A SIMPLE METHOD FOR DETECTING WHITE SPECK POTENTIAL IN UNDYED COTTON

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Abstract

Dyeing imperfections that appear as white specks on cotton fabrics that have been dyed deep shades are a major problem in the textile industry. The presence of these imperfections in raw cotton is not evident since they only show up after dyeing. Processing through fabric dyeing results in both time and product losses when white specks are present. Approaches for eliminating or minimizing the problem include plant breeding, changes in growing and harvesting procedures, and additional finishing during dyeing. None of these provide immediate cost free solutions. A method of screening samples for dye defect potential before processing would allow mills to divert affected cotton batches to non-problem products. In this paper, a simple light microscopy process is described for screening undyed fabrics, yarns, and sliver. This darkfield procedure discriminates between common fiber tangle neps that are not dye resistant, and those that consist of bundles of extremely thin-walled fibers that will not dye.

Introduction

The nature and effect of undyed white defects in cotton fabrics has been extensively investigated (Goynes et al., 1993, Goynes, et al., 1995, Goynes et al., 1996, Bel-Berger et al., 1995). These defects have been confirmed to be bundles of extremely immature (undeveloped) fibers that come in with ginned cotton, and though some are removed in cleaning processes many are carried through processing to the final fabric, and become apparent on dyeing. Processing can affect apparent size and number of defects. Growing location and conditions can influence the number of defective fiber bundles in a harvested lot. Variety also is responsible for amount of defects in a lot. Breeding programs can possibly decrease the pre-disposition for production of motes, which in turn produces undeveloped fibers. Effects of environmental conditions in open fields are difficult to control. It is possible to adjust dye formulations for variations in overall bulk maturity, but it is difficult to achieve even dyeing when concentrated areas of undeveloped fibers are present in lots of otherwise average maturity. Therefore, the most immediate solution to the problem would seem to be a system for predetermining presence of large quantities of undyeable materials. If such tests could be developed for incoming lots, then those with high speck potential could be rejected, or at least diverted to non-problem uses. Detection even at the yarn or pre-dyed fabric level would at least prevent use of white speck goods for dark textiles. Therefore, we attempted to develop a method to "see" white specks in undyed cotton.

Materials and Methods

Samples used in the study were from a series of cottons especially grown for white speck studies (Goynes. et al., 1996). They were grown under irrigated conditions in a field in the San Joaquin Valley in California, and included a commercial Delta Upland (DP-90), a Mississippi hybrid (ST-825), and two Acalas (EA-C 30, early maturing; and EA-C 32, a Prema). Each sample was available as bale cotton, sliver, yarn, undyed fabric, and dyed fabric.

For microscopical examination, a wide field stereo zoom light microscope equipped with substage darkfield illumination was used. Observations were made at 10-20X magnification. Identified defects were marked, cut from the sample, and prepared for examination at higher magnification using a scanning electron microscope (SEM).

Discussion

When textile fabrics are examined using surface lighting with a stereo light microscope, it is possible to see the weave of the fabric, outlines of fibers within yarns, and both contamination and fiber defects on the fabric surface. Contamination defects such as seed coat fragments, and leaf and bract materials appear very dark, and can easily be segregated from fiber defects. One type of fiber defect consists of individual fibers that have been tangled with other fibers during processing (Hebert, et al., 1988). These defects do not normally cause dye defects. Another type of fiber defect is caused by bundles of undeveloped fibers. Both of these fiber defects can be seen using surface lighting. However, it is not possible to distinguish them as two different types using surface illumination, so determinations of white speck potential cannot be made from such observations. If the fabrics are examined using dark field lighting, there is an obvious difference in the two types of fiber defects.

Dark field illumination is accomplished using a substage lighting system, and a field stop that blocks the path of the light beam that normally is projected through the sample. This system forms a hollow cone of light that travels around the field stop. A ground glass or filter system can be used to decrease the intensity of the light. With small objects scattered on a clear field, the field appears black, and the sample appears self illuminated because the light observed is that transmitted to the objective lens by the sample itself. Thus the nature of the sample determines the brightness of the object in the observed field.

If samples containing fiber defects are examined first using surface illumination to show presence of the defect, then the lighting is switched to darkfield, an immediate difference

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can be seen in the fabric image. Yarns appear with bright edges because they are thinner at the edge, and more light is transmitted. Differences can also be seen in thick and thin yarns because of the amount of light that passes through them. Thick, non-fiber neps (usually plant parts) appear completely dark, and those containing only thin areas of seedcoat may appear gold or orange. Of greater significance, differences can be seen between fiber neps. Tangled fiber neps blend into the yarn and are hardly seen, but defects formed from clumped, undeveloped fibers appear as a shadow on, or in the yarn. The tangled network of the thin-walled fibers can be seen. This difference is subtle, and careful observation is required to become familiar with the differences in appearance. However, switching back and forth between surface and darkfield, subsurface lighting shows the obvious differences in tangled fiber neps and undeveloped fiber neps.

To verify that defects identified as undeveloped fiber clumps were actually the same undyeable white defects that were found in dyed fabrics, the defects identified by dark field microscopy were cut from the fabric and examined using scanning electron microscopy. Results of these examinations showed that all examined defects were composed of undeveloped fiber clumps.

Although detection of white speck potential of fabrics is of great significance because it would prevent dyeing of fabrics that would be unusable, detection of these defects at earlier stages of processing would be of even greater value. Therefore, a procedure was devised for examination of yarns using darkfield illumination.

Yarns are more difficult to examine at low magnifications than are fabrics. Even in samples of high white speck content, an individual defect may only be found once in a 36 inch length of yarn. Therefore, yarns must be moved rapidly through the viewing field because a large portion of the yarn has no defect. This was accomplished by locating a spindle containing yarn on the left side of the microscope stage, pulling the yarn across the stage so that it was visible through the binoculars, and rolling the examined yarn onto a dowel attached to the right side of the stage. Turning the dowel pulls yarn from the spindle, across the stage and re-rolls it onto the dowel while the yarn is being observed. When a defect is detected, that section of the yarn can be clipped and prepared for examination by SEM. As with defects found in fabrics, those cut from yarns and examined by SEM were also identical to white speck defects on dyed fabrics.

Similar examinations were made on cotton in the sliver form. Sliver was flattened and thinned so that light could pass through. A cast aluminum plate with a 2 in^2 opening was placed over the sample to maintain the proper location of the examined area. Dark defects detected by darkfield microscopy were removed and examined by SEM and were shown to be the expected bundles of undeveloped fibers.

Of the four specifically grown cotton varieties, the EA-C 32 sample was found to have the highest number of white defects as shown by image analysis, and EA-C 30 the lowest (Goynes et al., 1996). In developing the darkfield procedure for dye defect surveys, these two samples were compared. Results indicated significantly more defects in the EA-C 32 sample than in the EA-C 30, which is consistent with data from image analysis on dyed fabrics.

This method provides a means of determining presence of dye defects in undyed cotton. Fabrics with high and low defect counts can be distinguished. However, standardization of the method would require a sufficient number of samples from different sources to be examined to determine a thresh hold level of defects that would make fiber lots unusable for dark shade dyeing.

Summary

1. Defects that appear as white specks on dark cotton fabrics are bundles of undeveloped, extremely thin-walled fibers.

2. Although many fiber-bundle defects can be seen on fabric surfaces using low magnification widefield light microscopes, all fiber defects do not become dye defects. Fiber defects that become white specks and those that do not cannot be distinguished using normal surface lighting.

3. Use of substage, darkfield lighting distinguished potential white speck defects from other fiber bundle defects in undyed samples. White specks defects appeared as dark shadows in fabrics, yarns, and sliver. The nature of the detected defects was verified by removing the defects from the sample and examining in the SEM. All defects detected by darkfield microscopy were confirmed to be thin-walled fiber bundles that cause undyeable defects.

4. Therefore, low magnification darkfield microscopy provides a simple procedure for predetermining white speck potential in undyed cotton samples.

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