JUST PAINT

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Aspects of Longevity of Oil and Acrylic Artist Paints

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This article will compare acrylic and oil artist paints from the point of view of a scientist who specializes in coatings. It is not meant to be the "end-all" source on the topic. However, it is meant to make the reader more informed regarding long-term durability issues for both these materials.

Below are three excerpts from recent artists' list serves and internet chat rooms regarding the quality of oils and acrylics and the information available to them. These statements will help guide us as we explore the archival qualities of oil and acrylic artist paints.

> ✍ *"Acrylic paint is the MOST stable and permanent material available to the artist today and if properly used will outlast all other materials."* [1]

> ✍ *"One should beware of acrylic paints…At first…they were thought to be wonder media, but the binder has aged faster than oil colors and has caused the colors to yellow."* [2]

> ✍ *"Man o man…so much information and it's all good."* [3]

The first two people making the statements above feel strongly in their differing opinions, so where does that leave the artist? Probably uncertain about long-term durability of the materials they use. This article will help the artist become more aware of the issues associated with each material by focusing on such areas as film formation, film degradation, cracking, yellowing, cleanability, adhesion, and fading. This will give them the knowledge necessary to make an informed decision about the medium they use and what their artwork might look like in 500 years. In order to do this, we must first understand how paint films form.

1. Film Formation

To visualize the polymer molecules that hold paint films together, imagine a large mass of cooked spaghetti, with very long, strong strands. The strands are roughly analogous to polymer chains. The mass of material can be deformed because individual strands can bend and slide past one another, but movement is partly restricted by tangles. Touching this mass, one would sense that it is solid but not rigid; it is rubbery. Now imagine that we begin randomly gluing strands together at small points where they intersect. These connections furnish additional resistance to deformation. As we glue more and more strands together, the mass becomes more and more rigid. Finally, when the strands are all glued together at many points, the mass becomes very rigid and can be deformed only by breaking strands. The mass resists deformation, but under sufficient stress, will crack. The gluing together of individual strands is analogous (again roughly) to what polymer chemists call "cross-linking."

On the canvas, acrylics and oils end up as high molecular weight polymer (see Glossary) films, essentially thin layers of plastic, usually containing a lot of pigment particles. But there are big differences as to how they get there.

■ Oil paints in the tube are primarily vegetable oils, such as linseed oil, and pigment. Oils harden after they are applied to the canvas in a complex chemical process in which they react with oxygen. This process forms longer chains and many cross-links, leading to a cross-linked network of polymer. Because the oil molecules were relatively small at the start, many cross-links are required to reach a satisfactory state of hardness. The chemical reactions get slower as the film hardens, but they never completely stop (under normal display and storage conditions). Over time, continuing cross-linking can cause

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the film to become too brittle.

■ Acrylics are polymerized before the paint is manufactured, and no further chemical reactions are needed to form a film. The acrylic polymers are very large molecules (long strands) that form films through a process called coalescence (see Glossary) and do not need to be cross-linked to form a good film, although sometimes they are polymerized in a way that induces a small level of cross-linking. Recently painted acrylic films are softer, more flexible and less brittle than oil paint films (except perhaps at cold temperatures – see below). Acrylic films can undergo chemical changes as they age, but when a painting is kept indoors these changes that cause hardening are very slow.

Now that we have a better understanding of how films form, we need to explore the causes of film degradation.

2. What can cause paint films to physically degrade?

Polymer films can undergo degradation in several ways. Two common ways can be classified as (1) chemical changes that increase cross-linking beyond the optimum level and (2) chemical changes that gradually break the polymer chains. Excessive cross-linking makes paint films brittle and vulnerable to cracking and flaking. Breakage of polymer chains results in smaller molecules, and if a large number of chains is broken, the films weaken and in extreme cases, disintegrate.

As noted above, oils would not harden without cross-linking, which for artist oils usually takes months to reach an optimum level. By then, the chemical changes that cause cross-linking will have slowed, but they do not stop. The ongoing chemical changes cause oils to become harder, less flexible, and more brittle as they age.

There are also chemical reactions that can break the polymer chains in oils. The most common is chemical reaction with water. This reaction is usually slow, but it gets much faster if the paint film is exposed to humid air under alkaline conditions. This becomes a problem if the paint is formulated with alkaline pigments or if it is applied over an alkaline surface. Alkaline pigments may cause general deterioration, and alkaline surfaces may cause loss of adhesion. Masonry (brick, concrete, plaster, grout, stucco) surfaces are often alkaline, and it is undesirable to paint them with oils.

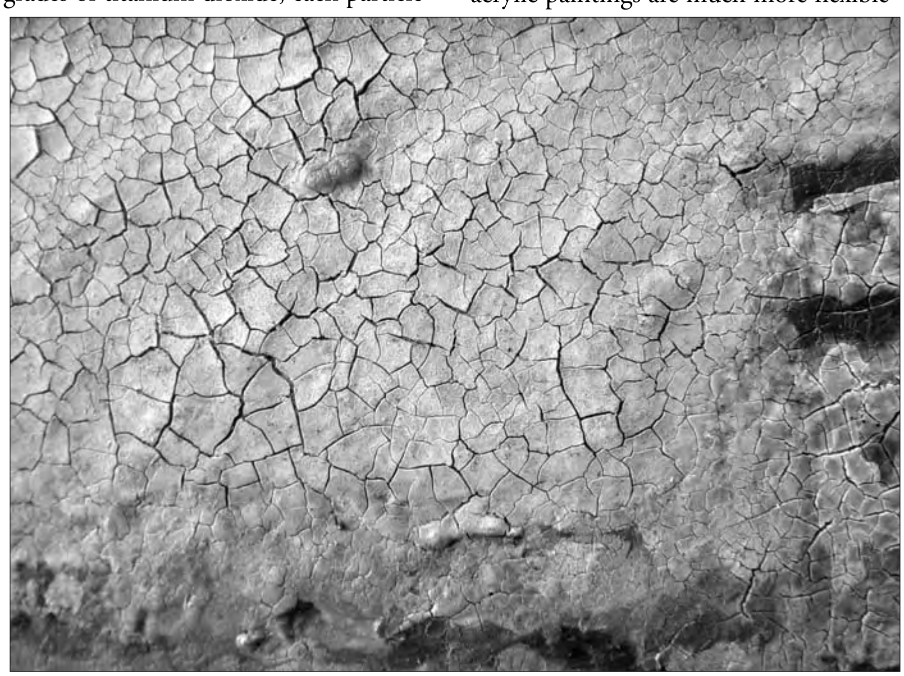
On the other hand, acrylics do not need to cross-link to form good films. The acrylic polymers used in modern acrylic paints are designed with the goal of making them resistant to chemical changes resulting from reactions with oxygen and water and by exposure to ultraviolet light. This goal is not completely achieved, and chemical changes occur slowly as paintings age. The changes are slow outdoors and much slower under indoor conditions. While it is not known how long acrylic films will retain their physical qualities, evidence presented below suggests they will last hundreds of years or more. The chemical changes that could occur might either cause chain breakage or additional cross-linking. Lastly, the combination of humid air and alkaline conditions has little effect on acrylics, making them a paint of choice for alkaline surfaces such as masonry and plaster.

Pigments can influence degradation rates in several ways. First, the pigment particles themselves may deteriorate, usually causing a change in color. (Fading is discussed below in Section 7.) Second, pigments may affect the polymeric binder. For example, certain grades of titanium dioxide white pigments can catalyze photochemical deterioration; in the most appropriate grades of titanium dioxide, each particle is coated with glass and/or alumina to prevent this. As another example, high loadings of many types of pigments can make the paint harder and less flexible; this is generally a manageable problem, but high loadings in paints that tend to embrittle with age could potentially accelerate problems such as cracking. On the other hand, certain pigments such as iron oxides and carbon blacks are good UV screeners and generally enhance the outdoor weatherability of paints.

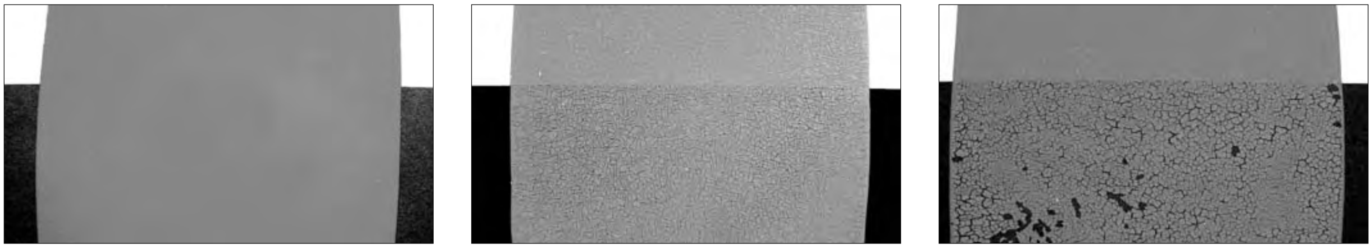
3. Cracking

What are the consequences of these different chemistries? Oil paints become somewhat brittle as they cure, and the ongoing chemical changes will gradually increase this brittleness as they age. As a result, oil paints are increasingly vulnerable to cracking over time. Mayer's compendium on artist materials [4] lists seven expedients that will minimize the tendency to cracking, including proper preparation of substrates, painting fat over lean and avoiding painting fast drying colors (*e.g.* burnt umber) over slow drying colors (*e.g.* alizarin crimson). Nonetheless, the author has observed that many, if not most, 100+ year-old oil paintings in several leading museums have cracked, as have some relatively recent paintings. Thick films on flexible grounds, such as canvas, appear especially vulnerable.

At normal indoor temperatures, acrylic paintings are much more flexible



Above is an example of an oil painting circa 1950 (artist unknown) becoming brittle and cracking over time.



Shown above is a Fluid Acrylic Naphthol Red Light film forming at ambient temperatures (left), at temperatures 38° - 40° F (center) and at 26° - 28° F (right). This clearly demonstrates acrylics' inability to form coherent films below 49° F.

than oils. Thus, newly painted acrylics are expected to resist cracking better than newly painted oils in these conditions, even in very thick films. At low temperatures, however, the acrylics become brittle. Typically their flexibility drops sharply at temperatures a bit above freezing, say between 0° and 15° C (32° to 59° F), depending on the color, the composition of the acrylic, and the relative humidity. [5] Oils also become more brittle when cold, but embrittlement occurs at temperatures below freezing. Mecklenburg et.al. have shown that significant drops in temperature from 23° C down to below freezing at very low humidity can create stresses in a fairly young 13 year old oil paint film that will exceed its breaking point. [6] Both types of paintings should be handled very carefully when they are cold, especially when the air is dry. [7]

Do artists still work in freezing garrets? If so, oils will work better. The temperature at which the paint is applied is more of a concern with acrylics than with oils. Acrylic house paints should not be used when the temperature is below about 5° C (about 40° F) or when the temperature is expected to fall below this level for 4 to 8 hours after the paint was applied. The reason is that strong, coherent films cannot form at low temperatures, and even if the film later becomes warm, it will never recover. Acrylic artist paints are similar. To be on the safe side, they should be used only at temperatures above 10° C (about 50° F), and the painting should be kept above this temperature for several days after it has dried. [8] Acrylics painted and dried under cold conditions may look OK, but the films will be less durable and more vulnerable to cracking. Oils, on the other hand can be used at freezing temperatures or below.

While newly painted acrylics will be more crack resistant than newly painted oils, the question is how the film properties change with age. We know a lot about acrylic films for other applications (briefly described in Section 9) but only a few published studies concern artist paints. In one series of studies, Professor Whitmore and Dr. Colaluca at Carnegie Mellon University attempted to accelerate the deterioration of "Liquitex Acrylic Gloss Medium" films. [9,10] *"While films of Liquitex Gloss Medium did photo-oxidize upon exposure to ultraviolet light, the material generally demonstrated the remarkable photochemical stability associated with this class of acrylic polymers. In comparison to the mechanical property loss under UV-B exposure, tensile strength loss under UV-A lamps would have been observed only after about 200 days, a dose of near ultraviolet light equivalent to about 5,000 'museum years.'"* [9.10] Encouraging as this conclusion is, one must recognize that accelerated testing of paints is notoriously unreliable, especially when the acceleration factor is high. In this study the factor was about 8700:1 – one museum year = about one hour of accelerated testing. Furthermore, many paintings are subjected to rough handling and exposed to light, humidity, and temperature fluctuations more severe than they would encounter in a museum.

Oils that have cracked are vulnerable to other problems. If adhesion is less than excellent, flakes of cracked films may delaminate. Even if the film remains attached to the ground, the cracks may open up, making them highly visible. Cracked oils may also suffer cupping, defined by Mayer as *"concavities or depressions that sometimes exist inside the boundaries of a network of cracks."* [11]

4. Yellowing

Oils tend to be slightly yellow from the beginning, and the oxidation processes that cause hardening also cause additional yellowing. Different oils yellow to different degrees. Exposure to certain common chemicals, such as ammonia vapor from household cleaners, can make yellowing worse. There have been many efforts, spanning at least a century, to solve the yellowing problem. None have been completely successful. A detailed study of the chemical causes of yellowing by Professors Mallegol, Lemaire and Gardette at University Blaise Pascal in France concluded, *"Yellowing must therefore be considered as an unavoidable characteristic of drying oils and this must be kept in mind by users."* [12]

There is divided testimony in the literature as to how badly oils yellow. Crook and Lerner [13] state that *"Linseed oil … has been used most widely due to its relatively rapid drying time. However, this is unfortunately accompanied by a tendency to yellow with age. Other, less yellowing oils have sometimes been used, especially for white paints and other light colors."*

On the other hand, many artists agree with Mayer when he [14] says that yellowing *"…concerns only clear oil films and the use of oils in techniques other than normal oil painting"* and that *"correctly executed oil paintings do not turn yellow."* Perhaps the difference of opinion results from differing views as to how much yellowing is tolerable. This author's observations in museums suggest that yellowing is discernable in whites and pastel colors of older oil paintings, although it is hard to tell how much of the problem is the paint and how much is the varnish. Franz Hals' lacework may look white, but not when it is compared to a piece of white paper. The behavior of oil household paints suggests that the problem is significant. The whites gradually turned yellow and then tan when used indoors. This is one of the main reasons such paints have become almost obsolete in architectural applications.

The acrylic polymers used in high quality artist paints are almost colorless when they are first used, and with age they yellow very slowly under normal conditions. The very low tendency to yellow is the main reason acrylics are candidates for use as varnishes. Whitmore and Colaluca [15] reported slight yellowing of the acrylic medium they studied. Levison saw *"no perceptible yellowness in any of the acrylic specimens*." [16] Based on well established behavior of architectural and artist paints, it is safe to say yellowing of acrylics is much less of a problem than it is with oils.

5. Dirt pick up and cleanability

Oils have a clear advantage to acrylics regarding dirt pickup. Cleanability of oils is much more complicated, however. [17] Acrylic paint films are slightly porous and are softer than oil paint films, making dirt more likely to stick to them. Polymer molecules in the acrylics are at most only slightly cross-linked, making the films hard to clean because solvents and cleaners can degrade the acrylic surface. In theory, this problem could be overcome by increasing the cross-linking level in acrylics. Researchers have found practical ways to cross-link acrylics for other applications, (*e.g.* varnishes for wood cabinets). Introduction of such technology into artist paints is possible but would require great caution because of the possibility of undesired effects on other properties and the uncertain effect on long-term durability. Research is also underway to define the best methods of cleaning unvarnished acrylics. (See article on Page 6 regarding the Samuel Golden Fellowship for Research into Modern Painting Materials at the National Gallery of Art in Washington, D.C.) The tendency to pick up dirt can also be reduced by varnishing acrylic paintings, but many painters prefer the appearance of the unvarnished surface.

6. Will the nose fall off?

Another aspect of durability is adhesion of the paint to its substrate. As Mayer points out, *"linseed oil is not a strong adhesive"* and the same could be said of the acrylic binders used in artist paints. What is most important is that with proper use both oils and acrylics are capable of giving fully satisfactory adhesion, and with improper use they are likely to fail. As with most paints, the most critical factor in obtaining good adhesion is to properly prepare the substrate ("the ground"). Gottsegen extensively discussed grounds for oil painting. [18] With oils, canvases must be undercoated with a ground that can protect the canvas from the oil. With acrylics, undercoating is desirable but not essential. Artists use many substrates, and recommendations for how to prepare them are published.

Overpainting artist oils with artist acrylics is definitely bad practice. The surface of hardened oil paint does not have "tooth." It is too hard and often too shiny to afford good adhesion by acrylics. Paints stick better to rough surfaces than to smooth ones if other factors are equal. The roughness may be visible to the naked eye or microscopic. Either way, roughness increases the surface area upon which the attractive forces of the paint to the ground can act. On very rough surfaces, the paint may penetrate into recesses; then when it hardens mechanical interlocking, analogous to dovetail joints, can strongly enhance adhesion. Thus, rough surfaces are said to have "tooth." Primers usually have low gloss, evidence of microscopic tooth. Most acrylics have more tooth than most oils, and overpainting acrylics with oils has a better chance to work, but the artist should be aware of potential problems.

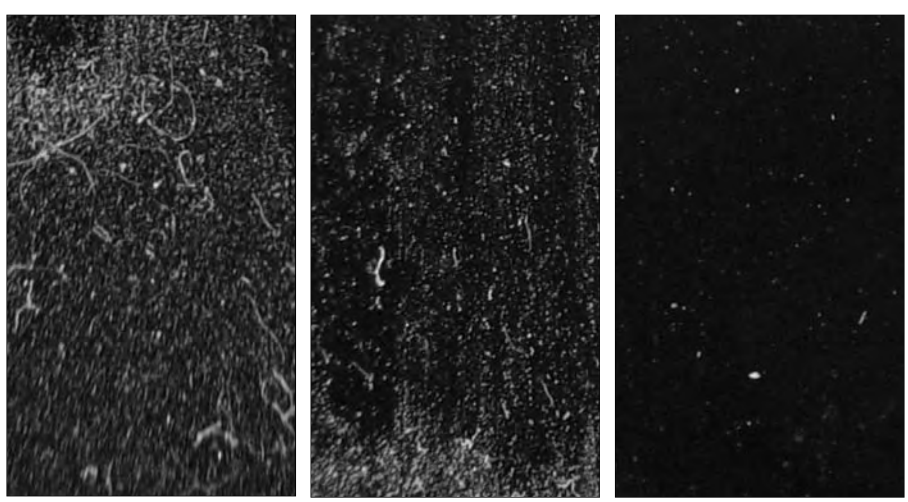
7. Will colors fade?

Fading has been a problem for centuries. The stability of colors in both acrylic and oil paints depends primarily on the lightfastness of the pigments used. Most pigments used in contemporary artist paints are selected from lists of about 115 pigments that are established by ASTM International (formerly The American Society of Testing & Materials) to be lightfast in acrylics [19a] and in oils.[19b] The lists are somewhat different to avoid alkaline pigments in oils and pigments that could be affected by water in acrylics. Artist paints are labeled with the lightfastness grade of the pigment; only pigments graded I (excellent) or II (very good) are considered suitable for archival paints. Use of lightfast pigments makes severe pigment-related color changes very unlikely for paintings that are kept indoors. Artists should be aware, however, that certain special colors, such as fluorescent colors, are not lightfast.

8. What can we learn from other types of paints?

Most (not all) artwork is kept indoors where it is protected from most of the damaging UV light in sunlight and from weather extremes. Window glass filters out the most destructive UV light in sunlight. It is widely accepted in the paint industry that indoor exposure is much less damaging to paint than outdoor exposure. In addition, it is widely assumed that paint that is durable outdoors will be very long-lived indoors.

The binders of exterior house paints evolved from vegetable oils to alkyd resins (starting in the 1930s) to acrylics (starting in the 1950s). It is almost universally recognized that each step was a major advance in outdoor durability. The acrylics used in contemporary artist paints are chemically similar to those

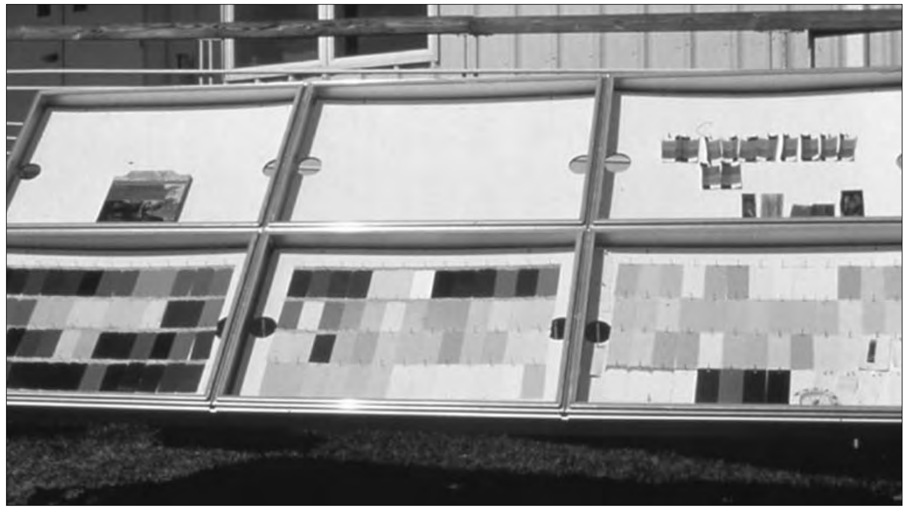


Above is an example of a dirty acrylic film showing two types of cleaning methods. Pictured left to right is the dirty acrylic film, the dry cleaning method and a wet cleaning method.

used in high-quality house paint. Oil and alkyd paints (alkyds are synthesized from oils) are more vulnerable than high quality acrylics to the enemies of paint — ultraviolet radiation, water and heat. A tour of older neighborhoods will show examples of house paints that are severely cracked. These are almost always oil or alkyd paints that have become so brittle that they cannot accommodate expansion and contraction caused by temperature fluctuations and moisture. In contrast, acrylic house paints retain their flexibility for many years. By now, over 80% of exterior paints used in the U.S. are water-borne "acrylics." In this context "acrylics" means polymers that contain some acrylic monomer, but some also contain less expensive monomers such as styrene and vinyl acetate; the highest quality paints are 100% acrylic. Better durability is a major reason for acrylics' popularity, but not the only reason. Soap and water clean-up and reduced organic solvent evaporating into the environment are also important advantages of acrylics. The alkyds that are still used as exterior house paints are used mainly as primers (where they are not exposed to direct sunlight) and by contractors who like the superior one-coat hiding of alkyds or who want to paint at temperatures near or below freezing (see section 2).

Most paints for home interior walls are based on poly (vinyl acetate) ("PVAC"). PVAC is used indoors because it is less expensive than acrylics, but it lacks satisfactory durability outdoors. PVAC based paints have been used by artists since the 1930s, but their usage appears to have been rather limited. [20] PVAC paints are used in art restoration and conservation. According to Horie, [21] attempts to remove them are sometimes quite successful and sometimes not. As media for archival painting they are almost certainly inferior to acrylics.

Automotive paints evolved from oils to nitrocellulose lacquers to alkyds to acrylics. Again, each step improved durability. The days are long past when cars were waxed and polished frequently to keep their shine. Introduction of acrylics made durable metallic car paints and durable clearcoats possible. Modern acrylic car paints are expected to retain good appearance for 10 years or more, even when the cars are driven and parked outdoors in harsh environments such as south Florida or Arizona. Acrylic car paints and acrylic artist paints both depend on the acrylic backbone for their durability. [22]



The GOLDEN Lab conducts exposure testing to be able to evaluate new materials for durability. This photo shows the test fence at Golden Artist Colors, Inc.

9. Are all acrylics the same, and are they really acrylics?

Learner at the Tate Gallery in London used sophisticated instruments to analyze synthetic paint binders used in 20th Century artist paints. [23] He studied paints on a large number of modern paintings, including paintings by many well-known artists. Learner found 100% acrylic co-polymers on some paintings. He also found acrylic/styrene co-polymers, acrylic/(vinyl acetate) co-polymers, poly (vinyl acetate), and vinyl acetate/vinyl neodecanoate co-polymers. Any of these latter types could easily be mistaken by artists for 100% acrylics, since they are all based on emulsion polymers of similar physical appearance. Among the paints that were 100% acrylics, Learner found two types of co-polymers: [p(EA/MMA)] and [p(nBA/MMA)] (see Glossary).

The author has studied and researched a wide variety of paints for 35 years, and has recently researched artist paints.[24] Based on this experience he has developed opinions about what types of chemistry are most likely to perform well as archival artist paints:

■ Learner identified many kinds of polymers that have been used in artist paints. Two kinds, 100% acrylics and certain polyurethanes, are expected to be the most durable. Based on their performance in architectural paints, 100% acrylics are preferable to acrylic/(vinyl acetates), acrylic/styrenes, and, especially, poly (vinyl acetates).

■ Unfortunately, in the commercial paint industry it has been common to represent acrylic/styrenes and acrylic/(vinyl acetates) as "acrylics." It is not known to the author whether this practice spread to the artist paint field.

■ Among 100% acrylics, [p(nBA/MMA)] is expected to be superior to [p(EA/MMA)]. Experience with house paints has shown that [p(nBA/MMA)] based paints weather better than [p(EA/MMA)] paints.

Quoting Learner's paper: [23]

"*Although both types of pure acrylic emulsion are utilized in current (artist) paint formulations, over the years there has been a gradual increase in use of p(nBA/MMA), as the production of many p(EA/MMA) emulsions has been terminated. This is because the principal commercial use of these emulsions, namely exterior house paints, requires a hydrophobic material and in general the [p(nBA/MMA)] co-polymers show a superior hydrophobicity. Out of 10 brands of acrylic emulsion paint obtained in 1993, [p(nBA/MMA)] was found to be the binder in four of them, and most new formulations produced since then have been based on this emulsion.*"

Combining the author's opinions (unproven) with Learner's findings (established facts), we can conclude that:

■ Many types of emulsion polymers and co-polymers have been used in artist paints.

■ In the early decades of "acrylic" paint use, it is likely that many artists used "acrylics" that were inferior to modern acrylics and were, perhaps, not acrylics at all.

- The acrylics available today from reputable suppliers are probably better from the standpoint of longevity than some of those in use 25-50 years ago.
- Information available today indicates that artist paints made with [p(nBA/MMA)] co-polymers are very likely to afford long-lived paintings.

10. What does practical experience tell us?

The most reliable way to assess the durability of paints is to evaluate them in actual service in the field. That is why car manufacturers send out survey teams to inspect cars that have been in use. They can observe cars in the field for their entire lifetimes, and they can tell from the Vehicle Identification Number (VIN) of the car exactly what day the car was painted and what paint was used. Artist paint manufacturers are not so lucky. Often, it is not known what brands of paint, ground, and canvas were used in a painting made twenty or fifty years ago, although their chemical types can be established by chemical analysis.

So, what do we know about artist acrylics in service? Most important, the vast majority of acrylic paintings made since the introduction of acrylics are holding up well, including many that were made with paints that were probably inferior to the acrylics available today, as explained in Section 9. Acrylics can crack, especially if they are roughly handled when they are cold. [25]

Despite the good record of acrylics so far, some artists and conservators remain concerned about the long-term durability of acrylics because of their relatively short history. After all, acrylics have been used only for about 70 years and paints based on acrylic dispersions for about 50 years, while oils have been around for 500 years.

Such concerns have been fueled by a few well-publicized [26-29] failures of "acrylic" paintings by major artists. The failures of acrylics reported in the popular press have been variously described as fading, flaking, cracking, and crumbling. Beyond that, there is little information available that would enable a rigorous judgment of the causes of failure. One can only speculate based on knowledge and experience:

- The most likely cause of fading is use of pigments that are not lightfast; this statement applies equally to oils and acrylics.
- The most likely cause of flaking (presumably loss of adhesion) is painting over dirty or improperly prepared surfaces. Many other causes are possible, including poorly formulated paint.
- The most likely causes of cracking and crumbling are the paint itself and/or bad painting technique. As discussed above, acrylics can certainly crack, but on the whole they are less vulnerable to cracking than oils.
- Many of the paintings attributed to acrylic (including Rothko's Harvard Murals) were done in other media. [28]

Summary

Fears have been expressed that there might be wholesale failures of acrylic paintings after they have aged longer.

National Gallery of Art Fellowship News

In 2003, Dr. Gregory Smith began his tenure as the first Samuel Golden Research Fellow at the National Gallery of Art in Washington, D.C. The project collaborators - Golden Artist Colors, Inc., the National Gallery of Art, Tate in London, and the Getty Conservation Institute in Los Angeles - were tasked with examining the effects of conservation cleaning treatments on acrylic emulsion paintings. Dr. Smith's role in the research was to identify specifically the paint additives that were extracted during aqueous cleaning treatments and to characterize the physical changes in the acrylic paints as a result of the loss of these additives.

As the two year fellowship draws to a close, it is astounding how much has been accomplished during this short period. Some of the many significant achievements accomplished by Greg during the course of the work include the assembly of a library of scientific and technical publications relevant to the research; the collection of reference materials and additives which have been characterized for use in further testing; the creation, aging, and treatment of a corpus of simulated paintings to be analyzed in subsequent tests; and the development of analytical methods using thermal, mechanical, spectroscopic, and chromatographic instrumentation. The carry over effects of these advancements within the arts community at large include the increased confidence that individual collectors and institutions will gain in the acquisition and care of acrylic based artworks. The acrylics conservation work being done by Greg and his few predecessors in this area will also impact curatorial academia through the eventual publishing of his and other findings.

Of key importance has been the creation and implementation of an analysis protocol for separating and identifying the many components such as surfactants, biocides, wetting agents, and dispersants that are extracted from acrylic paintings when they are treated with cleaning solvents. The protocol relies on a high pressure liquid chromatograph coupled to a mass spectrometric detector (HPLC-MS). This research has shown that the surfactants used to emulsify the acrylic polymer and to wet the surfaces of pigments are the most labile and abundant materials extracted from the paint. Mechanical and thermal analyses have revealed that the loss of these additives, which are actually vestigial once the paint surface has coalesced and cured, can possibly be beneficial to the painting, leaving it slightly less tacky and perhaps less prone to dirt pickup, fingerprints, and impressions from poor handling or storage. Further assessment of the changes in the tactility of the paints will provide additional information regarding the benefits and concerns of additive losses.

The Samuel Golden fellowship has prepared Dr. Smith for a career in conservation science research. He was recently named the first Andrew W. Mellon Assistant Professor of Conservation Science at Buffalo State College's art conservation program where he will teach materials science and instrumental analysis to graduate students in fine arts and archaeological conservation. Dr. Smith will also establish a research program at the college where he will continue to pursue studies of acrylic emulsion paints and other modern synthetic artists' materials. The proximity of Buffalo State College to the GOLDEN facilities in New Berlin, NY, will allow continued close collaboration between Greg and the scientists and engineers at Golden Artist Colors, Inc., an enviable partnership in the art conservation field and the artists' paint industry.

Acrylics have not been around long enough, and accelerated testing is not reliable enough to definitively prove that this won't happen.

But to this author, it seems far more likely that acrylic paintings will prove very long lived, especially if they are properly painted with high quality contemporary materials and well cared for. The weight of available evidence indicates that acrylics will prove to be more durable than oils, and oils have been around for 500 years.

Acknowledgements

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22 Other features of their chemistry are different. Car paints are highly cross-linked, and in the factory they are cured by baking at temperatures above 120 °C (250 °F).

Continued on page 11

Sam and Adele Golden Foundation[SM] for the Arts, Inc. Announces Award Recipients

The Golden Foundation, a family foundation created in 1997 as an enduring gesture to the memory of Sam and Adele Golden, the founders of Golden Artist Colors, Inc., is operated exclusively for the charitable purpose of promoting the visual arts by assisting and supporting the work of individual artists and art organizations. In a continuing effort to become a significant supporter of the art community, the Foundation identified four individual artists to be recipients of awards in 2004.

Mark Golden presented these individual artists' awards to Curt Barnes, Richard Harden, Haley Hasler and Teresa Stanley in recognition of their exceptional creative ability and innovative use of paint. The selection of individual applicants to receive an award was made by a committee consisting primarily of artists and art professionals of distinction. The committee's criteria focused on innovative uses of paint and quality of work.

The artists were chosen from hundreds of career professionals who applied by an independent selection committee consisting of Mary Murray, curator of Contemporary Art at Munson Williams Proctor Art Institute, Utica, NY; Dr. Dewey Mosby, Gallery Director (on Sabbatical) Picker Art Gallery, Colgate University; and Ronnie Landfield, a distinguished artist.

Curt Barnes received his MFA from Pratt Institute in New York City where he continues to live and work. He was awarded a residency at the British Academy in Rome, Italy and was guest editor of the College Art Association Art Journal issue on "constructed painting." He has exhibited widely in the US and Europe and most recently at the Whanki Museum in Seoul, Korea. This award will provide the opportunity for the artist to make larger paintings and assist him as he explores and advances his reach into the relatively uncharted realm of painting on a convex surface.

Richard Harden, a graduate of Syracuse University, began work on themes that 26 years later still influence the content and form of his painting. His work is included in permanent collections of the Metropolitan Museum of Art and the Vatican and is widely exhibited in the US and Europe. This award will help support a "Regions" project. The artist will explore how the cycle of form and epic human subjects bear on the present discourse and practice of painting and anticipate the future of the medium.

Haley Hasler received her MFA in painting from Boston University and is the recipient of a Fulbright grant. Presently she is an adjunct instructor of painting at Piedmont Virginia Community College. Her work is exhibited primarily in academic settings and is deeply autobiographical. The recent birth of her son is the underlying inspiration for a series of paintings. She hopes to transform her autobiographical self-portrait into a metaphorical, iconic character containing a more universal, human significance.

Teresa Stanley obtained her MFA from UC Berkeley and currently lives in rural Northern California. She is employed as Associate Professor of Painting at Humboldt State University. Her work is included in several corporate galleries and the American Embassy in Nairobi, Kenya. She has devoted her creative life toward seeking innovative ways to approach the painting process. This award will allow her to build painting surfaces of greater complexity and interest. It will assist her as she further develops her ideas in preparation for a solo exhibition in 2005.

In addition to supporting individual artists, The Sam and Adele Golden Foundation for the Arts, Inc. awards grants to cultural organizations. This year the foundation is accepting applications for cultural organizations who have received their 501-C3 IRS designation and whose purpose is to promote and support visual artists working in paint. In the year 2005, the Foundation will again award grants to professional artists working in paint. A full listing of grant awards, the application and additional information is available on the Web site: www.goldenfoundation.org.

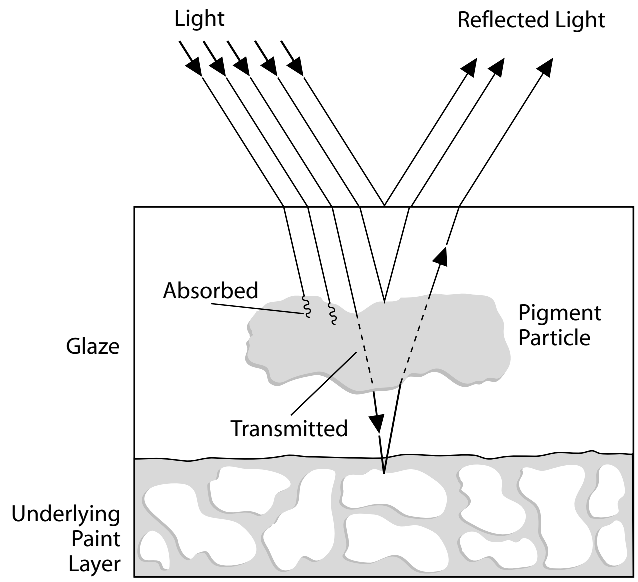
Defining *"luminous effects"*

Sarah Sands

This article examines the technical aspects of creating "luminous effects" in acrylic painting. By "luminous effects" we primarily refer to the use of transparent layers, called glazes, to create a sense of luminous, glowing color and depth. We will not touch upon Fluorescent or Phosphorescent pigments, which act by a completely different mechanism and literally emit light.

Early history

Prior to the Renaissance, artists created luminous effects mainly by the direct incorporation of transparent or highly reflective materials. Examples include the gilded surfaces of Medieval Icons, the richly colored stained glass windows of Chartres, or the glass tessera used in the mosaics of Ravenna. By the late 15th Century, with egg tempera paintings still the dominant medium, Northern painters developed the technique of using pigments bound primarily in linseed oil and applied in thin transparent layers over tempera underpaintings. [1] This method of glazing, which was first perfected by Jan van Eyck and marked the birth of oil painting in general, allowed painters to develop layers of translucent, luminous color for the first time. [2] Glazing spread eventually to the rest of Europe and played a major part in the technique of oil painting up through the Classical and Romantic periods, only falling out of favor after the advent of Impressionism and its preference for a more direct approach. Since then it became increasingly draped in mystique and seen as inextricably bound to the world of the Old Masters and more traditional, Classical styles in general. This is unfortunate as it ignores the significant and ongoing contribution of modern artists and materials in extending the possibilities that glazing had opened up and pushing this traditional technique in new directions.



Refractive index is the measure of how much a substance slows the speed of light in comparison to an ideal vacuum. In more practical terms, it can be thought of as the measure of how much it bends, or refracts light when compared to air. Because of this, the closer a pigment's index matches that of the binder, the more transparent it will appear.

Refractive Index of Common Materials

Air	1.0008
Water	1.33
Precipitated Silica	1.45
Glass (typical)	1.5 - 1.8
Linseed Oil	**1.48**
Acrylic	**1.49**
Ultramarine Blue	1.5
China Clay (Aluminum Silicate)	1.55
Calcium Carbonate	1.59
Cobalt Blue	1.74
Zinc White	2.01
Yellow Ochre	2.2
Cadmium Yellow	2.42
Cadmium Red	2.7
Titanium Dioxide	2.71
Red Oxide	2.8

How glazes work[3]

Glazes allow for a unique development of color that cannot be achieved by any other means. A bright yellow, glazed with a transparent red, will result in an orange completely different than if they were mixed together on the palette. There is a sense of luminosity and greater saturation of color caused by the light traveling through one or more translucent films before reaching the viewer. And because it is no longer tied to an opaque surface, color can describe light and atmosphere in many new ways.

The most common visualization of how glazes work has light passing through transparent pigment particles, as if they were pieces of colored acetate, eventually hitting the ground and being reflected back through the paint film once again, like light through a stained glass window. While perhaps useful as a metaphor, the actual mechanics are more complex. To begin with, colors appear transparent primarily as a function of the pigment's refractive index (see table) rather than light actually passing through the particles. Because the scattering of light is greatest at the boundary of two materials with very different refractive indices, the closer a pigment's index comes to the medium that surrounds it, the more transparent it will appear. Titanium White is opaque because its refractive index, 2.7, is much greater than the typical binders of oil or acrylic (~ 1.4), so it tends to scatter a maximum amount of light and possess excellent hiding power. Ultramarine Blue, on the other hand, is highly transparent because its index of 1.5 is much closer to the binder's own. The best colors for glazing, therefore, will nearly always be those that have a relatively low refractive index, like the quinacridones, phthalocyanines, and other organic pigments. Particle size will also play a role as smaller pigments will present a greater surface area to light, giving them a higher tinting strength and allowing even a very thin film to possess rich color. [4] The newer transparent iron oxides are a good example of this, providing the painter an alternative to the more opaque earth colors like Burnt Sienna or Yellow Ochre.

As a consequence of the pigment and the binder having a close refractive index, more light is able to enter the pigment particles where some wavelengths will be selectively absorbed while others are reflected back to the viewer. No longer neutralized by scattered, diffused light reflected from the particles' irregular surface, colors appear deeper, more saturated, and richer in tone. What light manages to pass through or between the particles is ultimately absorbed or reflected by the lighter, underlying ground, gaining a second opportunity to interact with the pigment particles before making its way towards the viewer. This complex interplay of light within the paint film creates the particular sense of glow and luminosity that is one of the prized attributes of glazes.

Since the binder's refractive index plays such a critical role in limiting the scattering of light, having the particles well bound in a paint film becomes crucial for creating a luminous translucent glaze. For this reason a glaze needs to be made with plenty of medium to insure the pigment is fully suspended. A 10:1 ratio of binder to color is a good place to start your mixtures. A very common mistake is to simply thin the paint with water, which only leaves the pigments more exposed to the air, where the scattering of light is greatest. Rather than a smooth translucent film, the paint will also tend to create a rougher, matte surface that further dissipates the light and leaves the color feeling washed out.

Lastly, it is important to remember that glazes will always lower the value of the underlying color. Less light, not more, is ultimately reflected back from a glazed surface, so it is important to keep the underpainting or ground at a higher value then you anticipate for the final result. This will also increase the sense of luminosity as more light is reflected back through the paint film.

Acrylics' versatility

Acrylics can create a fuller range of luminous effects than any other medium available. It can emulate stained glass when applied transparently over clear grounds like Plexiglas™; gilded surfaces with its range of Iridescent colors; the translucent washes of watercolors. Despite this incredible versatility, many artists still look to oils as the preeminent medium for glazing, often leaving the acrylic painter feeling separated from the great traditions and techniques that oil painting created. Contrary to those beliefs, however, acrylics can successfully emulate most of these effects, have a greater range of freedom in application, and better long term clarity and flexibility. And in a fraction of the time required by oils, an acrylic painter can more easily develop complex passages of translucent color. Which is not to say there is no room for improvement. Usually the fast drying nature of acrylics will be seen as the biggest stumbling block, although by using products like Acrylic Glazing Liquid and understanding how to increase open time, acrylics can be kept workable long enough to create very subtle and complex transitions (see our Technical Notes on Drying, http://www.goldenpaints.com/technicaldata/drying.php). In addition many painters assume the milkiness of acrylic dispersions might make it difficult to accurately judge the final appearance of a glaze since colors might shift in value as they dry. However, this effect is negligible and largely indiscernible in the very thin films typically used for glazes.

Advantages of acrylics

Beyond versatility, acrylics have several distinct advantages when it comes to glazing. Acrylic polymers will retain both their clarity and flexibility long past the time linseed oil begins to yellow and becomes more brittle. In addition, as linseed oil ages its refractive index increases, causing many colors to become increasingly transparent and therefore revealing underlying layers that were painted over. This is why pentimenti will appear long after a painting is completed, and many oil paintings will become darker when done on a toned ground. [5] In fact, numerous masterpieces have become hopelessly obscured because of this phenomenon. [6] Acrylics are also free from the common restrictions inherent in oil painting where rules such as thick over thin, fat over lean, and slow drying over fast, must be strictly followed to avoid cracking. These rules limit the ability of the oil painter to use glazing as part of a spontaneous process and restricts the choice of colors that can be used. By contrast, acrylic painters can apply an indefinite number of layers, of any color, and create incredibly complex surfaces in a relatively short time. And lastly, it has by far the widest range of viscosities at its disposal, from the nearly water-thin Airbrush Medium to the thickest of gels.

New areas & effects

Liberated from the need to keep glazes thin, acrylics can create dimensional glazes of almost any thickness by adding small amounts of color into our thickest gels. Textural glazes can be made using our Clear Granular Gel, Acrylic Ground for Pastels, or by using a gel to embed other translucent materials into. Some of the newest special effects pigments, like the ones used in our Interference colors, can create ephemeral and illusive effects when added to a gel or glazing medium and applied in a translucent layer. In other areas, acrylic glazes have found increasing roles in such important newer media as giclée and ink-jet prints, as well as contemporary printmaking and photography, where the acidic nature of oils would be archivally unsound. And of course acrylic glazes can play a significant role in the emerging area of multimedia works, where a variety of surfaces and materials must be dealt with, or in sculpture where its durability remains unmatched. In all, while acrylics can certainly allow artists to draw from the past, their advantages make them uniquely suited to extend glazing and its luminous effects into new areas of expression and emerging media.

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2 Philip Ball, Bright Earth, Art and the Invention of Color, University of Chicago Press, 2001, pp113-14
3 W. Stanley Taft Jr., James W. Mayer, The Science of Paintings, Springer-Verlag, New York, 2000, pp.66-74, 107-117
4 Brock, Groteklaes, Mischke, European Coatings Handbook, Hannover, Germany, 2000, pp 112-116
5 Mayer, Ralph. The Painter's Craft. An Introduction to Artist's Methods and Materials. Revised and updated by Steven Sheehan, Director of the Ralph Mayer Center, Yale University School of Art. 1948, 1991, pp 115-116
6 Sir C.J.Holmes, Director of the National Gallery London, Notes On The Science Of Picture Making, Chatto & Windus, London, 1927, Chapter XV

GAC Specialty Polymers

Dana Rice

You're seated at a white clothed table in an uptown restaurant; the chef has just placed an incredible creation down in front of you. You take a bite and a complex mixture of flavors and spice awaken your palette. You can't quite put your finger on it, but there is an ingredient that pulls the whole dish together, something added that brings out just the right flavor.

For many artists, that unique, additional ingredient for their work can be found in the line of GOLDEN products called Specialty Acrylic Polymers. Within the line, the products are identified by the letters "GAC" followed by a number. The letters "GAC" stand for Golden Artist Colors, but commonly the line of products is referred to as the "GACs" (pronounced: gaks, rhymes with yaks). The number that follows is an identifier, but does not have significance relative to any other product, or to the product's capabilities.

The Specialty Acrylic Polymers, or GACs, are formulated based on 100% acrylic dispersion polymers with only a minimum amount of thickeners, freeze/thaw stabilizers, defoamers and preservatives. The GACs are fluid and thin, and are therefore generally considered a component to be used in conjunction with something else, rather than as a stand-alone product. Each GAC represents a unique polymer that offers certain specific attributes; therefore, each GAC will have its own unique benefits and applications. They are building blocks.

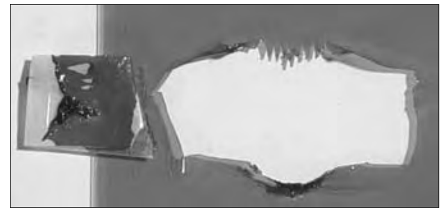
With this in mind, the GACs can be blended with GOLDEN Acrylic Paints to extend the paint, regulate transparency, create glazes, increase gloss, reduce viscosity or improve adhesion and film integrity. Since the GACs have minimal thickeners added, these polymers will reduce the thickness of most GOLDEN Acrylic Paints. GOLDEN Fluid Acrylics are slightly thicker than the GACs, but is the color line least changed in viscosity with any addition of a GAC polymer.

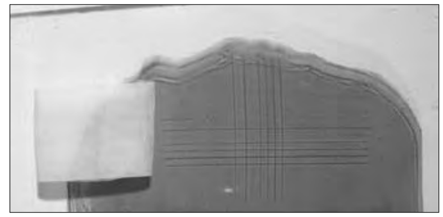
Over the years, the line of GACs has been developed based on requests for different types of building blocks containing attributes for specific applications or effects. What follows is a description of each GAC product and its particular attributes.

GAC 100 will wet out solids, including pigments, more readily than other polymers and is useful for artists formulating their own paints.

GAC 100 is a multi-purpose acrylic polymer. GAC 100 is ideal as a sealer for protecting against Support Induced Discoloration (SID), a condition resulting from impurities that are drawn up through an unprimed substrate as the acrylic paint dries, discoloring the paint. GAC 100 is also useful for diluting and extending colors, increasing flexibility and film integrity, sizing for fabric, and sealing for wood. GAC 100 will wet out solids, including pigments, more readily than other polymers and is useful for artists formulating their own paints. GAC 100 is soft and flexible, so if the color blends get too tacky, modifying with GAC 200 will reduce the tack.
Common Uses: Sizing, protection against Support Induced Discoloration (SID), linseed oil blocker, extending Heavy Body paints, paint-making with dry pigment

GAC 200 is an acrylic polymer designed for increasing film hardness. The hardest and least flexible of our polymers, GAC 200 is ideal for mixing with acrylic colors to increase film hardness and reduce dry film tack. This is particularly useful when using masking tools such as painter's tape. The increased film hardness ensures a cleaner edge when the masking tape is removed. In addition, GAC 200 can be mixed with acrylic colors for increased adhesion to nonporous surfaces such as glass or plastic. Due to the film hardness





Pictured here are images after a "Tape Pull" glass adhesion test done in the GOLDEN Lab. GAC 200 (bottom) demonstrates its ability to adhere to nonporous surfaces such as glass.

achievable with GAC 200, if the mixture contains more than 50% GAC 200, it is not recommended for use on flexible supports, as cracking may result. On rigid supports, a maximum of 75% GAC 200 is recommended.
Common Uses: Increase film hardness, reduce tack, masking techniques, increase adhesion on nonporous surfaces

GAC 400 is an acrylic polymer designed to stiffen natural fibers, including fabric and some types of paper. Fibers saturated with GAC 400, or GAC 400 blended with color, will dry to a hard, stiff film. Lightweight fabrics, such as cotton and linen, can be molded and shaped into fixed forms.
Common Uses: Stiffen and form fabric/paper, create sculptural elements, size canvas

GAC 400 is an acrylic polymer designed to stiffen natural fibers.

GAC 500, with a unique balance of film hardness and flexibility, is the hardest acrylic polymer within the product line that is still pliable enough to be used on flexible supports. GAC 500 offers increased leveling, increased mar resistance and decreased dry film tack. The increased film hardness ensures a cleaner edge when using masking techniques. GAC 500 is particularly useful for extending Fluid Acrylic colors with minimal property change. In addition, GAC 500 can be mixed with Airbrush Transparent Extender to create a fast-drying, sprayable isolation coat.
Common Uses: Decrease brush strokes, increase mar resistance, masking techniques, base product for airbrush sprayable isolation coat

GAC 700 has higher solids in the base resin formula than most other polymers (60% versus 48%). The higher solid content increases film clarity and transparency, while minimizing shrinkage. GAC 700 is useful for sealing porous materials. Relatively soft, GAC 700 blends can result in an undesirable degree of tack. Modifying the blend with GAC 200 will reduce the tack. The GAC 700 dispersion has a tendency to generate foam during application, so care should be exercised when brushing.
Common Uses: Increase transparency, seal cork

GAC 800 is an acrylic polymer designed to reduce crazing in puddles, pours, and other thin pourable paint applications. As puddles dry, uneven drying rates within the layers of the pour can result in "crazing," shrinkage crevices that run across the surface. The addition of GAC 800 to the acrylic color promotes drying with a smooth, even film. In addition, GAC 800 is also useful for adhesion to chalky surfaces. GAC 800 dries with good gloss and film flexibility, but with a slight "hazy" quality. When mixing GAC 800 with color, gently stir to avoid foaming. If foaming does occur, place the mixture in an air-tight container and allow to sit for 1-2 days, until the bubbles have enough time to rise to the top and dissipate.
Common Uses: Reduce crazing with puddles and pours, increase adhesion to chalky surfaces

GAC 900 is an acrylic polymer designed for fabric and clothing applications. When heat-set properly, the addition of GAC 900 to color lends painted fabrics a very soft hand and laundering stability. GAC 900 can be mixed with Airbrush colors to produce "tie-dye" effects on pre-wetted material, or blended with GOLDEN Heavy Body, Matte or Fluid Acrylics for brush or screen application. To further promote launderability during spray applications, GAC 900 may be used full strength as a basecoat, as well as a thin topcoat. Optionally, GAC 900 applied as a basecoat, then heat-set, will "seal" the fabric surface prior to paint applications. For thicker screen or brush applications, mix color with Silkscreen Fabric Gel, a gel product with the same soft-hand and launderability properties of the lower viscosity GAC 900.
Note: Provide adequate ventilation when heat-setting with GAC 900 as the process releases low levels of formaldehyde.
Common Uses: Soft-hand and laundering stability for painted fabric, "tie-dye" effects

GAC 800 is an acrylic polymer designed to reduce crazing in puddles, pours, and other thin pourable paint applications (left). As puddles dry, uneven drying rates within the layers of the pour can result in "crazing," shrinkage crevices that run across the surface (right).

Aspects of Longevity of Oil and Acrylic . . .
Continued from page 7

23 T. Learner, *Studies in Conservation*, *46* (2001) 225-241.
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GLOSSARY
Coalescence. To arise from the combination of distinct elements.
Plastics. Capable of being molded or modeled. Capable of adapting to varying conditions. Capable of being deformed continuously and permanently in any direction without rupture.
Polymers. Large molecules, usually formed by chemical reactions that join many small molecules (monomers) together. The molecules may be long chains or they may be chemically tied together (cross-linked) to form, in effect, a single giant molecule.
Monomers. Relatively small molecules that are capable of forming polymers.
Co-polymers. Polymers made from two or more chemically different monomers.
Emulsion polymers. Polymers and co-polymers that are manufactured by a process called emulsion polymerization. The result is a dispersion of small polymer particles in water. They are also called latexes. Emulsion polymers are the binders of most water-borne acrylic artist paints.
Acrylic polymers and co-polymers. Polymers in which the monomers are esters of acrylic acid and/or methacrylic acid. Depending on which monomers are used, they can be hard and stiff (Plexiglas™), soft and flexible, or anything in between. Frequently made by emulsion polymerization.
100% Acrylic co-polymers; 100% acrylics; pure acrylics. Co-polymers made entirely from acrylic and methacrylic monomers. May be emulsion polymers.
Acrylic/styrene and vinyl acetate/acrylic co-polymers. Co-polymers made partly from acrylic monomers and partly from less expensive monomers, styrene and vinyl acetate. Also may be emulsion polymers.
Poly(ethyl acrylate/methyl methacrylate) [p(EA/MMA)]. A class of 100% acrylic co-polymers made from monomers ethyl acrylate and methyl methacrylate.
Poly(*n*-butyl acrylate/methyl methacrylate) [p(nBA/MMA)]. A class of 100% co-polymers made from the monomers *n*-butyl acrylate and methyl methacrylate. Has largely replaced p(EA/MMA) in high quality house paints because of superior durability.
Linseed oil. The oil obtained by crushing flax seeds. It contains mostly unsaturated fatty acids that are capable of reacting with oxygen to form a cross-linked polymer. In a sense, linseed oil is a monomer.
Alkyd resins. Polymers made from vegetable oils (linseed oil, soybean oil) and certain petrochemicals. They are widely used in paints and to some extent in artist paints. The types used in artist paints are capable of further polymerizing with oxygen, like linseed oil.

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GOLDEN ARTIST COLORS®

Contents:

Quinacridone/Nickel Azo Gold

First the bad news:
We have been forced to discontinue our most venerable color, a color we introduced to the marketplace, and one that soon became our signature color — Quinacridone Gold. The pigment manufacturer will no longer support the required pigment, and despite an exhaustive search, there is simply no other source to be found.

Now the good news:
Through a vigilant effort, the GOLDEN Lab, led by fearless director Jim Hayes, has created a well-matched solution to the original Quinacridone Gold. By blending a Quinacridone Gold Red Shade with Nickel Azo, the new blend called Quinacridone/Nickel Azo Gold achieves the wonderful characteristics of the original Quinacridone Gold, including a warm yellow-gold quality in the undertone as well as a tight tint. Golden Artist Colors, Inc. is excited about the new formula and we hope you too will delight in its rich qualities. Watch for Quinacridone/Nickel Azo Gold in stores now. Samples of the new color are available upon request through Customer Service. For questions or assistance on specific projects, please contact Tech Support at techsupport@goldenpaints.com or 800-959-6543/607-847-6154
Mon. - Fri. 8:30 a.m. - 5:00 p.m. EST.