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CRC for Sheep Industry Innovation

Project 2.2 Whiter lightfast wools

Development of a method to measure the colour and photostability of small fleece wool samples

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Development of a method to measure the colour and photostability of small wool samples

1 INTRODUCTION

The standard method for colour measurement of wool is described in the International Wool Testing Authority test method IWTO-56-03 (Method for the measurement of raw wool colour) and requires 5g of wool. The Australian Wool testing Authority (AWTA) have measured the colour of 1288 scoured samples from Merino sheep in the Sheep CRC Information Nucleus (IN) Flocks using this method, as part of the Sheep CRC Whiter Lightfast Wools program to examine the genetic and environmental influences on the colour and photostability of wool.

AWTA have developed a method to measure the photostability of wool after irradiation under a UVB (280-320 nm) light source for four hours[1] . The samples are prepared as webs which are mounted in frames and the colour is measured before and after exposure. The photostability of the sample is calculated from the change in yellowness (Y-Z). A correlation was not observed between the initial scoured wool colour and the rate of photoyellowing as expected which casts doubt about the reproducibility and precision of the photostability test used by AWTA.

An alternative method for assessing yellowness and photostability using a conventional reflectance spectrometer has been developed which requires 0.5g samples and ensures that the fibres remain immobile during irradiation and colour measurement. The method currently provides an "in house" assessment for comparison of colour with a limited amount of wool and complies with most of the criteria required by the IWTO-56-03 Test Method .

2 EXPERIMENTAL

2.1 Sample selection and preparation

Wool samples were collected from the mid-side of Merino sheep (~100g) of the 2007 drop of the Sheep CRC Information Nucleus flocks which are located at sites in Hamilton and Rutherglen (Victoria), Turretfield and Struan (South Australia), Cowra and Kirby (New South Wales) and Katanning (Western Australia). A total 1288 samples were scoured and the colour and photostability were measured at AWTA.

A ram's fleece sourced from Lance Mann, 13 Mayfair Drive, Newtown, Victoria, 3220 was used as a control wool. The tips of the wool were removed and the wool was scoured using the method developed for maximizing whiteness (Project 2.2 Task Report R4.2.2.1, Part 2) and then passed through a Shirley Analyzer twice. This control wool has been used for the development of the method for trace metal analysis (Milestone R4.2.2.1, Part 1) and as a quality control standard for each analytical run.

The scoured wool fibres were cut into approximately 2cm lengths, teased out and all visible vegetable matter was removed. Approximately 0.512g $\pm$ 0.005 wool samples were evenly compressed into 3.2cm^3 volume (packing density 160kg/m^3) in a polymethylmethacrylate (PMMA) disposable cuvette (Brand) and secured with either Blutak or capped with a 10mm perspex cube with a 1mm hole drilled through the centre (Figure 1).

The packing density was equivalent to the IWTO-56-03 requirement. Dry wool was at ambient temperature and humidity prior to packing. Wet wool samples were prepared by either soaking in 0.1% Leophen M solution and removing the excess liquid prior to packing, or by injecting approximately 3ml of 1% aqueous Leophen M into cuvettes which were packed with dry wool.

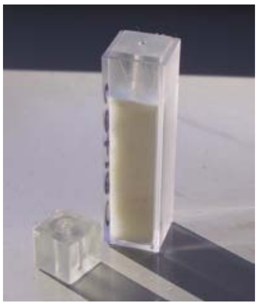

Figure 1 packed cuvette and Perspex cap

Plain weave pure wool fabric samples (Armitage A001) were sealed in plastic bags prior to irradiation. Fabric was wet out in the surfactant solution and the excess was removed before sealing in bags.

2.2 Colour measurement

The colour of the wool samples was measured by placing the cuvettes over the small area view (SAV) aperture (0.8cm x 1.0cm) in the inspection port of a Gretag Macbeth Color-Eye 7000A spectrophotometer. The spectrophotometer was configured with a D65 light source and a 10^{o} collection angle with the spectral component included (SCI). The tristimulus values X , Y and Z were measured by averaging 2 reads and used to calculate the wool yellowness (Y-Z) and the Yellowness Index (YI D1925), where

$$\text{YI D1925} = \frac{100(1.28\, X_{CIE} - 1.06\, Z_{CIE})}{Y_{CIE}}$$

2.3 Assessment of photostability

The cuvettes were secured in direct contact with a Philips TL20W/12RS (UVB) light source and irradiated for four hours or with a Philips TUV (UVA) light source and irradiated for 24 hours. The yellowness of the wool was measured in the cuvettes before and after exposure and the change in yellowness was calculated to estimate the photostability.

Wet wool samples were dried out in the cuvettes in an oven at 50^{o}C overnight.

3 RESULTS AND DISCUSSION

3.1 Method development

3.1.1 Colour Measurement

The colour of loose fibre cannot be measured reproducibly by placing a sample directly against the observation port of a spectrophotometer. Fibres tend to protrude into the aperture causing errors in the measurement and loose fibres can fall inside the instrument. Also there will be variations in the sample density, and this is known to affect colour measurements on scoured wool samples[2]. The standard test method for measuring the colour of scoured wool is the IWTO-56-03 Test Method which requires 5g of wool and an apparatus that is not commonly used for colour measurement of textiles by industry. The wool is compressed into a cell with a packing density of 160kg/m^3 to ensure even distribution of the fibre and sufficient thickness to prevent light penetrating the sample. The colour is measured behind a layer of glass and correction for the effect of the glass and the calibration of the instrument requires 12 standard ceramic tiles.

The alternative method of presenting small samples of loose wool for colour measurement has been developed which requires 0.5g samples and a conventional reflectance spectrophotometer. Scoured loose wool was compressed into cuvettes which are normally used for measuring the absorbance and transmittance of liquids using a UV/Vis spectrometer. Cuvettes are available in different materials: quartz, polystyrene (PS) and polymethylmethacrylate (PMMA). Disposable PMMA cuvettes were selected for use as compression cells because they are inexpensive, durable, transparent to 300 nm and are relatively unaffected by exposure to UVB for four hours (Figure 2).

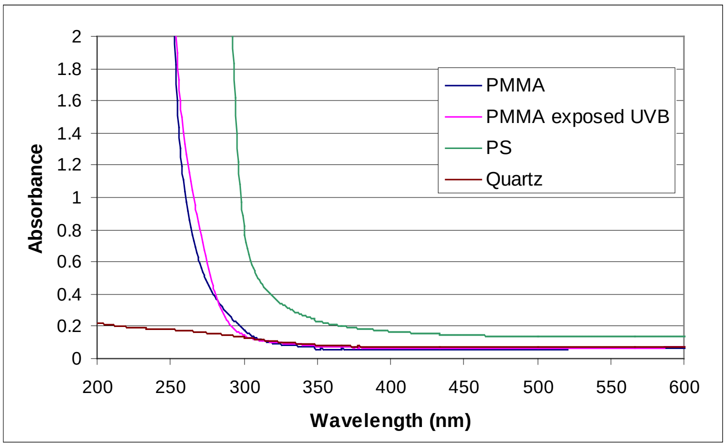

Figure 2 Absorbance of quartz, polystyrene and PMMA cuvettes

The wool is compressed into cuvettes at the packing density required for the IWTO-56-03 test method. The dimensions of the cuvettes are 10x10x45 mm which complies with the requirement of the IWTO method that the sample thickness should be a minimum of 8mm to ensure that the wool is “infinitely thick” and that light does not penetrate the sample. The wall thickness of the cuvettes is 1mm which also complies with the test method requirement that the cell material is preferably less than 3mm. The IWTO test method states that the instrument port must be a minimum of 10mm smaller than the compression cell however a difference of less than 10mm is acceptable providing the wall of the cell is not detected during measurement. The sample port was opened and the cuvette was aligned before each read to ensure that the sides of the cell were not visible through the aperture during measurement.

The effect of measuring behind PMMA can be corrected if required. The tristimulus values and Yellowness Index (D1925) of twelve IWTO standard ceramic tiles and five fabrics of varying yellowness were used to determine the difference in measurement due to PMMA. The standard tiles are used for instrument calibration and the fabrics included fluorescent whitened wool and wool polyester that was thermally yellowed to varying extents. The IWTO ceramic tiles and four layers of fabric were measured directly against the observation port and again behind PMMA. The results are tabulated in Appendix 1.

Regression analysis indicates a linear relationship between measurements behind PMMA and against the port of the spectrophotometer (Table 1) and that the effect of PMMA on colour measurement can be corrected using the formula:

$$y = Ax + B$$

where y is the corrected value, x is the measured tristimulus value (X, Y or Z) or the yellowness index D1925, A is the gradient and B is the intercept.

	X	Y	Z	YI-D1925
B Intercept	6.111	6.438	6.958	-0.045
standard error of intercept	0.346	0.365	0.382	0.284
A Gradient	0.868	0.868	0.862	0.932
standard error of gradient	0.006	0.006	0.006	0.015
R^2	0.999	0.999	0.999	0.996
Standard Error of R^2	0.554	0.584	0.653	0.996
No. of observations	17	17	17	17

Table 1 Regression analysis of measurements against the observation port and behind PMMA

The yellowness measurements were not corrected for the PMMA when developing the test method because a standard method was not required and the results were comparative.

The AWTA has prepared, scoured and measured the colour of 1288 samples from the 2008 shearing of the 2007 drop of Merinos from the IN flock samples. The relationship between the colour measured by AWTA using IWTO-56-03 method and the method using cuvettes as compression cells was determined by comparing the yellowness (Y-Z) of 75 of these samples. The relationship is linear (R^2=0.83) (Figure 3) and direct comparisons can therefore be made between samples measured using the two different methods. The data is tabulated in Appendix 2.

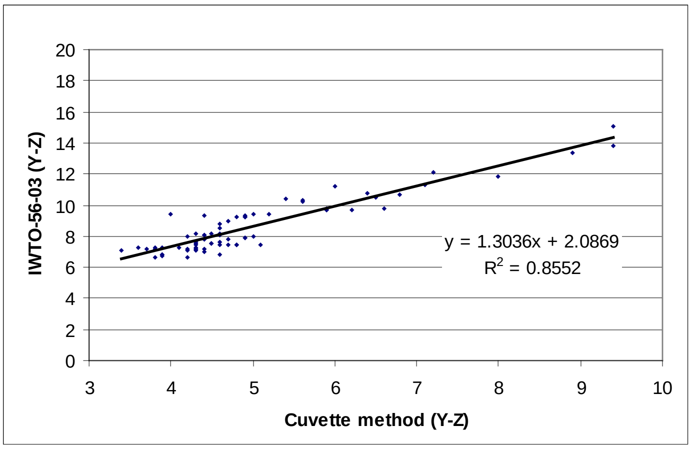

Figure 3 Yellowness (Y-Z) of wool measured in cuvettes and by IWTO-56-03 test method

3.1.2 Measurement of photostability

A test method to determine the photostability of scoured wool samples was developed by AWTA to evaluate the possible influences of genetic traits and environmental effects on the extent of wool yellowing[1]. The 1288 Merino wool samples from the IN flock that were measured for initial scoured wool colour were prepared as webs, mounted in frames and irradiated with UVB for four hours. The yellowness (Y-Z) was measured before and after exposure and the photostability was determined from the difference in yellowness.

Analysis of all the INF 2008 data showed that photostability (as measured by the AWTA method) had zero heritability and is not correlated phenotypically to other wool traits, and the genetic correlations were also close to zero (Jen Smith, 4/5/09). A correlation was also expected between trace metal content and the degree of photoyellowing, since photoyellowing increases in the presence of absorbed trace metals in wool [3] (Project 2.2 Task Report R4.2.2.1 (Part 2)), but this was not observed. The validity and precision of the AWTA test was therefore questionable, and hence an alternative method was required to check the test method used by AWTA and to verify the lack of correlation.

The penetration of UV through wool is poor and only the surface fibres are yellowed. It is paramount that the fibres remain in the exact position during measurement and irradiation because small movements and rotation of the fibres may mean that the yellowed portion may not be measured. By compacting wool in a cell, the fibres are completely restrained and the wool exposed to the radiation remains facing the measured surface.

Samples that were prepared for colour measurement in cuvettes were irradiated with UVB for four hours using a Philips TL20W/12RS tube. The spectral intensity of the light source is shown in Figure 4. The maximum intensity occurs at approximately 300 nm and the major peak ranges from 280–320 nm which corresponds to the range at which wool photoyellows most rapidly. The relationship between the yellowness (Y-Z) before and after irradiation is linear (R^2=0.81) (Figure 5) .

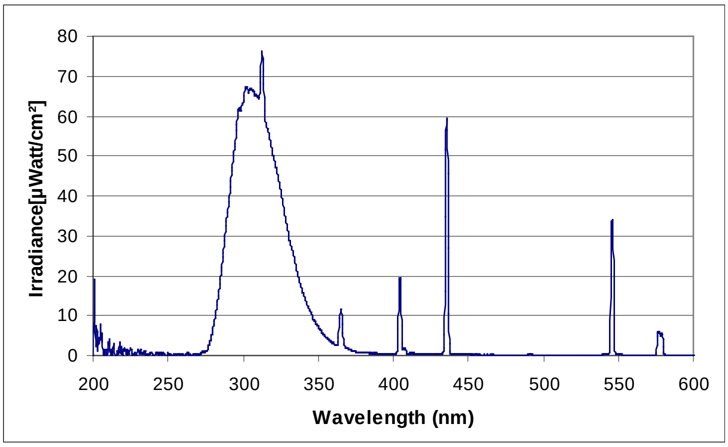

Figure 4 Spectral intensity of Philips TL20W/12RS (UVB) lamp

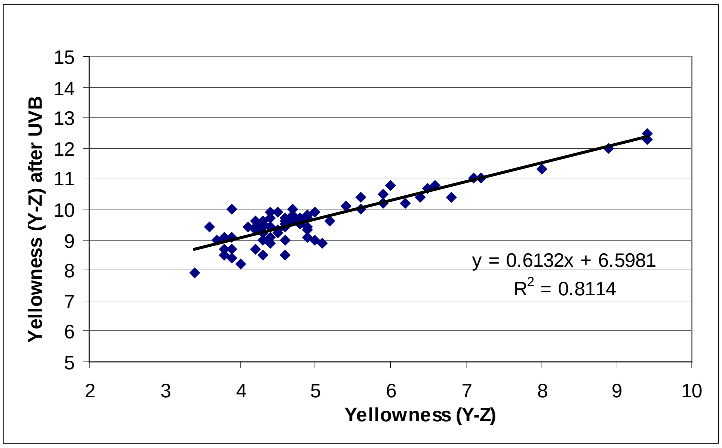

Figure 5 Yellowness (Y-Z) of IN flock samples measured in cuvettes before and after exposure to UVB for four hours

The relationship between the initial yellowness and the change in Y-Z is also linear (R^2 =0.644) (Figure 6) which suggests that the effects of phenotype, genotype and environment on photostability are small. A linear relationship between scoured wool colour and change in colour after exposure to UVB was observed previously by Lennox and King[4] who suggested that the initial colour is the dominant factor governing the observed colour change.

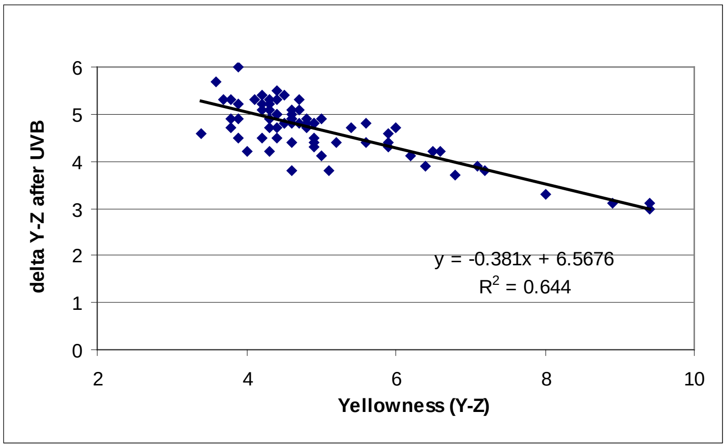

Figure 6 Yellowness (Y-Z)) of IN flock samples measured in cuvettes before exposure and the change in yellowness after exposure to UVB for four hours

It is possible that the deviations from linearity observed in Figure may be due to phenotypic, genetic or environmental effects.

To investigate this further, the photostability of all 2007 samples from the Turretfield and Katanning flocks (flocks that were not tip-sheared) will be re-examined and the heritability analysis repeated using only Hamilton, Turretfield and Katanning data.

Oxygen is required for photoyellowing to occur [5] and to confirm that wool packed inside the cuvettes has access to an adequate supply of oxygen, the yellowness of dry samples of control wool were measured in cuvettes with and without holes pierced in the bottom, and plugged with Blutak (Table 2). The samples were exposed to UVB for four hours and two-tailed T test analysis of the data (α=0.5) indicates that there is no significant difference in yellowness (YI 1925) after exposure to UVB (t_{stat} -2.10, $t_{critical}$ two-tail 2.78

Sample Number	Before exposure		4hr UVB	
	no holes	holes	no holes	holes
1	12.72	13.03	23.85	23.83
2	13.13	13.16	24.00	24.7
3	13.04	13.5	24.36	24.25
4	13.01	13.22	23.58	24.34
5	12.82	12.91	22.77	23.69
Mean	12.94	13.16	23.71	24.16
SD	0.17	0.22	0.60	0.41

Table 2 Yellowness (YI-D1925) of wool in PMMA cuvettes before and after irradiation for four hours in UVB

Irradiating wet wool samples was anticipated to provide an accelerated test for photostability, since the rate of yellowing is much greater for wet wool than for dry wool[6]. Also, a method to examine the catalytic effect of trace metals within the fibre on the photostability requires wet wool to enable Fenton-type reactions to occur. Since the rate of yellowing is faster, the oxygen demand is likely to be greater when irradiating wet wool. To determine if the cuvettes allow sufficient diffusion of oxygen for photoyellowing of wet wool to occur, control wool samples were wet out and the excess fluid was removed before packing into cuvettes which were either sealed with Blutak or capped with a holed plastic cube. Holes were pierced in the bottom of four cuvettes which were capped with holed plastic cubes. The yellowness was measured while the wool was wet before and after irradiation in UVB for two and four hours (Table 3). Single factor analysis of variance (α=0.05) indicates that there is no significant difference in Yellowness Index of samples after four hours irradiation and that placing holes in the cuvettes is not required.
(F_{calc} 1.93, P-value 0.2, $F_{critical}$ 4.25)

Sample Number	Before exposure			2hr UVB			4hr UVB		
	no holes	holed lids	holed lids & cuvette	no holes	holed lids	holed lids & cuvette	no holes	holed lids	holed lids & cuvette
1	10.78	10.67	11.18	13.57	14.44	14.79	14.85	15.72	16.17
2	10.39	11.09	10.26	12.68	15.68	14.33	13.47	16.62	15.69
3	11.63	10.92	11.02	15.01	14.63	14.92	14.78	16.05	15.92
4	11.13	10.97	10.69	15.31	15.09	14.33	16.71	16.09	15
mean	10.98	10.91	10.79	14.14	14.96	14.59	14.95	16.12	15.70
SD	0.46	0.15	0.35	1.07	0.48	0.27	1.15	0.32	0.44

Table 3 Yellowness (YI-D1925) of wet wool in PMMA cuvettes after irradiation for two and four hours in UVB

Wetting wool after packing is a more convenient method when testing a large number of samples. By injecting surfactant solution into cuvettes, the wool is evenly wet out and saturated. Dry wool and wool that was wet out in surfactant with the excess removed prior to packing were tested for comparison. All cuvettes were capped with holed lids and the Yellowness Index was measured while dry and after exposure to UVB and oven drying overnight at 50^{o}C (Table 5). Contrary to expectations, wet wool yellowed to a lesser extent than dry wool and the colour of saturated wool was unchanged. The technique of wetting wool by injecting the solution is obviously unsuitable and removing the excess fluid is prior to packing is preferred. Also, because optical effects for wet wool made it appear less yellow and uneven, samples should be dried at a low temperature after irradiation and prior to colour measurement.

Samples were irradiated in quartz cuvettes under the same conditions to determine if any material could be leached from the PMMA and affect the rate of yellowing (Table 4). There was no difference in the trend as a result of the cuvette material.

	PMMA cuvettes		Quartz cuvettes*	
	Initial dry measurement	4hr UVB and dried	Initial dry measurement	4hr UVB and dried
dry wool	12.56	22.87	12.00	24.58
wet wool excess removed	12.68	18.17		14.21

Table 4 Yellowness (YI-D1925) of wet and dry wool measured in cuvettes exposed to UVB for four hours

* Yellowness indices have not been corrected for measurement behind quartz

The yellowness of pure wool fabric was compared after irradiation in UVB for four hours and UVA for 24 hours using a Philips TUV tube. The wavelength of the maximum intensity of the UVA light source used is 365 nm and the spectra is shown in Figure 7.

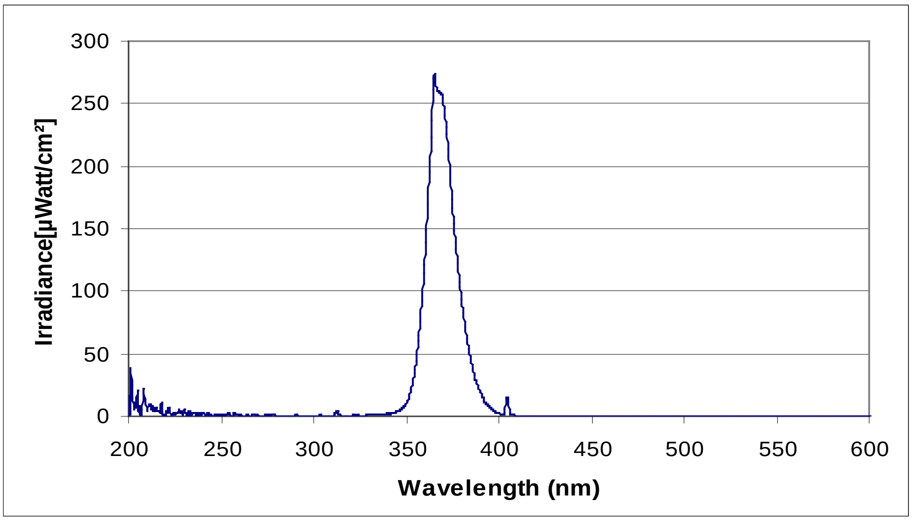

Figure 7 Spectral intensity of Philips TUV (UVA) lamp

Previous studies have demonstrated that wet wool fabric yellows more than dry wool after exposure to light. This result was confirmed by irradiating wet and dry samples of pure wool fabric with UVA and UVB (Table 5). Wool that was wet out and the excess removed prior to packing in a cuvette also yellowed more than dry wool in UVA. An explanation for the difference between exposing wet wool to UVB as compressed loose wool fibre or constructed as a fabric has not been confirmed.

	Initial measurement	4hr UVB and dried	24hr UVA and dried
FABRIC			
dry	19.27	35.4	26.75
wet		37.55	49.99
FIBRE			
dry	12.56	22.87	16.25
wet excess removed	12.68	18.17	32.93
saturated	12.04	12.62	14.17

Table 5 Yellowness (YI-D1925) of wet and dry wool fabric and wet and dry wool in cuvettes after irradiation UVB for four hours and UVA for 24hours

4 CONCLUSIONS

A convenient method for measuring the colour and photostability of small samples of dry scoured wool has been developed and will be used to determine the effect of trace metals on the colour and photostability of wool.

A strong correlation between the initial yellowness of dry wool and the yellowness after irradiation with UVB was observed. A linear correlation was also found between the initial yellowness and the change in yellowness (R^2=0.644) suggesting that the photostability can be predicted from the original colour, and that a test may not be required.

It is possible however that small deviations from linearity may be due to phenotypic, genetic or environmental effects. To confirm this, the photostability of all 2007 samples from the Turretfield, Hamilton and Kirby flocks (flocks that were not tip-sheared) will be re-examined and the heritability analysis repeated using only Turretfield, Hamilton and Kirby data.

Irradiating with UVB for four hours is suitable for determining the photostability of dry scoured fleece wools, whereas it is more appropriate to irradiate wet wools with UVA for 24 hours.

6 REFERENCES

1. WANG, H., FISH, V. & MAHAR, T. (2008) Development of a method for testing photostability of raw wool. CRC Project 2.2 Milestone report.
2. HOARE, J. L. & THOMPSON, B. (1974) Reflectance measurements on scoured wool. *Journal of the Textile Institute*, 65**,** 281-287.
3. MILLINGTON, K. R. & KIRSCHENBAUM, L. J. (2002) Detection of hydroxyl radicals in photoirradiated wool, cotton, nylon and polyester fabrics using a fluorescent probe. *Coloration Technology,* 118, 6-14.
4. LENNOX, F. G. & KING, M. G. (1968) Studies in wool yellowing Part XXIII: UV yellowing and blue light bleaching of different wools. *Textile Research Journal*, 38, 754-761.
5. LEAVER, I. H. & CAIRD-RAMSEY, G. (1969) Sensitized photo-oxidation of wool and silk by triazinylstilbene. *Photochemistry and Photobiology,* 9**,** 531-536.
6. MILLINGTON, K. R. (2006) Photoyellowing of wool. Part 1: Factors affecting photoyellowing and experimental techniques. *Coloration Technology*, 122, 169-186.

APPENDIX 1

Tristimulus values (X,Y,Z) and Yellowness Index D1925 of fabric and IWTO standard tiles against the spectrophotometer port and behind PMMA

	Against port				Behind PMMA			
	X	Y	Z	YI-D1925	X	Y	Z	YI-D1925
Fabric 1	73.595	76.504	91.038	-11.64	70.561	73.512	85.457	-8.76
Fabric 2	68.056	71.895	66.701	16.51	65.436	69.061	64.55	15.83
Fabric 3	63.383	67.377	60.74	18.76	61.023	64.795	58.959	17.93
Fabric 4	63.875	67.74	51.295	35.64	61.83	65.422	50.56	34.12
Fabric 5	58.833	61.238	39.306	51.22	57.411	59.656	40.442	47.29
IWTO white	85.002	89.799	94.795	1.8	80.849	85.437	90.08	1.91
IWTO 80% grey	77.9	82.269	87.435	1.02	74.02	78.203	83.014	1.12
IWTO 70% grey	68.864	72.803	77.95	-0.02	65.591	69.365	74.182	0.09
IWTO pale grey	60.627	64.072	68.342	0.49	58.236	61.562	65.645	0.49
IWTO 50% grey	50.32	53.202	57.169	-0.47	49.116	51.935	55.79	-0.45
IWTO 40% grey	40.758	43.149	46.241	-0.3	40.82	43.203	46.329	-0.35
IWTO 33% grey	35.645	37.511	40.333	0.03	36.407	38.339	41.241	-0.11
IWTO mid grey	26.818	28.309	30.083	1.09	29.097	30.716	32.789	0.53
IWTO deep grey	8.286	8.724	9.241	1.81	13.858	14.604	15.729	-0.35
IWTO black glass	3.91	4.118	4.407	0.52	10.407	10.971	11.929	-1.57
IWTO wool 1	69.225	72.905	63.941	22.72	66.08	69.588	61.681	21.65
IWTO wool 2	59.835	62.391	48.821	34.83	57.593	60.071	48.446	32.03

APPENDIX 2

Tristimulus values (X,Y,Z) and Yellowness Index D1925 SheepCRC Information Nucleus flock wool samples using the cuvette method and the IWTO-56-02 test method

TAG ID	AWTA ID	Cuvette method					IWTO-56-03			
		X	Y	Z	Y-Z	YI-C1925	X	Y	Z	Y-Z
982 000082604065	61396	60.6	64.1	57.6	6.5	19.5	70	74	63.5	10.5
982 000082603987	61402	62.8	66.7	62.4	4.3	15.1	73.5	78	69.8	8.2
982 000082604100	61403	64.3	68.2	63.9	4.3	14.9	73.7	78.1	70.5	7.6
982 000082592231	61416	64.3	68.2	63.7	4.5	15.3	73.3	77.7	69.5	8.2
982 000082603865	61430	61.7	65.4	59.3	6	18.4	69	73	61.8	11.2
982 000082604192	61452	65.2	69.1	64.9	4.2	14.6	73.2	77.7	69.7	8
982 000082604011	61461	63.4	67.5	62.1	5.4	16.5	72.8	77.2	66.8	10.4
982 000082592226	61463	61.8	65.7	60.2	5.6	17.2	71.6	76	65.8	10.2
982 000082592481	61466	61	64.7	59.1	5.6	17.5	71.1	75.3	65	10.3
982 000082603835	61481	61.8	65.6	58.6	7.1	20	70.5	74.7	63.4	11.3
982 000082604214	61488	60.8	64.5	56.6	8	21.9	67.1	71	59.2	11.8
982 000082615445	61489	61.2	65.1	57.9	7.2	20.2	69.3	73.5	61.4	12.1
982 000082604134	61516	59.4	63.1	56.7	6.4	19.2	69.6	73.8	63	10.8
982 000082604215	61518	61.5	65.2	58.5	6.8	19.6	69.6	73.7	63	10.7
982 000082604123	61519	62.9	66.7	62.4	4.4	15.1	71.3	75.6	67.5	8.1
982 000094502841	62049	62.3	66.1	61.8	4.3	15.2	70.7	74.9	67.4	7.5
982 000094510748	62050	62.5	66.3	61.7	4.6	15.7	70.7	75	66.8	8.2
982 000094502822	62053	63	66.7	61.9	4.8	16.1	69.8	73.9	66.5	7.4
982 000094510938	62056	61.7	65.4	61	4.4	15.5	68.9	73	64.9	8.1
982 000094502728	62071	61.2	64.8	60.3	4.5	15.9	68.8	72.9	65.4	7.5
982 000094503498	62072	60.4	64	59.6	4.4	15.7	69.6	73.8	66	7.8
982 000094502902	62075	62.3	66	61.3	4.6	16	67.4	71.5	64.7	6.8
982 000094502666	62092	60.9	64.5	59.3	5.1	17.2	67.6	71.5	64.1	7.4
982 000094502689	62094	63.2	67.1	62.6	4.4	15.4	70.2	74.5	67.3	7.2
982 000094502928	62095	62.7	66.4	61.5	5	16.4	70.4	74.6	66.6	8
982 000094502628	62097	62.2	65.9	61.3	4.6	15.8	69.5	73.7	66.3	7.4
982 000094510947	62098	62.8	66.5	61.9	4.6	15.8	69.5	73.7	65.6	8.1
982 000094502776	62100	63.3	67	62.4	4.6	15.8	69.1	73.2	65.6	7.6
982 000094483154	62103	63.2	66.9	62.6	4.2	15.3	67.8	71.8	65.2	6.6
982 000094510601	62104	63.6	67.5	63	4.4	15.2	71.4	75.9	68.1	7.8
982 000094502800	62126	63.4	67.2	62.7	4.5	15.5	70.1	74.3	66.8	7.5
982 000094510677	62129	62	65.6	61.3	4.3	15.5	66.8	70.7	63.3	7.4
982 000094510665	62131	62.4	66.1	61.2	4.9	16.5	69.7	73.8	65.9	7.9

982 000094502699	62133	62.2	65.9	61	4.9	16.6	69.6	73.6	65.7	7.9
982 000094502726	62135	61.8	65.4	60.8	4.7	16.1	69.8	74	66.6	7.4
982 000094502801	62137	62.1	65.8	61	4.8	16.3	69	73	65.6	7.4
982 000094502869	62148	63.1	66.9	62.2	4.6	15.8	69.7	73.8	65.3	8.5
982 000097598803	62456	62.8	66.7	61.8	4.9	16.1	71	75.3	66.1	9.2
982 000097608621	62583	59.7	63.5	58.6	4.9	16.3	70.5	74.8	65.6	9.2
982 000097608357	62595	62.2	66.1	61.2	4.8	15.9	72.3	76.7	67.5	9.2
982 000097598947	62614	56.9	60.5	56.6	4	14.9	69.4	73.7	64.3	9.4
982 000097598732	62697	58.6	62.3	57.9	4.4	15.5	71.4	75.8	66.5	9.3
982 000094487901	61118	62	65.9	61	4.9	16.1	70.7	75.1	65.8	9.3
982 000094487509	61230	64.2	68.1	64.3	3.8	14.2	71.7	76	69.4	6.6
TAG ID	AWTA ID	Cuvette method					IWTO-56-03			
		X	Y	Z	Y-Z	YI-C1925	X	Y	Z	Y-Z
982 000094487646	61244	61.5	65.1	58.5	6.6	19.7	67.7	71.6	61.8	9.8
982 000094493199	61284	65.4	69.4	65.4	3.9	14.2	72	76.4	69.6	6.8
982 000012159770	61637	64.2	68	63.6	4.4	15.4	69.2	73.3	66.3	7
982 000094512593	62807	65.3	69.4	65.7	3.6	13.6	74.4	78.8	71.5	7.3
982 000094512528	62808	63	66.9	62.3	4.6	15.4	72.2	76.5	67.7	8.8
982 000097606536	62845	61.3	65.1	60.4	4.7	15.9	70.6	74.8	65.8	9
982 000094508987	62860	65.4	69.4	65.6	3.8	13.9	75.3	79.8	72.5	7.3
982 000093565538	62873	63.6	67.4	63.2	4.2	15	71.5	75.8	68.7	7.1
982 000097606244	62885	64.4	68.3	64.2	4.1	14.7	72.9	77.3	70	7.3
982 000094508745	62887	61.4	65.1	60.8	4.3	15.3	68.9	73.1	65.8	7.3
951 000002472055	62334	59.5	63	56.8	6.2	19.2	67.5	71.4	61.7	9.7
951 000003927060	62343	59.2	62.6	56.8	5.9	18.9	65.3	68.9	59.2	9.7
951 000005622277	62379	63.4	67.1	62.4	4.7	15.9	70.2	74.3	66.5	7.8
951 000000619820	62410	62	65.6	59.7	5.9	18.2	70.1	74.1	64.4	9.7
951 000006247766	62411	59.9	63.5	57.6	5.9	18.5	69.4	73.4	63.6	9.8
951 000006815689	62424	60.2	63.7	54.8	8.9	24	67.2	70.9	57.5	13.4
951 000005560984	62438	61.9	65.5	60.1	5.4	17.5	69.8	73.9	64.2	9.7
951 000006492330	62440	59.9	63.5	54.1	9.4	24.9	67.8	71.6	56.5	15.1