Blacker than the Blackest

'Dark Knight' for Deeper Shades by Padding or Exhaust

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TODAY, BLACK-dyed fabrics are the most popular evening and fashion wear. Dyers across the world have always struggled to achieve deeper blacks or a cellophane-black shade – that is to say, the 'blackest black'. The reason for this is that fabric reaches a saturation point, beyond which addition of dyestuff does not increase the depth and, if anything, leads to poor wash fastness.

Hence, there is a need to develop the blackest black to fill this gap and satisfy the requirements of high-fashion wear, while overcoming fibre/fabric limitations. Such colour-deepening agents are commonly described as blooming agents, bathochromic agents or colour intensifiers.

For example, the colour of a dyed fabric is observed to be deep and sharp when it is wetted with water, having a refractive index of 1.33 (Figure 1). It is taught that the reason for this effect is that the surface reflectivity is reduced by this treatment. Reflection of light occurs when the waves encounter a surface or other boundary that does not absorb the energy of the radiation and bounces the waves away from the surface. The amount of light reflected by an object, and how it is reflected, is highly dependent upon the degree of smoothness or texture of the surface. In this case, the wet surface decreases the reflection of light, and hence looks darker.

A serious defect of synthetic fibres, especially polyester or microfibres, is the poor depth or sharpness of the colour of dyed fibrous products made from them, in comparison with the deepness or sharpness of the colour of dyed fibrous products made of natural fibres, such as wool and silk. Surface roughening by surface hydrolysis may enhance the colour depth; however, such processes also add to environmental pollution. Accordingly, research has been conducted to improve the depth or sharpness of the colour of dyed fibrous products made of synthetic fibres.

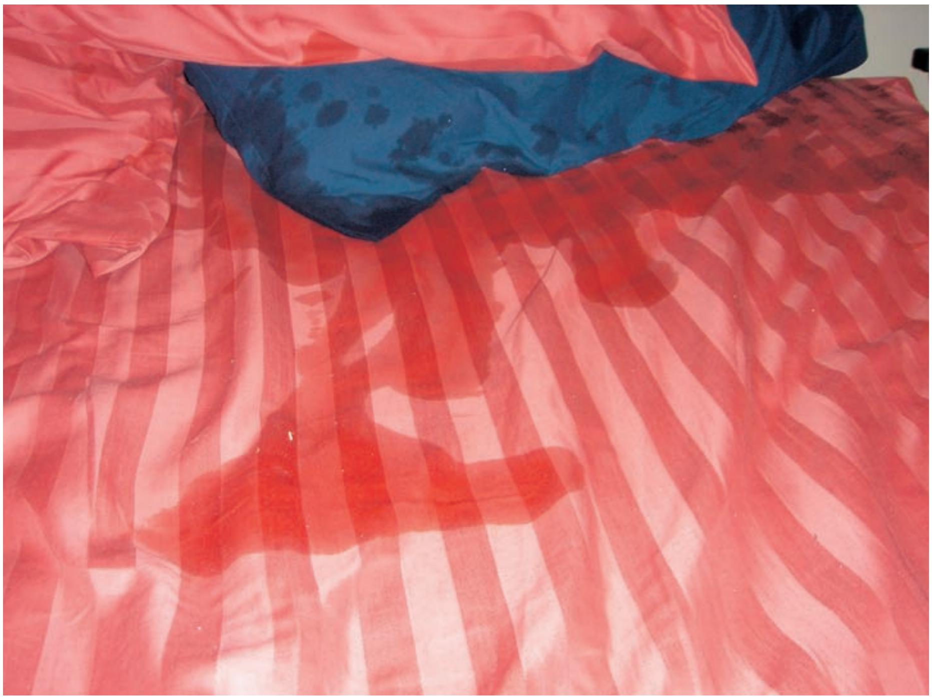


Figure 1: Material wetted with water looks deeper and sharper than the dry portion

In order to enhance the colour-deepening effect, by reducing the reflection of the surface layer and thereby increasing the quantity of light that is transmitted into the interiors of fibres in a dyed substrate, the formation of a layer with a reduced refractive index on the fibre surface is effective (refractive index less than 1.5). This results in a decrease in the lightness value (L value), which helps the textile dyer to increase the depth of the shade.

What is Lab colour space?

Lab is now more often used as an informal abbreviation for the CIE 1976 *(L*, a*, b*)* colour space (also called CIE Lab, whose co-ordinates are actually *L**, *a**, and *b**). The uses of CIE Lab include providing exact colour specifications for dyes, including textiles, plastics, etc, printing ink and paper. L*a*b* measurements are based on the Herrings Opponent Colour Theory, which states that red, green and blue signals get converted into three opponent channels – lightness/darkness, red/green and yellow/blue. The *L* component closely matches human perception of lightness. A colour expressed in the L*a*b* colour space is composed of L, a and b component values; ***a*** and ***b*** are termed opponent colour axes, where ***a*** represents (roughly) Redness (positive) versus Greenness (negative). The other opponent colour axis, ***b***, is positive for yellow colours and negative for blue colours, as shown in Figure 2.

In Lab measurements, for perfect white, *L* is 100 and for black it is zero. When *L* is 70, colour is light; when *L* is 50, colour is light grey, and when *L* is 25 or less, colour is medium grey. When it is 15, it is dark grey. And when *L* is near zero, it is black. There is no colour having $L = 0$. For *a* values, when *a* is positive, the colour is red, and when *a* is negative, the colour is green. A positive value of *b* indicates that colour is yellow, while negative indicates blue.

When *a* and *b* are both zero, that means the colour is neither red (or green) nor yellow (or blue). In simple words, it does not have any tone (or chroma). In colorimetric language, it is known as achromatic colour. Such colour may be neutral grey – light or dark – or black or white, depending on *L* value.

What is ΔE?

ΔE is a single number that represents the 'distance' between two colours and is intended to be proportional to the difference seen. An idea of the size of ΔE units can be gained by considering that the difference between black and white corresponds to 100 ΔE units, while commercial tolerances are often between 1 and 2 ΔE units. The idea is that a ΔE of 1.0 is the smallest colour difference the human eye can see. So any ΔE less than 1.0 is imperceptible. Unfortunately, and probably not surprisingly, it's not that simple. Some colour differences greater than 1 are perfectly acceptable, maybe even unnoticeable.

Differences in the colour can be quantified by ΔE according to the equation:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Colour Deepening Finish from Sarex

Today, though blooming agents are available in the market, all the blooming agents are applied by the padding technique. To the best of our knowledge there is no blooming agent available that can be applied by exhaust application. The present development relates to development of a

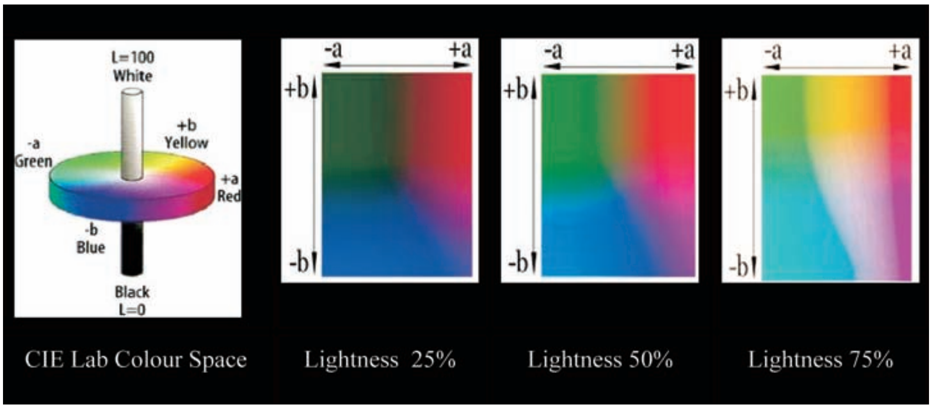


Figure 2

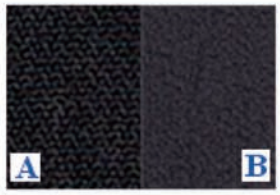
Substrate	Dark Knight 101 (4%)	
	Fabric 1	Fabric 2
Polyester Fabric		
Polyester/Viscose Fabric (65:35 blend)		
Polyester/Wool Fabric		
Cotton: Bottom weight		
Cotton: Knitted		

Figure 3: Fabrics finished with Dark Knight PAD (A: Finished substrate; B: Unfinished substrate)

Figure 4: Fabrics finished with Dark Knight 101 (A: Finished substrate; B: Unfinished substrate)

colour-deepening agent for synthetic as well as natural textiles – more particularly, a colour-deepening agent for improving the depth of a dyed substrate by exhaust application as well as by padding.

We, at Sarex, conducted research with a view to developing a colour-deepening agent that would be capable of forming a uniform film on synthetic as well as natural substrates, using a low temperature, which also helps to reduces the amount of energy required. We developed an aqueous composition of blooming agent, Dark Knight PAD and Dark Knight 101, capable of satisfying these requirements. It is interesting to note that these newly developed colour-deepening formulations for synthetics work by an entirely different route, without any hydrolysis process.

Results and Discussion

Generally, a blooming effect with higher colorant strength is obtained when the refractive index of the product and substrate is modified. With this principle, Sarex developed new-generation speciality products, viz. Dark Knight PAD for padding and Dark Knight 101 for exhaust. These products increase the depth of dark shades considerably, depending on the type of substrate.

During the study, the blooming agents Dark Knight PAD and Dark Knight 101 were applied on polyester, polyester/wool, polyester/viscose, cotton bottom weight and cotton knitted substrates of different constructions. The application was carried out by following techniques.

Application:

20-40 g/l Dark Knight PAD and 2-4% Dark Knight 101 were applied by a finishing bath at pH 5.0-5.5, by padding and exhaust methods respectively. In the case of pad application, padding was carried out for 65-70% expression, dried at 90°C for 2-3min and cured at 160°C for woven cotton and knit and 170°C for 60sec to polyester and its blends. Exhaust application was carried out at temperature 40°C for 30 minutes.

The results of % improvement in colour strength and *L* values are expressed in Table I and Table II, while pictorial representation is shown in Figures 3 and 4.

In the case of substrates treated with Dark Knight PAD by pad application the following results were observed:

- When two different varieties of polyester fabrics were finished with 20-40g/l Dark Knight PAD, improvement in colorant strength of 48-55% and 73-75% was observed with decrease in *L* value from 12.866 to 9.025 and 13.891 to 9.263 for fabrics Nos. 1 and 2 respectively.
- In the case of polyester/viscose fabrics finished with 20-40g/l Dark Knight PAD, fabrics Nos. 1 and 2 showed improvement in colorant strength of 33-44% and 50-55 % with decrease in *L* values from 18.099 to 14.225 and 17.386 to 13.096 respectively.
- Polyester/wool fabric finished with 20-40g/l Dark Knight PAD showed improvement in colour strength of 29-30% and 28-34 % for fabrics Nos. 1 and 2 and with decrease in *L* values from 15.271 to 12.709 and 14.219 to 11.532 respectively.
- Cotton bottom weight fabric finished with 20-40g/l Dark Knight PAD showed improvement in colour strength of 38-44% and 32-40% for fabrics Nos. 1 and 2, with reduction in *L* value from 16.975 to 13.333 and 18.040 to 14.429 respectively.
- Knitted fabric finished with 20-40g/l Dark Knight PAD showed improvement in colorant strength of 37-43% and a decrease in *L* value from 14.457 to 10.871.

In case of substrates treated with Dark Knight 101 by exhaust application, the following results were observed:

- Three different varieties of polyester fabric finished with 2-4% Dark Knight 101 showed improvement in colorant strength of 27-42 % and 16-21 % for fabric No. 1 and fabric No. 2 respectively, while fabric No. 3 showed 26-32% improvement in colour strength. Fabric finished with Dark Knight 101 showed a decrease in *L* values from 13.579 to 10.431, 12.525 to 11.128 and 12.110 to 9.845, for fabrics 1, 2 and 3 respectively.

- Application of 2-4% Dark Knight 101 on two different varieties of polyester/viscose fabric showed improvement in colorant strength of 14-16% and 29-41% for fabrics Nos. 1 and 2, with a decrease in *L* values from18.099 to 16.631 and 17.386 to 14.116 respectively.
- Polyester/wool fabrics finished with Dark Knight 101 showed improvement in colorant strength of 21-27% and 27-28% for fabrics Nos. 1 and 2, with a decrease in *L* values from 15.271 to 12.978 and 14.219 to 11.984 respectively.
- Bottom-weight fabrics finished with 2-3 % Dark Knight 101 showed an improvement in colorant strength of 11-23 % 12-20 % for fabric Nos. 1 and 2, with a change in *L* values from 14.457 to 12.429 and 15.840 to 15.035 respectively.
- Knitted fabric finished with 2-3% Dark Knight 101 showed improvement in colorant strength of 11-23 %, with a decrease in *L* value from 14.457 to 13.224.

Conclusion

From the above results it is clear that finishing with Dark Knight PAD shows improvement in colour value for polyester, polyester/viscose, polyester/wool, cotton bottom weight and knit fabric in the range of 30% to 75% by pad application. Polyester, polyester/viscose, polyester/wool, cotton bottom weight and knit-fabric substrates finished with Dark Knight 101 show improvements in colour values in the range of 15% to 40% by exhaust application.

This drastic improvement in the colour values of finished substrates is due to considerable decrease in the L values of treated material, as explained in Figure 2. Slight variation in the improved values depends on various factors, such as the construction, shade, etc, of the material.

In addition, Dark Knight PAD and Dark Knight 101 not only improve colour values but also impart a soft and pleasing handle to the finished material. Both the products are fast to domestic washing, with no thermomigration and no change in sublimation and wet fastness. ID

Table 1: Colorant strength and L value of fabrics finished with Dark Knight (PAD), by pad application

Finishing agents	Colorant strength,%	dE	Da	Db	L
Polyester Fabric					
Fabric 1 Untreated	100	-	-	-	12.866
20g/l Dark Knight PAD	148	3.373	0.177	0.055	9.498
40g/l Dark Knight PAD	155	3.944	0.856	0.265	9.025
Fabric 2 Untreated	100	-	-	-	13.891
20g/l Dark Knight PAD	173	4.910	0.625	1.544	9.272
40g/l Dark Knight PAD	173	4.934	0.331	1.679	9.263
Polyester/Viscose Fabric (65:35) Fabric					
Fabric 1 Untreated	100	-	-	-	18.099
20g/l Dark Knight PAD	133	3.242	0.841	-0.423	14.997
40g/l Dark Knight PAD	144	3.945	0.695	-0.267	14.225
Fabric 2 Untreated	100	-	-	-	17.386
20g/l Dark Knight PAD	150	4.162	0.547	0.595	13.303
40g/l Dark Knight PAD	155	4.399	0.563	0.792	13.096
Polyester/Wool fabrics					
Fabric 1 Untreated	100	-	-	-	15.271
20g/l Dark Knight PAD	130	2.571	0.130	0.167	12.709
40g/l Dark Knight PAD	129	2.412	-0.085	0.295	12.879
Fabric 2 Untreated	100	-	-	-	14.219
20g/l Dark Knight PAD	128	2.327	-0.022	0.518	11.951
40g/l Dark Knight PAD	134	2.741	0.112	0.530	11.532
Cotton: Bottom Weight Fabric					
Fabric 1 Untreated	100	-	-	-	16.975
20g/l Dark Knight PAD	138	3.244	-0.109	0.437	13.762
40g/l Dark Knight PAD	144	3.655	0.018	0.305	13.333
Fabric 2 Untreated	100	-	-	-	18.040
20g/l Dark Knight PAD	132	3.313	0.508	-1.030	14.932
40g/l Dark Knight PAD	140	3.807	0.548	-1.074	14.429
Cotton Knitted Fabric					
Untreated	100	-	-	-	14.457
20g/l Dark Knight PAD	137	3.656	0.386	-1.707	11.247
40g/l Dark Knight PAD	143	4.002	0.456	-1.718	10.871

Table 2: Colorant strength and L value of fabrics finished with Dark Knight 101, by exhaust application

Finishing agents	Colorant strength,%	dE	Da	Db	L
Polyester Fabric					
Fabric 1 Untreated	100	-	-	-	13.579
2%Dark Knight 101	127	2.251	0.380	0.731	11.484
4%g/l Dark Knight 101	142	3.194			10.431
Fabric 2 Untreated	100	-	-	-	12.525
2%Dark Knight 101	116	1.516	0.099	0.919	11.324
4%g/l Dark Knight 101	121	2.168	0.125	1.653	11.128
Fabric 3 Untreated	100	-	-	-	12.110
2%Dark Knight 101	126	2.056	-0.201	0.871	10.259
4%g/l Dark Knight 101	132	2.421	-0.039	0.855	9.845
Polyester/Viscose Fabric (65:35) Fabric					
Fabric 1 Untreated	100	-	-	-	18.099
2%g/l Dark Knight 101	114	1.676	0.689	0.422	16.631
4%Dark Knight 101	116	2.009	1.047	-0.136	16.390
Fabric 2 Untreated	100	-	-	-	17.386
2%Dark Knight 101	129	2.684	0.236	0.829	14.844
4%g/l Dark Knight 101	140	3.372	0.102	0.815	14.116
Polyester/Wool (52:48/65:35) Fabric					
Fabric 1 Untreated	100	-	-	-	15.271
2%Dark Knight 101	121	1.835	-0.008	0.510	13.508
4%g/l Dark Knight 101	127	2.356	0.166	0.515	12.978
Fabric 2 Untreated	100	-	-	-	14.219
2%Dark Knight 101	127	2.249	0.204	0.534	12.044
4%g/l Dark Knight 101	128	2.314	0.253	0.544	11.984
Cotton Bottom Weight Fabric					
Fabric 1 Untreated	100	-	-	-	14.457
2%Dark Knight 101	111	1.844	0.510	-1.273	13.224
3%g/l Dark Knight 101	123	2.202	0.315	-0.798	12.429
Fabric 2 Untreated	100	-	-	-	16.975
2%Dark Knight 101	112	1.456	-0.295	0.863	15.840
4%g/l Dark Knight 101	120	2.009	0.282	0.440	15.035
Cotton Knitted Fabric					
Untreated	100	-	-	-	14.457
2%Dark Knight 101	111	1.844	0.510	-1273	13.224
4%g/l Dark Knight 101	123	0.948	0.149	-0.176	13.224