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Performance Testing of Anti-graffiti Coatings for Painted Outdoor Murals in Canada

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Outdoor murals are sometimes defaced by graffiti that introduces unwanted painting, tagging or "bombing" on the surface. The purpose of this study was to compare the performance and handling characteristics of ten anti-graffiti coatings and five acrylic varnishes that could potentially serve as anti-graffiti barriers on outdoor murals in the Canadian climate. A selection of both permanent and temporary coatings was made after carrying out a literature search for products available in Canada. Painted test panels were prepared with acrylic latex exterior house paint, following the procedure of a muralist. Protective coatings were applied to each panel based on manufacturers' recommendations. The panels were aged outdoors for two years, then marked with graffiti materials. Solvents and other methods were used to reduce or remove graffiti marks to determine which coatings provided good protection to the underlying paint. The overall performance of the coatings was assessed on the following criteria: initial and aged appearance (gloss, dirt pickup, colour change), ease of coating application and handling, effectiveness as a graffiti barrier, and ease of local reapplication after graffiti removal. Observations were documented by photographs, videos and notes using customized forms and a standardized rating system. Quantitative gloss and colour measurements were made during the first three years of outdoor exposure to chart the rate and amount of visual change. Of the fifteen coatings studied, many performed adequately as graffiti barriers, but three products were deemed best overall because they performed well across the entire range of the assessment criteria. These included a double-component acrylic varnish system and two aqueous, wax-based anti-graffiti coatings. Overall, increasing the number of applied layers did not adversely affect the appearance of the coatings, and additional layers gave some coatings better resistance to graffiti, as well as protecting the paint layer from solvents and other cleaning methods required for graffiti removal.

Les peintures murales extérieures sont parfois altérées par des graffitis qui se présentent sous formes de traits de peinture indésirables à la surface de l'œuvre. Le but de cette étude visait à comparer les caractéristiques et la performance de dix revêtements anti-graffitis et de cinq vernis acryliques qui pourraient potentiellement servir de barrières anti-graffitis sur des peintures murales dans le contexte du climat canadien. Une sélection de revêtements permanents et temporaires a été réalisée suite à une recherche documentaire sur les produits disponibles au Canada. Dans le but d'expérimentation, des panneaux ont été réalisés avec de la peinture extérieure au latex acrylique, selon la procédure muraliste. Des revêtements ont été appliqués sur chaque panneau selon les recommandations des fabricants. Ces panneaux ont été exposés aux conditions climatiques extérieures pendant deux ans, avant la pose de graffitis. Des solvants et d'autres méthodes ont été utilisés pour réduire ou éliminer les marques de graffitis afin de déterminer quels revêtements offraient une meilleure protection à la peinture sous-jacente. La performance globale des revêtements a par la suite été évaluée selon les critères suivants : l'aspect initial et vieilli (brillance, attirance pour la saleté, changement de couleur), la facilité d'application du revêtement, son efficacité en tant que barrière contre les graffitis et la facilité de la ré-application locale du revêtement après l'élimination des graffitis. Les observations ont été documentées par des photographies, des vidéos et des notes à l'aide de formulaires maison et d'un système de notation normalisé. Des mesures quantitatives de la brillance et de la couleur ont été effectuées au cours des trois premières années d'exposition afin de documenter le taux et l'amplitude des changements visuels. Sur les quinze revêtements étudiés, plusieurs ont montré leur efficacité de manière adéquate pour agir en tant que barrières anti-graffitis. Trois produits se sont démarqués, car ils ont entièrement répondu à l'ensemble des critères d'évaluation. Il s'agit d'un système de vernis acrylique à deux composants et de deux revêtements anti-graffitis à base de cire aqueuse. L'augmentation du nombre de couches appliquées n'a pas eu d'incidence négative sur l'apparence des revêtements. De plus, la pose de couches supplémentaires a donné à certains revêtements une meilleure résistance aux graffitis, aux solvants, et aux autres méthodes de nettoyage nécessaires lors du retrait des graffitis.

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INTRODUCTION

While outdoor murals are often considered to be ephemeral works of public art, the question of finding practical and effective protection from graffiti vandalism continues to be a major concern, not only for muralists and conservators, but for all stakeholders who appreciate and care for murals.

In late November 2012, a large unprotected mural in Sherbrooke, Québec was subjected to a major act of graffiti vandalism. Conservators at the Centre de conservation du Québec (CCQ) were asked to find a quick and inexpensive solution to remove or reduce disfiguring marks of red spray paint before the onset of winter. This incident became the impetus to mount a research project to better inform ourselves and our clients of the properties and suitability of potential coating products for painted outdoor murals. For practical purposes, muralists often select readily available exterior latex house paints for their work, and murals are often left unvarnished. The soft, porous nature of unprotected acrylic latex paint allows dirt and graffiti to become embedded in its surface, making it difficult to clean. Acrylic paints are particularly sensitive to abrasion and to the organic solvents that are often required for graffiti removal. This is further exacerbated when the surface has a rough or raised texture.

Acrylic outdoor murals are subject to the detrimental effects of solar radiation, weathering and atmospheric pollution. There is scant published information on the choice of specific coatings appropriate for painted murals. Anecdotal evidence informs us that coatings can provide aesthetic, protective and even restorative benefits, but most published sources simply offer general guidelines for coating choices, as opposed to recommending specific products.[1] The selection of an appropriate coating can be critical to the longevity of a mural, especially since some coatings may darken, turn yellow, become cloudy or delaminate in outdoor settings.[2]

Anti-graffiti coatings are designed to limit adhesion and penetration of unwanted marks and to facilitate their removal. However, to date, there are no commercial anti-graffiti coatings available that are specifically formulated for use on painted outdoor murals. Such products are often intended for use on unpainted substrates, such as stone, metal or wood.

Study Purpose and Structure

The purpose of the CCQ study was to test and compare the performance and handling characteristics of ten anti-graffiti coatings and five acrylic varnishes that could potentially serve as anti-graffiti barriers on painted murals. A selection of both permanent and temporary coatings was made following a literature review, discussions with mural artists and conservators, and a search for products available in Canada. The study extended over a three-year period from 2013 to 2016.

To monitor the rate and amount of visual change that affected the different coatings, visual observations were accompanied by quantitative gloss and colour measurements made during the three years of the study. Documentation included notes made on customized forms, photographs and videos.

The CCQ was responsible for project design, sample preparation and periodic ratings, including measurements, while the Canadian Conservation Institute (CCI) provided analytical equipment (chroma meter and gloss meter) and analysis of gloss and colour measurement data.

Performance Criteria

Desirable performance characteristics of anti-graffiti coatings include the ability to prevent graffiti markings from reaching the underlying paint layer before and during graffiti removal. Such barriers must also protect the underlying paint from the softening and abrasion associated with cleaning. Other performance criteria include appropriate optical properties (sheen, colour, transparency), good handling properties, low toxicity, and in the case of temporary coatings, ease of removal and reapplication. Permanent coatings must show good physical and chemical ageing properties. Ideally, both permanent and temporary coatings should allow for some localized reapplication of the coating, if needed, after graffiti removal.

In this study, the performance of the coatings was specifically assessed on the following criteria:

- initial overall appearance,
- aged appearance (gloss, dirt pickup, colour change),
- ease of coating application and reapplication after graffiti removal,
- ease and extent of graffiti removal, and
- effectiveness as a graffiti barrier.

Comparison with Getty Conservation Institute Anti-graffiti Test Protocols

The CCQ test program was developed to see how different coatings could perform on paint samples aged outdoors under the conditions of changing seasons and the rigours of the Canadian winter. Its design complements earlier anti-graffiti coating tests carried out by the Getty Conservation Institute (GCI) in Los Angeles from 2008–2011.[3] It is worth noting several differences in the sample preparation and testing protocols for these two projects with similar goals, undertaken at the GCI and the CCQ.

In the GCI project, outdoor walls were painted with multicoloured artist-grade acrylic paints and the paint then coated with clear acrylic varnish. Anti-graffiti coatings were then applied to these surfaces. The application of a clear coat of varnish between the paint and anti-graffiti coatings may have complicated the interpretation of results, since varnish layers also offer potential protection to a painted mural. The CCQ project was limited to two paint colours, and all coatings were applied directly over the painted layers. This strategy enabled us to evaluate and distinguish the anti-graffiti potential of varnishes among the other anti-graffiti products.

An airless sprayer was not used to apply the coatings in the CCQ study; instead, an HVLP sprayer, already on hand, was used. Our project did not allow for such rental costs and experimentation with unfamiliar equipment.

In the GCI project, graffiti was applied, then removal methods tested, followed by reapplication of coatings and more graffiti application and removal testing at several different times within the course of the first year. By contrast, in the CCQ study, the graffiti markings were applied to coatings that had aged outdoors for two years. Graffiti removal tests were undertaken only once, one to two months after graffiti application.

The GCI conservators used industrial high-pressure hot water sprays for initial graffiti removal as recommended by some manufacturers, followed by solvent cleaning when necessary. Based on the GCI's findings that high-pressure hot water spray could be damaging to the paint layer, high-pressure spray was not used in the CCQ protocol. Instead, low-pressure hot water vapour was used.

The CCQ study used a limited range of standard solvent mixtures to remove all graffiti. In contrast, the GCI conservators often chose tailor-made solutions developed for each coating, or used various different proprietary solvent formulations as recommended by product manufacturers.

The hot sunny climate of southern California did not permit observation of the effects of freeze-thaw cycling, cold temperatures and winter weathering on the coatings as

observed in Québec. In addition, changes of gloss, colour and dirt pickup were observed but not quantified in the GCI study.

Coatings Studied

Fifteen different coatings were studied, as listed in **Table I**, comprising permanent varnishes, permanent anti-graffiti coatings and temporary anti-graffiti coatings. By definition, permanent coatings cannot be removed from the mural surface. They are formulated to withstand repeated cleaning treatments with minimal or no reduction of the coating. By contrast, temporary coatings have a relatively short working life of three to five years. Such coatings must be easily removed by methods that do not damage the underlying mural. This category includes semi-permanent coatings, which have an intermediate working life, and sacrificial coatings, which are significantly reduced or removed during the elimination of graffiti markings and must therefore be reapplied locally or in their entirety after graffiti removal.

In most jurisdictions today, the organic solvents used in architectural coatings are now regulated, by law, to be VOC-compliant, which means they must contain very low or negligible amounts of volatile organic compounds. This limits considerably the solvent choice for diluting and applying such coatings. For the purposes of this study, both solvent-based and water-based products were examined.

The permanent coatings studied included six products based on acrylic polymers: Behr Acrylic Base, Paraloid B-72, Golden MSA (with and without the application of a water-based Golden Soft Gel acrylic undercoat), Nova Color 216 exterior varnish and TSW8 Matte (a cross-linked acrylic copolymer). A permanent polyurethane-based anti-graffiti coating, Sherwin-Williams 2K (SW 2K), was also included for study. Technically speaking, the Golden MSA varnish could be classified as a semi-permanent coating. Since the solvents needed for its complete removal after outdoor ageing would not necessarily be VOC-compliant, it is listed among the permanent coatings for the purposes of this study. The effect of additives to forestall paint or coating degradation by ultraviolet light was not examined in this study, although the Golden MSA varnish used here contains both a UV light absorber and a hindered amine light stabilizer.

Several temporary coatings, including both semi-permanent and sacrificial coatings, were also examined. Among these coatings were two silicone-based products, CSL Si-COAT 531 and Sherwin-Williams B97 C150, and three aqueous wax-based coatings, Graffiti Melt, Prosoco SC-1 and Grizzly. Two similar starch-based coatings were also examined, PSS 20 and APP S. A newly marketed product by Dumond named Watch Dog SC-101, a proprietary mixture based on polyvinyl alcohol (PVOH), was also tried.

METHODS

Sample Preparation and Ageing

Mural Panels

Painted sample panels were prepared in much the same way a muralist would proceed with the painting of an outdoor wall support. Magnesiacore[4] panels, 3/8 in. (9 mm) thick cut to 18 x 24 inches (46 x 61 cm), were used as the support on which appropriate preparatory layers were first applied. Magnesiacore panels are light, transportable, synthetic, construction-grade panels that mimic the properties of a masonry wall with regard to texture, water impermeability and paint adhesion. The panels were double-primed with Zinser Bullseye 123 Primer (indoor/outdoor white acrylic latex). A simulated mural "painting" was then created by applying layers of exterior flat latex paint (Behr Premium Plus No. 4400) using a velour roller. For reasons of economy and accessibility, artists frequently choose exterior house paints over more expensive artist-grade acrylic paints. Two paint colours were chosen, white and azure blue. The white paint was chosen to best identify and document colour change and graffiti residues, while the blue paint was chosen because our experience with previous cleaning tests on defaced murals in Sherbrooke, Québec showed that the blue latex paint was particularly sensitive to solvent cleaning. Two coats of blue paint were applied overall, followed by four coats of white, restricted to two thin strips applied over the blue paint.

Coating Application

Each panel was then given a protective coating of either a varnish or an anti-graffiti coating, most often applied in two or more layers, according to manufacturers' specifications. Individual boards were sprayed with varnishes or various anti-graffiti coatings using an HVLP Chiron SG 90 spray gun. Practical considerations excluded the use of an airless sprayer, as recommended by some manufacturers, for these tests. This ultimately proved to be a weakness in the test design for some products; issues with two coatings, PSS 20 and APP S, will be raised later in the discussion section.

The panels were divided vertically into two sections, right and left, allowing for the application of the minimum number of recommended layers on the left, followed by added extra layers on the right portion of each panel. This was done to test the hypothesis that thicker coatings could offer better protection, without sacrificing aesthetic considerations with respect to sheen. Exceptionally, the silicone-treated panels received only one layer of each coating, in accordance with the manufacturer's instructions. The total number of layers applied could, therefore, vary from one to six, depending on the coating type and the manufacturer's recommendations. See **Table I** for details on coating description and application.

Panels were further subdivided into three horizontal bands, to allow for future graffiti application and cleaning tests. Areas of blue and white paint on the left-hand side of all panels were left unprotected to compare the solvent action and graffiti elimination on both coated and uncoated areas of paint.

The painted boards were sprayed at a distance of approximately nine inches (23 cm) from the surface in a booth that provided specular light illumination to assure consistency and evenness of each application. Areas to be sprayed were delineated by tape and Mylar masks. The thickness of the wet coatings was measured with a comb gauge. The wet thickness measured could vary between 3.5 and 7 mil (0.09 and 0.18 mm) across the coatings.

Table I. Coatings studied.

Coating	Main component	Layers applied* (left and right sides)	Additional layers (right side only)	Initial solubility
Permanent Coatings or Varnishes				
Behr Base (used as a varnish)	acrylic	2	1	water
Paraloid B-72 varnish (10% in xylene)	acrylic	2	1	solvent
Golden MSA varnish with Soft Gel Gloss undercoat	acrylic/acrylic	2 (spray) over 1 (brush)	1 (spray)	solvent/water
Golden MSA varnish used alone, no undercoat	acrylic	3	1	solvent
Nova Color 216 Exterior Varnish	acrylic	2	1	water
TSW8 Acryli-Master Graffiti Resistant Coating	acrylic	3	1	water
Sherwin-Williams 2K (satin)	polyurethane	1	1	water
Temporary Coatings				
Graffiti Melt	wax – proprietary	3	3	water
Prosoco SC-1	wax – proprietary	3	3	water
Grizzly	fish-based glucoside/wax – proprietary	2	1	water
Sherwin-Williams B97C150	silicone	1	0	solvent
CSL Si-COAT 531	silicone	1	0	solvent
PSS 20	starch – proprietary	2 (later 3 brush coats)	1 (failed)	water
APP S	starch – proprietary	2 (later 3 brush coats)	1 (failed)	water
Dumond Watch Dog SC-101	polyvinyl alcohol – proprietary	1	1	water

*as recommended by the manufacturer

For the purposes of collecting gloss and colorimetric data, two additional sample panels were made comprising all of the coatings, applied in narrow vertical strips over the blue and white paint. These sample panels would also facilitate visual comparison of the coatings placed side by side. One panel served as an indoor control, while the other was exposed outdoors with the other coated panels.

Outdoor Weathering

Once prepared, the panels were photographed then placed outdoors in a vertical orientation on a rack designed and fabricated in-house for exterior weathering on the roof of the CCQ (**Figure 1**). The rack was installed in December 2013 facing southeast to receive about seven hours of direct morning sunlight per day. The panels were left to age naturally for two years, during which time they were subjected to the typical meteorological conditions of seasonal change in the Canadian climate. Winter months (December to March) have minimum mean temperatures ranging between -17°C to -5°C, and maximum mean temperatures of between -7°C to 2°C. In summer months (June to September), minimum mean temperatures can vary from 8°C to 11°C, while maximum mean temperatures range from 19°C to 25°C. Total precipitation can be from 55 mm to 170 mm per month in any given year. Freeze and thaw cycles are also common during the winter months, early spring and late fall.

Figure 1. Outdoor exposure rack in 2015, before graffiti removal. Blue and white painted panels (vertical bands) have been marked with black, silver and red graffiti (horizontal markings). The unmarked, upper right sample strip panel comprises all the coatings and was used for gloss and colour measurements. The lower right Magnesiacore panel consists of two thin vertical bands of uncoated blue and white paint on a grey background.

Graffiti Application

After two years of outdoor weathering, four types of graffiti markings were systematically applied to the panels by hand on both the protected and unprotected areas of the blue and white paint (**Figure 2**). While not exhaustive, the graffiti markings chosen were representative of commercially available products: Sharpie permanent ink marker (silver), Montana acrylic ink marker (black), Pilot permanent ink marker (black), and Krylon Colour Master gloss spray paint (cherry red), a modified alkyd enamel. The marked panels were left to age for three to six weeks before graffiti removal trials were undertaken during the summer of 2015.

Figure 2. An example of a coated panel marked with applied graffiti before removal tests. Products used for graffiti markings were (from top to bottom): Montana acrylic ink marker (black), Sharpie permanent ink marker (silver), Pilot permanent ink marker (black) and Krylon Colour Master gloss spray paint (cherry red). For each panel, the first blue vertical band at left and a vertical portion of the first white band were left uncoated.

Gloss and Colour Measurement Protocols

Quantitative measurements were made to document the nature, amount and comparative rates of colour and gloss change on the weathered coatings, changes that are not easy to evaluate visually. A comparison could then be made between the indoor aged control sample panel and its counterpart aged outdoors. In the case of the outdoor samples, the data were collected before initial outdoor exposure, then once a year in the ensuing three years of outdoor exposure (2013–2016). The same data measurement procedure was followed for the indoor control samples.

To provide precise locations for taking repeated gloss and colour readings, a transparent Mylar template was made with areas cut away to allow direct contact between the coated surfaces and the analytical instruments used, namely, a Minolta CR-400 Chroma Meter and a BYK Gardner micro-TRI-gloss meter. Three data points were recorded on each coating for each paint colour (L*, a* and b*) and for each gloss reading. Gloss was measured using an 85° angle geometry, which is most suitable for low-gloss or matte surfaces. Both instruments were first calibrated on appropriate standards before each annual data collection session.

Visual Observation Protocol

A detailed observation sheet was filled out during the application procedure for each coating, noting the application method, thickness, drying time, number of layers and general appearance. Photographs were taken throughout the test period, and videos were made of operations comprising hot vapour removal of the graffiti. Empirical visual observations on the appearance of the coatings were also noted each year on standardized forms.

Graffiti Removal

Systematic testing was used to remove graffiti marks and determine which coatings provided good protection. Graffiti removal was attempted using different techniques, including swab rolling with organic solvents, hot water vapour, mechanical scraping, the use of an eraser, and combinations of these techniques. Coatings were then evaluated overall by a rating system.

Solvent testing was carried out with a limited range of solvents to determine the solubility of the graffiti, the coatings and the underlying paint. Some manufacturers of anti-graffiti protection products recommend using their proprietary solvent blends formulated for graffiti removal. However, such commercial mixtures are designed for use on robust surfaces such as metal or stone, and are not usually suitable for use on painted substrates. Such mixtures are often difficult to control

because they contain aggressive solvents that can easily solubilize underlying original paint. In the interest of standardizing the trials, known simple solvent mixtures were chosen with relatively low polarities that could potentially dissolve graffiti marks without readily solubilizing the protective coatings and the underlying paint. The mixtures used were: toluene/isooctane 1:1 (v:v) and acetone/isooctane 1:1 (v:v). When only partial cleaning of the graffiti was achieved with these mixtures, more polar solvent blends were also tried: acetone/water 55:6 (v:v) and MEK/water 55:6 (v:v). These mixtures were chosen since they have a range of polarities appropriate for dissolving paint, and they had been used successfully on the vandalized mural in Sherbrooke, Québec. This narrow range of solvents remains a key limitation of these trials.

Graffiti removal by solvents was carried out over both the coated and unprotected areas of each panel. When any underlying paint began to show solvent sensitivity (as seen by colour pickup on the swabs), removal attempts were halted. Two conservators carried out the graffiti removal trials. There may have been some variability in the results due to the small differences between individual operator techniques.

Other graffiti removal methods were also tried in conjunction with solvent cleaning. Hot water vapour and liquid were used for some sacrificial coatings. A Robby 3000 hot vapour steam cleaner produced a robust spray of hot vapour discharged from a nozzle tip held close to the surface of the panels and applied at a temperature of 75°C. This did not compromise the adhesion or integrity of the paint or the priming layers. Water at 85°C was also hand-delivered by sponge. Solvent cleaning, in conjunction with mechanical scraping using a sharpened wooden swab stick was also sometimes attempted to reduce or remove the surface of wax-based coatings or to dislodge graffiti residues stuck in paint depressions. The effect of a Pentel Hi-Polymer block eraser was also tried on several coatings.

RESULTS

Empirical Visual Observations

Although all applied coatings were low gloss, with surfaces ranging from matte to satin finish, slight variations of saturation and gloss could be seen initially (at time zero, T-0) on the two sample strip panels, since the coatings could easily be compared side by side under illumination by specular light. However, such differences were harder to distinguish when viewing the larger test panels mounted outdoors under day-light conditions at a distance, where they all appeared quite similar with respect to colour and gloss. An exception was the Behr Base acrylic coating, which had a somewhat cloudy appearance at the outset compared to the other acrylic coatings. At the one-year mark, the two silicone coatings already began to show signs of slight darkening, likely due to dirt deposition. Of the three coatings containing wax, the Graffiti Melt had darkened more visibly than the others. One product, the Dumond Watch Dog SC-101, rapidly turned dark grey under outdoor conditions, in contrast to the indoor control sample, which remained clear.

After two years of ageing, a visual comparison of the two strip panels placed side by side already showed some marked differences between the aged indoor controls (**Figure 3 left**) and the aged outdoor counterparts (**Figure 3 right**). While some coatings appeared to be relatively unchanged, others had darkened and taken on warmer or cooler tones from outdoor exposure.

Also worth noting is that within two years outdoors, the exposed uncoated paint samples had also darkened somewhat and become slightly greyed, likely due to light dirt deposition. No delamination was observed on any of the coatings.

Changes in Colour and Gloss after Outdoor Weathering

Colorimetry and gloss measurements were made on both the indoor control and the outdoor sample strip panels before exposure and in each of the succeeding three years from 2013–2016 (up to 986 days). **Figure 3** shows what these samples looked like after 2 years of ageing, while **Figures 4** and **5** show the data obtained before (T-0) and after a three-year weathering period (T-986) for outdoor samples. Both visual observation after two years of exposure, as well as quantitative evaluation after three years of exposure clearly indicated darkening and overall colour change.

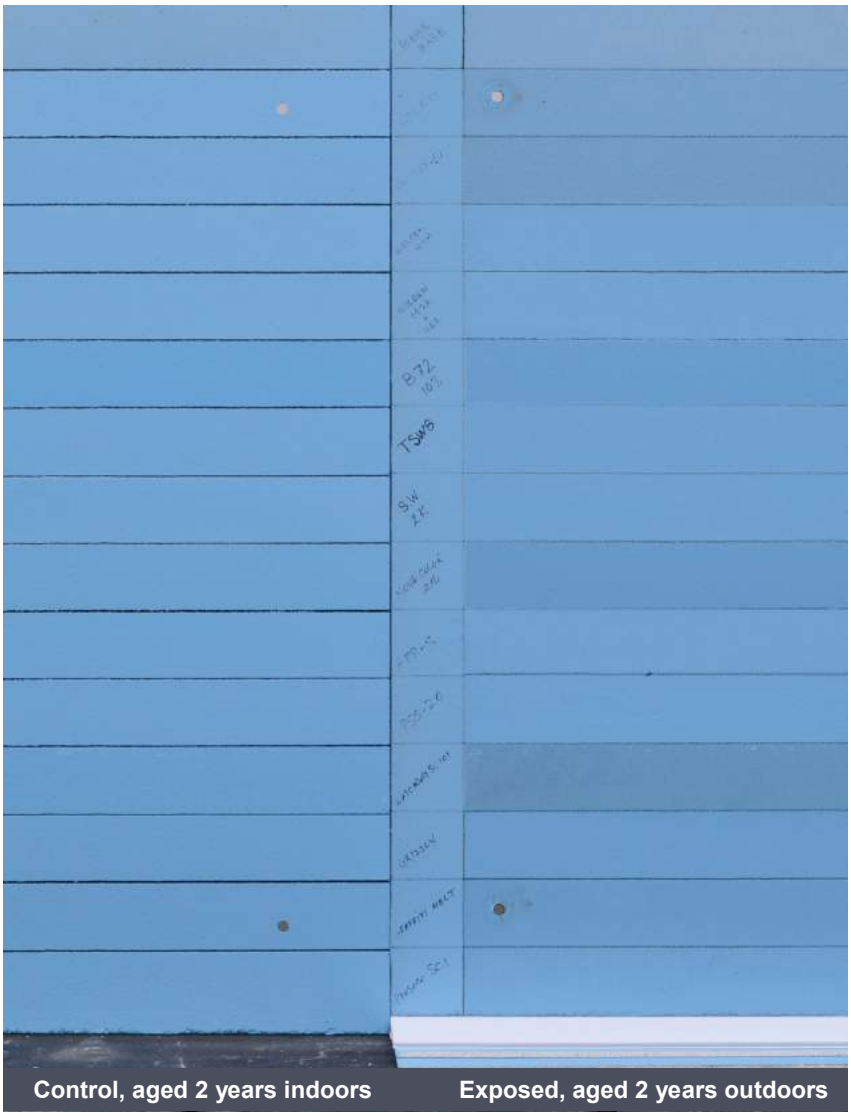
The coatings in **Figures 4** and **5** are sorted from least to most change after 986 days of exposure. Decrease in L* values indicates darkening (**Figure 4**). Overall total colour change, ΔE_{76}, includes changes in lightness (L*) and hue, red-green (a*) and yellow-blue (b*) (**Figure 5**). Yellowing of the coatings and any other changes in hue are captured by ΔE_{76}.

All weathered coatings showed a decrease in lightness over three years (**Figure 4**). A change of 3 units is subtle, but can be seen by the naked eye. The products that darkened the most visibly included the Watch Dog SC-101, the two silicone-based coatings (CSL Si-COAT 531 and SW B97 C150), the Graffiti Melt and the Nova Color 216 varnish. This darkening was likely a result of dirt pickup; but, in some cases, it may also have indicated photochemical change.

There is no data presented for APP S and PSS 20 coatings after 3 years because these coatings had failed outdoors by 2014; there was no intact coating left to measure.

The products that showed the least total colour change overall were the permanent coatings based on polyurethane (SW 2K) or acrylic (Behr, B-72, TSW8, MSA, MSA + Gel). By contrast, the coatings that showed the most overall colour change were the softer temporary coatings, based on silicone or wax emulsions.

Figure 6 shows the changes in gloss after three years of outdoor ageing. All coatings decreased in gloss with time. The coatings with the least amount of gloss change were Grizzly (temporary coating), Nova Color 216 (permanent coating), Behr (permanent coating) and SW 2K (permanent coating). These all fell within ± 1 Gloss Unit. The largest gloss decrease was seen with the Sherwin-Williams B97 C150 (temporary coating), nearly triple the amount seen for the Grizzly. Other coatings showed small changes that, while measurable, were not easily apparent to the naked eye. However, the difference



Behr base (acrylic)

CSL Si-COAT 531 (silicone)

Sherwin-Williams B97 C150 (silicone)

Golden MSA (acrylic)

Golden MSA + Soft Gel Gloss undercoat (acrylic)

Paraloid B-72 (acrylic, 10% in xylene)

TSW8 (acrylic)

Sherwin-Williams 2K (polyurethane)

Nova Color 216 (acrylic)

APP S (polysaccharide)

PSS 20 (polysaccharide)

Dumond Watchdog SC-101 (proprietary PVOH)

Grizzly (acrylic latex, fish-based glucoside, wax)

Graffiti Melt (aqueous/wax)

Prosoco SC-1 (aqueous/wax)

Figure 3. Comparison of the indoor control (left) and the exposed (right) sample panels viewed side by side in 2015 after two years of ageing.

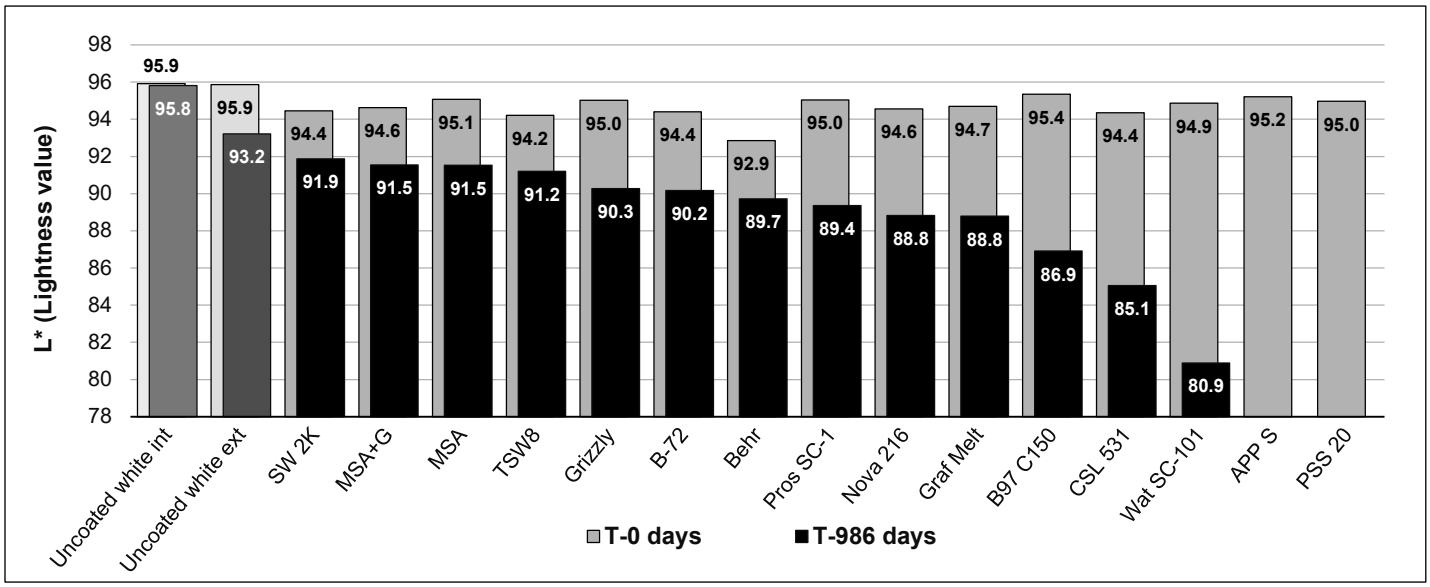


Figure 4. Change in lightness (L*) after 3 years (986 days) of outdoor ageing ranked from smallest to largest.

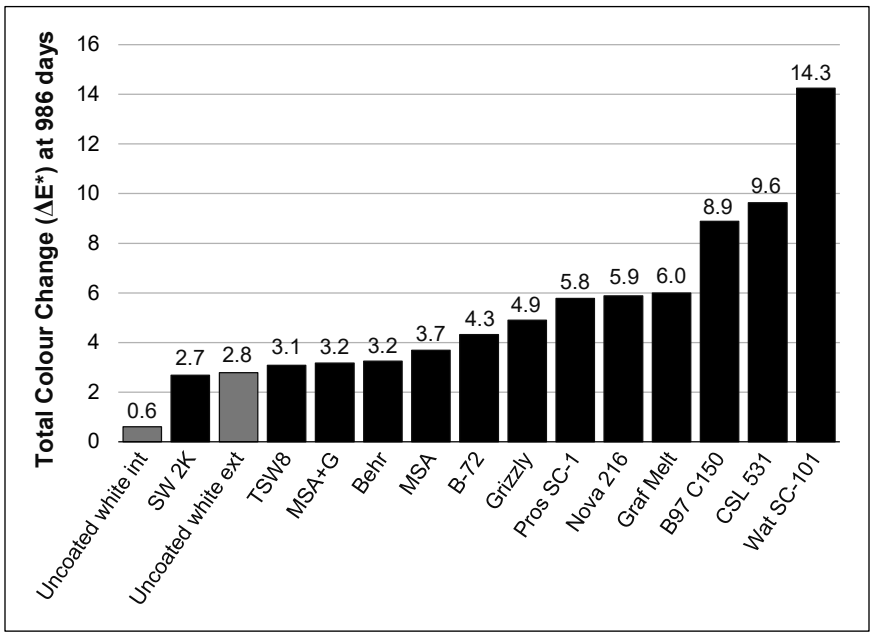


Figure 5. Overall colour change (ΔE_{76}) after 3 years (986 days) of outdoor ageing ranked from smallest to largest.

in gloss change measured for Grizzly as compared to the silicone coating SW B97 C150 (about 9 Gloss Units) was readily visible. Good performance here is indicated by the coatings that showed the least gloss change, those that were less affected by outdoor weathering. Those that showed the greatest decrease in gloss became dulled from weathering or dirt pickup, a less desirable result. Changes observed in colour and gloss are less critical for the temporary coatings, since by definition they are routinely removed and replaced.

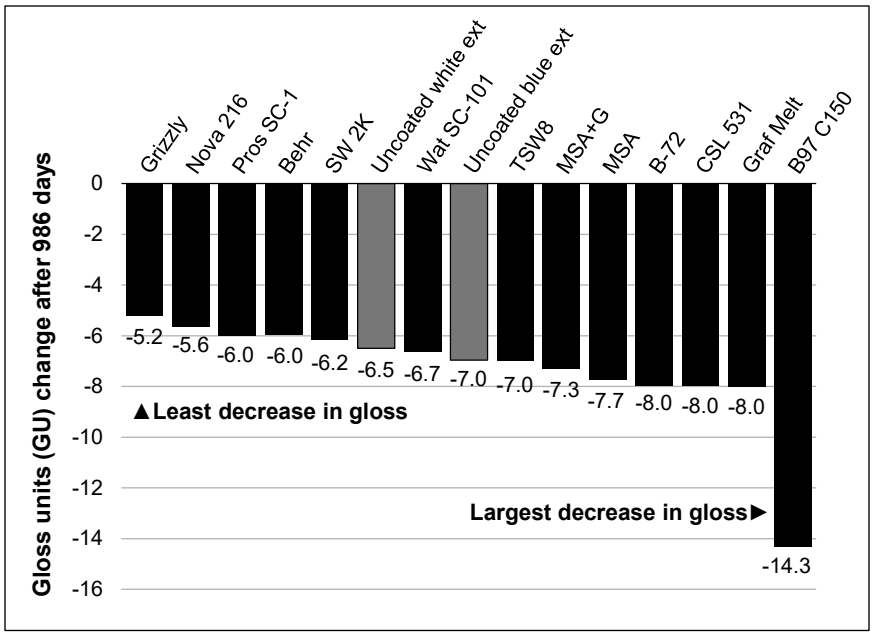


Figure 6. Decrease in gloss after 3 years (986 days) of outdoor ageing ranked from smallest to largest.

Results of Graffiti Removal Trials

A summary of the relative performance of the different coatings as graffiti barriers is presented in **Table II**. Some representative photographs of the panels after graffiti removal are shown in **Figure 7**.

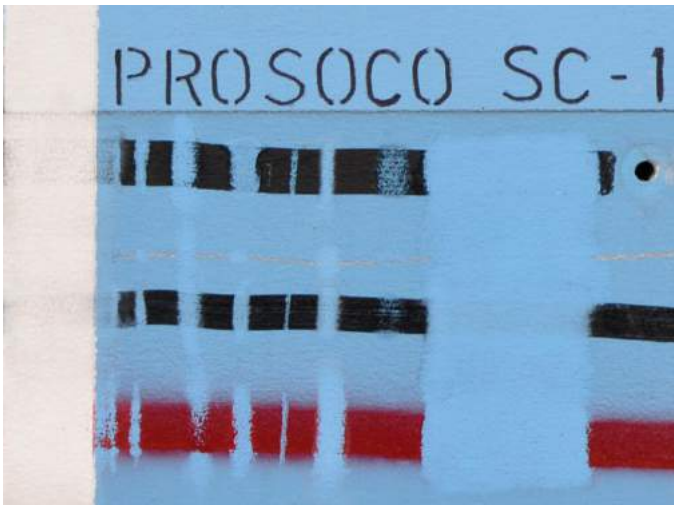
While all of the coatings offered a degree of protection to the underlying paint, some were better than others. The best barriers included many of the permanent acrylic coatings: the Behr Base, Paraloid B-72, and Golden MSA with and without an acrylic gel undercoat. Three temporary coatings containing wax, Prosoco SC-1, Graffiti Melt and Grizzly, were also very good, as were the two temporary silicone-based products, Sherwin-Williams B97 C150 and CSL Si-COAT 531.

Most graffiti marks could be removed or reduced considerably by controlled swab rolling and rubbing with solvent mixtures or by treatment with hot vapour. However, several panels could not be cleaned entirely of all graffiti marks, leaving faint graffiti residues or "ghosting" after cleaning. It should be stated that in the case of a real mural, faint residues might be deemed acceptable and could be overpainted. The type and extent of graffiti residue varied among the different coatings, but complete elimination of the graffiti from the white paint proved to be the most difficult. Graffiti residues remained in small surface pits and depressions because the underlying paint became too sensitive to solvents when they eventually permeated or dissolved the coatings. Graffiti residues were sometimes redeposited on the surface of the coatings, but there was no evident transfer of graffiti residues into the underlying paint.

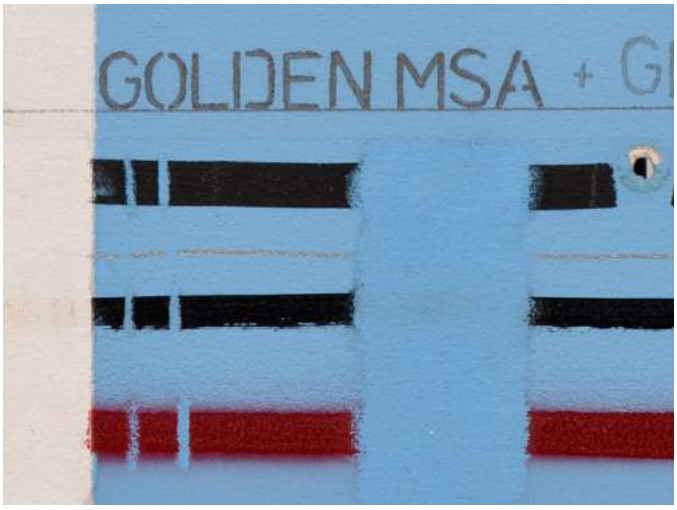
With most of the permanent coatings tested, graffiti removal could not be achieved without some disruption and thinning of the coatings by solvent action. The exceptions were the TSW8 (acrylic-based) and SW 2K (polyurethane-based), both permanent coatings that remained visually intact after solvent cleaning. However, the graffiti removal by swabbed solvents was somewhat incomplete on both of these coatings (**Figure 7**). Perhaps these coatings could have been cleaned more thoroughly with proprietary solvent mixtures recommended by their manufacturers.

For many coatings, the application of one or more extra layers beyond the recommended amount had little effect on their ability to resist graffiti and solvents, but in some cases, better protection and performance were observed with the addition of extra layers. These included

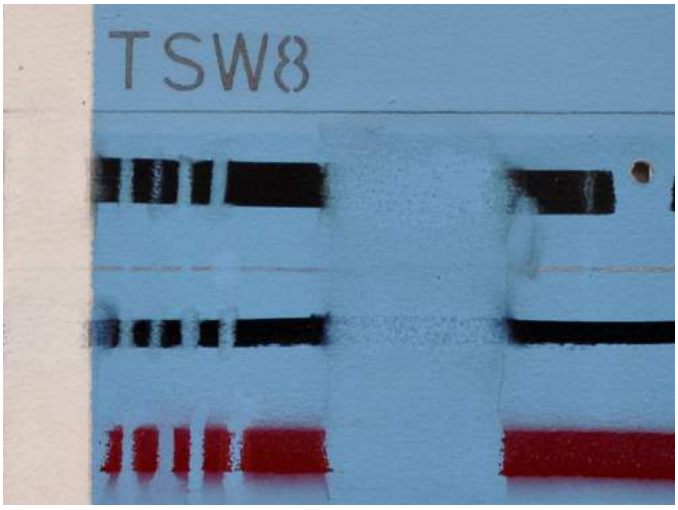
Graffiti Melt temporary anti-graffiti coating (6 layers)



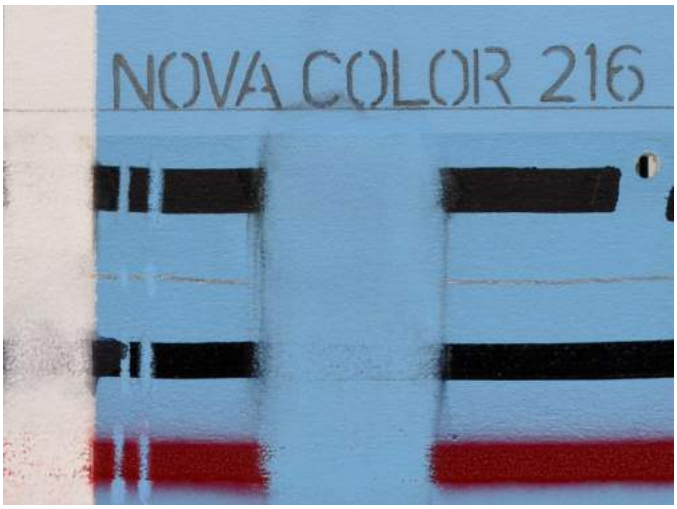
Prosoco SC-1 temporary anti-graffiti coating (6 layers)



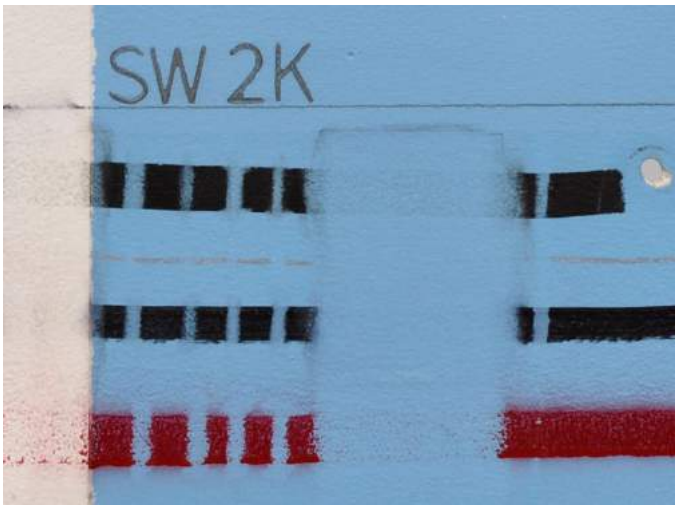
Golden MSA permanent varnish (3 layers)
with Soft Gel undercoat (1 layer)



TSW8 permanent anti-graffiti coating (4 layers)



Nova Color 216 permanent exterior varnish (3 layers)



SW 2K permanent anti-graffiti coating (2 layers)

Figure 7. Some representative results after solvent and/or steam cleaning in 2015. Small initial solvent tests are shown as narrow vertical lines. The best results among the permanent coatings were achieved with the Golden MSA varnish with a Soft Gel undercoat, but most of the acrylic coatings offered substantial graffiti protection. Somewhat more graffiti residues remained on the Nova Color 216 varnish, the SW 2K and the TSW8 coatings. Most of the temporary coatings also provided very good protection, with the Prosoco SC-1 as the best performer overall.

Table II. Results of graffiti removal trials. Grey shading indicates best protection from graffiti.

Coatings (# layers applied)	Degree of graffiti removal			Coating removed or reduced	Graffiti residue	Effectiveness as a graffiti barrier
	Solvents – blue paint*	Solvents – white paint*	Hot vapour or mechanical*			
Permanent Coatings and Varnishes						
Behr Base (2)	NC	NC	–	reduced	minimal	very good
Behr Base (3)	C	C	–	reduced	none	very good
Paraloid B-72 (2)	C	NC	–	reduced	minimal	very good
Paraloid B-72 (3)	C	NC	–	reduced	minimal	very good
Golden MSA (2) with undercoat (1)	C	NC	–	reduced	minimal	very good
Golden MSA (3) with undercoat (1)	C	NC	–	reduced	none	very good
Golden MSA (3) no undercoat	NC	NC	–	reduced	minimal	very good
Golden MSA (4) no undercoat	NC	NC	–	reduced	minimal	very good
Nova Color 216 (2)	NC	M	–	reduced	moderate	good
Nova Color 216 (3)	NC	M	–	reduced	moderate	good
TSW8 (3)	M	NC	–	intact	moderate	good
TSW8 (4)	M	NC	–	intact	moderate	good
Sherwin-Williams 2K (1)	NC	M	–	intact	moderate	good
Sherwin-Williams 2K (2)	NC	M	–	intact	moderate	good
Temporary Coatings						
Graffiti Melt (3)	NC	NC	Vap-NC	removed	minimal	very good
Graffiti Melt (6)	C	NC	Vap-NC	removed	minimal	very good
Prosoco SC-1 (3)	NC	NC	Vap-NC	removed	minimal	very good
Prosoco SC-1 (6)	NC	NC	Vap-NC	removed	none	very good
Grizzly (2)	NC	NC	–	reduced	minimal	very good
Grizzly (3)	NC	NC	–	reduced	minimal	very good
Sherwin-Williams B97 C150 (1)	NC	NC	Mech-C	removed	minimal	very good
CSL Si-COAT 531 (1)	NC	NC	Mech-C	removed	minimal	very good
PSS 20 (3)	M	M	Vap-M	removed	moderate	moderate
APP S (3)	M	M	Vap-M	removed	moderate	moderate
Dumond Watch Dog SC-101 (1)	M	M	–	reduced	moderate	moderate

*Degree of graffiti removal: C=complete, NC=near complete, M=moderate

the permanent acrylic coatings Behr Base and Nova Color 216, as well as the sacrificial coatings Graffiti Melt and Prosoco SC-1. The addition of extra layers did not adversely affect the appearance or gloss of any of these coatings; therefore, increasing the number of applied layers may be desirable, since this provides a thicker barrier that may ultimately offer more protection and better resistance to both the graffiti and to the solvents that may be subsequently required for graffiti removal.

Overall Performance Results

While anti-graffiti barrier potential is the most important criterion in such a study, it must be considered among the other performance indicators, namely, general appearance, ease of handling and ease of reapplication. A summary of how the coatings met all these criteria is presented in **Table III**. Three products were deemed best because they performed very well across the entire range of the assessment criteria.

Table III. Overall performance after 3 years outdoor ageing: VG = very good; G = good; M = moderate; P = poor. Grey shading indicates most desirable properties.

	General appearance	Handling – Ease of Application*	Colour stability (ΔE_{76}**)	Dirt resistance	Effectiveness as a graffiti barrier	Ease of local re-application
Permanent Coatings and Varnishes						
Behr Base	M	VG – wb	VG (3.2)	VG	VG	VG
Paraloid B-72	VG	G – sb	VG (4.3)	VG	VG	VG
Golden MSA with undercoat	VG	VG – wb /sb	VG (3.2)	VG	VG	VG
Golden MSA, no undercoat	VG	VG – sb	VG (3.7)	VG	VG	VG
Nova Color 216	VG	VG – wb	G (5.9)	VG	G	VG
TSW8 (matte)	VG	G – wb	VG (3.1)	VG	G	G
Sherwin-Williams 2K (satin)	VG	G – wb	VG (2.7)	VG	G	G
Temporary Coatings						
Graffiti Melt	M	VG – wb	G (6.0)	M	VG	G
Prosoco SC-1	VG	VG – wb	G (5.8)	VG	VG	G
Grizzly	VG	VG – wb	VG (4.9)	VG	VG	VG
Sherwin-Williams B97C150	P	M – sb	M (8.9)	P	VG	M
CSL Si-COAT 531	M	M – sb	M (9.6)	M	VG	M
PSS 20	VG	M – wb	*coating failed*	–	M	M
APP S	VG	M – wb	*coating failed*	–	M	M
Dumond Watch Dog SC-101	P	VG – wb	P (14.3)	P	M	–

*sb = solvent-based; wb = water-based

**ΔE of coatings over white paint after three years ageing outdoors

One is a permanent coating, the acrylic varnish Golden MSA with a gel undercoat, while two others are temporary aqueous proprietary coatings containing wax, Grizzly and Prosoco SC-1.

DISCUSSION

Although the CCQ study was neither intended to replicate nor to transpose the GCI project to a northern climate, the results obtained in these two studies bear comparison and merit discussion, even though the materials, test protocols and ageing conditions were different.

The Getty conservators and scientists defined desirable characteristics for an ideal anti-graffiti coating: ease of application, VOC compliance, aesthetic integrity, ease of graffiti removal, simple maintenance, durability (for permanent coatings) and low cost.[3] No coating tested in the GCI project completely satisfied all these requirements; but, in general, they observed that the sacrificial coatings gave better performance results than the permanent coatings. The GCI has a policy of not endorsing specific brand-name products, since product formulations may change over time, older products may be discontinued, and improved products may come to market. That said, the two best sacrificial coatings in their study were Graffiti Melt (aqueous/wax) and PSS 20 (starch-based). Sacrificial coatings are easy to apply, they can be effective barriers, they are easily reversible, but they can also be less aesthetically pleasing (i.e., dirt pickup) and may require more costly maintenance such as surface cleaning, and routine removal and replacement. They also observed that some of the permanent coatings performed less well than others and were less durable than anticipated. Some showed delamination or partial removal under the effect of hot water pressure or solvents. Some allowed the graffiti to penetrate to the paint layer, which made subsequent solvent cleaning problematic. Despite these caveats, they highlighted the performance of two permanent coatings that gave acceptable results: GCP 1000 (polyurethane-based) and TSW4 (acrylic-based).

By comparison, the handling and application of some of the sacrificial coatings in the CCQ study was not so straightforward, as seen in the case of the two starch-based coatings discussed below. The Graffiti Melt was easy to apply and it proved to be a good enough graffiti barrier, especially when applied in 6 coats, but the fact that it became readily soiled by surface dirt compromised its appearance.

In the CCQ study, the water-based coatings were more easily applied than solvent-based coatings, and the spray equipment was easier to clean after use. Water-based coatings have many desirable characteristics for muralists, including low toxicity, relative environmental friendliness, and ease of clean up. The water-based coatings that performed best according to the criteria assessed by the CCQ study were two permanent acrylic coatings, Nova Color 216 and TSW8, and the temporary coatings containing wax, Prosoco SC-1 and Grizzly. The water-based, permanent polyurethane coating, SW 2K, also provided good protection and exhibited the least colour change of all coatings in this study, according to the colorimetry data. Polyurethane coatings tend to be very tough, insoluble and impervious to moisture, so they may not be the coating of choice for direct application on masonry or on walls that require a certain degree of moisture permeability.

We also learned that the method of application can be an important factor in determining the surface gloss of a coating. For example, brush versus spray application of the same coating can produce a distinct and different appearance. This became apparent with some coatings when localized patching was attempted by simple brush application. The difference was especially noticeable with the silicone products, where brush application produced a glossy surface that contrasted with the matte surface obtained by spray application. This implies that aesthetically acceptable results may sometimes only be achieved for many coatings when the same technique used initially to apply the coating is also used to replace a partially worn or removed coating.

Permanent Coatings

The CCQ tests showed very good performance results for all the permanent acrylic-based varnishes. Despite the fact that they are not marketed as graffiti-protection products per se, the acrylic varnishes in this study performed as well as any other coating. Specifically, the Golden MSA varnish with a Soft Gel Gloss acrylic undercoat responded especially well to solvent cleaning and left hardly a trace of the graffiti (**Figure 7**). In fact, the gloss of the Soft Gel underlayer was left intact after solvent cleaning of the uppermost layer of the MSA varnish. This system has the added benefit of being easily patched locally after solvent cleaning, which is not necessarily the case with all the coatings tested, as indicated in **Table III**. It is interesting to note that the Golden MSA varnish that fared very well as a graffiti barrier in the CCQ tests had first been applied as a varnish beneath most of the anti-graffiti coatings tested in the GCI study.

The Golden MSA acrylic varnish system with a gel coat isolation layer comprises a two-step process. The first entails the application of an aqueous permanent isolation coat of the acrylic dispersion, Golden Soft Gel, followed by the application of three layers of the solvent-based Golden MSA varnish. The function of the isolation coat is to physically separate the paint from the upper layer of varnish. The soft gel coat also fills voids and pores in the paint. The added thickness provided by the gel undercoat and its slightly different solubility were surely factors that facilitated solvent cleaning of the graffiti from the upper layers of varnish.

Golden technical literature states that MSA varnish can be redissolved by a variety of organic solvents, including Stoddard solvent. Indeed, after six years of natural ageing under lab conditions, the indoor varnish strips remained soluble in Stoddard solvent. However, this was not the case with the MSA samples aged outdoors, where more polar solvent mixtures were needed to dissolve it.

When MSA varnish is manufactured for outdoor use in containers larger than 1 litre (which would typically be required for outdoor applications), VOC regulations require that a VOC-compliant organic solvent be used, such as Oxsol 100 (para-chlorobenzotrifluoride or 1-chloro-4-(trifluoro-methyl) benzene).[5] This particular MSA varnish formulation was not examined in this study, but it should be tested in future studies.

It was interesting to compare the performance of the MSA varnish used in conjunction with an acrylic gel undercoat with the MSA varnish used alone directly on the paint samples. Even four sprayed layers of the MSA varnish used alone did not allow for the complete removal of all the graffiti from both paint colours. While the residues were deemed visually acceptable, small specks of graffiti remained in the pores of the paint, making it a less effective option than the double-layered coating system. It appears that the addition of the gel undercoat better levelled the surface and prevented the graffiti from being deposited in pits or low points in the paint.

Other acrylic varnishes also performed well. The 10% Paraloid B-72 varnish in xylene offered very good protection and stood up well to outdoor weathering. The B-72 most saturated the paint colour upon initial application, likely because of the effect of the xylene carrier solvent on the paint. It should be noted that xylene is not a VOC-compliant solvent and is not recommended for large-scale use when coating outdoor murals. It was tested here for the sake of comparison with other acrylic-based coatings because it is widely known and used by paintings conservators. It is also used by some practitioners to re-saturate faded outdoor murals.[6] It would be useful to test the performance of B-72 for this purpose in a VOC-compliant solvent. The Behr acrylic coating also proved to be a very good graffiti barrier, especially with three applied coats, but from the outset it had a somewhat cloudy appearance that was aesthetically less acceptable than the other acrylic coatings tested.

The nature of the coating beneath the graffiti may significantly affect the solvent action during graffiti removal. For example, the solvent mixtures used in this study did not perform equally well on all the acrylic coatings. The Nova Color 216 varnish is based on a harder acrylic resin than others examined in this study.[7] This is likely due to the relatively elevated glass transition temperatures of its constituent copolymers. This varnish seemed to somewhat resist the solvents, which caused some redeposition of the black graffiti into the surface of the varnish, especially visible on the area of white paint (**Figure 7**). An alternate solvent choice or cleaning system may have fared better here.

Temporary Coatings

Among the temporary coatings, the proprietary water-based Canadian product, Grizzly, offered very good protection to both paint colours, and the graffiti was easily removed with solvents. It was also easy to reapply locally, if needed. Unfortunately, over the course of this study, the manufacturer ceased production and distribution of this product for economic reasons.

Of the two similar aqueous wax-based emulsions, Graffiti Melt and Prosoco SC-1, the latter was the slightly better performer over time, since it appeared brighter and less greyed than the Graffiti Melt. While visually there was no discernible difference between three and six coats, the Graffiti Melt better protected the underlying paint when six spray coats were applied. The recommended minimum number of coats (3) was thus seen to be less effective in providing protection. The application of hot water vapour worked immediately to reduce or remove graffiti on both the Prosoco SC-1 and Graffiti Melt coatings, but localized hot vapour cleaning left a blanched, whitish ring in the coating around the perimeter of the cleaned areas (**Figure 7**). These blanched areas can be partially reduced by solvents and by reapplying more of the coating. Both coatings have the advantage that overlying graffiti marks can sometimes be mechanically reduced and scraped away. The addition of mechanical cleaning and polar solvents was needed to achieve complete removal of the graffiti for both coatings. Both coatings could benefit from periodic surface cleaning to remove imbibed dirt, and both products have a serviceable life of at least five years, possibly more.

The two temporary silicone products, Sherwin-Williams B97 C150 and CSL Si-COAT 531, proved to be very good graffiti barriers, but both coatings darkened visibly and quickly after outdoor exposure. The Sherwin-Williams silicone product picked up more dirt than the CSL product. Graffiti removal could be accomplished on these coatings either with solvents, by mechanical scraping or by complete removal of the coating and graffiti by mechanical rubbing.

The Dumond Watch Dog SC-101, another temporary coating, was the poorest performer of all coatings tested. While it did offer some protection from graffiti, it darkened quickly and unacceptably after only one season of outdoor weathering and became progressively more yellowish with time. By comparison, the indoor control sample of this coating has aged well and remains clear. The poor performance of this coating was unexpected, since it was marketed directly to conservators and touted as a new viable product.[9] It has since been taken off the market. This suggests some caution should be exercised before espousing new commercial products.

Starch-based Coatings

Our experience with the performance of the two similar starch-based coatings, APP S and PSS 20, was disappointing in several regards. Initial attempts to spray multiple layers of both PSS 20 and APP S using an HVLP sprayer (on two different occasions over two years) ultimately proved inadequate to withstand outdoor weathering, as the spray method used did not achieve a sufficiently cohesive film. An airless sprayer should have been employed, but application by brush or paint roller is also possible. For the purposes of continuing these tests, both products were finally applied by thick brush coats to the test panels. Later, the action of hot water vapour combined with light abrasion using a bristle brush only partially removed the graffiti from the brush coats, but residual graffiti marks could be further reduced by the application of swabbed solvents. Gloss change, colour stability and dirt pickup were not evaluated for these two products because of their initial failure after one winter of weathering and the significant delays that were incurred to achieve coatings of adequate thickness.

The advantages of the two starch-based coatings, PSS 20 and APP S, are their invisibility, environmental friendliness, water solubility and low toxicity. Unfortunately, it is precisely this invisibility, once dry, that makes the thickness and therefore the potential integrity and future performance of the coatings difficult to ascertain. The starch-based coatings also have another major disadvantage: they have a very short service life and soon disintegrate when exposed outdoors. They must, therefore, be replaced regularly.

These two sacrificial coatings were also the focus of previous tests in a study undertaken in the context of a research project at Queen's University.[8] In that study, the coatings were not sprayed but were applied to different substrates with a velour paint roller. The test samples were not aged naturally outdoors and they were not subjected to cold or fluctuating temperatures. Instead, they were aged artificially under laboratory conditions. The applied graffiti marks were removed by hot water jets delivered by a pressure washer. The study gave significantly better test results, suggesting that the coating application method produced a substantial protective coating for each product. The general conclusions were:

- After three years of artificial ageing, all samples remained fairly efficient as barriers against graffiti, but both coatings proved to be less effective barriers against the black marks made by a Sharpie marker.
- Cement boards with highly textured surfaces were more difficult to fully clean of all graffiti markings.
- Overall, both PSS 20 and APP S proved to be efficient and adequate barriers against graffiti, with the PSS 20 showing slightly better results.

It is worth noting that an additional sample of a PSS 20 sacrificial coating was later made outside the immediate context of the CCQ study as a result of an instructional training exercise for conservators given by a professional on the application of PSS 20 with an airless sprayer. In this instance, multiple spray coats of PSS 20 were professionally applied to a painted plywood panel. The coated panel was then aged outdoors for one year, and similar graffiti markings were applied. Again, the use of hot vapour and gentle scrubbing was not able to completely remove all the traces of red and black graffiti markings on this additional panel.

It should be highlighted that the PSS 20 fared quite well as a protective coating in the GCI study, and it was one of the two best performers among the sacrificial coatings tested.

However, they felt that the elevated temperature required to effectively remove the graffiti and the coating could be potentially unsafe for acrylic latex murals.

CONCLUSION

Tests for the removal of graffiti from protective coatings can be contingent upon and limited by many factors, including the test parameters, available resources, choice of materials and weathering conditions. The results presented here might be considered preliminary since they stem from observations made primarily during three years; they should be considered in that context. Repeated testing over a longer time period could be useful to confirm or challenge these findings.

While no one product tested here was ideal, all but four of the coatings provided a certain degree of protection to the underlying paint and maintained a generally acceptable appearance over three years of ageing through seasonal variations with harsh outdoor conditions.

None of the sacrificial or permanent anti-graffiti coatings tested were markedly more effective in protecting the paint surface than the acrylic varnishes. Based on these trials and on the labour and cost involved in maintaining and replacing temporary coatings, a good compromise appears to be the application of several coats of a good quality, low-gloss acrylic varnish that can withstand some solvent cleaning. Varnish also has the added and significant function of filling paint voids, preventing penetration of graffiti into the paint, and absorbing harmful UV radiation, thereby extending the life of the pigments and the paint binder.[10] For this reason, outdoor murals should always be coated with a sufficient number of varnish layers to provide additional protection. Alternatively, a permanent anti-graffiti coating based on acrylic could be considered in lieu of a final layer of acrylic varnish. If resources are available for ongoing mural maintenance and coating replacement, a good temporary anti-graffiti coating could also be applied over any chosen varnish.

The appearance of the permanent coatings in this study will continue to be monitored as they age. Further graffiti removal trials may be carried out in the coming years on these panels or on new ones, when time and resources permit. As new water-based, VOC-compliant coatings become available, they should be examined and tested for their efficacy as anti-graffiti coatings. For example, a recent publication presents encouraging results for graffiti removal trials on painted test samples in a laboratory setting.[11] The product tested was a permanent, water-based, fluorinated acrylic polymer coating designed for masonry protection.[12] It appears to show great promise for painted murals and should be tested further.

Other questions beyond the initial scope of this study remain to be explored. For example, the inevitable and relatively rapid degradation of many sacrificial coatings requires their removal as part of regular maintenance. Do the cycles of removal and replacement pose risks to unvarnished murals?

The surface protection of painted murals continues to be an evolving field with much potential for study. All protective coatings should be tested, documented and monitored. Information pertaining to new products, including test results carried out in laboratory and outdoor environments, should be shared as widely as possible among conservators, artists and other stakeholders to establish the best protocols for good practice and to extend the longevity of outdoor murals.

ACKNOWLEDGEMENTS

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MATERIALS AND EQUIPMENT

Anti-graffiti Coatings

APP S (starch-based): APP All Remove B.V., Leuvert 8, NL 5437 AG Beers, The Netherlands; Tel.: +31 485 315621; Website: <www.app-protect.com/>

Behr Acrylic Medium Base (acrylic): Behr Paint Company, 1801 E Saint Andrews Place, Santa Ana, California 92705, USA; Tel.: 1-800-854-0133; Website: <www.behr.com/consumer/>

CSL Si-COAT 531 (silicone): CSL Silicones Inc., 144 Woodlawn Road W., Guelph, Ontario N1H 1B5, Canada; Tel.: 1-800-265-2753; Website: <www.cslsilicones.com>

Dumond Watch Dog SC-101 (proprietary mixture polyvinyl alcohol, polyethylene glycol and vinyl acetate ethylene copolymer): Dumond Chemicals, Inc., 83 General Warren Boulevard, Suite 190, Malvern, Pennsylvania 19355, USA; Tel.: 609-655-7700; Website: <www.dumondchemicals.com/>

Golden MSA Varnish (acrylic): Golden Artist Colors, Inc., 188 Bell Road, New Berlin, New York 13411-9527, USA; Tel.: 1-800-959-6543; Website: <www.goldenpaints.com/>

Golden Soft Gel Gloss (acrylic): Golden Artist Colors, Inc., 188 Bell Road, New Berlin, New York 13411-9527, USA; Tel.: 1-800-959-6543; Website: <www.goldenpaints.com>

Graffiti Melt (proprietary aqueous wax emulsion): Genesis Coatings, 2780 La Mirada Drive, #D, Vista, California 92081, USA; Tel.: 1-800-533-4273; Website: <http://dtaggettsch.awardspace.biz/graffiti.html>

Grizzly (proprietary aqueous, latex, fish glucoside, wax emulsion): Graffiti Solutions Canada, 7785 Franktown Road, Richmond, Ontario K0A 2Z0, Canada; Tel.: 613-838-5842; Website: <www.graffitisolutionscanada.com/>

Nova Color 216 Exterior Varnish (acrylic): Nova Color Acrylic Paints/ Artex Manufacturing Company, 5894 Blackwelder Street, Culver City, California 90232-7304, USA; Tel.: 310-204-6900; Website: <https://novacolorpaint.com/>

Paraloid B-72 (acrylic): The Dow Chemical Company, agent for Rohm and Haas Chemicals LLC, 100 S Independence Mall West, Philadelphia, Pennsylvania 19106, USA; Tel.: 215-592-3000; Website: <www.dow.com/en-us/pdp.paraloid-b-72-100-resin.154799z.html>

Prosoco Defacer Eraser Sacrificial Coating SC-1 (proprietary aqueous coating): Prosoco, Inc., 3741 Greenway Circle, Lawrence, Kansas 66046, USA; Tel.: 1-800-535-5053; Website: <https://prosoco.com/product/sacrificial-coating-sc-1/>

PSS 20 (starch-based): PSS Interservice AG, Poststrasse 1, P.O. Box 315, CH-8954 Geroldswil, Switzerland; Tel.: +41 44 749 24 24; Website: <www.pss-interservice.com>

Sherwin-Williams B97 C150 (polysiloxane): The Sherwin-Williams Company, 101 Prospect Avenue NW, Cleveland, Ohio 44115, USA; Tel.: 1-800-524-5979; Website: <www.sherwin-williams.com>

Sherwin-Williams 2K Satin (polyurethane, water-based): The Sherwin-Williams Company, 101 Prospect Avenue NW, Cleveland, Ohio 44115, USA; Tel.: 1-800-524-5979; Website: <www.sherwin-williams.com>

TSW8 Acryli-Master Matte Finish Graffiti Resistant Coating (crossed-linked acrylic copolymer): This Stuff Works Inc. (TSW), Sacramento, California 95823, USA; Tel.: 1-800-447-2334; Website: <www.tswwarehouse.com/>

Equipment

BYK Gardner micro-TRI-gloss meter: Folio Instruments, 277 Manitou Drive, Unit A, Kitchener, Ontario N2C 1L4, Canada; Tel.: 1-800-683-6546; Website: <www.folioinstruments.com/>

Chiron SG 90 Spray Gun: Conservation Support Systems, P.O. Box 91746, Santa Barbara, California 93190-1746, USA; Tel.: 805-682-9843; Website: <https://conservationsupportsystems.com/product/show/chiron-sg90/sprayers>

Magnesiacore panels: Magnesiacore Inc., 15 Manswood Crescent, Brampton, Ontario L6T 0A3, Canada; Tel.: 905-794-1333; Website: <http://magnesiacore.com/>

Minolta CR-400 Chroma Meter: Folio Instruments, 277 Manitou Drive, Unit A, Kitchener, Ontario N2C 1L4, Canada; Tel.: 1-800-683-6546; Website: <www.folioinstruments.com/>

Robby 3000 steam cleaner: OspreyDeepclean, 41 Central Way, Cheltenham Trade Park, Cheltenham, Gloucestershire GL51 8LX, UK; Tel.: +44 1242 513123; Website: <https://ospreydc.com/collections/robby-range>

NOTES AND REFERENCES

[1] Norbutus, Amanda J., "Common threads, common goals: Protective coatings for outdoor murals," in: *Conservation Issues in Modern and Contemporary Murals*, edited by M. Sánchez Pons, W. Shank and L. Fuster López (Newcastle upon Tyne, UK: Cambridge Scholars Publishing, 2015), pp. 218–237.

[2] Norbutus, Amanda J., *New Approaches for the Preservation of Outdoor Public Murals: The Assessment of Protective Coatings for Mural Paintings and Painted Architectural Surfaces*. Unpublished doctoral dissertation, University of Delaware, 2012, p. 195.

[3] Macdonald-Korth, E., L. Rainer and T. Learner, "Research into anti-graffiti coatings for acrylic murals: Preliminary testing and evaluation," in: *Conservation Issues in Modern and Contemporary Murals*, edited by M. Sánchez Pons, W. Shank and L. Fuster López (Newcastle upon Tyne, UK: Cambridge Scholars Publishing, 2015), pp. 238–259.

[4] Magnesiacore is a registered trademark for a proprietary board used in the construction industry that contains magnesium oxide compounds as fillers. See Magnesiacore Inc., <www.magnesiacore.com/index.html>. Accessed November 2020.

[5] Townsend, Mike (Materials Specialist, Technical Department, Golden Artist Colors, Inc.), personal communication, 2016.

[6] Global Mural Association, "What is Miracle Coat (B72)," <http://globalmuralassociation.com/mural-medic/>. Accessed November 2020.

[7] Amparan, Mark (President, Nova Color Acrylic Paints), personal communication, 2016.

[8] Gagné, Laurence, *Evaluation of Two Sacrificial Anti-graffiti Polysaccharide Coatings for the Conservation of Outdoor Contemporary Murals*. Unpublished master's research project, Queen's University, 2014.

[9] American Institute for Conservation Annual Conference trade show, Albuquerque, NM, 9–10 May 2012.

[10] Norbutus, *New Approaches for the Preservation of Outdoor Public Murals*, 2012, p. 158.

[11] Macchia, Andrea, Silvestro Antonio Ruffolo, Laura Rivaroli, Marco Malagodi, Maurizio Licchelli, Natalia Rovella, Luciana Randazzo and Mauro Francesco La Russa, "Comparative study of protective coatings for the conservation of Urban Art," *Journal of Cultural Heritage*, vol. 41, 2019, pp. 232–237, <doi.org/10.1016/j.culher.2019.05.001>.

[12] "Prostone" is a fluorinated acrylic polymer coating made by the French company, Pelicoat.