Fibers can be key pieces of associative evidence. One method that can be used in fiber analysis is chemical testing, a quick, easy, and relatively cheap presumptive method to qualitatively identify fiber type. Chemical tests are usually performed on fibers based on color change, and cupric cyanide and cupric chloride are the most common. These differences in color are due to the different chemical reagents used, and the differences in color are clearly visible to the eye. These differences can help forensic scientists identify the source of the fibers and determine the value of the fiber analysis.

The purpose of this research was to apply the chemical tests to various modern regenerated cellulose samples to test if actual results were consistent with expected results. While there is some information about the possibility of identifying these fibers using zinc chlora-iodide and cupric chloride, these results have not been confirmed in forensic science. The fibers chosen were sourced from threads, garments, fabrics, and yarns of different dyes, textures, and manufacturers. These differences could all potentially affect how the fibers react. Some samples were compared between classes and within classes. For the observation of false positives, synthetic fibers, which contain no cellulose, were also tested.

Materials and Methods

Positive controls: 100% off-white cotton and 100% off-white cotton samples (cotton contains ~85-90% cellulose)
Negative control: 100% off-white polyester (contains no cellulose)

Results

Semisynthetic regenerated cellulose fibers: viscose (n=6), modal (n=6), rayon (n=8), acetate (n=7)
Synthetic fibers: polyester (n=8), acrylic (n=3), nylon (n=6)

Fibers were obtained from samples by using tweezers and scissors. 12 regenerated cellulose blind samples were tested for accuracy of the tests. These results were then compared to the expected results.

Positive Controls:

100% cotton:
 txn: Yellow-brown to yellow-orange, consistent with expected results

100% rayon:
 txn: Blue-violet to wine-red on purer cellulose, blue-green for viscose rayon, brown for cuprammonium rayon, violet for cotton, yellow for acetate. Most other fibers will turn yellow-brown shades.

Synthetic:

Acetate:
 txn: Slow solubility, inside of fiber becomes slightly soluble, while structure of fiber left intact after 5 minutes, consistent with expected results

Nylon:
 txn: Slight yellow to yellow-brown tint, consistent with expected results

ZCI:
 txn: Maroon, brown, purple, consistent with positive controls and expected results for viscose rayon, but consistent with other expected results

Modal:
 txn: Maroon, brown, purple, consistent with positive controls and expected results

Rayon:
 txn: Maroon, brown, purple. Some variation with a lot of grey also being observed that wasn’t as prominent in the other fiber types, consistent with positive controls as the main color, consistent with rayon with grey color closely coincides with a blue-green expected result, but unknown if viscose or cuprammonium process was used in manufacturing

Acetate:
 txn: Orange-yellow to orange, consistent with expected results and consistent with expected results. Also a distinct color difference from the other regenerated cellulose samples

Pink Samples of viscose, modal, and rayon also exhibited a pink color in some fibers. The pink sample of acetate did not exhibit this reaction

Synthetic:

Most had yellow tint or faded color, consistent with negative control and expected results

Fail Positive:

Nylon:
 txn: Some samples behaved as the negative control in the body of the fiber, but the end turned yellow/orange, while some other nylon had alternating bands of negative control color and yellow/orange, inconsistent with negative control, false positive for acetate

Orange-red Polyester:
 txn: Orange, inconsistent with negative control, false positive for acetate

Viscose:
 txn: Orange, inconsistent with negative control, false positive for acetate

Dark Country Blue Acrylic:
 txn: Grey, grey-brown, inconsistent with negative control, false positive for rayon

Expected Results for Cupro-hydrazine: Solubility. Dissolves cellulose material

Positive Controls: Immediately soluble, consistent with expected results

Negative Control: Insoluble after 5 minutes, consistent with expected results

Semisynthetic regenerated cellulose:

100% Cotton:
 txn: Slow solubility for 30 seconds, then quickly dissolved, slight variation from positive controls, consistent with expected results

100% Rayon:
 txn: Slow solubility for 30 seconds, then quickly dissolved, slight variation from positive controls, consistent with expected results

100% Acetate:
 txn: Slow solubility, inside of fiber becomes slightly soluble, while structure of fiber left intact after 5 minutes, difficult to distinguish for some samples, variation from positive controls, slightly inconsistent with expected results

Vicose Thread vs Modal Garment: Similar color change and solubility, different inconsistent did not affect results

Results for Blinds:

The unknowns which were acetate were correctly presumed. The unknowns which were modal and rayon were correctly presumed as not acetate.

Conclusion

This research shows how fiber type and dye influence results of these chemical tests. There was variation across the regenerated cellulose classes. This can be seen with the acetate and rayon samples with both the zinc chloro-iodide and cupric cyanide-hydrazide tests. There was also variation within the classes since not every fiber exhibited the same exact color change when zinc chloro-iodide was applied, however, they were very similar. Fibers need to be light in color to see the color change because the color change is not evident on fibers that are too dark. Fibers also need to be dyed different colors than the positive color changes to avoid false positives. Even though the negative fibers were all pure synthetics, they did not test the same as the pure synthetic negative control. While cupr-hydrazine did dissolve cellulose and is a known solvent, the acetate samples were difficult to distinguish and had very slow solubility which could lead to a negative false.

These tests may assist in helping determine if a fiber is a regenerated cellulose fiber, however, it may not be able to distinguish the specific class. This can be seen when testing the blinds since only acetate could be eliminated as a class. Thus, chemical processes, dyes, and cellulose percent content are all likely contributors to the variation in color and solubility changes.

Chemical tests are a destructive technique, but can be used when multiple fibers are present in a forensic setting. In conclusion, zinc chloro-iodide and cupr-hydrazine are beneficial presumptive tests used to assist in qualitatively identifying fiber classes, but other tests are still needed to confirm identities.

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References


J. Weinstock and H. Templeton (1917).


M. Steidler, MSFS. Digital photographs were taken with Motic BA310Pol, MotiCam 3.0MP, and Motic Image Plus 2.0 Software at 50x total magnification.

Semisynthetic Regenerated Cellulose:

100% rayon:
 txn: Yellow-brown to yellow-orange, consistent with expected results

100% rayon:
 txn: Yellow-brown to yellow-orange, consistent with expected results

100% Acetate:
 txn: Orange-yellow to orange, consistent with expected results and consistent with expected results. Also a distinct color difference from the other regenerated cellulose samples