Article: Encountering the unexpected in Southeast Asian lacquer: Treating the Doris Duke Collection at the Walters Art Museum
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1. INTRODUCTION

Doris Duke (1912-1993) was the American heiress of a large tobacco and energy fortune. During her lifetime, she had numerous estates and amassed a large collection of antiques and fine art from all over the world. On her around-the-world honeymoon in 1935, she traveled to Bangkok and other parts of Asia and started to collect Southeast Asian antiques. From the 1950s through the 1970s, she made the bulk of her purchases through an antiques dealer named François Duhau de Bérenx. At the time, she was the only active Western collector outside of Thailand with an interest in objects of this type and caliber (Tingley 2003). Much of her Southeast Asian art collection was stored at Shangri La, her estate in Hawaii where she planned to build a Thai Village to display the objects and paintings. She was unable to find an appropriate location for the Thai Village in Hawaii, however, and her collection was eventually moved to her estate in New Jersey, called Duke Farms. She started construction of the Thai Village in New Jersey, but it was not completed before she passed away in 1993. In 1999, Hurricane Floyd struck the East Coast of the United States, causing significant flooding at Duke Farms that damaged many of the objects, especially those that were stored on her indoor tennis court.

In 2002, the Walters Art Museum received a gift of 150 objects of Southeast Asian Art. Many of the objects originated from Thailand and Myanmar (formerly Burma) and were created in the 19th century. In 2014, the Department of Conservation and Technical Research embarked on a three-year grant from the Institute of Museum and Library Services to treat the objects that were previously identified as conservation priorities. These objects exhibited varying degrees of deterioration due to age, flood damage, and prior intervention. Many of the lacquered and gilded surfaces were actively flaking, and a majority of the objects were covered in an unusual sticky brown coating that was eventually identified as modern. Additional information was collected about the decorative surfaces with a variety of analytical techniques. Once treatment work began, it was readily apparent that Southeast Asian lacquer behaves differently than East Asian lacquer. The largest issues involved solvent sensitivity as it relates to consolidation and cleaning. Questions regarding the visual reintegration of loss were addressed through research travel to Thailand and Myanmar and collaboration with curators. It is hoped that the information gained from this project will be a catalyst for future research and study regarding the treatment of Southeast Asian lacquered objects.

KEYWORDS: Southeast Asia, Lacquer, Cross section, Py-GC/MS, XRF, FTIR, Gel
difficult for the conservators to speak to visitors. The extended use of solvents was therefore limited to days and times when the conservation space was not open to the public. Due to these restrictions, as well as the needs of the objects, water-based treatment systems were favored for cleaning and coating removal when possible. Similarly, consolidation with solvent-based adhesives was not completed in view of the public. To date, more than 6500 visitors have watched the Doris Duke Collection conservation project and have responded very positively to the opportunity to view conservation work in progress (fig. 1).

2. SOUTHEAST ASIAN LACQUER

In recent years, researchers at the Getty Conservation Institute and the J. Paul Getty Museum have made significant contributions to the study and analysis of Asian lacquer. An expert system developed for interpreting test results of Asian lacquers from thermally assisted hydrolysis and methylation with pyrolysis-gas chromatography/mass spectrometry (THM-Py-GC/MS) makes it possible to identify a wide range of raw materials and additives. The system relies on AMDIS (Automated Mass Spectral Deconvolution and Identification System), a freeware program developed by the National Institute of Standards and Technology (NIST), to identify marker compounds in pyrograms using a library compiled from in-house and published studies of reference samples. A custom Excel workbook organizes the marker compound results in the AMDIS report and displays sorted information in diagnostic graphs that aid in artists’ material identification (Schilling et al. 2016). A procedure developed for microexcavation of lacquer cross sections makes it possible to analyze the materials in individual layers. Their studies have drawn attention to the fact that although there are three main species of lacquer trees with different growing regions, commercial trading of raw materials to other regions broadened the range of availability (Heginbotham and Schilling 2011).
Southeast Asian lacquer trees grow in Thailand and Myanmar, although the main source of lacquer today is the Shan State of Myanmar (Fraser-Lu 2000). Southeast Asian lacquer comes from the *Melanorrhoea usitata* tree and is known as *thitsi*. The lacquer is harvested by cutting “v”-shaped notches into the bark of the tree, and the sap drips out of a bamboo spout. When the lacquer sap first comes out of the tree, it is milky white in color, but it turns black upon exposure to the air and sunlight (Journal of the Royal Society of Arts 1919). Therefore, Southeast Asian lacquer is naturally black without the addition of pigment, and the richness of the black color is noted as a unique characteristic of Southeast Asian lacquer (Honda et al. 2007).

Lacquer that is being used in Southeast Asia today has numerous other additives because the raw lacquer sap is so expensive (Simatrang 2002). There are some references to historic lacquerware techniques in Southeast Asia from the British Colonial period, but there is also confusion about how closely modern and historic methods relate. Consequently, part of this project involved visiting the region and making connections with people familiar with the industry. There are some general principles of Southeast Asian lacquerware production that are consistent with both historic and modern descriptions, the first of which is the manufacture of *thayo*, or bulked lacquer (referred to as *smook* in Thailand). Bone ash, teak wood sawdust, or burnt organic material such as rice husk and cow dung are added to raw lacquer to create a thick putty. This thicker lacquer layer is applied on top of a substrate (usually wood or bamboo) to create a smooth surface (Yoe 1896). It is applied by hand and allowed to dry in an underground cellar for five to seven days depending on the weather, as high RH is required (fig. 2).

Multiple bulked lacquer layers are sometimes applied, and the layers are polished in between applications with a variety of abrasive materials. Some round objects are turned on a wheel for this smoothing process (Fraser-Lu 2000). The drying time for the preparatory layers alone can take months, which is much longer than Japanese and Chinese lacquer and has been noted as one of the main disadvantages of Southeast Asian lacquer (Honda et al. 2007). Multiple recent studies focus on methods for altering thitsi lacquer to reduce the drying time. These studies also clarify the chemical differences...
between the various types of lacquer (Tun and Lwin 2001). It remains uncertain as to whether these alteration methods will be adopted by craftspeople in the near future or how the changes would affect the aging properties of Southeast Asian lacquer.

While current practice includes the application of multiple finishing layers of lacquer for fine pieces, cross section analysis of samples from the Walters’ 19th century objects does not indicate more than one or two. It is unclear whether this discrepancy is the result of a change in working methods or the inability to distinguish the number of layers because of the polishing steps. Cross section analysis of modern lacquerware samples with a known production method would help to answer these questions. There is also conflicting information regarding the inclusion of diluents in the upper lacquer layers. Some accounts of modern lacquer production do not mention any additives in the final layers (Isaacs and Blurton 2000). Other modern descriptions indicate that it can be difficult to create smooth coatings with Southeast Asian lacquer, which necessitates the addition of other ingredients like wood oil and drying oil (Heginbotham and Schilling 2011). Historic descriptions of Burmese lacquerware production also mention the addition of wood oil, but this term is also sometimes used to refer to the lacquer itself. In both modern and historic accounts, lacquer is also sometimes referred to as varnish, and shansi (tung oil) is sometimes described as wood oil. Additional scientific analysis of historic samples and modern reference materials would help to answer many of these questions. There is also the possibility that artists were using whatever materials were on hand, which could account for the differences within historic and contemporary descriptions.

The application of gold decoration on lacquer appears to be fairly well understood historically, and the practice does not significantly differ today. The technique is referred to as lai ra nam in Thailand and shwe-zawa in Myanmar. For patterned gilded designs, areas that are to remain black are painted with a water-soluble pigmented gum resist, then gold leaf is applied over the entire surface while the exposed lacquer design is still tacky (fig. 3).

Once the gold is applied and the lacquer dries, the entire surface is washed with water, which removes the water-soluble gum along with the gold leaf on top (Isaacs and Blurton 2000). Some
historic accounts describe the application of a varnish over the decorative surface, but that was not described by current artisans. Examination of objects in the Walters collection indicates that the patterned gilded surfaces were originally uncoated. The significant abrasion of the gilding on many pieces in other Southeast Asian collections also indicates that no protective coating was applied. There are descriptions of the addition of sesame oil or shansi (tung oil) to ungilded lacquered surfaces for added sheen, but there was no mention of a final surface coating application in modern workshops (Journal of the Royal Society of Arts 1919). There also seems to be some confusion about whether or not it is possible to achieve a clear coating of Southeast Asian lacquer, or if the clear coating would have been made of another material. Unlike Japanese lacquer that is processed to create a clear coating, current and historic accounts of the industry do not mention the purification of raw Southeast Asian lacquer sap other than straining out debris. Henry Burney’s historic account of lacquerware production in Ava (Burney 1834) says that there is no form of clear Burmese lacquer, only a semitransparent mixture of 3:10 shansi (tung oil) to thitsi. Conversely, a modern interview of a Thai lacquer craftsman reported that the pieces were finished with a final clear coat of lacquer (Nilvilai 2000). It is uncertain if this confusion is the result of the translations of words like clear, lacquer, and varnish, or if a clear coating was achieved by the mixture of lacquer with another material. Modern workshops use a small amount of lacquer mixed with tung oil for the application of pigmented lacquer, which could perhaps be used as a clear coating (Fraser-Lu 2000). There are also descriptions of tung oil mixed with sesame oil in a ratio of 1:3 to protect the carved and colored lacquer surfaces and provide added sheen (Htun 2013).

Once Southeast Asian lacquer dries, it has slightly different properties than other types of lacquer, including greater flexibility. Interestingly, the composition of the Burmese lacquer sap is not very different from Japanese lacquer sap in terms of the proportions of water, plant gum, glycoprotein, laccase enzyme, and polyphenol (Wang et al. 2014). The main differences lie in the chemical structures of the polyphenols (specifically catechols). Thitsiol contains significant amounts of alkylphenyl catechols, which are absent in urushiol and laccol and affect the polymerization of the lacquer. Prolonged exposure to polar solvents such as ethanol and acetone during consolidation tests at the Walters caused the lacquer layers to deform upon drying. Some sensitivity to xylene was also noted. The differences in the behavior of the dried lacquer layer in terms of increased flexibility and sensitivity to a wide range of solvents could also be related to the additives that are sometimes described as part of the production process.

3. ANALYSIS

A variety of analytical methods were used to examine these objects with the help of the conservation science departments at both the Walters Art Museum and the Getty Conservation Institute. In general, the materials that were identified were consistent with those described in period accounts of lacquer production in Southeast Asia with the exception of the surface coating, which is likely a mid-20th century addition.

3.1 UV EXAMINATION

The most important aspect of the examination in longwave (365 nm) ultraviolet radiation (UV) was the appearance of the surface coating before and after cleaning. The surfaces were constantly examined in UV during cleaning to assess how much of the coating was removed, and also to identify areas where multiple coatings were present. The autofluorescence color of the surface coating ranged from yellow to green, and in some areas fluorescence was suppressed due to dirt that was trapped in the coating (fig. 4).
3.2 CROSS SECTION ANALYSIS

In general, the objects were found to have multiple thick layers of bulked lacquer, followed by thinner layers of fine lacquer. In some instances, red pigments were added to these underlying fine lacquer layers, while others were unpigmented. Gold leaf was applied directly to the lacquer while still tacky, and there were some samples with multiple layers of gold leaf that may have been applied during a restoration campaign or possibly by practicing Buddhists who wished to earn merit (fig. 5).

Fig. 4. During cleaning comparison of normal light versus longwave UV-induced visible fluorescence of the modern surface coating. *Seated Buddha*, 19th century, dry lacquer, wood, gold leaf, mirrored glass, red and black lacquer, 181.5 × 120 × 60 cm, The Walters Art Museum, 25.232 (Courtesy of Gregory Bailey)

Fig. 5. Sample from the seated Buddha (54.2987). Multiple gilding layers are visible, as well as fluorescent surface coatings (Courtesy of Stephanie Hulman)
The cross section samples also show the presence of surface coatings, sometimes more than one. In some of the bulked lacquer layers, the filler appeared similar to plant material, such as rice husks (fig. 6).

3.3 ELEMENTAL INFORMATION

The primary use of XRF was to confirm the presence of gold in the metallic leaf and identify the metal substrate on some of the objects. The two metal Buddha sculptures were found to have copper and zinc components, indicating brass. The metal leaf on these surfaces was found to contain mostly gold with some copper. In addition, the metallic backing on the mirror pieces for the standing Buddha (54.3000) was found to contain lead and tin, and the red pigment on the seated Buddha (54.2987) contained mercury (associated with vermilion—HgS). (See the appendix for equipment and collection information.)

3.4 LACQUER ANALYSIS

Tests at the Getty Conservation Institute revealed the presence of thitsi lacquer and a drying oil in samples of the upper lacquer layers from the seated Buddha (54.2987). The presence of characteristic phenyl catechols confirmed thitsi lacquer, which comes from the *Melanorrhoea usitata* tree of the Anacardiaceae family. Perilla oil was also identified in these layers, which has a palmitic/stearic acid ratio of about 2.4. The bulked lacquer layer contains thitsi with a small amount of drying oil and a material with high saturated fatty acid content like a nondrying fat or lipid. Period recipes call for the addition of vegetable oils to later lacquer layers and pigmented layers, but the addition of nondrying oils to bulked lacquer is not mentioned (Burney 1834). It remains uncertain as to which oil was used in this instance and why it was used.

3.5 SURFACE COATING ANALYSIS

Since so many of the objects in the Duke Collection were covered in the sticky brown surface coating, it was important to determine its composition. The composition of the coating would affect decisions about its possible removal, as well as ways to remove it safely. Samples of the coating were
removed from six objects in the collection and analyzed by GC/MS at the Walters following
derivatization with MethPrep II using the method devised by the Getty Conservation Institute (Schilling
and Keeney 2003) (fig. 7).

The results showed a drying oil and also a phthalate—likely dioctyl phthalate. Although dioctyl
phthalate was commonly used as a plasticizer in the 20th century, there is also information regarding the
inclusion of dioctyl phthalate in agarwood (or eaglewood):

Agarwood is a known aromatic from Southeast Asia that is used in culturally significant practices. Agarwood
exudes a sap rich in dioctyl phthalate when the tree is tapped; the tapped tree exudates also contain sesquiterpenes
(aristolene). No sesquiterpenes have yet to be identified in the coating samples from the objects. However,
agarwood essential oil is expensive and imitations or counterfeits can contain up to 100% dioctyl phthalate.
(Gates 2015, 19)

In addition to the results of the coating analysis indicating a modern plasticizer, numerous objects in the
Duke Collection were covered in this coating, including objects that were not used as part of religious
ceremonies. It is likely that the coating was applied to either protect the surfaces or act as a consolidant,
and it is unlikely that the coating was added for ritual purposes while the objects were in use in Southeast
Asia, justifying its removal.

4. CASE STUDIES

Although many objects were treated during the course of the IMLS grant, the five that are highlighted
here represent different substrates and decoration techniques and also illustrate the various approaches to
treatment and object interpretation.

4.1 LARGE SEATED BUDDHA (25.232)

This dry lacquer seated Buddha was likely made in the Shan State of Myanmar and may date to
the 18th or 19th century (fig. 8).
The figure is just under 1.8 m tall and 1.2 m wide. The main body of the figure was made by applying multiple layers of lacquer on top of a clay core. The first lacquer layers were bulked with fill materials, and progressively finer layers of lacquer were applied to create a smooth surface. Once the lacquer was dry, the clay core was removed, leaving a hollow sculpture (Isaacs and Blurton 2000). The raised ornament on the Buddha is made of bulked lacquer. While the lacquer surface was still tacky, a very thin layer of gold leaf was applied to much of the surface. Some areas, such as the base, are highlighted with red lacquer as well. The garments are ornamented with pieces of colored and mirrored glass, and fibrous material is visible behind the glass pieces. These fibers may be remnants of the paper backing that is described as part of the production method for the glass pieces (Tilly 1901). The flames that adorn the ears, shoulders, elbows, and knees are made of wood, and some are visually obvious replacement pieces. The Buddha’s finial is made of a solid piece of wood and may have been replaced as well.

The Buddha figure was significantly damaged in the past and has undergone multiple restorations. At one point, the Buddha was broken into many pieces and reassembled using traditional materials including lacquer, thayo, and gold leaf, and some of those repairs had failed. The replacement pieces were also made using traditional materials, although the wood carving is not as fine and many of the glass pieces are highly reflective and do not appear to be backed with the same material as the original. The thin gilded surface was significantly abraded on the face, hands, and feet. New cracks had formed at the base, especially around nails that went into an interior wooden support that was added later. Similar cracks were noted on a dry lacquer Buddha at the British Museum that had completely

Fig. 8. Dry lacquer seated Buddha before treatment (25.232) (Courtesy of Gregory Bailey)
broken early in its tenure at the museum (Minney 1994). A dark orange sticky coating had been applied to the majority of the surface and extended over areas of loss and abrasion. Since the coating was still sticky, a significant accumulation of surface dirt within the coating could not be removed by dusting alone. There were also scattered drips of white glue from previous repairs.

4.2 THAI SEATED BUDDHA (54.2987)

The smaller seated Buddha statue from Thailand illustrates the defeat of Mara’s army (fig. 9). Phra Mae Thorani is depicted with water coming from her flowing hair, and heads of soldiers float in the water below. Given the style of ornament and dress, this Buddha may date to the 19th century. The heavily patterned robes would have been covered with mirrored glass pieces. The brass sculpture was created using the lost-wax casting method, and the clay core remains inside to support the very thin casting (0.44 mm in some areas). The metal surface was covered with multiple layers of lacquer, the last of which was used to adhere a thin layer of gold leaf. Although obscured by a heavy layer of dirt and surface coating, horizontal surfaces on the tiered throne are accentuated in red lacquer. This Buddha also shows evidence of previous repair, as areas of lacquer loss were covered in gold leaf without leveling the surface. Like the large seated Buddha (25.232), the Thai Buddha was covered in a visually similar orange-brown sticky coating. A heavy accumulation of dirt was also trapped in the coating. Previous areas of restoration with brass paint had darkened.

4.3 THAI STANDING BUDDHA (54.3000)

Although likely from the same time period as the Thai seated Buddha (54.2987), the standing Buddha is shown in royal attire with his upraised left hand in the Abhāya mudrā position (fig. 10). The Buddha was also made using the lost-wax casting method, and the finial was cast as a separate piece. The exposed metal surface in areas of loss is very rough, and deep scratch marks are visible
from finishing. The scratch marks would have helped lacquer adhere to the metal surface, and a bulked lacquer layer was necessary to create a smooth surface for gilding. The Buddha retains many of its mirrored glass inserts that were attached with bulked lacquer.

The most significant condition issue was flaking lacquer on both the front and back. The back had already suffered a significant amount of lacquer loss, and only about 10% of the remaining lacquer was well adhered to the metal surface. The gilded surface had suffered from abrasion, especially on the proper right arm and on the back. The surface was unevenly covered with the same dark sticky coating found on both seated Buddha figures (25.232 and 54.2987). Drip marks were visible, and the largest accumulation of the coating was on the top of the crown and the bottom of the jeweled neckline.

4.4 BURMESE MANUSCRIPT CHEST (65.142)

Doris Duke also collected furnishings that were used as part of Buddhist practice, and this manuscript chest is a wonderful example of the special housings that were created for sacred Buddhist texts. The piece was likely made in Myanmar during the 19th century and is constructed of six large single planks of wood, probably teak (fig. 11).

The front three sides of the chest feature an elaborate scene of the Bhûridatta Jâtaka, number 543 in the Pâli-language collection and number six among the last 10 Jâtaka (Woodward 2015). The scene is illustrated in bulked lacquer that was pressed into a mold to form the ornamental patterns and figures, and many of the figures on this chest are repeated. The raised lacquer designs are gilded. Portions of the interior of the chest and trim elements are coated with red lacquer.

Like many of the other objects in the collection, the manuscript chest was covered in the dark orange-brown sticky coating. The coating was especially fluid on this object and could reform and level after a sample was removed. A significant accumulation of dirt was also embedded in the coating on the bottom trim piece. The lid of the chest was covered in dirt and had suffered from water damage. The lid would have originally been covered with red lacquer, but the surface was entirely stripped or sanded at one point in its history. In addition, much of the gilding on the raised ornament was abraded, which created a black and gold color scheme that distracted from the narrative scenes depicted in thayo.

Fig. 11. Burmese Manuscript Chest, 19th century, wood, bulked lacquer, red and black lacquer, gold leaf, 63 × 98.5 × 62.5 cm, The Walters Art Museum, 65.142 (Courtesy of Susan Tobin)
4.5 THAI MINIATURE SHRINE (64.183)

The miniature shrine would have been used as part of Buddhist practice in the home of a wealthy individual (fig. 12).

Typically, a small Buddha statue would be placed in the center of the shrine with vases of flowers on either side. The shrine is architecturally similar to many of the temples in Thailand in terms of the roof ornamentation but has a slightly different floor plan and proportion than an actual temple. This piece was created with a different series of surface layers, showing a white filler material, multiple fluorescent coatings, a chrome yellow pigmented layer, and gold leaf on top (fig. 13).

The presence of this yellow layer is unusual, as all of the other gilded objects have dark brown, black, or red surfaces underneath. The hand-carved wooden structure is likely teak. The miniature shrine was also covered in the sticky brown coating, which was exceptionally dirty on the horizontal surfaces. There were numerous broken and missing roof ornaments, some of which had been saved and stored with the object. Although very dirty and heavily coated, the majority of the gilding underneath was intact.

5. TREATMENT

5.1 CONSOLIDATION

The most challenging consolidation treatment was on the Thai standing Buddha (54.3000). Only approximately 10% of the lacquer on the back of the figure was securely attached to the metal surface. Lifting areas projected as far as 0.5 cm from the surface. To further complicate the situation, initial consolidation tests showed that the lacquer was extremely sensitive to polar solvents and even xylene, which was particularly challenging given the extended drying times associated with a metal substrate. The chosen consolidant needed to be soluble in mostly nonpolar solvents, and it needed to have tack so that it could adhere the flakes to the surface quickly due to the vertical orientation of the object. Lascaux

Fig. 12. Thai Miniature Shrine, late 19th century, wood, gold leaf, white and yellow ground, 181.5 × 47 × 68.5 cm, The Walters Art Museum, 64.183 (Courtesy of Susan Tobin)

Fig. 13. Cross section sample of miniature shrine decorative surface showing a yellow pigmented layer underneath the gilding (Courtesy of Stephanie Hulman)
P550-40TB (butyl methacrylate resin) was selected for testing in a 10% v/v mixture of xylene in mineral spirits because a slight aromatic component was found to be necessary to dissolve the adhesive. Initial tests in dilute liquid form were unsuccessful because the consolidant ran down the vertical surface and took more than 24 hours to dry completely. To address this issue, sheets of Lascaux P550-40TB were cast and allowed to dry on silicone release Mylar. The thin sheets of cast adhesive were placed behind the flaking lacquer and then reactivated with solvent and some dilute adhesive. The lacquer was still rather flexible, but thicker flakes needed to be relaxed with a heated spatula and pressed into place (no color change was observed due to the introduction of heat). Once the adhesive residues were removed, B-72 Retouching Gels were applied around the thick break edges to avoid snagging and future loss, as the curator did not want the losses completely filled. Adhesive sheets were not necessary on objects with less severe flaking, and the xylene-mineral spirits solvent mixture for the adhesive worked well without causing cockling and distortion of the lacquer surface upon drying (fig. 14).

5.2 SURFACE COATING REMOVAL

The next phase of treatment was removal of the dark and sticky surface coating from the gilded surfaces on many of the objects. On some objects, a water gel was found to remove the majority of the coating in a timely fashion without disturbing the gilded surface. The gel used xanthan gum as the thickener and was adjusted with acetic acid to a pH of 5.0, which is slightly acidic and safer for the lacquered surface underneath the gilding. On surfaces where the gilding layer was thicker and intact like the miniature shrine (64.183), a pH of 6.5 was safe to use. Citric acid was added as a chelator (1%-2% w/v), and Surfonic JL-80X was used as the surfactant (0.4% w/v). In some instances, a small amount of isopropanol was mixed into the gel where the coating was thicker and more difficult to remove. In general, the gel was allowed to sit on the surface for two-and-a-half minutes before clearing with a cotton swab dipped in pH-adjusted water (fig. 15).

Recently, the coating has been safely removed on additional objects by first flooding the surface with octamethylcyclotetrasiloxane (Cyclo-2244 D4 cyclomethicone fluid) and then applying a water gel at a pH of 5.5 with diethylenetriaminepentaacetic acid (DTPA) as a chelating agent (2% w/v) and 2-(N-morpholino)ethanesulfonic acid (MES) as a buffer. Benzyl alcohol was added to the gel at roughly
7% w/w until an emulsion forms. The surface was then cleared with a pH 5.5 solution adjusted with acetic acid and ammonium hydroxide. It is important to note that this gel was not safe to use on the red lacquer surfaces and that the use of a silicone solvent as a barrier layer was necessary on the gilded surfaces.

On some objects, such as the small seated Buddha figure (54.2987), a gel was inappropriate given the detailed ornamentation and inability to properly clear the surface. In those instances, a variety of solvents were tested in numerous areas on the object. Acetone was found to be the most effective at removing the coating from gilded surfaces and required the least amount of rubbing. The red lacquer was solvent sensitive, so the entire coating could not be safely removed and a thin layer was left behind. In some areas where the coating was very thick, acetone was applied on a cotton pad and placed on the surface for 30 seconds to one minute. Much of the coating soaked into the cotton pad, which required less use of abrasive swabs. Following solvent cleaning, 2% w/v citric acid in distilled water (pH of 2.0-3.0) was mixed 1:1 with acetone and applied with a swab or cotton pad to remove remaining surface dirt that was trapped underneath the coating. The surface was rinsed with 1:1 ethanol/distilled water to remove the citrate and any additional dirt or coating.

5.3 INPAINTING

Once the surfaces were clean and the lacquer was consolidated, the curator was consulted to determine the extent to which losses would be inpainted. The Thai seated Buddha (54.2987) provided inspiration for the chosen inpainting method, since there were already visible regilding campaigns that were lower than the other surfaces. The curator decided to continue with this aesthetic and not level the areas of loss with fill material. Only the most distracting losses on the objects were addressed, which was consistent with the approach to inpainting that was observed at museums in Thailand and Myanmar. Conversely, religious objects at active temple sites are regularly refinished or completely replaced when new objects are donated. For this project, losses were inpainted with metallic watercolors (fig. 16).

The metallic watercolors are comprised of mica pigments (natural mica particles coated with interference layers of titanium dioxide and/or iron oxide) in a gum arabic binder. Schmincke watercolors were selected because the paint adhered well to the metal surface without easily rubbing off. One benefit of the use of watercolors is that inpainting can be easily removed with water if it ever needs to be redone without disturbing consolidated areas.

5.4 STRUCTURAL LOSS COMPENSATION

The only object that required significant loss compensation was the miniature shrine (64.183). Many of the roof ornaments were missing and needed to be replaced to restore symmetry in some of the more prominent areas. Molds for the replacement pieces were made by forming the shapes out of Plasticine
in the area of loss overtop of an isolating piece of plastic wrap. This technique helped to ensure a tight fit
given the irregularity of the break edges. Silicone molds were made of the Plasticine pieces, and the actual
replacement pieces were cast in dental plaster. The pieces of plaster were soaked in 3% to 5% w/v Paraloid
B-72 in acetone for greater strength. Golden acrylic paint was used to match the chrome yellow underlying
surface on the object, and Regalrez 1094 varnish was used as a size for the gilding layer. After the majority
of the decoration was complete, the pieces were attached to the object with 30% w/v B-72 in 1:1 ethanol/
acetone over an isolation layer of Regalrez 1094. The remaining gaps were filled with Modostuc calcium
carbonate putty (PVA binder) and inpainted with Schmincke metallic watercolors (fig. 17).

5.5 DIGITAL RECONSTRUCTIONS

A few of the objects in the Duke Collection have significantly abraded gilded surfaces that make
the objects difficult to visually understand, most notably the manuscript chest (65.142). The use of a
black layer under the gold creates a strong contrast wherever abrasion occurs, which distracts the viewer
from the detailed designs of raised lacquer or facial features of the Buddha figures. For some objects, the
amount of missing gold would mean a complete regilding campaign, which was not appropriate from a
curatorial or conservation perspective. The gilded surfaces on these objects are exceptionally susceptible to
abrasion, especially where little gold remains, so it is unlikely that a later gilding layer could ever be
removed from the surface without losing more of the original gilding below. To strike a compromise for
the manuscript chest and to give visitors a better sense of how the object would have originally appeared,
a rendering was created in Photoshop with overlays of red and gold in the appropriate locations (fig. 18).
6. CONCLUSIONS

The information that was collected during the analysis and conservation treatment of these objects has shown that the properties of Southeast Asian (thitsi) lacquered objects vary from their East Asian (urushi) lacquer counterparts. The issues of solvent sensitivity are related to the composition of the lacquer, both in terms of the thitsi and the additives. The methods that were developed to treat these objects worked well, but there may be other adhesives and cleaning methods that work better. It is also important to note that although general trends were observed, each object had a varying range of pH and solvent sensitivity, and extensive testing was necessary. Hopefully, further research will be completed and shared about other Southeast Asian lacquered objects to add to these findings.

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Appendix 1: EQUIPMENT SETTINGS

54.3000 metal surface analyzed with an Elio Device SN605 with a rhodium tube (40 kV, 80µA, 240 s, 12000 cps, no filter). 54.2987 metal surface analyzed with a Bruker AXS ARTAX system with a rhodium tube (50 kV, 200 µA, 120 s, 46412 cps, collimator 1.500, no filter, helium purge). Major elements for both: Cu, Zn. Minor elements for both: Fe, Si, Pb, Sn, Ca, Mn, Ni.

54.3000 gilded surface analyzed with Bruker AXS ARTAX system with a rhodium tube and polycapillary lens (50 kV, 252 µA, 120 seconds, 4128 cps, no filter, helium purge). Major elements: Au, Cu, Fe. Minor elements: Hg, Zn, Ca, Mn, K, Ni, Ba. 54.2987 gilded surface on top of metal surface analyzed with a Bruker AXS ARTAX system with a rhodium tube (50 kV, 200 µA, 120 seconds, 43633 cps, collimator 1.500, no filter, helium purge). Major elements: Au, Cu, Zn. Minor elements: Fe, Mn, Pb, Sn, Ca.

54.3000 metallic backing and glass piece analyzed with an Elio Device SN605 with a rhodium tube (40 kV, 80 µA, 120 seconds, 12,000 cps, no filter). Major elements: Pb, Sn (possibly from glass). Minor elements: Cu, Ca, Zn, Fe, Si, Sr, Ti, Cl, Zn.

54.2987 red lacquer analyzed with a Bruker AXS ARTAX system with a rhodium tube (50 kV, 200 µA, 120 seconds, 20876 cps, collimator 1.500, no filter, helium purge). Major elements: Hg, Cu, Zn. Minor elements: Pb, Fe, Ni, Ti, Ca, Sn, Ba, Mn, Cl, K.
REFERENCES


**FURTHER READING**


SOURCES OF MATERIALS

2-(N-morpholino)ethanesulfonic acid (MES) hydrate, 99+% for biochemistry
ACROS Organics
500 American Rd.
Morris Plains, NJ 07950-2462
800-ACROS-01
http://www.acros.com

Acetic acid 80% reagent grade
Fisher Scientific
1 Reagent Ln.
Fair Lawn, NJ 07410
201-796-7100
https://www.fishersci.com

Benzyl alcohol
Talas
330 Morgan Ave.
Brooklyn, NY 11211
212-219-0770
http://www.talasonline.com

Citric acid monohydrate
Sigma
PO Box 14508
St. Louis, MO 63178
800-325-3010
http://www.sigmaaldrich.com

Diethylenetriaminepentaacetic acid (DTPA)
Conservation Support Systems
PO Box 91746
Santa Barbara, CA 93190
805-682-9843
http://www.conservationsupportsystems.com

Golden Acrylic Paint
Golden Artist Colors Inc.
188 Bell Rd.
New Berlin, NY 13411
607-847-6154
http://www.goldenpaints.com
Lascaux P550-40TB
Alois K. Diethalm
AG, OH 8360
Brüttisellen
Switzerland
+41 1 833 0786

Modostuc
Plasveroi International
Via Camussone 38
27010 Vellezzo Bellini (PV)
Italy
+39 038 292 6896
http://www.plasveroi.it

Octamethyldicyclosiloxane (Cyclo-2244 D4 cyclomethicone fluid)
Clearco Products Co. Inc.
3430 G. Progress Dr.
Bensalem, PA 19020
800-533-5823
http://www.clearcoproducts.com

Paraloid B-72
Conservation Resources International LLC
5532 Port Royal Rd.
Springfield, VA 22151
703-321-7730
http://www.conservationresources.com

Plaster-Hydrastone Merlin’s Magic
Garreco LLC
P.O. Box 1258
Herber Springs, AR 72543
800-334-1443
http://www.garreco.com

Plasticine Modeling Clay
Flair Leisure Products PLC
Anne Boleyn House
Ewell Rd.
Cheam, Surrey SM3 8BZ
England
+44 0845 456 1775
http://www.flairplc.co.uk
Regalrez 1094
Conservation Support Systems
PO Box 91746
Santa Barbara, CA 93190
805-682-9843
http://www.conservationsupportsystems.com

Silicone Mold Material—Elite Double 8 (vinylpolysiloxane)
Zhermack Technical
Via Bovazeccchino
100 45021 Badia Polesine (RO)
Italy
+39 042 559 7611
http://www.zhermack.com

Surfonic JL-80X
Conservation Support Systems
PO Box 91746
Santa Barbara, CA 93190
805-682-9843
http://www.conservationsupportsystems.com

Xanthan gum
The Personal Formulator
97 South Red Willow Rd.
Evanston, WY 82930
307-264-0367
https://www.personalformulator.com

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