Name: _____ Period: __ Date: _____

Forensics of Fibers: Dye Test

Introduction

Crime scene investigators obtain many different types of evidence at a crime scene, including samples of fibers. With this experiment you will identify the type of fiber left at the crime scene by performing a series of three tests on the obtained evidence.

Background

Fibers are the smallest component of a textile material. They are used to form fabric, rope, carpet, etc. Fibers gathered as evidence at a crime scene may arise from numerous scenarios. They may be transferred via personal contact between suspect and victim and they can also be transferred to other items at the crime scene, such as furniture, weapons or flooring, due to physical struggle.

Fibers may be analyzed by visual inspection, based on their appearance and comparison with known samples. Identifying fibers based on appearance requires the use of a microscope to view miniscule details. Natural fibers are easier to distinguish under a microscope. Synthetic (man-made) fibers are traditionally less descriptive under a microscope because they can consist of practically any strand diameter or color. Synthetic or man-made fibers have typically have a more uniform diameter and appearance than natural fibers. Therefore, microscope analysis is not the main determining test used to identify fibers but it can be helpful as an ancillary test.

In most cases, fibers are analyzed based on their physical and chemical properties. The burn test is a primary identification technique used to determine fiber identity. When held near a flame different fibers will exhibit different behaviors. Some will begin to melt and others will twist or curl up. When ignited they will also react differently. Some fibers burn slowly, others burn quickly. Some will melt and drop off before the flame reaches the rest of the fiber. Odor is also a powerful tool in identifying an unknown burnt fiber. If the smell is similar to that of burning hair, the fiber is most likely silk or wool. If the smell is similar to burning paper or burning wood, the fiber is probably cotton, rayon or linen. If the fiber melts, it is likely a synthetic material such as nylon or polyester.

Fabrics are also identified based on how chemical dyes bond them. How well a dye is attracted to a piece of cloth (its *affinity*) depends on both the fabric and the dye molecules. Chemistry thus plays an important role in how and why dyes work. Dyes are water-soluble compounds that are charged. Animal fibers such as wool, which are composed of protein molecules, are usually easier to dye than plant fibers such as cotton, which are composed of cellulose. Wool fibers have many *dye sites* – groups of molecules that have positive or negative charges and thus attract the charged dye molecules. Dye sites may be ionic, that is, fully charged, or polar, that is, partially charged. In general, dyes have a greater affinity for natural fibers like wool and cotton than for most synthetic fabrics. Many synthetic fabrics such as acrylic and polyester are *hydrophobic* (water-fearing) and have fewer dye sites, making them more difficult to dye. One exception is nylon, the first completely synthetic fiber developed in the 1930s from petrochemicals. Nylon dyes more easily than many other synthetic fabrics because it has polar dye sites. Acetate, another synthetic fiber, is chemically similar to cotton, but has fewer dye sites.

Experiment Overview

The purpose of this experiment is to examine six different types of fibers using a burn test and dye analysis to observe their unique physical and chemical properties.

Pre-Lab Questions

1. Why is it important to not rely solely on visual inspection of a fiber to determine its identity?

2. When an unknown fiber is heated in a flame, it smells like burning paper. What type of fiber does this odor indicate?

Materials

- Congo red dye bath, shared
- Water, tap
- Beaker, 50-mL
- Bunsen Burner
- Forceps, metal
- Multi-fiber test fabric, 6-cm, 2
- Paper towels
- Pencil
- Weighing dish or aluminum foil

Safety Precautions

Exercise caution when heating fibers over the Bunsen burner. If any fiber begins to burn dangerously, quickly dip it in water to extinguish the flame. Congo red will stain skin and clothing. Wear chemical splash goggles, chemical resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Please follow all laboratory safety guidelines.

Procedure

Note: The multi-fiber test fabric consists of six different fibers in the following order starting at the cream colored end: wool, acrylic, polyester, nylon, cotton, and acetate.

Part A. Burn Analysis

1. Fill a 50-mL beaker with tap water. This will be used to extinguish any stubborn flames resulting from the burn analysis test.
2. Obtain the multi-fiber test fabric strip and pull it apart slightly by grabbing the wool section and the acrylic section. Once the fabric is loose enough, pull out a single wool strand.
3. Light the Bunsen burner. Using forceps, hold the single fiber over the heat but not within the flame. Record observations on the Forensics of Fibers Worksheet.
4. Place the fiber into the flame. Does it ignite quickly or slowly?
5. Remove the fiber from the flame on the Bunsen burner. Does it extinguish quickly? Does it melt or drip? Record observations on the worksheet.

6. Repeat steps 2-5 to test single strands of all the different fibers in the multi-fiber fabric. *Note:* With some fibers the reactions in step 2-5 may occur very quickly. Repeat tests as needed in order to make accurate observations.

Part B. Fabric Dyeing Analysis

7. Obtain a second multi-fiber test fabric strip. Mark one end of the strip with pencil so that the wool side is differentiated from the acetate side.
8. Using forceps or tongs, immerse the test strip into the congo red dye bath. *Caution:* The dye bath is red. Exercise caution to avoid burn.
9. After 5-10 minutes, remove the dyed test strip from the bath using forceps. Hold the fabric above the dye bath for approximately one minute to allow excess dye to drain back into the dye bath.
10. Pat the test strip with paper towels and rinse the dyed test strip under running water from the faucet or use a wash bottle. Continue rinsing the test strip until all of the excess dye has been removed and the rinse water is colorless.
11. Place the test fabric on a small piece of aluminum foil or weighing dish and allow it to dry overnight.
12. Record observations on the Forensics of Fiber Worksheet the following day.

Forensics of Fiber Worksheet

Observations

Part A. Burn Analysis

Fabric Type	Observations When Heated	Observations When Ignited
Wool		
Acrylic		
Polyester		
Nylon		
Cotton		
Acetate		

Part B. Fabric Dyeing Analysis

Fabric Type	Wool	Acrylic	Polyester	Nylon	Cotton	Acetate

Color						

Post-Lab Questions

1. Which of the lab fabrics samples when burned produced an odor similar to burning hair in the flame test? Why would this occur?

2. Mrs. Nelson's house was robbed on the evening of Friday, May 13, 2011. The crime lab obtained a fiber from a broken screen where the suspect entered. The fiber was tested and found to twist and turn brown when heated but did not melt. When the fiber was ignited it burned extremely quickly with no smoke produced. When it was dyed with congo red it turned dark red. What type of fiber is it?

3. Which type of fabric would be an ideal material to make a blanket used to extinguish fires? Explain.

4. Which type of fabric would you be unlikely to find in firefighter uniforms? Why might this be the case?

5. Rank the six fabrics tested in order of their affinity for dyes, starting with the greatest affinity.