# MAKER: Design and Create with Natural Dyes

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# MAKER: Design and Create with Natural Dyes

Dyeing with natural dyes is a combination of science and art. The science dictates that a permanent bond requires a metal ion – a mordant – to bridge between the fabric and the dye. The art allows a multitude of colors. By varying the combination of dye and mordant, and the purity and concentration of each, a nearly infinite number of shades can be obtained.

A course open to all students, both engineers and nonengineers, explored the history and technology of dyes and the dyeing process[1]. Simple exercises allowed students to extract dyes, discover the colors obtained by combining different mordants and dyes, and note how fabric type contributed to the shade. Other laboratory exercises introduced resist dyeing techniques from Asia and Africa. For the final course project, each student designed and created his or her own silk scarf using the techniques learned in class.

The scarves created by the students were outstanding and exhibited their willingness to try a new design. For example, one student wanted to create the illusion of a branch of bamboo growing along the length of his scarf. He planned three different colors: a brown foundation representing the dirt, followed by yellow changing gradually to green and finally blue. He used Shibori techniques to design the bamboo branch, and used scraps of silk to determine the combination of mordant and dye to yield the shades he desired.

The students kept the scarves they dyed, so photos of them will be displayed. However, the author dyed silk squares in various combinations of mordant and dye, and and crafted a quilt from the squares. The quilt demonstrates the range of colors available with four natural dyes and five mordants, as well as some artistic flair.

Method:
The dyeing procedure is divided into four steps. Each step can be modified for different effects. The students completed these steps throughout the semester.

Step 1: Mordant the fabric
Natural dyes will not permanently dye natural fabrics without the aid of a mordant. Typical mordants include alum, tin, chrome and copper (available from aurorasilk.com[2], or in many chemistry laboratories). The combination of fabric, mordant and dye determine the final shade. An early experiment helped students learn what the combinations yielded (see Attachment 1 for the details). The concentrations of mordant used were:

Alum: 25% by weight of fabric
Tin: 3% by weight of fabric
Copper: 3% by weight of fabric
Chrome: 1% by weight of fabric

The mordant is dissolved in hot water (enough water in a big enough pot so the fabric can be stirred freely). Enamel cooking stockpots work well. Cotton, wool, silk and linen fabric swatches were wet with warm water, and then soaked in the mordant solution at room temperature for 24 hours. Many instructions indicate the water should be kept hot, but the longer time at lower temperature worked successfully. Only about 25% of the mordant binds to the fabric, so the remaining solution can be stored and reused.

Step 2: Extract the dye

Many natural dyes are available as the bark (aurorasilk.com[2]). The bark is typically put into boiling water, and extracted for about an hour. The bark can be removed and placed in clean water for a second extraction. Many dyes can be stored after extraction for several weeks. Logwood, however, seems to lose the purple shades after a day or two, although it will still dye fabric brown. The dyes extracted from bark for this course were:

Logwood
Brazilwood
Fusticwood
Cochineal (extracted from an insect)

For the class, the students removed 1 ml samples of the extract every minute for 45 minutes, after the bark was placed into the hot water. The sample concentration was read by a spectrophotometer so the students could model the extraction kinetics.

In addition to the dyes from bark, dyes from ground extracts (lac, cutch and catechu) were available for the students to create more colors. Indigo dye, which requires a different dyeing technique (and no mordant), was a central theme of the course, and was also available. Thus students had access to a range of red, purple, yellow, brown and blue shades.

Step 3: Prepare the fabric

Early in the semester, the students had investigated the colors obtained by different silk and mordant combinations. Near the end of the semester, they practiced different resist techniques: Japanese Shibori and Nigerian pole-wrapping methods. Shibori techniques require hand-stitching designs into the fabric, creating pleats, or stitching small objects into the fabric. The pole-wrapping methods involve complicated folding patterns followed by wrapping the fabric around a piece of PVC pipe, and tying it with string. Each student prepared a small piece of cotton fabric with each method, and then dyed it. When it was dry, they opened the scraps and observed the dyed pattern.

Next, during the last two weeks of the semester, each student was given an undyed pure silk scarf (dharmatrading.com[3]). Using their "data" from the color and tying exercises, they designed a pattern for their scarf. Each student prepared his or her scarf for dyeing, usually with multiple colors and techniques.

Step 4: Dye the scarf

During the last two lab periods of the semester, the students were given access to all of the mordants and dyes to create their final project. Some students left the silk scarf in the dye overnight and obtained deep colors with good contrast with the folded or stitched fabrics. Other students draped their scarf between beakers of two different dyes, and obtained a "color-fade" effect. On the last day of class, the students all proudly showed their scarves to everyone – they were truly beautiful.

**References**


1. Piergiovanni, P.R., "A Chemical Engineering Course for Liberal Arts Students – Indigo: A World of Blues", Chemical Engineering Education, 46:223-230 (2012).
2. AuroraSilk.com http://www.aurorasilk.com/natural_dyes/mordants.htmlAurorasilk.com,. 'Aurora Silk: 100% Natural Dyes'. N.p., 2015. Web. 24 Mar. 2015.
3. Co., Dharma. 'Habotai Scarves 8Mm'. *Dharma Trading Co*.. N.p., 2015. Web. 24 Mar. 2015.


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**Attachment 1**: Dyeing Procedure Provided to Students

Dyeing Procedure

Six dyes are available:

Brazilwood – shades of red
Catechu – shades of brown
Cochineal – shades of red
Fusticwood – shades of yellow and green
Lac – shades of red
Logwood – shades of brown, black and purple

You can choose to use any 3 – 6 dyes.

Be patient, and take turns with the dye baths. Use trays to transfer wet fabric to the center island for drying, and keep the floor dry.

1. Cut each fabric into 3 – 6 pieces. Use some method to keep track of the mordant used for each fabric. (Sharpie will work for lighter colors, but not for darker colors. Consider keeping fabric mordants in the same order: alum, chrome, copper, tin, or some other method. Once they are dyed, you can't tell which mordant was used.)
2. Arrange fabric pieces in piles for each dye you will use. (For example, arrange wool-tin, wool-alum, wool-chrome, wool-copper; followed by the same sequence for silk, linen and cotton for dye 1. Then the same for dyes 2, 3 and 4.) As you can see, organization is key for this experience!
3. For each dye:

- Wet the fabrics thoroughly with warm water
- Dip the fabrics in the dye for about five minutes
- Remove the fabrics from the dye, squeeze out until damp, and arrange to dry
- As you arrange them to dry, keep track of mordant/dye combination!

Assignment: Due 3/5/14

Arrange your dry fabric swatches in a pattern so you can draw conclusions about the effect of mordant and fabric type. You may cut the fabric if you wish. Hand in the arrangement(s) along with the worksheet (below).

Name: _____

Dyeing Conclusions (available on Moodle)

| Effect of: | | | | |
|---|---|---|---|---|
| Fabric Type | wool | silk | linen | cotton |
| | | | | |
| Mordant | alum | chrome | copper | tin |
| | | | | |
| Dye | | | | |
| | | | | |