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Introduction

This is a practical guide to finding and interpreting data for key fabrics, paints and other materials in the master ACCESS database **FABRICS.MDB**. The database contains the form FABRICMASTER with all details as a master reference. Matching spectra are available for most materials. Some colour statistics are also stored. The form is duplicated in EXCEL for those who do not have the ACCESS program.

FABRICMASTER is a collation of the table used for data (DATA ENTRY) and a manually-imported table of colour statistics (COLORIMETRY DBASE.XLS). This is a list of output from the EXCEL tool **COLORIMETRY CALCULATOR.XLS**, indexed on unique fabric codes. Colour statistics are automatically calculated for one fabric at a time using this simple tool. I have only taken the time to calculate representative statistics for a few fabrics. The ACCESS database also contains earlier colour statistics typed in from calculations done by the software that came with the Li-Cor 1800 device.

Each material has a unique numeric code, sometimes with additional letter codes to identify sub-samples or duplicate scans. This identifier matches reflectance and transmittance spectra that are stored in the EXCEL file **SPECTRA REFERENCE.XLS**.

Spectra that have not been indexed are in the EXCEL file **SIGMA PLOT ARCHIVE.XLS**. This file contains only a few notes and simple labels. To understand what is available, browse the graphs in the POWERPOINT file **USEFUL GRAPHS.PPT**.

At the end of this compendium, useful spectra that have been published in the tsetse and biting fly literature are discussed. These are stored in **SPECTRA FABRICS DIGITIZED.XLS**.

Methods

The **FABRICS** database contains “materials” in a broad sense (fabrics, netting, plastics, optical filters, cattle/goat/human skin, vegetation, etc.) examined since the early 1990’s to support research on the visual responses of tsetse and biting flies. Materials were numbered as they were obtained, but some are out of sequence as they were added in later years. There are duplicates of various types, including different lots of similar or virtually identical materials. These have been associated as much as practical without making it difficult to track codes in original reference materials. Cross-references are provided for most key fabrics of interest to researchers.

The **SPECTRA REFERENCE** file contains reflectance and transmittance scans with associated information typed in manually for a convenient reference. In case of any discrepancies in fabric codes, dates, descriptions, etc., the original information is in the FABRICS database. Not all materials in FABRICS will have associated spectral data.

Up till 1998 or fabric #209, materials were scanned by Steve Mihok with a sophisticated device with an integrating sphere (Li-Cor 1800) to measure standard diffuse reflectance. Afterwards, materials were scanned with a simpler device (Ocean Optics) without an integrating sphere by Dave Carlson to measure total reflectance. The Ocean Optics measurements used a 45/45 degree geometry that can be affected by texture (e.g. shininess). There are also a few diffuse reflectance scans by Floyd Dowell that were done in 2002 using the most sophisticated device (Cary 500) with an integrating sphere and a white tile standard. More details of methods are in the worksheet NOTES. The small number of duplicates by Carlson-Dowell-Mihok were done at different times on mostly different fabric swatches, so only general comparisons can be made.

When graphing data, note the source of each spectrum (Mihok, Carlson, Dowell) and use the appropriate x-axis column for the proper wavelength range (column B, C, or D). Note that the starting and finishing wavelengths may differ; Mihok (column B) and Carlson (column D) ranges both start at 370 nm.

To use the COLORIMETRY CALCULATOR, simply follow the instructions in the file, using reflectance data at 1 nm intervals from any source. Take care when using this tool as none of the cells that perform calculations are protected. Anything can be edited by the user.

If details in graphs in this document are too small, use the zoom tool, or copy the image to another document window (e.g. in landscape format). All of these graphs are simply pasted in from EXCEL and hence can be examined and manipulated in SPECTRA REFERENCE.XLS.

Many of the materials mentioned here are also discussed at http://www.nzitrap.com. The web site contains numerous scanned colour images of fabrics, links to useful resources, and many literature references.

Accuracy

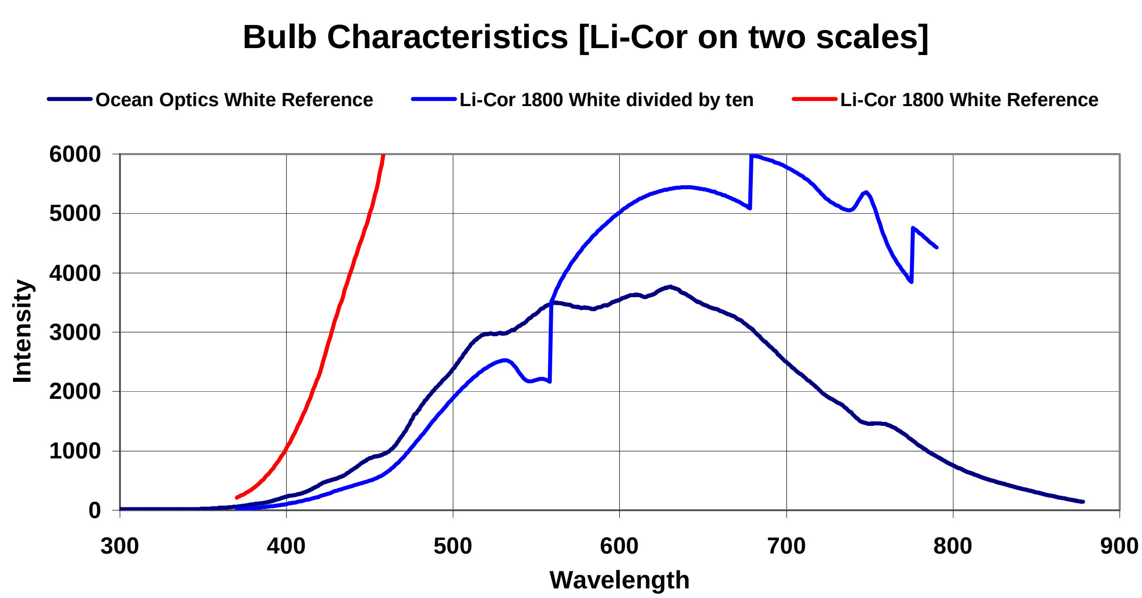
The few spectra taken with the Cary 500 instrument are likely the most accurate, given the equipment used, followed by the Li-Cor 1800 readings. The Cary 500 spectra extend to 200 nm, but no data were taken in the infra-red (> 700 nm), as with the other devices.

Spectra from the Li-Cor 1800 are accurate in the visible range, and are reasonably quantitative between 370 and 400 nm. The spectra from the Ocean Optics device in this range are qualitative only. This is a function of the low power output of tungsten bulbs in the ultraviolet.

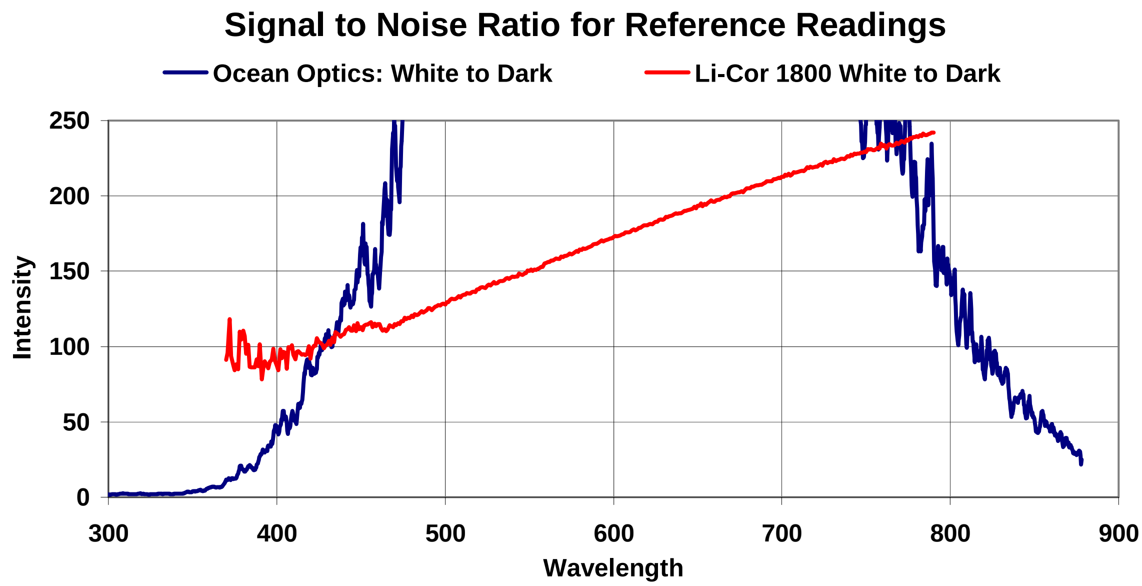
Reference white and dark raw "scope" readings for the Ocean Optics device and the Li-Cor 1800 device are provided in the file **DEVICE REFERENCE.XLS**. The Li-Cor 1800 had a high signal to noise ratio at all wavelengths (ratio of white to dark). Signal to noise ratio was only 50 x at 400 nm and 10 x at 370 nm for the Ocean Optics device. Overall, the Li-Cor 1800 device had much greater sensitivity than the Ocean Optics device (about 10+ times), given capture of reflected light at all angles by the integrating sphere.

Below is an example of the wavelength profiles for the RAW intensity readings for 100% white (barium sulphate) with both devices (largely a function of the power output of the bulbs). Note that the red line is the actual intensity reading for the Li-Cor device, which goes off scale at about 450 nm. The blue line is the intensity of the LiCor device divided by ten.

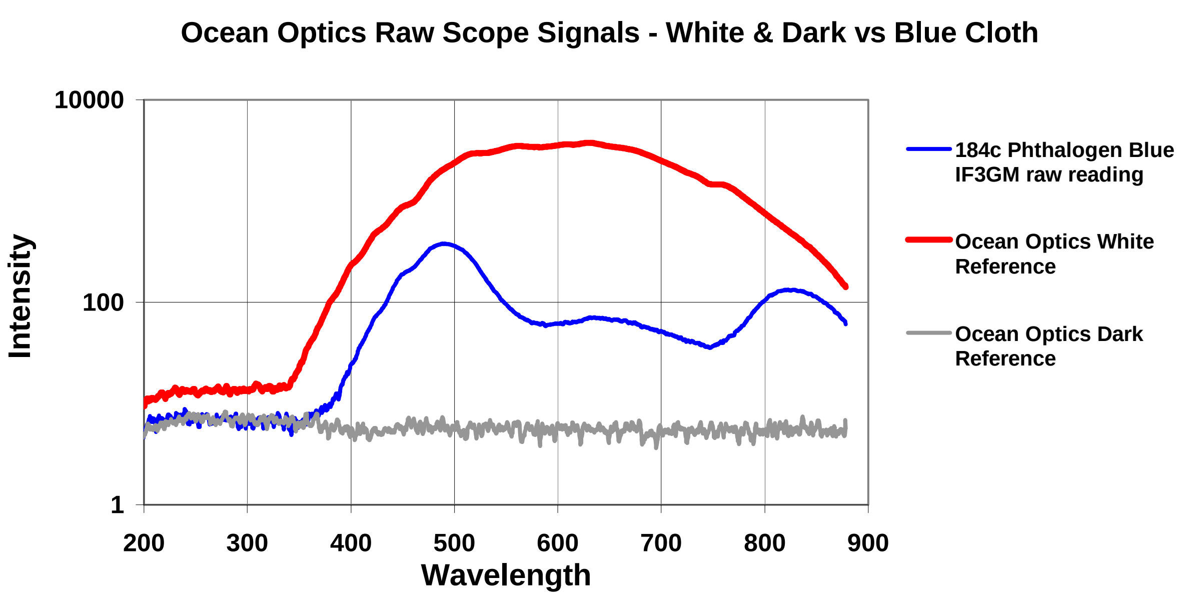
Dark readings for both devices were low, so the sensitivity across wavelengths of the instruments is largely determined by these profiles.



Below is a typical example of the raw signal to noise ratio (white to dark) for the two devices. The rapidly dropping ratio below about 420 nm for the Ocean Optics device is why caution should be used when interpreting ultraviolet readings from this simple device.



Below is an example of raw "scope" readings for a standard blue fabric. Note the log scale.



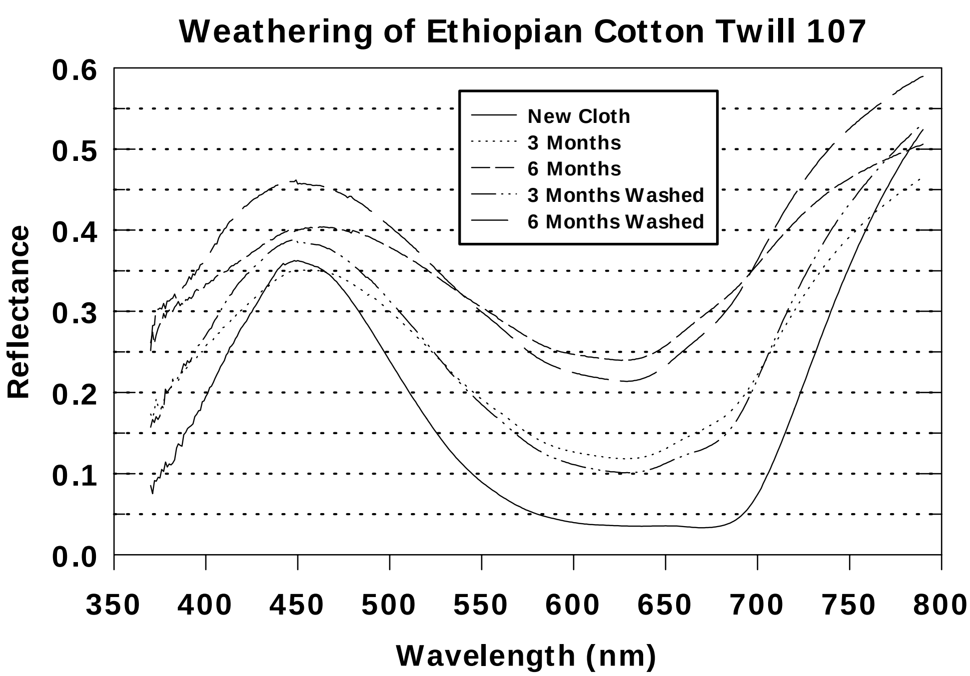
Interpretation

When interpreting spectra, it is important to take into consideration the difference between a standardized laboratory measurement of "% reflectance" against "white" and what would be the "appearance" of a material under varying conditions of natural light. The colour of incident light changes with the time of day, season, latitude, cloud cover, etc. The contribution of reflected light to appearance is also a function of the environmental background. Rain, morning dew and shade will also affect appearance in the real world. Most fabrics are not completely opaque, and hence, both reflected and transmitted light will influence appearance and contrast with other objects. Lastly, materials will change in both colour and texture with time outdoors.

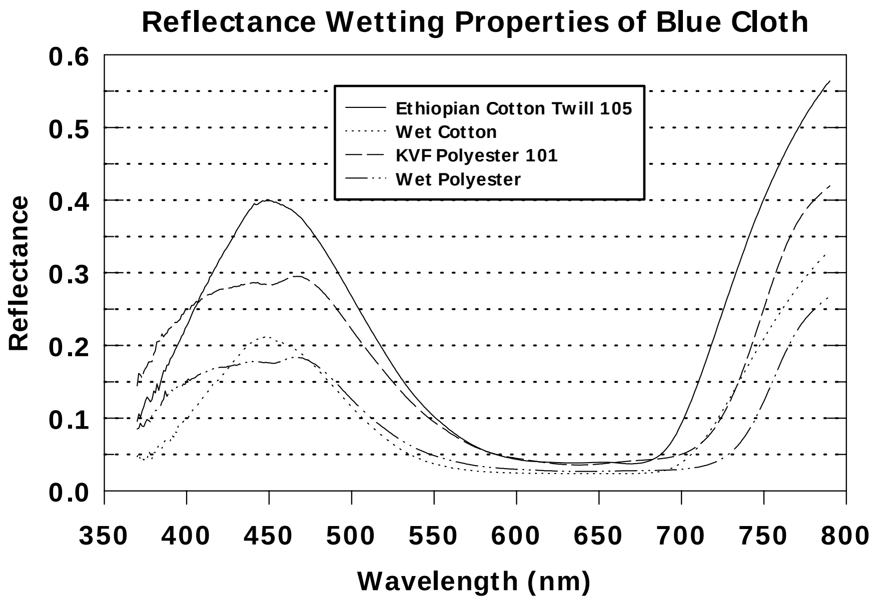
Also, none of the readings in this database have measured specular reflectance or shininess as this requires special equipment or specially-designed integrating spheres. Biting flies and tsetse are both sensitive to polarized light and hence will react to both texture and colour. Similarly, with exquisite sensitivity to ultraviolet and blue light, small differences in the 350-500 nm range to our eye will likely appear as major differences to the eye of a fly.

Below are a few examples of data from USEFUL GRAPHS.PPT that illustrate these points.

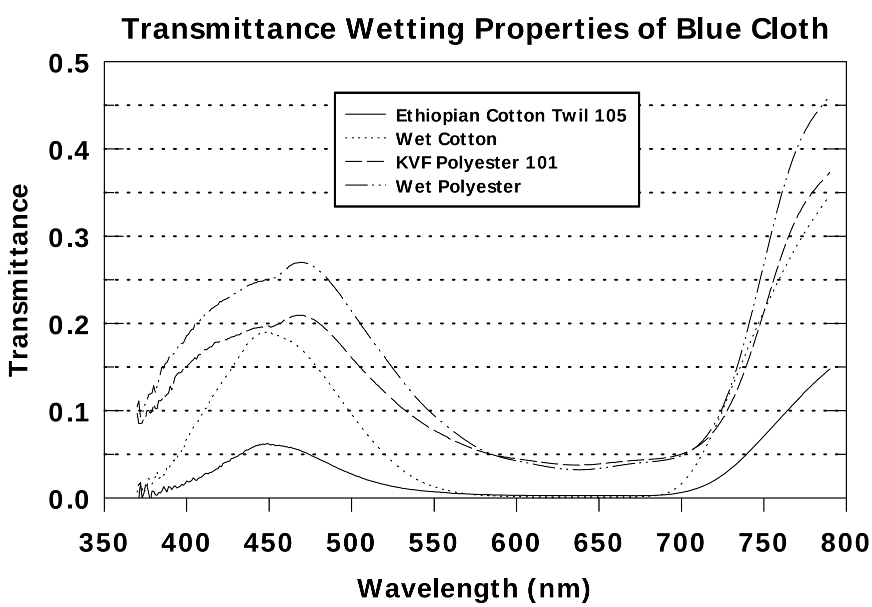
Poorly-dyed cloth may fade badly with time, and colours may also be obscured by dust, mud splash, etc. In contrast to the material shown below, properly-dyed phthalogen blue IF3GM cotton hardly fades in 3-6 months.



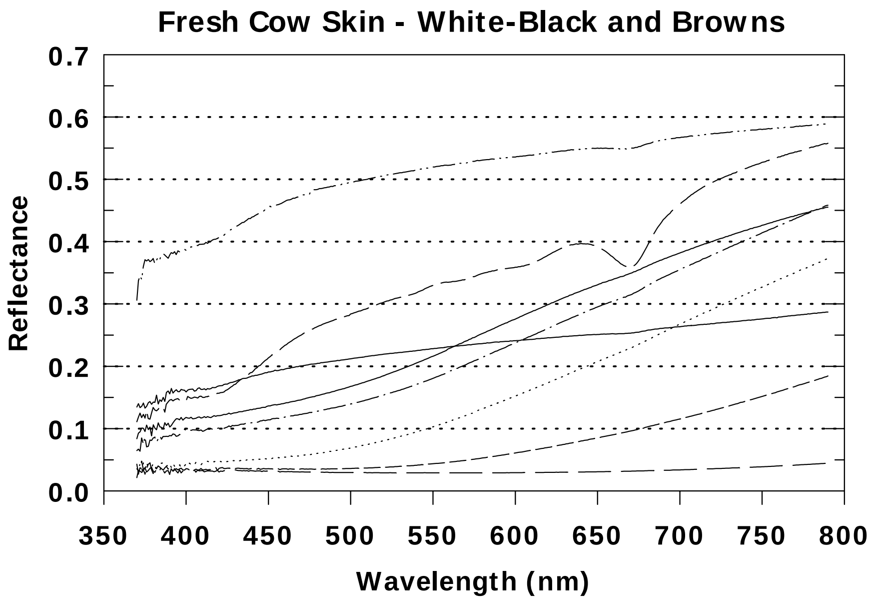
When cloth is wet it is darker, and changes in terms of opacity versus transparency. Phthalogen blue cotton darkens more than a similar blue polyester when wet.



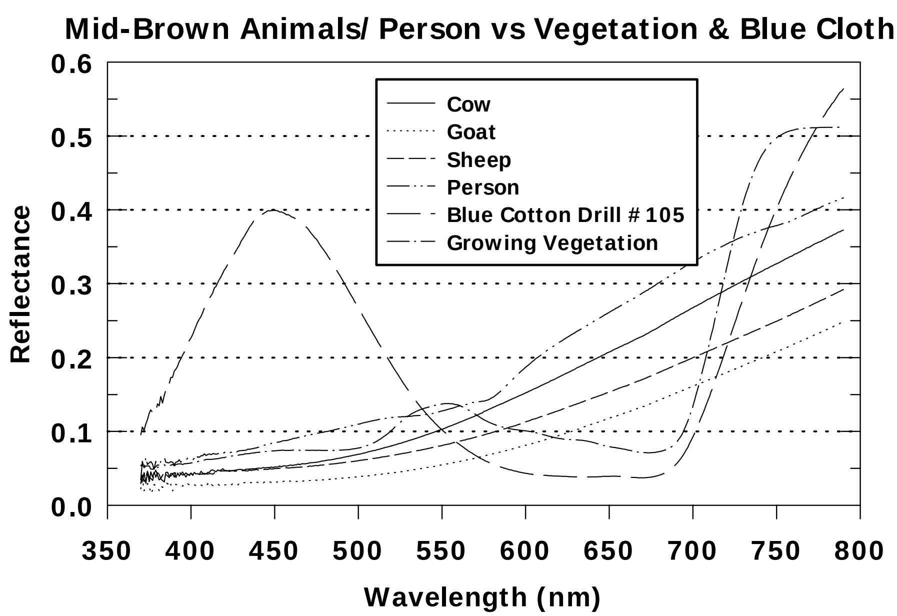
Phthalogen blue cotton is nearly opaque when dry (5% transmittance). When wet, transmittance changes to 20%, a much larger change than for a similar blue polyester.



Examples of some hosts (cows in different colours).



Phthalogen blue cloth is a striking visual stimulus in the environment relative to animals and people (fresh skin), and relative to green vegetation.



Raw Materials

181 & 184a – Natural cotton drill before and after dyeing with Phthalogen Blue IF3GM
201 & 101a – 100% pongee polyester before and after dyeing with unknown blue dye(s)

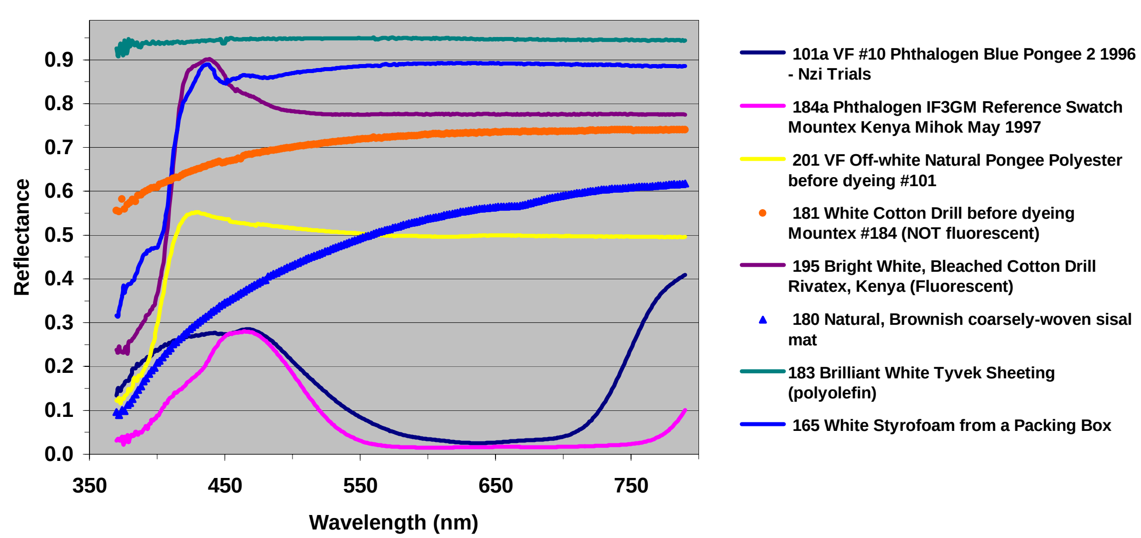
There are several examples of white and off-white materials. Two of these show how spectral reflectance profiles change when cotton or polyester is dyed blue. Note how raw cotton and another cellulosic material (sisal) have natural absorbance in the ultraviolet. Bright white (bleached) cotton often has added optical brighteners, shown here by a sharp ultraviolet drop and a consequent small blue peak. The raw pongee polyester used by Vestergaard Frandsen also appears to contain optical brighteners. Spectrophotometers designed for examining textiles will take readings with or without ultraviolet illumination included so that one can detect the presence of optical brighteners (the Li-Cor 1800 did not have this feature).

Tyvek (polyolefin - many types) is included on this graph to illustrate its brilliance relative to other whites in both the visible and the ultraviolet. A craft/hobby material called “zippyfoam” is very similar. Teflon (poly tetrafluoroethylene) is even brighter and is the basis for modern 100% white standards in reflectance spectrophotometry (“Spectralon” tiles). Detailed spectra for Tyvek and other special materials are provided at:
http://www.fnal.gov/projects/ckm/photon_veto/misc/tyvek_reflection/tyvek_reflection.pdf

Generic styrofoam in contrast absorbs ultraviolet light. Altogether, it is impossible to guess how any white material will appear in the ultraviolet without a reflectance spectrum. The best one can do is examine for fluorescence to the detect optical brighteners (e.g. with a black light blue bulb, lights used for examining bank notes).

After dyeing, phthalogen blue IF3GM strongly absorbs all wavelengths except in the blue region. The blue dyes used with this particular VF polyester have little absorbance in the ultraviolet and also in the infra-red approaching 800 nm. With other blue dyes (e.g. reactive dyes for cotton), one also sees this pattern in the infra-red.

Plain Raw Materials, Samples of Polyester and Cotton are shown before and after Dyeing



Reference Fabrics

http://www1.dystar.com/index_textile.cfm

293 - Type IF3GM from Dystar, Germany (cloth) - Ocean Optics
294 - Type IF3GK from Dystar, Germany (yarn) - Ocean Optics

184a - Type IF3GM from Mount Kenya Textiles, Nanyuki (Li-Cor 1800)
184b,g - Same material with best ultraviolet data (Cary 500)
184-pool - Same material, average for different swatches (Ocean Optics)
168a - Earlier lot of the same material (Li-Cor 1800)

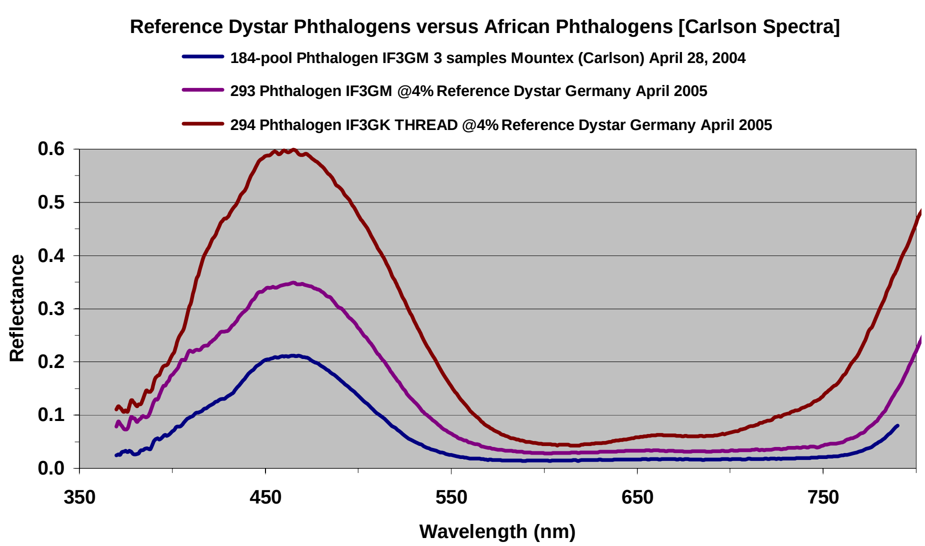
326-328 – Types IF3GM, IF3G, IF3GK from Sitaram, India (no spectra yet)
331-334 – Types IF3GM, IF3G, IF3GK, IBN from Manibhadra, India (no spectra yet)

The materials from Dystar were obtained directly from the original manufacturer of phthalogen dyes in 2005 (Bayer's new name after a merger). Unfortunately, these recent spectra were obtained using the least-sophisticated equipment.

The two fabrics from Mount Kenya Textiles were custom-dyed using type IF3GM from Gharda Chemicals, India in 1997. The spectra are nearly identical to several published spectra for type IF3GM from Chris Green in the 1980s.

I have not yet obtained spectra for fabrics provided in 2006 by Sitaram and Manibhadra in India (dye manufacturers only). There are at least four other sources of phthalogen dyes in India, but these are the only two companies that have responded to requests for samples.

Note the brilliance of type IF3GK (peak at nearly 60%). This variant is used for thread/yarn in exhaust dyeing. I have two other examples of IF3GK which are also very impressive. Coats is one of the companies that uses IF3GK for its products.



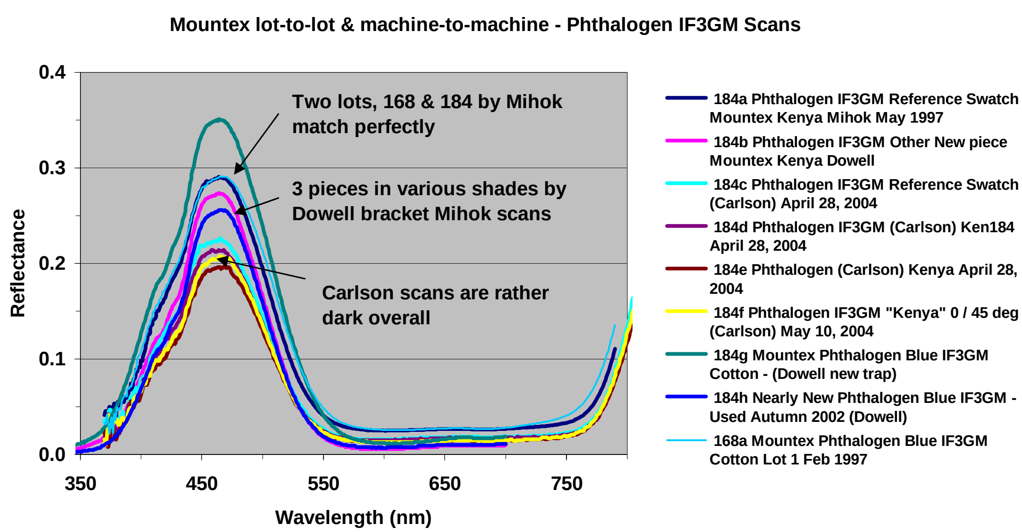
Variability Among Scans

184 - Phthalogen Blue IF3GM from Mount Kenya Textiles, Nairobi
168 - Earlier lot of same material

The graph below provides examples of how reproducible scans are with different equipment for one type of phthalogen blue fabric from one textile mill. I unfortunately do not have a proper series of duplicate scans of the same samples taken at the same time to document the nuances of small differences in the scans performed by different people / equipment / geometry.

Note that duplicate lots of material (#168 and #184a) are nearly identical when scanned with the Li-Cor 1800. When I stored these data, I also intentionally chose an “average” scan from large lots of cloth. In reality, there was bolt-to-bolt variation in dyeing and this would show up in scans of individual pieces of fabric.

Bolt-to-bolt variation in fabrics is shown below in scans of different swatches of fabric #184 by Carlson using the Ocean Optics device. For whatever reason (geometry and use of an integrating sphere are major differences relative to the Li-Cor 1800 scans by Mihok), the Ocean Optics “total reflectance” scans are often darker, even though both have been standardized for 100% white relative to pressed barium sulphate. Dowell also did a few scans of various swatches of #184 with a Cary 500 equipped with an integrating sphere. His scans match the Li-Cor 1800 scans well, with various swatches bracketing the “average” scans stored by Mihok. There are several further possible comparisons in the database for multiple scans of the same material.



Phthalogen Blues

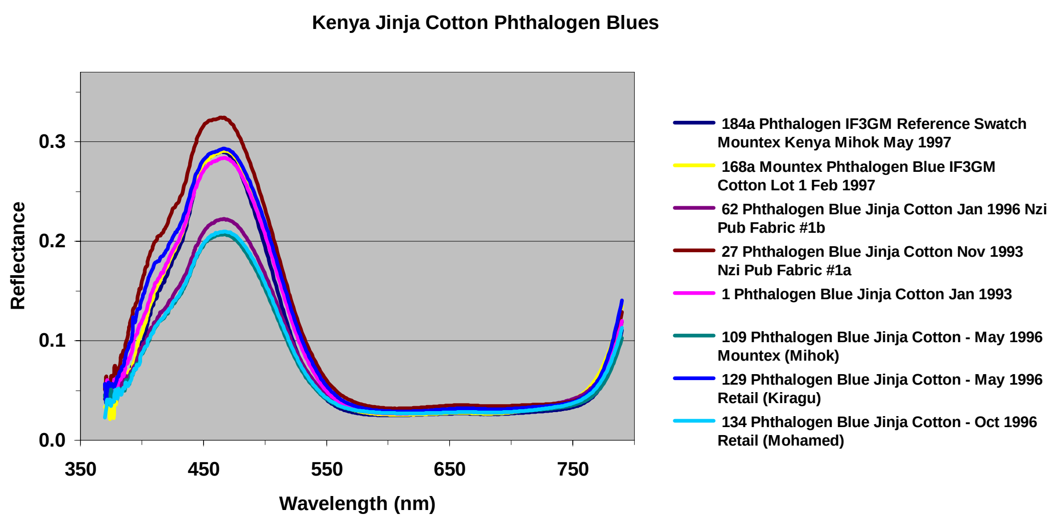
Kenya

http://www.epzakenya.com/news.php?type=press&itemno=45

1, 27, 62, 109, 129, 134 - "Jinja" phthalogen blue (light-weight cottons, retail)
168, 184a - Phthalogen Blue IF3GM reference cotton drills from Mount Kenya Textiles

Light-weight cottons from the retail market used by various researchers in Kenya in the 1990s are essentially all the same, differing only in depth of shade (e.g. about 4 to 5-6 % dye based on the Dystar and Indian dye manufacturer's reference materials).

These "Jinja" cottons from the Nairobi market were likely all dyed with phthalogen blue IF3GM, given the very close match to reference spectra. There were three textile mills producing fabrics in Kenya during this time period: Kicomi, Rivatex and Mount Kenya Textiles.



Ethiopia

60, 105a, 107, 131, 250 - “Phthalogen Blues” from Awassa Textiles
124, 127 - “Royal Blues” from Awassa Textiles

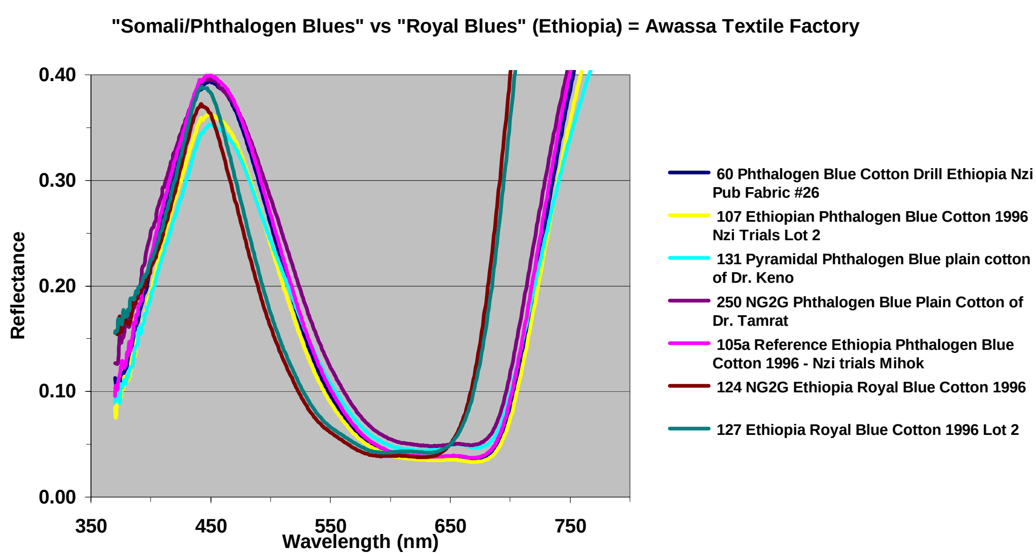
The factory manager at Awassa Textiles stated in 1995 that they were producing two main shades of blue cotton for the local market. He said the brighter colour, known as “Somali Blue”, was dyed “phthalogen blue”, but he never disclosed the technical details, despite many requests. This “phthalogen blue” cloth was used by the government and researchers associated with ICIPE for large tsetse control programs, and could only have come from this source. I obtained several samples from different times with minimal variation in colour.

The other standard blue from Awassa Textiles (a “royal blue”) was also sometimes used for making tsetse traps (e.g. 1,000 were made in royal blue in the southern region at Arba Minch).

Given the infra-red signature below, these Ethiopian blues were clearly not dyed with phthalogen blue IF3GM, but were instead prepared with other dyes to imitate this colour. How this can be done with a relatively simple formulation is explained later. With this strategy, there is a slight shift in the blue peak, and there is a very obvious signature in the infrared (> 700 nm) that is absent from genuine phthalogen blue cloth.

The royal blue fabric is very similar to the “Somali” blue, but with a slight reddish tint (earlier rise in the reflectance at about 650 nm).

I have no recent fabrics from Ethiopia for comparison. The Awassa Textiles Factory is a large mill that has been in operation as a state industry since 1981. There is also a textile mill at Dire Dawa under the same organization. There have been ongoing negotiations for privatization of the textile industry in Ethiopia for several years.



Zimbabwe

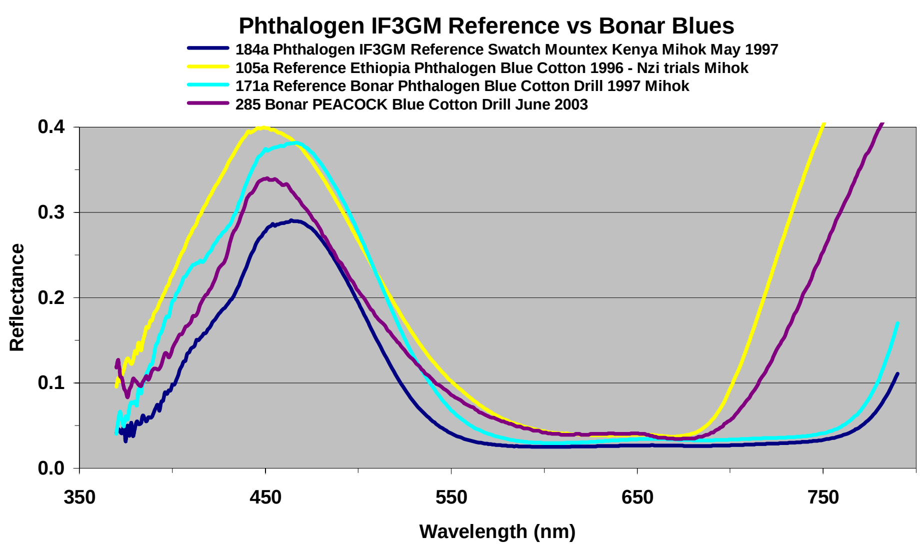
http://www.puc-rio.br/parcerias/untpdc/incubator/zwe/tphar/ztcd0072.htm

171a - Tsetse phthalogen blue fabric from 1997 from Bonar Industries, Harare
285 - Equivalent "tsetse" fabric in "peacock blue" from Bonar in 2003

According to Glyn Vale, Bonar Industries supplied tsetse researchers with genuine phthalogen blue IF3GM fabric from the early 1980s, up to the time I obtained the single sample below in 1997 (from a Zambian researcher buying cloth directly from Bonar).

Bonar was a supplier and not a manufacturer, so it could have sourced materials from any local or foreign textile mill through time. The 1997 sample is an excellent match to phthalogen blue IF3GM, confirming that the proper material was being sold at that time.

When contacted in 2003, Bonar was selling a "peacock blue" fabric in place of "phthalogen blue". Bonar said it was equivalent, but never provided technical details. The match to the correct colour is reasonable, but as with Ethiopian "Somali" blue, the spectral signature is not that of phthalogen blue. The obvious clue to the nature of this material is the infra-red signature typical of reactive or direct dyes (present in both the Ethiopian and recent Zimbabwe fabric).



France

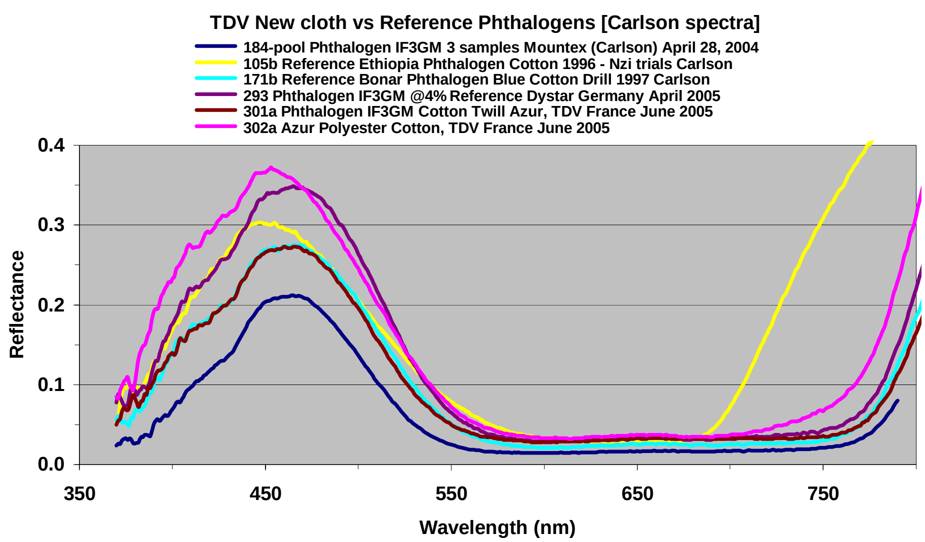
http://www.tdv-industries.fr/en/produits/index.htm

301a - "Azure" heavy cotton twill type CV47 from TDV Industries (special order)
302a - Equivalent "Azure" polyester/cotton in type S250 (in regular production)

Dystar informed me in 2005 that its only current customer for phthalogen blue IF3GM for solid shade dyeing was TDV Industries in Laval, France. TDV sent a "leftover" from a previous special order dyed with phthalogen blue IF3GM, and labeled it as "Azur" [sic]. TDV said phthalogen blue dyeing on cotton could be done on request with any weight of fabric, given a minimum order of 1,000 metres. TDV also supplied a sample of its regular production of a similar colour in polyester/cotton, which can be purchased at any time.

The cotton is a perfect match to phthalogen blue IF3GM, and the polyester/cotton is a very good imitation. The Ethiopian (other dyes) and Zimbabwean (IF3GM) phthalogen blue fabrics are also on this graph for comparison. All of these spectra were taken with the Ocean Optics device.

The phthalogen blue cotton from TDV Industries in France in 2005 is almost identical to the genuine material sold by Bonar Industries in Zimbabwe in 1997. This could be a coincidence, but it may be that Bonar sourced some material from overseas.



Ivory Coast

http://www.cirad.fr/fr/index.php
http://www.itc.gm/

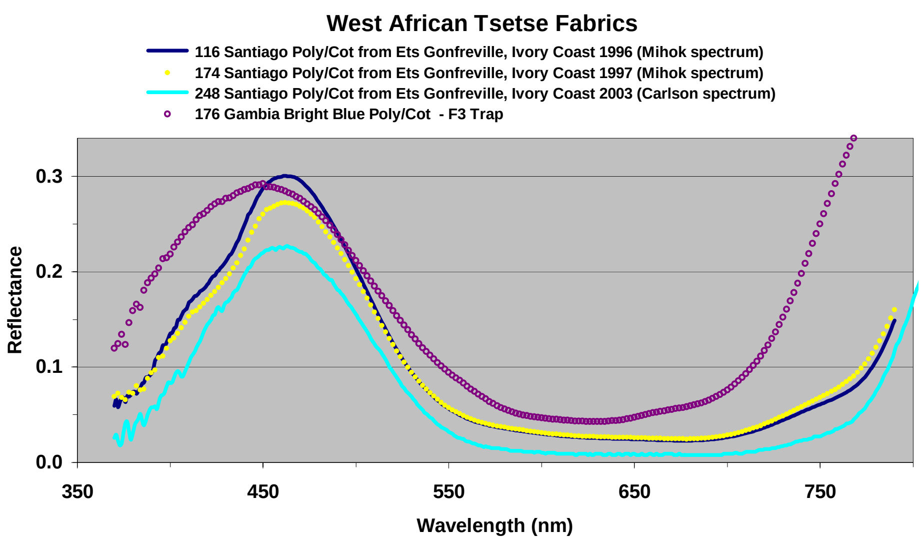
116, 174, 248 -"Santiago" standard tsetse fabric, polyester/cotton from CIRAD / CIRDES
176 - brighter blue, uncharacterized polyester/cotton used at ITC in the Gambia

I have three samples of the same standard fabric used for many years in tsetse traps/targets in West Africa. These date from 1996 to 2003 and were obtained from different researchers. The samples were all said to have come from the well-established textile mill of Ets. Gonfreville in Bouaké, Ivory Coast.

At the International Trypanotolerance Centre in the Gambia, a different poly/cot was preferred, but no information was provided on the source, other than that it was local.

The Santiago fabrics are all essentially the same and match the spectrum of the historical fabric of Laveissière et al. (1987). The Gambian material is clearly different.

Ets. Gonfreville has not been operating for several years since the civil war.
It was founded in 1932. (http://www.fes.de/fulltext/iez/00061005.htm)



Polyester Blends

http://www.klopman.com/pages/home.asp?lang=en
http://www.vestergaard-frandsen.com/

174 -“Santiago” poly / cot from Ets. Gonfreville, Ivory Coast
207 - “New Azzurro” poly / cot in fabric “Utopia” from Klopman, Italy
302a - “Azure” poly / cot in fabric “S250” from TDV, France

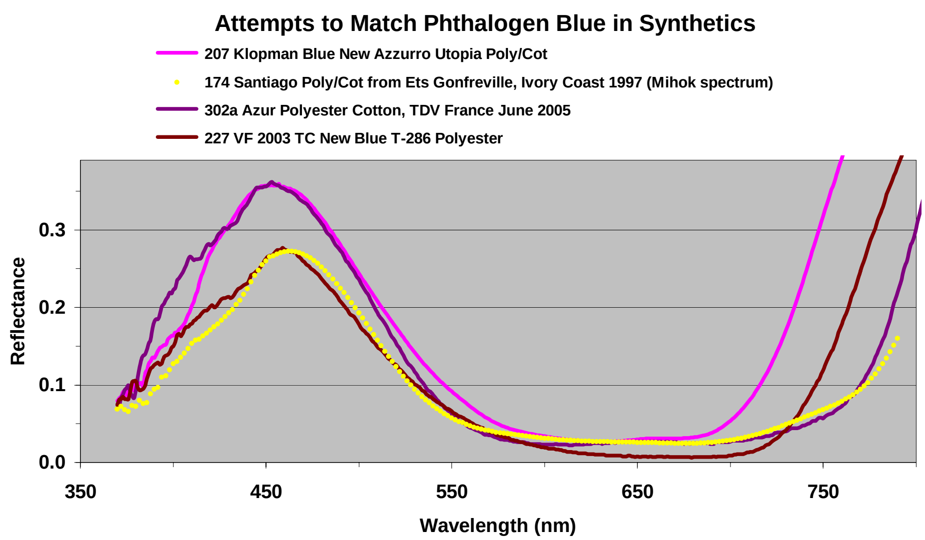
227 - “TC New Blue 286” 100% polyester from Vestergaard Frandsen (2003)

The “Azur” fabric from TDV Industries in France is contrasted below with a similar poly / cot produced by Klopman (#207), and the standard West African tsetse fabric (Santiago).

In 2003, Vestergaard Frandsen in Denmark reformulated the colour of its former bright blue polyester fabrics to obtain a new match to phthalogen blue (#227).

All of these fabrics are good imitations of phthalogen blue, but are not exact matches. This is because it is impossible to use CuPc in a conventional dye to produce this exact colour. The Ingrain “dyeing” process for cotton is unique in that it forms the CuPc pigment *in situ*.

From differences in the infra-red spectra, colours that mimic phthalogen blue in poly/cot or polyester fabrics have likely been produced with several different dyes. Although I cannot be sure, we can probably assume that only Ets. Gonfreville and TDV have actually used phthalogen blue IF3GM to dye the cotton part of the poly/cot mix. If so, this would be reflected in excellent light-fastness, which is definitely the case for “Santiago”.



Acrylic

http://www.sunbrella.com/usa/

214a-e - Sunbrella acrylic awning fabric in Pacific Blue from Canada and the USA

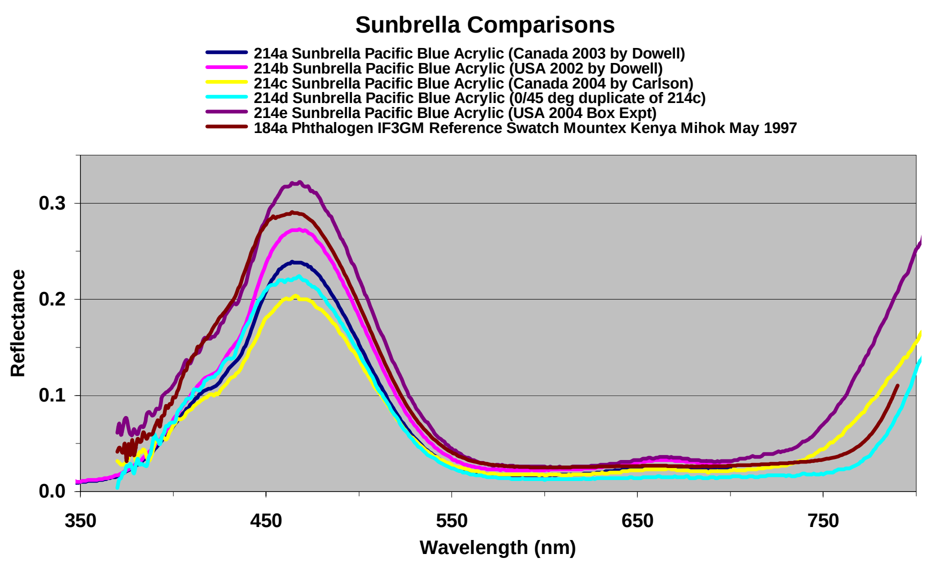
Sunbrella is nearly identical to phthalogen blue IF3GM across all wavelengths. This is probably because copper phthalocyanine itself is used during “solution dyeing”, i.e. CuPc is incorporated in solution in the raw polymer before fibres are formed or cloth is woven. Sunbrella has a “fluorocarbon finish” of some kind; this may also partially account for its light-fastness. Some fluorocarbon films specifically block ultraviolet light as well as repel water.

The scans by Dowell (214a,b) show very low reflectance in the ultraviolet as well as small differences in depth of shade from separate purchases in Canada and the USA; these are also visible to the eye. As with phthalogen blue cotton, there is variation in dyeing that is not simply due to the use of different equipment.

Sunbrella as well as phthalogen blue dyed cloth and CuPc paints often have an inflection point or shoulder in the curve at about 410-420 nm. This is more obvious in brighter shades.

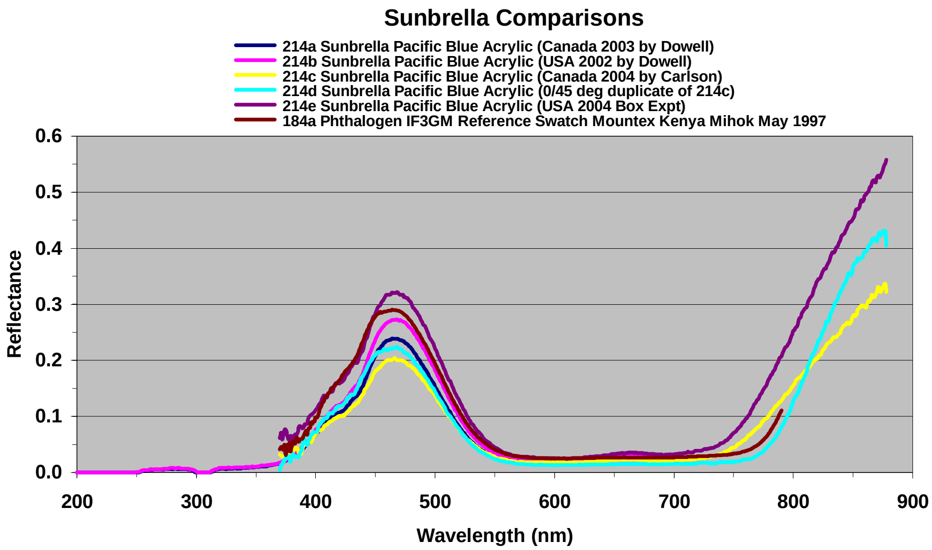
Sunbrella also has a small bump in reflectance at about 665 nm that is also present in other CuPc-based materials in the 650-670 wavelength range.

A graph with an extended wavelength range is also shown on the next page.



Note the very low reflectance in the ultraviolet.

CuPc-based materials also have low reflectance in the infra-red between 700-750 nm.



Plastic

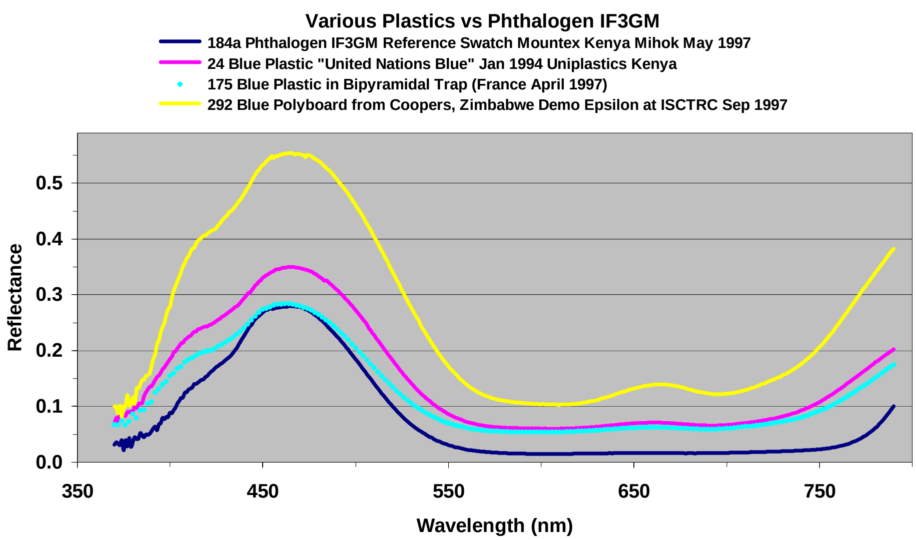
24 - “United Nations Blue” used for tarpaulins at refugee camps, Uniplastics, Nairobi
175 - Original plastic used in bipyramidal traps for riverine tsetse by Gouteux (France)
292 - “Polyboard” from Coopers, Zimbabwe, used in a demonstration for the Epsilon trap

Copper phthalocyanine, which produces the colour “phthalogen blue”, is a major industrial pigment, but it is typically difficult to find practical materials in exactly the right colour.

However, as demonstrated below, the right materials do exist.

To custom-dye the right colour is possible, but manufacturers only work on a large scale. For example, Uniplastics in Nairobi had a minimum order of 600 kg of plastic sheeting - that is a lot of plastic!

Polyboard is available in large hardware stores (corrugated plastic like cardboard), but I have yet to see any material in just the right colour of blue.



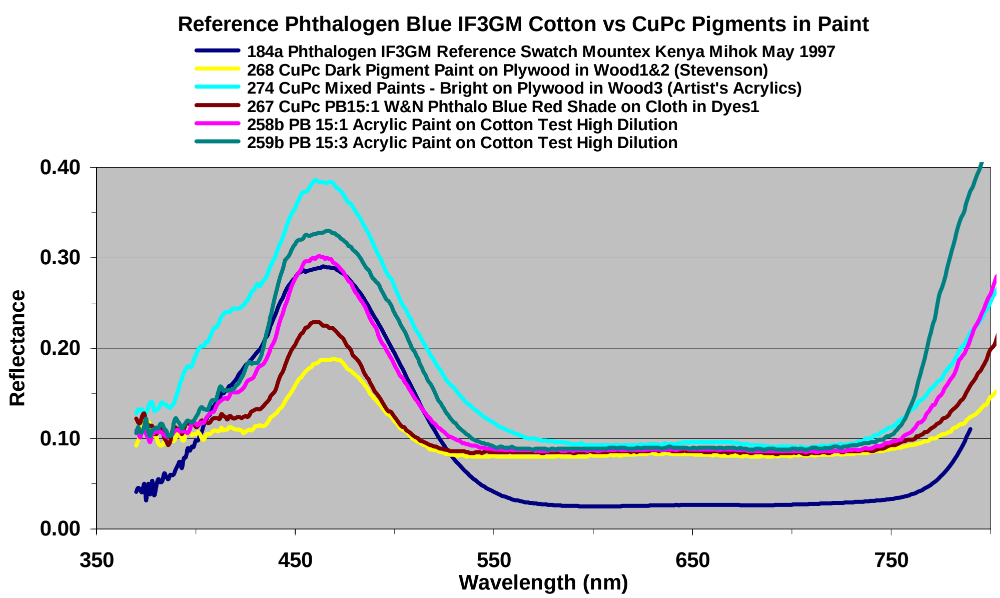
CuPc Paints

258, 259, 267, 268, 274 - Copper phthalocyanine acrylic paints on cloth or plywood

The database contains several standard phthalogen blue paints in a range of shades and pigments from different sources (CuPc can be formulated in slightly different ways). These were prepared from either dry CuPc pigment, or pigment-based artist's acrylics, mixed with exterior non-glossy acrylic paint. Some of these paints also contained white paint and/or matt medium to lighten the colour, along with the solids present in the clear base.

Pure pigment paints of known composition match dyed cloth well, but with an elevated baseline at higher wavelengths. This is presumably due to the other solids present, especially any white pigment added or included in the clear base (often titanium dioxide).

These scans were all obtained with the Ocean Optics device and would have been affected by texture differences, which are noticeable when working with dry pigment versus artist's acrylics, and wood versus cloth. The signal to noise ratio of the regular tungsten bulb used was also not optimal in the 550-750 nm range for these dark materials. Hence the exact baseline in this range is not very precise.

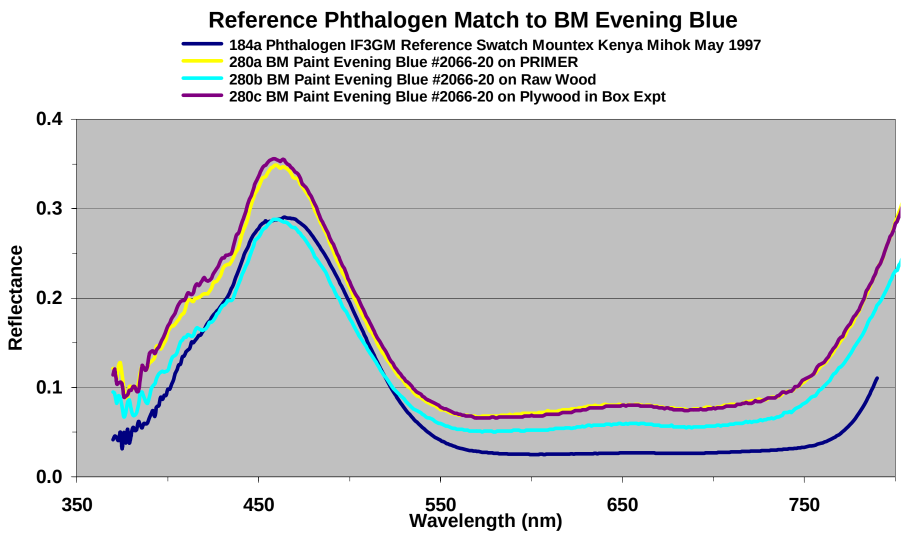


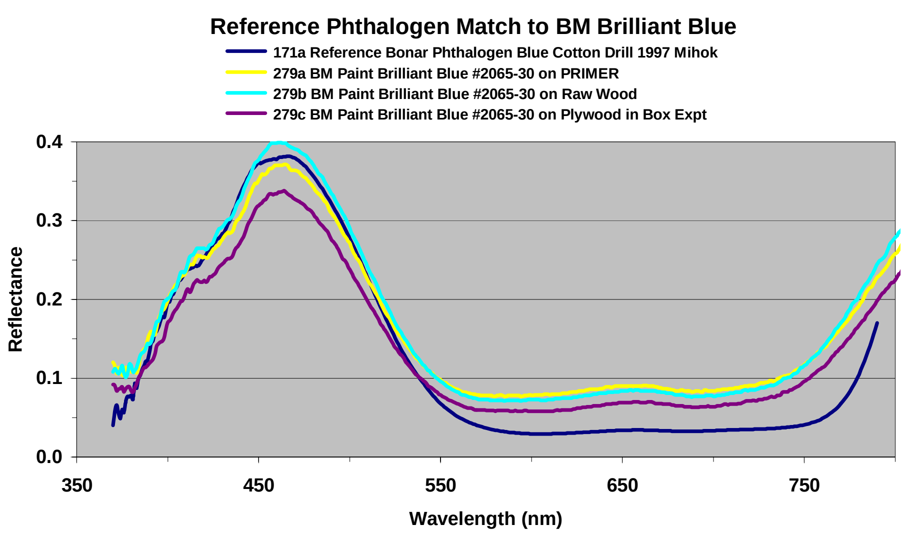
Benjamin Moore Paints

http://www.benjaminmoore.com/index.asp

279 - Brilliant Blue, **280** Evening Blue - Exterior flat acrylic paint

I had phthalogen blue IF3GM cotton from Zimbabwe and Kenya scanned at a paint store to obtain the best matches in Colour Preview formulations. The Brilliant Blue contains only blue tint and is a match to the brighter cloth from Zimbabwe. The Evening Blue contains some magenta tint as well as blue tint, and is a match to the darker cloth from Kenya. The different samples represent paints from Ontario and Florida. These scans had a better signal:noise ratio for the higher wavelength baselines, so the small bump of CuPc at 650-670 nm is visible, especially in the Brilliant Blue. The shoulder of CuPc at 410-420 nm is also visible.



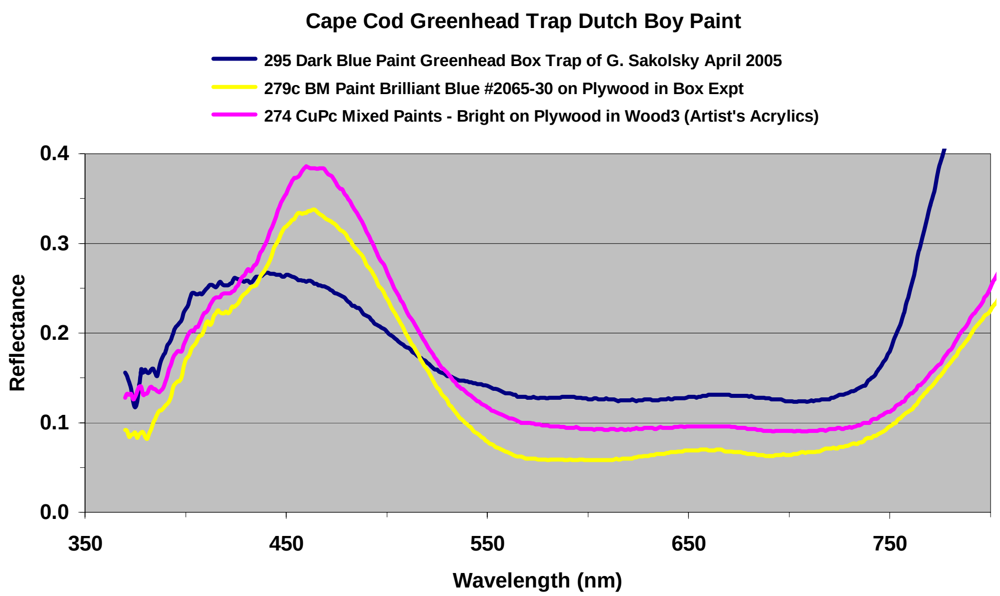


One cannot take for granted that any "basic blue" paint will only contain one pigment, e.g. the most common industrial blue pigment, copper phthalocyanine or PB 15. Ultramarine Blue (PB 29) and Indanthrone (PB 60) are also light-fast "permanent blues" and could be used in some paints for nuances of shade. Since paint companies do not disclose this information, the only way to be sure is to obtain a spectrum and know some details of the formulation. Benjamin Moore paints are ideal for this purpose as the colour formulations are publicly available on the web (although what is in each tint is not disclosed). Special pigments are expensive, so it is unlikely that one will encounter unusual pigments in products sold for home use.

I also have a scan of a sample of the current paint (#295) used for greenhead (*Tabanus nigrovittatus*) box traps at Cape Cod, provided by Gabrielle Sakolsky in 2005. The colour contains several tints besides blue and has been used for many years in these traps. The decision to use this specific colour dates back to tests of a Dutch Boy blue paint in 1980. Later, in the mid-1980s, Sandra Allan did further research on greenheads using a "permanent blue" artist's oil paint. As confirmed by Winsor & Newton, this historical colour was actually "ultramarine blue" or Pigment Blue 29, and not copper phthalocyanine or Pigment Blue 15.

A graph of the current Dutch Boy blue formulation is contrasted below relative to a CuPc standard I prepared myself, and BM paint in Brilliant Blue.

The paint is a rather dark, somewhat dull blue (broad peak) and has a reddish tint.



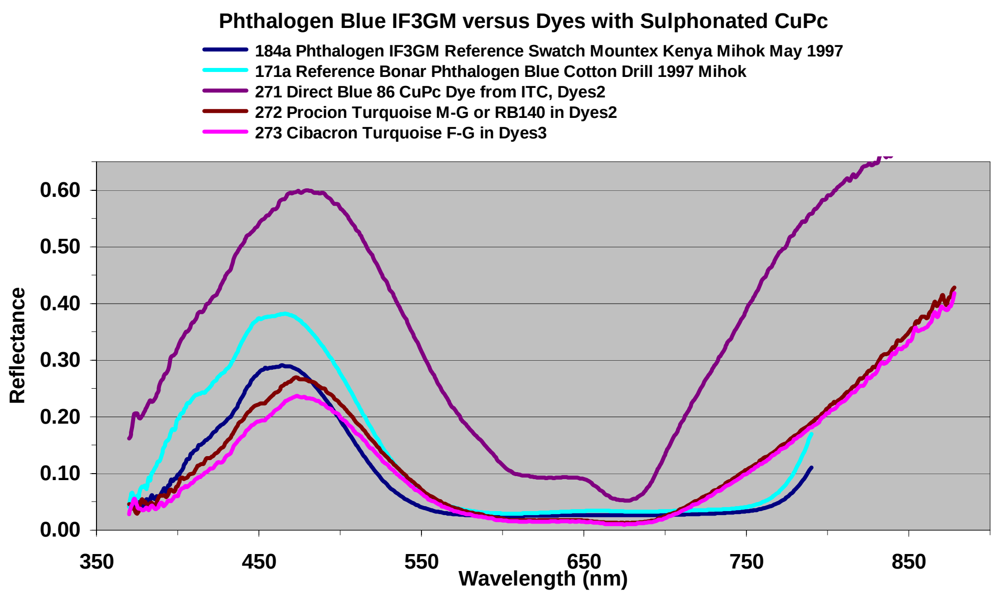
Sulphonated Copper Phthalocyanine

271- Cotton dyed with Direct Blue 86
272 - Cotton dyed with Procion Turquoise M-G
273 - Cotton dyed with Cibacron Turquoise F-G

A greenish blue or turquoise, ranging all the way to cyan or green can be produced by solubilizing CuPc or by substituting copper with another metal. Halogenated compounds are found in paints as green pigments (e.g. Pigment Green 7 and 36). Sulphonated compounds are used in dyes and in printing inks to obtain turquoise or cyan. The amount of sulphonation and the use of other modifying chemical groups provides a variety of green/blue shades. There are many reactive dyes for cotton based on sulphonated CuPc, but the exact nature of the chromophore is typically only listed as CuPc. Some structures have nevertheless been deduced and are provided in publications, even if they are not explicitly provided in the Colour Index.

For the dyes shown below, the turquoise colour is the result of a shift of the phthalogen blue peak to higher wavelengths; otherwise the shape of the spectra are very similar to phthalogen blue in the ultraviolet and visible range with a simple, nearly symmetrical peak.

Direct Blue 86 has slightly different features, with a striking infra-red reflectance starting at 700 nm; the two reactive dyes rise only gradually in the infra-red.



Imitation Phthalogen Blue

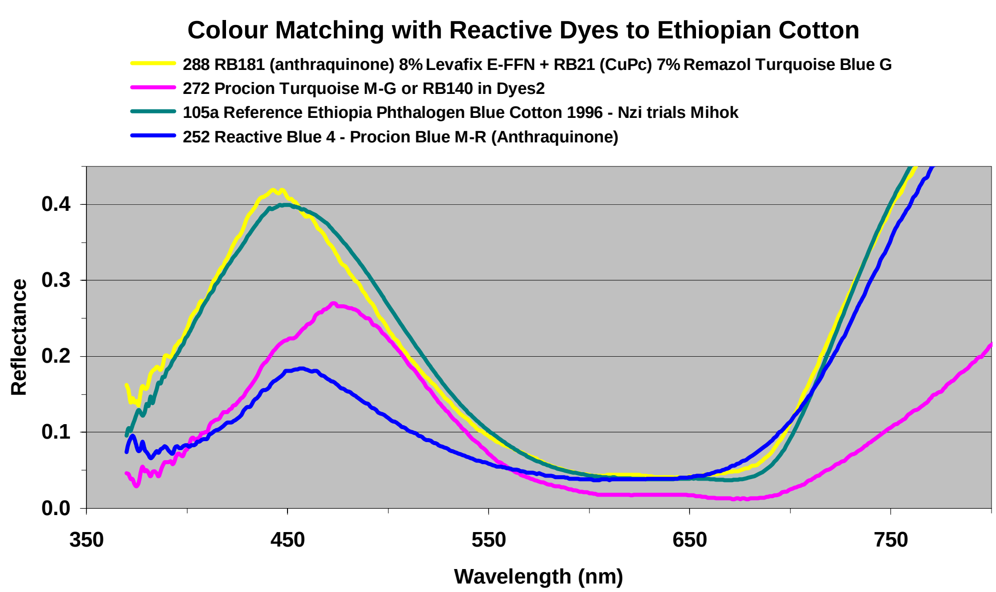
288 - Mixture of an anthraquinone and a sulphonated CuPc reactive dye

Cloth that appears phthalogen blue to the eye (e.g. Ethiopian fabric #105 from Awassa Textiles) is not necessarily genuine phthalogen blue IF3GM cloth.

Colour-matching software can be used to create a nearly identical colour in many different dye formulations even though the underlying dyes produce different colours individually. Clariant for example provides a free software tool on the web to calculate formulations of its dye products to match a colour spectrum or colour statistics provided by the user. Many sophisticated tools are available, but almost none are free. Unfortunately, even when one knows the formulation, many products are proprietary and hence there is little or no information on their chemistry.

Colour matching to phthalogen blue is shown below with a simple 2-part mix of Reactive Blue 181 and Reactive Blue 21. The underlying chromophores produce different blues, but with the right combination, it is possible to produce the correct phthalogen blue colour.

In this particular example, the clue to the use of other dyes lies in the non-visible region. The high infra-red reflectance of the Ethiopian cotton is not a feature of phthalogen blue IF3GM. Like us, flies do not see in the infra-red, so this is of no practical significance in terms of trap performance. The main significance of the use of alternative dyes is in the fading characteristics of the fabric. Use of reactive or direct dyes will result in material that does not weather as well as phthalogen blue IF3GM. Also, colour shifts will occur as the anthraquinone-based dye will fade faster than the copper phthalocyanine-based dye.



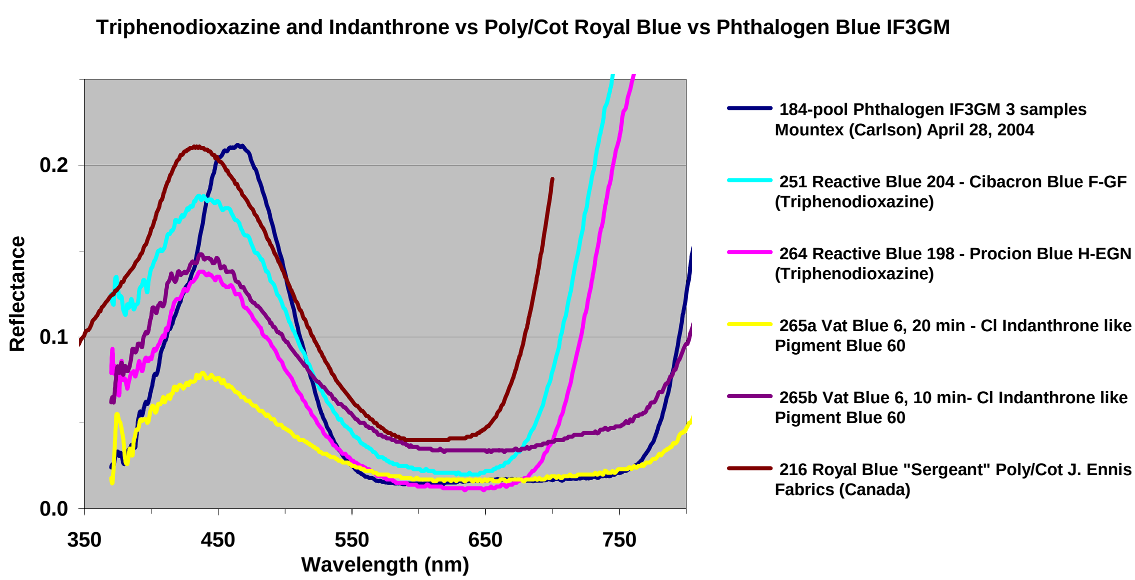
Other Blues

There are a few key chromophores that provide the chemical palette for the colour blue when dyeing cotton and other cellulosic fibres, typically with reactive, direct or vat dyes. Azoic dyes can also be used, with many dye and chromophore variations. All dye classes have a share of the market based on end-use requirements, or cost. Reactive dyes are special because they produce brilliant and saturated colours at reasonable cost and with a simple dyeing process. The database contains several examples of common dyes at about 5% owg (dyed by Mihok), in addition to the ones presented earlier that produce turquoise colours (sulphonated copper phthalocyanines).

Anthraquinone	brilliant blues
Triphenodioxazine	royal blues
Formazan	medium, basic blues
Disazo	dark navy blues
Indanthrone	dark, dull blues (like indigo)

Although it is perhaps not logical from examining raw spectra, colorimetry statistics actually show that the royal blues produced by the triphenodioxazine chromophore are similar to “phthalogen blue” in terms of how people perceive colour (since the spectra are weighted by visual response functions in the calculations). In plain language, this means a person could easily select a royal blue fabric as being similar to “phthalogen blue”. In the literature, one can find the terms “phthalogen blue” and “royal blue” sometimes used interchangeably. For example, given the choices available on the retail market in Canada, I chose to test a “royal blue” in poly/cot as a “reasonable” match to phthalogen blue in early experiments (“Sergeant” fabric below).

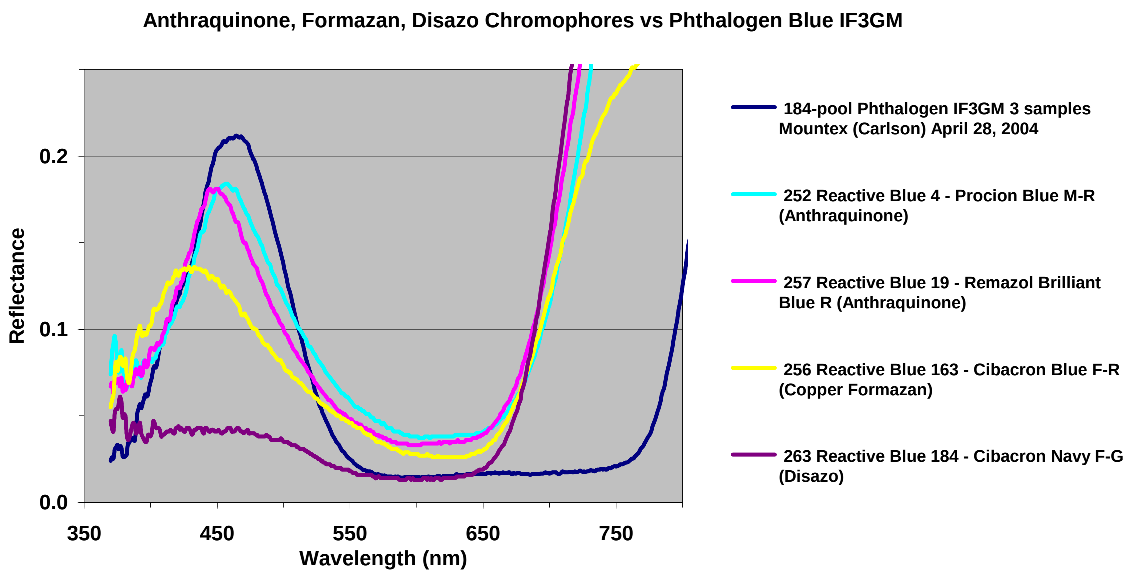
Vat dyes based on indanthrone derivatives produce much duller blues than the brilliant colours possible with reactive dyes. Indanthrone and triphenodioxazine chromophores also both produce lower wavelength peaks than phthalogen blue (about 445 nm versus 465 nm for the dyes below).



The navy blues typically produced by the disazo chromophore are dark and plain and would likely never be mistaken for phthalogen blue. Navy blues are sometimes used with other dyes to produce black. Simple blacks are typically produced with sulphur dyes.

The blues produced by copper formazan and anthraquinone provide considerable latitude in the production of medium to brilliant blues that are not dramatically different from phthalogen blue. In synthetics (e.g. polyester) there are also a large number of disperse dyes based on azoic chromophores; these provide for a particularly wide range of blues.

Anthraquinones are cheap and popular and are typical of many brilliant blues. The sharp peak of anthraquinone dyes at about 450-460 nm is crudely similar to the peak of phthalogen blue at 465 nm, but differs in its asymmetrical profile, e.g. with a large shoulder into the blue-green and yellow-green. This translates into only a minor difference in terms of colorimetry statistics for human vision, but appears to be critical for how biting flies respond to colour.



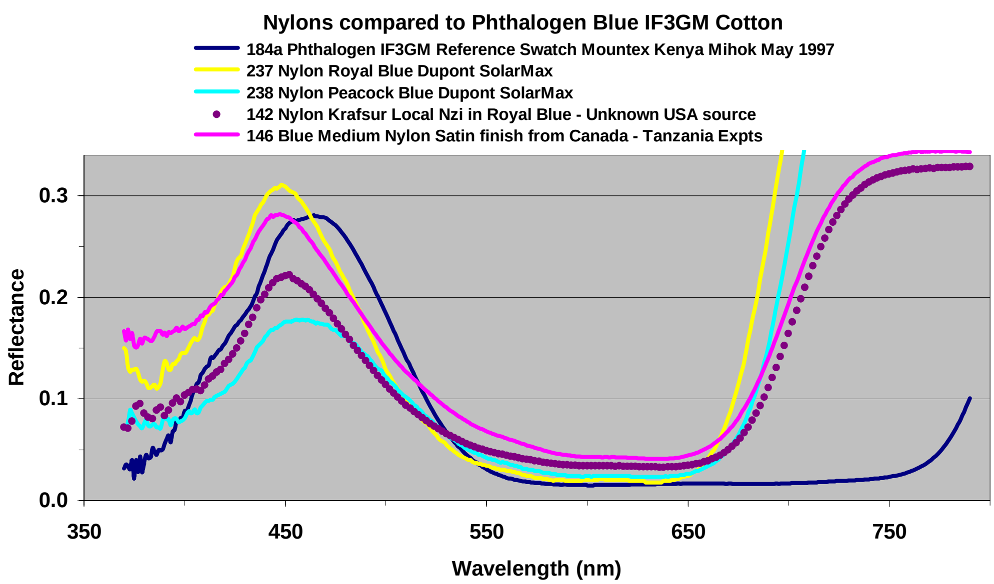
Nylon

142, 146, 237, 248 - Nylons in royal blue and peacock blue from the USA / Canada

Synthetic fibres cannot be dyed effectively with variants of copper phthalocyanine due to the large size of the CuPc molecule, and the high temperatures required to achieve penetration of nylon, polyester, acrylic, etc. Hence, synthetic blues are produced with small blue chromophores (anthraquinone, monoazo, etc.) typically with one class of dye (disperse dyes).

As with Sunbrella acrylic, it may be possible to incorporate CuPc pigment in the polymer prior to fibre formation, but I have yet to find any material with just the right colour on the market.

As shiny fabrics have always performed poorly when used in traps, I have only a few examples of blue nylon fabrics in the database.



Vestergaard Frandsen Fabrics

VF introduced polyester "tsetse fabrics" to researchers early in 1995, with many changes in their fabrics since then. Material and/or colour changes were often publicized at the biannual meetings of the ISCTRC. Through direct collaboration with Torben Vestergaard Frandsen, I have been able to assemble a history of the fabrics available at various times. I have no information on the quantities and shades actually sold to researchers at specific times, nor have I ever managed to obtain technical information on the dyes used. Polyester is normally dyed with disperse dyes, of which there hundreds of variations for the colour blue. Hence it is impossible to "guess".

For each VF blue, there is typically a matching black in the database. There are also several samples of white polyester netting through time. The VF white netting was also "improved" through time, but I do not have a proper history. It eventually became the product that is currently marketed as Permanet.

<u>March 1995 +</u>

48 - Brilliant Blue 589, the very first SHINY BASIC BLUE polyester @ 54 g/m^2, semi-opaque, and with poor light fastness (only 4-5 on an 8-point scale). This introductory fabric was produced in Thailand. Samples were provided to researchers with detailed technical information in a letter and/or flyer, along with a matching black polyester, and white netting.

<u>October 1995 +</u>

51 - Lucky Uganda, a SHINY ROYAL BLUE polyester supposedly preferred by Ugandan researchers, presumably the same material as #48, just in a different colour, no technical details

53 - Art SED, test material from Taiwan with 50% texturized yarn to remove some of the shininess, bright blue similar to later #65, perhaps only experimental, no technical details

55 - Art CON, test material from Taiwan with 50% texturized yarn to remove some of the shininess, bright blue similar to #48, perhaps only experimental, no technical details

These first four materials (48-53) have been characterized and tested (Mihok, 2002). They may have been sold only in 1995-1996, as shiny materials did not perform well in early experiments.

<u>January 1996 +</u>

VF introduced "Pongee" polyesters from Cheng Cheng Textiles in Taiwan that were made from only 100% texturized yarns. I tested these materials in Mihok (2002), and chose one of them (which I called "pure blue" at that time) for coordinated trap trials around the world.

VF coded these fabrics as #10 (a bright blue) and #11 (a darker royal blue). The bright blue was almost the same colour of the ART Sed from a few months earlier. Samples of these pongee fabrics were provided to researchers at ISCTRC up to October 1997, typically hanging from a white cardboard sleeve with a sample of black, and a sample of white and black netting. In my records, the royal blue was Pongee #1 and the basic blue was Pongee #2, but this does not seem to have been written down in promotional material I still retain from VF.

I believe these two blue fabrics were essentially stable products up to about early 1998.

65, 101 - Bright Blue Pongee 2 or VF #10
64, 245 - Royal Blue Pongee 1 or VF #11

Blue polyester #101, its matching black #102, and white netting #103 have been characterized in terms of long-term weathering in two environments (SIGMA PLOT ARCHIVE.XLS).

January 1997 +

An opaque version coded as VF#15 of approximately the same colour as VF#10 was produced and sold for perhaps a few years in 1997 and beyond. It was 136 g/m^2.

161- Bright Blue "Opaque" Pongee 2 or VF #15 (adjusted weight)

A subtle colour change may have been made at this time to VF #10 to produce a colour which VF now labeled "phthalogen blue", but which was still referred to as #10. The fabric weight was also increased to 75 g/m^2. I received material directly from VF, so I am not sure what publicity material was used to identify this new shade and new weight of fabric. From "ART" codes on the fabric bolts, I believe these materials were still from the same source in Taiwan.

162a,b - FIRST "Phthalogen Blue" VF #10 (adjusted colour and weight)

February 1998 +

In July 1997, VF was experimenting with ultraviolet protectants after it had adjusted the weight and colour of VF #10. This was followed in February 1998 by a brochure, distributed under the name of DCT - Disease Control Textiles, with samples of VF #10 labeled as "phatalogen blue" [sic]. The brochure gave details on this new fabric with added ultraviolet protection, better light fastness, etc. This new fabric was very similar, but not identical to, the previous phthalogen blue fabric from January 1997.

Since all of the 1996-1998 VF #10 or #15 fabrics are very similar, the only way to tell them apart (bright blue vs phthalogen blue vs phthalogen blue + ultraviolet protectants) is to examine fabric weights and reflectance spectra. I'm not sure how leftover stocks of the discontinued materials were handled during this transitional period from 1997-1998. Presumably, stocks were simply sold until they ran out.

162c - SECOND "Phthalogen Blue" VF #10 (now with ultraviolet protectants)

June 2000 - May 2002 +

There is a gap in my record of products from mid-1998 to mid-2000. During this period VF's supplier in Taiwan went out of business, and VF also shifted operations to Vietnam. In 2000 and 2002, VF supplied finished Nzi traps to American researchers in a ROYAL BLUE, oddly-textured polyester from Vietnam, that crudely resembled the former matt royal blue VF #11 from Taiwan. This new fabric was also heavier at 114 g/m^2. The fabrics from 2000 and 2002 were similar, but not identical. No technical details were provided. The 2000 fabric was a deeper royal blue, and was less shiny than the 2002 fabric (Torben stated that the materials should have been the same). The 2002 fabric had an odd, almost satin-shiny texture. Regardless of details, these new fabrics from Vietnam were clearly more shiny than the older "Pongee" fabrics from Taiwan. To my eye they resembled the Con/Sed 50% texturized products that had a brief lifespan.

244 - Royal Blue Vietnam shiny polyester June 2000
210 - Royal Blue Vietnam satin-shiny polyester May 2002

October 2003+

During late 2002 and early 2003 in Vietnam, VF tried to recreate the former matt, "phthalogen-like" pongee fabrics from 1996-1998 with new dyes, materials, etc. with new suppliers. It came up with two similar blue fabrics in 100% polyester (Vietnam?) and 95% polyester + 5 % viscose (India) at 114 g/m^2 (nearly opaque). These were treated with ultraviolet blockers and were said to have an excellent light fastness rating (7-8 on an 8-point scale). The fabrics were available to me in May 2003, and were publicized at ISCTRC in October. Emails with technical details and reflectance spectra were sent to researchers as well. Both fabrics have a matt, crepe-like appearance and are a reasonable colour match to phthalogen blue. I did not pursue further collaboration with VF after these fabrics performed poorly for tabanids in Canada. This is my last point of reference.

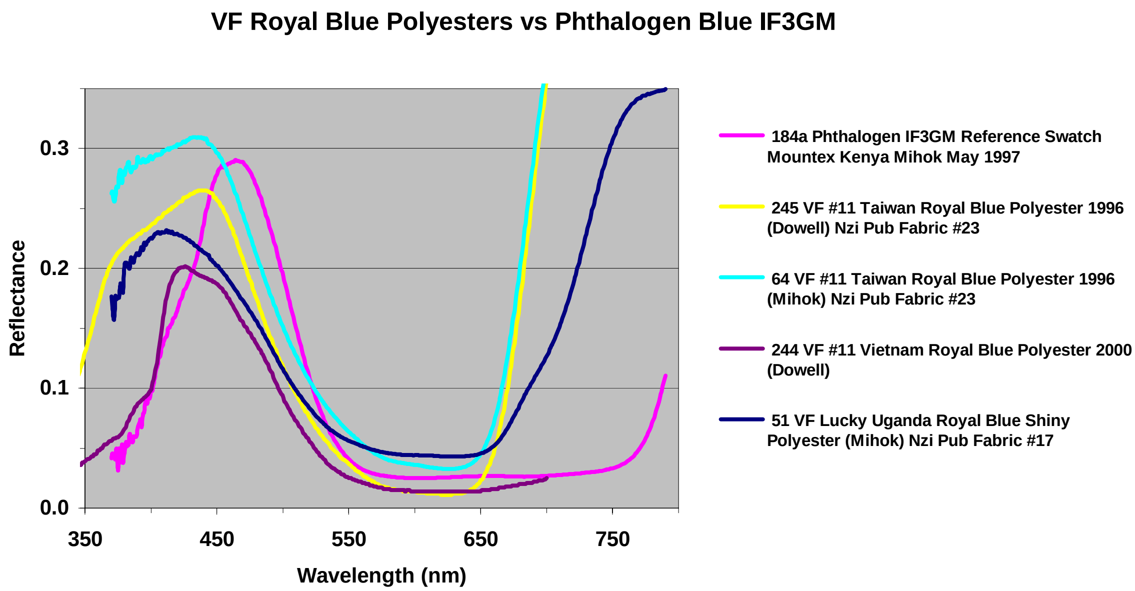
227 - TC New Blue T-286 Polyester
230 - Mixed Yarn Blue 286 Poly/Vis

Royal Blues

51 - Lucky Uganda - the first royal blue polyester from 1996
64, 245 - Royal Blue Pongee 1 or VF #11 [different lots, scans by different people]
244 - Royal Blue Vietnam shiny polyester June 2000

210 - Similar but not identical to #244 from May 2002, no spectral scan available

The royal blues from VF were all different from each other and from phthalogen blue IF3GM cotton. The material from Vietnam in 2000 stands out in terms of having a sharp ultraviolet cut-off. Unfortunately, I have not yet obtained a scan for the same fabric purchased in 2002.



Early Basic Blues

48 - Brilliant Blue 589, shiny first fabric from 1995

53 - Art SED, 50% texturized yarn, experimental
55 - Art CON, 50% texturized yarn, experimental

65 - Bright Blue Pongee 2 or VF #10 from January 1996
101a - Bright Blue Pongee 2 or VF #10 from March 1996

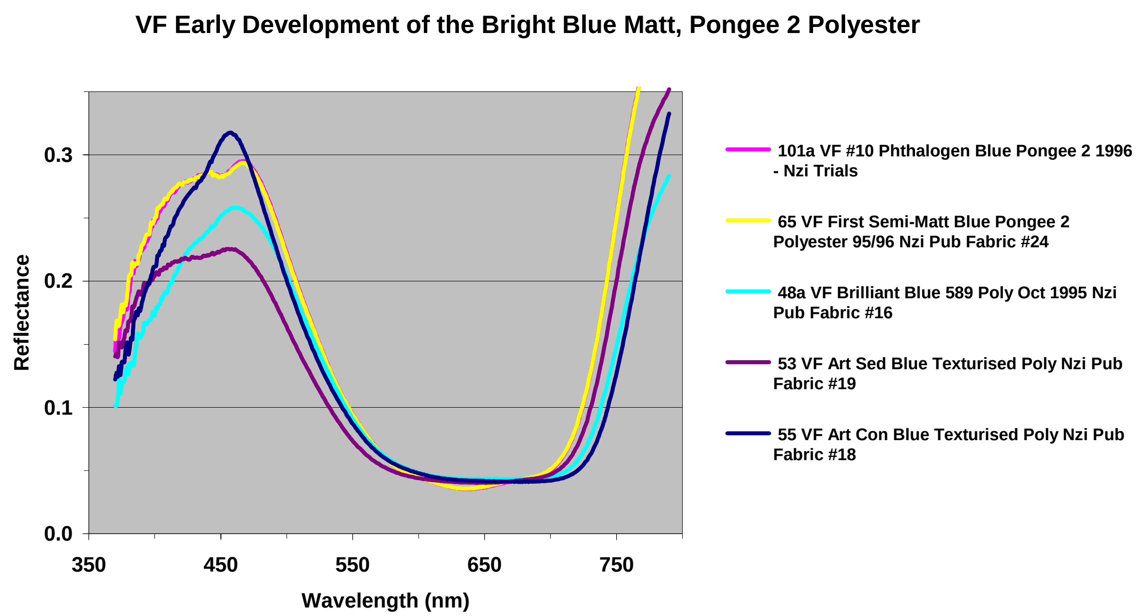
In future graphs #101a is used as a reference to show how fabrics changed with time.

The spectra show that the first fabric from 1995 (#48 Brilliant Blue 589) was a simple blue, presumably dyed with a single, cost-effective dye (e.g. anthraquinone or monoazo). This fabric was likely reproduced with the same dye as Art CON in 50% texturized yarn.

Art SED in 50% texturized yarn was a similar experimental fabric that clearly used new dyes. It had a broad peak, possibly doubled as in the fabrics that followed shortly afterwards.

The double peak is obvious in the brighter 100% texturized fabrics, of which I have two nearly identical samples (#65 and #101a) from early 1996. This nearly “stable” pongee 2 product was likely produced with a combination of two or more dyes in order to shift the peak closer to that of phthalogen blue.

Note the high reflectance in the ultraviolet relative to phthalogen blue cottons. This is a continuing theme in VF polyesters and was first thought to be the “residual” cause of why even nearly matt, 100% texturized fabrics did not always perform well for all species of biting flies.



Bright Pongee 2 Blues

“Pongee” is a term for any fabric that imitates the original thin, soft fabric of Chinese origin woven from raw silk, generally made from combed yarns (i.e. texturized?)

101a - Bright Blue Pongee 2 or VF #10 from March 1996
161a,c - Bright Blue “Opaque” Pongee 2 or VF #15 (adjusted weight)
162a,b - FIRST “Phthalogen Blue” VF #10 (adjusted colour and weight)

162c - SECOND “Phthalogen Blue” VF #10 (now with ultraviolet protectants)

Except for #162c, colour adjustments to fabrics in 1997-1998 are difficult to see unless one has the entire series at hand, but are clear in spectra. Graphs are on the following page.

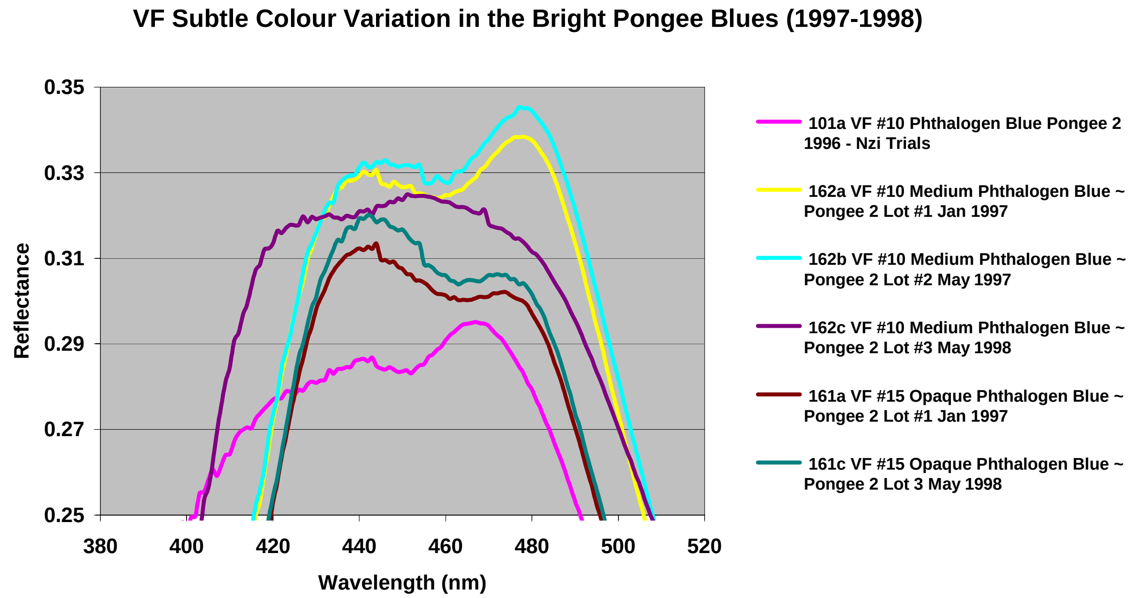
VF #10 (coded as #101a) was clearly adjusted in 1997 with two samples available as #162a and #162b (slightly heavier fabric, just different lots). The new fabric had a similar double peak to #101a, but with a sharper profile and a better ultraviolet cut-off. There must have been a change in at least one, if not both, of two dyes. There is also a major change at high wavelengths with sharply rising reflectance beginning in the red region at 650 nm. Only the higher of the two blue peaks is substantially shifted, possibly because of the use of closely-related dyes.

Two samples (#161a,c - different lots) are available of the opaque fabric coded as VF #15. These appear to be only a minor variation on #162a,b in a heavier fabric. This is shown by the identical rising red reflectance (lines are on top of each other) and by almost the exact same double peak. For whatever reason, the balance between the two blue peaks is shifted in favor of the lower peak in this opaque fabric. The upper blue peak is just slightly shifted relative to #162.

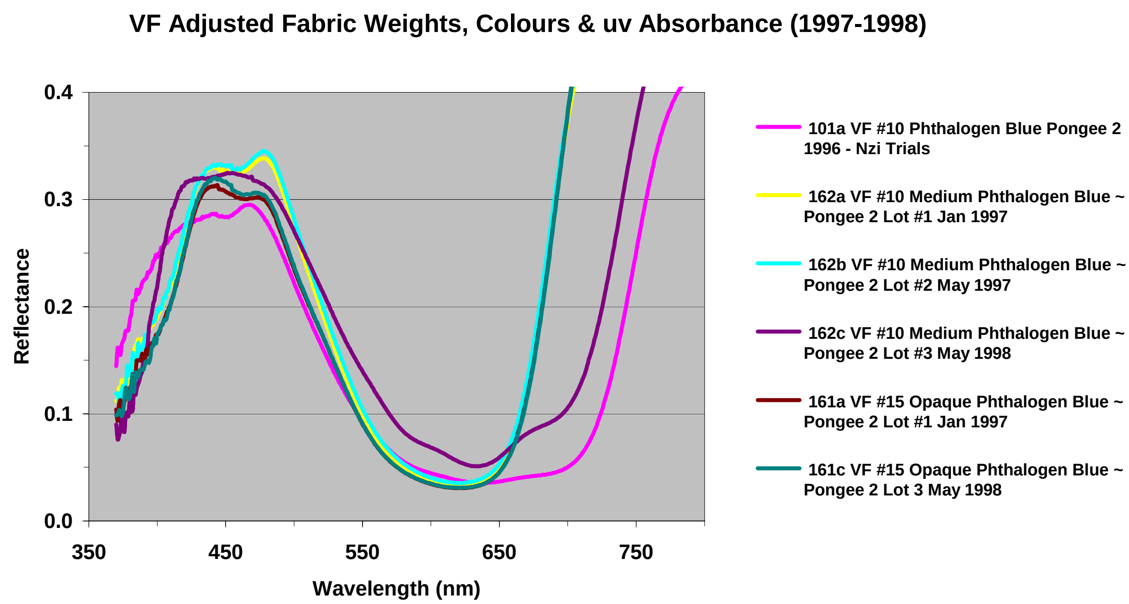
Fabric #162c, which followed in 1998, was still coded as VF #10 in brochures, but was clearly revised in major ways, presumably with more substantial changes in the dyes used. It was publicized as “phthalogen blue” with ultraviolet protection. The spectrum now has a relatively flat, broad peak with just a hint of doubling, and with a steep ultraviolet cut-off at 400 nm. The infra-red profile is different as well. New dyes may have been used rather than minor variations on the previous dyes.

In summary, this is what the spectra suggest for the changes to the bright / phthalogen blues in what I call “pongee 2” fabrics in a logical developmental sequence.

Dye A	Brilliant Blue 589, followed by ART Con (simple blue)
Dye B+C	ART Sed leading to Bright Blue VF #10 Pongee 2 (complex blue)
Dye B_1+C_1	(reddish complex blue) VF #10 First Phthalogen Blue in 1997
Dye C_1+B_1	(reddish complex blue) VF #15 Opaque Blue (different dye ratios only?)
Dye D + E + uv	(new formulation) VF #10 Second Phthalogen Blue in 1998



The first curve that rises in the infra-red at 650 nm is #161a,c and #162a,b superimposed.

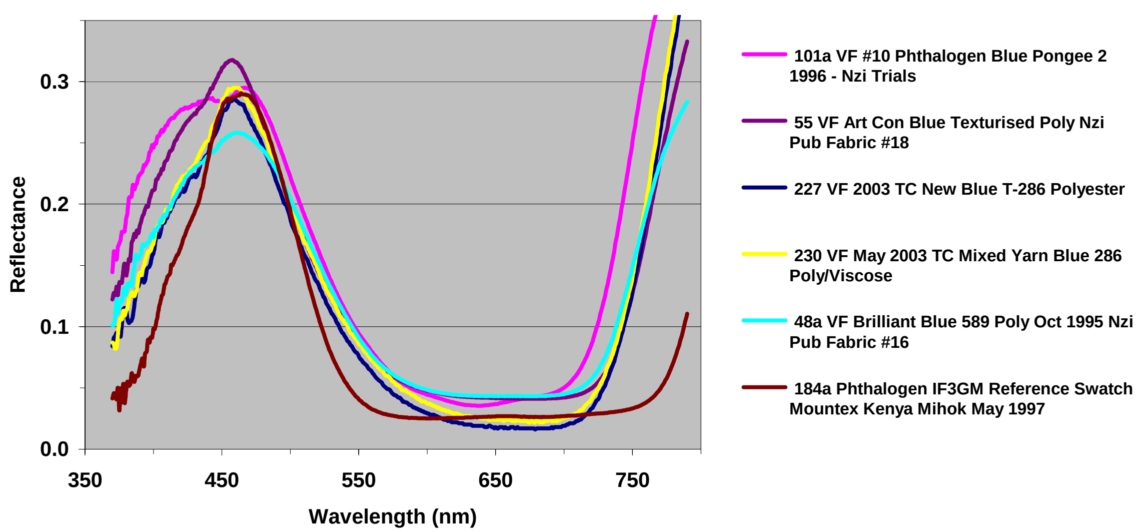


286 New Blues

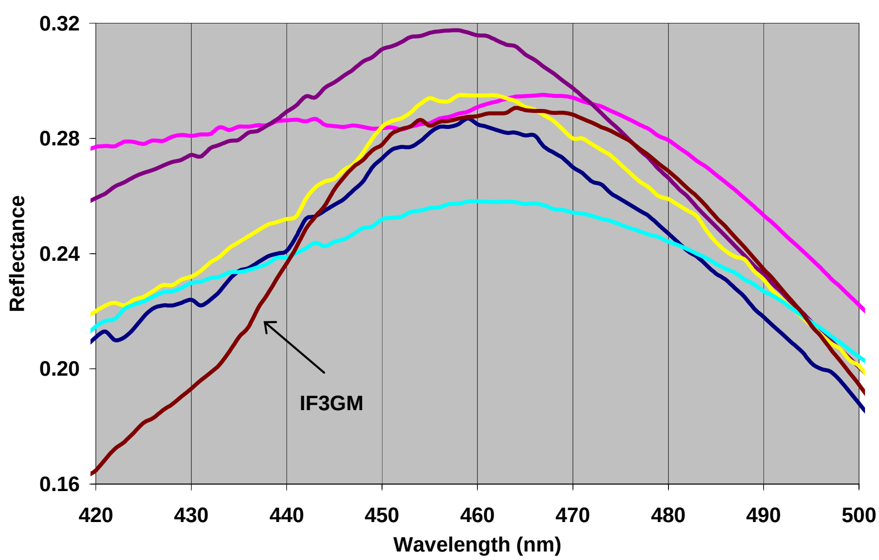
227 - TC New Blue T-286 (100% Polyester)
230 - Mixed Yarn Blue 286 (95% Polyester / 5% Viscose)

The two new "phthalogen blues" in slightly different fabrics from 2003 represent a return to the simple blues of the earliest fabrics, e.g. Brilliant Blue 589, and ART Con. The complex blues of "Pongee 2" series were not revisited (as in #101a). These "286" fabrics look like they have been produced with a single dye + uv protection. Phthalogen Blue IF3GM cotton is also shown for reference. There is a good match in peak wavelengths relative to phthalogen blue.

VF 286 "New Blues" from Vietnam in 2003 contrasted with the 1990's



Close-up of the Blue Peaks



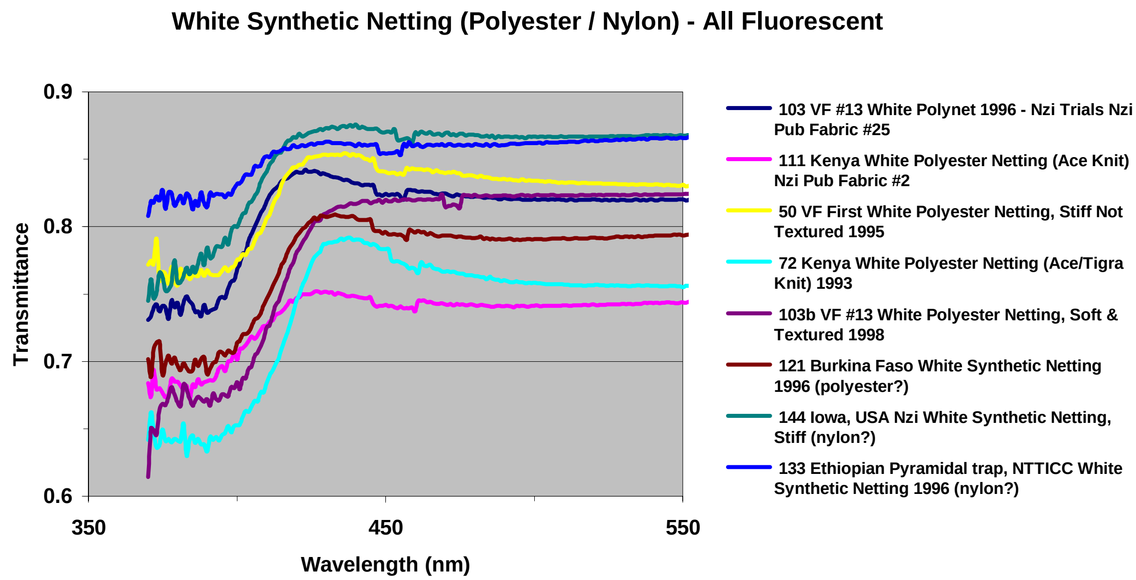
Transparent Materials

There are many different types/colours of netting used by various researchers in traps or electric nets for which I have transmittance data, all of these were obtained with the Li-Cor 1800. Only a few are shown here.

White Netting

There are many examples of white "mosquito netting" from different countries, mostly from polyester, with a few examples of nylon. The graph below also includes three versions of the netting sold by Vestergaard Frandsen between 1995 and 1998. These varied in subtle features through time (stiffness, texture). VF now makes a much finer mesh product - "PermaNet".

All of these white nettings are very similar with about 75-85% transmittance in the visible range. Optical brighteners were used in all of them (fluorescent), and we can probably assume that uv protectants were also added.



Dark Netting

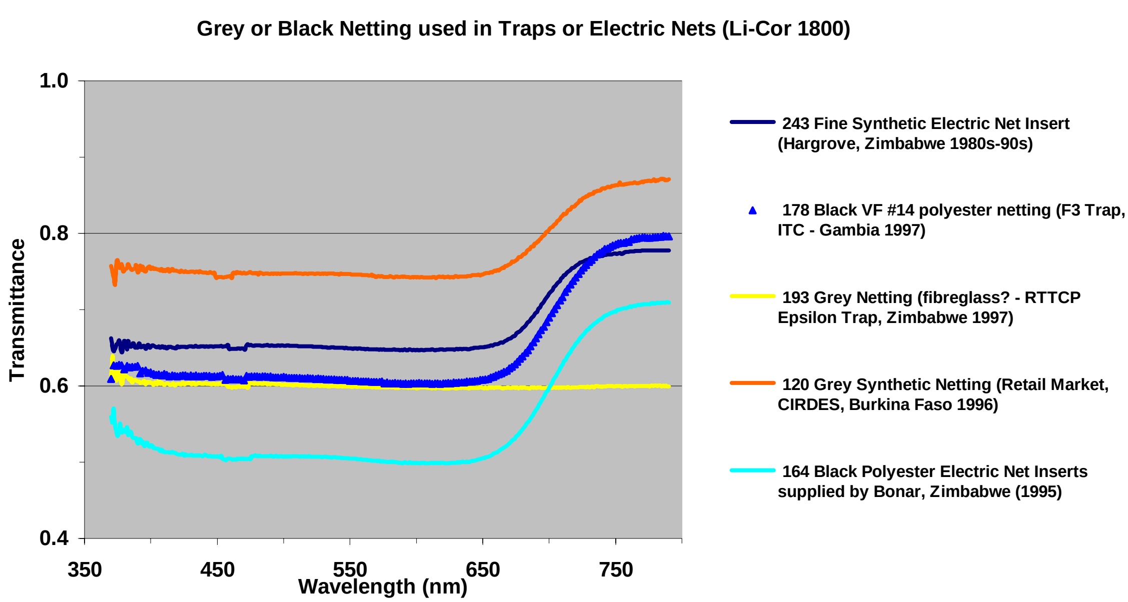
Several researchers use grey / black polyester or nylon netting for traps with recessed cones (Epsilon, F3) and for inserts in electric nets. These typically transmit only about 50-65% of visible light and do not have the ultraviolet/blue signature of optical brighteners typical of fluorescent white netting (these dark nettings are not fluorescent).

Sample #243 is an example of the type of very thin, gossamer-like netting used by Zimbabwe researchers for many years in electric nets - quite “invisible”. Vestergaard Frandsen #14 black polyester netting is very similar to this material (#178). Bonar supplied a much thicker, more visible netting with the electric nets it sold between 1995-1997 (#164).

The netting in Epsilon traps from RTTCP in Zimbabwe in the mid-1990s (#193) may have been something other than polyester or nylon as the characteristic infra-red signature is missing. I did not retain a sample of this netting and cannot check this. From memory I think it had the feel of a synthetic rather than cotton, and hence it may have been fiberglass, which also has a very even profile (see the reflectance reading for charcoal fiberglass a few pages down).

ITC in the Gambia was using Vestergaard Frandsen #14 black polyester netting in F3 traps.

The material from CIRDES at Burkina Faso was from the local market, feels like nylon. It had very thin yarn and hence had the best light transmittance of all samples.



Sticky Materials

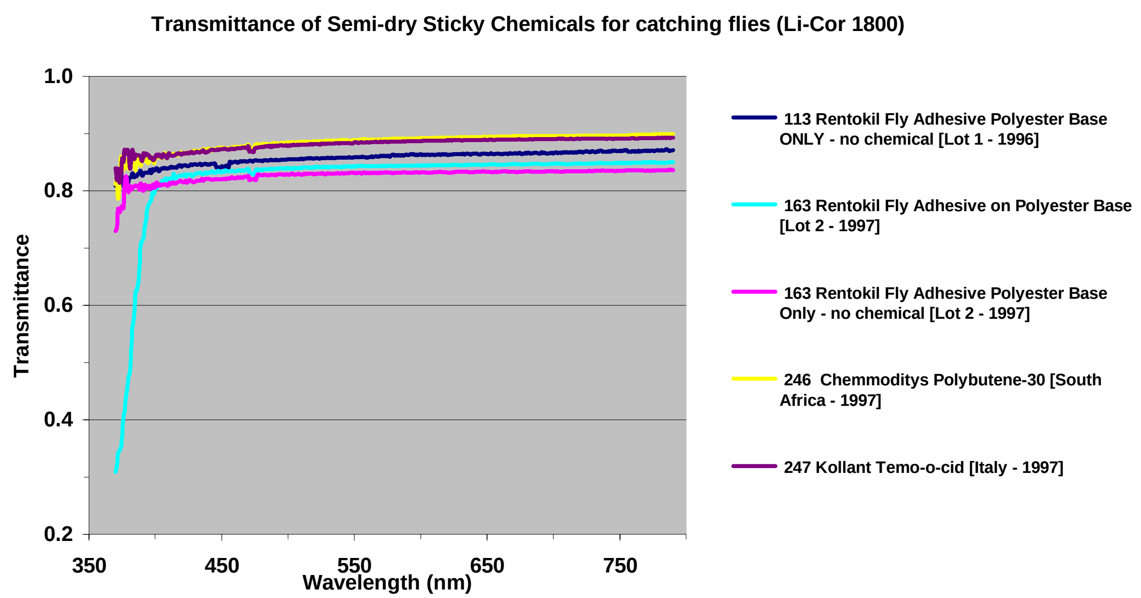
There are three examples in the database of the transmittance of semi-dry adhesives that are used by biting fly, tsetse and screwworm researchers for various applications. One of these is used for catching flies as they drop down from electrocuting nets (polybutene). The rest are typically used for sticky traps, e.g. in ready-made rolls or sheets, or simply applied to objects.

Two of the materials were assayed with the adhesive applied in a thin layer to the clear plastic base (most likely polyester) of the Rentokil product (using the plain, leading edge of the roll). The Rentokil adhesive was already applied to this plastic base when purchased. This plastic base is highly transparent at all wavelengths and is graphed below for two lots of the product.

Temo-o-cid, which is commonly used for *Glossina austeni* leg panel traps, was evenly transparent across all wavelengths, with a minimal effect on light transmission.

Polybutene-30 was also highly transparent. Polybutenes are the major ingredient of many sticky chemical formulations. The #30 formulation tested here from Chemmoditys in South Africa is the material used by Zimbabwe tsetse researchers. This brand of polybutene is shiny and is fairly moist- somewhat similar to the “Tanglefoot” product sold in North America.

The Rentokil fly adhesive was different. Either the adhesive itself or an additive strongly absorbed ultraviolet light with a sharp cut-off at about 400 nm. This is an unknown chemical formulation. It is drier and stronger in terms of adhesion than the sticky adhesive supplied with Alsynite cylinder traps from Olson Products. The Olson product (2005) does not absorb in the ultraviolet (checked with an ultraviolet lamp and fluorescent powder).

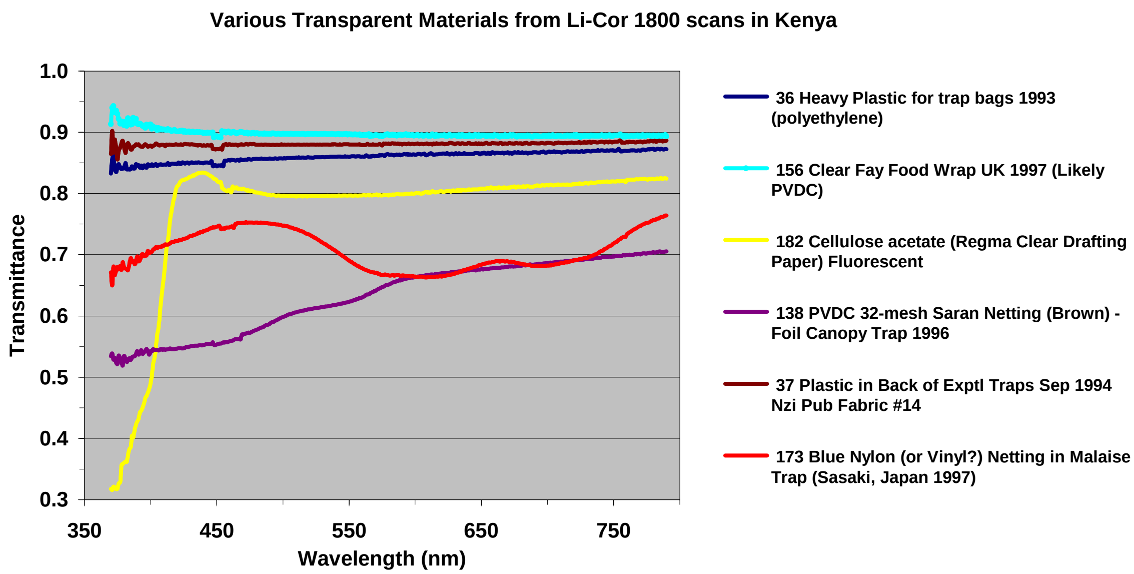


Miscellaneous Materials

Plain plastic (polyethylene) and many other clear plastic films are like glass; they have even light transmittance at about 85-90% in the visible and the ultraviolet, unless they are specifically treated to absorb ultraviolet light. Transparent drafting film (cellulose acetate) is different, with dramatic absorbance in the ultraviolet and some re-emission in the blue (fluorescent).

Saran or PVDC was the original “plastic” food wrap (assumed for the Fay wrap from the UK). Before PVDC became unpopular for environmental reasons, saran (mesh) was recommended for tabanid traps such as the Malaise trap. Below is an example of a tough, light-brown saran mesh from Chicopee Manufacturing. It was used by Lane Foil in canopy traps in the 1990’s. A last contrast is provided for some blue nylon or vinyl mesh used in Malaise traps in Japan.

In these variably-transparent materials, note that transmittance at 370 nm in the ultraviolet varies substantially between about 30 and 90%.



Reflectance Readings

Recent materials were measured only for reflectance against a white background of Benchkote (Whatman filter paper used on laboratory benches) with the Ocean Optics device (coded as Carlson in the database). Although not ideal for interpretation, these scans still provide useful information when interpreted relative to the reflectance of the Benchkote itself. Benchkote had a fairly even reflectance of about 60% across both visible and ultraviolet wavelengths.

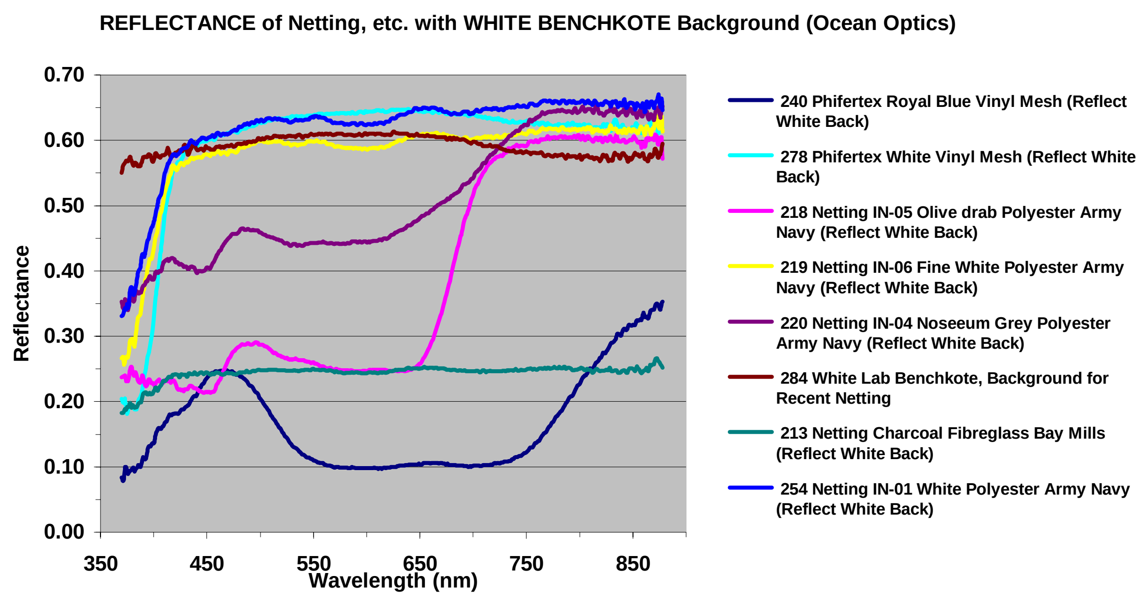
Two white polyester nettings from Army-Navy (non-fluorescent) with added ultraviolet protectants have roughly the same profile as the background, but with strong absorption in the ultraviolet. White Phifertex mesh (vinyl coated) has this same feature. It is also not fluorescent.

Unfortunately, product features often change with time as suppliers substitute similar materials or manufacturers respond to the market. For example, type IN6 fine white mesh polyester netting from Army Navy changed to being fluorescent when I last purchased it in 2005.

Grey and olive drab polyester nettings from Army Navy have roughly similar ultraviolet absorbance but this is not as dramatic as with the whites.

Charcoal fiberglass is almost perfectly neutral, again with good uv absorbance.

The “Royal Blue” brand of Phifertex vinyl mesh (called Marine Blue by Beacon Fabrics Florida) may very well be true phthalogen blue. This could be done by simply incorporating CuPc in the vinyl pellets which are melted and then used to coat the inner polyester fibre. Note that the blue peak is in the right spot, there is a shoulder at about 410-420 nm, and there is a small bump in reflectance at about 660 nm. These are all features of CuPc fabrics and paints.

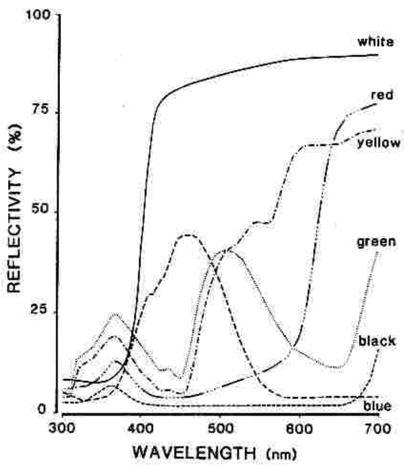


Digitized Spectra

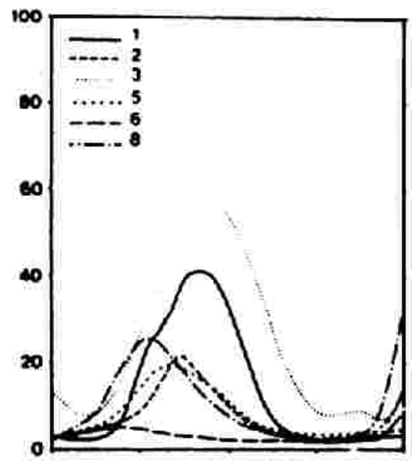
This section presents spectra from the literature in **SPECTRA FABRICS DIGITIZED.XLS**. A few contrasts are provided to comparable spectra stored in **SPECTRA REFERENCE.XLS**.

Phthalogen Blue Cottons

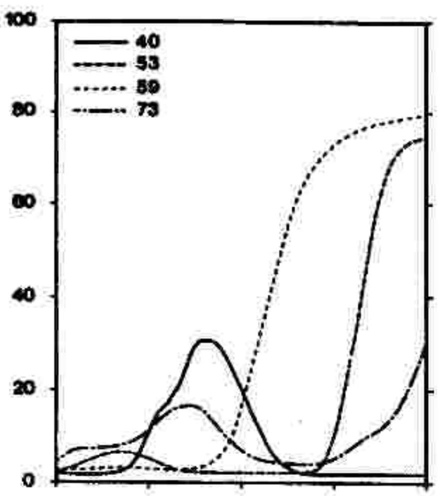
All samples were measured in the UK by Chris Green on a Pye Unicam SP8-100 spectrophotometer fitted with an integrating sphere, against a barium sulphate standard. The 1986 samples were almost surely from Bonar Industries in Zimbabwe, the 1988/89 samples were probably from Ets. Gonfreville in the Ivory Coast (“bought locally”). The papers mention both IF3GM and IF3GK dyes, although IF3GK is only used for exhaust dyeing of yarn/thread.



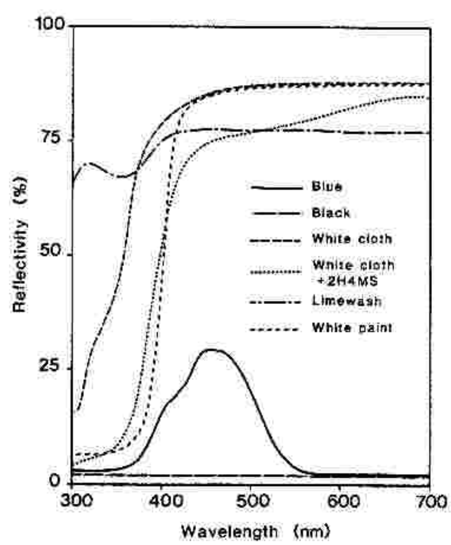
(Green & Flint, 1986) Figure 1 blue



(Green, 1988) Figure 1 #1



(Green, 1989) Figure 1 #40



(Green, 1993) Figure 1 blue

West African Synthetics/Blends

Samples were measured by Chris Green for Claude Laveissière (footnote to Figure 1) and were all probably purchased from Ets. Gonfreville in the Ivory Coast. Two samples are of historical interest, a 100% polyester (Désiré, sky blue), and a 67% polyester/33% cotton (Santiago, essentially phthalogen blue, “electric blue”). Désiré was best in comparative tests for *Glossina palpalis* but faded badly. Most experiments were therefore done with the colour-fast fabric Santiago, which was generally adopted for routine use by West African researchers some time after this paper (Laveissière, Couret & Grébaut, 1987).

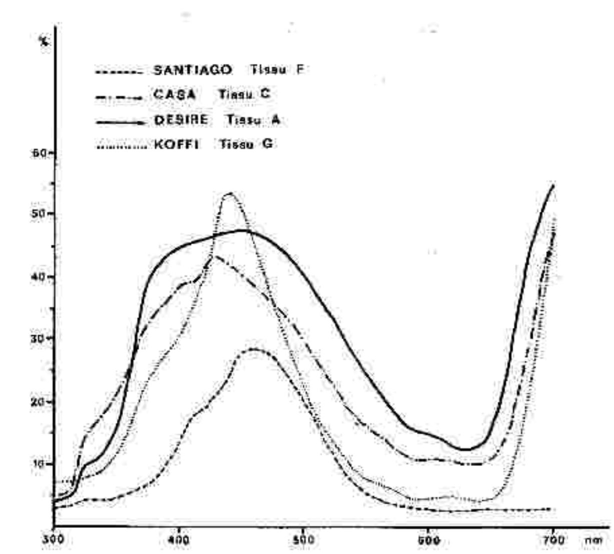


Figure 1 showing the fabrics, see colour image on next page

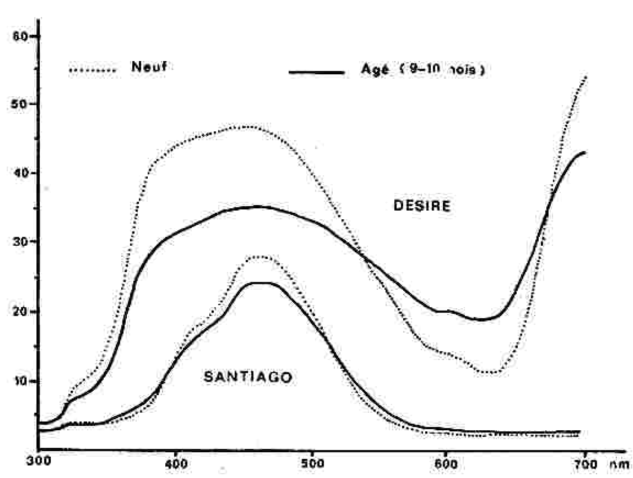
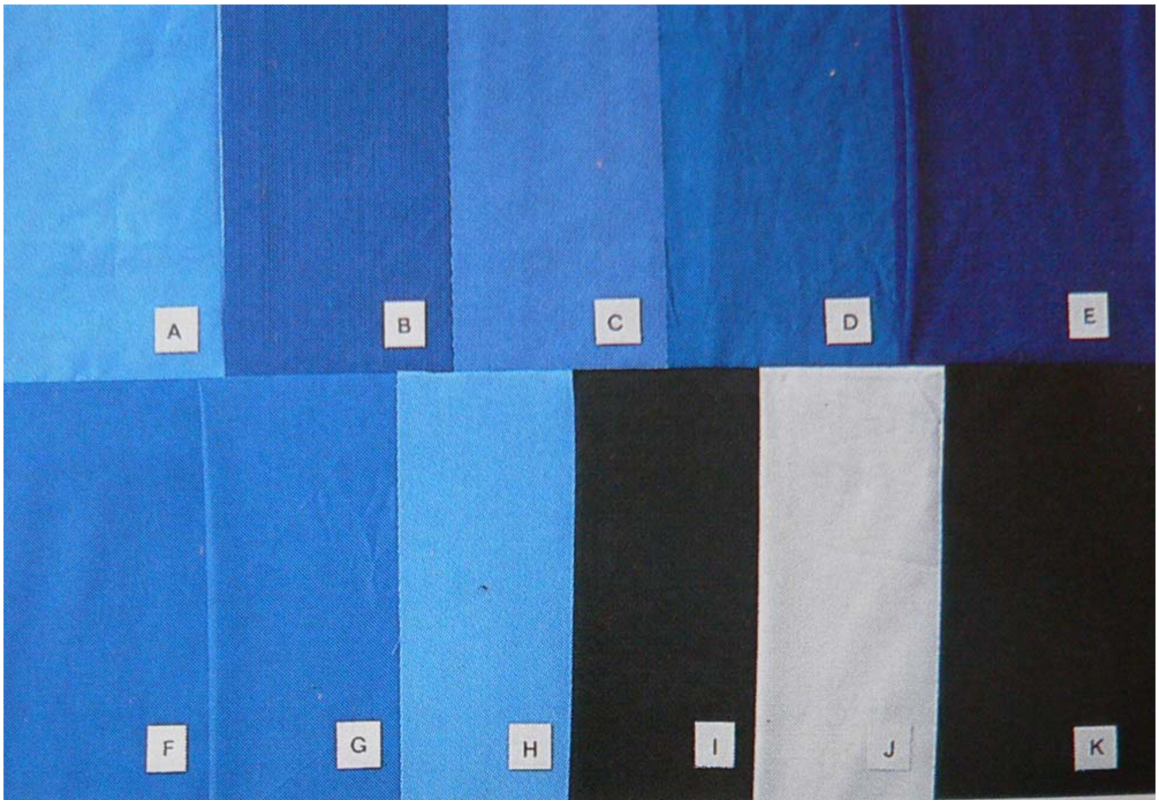


Figure 13 showing how Désiré fades badly after 9-10 months

This paper contains a photograph of the fabrics (Photo 2). Claude Laveissière provided a scan of the reprint in 2006. It is inserted here at high resolution.

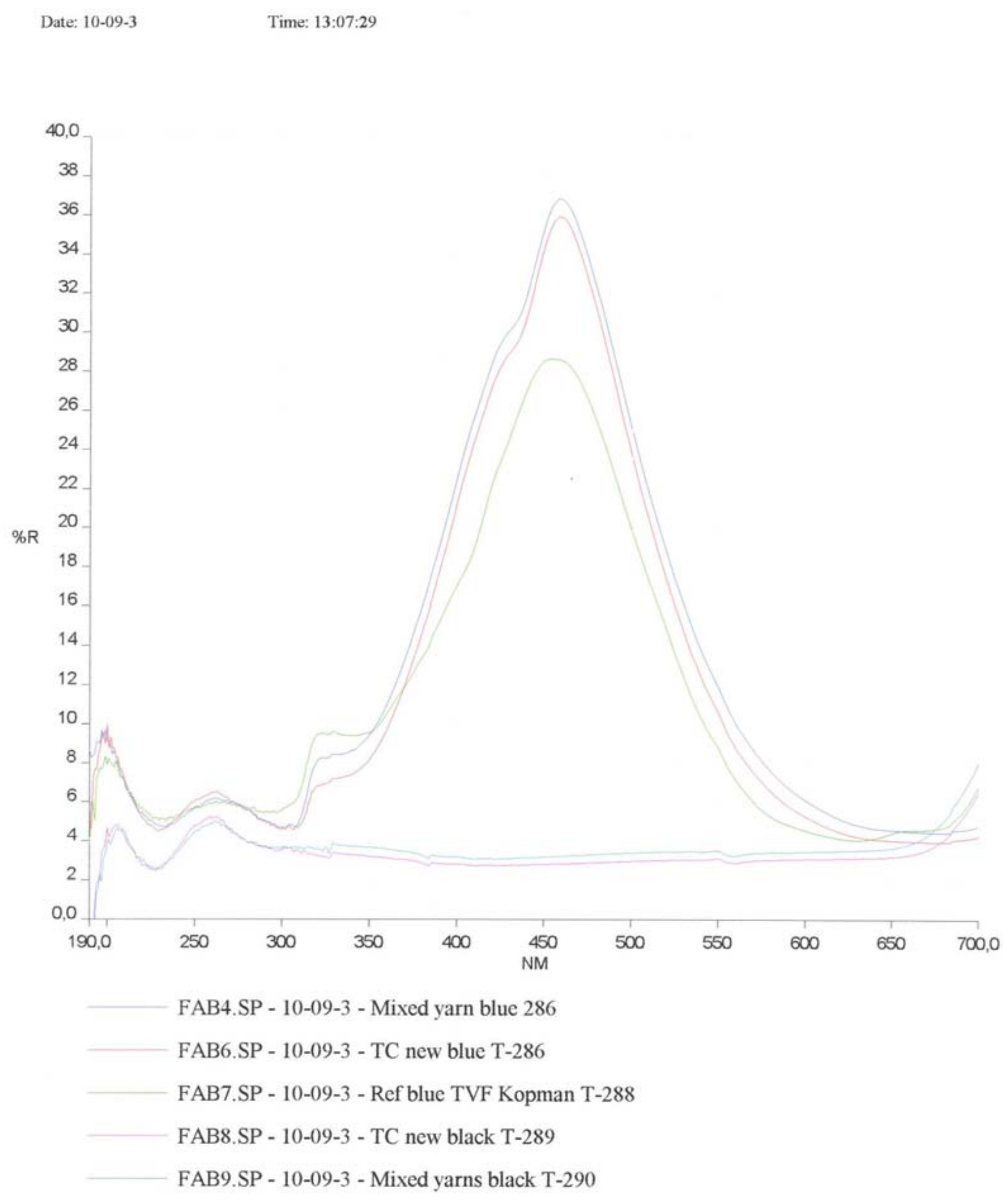
A	Désiré	polyester [bleu ciel] = sky blue
B	Jersey 1	polyester
C	Casa	80% polyester + 20% viscose
D	No name	cotton
E	Jersey 2	acrylic
F,J,K	Santiago	67% polyester, 33% cotton [bleu électrique] = phthalogen
G,I	Koffi	nylon (polyamide)

H	Missing in the published figure legend



Vestergaard Frandsen New Blue Polyesters

Coinciding with ISCTRC in October, 2003, VF sent out information on its new fabrics by email. A figure with a reflectance scan of two new fabrics in 100% polyester or 95% polyester + 5% viscose was provided. No details of methods were given. The lines in the figure are weak. The fabric used as a reference blue is not clear, but I think it is from Klopman International in Italy, and is probably the colour “New Azzurro”.

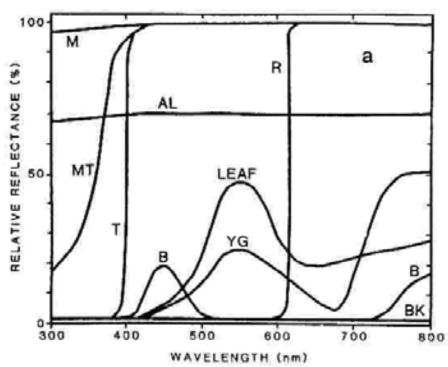


Blue Paints

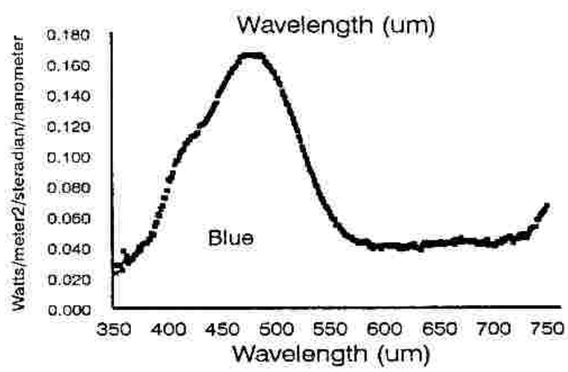
There have been very few studies on biting flies that have used defined paint types with accompanying reflectance spectra. Most just give qualitative descriptions of colour.

Allan & Stoffolano (1986) did sticky panel experiments with *Tabanus nigrovittatus* and published the spectrum for Winsor & Newton "Permanent Blue" artist's oil paint, presumably without "TangleTrap" applied. W&N confirmed that this paint was made with Pigment Blue 29, Complex Sodium Alumino-Silicate containing Sulphur, C.I. No. 77007:00. PB29 is still used in their artist's oils for the colours ultramarine blue (green shade) and French ultramarine. The spectrum was taken with a Shimadzu Spectronic Spectrophotometer 210 uv with a uv 200 integrated sphere attachment.

Moore et al. (1996) studied the attraction of *Tabanus abactor* to buckets painted with Sherwin Williams latex paints identified only to colour, e.g. "blue". The readings were taken with a Personal Spectrometer II (Analytical Spectral Services, Boulder, Co. – no sign of this company now?) in the field in August from four compass directions with Tanglefoot applied. I have not tried to adjust these absolute reflectance readings to percent reflectance as no perfectly reflecting white standard was used.



(Allan & Stoffolano, 1986) Fig. 1 "B"



(Moore *et al.*, 1996) Fig. 1a

Bracken et al. (1962) did considerable work on the attraction of *Hybomitra* in Manitoba to painted spheres using Sherwin Williams Blue #76G18. They measured reflectance, but their published results do not make sense. Their reflectance readings for the blue paint are all <1.2% when the black paint was at about 2% (Bracken, Hanec & Thorsteinson, 1962)! In Table 2, they took a light meter reading off the blue paint and its reflectance was 9%, so perhaps they were in fact using extremely dark blue paint, but clearly not equal to black.

Wall & Doane (1980) compared catches of *Tabanus nigrovittatus* in painted box traps before Allan's studies. They used Dutch Boy high gloss enamel No. 292 blue, but provided no reflectance information. The current paint used in the Cape Cod greenhead trap is in the spectral database (#295); it is dark, reddish blue (Wall & Doane, 1980).

Plastic Corrugated Board

Cilek (2003) tested corrugated plastic boards (Aluma panel, Cumming, Ga). There are a lot of different blue boards on the market so it is difficult to know which exact colour he tested. The spectral readings were taken by Dave Carlson using the same method as in the spectral database, e.g. with an Ocean Optics USB 2000 Fiber Optic Spectrophotometer. The graph is on an absolute scale of intensity, but this is going to be reasonably close to an actual measure of percent reflectance, given the way the readings were taken (100% = ~3,500).

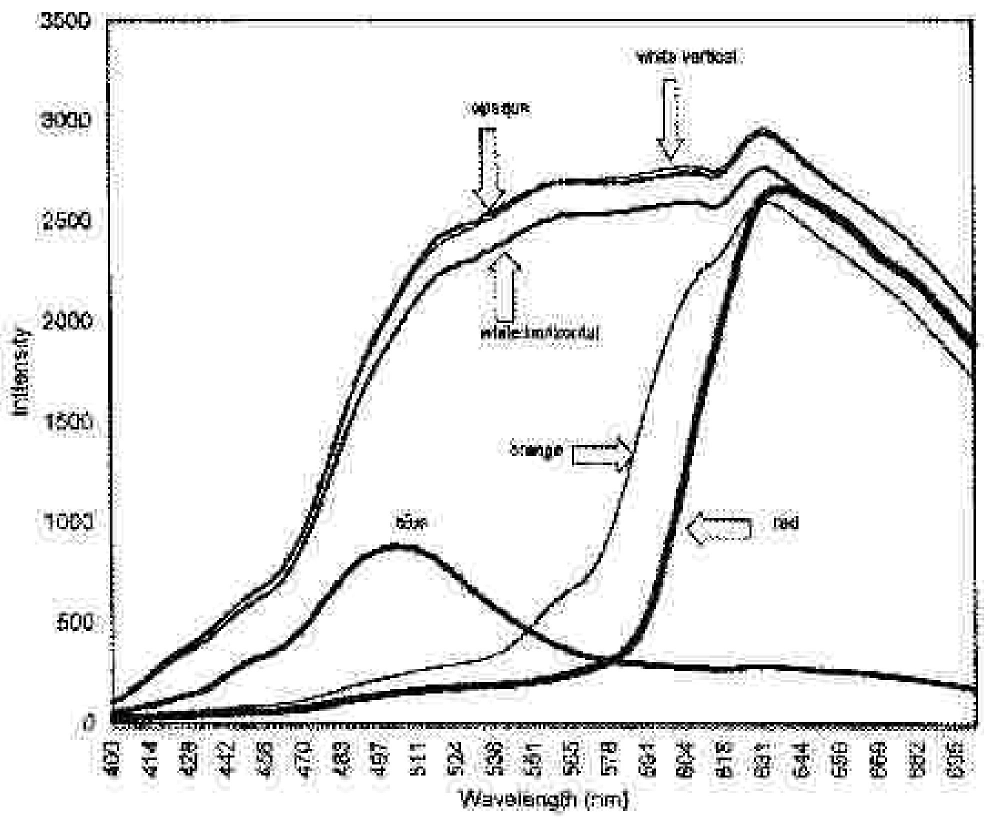


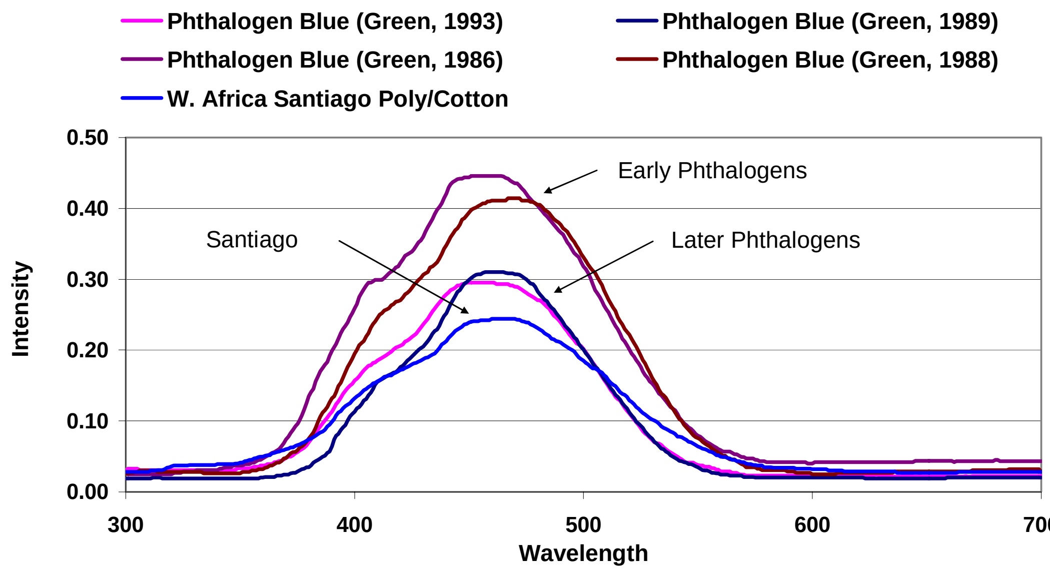
Fig. 1 Spectral reflectance curves of various colors and types of plasticized corrugated boards.

(Cilek, 2003) “blue”

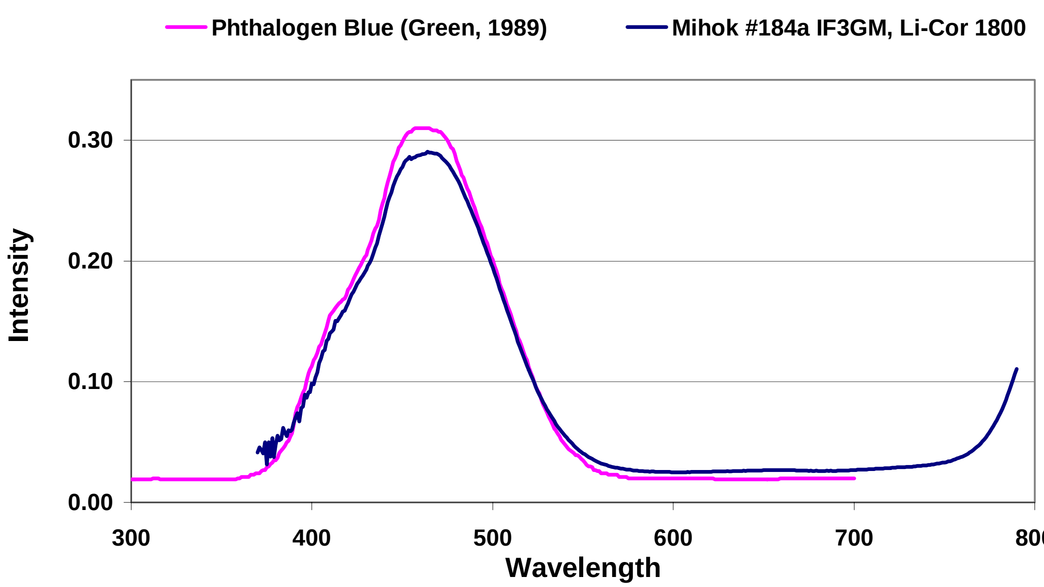
Interesting work was done many years ago on the attraction of stable flies to various kinds of fiberglass panels and a few other transparent materials (Agee & Patterson, 1983). A “light blue” Alsynite fiberglass panel was tested, but no information was provided on its characteristics.

Comparison of Phthalogen Blues

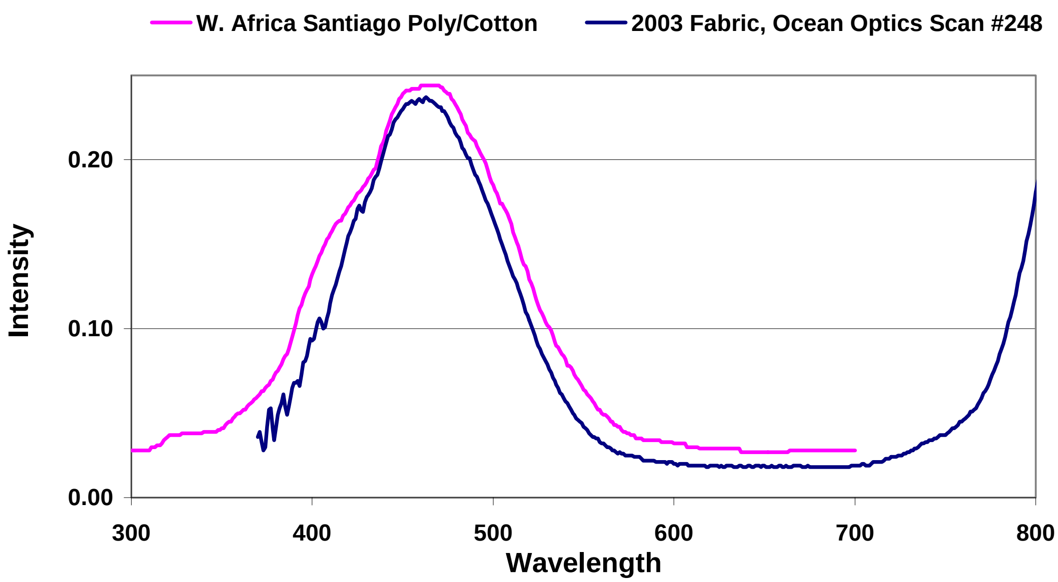
Digitized spectra from the literature are assembled below. Note the shift to a darker phthalogen blue fabric by Green through time, but with a good match for all fabrics from both East and West Africa. The poly/cot Santiago fabric from West Africa is an excellent match, probably because the cotton component was dyed with phthalogen blue.



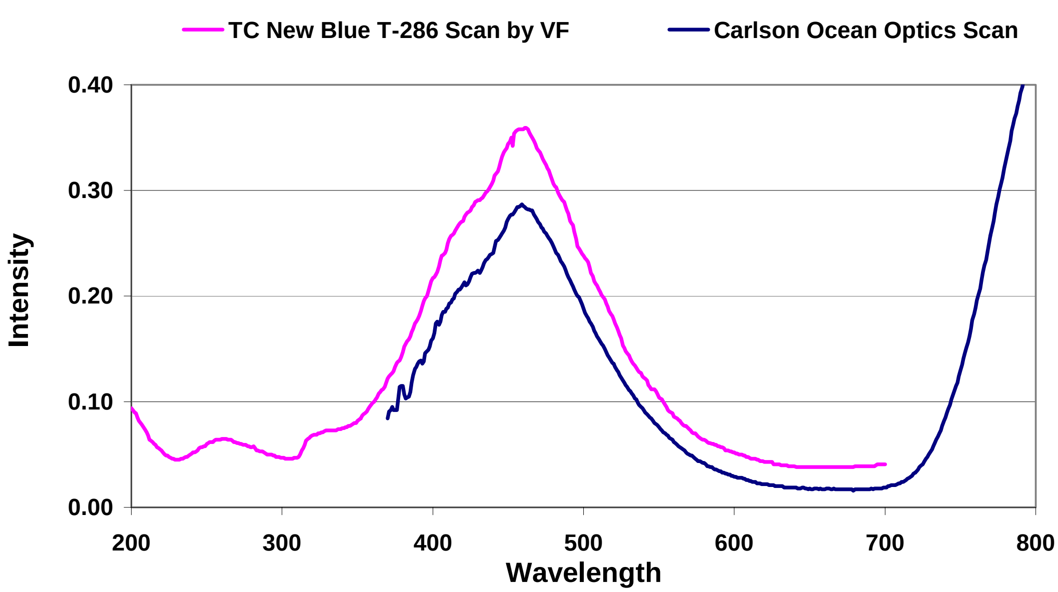
A 1997 reference sample from Mount Kenya Textiles of phthalogen blue IF3GM is a nearly perfect match to Green's 1989 fabric.



The Santiago fabric produced by Ets. Gonfreville in 2003 is a nearly perfect match to the historical fabric published by Laveissière in 1987.



The “New Blue” VF fabrics from 2003 are a good imitation of the colour phthalogen blue on cotton and are also very similar to the Santiago poly/cot, and the Klopman “New Azzurro” poly/cot. Below is a comparison of the digitized spectrum and a spectrum taken from the actual fabric with the Ocean Optics spectrophotometer.



Comparison of Other Blues

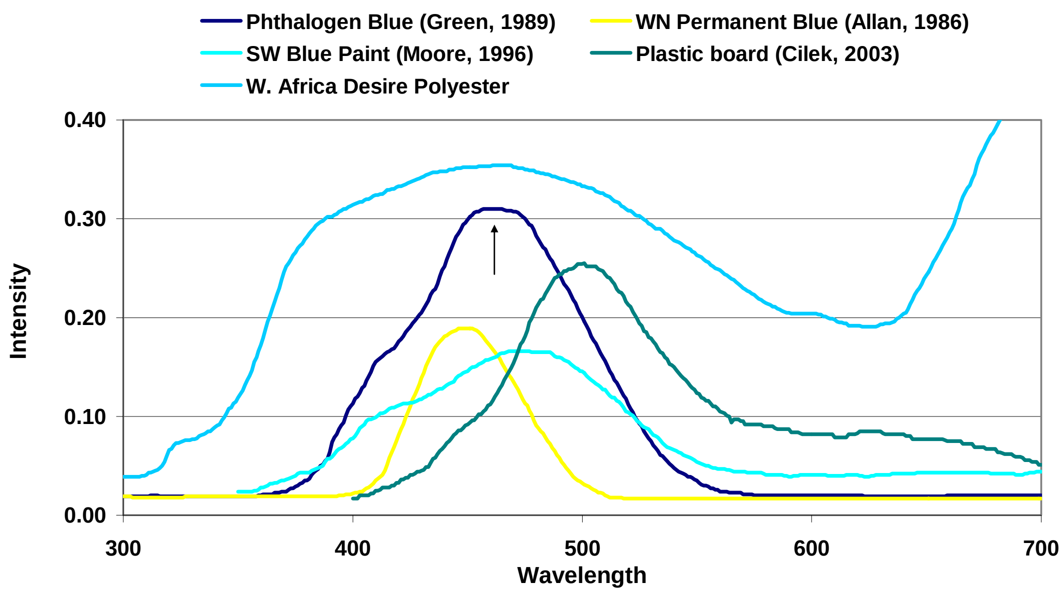
The spectra from other materials represent a variety of blues. The arrow points to an example of phthalogen blue cotton from Green (1989).

Only the Winsor & Newton ultramarine blue / Pigment Blue 29 of Allan & Stoffolano (1986) approaches the colour of phthalogen blue. Its wavelength peak is about 10 nm lower than CuPc. The peak is very symmetrical, but it lacks the shoulder or "bump" in the spectrum typical of CuPc at 410-420 nm. This is a subtle inflection point that can be seen only in spectra at high resolution. It is also only obvious in brighter shades.

The Désiré "sky blue" polyester stands out as both a very bright fabric and one with unusually high ultraviolet reflectance.

The plastic board is a complex colour, clearly greenish and with some red, I would probably call it "turquoise" rather than blue.

The Sherwin Williams paint has a very broad peak approaching green. This paint would have been a dark, rather dull blue.



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