Micro-fading report

www.microfading.com

Object:	Fabrics from Propert *Trailway* touring caravan.
Maker:	Propert
Accession No:	[redacted]
Materials and media	Textile, dyes, vinyl plastic.
Collection:	NHC
Collection type:	Permanent
Year of production	c.a. 1956
Exhibition:	Main Hall
Test Date:	24-3-17
Operator:	Bruce Ford
Requested by:	[redacted]

Summary

The least lightfast dye within the curtain (1-9) is yellow (7), which faded faster than BW1 (CIE76) under the test conditions (Endnotes 1 & 2). This is equivalent to approximately 0.1 Mlux h/JND (4-6 months at 50 lux) or less (Endnote 2). It is at the least stable end of the range of lightfastness (BW1 or worse to BW3) for colourants described in the CIE standard for museum lighting as having “high responsivity to light” for museum purposes (CIE 2004). Green (4) and orange-yellow (2) are also very fugitive and it is very likely they both contain the same yellow dye: G = Y+C and OY = Y+R. The exception is the yellowish beige background (6), which is not dyed with the fugitive yellow. The colours in which yellow is probably a component all darken and lose chroma – further evidence that their fading is largely driven by the response of the yellow dye.

Normally the light-sensitivity of this fabric would allow about 2-4 months/decade display at 50 lux. Its sensitivity to light precludes hanging the curtains inside the caravan within the Main Hall with any of the windows or doors open, bearing in mind that the constantly changing pattern of direct and reflected sunlight within the hall itself is complex, even more so within a partially exposed enclosure like the caravan with the door open and/or windows uncovered. Replica or replacement fabrics are recommended.

The red cushion (10, BW2-3) could withstand the equivalent in lux hours of 2 years/decade at 50-100 lux, but it should not be exposed to direct sunlight or strong reflected sunlight, which in the main hall can reach hundreds and in some places thousands of lux. Without logging (electronically or using a BW dosimeter), it would be difficult to estimate the annual cumulative exposure of any particular location inside the caravan. The Sunseeker or Sun Surveyor apps for Android and iPhone allow a check for direct sunlight.

The vinyl bench seat (11, >BW4) is probably pigmented and as far as light-fading of the colourant is concerned can withstand indefinite exposure. It would, however, be imprudent to expose it to direct sunlight which will eventually destroy the plastic. This would probably become visually apparent as decreased surface reflectivity (because of chalking or plasticiser weeping), which can be mistaken for the light-fading of colourant.

Figure 1 Test positions: cushion left insert, vinyl bench cushion right insert.

	CIE76			CIE2000							
Colour	BW Range	BW Equivalent	ΔE76	BW Range	BW Equivalent	ΔE2000	ΔL*	Δa*	Δb*	ΔC	Δh
BW1			12.2			4.5	3.8	-3.7	11.0	-10.9	6.2
BW2			6.0			1.8	1.0	-1.0	5.9	-5.7	3.0
BW3			2.7			0.8	0.6	-1.1	2.4	-2.6	0.7
BW4			1.0				0.0	0.3	1.0	-1.0	-0.4
1 curtain grey	BW4	3.8	1.4	BW3-BW2	2.3	1.6	0.0	1.2	-0.6	-0.1	-4.8
2 curtain orange-yellow	BW2-BW1	1.5	9.3	<BW1	<BW1	5.7	-4.3	-4.3	-7.0	-7.6	4.8
3 curtain magenta	BW4	3.9	1.3	>BW3	>BW3	0.4	0.0	-1.2	-0.5	-1.2	0.2
4 curtain green	BW3	2.8	3.5	BW2	1.8	2.4	-1.9	-0.2	-2.9	-2.4	4.0
5 curtain cyan	BW4-BW3	3.6	1.7	BW3-BW2	2.5	1.3	-0.1	0.9	-1.5	-1.7	1.6
6 curtain beige	BW4-BW3	3.7	1.6	BW3	2.9	0.9	0.5	-0.8	-1.3	-1.4	1.0
7 curtain yellow	BW2-BW1	1.1	11.8	<BW1	<BW1	6.5	-5.9	-5.5	-8.7	-9.4	5.0
8 curtain "black"	>BW4	>BW4	0.5	>BW3	>BW3	0.6	-0.2	0.5	-0.1	0.4	-2.7
9 curtain dark blue	>BW4	>BW4	0.5	>BW3	>BW3	0.5	-0.1	0.5	-0.1	0.4	-2.0
10 cushion red	BW3-BW2	2.7	3.7	BW3-BW2	2.4	1.4	-0.1	-2.8	-2.4	-3.6	-1.0
11 vinyl seat	>BW4	>BW4	0.4	>BW3	>BW3	0.3	-0.4	-0.1	-0.1	-0.1	-0.1

Table 1. Colour change summary. See last page for CIELAB diagram and Endnote 2 for a discussion of CIE76 vs CIE2000 results.

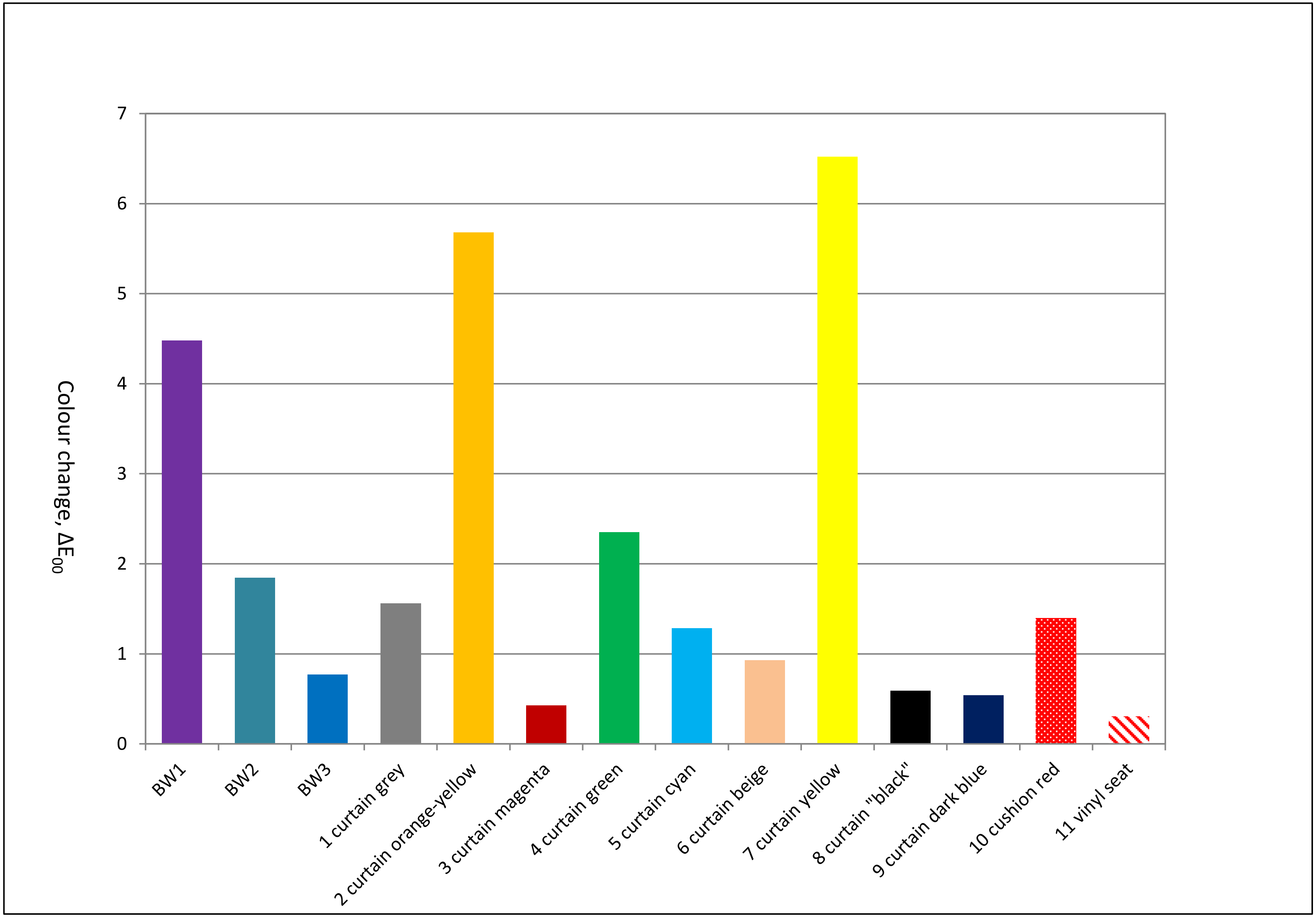


Figure 2. Relative colour change rates , CIE2000

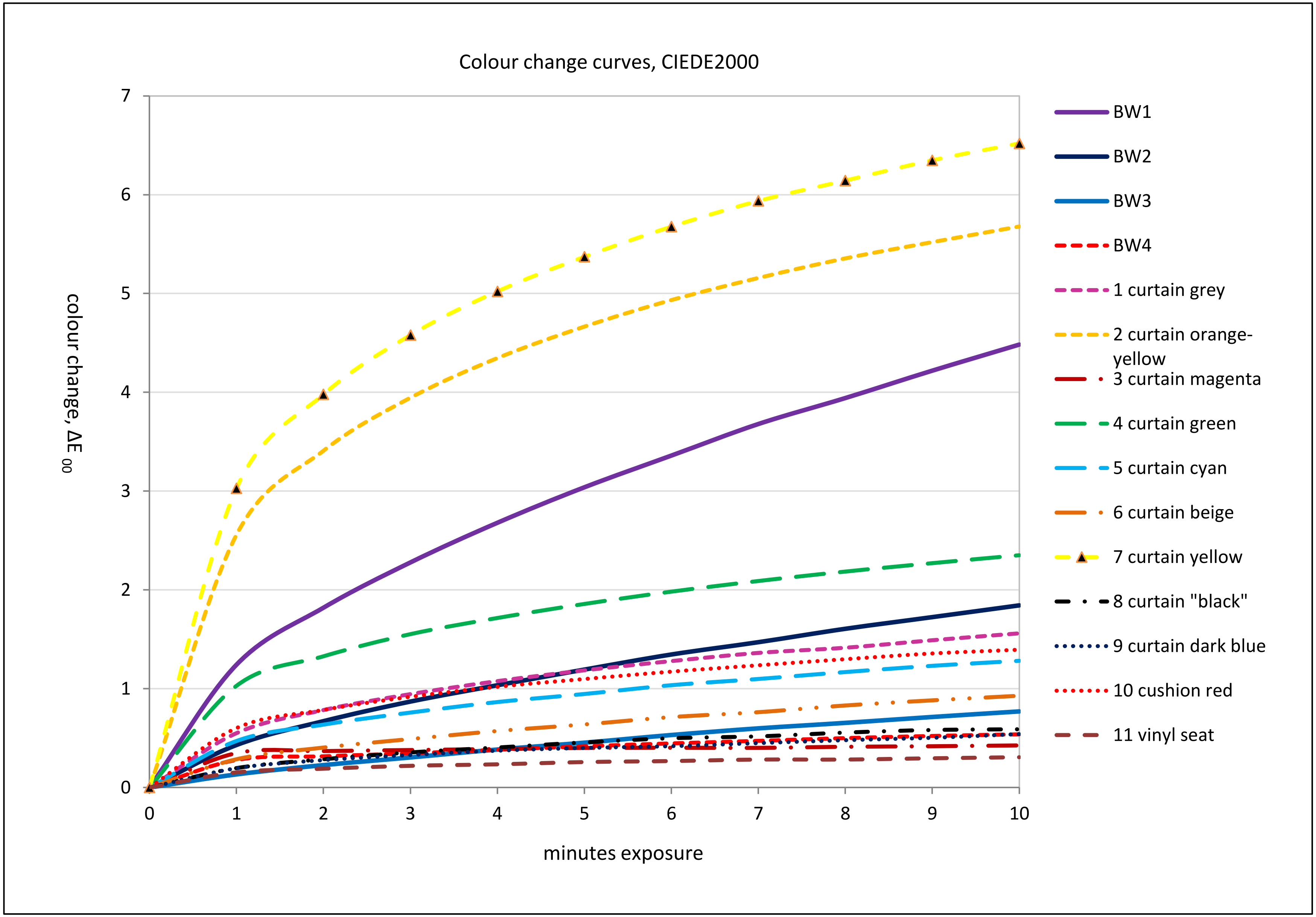


Figure 3. Colour change curves, CIE2000

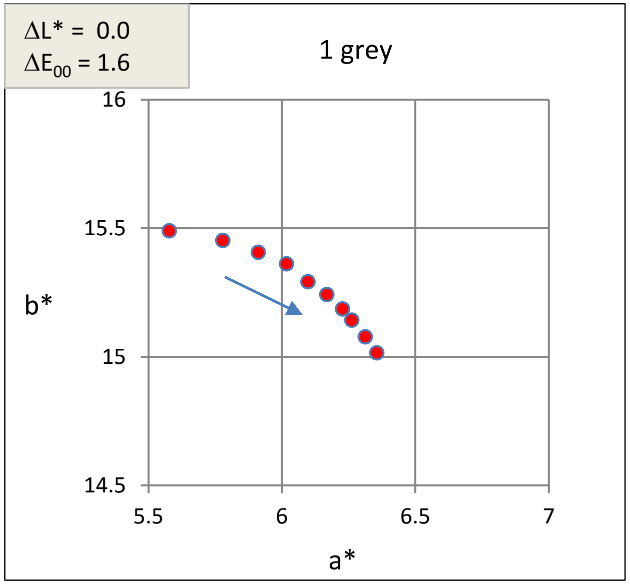
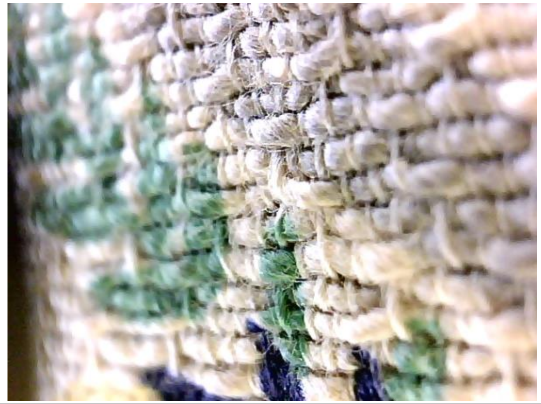
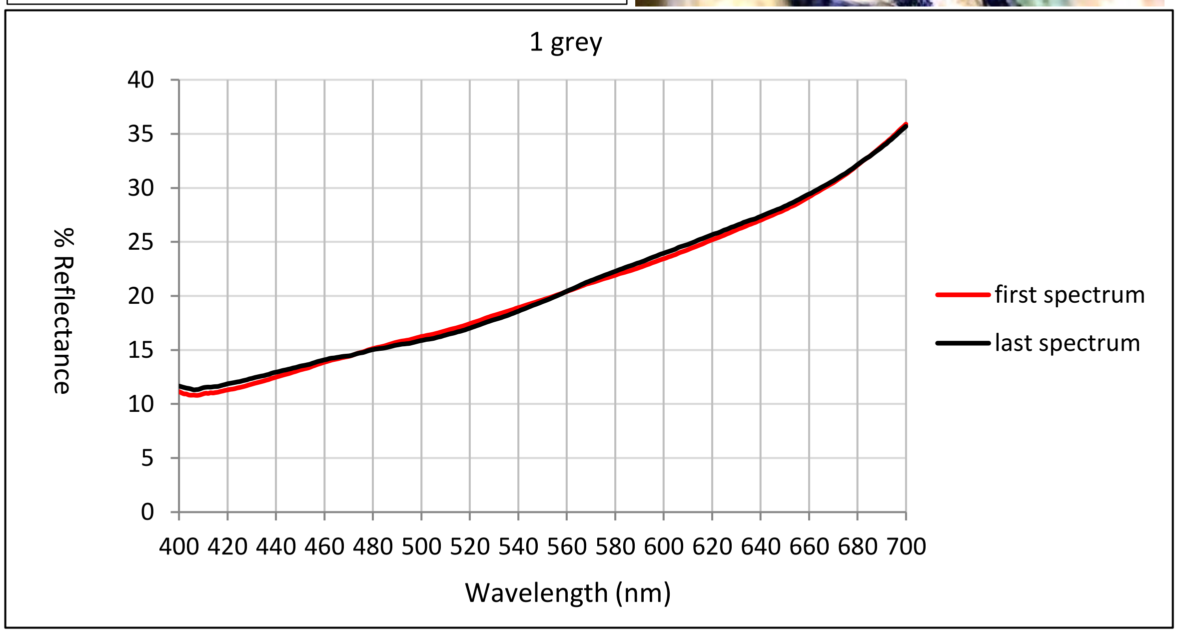


Figure 4. Curtains grey (1): mostly hue shift, redder.





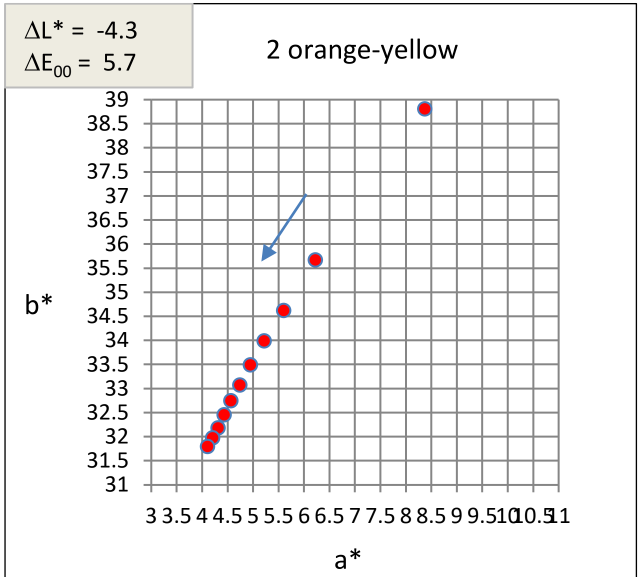
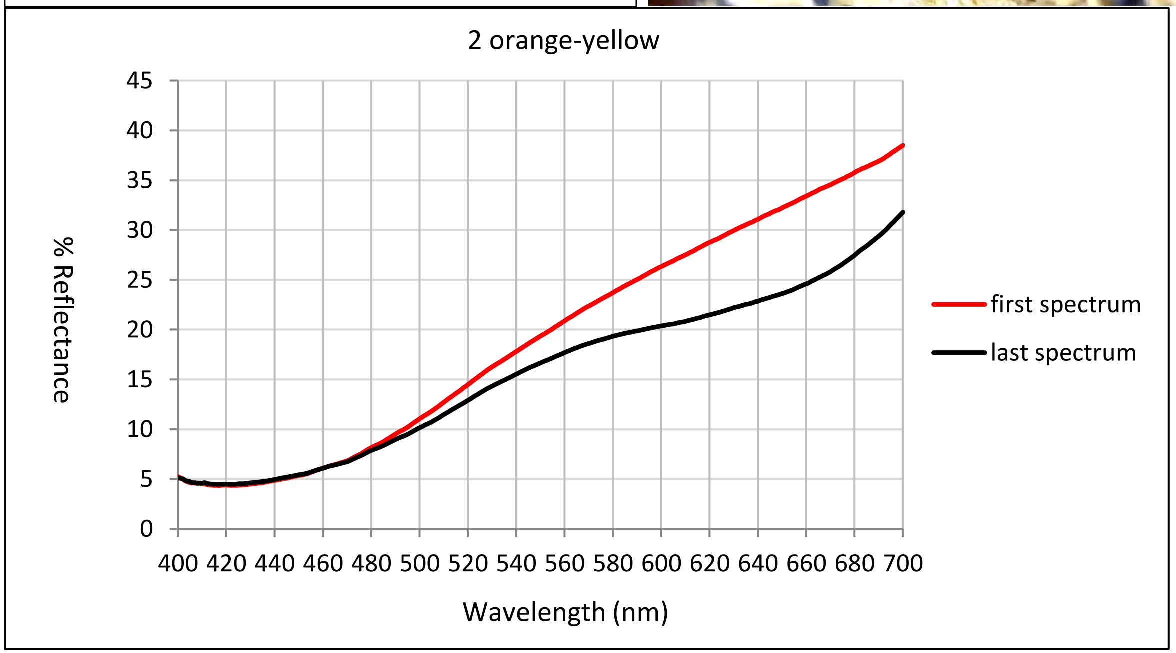


Figure 5. Curtains orange-yellow (2): darker, chroma loss, hue shift. It has lost a lot of reflection in the yellow (G+R) region of the spectrum, indicating the fading of yellow in a mixture. See Figure 10, yellow.



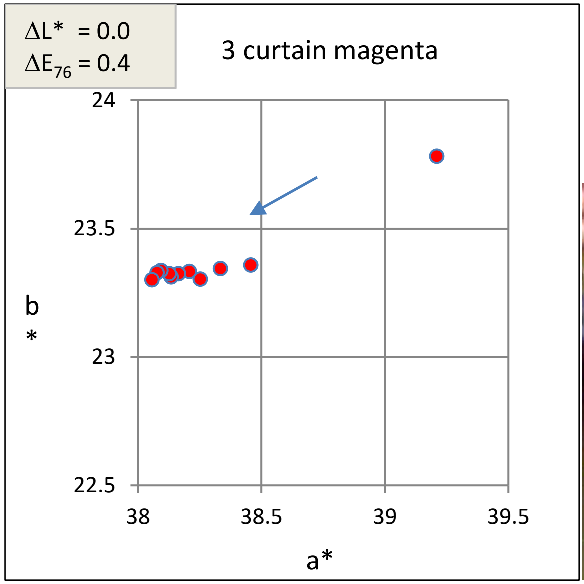
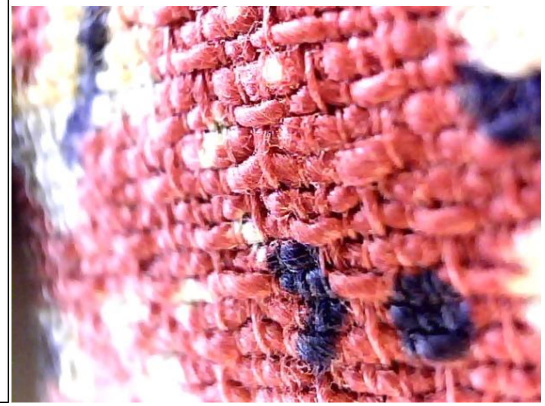
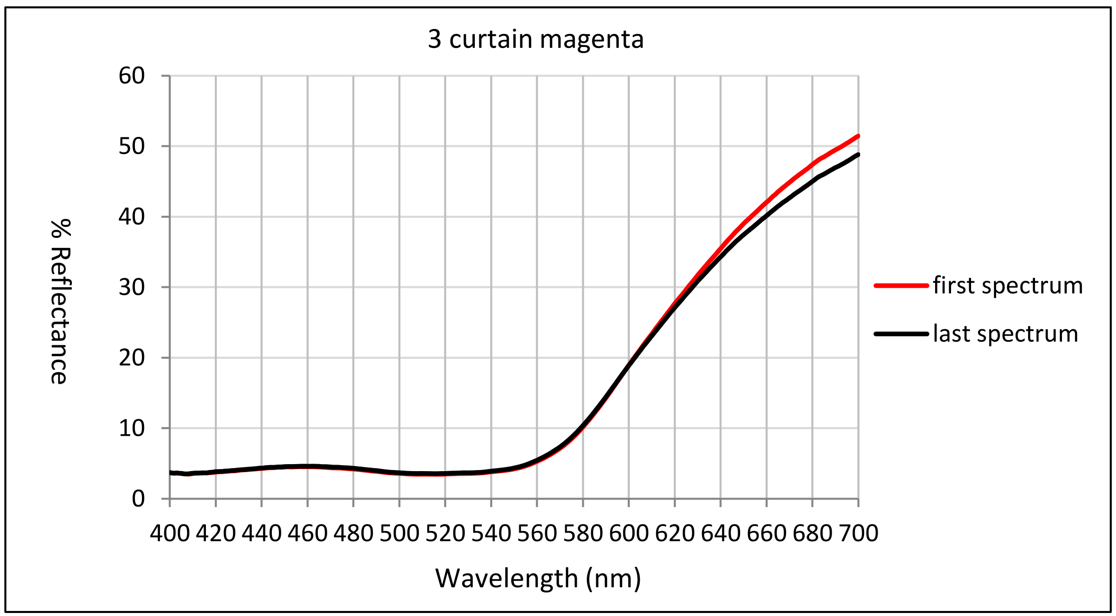


Figure 6. Curtain red (3): chroma loss.





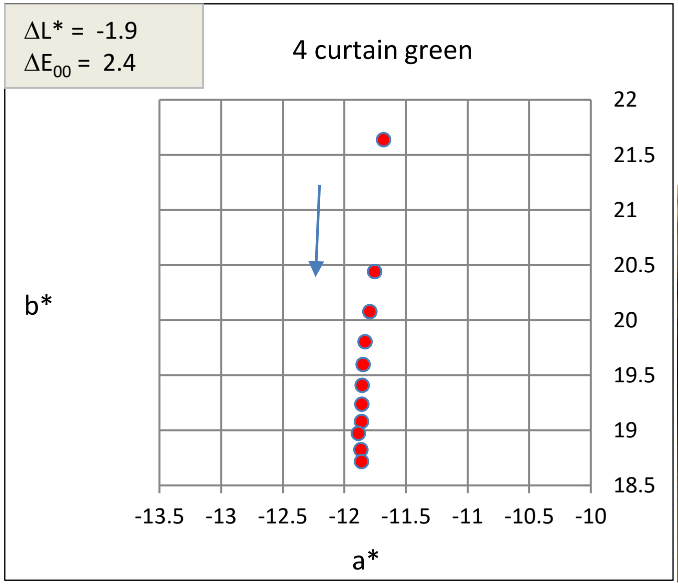
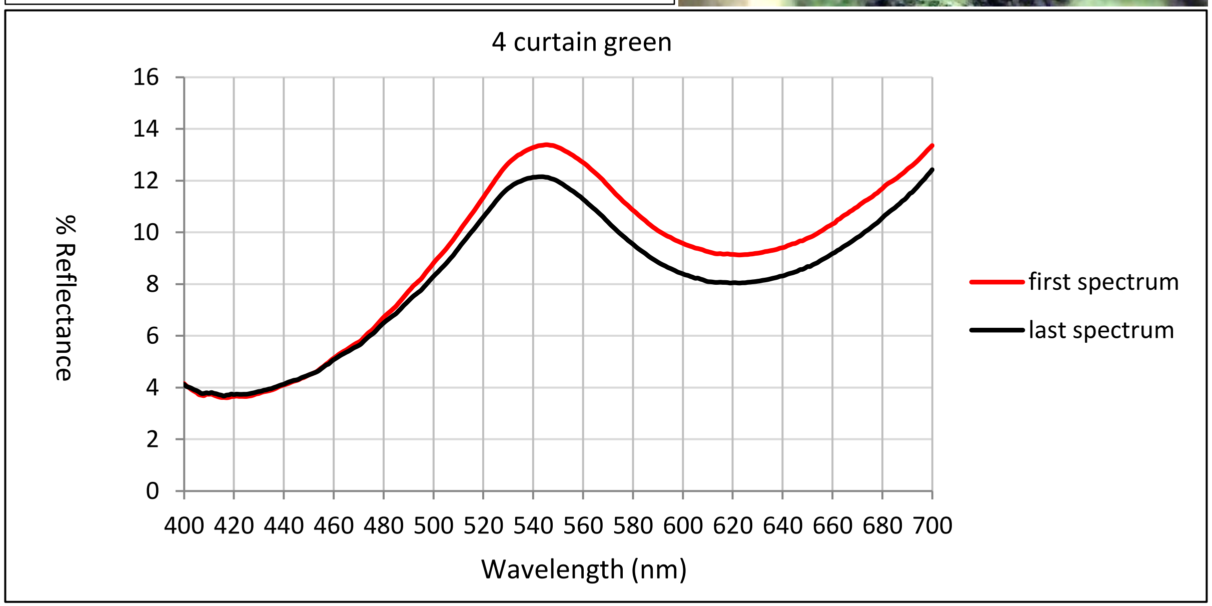


Figure 7. Curtain green (4): darker, loss of chroma (less yellow). The green is almost certainly a mixture of the yellow and cyan dyes. See Figure 10, yellow.



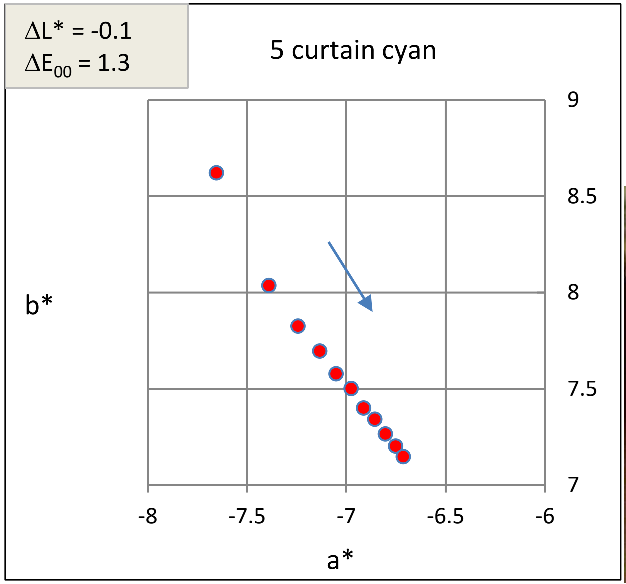
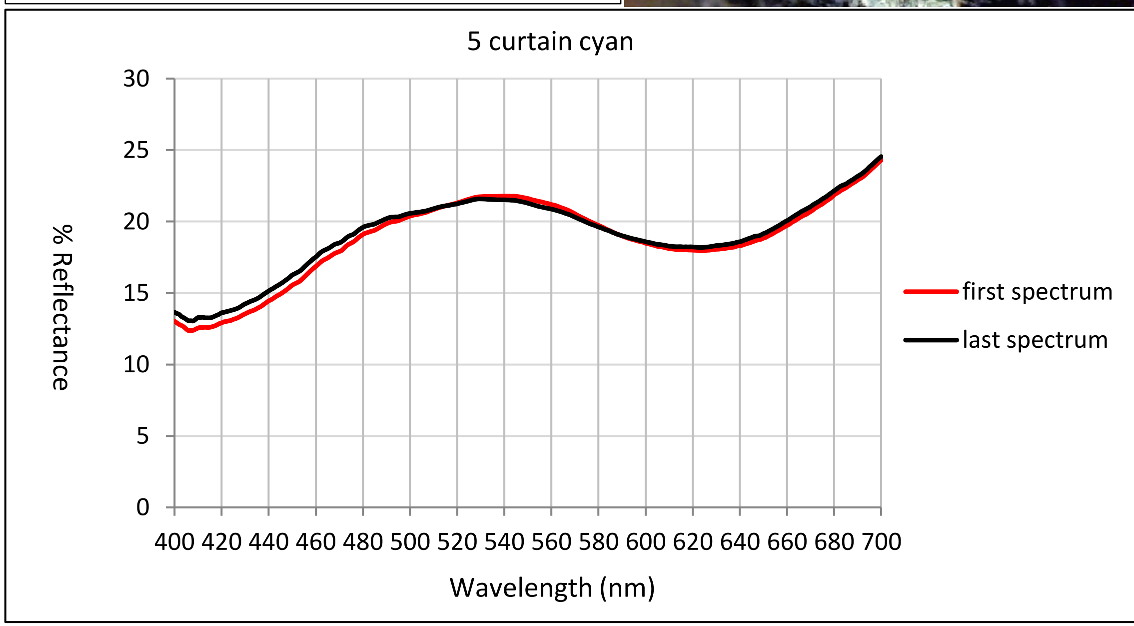


Figure 8. Curtain cyan (5): chroma loss (less green).



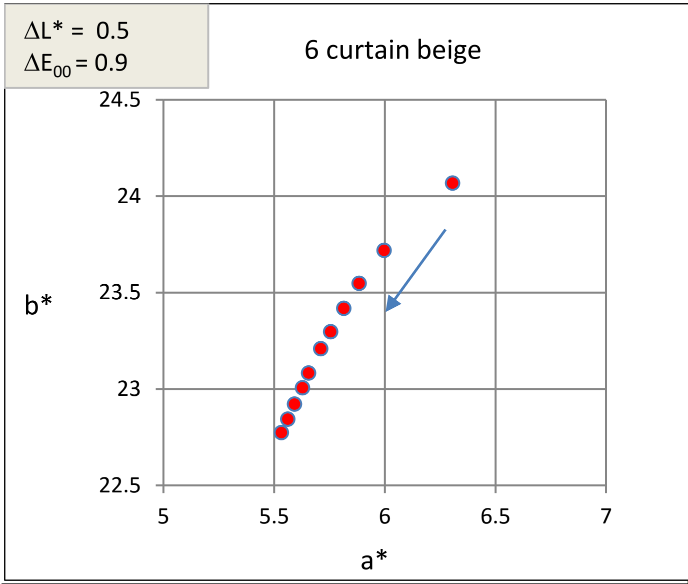
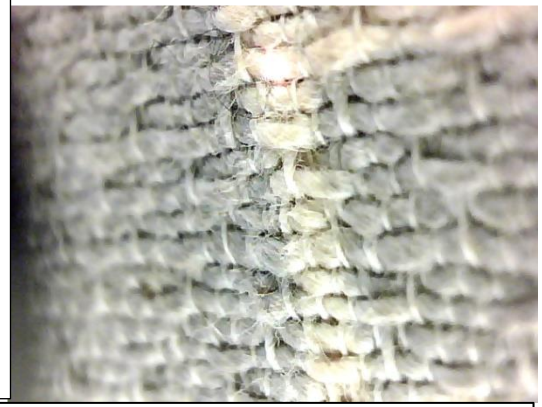
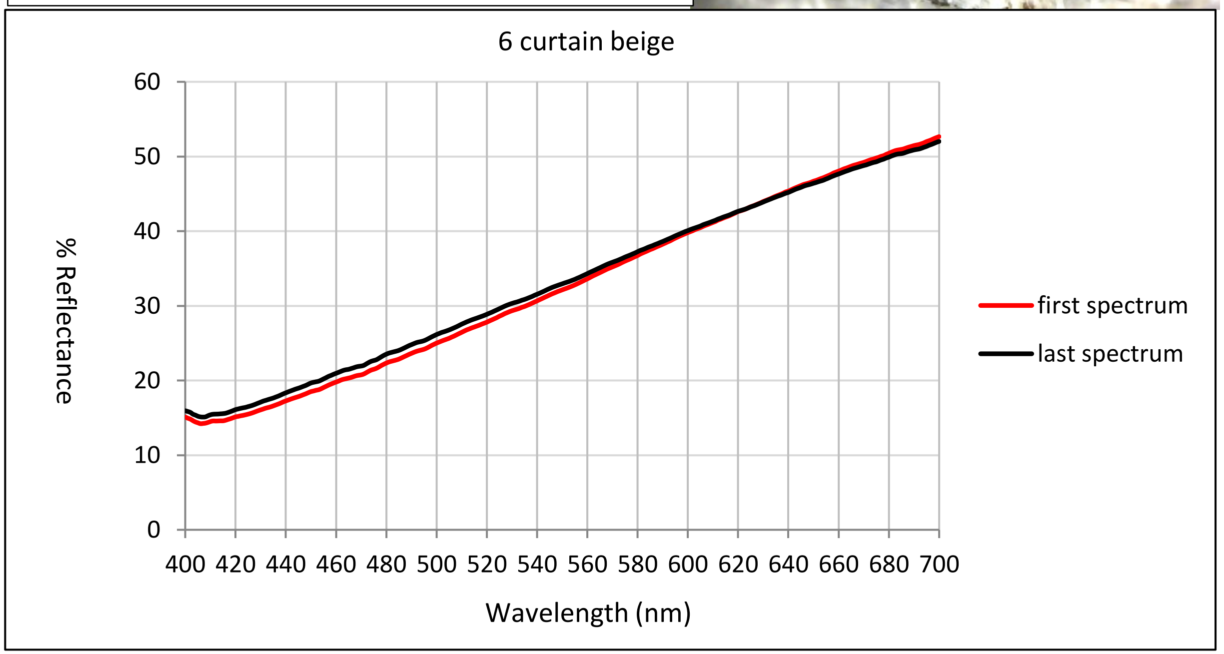


Figure 9. Curtain beige (6): lighter, less yellow. This does not contain the other yellow dye (7), and is probably the background fabric colour upon which the other dyes are printed.





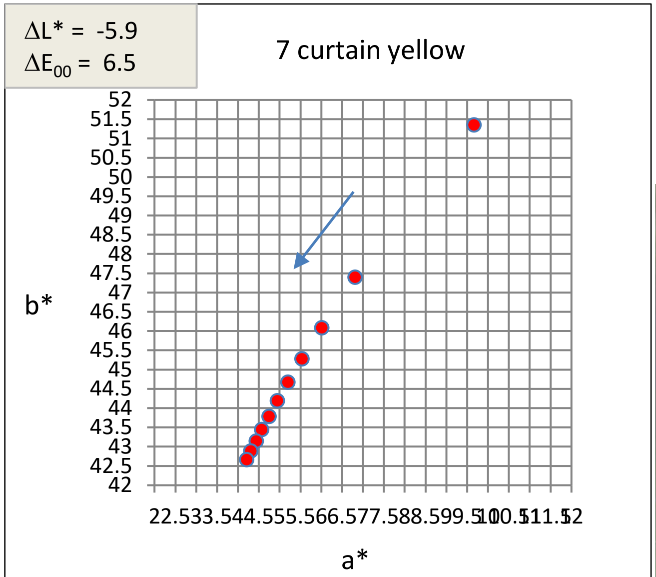
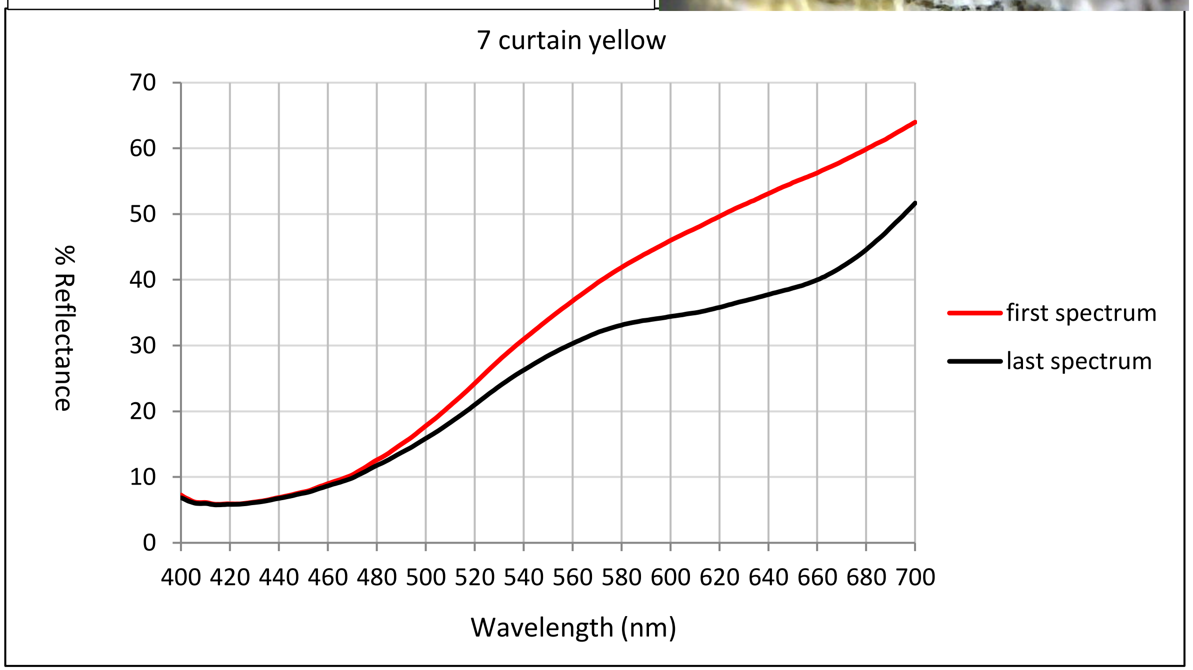


Figure 10. Curtain yellow (7): mostly faded out, but still close to BW1. It would have faded faster when it was new. This is the most fugitive component in green (C+Y) and orange (R+Y)



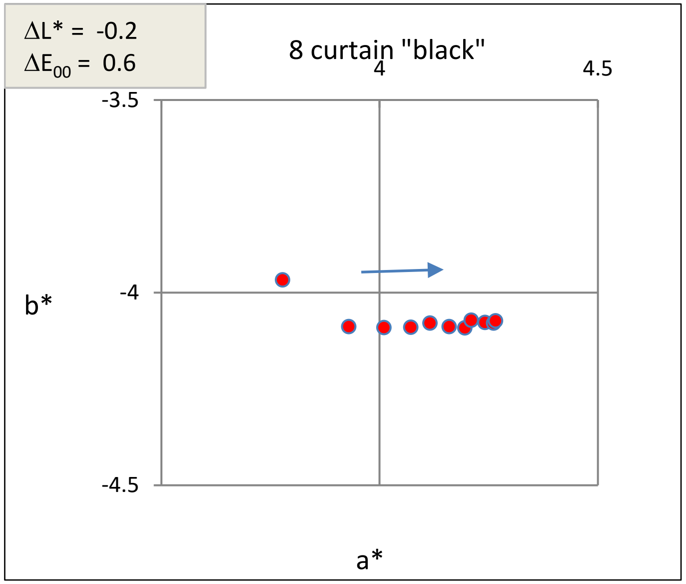
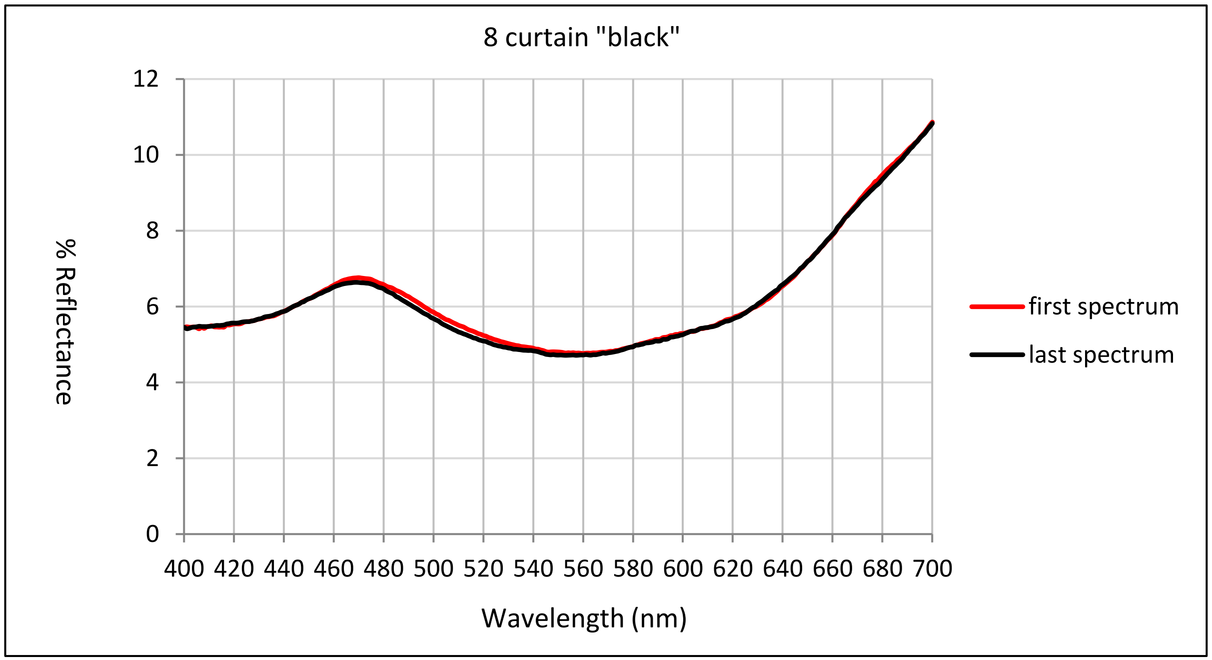


Figure 11. Curtain “black” (8): really a very dark blue (C+M), see Fig. 12 & 15 spectra.



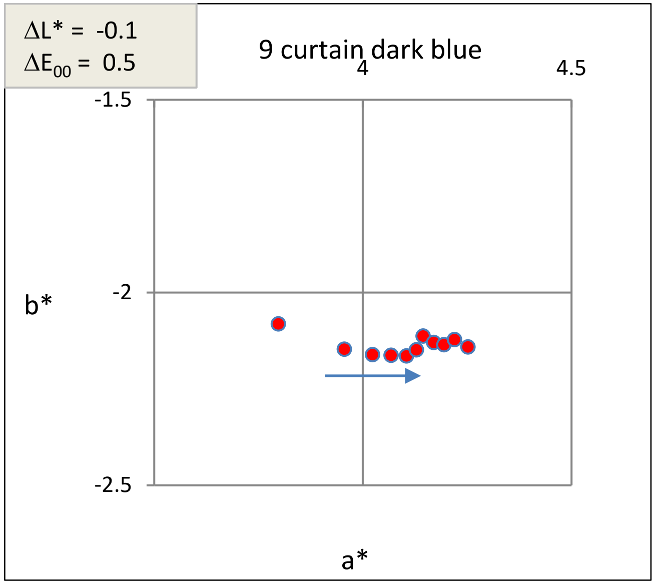
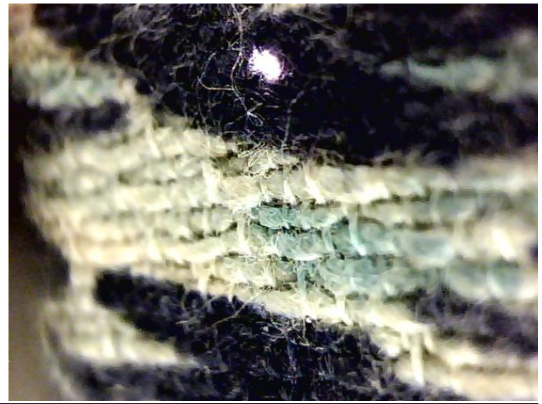
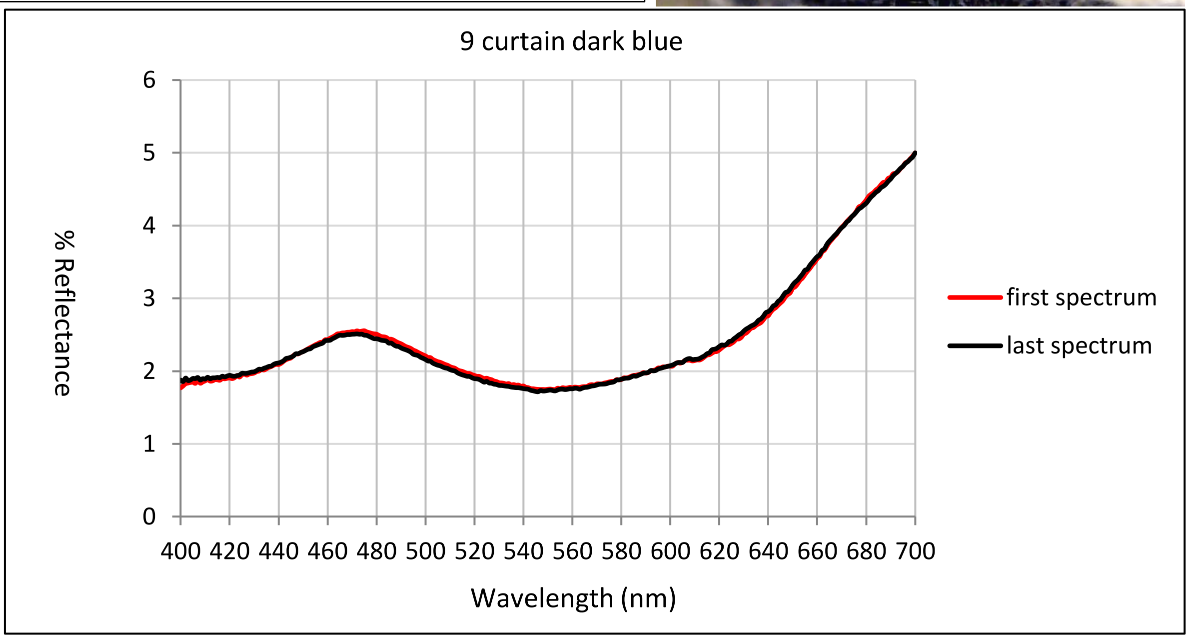


Figure 12. Curtain dark blue (9): same as "black" Figure 11. More obviously dark blue because of the surrounding colours.





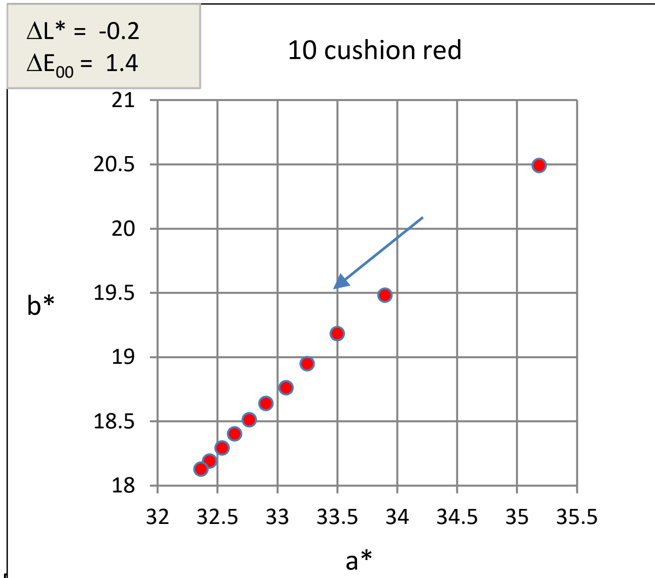
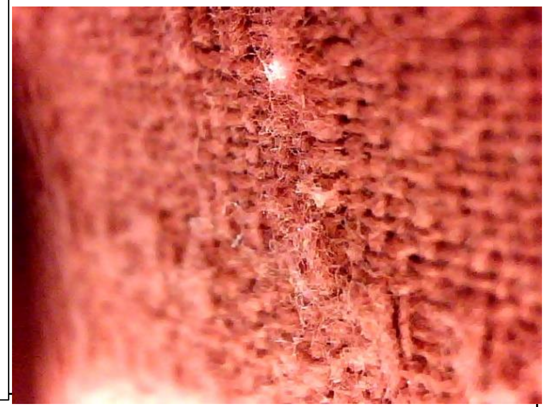
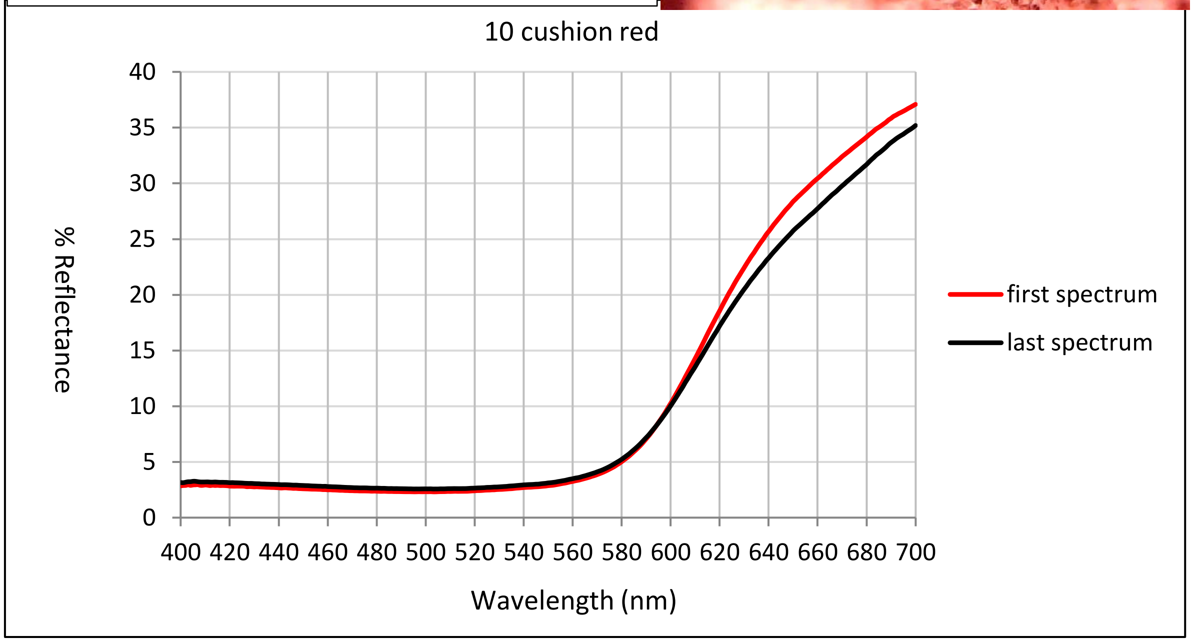


Figure 13. Cushion red (10): slight darkening, chroma loss





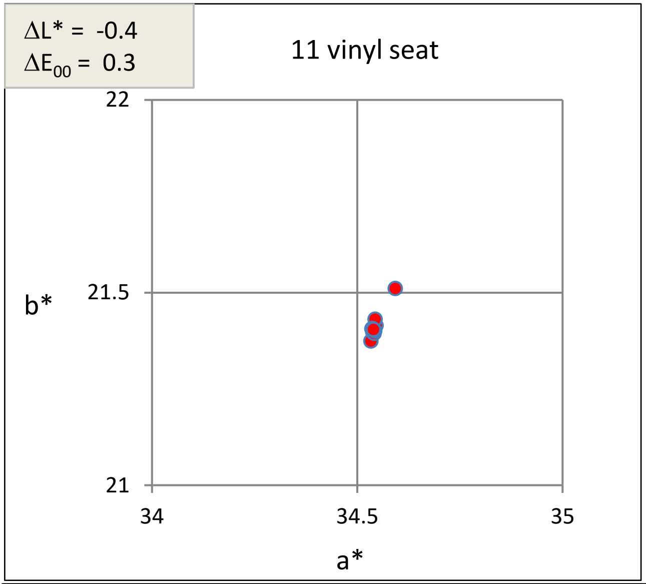
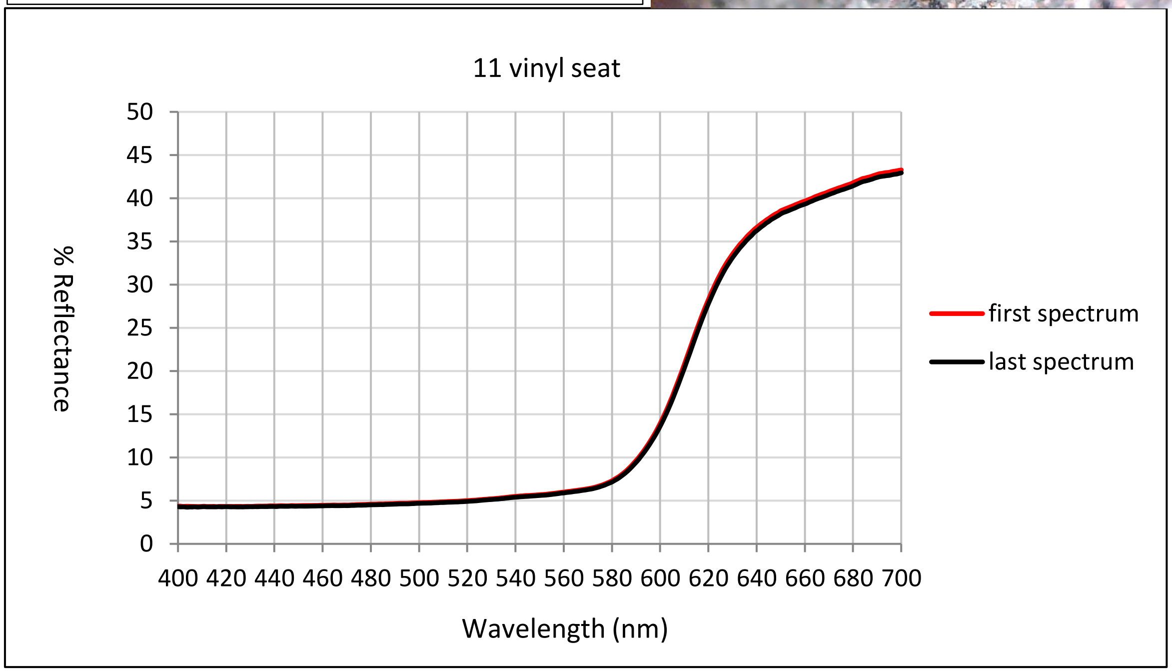


Figure 14. Vinyl bench seat red. Little if any response (lightfast). The very small initial change is probably bleaching of the yellowed plastic.



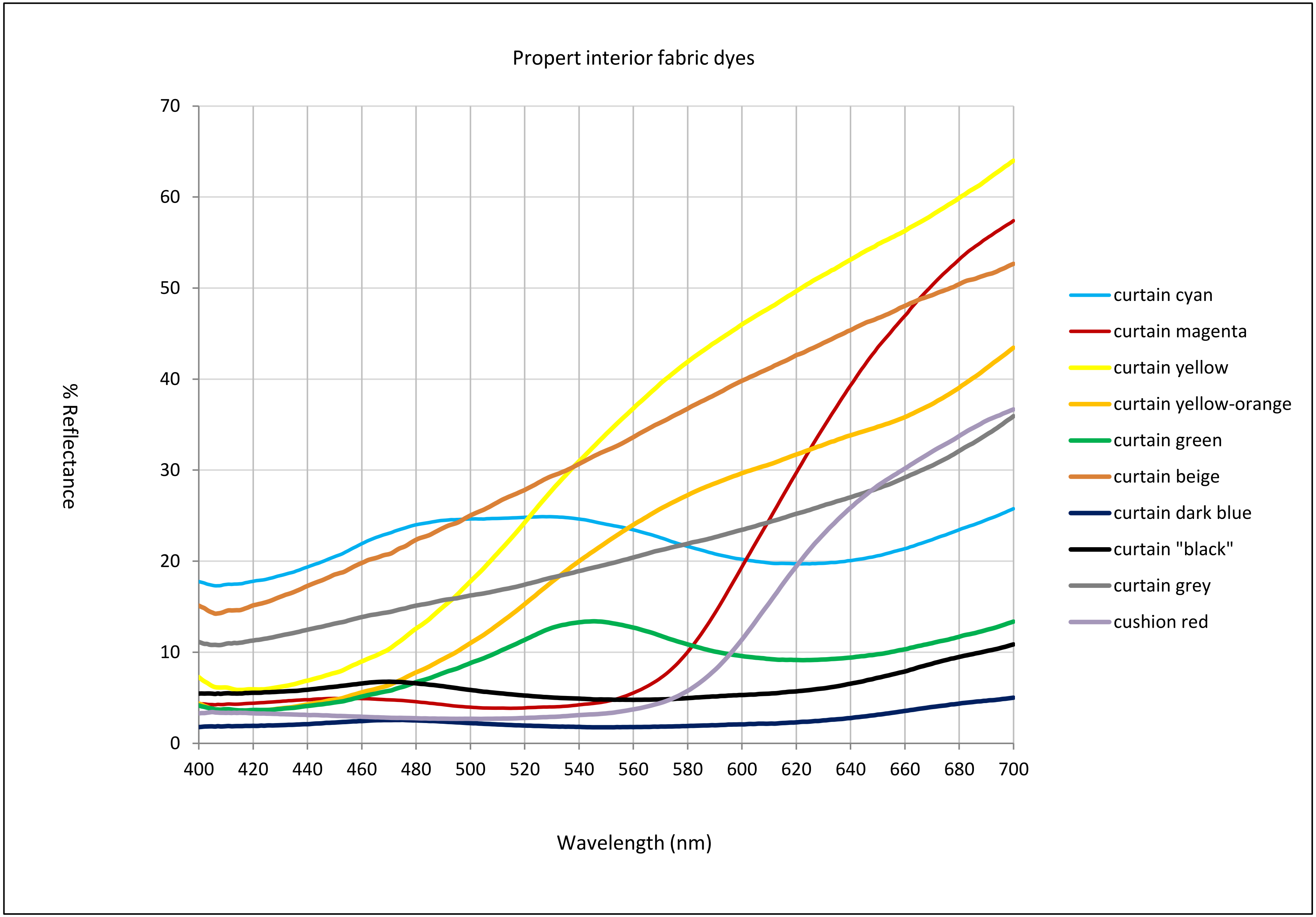


Figure 15. Dye spectra. It is probable that only three dyes were used for the image colours – cyan, magenta and yellow. Green is a mixture of yellow and cyan and yellow-orange a mixture of red and yellow, dark blue ("black") may be all three.

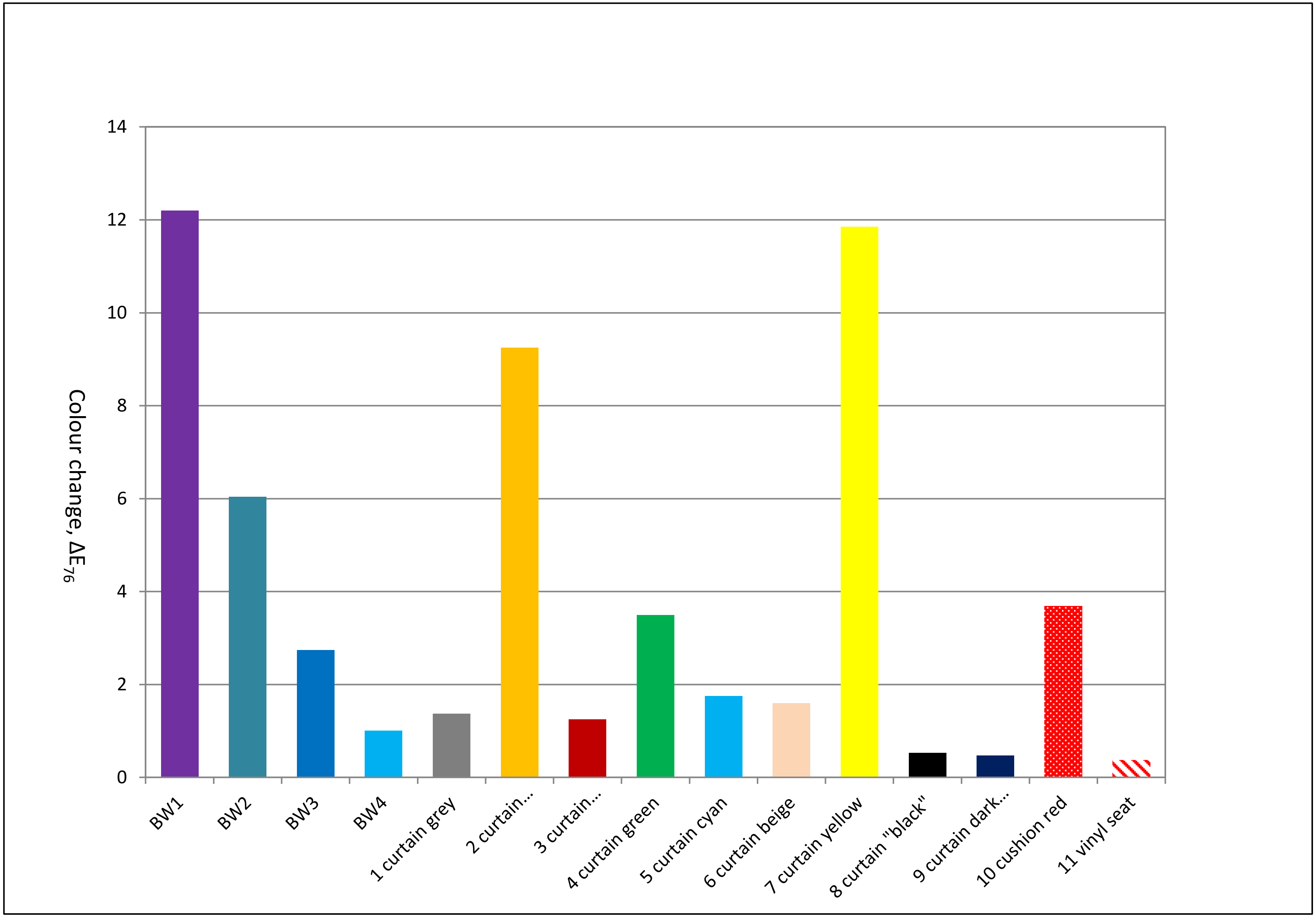


Figure 16. Relative colour change rates , CIELAB (CIE1976)

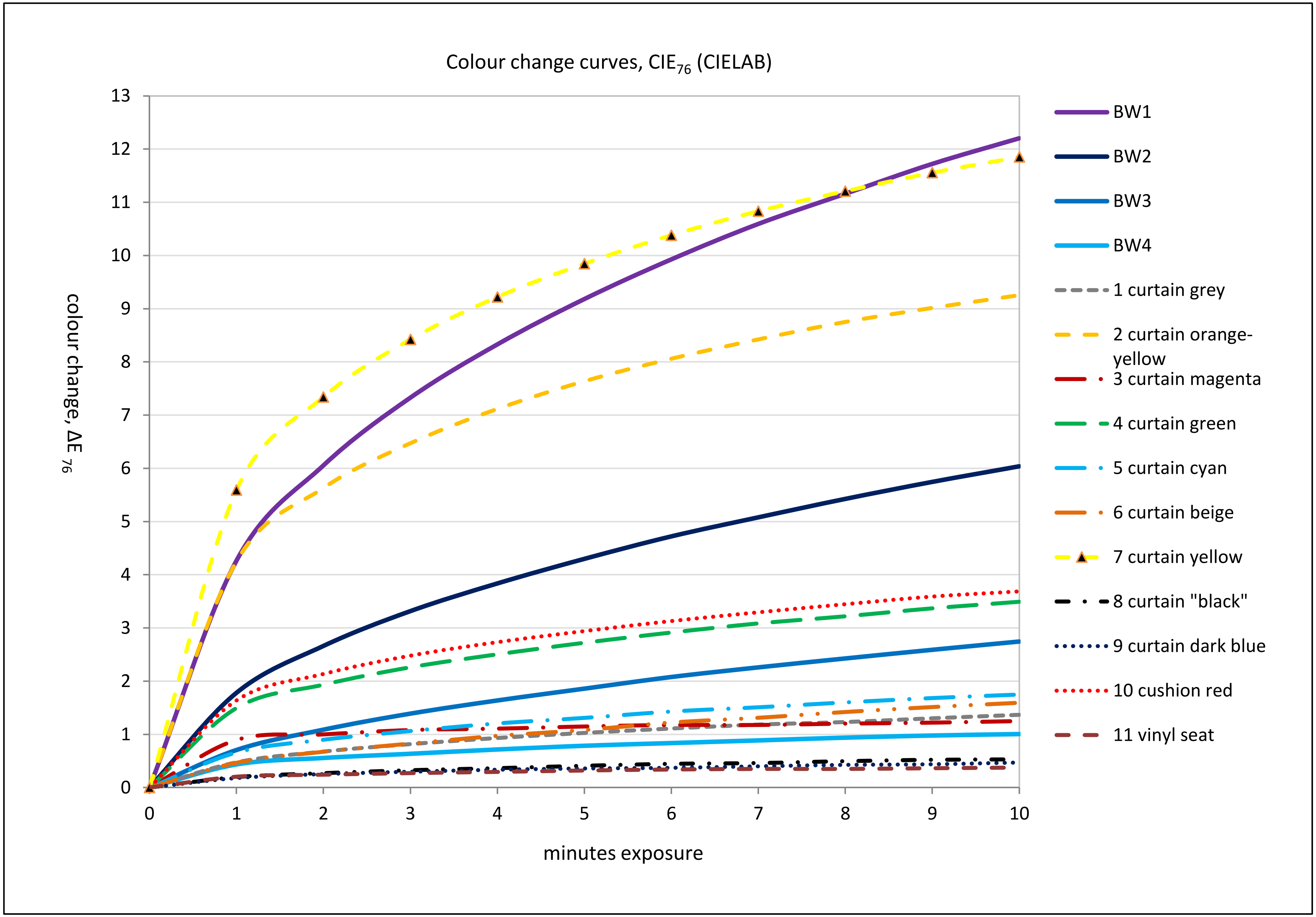


Figure 17. Colour change curves, CIELAB (CIE1976)

Endnote 1

Microfade testing is an accelerated test method and there are uncertainties surrounding the correlation between what is observed at very high intensities and what is likely to occur on display and during subsequent storage (Whitmore et al 2000). It is a semi-quantitative risk assessment tool rather than necessarily predictive. The results in this case apply only to UV-free light.

Endnote 2

For the purposes of this report colour change (ΔE) has been calculated using the CIE's 2000 (CIEDE2000) colour difference formula which replaced the earlier and much simpler 1976 (CIE76 or CIELAB) equation. Relative fading rates using the latter calculation are also provided in Table 1 and Figures 16 & 17. While much of the accelerated and ambient fading instrumental data in the conservation literature has been calculated using CIELAB, CIEDE2000 is likely to be more representative (CIE 2001). The ability of an "average observer" to notice differences between blues was exaggerated by a factor of about two in CIELAB. This affects the relative fading rates of the ISO Blue Wools (BWs) used as internal standards and other colourants not affected by the revision to the same degree. There are many other colour difference equations, all of which will give different results - for example CMC, S-CIELAB, and a proposed I* (I-star) metric for photographs (McCormick-Goodhart 2007).

Michalski's estimates of cumulative exposure (megalux hours, Mlux h) resulting in a just noticeable fade or difference (JNF or JND) for each of the BWs (CIE 2004) are themselves approximations with an estimated maximum error of ± 1 BW step (Michalski 2010). Therefore absolute predictions of the response of a colourant to a particular exposure (mlx-h) are possibly uncertain to a similar extent. The most recent (unpublished) research by the CCI and GCI indicates that for BWs 2-5 Michalski's estimates are reasonable, but the lightfastness of BW1 is overestimated by as much as a factor of two or three (Druzik 2016).

Endnote 3

Microfading cannot predict post-exposure colour changes that may occur in undyed and unpigmented fibres and paper because only the immediate photochemical response is measured and not the effect of concurrent and subsequent thermal (oxidative) yellowing reactions (Feller 1994). Light exposure accelerates subsequent yellowing of paper via a thermal (non-photochemical or "dark") mechanism involving residual photochemical reaction products. Thermal discolouration depends heavily on temperature, chemical processing of fibres, pH, exogenous and endogenous pollutants, prior conservation treatments and so on. To further complicate matters, ultraviolet directly yellows, rather than bleaches, groundwood paper and most natural fibres like wool. For example the rapid discolouration of newspaper in sunlight is the result of UV (<400nm) yellowing outpacing visible (>400nm) light bleaching.

Endnote 4

The NMA assumptions (Ford BL & N Smith 2009) are based on those of the V&A Museum (Ashley-Smith et al 2002): that is works should last for at least 500 years in a coloured form; a Just Noticeable Difference (JND) = 1.6ΔE and 10 JNDs signal the effective end of coloured life for an object. This may sometimes be a conservative estimate because approximately 30ΔE represents complete fading, but for low chroma colours it seems reasonable. The absolute fading rates of the BWs are taken from CIE157 (2004), see Endnote 2. CIE157 recommends colourants less lightfast than BW3 be exposed only half as much as the V&A's 2 years/decade at 50lux recommendation.

The NMA further makes a judgement based on a significance test as to whether the object/collection is likely to be in strong demand for exhibition in the future (i.e. at higher risk of fading over time) and adjusts recommended exposures accordingly. Objects judged more likely to be in continuing demand are displayed more conservatively (Ford BL & N Smith 2009) .

References

Ashley-Smith, J, Derbyshire, A & B Pretzel 2002, The continuing development of a practical lighting policy for works of art on paper and other object types at the Victoria and Albert Museum, *Preprints of the 13th triennial meeting of the ICOM Committee for Conservation in Rio de Janeiro*, vol.1, pp. 3-8.

CIE 2004, *CIE157-2004*, *control of damage to museum objects by optical radiation*, Vienna: Bureau Central de la Commission Internationale de l'Éclairage.

CIE. 2001. Improvement to industrial color difference evaluation, *CIE technical report 142-2001.* Vienna, CIE Central Bureau.

Druzik J.M., Getty Conservation Institute (GCI), personal communication, 18th November 2016

Feller, RL. 1994. *Accelerated ageing: photochemical and thermal aspects*. Research in Conservation No. 4, GCI. http://www.getty.edu/conservation/publications_resources/pdf_publications/accelerated_aging.html

Ford, B & N Smith, 2009, The development of a significance and risk based lighting framework at the National Museum of Australia, *AICCM Bulletin* vol. 32 pp. 80-86.

Michalski, S., Canadian Conservation Institute (CCI), personal communication, 10th October 2010.

Refs ctd.

McCormick-Goodhart, M. 2007. *An introduction to the I* Metric*. Aardenburg Imaging and Archives.

Tse, S. 2016. Personal communication.

Whitmore, PM, Bailie, C & S Connors 2000, Micro-fading to predict the result of exhibition: progress and prospects, in *Tradition and Innovation: Advances in Conservation*, ed. A. Roy and P. Smith, pp. 200-205. London: IIC.

The Canadian Conservation Institute website has an excellent general introduction to light and museum collections: http://www.cci-icc.gc.ca/resources-ressources/agentsofdeterioration-agentsdedeterioration/chap08-eng.aspx

For a complete list of references to microfading and its applications see http://www.microfading.com/resources.html

Blue wool equivalent (BWE)	1	1.5	2	2.5	3	3.5	4
Lightfastness (Mlux h/JND)	0.2	0.6	1.0	1.8	3.0	5.5	10
Light level (lux)	up to 50 lux		50 - 80 lux*		50 - 80 lux*		lighting as required*
Display high significance	individually decided		2 years/decade		5 years/decade		period of exhibition
Display normal significance	individually decided (2 years/decade)		5 years/decade		period of exhibition		period of exhibition
*minimum consistent with good display							

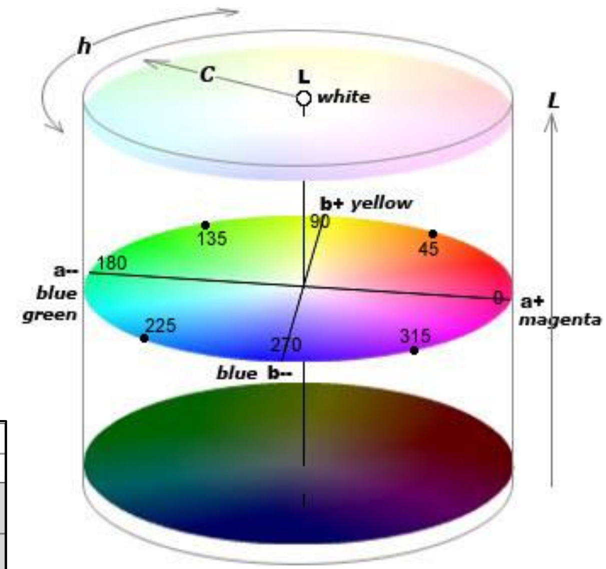
Figure (a) Appendix NMA lighting guideline

BW4-2 taken from Michalski's BWFS estimates from *Running A Museum, a practical handbook* ICOM 2004. *http://portal.unesco.org/culture/en/ev.php-URL_ID=36646&URL_DO=DO_TOPIC&URL_SECTION=201.html More recent estimates of BW1 put it at about 0.1-0.2 Mlux h/JND (UV-free), less lightfast than Michalski's estimate (Druzik 2016)*

Instrument Settings

Luminous flux (mlm)	~650
Spot lux (megalux)	~ 6-8
Spot diameter (mm)	0.4

Figure (b) Appendix. Simplified L*a*b* colour space



L* a* b* and L C h are different ways of describing the same shift in CIELAB space

L* = Lightness
a* = red-green axis
b* = yellow-blue axis

C = vividness (chroma)
h = hue angle anticlockwise from red (0)