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METHODS AND MATERIALS FOR FILLING LOSSES ON LACQUER OBJECTS

MARIANNE WEBB

2 FILLS FOR ASIAN LACQUER

2.1 CHARACTERISTICS TO BE CONSIDERED DURING TREATMENT

The two main agents of deterioration of Asian lacquer are light and relative humidity, although temperature also plays an important role. Lacquer falls into the same category as blue wool standard 4. That is, lacquer can be displayed for 40 years at 100 lux or 80 years at 50 lux (UV excluded and 8 hours display per day) before damage will be physically evident. As the surface of light-damaged lacquer may be soluble before a visible change has taken place, extra precautions must be taken when handling. Since aqueous substances cause discoloration, lacquer should be exposed to water only if tests show that it is not damaged by water. Test swabbing should be carried out in areas that have received the maximum exposure to light, not the underside of the artifact. Nonpolar solvents are safest for use with lacquer.

There is evidence that lacquer exposed to a combination of heat and moisture undergoes a thermochromatic change. The author has observed this color change at temperatures as low as 50°C. Therefore heat must be used with extreme caution during treatment.

Lacquerware is also susceptible to damage from fluctuating relative humidity. A decrease in RH can cause a wooden core to shrink, causing stress between it and the inflexible lacquer surface. Cracks will form in the lacquer to relieve the stress. If lacquer is exposed to cycles of low and high relative humidity, the lacquer will eventually start to flake off its wooden core. Sometimes the wooden core will shrink permanently and the lacquer surface will no longer lie flat. During treatment as well as storage and display, it is important not to let the relative humidity drop too low or fluctuate wildly. A stable relative humidity of 50–60% is recommended.

Asian lacquer is often coated onto a number of substrates and grounds. Not all ground layers are a durable lacquer-based variety. In many cases they are a water-soluble animal glue mixed with clay or another inert material. This material can also contribute to the deterioration of the object, and its sensitive nature must be taken into account during

treatment. A number of water-soluble methods are discussed below, and all must be used with caution to ensure that further damage does not occur. Due to the variety of grounds in use and the mostly organic materials of the substrate, relative humidity should remain stable during storage, treatment, and display.

2.2 ASIAN LACQUER (*URUSHI*)

Assuming the need for a fill has been established, what are the materials available to the modern conservator? A natural choice might be to fill the loss with the same material as the original. In the case of Asian lacquer, this choice might not be suitable or practical for most Western conservators. Asian lacquer is difficult to work with, and excellent results are hard to achieve. It takes years of training to be able to select the appropriate mixture for consolidation and infilling. Even satisfactory results might be unlikely for the typical Western-trained object conservator, because the application technique is as important as the material itself.

There are additional factors to consider as well. For most practical purposes, Asian lacquer is an irreversible medium; it cannot be dissolved with solvents, although fills can be picked out with a scalpel. Additionally, lacquer fills are difficult to color-match and over time will change color at a rate different from that of the original, producing an increasingly mismatched fill. Moreover, many conservators consider it of prime importance to use fill materials that are not the same as the original so that the restoration can never be mistaken for the original.

The above notwithstanding, there is a growing body of literature written in English that outlines the procedures for filling with Japanese *urushi* (Arai 1985; Nakajima 1985; Konishi 1993; Piert-Borgers 1993; Murose 1996). Throughout these articles the general theme is the same: repairs are done in the same manner as the original object was made, and each layer lost is repaired with the same material as the original. In the case of objects that were originally created with many layers, infills are often simplified to a few layers. When fills are not done, the remaining ground is consolidated with raw *urushi*. As always, each object is considered on an individual basis (Yamashita 1995).

While it is unlikely that any of the methods described below will be used by Western conservators, they are explained to aid in recognizing the previous repairs. Many pieces now in U.S. or Canadian collections were repaired in the traditional methods prior to leaving Asia.

Kokuso, a mixture of *urushi*, baked sawdust, and flour (Kitamura 1985), is commonly used as a fill material on sculpture and other large wooden objects (Onodera 1982). It is used primarily for deep cracks and losses to the foundation layer. In Japan, many conservators have adapted the standard *kokuso* recipe to best suit their own needs. Usually, *mugi urushi* is made first by mixing flour and water into a paste and adding the *urushi* slowly, then finally adding the sawdust to make *kokuso*. Variations include the addition of *nori urushi* (rice flour and *urushi*) or chopped linen fibers. Depending on the amount of *urushi* in the mixture, the final fill may vary in color from beige, containing little *urushi*, to dark brown.

Although the basic mix of *sabi* is raw *urushi* and *tonoko* (pulverized baked clay), there are many subtle variations on this recipe and its appearance. The clay may vary in color from

dark gray to beige depending on its origin. A great many grinds are available for use, including the coarser baked clay known as *jinoko*, although it is used infrequently for repairs.

The final finishing layers over the ground must be the right type of refined *urushi*. Conservators in Japan often spend a great deal of time achieving the proper combination to blend with original surface. Even a cursory examination of the materials and methods of repair confirms the complexity of these repair techniques.

2.3 WAXES

Wax is a common fill material that has been used successfully for many different types of restorations in the past. Indeed, even the Romans used it to repair Greek marble statuary broken during transport. Marbles that had not been repaired with wax were marked *sine cere* (without wax), hence our word "sincere." Some conservators contend that lacquer fills should also be marked *sine cere*, because wax restorations can cause problems for future conservators.

Although the literature documents a number of successful treatments involving wax, there are a great many concerns about its use. Asian conservators point out that wax residues may make it impossible for them to do a subsequent *urushi* repair. Much discussion has taken place on whether the wax inhibits the *urushi* drying process and causes additional cracking (Nakajima 1985). An experiment by Piert-Borgers (1993) shows recently applied beeswax does not affect the drying of *urushi*, but there may be problems with unknown wax formulations or aged wax surfaces.

There is also the consideration of whether wax is truly reversible. In theory it is, but in practice removing all traces of the wax from the ground layers without harming the object is just about impossible. Once wax has been introduced to the porous ground layers, the choice of subsequent treatments is severely limited. Any fill area where wax is used should be lined with Paraloid B-72 before filling to ensure that the wax does not enter the ground layers. The author now restricts the use of wax to objects where small losses, less than 1 cm in diameter, occur in areas of thick lacquer, .318 cm or more, such as on Chinese carved lacquerware.

At the Royal Ontario Museum, extensive use of wax was made for the infilling of losses on a *namban* lacquer chest in 1984. At the time, wax seemed suitable for this project since the fill areas between the mother-of-pearl were small and the *urushi* layers were fairly thick. A combination of beeswax and carnauba with vine black pigment was used for infilling the numerous losses at the edges of the cabinet. The wax was first heated, pigment added, and then allowed to cool into colored wax blocks. A hot stylus for batik wax was used to melt the wax and guide the flow into the loss. The small fill areas on this object were easy to smooth out with odorless mineral spirits, but slightly larger areas were problematic.

Although the wax fills appear to have worked quite well in this circumstance, they will not be undertaken again for a number of reasons. Because beeswax corrodes copper, this formula cannot be used near any metal fixtures. Also, unless the beeswax is extremely pure, the wax fills may bloom over time. In the case of this *namban* cabinet, all the surfaces had to be coated with PVA resin shortly after conservation treatment to prevent blooming. Inpainting was also difficult, as few standard mixtures are compatible with wax (fig. 1).

Fig. 1. Back panel of Japanese *namban* cabinet. The lower decorative edge has been restored using a beeswax and carnauba wax mixture. Note the beginning of wax bloom.

The wax mixture that has been used at the Freer Gallery of Art for thick layers of carved lacquer in the past is perhaps a better choice. Chase (1985) reported that after lining the loss with 10% Paraloid B-72, a mixture of 38% carnauba, 38% paraffin wax, and 10% microcrystalline was used for filling in a Ming dynasty carved dish. When additional tack is needed a resin may be added (Norman and Koob 1994).

Wax has also been used in combination with resin mixtures in Russia. Simonov (1996) reports success with a wax dammar resin mixture used either as a direct fill or as cast sheets that are then cut to shape. He has used the technique of taking a mold of low relief areas, then casting missing areas using Montan wax. He advises that extra caution be taken when applying any hot wax to lacquer, as the lacquer may undergo a color change at around 100°C (Simonov 1990). Those who have seen the dramatic discoloration in lacquer soup bowls are aware of this problem.

In conclusion, the various problems with wax fills—difficulty inpainting, danger of thermochromatic changes, lack of complete reversibility, and the possible effect on the drying of *urushi*—preclude its use in most cases.

2.4 POLYESTER RESINS

Polyester resin has been used by some conservators for infilling losses in lacquer. It is used successfully to infill losses in glass, another hard glossy material, so it is logical that it should be tried for lacquer.

Since polyester is generally considered an irreversible resin, there are only a few acceptable ways that it can be used on lacquerware. The first involves lining the fill area with a barrier such as a flexible plastic wrap, then pouring in the fill, letting it dry, removing the wrap, and gluing in the fill using a reversible adhesive. The second is casting the polyester separately, then cutting it to fit the shape of the loss. The third is lining the fill with a reversible resin,

then casting and finishing the polyester *in situ*. Each method has its difficulties.

Jackson (1994) has given a detailed description of the working procedure for producing missing pieces of carved lacquer in polyester. She found polyester particularly useful for reproducing the colored layers of lacquer for carving. The cast, layered polyester fills were carved, then polished to match the *urushi*, and adhered with Paraloid B-72, making them completely reversible.

Jaescheke(1993, 13) gives a very good description of the use of polyester *in situ*:

> The area to be gapfilled was then coated with a layer of Paraloid B-72 (20%) to provide a protective barrier which is readily soluble if the gapfill is to be removed at some later date. The gap was then filled with polyester resin tinted with polyester black pigment and catalyzed with standard peroxide catalyst. The environmental grade of polystyrene was used. This contains some crystic wax, helping to prevent the release of styrene monomer and preventing the formation of a sticky surface when the polyester is in contact with moisture in the atmosphere. The resin sets hard in about 20 minutes, with a slightly dull surface.

She goes on to describe the polishing process for the polyester. Extra care must be taken when polishing this type of fill *in situ* as it is easy to abrade the adjacent lacquer area. Water should be avoided to ensure that there is no damage to the lacquer or the ground layers. Micro-Mesh cushioned abrasive cloths, available in grades from 1,500 to 12,000, can be used for polishing without the use of a medium.

In 1990 a series of tests for the use of polyester as a fill material were carried out (Webb 1994). The method chosen was to cast polyester sheets, then to cut shapes for insertion into the lacquer. In general this method was not successful. The pure polyester was too brittle for cutting to shape, and bulking materials that softened the final product made it opaque and pale in color so that it no longer matched the lacquer. It would be also difficult to blend the fill with the surrounding lacquer without putting the lacquer in direct contact with the resin.

2.5 POLYVINYL ALCOHOL AND CALCIUM CARBONATE

Some conservators have used polyvinyl alcohol with calcium carbonate for infilling losses in gilding (Hebrard and Small 1991; Thornton 1991). Since it could be applied easily, dried fast, and also could be burnished to a very smooth finish, it seemed a good candidate for use as a fill in lacquer. Sample panels made at the Royal Ontario Museum and cycled several times through humidity changes from 20 to 90% RH showed that the polyvinyl alcohol and calcium carbonate applied to the surface remained intact and adhered to the wooden substrate. A polyvinyl alcohol and whiting fill is readily reversible using only slightly damp swabs.

For use as a fill, polyvinyl alcohol is dissolved in water to make a solution between 6 and 8%. In the past the author has used a low-molecular-weight polyvinyl alcohol with a high degree of hydrolysis because it was readily available. However, Hebrard and Small (1991) suggest that one with a low degree of hydrolysis may have better working qualities. Calcium carbonate is added to the solution until the mixture reaches the desired consistency—a dough

for deep fills or a much less viscous consistency for use as a coating. The resulting mixture is thixotropic, which makes it difficult to spread like a traditional gesso. It is best to apply it with a rubber spatula to obtain a smooth finish in the first attempt. It can be wetted again later for further smoothing but should be dry-sanded for the final finish. Conservators who are accustomed to working with traditional gesso often have difficulty adapting methods to this product, but with practice a very smooth surface can be achieved in a relatively short time.

Some conservators have expressed concerns about using this water-based material with *urushi*. However, to date the author has not seen any effect on the surrounding *urushi* of the small amount of water necessary to apply this material or to reverse it. As with any fill material, care must be taken not to expose the surface of the *urushi* to this material. Another concern is that polyvinyl alcohol cross-links in ultraviolet light. Used in this way, however, this material is not exposed to light.

At the Royal Ontario Museum this fill material was first used for the extensive losses on an 18th-century Japanese palanquin. As one-third of the lacquer on the pole was missing, the polyvinyl alcohol fill worked well to fill large areas quickly and efficiently. At present, 8 years since treatment, the fills remain unchanged (fig. 2).

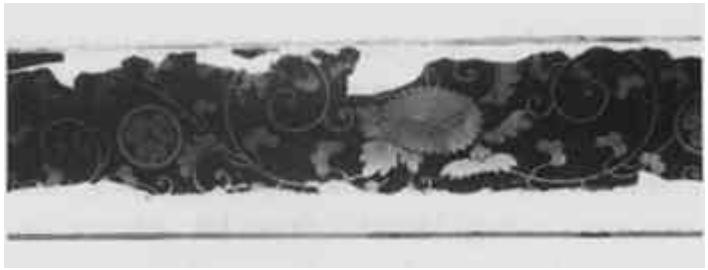

Fig. 2. Detail of the Japanese palanquin pole with polyvinyl alcohol and calcium carbonate fills, before inpainting

This method has also been used with success by Jackson for infills on Chinese lacquerware from the Warring States period (Jackson and Watson 1995).

2.6 EPOXY RESIN

In general, because they are insoluble, epoxies are not recommended for lacquer, but in certain circumstances Milliput, a two-part filled epoxy, has been used successfully. Because Milliput can be shaped wet using molding tools, a very smooth surface can be obtained without sanding. This procedure reduces the danger of abrading the adjacent lacquer surface when smoothing the fill. In describing her method for filling a smooth lacquer screen, Jaeschke (1993) reports she used 20% Paraloid B-72 as a barrier to ensure that the fill would be reversible.

Neuman used Milliput to fill losses on a modern sculpture consisting of nine giant lacquered wooden links of chain (Neuman and Martin 1996). In this case, not only was the avoidance of abrasion a consideration, but the fills would be subjected to a great deal of stress during display. A softer fill material such as polyvinyl alcohol would have been completely unsuitable.

Often the hinges on heavy Chinese screens have been ripped out or loosened through improper handling or extended use. Epoxy resin mixed with an equal amount of glass microballoons is very useful for filling these enlarged holes. The epoxy resin provides the necessary strength to allow the reattaching of the hinges in the same position as in the original, and the final surface finish may be carried out using another method.

In general epoxy is not the first material a conservator would consider for filling lacquer. Its poor aging characteristics and lack of reversibility are valid reasons for rejecting it. However, there may be circumstances, as described here, in which it would be considered acceptable.

2.7 PARALOID B-72 AND MICROBALLOONS

As the surface gloss of Paraloid B-72 is quite unlike lacquer, it is not used as fill material on its own. It has, however, been used successfully bulked with glass microballoons as a fill to support tented lacquer. When an organic substrate, usually wood, has permanently shrunk and the surface layers of lacquer no longer fit, the conservator must choose one of three treatment options. Part of the lacquer could be removed so the remaining lacquer will lie flat, or the lacquer could be adhered to the surface with an overlapping portion. The third option to prevent loss of design or original material is to support the tented lacquer in its distorted position.

At the Royal Ontario Museum tests were performed to find a suitable material to support tented areas of lacquer. A combination of Paraloid B-72 and glass microballoons seemed to hold a lot of potential, as it could be injected through a syringe and would be strong enough to support the fragile lacquer surface. Paraloid B-72 was chosen due to its good aging characteristics and reversibility and because it can be dissolved in a number of solvents. Other resins might also be appropriate for use.

Tests were performed to find the appropriate formulation that would allow the resin and microballoons to flow under the lacquer, spread out evenly, adhere to the surface, and dry. These activities had to be carried out without affecting the lacquer surface and also be reversible in the future. The tests were carried out on strips of distorted 200-year-old lacquer that were no longer attached to an artifact. The strips were adhered to 4-ply mat board, leaving the distortions in place.

The Paraloid B-72 was dissolved in different solvents, then microballoons were added with approximately 1 part resin mixture to 2 parts microballoons by volume. The following combinations were tried: 50% B-72 in acetone/ethanol 1:1, 30% B-72 in xylene, 40% B-72 in acetone/ethanol 1:1, 10% Klucel G (hydroxypropyl cellulose) in ethanol, 15% B-72 in Super Hi-Flash (a petroleum distillate), 25% B-72 in acetone/ethanol, and 30% B-72 in Super Hi-Flash. The results of these mock-ups—subjective judgment based on appearance of the lacquer, ease of use, and drying time—indicated that the nonpolar solvents are the safest because they will not affect the lacquer layers. Unfortunately the toxicity and the long drying times sometimes makes them impractical for large objects. The combination of acetone and ethanol works well, but it will soften lacquer if it is exposed too long. This problem can be overcome by treating one small area at a time and allowing for thorough drying before proceeding to the next section. Of course, as with any method, tests should be carried out to ensure the mixture chosen will not affect the particular object.

These formulations with microballoons are also useful for deep cracks. For example, the author has used it on several late Chinese cabinets in which the wood had shrunk to such an extent that there were large gaps between the panels. In addition, polyvinyl acetate in acetone/ethanol with microballoons can also be used for filling these deep cracks. Air trapped in the mixture adds to the elasticity, making it flexible enough to accommodate small dimensional changes.

2.8 SURFACE FINISHES TO IMITATE LACQUER

With the exception of the wax and polyester fill, all of the above require separate matching of the surface. In the past, the author has tried many materials to imitate the surface of lacquer. It makes little difference to the top coat whether a traditional rabbit skin glue gesso or the polyvinyl alcohol fill is used. What is required is that the underfill be smoothed perfectly, as any imperfections may show up in the final product.

A number of materials have been tried as the top coat and immediately rejected. Paraloid B-72, for example, did not have the right gloss, and watercolors with varnish did not have the depth of color necessary. These methods work for small areas of inpainting but not for large areas where matching the color and luster is more difficult. In addition, methods requiring solvents were unsuitable for inpainting large objects where adequate ventilation was unavailable.

2.9 ACRYLIC EMULSIONS AND DISPERSIONS

Acrylic paints have been used for the past decade to imitate lacquer (Umney 1987). They clearly have many advantages, such as ease of use, numerous available colors, and no special ventilation requirements. In addition, the surface of the surrounding area can easily be matched by coating thin layers of gloss medium until the right luster is reached. Unfortunately there are also many disadvantages to acrylic paints. Most of the colors available are opaque and do not match the translucency of lacquer. To paint the acrylic smoothly, it has to be diluted to such an extent that the water may soften polyvinyl alcohol or gesso fills. Also, in this diluted state the paint loses most of its flow qualities and hiding power. Each subsequent layer increases the possibility of brush strokes showing, and since the final surface is very soft, it cannot be polished.

However, instead of paint, if one uses an acrylic emulsion that drys hard enough to be polished and one adds dye instead of pigment, the results can be impressive. Several years ago, a series of sample boards were created in order to try different materials that might prove useful. Rohm and Haas had several new water-based acrylics available, including Acrysol WS-24. A commercial water-based lacquer formulation, Mohawk Water Based Clear Lacquer is also available, although it must be used with ventilation.

Acrysol WS-24, an acrylic copolymer dispersion resin, seems to hold great promise for the museum conservator in imitating lacquer. It can be dyed with water-based aniline dye, and the surface can be polished to match the degree of gloss left on the original lacquer. It is easy to work with and readily reversible in alcohol or ammonium hydroxide (Rohm and Haas Co.

1983). But there are also a few disadvantages to Acrysol WS-24. The first is that it is a bit too reversible in alcohol. In a museum setting this is not a problem, but for objects that will be returned to private homes it may not be the best choice; an alcoholic beverage spilled accidentally on the surface will leave a mark. The second disadvantage is that there is some off-gassing of this material after drying. Oddly, tests done at the Royal Ontario Museum show that the vapor given off will tarnish silver in an enclosed space; therefore, it might not be suitable for imitating lacquer with silver decoration. As with all water-based materials, acrylic emulsions spilled on the surrounding area can leave marks on the surface of light-damaged lacquer. The high alkalinity of the emulsion accelerates this damage.

Mohawk Water Based Clear Lacquer is not as readily reversible in alcohol as Acrysol WS-24, so it is suitable for objects that will be handled. Because it has a pH of approximately 7, it is less likely to mark a light-damaged surface. Unfortunately Mohawk Water Based Clear Lacquer has not yet been tested for long-term stability. It can be used in exactly the same method as the WS-24 with two caveats. It does contain some solvent, so it must be used with ventilation, and a drop in temperature below 15°C during drying will result in a cloudy coating. Mohawk comes in two types, matte and glossy, but either can be used to match a finish by polishing.

The following is an example of the technique using acrylic paints to achieve the smooth look of a lacquer finish. To imitate the surface of lacquer on an 18th-century palanquin at the Royal Ontario Museum, Liquitex acrylic paint was selected because of its ease of use, in terms of time and health hazards (fig. 3). A transparent purple dye was added to the ivory black to give the paint some translucency, and three or four thin coats were applied. While this coating did not come close to imitating the effect of lacquer, it was an improvement over opaque colors. The goal of the decoration was to achieve the same effect as the *maki-e* (“sprinkled picture” in Japanese), so similar processes were followed. First, a red acrylic layer was applied, followed by a gold layer. These were then touched up to match the existing original in color and gloss. Mica-based pigments were mixed with acrylic gloss medium to imitate gold, since genuine gold was too expensive for these extensive fills. Not only does this mica- and titanium-dioxide-based pigment reflect light in a way that imitates gold, but it also has the added benefit of not tarnishing since there is no metal in the pigment.

Fig. 3. Same area of palanquin pole as figure 2, now inpainted with Liquitex paints and Liquitex medium with mica-based pigments

The following procedure can be used to imitate black or translucent lacquer using an acrylic emulsion such as Acrysol WS-24 or Mohawk Water Based Clear Lacquer. Apply a polyvinyl alcohol or gesso underfill, and smooth it to a level lower than the surrounding surface. Select an appropriate color of dye, mix it up with the minimum amount of water necessary to dissolve the dye, then strain it and mix it with the Acrysol WS-24. The color and amount of dye depend on the piece to be imitated, but generally the same depth of color should be achieved in three or four coats. Apply the acrylic with a soft brush, taking care to avoid air bubbles. As in applying shellac, do not go over the same area twice when it is wet. The

surface drys to the touch in about 20 minutes and can be lightly sanded in a few hours. Apply approximately four layers until the color is right, then apply two coats of the clear WS-24 before the final sanding and polishing. The surface can be polished much like a shellac finish. Start with 600-grade lubricated sandpaper and increase to 1,200, then switch to tripoli powder followed by finer polishing powders until the same depth of gloss is reached as the surrounding original lacquer. Again Micro-Mesh cushioned abrasive cloths are useful for polishing without a medium. In general, liquid or paste polishing compounds are incompatible with the acrylic, as even Solvol Autosol dissolves the surface.

The author has also used these acrylics with Japanese silver and gold powders and sprinkles to imitate a Japanese *nashiji* ground. By choosing the right grade of *nashiji* or metal powders and matching the color of the translucent *urushi* finish, one can come very close to the original finish (fig. 4). Red lacquer can also be matched by first dyeing the Acrysol WS-24 to the color of liquid *urushi*, then adding vermilion pigment.

Fig. 4. A comparison of Acrysol WS-24 (left), Mohawk Water Based Clear Lacquer (bottom), and shellac japanning (right) against *urushi* with *nashiji* and *maki-e* decoration. The size and amount of *nashiji* were different from the Japanese piece; however, one can see that the color and gloss come close to the original for the WS-24 and the Mohawk samples.

2.10 OTHER COATINGS

Polycite and Cashew are two synthetic coatings produced by Saito and Company in Japan to imitate *urushi*. Literature from Saito (1989) states that “the main materials consist of the principal ingredients of lacquer, such as Urushiol, Laccol, Thitsiol, and a similar chain compound Catechol or derivatives of Phenol and these are compounded by special process with Trialkenyl Phenol derivatives.” The literature goes on to say that Polycite is easy to use, may be applied by brush or spray, and can be polished just like *urushi*. Another advantage is that it does not cause a skin reaction, as does natural lacquer.

Polycite and Cashew do indeed do a good job of imitating lacquer, as company literature states. The main drawback for conservators, however, is that they are not reversible resins: they are extremely difficult to remove. They do have potential if used over a reversible underlayer, such as polyvinyl alcohol or Paraloid B-72. They have extremely good hiding power, and a lacquerlike surface can be achieved with as little as two coats. Minor difficulties

are that they require a long drying time, during which dust becomes a problem, and as the vehicle is a petroleum solvent, they require proper ventilation.

2.11 TRADITIONAL JAPANNING

Traditional japanning with seed lac or other natural spirit resins used in European lacquer still have a place in restoration work. After all, European lacquer was developed to imitate Asian lacquer in the first place. This method is useful for replicating a missing part. The drawback to using this method as the surface for a fill is the application of numerous coats to achieve the right finish. Sanding between coats risks damaging the surrounding *urushi*, and in addition the whole process is very time-consuming. The surface does not last very long, but soon develops its characteristic craquelure. Instructions for japanning can be found in historical texts such as Stalker and Parker's *Treatise on Japanning and Varnishing* ([1688] 1971) or Dossie's *Handmaid to the Arts* (1764). A little experimentation and practice are required to adapt these recipes to modern use.

2.12 CONCLUSION

All of the above materials offer possible solutions to the problem of imitating lacquer for infilling. The author has not found a single method that can be used in all circumstances. In a way it is unreasonable to expect one method to answer all needs. After all, many different grades of *urushi* combined with other materials were used to create the original. The acrylic emulsions hold the most promise, as they are good at recreating the look of the basic lacquer.

Because a suitable substitute for *maki-e* decoration has not been found, the author carried out further experiments with traditional *maki-e* decoration on top of acrylic fills. The *urushi* adhered nicely to the acrylic, yet the whole fill remains reversible. The combination of a reversible base with *urushi* used for the decorative layers may answer the objections some people have to *urushi* as a repair material.