Investigation of the Implementation Aspects of the M1 Condition

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A Tale of Two Instruments

Non-fluorescent samples: Instrument #1 CIELAB = Instrument #2 CIELAB
Fluorescent samples: Instrument #1 CIELAB ≠ Instrument #2 CIELAB

The discrepancy is caused by the difference in instrument source content in the excitation region of the fluorescent sample.

Questions For Today

1. Are ISO 3664 and ISO 13655 adequate for the evaluation of instrument sources?
2. Using various hypothetical instrument sources how do measurements of the acrylic standards compare?

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FTS Acrylic Standards

- FTS standards sourced from Avian Technologies, LLC. Previously made by Color Control Systems. Same products, same formulations.
- FTS = Fluorescent Transfer Standards. Also to pay homage to the late Frederick T Simon, who originally developed the product line.
- Inorganic fluorescent compounds intended to mimic the behavior of typical paper OBAs.
- Full disclosure...

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FTS Acrylic Standards

FTS 17b 15a 13a 11a
CIE W 155 142 128 108

Bispectral Measurements

- Think reflectance but in 2D.
- Each column represents a complete reflected spectrum at one incident wavelength.

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Bispectral Calculations

- Sum over all incident wavelengths (excluding diagonal) to find the "emission region".
- Sum over all detection wavelengths (excluding diagonal) to find the "excitation region".

NRC Measurements

CIE Illuminants

"Total Radiance Factor"
On to the questions:
Are ISO 3664 and ISO 13655 adequate for the evaluation of instrument sources?

Danny Rich

Three Ways to Achieve M1

Simply match the D50 spectral power distribution
Adjust the UV to achieve D50 colorimetry (single flash, Gärtner and Griesser)
Mix reflectance from high and low UV sources to achieve D50 colorimetry. (dual flash, Imura)

Experiment

Hypothetical Illuminants
“Total Radiance Factor”

FTS tiles
CIELAB
Virtual Sources 1: CIE Daylight

CIE Daylight between 4976K and 5028K are M1 compliant. The range is only about 1/2%

Virtual Sources 1: CIE Daylight

But can we measure it?

Yes.

Virtual Sources 1: CIE Daylight

Virtual Sources 2: Scale D50 UV

Compliant CIE Daylight

λ≤400=0

Typical UV

Cut Filter

Fully eliminate

Fluorescent Emission

Virtual Sources 1: CIE Daylight

FTS a* b*

11a 0.003 0.047
13a 0.007 0.078
15a 0.008 0.118
17b 0.010 0.133

Ranges

Compliant CIE Daylight

λ≤400=0
Virtual Sources 2: Scale D50 UV

±40%: still M1 complaint

Compliant Scaled UV

Virtual Sources 2: Scale D50 UV

FTS a*  b*

11a  0.69  2.82
13a  1.13  4.41
15a  1.51  6.15
17b  1.98  7.28

Compliant Scaled UV λ≤400=0

Conclusions for question #1

Are ISO 3664 and ISO 13655 adequate for the evaluation of instrument sources?

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<th>CIE Daylight</th>
<th>Scaled UV</th>
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Question #2

Using various hypothetical instrument sources how do measurements of the acrylic standards compare?

To reasonably model instrument sources, we first examine four currently implemented instrument sources:

- Barbieri SpectroPad Series 2
- Techkon SpectroDens
- Konica-Minolta FD-7
- X-Rite eXact, and i1Pro

Large b* range!
Barbieri SpectroPad Series 2

“Thanks to 7 LEDs, D50 illumination is reached. This illumination is based on LED technology by Just Normlicht. It fully matches the new measurement condition M1 introduced with the ISO standard 13655-2009.”

Techkon SpectroDens

“Using the latest LED technology, the new SpectroDens provides D50 illumination and therefore fulfills the M0 – M3 measuring conditions in accordance to ISO 13655.”

Konica-Minolta FD-7

Product literature mentions their “Virtual Fluorescent Standard”, which is a phrase used in the dual-flash papers by Imura. We infer that the FD-7 uses the two flash method. Their literature also states that the light source is LED based.

X-Rite eXact, and i1Pro

Product literature refers to “gas filled tungsten (illuminant type A) and UV LED”. It is not clear the precise method of the i1Pro. An X-Rite patent describes a method similar to the two-flash.

Forgive the legalese: The authors are not endorsing any of these products, nor are they necessarily agreeing with the claims of the product literature we reference. Our sole criterion was the claim of M1 compliance.

Real World Results

- Facility #1: A, B1, C1, D
- Facility #2: B2, C2, E (no 9a)
Hypothetical Sources

Four sources were modeled, each with an adjustable UV component and one or more visible components.

Experimental Procedure

We illuminate a fluorescent sample with D50 and the test source. Adjust UV component to minimize $\Delta E_{ab}$.

Experiment: Two Paths to CIELAB

Hypothetical Instrument

“Total Radiance Factor”

FTS tiles or paper

CIELAB

Experiment: Two Paths to CIELAB

D50

“Total Radiance Factor”

FTS tiles or paper

CIELAB

Experimental Results: $\Delta E_{ab}$ to D50

Is the FTS tile as good a standard as paper?
Experimental Results: $\Delta E_{ab}$ to D50

Is the FTS tile as good a standard as paper?
Conclusions for question #2

Using various hypothetical instrument sources how do measurements of the acrylic standards compare?

- Calibrating against paper does produce slightly better results.
- We believe that the difference between the test sources and D50 accounts for more of the color differences.
- The technique can expose the differences between illumination technologies.

Future Work

- Modeling of the dual flash method.
- Better understanding of the implications of differences in the bispectral matrices of paper and FTS standards.
- Can the acrylic standards adequately simulate the behavior of the fluorescent compounds in commercial papers?
- How might acrylic fluorescent standards be applied to the instrument profiling process?

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