THE CHEMISTRY OF TEXTILE FIBERS

Manufacturers use a range of materials in the clothes we wear. Here we look at the molecular details of these textile materials and how those properties affect our clothing.

WHAT ARE TEXTILE FIBERS?

Textiles are long, thin fibers held together by intermolecular attractions that affect their strength and flexibility. Natural fibers usually exist as short fibers called staples that are spun into a yarn. Synthetic fibers are produced as continuous-filament yarns.

Staple fibers

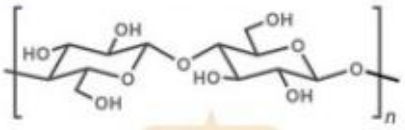
Continuous-filament yarn

Cotton and polyester are the most produced fibers worldwide by mass.

NATURAL FIBERS

CELLULOSE-BASED FIBERS

Cellulose-based fibers come from plant seeds, stems, or leaves. Cotton comes from the seeds of *Gossypium* plants.

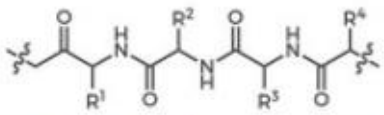


Cellulose

When you wash cotton clothes, water disrupts the hydrogen bond network that holds cellulose chains together. When the clothes dry, hydrogen bonds between chains re-form, causing creases.

PROTEIN-BASED FIBERS

Protein-based fibers come from wool, hair, and silk.



Protein (R = variable side chains)

Wool fibers have protein-based scales that align in one direction. When wool is washed, the fibers can move and the scales can interlock, causing irreversible shrinkage.

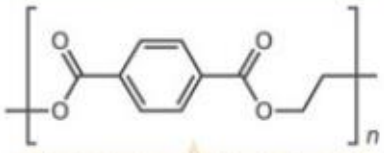
MANUFACTURED FIBERS

REGENERATED FIBERS

Manufacturers make regenerated fibers such as rayon by dissolving cellulose fibers, then purifying and extruding them.

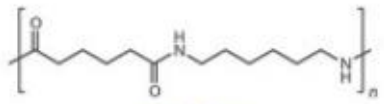
SYNTHETIC FIBERS

Manufacturers commonly make synthetic fibers such as polyester and nylon from nonrenewable petroleum derivatives.



Polyethylene terephthalate (a polyester)

Most synthetic materials don't shrink when washed and are more wrinkle resistant than cotton, but they absorb less moisture. Often, polyester and cotton are blended to combine the benefits of the two fibers.



Nylon 6,6

Nylon degrades in sunlight, so stabilizers need to be added during polymerization.

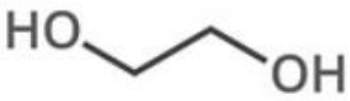
PERIODIC GRAPHICS

THE CHEMISTRY OF WRITING INKS

It's back-to-school season, which means stocking up on office supplies. Billions of pens are manufactured every year, and a blend of chemicals dictates the color and flow of their ink.

BALLPOINT PEN MECHANISM

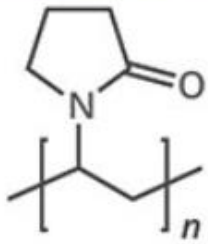
SOLVENTS



ETHYLENE GLYCOL

Solvents suspend or dissolve dyes and pigments in ink, allowing them to flow onto paper. In ballpoint pens, solvents are often glycols, such as ethylene glycol. Manufacturers also add lubricants to ensure that the metal ball doesn't stick.

BINDERS



POLYVINYLPYRROLIDONE

An example binder compound

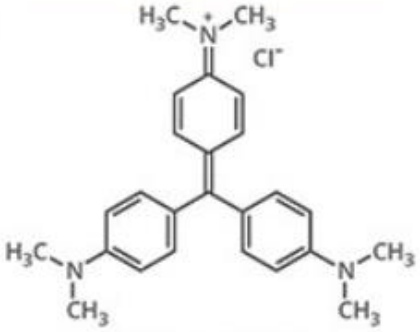
A variety of different binder compounds help carry an ink's dye or pigment and also help stick it to the surface of the paper.

INK COLORANTS

Inks get their colors from pigments, which are insoluble compounds suspended in a solvent, or from dyes, which are soluble. Writing inks tend to use dyes because pigments can clog the pen tip.

Black inks use carbon black or a mixture of colored compounds. Blue ink usually gets its hue from triphenylmethane dyes, and red ink is often based on eosin dye.

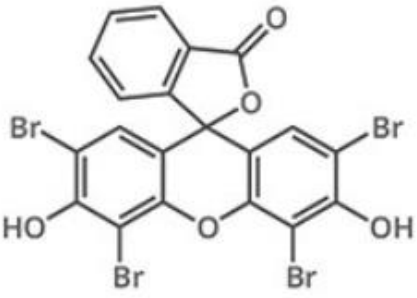
BLUE INKS



CRYSTAL VIOLET

Substituted triphenylmethane dye

RED INKS



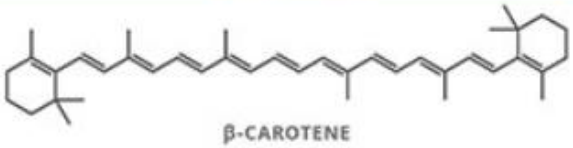
EOSIN Y

Used in dilute solution for red ink

THE CHEMISTRY OF PUMPKINS

Halloween's approaching. Before you get out the pumpkin-carving kit, take a look at this spooktacular review of the chemicals behind the color, aroma, and taste of this seasonal squash.

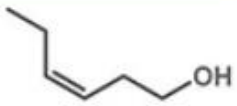
COLORATION



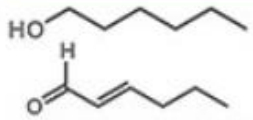
β-CAROTENE

A pumpkin's hue is due to carotenoid compounds such as β-carotene, the same compound that gives carrots their orange color. Other carotenoids include lutein, found in egg yolks, and zeaxanthin, found in corn.

AROMA



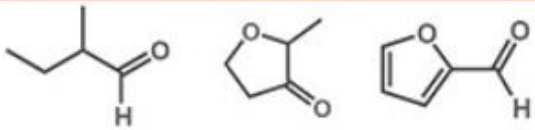
cis-3-HEXEN-1-OL



n-HEXANOL & 2-HEXENAL

When cut, pumpkins emit a vegetal aroma thanks to several compounds. The main aroma contributor is *cis*-3-hexen-1-ol, along with other six-carbon alcohols and aldehydes. Buttery-smelling diacetyl is also present.

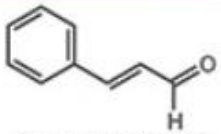
CANNED PUMPKIN



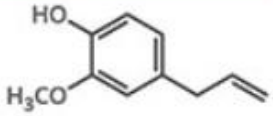
2-METHYLBUTANAL, COFFEE FURANONE & FURFURAL

Canned pumpkin emits almost none of the six-carbon odor compounds given off by a freshly carved pumpkin. Instead, its volatiles include burnt-smelling 2-methylbutanal, coffee furanone, and furfural.

PUMPKIN SPICE



CINNAMALDEHYDE



EUGENOL

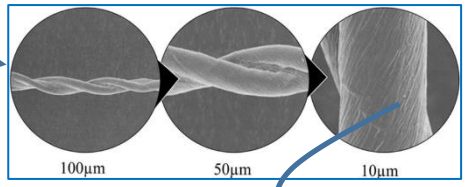
Pumpkin spice flavor has little to do with pumpkin and more to do with the spices added, including cinnamon (cinnamaldehyde), nutmeg, and clove (eugenol). Other compounds in the mix add caramelized notes.

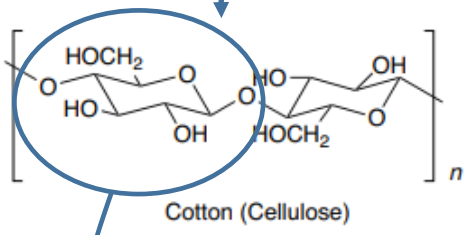
THE CHEMISTRY OF FIBERS & DYES

Did you know that by the end of general chemistry, you can understand, explain, and apply basics of dying fabric via intermolecular interactions? *(ie – H-bonding, VanderWaals Forces, etc.)*

Cotton from the field to the loom

Cotton fibers are natural polymeric staple fibers of cellulose (read "The Chemistry of Textile Fibers") that, when placed next to one another, are drawn into long and continuous strands.





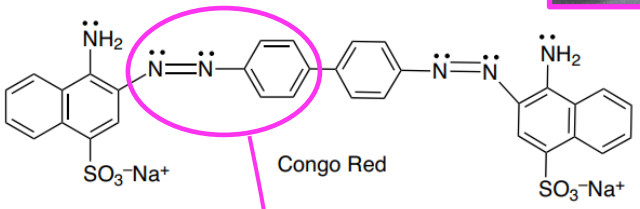
Cotton (Cellulose)

Cellulose nanofibers have diameters between 2-10 nm and a length ranging from 100 nm to a few micrometers!

From natural to synthetic dyes from the lab

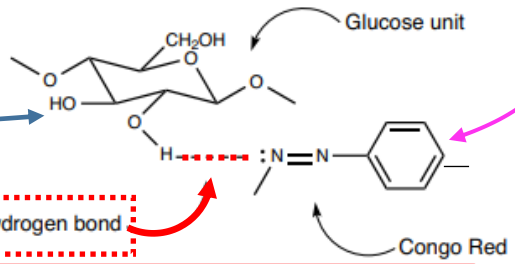
For the duration of human history, since time immemorial, fibers with natural pigments have been chosen based upon anything from utility in context to signifying social status. (read "Chemistry of Natural Dyes")

In the last ~200 years, with the advent of synthetic or human-made fibers, (ex. nylons, polyesters, etc.) synthetic dyes provide for a more vibrant color and bind themselves more readily to both synthetic and/or natural fibers. One of which is Congo Red (IUPAC Name – *disodium 4-amino-3-[4-[4-(1-amino-4-sulfonato-naphthalen-2-yl)diazenylphenyl]phenyl]diazenyl-naphthalene-1-sulfonate*), synthesized by a German chemist, Paul Böttinger.



Congo Red

Congo Red is **NOT** a **natural dye**!



Congo Red is bound to **cellulose** through **H-bonding**!

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- http://www.chm.bris.ac.uk/motm/congo-red/congo-redh.htm Last Accessed on 10-14-2022