# Encaustic Substrates: What Does Encaustic Adhere to Best?


The choice of a substrate is in many ways as important to the physical structure and visual impact of a painting as the paint medium itself because it affects both the paint's adhesion to the surface and its optical characteristics. In order to determine the most dependable substrates, it is necessary to explore many of the options that are available for working in encaustic.

Substrates differ by whether they are smooth or coarse, white or toned. These differences affect the luminosity of the final paint layer, the facility of laying the paint onto the surface, and the texture of the paint film, among other things. While much of this has to do with aesthetic considerations, it is equally important to take into account the mechanical bond between paint and ground because it plays a significant role in the long-term durability of the work.

Encaustic painting has an ancient history, but the narrative of proven technical investigation is relatively limited. There are many inaccurate assumptions about what grounds are suitable for encaustic. As the use of encaustic has expanded into the realm of mixed media over the last 60 years, it is being applied to a greater range of surfaces, including glass, plexiglass, metals, papers, fabrics, commercial panels, ceramic, stone, other paint mediums, etc.

The purpose of this investigation, therefore, is to develop a systematic approach to testing and answer the question, what does encaustic adhere to best?

## I. Test Preparation

We designed a series of rigorous tests on 38 different substrates to investigate the adhesive properties of encaustic paint. The tests were based on methods that we developed in 2008 prior to introducing R&F Encaustic Gesso® and R&F|Ampersand Encausticbord™.

### Terminology

***Support*** *is the physical structure that holds the painting. Examples are panels, stretched canvas, and paper.*

***Substrate (or ground)*** *is the surface on which the paint is directly applied. In some cases this substrate is a film, like gesso, which has been painted onto a panel. In others it may be the support itself, such as an unprimed panel or paper.*

***Delamination*** *specifies a separation of the paint layer from its substrate. This is not always apparent from the paint surface.*

***Detachment*** *refers to a paint film that has visibly cracked, lifted, or broken off the substrate.*

**Supports.** The tests were done on rigid supports only. In the case of unprimed wood, metal, glass, etc., the support and the substrate are the same. Flexible supports, such as paper, were mounted onto rigid supports. We did not test stretched canvas or loose-hanging fabric because their flexibility adds a factor of unreliability.

| CATEGORIES OF SUBSTRATES | |
|---|---|
| Wood (abraded) | |
| Pine ply 1/4″ | MDF 1/4″ |
| Luan ply 3/16″ | Bass wood 1/2″ |
| Birch ply 3/16″ | Balsa wood 1/2″ |
| Metal (abraded, except for rusted steel) | |
| Copper 1mm | Aluminum 1mm |
| Steel 2mm | Aluminum 2mm |
| Rusted Steel 2mm | Aluminum 6mm |
| Plexiglass/Glass | |
| Plexiglass 1/4″ | Window glass 1/8″ |
| Plexiglass 1/4″ abraded | Window glass 1/8″ abraded |
| Oil | |
| Oil paint | Alkyd Paint |
| R&F Pigment Sticks® | |

| | |
|---|---|
| Acrylic | |
| Ampersand Encausticbord™ | Standard acrylic gesso for acrylic painting |
| R&F Encaustic Gesso® | Acrylic gel medium |
| Acrylic paint | Hard sandable gesso |
| Pumice gel | |
| Matte | |
| Casein | Gouache |
| Flashe | Egg Tempera |
| Glue and resin | |
| Rabbitskin glue applied over a porous surface | Rabbitskin glue applied over a non-porous surface |
| Shellac | |
| Gypsum | |
| Joint compound | Casting plaster 3/4 |

## II. Test Procedure

### Preparation of encaustic paint layer

The encaustic paint was applied over each substrate in a 5″ x 7″ area in a uniform thickness of 20 mil, using a draw-down bar. The paint was applied at 200°F (93°C) and  the substrate was not preheated.


(Applying paint)

(Using the draw-down bar)

**Freezing and slam tests**
The panels were subjected to a total of 6 freezing cycles with a freezing period of 1 hour per cycle. The panels were then stored at room temperature for a minimum of 3 hours before being put back into the freezer.

After the panel returned to room temperature, it was slammed onto a hard surface. The purpose of this step was to create a detachment of the paint film in order to discover any hidden delamination.

***Note:*** *The purpose of the slam test is <u>not</u> to find out how well encaustic stands up in frigid weather (particularly for shipping). Encaustic, as well as oil or acrylic, on almost any surface can be damaged by cold.*

The panels were given a grade of 1-7, based on which cycle the detachment occurred. When detachment occurred, the panel was removed from further testing. A grade of 7 meant there was no detachment.

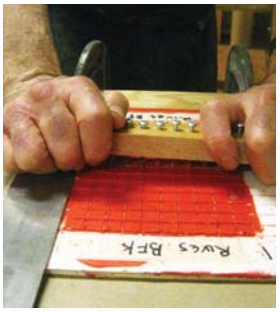
**½" Scoring test**
The panels were then scored every ½" with a blunt tool (in this case, the tips of machine screws). Pushing the screw tip forcibly through the paint film applied a lateral, or shear, stress to the film and in turn resulted in the detachment of the ½" squares. A grading system of 1-4 was used to evaluate the extent of detachment of each square. A grade of 4 represented no damage to the area. A perfect grade was 4 x 140 squares = 560.

**¼" Scoring test**
One half of each panel was then scored every ¼", which increased the lateral pressure on the paint film. The grade was combined with that of the next test.

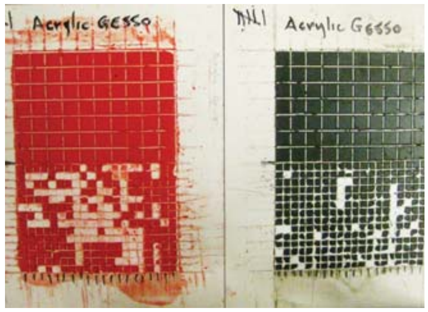
**"Pull-up" test**
Cheesecloth was laid down over the half of the panel with the ¼" scores. Encaustic medium, at 200°F (93°C), was then brushed over it until it was absorbed through the cloth. Fusing was avoided in order to keep the underlying scored paint from melting. The panels were left overnight to allow the medium to cool and harden.

The next day, the ends of the cheesecloth were firmly pulled up. This created a perpendicular, or tensional, stress on the paint film. The individual squares were then evaluated and graded. A perfect grade was 4 x 280 squares = 1,120.

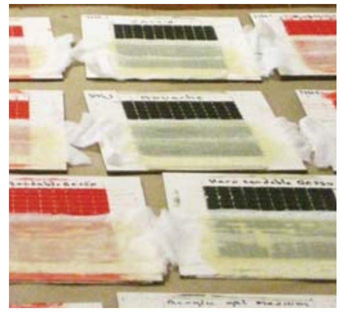
**Final grading**
Since almost all surfaces did well on the ½" test, only the final grade following the pull-up test was used to compare the success of the various substrates.



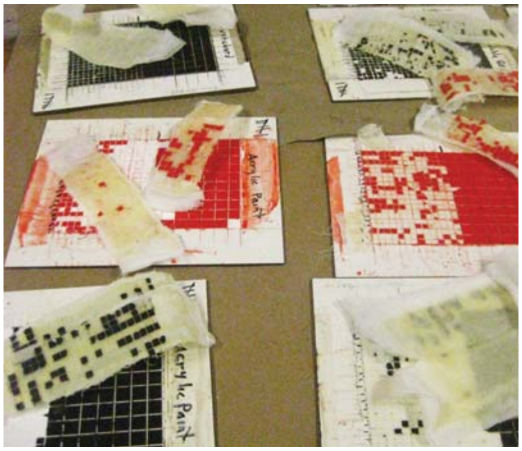
(½" Scoring test)




(¼" Scoring test)



("Pull-up" test preparation)




("Pull-up" test results)


(Grading sheets)

## II. Test results

### Excellent

Encausticbord™, Encaustic Gesso, pine ply ¼", luan ply 3/16", MDF ¼", basswood ½", birch ply 3/16", rusted steel 2mm, aluminum 1mm, plexiglass ½" (abraded), printmaking paper (Rives BFK), Pigment Stick®, casein paint, Flashe.

### Good

Plexiglass ½" (unabraded), watercolor paper (Artistico 140 lb HP), gouache.

### Fair

Balsa wood ½", copper 1mm, museum board (4-ply), egg tempera, acrylic hard sandable gesso, rabbitskin glue on porous ground

### Poor

Aluminum 6mm, steel 2mm, oil paint, alkyd paint, acrylic gesso, acrylic paint, acrylic gel medium, acrylic pumice gel, rabbitskin glue on non-porous ground, shellac.

### Unresolved

Window glass 1/8", joint compound, casting plaster ½".

## IV. Explanation of why substrates passed or failed the tests

What these tests demonstrate is **not** which substrates work or don't work but that those substrates with the highest evaluations give the greatest assurance of durability. We know from experience, however, that some substrates that got a "poor" evaluation in our tests have fared fairly well in the real world. The paintings done on those surfaces have survived intact for a number of years despite frequent handling and shipping and variations in temperature and humidity.

As with any test, that assurance is only an educated guess. The ultimate test of time — the experience itself of using encaustic on diverse substrates over decades and centuries — is beyond the present scope of any tester.

### Historical perspective: Fayum Portraits

The Fayum funeral portraits painted during the 1st through 3rd Centuries, however, have survived the test of time — almost 2,000 years, in fact — to give an idea of how well encaustic adheres to certain substrates

The Fayum portraits were painted on thin, slightly curved panels of various woods — sycamore fig, cypress, cedar, pine, fir, and lime. These panels were sized with animal glue (possibly to stiffen them). The composition of the encaustic paint seems to have varied from portrait to portrait. Examination by conservators has raised the possibility that the paint was sometimes applied molten, other times saponified; in some cases it was mixed with resins, olive oil, or egg. The main ingredient in all of these, however, was beeswax, which, regardless of any other ingredients, defined the medium both physically and aesthetically.

The portrait was fixed onto the mummy of the deceased, which was kept in the family house for a generation or so. Eventually it was buried, quite casually, along with other discarded mummies, not to be discovered and unearthed until the 19th Century. The necropolises where they were buried were located on the escarpment above the Fayum depression. The sands there provided a cool, dry environment that preserved the wood from completely deteriorating.

The condition of the paint, cleaned of both dirt and 19th Century restoration methods, does show cracking and detachment. Much of this, however, is attributed to splitting and cracking of the wood supporting the paint and to a lesser extent to the aging of the paint itself.

***Note:*** *The information in this section was derived from the following works:*

Euphrosyne Doxiadis, *The Mysterious Fayum Portraits*, Harry N. Abrams, 1995.

Richard & Helena Jaeschke, *The Cleaning and Consolidation of Egyptian Encaustic Mummy Portraits*, Journal of the International Institute for Conservation of Historical and Artistic Works, 1990.

**Characteristics of substrates that affect adhesion**
In developing these tests, we focused on two interrelated characteristics of the substrate:

1. Differences in expansion between the substrates (both support and ground) and the encaustic

2. Character of the substrate surface.

**Expansion/contraction.** The purpose of the freezer test was to create an exaggeration of the expansion and contraction that occur when temperatures fluctuate under normal living conditions. If there is a large difference between how much a substrate expands and contracts and how much the encaustic layer expands and contacts, it can cause the encaustic to crack or detach. However, this also depends on how well the encaustic adheres to the substrate.

**Surface characteristics.** The adhesive bond that wax forms with a substrate is not a strong one. When a substrate is smooth, the encaustic has little to hold onto and will more readily separate from it when it is stressed. This is what caused a number of substrates to fail the freezer test.

| CATEGORIES OF SUBSTRATES - Failed Freezer Testing | |
|---|---|
| Metal (abraded, except for rusted steel) | |
| Aluminum 6mm | Steel 2mm |
| Plexiglass/Glass | |
| Window glass 1/8″ unabraded | |
| Oil | |
| Oil paint | Alkyd paint |
| Glue and resin | |
| Rabbitskin glue applied over a non-porous surface | Shellac |

(Examples of substrates that failed the freezer test)

**Porosity.** High solid gessos, low-fired ceramic, and many woods and papers are examples of porous surfaces that make excellent grounds for encaustic. The irregularity, or texture, is the result of tiny voids in the form of pores, fissures, or webbing (as in fibers). In making the surface porous, the voids increase the surface area per square inch for the encaustic to adhere to. The irregularity also creates angles to "hook" into.

The irregularities in a substrate's surface, are what enable it to resist delamination due to expansion differential or any other stress, such as scraping or impact. Abrading with sandpaper, file, steel wool, etc. creates tightly condensed patterns of ridges and gouges, that gives tooth to otherwise smooth substrates like glass, plexiglass, metal, or planed wood.

Birch ply smooth magnifed)

(Birch ply abraded magnifed)

(Plexi abraded magnifed)

**Permiability.** The more interconnected these voids are throughout the substrate the more permeable and absorbent the substrate becomes. A high degree of permeability may seem like an ideal quality for an encaustic substrate, but it presents two problems:

1. A substrate, such as plaster, that is too absorbent, will suck up so much of the paint that it is difficult to build up a paint film. This results in a flat stain on the surface. In this case, cutting back on the porosity by pre-sizing with a light acrylic or PVA solution can help solve the problem.

2. A lack of cohesiveness within the substrate itself can make the bond holding it together weaker than the adhesive bond holding the encaustic to the substrate. In our tests, this caused some substrates to come apart under stress. But this kind of stress would normally occur only in the case of extremely thick buildups of encaustic. The substrates in this category included joint compound, plaster, and some papers.

(Separation of plaster)

(Rives BFK separation of paper)

(Rives BFK cross-section magnified)

**Technique.** The method of applying encaustic can also affect its adhesion to a surface. Because encaustic relies so heavily on the porosity of its substrate, the paint requires an adequate heat (approx. 200°F, 93°C) to sink into the pores. Paint laid on at a cool temperature and not adequately fused will not sink into the pores as well as it will at higher temperatures. In the case of a low heat technique, it is advisable to first size the substrate with hotter wax.

**Acrylic.** It has become an accepted truth in the encaustic "rule book" that acrylic is an unsuitable ground for encaustic paint, yet certain acrylic-based grounds, such as our R&F Encaustic Gesso® and Ampersand's Encausticbord™ passed our tests with the highest marks. True, most acrylic mediums and gessos in our tests proved to be less than optimal. But the same was true of rabbitskin glue, the binder for traditional glue gesso, which has long been used as a white ground for encaustic.

What is missing in this common assumption about acrylic is an understanding of the ratio of binder to solid. Every primer and every paint is composed of two components: a solid and a binder. In primers, the solid is usually a combination of inert filler (chalk, kaolin, etc.) and white pigment. In paint, it is the pigment and whatever additives may be included. The binder has four purpose: 1) to act as a glue adhering the paint to the ground, 2) to cohere it to itself, 3) to lock in the pigment, and 4) to give the paint the fluidity it needs to be applied.

The glue's cohesive bond makes it stick together and form a smooth, non-porous surface when it dries. The presence of solids lessens the binder's cohesiveness, flexibility, and uniformity. In acrylic paints where a relatively high ratio of binder is necessary in order to remain flexible, this loss is not as noticeable and the medium retains a flexible and relatively non-porous surface. This is the reason that acrylic paint and acrylic gesso did not perform well as grounds for encaustic. When the ratio of acrylic to solid is very low, as in the Encaustic Gesso® and Encausticbord™, there is enough acrylic to adhere the gesso to the support but not enough to make a uniform film. The result is an irregular and porous surface that is a very receptive ground for encaustic paint.

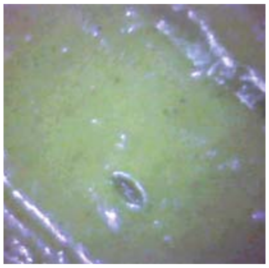
In other words, there is nothing wrong with acrylic itself. What matters is how it is used.


(Acrylic gesso-brushed magnified)


(Encaustic gesso-brushed magnified)


(Encausticbord™ magnified)


(Cross-section of cadmium red on Encausticbord™ magnified)



(Cadmium yellow oil paint magnified)

**Oil paint vs. oil stick.** Encaustic adhered poorly to oil paint but very well to our Pigment Sticks®. The dry film of an oil stick is not necessarily more porous than that of oil paint, but it does contain wax, which is locked inside the oil. When the encaustic over it is fused, the wax of the oil stick fuses with it.

(Rives BFK magnified)

**Papers.** Low-sized printmaking papers, such as Rives BFK,performed excellently. Other papers and boards, such as water color papers and museum board, do not perform as well. In the case of water color paper, the sizing can act as a hindrance to the penetration of the encaustic (although it may depend on the type of sizing, and we only tested one). In the case of museum board, it may be the density of the fibers that acts as a resist.

**Rabbitskin glue.** Rabbit skin glue has a non-porous surface. When it is applied over a non-porous substrate, encaustic will not adhere to it well. When it is applied over a porous substrate, however, it absorbs in and performs somewhat better as a ground for encaustic. In this case, the weaker the glue strength, the better it will perform.

**Egg tempera** is generally studio made. It can therefore have varying degrees of porosity depending on the ratio of egg/water/pigment. Less egg would create a more porous surface but may not bond well to its substrate. Experimentation is advised.

**Metals.** The purpose in using three different thicknesses of aluminum was to demonstrate the role that the volume of the support/substrate plays in the degree of its expansion. The 6mm aluminum failed, while 2mm and 1mm did not. Although the alloys of each aluminum sample were not known, it is pretty reasonable that this result shows that the greater the thickness of the metal, the greater the expansion differential compared to encaustic. A future test of various thicknesses of encaustic on a single thickness of aluminum should further demonstrate the expansion differential of encaustic itself.

One seeming contradiction is that aluminum is known to have a greater expansion coefficient (expands more) than steel. Yet, in the case of similar thicknesses, the encaustic adhered better to the aluminum than to the steel. Both metals were abraded, and it is quite possible that the softer aluminum had greater porosity as a result.

Rusted 2mm steel fared quite well throughout the tests because of its highly textured surface, while non-rusted 2mm steel failed the freezer test.

**Possible influences of pigment on adhesion**
Each test was done with Cadmium Red Medium and Raw Umber encaustic. These two colors represent opposite effects of standard pigments on the wax|resin medium. Cadmium colors are softer and more pliable, while umbers are harder and less pliable thus bracketing the range of adhesive properties. One would think that this affects adhesion, and it may — but in a surprising way.

The evaluation of each substrate was based on an average of the performance of both colors. Based on the individual color, a number of the substrates with poor to good overall evaluations performed far better under one color than under the other. (Of course, substrates that performed excellently did so under both colors.)

The two most striking examples as seen below were the acrylic pumice gel and the clear glass performed better and worse on opposite colors.

| | Cadmium Red | Umber |
|---|---|---|
| Pumice Gel | very good | poor |
| Rabbitskin glue on porous ground | very good | fair |
| Acrylic paint | poor | very poor |
| Acrylic gel medium | poor | very poor |
| | Cadmium Red | Umber |
| Window glass (un-abraded) | poor | very good |
| Watercolor paper (surface sized) | fair | very good |
| Joint compound | fair | very good |
| Gouache | fair | very good |
| Copper fair | fair | good |

## V. Conclusion
To our knowledge, this is the first systematic testing done to evaluate proper substrates for encaustic paint. As thorough and deliberate as we attempted to be, it is still an initial step in a continuing investigation. The tests were not only intended to scrutinize a wide range of substrates, but also to determine the validity of the tests themselves. The peculiarities of an encaustic paint film are different from those of oil or acrylic films, which have long been documented. We had to conceive and revise our methods more than once, yet we feel enough questions were answered to present our conclusions to the encaustic community.

## How to do your own testing

This brings up the obvious question – what about those substrates that we haven't and may never test? Here are some rules of thumb:

1. Follow the procedures described above — the freeze|thaw cycles, the "slam test" (only when the sample has returned to room temperature for at least 3 hours) scoring and "pull up" test. Do all tests with both cadmium red and umber.

2. Do this **not only** on the substrate you are testing, but on one that is known to be dependable. This will be your control to which you can compare the new substrate.

3. Mount any flexible substrate on a rigid support, at least ¼" thick.

4. If you are testing a substrate that will remain flexible, do the above tests on one version that is mounted on a rigid support and another on the flexible substrate/support. This will tell you whether any failure that occurs has to do with the nature of the surface or with the flexibility of the support. Wait a month or so then run the unmounted flexible substrate back and forth over the edge of a table. No doubt you will get cracking of the paint film, but will you get detachment? If not, it should be fine. If you do get detachment, remember that this is an extreme test.

## A note about methodology vs. creativity

The entire discussion here has been about what substrates and supports tested best and why. It is meant to be only a guideline, not a set of unbreakable rules. Creativity often springs from breaking rules. All kinds of encaustic techniques have been developed because some artist tried doing something no one else ever had.