ROBERT KOCH Industries, Inc.

Dyes • Pigments • Fragrances • Specialty Products

DYEING FLORAL & CRAFT PRODUCTS BY IMMERSION WITH BASIC DYES

Product Reference Sheet #200

web version 2.0

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KOCH COLOR

Quick Reference

Dyeing Floral & Craft Products by Immersion with Basic Dyes

Dyeing is typically carried out by immersing the materials to be dyed in a hot water dyebath. Most products are dyed at temperatures in the range of 160-180°F (70-80°C). A thin layer of wax called the cuticle covers the surface of most plants. Penetrating this layer is very difficult using cold water. Heat helps melt surface waxes and opens plant fibers allowing for better dye penetration. Items that are highly absorbent like wood excelsior and mosses are easier to dye and can be dyed at lower temperatures in the range of 110-150°F (40-65°C).

Typical Dyeing Recipe

Basic Dye: (Predissolve in very hot water)

	Dye Concentration		% Dye on Weight of Goods
Very light Shade	0.003 oz/gal	(25 mg/l)	(0.01% - 0.10% owg)*
Light Shade	0.02 oz/gal	(150 mg/l)	(0.10% - 0.50% owg)
Medium Shade	0.07 oz/gal	(0.5 g/l)	(0.50% - 1.50% owg)
Heavy Shade	0.13 oz/gal	(1 g/l)	(1.50% - 3.00% owg)

* % owg stands for on weight of goods, i.e., 0.50% owg means that 0.50 lbs. of dye is needed for 100 lbs. of goods. The above dye concentrations assume that dyeing goes to completion. For faster dyeing cycles, dye concentrations may need to be increased.

Optional Ingredients (Add only if necessary)

- Nonionic Surfactant — 0.12 fl oz per gal (equivalent to 3/4 tsp/gal or 1 ml/l)
- Glacial Acetic acid or citric acid — Reduce pH to approximately 4.5. Test with pH meter.

Many materials can be dyed in a solution a simple as water and dye. The general principle for additives is to use them only when needed.

The nonionic surfactant assists in wetting-out the fibers, promoting uniform dyeing.

Preparation

Materials to be dyed should be rinsed before dyeing. This prevents dirt and other debris from contaminating the dyebath. An optional pre-soak in hot water will break down surface waxes, enabling a more uniform dyeing.

Dyeing Procedure

Predissolve the dye in very hot water (preferably boiling) and add to the dyebath. If acetic acid or citric acid is being used, this can be added directly to the dye along with the hot water to aid in dissolving. Immerse goods into the dyebath until the desired depth of shade (color intensity) has been reached. Immersion times vary considerably from a few minutes to a couple of hours depending on the material being dyed. Immerse products long enough to allow the dye to become fixed to the fiber. After dyeing, rinse materials in water to remove surface dye and allow to dry. Thorough experimentation is recommended before production on a large scale.

Introduction

Dyes may be used to color many decorative plant materials and craft products. There are many different dye classes, each being suited to a specific fiber or application. This guide focuses specifically on a class known as **Basic Dyes**. Natural fibers such as raffia, straw and jute have been dyed with basic dyes for well over a hundred years. Because of there affinity for plant fibers, basic dyes can also be used to dye a wide assortment of dried flowers , foliage, berries, cones, pods etc.. Wood products such as excelsior, paper, and wood chips are easily dyed with this dye class. In the textile world, basic dyes are used to dye fibers such as silk, acrylic, modified nylon and polyester.

Dyeing is typically done by immersing the products in a hot water dyebath. Under certain conditions, auxiliary chemicals such as surfactants, acidifiers, and retarders are added to enhance performance.

This dyeing primer covers the general principles of dyeing wood and craft products, vegetable fibers, and ornamental products such as dried flowers and foliage. It is broken down into the following sections:

- Color Basics.......................Page 3
- Fiber Basics....................... Page 5
- Dyeing Basics.................... Page 7
- Dyeing Equipment............. Page 8
- Preparing the Dyebath....... Page 10
- The Dyeing Process............Page 16
- Special Applications.......... Page 20
- Key Terms..........................Page 22
- References......................... Page 25

Color Basics

A few words about Color

Before discussing the details of dyeing, it is important to understand a few important principles about color and plant fibers.

The color that is obtained by dyeing something is a combination of the base color of the undyed material and the color of the dye applied. Dyes, unlike paints (which use pigments) doe not hide or mask the substrate. One can dye something darker, never lighter. The final color of the dyed plant material will depend on how much dye is applied to the fiber. In layman's terms one might say that something is dyed lightly or heavily. In the terminology of dyes, this is referred to as **depth of shade.**

Qualitatively, depth of shade is described with terms such as light, medium, dark or heavy. Quantitatively, depth of shade is calculated as the ratio of the weight of dye to fiber weight, expressed as a percentage. For example, if 100 pounds of fiber were dyed with 2 pounds of dye, the depth of shade is computed as 2/100=2% owg (on weight of goods). The illustration below demonstrates the principles of depth of shade.

Wood curls dyed five different shades using Renaissance Red 8472 dye

Several shades can be produced with a given dye. In the sequence of gourds below, a light shade of blue dye on the yellowish undyed base gives a green hue. As the depth of shade increases, the hue becomes progressively bluer. A very heavy shade of blue may require 3% or greater dye on weight of goods whereas a light shade may require 1/10th of that amount. The concept of depth of shade is very important. Light shades require careful control over depth of shade. It is easy to allow these materials to be overdyed.

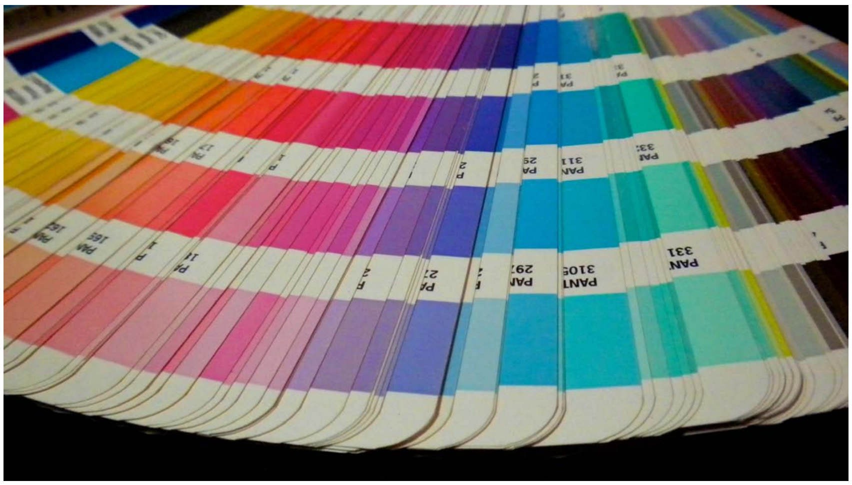
These gourds are all dyed with the same dye, Azure Blue 8020. The gourd on the left is undyed. The depth of shade increases from left to right.

An important factor to consider before beginning the dyeing process is the base color of the material you will be dyeing. The darker the plant or material is before being dyed, the darker the final shade will be. In the adjacent photo the base color of the four sticks varies from a light cream to a darker tan. After being immersed in the same dyebath, at the same concentration and for the same amount of time, the sticks displayed varying shades of the same color blue. The base color can be seen above the dyed portions, displaying just how prominently the base color affects the final product.

Describing Color

Color can be very subjective. How do you describe color to customers? Here is a quick guide that makes it easier for customers to understand exactly what color you are talking about:

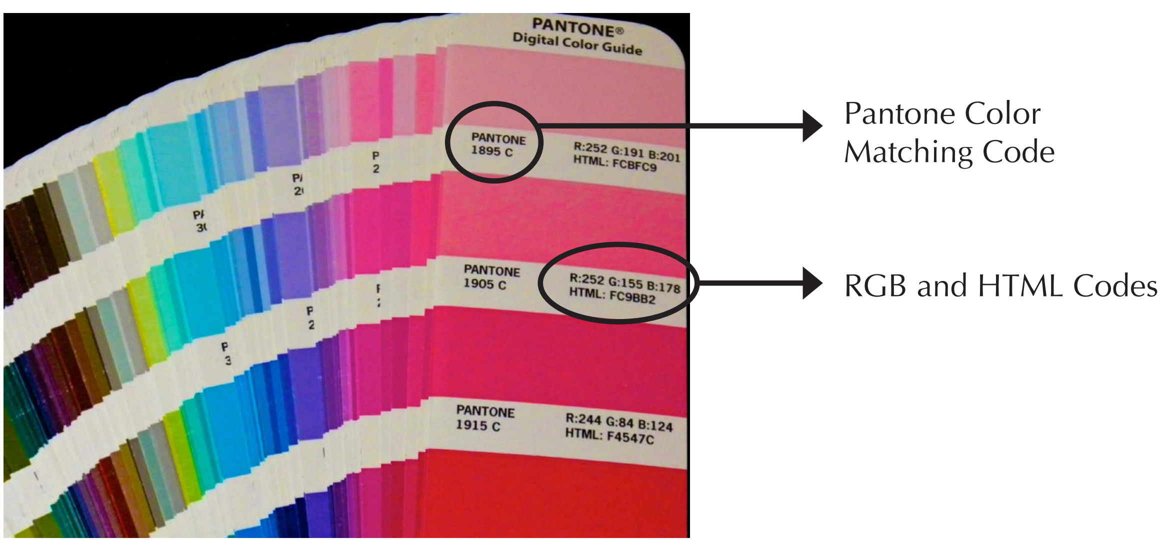
Perhaps the best way to explain a color over the telephone or in an email, is by using a Pantone® color guide. Pantone created a unique color-matching system, in which colors are given unique identifiers. We recommend using either the Pantone® Formula Guide or the Pantone® Digital Color Guide. Using these guides often alleviates misunderstandings between you and your customer.



The Pantone® Digital Color Guide

Using the Pantone Color Guides

Pantone color guides come in a fan of color swatches. Colors are labeled with a three- or four-digit code followed by a C, M or U. The letter refers to the type of paper on which the color is printed: a "C" for coated or gloss paper, "U" for uncoated paper and an "M" for matte or dull paper. [9] The color chips are also identified with RGB and HTML codes. These codes allow you to easily describe colors using a scientific system, rather than using subjective descriptors.



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Fiber Basics

Before discussing the details of dyeing, it is important to understand a few important principles about color and plant fibers.

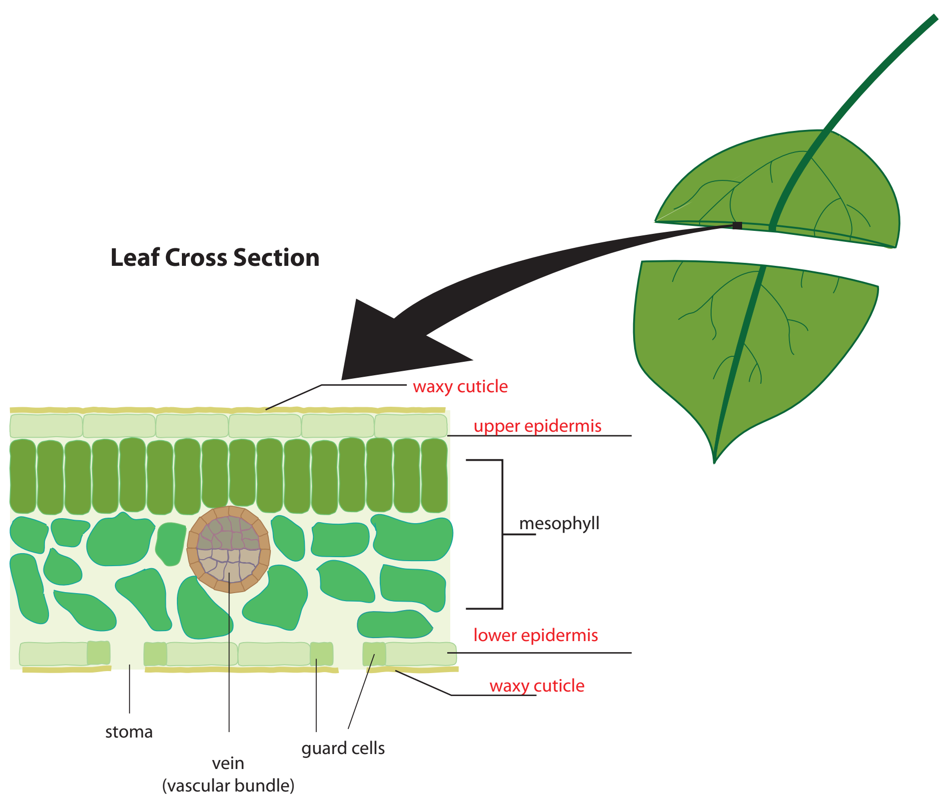
Plant Fiber

The composition of natural plant fibers is important when considering the dyeing process. Various plant parts are dyed such as leaves, pods, cones, berries, stems etc. In some cases the entire plant is dyed, while in others an internal fiber stripped from the foliage. The different parts of the plant have different dyeing characteristics. Plant tissues contain cellulose, lignin, tannins, pigments, pectins, oils and waxes; all which affect dyeability. **Cellulose** is the chief building block of the cell wall. **Lignin** adds strength and stiffness. The cellulose and lignin are not distinctly separate but found intertwined. [10] Natural fibers are sometimes referred to as *lignocellulosic fibers*.

A waxy coating called the **cuticle** surrounds the outer surface (epidermis) of plants. This waxy coating is nearly impermeable to water and is difficult to penetrate. This layer must first be broken down before dye molecules can penetrate into the fibers below. The cuticle layer varies considerably among plants. In hot, dry areas, plants generally have heavier cuticle layers to help prevent water loss. Grasses like wheat and rye are good examples of plants with a heavy cuticle. The easiest way to break down this wax is to melt it by heating the dyebath. Internal fibers below the surface that are extracted have no cuticle and are easier to dye.

Illustration A

Leaf Cross Section



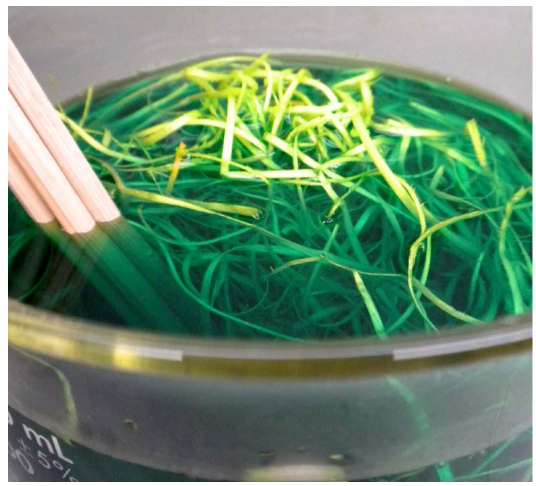
__Tip__: The variable composition of plant material can make dyeing a challenge. It can be beneficial to presoak materials in hot water containing a surfactant prior to dyeing. This will break down the cuticle and swell plant fibers, improving dyeability.

Fiber density varies significantly among different plants and even within the same plant. Dense, woody fibers dye differently than herabaceous (soft) fibers. For example, mosses dye faster than bamboo canes.

Effect of Fiber Density

Fiber density has a large effect on the dyeing process. This can be demonstrated by dyeing two very different materials simultaneously. Excelsior is made from shaving a soft wood such as aspen. It has low fiber density and a high concentration of lignocellulosic fibers. This material takes up dye very quickly. Straw reeds, in contrast, have very dense fibers. Compared to excelsior, the reeds require more time in the dyebath and a hotter dyebath temperature (and often a higher dye concentration) in order to achieve the same results.

1) Undyed reeds and aspen excelsior



2) Both the reeds and the excelsior are immersed in a dyebath for one minute.

3) After one minute in the solution, the dye is quickly adsorbed onto the excelsior, while the reeds show little coloration.

4) The reeds are placed back in the dye solution. After an additional 45 minutes & with the solution at much higher temperature, the reeds show significant color.

Dyeing Basics

What is Dyeing?

Dyeing may be defined as the process in which molecules of dye are transferred from a medium (water, alcohol, etc.) to a fibrous substrate (the products being dyed). [4] The dyeing process requires the following elements:

- Plant Fiber
- Affinity of the dye for the fiber (substantivity)
- A transfer medium - usually water
- Necessary equipment

Dye Affinity

Certain dyes have a natural attraction or ability to dye certain fibers. This is known as **substantivity**. Over the years several different classes of dyes have been tested and basic dyes show the best results on dried flowers and foliage as well as many natural fibers used in the craft industry. Surprisingly, other major dye classes such as direct and reactive dyes which are often used to dye cellulosic fibers like cotton, have been found to be ineffective at dyeing many plant fibers. The chemistry behind dye substantivity is rather complex and beyond the scope of this bulletin.

What Are Basic Dyes? Basic dyes are water soluble dyestuffs in which the colored part of the molecule is a positively charged (cationic) ion. [1] Basic dyes provide strong tinctorial strength and a broad color spectrum. In the floral industry, basic dyes are often referred to as *dip dyes* or *immersion dyes*; terms arising from their method of application.

Transfer Medium

The solvent in which the dyes are dissolved when preparing the dyebath is called the **transfer medium**. In almost all cases, the transfer medium is water. In a few special cases a form of alcohol is used. The transfer medium, dye, and optional adjuvants makeup the **dyebath**. In the textile industry, the dyebath is often referred to as the dye liquor.

Basic Dye in Powder Form

Dyeing Equipment

Dyeing Vats

Most materials are dyed by immersion in some form of vat or tank. Vats used for immersion dyeing vary considerably from simple to elaborate. Rectangular shapes tend to be preferred to square or circular shapes. Ideally, containers should be made from stainless steel. While plastic, fiberglass, and galvanized containers are sometimes used, these materials may not be stable to prolonged periods of high heat. They also are easily stained, making it difficult to clean when changing colors.

New equipment can be very expensive. Many dye vats are custom fabricated. One of the best sources of available equipment for dyeing craft and floral products is surplus stainless steel dairy equipment. Used bulk tanks and pasteurizing tanks are available at moderate prices and can easily be adapted for use as a dye vat. These tanks also have steam fittings to allow for heating the dye solution.

Heating Dyebaths

Heating large volumes of water is done most efficiently with steam. Live steam is sometimes injected into the dye solution. More often, dye vats have an internal jacket in which the steam circulates. Heating coils are also common and circulate through the bottom of the vat.

Small dyebaths may be heated by use of an electrical immersion heater. These heaters are readily available and are relatively inexpensive and simple to install. Immersion heaters are often used to heat tanks up to 500 gallons and consist of a long metal rod or coil placed in the vat. They typically operate on either 120 or 240-volt ac. It is essential that these heaters be properly installed to prevent electrical shock.

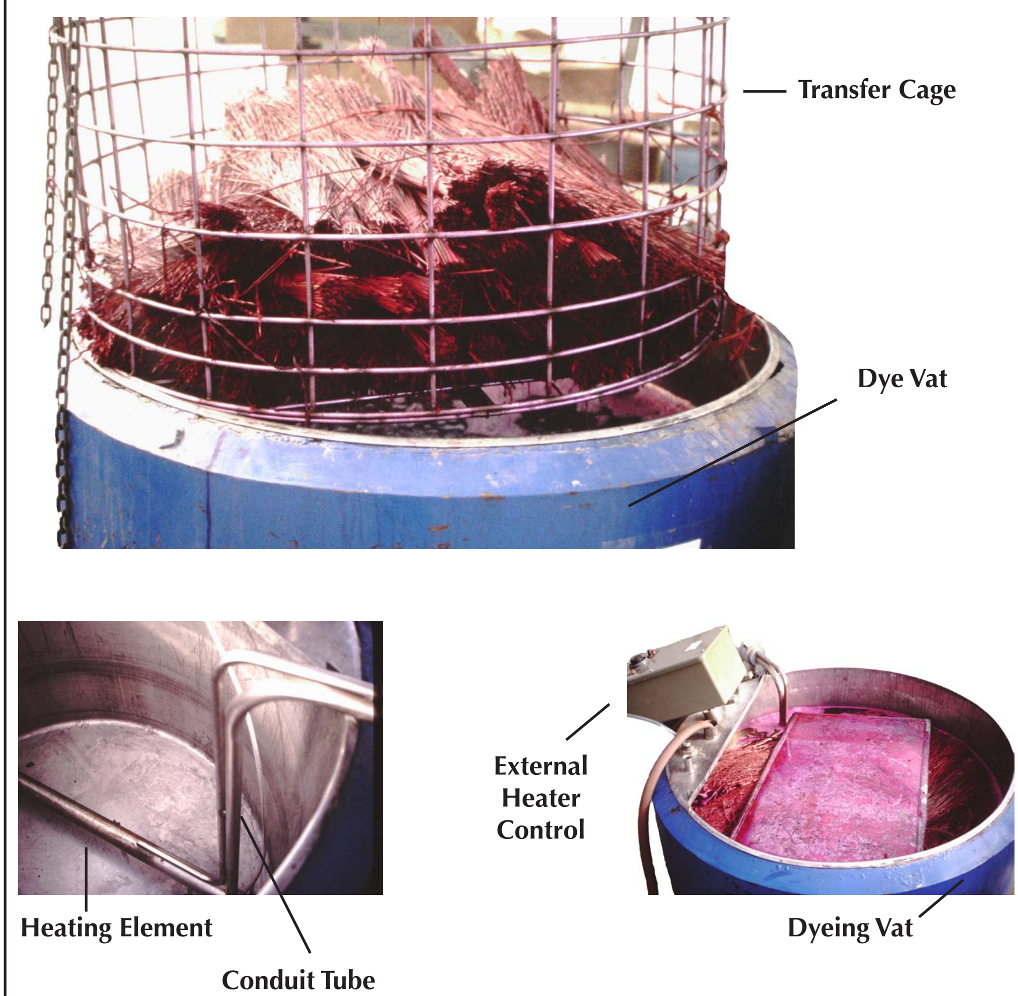
Important Note

Important note: when the dyebath consists of an alcohol, proper ventilation must be provided. Alcohol dyebaths are not heated. Vapors from alcohol are flammable and may be harmful if inhaled. Many users of alcohol locate their vats outdoors under protective cover. The subject of an alcohol dyebath is treated in more detail in the section on special applications.

One other item sometimes added to large dye vats is a mixer or circulating pump. The dyeing process is enhanced by circulation of the dyebath. More uniform dyeing is possible when the dyebath solution is always uniform in composition and in equal contact with all parts of the goods. Regardless of the type of container used, all dye vats should be equipped with covers to prevent evaporation and contamination of the dye vat when not in use.

Dyeing Equipment

Illustration D



When large amounts of product are being dyed by immersion, it is helpful to add the goods to a separate transfer cage that is lowered into the vat. This cage eliminates the burdensome task of adding and removing goods by hand. When the solution is heated, use of a transfer cage greatly reduces the possibility of accidental burns. A hinged lid and bottom may be added to facilitate loading and unloading of the cage. The lid also ensures complete immersion of the goods in the dyebath. Without a cage, most foliar goods will float on the surface, leaving much of the foliage out of the dye solution.

After the goods are processed, the cage is raised above the vat and held in position allowing the remaining solution to drain back into the vat. The transfer cage may then be lowered into an adjacent rinse vat. Since many operations involve pre-rinsing the substrate before dyeing and a post rinse, the use of a transfer cage greatly simplifies the handling involved.

Preparing the Dyebath

Typical Dyebaths

The typical immersion dyebath consists of the following ingredients:

- **Water**
- **Basic Dye**
- **Surfactant** (optional)
- **Acid** (optional)
- **Cationic retarder** (optional)

Estimating Dye Requirements

The amount of dye that is added to the dyebath depends on the depth of shade desired. Deep, rich colors obviously require more dye than do pastel colors. The best way to estimate how much dye is needed is to conduct some tests on a small scale. Dye requirements can be stated in terms of concentration (i.e. ounces per gallon) or as a percentage on weight of goods.

The following table serves as a guide for estimating dye requirements.

	Dye Concentration		% Dye on Weight of Goods
Very light Shade	0.003 oz/gal	(25 mg/l)	(0.01% - 0.10% owg)*
Light Shade	0.02 oz/gal	(150 mg/l)	(0.10% - 0.50% owg)
Medium Shade	0.07 oz/gal	(0.5 g/l)	(0.50% - 1.50% owg)
Heavy Shade	0.13 oz/gal	(1 g/l)	(1.50% - 3.00% owg)

Wood curls dyed five different shades using Renaissance Red 8472 dye

It is interesting to note that the concentration of dye in solution (i.e. ounces per gallon, grams per liter, etc.) does not have to be specified in order to determine depth of shade. It does however determine the rate at which dyeing occurs.

While it is best to determine dye requirements as a percentage of the material being dyed, it is also common to state dye requirements based on their concentration in the dyebath, i.e. one-quarter ounce per gallon. When estimating dye requirements in this manner, dye concentration ranges from as low as 0.003 ounces per gallon for very light shades all the way up to 0.25 ounces per gallon or higher when dyeing heavy shades.

Unless small volumes are being prepared, dyes should always be predissolved before being added to the dyebath. Most basic dyes will dissolve well in very hot water. However dyes are best predissolved by first forming a paste with glacial acetic acid and then adding hot water, (preferably boiling) to liquefy. The amount of acetic acid is that required to reduce the pH of the dyebath to approximately 4.5. A simple procedure often used is to form a paste by adding 2 parts dye to 1 part glacial acetic acid and then adding 1 part boiling water. Predissolving the dyes will aid significantly in producing uniform dyeings.

* % owg stands for on weight of goods, i.e., 0.50% owg means that 0.50 lbs. of dye is needed for 100 lbs. of goods. The above dye concentrations assume that dyeing goes to completion. For faster dyeing cycles, dye concentrations may need to be increased.

Preparing the Dyebath

There are three important factors to consider when selecting basic dyes. For use in coloring floral, wood, and craft materials, **light fastness**, **strike rate** and **k-value** are three key factors that help determine the effectiveness of dye(s) for a given application.

Light Fastness

Light fastness is a measure of a dye's resistance to fading or color change due to exposure to light. [4] The American Association of Textile Chemists and Colorists (AATCC) has developed testing methods for light fastness.

Light fastness is measured on a scale of 1-8 where:

8 = outstanding	7 = excellent
6 = very good	5 = good
4 = fairly good	3 = fair
2 = poor	1 = very poor

This rating system is meant only to serve as a guide to light fastness. It does not imply actual performance. Actual light fastness will vary depending on method of application, depth of shade, fixatives, auxiliaries, etc.

k-Value and Strike Rate

Strike rate refers to the rate at which a dye exhausts; that is, transfers from the dyebath to the substrate. Some dyes have fast strike rates while others are much slower. This becomes important when dyeing with blends of two or more basic dyes. Each dye in the mixture should have similar strike rates. If not, one dye exhausts faster than the other and the color of the dyebath is continuously changing. Strike rates for basic dyes can be measured quantitatively in a laboratory and assigned an arbitrary value for comparison purposes. These values are often referred to as combination constants or **k-values**.

A k-value is a relative indicator of the rate of exhaustion for a basic dye. A testing procedure developed by the American Association of Textile Chemists & Colorists (AATCC) creates a range of k-values from 0.5 - 5.0 in increments of 0.5. The lower the k-value, the faster the exhaustion rate for a basic dye. A dye with a k-value of 1.5 exhausts at a much faster rate than a dye having a k-value of 4.0.

It becomes important when dyeing with a blend of basic dyes that the only dyes having similar k-values be used. The general rule is that the difference in k-values should be kept to a maximum of 1. Thus a dye with a k-value of 2.5 could be blended with another dye having a k-value in the range of 1.5 to 3.5. One should not blend a dye with a k-value of 1 with another dye having a k-value of 4. Ideally, only dyes with the same k-value should be used in blends.

Preparing the Dyebath

Optional Adjuvants

Three other additives are often added to the dyebath to aid in the dyeing process. These include:

An **acidifier** such as glacial acetic acid or citric acid to lower the pH of the dyebath, improving dye solubility.

A **surfactant** or wetting agent to lower the surface tension of the dyebath; aids in wetting out the fiber.

A **cationic retarder** is used to control the rate of exhaustion. This can be helpful when dyeing light shades with a blend of basic dyes.

It is important to understand that additives to the dyebath are not always necessary. In many cases a dyebath composed simply of dye and water will suffice. As a general rule, additives should only be used when necessary. There are some cases where the above adjuvants can be beneficial. The following paragraphs outline their use.

Acidifying Dyebath for pH Control

Basic dyes perform best under acidic conditions. It is very important when dyeing that dyes be fully dissolved and in solution at a monomolecular level, i.e., in solution as single molecules. Dyes have a tendency to form aggregates in solution, clusters of 15-20 molecules loosely bonded to each other. These aggregates do not migrate easily through plant fibers and can lead to non-uniform dyeing.

The solubility (ability to remain dissolved in solution) of basic dyes is improved by lowering the pH (degree of acidity or alkalinity) of the dye solution with the addition of an acid. When dyeing with basic dyes, it is recommended that the pH of the dyebath be in the range of 4.0 - 4.5. Therefore, basic dye solutions generally contain an acidifier.

Acetic acid is the acid most recommended for this purpose. Although acetic acid is a rather weak acid, it is considered hazardous in its undiluted form. A safe acid, though less effective, is citric acid. In many cases basic dyes can be used without the addition of acid to the dyebath, however acidifying the solution is generally recommended.

What is pH?
The term pH is used to describe the acidity or alkalinity of a solution. It is a number. The pH scale runs from 0 to 14 with 7 indicating neutrality. Solutions with a pH value less than 7 are acidic, and solutions having a pH greater than 7 are referred to as alkaline.

Preparing the Dyebath

Testing for pH Level

A pH meter can be used to check the pH level of the solution. There are a variety of models available, such as the pocket pH meter, manufactured by Hanna (pictured below).

Surfactant (Wetting Agent)

The surfactant helps in wetting out the material being dyed, helping promote uniform dyeing. The surfactant is generally added to the dyebath at a concentration of 0.1% on weight of the dyebath. Nonionic surfactants are recommended for use with basic dyes. The following data gives some helpful conversions:

Table 2

Nonionic Surfactant

SUGGESTED USE IN IMMERSION DYEING SOLUTIONS:

0.10% w/w = 1.0 g/l = 0.9 ml/l = 0.12 fl oz/gal = 0.7 tsp/gal = 3.8 g/gal

g=gram	l=liter	ml=milliliter
oz=ounces	gal=gallon	tsp=teaspoon

wt oz/gal = weight ounces per gallon (16 wt oz = one pound)
fl oz/gal = fluid ounces per gallon (128 fl oz = one gallon)
ml/l = milliliters per liter (1000 ml = 1 liter)
w/w = indicates concentration as a percent of weight

Cationic Retarder

The purpose of the cationic retarder is to slow down the rate of exhaustion. This is often important when dyeing light shades. When dyeing with a blend of two or more basic dyes, it is not uncommon to see one dye in the blend go onto the fiber at a faster rate than the others, producing undesirable non uniform dyeings. The retarder acts to slow the rate of dyeing to ensure that blends exhaust from the dye solution at a uniform rate. The retarder, like the basic dyes, is cationic and competes with the dye molecules for dye sites. In a certain sense, it can be viewed as a colorless dye. Retarders are usually only necessary when dyeing light shades.

Preparing the Dyebath

Cationic Retarder

The retarder is generally added to the dyebath at about 0.30% - 1.50% on weight of goods. As the depth of shade becomes lighter, it is necessary to use more retarder. As with all adjuvants, they should only be added when needed. The retarder is added to the bath along with the dye and other additives. Thorough testing is important. The following data summarizes the application of a cationic retarder in the dyebath:

Table 3

Depth of Shade	% Dye on Weight of Goods
Very Light Shade	(1.50 % owg)
Light Shade	(1.0 % owg)
Medium Shade	(0.3 % owg)
Heavy Shade	(none)

Transfer Medium

The transfer medium is the solvent in which the dyes are dissolved. Water is the usual transfer medium when using basic dyes. Water should be of good quality. Hard water will require correction with acetic acid to reduce the pH. Basic dyes exhibit poor solubility in hard water. The presence of excess iron can also cause problems when dyeing with basic dyes.

Liquor Ratio

The term **liquor ratio** represents the ratio of the weight of the dyebath to the weight of the goods being dyed. For example, if 2000 pounds of water (240 gallons) were used when dyeing 80 pounds of product, the liquor ratio is 2000/80 = 25:1. It is customary to use a low liquor ratio when dyeing to conserve water and to speed up the dyeing process. Since the dye solution is heated, it makes sense to heat as little water as possible. Dyeing at high liquor ratios takes longer because dye molecules must diffuse through more water before coming into contact with the goods. For most dried floral goods and craft products, the liquor ratio is usually in the range of 10:1 to 40:1.

It is interesting to note that the same depth of shade can be obtained over a wide range of liquor ratios. This is because the basic dyes have strong affinity for the lignin and tannins in plant fibers. As previously stated the liquor ratio affects the rate at which dyeing occurs. It takes more time to achieve a given level of shade when the liquor ratio increases.

Summary - Table 4

PREPARING THE DYE BATH

BASIC DYE

Depth of Shade	Dye Required (% OWG)
Very light	0.01% - 0.10%
Light	0.10% - 0.50%
Medium	0.50% - 1.50%
Heavy	1.50% - 3.00%

TRANSFER MEDIUM

Good quality water heated to 140°F - 180°F (60°C-80°C)
Liquor ratio 10:1 - 40:1

OPTIONAL ADJUVANTS

Add only if needed

a) **Nonionic Surfactant**

0.10% w/w = 1.0 g/l = 0.9 ml/l = 0.12 fl oz/gal = 0.7 tsp/gal = 3.8 g/gal

g=gram	l=liter	ml=milliliter
oz=ounces	gal=gallon	tsp=teaspoon

b) **Acid**

Adjust pH of dyebath to pH 4.0-4.5 with glacial acetic acid or citric acid
Approximately 0.25% - 0.50% owg glacial acetic acid

c) **Cationic Retarder**

Depth of Shade	Dye Required (% OWG)
Very light	1.50%
Light	1.00%
Medium	0.30%
Heavy	none

The Dyeing Process

The Stages of Dyeing

Dyeing may be broken down into three stages:

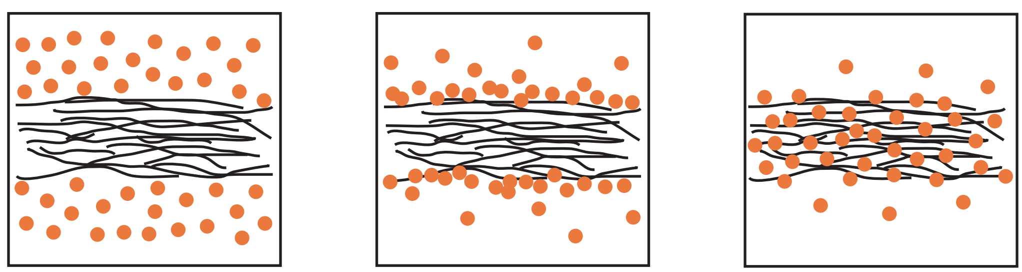
- **Diffusion**
- **Adsorption**
- **Migration**

Diffusion is the process in which dye molecules make their way through the dyebath to the plant fiber. **Adsorption** is the process in which molecules of dye become attached to the fiber surface. **Migration** is the movement of dye molecules from the fiber surface inward toward the center of the fibers.

The *rate* of diffusion depends upon dye concentration and dyebath temperature. The higher the dye concentration, the faster the rate of diffusion. Diffusion also increases slightly with increasing dyebath temperature. Adsorption occurs relatively quickly. Migration, however, can be a slow process, depending upon the nature of the substrate, dyebath temperature and immersion time. Migration increases with time. The rate of migration increases as dyebath temperature increases.

Illustration F

The Stages of the Dyeing Process



Diffusion **Adsorption** **Migration**

It is important to understand that dyeing occurs only after all three phases (diffusion, adsorption and migration) have taken place. All too often, producers of dyed products remove the goods from the dyebath after the adsorption phase. The material will *look* dyed, but in reality the dye is resting on the surface. Customers handling these products are likely to see dye coming off onto their hands after handling these materials. Bleeding will also occur if these materials get wet.

Dyeing Different Materials

The rate at which the three stages of dyeing proceed is dependent largely upon the nature of the goods being dyed. Wood products such as chips, curls, excelsior and paper are highly absorbent as are many mosses used in the craft industry. These products dye quite readily, even at lower dyebath temperatures. Natural plant fibers such as jute and raffia as well as dried flowers and foliage and grasses are much more difficult to dye because of the presence of a substantial **cuticle**.

The Dyeing Process

Migration and Dyebaths

Migration is dependent upon breaking down this waxy barrier. This is best achieved by heating the dyebath. The surface wax literally melts at high temperatures, exposing the inner plant fibers and allowing migration to occur. Dyeing with an unheated dyebath (often termed cold water dyeing) is not recommended because migration does not take place. The length of immersion time and dyebath temperature required for optimum dyeing varies considerably for different materials. In general, a dyebath temperature of 180°F (82°C) is optimum. Immersion in the dyebath can range from a few minutes to well over an hour.

Three Steps of Dyeing

The dyeing process may be broken down into three steps:

- **Prerinse and wetting (optional)**
- **Dyeing**
- **Rinsing**

Prerinse and Wetting

Before dyeing, products are often wetted-out in a solution of water and a nonionic detergent. While this step is optional, a more uniform dyeing is achieved. After wetting, the plant fibers have a more uniform consistency and tend to absorb dyes at a more uniform rate. Many impurities in the product are removed, helping to prevent contamination of the dyebath. A soaking period of 5-10 minutes is usually satisfactory. This solution does not need to be heated, although it is beneficial to do so. The solution is prepared by adding a nonionic surfactant to water. The surfactant is generally added at a rate of 1/10 of 1 percent of the weight of solution.

Dyeing

There are two procedures routinely used to dye dried plants and craft materials: **continuous dyeing** and **exhaust dyeing**. A continuous dye operation utilizes the same dyebath to dye several batches of goods, while an exhaust procedure dyes a single batch of product with the dyebath. With an exhaust system, the goods remain in solution until nearly all of the dye has left the solution in favor of the substrate - a process called **exhaustion**. An exhaust system is a slower process than a continuous system. Specifying dye required as a percentage of the weight of the goods being dyed as outlined in previous sections controls depth of shade. Exhaustion occurs faster as the dyebath temperature increases and liquor ratio decreases. In typical dye applications with basic dyes, exhaustion goes to approximately 80-90% completion. If the transfer medium is reused, the remaining dye (estimated) is subtracted from the amount required for the next batch. Consistency of dye lots is usually good when exhaust dyeing is employed.

The Dyeing Process

Dyeing Continued

When a continuous dyeing procedure is being used, several batches of goods are dyed with the same dyebath. The initial dye concentration is usually very high, containing enough dye for many batches of goods. Goods are left in the dyebath until the desired depth of shade is reached, at which point they are removed and the next batch is put into the vat. Continuos dyeing is somewhat of an art; requiring a skilled dyer with a good eye for color. Consistency between batches can be very difficult. The concentration of dye is continuously decreasing as dye leaves the dyebath in favor of the substrate. Thus the rate of exhaustion is continuously decreasing.

Successive batches will require longer and longer immersion times to reach the desired depth of shade. To counter this, dyers will often add dye to the dyebath between batches to keep the operation running quickly. A continuous dye system requires a skilled, experienced dyer. This system is the most common used in the floral and craft industry today.

Rinse Stage

After dyeing, materials should be rinsed thoroughly in water. This will lessen the possibility of the dye running or coming off of the material during later contact and handling. Products that are properly dyed will not show noticeable loss of color after rinsing. After rinsing, the materials must be allowed to dry completely before being packaged for shipment or storage.

Drying

After the materials have been dyed and rinsed, they need to dry completely before being packaged. The importance of complete drying cannot be overstated. If the material is not allowed to dry completely before it is packaged, mold and mildew will likely develop.

In general, dyed goods should not be dried in the sun. While many basic dyes used to color these materials are selected from dyes having moderate to good light fastness, exposure to enough sunlight will result in fading. This is particularly noticeable among the blue and green dyes.

A Matter of Time

How long should I leave my materials in the dyebath?

The amount of time materials should be dyed depends on three factors: the temperature of the dye-bath, the intensity of color desired (depth of shade), and crock fastness and wash fastness.

Temperature of the Dyebath

The warmer the dyebath, the quicker materials will adsorb the dye. A higher temperature solution helps break down heavy, waxy cuticles and also increases the absorbency of fibers.

Intensity of Color

The desired color of your final product bears a great deal on the amount of time the material should remain in the dyebath. The longer the material is in the dyebath, the darker the final shade will be. When dyeing a white flower red, for example, a quick immersion of 15 seconds will leave the flower a light pink. The longer the flower remains in the dyebath, however, it will become a richer and darker red.

Crock Fastness and Wash Fastness

Crock fastness is the ability of a dyed material to resist crocking, or the staining of adjacent skin by physical abrasion or contact. When an item is not left in a dyebath for the appropriate amount of time, the color may rub off the dyed object and onto skin or other materials upon contact. Similarly, wash fastness is the ability of dyed object to resist the bleeding or removal of color when washed. The longer an item remains in the dyebath, the better it is able to adsorb dye into the fibers, rather than simply staining the surface.

An example of crocking: These rice grains were immersed in a hot pink dyebath and removed too early. The resulting crocking leaves a hot pink stain on the hands. Leaving the grains in the dyebath for a greater period of time allows the dye to soak into the plant's fibers, rather than simply staining the surface of the grains.

Special Applications

Dip-Dyeing Fresh Cut Flowers using an Alcohol Dyebath

An alcohol dyebath is sometimes used to dye certain fresh cut flowers that are not readily dyeable by conventional systemic means using acid dyes. Examples include marguerite daisies, calla lilies and gerbera. Each of these flowers dye poorly by systemic means.

Alcohol dyebaths are not intended for dried materials. This method of dyeing is merely a surface stain in which dye molecules are deposited onto the surface of the foliage. They do not adequately diffuse through the plant surface and as such may bleed or be removed by physical contact.

Prepare the immersion dye solution as follows: (Formula makes one gallon)

1. Add one-quart isopropyl alcohol (anhydrous grade) to a one-gallon container.
2. Add one-quart good quality water and mix.
3. Add one teaspoon (approximately 4 grams) Versene 100 Chelating Agent and mix well.
4. Add one teaspoon (approximately 4 grams) nonionic surfactant such as our TW-80 and mix well.
5. Add 3/4 ounce (approximately 21 grams) of Gum Arabic powder to an empty 1-quart container and fill with 3/4 quart of water and shake vigorously to dissolve the Gum Arabic. After the Gum Arabic is fully dissolved pour this solution into the one-gallon container holding the water/alcohol solution.
6. Dissolve 4 grams of Tannic Acid in 1 cup of warm water and add to gallon container.
7. Add Immersion Floral Dye (our 8000 series dyes) to this solution as follows: Measure out dye required in a small container according to the following recommendations:

a.	Light shade	2 grams
b.	Medium Shade	8 grams
c.	Dark Shade	15 grams

Dyeing Procedure

Measure dye needed and predissolve in hot water. Stir thoroughly to make sure that the dye is fully dissolved. Pour this solution into the above alcohol/water mixture. The dye solution is now ready for use.

(procedure continued on next page)

Special Applications

Dyeing Procedure cont.

Pour dye solution into a suitable dyeing container. Dip flowers into solution and remove. Lightly shake flowers and allow excess solution to drain back into dye container. Allow flowers to dry thoroughly before shipping or packaging. Periodically strain the solution to remove contaminants. Dye solution may be diluted with water or isopropyl alcohol. Keep dye containers closed when not is use. Use only in a well ventilated area away from heat, spark or flame.

Note: Dyeing flowers in this manner assumes certain risks. The dye applied to the flowers is not permanent and will bleed when wet. In addition, color may come off onto customers hands when handled excessively. The amount of alcohol in the above formula may be increased to reduce drying time. Do not exceed 50% total alcohol by volume. Isopropyl alcohol is flammable and should be used with caution in a well-ventilated area. Read all material safety data sheets (MSDS) prior to using these materials.

Dyeing Preserved Material

Decorative plant materials previously preserved with glycerin are occasionally dyed by immersion with basic dyes. Examples of such products include baby's breath (*Gypsophila paniculata*) and Sweet Annie (*Artemesia annua*). The difficulty in dyeing these items is that during the period of immersion, while dye is going onto the plant material, the internal glycerin is diffusing out of the plants and into the dyebath. To minimize the loss of glycerin, many dyers will use a very hot dyebath, near boiling, and immerse the material for as short a time as possible to reduce the loss of glycerin. The danger with this approach is that a surface dyeing (adsorption) results, with the dye easily removed by washing or physical contact.

Others try to minimize the problem by including glycerin in the dyebath at a concentration high enough to stop diffusion. This often gives satisfactory results. However, many delicate flowers appear oily when immersed in a glycerin solution.

Undyed Baby's Breath

Key Terms

Adsorption

The adhesion of a thin layer of molecules to the surfaces of solid bodies or liquids with which they are in contact. [5] In immersion dyeing, adsorption is the second stage in the dyeing process in which molecules of dye become attached to the fiber surface. This is the fastest of the three stages of dyeing.

Basic Dye

Water soluble dyestuffs in which the colored part of the molecule is a positively charged (cationic) ion. [1]

Cellulose

A water insoluble carbohydrate polymer that is the chief building block of the cell wall. [2]

Crock Fastness

A relative measure of a dye's resistance to crocking (the transfer of colorant from the surface of a colored material to another surface, or to an adjacent area of the same material, principally by rubbing). [8]

Cuticle

The waxy layer covering the outer wall of epidermal cells, formed of cutin and wax. The cuticle protects plants from water loss, disease and insect damage.

Depth of Shade

Refers to the quantity of dye applied to the fiber. Qualitatively, depth of shade is referred to with term such as very light,, medium, dark or heavy. Quantitatively, depth of shade is calculated as the ratio of the weight of dye to fiber weight, expressed as a percentage.. For example, if 100 pounds of fiber were dyed with 2 pounds of dye to full exhaustion, the depth of shade is computed as 2/100=2%. Several shades can be produced with a given dye. A light shade of red on white fiber will look pink. As the depth of shade increases, the pink hue becomes progressively redder. A very heavy shade of red may require 3% or greater dye on weight of goods. A breakdown of depth of shade is as follows:

Very Light Shade	0.01% - 0.10% owg
Light Shade	0.10% - 0.50% owg
Medium Shade	0.50% - 1.50% owg
Heavy Shade	1.50% - 3.00% owg

Diffusion

The process by which difference substance mix as a result of the random motions of their component atoms, molecules, and ions. [6] In immersion dyeing, diffusion is the first stage in is the dyeing process in which the dye molecules make their way through the dyebath to the plant fiber.

Key Terms

Dye

Substances used to impart color to textiles, leather, paper, etc. Compounds used for dyeing are generally organic compounds containing conjugated double bonds. The group producing the color is the chromophore; other non-colored groups that influence or intensify the color are called auxochromes. [6] Dyes by definition are soluble in the medium in which they are applied, and the medium is almost always water. [7]

Dyebath

The solution consisting of the transfer medium, dye and adjuvants in which the goods are dyed. In almost all cases, the transfer medium is water.

Dyeing

The process in which molecules of dye are transferred from a medium (water, alcohol, etc.) to a fibrous substrate (the material being dyed). [4] Dyeing may be broken down into three stages: Diffusion, Adsorption and Migration.

Dye Liquor

A synonym for the dyebath.

Exhaustion

The degree to which dye molecules have left the dyebath and have adsorbed onto and possibly migrated into the fibers being dyed. Percent exhaustion refers to the percentage of dye molecules that have been taken up by the fibers being dyed.

k-Value

A relative indicator of the rate of exhaustion for a basic dye. A testing procedure developed by the American Association of Textile Chemists & Colorists (AATCC) creates a range of k-values from 0.5 - 5.0 in increments of 0.5. The lower the k-value, the faster the exhaustion rate for a basic dye. When dyeing with a blend of two or more basic dyes, only dyes having similar k-values should be used. The k-value is also referred to as the combination constant.

Light Fastness

A relative measure of a dye's resistance to fading or color change due to exposure to light. [4] The American Association of Textile Chemists and Colorists (AATCC) has developed testing methods for light fastness. Light fastness is measured on a scale of 1-8 where:

8 = outstanding	7 = excellent
6 = very good	5 = good
4 = fairly good	3 = fair
2 = poor	1 = very poor

Key Terms

Lignin

A glue-like polymer that binds cellulose fibers together, providing strength and stiffness to the cell wall. [3] Basic dyes have high affinity for lignin.

Liquor Ratio

The ratio of the weight of the dyebath (dye liquor) to the weight of the goods being dyed. For example, if 100 pounds of raffia were being dyed in a dyebath weighing 1200 pounds, the liquor ratio is computed as 1200/100 and stated as 12:1, meaning that exists 12 pounds of dyebath for every pound of fiber being dyed. The rate of dyeing typically increases as the liquor ratio decreases.

Migration

The movement of dye molecules from the surface inward toward the center of the plant fibers. This is the slowest of the three stages of dyeing.

Strike Rate

The rate at which a dye exhausts; that is, transfers from the dyebath to the substrate.

Transfer Medium

The solvent in which the dyes are dissolved when preparing the dyebath. In almost all cases, the transfer medium is water.

Water Fastness

A relative measure of a dye's resistance to bleeding or the loss of colorant from the surface of a colored material to another surface, or to an adjacent area of the same material, upon contact with water.

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Technical Bulletin #200

Published by Robert Koch Industries, Inc. Bennett, CO.

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