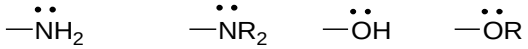
CH 227
Dyes and Dyeing
General Principles

Dyes are colored because they absorb light in the visible region of the spectrum-light with wavelengths between 400 and 800 nm. The visible color that an observer sees in the complement of the color absorbed by the dye; that is, it is the sensation produced by all wavelengths of light to which the eye is sensitive *minus* those wavelengths absorbed by the dye.

Light absorption is usually associated with the presence of a **chromophore** (Greek *chroma*, color, and *phoros*, bearer), which is an unsaturated group such as the following:

azo nitro carbonyl vinyl

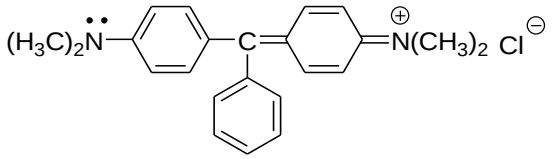
Dyes may also contain **auxochromes** (Latin *auxilium*, aid), usually groups such as these:



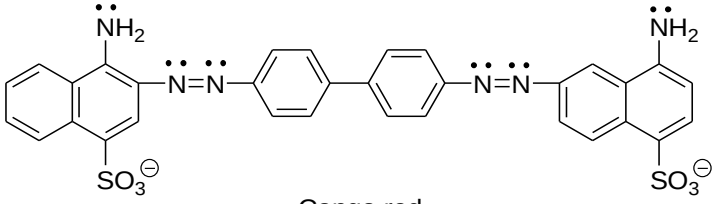
When suitably attached to a conjugate system, these groups may increase the wavelength at which light is absorbed and intensify the absorption. Auxochromes have an atom with at least one unshared electron pair. When attached to a conjugate system, auxochromes can delocalize electrons through resonance.

Dyes usually also contain an **anchoring group**. This is a group that, through ionic, covalent, or hydrogen bonding, helps bind the dye to the substance being dyed. The chemical formulas for the dyes you will use in this experiment are shown below. Note the extended chain of conjugation in each dye. Also note the presence of auxochromes and anchoring groups.

For a dye to be fast (securely attached), it must penetrate the fiber and remain firmly bound to it during washing and cleaning.



malachite green



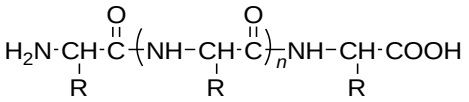
Congo red

Direct, or Substantive, Dyes

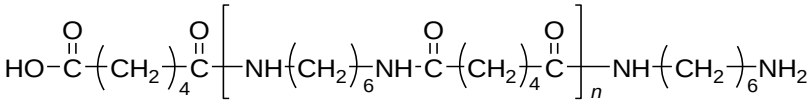
Direct dyes adhere to cloth without the aid of additional chemicals. Wool and silk, which contain many anionic polar sites, readily form ionic bonds with the cationic sites in triphenyl methane dyes such as malachite green.

Cotton, linen, and rayon, which are cellulose fibers, are somewhat less polar than wool and silk and are more difficult to dye directly. The first satisfactory direct dye to be developed for cotton was Congo red. Congo red has two azo (-N=N-) groups that are spaced just the right distance from each other to form hydrogen bonds to repeating hydroxyl groups in cotton, thus making the dye less susceptible to removal by washing.

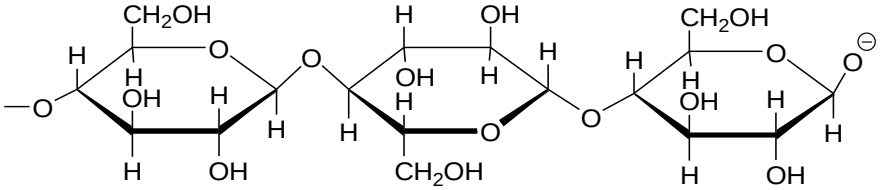
Chemical Types of Fibers



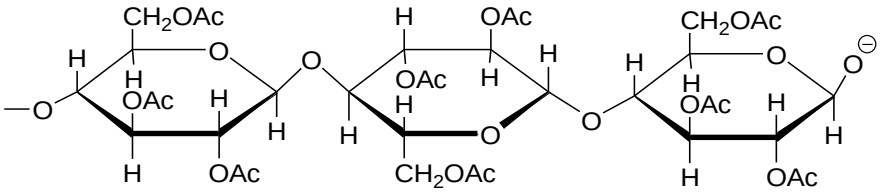
wool or silk



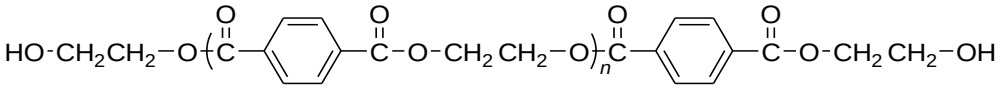
nylon



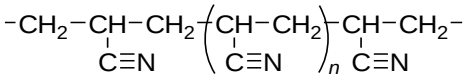
cotton



acetate

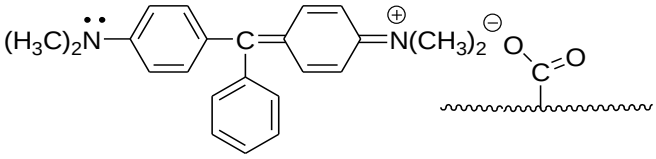


dacron



orlon

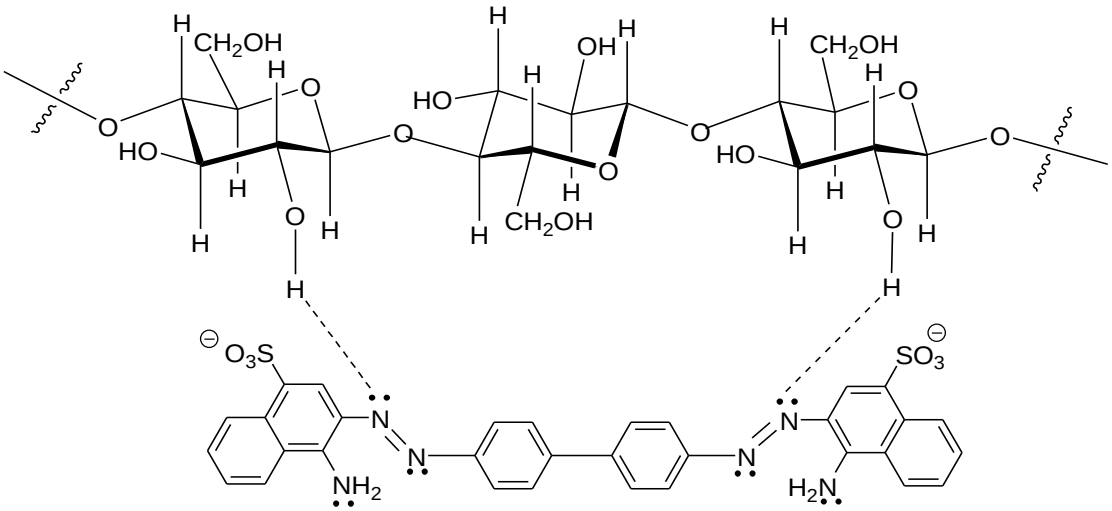
Ionic triphenylmethane dyes like malachite green form ionic bonds to polar materials like wool, a polypeptide that contains anionic polar sites.



malachite green polypeptide fiber

Congo red can hydrogen-bond to the hydroxyl groups in cellulose materials such as cotton.

a cellulose fiber



Congo red

PROCEDURE

Malachite Green

Dissolve about 0.1 g of malachite green in 200 mL of water in a 250 mL beaker. Heat the solution on a hot plate until it begins to boil. While maintaining a gentle boil, add a Test Fabric strip. Keep the strip in the solution for about 2 min; then remove and rinse the fabrics in a 400-mL beaker containing 300 mL of water. Note whether the color is reasonably fast on each kind of fabric.

Congo Red

Dissolve about 0.1 g of Congo red in 40 mL of water in a 150 mL beaker. Add to this a solution of 0.1 g of sodium carbonate in 5 mL of water; then heat the mixed solution to boiling on a hot plate. While maintaining a gentle boil, add a Test Fabric strip and continue heating for 2 min. Remove the strip, and wash it in a 400 mL beaker containing 300 mL of water. Note the fastness of the color on each kind of fabric.

Tie Dyeing

Dye a fabric of your own choosing, for fun.