Hindawi Publishing Corporation
Journal of Textiles
Volume 2014, Article ID 267530, 13 pages
http://dx.doi.org/10.1155/2014/267530

Research Article

# Effect of Fabric Layers on the Relationship between Fabric Constructional Parameters and Percentage Reflectance Values of Polyester Fabrics

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Received 20 May 2014; Revised 30 September 2014; Accepted 30 September 2014; Published 16 October 2014

Academic Editor: Phillip W. Gibson

This paper focused on the assessment of the relation between constructional properties and percentage reflectance values of fabrics woven from polyester yarns through fabric layer numbers. Reflectance measurements were conducted on pretreated but undyed fabric samples at five different fabric layers. Twelve polyester fabrics having different constructional parameters were used and fabrics differed from each other by their weft yarn densities, weave patterns, and weft yarn filament fineness. Warp yarn properties (type, count, and density) were the same at all the fabrics. Percentage reflectance values of the fabrics changed according to yarn density, weave pattern, and filament fineness in accordance with fabric layer numbers during reflectance measurement. Percentage reflectance values gradually increased as fabric layer numbers increased. The highest reflectance values were obtained at 16 layers of fabric. The effects of single constructional parameters on reflectance values disappeared as fabric layer numbers increased. Percentage reflectance values were analyzed according to ANOVA (Analysis of Variance) and statistical results revealed the cross relations obtained. Light-trap phenomenon was discussed according to reflectance characteristics of woven fabrics.

## 1. Introduction

Color measurements on opaque surfaces (textile fabrics) are made by measuring the percentage reflectance of surfaces and the measured reflectance values are transferred to color computing software for the determination of color coordinates and other color related properties, that is, whiteness. Whiteness of textiles is an important aspect which is considered in daily life. White textiles are usually preferred by customers especially in summer because of comfort reasons. Also white, being an achromatic color, has a physiological effect on human sensation.

Fibers which are used in textile fabric production for domestic purposes have intrinsic colors of their own mainly given at the production stage. Polyester fibers, being synthetic ones, are usually produced in white color from matt to bright by the usage of delustering agents such as titanium dioxide. The white color of fabrics produced from polyester yarns could be changed to a whiter shade by wet treatments using textile auxiliary agents or by applying fluorescent whitening agents (FWAs) to fabrics. Depending on the domestic usage, polyester fabrics could be used without any application of FWAs.

When the constructional properties of fabrics are considered in relation with their color, it is recognized that the visual color could change according to the effect of constructional properties on appearance of fabric samples. Under these circum-stances appearance properties of fabric structures become important.

Appearance is a variable of the perceptual world detected by the visual system. Characterization of appearance, new approaches to appearance definition, past considerations, and appearance related subjects were well documented and referenced by Lozano and Caivano [1, 2]. According to Lozano and Caivano, appearance can be divided into three components: color, cesia, and spatial variation or spatiality. Also color is divided into three parts: lightness, chroma, and hue. The last two variables form what we call chromaticity. Lightness is related to cesia when it is converted to luminosity, also giving place luminous transmittance or reflectance. Color will include whiteness and yellowing and is related to optical power spectral properties of the stimulus detected by observers [1].

In most cases color is an important factor in the production of the material and is often vital to the commercial success of the product. The color of an object depends on many factors, such as lighting (illumination), size of sample, and background and surrounding colors. Much more importantly, color is a subjective phenomenon and depends on the observer [3, 4].

When a beam of light encounters the surface of an object, a small portion of it is reflected and does not penetrate. The actual amount of reflected light is dependent upon the smoothness of the surface, the refractive index of the material, and the angle at which the beam strikes the surface. The light striking an object will be affected by interaction with the object in a number of different ways. The resulting light distributions give us our expressions of what that object looks like. The diffuse reflection caused by the scattering of light within a material, where no selective absorption by dyes and pigments is involved, causes a white appearance. In the majority of objects specular (shiny) reflection, diffuse reflection by scattering, and absorption operate which result in the color and appearance of the objects [5].

Steen and Dupont [6] researched the reflectance measurements of the highly structured white textiles. White can be defined as an aspect of color corresponding to a high luminosity and an absence of the hue. The impression of whiteness of a surface implies two conditions: a diffuse reflectance which is as flat as possible (achromatic) and the highest possible reflectance values. A white textile can rarely be compared to a sheet of white paper or a flat surface which is painted white. A textile surface is often highly structured, permeable to light, and composed of different materials. Highly structured surfaces (lace and embroidery in the lingerie sector) can mean that difficulties arise when measuring the color or whiteness of such a material.

There is also another phenomenon linked to structured white textiles, known as the light-trap rule. A so-called "flat textile" is structured with more or less regularly spaced hollows and bumps. This regularity allows good colorimetric measurements to be made in certain conditions (i.e., maximum aperture, sample layered until it is opaque, and multiple measurements). These simple rules mean that it is possible to limit the differences between two measurements of the same flat textile article. Nevertheless, each hollow between the yarns or fibers is a light trap which darkens the color of the fabric [6].

It was concluded by Steen and Dupont that the lighter a textile was, the greater the influence of its physical structure on the color would be and the less tolerant they would be in accepting it. With regard to whites, they observed light-trap phenomenon for a large number of different structures. The magnitude of the phenomena was linked to the physical structure of the textiles. Steen and Dupont showed that the distribution of the measurements of a white textile sample gets more dispersed as the sample gets more structured.

Relations between the physical structure of textile surfaces and light reflectance through fiber fineness were researched by Kobsa et al. and Rubin et al. [7, 8] in detail. The greater amount of the reflected light which appeared from textile surfaces containing microfiber (microdenier) yarns was attributed to the peculiar properties of these fibers during production, to their physical forms, and to their physical existence and settlement in textile structures. The light-trap phenomenon was discussed from another aspect related with microfiber properties.

The relation between fabric cover factors and light reflectance of polyester fabrics was researched by Akgun et al. [9]. A novel formula was proposed and its results were tested in accordance with reflectance measurements.

Many research works [1, 2, 6–12] showed that physical structure of fabric samples strongly affects reflectance measurements and color results obtained. When reporting about color of a fabric surface, the physical structure of fabric surface surely plays an important role in obtaining the results. The complex phenomena of color when altered with physical structure implied that color could be considered as a subgroup of appearance. More strict rules might be needed in color measurement to avoid the results to be dependent more on physical structure. Also the term of "appearance measurement" could be proposed to measure the reflectance properties of the highly structured textiles.

This paper focused on the assessment of the relation among constructional properties and percentage reflectance values of fabrics woven from polyester yarns through fabric layer numbers. The relation phenomenon between physical structure and percentage reflectance values was considered from the view point of fabric layers of woven fabrics. Percentage reflectance values of fabrics changed according to the yarn density, weave pattern, and filament fineness in accordance with fabric layer numbers during reflectance measurement. Cross relations among fabric constructional properties and fabric reflectance values were obtained.

## 2. Materials and Methods

*2.1. Materials.* Fabrics consist of weft yarns having the same yarn count but different filament numbers (filament counts), and yarn densities were used in the experimental part. Also different weave patterns were considered to assess the relations among fabric percentage reflectance values and properties of fibers, yarns, and fabrics through fabric layer numbers.

Twelve polyester woven fabrics with different constructional parameters were used. Fabrics were woven under controlled mill conditions in order to obtain exact constructional properties. After weaving, woven fabrics were pretreated (washed with 2 g/L nonionic agent at 60°C for 30 minutes and later stentered without tension at 180°C for 60 seconds) under mill conditions and prepared for reflectance measurement in the laboratory. Constructional parameters of the fabrics were given in Table 1. Twill and sateen fabrics were weft faced ones. Fibers of the yarns had round cross-sectional shapes and they were semidull fibers (commercially available from a spinning mill in Bursa). Warp yarn properties and warp densities were the same for all the fabrics under consideration. Weft yarn properties differed from each other in terms of weft yarn densities and weft yarn filament fineness.

Table 3: ANOVA results according to fabric layer number.

| Factors | Treatment | Fabric reflectance *Rank |
|---|---|---|
| Fabric layer number | 1 (1th) | 5 |
| | 2 (2nd) | 4 |
| | 3 (4th) | 3 |
| | 4 (8th) | 2 |
| | 5 (16th) | 1 |

*The rank is presented from the highest reflectance to the lowest reflectance.

samples were reported in accordance with fabric layer numbers. Percentage reflectance results showed that the inherited properties of white fabric samples were lost when they were layered more than eight times for reflectance measurement.

Constructional parameters affected the measured percentage reflectance values at single, 2, and 4 fabric layers at most. The differences in constructional parameters lost their effects on percentage reflectance values when fabric layer numbers increased up to 16 layers. Fabric constructional parameters showed cross relations with percentage reflectance values. Percentage reflectance values were directed in different manners by constructional parameters and it became impossible to make an exact conclusion on the single effects of these parameters on reflectance. The cross relations were also revealed by statistical results. Change of percentage reflectance values with constructional properties implied that the intrinsic reflectance properties of fabric structures must be measured at single fabric layer in order to avoid the cross relations. Considering the results which were presented in this paper and in the former papers [1, 2, 6–9, 14], the usage of the term of "appearance measurement" could be proposed instead of "color or reflectance measurement" to consider the reflectance measurements of the white and patterned fabric structures.

Textile fabrics have constructional characteristics changing from noncompact structures to compact ones. For that reason, reflectance behaviors of fabric samples depended on constructional factors (yarn density, yarn filament numbers, weave pattern, etc.) which directed the compactness of structures. The optimum layer number suitable for each fabric could be determined in the beginning of measurements. The light-trap phenomenon was observed both in fabrics with loose structures during measurement at low fabric layers and in fabrics with compact structures during measurement at high fabric layers. The determination of suitable fabric layer for reflectance measurement should be made prior to the measurement cycles to perform a better application regarding the fabric compactness.

## Conflict of Interests

The authors do not have any stake in Macbeth Kollmorgen (former) or AATCC and their names appear in the paper purely in coincidental and academic nature. Their reference is made to indicate standard equipment and test method made use of in this work and in no way it advocates these brands.

## References

[1] R. D. Lozano, "A new approach to appearance characterization," *Color Research & Application*, vol. 31, no. 3, pp. 164–167, 2006.

[2] J. L. Caivano, "Cesia : a system of v isual signs complementing color," *Color Research and Application*, vol. 16, no. 4, pp. 258–268, 1991.

[3] B. Rigg, "Colorimetry and the CIE system," in *Colour Physics for Industry*, R. McDonald, Ed., Society of Dyers and Colourists, Bradford, UK, 1987.

[4] R. Berns, *Billmeyer and Saltzmann's Principles of Color Technology*, John Wiley & Sons, New York, NY, USA, 2000.

[5] R. S. Hunter, *The Measurement of Appearance*, John Wiley & Sons, New York, NY, USA, 1975.

[6] D. Steen and D. Dupont, "Control of structured white textiles," *Coloration Technology*, vol. 119, no. 4, pp. 205–211, 2003.

[7] H. Kobsa, B. Rubin, S. M. Shearer, and E. M. Schulz, "Using optical ray tracing to explain the reduced dye yield of microdenier yarns," *Textile Research Journal*, vol. 63, no. 8, pp. 475–479, 1993.

[8] B. Rubin, H. Kobsa, and S. M. Shearer, "Modelling the dependence of fabric reflectance on denier per filament," *Textile Research Journal*, vol. 64, no. 11, pp. 685–689, 1994.

[9] M. Akgun, B. Becerir, and H. R. Alpay, "Assessing the relationship among fabric constructional parameters, fractional reflectances and cover factors of polyester fabrics by experimental and mathematical methods," *Fibers and Polymers*, vol. 11, no. 2, pp. 291–302, 2010.

[10] B. Becerir and M. A. Iskender, "Comparison of some process components of polyester microfibre dyeing by using mathematical and experimental methods," *Fibers and Polymers*, vol. 5, no. 4, pp. 309–315, 2004.

[11] B. Becerir, "A novel approach for estimating the relation between K/S value and dye uptake in reactive dyeing of cotton fabrics," *Fibers and Polymers*, vol. 6, no. 3, pp. 224–228, 2005.

[12] B. Becerir, "Assessment of the results of different color difference formulae under different illuminants by wash fastness tests," *Fibers and Polymers*, vol. 12, no. 7, pp. 946–956, 2011.

[13] American Association of Textile Chemists and Colorists, *AATCC Technical Manual*, vol. 74, AATCC, Research Triangle Park, NC, USA, 2005.

[14] M. Akgun, B. Becerir, and H. R. Alpay, "Abrasion of polyester fabrics containing staple weft yarns: color strength and color difference values," *AATCC Review*, vol. 6, no. 3, pp. 40–43, 2006.