Twists in the Fibers

Time Suggested: 3 sessions of 60-80 min each

Have you or your family ever purchased a cloth thinking it to be cotton or wool and later found it to be a synthetic fiber cloth? There are variety of fibers we use in our lives for clothing, making ropes, bags and containers, and cleaning materials. Usually by looks, touch, texture, sense of weight we try to identify and classify them. But sometime we can be easily cheated by just looks. For example, a thread may look like cotton but may be synthetic or it may look synthetic but may be a natural fiber.

Do you think an understanding of material chemistry and microscopic shape of fibers can help us? In this unit, we will try learning their identification based on their properties.

Before that we must remember that threads are not fibers but any thread is made by combining several fibers together. In the pictures of fabric below, you can see bundles of fibers within each thread.

Burning Test for Fibers

Careful combustion can be an important way to identify materials. Textile experts have been using burning tests to identify fibers. This identification is based on the following observations:

(i) Plant based fibers (cotton, linen, hemp, sugarcane, jute) have high amount of cellulose which burns easily. However, these also have some amount of silica and metals (~0.1-0.6% by mass) which lead to ash formation (~0.5 - 1.2% by mass). These fibers burn slowly with a flame. When the flame gets extinguished, the burnt fiber glows red like burning coal—a phenomena known as afterglow. As the burnt fiber/ash cools down, the afterglow disappears and fine ash is obtained. This ash retains the form or shape of the fibers, a property popular as the saying in Hindi "*Rassi jal gai, par bal nahin gaye*.", meaning " the rope got burnt, but the twists in the rope have remained (in the form of ash)".[1]

(ii) Synthetic fibers usually do not have much silica or metals. These are often produced from polymers made of non-metallic elements such as carbon, nitrogen, oxygen, and hydrogen. These fibers have low melting temperatures. When exposed to flame, they melt, decompose with evolution of a lot of heat. They do not form any ash, but may form a bead, which is not easily crushable. They may or may not form smoke (depending on percentage

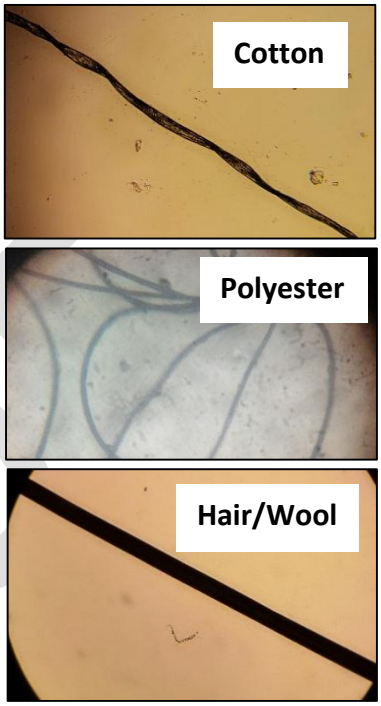
[1] Sometimes also refers to someone's personality traits that did not change even after very adverse circumstances.

of carbon). The above Hindi saying is not true for synthetic fibers as the shape of the fiber is lost after burning.

(iii) Animal based fibers: wool, silk, are predominantly made of proteins (such as keratins) which burn with a very unpleasant smell, like that of burning meat/flesh. These usually do not leave much of ash, but form a bead which can be easily crushed to fine ash.

Fibers under Microscope

Different fibers have different microscopic shapes and surface features. Depending on the conditions in which fiber has formed, a fiber can have a circular, elongated, or irregular cross section. Cotton fibers, in particular, have non-circular cross-section due to which twists in the fibers can be easily observed in a microscope. Plant fibers, in general also have rough surfaces.



Synthetic fibers are usually circular in cross-section and have very smooth surfaces because they are formed by passing of a molten polymer through circular holes. Thickness of a synthetic fiber is uniform along the length of a fiber, and is also same for different fibers in a thread. On the other hand, natural fibers may have varying thickness across different fibers.

Animal fibers such as wool and silk have circular cross-sections and look smooth on surface. Wool/hair may have some scaly appearance on surface. Used fibers (even synthetic fibers) usually develop surface roughness due to wear and tear.

Q 1. What differences do you observe between cotton and polyester fibers in the image above?

Materials Required

- Threads- at least one cotton, a polyester (or any other synthetic) thread, one wool (if you don't get real wool, a broken hair can also be taken), and an unknown thread. The fibers should be clean, so that any other substance sticking to them does not affect the results of observations.
- Candle, match stick, Beaker, forceps, watch glass, water.
- Microscope, glass slide, and cover slip.

Task 1: Known Fibers

Take one cotton and a polyster or a synthetic thread (like nylon or acrylic).

1. Observe the fibers in each thread with naked eye. Note its physical properties such as shiny, rough texture by looks and if it is smooth or rough by touch. Also write if you think it is a natural or a synthetic fiber.

S. No.	Observations (shiny/rough/smooth texture)	Natural/Synthetic

2. Take a tray, and fix a candle in middle of it. Fill the tray slightly with water. Light the candle. Hold the thread with a pair of forceps or tongs and bring one end of it close to the flame. Observe if the fibers catch fire, it melts, there is any foul smell, or if there is ash formation, any afterglow or a bead is formed. Collect the ash/bead formed on a watch glass. Note the following observations for each fiber.

Safety: Be very careful while doing this activity. Do not be too close to the flame or burning fiber and do not throw burnt threads anywhere. Some fibers may burn very vigorously and their melts can also cause burns or damage to surrounding objects. Keep a watch glass or a container having water in it and put the burnt fibers in this water.

S. No.	Did it melt? (Yes/No)	Any smoke? (Yes/No)	Smell (like burning paper or plastic)	Ash/ Bead formed	Afterglow? (Yes/No)

3. Add one drop of water to ash/bead on the watch glass. Wait for 1-2 minutes and then with a litmus paper, or a drop of phenolphthalein solution, or a pinch of turmeric. Check if this water has become acidic or basic on contact with the ash/bead (Ash or bead will not completely dissolve in water).

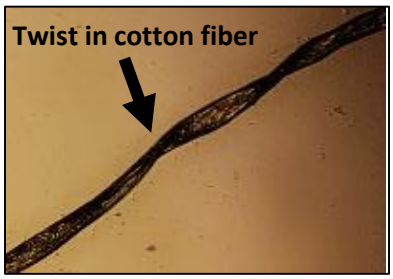
S. No.	Thread burnt	Ash + Water (Neutral/Basic/Acidic)

4. Now observe the thread under a microscope as described below(did you know that Antonie van Leeuwenhoek was a cloth seller and had discovered microscope to observe fibers only).

   Pull out a fiber from the cotton thread. A thread usually has several fibers bundled together. So using a pin or forceps, loosen out the fibers in a thread. Put the fiber on a glass slide and cover it with a cover slip. Observe it under 10x objective [if you are not able to focus on the fiber, make sure that the fiber is under the objective lens and while focusing, the distance between lens and the cover-slip is ~ 0.5 cm].

   Note the features of the fibers. Then, put 3-4 fibers together on the slide and observe variation in thickness between different fibers.

Q 2. Are they uniform in thickness along length or it is different across the length?



Q 3. Do you observe twists in the cotton fibers?

Q 4. Do observe fold in the cotton fiber?

Q 5. Is the thickness of fibers same in all the fibers?

Now sketch the shape of fiber observed and write its features:

Fiber	Sketch	Fiber description (straight or twisted, transparent or opaque, uniform or variable thickness along length)	Are all fibers same or different in shape?
Cotton			
Polyster			

5. See sketches of your classmates and copy here at least one different sketches of cotton and polyester drawn by your classmate in their sheets.

Cotton:	Polyester:

Q 6. Based on your observations, what features/properties can you conclude about the features of cotton (a plant-based fiber), and polyster (a synthetic fiber).

Q 7. Why did ash obtained from burning cotton change the (acidic/basic) nature of water?

Task 2: Wool/hair (Animal Fiber)

Take a woolen thread/hair and perform the following steps.

1. By burning test as done in part 1, check if it is natural or synthetic.

How did it melt (smell, smoke, afterglow, ash/bead formed? Ash/bead + water: Acidic or basic or neutral?

(If it is synthetic, then try finding a real wool/hair sample.)

2. Separate fibers out of the thread, as done in Task 1 and observe the fibers under microscope.

Sketch	Fiber description (straight or twisted, transparent or opaque, uniform or variable thickness along length)	Are all fibers same or different in shape?

Task 3: Unknown fiber

1. Take an unknown thread. By observing this thread with naked eye, guess if it is a natural or a synthetic fiber.

S. No.	Observations	Natural/Synthetic

2. By burning test as done in Task 1, identify if it is natural or synthetic.

Observations of burning test:

3. Separate fibers out of the thread, as done in Task 1 and observe the fibers under microscope.

Sketch	Describe a single fiber	Variation in a bunch of fibers

Note: Do check if the thread you have is not composite (i.e., if it consists of more than one kind of fibers) and hence may give properties of both kinds of fiber, such as giving both ash and bead on burning.

Based on the above tests, try to identify the fiber: The observed fiber is _____ because_____

_____

_____

4. Paste/staple a sample of the thread here.

Task 4: Fibers and Society

As a customer, the nature of fibers is important to us. But have you thought how the livelihoods of millions of people depend on the fibers that we choose to use.

1. For each of the fibers you identified, list the people who are involved in production of this fiber till you purchase the fibers or clothes made of those fibers?

2. Do you know of any fibers that are produced in your locality and are used for making textiles? If yes, briefly describe the process used to prepare the threads from the fibers.

3. Based on what you have learned above, can you tell if wicks for candles and oil lamps can be made using synthetic fibers? Why? How does this different in burning properties of cotton vs synthetic fibers affect the lives of people who sell cotton?