PATINATION

General types of Patinas: natural, chemical, superficial
natural patina: occurs when metal oxidizes on the surface, i.e. bronze will turn green in an alkaline atmosphere and brown in a sulfur atmosphere.
chemical patina: created using sulfides, nitrates and oxides which bond chemically to the metal surface and stimulate the natural effects of exposure the artist wishes to impose.
superficial patina: any coating applied to the surface which does not bond chemically to the metal surface, i.e. oil paint, varnish, colored gesso, acrylic, plastics, lacquer.

EQUIPMENT

brushes:
- ferrules should be plastic or leather (metal ferrules will oxidize and contaminate the patina solutions)
- for "stippling" round brushes are best for even distribution of the patina solution
- size will range depending on purpose – 1/4" diameter for delicate work to 3" diameter for large pieces
- natural bristles are greatly preferred as they do not melt with heat or disintegrate with solvents, also they retain the chemicals better due to the hollowness of each strand .

torches:
- propane is a preferred gas to use with your heating-torch when applying patinas because it leaves no residue to contaminated the patina (a plumber's torch with a 1/2" to 3" diameter orifice is substantial, easy to use, low cost, and maintenance free---the tank regulator should be set between thirty and fifty pounds p.s.i.)
- natural gas with air back-up is also a good choice to use with your heating-torch when applying patinas, it will leave little residue to contaminate the patina
- oxy-acetylene mix is not a good gas to use with your heating-torch when applying patinas, this type of gas mixture leaves residue on the metal which will contaminate the patina

working surfaces:
- working surfaces, when using torch patina techniques, should be insulated from the piece with fire retardant material such as transite or fire brick. For smaller pieces a metal, revolving stands works well. Larger sculptures should be done on a floor area which is covered with transite or firebrick.

spray guns:
- spray guns, such as those used in auto body industries are good, but it is advisable to choose one built entirely of stainless steel parts (in this way chemical corrosion or contamination may be kept to a minimum)
- a small air brush may be used but usually they are delicate and will not withstand all of the chemical solutions your patina formulas might require
- an inexpensive and fairly sturdy spraying device is a plant sprayer made of plastic (some of the parts in the spray mechanism may be affected by the chemical solutions therefore it is advisable not to store your patina solutions in the spray bottle and to rinse the spraying mechanism after each use so that the chemical solutions will not prematurely disintegrate any of the parts)

buffing materials:
- a finished patina is usually sealed with a wax mixture to prevent any change in the patina that may occur due to atmospheric conditions. As a final step the wax is buffed. A rag which is 100% cotton and has a tight weave is the suggested type to use for buffing.
- burnishing areas of the patina is done for the purpose of highlighting parts of the piece. Materials used for burnishing include fine steel wool, bronze wool, and synthetic buffing pads. When using steel wool you run the risk of leaving small iron deposits in the metal which will become visible as rust spots. Bronze wool is affective as a means of burnishing but it is more expensive. An effective and inexpensive solution is a synthetic pad such as 3M pads. These pads produce a flatter sheen than either steel or bronze wool, and like bronze wool, will not leave pieces which will spot the metal surface.

containers:
- glass jars work well to hold patina solutions which have been mixed, but metal lids will contaminate the patina. Plastic jars with plastic lids are effective storage containers. Also, be aware that once patina solutions have been mixed they will quickly lose their potency, therefore it is advisable not to mix up solutions which will not be made use of with in a two week period and to store any mixed solutions in a dark area away from sunlight.

be accepted on the surface. Testing for surface temperature should be done with water; at 180° F the solution will take approximately 10 seconds to evaporate from the surface, and will take progressively less time to evaporate as the surface temperature approaches 250° F. An approximate 250° temperature has been reached if the water, when it touches the metal, disperses and dries without spitting or remaining wet for more than a moment. Solution will spit and pop on a surface over 250° F. It is important never to reheat the surface with the torch in order to dry the solution if it remains wet. This will burn the chemicals and they will not react in the desired way to the surface. Always let the solution evaporate on its own and then continue with the application. Fumes and vapors will inevitably be produced as solutions are applied to the hot metal. These must not be inhaled. Adequate ventilation must be provided, and a nose and mouth face mask fitted with a fume filter should be worn.

Steps for a hot patina:

1) Choose a brush of a comfortable size and shape (preferably without metal ferrules). Some individuals prefer a round brush approximately 1" diameter and others prefer a flat brush 3" wide.

2) With a torch, heat the area of the metal which is to be patinaed.

3) Test the surface with water for readiness.

4) Using a sprayer or a brush, apply the chemical solution to the surface of the metal. When using a brush either flick it in a direction away from the sculpture, squeeze it , or wipe the bristles with a cloth to eliminate excess solution that would otherwise drip down the metal. Techniques with a brush also require that you use either a stippling motion or a rolling motion of the brush as it interacts with the surface of the metal. Practice will allow you to discover the stroke that will produce the effects you want.

5) Work with your sprayer or brush in one hand and the torch in the other. This will allow you to work quickly and with flexibility, alternating the torch to heat the surface with the application of the solution.

6) Allow the sculpture to dry, and then wax it while the surface is warm.

Cold Method

This is a patina in which a chemical solution is applied to the piece at room temperature. Colors usually include greens, browns, and blacks. With this procedure the chemicals can be stippled, wiped, swabbed, splashed and sprayed onto the metal surface or the piece may be dipped in to the solution. Often a cold patina is used for a very large sculpture (i.e. monumental works) where other processes would be problematic. Cold patinas usually require a number of applications of the solution, allowing sufficient drying time between each layer. Some patinas may require the application period to extend over a series of days and even weeks. Cold patinas are generally more successful on a rough cast surface than on plate or a polished surface.

There are four general methods for applying the solution: spraying, wiping, brushing, and dipping.

Spraying Method:

The spray method of applying the chemical solution allows for a good, first step undercoat in all cold processes because it can be done quickly and liberally. However, in using this method throughout the application of the patina, practice and skill are needed to produce a finish without patches or streaking. It is helpful to have a cotton cloth at hand to absorb areas which are dripping or puddling.

Wiping Method:

The wiping method of applying the chemical solution calls for a lint free cloth to be saturated with the chemical solution and then used to wet the surface of the piece. A second cloth, slightly dampened with the solution is then wiped over the piece so that just a glaze of moisture is left on the piece. The sculpture is then left to dry thoroughly. This sequence is repeated until, gradually, color is developed to the desired stage. If chemicals are applied too rapidly (sufficient drying time is not allow between coats) an opaque "skin" will develop which will tend to break down with further applications of the patina solution.

Brushing Method:

The brushing method of applying the chemical solution is especially useful on textured areas because of the use of a bristle brush. A french pastry brush is a good brush to use because of the plastic ferrules (which will not contaminate the solution or retain chemicals from previously used solutions). For textured areas, a stippling action with the brush gives the best results. Two brushes are advised in this application. The first is dipped into the solution and applied vigorously so that the entire surface of the piece is wetted. This is followed by a second, dry brush applied in a rapid multi-directional manner to thoroughly dry the surface. Any solution remaining in the recesses should be wiped away with a cloth. The piece is left to dry completely before the next application. Washing the surface with warm, distilled water, and drying it again between coats is advised.

Dipping Method:

The dipping method of applying the chemical solution requires the piece to be completely submerged in the solution. Over a period of time, the piece is submerged repeatedly until the desired coloration has been

should hold together but release no drops of the solution. A second test is to take a sample of the prepared mixture, press it out on to a smooth non-absorbent surface, such as a sheet of plastic, and press it down firmly. If mixed in the correct proportions the sample should leave only a slight trace of dampness which reflects the texture of the medium. It should not significantly wet the surface, producing drops or smears of the solution.

Packing the Object:

When the mixture is found to be ready it should be packed correctly in a container around the piece to be colored. The container must not react with the chemical agents and you must be able to seal it completely. Also, it is advantageous to use a container which is approximately the same form as the object to be colored. This insures that there is a reasonably even depth of medium around the object. Suitable containers include plastic boxes, buckets or a heavy plastic bag supported by a wooded or cardboard box. The mixture is sprinkled into the container and lightly tapped down to form a "bed". The object is then placed on the bed, and further mixture is sprinkled and firmly packed around the object until it is surrounded completely and evenly of all sides.

Color Development:

The majority of solutions used in particle patinas color the surface as well as etching it. A granular sawdust will produce localized points of action where ever the individual grains are in contact with the metal surface. The areas surrounding the points where the etching occurs gradually become colored by the effect of the moist atmosphere of the solution, but generally are not etched initially. The process is progressive and effects will parallel the length of time the object remains buried.

Monitoring the Object:

Determining when it is time to remove the object from the mixture is a subjective decision. The difficulty lie in not being able to view the surface. The object is totally covered and the changes can not be seen. To monitor the progress of the process you can pack small samples in with the object and remove them in order to check the coloration, or you may unpack and repack the actual object each time you check the progress. One disadvantage of disturbing the actual object is that the sharp quality of a textured surface may tend to be lost if the object is repeatedly repacked and new areas of the surface are brought into contact with the granular particles. If the object is removed, then the medium should be thoroughly mixed again before it is repacked.

Removing the Object:

The object should be removed before the mixture has thoroughly dried out. A completely dried mixture will leave particles which adhere to the surface of the metal. Removal of these particles requires rubbing and this action may disturbed the patina. If the mixture is dried out and the coloration is still insufficient, the object will need to be repacked with fresh medium. When the piece reaches the desired coloration remove it from the container and wash it with cold water to clean the surface. Allow the piece to dry thoroughly. Brush with a soft dry bristle-brush before waxing or lacquering.

Extensions of the Technique:

Additional effects may be achieved by building on variations of the burial technique or coupling the burial method with other chemical application techniques. The burial application may be applied to a surface which has been provided with a ground color produced by another patination technique. Also, different solutions can be used in succession, possibly with mediums that have different degrees of coarseness. If you desire only sections of the piece to be affected by the burial patina, mask off the areas you do not want affected by sealing them with self adhesive tapes, wax, or stop-out varnish prior to putting the piece in to the mixture.

Wetting Problems:

If the surface is highly polished there is often the problem of achieving an even wetting of the surface (rather a pooling or running of the solution occurs causing streaks or spots on a predominately bare metal surface). To overcome this situation add a small amount of a commercial wetting agent or of methylated spirit to the chemical solution to improve the contact between solution and surface. Also, the initial application of the solution may be done with a vigorous dabbing or pounding of the surface with a soft cloth pad moistened with the solution.

Greens

1. Light Green

Cold Method --Apply solution with a brush, cloth or sponge and rinse lightly between coats. Wax cold

Cupric Acetate	3 tablespoons
Cupric Sulfate	3 tablespoons
Cupric Carbonate	3 tablespoons
water (distilled)	2 quarts

NO

2. Light Blue-green

Cold Method --Apply solution with a brush, cloth or sponge and rinse lightly between coats. Wax cold

Cupric Chloride	6 tablespoons
Ammonium Chloride	1 tablespoon
water (distilled)	1 quart

NO

3. Basic Green

Torch Method -- Using a brush or sprayer, apply solution to the metal when the surface has been heated to 250° F. Wax warm

Copper Nitrate	1 tablespoon
water (distilled)	1 pint

YES

4. Dark Green

Cold Method -- Apply an Ammonium Sulfide solution (2 ounces of Ammonium Sulfide to 1 quart of water) as a base coat, then apply the solution used for the Light Blue-green patina.

5. Dark Green

Torch Method -- Following the steps for a torch patina, apply a Copper Nitrate solution (1 tablespoon Copper Nitrate to one pint of water) to the metal when the surface has been heated to 250° F. When the metal has cooled, apply the solution of Ammonium Sulfide (1 tablespoon of Ammonium Sulfide to 1 quart of water) and burnish back lightly. Wax warm

6. Dark Green Stippled

Torch Method -- Heating the metal to 250° F, apply an Ammonium Sulfide solution (1 tablespoon of Ammonium Sulfide to 1 quart of water) as a base coat. While the metal is still warm apply the solution used for Basic Green patina. This solution should be applied with irregular brush strokes. Wax warm

12. Turquoise Green

Fume Method -- Put all of the solutions in separate containers and distribute them evenly around the base of the covered sculpture. Allow this to sit for 24 hours. After a period of 10 hours a blast of oxygen may be released into the container to quicken the coloration process. This is a fragile patina and it is advisable not to wax the surface at all, but if you choose to, wax it carefully and while cold.

Nitric Acid	1/2 ounce
ammonia	2 ounces
Potassium Permanganate	1 teaspoon

Yes

13. Greenish-gray

Burial Method -- Following steps for the burial patina method, allow sculpture to remain buried for a period of 20 to 30 hours. A polished surface will be etched by the solution, producing an evenly textured surface. The greenish-gray patina develops over the whole surface, but is slightly darker on the least etched parts. Some spots of a more blue patina may also form as small incrustations. Rough or as-cast surfaces, tend to develop incrustations of the blue patina on a brown and gray ground. When color has reach a satisfactory stage, remove article and wash it in cold water. Allow to air dry for several hours. When thoroughly dry then wax cold.

Ammonium Chloride	100 grams
Ammonium Carbonate	150 grams
water (distilled)	1 liter

No

14. Olive Green

Dipping or Brushing Method with Hot Solution -- Dip the piece completely in to the solution or brush it on to the surface. If Dipped, leave the sculpture submerged for 4 hours. Wax cold

Nickel Ammonium Sulfate	8 ounces
Sodium Thiosulfate	8 ounces
hot water (distilled)	1.5 gallons

No

15. Yellow Green

Cold Method -- Allow solution to sit on the surface until film develops. Between coats rinse with warm water. Repeat cycle until desired coloration is achieve. Wax cold

Ammonium Chloride	7 tablespoons
Copper Acetate	4 tablespoons
water (distilled)	1 quart

No

Browns & Blacks

16. Blue-green Patina /Orange-Brown Ground (predominately brown with blue speckles)

Burial Method -- Following steps for the burial patina method, allow sculpture to remain buried for approximately 48 hours. Coloration may be monitored by either sample objects or unpacking and repacking the piece. The mottled orange-brown ground develops first, and darkens as the blue-green patina appears. The patina tends to develop further as the moist medium dries out. The ground color can be darkened by removing the object before the medium becomes dry, and repacking in freshly moistened sawdust. On rough or as-cast surfaces a stipple of blue-green patina develops on a dark brown ground. When color has reach a satisfactory stage, remove article and wash it in cold water. Allow to air dry for several hours, then wax cold

Copper Nitrate	200 grams
water (distilled)	1 liter

Yes

23. Black

Torch Method -- When mixing solution, boil water to break down crystals.
Using a brush, apply the solution to the metal when the surface has been heated to 250° F. Use a stippling method when applying the solution. Wax warm

Potassium Sulfide	1 tablespoon
water (distilled)	1 pint

NO

24. Dark Brown

Dipping Method in Hot Solution -- Heat solution to near boiling. Completely immerse sculpture for thirty minutes. When desired coloration has been reach remove sculpture and allow to air dry. Cold wax when thoroughly dry

Copper Sulfate	20 grams
Lead Acetate	20 grams
water (distilled)	1 quart

NO

25. Dark Brown/Black

Torch Method -- Using a brush or a sprayer, apply the solution to the metal when the surface has been heated to 200° F. Wax warm

Ferric Nitrate	2 ounces
Sodium Thiosulfate	6 grams
water (distilled)	1.5 quarts

Yes

26. Rust Brown

Torch Method -- Using a brush or a sprayer, apply the solution to the metal when the surface has been heated to 200° F. Wax warm

Ferric Nitrate	1 tablespoons
Ferric Chloride	1 teaspoon
water (distilled)	1 quart

Yes

27. Opaque Black

Torch Method -- Using a brush or a sprayer, apply the solution to the metal when the surface has been heated to 250° F. Wax warm

Ammonium Sulfide	1 tablespoon
water (distilled)	1 pint

NO

28. Transparent Black

Cold Method -- Using a brush, cloth, or sprayer, apply the solution to the metal. Burnish back. Wax cold

Ammonium Sulfide	1 tablespoon
water (distilled)	1 pint

NO

29. Blue Black

Torch Method -- Using a brush or a sprayer, apply the solution to the metal when the surface has been heated to 250° F. Wax warm

Ammonium Sulfide	2 ounces
water (distilled)	1 quart

NO

36. Blue

Dipping Method in Cold Solution -- Completely immerse sculpture in chemical solution. The resulting surface is very fragile. Allow to air dry thoroughly. It may be waxed, but lightly.

Sodium Hypo sulfate	60 grams
Nitric Acid	4 grams
water (distilled)	1 quart

Yes

37. Blue

Cold Method -- By brushing, dabbing, wiping the solution, completely cover the surface. This should be repeated once a day for several days. Allow to air dry thoroughly and wax cold

Ammonium Chloride	25 grams
Copper Acetate	20 grams
water (distilled)	1 quart

NO

38. Blue Green

Torch Method -- Using a brush or a sprayer, apply the solution to the metal when the surface has been heated to 200° F. Wax warm

Copper Nitrate	4 tablespoons
Nitric Acid (70% solution)	2 drops
water (distilled)	1 quart

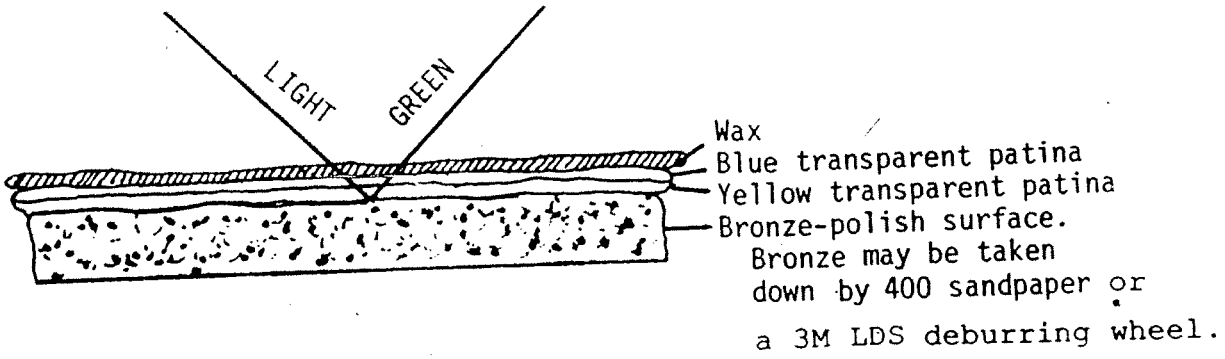
Yes

39. Dark Blue

Torch Method -- Using a brush or a sprayer, apply the solution to the metal when the surface has been heated to 250° F. Wax warm

Potassium Ferricyanide	1 tablespoon
Ferric Chloride	1/2 teaspoon
water (distilled)	1 pint

NO



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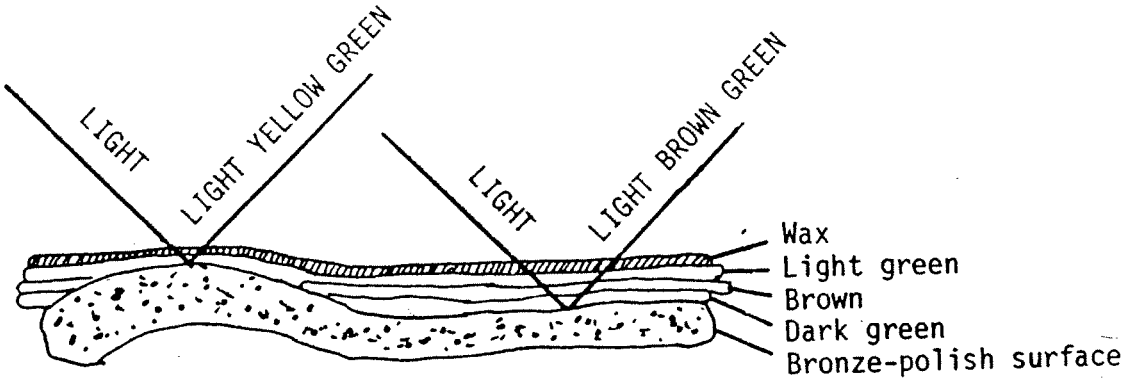

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Figure 6. OPTICAL EFFECTS OF PATINA LAYERS

Gold to Brown (Rows 2 and 3)

This formula can produce a patina with varying degrees of transparency. The basic formula is as follows:

Ferric nitrate	1 to 3 teaspoons
Water	1 pint

First heat the object with a torch. When you have achieved the correct temperature (150° to 250° F), apply the solution sparingly with a brush, either stippling or using small circular motions and working across the surface. The metal will first gradually turn gold and then darken to a reddish brown. A darker shade can be obtained by additional dabbing with a stronger solution. Depending on the surface you begin with, the effect could be either opaque, as in Row 2, or shiny, as in Row 3. (The patinas in Row 2 were produced on matt surfaces; those in Row 3 were achieved on polished surfaces.) When the color is complete, you may wish to polish it with a rag or brush for a more transparent surface. Finally, when the object has cooled to where it is no longer hot but still warm, apply a coat of wax to retain the shine and color.

As noted earlier, use a very weak solution of ferric nitrate for a transparent patina. Do not overheat the bronze, because the patina will darken if the bronze gets too hot. Wash the surface well with water after you have the color you want. To prevent the patina from going dark over time, be sure to wax or otherwise protect it. You may wish to shine the object with a rag or brush before waxing.

Mustard Brown (Row 4)

Potassium dichromate	2 teaspoons
Cupric nitrate	2 teaspoons
Water	1 pint

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First, heat the bronze with a torch and sparingly apply the solution with a brush. For a transparent effect, apply the solution so lightly that you can still see the metal. For the same mustard tan, but with more depth, apply additional solution so that not as much of the bronze shows through. To achieve an orange patina, you can use a solution of the potassium dichromate alone with the water. When you are satisfied with the color, wash the piece well, let it dry, and then apply a coat of wax. (With time, this patina may darken and lose some of its mustard yellow color; some green may appear.)

Rust-Brown (Row 5)

Ferric nitrate	1 to 3 teaspoons
Ferric chloride	1 to 3 teaspoons
Water	1 pint

Yes

Heat the sculpture with a torch and apply the solution sparingly with a brush in a dabbing motion, working your way across the surface. The bronze will gradually darken to a rust-brown. When you achieve the color you desire, let the metal cool; then wash it well and let it dry; some spots of green may eventually appear. After the object cools so that is no longer hot but still warm, wax the surface to minimize its darkening over time.

Dense Red-Brown (Row 6)

Cupric sulfide	6 teaspoons
Liver of sulfur	6 teaspoons
Red ferric oxide	16 tablespoons
Water	1 pint

NO

Note: this formula improves with time. Therefore, mix it at least a week in advance.

The solution creates a very dense patina resembling a red primer paint; use it sparingly, and keep in mind that other patinas do not show well if applied over this one. The author sometimes uses a small amount (8 drops or so) of this formula with a solution of about a cup (8 ounces) of water and 1 teaspoon of ferric nitrate to produce a rich red-brown.

First heat the bronze with a torch; apply and finish this patina in the same manner as with those above to protect the patina and prevent it from darkening over time. Wash and wax well.

Green (Row 7), **Blue-Green** (Row 8)

Cupric nitrate	6 teaspoons
Water or ammonia	1 pint

Cupric nitrate and water will give you a green patina, as shown in Row 7. If you substitute industrial grade ammonia for the water, you obtain a blue-green to a purple-blue-green, as shown in Row 8. To darken the color, add more cupric nitrate. For a lighter patina, add less.

With this patina, you can achieve various surface qualities by using different kinds of brushes in different ways. For an even patina, first heat the metal surface with a torch and apply the solution with a medium-bristled brush until the desired color emerges. For a stippled surface, use a very dry, short-bristled rush. For a marbled effect, use a long-bristled brush loaded with the solution, gently guiding the weaving motion of the brush from top to bottom. The green patina (Row 7) will stay about the same with time, although you may wish to wash and wax it. The blue-green patina (Row 8) will lighten and become more turquoise green with time; for a more lasting blue-green, add 1 teaspoon ammonium chloride to the ammonia-cupric nitrate solution.

Cupric nitrate can be used to create an antique effect. Wash either clean or patined bronze with the cupric nitrate solution; then stipple over with a mixture of ammonium chloride and pulverized dry modeling clay (gray or brown). Add a little powdered chalk to the ammonium chloride/clay mixture and reapply. Spray the entire surface with milk and let it dry to set the colors. Wax after 24 hours.

Dark Brown to Metallic Black

Ferric nitrate	1 to 3 teaspoons
Sodium thiosulfate	1/2 teaspoon
Water	1 pint

Heat the object with a torch and dab the solution over the surface with a natural bristle brush. The metal will quickly darken to a variegated dark brown to black. For a more even surface, use a stronger solution and more heat. When the patina has developed to your satisfaction, wash it well and then wax it.

Matt Black (Row 9)

Liver of sulfur	2 teaspoons
Water	1 pint
Ammonium sulfide	2 teaspoons
Water	1 pint
Ferric nitrate	3 teaspoons
Water	1 pint

Prepare the solutions separately; then mix them together to form a thick black liquid. Heat the bronze surface with a torch and apply the combined solution with a brush; this will very quickly form a very dense black patina, which is excellent for concealing flaws. When you have the color you want, rub the patina with a soft cloth for a nice shine. Because this patina will blacken all the more with time, you can wax it without washing it first.

Green, Gray, and Black

Cupric nitrate	6 tablespoons
Water	1 pint
Liver of sulfur	1 teaspoon
Water	1 pint
Oxygen acetylene welder	

First, heat the bronze with a torch; then apply the cupric nitrate solution until you have a nice green buildup. Next, apply the liver of sulfur to produce black over the green; you can easily remove some of the black to expose the green by using steel wool or a Scotch Brite pad. You may also reapply the cupric nitrate to obtain a greenish black.

For a gray color over the black-green, use the acetylene part of the torch only. It produces a black smoke that is very good for producing gray on almost any hot patina. Apply a large flame 6 inches from the surface to get a dense opaque black. Then either rub off the excess soot with a cloth and wax the piece or continue applying the cupric nitrate solution for more green or the liver-of-sulfur mix for more black.

Green on Brown-Black

Cupric nitrate	3, 6, or 9 teaspoons
Nitric acid	3 teaspoons
Water	1 pint

Note: The more cupric nitrate you add, the deeper the green and the faster the chemicals work.

Heat the object with a torch and apply the solution sparingly with a brush. The solution will probably turn dark brown to black very quickly, although it may become yellowish brown where the torch is not directly applied. Additional heat will cause the surface to darken and begin to form areas of blue-green. The blue-green patina tends to be superficial at this stage; continue heating the surface and stippling it with solution until a good dark brown has been established. Then heat the object gradually, while stippling the surface with a brush barely damp with the solution until you obtain an even distribution of green over the brown; you can stop with a mottled effect or eliminate the brown altogether. This process may take time to master; note also that different bronze alloys will cause different colors and patina surfaces to develop. When the patina is complete, cool, wash well, and wax.

Green Patina on Brown

Cupric nitrate	3, 6, or 9 teaspoons
Hydrochloric (muriatic) acid	3 teaspoons
Water	1 pint

Note: The more cupric nitrate, the greener the patina.

As with the previous formula, heat the object with the torch and apply the solution sparingly with a brush. A heavy deposit of yellow-green patina quickly forms, but it is rather powdery at this point. Continued heating, as you stipple on small amounts of the solution, will darken the surface to brown. When this color is established, you can build up the green patina by continuing to stipple on solution and frequently applying heat to the area being worked. When you obtain the patina you desire, wash the piece; then burnish the surface with a dry brush or cloth. Wax the sculpture when it is still warm. (The wax should melt easily on the surface.)

Note: As with the previous cupric nitrate formula, different bronze alloys will produce different colors and patinas.

Grey to Silver (Row 10)

Silver nitrate	2 to 6 teaspoons
Water	2 pints

Yes

This is one of the author's favorite formulas, providing a range of patinas from a soft gray to a moderately bright silver. One teaspoon silver nitrate per 8 ounces of water will result in a grey color; 3 teaspoons per 8 ounces of water will result in a bright silver.

Heat is very important: the more heat applied to the bronze, the more silvery it becomes when the solution is applied (provided that the proportion of silver nitrate is high enough). The bronze should be approximately 400° F. A little water sprayed on the object should bounce right off it.

This patina will sometimes get a bit muddy during application. To counteract this, wash the sculpture well and reheat until the sculpture is quite hot. Then rub the surface with a piece of 000 steel wool to bring up the silver color while the piece is still hot (you are wearing heat-resistant gloves, of course). Because the color will darken a little with time, wax the sculpture well.

This patina solution can be used both by itself or in combination with other patinas. For instance, applied as a middle strip between a black patina (ammonium sulfide) and a white patina (bismuth nitrate, see next page), it can blend white with black by producing a gray middle tone. The author has used this patina combination on sculptures of gray whales, killer whales, and great white sharks.

Silver nitrate works best on bronze, but can also be used with success on both brass and copper. The formula lends itself well to polished surfaces; its drawback is the expense of silver nitrate.

White Patina (Row 11)

Bismuth nitrate	4 tablespoons
Tin oxide	4 tablespoons
Titanium dioxide	4 tablespoons
Water	1 pint

(Note: For a tan-white that bites better into the metal, try adding about 4 tablespoons of zinc oxide to the mix.)

This white patina is very fragile, and you may require time to master the technique for making it come out right. The formula must be made in at least 3 days in advance so that the chemicals mix together thoroughly; the author usually makes it a week before he uses it —the solution improves with age. When you are ready to apply the solution, first heat the bronze with a torch; then apply the solution sparingly with a short-bristle brush. At first the bronze may darken slightly, but the white will appear after a few applications. As soon as the patina is what you want, withdraw the heat: any added heat may blacken the white you have obtained. Do not wash this patina. Apply paste wax while the bronze is still warm; stipple it on gently and do not rub, because this patina is extremely delicate. Incralac, varnish, and spray lacquer, which will not affect the color, also work well on this patina; spray on one or the other after the sculpture has cooled. (Do not wax the sculpture if you are going to use lacquer or Incralac. However, you may wax over the lacquer or varnish.)

You can also use this patina in combination with other coloring agents to produce various pastels and off-whites. With this white patina, the base coats will show through; therefore, a base coat of cupric nitrate will give you a greenish white; one of ferric nitrate will produce a brownish white. For pastel green or brown, apply the cupric nitrate or ferric nitrate solution on top of the white patina —do this immediately after the white color has formed. To produce other pastels, colored pigments (see Chapter 9) work very well. As indicated previously, patinas made with this formula should not be washed. Even with a protective coat of wax or lacquer, the sculpture tends to develop a slight green or light tan over the whitened surface after a few months.

Chemicals

For good results with cold patinas, the chemicals should be fresh and very accurately mixed. As stated above, a few drops of nitric acid may be used to help the patina bite. Also, to speed up the process, you can heat some of the chemicals, depending on their reactive properties. In the following sections, the author notes chemicals that withstand heating. Be sure never to boil the solutions unless you have explicit instructions to do so. Be careful not to inhale the fumes from the hot chemicals, and always wear proper safety clothing and masks.

Finishing Cold Patinas

Unlike hot patinas, cold patinas do not shine when complete and dried. They can be left with their natural matt finish or given a gloss with wax or lacquer. You may also wish to wash your cold patina; in some cases this will be necessary to neutralize the chemicals.

COLD PATINA FORMULAS

Rust Brown

The following is an excellent cold or hot process formula that works well on all copper alloys to give a semi-opaque or opaque patina:

Ferric nitrate	1 to 3 tablespoons
Ferric chloride	1 to 3 tablespoons
Water	1 pint

Applied cold, it takes from one to three hours to turn a rust-brown color. It may be stippled, brushed, or sprayed on. Wash the sculpture well, and let it stand a few days if possible before waxing. The sun works well to neutralize the chemicals.

The Henry Moore Formula

The master English sculptor Henry Moore used the formula below to produce a modulated green and brown patina on his bronze sculptures. This patina is formed by applying first the ferric chloride solution and then the copper sulfate solution over a base coat of liver of sulfur. (Note: Unless stated otherwise, quantities are for sculptures approximately 16 inches in height. Increase proportionately if needed.)

1. Ferric chloride (cold)	1 tablespoon
Water	1 pint
2. Copper sulfate (cold)	1 tablespoon
Water	1 pint

The first step is to apply the liver of sulfur base coat (see page 31) a day in advance. Before applying any further chemicals to the bronze, you must wash the sculpture in cold water to stop the reaction of the liver of sulfur.

Next, apply alternate layers of the ferric chloride and copper sulfate solutions, beginning with the ferric chloride. These solutions produce greens and blues (the blue is generally less prominent).

Continue alternating between the two solutions until you have the depth and color you want. Then let the piece sit for a few hours until it is thoroughly dry. For a gold color, heat the bronze at this point; then dunk it in cold water to stop the reaction. To wash out the gold and bring blues into the patina, reapply the copper sulfate after the bronze has cooled.

Apple Green, with Variations (Row 12)

The author has used the following cold process patina formula successfully for years. It works on copper and brass, as well as bronze, and adheres very well to the surface of the metal. (Note: always add chemicals to water, not the other way around.)

Copper chloride	3 ounces
Ammonium chloride	1/2 ounce
Water	1 pint

Put on cold, this patina will turn apple green. To apply the solution, use a brush, sponge, or even a paint roller. Leave the piece to dry for at least 4 hours. For a more blue-green color, use more ammonium chloride.

The use of heat with this patina can result in a variety of colors. For a gray-green color on bronze, heat the solution before applying it. Or, after applying the cold solution, either rinse the sculpture in hot water or leave it in the sun for approximately 3 hours. The metal will turn chalky and develop blotches of orange, green, and brown that will completely cover the surface. To prevent the chalkiness, put on a protective coat of lacquer on it when the piece is dry.

The author has found this patina to work very well on copper structures, such as roofs, that are to remain outdoors. However, on copper and brass, it is advisable to use only one coat of patina, because the next application may peel off. To compensate for the lack of repeated applications, make the solution very strong (6 ounces copper chloride and 1 ounce ammonium chloride per pint of water).

The green in this patina will lighten and the other colors darken in time; therefore, wash it well to help retain the original color. Hot water, if used, can bring about oranges and dark browns: the longer it runs over the patina, the more pronounced these colors will be.

Powder Blue (Row 13)

The patina solution above may be used in reverse proportions for a beautiful blue-green. The author has used this reverse solution successfully on copper and brass, as well as bronze:

Copper chloride	1/2 ounce
Ammonium chloride	3 ounces
Water	1 pint

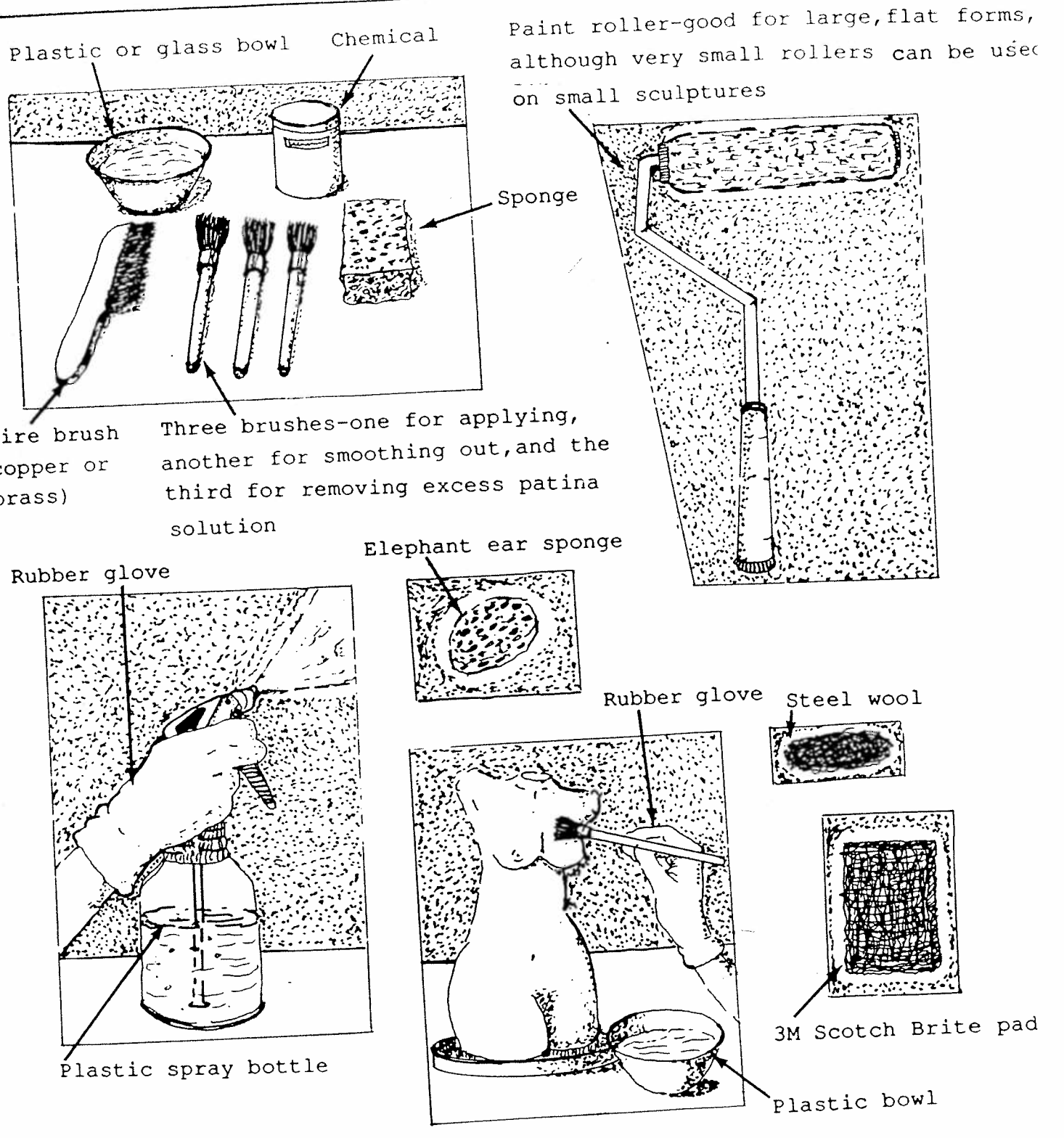


Figure 8. COLD PATINAS- APPLICATION AND EQUIPMENT

Wash the piece thoroughly after applying the solution. This patina maintains itself well over time.

Light Blue-Green (Row 14)

Here is another formula that produces a blue-green:

Vinegar	1 quart
Ammonium chloride	8 ounces
Sodium chloride (salt)	8 ounces
Liquid industrial strength ammonia	1/2 ounce

Dissolve the two salts (the sodium and ammonium chlorides) in the vinegar; add the ammonia *only* when you are ready to apply the solution. Because these chemicals react very quickly, you must cover the surface of the sculpture as uniformly and rapidly as possible, taking care to keep every part moist. Within seconds, the metal takes on a green tint, and a greenish froth begins to form. Next, spread the froth all over the piece. When the surface has taken on the desired color and the liquid begins to dry, brush the wet parts with a dry, clean, long-haired brush until the piece is completely dry. Then leave it in a warm place for 24 hours before proceeding with the second coat, which is applied in the same manner as the first. The color will assume a deeper tone with each additional application: repeat as necessary for the desired shade. Then, let the sculpture stand for 24 more hours and finish it with a coat of clear paste wax applied gently with a soft, long-haired brush.

If you need to hurry up the application process for any reason, double the amounts of ammonium chloride and salt in the second coat. Use the same quantity of liquid. (Remember, however, that because the patina will develop more quickly, you will have much less control over the coloring process. The color could become too deep before you have time to stop it.)

With time, this patina may become more blue and the green may lighten. Wash it well to counteract these tendencies and to dissolve the salt, which will otherwise make the patina very crusty. If you want a crusty patina, do not wash it.

Chapter 8

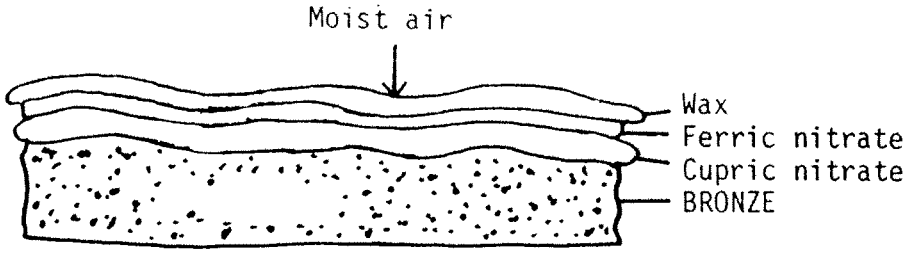
PROTECTING THE PATINA

When a bronze patina is left unprotected, whether indoors or outside, it will be affected by moisture and chemicals in the air, just as bronze alone is. The carbon and oxides in urban air cause an unprotected piece to turn brown or black; rural air contains more nitric oxides, which produce brown hues; and near the ocean, copper salts cause green coloring. Different alloys oxidize at different rates; a textured surface will tend to oxidize faster than a smooth surface.

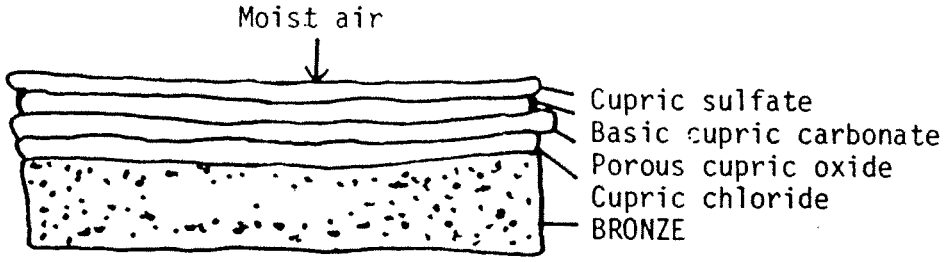
Moisture is the main danger to bronze. In the presence of moisture, some chemicals work on the bronze and some work on other chemicals in the patina. Oxygen (O_2) in the air also contributes to the damage. Accordingly, if the piece is left outside, moisture and various chemicals in the atmosphere will eventually attack it in a number of ways that are still not entirely understood. Some twenty copper-containing compounds have been identified in natural patinas, and there are at least six dark-colored compounds that can form when copper alloys corrode in the presence of sulfur compounds.

To protect your patina, you can apply any of a number of organic or inorganic protective coatings. Some sculptors use wax to protect a patina and endow the piece with a well-cared-for appearance. For fume, bury, or other fragile and easily damaged patinas, a spray —shellac, Incralac, lacquer, or acrylic — should be used instead.

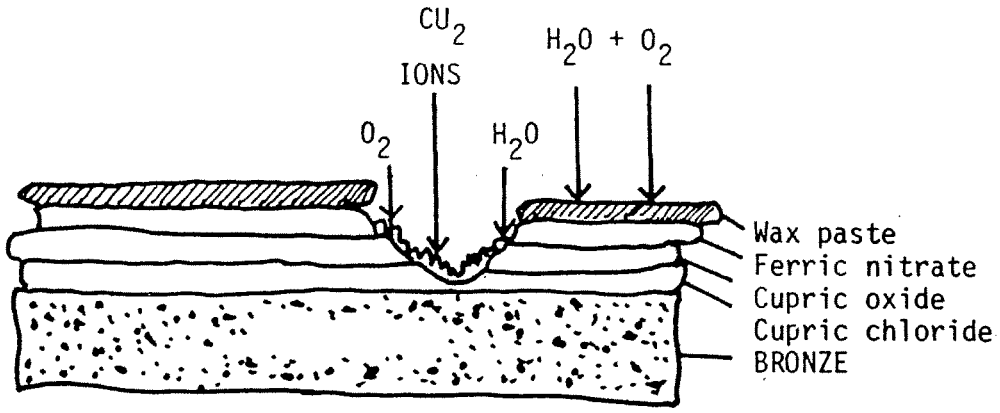
However, even the most thorough waxing or inorganic coating will not protect bronze forever. After several months or a year, a patina on a sculpture left outside will begin to show signs of damage. The different parts of Figure 13 illustrate different chemical buildups on



A. Brown-green patina builds up under wax



B. Green patina many years old has built up



C. Cupric Chloride disease

Figure 13. MOIST AIR ATTRACTS ON BRONZE

waxed and unwaxed bronze surfaces. Part A shows how, even when waxed, a bronze surface can corrode and show a "natural" brownish-green patina. A bronze left unprotected for years (Part B of Figure 13) will show a green patina. When moisture penetrates the wax or is trapped in the patina, copper chloride disease ("bronze disease") can occur, the main symptom of which is a pale green powder — see part C of the figure. Bronze disease, a serious form of corrosion, is discussed in Appendix G.

Another problem, illustrated in Figure 14, is called "bronze rot." It is evidenced by a white-gray film that forms under the wax when high humidity or a change in temperature causes the bronze to "sweat" water, which is then trapped between the patina and the wax. It can be arrested by putting the sculpture in an oven or kiln at a very low temperature for 1 to 6 hours. Then remove the wax with a solvent and wax again.

To prevent bronze rot, it is important to leave a cold patina for at least 3 hours — or up to 2 days, and preferably in the sun — to stabilize it before waxing. Putting the piece in an oven at a very low temperature for 1 to 3 hours is a good way to be sure that all the water has evaporated.

Once you have cured bronze rot, try to prevent further trouble for as long as possible by carefully rewaxing the bronze. If the patina or the bronze itself needs restoration, call your local museum for advice, help, or referrals to other resources.

For more information about corrosion of copper alloys, see Appendix G.

WAXES

Wax serves as an excellent protection for bronze surfaces, sealing them off from the atmosphere and elements. Also, a well-buffed wax coating imparts a soft pleasant luster to the finish that can accentuate both the bronze itself and its patina.

The key to understanding wax lies in knowing its properties, as well as the properties of the natural and synthetic waxes that make up the mix that you are using. Wax is insoluble in water and creates minimal