Surfactants and Acrylic Dispersion Paints: Evaluating Changes Induced by Wet Surface Cleaning Treatments

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ABSTRACT. This paper summarizes recent research on the presence of surfactants on the surface of acrylic dispersion (emulsion) paint films and the impact of wet surface cleaning treatments on them. Empirical and analytical tests used to assess the presence of migrated surfactants to the film surface are described. The risks associated with conservation treatments are not always apparent at the time they are carried out. Findings from recent scientific research are therefore summarized into sections outlining current knowledge on the effects of surfactant removal through conservation treatment and aging and outlining the potential risks of the preservation of migrated surfactant on acrylic dispersion paint films. Surface surfactants are also discussed in the context of artists’ intention, conservation ethics, cleaning efficacy, and the resoiling of cleaned paint films. Areas requiring further research have also been identified.

INTRODUCTION

Much of the significant body of recent research into the effects of surface cleaning treatments on acrylic dispersion (emulsion) paints is directed toward the role of non-volatile polyethoxylate (PEO)-based nonionic surfactant paint additives, which has been presented in detail elsewhere (Ormsby and Learner, 2009). These water-soluble materials are typically added as stabilizers and pigment-wetting agents at various stages of both the base dispersion and paint production (Croll, 2007). The amounts and types of surfactant present in bulk acrylic dispersion paint films vary with paint copolymer type, paint film age, pigment type, and brand (Ormsby et al., 2009). Despite the fact that these surfactants no longer serve their original function(s) after the paint film has dried, they remain distributed within the bulk film, continue to affect the paint’s overall properties, and can migrate to the paint surface in significant amounts.

The precise mechanisms behind surfactant migration are still unclear; however, the process is somewhat dependent on surfactant concentration, paint film thickness, substrate type, and environmental conditions (Ormsby and Learner, 2009). The fact that these materials can be significantly impacted by surface cleaning treatments has prompted discussion on the significance of surfactants to the understanding, conservation, and preservation of acrylic dispersion works of art. This paper summarizes what is known and outlines some potential risks associated with the removal and/or preservation of migrated surfactants to the surface of acrylic dispersion paint films, aiming to encourage debate, clarify risk where possible, and support collection care decision-making processes.
DISCUSSION

THE APPEARANCE OF MIGRATED SURFACANTS

It is not easy to determine the presence of migrated surfactants on acrylic dispersion paint films through visual assessment alone. Surface surfactants are not going to be present on all films; however, where present, they can appear as matte spots or create a mottled surface effect, as shown in Figure 1, and may eventually form a coherent film, which may impart a hazy effect to the paint surface.

Combined soiling-surfactant layers can appear as light gray or white veils across paint surfaces, which can be visually distracting, particularly if additional marks and scuffs are also present. Recent case studies on surface cleaning treatments as part of the Tate AXA Art Modern Paints Project (TAAMPP) demonstrated that cleaned paint films often show a marked increase in color saturation, as shown in Figure 2, and that subtle surface textures were more visible (Ormsby, 2010).

THE PRESENCE OF MIGRATED SURFACANTS

Tracking the progress of surfactant migration on several acrylic dispersion paint films with Fourier transform infrared–attenuated total reflectance spectroscopy (FTIR–ATR) has thus far indicated that naturally aged Talens paint films of the poly(ethyl acrylate/methyl methacrylate) (P(EA/MMA)) copolymer type (as per early acrylic paint formulations) tend to have high surfactant levels and that the group of three poly(n-butyl acrylate/methyl methacrylate) (P(nBA/MMA)) copolymer films tested tended to have lower levels, as shown in Figure 3 (Ormsby et al., 2009), suggesting that brand and base dispersion copolymer type play a significant role. However, recent investigations have indicated that some Liquitex P(nBA/MMA) paint samples are now beginning to register higher migrated surfactant levels (A. Soldano and B. Ormsby, Tate, unpublished internal report, “Cleaning Efficacy Study Report,” 7 May 2010). Figure 3 also clearly illustrates that thermal aging (in this case at 60°C and 55% RH) accelerates post-ageing surfactant migration and that exposure to accelerated light aging (in this case with no UV component for equivalent to ~50 years of display) destroys the surface surfactant, presumably via photodegradation reactions (Ormsby et al., 2009).

It is not known how long it may take for surfactant layers to degrade through typical museum display conditions; indeed, surfactants have been detected on the surface of several works of art in Tate’s collection dating from 1962 that have been infrequently displayed since acquisition (Ormsby et al., 2008b; Ormsby, 2010).

IDENTIFYING MIGRATED SURFACANTS

In addition to FTIR-ATR analysis, mass spectrometry techniques and mid-infrared reflectance spectroscopy have been used...
to identify surfactants on painting surfaces and within aqueous extracts of bulk paint films (Ormsby et al., 2008b; Ormsby and Learner, 2009). A convenient, low-cost testing method for the identification of surfactants within a studio setting is not yet available and may become a research priority if surfactant materials become increasingly valued.

Aqueous paint surface extractions (assuming that paint films can take prolonged aqueous exposures) involving placing a droplet of deionized water (e.g., 60 μL) onto the paint surface for 1–2 minutes can, however, provide useful information. In the presence of significant quantities of surface surfactant, the diameter of the water droplet increases markedly when compared to films with no surfactant, as illustrated by the images included in Figure 4.

After observing the water droplet diameter, the extract can be drawn up and released onto a cavity slide and left to dry in dark, dust-free conditions. Once dry (or semidry), the extract can then be analyzed using transmission micro-FTIR spectroscopy (Ormsby et al., 2009). Although this is relatively rudimentary, PEO-based surfactants were identified on several case study paintings using this method (Ormsby et al., 2008b). The precise amount of migrated surfactant required for detection has not been established, but bubbles were often noted in extracts containing significant amounts of surfactant.

Surface conductivity tests also carried out on acrylic paint films (Ormsby, 2010; Soldano and Ormsby, 2010) have thus far not confirmed a direct relationship between surface conductivity and (nonionic) migrated surfactant abundance apart from a possible increase resulting from the larger water droplet diameters (increased surface area contact) facilitated by surfactant-rich paint surfaces.

**Ethical Considerations and the Removal of Surfactants from Surfaces**

The potential removal of surface surfactants during conservation treatment in the context of conservation ethics and artists’ intention has been recently discussed (Learner and Ormsby, 2009).

**FIGURE 2.** Raking light detail during treatment of Alexander Liberman’s *Andromeda* (Tate accession number T00650). The dark area has been wet cleaned and illustrates the increased color saturation achieved though the removal of the combined soiling-surfactant layer. Tate 2007 © Alexander Liberman Trust.

**FIGURE 3.** Tracking the presence of surfactant with FTIR-ATR analysis on titanium white paint films over four years. The y axis “before” figures reveal differences in initial surfactant levels; that is, the Talens sample (at 3.4) had more surfactant than the Liquitex sample (at 0.0).
The argument that these materials are original to these paints is, of course, valid; however, both the risks associated with preserving this layer and the practicalities of removing soiling without disturbing this layer are problematic and require further investigation.

Outside of conservation, paint manufacturers are aware of the surfactant migration process, and the house paint industry acknowledges that surfactants will be washed away (Golden Artist Colors, 2001:3–4). Within conservation, however, a recent study of paintings by Italian artists Alberto Burri and Sergio Lombardo described a presumed surfactant layer as a patina (De Cesare et al., 2009), and a recent interview with British artist Frank Bowling revealed his practice of adding soap flakes to the water he was using to dilute his acrylic paints to achieve a deliberate “graying out” or “veiled” effect on the paint surface (L. Mills and R. Barker, Tate, artist interview with Frank Bowling, 26 May 2009). Bowling stated that this was common practice amongst artists at that time (the early 1960s), which suggests that early acrylic dispersion paint surfaces may be more complicated still.

In the light of these studies, it may prove beneficial to incorporate questions exploring these issues into artists’ interviews.

**Migrated Surfactants and Wet Cleaning Treatments**

The PEO-based surfactants are highly vulnerable to removal with aqueous cleaning treatments. Thin surfactant layers can be removed with a few seconds of aqueous swabbing (Ormsby et al., 2009). Although nonpolar organic solvents do not directly dissolve these layers, surfactant can be partially removed or disturbed through mechanical action alone (Ormsby et al., 2008a), and blanching and pigment transfer have been noted with the use of these solvents (Golden Artist Colors, 2001:3–4). In addition, it is probable that dry-cleaning methods partially remove, disturb, or redistribute surfactant layers where present.

Changes in surface gloss after the aqueous wet-cleaning treatment of case study paintings were also detectable (see Table 1); however, it was impossible to distinguish the effect of the removal of surfactant from the simultaneous removal of the deposited soiling layer. It was also noted that where the combined soiling-surfactant layer was relatively thick, several passes of the swab were required for complete cleaning (Ormsby, 2010). Gloss readings taken from cleaned, unsoiled test paint films revealed that changes caused by the removal of migrated surfactant without soiling layers were of a similar range (Ormsby et. al., 2007).

Changes in bulk film mechanical properties arising from aqueous swabbing treatments have been found to be essentially indistinguishable from untreated control samples (Ormsby and Learner, 2009). However, any changes from light exposure and conservation treatment at the very surface of these paint films have yet to be fully explored.

After initial removal through one aqueous cleaning treatment, surfactant migration quickly resumes (Ormsby et al., 2009), and the rate of surfactant migration can be enhanced (post-cleaning) by increased temperatures (e.g. during travel). The surfactant is likely to continue migrating until either the reservoir within the paint film is exhausted or the driving forces behind the migration process (which may include the removal of surfactant layers through cleaning or exposure to light) are minimized.

**TABLE 1.** Gloss changes (measured at a 60° angle) induced by wet surface cleaning treatments for five of the acrylic dispersion paintings cleaned as part of the Tate AXA Art Modern Paints Project (TAAMPP).

<table>
<thead>
<tr>
<th>Artist</th>
<th>Painting title (Accession number)</th>
<th>Date</th>
<th>Range of change in gloss units (all colors) after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeremy Moon</td>
<td>Untitled 2/72 (T02052)</td>
<td>1972</td>
<td>-0.4 to 2.0</td>
</tr>
<tr>
<td>Jeremy Moon</td>
<td>Hoop-la (T012240)</td>
<td>1965</td>
<td>+0.1 to 1.0</td>
</tr>
<tr>
<td>Alexander Liberman</td>
<td>Andromeda (T00650)</td>
<td>1962</td>
<td>-0.2 to 0.8</td>
</tr>
<tr>
<td>John Hoyland</td>
<td>25.4.69 (T01129)</td>
<td>1969</td>
<td>-1.7 to +1.3</td>
</tr>
<tr>
<td>Bernard Cohen</td>
<td>Painting with Three Spots, Two Yellow and One Blue (T01538)</td>
<td>1970</td>
<td>+0.1 to 2.3</td>
</tr>
</tbody>
</table>
GENERAL CONCERNS WITH WET-CLEANING TREATMENTS

Although beyond the scope of this paper, other issues associated with applying wet surface cleaning treatments to acrylic dispersion paint films are naturally of high importance. These include: the abrasion and burnishing of paint surfaces, pigment loss, paint swelling, cleaning system residues, and the extraction of soluble paint components. Several of these aspects have been addressed elsewhere (Ormbey and Learner, 2009).

SURFACANT, SOILING REMOVAL EFFICACY, AND THE RESOILING OF CLEANED FILMS

The TAAMPP case study treatments (Ormsby, 2010) and recent soiling removal studies have confirmed that deposited soiling (and surfactant) is generally more efficiently removed from acrylic paint surfaces using aqueous wet-cleaning systems (Ormsby et al., 2007; Soldano and Ormsby, 2010). As stated earlier, nonpolar organic solvents remove less surfactant; however, they are also markedly less efficient at removing soiling.

During recent studies, the presence of a substantial surfactant layer was noted as possibly enhancing the removal of soiling from heavily soiled paint films. It may be the case that the surfactant acts as an additional cleaning agent or as a release layer. However, it is possible that a substantial surfactant layer may also act as a physical barrier to the permanent embedding of soiling, which has potential repercussions for the resoiling of surfactant-free films. An ongoing study at Tate into the passive soiling of a series of treated and untreated paint films (with and without surface surfactant) will hopefully contribute to our understanding of these issues in the near future.

POTENTIAL EFFECTS OF THE PRESERVATION OF SURFACANTS ON THE SURFACE

When contemplating the decision to preserve a migrated surfactant layer on an acrylic dispersion paint film, artists’ intention, appearance, and the empirical and scientific information available on possible repercussions for future condition need to be considered. It is probable that hygroscopic surfactant layers retain deposited soiling, and the potential action of radical species created during the photodegradation of PEO surfactants requires investigation; however, little evidence exists for paint degradation caused by the presence of migrated surfactant layers.

Nonetheless, the permanent embedding of deposited soiling into paint films can be a risk when soiling is not removed. The embedding process is not necessarily dependent on the presence or absence of a surfactant layer; however, choosing not to clean a work of art inherently increases the risk of embedded soiling. This clearly requires further investigation, with the aim of determining optimal cleaning cycle frequency.

Water has been found to play a role in the embedding process, which also highlights one of the inherent risks of wet-cleaning these paint films. Deionized water droplets applied to soiled acrylic dispersion paint films caused the permanent embedding of soiling when allowed to dry naturally, as demonstrated in Figure 5. This suggests that soiling should be routinely removed from these paint films and, equally, that the use of water (and other solvents) should be carefully controlled. Recent studies have, however, also revealed that soiling can be embedded without any contact with water (Soldano and Ormsby, 2010). It is therefore also important to determine whether migrated surfactant layers contribute to the embedding process or whether they act as a physical barrier to the embedding of soiling.

CONCLUSIONS

This paper attempts to contextualize information relating to migrated surfactant layers on the surfaces of acrylic dispersion-based paint films. Although research in this area is ongoing, summarizing current knowledge on the pros and cons of the removal or preservation of these layers is beneficial.

Concerns about surfactant removal during treatment need to be considered within the context that surfactants may not always be present, can be present on specific paint passages only, can be degraded by light, and will be at least partially removed, reduced, or redistributed by most cleaning and varnishing processes and that the ability to remove deposited soiling without also affecting the surfactant layer (if present) is essentially impossible. In addition, it has been found that surfactants continue to migrate after one aqueous treatment; hence, removal does not necessarily ensure a surfactant-free paint surface in the future.

The decision to remove, reduce, or preserve surfactant layers also needs to be considered with respect to ethical and aesthetic requirements, as migrated surfactant originates from within acrylic dispersion paint films and can therefore be described as a patina. In some cases this layer may be of aesthetic and historical importance to individual artists or groups of works.

The decision to preserve surfactant layers also requires an evaluation of the potential aesthetic consequences, including a gradual loss of color saturation and the masking of surface texture as the layer increases in thickness and attracts soiling. The partial removal of soiling-surfactant films as a compromise option can also be difficult to achieve, often resulting in uneven gloss and color saturation.

The greatest risk associated with not removing deposited soiling, however, is the permanent embedding of soiling into these paint films. In this case, none of the currently available wet- and dry-cleaning systems, including newly introduced options (Ormsby and Phenix, 2009), will be particularly effective.

Despite the growing body of scientific research characterizing the properties of these paints, assessing the risks associated with migrated surfactant removal or preservation remains somewhat hampered by a lack of information. Perhaps even more pressing for practicing conservators faced with works of art of unknown paint types is the need to find an easy-to-use, reliable, low-cost method for determining whether a work of art contains
acrylic dispersion paints and whether migrated surfactant is actually present.

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REFERENCES


