OPTICAL BRIGHTENERS EFFECT ON WHITE AND COLOURED TEXTILES

M. Fátima Esteves,*[1], A. Cyrne de Noronha[2], R. Marques Marinho
[1] Dep. of Textile Engineering, School of Engineering, University of Minho, Campus of Azurém, 4800-058 Guimarães, Portugal
festeves@det.uminho.pt

[2] COELIMA, Indústrias Têxteis, SA,
Pevidém, 4835-368 Guimarães, Portugal

ABSTRACT **O-COL5**

Optical brighteners are colourless to weakly coloured organic compounds that, in solution or applied to a substrate, absorb ultraviolet light and re-emit most of the absorbed energy as blue-violet light between 400 and 500 nm. These compounds are included in commercial detergents formulation in order to increase whiteness and intensifying the colours. The aim of this work was to study several industrial situations related with colour changes after domestic washing. In order to achieve that, the effect of optical brighteners on white and coloured textiles was considered. The action of eight of the most known commercial detergents, on different colours, was tested. Among the selected washing agents, three of them were more specific products: a 'colour protector', 'for black and dark colours' and 'with active oxygen'. Fabrics with and without pre-brightening were tested. In all the cases, colour fastness tests to washing (with ECE detergent and standard soaps) and to rubbing were done in order to conclude about the influence of these parameters on final results.

KEYWORDS
Optical brighteners, whitening effect, brightness, colour fastness

1. INTRODUCTION

Natural fibres generally absorb more light in the blue region of the visible spectrum than in others because of impurities (as natural pigments) they contain. As a result, natural fibres take on an unwanted, yellowish cast. In the case of synthetic fibres the effect is not so pronounced. Whiteness in these substrates can be improved by the action of products named optical brighteners, fluorescent brightening agents or fluorescent whitening agents (FWA), by intensifying the whiteness level or the colour of the material [1].

A optical brightener or fluorescent whitening agent is a compound which, when applied to a textile material, absorbs the short wavelength electromagnetic radiation (300-400 nm) which is invisible to the human eye, and converts it into visible light of longer wavelength between 400 and 500 nm, which is emitted either as violet, pure blue or greenish blue. Chart presented in Figure 1 represents the situation. When this radiation is combined with the more yellowish self-colour of a textile material, a brilliant white is produced [2]. In coloured textiles, the presence of an optical brightener or fluorescent whitening agent will intensify the colours. In practice, this is not correct for all situations, as it will be presented in this work.

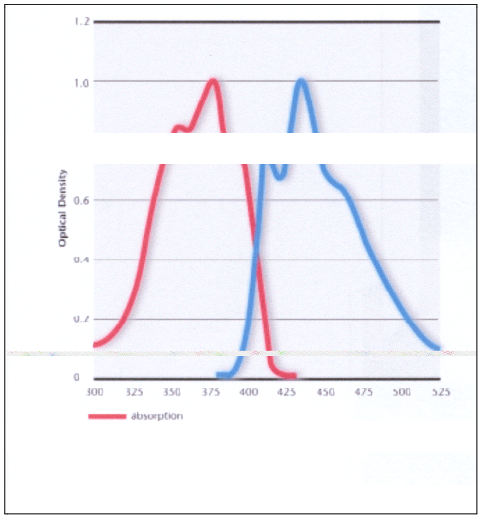

Figure 1 – Absorption and fluorescence emission curves for a FWA [3]

Before the use of FWA, common practice was to apply small amounts of blue or violet dyes (called 'bluing') to boost the visual impression of whiteness. These dyes absorb light in the green-yellow region of the spectrum, thereby reducing lightness. But, since at the same time they shift the shade of the yellowish material towards blue, the human eye perceives an increase of whiteness. Unlike blue dyes, optical brighteners offset the yellowish cast and at the same time improve lightness because their bluing effect is not based on subtracting yellow-green light, but rather on adding blue light [3]. In Figure 2, a schematic representation of physical principles of whiteness improvement is presented.

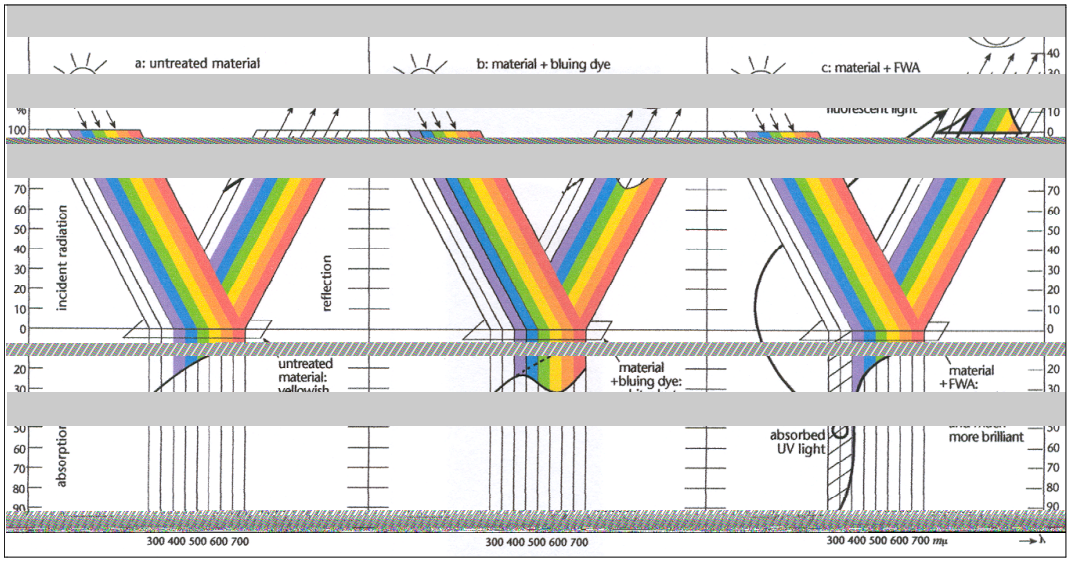

Figure 2 – Physical principles of whiteness improvement [3]

Several types of compounds can be used as optical brighteners like coumarins, naphthotriazolylstilbenes, benzoxazolyl, benzimidazoyl, naphthylimide and diaminostilbene [4]. In Figure 3 the structure of an industrial optical brightener is presented [5]. This is a product commonly used in textile industry for pre-brightening.

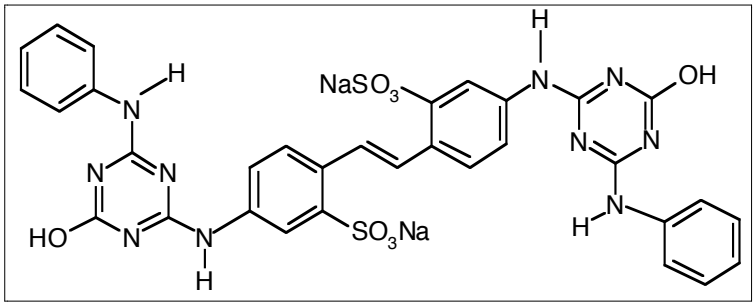

Figure 3 – Example of an optical brightener's structure (Blankophor B)

Textile materials like cotton or cotton/polyester blends are almost always pre-brightened when manufactured. This is because the printing and colours will be brighter and more attractive if applied to bright fabric. Moreover, the washing agents and commercial detergents available nowadays commonly have optical brighteners combined in them [6] and while washing the fabric gets whiter.

It is known that, in most cases, the presence of an optical brightener causes a decrease in the light fastness of a dyed fibre [7,8]. These compounds can also have a direct photochemical effect on the fibre in the absence of dyes, as in the case of wool. Optically whitened wool will yellow on exposure to light much faster than untreated wool by a photocatalytic process [9].

However, in coloured textiles, sometimes a difference on hue is detected already in the first domestic wash, even in the case of solid colours. This undesirable effect has been a considerable obstacle for several textile industries, with clients and consumers becoming more and more demanding. Therefore, it's important to study the effect in order to avoid, as much as possible, similar situations.

2. EXPERIMENTAL

2.1. Material

The aim of this work was to study the effect of optical brighteners on white and coloured textiles. The action of eight of the most known commercial detergents, on different colours, was considered. Among the selected washing agents, one was a 'colour protector', other 'specific for black and dark colours' and another 'with active oxygen'. The commercial detergents tested were: B, C, D, F, and H (five typical products for domestic laundering), A (colour protector), E (dark colours) and G (active oxygen). Fabrics with and without pre-brightening were tested. In all the cases, colour fastness tests to washing (with ECE detergent and two standard soaps) and to rubbing were done in order to conclude about the influence of these parameters on final results. Eleven fabrics with different compositions and colours were considered.

2.2. Experimental procedure

Washing with commercial detergents was considered as colour fastness to domestic and commercial laundering test, procedure according ISO 105-C06, at a temperature of 60ºC and cotton as test fabric.

Colour fastness tests to washing with ECE detergent and two standard soaps (according ISO 105-C06, at 60ºC, cotton as test fabric) were also carried out.

Colour fastness tests to rubbing (according ISO 105 X12, cotton as test fabric, ten cycles) were also considered.

In each case, change in colour of the specimen (according ISO 105-A02) and staining of the test fabric (according ISO 105-A03) were assessed with suitable grey scale, under daylight conditions.

The effect of three different industrial optical brighteners was also considered by the pre-brightening of fabrics 7, 8 and 9, with 1 and 2 gL^{-1} of product, followed by washing with detergents A and C.

Finally, adjustments were made in order to find the best colour combinations in order to reduce the difference between initial and final situation.

3. RESULTS AND DISCUSSION

Results to colour fastness to washing with ECE detergent and two standard soaps are presented in Table 1. Fabrics without pre-brightening.

Table 1 – Colour fastness to washing

Fabric	ECE detergent		Std. Soap 1		Std. Soap 2	
	Staining	Col.ch.	Staining	Col.ch.	Staining	Col.ch.
1 (PES/CO, yellow)	4	4	4	4	4-5	4-5
2 (PES/CO, orange)	4	4	4-5	4	4-5	4-5
3 (PES/CO, brown)	3-4	3-4	4	3	4-5	3-4
4 (CO, pale blue)	4-5	4	4-5	4	4-5	4
5 (CO, blue)	4-5	4	4-5	4	4-5	4
6 (CO, green)	4-5	4-5	4-5	4-5	4-5	4-5
7 (CO/CMD, rose)	4	4	4	4	4	4
8 (CO, red)	4	4	4	4	4	4
9 (PES/CO, dark red)	3	4	3-4	4	4	4
10 (CO/CMD, blue)	4-5	4	4	4	4	4
11 (CO/CMD, lilac)	4-5	4	4-5	4	4-5	4

Results to colour fastness to rubbing are presented in Table 2. Fabrics without pre-brightening.

Table 2 – Colour fastness to rubbing

Fabric	Staining	
	Dry	Wet
1	4-5	4-5
2	4-5	4
3	5	4-5
4	5	4-5
5	4-5	4-5
6	4-5	4-5
7	4	4-5
8	4-5	4
9	4	3-4
10	4-5	4
11	4-5	4

Results to colour fastness to washing with the several commercial detergents are presented in Tables 3 and 4. Fabrics without pre-brightening.

Table 3 – Colour fastness to washing with commercial detergents

Fabric	Detergent A		Detergent B		Detergent C		Detergent D	
	Staining	Col.ch.	Staining	Col.ch.	Staining	Col.ch.	Staining	Col.ch.
1	4-5	4-5	*4-5	4-5	*4-5	4-5	*4	4
2	4-5	4-5	*4-5	4-5	*4	4-5	*4	4-5
3	4-5	3-4	*4-5	3	*3-4	3	*3-4	3
4	4-5	4-5	*4-5	4	*4-5	3-4	*4-5	3
5	4-5	4-5	*4-5	4	*4	4	*4	4
6	4-5	4-5	*4-5	4-5	*4-5	4	*4	4-5
7	4-5	4	*4	4	*4-5	4	*4-5	4
8	4-5	4	*4	4	*4	4-5	*4	4
9	4	4	*4	4	3-4	4	3-4	4
10	4-5	4-5	*4-5	4	*4-5	4-5	*4-5	4-5
11	4-5	4	*4-5	4	*4-5	3-4	*4-5	3-4

Table 4 – Colour fastness to washing with commercial detergents

Fabric	Detergent E		Detergent F		Detergent G		Detergent H	
	Staining	Col.ch.	Staining	Col.ch.	Staining	Col.ch.	Staining	Col.ch.
1	4-5	4-5	*4	4-5	4-5	4-5	*4-5	4-5
2	4-5	4	*4	4	4-5	4-5	4	4
3	4	3-4	4	3	4-5	3	*4-5	3-4
4	4-5	4-5	*4-5	3-4	4-5	4	*4-5	4
5	4-5	4-5	*4	4	4-5	4-5	*4-5	3-4
6	4-5	4-5	*4	4-5	4-5	4-5	*4-5	4-5
7	4-5	4	*4-5	4	4-5	4	4	4
8	4-5	4	*4	4	4-5	4	4	4
9	4	4	3-4	4	3-4	4	4	4
10	4-5	4-5	*4-5	4	4-5	4-5	*4-5	4
11	4-5	4	*4-5	3-4	4-5	4	*4-5	3-4

In several cases, an increase in brightness of the test fabric was noticed after washing. The corresponding assessed staining values were marked as *.

Considering experimental results in Table 1, we can see that colour fastness to washing with ECE detergent and standard soaps are good, except for fabrics 3 and 9. Results concerning Table 2 show also a high fastness to rubbing, except for fabric 9. In Tables 3 and 4 can be remarked that detergents A, E and G do not present evidence of optical brighteners or to have them in slight amount. Experimental results agree with fastness values in Table 1. On the other hand, detergents B, C, D, F and H appear to have optical brighteners in their formulation, increasing brightness of test fabrics. The effect is not perceptible when a higher level of staining is concerned, as in the case of fabric 9. Besides, fabrics 3 and 9 present the more significant change in colour, as well fabric 11. In this last case, a slight staining corresponds to a higher change in color, probably related with the presence of optical brightener. Also fabric 4 presents with detergents D and F a significant change in colour, in spite of a staining degree of 4-5 in this test and a colour fastness to washing with ECE and standards soaps of 4.

Later on, results concerning pre-brightening of fabrics 7, 8 and 9, with 1 and 2 gL^{-1}, followed by washing with detergents A and C showed that, in the first case, the effect of the optical brightener was annulled. Apparently, the increase in brightness due to presence of optical brightener was canceled by detergent A. Pre-brightening white cotton washed with detergent A showed exactly the same result. Fabric 8 presented the best results when washing with detergent C is considered. The opposite situation was found for fabric 9, being the effect even more stressed in the case of higher concentration of optical brightener.

A new selection of colours was considered with the aim of correct, if possible, the effect of optical brighteners by an adjustment of the colour, in order to avoid considerable colour changes. The new set of colours is indicated in Table 5, as well colour fastness to washing with ECE detergent, standard soap 1 and detergent H. The fabrics were pre-brightened with a concentration of 1 gL^{-1}.

Table 5 – Colour fastness to washing

Fabric	ECE detergent		Std. Soap 1		Detergent H	
	Staining	Col.ch.	Staining	Col.ch.	Staining	Col.ch.
12 (bright green)	4-5	4	4-5	4	*4-5	4
13 (dark beige)	4-5	4	4-5	4	*4-5	3-4
14 (light beige)	4-5	4	4-5	4	*4-5	4
15 (rose)	4-5	4	4-5	4	*4-5	4
16 (blue)	4-5	4	4-5	4	*4-5	4
17 (light orange)	4-5	4	4-5	4	*4-5	4
18 (pale blue)	4-5	3-4	4-5	3	*4-5	3-4

A considerable number of attempts were made in other to achieve a final colour that, after the first domestic wash, could correspond to a smaller colour change. By reasons of practical order, washings were made with detergent C (instead of detergent H).

In the case of colours 15 and 17 it was possible to find adjustments of the initial colour that could result in an acceptable colour change after washing. In Table 6 ΔE values (corresponding to colour differences) are presented for each case. The limit value for ΔE was considered 1.20 and only one case (15b) presented a lower value.

Table 6 – ΔE values after colour adjustments

Fabric	ΔE values	
	Before washing	After washing
15a	1.56	3.14
15b	0.66	1.05
17a	1.43	1.48
17b	2.18	2.12

4. CONCLUSION

As first conclusion we can say that most of the typical commercial detergents of domestic use appear to contain a considerable amount of optical brighteners.

The effect of optical brighteners on coloured textiles appears to be different depending on colour, that is to say, on the corresponding region of the spectrum. It seems to be more visible on the violet-blue colours and almost insignificant on orange and red. However, even in these colours a slight effect can be observed in case of lower fastness.

The lighter the colour is more intense the optical brightener's effect can be, even in colours with a good fastness. Dark colours presenting lower fastness to washing showed only a small difference on hue.

The effect of optical brighteners was considerably more evident on fabrics submitted to pre-brightening and washed with detergent C, particularly in concentration 2 gL^{-1} of whitening agent. Washed with detergent A, after being washed with detergent C, fabrics presented a clear reduction of the effect.

Actually, this kind of situation can be rather difficult for textile industries, the problem being related not with colour fastness but with brightner's optical effect on specific colours and hues. A possible way to avoid it will be the study of the effect before it happens, which means select, test and correct the colours where the effect can be minimized. This was done in the following of the present work, with a selection of new colours. It is not, for sure, the easiest way to solve the problem. Moreover, the presence of optical brighteners in domestic washing agents formulation, particularly in the case of light colours, seams to be the most important aspect to consider.

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