



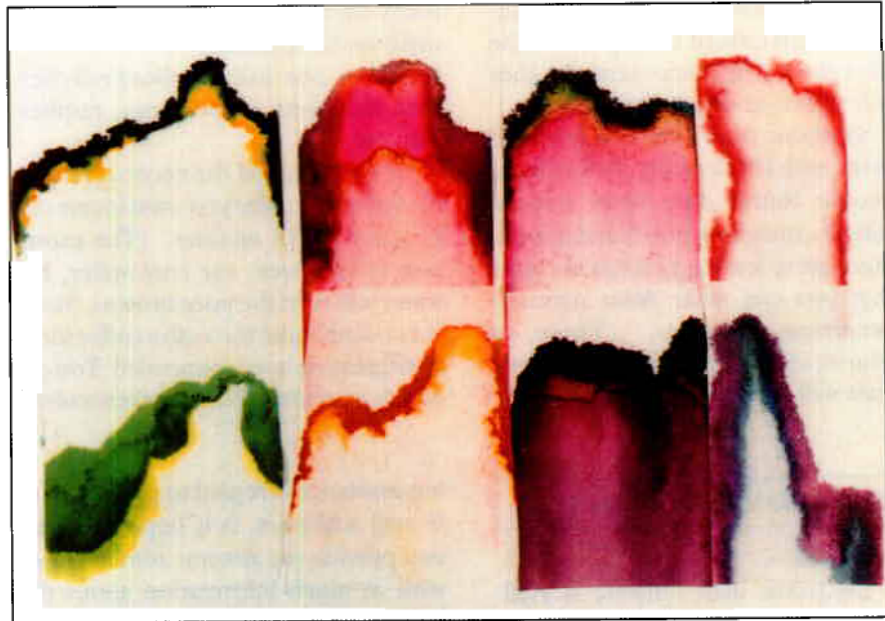
Kitchen chromatography

Most primary school kids are taught that white light can be dispersed into a spectrum and that light of any spectral color can be synthesized by combining various intensities of red, blue, and green light. However, when kids mix paints they see that red paint mixed with green paint is not yellow; rather, it's olive-drab or brown.

We usually explain that pigments and dyes selectively absorb portions of the spectrum *in terms of ideal filters*. An ideal filter is one that transmits either 0 or 100% of any given color. Color mixing using a succession of ideal filters is referred to as "subtractive" color mixing, because the filters seem to be removing, or subtracting, color components from the incident light. In fact, the transmittance functions (percent light intensity transmitted as a function of wavelength or color) of successive filters are multiplied, which is necessary to account for partial absorption of any one color by a real filter.

Most real filters and dyes have complicated transmittance functions that can lead to unexpected colors when used in combination. Suppose you had three identical filters, each with a transmission function that absorbs all of the incident green and blue light, but passes violet completely undiminished. Each filter also passes half of any incident yellow, orange, and red light. White light passing through just one of the filters looks orange-ish. On passing through two of the filters in succession, only one-quarter of the incident yellow and red emerge. Again,

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Separated dyes on "Mr. Coffee" and "Melita" filter paper. Top row, left to right: "French's" brand green food color, red food color, one drop each of red and green food color, strawberry;; Bottom row, left to right: green Magic Marker, yellow food color, black Magic Marker, red cabbage.

all of the violet gets through. On passing through the three filters together, only a small fraction of the yellow and red get through, but still all of the incident violet light will get through.

Unless the intensity of the white light illumination is increased, the light emerging from the three filters will be relatively dim, but it will have a violet hue in any case. This from three "orange" filters! Saturated dye solutions may also appear to be a different color in their dilute form. An example is yellow food coloring. In the bottle, it looks red. When a couple of drops are mixed with a cup of water, however, the dye looks yellow.

You can isolate the various dye components that make up an ink or other composite dye using chromatography. Dyes are molecular and can

be dissolved in either water or alcohols, and carried by capillary action through a porous material, such as filter or blotter paper. The individual dye components travel at different speeds and disperse along the length of the porous material. You can demonstrate this easily in your kitchen. Here's what you'll need:

- Felt-tip pens or food coloring
- Strips cut from either coffee filters ("Mr. Coffee" and "Melita" filters work well) or blotter paper. The strips should be 1/2"-1" wide and about 9-12" long.
- A bowl of water and a way of suspending the filter paper strips vertically over the bowl.

Put a drop of food coloring (or draw a 1/2" diameter spot with your felt-tip pen) near the bottom end of one of

Continued on next page

the filter paper strips. There should be about one inch between the color spot and the bottom edge of the paper. Hang the paper strip above the water so that the bottom strip edge is barely immersed in the water. Take care not to get the ink spot wet. Almost immediately, you will see the water climbing up the paper. The dye components will separate as the solution creeps toward the top end of the filter paper strip. Left overnight, they will appear as in the photograph.

Synthetic dyes were first invented in the mid-19th century. Before then, people found dyes from natural sources, including plants and insects. Here are a few suggestions for dyes that you can make from naturally occurring substances. (These, of course, are all juices that Mom rightly fears will stain your clothes!)

■ Purple — one-half cup sliced red cabbage or blueberries

■ Blue — one-half cup sliced red cabbage or blueberries (see extra step below).

■ Green — lawn grass clippings, fine chopped with a blender (see note below).

■ Yellow — one teaspoon saffron stamens or the dry, outer skin of one medium-sized onion.

■ Red — one-half cup sliced red cherries, red beets, strawberries, raspberries, etc.

To prepare, boil the necessary ingredients for the color you want in one cup of water for 15 minutes. (The exception is for green: use cool water; hot water will turn the juice brown). Strain the cooled liquid through a coffee filter. Refrigeration is recommended. You can dye clean, white cloth with these colors,

but don't use cloth that has been treated with fabric softeners because the dye may not "stick." (To get blue, stain as for purple, but give an extra water rinse afterward. The remaining stain will be blue.) Any odor will soon leave fibers dyed with these solutions.

REFERENCES

Much of this material was taken from the following books:

1. B. Walpole, *Fun with Science: Light, Kingfisher Books, London (1987)*. Experiments for primary schoolchildren.
2. D. Falk, D. Brill, and D. Stork, *Seeing the Light: Optics in Nature, Photography, Color, Vision and Holography, Harper and Row, N.Y. (1986)*. Non-quantitative optics text for secondary school and freshman college students.
3. S. Williamson and H. Cummins, *Light and Color in Nature and Art, John Wiley and Sons, N.Y. (1983)*. Non-quantitative optics text for college undergraduates.

ELECTRONIC, from page 43

networks.

Electronic mail software is available on many time-sharing computers and networked PCs. These E-mail programs allow you to send mail, including text files, as well as to read and file away incoming mail for later use. Instructions are usually available for these programs either "on-line" or in a user manual.

Should you find this information inadequate, a computer administrator in your organization or at the remote host can explain the intricacies of the E-mail software. This person can also describe how colleagues outside your institution should address computer mail to you, including any variations that allow for transfer of the E-mail from one network to another through a gateway.

The most difficult problem you will encounter in sending E-mail is in providing a complete and accurate address for your recipient in a form that can be properly interpreted by the mail program on your computer and on other computers that may be needed to pass the message on to its appropriate destination. When seek-

ing assistance in regard to proper use of E-mail addresses, it is important that you provide the systems administrator with as much information about the address of the recipient as is available, including the names of the user, host computer, institution, and network.

The American Astronomical Society has prepared a "Users Guide to Electronic Mail" that offers a detailed discussion of the format of electronic mail addresses as well as descriptions of the

various networks and the methods for addressing across networks. OSA members may contact *OPN* for a copy of this guide. Also, as a service to members, OSA will begin publishing electronic mail addresses in the Membership Directory in about two years.

If you have any questions and comments on this article or suggestions for future articles in this column, please send them via electronic mail to:

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ENGINEERING, from page 9

solicited papers. This is probably the best way the Optical Society can serve and attract the optical engineering community, by soliciting selected papers from competent engineers for conferences and subsequent publication without the necessity of peer review—the

selection process should be enough.

Well, there it is—one engineer/author/editor's opinion on the subject. Probably the most significant fact about this article is that it was solicited, otherwise it would never have been written!