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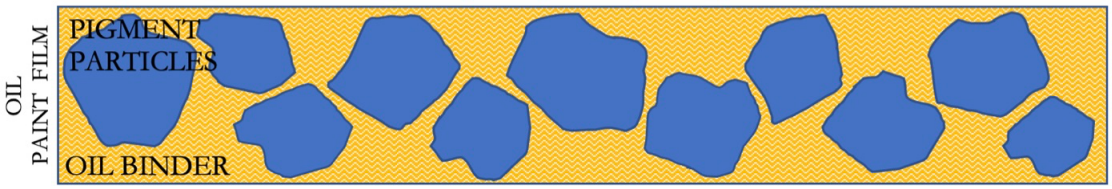
PIGMENT VOLUME CONCENATRATE[1]

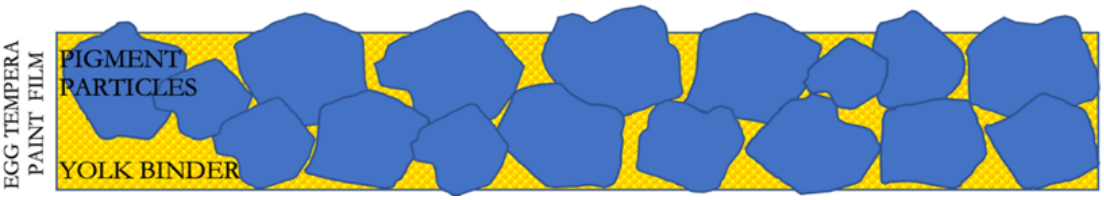
Pigment Volume Concentrate (PVC) is the amount of pigment relative to the amount of binder in a ground or paint.[2] **Understanding PVC is essential to understanding egg tempera in greater depth.**

In the critical PVC of many paints (oil, acrylics, encaustic) there is a greater percentage of binder (drying oil, acrylic polymer, wax) than pigment. In these paints, pigment particles are fully surrounded by binder.



In **high PVC** paints (egg tempera, casein, distemper) the amount of pigment is greater than the amount of binder (egg yolk, milk protein, animal collagen).[3] In fact, there is *so* much pigment that binder does not fully surround pigment particles, and pigment particles protrude above the surface of the paint film.
High PVC imparts several important qualities to a ground or paint film:

1. Porous and absorbent
2. Less plasticity, less flexible[4]
3. Irregular surface
4. Matte finish



[1] Thanks to George O'Hanlon at Natural Pigments and Sarah Sands of Golden Artist Colors for introducing and explaining PVC to me. The illustrations in this appendix are roughly accurate albeit over-simplified representations of paint films, intended to convey general characteristic. Actual paint films have greater complexity (such as more varied particle sizes and morphologies/shapes). For an in-depth discussion of PVC (including an explanation of CPVC, "critical pigment volume concentrate") refer to: www.justpaint.org/pigment-volume-concentration-and-its-role-in-color, Sarah Sands, and The Effect of Pigment Volume Concentration on the Lightness or Darkness of Porous Paints, Robert L. Feller and Noel Kunz. The MITRA forum also has several good discussions - enter PVC into the site's search engine: https://www.artcons.udel.edu/mitra/forums.

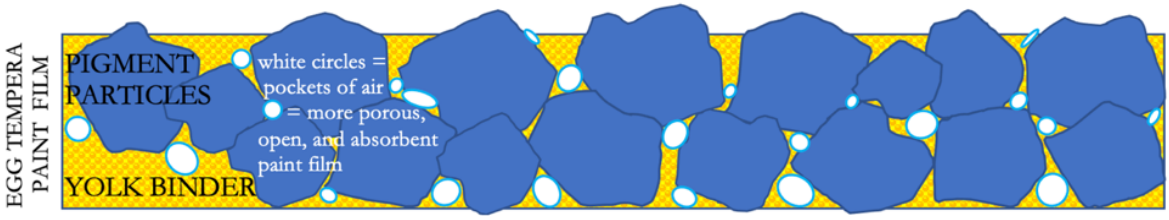
[2] 'Pigment' refers to particles of color but may also reference fillers or extenders added to a ground or paint. All grounds (gessoes) are formulated with a high solid content in order to create an irregular, absorbent surface that encourages adhesion between ground and subsequent paint or drawing layers; consequently **all grounds/gessoes are high PVC** (and you can presume high PVC characteristics for them). Paints, on the other hand, are *not* all high PVC; high PVC is a consideration for just a few paint systems.

[3] Egg tempera and casein have the highest PVC of any artists' paints, with approximately two to three times the pigment load of an equivalent amount of oil paint. Watercolor and gouache (gum Arabic binder) are also high PVC paints, but because they remain soluble (don't polymerize), they can't be built up in multiple layers to form a substantial paint film, and thus high PVC characteristics are not as much of a consideration. Pastel sticks (bound with gum or resin; or, with no binder, which is the apex of high PVC!) are used in such varied ways (sketching, drawing, painting) that the degree to which pastel embodies high PVC characteristics is varied, depending on how extensively the pastel is layered.

[4] The necessity that a tempera ground be 'high PVC' creates a dilemma for companies developing alternative gesso for egg tempera; the higher the PVC, the more porous and absorbent the gesso, the better its working properties for tempera paint. However the higher the PVC, the more a gesso is inflexible, friable, and prone to cracks or chipping. Natural Pigments' Tempanels are the most absorbent *alternative* gesso I've ever worked on, and absorbency is key to getting egg tempera to behave. However this absorbency is achieved via a very high solid content in the gesso (lots of chalk), which makes the gesso brittle. Thus, it's hard to incise into a Tempanel (i.e. to inscribe an architectural line or letter) because it tends to crumble, and when a Tempanel ground is cut very small and/or with a power saw, the edges are apt to chip. If Natural Pigments cut back on added solids, the panels would chip less - but then the surface would be less absorbent and the paint would more apt to misbehave. It's a tradeoff either way.

1. POROUS and ABSORBENT

In a high PVC paint, there is such a crowd of pigments that binder can't flow freely around particles to fully surround them. Instead, small air pockets appear within the paint film. Additionally, pigment particles jutting above the binder prevent a consistent 'sealing' off of the surface via an uninterrupted layer of binder.



The result is a more open, porous, and absorbent paint film. This porosity creates a delicious receptivity in egg tempera, so that layer upon layer of paint sinks into and interlocks with underlying layers. Absorbency gives the water content in tempera paint someplace to go; hence, as layers accumulate the paint increasingly dries a bit more quickly, which makes it less apt to lift and easier to control.[5] On the downside, porous paint films are vulnerable. Dust, moisture, pollutants and other problematic elements more readily enter in, to bind with or degenerate the paint.[6] A pigment's lightfast rating is more relevant, as pigments are more exposed to UV radiation. Varnishing (especially a UV resistance one) adds protection to this susceptible surface but, at the same time, a porous surface makes varnishing a more complicated and potentially problematic process.[7]

ABSORBENCY

• Absorbency in a **support** is created by porosity in the material (i.e. wood).

• Absorbency in a **ground** is created by a high solid content *and* a water-loving binder (such as animal glue, versus a water-repelling binder such as an acrylic or vinyl polymer [i.e. plastic]).

• An absorbent support allows a ground to sink into the support. An absorbent ground allows for tempera paint to sink into the ground. Sinking in allows layers to 'mechanically' adhere (akin to Velcro or sewing). In my experience, mechanical adhesion is important, perhaps critical, to true gesso and tempera's long term adhesion.

• An absorbent support and ground take up the water content in egg tempera paint. The more water is 'whisked' away from the painting surface, the more control the painter has over the paint, and the less apt paint is to lift (since water is the diluent/thinner for the paint).

• An absorbent support and ground are places for non-drying, mobile lipids in egg yolk to be stored. Without these storage areas, mobile lipids are forced to the surface to be expelled as 'fatty acid migration', which decreases plasticizing elements within the paint.
(FAM also can affect a painting's appearance but, if recognized, can be effectively wiped away).

• At the same time, a porous and water-loving support and ground continue to attract moisture throughout the life of a painting, which can be detrimental to the painting.

In summary: Absorbency in a support and ground helps egg tempera paint to behave and adhere in the long and short terms. Absorbency also continually invites in moisture, the enemy of durability. This is the double-edge sword of absorbency in an egg tempera support and ground. Each action taken to mitigate the faults of moisture absorption (i.e. work on an aluminum panel; synthetic polymer binders in gesso) also counters the *benefits* of moisture absorption! There is no ideal resolution to this conundrum. Whichever way an artist chooses to address these challenges, it will invariably be an imperfect solution.

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[5] A caveat: as layers accumulate, paint is less apt to lift *when applied with an experienced hand.* Inexperienced tempera painters who haven't yet mastered the brushstroke (i.e. work with a well-wiped brush, don't rework a stroke, etc.) can get lifting no matter how receptive the underlying surface!

[6] Some of the elements that may enter into a high PVC paint film include: moisture and UV light, which can degrade all materials and affect the permanence of certain colors (i.e. cadmiums, see https://justpaint.org/will-cadmium-always-be-on-the-palette/); inorganic acids, which can darken ultramarine; hydrogen sulfide and sulfur dioxide, which darken lead and mercury-based pigments.

[7] Among the challenges: a varnish sinks into a porous surface, resulting in an uneven application; a sunk-in varnish isn't as exposed to light and oxygen, and thus may dry very slowly; a varnish, ideally supposed to be reversible, meshes irreversibly with the paint film (particularly if a paint film is still cross-linking, i.e. polymerizing).

2. LESS PLASTICITY, LESS FLEXIBILITY

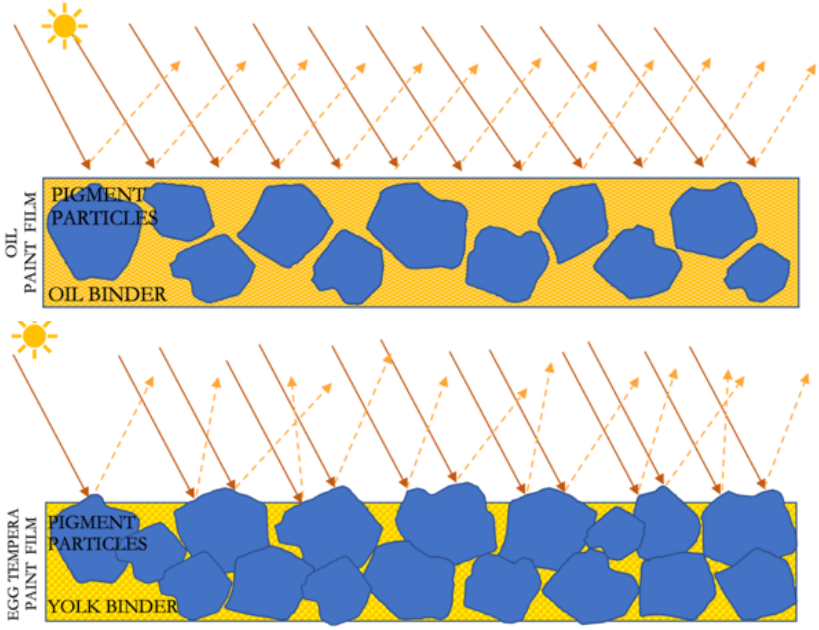
The various binders used to make paint all have some degree of plasticity and flexibility. Pigments do not. They are rigid solids, like tiny pieces of stone (many are literally bits of stone). The less binder, more pigment in a paint film (high PVC) the less plastic and flexible, more hard and brittle the paint is. On the upside, this means egg tempera is amendable to being scratched or carved into; draw a fine pointed tool across a tempera paint film and it yields a pleasingly precise, inscribed line that may be used to delineate architectural elements and lettering, or denote a whisker or wisp of hair. Do the same with a more plastic medium, such as oil, and instead of a crisp incision you're likely to get a ragged tear in the paint.[8] On the downside, high PVC, less flexible paint films are prone to cracking if the surface beneath flexes, contracts, expands. The high PVC of both traditional gesso and egg tempera paint is the primary reason for recommending a rigid support.

3. IRREGULAR SURFACE

On a microscopic level, a high PVC surface is irregular and rough. This creates good wetting properties and adhesion for paint layers (which is why all gessoes are formulated high PVC). An irregular surface also has vulnerabilities. Dust, pollutants and other impurities can settle into surface nooks and crannies, making the surface more difficult to clean or conserve. Surface pigments, not fully encased by binder, are partially exposed. This makes them more vulnerable to abrasion, and a potential liability for painters who work with toxic colors and regularly touch a painting's surface. An irregular surface also has consequences for tempera's finish, as discussed next.

4. MATTE FINISH

A smooth paint surface (oil, encaustic, most acrylics) reflects light consistently – akin to a sheet of polished glass or mirror. Values and colors appear richer and more saturated, like a dry rock dipped into water.[9] The resulting finish has a shine: either satin, semi-gloss or high gloss, depending on how consistently smooth the surface is.



The irregular surface of a high PVC paint, on the other hand, scatters light; it behaves more like frosted glass. This creates a matte or 'eggshell' surface, the natural finish for egg tempera. Slight variations occur depending on how well an artist has tempered the paint (i.e. an *under* tempered paint [less binder] appears more matte; an *over* tempered paint [more binder] has more shine), and the size and morphology of pigments (larger, more irregularly-shaped pigments [historic and natural earths] produce a more matte finish; very small and regularly shaped pigments [many modern colors] create a smoother surface with greater shine).

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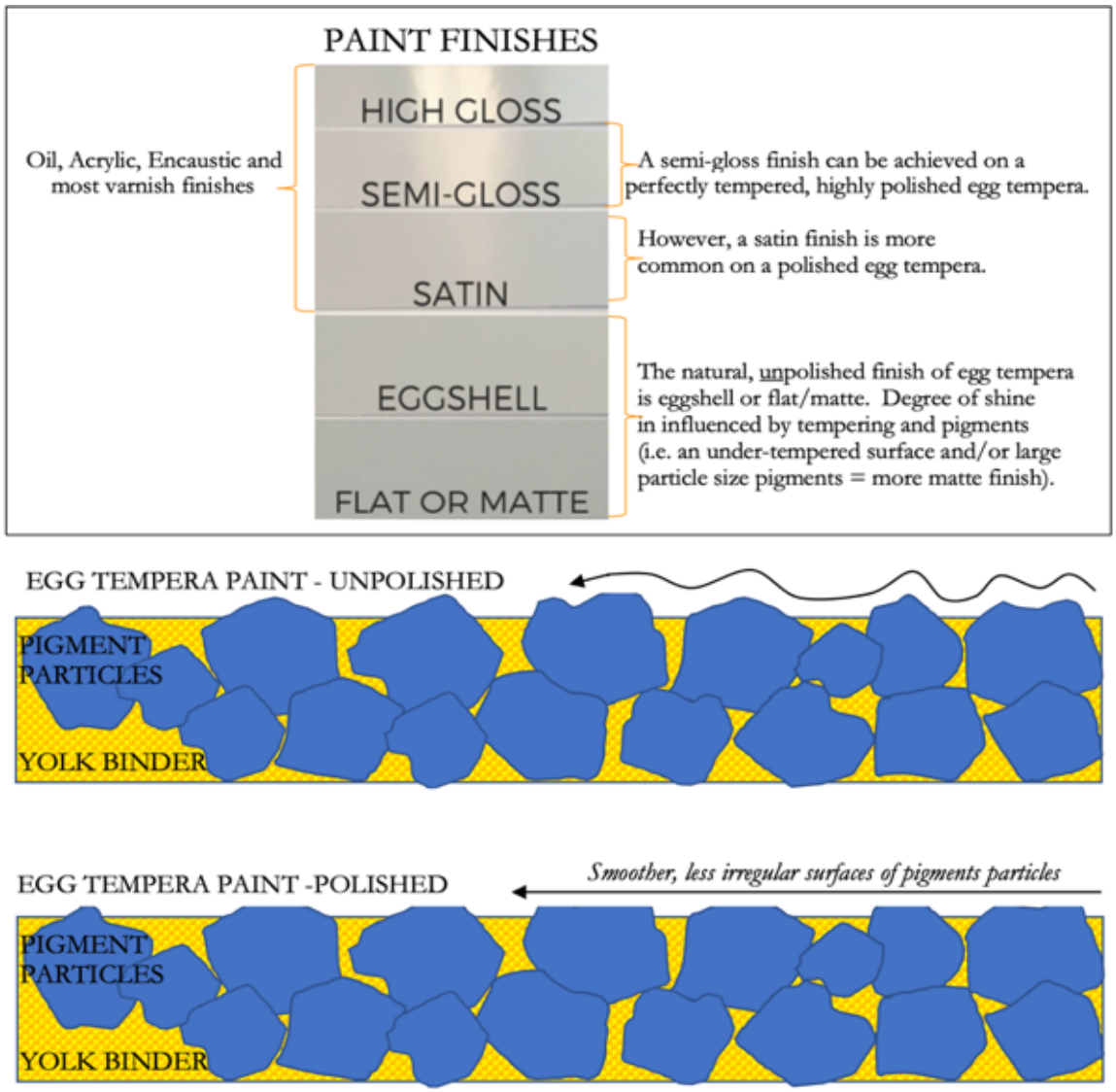
[8] The first time I used a sharp point to incise lettering into a tempera grassa (egg and oil emulsion) painting, I was surprised by how prone the paint was to ragged tears; it was nothing like the crisply etched lines I was accustomed to making in pure egg tempera.

[9] There is a misconception that egg tempera paintings are more colorful because artists work with pure pigment, and/or because the medium's pigment load is high. All paints contain the same, 'pure' pigments; and high PVC, because it yields less saturated paint films, can actually decreases the chromatic intensity of some colors. For more on how value, chroma and opacity are affected by PVC, see Sarah Sand's article, https://www.justpaint.org/pigment-volume-concentration-and-its-role-in-color/



The natural, low shine finish of egg tempera can be increased, potentially dramatically, via polishing. As long as the paint is sufficiently well-tempered (so that pigments stay bound to each other and the ground), a gentle but consistent buffing with a soft cloth decreases (on a microscopic level) surface irregularity, which in turn increases shine. Through careful, gradual polishing I've seen a genuine gloss finish (akin to fine porcelain) brought out on egg temperas composed of properly tempered paint and modern, small particle size pigments.[10]

Whether your preference is for a matte finish or more enhanced shine, understanding tempera's high PVC can help you achieve your finishing goals. Above average pigment content is among egg tempera's notable characteristic, and understanding the pros and cons of high PVC takes you a step closer to mastering the medium.

[10] Isolating and/or varnishing are other ways to increase gloss on a tempera painting because applying a consistent coating evens out surface irregularities.