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Mathematics of Dyeing

Dialogue box from Adobe CS3 suite.

Many computer programs provide the CMYK (subtractive primary) coordinates for the colors on our monitors, (which are RGB), but how do we convert the CMYK formats for use in dyeing?

It takes a combination of knowledge—objective (simple mathematics) and subjective (dyer's experience).

Using the turquoise swatch above for the exercise, the simple mathematics:

1. Add together the CMYK coordinates:

   C = 57
   M = 2
   Y = 23
   K = 0

   57 + 2 + 23 +0 = 82

2. Divide each individual number by the total to determine the percentage each color has to the whole:

   C = 57/82 = 70%
   M = 2/82 = 2%
   Y = 23/82 = 28%
   K = 0/82 = 0%

The turquoise is composed of 70% Cyan, 2% Magenta, 28% Yellow, & 0% Black. Verify the calculations by determining that they total 100%. I said the math was simple!

The percentages are the starting point. Percentages of what?

The percentages are the amount of each of the subtractive primary colors required to produce that hue.

The dyer has to first decide the depth-of-shade (DOS) of the hue. This is where subjectivity and experience come into play.

With acid dyes 1% is generally considered the saturation level of a pure hue (2% for fiber reactive dyes)—many dyers have their own preferences.

Only experience tells a dyer the total percentage of dye needed to obtain a specific DOS of a specific hue on a specific yarn.

Solely for the purposes of this exercise, we will assume that our turquoise can be obtained at 2% DOS on the yarn we're using.

To make the calculation of the dye color formula a little more interesting, let's use:

Skein of yarn = 248 grams
Depth-of-shade = 2%
Stock solution = 1%

The dyer now knows that a total of 496 ml (248 x 2) of 1% stock solution is required. The calculations for the individual colors are:

C = 248 x 70% x 2 = 347 ml
M = 248 x 2% x 2 = 10 ml
Y = 248 x 28% x 2 = 139 ml

A quick check: 347 + 10 + 139 = 496 proves that the calculations are correct.

This article assumes some knowledge of stock soslutions and their role in dyeing.
For further information refer to the Precision Dye workshop handouts and the MoA spreadsheet.