INTRODUCTION

In her article from the “Modern Paints Uncovered” conference, Smithen (2007:166–167) states “Some currently available commercial varnishes are formulated to be removed, but there are no reports in the conservation literature discussing successful removal of these coatings from acrylic paintings.” The present research attempts to address this by investigating different commercially available varnishes (Cyr, 2007; Min, 2009). Although varnishes are commonly applied to many traditional oil paintings, the same is not true for modern and contemporary works. Acrylic paint manufacturers and some artists have suggested that acrylics require an additional protective coating; however, removing such a coating with solvents could harm the underlying acrylic, possibly partially dissolving it and leaching additives (Quillen Lomax and Fisher, 1990; Samet, 1998; Jablonski et al., 2003; Learner, 2004). The effect of wet-surface cleaning on acrylics using aqueous solution and solvent systems has been studied by a number of researchers, including Ormsby and Learner (2009), whose review article gives an overview of this topic. The research presented here describes the level of difficulty when removing the varnish layer from acrylic paint samples and documents resulting changes to the paint layer.

EXPERIMENT

Two studies were performed following manufacturers’ directions for varnish removal. The first study used Soluvar Gloss Picture Varnish (Soluvar), an n-butyl and isobutyl methacrylate, to coat acrylic paint samples from Liquitex Artist Materials and Mineral Spirit Acrylic Gloss Varnish (MSA), a solution of isobutyl and n-butyl methacrylate (Golden Artist Colors, 2006), to coat acrylic paint samples from Golden Artist Colors. Ultramarine blue and titanium white paint samples were first left to dry for different periods: one week, two months, and eight years. The eight-year-old paint samples had been cast on Mylar (4 mils thick) for a previous study; therefore, the new samples were prepared following the same method. Paint strips (0.2 mm thick and 5 cm wide) were first cast onto Mylar and left to naturally age for the desired length of time. Strips (2.5 × 7.5 cm) were then cut from all samples and applied to glass slides. The coatings were prepared as indicated by the manufacturer, brushed in a single stroke onto the samples, left on for one week or one month, and then removed by lightly rolling cotton
swabs dipped in different organic solvents. The number of passes with the swab for the coating to be completely removed varied from one sample to the next. The manufacturer-recommended solvents were first used, and when they were found to be ineffective, more polar solvents were tested. This procedure was used to emulate a real-life studio scenario where a variety of solvent mixtures would be tested. Free films of varnish on glass slides were also made and naturally aged in ambient conditions for one week or one month. Several techniques were used to record the condition of the surfaces before coating with the varnish and after its removal, including color and gloss measurements and scanning electron microscopy (SEM) of select samples. The free films were also examined using Fourier transform infrared (FTIR) spectroscopy, as well as color and gloss analysis. Differential scanning calorimetry was used to determine if the solvent had any effect on the glass transition temperature $T_g$ of the acrylics.

The above-mentioned samples did not include isolation barriers since it was felt that some artists would not follow the manufacturers’ recommendations. Therefore, additional samples were prepared with isolation barriers as recommended by the two manufacturers (Liquitex Gloss Varnish for the Liquitex samples and Golden Soft Gel Gloss diluted 2:1 with water for the Golden samples) before varnishing. These samples were only observed visually to detect changes in color, gloss, and surface texture, and the handling properties were noted.

The second study used Golden Polymer Varnish, an acrylic-styrene copolymer solution containing ammonia and propylene glycol, with ultraviolet light stabilizers (UVLS), i.e., benzenetriazolyl-OH-butylphenyl propionate, in both gloss and matte versions; this waterborne coating is meant to be removable by alkaline reagents. Research has found that acrylic emulsion paint has a tendency to swell when using water and aqueous solutions within a specific pH range for wet-cleaning treatments; acrylic paints may slightly swell at a pH of 4 or 5 and below, and they swell significantly when exposed to a pH above 8 (Ormsby and Learner, 2009). The purpose of this study was to examine the removability of this widely available waterborne coating and the effect on acrylic emulsion paint films when removed using alkaline reagents, specifically following instructions recommended by the manufacturer. The samples were prepared on the basis of common materials and techniques available to artists in the preparation and execution of acrylic paintings. Acrylic emulsion paint samples were cast onto untempered Masonite panel supports prepared with Golden Acrylic Gesso, 2.5 × 7.5 cm in dimension, with a consistent thickness of 0.2 cm. Each panel had 15 acrylic paint films: 5 titanium white films, 5 ultramarine blue films, and 5 cadmium red medium films (Figure 1).

The acrylic paint samples were left to dry for either one week or 50 days before being brush varnished. The coatings were either naturally aged for one week or one month or were placed under UVA fluorescent light (long-wave UV) in a Q-Lab QUV test chamber for 1200 hours to represent 100 years of indoor UV light exposure. Free films of varnish were exposed to the same conditions. Three alkaline reagents, suggested by the manufacturer, were used to remove the varnish, Goldex household ammonia, N,N-dimethylethanolamine (DMEA), and AMP-95 (2-amino-2-methyl-1-propanol), and two different concentrations were tested for each of these reagents. Cotton swabs were dipped in the reagent and rolled over the test samples in a uniform and consistent manner, applying little to no force on the swab. Depending on the activity of the reagent, rolling was carried out for a few seconds to one minute, until the varnish was completely removed from the paint samples. The speed and ease of the solubilization and removability of the coatings were rated according to each solution as being insoluble, partially soluble gel, soluble, or readily soluble. The SEM of selected samples, FTIR spectroscopy, and testing for solubility, color, and gloss evaluations were carried out. As the two main studies were performed in different years, no direct comparison for the amount of pigment pickup during varnish removal could be made.

FIGURE 1. Cast acrylic emulsion paint samples with the painter’s tape borders (left) built up to a depth of 0.2 cm and (right) removed.
RESULTS AND DISCUSSION

For the first study, solubility evaluation showed that only mineral spirits were required to remove the MSA varnish from the Golden paint samples; however, for removal of Soluvar from the Liquitex paint samples, a 1:1 mixture of xylene or ethanol with mineral spirits was needed to resolubilize the coating (the first mixture had less visual impact on the paint films). No pigment release was noted after a single pass with mineral spirits on the uncoated, cured samples, although upon a second pass on the Liquitex samples and a third pass on the Golden samples, the swab started to visibly pick up some color. The samples were sensitive to all other solvents tested. There were minimal differences between the free films cured for one week and one month in terms of gloss, solubility, and FTIR spectra, and there was a slight tendency for yellowing.

The measured color change for titanium white after varnish removal was not significant. Some variation in color apparent in ultramarine blue, the darker and more sensitive color, was linked to the age of the acrylic paint films rather than the length of time the varnish was left on the paint film, although the results were not consistent for whether an older film or a younger film caused the least change for different manufacturers. Liquitex showed the smallest change in color for the ultramarine blue for paint samples cured for eight years, whereas Golden showed the smallest change in ultramarine blue for samples cured for one week. More work is needed to explain these results. Greater general variations in gloss after varnish removal were observed for Liquitex samples in the white and Golden samples in the ultramarine. The one-week-old and eight-year-old paint samples varnished for one week were analyzed with SEM before and after the varnish was removed; no samples showed any notable topographical change. The differential scanning calorimetry results showed no significant change in $T_g$.

In the additional samples prepared according to the manufacturers’ specifications, the intermediate layer was meant to remain on the paint layer permanently to protect it from being adversely affected by any varnishing or varnish removal process. As noted through visual examination, the presence of the isolation layer was found to alter the color, gloss, and texture of the paint layer significantly for both sets of samples. A marked darkening of the ultramarine blue films occurred in both the Liquitex and Golden samples upon application of the isolation layer. Once saturated by this coating, the color did not noticeably vary again upon varnishing or varnish removal. In addition, the presence of the isolation layer considerably increased the gloss of all samples and also altered their surface texture. Although the manufacturers’ instructions were followed diligently, the handling properties of both isolation layers were found to impact the results greatly. The Liquitex Gloss Varnish used as the isolation layer for the Liquitex samples dried too quickly and was not self-leveling; therefore, brushstrokes remained visible, affecting the surface texture and ultimately the gloss as well. Although the Soluvar applied over this layer had very good working properties, once it was removed, which required extensive swabbing, the unvarnished surface had an uneven gloss as some varnish was still lodged in the textured isolation layer. The Golden Soft Gel Gloss solution used as the isolation layer for the Golden samples had better working properties, but it was still very difficult to get a brushstroke-free application. The gloss increased and the surface texture was altered, but varnishing with MSA leveled the surface. As previously discussed, varnish removal in this case proved easier than with the Liquitex samples and seemed to take away a very thin film from the isolation coat, slightly evening out its texture. The resulting surface was quite smooth and less glossy than with the varnish.

For the second study, only minor changes in gloss were detected for the free films. There was no significant color change for the naturally aged samples, and these samples could be solubilized in the alkaline reagents. For the UVA-exposed samples, the matte films became slightly darker, and both the matte and the gloss films became slightly more yellow. Solubilizing these samples required more time and a higher concentration of alkaline reagent (Table 1). The FTIR spectra did show differences in the matte varnish after aging, possibly indicating chemical changes due to the presence of amorphous silica used as the matting agent; these samples were also more soluble compared to the gloss samples (Figure 2).

<table>
<thead>
<tr>
<th>Alkaline reagent</th>
<th>pH</th>
<th>Varnish naturally aged 7 days</th>
<th>Varnish naturally aged 30 days</th>
<th>Varnish exposed to UVA light for 1200 hours</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Gloss Matte</td>
<td>Gloss Matte</td>
<td>Gloss Matte</td>
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<tr>
<td>Goldex, full concentration</td>
<td>10.5</td>
<td>RS RS</td>
<td>RS RS</td>
<td>S S</td>
</tr>
<tr>
<td>Goldex and distilled water, 1:1</td>
<td>10.5</td>
<td>S S</td>
<td>S S</td>
<td>PS PS</td>
</tr>
<tr>
<td>DMEA, full concentration</td>
<td>11</td>
<td>RS RS</td>
<td>RS RS</td>
<td>S S</td>
</tr>
<tr>
<td>DMEA and distilled water, 1:1</td>
<td>11</td>
<td>S S</td>
<td>S S</td>
<td>PS PS</td>
</tr>
<tr>
<td>AMP-95, full concentration</td>
<td>11</td>
<td>PS PS</td>
<td>PS PS</td>
<td>PS to I</td>
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<tr>
<td>AMP-95 and 10% distilled water</td>
<td>11</td>
<td>PS PS</td>
<td>PS PS</td>
<td>PS to I</td>
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TABLE 1. Solubility testing of the different aged free varnish films using Goldex household ammonia, DMEA, and AMP-95. I = insoluble, PS = partially soluble, S = soluble, RS = readily soluble.
After one month of natural aging, the varnish required slightly stronger alkaline solutions for effective removal, at a pH range of 11–12. The UVA-aged samples were the least soluble, requiring a higher concentration as well as more mechanical action and repeated clearance with distilled water, thus potentially incurring the greatest physical change. Because of overall handling properties, Goldex household ammonia proved to be the most effective reagent. The DMEA solubilized the varnish as readily and in less time; however, the swab turned a bright yellow color when picking up the solubilized varnish, which was not the case with either Goldex or AMP. The AMP was the least successful reagent; it required considerably more time to solubilize and remove the varnish and, being slightly viscous, made clearance more difficult and required repeated applications of distilled water. All alkaline reagents had difficulty in removing the milky white solubilized Polymer Varnish, and repeated swabbing with distilled water was needed for it to be fully cleared and rinsed off the surface. Pigment transfer from the acrylic emulsion paint samples onto cotton swabs was observed with all the alkaline solutions tested to remove the coatings. Once the coating was solubilized with repeated swabbing and the barrier between the varnish and acrylic emulsion paint film surface was broken, pigment transfer immediately followed. Ultramarine blue had the greatest pigment transfer, whereas cadmium red had slightly less, and titanium white had minimal color pickup. Increasing the pH of the alkaline solutions (7.5–8 to 10–12) showed greater pigment transfer and sensitivity of the acrylic emulsion paint films.

After varnish removal from the paint samples, changes in color and gloss were greatest for ultramarine blue, followed by cadmium red, and least for titanium white; often, the UVA-aged samples showed the greatest change because of the increased insolubility of the varnish. This varnish therefore required a stronger alkaline solution and more mechanical action during swabbing. Overall, the different alkaline solutions affected the acrylic paint color and gloss to the same degree. The SEM images were taken before and after varnish removal for only the paint samples naturally aged for 50 days, with the varnish layer left on for one month (Figure 3). All paint colors showed some changes (the surfaces were smoother), greatest for the ultramarine blue and smallest for the cadmium red. This change in surface characteristic may be related to the migration of surfactants from within the bulk film of acrylic paints onto the surface, forming crystals or layers. These surfactants can be removed during wet-cleaning treatments where water and aqueous solutions remove more material compared to nonpolar aliphatic solvents such as mineral spirits (Ormsby et al., 2006).

**CONCLUSIONS**

In both studies, the ultramarine blue proved to be the color most sensitive to varnish removal. In the first study, the age of the paint film and the type of solvent used proved to be important. Xylene with mineral spirits was required to remove the Soluvar
varnish from the Liquitex acrylic paint samples, but this was not true for the Golden MSA varnish, which only required mineral spirits. The SEM showed no surface topography change after varnish removal for the samples examined. As expected, the sensitivity of the cured acrylic emulsion paint film significantly restricted the choice of solvents used to remove a coating; the only solvent that did not pick up color with light swabbing was mineral spirits. All paint samples were affected by repeated swabbing (two or three passes or more) with any solvent. The age of the paint film before varnishing seems to be a more significant factor than the age of the coating, but more research is needed to clarify the nature of the effect.

For the second study, which investigated the Polymer Varnish with UVLS, the UVA-exposed samples had the greatest changes, for example, in decreased ease of solubilization and often in color change after varnish removal. The alkaline solutions affected paint colors and gloss to the same degree. All reagents caused some color transfer to the swabs with repeated swabbing; pigment transfer became greater with increasing the pH of the alkaline solutions from 7.5–8 to 10–12. The samples examined by SEM showed that the surface topography was smoother after varnish removal, indicating the possible removal of surface surfactants during wet-cleaning treatments. Additionally, because the UVA-exposed samples were slightly more yellow, waterborne polymer varnishes may have a greater tendency to discolor or yellow over time in comparison to solvent-borne varnishes, therefore having a greater potential for change in the overall visual appearance of the artwork. Using alkaline reagents and aqueous cleaning methods may be beneficial to the overall health and safety of the conservator by minimizing exposure to solvents used in everyday conservation practices; however, the efficacy of using alkaline reagents to remove varnish from acrylic paintings is still questionable because of the inherent sensitivity of acrylic paint to aqueous cleaning systems and to the high pH levels that result in changes in gloss and physical properties such as swelling (Ormsby and Learner, 2009). Further work is needed on older varnishes and different removal methods for both samples and actual paintings.

Acknowledgments


REFERENCES


Min, E. 2009. To Varnish or Not to Varnish: An Investigation of the Removability of a Proprietary Varnish from Acrylic Emulsion Paint Films. Research project...


