

# Influence of Dendrimer Finishing on Color Assessment of Co/PES Blended Fabrics

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## Abstract

This research focuses on the assessment of color modifications occurring on the dyed cotton/polyester blended fabrics due to the nanoparticle sized dendrimer, dendrimer-fluorocarbon and fluorocarbon finishing which can substantially alter surface properties. Thanks to the nanoparticle size, the fabric surface area is increased improving the interaction with the matrix polymer. By this way highest performances are achieved in some typical textile finishing applications. A remarkable influence of finishing onto reflectance and color difference of fabrics were observed. In fact, roughness influences the surface reflectance, as it increases the scattering of light thus decreasing surface reflectance. Particle sizes of chemicals designate the distribution and orientation of surface roughness and in addition the overlay of their absorbance values in the short wavelength results in color differences.

## 1. Introduction

Chemical finishing procedures are widely used to improve the properties of natural and synthetic fibers and fabrics. For this purpose, textile materials are treated with different functional finishes, such as repellent, durable press, soil-release, flame retardant, antistatic, and antimicrobial (Cerne 2004). During the last few years, finishes that repel water and oil are gaining relevance in many textile applications (Schindler 2004). Water repellent finishing on fabrics is mostly imparted by the incorporation of low surface energy compounds, accompanied by the increase of the contact angle of liquids on its surface. Recent approaches are based on the use of nanoparticles such as highly branched 3D surface functional macromolecules called dendrimers to enhance water repellency. Dendrimer effect mechanism on repellency depends on being in a position to build-up crystal structures in nano-range which produces wash-permanent, water-repellent and highly abrasion resistant effects. When combined with fluoropolymers dendrimers force them to co-crystallize leading to a self-organization of the whole system and to an enrichment of the fluoro polymers on the most outer layer of the textile (Schindler 2004). Functionality and properties of dendrimers can be changed by filling their cavities or modifying core and chain-ends (Tully 2001). Conformational flexibility of dendrimer branches is capable of placing their hydrophilic interior in contact with aqueous subphase, extending their chains into the air above the air–water interface (Menger 2001). For dendrimer effect on interfacial properties, phase isotherms, conformational states, significance of small and mobile dendrons on construction of stable and ordered films should also be taken into consideration (Ahmad 2006). Particle size of these repellent finishes also plays a vital role because, when the inorganic particle size is reduced, the surface area is increased; this leads to good interaction with the matrix polymer, and the highest performance is achieved (Mani 2003). When the size of the particles is reduced to a nanometer range, they can substantially alter surface properties in some typical textile finishing applications and show the less effect on the color change which can be explained by a smoother reflecting surface (Qian 2004). In this study the effect of particle size on

surface roughness and color assessment after treatment of cotton/polyester fabrics were evaluated. For this purpose, three types of commercially available reagents (dendrimer water repellent, fluorocarbon included dendrimer water-oil repellent and fluorocarbon water-oil repellent) were compared, for two kinds of disperse dyes. Moreover, water and oil repellency performances were measured as well as mechanical properties. Reflectance, color coordinates and absorbance curves of treated and untreated samples were then measured, allowing to fully understand the color changes due to the different finish and disperse dye combination.

## 2. Experimental

### 2.1. Fabrics

Scoured and bleached woven Co/PES fabrics (95 g/m<sup>2</sup>) were employed in this study. Each sample (10 g) was immersed for 30 minutes at 60°C in 5 g/L ECE solution with 0.5 g/L soaking agent, in a conical flask with a continuous shaking. ECE is a non phosphate detergent to be used in the ISO 105 series of color fastness test, free from fluorescent brightening agent. The samples were then thoroughly rinsed and dried at room temperature and stored at laboratory conditions (25 ± 2 °C and 65 ± 2% relative humidity).

### 2.2. Dyes

Commercial Remazol (Dystar) reactive dye with vinylsulphone groups (Reactive Red 180) was used for dyeing cotton component; Terasil (Ciba) disperse dyes with azo (Disperse Red 82) and anthraquinone (Disperse Red 60) groups were used for dyeing polyester component (Table 1).

**Table 1 - Reactive and disperse dyes used**

Commercial name	$\lambda_{max}$	C.I. generic name
Remazol Red F3B	541	Reactive Red 180
Azo Terasil Red 3BL-01 150%	603	Disperse Red 82
Anthraquinone Terasil Red FBN	589	Disperse Red 60

Figure 1 reports their molecular structures. All dyes were of commercial grade and were used as received.

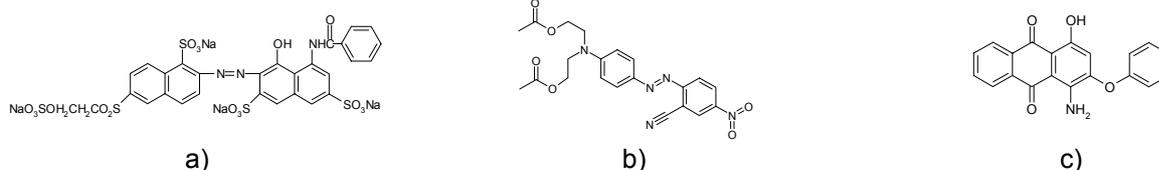


Figure 1 – a) Reactive Red 180 (Remazol Red F3B), b) Disperse Red 82 (Azo Terasil Red 3BL-01 150%) and c) Disperse Red 60 (Anthraquinone Terasil Red FBN)

### 2.3. Dyeing agents

All chemicals are commercial products. For level and consistent dyeing of Co/PES fabrics, Bersol CM (1g/L) (sequestering agent by Europizzi, Italy), Berdet WF (1g/L) (wetting agent by Europizzi, Italy), Depsolube ACA (1g/L) (anti-creasing agent from Basf, Italy) and Super NSI (dispersing agent by Europizzi, Italy) were used.

### 2.4. Repellents

Under patent dendrimer water repellent (density = 1.1 g/cm<sup>3</sup>), fluorocarbon/dendrimer water-oil repellent (density = 1.03 g/cm<sup>3</sup>) and also fluorocarbon water-oil repellent (density = 1.03 g/cm<sup>3</sup>) provided by Rudolf Chemie (Turkey and Italy) were used as finishing agents and coded as DWR, DWOR and FWOR respectively.

## 2.5. Buffer

The pH 5.5 buffer used for dyeing, neutralization and finishing applications comprised acetic acid ( $9.60 \text{ g dm}^{-3}$ ) and sodium acetate ( $3.56 \text{ g dm}^{-3}$ ). Chemicals were obtained from Sigma-Aldrich (Germany) and are of analytical grade.

## 2.6. Dyeing

Untreated fabrics were dyed using proper methods depicted in Fig. 2, depending on selected dyes. In particular, for both methods, all dyeing agents are added together then heated up to a proper temperature level ( $60^\circ\text{C}$  for reactive dye and  $130^\circ\text{C}$  for disperse dyes). Reactive and disperse dyeing were carried out using a liquor ratio of 10:1 and 15:1 respectively. Samples were then washed, rinsed and eventually neutralized at proper temperature levels, to be finally left to dry under laboratory conditions.

## 2.7. Application of repellents

Dyed Co/PES samples were padded separately in aqueous baths with finishing chemicals (DWR DWOR and FWOR). All of the three products were applied to the fabrics with the pad-cure method, including full immersion into the bath to a wet pick-up of 60-80% at  $20^\circ\text{C}$  and were cured at  $140\text{-}150^\circ\text{C}$  for 120 seconds. The application conditions for the three tested finishes are reported in Table 2: for all of the products two different concentrations were investigated. Both of the concentration values applied for each three finishing chemicals are in the range recommended by the supplier.

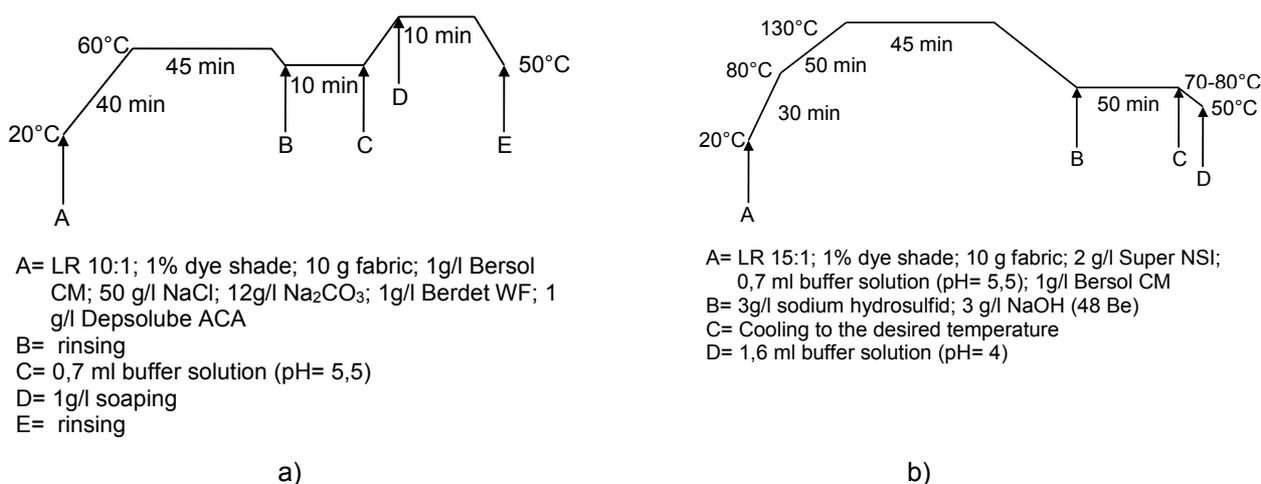


Figure 2 - Dyeing profile method for a) reactive and b) disperse dyes.

**Table 2** - Dendrimer and fluorocarbon application conditions

Conditions	DWR		DWOR		FWOR	
	80	130	30	50	30	50
Concentrations (g/L)	80	130	30	50	30	50
Pick up (%)	60-80		60-80		60-80	
pH	5-5.5		5-5.5		5-5.5	
Fixation temp ( $^\circ\text{C}$ )	150		140		150	
Fixation time (min)	2		2		2	

## 2.8. Particle size measurement

Particle size measurement of the finishing agents was performed with a Malvern Instruments Mastersizer 2000. During the laser diffraction measurement, particles are passed through a focused laser beam. These particles scatter light at an angle that is inversely proportional to their size. The angular intensity of the scattered light is then measured by a series of photosensitive detectors. The number and positioning of these

detectors in the Mastersizer 2000 has been optimized to achieve maximum resolution across a broad range of sizes.

### 2.9. Textile Testing

Grams per square meter GSM ( $\text{g/m}^2$ ), tensile strength TS (N) and elongation at break ELB (%) of Co/PES fabrics were also measured for all of the applications. GSM is a standard measurement of fabric weight per unit area carried out as follows: the weight of samples with the size of  $20 \text{ cm}^2$  was measured by a Mettler balance ( $\pm 10^{-5} \text{ g}$ ). The percentage change of fabric weight was calculated with Equation (1).

$$\text{Weight change (\%)} = \frac{W_1 - W_0}{W_0} \times 100 \quad (1)$$

where  $W_1$  is the weight of the substrate after treatment and  $W_0$  is the initial weight of the untreated substrate. Tensile strength and breaking elongation were measured according to ISO 13934-1, using standard test methods on dynamometer Instron Tensile Tester model 4501 (CRE). To thoroughly evaluate both water and oil repellency, these performances were measured after abrasion, washing and iron treatments. Water and oil repellency tests were reformulated after 5 and 15 repeated home launderings carried out at  $40^\circ\text{C}$ , as described in the ISO 6330, followed by tumbler drying at  $80^\circ\text{C}$  for 20 min. Half of the samples were also ironed at  $150^\circ\text{C}$  for 60 seconds for observation of heat effect on recovery of repellency. The abrading cycles of the treated and control fabric samples were performed on a Nu-Martindale abrasion tester (Mesdan Italy) according to ISO 12947-3 with two different abrasion cycles (150 and 300). Water resistance tests measure the resistance to surface wetting, water absorption and penetration. To determine the extent of surface wetting, the ISO 4920 spray test was used. Oil repellency was measured according to ISO 14419.

### 2.10. Surface reflectance and roughness measurement

The reflectance of undyed samples (untreated and treated) was measured with a Lambda 950 Perkin Elmer apparatus, equipped with an RSA-PE-150 Labsphere accessory for reflectance measurements. Each reflectance value  $R$  (%) was determined as the average of four measurements, with an experimental error of about 1-2%. For a randomly rough surface having a Gaussian type surface heights distribution, the reflectance can be expressed as follows:

$$R_r = R_s \exp[-(4\pi\sigma \cos i / \lambda)^2] \quad (2)$$

where  $R_s$  and  $R_r$  are the specular reflectance of perfectly smooth and rough surfaces, respectively;  $\sigma$  is the standard deviation of the surface from its mean level, function of the surface roughness; and  $i$  and  $\lambda$  are the incident angle and wavelength of light, respectively. According to equation (2) specular reflectance reduces increasing the surface roughness which rises the scattering of light and decreases the surface reflectance, or vice versa (Jang 2006). So small particle sized chemicals, having a higher surface area, give a more uniform dispersion and thus a smoother reflecting surface.

The morphological changes of fabrics after finishing were investigated by an AutoProbe CP Research Atomic Force Microscope (AFM) (ThermoMicroscopes, USA). Square areas of  $1 \mu\text{m}$  side (X-Y dimensions) were scanned, operating in non-contact mode. All AFM images were collected in air at room temperature. Changes in surface roughness of treated fabrics were expressed as differences in the root-mean-square of the vertical Z dimension values within the examined areas, which were calculated using the following equation:

$$RMS_{xy} = \sqrt{\sum_{x,y=1}^N \frac{(z_{x,y} - z_{average})^2}{N^2}} \quad (3)$$

### 2.11. Absorbance measurement and color difference assessment

The ultraviolet–visible absorption spectra of finishes were recorded on a Thermo Nicolet Evolution UV–Vis 500 spectrophotometer and Vision 32 software, using a 1 cm path length cell. All the spectra were recorded at room temperature in the wavelength range from 750 to 350 nm at the rate of 300 nm min<sup>-1</sup>. Finish/dye solutions were evaluated from the change of absorbance at the  $\lambda_{\max}$  of the dye in the UV-Vis spectra of the sample solution.

The color coordinates of dyed cotton/polyester (untreated and treated) samples dyestuffs selected for dyeing Co/PES fabrics were measured on the same spectrophotometer used for absorbance measurement equipped with an integrating sphere with a 10mm opening, under a D65/10<sup>0</sup> illuminant according to ISO 105 J01. Total color difference ( $\Delta E$ ) values, in the three-dimensional color space, were calculated as follows from  $\Delta L^*$ ,  $\Delta a^*$  and  $\Delta b^*$  values given by CIELAB system (eq. 4):

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad (4)$$

## 3. Results and Discussion

### 3.1. Particle size and surface roughness

The nano particle size measurements for DWR, DWOR and FWOR finishing agents have shown that all of the chemicals in the three products have dimensions in the nano range. Only DWR shows another concentration peak between 10-100 nm that can be due to a self-assembling of dendrimers (Dykes 2001). From these results specific surface areas of nano particles were determined: 6,6 m<sup>2</sup>/g, 38 m<sup>2</sup>/g and 40,1 m<sup>2</sup>/g for DWR, DWOR and FWOR respectively. Particle surface area increases as the particle size decreases. In fact, the highest particle surface area is achieved when there is a high concentration of nanometer or sub-nanometer sized particles. This is the reason why a higher concentration of DWR product is required to obtain the same repellency effects of DWOR and FWOR. From AFM measurements the distribution of particles fixed to the fabric treated with the three different finishes was evaluated. Table 3 compares the concentration and RMS<sub>x,y</sub> values of treated and untreated samples. For the selected chemicals concentrations, as expected, the smaller the particle size the smoother the polymer over the textile surface. Anyway, samples before and after dendrimer and fluorocarbon finishing have very similar mechanical properties, and in a range that is intrinsic to the raw material.

**Table 3** - Surface characterization by AFM of untreated and treated samples.

Samples	Concentrations (g/l)	RMS (Root-mean-square) nm
Untreated	0	25.41
DWR	80	13.7
DWOR	50	6.9
FWOR	50	7.1

### 3.2. Repellency measurements

Figure 3 reports water repellency test results for the three different finishing. In each picture, data belonging to the two different concentrations and after abrasion and laundering with and without iron are reported. In particular, the first column refers to data obtained just after the treatment; the two following columns testify the influence of abrasion on water repellency while the last four data quantify the combining effects of washing and ironing. Data for the untreated fabrics are not reported here, as no repellency behavior was detected. For all of the three different treatments water repellency was initially the same. From the presented results it can be observed that a high water repellency degree can be reached when dendrimers are combined with fluorocarbon polymers (FWOR). In this case, a reduced influence of finish concentration was also observed. After abrasion

and washing processes a decrease of performance took place particularly for lower concentrations. The binding properties of dendrimers give acceptable fastness values to the textile surface, resulting in an abrasion resistant repellency effect. The testing strategy already used for water repellency was also applied for oil repellency. It has to be underlined that samples treated with DWR showed no oil repellency effect. A possible reason can be related to the surface energy of DWR with respect to the oil surface tension (20-35 mN/m): this difference plays an important role against repellency over the textile surface. This is not the case for the two other finishes, thanks to the presence of fluoro carbon groups, giving DWOR and FWOR a very low critical energy of 6 mN/m, beneficial for oil repellency effect (Duschek 2001). The change in oil repellency for these last two products is shown in Figure 4.

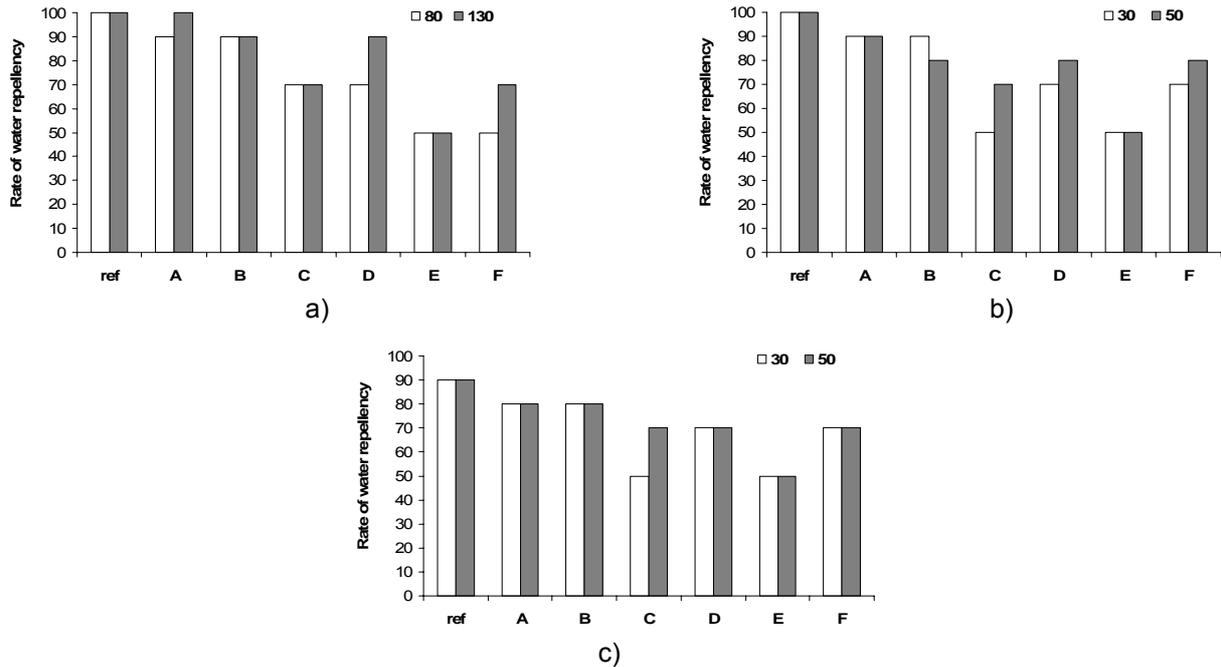


Figure 3 - Water repellency a) after DWR finish at 80 g/L and 130 g/L concentrations, b) DWOR finish at 30 g/L and 50 g/L concentrations and c) FWOR finish at 30 g/L and 50 g/L concentrations after: application alone (ref); 150 cycles of abrasion (A); 300 cycles of abrasion (B); laundering (5 cycles) (C); laundering (5 cycles) and ironing (D); laundering (15 cycles) (E); laundering (15 cycles) and ironing (F).

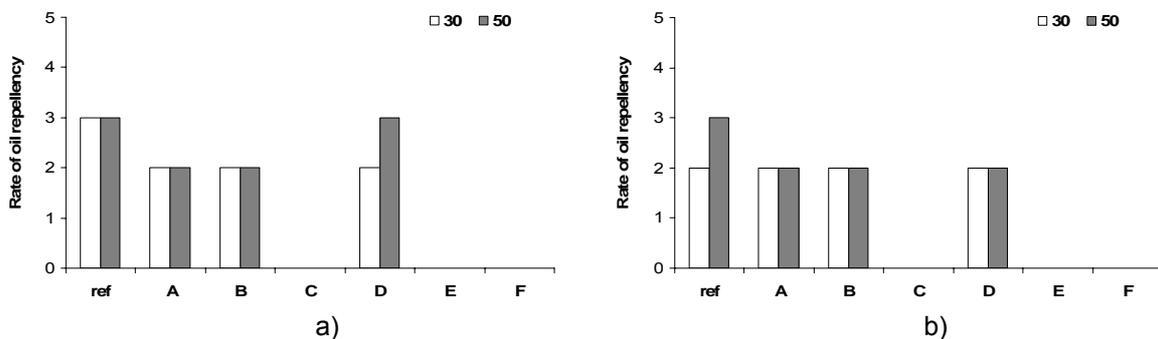


Figure 4 - Oil repellency after a) DWOR finish at 30 g/L and 50 g/L concentrations and b) FWOR finish at 30 g/L and 50 g/L concentrations after: application alone (ref); 150 cycles of abrasion (A); 300 cycles of abrasion (B); laundering (5 cycles) (C); laundering (5 cycles) and ironing (D); laundering (15 cycles) (E); laundering (15 cycles) and ironing (F).

The effect of concentration is more evident on FWOR treated samples with respect to DWOR; this is probably due to the orientation of fluorocarbon chains achieved by

dendrimers. For this reason even the lower concentration of DWOR is more efficient than FWOR that does not include dendrimers (Duschek 2004). Despite sufficient fixation, textiles finished with fluorocarbon suffer from a clear loss in effect after washing. This is due to the unfavorable conditions for the FC polymers prevailing in the washing machine. In fact surface-active surfactants, the extremely polar medium water, the elevated temperature of at least 40°C in combination with the mechanical influence lead to the fact that the orientated fluorocarbon chains “dive away” as soon as possible from the edge or that they are at least very much disturbed. As seen from the results, the polymer is still on the substrate; however, the side chains are in disorder and this is the reason why no oil and a reduced water repellent effects appear. As the melting temperature of fluorocarbon chains is at about 80-90°C, the fluorocarbon finish is not able to spontaneously regenerate at the room or drying temperature. A simple ironing and thus the heating up of the textile over the melting temperature of the fluorocarbon chains would be often sufficient to reorganize the finishing and to reproduce the performance level (Duschek 2001). In conclusion, DWOR shows better water and oil repellency performances when compared to DWR and FWOR. Similar optimal water repellency rates are obtained with a 130 g/L concentration of DWR and with a 50 g/L concentration of the two other finishes. But DWR finish did not show any oil repellency effect.

### 3.3. Color difference measurements

Color-difference evaluation in the visible waveband (400-700 nm) is depicted in Figure 5 for the three tested finishes on the Co/PES fabric samples. Beside the reactive dye used for the cotton component, two disperse dyes for PES component are compared: Azo and Anthraquinone disperse dyes, both combined with vinylsulphone reactive dye (VS).

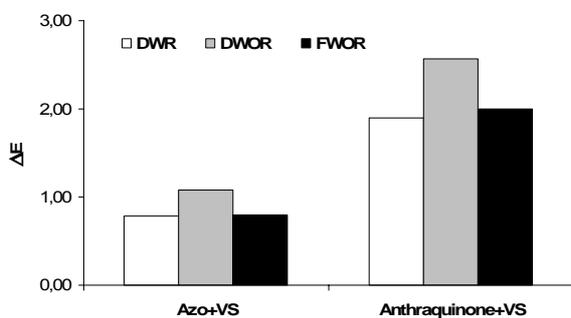


Figure 5 - Color differences between treated (with DWR, DWOR and FWOR) and untreated dyed Co/PES fabric samples.

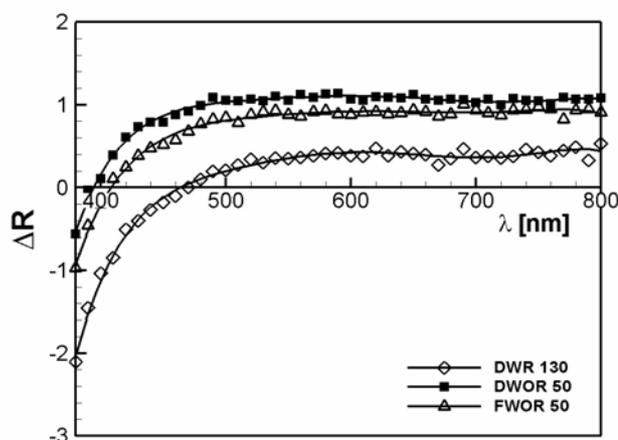


Figure 6 - Reflectance differences of DWR, DWOR and FWOR at the best water and oil repellency performance concentration (DWR 130 g/L; DWOR 50 g/L; FWOR 50 g/L).

Color matching as depicted in Figure 5 and  $\Delta L^*$ ,  $\Delta a^*$ ,  $\Delta b^*$  values of red dyestuffs selected for dyeing in Table 4 show a remarkable influence of finishing onto color difference of textile. This can be due to many factors, as a change in surface roughness or in absorbance values in the visible range.

**Table 4** - Color differences ( $\Delta L^*$ ,  $\Delta a^*$ ,  $\Delta b^*$ ) between dyed samples after DWR, DWOR and FWOR treatment on Co/PES fabrics.

Dye groups	$\Delta L^*$			$\Delta a^*$			$\Delta b^*$		
	DWR	DWOR	FWOR	DWR	DWOR	FWOR	DWR	DWOR	FWOR
Azo+VS	0.25	0.64	0.65	0.65	0.87	-0.29	-0.35	0.04	-0.14
Anthraquinone+VS	0.51	1.36	-0.21	1.73	2.08	-0.15	-0.59	-0.66	-0.41

### 3.4. Reflectance difference measurements

As already said, one of the major reason for color modification after finishing can be related to a surface roughness change. Figure 6 reports the distribution of reflectance difference ( $\Delta R$ ) over the waveband (380-800 nm).  $\Delta R$  values are computed as the difference between the finished and untreated sample results. Three curves are reported, each one related to a different finishing product. Only data corresponding to the finish concentration that gives the best water and oil repellency performance are reported. The results reveal that the fabric treatment changes the reflectance values of the fabric, depending on the chemical type; samples treated with chemicals that are smaller in particle size generally give higher reflectance values than untreated samples except in the short wavelength of visible spectrum. This pronounced decrease may be related to the height of the surface roughness, which can scatter short wavelength of the visible spectrum. As Figure 6 shows, the three finishes have similar curve of reflectance. After a rapid rise, all three curves stabilize around an almost constant level of about 0.4 for DWR, 0.9 for FWOR, and 1.1 for DWOR. This points out that, for  $\lambda > 500$  nm, all the agents have a refractive index higher than the fabric itself. The different level exhibited by the three finishes can be explained by the difference in the measured particle size values: in fact, DWR is characterized by a particle size much higher than that of DWOR and FWOR. Samples treated with fluorocarbon resins exhibit a stronger increase in the reflectance and positive values over most of the investigated wavelength domain. A smaller particle size thus allows the finishes to have a high surface area and obtain a uniform dispersion in the fabric to give a smoother reflecting surface. This behavior is even more pronounced when fluorocarbon is combined with dendrimers (DWOR). Again this can be related to a higher orientation of fluorocarbon chains achieved by dendrimers.

### 3.5. Absorbance measurements

Another effect of finishing agents on color difference can be correlated to their absorbance in the visible range. Figure 7 compares the absorbance curves measured over the 350-750 nm wavelength range for the three tested finishes. The concentrations selected for the measurement are related to the application concentrations of the products over the textile surface. In particular, two concentrations were tested for DWR: beside the 130 g/L concentration already tested for water and oil repellency, the same concentration applied to the two other finishes (50 g/L) was also tested. This is a low concentration level for DWR and was included for comparison.

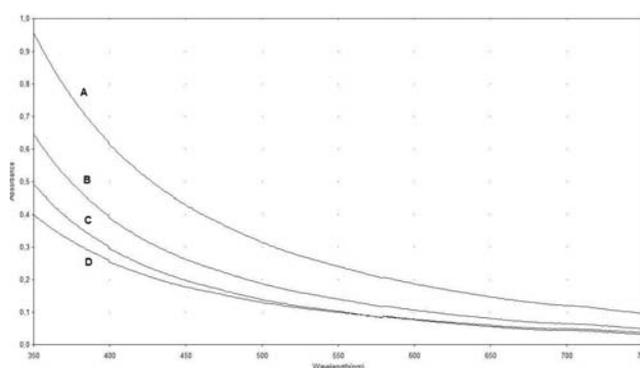


Figure 7 - Absorbance spectrum of DWR (A:1.30 g/L; D: 0.50 g/L), DWOR (B: 0.50 g/L), FWOR (C: 0.50 g/L) solutions in the visible range.

As shown in Figure 7, there are two distinct zones in each absorbance curve. The first zone approximately corresponds to 350-500 nm range; here a stronger absorption of products and higher difference between the four curves take place. Then, the rate of

absorbance gradually reduces and so the difference becomes smaller. This is valid under the same concentrations (B, C, D: 0.50 g/L). For DWR the absorbance increases with concentration. The absorbance curves for the three products are reported in Figure 8 for two different groups of the disperse dyestuff always combined with VS reactive dye in equal portion. Equal ratios of the dyestuff combination and water/product solutions are also shown for comparison.

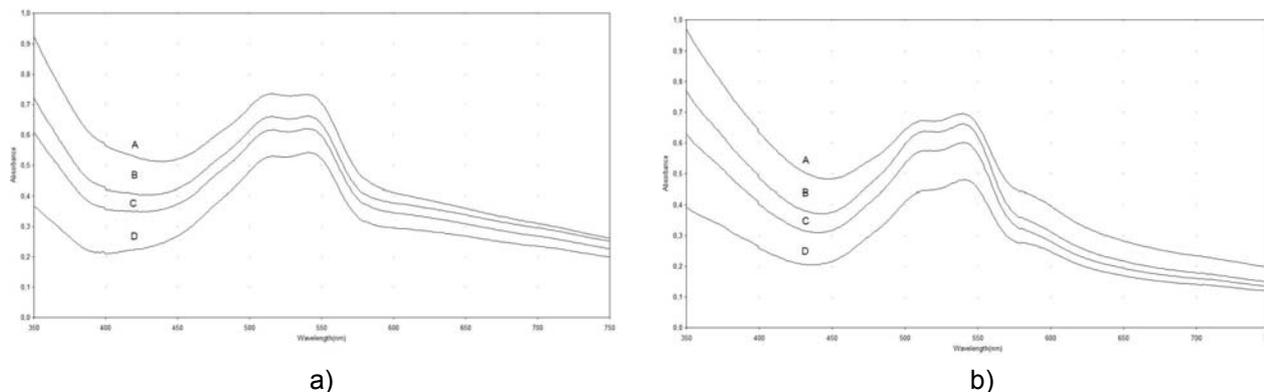


Figure 8 - Absorbance spectrum of Remazol Red F3B and a) Azo Terasil Red 3BL-01 or b) Anthraquinone Terasil Red FBN combination in water solution (D) and in solution with DWR (A: 1.30 g/L), DWOR (C: 0.50 g/L), FWOR (B: 0.50 g/L) products in the visible range.

In both cases there is no change in the absorbance spectrum of dyestuff solution with finishing agents but an overlay of the absorbance values in the short wavelength. This means that the dyestuffs do not interact with finishing agents. From these data, absorbance values at  $\lambda_{\max}$  of dyestuff with water and finish product solutions always obtained using the same liquor ratio (1:1) were computed (Table 5). It has to be reminded that reflectance measurements have shown that  $\Delta R$  values increase moving from DWR to FWR and finally to DWOR.

**Table 5** - Absorbance values of dyestuff with water/product solutions measured at  $\lambda_{\max}$  of each dyestuff (VS= 541 nm; Azo= 603 nm; Anthraquinone= 589 nm)

Dyestuff	$\lambda_{\max}$ (nm)	Absorbance			
		Water	DWR	DWOR	FWOR
Azo + VS	603	0.29	0.40	0.34	0.38
Anthraquinone + VS	589	0.27	0.43	0.30	0.34
Azo+VS	541	0.54	0.73	0.62	0.66
Anthraquinone+VS	541	0.48	0.69	0.60	0.66

Exactly the opposite takes place for the absorbance values (Table 5), and this behavior remains the same for the two tested disperse dyestuffs, being the reactive dye unchanged. Because of the highest absorbance value and lowest  $\Delta R$  characterizing DWR finish, the color difference  $\Delta E$  shown by DWR (see Figure 5) is always the lowest. The reason why  $\Delta E$  value of DWR is higher for anthraquinone + VS samples than for azo+VS ones cannot be clearly explained only looking at the  $\Delta R$  curves (Figure 6). In fact, in the 540-600 nm range, including the dyestuff  $\lambda_{\max}$  values, all three curves exhibit a constant behavior. To understand instead this color ( $\Delta E$ ) modification, the absorbance data have to be also considered. When VS dye is combined with azo dye,  $\lambda_{\max}$  absorbance value increases with respect to the combination with anthraquinone: it becomes 0.73 for DWR instead of 0.69 (Table 5). Moreover,  $\Delta L^*$  (Table 4) for anthraquinone+VS is higher than for azo+VS. All of these lead to the increase of  $\Delta E$  reported in Figure 5 for DWR. Looking at the DWOR  $\Delta E$  values also reported in Figure 5, higher values can be observed with respect to DWR as well as a more pronounced increase of  $\Delta E$  changing from azo+VS to

anthraquinone+VS. This phenomena can be mainly related to the  $\Delta L^*$  increase due to the greater  $\Delta R$ , as the  $\lambda_{\max}$  absorbance values remain almost the same. If results for FWOR are finally analyzed only looking at  $\Delta R$  data,  $\Delta E$  values higher than for the two other finishes would be expected. But  $\lambda_{\max}$  absorbance values now lay in between DWR and DWOR ones, and remain the same changing the dyestuff. As a consequence,  $\Delta E$  values of FWOR are located in between the two other cases.

#### 4. Conclusion

From the presented results it can be observed that a high water and oil repellency degree can be reached for dendrimers combined with fluorocarbon polymers (applied to 50 g/L concentration). This is probably due to the orientation of fluorocarbon chains achieved by dendrimers. In all case after abrasion and washing processes a decrease of performance was observed, particularly for lower concentrations. Color matching of dyed samples before and after repellency finish show a remarkable influence of finishing onto fabric color difference. This can be due to a change on the surface roughness, resulting in the reflectance differences, or in absorbance values in the visible range. The reflectance change of the treated fabric seems to be related to the particle size distribution of the applied chemical. In fact, DWOR, characterized by the lowest particle size, showed higher refractive index. In addition to the reflectance change the absorbance of finishing agents was also taken into consideration. It has been shown that the dyestuffs do not interact with finishing agents. But, as expected, also the concentration of finishing plays a relevant role in determining the influence of chemicals on color change. In fact DWR, whose application was performed with the highest concentration, gave the highest absorbance. Finally, to fully understand the influence of different disperse dyes and finishes on color difference, both reflectance and absorbance related data have to be considered.

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