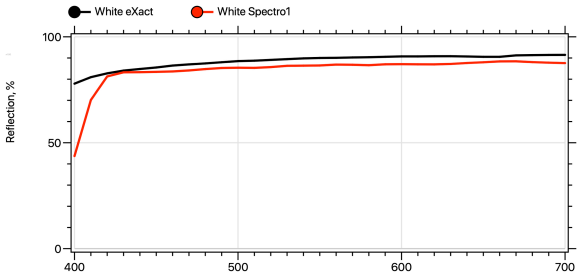


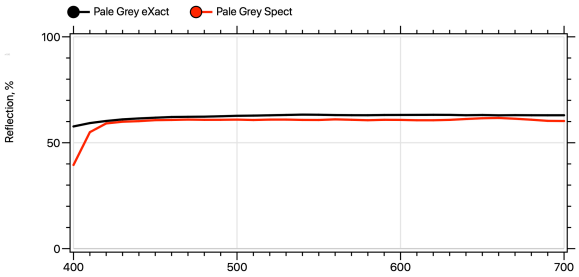


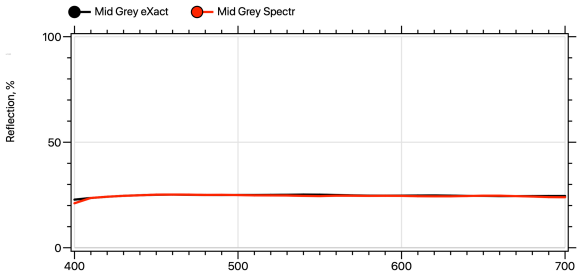
As the spectra show, the Spectro 1 produces results close to those of the eXact. This a remarkable result considering the difference in price.

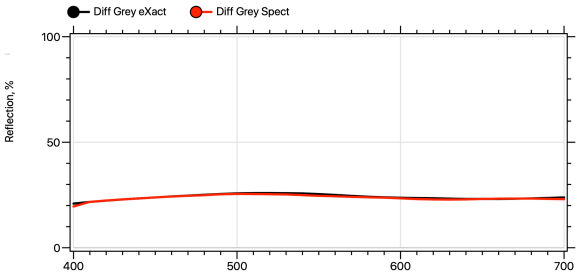
Now the glossy versions of the same CCSII patches will be compared to see if the glossy surface produces significant differences.

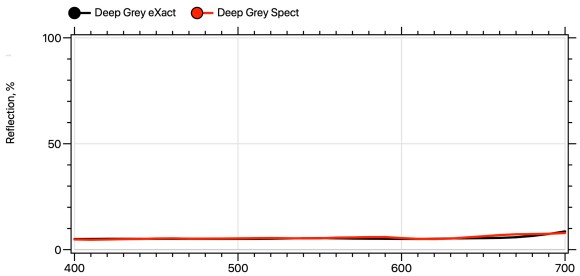
Glossy Tiles

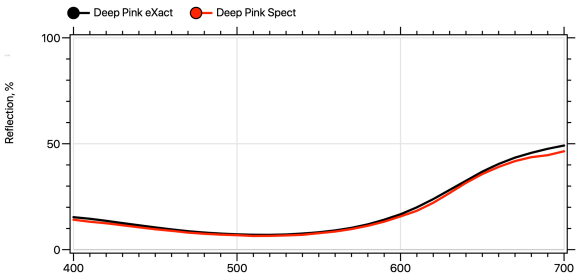


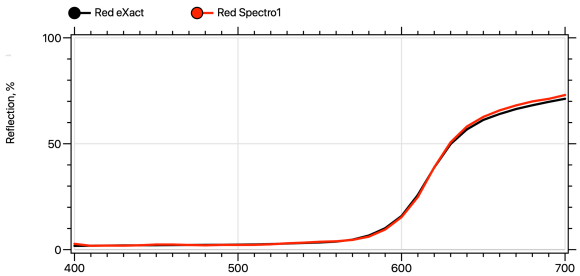


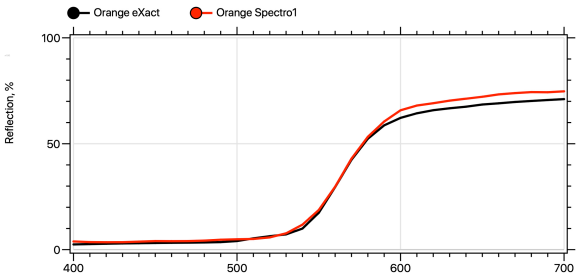


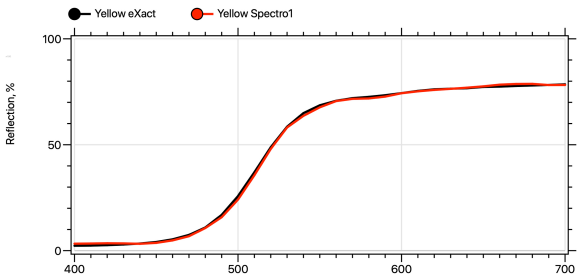


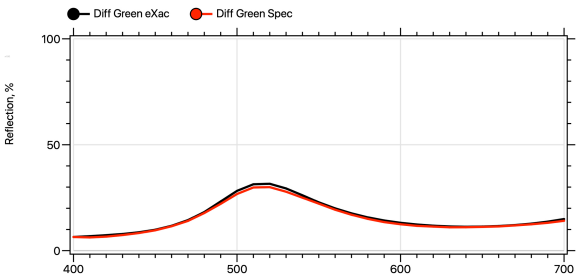


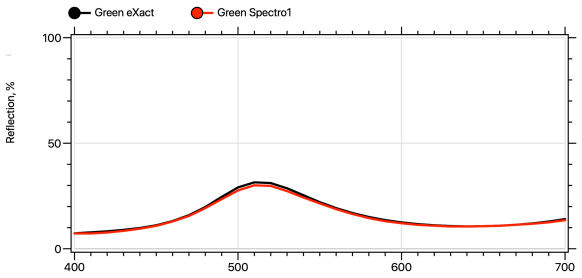


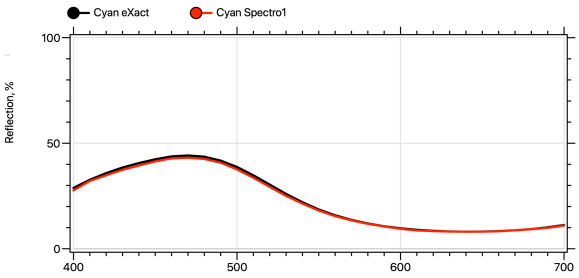


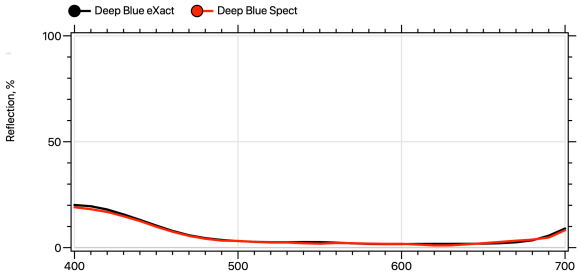


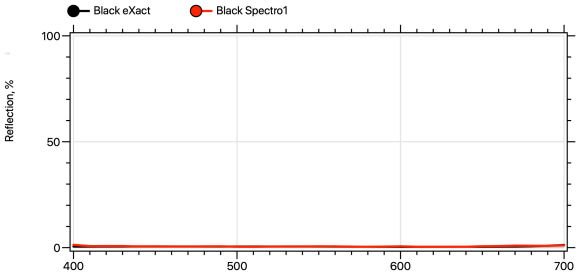








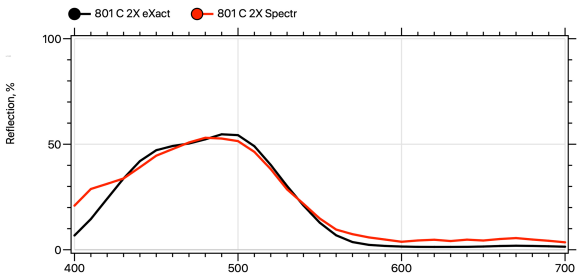


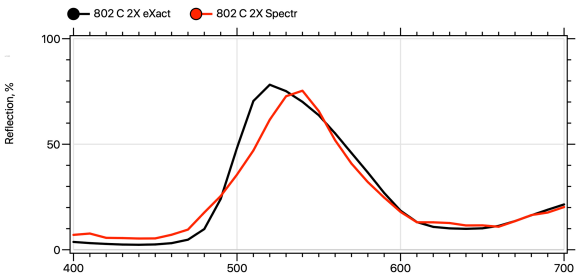


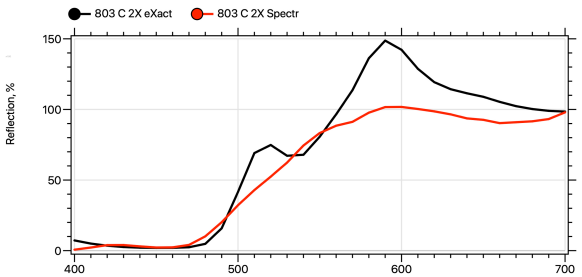
The results for the glossy CCSII tiles look very similar to the matte ones. This is good news. It means that the Spectro 1 can operate with a variety of surface glosses.

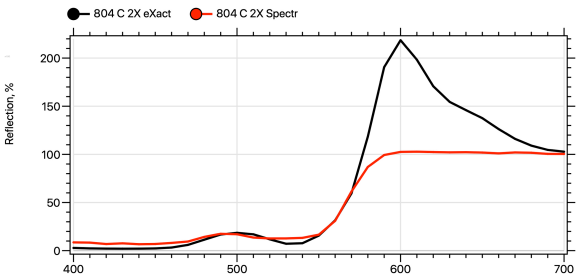
Fluorescence Test

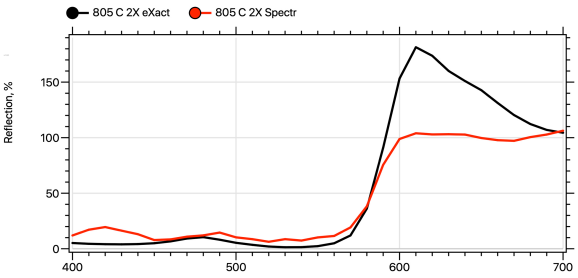
When fluorescent colors are measured, spectrometers can behave in odd ways. Some instruments refuse to measure the color, some scale the spectrum to something they can handle, some measure them just fine. For this test a set of Pantone® fluorescent inks from a Day-Glo book were used.

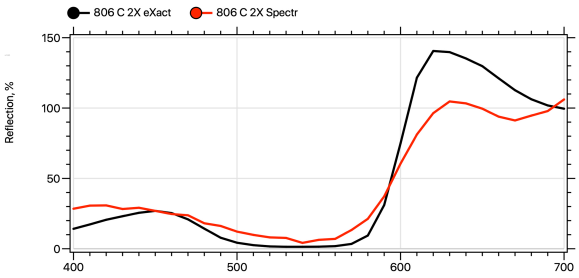


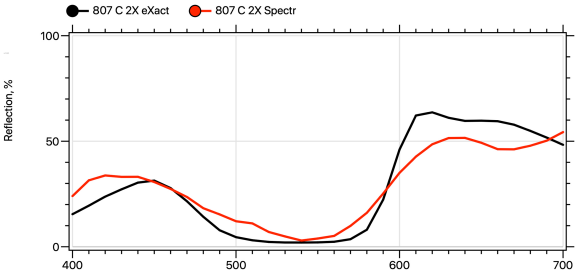












As expected, the Spectro 1's white LED does not have any UV light emission to excite the fluorescent inks, so the high fluorescent peaks were reduced. However, the instrument did not refuse to measure any of the inks. Amazingly it did try its best to give a spectrum within its range that would produce a color similar to the inks.

Colorimetric Comparisons

It can be difficult to understand visual color differences by looking at the spectral differences. Examining the colorimetric differences will aid in evaluating the visual differences.

All the following colorimetric values were calculated using D55 as the illuminant (more about that later).

Reflectance Colorimetric Differences

	Specimen	ΔL*	Δa*	Δb*	ΔE00
Reflectance Standard	**Fluorilon™ 99%**	-0.05	-0.36	-0.09	0.54
Munsell Glossy	**N9.5**	-0.93	0.14	-0.90	1.03
	N5.0	0.62	0.53	-0.80	1.26
	N0.5	2.39	-2.10	0.43	3.22

CCSII Colorimetric Differences

Specimen	ΔL*	Δa*	Δb*	ΔE00
White CCSII matte	-1.18	0.23	-0.59	0.93
Pale Grey CCSII matte	-0.89	0.16	-0.64	0.87
Mid Grey CCSII matte	-0.59	0.15	-0.81	0.96
Diff Grey CCSII matte	-0.26	0.20	-0.84	0.85
Deep Grey CCSII matte	-0.26	0.39	-0.20	0.65
Deep Pink CCSII matte	-1.11	0.34	0.63	1.20
Red CCSII matte	-0.18	1.48	-0.26	0.74
Orange CCSII matte	0.99	2.17	0.74	1.24
Yellow CCSII matte	0.69	0.88	1.27	0.78
Green CCSII matte	-0.61	0.18	-0.46	0.62
Diff Green CCSII matte	-0.55	-0.02	-0.43	0.56
Cyan CCSII matte	-0.01	0.08	-0.37	0.17
Deep Blue CCSII matte	0.27	-1.58	1.83	1.58
Black CCSII matte	0.01	0.09	0.12	0.16
White CCSII gloss	-1.43	0.16	-0.71	1.08
Pale Grey CCSII gloss	-1.17	0.17	-0.73	1.08
Mid Grey CCSII gloss	-0.28	0.34	-0.52	0.77
Diff Grey CCSII gloss	-0.48	0.54	-0.70	1.00
Deep Grey CCSII gloss	0.74	0.29	1.02	1.21
Deep Pink CCSII gloss	-1.19	-0.48	0.45	1.12
Red CCSII gloss	-0.08	0.28	-0.65	0.41
Orange CCSII gloss	1.09	1.16	-2.72	1.68
Yellow CCSII gloss	-0.32	0.72	0.61	0.47
Green CCSII gloss	-0.83	1.00	-0.30	0.93
Diff Green CCSII gloss	-0.99	0.70	-0.46	1.03
Cyan CCSII gloss	-0.61	0.53	0.22	0.67
Deep Blue CCSII gloss	-0.94	0.27	-0.01	0.66
Black CCSII gloss	0.26	1.22	0.05	1.75

ColorChecker Classic Colorimetric Differences

Specimen	ΔL*	Δa*	Δb*	ΔE00
Dark skin	0.63	0.22	-1.59	1.34
Light skin	0.10	0.06	-0.52	0.38
Blue sky	0.75	0.17	-1.04	0.89
Foliage	0.99	-0.47	-0.92	1.14
Blue flower	0.87	0.46	-1.05	0.97
Bluish green	1.01	-0.03	-1.09	1.06
Orange	0.54	0.20	0.89	0.54
Purplish blue	0.20	2.34	-3.06	0.83
Moderate red	0.79	0.14	0.64	0.85
Purple	-0.22	-0.71	-0.79	0.80
Yellow green	0.68	-0.15	-0.47	0.55
Orange yellow	0.97	-0.37	0.46	0.80
Blue	-1.16	1.56	-1.67	1.04
Green	0.84	0.24	-0.63	0.84
Red	0.25	0.28	3.27	1.67
Yellow	0.96	0.04	0.61	0.66
Magenta	0.06	0.57	0.30	0.26
Cyan	1.25	-0.14	-0.76	1.29
White	1.05	-0.12	-1.02	1.14
N8	1.04	-0.02	-1.02	1.22
N6.5	0.98	0.11	-0.98	1.25
N5	0.88	0.35	-0.93	1.37
N3.5	0.73	0.07	-0.47	0.77
Black	0.62	0.40	-0.09	0.74

Fluorescence Differences

	Specimen	ΔL*	Δa*	Δb*	ΔE00
Fluorescence Standard	**Fluorescence Std.**	-1.50	-2.81	10.56	9.43
Day-Glo Pantone inks	**801 C 2X**	1.68	8.65	3.68	3.52
	802 C 2X	-2.03	7.99	-12.09	3.36
	803 C 2X	-7.14	-6.17	-13.60	5.57
	804 C 2X	-12.60	-21.93	-36.96	11.55
	805 C 2X	-6.15	-24.64	-28.83	9.36
	806 C 2X	-0.63	-22.50	-6.81	5.25
	807 C 2X	0.99	-16.78	-3.10	4.93

Colorimetric Results

Here is a table with the average differences for the test sets.

Analysis

	Avg. ΔL*	Avg. Δa*	Avg. Δb*	Avg. ΔE00
Reflectance Average	0.51	-0.45	-0.34	1.51
CCSII matte Average	-0.26	0.34	0.00	0.81
CCSII gloss Average	-0.45	0.49	-0.32	0.99
ColorChecker Average	0.62	0.22	-0.50	0.93
Fluorescence Average	-3.42	-9.77	-10.89	6.62
Non-fluorescent Average	0.10	0.15	-0.29	1.06

Since the ΔL*, Δa* and Δb* averages are fairly close to each other, there does not seem to be a systemic issue with lightness or color measurement.

Notice that the CCSII gloss tiles are slightly less accurate than the matte tiles, but not by much. If gloss is affecting the instrument, it is not significant.

As expected, since the Spectro 1 has a light source without UV emission, the fluorescent materials produced the largest colorimetric difference.

The overall difference for the non-fluorescent materials is very impressive. This is a typical difference between two instruments from different manufacturers.

Conclusion

The Spectro 1 is very impressive spectrometer based on its performance, but when the price of $299 is factored in, the instrument is a fantastic bang for the buck! With such a low cost and outstanding performance, this device should be on everyone's wish list.

Note About D55 Colorimetry

In the publishing world, D50 is the most commonly used illuminant. For other industries, such as the fabric industry, D65 may be preferred. D55 was chosen for this report for several reasons.

Measurement by the author of direct sunlight at noon in the summer, when the sun is the highest in its arc, produces a CCT of very close to 5500K in the northern hemisphere. D50 corresponds to direct sunlight an hour or two before and after noon. It is thus slightly warmer in appearance to D55. It is the author's belief that it was chosen by the publishing industry for economic reasons over scientific reasons (i.e., customers are more attracted to, and will pay for, a slightly warmer print).

D65 corresponds to indirect daylight, such as that in an artist's studio with north facing windows. It is cooler in appearance than direct daylight and is a good choice for indoor use when the main illumination is provided by window light. However, the author opines that the human visual system has developed to prefer the color of direct sunlight with the least color cast being afforded by D55.

Interestingly, 5500K was the color balance built into daylight film for all those decades before digital cameras appeared. Kodak, Agfa, Fuji and others performed lots of research to arrive at this film balance, so choosing D55 seems to be a good choice.

Since the main purpose for the Spectro 1 is to select house paints, and its phone app gives lots of paint matches for each measurement, D55 is more appropriate for outdoor paint measuring than D50 or D65.

Note About the Data and Graphs

SpectraShop™, my spectral acquisition and analysis program, was used to import the Spectro 1 data from its iPhone app, prepare all the graphs and perform all the colorimetric calculations.

Manufacturer's Spectro 1™ Specifications

Spectral range:	400-700 nm
Sampling interval:	10 nm
Light source:	White LED
Measurement aperture:	8 mm (claimed), 11 mm (actual)
Measurement geometry:	Diffuse
Connection:	Bluetooth
Supported OS:	iOS, Android

References

Spectro 1™	https://variableinc.com
Fluorilon™	https://aviantechnologies.com
CCSII	https://www.lucideon.com/materials-technologies/colour-standards
Day-Glo®	https://www.dayglo.com
SpectraShop™	http://www.rmimaging.com/spectrashop.html