Indigo Dyeing

Level: 5-12th grades

Objectives:

1. Youth practice vat dyeing.
2. Youth understand the oxidation-reduction chemical reaction.
3. Youth learn that the dye process depends on the chemistry and morphology of both the dye and the fibers being dyed.
4. Youth learn safety procedures of the dyeing process.
5. Youth use the Internet to research traditional and modern technologies, history, and science of dyes made from plants.
6. Youth work with others to link project to community.

NYS Learning Standards:

Math, Science, and Technology

- Students access, generate, process, and transfer information using technologies.
- Students apply technological knowledge and skills to design, construct, use and evaluate products.

National Science Standards:

Content — Grades 5-12

Science as Inquiry
- Ability to do scientific inquiry (5-12)

Physical Science
- Properties and changes of properties in matter (5-8)
- Chemical reactions (9-12)

Science & Technology
- Understanding about science and technology (5-12)

Science in Personal and Social Perspectives
- Science/technology in society (5-8)
- Science/technology in local, national, and global challenges (9-12)

History and Nature of Science
- Science as a human endeavor (5-12)
- History of science (5-8)
- Historical perspective (9-12)

Vocabulary

Alkali — Basic substance (pH higher than 7) such as lime, lye or ammonia.

Cellulose – A polymer made of glucose units. Cotton, linen, and ramie are examples of cellulosic textile fibers.

Dye – Organic chemicals that diffuse into fibers and impart color.

Indican – The color-producing molecule in indigo.

Indigo – The plant or the resulting dye that produces a blue color.

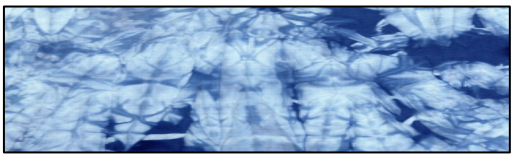
Oxidation-Reduction – Chemical reaction that adds and removes oxygen.

Resist – Anything that protects fabric from dyes. Paste, wax, string, pleats, and folds are common resists.

Vat Dye – Water-insoluble dyes that must be reduced in alkali to a soluble state before applying to fabric. They successfully color cellulosic fibers and are colorfast to light and washing.

History

Indigo is thought to be the oldest dye. It was found in mummy cloths over 5,000 years old and in the garments of Tutankhamen. Indigo was mentioned in the histories of Herodotus (circa 450 B.C.) and was a valued "spice" carried back to Europe during the Crusades. For centuries, European dyers used the woad plant to achieve blues and woad growers fought the influx of this cheaper, deeper blue dye. In 1598, indigo was prohibited in France and parts of Germany, and dyers had to swear, often on the pain of death, that they would not use indigo. By the 17th century, indigo was a chief trade article of both the Dutch and British East India Companies. In 1744, indigo arrived in South Carolina from which it traveled to other states, including New York. In 1883, Adolph von Baeyer synthesized the indigo molecule and by the early 1900s, the market for natural indigo collapsed. Indigo dye can be purchased in both its natural and synthetic forms and is still popular in the dyer's garden. Its primary uses are in cosmetics, as a laboratory indicator, and as the dye that makes blue-jeans blue.



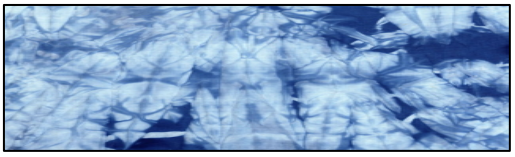
"IN-D-KNOW" Fun Facts

The law in France that threatened dyers with the death sentence if they were found using indigo instead of woad has never been repealed.

Ancient Egyptians, Greeks and Romans used indigo as eye shadow, crayons, and paint as well as for coloring fabric.

At best, a hundred pounds of indigo stems yield only four ounces of indigo dye.

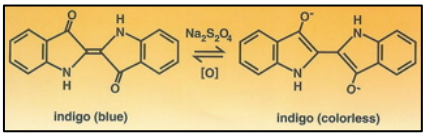
A 1762 indigo recipe recommends using urine, "preferably of those who drink strong drinks."



Science

Dyes may be natural or synthetic. Natural dyes come from animals, minerals, and plants. Plants of the species *Indigofera, Polygonum, Lonchocarpus, Marsdenia, Strobilanthes, and Isatis* contain indican, a chemical that gives a blue color. The leguminous *Indigofera* genus, with over three hundred species, contains the most indican. *Indigofera tinctoria* (native to India and Asia) and *Indigofera suffructiosa* (native to South and Central America) are the best know. These indigo plants grow from 2 to 6 feet in height, have a single semi-woody stem, dark green oval leaves, and clusters of red flowers that look like butterflies and turn into peapods.

Indigo works by a chemical reaction called oxidation-reduction. Indigo does not dissolve in water. It must be reduced — i.e. the oxygen must be removed— in the presence of alkali by a reducing agent such as thiourea dioxide (thiox), sodium hydrosulfite, Zinc, or bacteria. Upon reduction, indigo becomes colorless and water soluble. In this state, indigo has a high affinity for cellulosic fibers and enters the open spaces of the fiber. The dyed fibers are then exposed to air, which oxidizes the dye molecule back to its insoluble form. The insoluble dye particles are trapped inside the fiber, coloring them permanently blue. Unlike most dyes, indigo forms a mechanical, not chemical, bond.



Technology

Indigo is a vat dye, so named because the traditional processing of indigo included fermenting the leaves in a vat (vessel). The fermentation process reduces indican to its colorless, soluble form that fabric can absorb. To prevent premature oxidation, dyeing must take place in the absence of air. This fact dictates the technology of indigo dyeing. If one brushes the dye solution onto fabric, the brush might turn blue but not the fabric as the dye would become insoluble between the dye vat and the fabric. Traditional patterning of indigo-dyed fabrics usually depends on 1) fabric structure — mixing indigo yarns with other yarns, 2) physical resists that prevent dye penetration, 3) chemical resists that prevent dye oxidation, or 4) removal (discharge) of color after dyeing. A more recent option is the use of Inkodye, a soluble vat dye that has been preprocessed into the reduced form for direct application.