INTERNATIONAL JOURNAL
OF
CONSERVATION SCIENCE

ISSN: 2067-533X Volume 13, Special Issue 1, December 2022: 1567-1582 www.ijcs.ro

FLAKING PAINT ON ABSORBENT CANVAS: APPROACH, POSSIBILITIES AND CHALLENGES

Karolina W. SOPPA[1,*]

[1] University of Applied Sciences, University of the Arts – Conservation and Restoration,
Fellerstrasse 11 – 3027 Bern, Switzerland.

Abstract

One type of degradation commonly observed with paintings on absorbent canvas is flaking paint. Solutions to this degradation phenomenon are particularly challenging and the search for an ideal one - an on-going one. This paper reviews and summarises approaches that have developed over the past decade at the Bern University of Applied Sciences.
The goal set is to obtain a thin adhesive film or preferably a network of thin adhesive bridges between the adherends, but without penetration of either canvas nor paint flake. The catalogue of requirements for the adhesive is drawn up after an examination of the two substrates with respect to the most important criteria: solubility, porosity, accessibility and ageing behaviour of the applied medium. An adhesive medium is thus chosen based on these requirements, its application method and its film formation principle. Since each binder exhibits specific properties that must be taken into account during application and drying, it is essential to consider both processes and materials as an interacting system. Relevant techniques of application are presented based on exemplary use of the following adhesives: methylcellulose, gelatine, sturgeon glue, hydroxypropylcellulose and acrylate dispersions. Special attention is given to the important technique of "masking". Furthermore, an approach to visually qualify and assess both distribution and penetration of the adhesives by employing fluorochromes as a tracer is presented. Finally, some special cases of adhesion fillers and variations for liquid applications are introduced.

***Keywords**: Adhesion; Flaking paint; Absorbent canvas; Consolidation; Masking*

Introduction

Conservators regularly work with multi-layered artwork that often experienced a turbulent history. A common result of such an artwork's life is layer separation. Moreover, degradation forms may vary depending on paint composition, layer structure and treatment history. Very sensitive works have often been treated at multiple stages, while documentation of the interventions is rarely available. The conservator's ethic strives for the perfect, sustainable solution, yet in general both time and money set the limits. For these reasons, this review summarizes different approaches conducted at HKB of the Bern University of applied sciences over the past decade, discusses and intends to deliver conclusive results that can be derived from this decade of experiments.

Regarding the issue of material solubility, Zumbühl presented the mechanisms, as well as a simple approach with "How does it work?" in 2017 [1-4]. This was a very important step towards a systematization with basic tools and rules that can be employed to re-adhesion issues.

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[*] Author for correspondence: karolina.soppa@bfh.ch

This current paper focuses on presenting some basic steps to re-adhering loose and lifted paint layers from absorbent canvas with commonly used adhesives. The steps presented aim at providing the conservator with some fundamental facts that help to back his/her measure with some clear arguments. This will not only result in a simpler concept but shall be helpful as well in the case of legal disputes.

First Steps: Characterization of the two Adherends

In general, re-adhesion of a paint layer on canvas means: the paint layer has been inspected with a color shaper and found to be loose, while the loose flake is cohesively stable, but often separates from the textile support. This means that the paint flake needs to be layed back to the canvas and bonded with an adhesive layer. Ideally, for sustainable success, one should know the properties of both boundary layers to be bonded (Fig. 1).

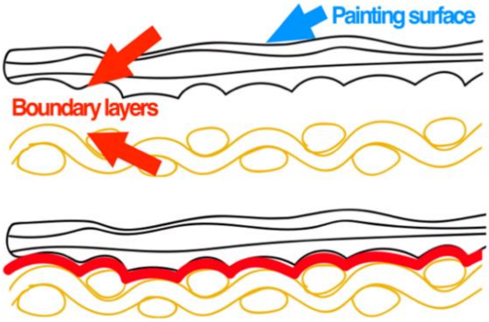


Fig. 1. Schematic illustration of the two adherends: flaking paint and canvas.
Below is the idealised adhesive film to be achieved (red line)

However, very often one looks only at the paint layer. If possible, it may be helpful to turn one flake over (a tungsten needle can be helpful here, figure 2 bottom, left) and examine the two interfaces, as well as both substrates under a stereo microscope. Quite often the two interfaces have completely different properties to the visible surface. Sometimes one can see or guess the characteristic of the surfaces to be bonded through small lacunas or larger distances in the craquelures. In those cases, the flake does not have to be turned over. The two interfaces to be bonded should be checked in terms of: solubility, porosity, and accessibility. These are the most important parameters (Fig. 3).

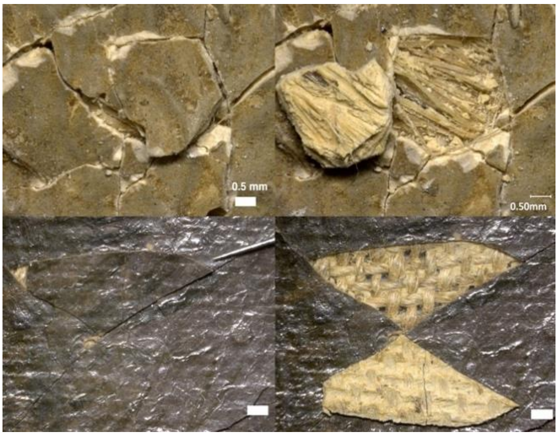


Fig. 2. Paint layer turned upside down. Visible are the two boundary layers,
which differ clearly in surface texture and porosity from the front side. The scalebar is 0.5mm

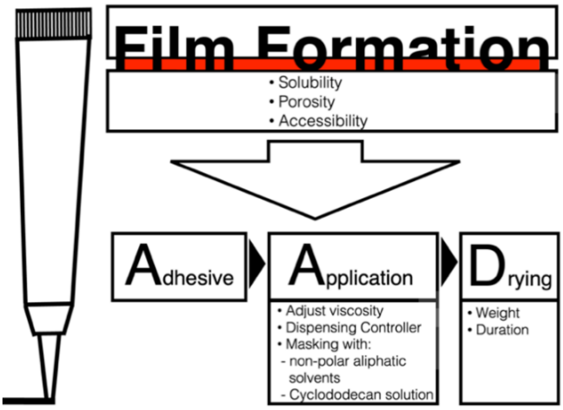


Fig. 3. Some of the most important parameters when gluing flakes to canvas

Solubility

According to Zumbühl [3], the solubility check is easiest to perform with micro particles or on small particles lying on a slide under a stereo microscope (fig. 4). The conservator is interested in the reactions of the solvents with the solid, as the classification with this simple tool will evaluate sequentially the most suitable solvent(s) to be applied to this material: e.g., non-aromatic petroleum spirit (with a high vapor pressure), then ethanol and finally water. With sufficient waiting time between applying the solvents, one could try testing all solvents on just one flake.

What may happen during these tests: Flakes do not dissolve, they fall apart, something is extracted, or the flakes turn out to be insoluble. The change in cohesion and the heat sensitivity can also be tested in combination with the solvent.

Fig. 4. Stereo microscope with a set of relevant tools and solvents for micro-sampling the substrates that need to be bonded. The tests performed examine the solubility (indirect indication for polarity) and the porosity of the materials in question

Porosity

During solubility tests, one instantly observes the porosity mostly with the non-aromatic hydrocarbon solvent. The absorbency of the canvas or paint layer, that cannot be removed from the painting, can usually be tested on the original with an aliphatic, aromatic-free hydrocarbon with 2µL of a 5µL glass syringe.

Accessibility

Conservators generally attempt to apply the adhesive under the flakes from the front. This depends on the gap between the flakes or the distance between the flake and the canvas. If there is not enough room to access from the front, the material may be applied from the reverse side (through the canvas) [5].

Example of the process

Paint flake

The example in figure 2 (top) shows a non-water-soluble, oil-based painting. By flipping the loose flake over, one can see the two surfaces to be bonded: the ground layer and the canvas. The properties of this interface are different from those of the visible paint surface, both in composition and structure. A solubility test on micro samples of the ground layer was completed in about 15 minutes and revealed that it was insoluble to all three test solvents. Porosity and further solubility tests were performed on a small flake (Fig. 4) laying on a microscope slide and showed that the ground layer was absorbent and slightly porous. Water led to the extraction of some component. Identification of the dried solute by infrared spectroscopy (FTIR) identified protein. However, the flake remained stable. In other words, the adhesive system may still be water-based, yet water input needs to be minimized. Thus, the viscosity of the adhesive should be as high as possible, causing minimal solubilization in the flake.

Ethanol and non-aromatic petroleum spirit obviously had no effect at all. Hence ethanol can be added to improve wetting. If needed, non-aromatic petroleum spirit can be used for masking (more on this later).

Canvas

The canvas solubility concerning the three solvents is well known [6]. None of the three solvents dissolves a cohesively stable canvas. The focus of the testing can thus be set on porosity. Knowledge on the porosity behavior of the canvas is very important to be able to achieve the desired adhesion in the form of a thin bonding layer. Tests to check the absorbency are performed in-situ with the non-aromatic petroleum spirit. During the investigation it is important that the canvas has minimal contact to underlying media that create further capillary action. In this case (Fig. 2a and b), the canvas turned out to be very absorbent. This means that there is no canvas impregnation present, i.e., the canvas still has its many capillaries and will absorb low-viscosity media very quickly. If this is not prevented upon applying the adhesive, the adhesive will first be absorbed by the canvas and only excess amounts of adhesive will achieve adherence to the paint flake. While adherence is achieved, the physical properties of penetrated canvas will be different, limiting the sustainability of the restoration measure.

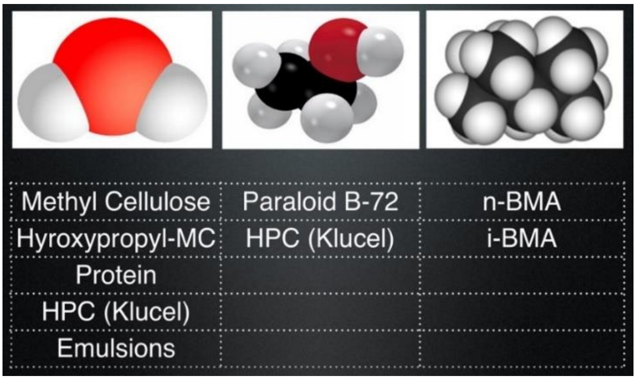
Next, it is essential to check whether a higher viscosity adhesive would also flow under the flake (for instance with a micro-dispenser) or, whether the canvas capillarity needs to be closed temporarily (e.g., with cyclododecane) to achieve an adhesive bond layer.

At this stage upon the simple characterization of the substrates, one has no information about the exact composition yet, but nevertheless, one has an idea how the materials will behave during re-adhesion, which is one of the most essential aspects of the process. If, however, chemical characterization is accessible, this will certainly help to better understand the degradation phenomenon and material compatibility and to further develop a restoration concept.

The next step is to select the adhesive system, taking into account the environmental conditions (e.g., climate, hanging position, later accessibility, retreatability, even reversibility(?), etc.).

Second Steps: Adhesives and Application

The choice of an adhesive system also determines the possibilities and limitations of its application and drying, since all elements are connected and influence each other mutually. Most adhesions fail not only because of the adhesive, but also because of the application. Either the adhesive never goes to where it is supposed to go, or it does not stay where it is supposed to stay. Fig. 5 shows the most often recommended adhesives, ordered horizontally according to their solubility.



Methyl Cellulose	Paraloid B-72	n-BMA
Hyroxypropyl-MC	HPC (Klucel)	i-BMA
Protein		
HPC (Klucel)		
Emulsions		

Fig. 5. The most commonly used adhesives and consolidants in conservation sorted by solubility. Protein means collagen based.

Methylcellulose and Hydroxypropylmethylcellulose

Methylcelluloses are a simple, heterogeneous polymer that has sections with methylated hydroxyl groups (R-O-CH^3) as well as -OH groups [7, 8]. In consideration of the excellent aging properties [9-11] and the adjustability of the viscosity [12, 13], the good cohesion (max. 43–100N/mm^2) [13-16], the unproblematic solubility, storage as well as handling, one can start with methylcellulose.

Methylcelluloses are soluble in water and insoluble in ethanol, though they can be diluted with ethanol up to about one third [12, 13]. The solubility limit becomes immediately visible as a part of the MC precipitates and the solution becomes cloudy. For film formation and cohesion, ethanol addition at 25% is even positive [14].

The combination of chain lengths and the concentration permits to adjust the viscosity for specific purposes (Fig. 6).

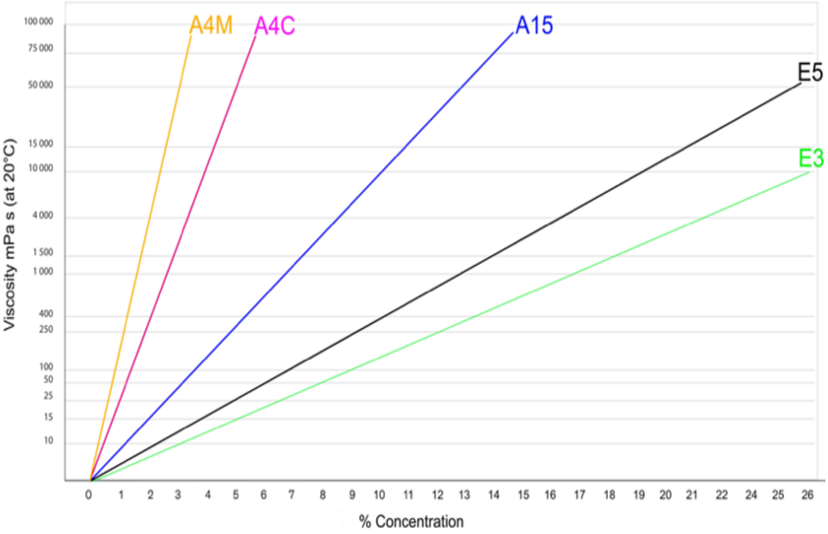


Fig. 6. Relationship between concentration and viscosity for MC (A) and HPMC (E)

All solutions in figure 7 have 5% and have been inverted shortly before the photo, so that the viscosity is obvious. Of all methylcelluloses available to conservators, A4M has the highest degree of polymerization (DP), while A15 has the lowest DP. A represents methylcellulose, 4M declares the viscosity of a 2% solution, that is 4x1000~4000mPa·s. Only the hydroxypropylmethylcelluloses (HPMC) have an even lower DP than the pure MCs, and these are E5 and E3. E stands for hydroxypropylmethylcellulose (HPMC) and the number indicates the viscosity. According to *Feller and Wilt* [9], the ageing properties are very good. However, according to *Steger et al.* [10] the latter 'recommendable', although only slightly worse than MC.

Fig. 7. Methylcelluloses and Hydroxypropyl cellulose (all 5%) with rising degree of polymerization and therefore rising viscosity. Visible are the different viscosities and the main associated properties

The most striking differences concerning DP are aging, cohesion and bonding of absorbent substrates. For our purpose, a high DP is better [16, 17]. Egeler and Krüger investigated this aspect in wood bonding and Gaasch in canvas threads by thread bonding; publications are currently in progress. Furthermore, solubility is significantly better for the short chains (low DP), whereas the shear viscosity for A4M is most pronounced and sorption is only slightly increased for higher DP [13]. If the methylcellulose is too viscous to flow from the brush, a syringe or dispensing controller unit is very helpful. An important property of MC is that upon heating to 50–60°C, they form solid gels after a short drop in viscosity and do not obtain very low viscosity like e.g., gelatins [13]. This is important for controlling the flowability and film formation of methylcellulose. A possible chain formation in gelling is shown by *Schmidt et al.* [18], Coughlin *et al*. [19] and *Niemczyk-Soczynska et al.* [20]. Thus, even the heating filler application could be advantageous for film formation here. However, adhesive strength reductions were not observed in a test series [21].

Masking

In case viscosity for adhesive placement needs to be lower than permitted without soaking the canvas, cyclododecane solution can temporarily block the capillaries of the canvas, while the MC still forms a bond. Highly water-sensitive, degraded flakes can be masked with non-aromatic petroleum spirit and methylcellulose can be applied subsequently with better results than without masking. The distribution of the adhesive is more even and the bond highly satisfactory [21]. If the viscosity of methylcellulose is still too high, they may be replaced by proteins, like gelatine, which are of lower viscosity, even at higher concentrations when heated.

Proteins from collagen: gelatine and sturgeon glue

Protein glues such as sturgeon glue and gelatine exhibit low viscosity and achieve similar cohesion values (max. 60–100N/mm^2) [22-24]. However, they have a complex structure [25, 26], exert high tension during drying which continues to build up during fluctuating relative humidity [27]. The solution can be stored in a refrigerator only for a limited time. There are three main differences: firstly purity – gelatine is purer than sturgeon glue; secondly, reproducibility - every sturgeon glue batch is different, thus essentially, we are talking about different glues [28]; and thirdly, their gelling temperatures [22, 26, 27]. A gelatine with 180 Bloom, 5%, gels e.g., at room temperature, whereas a sturgeon glue also (5%) gels mostly only at 11°C. This has an enormous influence on film formation, particularly between absorbent substrates. If an equal amount of adhesive with the same concentration is applied between two chalk flakes, gelatine is more likely to form an adhesive film because it gels faster and does not penetrate as deeply into the flake as sturgeon glue [29]). To reduce diffusion into the chalk ground and increase the adhesion, one could choose a gelatine with a higher Bloom grade. The higher the Bloom grade, i.e., the more gently it was produced, the purer is the solution, which results in longer molecules and faster gelling of the solution. The faster a solution gels, the less it can penetrate into the porous substrate, and this results in better adhesion (Fig. 8). For the adhesion of absorbent flakes, a high boom grade and a low application temperature are appropriate.

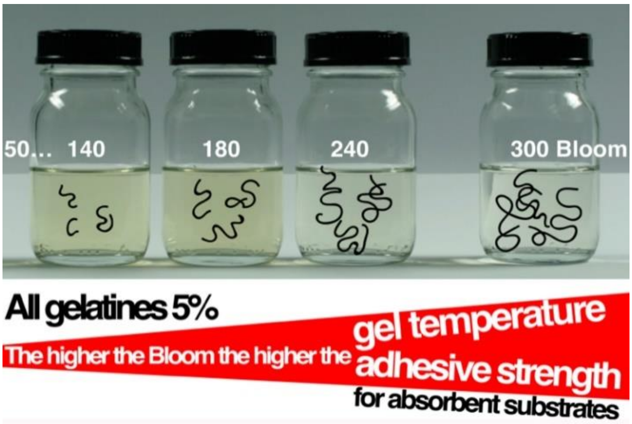


Fig. 8. Gelatines (all 5%) with rising Bloom grade. Visible are the different colours of the solutions and the main associated properties [17]

Masking

To achieve a higher adhesion, one can temporarily mask the absorbent ground with a non-aromatic, non-polar solvent, like ShellsolT. This is achieved as follows: each flake is saturated with Shellsol T, then the same gelatine as before is applied. Now one should wait for at least 12h or longer. The tensile tests reveal substrate break at 0.6N/mm^2. However, this is neglectable when compared to the possible cohesion of 60–100N/mm^2 for gelatine [30]. To investigate whether this would also work on a canvas with a much higher absorbency, it is important to firstly prevent any new capillaries from forming. Secondly, one should avoid any contact to the back of the canvas if the adhesive is liquid. So far, a polyurethane open cell hard foam (Fig. 9), has worked well. The foam is stiff enough and the drying process is faster than with a wooden or metal board underneath the canvas.

Pure gelatine (180 Bloom, 5%, 7µL) penetrates in about one or two minutes into the canvas, whereas a canvas fully masked with Shellsol T prevents the penetration. After 15min the gelatine is still on the canvas (Fig. 10). If one puts a flake on the masked canvas with the gelatine drop, instead of waiting to watch the gelatine gelling, a very good adhesion with the desired glue line is achieved after 24h.

The higher the Bloom the better the temporary masking will work. If complete masking with a nonpolar solvent is not applicable, a temporary masking with cyclodedecane is recommended [31].

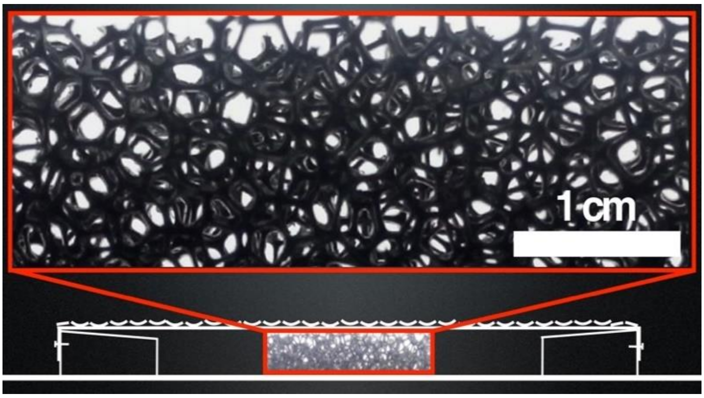


Fig. 9. Side view of a painting with polyurethane hard foam support beneath the canvas

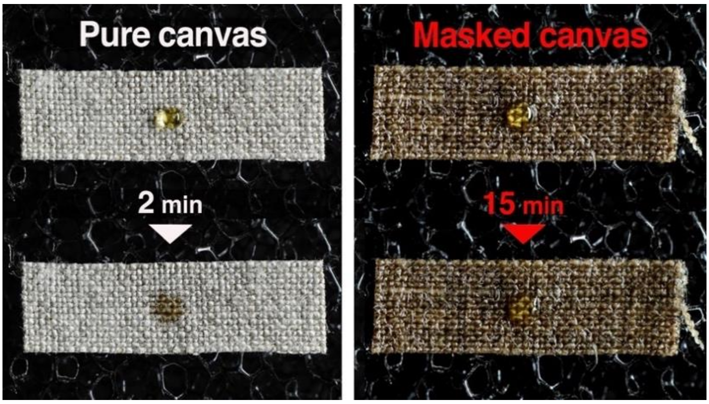


Fig. 10. Gelatine 7µl (180 Bloom, type A, 5%) on unsized canvas. Left pure, right temporarily masked canvas with Shellsol T

Thickening

Many conservators thicken gelatine and sturgeon glue with wheat starch paste or with cellulose ethers. In other words, methylcellulose is being diluted with gelatine. This allows for adjustment of the viscosity, while maintaining a high concentration of the adhesive. There are, however, huge differences among thickeners in terms of viscosity, penetration and adhesion, which results in heterogenous distribution of the adhesives a high variability of adhesive joints [29].

Hydroxypropylcellulose

Hydroxypropylcellulose (HPC) is probably better known as Klucel. Like MC and HPMC, Klucel is available in a wide range of viscosities [32]. The biggest advantage compared to MC is the solubility in alcohols, like ethanol and isopropanol. In case the artwork/object is highly sensitive to water, most conservators choose Klucel with alcohol as a solvent. It also differs greatly in physical properties. The T_g is significantly lower -4.5–15°C than that of MC at 135°C [33-37]. HPC is quite plastic and has a low tensile strength of 14–24 N/mm^2 [34, 37]. The tensile strength naturally decreases with increased relative humidity. It is therefore more suitable for consolidating powdery paint than for adhesion. However, a major disadvantage of HPC is that its ageing behaviour is difficult to predict. Even the data sheet of Ashland states with respect to the long-term stability: “That higher molecular weight Klucel grades have a 20% viscosity loss after two years.” Some of our old powders at the University have darkened and smell acidic (fig. 9). FITR measurements revealed some acid components. On the other hand, however, some powders are ~25 years old and in a very good state. This unreliable ageing behavior has also been observed by *Steger et al. 2022* [10]. Taking also into account the study of *Feller and Wilt* [9], current advice is to avoid Klucel. If alcohol is required as the suitable solvent, the HPMC option should be considered since the viscosity of HPMC can be adjusted over a wide range with variable amounts of ethanol.

Fig. 11. Some of our old Klucel powders at the University have altered considerably both in colour and morphology (i.e., no longer in powdered form)

Acrylates

Pure Acrylics basically exhibit good ageing behavior [38-41] and are stress free upon fluctuating climatic conditions, which is increasingly becoming a relevant factor in times of limited financial resources and increasingly dramatic climatic maxima. Acrylics are used as pure solutions or as dispersions. The latter often consist of one, two or three main components with an unknown number of additives that are subject changes not declared on the final product (e.g., due to availability, manufacturing process improvements or economic reasons) [41]. Thus, the ageing properties may vary by over time and are difficult to predict. It is thus recommended to rely on such ‘unknown’ mixtures in specific cases, weighing pros and cons for the better future of the object. They commonly are chosen because they are ready to use, exhibit very low viscosity with excellent wetting properties, have a high content of solids (25–50%), and thus dry quickly. They also have a high elasticity. This is, however, accompanied by lower cohesive strength [42]. Once dry, the acrylic dispersion can usually only be removed with acetone or toluene and often leaves a slightly shiny surface appearance. Thus, the fast drying, while an advantage on the one hand, it also requires fast (and stressful) application on the other. In any case, it is essential to be aware of the minimum film-forming temperature for each product. Low viscosity and good wetting allow dispersions to flow quite far, and it is precisely this aspect that may cause them to penetrate in an uncontrolled manner into intact structures.

Masking

Penetration into a porous flake can be hindered by applying non-aromatic petroleum spirit in advance, which will almost double the penetration depth, figure 12 [43]. Similar to gelatine, penetration into the canvas can be prevented by flooding the entire canvas with aliphatic hydrocarbons [43] or cyclododecane solution.

Pure acrylates are dissolved in solvents. Due to its non-polar solubility, Degalan PQ611 (iso-BMA, T_g 32°C) or Degalan P550 (n-BMA, T_g 25°C) are commonly used because they are soluble in aliphatic hydrocarbons (max. cohesion 5–14 N/mm^2 [34, 37, 38]). P 550 is preferred for its ageing properties, but PQ611 is chosen for its higher T_g value. Therefore, some conservators mix the two acrylics 1:1 [44]. Paraloid B-72, mostly EMA/MA, has a quite height

T_g of 40°C. Despite its proven durability, it is less frequently used for adhesion of paint flakes on canvas (cohesion max. 7–25 N/mm^2) [38]. While the wetting properties are excellent, the solubility also causes the acrylics to easily penetrate the canvas completely, similar to a warm protein glue on an absorbent canvas. If you want to mask the canvas against an adhesive that is soluble in aliphatic hydrocarbons. The canvas would have to be flooded with water. This would not only lead to swelling processes in the painting, but also the canvas would swell. In addition, the water evaporates very slowly. This would make adhesion difficult. Furthermore, acrylates are non-polar – which means that subsequent bonding (retreatability) with MC or proteins is no longer possible.

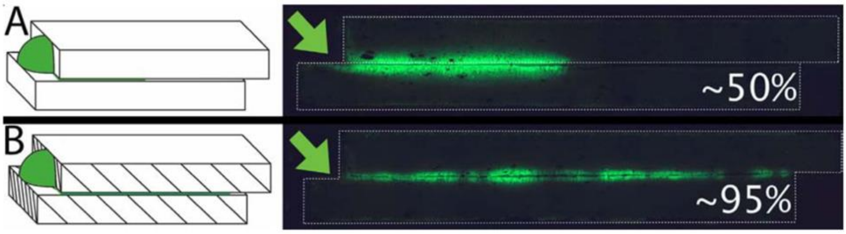


Fig. 12. Application of Medium for Consolidation (5μL) between two absorbent flakes. On the left is a schematic illustration, and on the right is a thin section from showing the transect of the sample. (A) Without masking: visible of penetration of the dispersion into the ground, with strongly reduced lateral dispersion, covering only ~50% of the interface. (B) Masking with Shellsol T (10μL): masking followed by application of Medium for Consolidation (5μL). penetration into the ground strongly reduced and increasing dispersion up to ~95% along the interface.

Application: Summarising and Supplementing

Based on different adhesive media, this article has discussed options to improve lateral penetration along the broken interface, while minimizing vertical penetration into canvas and ground or paint layer. In summary, these are physical application aids (micro-dispensing system), tempering, masking the substrates with non-polar media or, temporary masking of the canvas with cyclododecane or non-aromatic petroleum spirit.

Many conservators add ethanol to the adhesive to reduce the surface tension or pre-wet with ethanol or ethanol: water (5% of ethanol reduce the surface tension of the water considerably) [45]. A key factor is the timing: If the adhesive is applied too shortly afterwards, the result will be complete impregnation of the substrate with the adhesive. Waiting for a few minutes, however, not only leads to better wetting, but also to better lateral dispersion of the adhesive layer [46]. “Pre-consolidation” is also often used in practice [47]. This means that a diluted solution of the binder is applied initially. This improves the lateral penetration of the higher-percentage adhesive solution applied in a second step, while reducing vertical penetration of the concentrate. It should be noted, however, that the low-percentage solution penetrates the joint in an uncontrolled manner.

Third Step: Drying

If the stability of the layered painting permits, both weight and an open-pore support on the opposite side should be applied during drying, so that evaporation is unhindered. Polyurethane foam is recommended here. No flat metals or wooden plates should have contact to the canvas. Pressure should be minimal to absolutely avoid neither breaking of the flake nor extrusion of the adhesive. Sufficient drying time is essential for a successful bond. While it seems tempting to apply heat and pressure on individual flakes to speed up the drying time, it is not recommended and highly disadvantageous for the film formation of proteins [25]. In the case of methylcelluloses, drying over the gel phase (above 50°C) may lead to better fibril formation and thus higher cohesion. The exact process would still have to be investigated on works of art. So far, we have tested this in connection with masking on a sculpture and the adhesive strength was equally good with and without heating spatula [21].

Forth Step: Adhesion pre-test

First adhesion-checks can be conducted on a slide under a microscope with just a small part of a flake. If more pre-tests are necessary, it is recommended to use flakes or canvas that are as similar as possible in terms of material composition, solubility and absorbency. In order to gain better control on the lateral and vertical penetration behavior of the system of interest, adding a fluorochrome to the adhesive solution and observing transects with fluorescence microscopy is a recommended option. It is, though, advisable first to work with mock-ups.

Add 10µL (Fluorescein-Sodium 10% in deionized water (Fig. 12), price ~80 CHF for 100g) to 50mL of water-soluble adhesive solution. There is not one recommended ratio that fits for all cases and examination possibilities, simply because some pigments are fluorescence quenchers and visibility depend on the microscope setup. Multiple test fields made with different colors relevant to the case should be considered. Certainly, tests should be carried out on models first, but this will never replace tests on the original. Especially for large projects, it is advisable to create many test areas and to wait a year before treating all walls and ceilings, for example. Only the conservator can decide whether to use a little fluorochrome on the original and then take a small sample and quickly see the whereabouts of the adhesive thanks to UV-fluorescence or to accept the uncertainty.

The example given above (Figs. 2 and 4) worked very well on the slide by masking with non-aromatic petroleum spirit and then gluing with 5% A15. However, the same flake on the absorbent canvas required a completely different approach. Here we worked with a micro dispensing device and a 3% A4M solution.

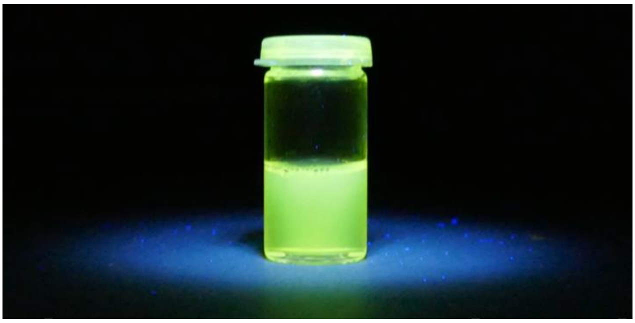


Fig. 13. Fluorescein-sodium 10% in water under UV-light

Specific cases

Adhesion Filler and Foam

More and more often, flakes are found that are warped, lifted from the support and cannot be made flexible. One of the reasons can be strong saponification of the oil. In earlier times, plasticizing solvents or resins were sometimes used for the paint layer. Another possibility was to treat the paint layer with moisture and heat for a long time and then to level it with a lot of pressure. The results were very often deformed paint layers and a lot of broken flakes.

Today, the aim is not to change the surface optically and not to create a sea of tiny flakes, but to work with adhesive fillers. There are several possibilities that can be applied with a syringe, e.g., binder mixtures with fillers, pigments, fibers and e.g., glass bubbles (3MTM *ScotchliteTM S22* glass bubbles, 30–35µm in diameter). If the adhesion filler should be applicable using the smallest tip size of a micro-dispensing system (0.11mm or 0.15mm inner tip diameter), cellulose beads made of regenerated cellulose are recommended. These are lightweight, round, white colored, hydrophilic, dimensionally stable and available in diameters of 5 or 10µm. To increase adhesion and cohesion, the addition of fibers has proven very effective [47].

Another option that has recently been developed is the application of methylcellulose foam using a simple double-syringe technique.

Variations for liquid application: Aerosol, Foam, Grid, Films

The adhesive is usually applied in liquid form. This is done e.g. with brushes, syringes, microdosing devices or in aerosol form. To ensure that one does not apply unnecessary amounts of adhesive to the artwork, the amount of adhesive should be controlled. This means that one calculates beforehand how much adhesive is necessary for a glue line on the given interface and tries to place it in the intended place. If there is a risk of not being able to achieve sufficient film formation, while at the same time access to the glue joint is given, an adhesive foam might be applicable; either in wet or dry form [48]. Dry foam made of methylcellulose is activated with water or an alcohol-water mixture. Depending on the DP of the methylcellulose, the foam density and the amount of water, the foam can be activated quickly or slowly. In addition, the foam structure can be completely transformed into a continuous film.

Another option is an adhesive grid, which has exact material specifications and remains in shape even after gluing [49]. Until now, melts such as Beva 371, from cans or in film form, have often been used. However, changes of the Beva 371 product mixture [50], the non-polarity and the high activation temperatures are counterproductive. More recent advances point towards the multiple advantages regarding the use of methylcellulose that may be produced without unknown additives as adhesive films or in variable shapes that can be reactivated with minimal amounts of water, after all eliminating many disadvantages of the commonly used media for consolidation.

Conclusions

The steps presented will hopefully help the conservator with some fundamental facts and a systematical approach for re-adhesion of lifted paint flakes on canvas.

The masking of porous flakes with nonaromatic aliphatic solvent allowed better penetration of a subsequently applied methylcellulose or gelatine. This is not due to better wetting, but to smaller capillaries, as the nonaromatic aliphatic solvent levels the rough surface of the substrates and narrows the gap. Cyclododecane has usually proven successful for masking the canvas.

However, brittle paint stays brittle. Therefore, all aspects of preventive conservation should be considered (e.g., back protection, stable climate, etc.). It is important to emphasize that no matter how good the ageing resistance of a binder is, residues or superfluous material should never be allowed in the structure. Thus, in addition to the ageing resistance, the controlled application of material quantities that have been determined as precisely as possible is an important consideration. Furthermore, systematic, and well-documented handling is the most important aspect. Afterwards, long-term monitoring should be arranged with the respective stakeholder.

Since every cultural object and situation is different, such basic steps can never include all eventualities. It is merely a starting point. All aspects and circumstances must always be weighed up by the conservator carrying out the work.

Acknowledgments

The author is grateful to the HKB-Lab, namely Stefan Zumbühl, Nadim Scherrer and Brigitte Lienert-Pärli. The author would likewise like to thank Jörg Scheller and Nadim Scherrer for reviewing the manuscript. I would also like to thank the many students who had many questions and picked up on some of them themselves. Last but not the least, a special thank you goes to the HKB research- and teaching-team.

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Received: August 16, 2022
Accepted: December 20, 2022