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Signed: Ellen Munro

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A Chemical Dye Comparison Using Four Dyes
On Handspun Wool and Mohair Yarns

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Abstract
I chose to study chemical dyes in order to understand them, as well as to broaden my knowledge about color. I wanted to broaden the range of the handspun yarns that I was using for garments and household furnishings. I had many naturally colored fleece giving me a monochromatic palate ranging from white to black. Now that I have opened the door on a world of color, I have broadened my horizon to include an unlimited rainbow of colors. I am presenting information here that I hope will help and encourage a novice dyer, starting with some history and color theory. I then go on to describe the four classes of dyes chosen for this study, and include information about them which is helpful when purchasing them. I explain what equipment is needed when preparing to dye and give explicit instructions for each four classes of dyes. I explain the color wheel, secondary colors and hues containing all three primary colors. I include the dye formulas for the 98 samples which I have mounted in such a way that they can be easily compared. (See appendices.) The information in this study could be used by a novice dyer when he or she chooses what dyes to use, as well as helping with color choices.
SOME HISTORY

In early times people used plants, insects and minerals as natural sources of color. Paleolithic people used colored clay to embellish their bodies, enhance their surroundings, color their clothing and paint pictures on the cave walls. They also used bits of shells, juices and blood to color their environment.

According to Sally Vinroot and Jennie Crowder, in their book *The New Dyer*, 1981, woven garments dating back to 4000 B.C. indicate that dyeing was an advanced art. Indications of early dyers have been found in the Mediterranean cultures. The Romans and Phoenicians traded dyestuffs during the middle ages. Color was used to denote rank. Purple was from a rare and expensive mussel, its color was only used by priests and kings. Woad (blue) was found in England. Safflower (red) came from Asia and Africa. Madder (yellow) and Indigo (blue) were imported from Asia.

The industrial revolution made it imperative that man develop synthetic dyes because the quantity of fabric being produced was difficult to color with the natural dyes and mordants that had been used for centuries.

In 1854 William Perkin of London accidentally produced a synthetic dye while he was trying to make synthetic quinine. Sally Vinroot and Jennie Crowder in *The New Dyer*, go on to say that these first chemical dyes, tested
by Pullers of Perth (a dyeworks), were called "aniline" - organic compounds made from nitrogen and benzine. These popular first dyes (aniline) were brilliant in color and cheap to produce but they faded easily and ran when washed. They have been improved over the years and are now called cationic or basic dyes and are used to color acrylics, polyesters and other synthetics.

Chemists isolated the coloring agent in madder -alizarin- in 1868, and later indigo in 1880, a substance called indigatín. These were vat dyes, they are bright and fast to light and washing, but expensive. Disperse and reactive dyes were developed in the 20th century, to dye cellulose acetate (rayon). The reactive dyes actually bond with the fibre molecule, are easy to use, are mostly washfast and have a wide range of colors.

Union Dyes such as Rit, Tintex and Cushing are not a separate class of dyes but are a mixture of several classes, designed to dye as broad a range of fibers as possible. They are expensive to use because whatever dye is not absorbed is wasted. They have a tendency to fade and wash out easily. However, they are very valuable to the dyer who wishes to dye a yarn made up of a blend of protein and cellulose fibers, for instance a wool/cotton, or a linen/wool. Each fiber would then accept a part of the dye in comparable shades.
Color

All colors have the following characteristics:

HUE: the pure color and name of family in the spectrum it belongs to. Red is a pure color; pink, rose, crimson, and wine belong to the red family.

VALUE: The amount of lightness or darkness in a hue. The hue remains the same, but with the addition of white or black the value changes. Pink is a light value of red; wine a dark value.

INTENSITY: the brightness or dullness of a color. Again hue is retained but the closer the color comes to the pure hue, the brighter it is; the further away, the duller it is. Colors are classified according to their positions on a color wheel.

PRIMARY: The pure colors from which all others derive. Red, yellow, and blue.

SECONDARY: The colors that lie between the primaries, made by mixing two primaries. Orange, violet, green.

INTERMEDIATE: mixture of adjacent primary and secondary. When dyeing, we simply manipulate the dye formula so that there is a higher percentage of one, or of the other, primary color.

COMPLEMENTARY: The colors opposite each other on the wheel. Red is the complement of green, blue of orange, etc.
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TINT: Blending hue with white (when dyeing this is done by using smaller amounts of dye stock solution so the white of the fibers show through).

TONE: Blending hue with gray (black and white). My dye samples are toned by overdying the natural grey romney handspun yarn.

Besides the three principle characteristics of color - hue, value, intensity - every color falls into one of seven categories - pure hue, black, white, gray, tint, shade, and tone. For example, a pale blue is a mixture of a blue hue with white and is called a tint. It also has a certain amount of value and intensity depending upon the amount of white and how far the resulting color is removed from the original hue.

Humans perceive color when light strikes and activates cone-like nerve cells, causing impulses which the brain must then interpret. Ants, bees, goldfish and monkeys see color the way we do but deer do not. The craftsperson working with color would benefit from an understanding of how personal experience, and educational background affect individual color preferences. Some cultures perceive black as evil, white as purity, red as joy and life.

Color begins with visible light - an electromagnetic energy. Sir Isaac Newton was the first person to prove that white light contains colors. Color can be seen when visible light is separated into its component sections, for
instance, with a prism. It is interesting to note that colors differ from one another in their frequency and wave length. Light is white when all of the visible portion of the electromagnetic spectrum is present. The light appears colored when some part is missing. A transparent sheet of glass or plastic may appear red if there is some pigment present. The dye absorbs all the light except the red. This is the part we see so we label the object red in color. The color we perceive will depend on which light rays are reflected and which are absorbed. Pure light, unrefracted is white and contains all colors. Black is the absence of light. This is the opposite of pigment. Of the colors in the spectrum, red is refracted the least, yellow is bent more, and blue is bent the most.

Visible light consists of three primary colors: red, yellow and blue. We cannot combine any two colors to obtain these three colors, nor can we break any of them down into other colors. When red, yellow and blue light rays are mixed, the result is white. When red, yellow and blue pigments are mixed equally the result is black. Dyes act like pigments, so that if you have almost equal amounts of red, yellow and blue dyes, they produce browns.

The visible spectrum further consists of the secondary colors: orange, green and violet. Each of these is made by mixing any two primary colors. Intermediate hues have less or more of each of these present. Tertiary hues are mixed
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from three primary colors or one primary color plus an intermediate hue, which is another way of saying the same thing because intermediate hues already contain two colors. Please refer to appendix "A" where the tertiaries give a visual reference to the intermediate hues containing all three primaries of red, blue, and yellow in differing amounts.

Colors are "felt" as being either warm or cold. Red, orange and yellow ranges are considered warm while the green, blue violet's are cool. Grief is symbolised as black, red usually means life. Color can be used to communicate if artists are aware of regional and learned attitudes toward it.

Colors are often referred to by their Colour Index numbers (CI numbers). It is an international system which can eliminate confusion arising from brand names, because it is constant. A standard color reference is important so naming and numbering systems have been developed. The CI number is one, another is The Munsell Color Notation which introduced the first standardized method of designating colors in 1898. Another is the Maxwell triangle. These are three-dimensional forms where colors are described by their location. The Standard Color Card is another reference.

A dyer/fiber artist must do a lot of experimental color work, in order to generalize from a limited inventory of
dyes. It is not difficult to develop dye formulas, but careful records should be kept in order to duplicate colors. **SOME COLOR GUIDEPOSTS** The following can help a spinner to choose a yarn’s desired color.

1. When deciding upon colors, consider where the finished work will be used and with what other colors it will be seen. Twist the colors together to see the effect, or wind yarn around strips of white paper to simulate the warp. Then interweave the filling colors. These tests show how colors reflect each other's hue and change character when placed together.

2. Color can be heavy, bright, light, sharp, or delicate. Reds, oranges, and yellows can be warm and exciting; blues, violets, and greens, cool and calming. White with a color makes the color look deeper and darker even though the overall effect may be light. Black gives the color a lighter and more brilliant look (black could outline a stripe for instance).

3. Neighboring colors on the wheel subtract their common color from each other. For example, in a green and turquoise combination, the green looks more like yellow-green since the blue in it combines visually with the blue in the turquoise. The same green next to lime will have a bluish green hue since the yellow in it combines with the yellow in the lime.
4. When using several colors of great intensity, the brightest will appear even brighter, and the least bright almost dull, even though it may have looked bright by itself. If you want bright colors, but not an overall bright "look," weave in enough neutral or dull colors to diminish the intensity of the bright ones.

5. In a rug, tapestry, or wall hanging an area of great darkness can be created by placing it next to a very light area. Bright areas next to dark ones make the bright, brighter; the dark, darker. Keep in mind when making stripes or plaids that equal amounts of a light or dark color make the light appear larger; the dark smaller. Warm colors also appear larger if combined with equal amounts of cool colors.

6. Complements can give very dramatic effects. When of the same intensity, they clash, but by changing the weave or by reducing the amount or intensity of one color, you get a less vibrant combination. A color and its complement, used in the right proportion, will retain that color closest to its original hue because the color does not borrow from or reflect the complement but fights with it for prominence. Neutrals also bring forth a color in its truest hue.
7. Two yarns of different hues could be combined to give the impression of a third hue. A red yarn and a blue yarn will give a purplish effect. Yarn texture will affect color. A fuzzy mohair in the same color as a gleaming smooth rayon will not look as bright as the rayon. In the sample skeins which I spun, the 100% mohair and the 100% merino appear to be almost different shades, while the 50/50 mohair wool is softer and the overdyed natural gray is much deeper in hue. The 70/30 corriedale/mohair is quite bright and distinct.
PURPOSE:

The purpose of this study is to compare different commercial chemical dyes in such a way that craftpeople and fiber artists could use it as a tool when choosing types, methods, and colors suitable for different projects. It is hoped that ordinary people, in a home setting, will be encouraged to mix their own hues with only the three primary colors, after choosing the suitable type of dye. I have limited myself to three primary hues of red, blue and yellow, and I have done 98 samples of each type of dye. I had to limit my samples because once I began to dye, I realized that the number of different hues available when a person is mixing their own dyes are unlimited. Subtle differences in each color occur between each fiber, as well as between the different types of handspun yarn. Further, I will show the subtle color differences which each class of chemical dye produces. See appendix "A" which shows the actual samples.

Mohair is the term given to the fleece of an Angora goat. Because these fibers grow to approximately 12 inches per year, they are usually shorn twice a year. Mabel Ross, in her book The Encyclopedia of Hand Spinning, 1988, tells us that the first shearing is done at six months of age, and this fleece is termed 'tight lock' or 'fall kid'; the second is 'spring kid'; the third, at 18 months is 'yearling mohair'. Further shearings are termed 'adult mohair'. I
used adult mohair in my study because it was readily available to me.

Romney wool was my choice for the wool mohair blends of this study, because the length and size of these fibers blended well with the adult mohair. I used a natural gray romney spun woolen to 'shade' each hue. I spun a 50% wool / 50% mohair blend and used two of these. I used a commercially carded and blended 70% corriadale wool, 30% mohair roving for one of my handspun yarns. The fifth yarn I handspun was 100% merino from New Zealand. It was a commercially scoured and carded roving. See samples in appendix "A" appearing at the end of this text.

Each of my dye samples contain two strands of the 50/50 wool/mohair, one strand 70/30 wool/mohair, one strand novelty 100% mohair, one strand natural gray 100% romney wool, and one strand 100% merino wool.

Mohair and wool are protein fibers. They are similar yet different. In Volume 2, issue 1 of the fall 1985 issue of the Color Trends Magazine, Michelle Wipplinger tells us that each of these fibers have scales on their outer layers. Mohair scales are broader and lie flatter and closer to the surface of the fiber while the scales on a wool fiber are twice as numerous and overlap more. These two protein fibers have a cortical layer below the scales. This layer is most responsive to dyes. The cell structure determines whether the fiber is more or less reactive to dyes and
chemicals. Kid mohair differs from adult mohair, and wool fibers differ from either kid or adult mohair. The Kempy fibers present in adult mohair and some wools, do not take dye well, and will appear lighter. If a frosty look is desired a handspinner will leave them in but they are generally removed from commercially spun mohair.

Dyes penetrate mohair more easily than they penetrate wool, and at a lower temperature. Because of the physical properties and reflective qualities of mohair, it appears to dye lighter than wool. Since mohair fibers are quite costly, and its lustre and sheen very appealing, it is often blended with wool or with other fibers to add its rich sheen and strength to a yarn.

The dyes that I am using are:

1: Luvotex -- These are a combination of a strong and a weak acid dye. I purchased them from Hannelore Lubben, Sun Bench Acres, 49612 Larsen Road, Sardis, British Columbia, V2R 1B1.

2: CK Acid -- Ciba Kiton dye, is a levelling acid dye which I purchased from Talisman Clay & Fibre Co. 1370-7th Ave., Prince George, British Columbia, V2L 3P1

3: Proclon MX -- Fiber reactive dyes normally used for cold water dying but used here with a different method for protein fibers using heat.

4: Lanacet (Telana) -- A combination 1:2 metal complex and reactive dye. These are manufactured by Ciba-Geligy and
are replacing the Cibalon premetalized dye series. I purchased mine from Cerulean Blue Ltd., P. O. Box 21168, Seattle, WA, 98111-3168, USA.

There are many practical benefits accruing to the fibre artist or craftperson when dyeing fibers. One of the most important ones is that it is possible to have any tint or tone of color, hue, value, etc., (in short – an unlimited palate) available to the home dyer, once the techniques are mastered. According to Linda Knutson, in her book, *Synthetic Dyes for Natural Fibers*, 1982, neutral yarns may be purchased in bulk, in neutrals or white, in a variety of textures, then later conveniently dyed in specific shades, in needed amounts for a particular project. Handspinners may produce yarns as needed and color them at will. Colors which are not readily available on the market can be mixed at home, giving the home dyer unlimited creative possibilities.

I will provide a visual aid as well as technical information in order to encourage a fiber artist to start a similar dye sample reference book. A handspinner could refer to this study when choosing what type of commercial chemical dye to use as well as using it as a reference in the selection of hue, tint or tone as desired. I will use
five different handspun yarns for each dye sample in each class of commercial chemical dye. These are:

1; merino wool - 100%
2; corriedale wool - 70% / mohair - 30%
3; mohair - 100%
4; romney wool, natural grey - 100%
5; romney wool/mohair blend, approx. 50/50 percent

The above are all protein fibers, as cellulose fibers require different chemical dyes.

These dye samples will be arranged in such a way that a dyer can compare them. The natural gray will provide the tone which could otherwise be obtained by adding a small amount of black or a complimentary color to a dyebath. A dyer should be able to sample colors quickly and systematically therefore I will use a canner with seven quart jars, as suggested by Linda Knutson on page 136 of her book *Synthetic Dyes for Natural Fibers*, 1982. My 98 dye sample skeins will weigh 10 g, and my dye stock solution will be 1%. This will allow for ease of calculations when measuring dye stock solutions, salt, acids or other chemicals needed for each class of dye. In order to achieve a color wheel I will use the three primary colors of dye to do percentage dyeing. I will have primary hues of red, blue and yellow, secondary mixtures of two primary's and intermediate hues of differing percentages of two primary colors. My other dye samples will include intermediate