Percentage or Depth of Shade Dyeing using Procion MX or Acid Dyes

If you want to achieve reliable, reproducible dyeing results, are interested in dyeing to match or achieve exact results, or wish to produce a carefully regulated series of colors, you will have to use dyes with great accuracy. This requires precise and consistent methods of weighing and measuring. The most accurate way to do this is with calibrated metric equipment--gram scales, graduated cylinders and liter containers, and syringes. This equipment is available from most dye companies, chemical supply houses, pharmacies, and cooking supply stores. While this is the most accurate and universally understood method of controlled dyeing, feel free to develop your own methods. <u>All that is really necessary is that you use the same equipment and procedures each time</u>.

There are two concepts that will help you in understanding controlled use of dyes.

1. Depth of Shade
This refers to a ratio of a certain weight of dye to a given weight of fiber. The given weight is usually one unit, such as 1 gram or 1 ounce. Depth of shade is usually expressed as a percentage. For instance:
3% depth of shade = .03 grams of dye per 1 gram of fiber OR .03 ounces of dye per 1 ounce of fiber.

To calculate the amount of dye for a given depth of shade on any weight of fiber, multiply the depth of shade by the weight of the fiber. For example, to find out how much dye to use for 5 grams of fiber at a 3% depth of shade, multiply:

.03 x 5 grams = .15 grams of dye.

Thus, .15 grams of dye will produce a 3% depth of dye on 5 grams of fiber/fabric.

2. Stock solution
A stock solution is simply powdered dye dissolved in concentrated form in water. It is one way of measuring and adding powdered dye to a dye-bath. One of the best reasons for making stock solutions is that dyes are safer to use once they are in solution. Most contamination occurs through inhalation of the powders. Also, when the dye is in solution it mixes more quickly and readily with the larger volume of water, it is more convenient, and it is easier to measure very small amounts of dyes when you are trying to get very light colors or to dye very small quantities of fiber or fabric. Once the powder is mixed into solution, you can convert the measuring system from weight to volume (from grams or ounces to liters or cups). Stock solutions also eliminate measuring or weighing and pasting dye for each dye-bath.

The strength of the stock solution can be adjusted to facilitate measuring but should not exceed 10% because most dye powders will not dissolve into solution at greater concentrations than this. 5% is a useful and workable percentage for most jobs. For very light depths of shade, it is helpful to make a weaker stock solution, such as 1% or 2%.

A stock solution consists of a specific weight (amount) of dye in a specific volume of water. The strength of the stock solution is a ratio of the weight of the dye to the volume of the water. This ratio is expressed either as a percentage or as a decimal equivalent.

For example, 50 grams of dye in 1 liter of water would be expressed as either a 5% solution or a .05 solution.

$$\frac{50 \text{ grams of dye}}{1 \text{ liter of water (1000 ml.)}} = .05 \text{ stock solution} = 5\%$$

Calculating a stock solution:
There is an easy formula for calculating the correct volume of stock solution to use to achieve a reliable depth of shade on the fiber:

$$\frac{\text{depth of shade x weight of fiber}}{\text{strength of stock solution}} = \text{volume of stock solution to use in the dye-bath}$$

Example: You have a .05 or 5% stock solution and you want to produce a 1% depth of shade on 5 grams of fiber. You would multiply:

$$\frac{.01 \text{ depth of shade x 5 grams of fiber}}{.05 \text{ (5\%) solution}} = 1 \text{ ml. stock solution}$$

Calculating the chemical assistants:
1. Common salt: use .5 grams of salt per gram of fabric.
Salt helps the fabric open up to accept the dye. It also allows the dye to distribute more evenly throughout the dye-bath. This allows for very even dye results.

2. Soda ash: use .09 grams of soda ash per gram of fabric.
Soda ash activates the dye. Without soda ash, Procion mx dyes are not wash or light fast and the color will not turn out as desired.

Making a stock solution:
Although metric measuring equipment is recommended for the most precise work, it is perfectly possible to measure weight in ounces or pounds and to measure volume in teaspoons, tablespoons, cups, pints and quarts-or to mix metric and these more familiar measures. The key is to be careful and consistent with whatever method you choose as easiest for you--and to keep records of what you do.

1. Weigh the correct amount of dye powder. Never place dye or chemicals directly on the pan of the weighing scale. When weighing the dye powder, place an empty container or piece of wax paper on the scale. Press the "tare" button on the scale to zero it out. Then measure your dry dye powder onto the wax paper or into the container. It is helpful to always use the same scale.
To find the correct amount of dye powder, multiply the amount of water times the desired percentage of stock solution.
Example: to make one cup (240ml) of 5% stock solution, multiply:
240ml x .05 = 12 grams of dry dye powder

2. Paste the dye. Add a small amount of warm water, from your total water needed, to the dye and stir into a smooth paste.

3. Add the specified amount of warm or room temperature water. Using distilled water alleviates the problem of impurities and lengthens the shelf life of the solution.

4. Label the stock solution with the type of dye, the color name or code, the strength of the solution (expressed as a decimal or a percentage), and the date the solution was mixed.

5. Store the solution in an air-tight plastic container or squeeze bottle out of direct sunlight. The shelf-life of a stock solution varies with the type of dye and the storage conditions. Most stock solutions can be stored for a month. Check the manufacturer's specifications to be sure. Be sure to stir or shake the solution carefully and thoroughly before each use. Over time, all stock solutions will hydrolyze and lose their strength and permanence.

Useful conversions:
1 liter = 1000 milliliters
1% = .01
.1% = .001
.01 % = .0001
1 ounce = 28.35 grams
1 pound - 453.6 grams
1/8 tsp = .625 ml
1/4 tsp = 1.25 ml
1/2 tsp = 2.5 ml 1 tsp = 5 ml
1 T = 15 ml
1 cup = 240 ml 1 pint = 480 ml 1 quart = 960 ml
3 tsp = 1 T
16 T = 1 cup
2 cups = 1 pint
2 pints = 1 quart

Approximate weights:
1 tsp of common salt = 9 grams
1 tsp of soda ash = 5 grams
1 tsp of procion dye = 3 grams

DYE RECORD SHEET

Color / Sequence _____

Depth of shade (DOS) _____

Weight of fabric (WOF)_____

% Stock solution _____

Formulas:

Water
Water to Fiber ratio of 20:1 for Procion MX, OR 20:1 to 40:1 for Acid dye on wool or silk

WOF_____ x 20 = _____ml water

Dye (stock solution or dry powder)
___DOS x WOF__= Volume of stock solution added to dyebath
  % stock solution

DOS_____ X WOF_____ / %SS_____ = _____ml stock solution

OR
DOS x WOF = weight of powdered dye (if not using stock solutions)

DOS_____ X WOF_____ = _____ g dry dye powder

Procion MX
Salt (.5 grams of salt per gram of fabric, 1 tsp salt = 9 grams)
.5 x WOF_____= _____grams of salt (divide by 9 for tsp of salt)

Soda ash (.09 grams soda per gram of fabric, 1 tsp soda ash = 5 grams)
.09 x WOF _____= _____grams soda ash (divide by 5 for tsp soda ash)

Washfast Acid Dye
Citric acid (3% WOF)
.03 x _____=_____grams of citric acid

Ammonium Sulfate (on wool or Nylon 3% WOF, on silk 1% or 2% WOF)
.03 (or .02 or .01) x _____ = _____grams of Ammonium sulfate

Salt or Glauber's salt (3% to 5% WOF)
.03 (or .05) x _____ = _____grams of salt

Dyeing Gradations of Colors
Gradations are gradual changes of color, usually from one piece of fabric to the next in a sequence of dye baths. The steps of change from one to the next are usually orderly and measured. They may vary in speed- the number of steps required to move from one color to another. Rapid change may provide visual jerks or be difficult to read as a sequence. Slow change can yield a smooth evolution or fluid transition in which the stepped colors seem to melt into each other. Color gradations can be of several varieties:

-Analogous – movement from hue to hue in order around the color wheel, but concentrating on groups of color that are close to each other (for example: yellows and oranges, or blues and purples).

-Complementary – movement between one hue and its complement across the color wheel (red to green, yellow to purple, blue to orange). These sequences create a range of neutral hues.

-Shade – additions of increasing amounts of black to a hue (for instance: adding black to red).

-Value/ Monochromatic – increasing/decreasing depth of dye (for example: adding increasing amounts of blue to successive dye-baths).

-Tonal – additions of increasing/decreasing amount of a toner to a hue. A toner usually contains a pair of complementary colors and sometimes black and is added to a hue to affect intensity and value. (For example: you can mix a toner containing black, green and red in whatever ratios you like, then add increasing amounts of it to yellow in successive dye baths.) These make brownish grayish color, earth tones.

All gradational series rely on keeping certain things constant while varying others. A constant is a given color (which may be a mixture of several hues) at a given depth of shade or strength that remains a consistent ingredient throughout a progression. Therefore, the constant can be mixed up ahead of time and added in the same amount to each dye bath. A variable is a given color, or a consistent mix of colors, which changes or moves along a specified depth of dye range, throughout the progression of dye baths. The movement of the variable can be from a smaller depth of dye to a larger one or vice versa. A gradational progression can be composed of any number of variables and constants working together.

If you like setting up systems, you can have a lot of fun playing with this kind of control of color. Mixing and experimenting with gradations is one way to locate unusual colors in combination. It can expand your color vocabulary dramatically. In addition, gradations of colors, because they usually contain some kind of constant, usually work well together in composition because they have a common ground which connects visually.

How to achieve specific gradations

1. Value/ Monochromatic sequence
Increase the depth of shade of a hue (could be one hue, or a couple mixed together). The general procedure here involves adding increasing amounts of this color or composite color to successive dye baths.

Procedure
1. Choose a depth of shade sequence, for instance: .25%, .5%, 1%, 2%, 4%, and 8% (doubling the depth of shade with each step).
2. Calculate the amount of stock solution you will need for each dye bath using this formula:

weight of fabric x depth of dye (for one dye bath) =   ml. of stock solution
           strength of stock solution (%)

3. Add up the amounts of stock solution for each dye-bath to get the total amount needed for the sequence. Round the number up a few ml so you won't run short.

4. If you are mixing colors and you want to find out how much of each color stock solution you need for each color, multiply the percentage of each color in the mix times the total ml. of stock solution needed (or the rounded up amount). For example, if you want to mix 80% of color 1 and 20% of color 2:

.8 (80%) x total ml. of stock solution needed = ml. of color #1

.2 (20%) x total ml. of stock solution needed = ml. of color #2

This will give you enough stock solution of your special color mixture to do the entire sequence of dye baths.

5. Add the dye to the dye baths and proceed with the usual dyeing process.

2. Shade sequence
Add increasing/decreasing amounts of black to a hue. This results in a sequence of color that becomes darker and darker, and where the chosen hue is eventually overshadowed by the black if the sequence continues far enough. The original color is also de-intensified in the process.

Procedure
1. Decide how many steps you want in the sequence.
2. Select a color or composite color at one depth of shade to remain constant throughout the sequence. The variable for this sequence will be the changing amounts of black added to that color. It is helpful to choose a depth of dye that is a medium to dark value to start. Very light values will be taken over by the black very quickly.
3. Decide how fast you want the change to occur from one step to the next and assign percentages. For instance: .25%, .5%, 1 %, 2%, 4%, 8%.
4. Line up your dye baths and place the same amount of the constant color in each dye bath.
5. Then calculate and add the varying units of black to each dye bath. (Use the formula above to calculate the amount of stock solution needed for each dye bath.)
6. Complete the dye process as usual.

3. Complementary or Two Color sequence with no increase in value/depth of dye
Select two complementary or near complementary colors and a depth of dye. This sequence involves two variables. Since the depth of dye or the resulting value of each of the dye baths is to remain constant, one variable must increase while the other one decreases. For instance, a sequence of 7 steps might be set up like this:

Color #1	0 parts	1 part	2 parts	3 parts	4 parts	5 parts	6 parts
Color #2	6 parts	5 parts	4 parts	3 parts	2 parts	1 part	0 parts

So, there are a total of 6 parts in each dye bath. In this case, one part = 1/6 of the total amount of stock solution. You will add the 2 colors to the dye baths in the appropriate relationships. With this scenario, an odd number of dye baths is usually the easiest to figure out mathematically.

Procedure
1. Decide how many steps you want in the sequence (odd numbers work best).
2. Select a depth of shade as a constant. Then select two hues or composite hues to vary throughout the sequence.
3. Calculate the number of ml of stock solution of each hue that constitutes one part, using the standard formula above.
Example: if your DOS is 4% and your weight of fabric is 50g for each dye bath, total stock solution for each dye bath is: .04 x 50g = 2 ml. So 1 part is 2ml/6 = .333ml.

4. Line up your dye baths and place the appropriate number of parts of each hue in each dye bath.
5. Complete the dye process as usual.

4. Complementary or Two Color sequence with increase in value/depth of shade
This series will have one constant and one variable. The constant will be a specific depth of shade of one hue. The variable will be your second color. This sequence is similar in execution to the shade sequence, however instead of using black, you are using a different color.

Procedure
1. Decide how many steps you want in the sequence.
2. Select a color or composite color at one depth of dye to remain constant throughout the sequence. The variable for this sequence will be the changing amounts of the second color.
3. Decide how fast you want the change to occur from one step to the next and assign percentages. For instance: .25%, .5%, 1%, 2%, 4%, 8% (doubling the amount each time).
4. Line up your dye baths and place the same amount of the constant color in each dye bath.
5. Then, calculate and add the varying units of the compliment to each dye bath. (Use the formula above to calculate the amount of stock solution needed for each dye bath.)
6. Complete the dye process as usual.

5. Toner sequence with an increase in value/depth of shade
A toner usually is made up of black and a pair of complements or near complements. Concoct one of your own, keeping track of the percentage relationships of the various components. Select a hue and a constant depth of shade for it. Add the same amount of that constant hue to each dye bath. Add the toner in a progression you have devised that increases the amount of toner in depth of shade.

OR select a constant depth of shade for the toner and then vary the sequence in the depth of shade of the hue you have chosen.

6. Toner sequence with constant depth of dye
This results in a sequence in which the value of the colors remains constant, that is, they are all equally light/dark, but the ratio of the pure hue to the toner changes. Concoct a toner of your choice, keeping track of the percentages of the components. Select a color. Arrange a sequence in the same manner as in series #3 above which has a constant value/depth of shade.

Procion MX Dye on Cellulose Fiber and Silk
(cotton, linen, rayon, hemp, etc.)
Immersion Dye

Supplies
Procion MX dye*
Soda Ash
Salt
Synthrapol

*Always wear a dust mask/respirator when working with powdered MX dyes. Always wear gloves when working with dyes, in powder form or dissolved in water.

Always pre-wash any fabric (even if it is labeled PFD) in hot water with laundry detergent or _ tsp synthrapol and 1 tsp soda ash.

1. Soak fiber in warm water. When you are ready to dye, gently squeeze out excess water before adding the fiber to the dye-bath.

2. Make dye-bath. Combine required amounts of water (20 x WOF) and salt (.5 x WOF) in a container. Stir well to dissolve salt.

3. Add required amount of stock solution to the dye bath. Stir well to distribute dye evenly through the dye bath.

4. Add damp fiber to dye bath. Stir well and often for 15 minutes.

5. Dissolve required amount of soda ash in a small amount of water. Move the fabric to one side of the dye bath and add the soda ash to the other side. Stir well and often for 30 minutes. The more you stir, the more evenly dyed your fabric will be.

6. Wash fabric. First rinse fabric in cold water until the water runs clear. Then increase water temperature to warm and add a few drops of synthrapol. Continue rinsing with warm to hot water and synthrapol until the water runs clear. This may take several changes of water. Gently squeeze out excess water and hang to dry or iron on a towel to speed up drying process.