REFINING LINSEED OIL

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There are now six different refining procedures, a specific bulk oil procedure, and the Emulsion Pre-Wash concept, an effective addition to any procedure. This update also features a refining method using the immersion blender. Have fun, make great paintings, and please ask me any questions.

THE FLAX OIL MINEFIELD
Also, please note that the flax oil used must be pure. Recently, flax oil has often been marketed with an “anti-oxidant mix” that contains sunflower oil. This oil cannot be made to dry quickly. Read the label carefully, it needs to have one ingredient, unrefined flax oil. Still, there are ‘bargain’ companies who simply lie. Amazon is now a complete minefield of cheap ‘linseed’ or ‘flax’ oil that is best avoided. For example, the Dr. Adorable brand flax oil, though labelled as “pure,” does not work for this method. On the east coast of the USA, Jedwards is a good source. On the west coast, Azure Standard is a better source. The raw Swedish linseed oils by Allback and Ottosson are also becoming increasingly available; I feel the Ottosson oil is better for fine art painting. The very high quality nutritional oils such as Flora or Barleans are also reliable, though inevitably more expensive. Unrefined linseed oil is orange, even dark orange. The wet colour is fugitive, and has nothing to do with the dry colour of the oil! If the oil is yellow, this is a sign of some form of processing or adulteration. Over a decade of answering reader questions suggests that you are far better off learning with a proven oil than wasting time and money on bargain oil.

INTRODUCTION
The goal of the refining process is to make an oil that dries hard, and yellows as little as possible. A stronger paint film occurs when the non-polymerizing components are removed, and quality refining of quality oil also makes the oil less prone to yellowing. This is especially important to modify the behavior of linseed oil, the oil which can dry fastest, and makes the strongest paint film, but whose high proportion of linolenic acid (C18:3, Omega 3) can cause yellowing, wrinkling and drying from the top. Commissioned by Her Majesty’s Government to save English painting in the 19th century, Eastlake typically explores many technical avenues based on older practice, but he gives succinct directions for linseed oil: it is to be cold-pressed, and washed thoroughly with salt and sand before any further modification or use.

Subsequently, not as much attention has been paid to beginning with a quality oil, or the long term potential of the non-polymerizing components or incautious processing to darken the paint film. The commodification of the paint, and mainstream art supply propaganda, mean the craft of the oil is now lost to most painters’ frame of reference. The 20th century wanted brave new paint for brave new painting, but this did not change the chemistry and physics of the planet. Linseed oil was crucial to the general paint industry for most of the 19th and the first half of the 20th century, and the vast majority of the oil produced was for this purpose. Given that modern paint manufacturers do not refine their
own oil, this situation may have created unavoidable yellowing issues at certain times due to the unavailability of higher quality oil. The oil used for painting was, during most of the 20th century, commercially refined, and often hot-pressed. The significant change in the crucial department of oil quality was so taken for granted that it was not thought – despite the presence of Eastlake's *Methods and Materials*, for example, in the bibliographies of all mid to late 20th century painting manuals! – that a procedure with origins in De Mayerne might be worthwhile or feasible. Yet, the darkening of the oil is a given in early 20th century books; the quest for how to avoid this is the focus of the entire text of Abendschein's *The Secret of the Old Masters* (1909). Recent conservations texts\(^1\) also suggest that all the various ‘scientific’ innovations of the 20th century coatings industry – most notably aluminum stearate – to oil paint have resulted in paint with a much shorter life expectancy.

Hand-refining a cold-pressed introduces a qualitative change to the painting process. Oil refined by Eastlake's sand and salt method dries about three times as quickly as either unrefined oil, or commercially refined oil. This oil has more body, or elasticity, in paint and mediums than its commercial counterpart, especially when autoxidized, and is virtually non-yellowing when it has been aged in the light or buffered in the putty medium. When aged in the light it also becomes more *gelatinous and elastic*, translating these qualities especially to handmade paint. Because the oil is the foundation of both the paint and the medium, this means two things. First, that the entire system can be constructed around a material that dries quickly and stably. Second, that the most important constituent of the process is not subject to the increasingly dubious definition of quality prevalent within mainstream art supply propaganda.

Sand and salt refined linseed oil is a significantly different material than even the most high quality or pedigreed commercial oil. Working with the first batch of this oil in 2007 was a revelation: the origin of certain more bravura techniques, and why linseed oil could have been preferred, finally became clear. From the perspective of the often shallow punditry in print about the behavior of linseed oil, it is important to note that *no commercial testing has ever been done on this oil* for the simple reason that it is not commercially available. The “linseed oil” of research is a different product entirely, not necessarily cold-pressed, and either unrefined, or commercially refined. These constitute substantial differences in practice. Organic linseed oil refined with salt and sand (the S&S method) offers a stable foundation for further manipulations in terms of rheology and working qualities. The materials that have evolved from this oil help explain why the use of resin in older painting turns out to be more tangential than was once generally believed. Using permutations of S&S linseed oil for the paint and medium, resins – and solvents – become optional, as technical art history has proved is the case with older practice.

For painters working with more emphatic techniques, the behavior of S&S linseed oil provides straightforward access to older methods, and is especially focal if using the putty medium – calcium carbonate and oil – for a broken surface approach. For smooth surface techniques, or those exploring a long open time, this is not as crucial; any of the other refining methods can be used.

**ORGANIC LINSEED OILS**

Organic, cold-pressed, unrefined linseed oil is now widely available because of its positive role in human nutrition. It is typically found in a health food store, but can almost always be purchased more economically online in quarts, gallons, or five gallon pails. Another possible source is the discount grocery or dented can store, as the expiration date is immaterial for painting. The product is called flax oil, not linseed oil, and is offered several

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\(^1\) Such as *Issues in Contemporary Oil Paint* (2014), edited by Klaas Jan Van Den Berg
in variations. For painting purposes, the plain, direct-from-nature variety is required, not “high lignin,” “strawberry shake,” or “lemon parfait.” The purity of the oil and the care with which it is extracted are unprecedented; some varieties are processed well below the 100°C limit of cold-pressed oil and packed under nitrogen. There are also brown seed oils from Sweden, such as Ottosson and Allback, traditionally pressed for painting, that are very high quality.

Avoid bargain oil, which is always adulterated! To create a fast drying oil, the flax oil used must be pure. Also, “budget” flax oil is being marketed with an “anti-oxidant mix” that contains sunflower oil. This oil cannot be made to dry quickly.

The quality of oil being marketed for painting has generally improved from earlier in the 20th century, but is still well below that of a cold-pressed organic oil. Once this oil is refined – by a process designed to increase the ability of the oil to polymerize, rather than by the standard commercial process for edible oils, designed to minimize the oxidation of the oil – it offers the foundation for a simple, yet versatile and uniquely powerful system.

TRADITIONAL REFINING PROCEDURES
There are three major sources of historical procedures in English. These establish the ingenuity and concern that older painters brought to the fundamental issue of refining the oil. The oil with which older painters began was probably fragrant and turbid, just as it was pressed from the seed at a relatively low temperature compared to modern oil.

Four traditional refining approaches have been reconstructed here:

1. Washing the oil in water over an extended period with or without salt
2. Removing impurities via ethanol
3. Boiling the oil in water to destroy the mucilage
4. Refining the oil using fresh snow

The fact that the oil is affected by sunlight via photo-oxidation is often factored into a given procedure. For example, the oil is washed, but specifically in the sun; litharge is added, the jar then exposed to the sun and shaken daily, etcetera.

All of these procedures improve the oil, but especially so if beginning with an unrefined cold-pressed oil. This is because, in addition to removing the mucilage and phospholipids, the commercial refining process focuses on removing the fatty acids that cause oxidation – rancidity – in an edible oil. Earlier texts, like De Mayerne, tend to collect any procedure of interest, but by the 19th century, variations of water washing begin to be more prevalent. Eastlake (I, 331-334) focuses on a particular recipe given to De Mayerne by the German painter Sorg (313). In the manuscript itself, De Mayerne notes that the oil is “well-defatted” by this process. This procedure involves washing the oil repeatedly – fifteen times – by shaking it with a mixture of rainwater and salt, then allowing the cleaner oil to separate. The oil is then washed three times with rainwater. Unfortunately, the amount of salt, and the ratio of water to oil, is not given. Whether on his own, or by consulting other painters of his time period, Eastlake develops the procedure to include sand, another traditional refining agent mentioned in De Mayerne, and recommends a six week procedure: shaking the oil several times each day, changing the water, sand, and salt every week, and finishing

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2 The first is the English translation of the De Mayerne Manuscript (Sloane 2052) published in Lost Secrets of Flemish Painting (2001) by Donald Fels. The second is Eastlake’s Methods and Materials published in 1847, which goes over other historical sources, as well as 19th century commercial methods. The third is Merrifield’s Medieval and Renaissance Treatises on the Arts of Painting (1849). An excellent summary of older procedures is also part of Rembrandt and his Circle: Seventeenth Century Dutch Painting Media Re-examined by Raymond White and Jo Kirby in National Gallery Technical Bulletin 15. These technical bulletins are all free online.
with a pure water wash for a week. Eastlake states unequivocally that this procedure is the prerequisite to make the oil ready for painting. The oil can then be used as is, aged, thickened in the sun, or treated with lead salts.

In her extended and recommended preface, Merrifield concurs with the usefulness of the procedure outlined by Eastlake. One of the texts Merrifield translates, *The Marciana Manuscript* (16th century Venetian), also lists a boiling water method of refining the oil. In his early *Facts About Processes, Pigments, and Vehicles, A Manual for Students* (1895), Laurie also goes into a variation of the washing procedure, and Arthur H. Church, Laurie's predecessor at the Royal Academy, mentions the process in *The Chemistry of Paints and Painting* (1915).

**THE CHEMISTRY OF THE PROCESS**

The older washing process is simple compared to the complex set of steps involved in refining an oil commercially, but surprisingly effective. Shaking the oil and water together greatly increases the amount of surface area of oil that is available to be acted on by the water and its ions. A liter of oil broken down into 100 micron (0.1 millimeter) droplets has a surface area of approximately thirty square meters. The addition of sand also plays a significant role. Silica (silicon dioxide SiO\(_2\)) is often thought of as inert, but it is coated with silanol (SiH\(_3\)OH), which is not. Silica particles also exhibit a complex set of electrical fields when surrounded by water. As an alcohol, silanol helps remove impurities and free fatty acids, while the electrical fields of silica allow it to act as a catalyst in the presence of other ions such as calcium. As such, the cleaning action of sand in hard water is enhanced: the sand, in these cases, becomes a solid mass of embedded grease. Further, while the combination of water, time, and light may not appear to be “doing much,” modern research has confirmed that various impurities are removed, and the fatty acid structure of the oil modified by this process through a combination of oxygenation, dimerization, and cis-trans isomerization, effectively pre-polymerizing the oil to some extent. The addition of salt to the water disrupts the loose hydrogen bonding in pure water by providing positive sodium and negative chlorine ions which, because of their opposite electrical charges, orient the water molecules around them in different ways. This means that the proverbial surface tension between the water and the oil is reduced in proportion to the salinity of the water. In conjunction with the great increase in the oil's effective surface area achieved by shaking the jar, this makes salt water efficient at separating impurities – mucilage, and the water soluble phospholipids – from the oil. While low levels of salt in the water have an antioxidant effect, higher levels (between 66 and 200 grams of salt per liter) have a pro-oxidant effect. At these higher concentrations, the dissolved salt releases oxygen from the water, acting as a catalyst for oxygenation of the oil, and also assisting in the breakdown of hydroperoxides by reaction with small amounts of the typical transition metals in the water. In the case of iron, for example, free hydroxyl ions form the insoluble ferric hydroxide, which can be seen in amorphous brown patches between the oil and the water. Research by Carlyle (Molart Fellowship: *Historical reconstructions of artist's oil paint: an investigation of oil processing methods and the use of medium-modifiers, 2000*) has shown that the addition of salt to the process aids the drying rate of the oil. Experience has confirmed that a non-yellowing oil with a much faster drying rate than a commercial cold-pressed linseed oil can be produced using a high level of salt in addition to water as a refining agent. Increased low level electrical activity from large concentrations of sodium and chloride ions allows the water to give up oxygen to the oil more readily, effectively pre-polymerizing the oil without making it thicker. Recent lipid research has also established that the small percentage of free fatty acids in a high quality oil is unusually active within a water emulsion at promoting oxidation: not helpful for an edible oil, but very helpful for a painting oil.
Oil refined by the washing procedures that follow exhibits none of the negative characteristics long associated with lower quality commercial linseed oil. These oils do not skin or wrinkle, dry hard without gumminess, and, once aged in the light, preheated, or used with a natural calcium carbonate, do not yellow perceptibly in pigment. Tests done with this oil a month after refining show barely perceptible yellowing after eight months on a white gesso ground. A three year old oil aged in the light exhibits no yellowing after this time period. Thicker auto-oxidized oils may yellow somewhat, preheating the oil before auto-oxidizing it minimizes this. In terms of long term yellowing resistance, several older sources point out that the older the oil is, the better. In my experience this is true. But also keep in mind that a linseed oil film brightens in the light, and darkens in the dark. A detailed PDF about the many factors that affect the yellowing of linseed oil, and how to circumvent them, is available [here](https://example.com).

The older sources also make numerous mention of procedures involving traditional varieties of lead: lead carbonate, lead oxide (litharge), and basic lead metal. In the De Mayerne formulas, lead salts and light are often used as refining agents without water. While research has shown that lead does modify the fatty acid structure, and a small amount of a lead compound helps the oil dry faster without inducing yellowing, most painters now want to avoid lead if possible. The fastest drying system uses S&S linseed oil for the paint and medium. The system also works well with quality commercial paint, using variations of S&S oil in the medium.

**REFINING OVERVIEW**

*The Water:* The washing procedure is very sensitive to the type and quantity of ions in the water. Tap water is fine to use unless it is quite hard, in which case spring water or distilled water will capture less oil. When in doubt, use distilled water. The branded oils packed in quarts are new, dated, and often kept under nitrogen. Oils marketed in bulk in gallons or five gallon pails are older, significantly less expensive, and have been exposed to more oxygen. Branded oil is extremely pure and extracted at a relatively low temperature (50°C is stated for the Flora brand, as an example). However, the qualitative difference from the use of the more expensive oils is small to moderate, the behavior of the final oil at the easel is the very similar. Although most organic flax oils have been filtered, some bulk oils contain a natural precipitate that alters the colour towards green: this is removed by washing. All edible organic cold-pressed flax oil encountered has had a relatively alkaline smell, the branded oils being freshest and most floral. Quality cold-pressed oil for painting, manufactured in Europe — easel or house, organic or not — can be significantly older, and may have a more industrial odor, but is sourced from an historically excellent location for growing flax for painting oil and works well for this process.

*The Salt:* The least expensive fine salt available at larger grocery stores in America is pickling salt, available in four pound boxes. The least expensive clean salt is the fifty pound bag used for water softeners, although it must be ground prior to use. A medium size electric coffee grinder works well for this, pulverizing the salt quickly. A bulk source that is finer is salt for domestic animals from a farm supply store. Sea salt is fine to use, the most important thing for any salt is no additives.

*The Sand:* To function, the sand must be silica sand. #20 grade silica pool sand (cracked flint) is ideal for this procedure but is usually only available in 50 lb. bags. Alternatives for silica sand can be the sand used for gas fireplaces, the sand used in smoking urns, graded lab sand, sand for succulents, etc. Aquarium silica sand is too fine to use without capturing oil. This can be spun free but is often more stuck than it first appears.

Processing linseed oil by hand is an inexact science. It can be messy as oil is transferred from jar to jar; a sheet of plastic can be helpful for protecting a work surface or maintaining...
domestic tranquility. The procedures below are straightforward, but variables of processing ingredients, oil quality, oil age, and ambient temperature can cause slight changes in practice. Even a series of jars processed the same way may show variations.

A NOTE ON REFINING HEMP OR WALNUT OIL
The fatty acid structure of walnut oil means drying speed will not increase greatly if it is washed with sand and salt. Some increase in body and drying speed occurs, especially with the very high quality European artisanal oils, or with an organic cold-pressed nutritional oil sold under nitrogen. Also, walnut oil is very sensitive to calcium ions and needs to be washed with distilled water to avoid persistent emulsions.

The fatty acid structure of hemp oil is halfway between that of walnut and linseed, as is its behavior as a painting oil. Hemp can be made to dry more quickly by refining with sand and salt. The green colour is from chlorophyll and is fugitive. Hemp is less yellowing than expected but also makes a somewhat soft film by itself. Organic unrefined hemp oil is reasonably priced at this point. Again, make sure it contains nothing but hemp oil.

THE S&S METHOD
The length of Eastlake’s procedure led to a search for a similar but faster approach. By hand – Method 1 below – three factors emerged as significant. First, that the water is hot to begin with, 60°C (140°F) is sufficient and poses no risk of cracked jars. Second, that the sand is somewhat coarse silica. Third, that the oil is shaken thoroughly, then shaken again several times while the water is warm. This procedure maximizes the oxygen available to the oil when the interface between them is most intimate. The procedure can also be done using a small immersion blender – Method 2 below – which has somewhat different technical priorities and may clean the oil more efficiently. A water emulsion prewash can also be incorporated – Method 3 below – which shortens the number of washes needed. The oil is always turbid during the process from the water it contains.

FORMULA ONE – SALT, SAND, & WATER (S&S) REFINING

METHOD ONE: BY HAND
For each half-gallon or 2000 ml glass canning jar:
0.50 liters (2 cups) cold-pressed unrefined linseed (flax) oil
120 cc (½ cup) pool sand or other coarse silica sand
190 g (If fine, this is 135 cc or 9T) plain or sea salt
0.75 liter (3 cups) hot water, tap or distilled, at 60°C (140°F)

First Wash: Add the oil and sand to the canning jar. In a second jar, or similar container, dissolve the salt in the hot water and add to the oil and sand mix. Lid the jar tightly and shake it until it has emulsified. Allow it to rest, then shake it again off and on over a period of ten minutes. The mix emulsifies more quickly, and remains emulsified longer, as it cools, but it is important not to skimp on shaking, which creates a fine interface between the hot salt water and the oil. After the rounds of shaking, clearing, and shaking again, the bright yellow emulsion slowly separates into a layer of orange oil on top, and a variable layer of impurities (possibly solid, possibly hanging in a loose skein) in the middle between the oil and water. This takes about half an hour to an hour. The jar is then spun gently until the impurities detach, droplets of oil may also release from the sand and rise. Or, plain cold water can be gently added from the top, separating the layer of break from the oil. At this point most of the oil can be removed to a new jar using a bulb baster, but waiting overnight or a few days is fine. Cold water is then added gently to the first jar, bringing the remaining
oil to the top. This can be moved to a new jar with a small ladle, a bent spoon, or a large syringe. Small amounts of impurities can continue to the second wash. If processing several jars at once, the oil can be consolidated into 0.50 liter (2 cups) or a little more again for each jar. Any leftover oil can be added to the first wash of the next batch of oil, if that occurs within a week or two. An efficient oil recovery program adds up in terms of the amount of final product. The first wash removes about 10 percent of the oil by volume.

Second Wash: This repeats the same ingredients and procedure as the first. The mix will not emulsify fully, and more rising and falling activity – the lava lamp effect – may be seen between the oil and the sand. Small amounts of leftover oil can be consolidated and recovered, or incorporated into a future washing cycle. Oil volume is reduced by 10 - 15 percent.

Third Wash: Repeat the ingredients and procedure of the first wash, then transfer the oil to a clean jar. Again, about 10 to 15 percent loss. Note: The third wash is optional when using high quality, extra-fresh branded oil, or any of the pre-washes, see the Refinements heading below.

The Standard Rinse Cycle: One rinse is up to 0.50 liters of oil (2 cups) shaken with 1 liter (4 cups) of distillate, spring, or filtered tap water and 80 g (¼ cup) of sand. This is done three times, changing the water each time, a syphon can be used, a rinse can be done each day, or every two or three days. The sand can remain the same unless it becomes clogged. After the final rinse settles for a few day, a fine line of light yellow break can usually be seen between the oil and the water. The oil can now be carefully removed from the water with a baster or large syringe. Water is then added so the remaining oil it close to the top of the jar, making it easy to ladle or spoon off. This oil needs to be clean. Leftover oil can be consolidated, making it easier to recover. The refined oil is somewhat lighter in colour, but turbid or cloudy due to significant residual water in the oil. Letting it rest a day or two after the final rinse, before decanting, lets most of the trapped water fall out. Further processing instructions follow the alternate methods below.

SECOND METHOD: USING AN IMMERSION BLENDER

Acid Prewash: (See also page 16 for acid pre-wash details). To 750 ml cold-pressed, unrefined linseed oil, add 600ml distilled water and 150ml raw apple cider vinegar. With the immersion blender on low or medium, blend for 30 seconds, wait five to ten minutes, then blend again for thirty seconds. Let this sit half an hour or more, then spin the jar from side to side lightly for a minute. Syphon off the vinegar-water mix with food-grade vinyl tubing, ⅜ to ⅝ inch diameter or similar, or larger diameter aquarium airline tubing.

First Wash: Add 750 ml distilled water (3 cups) and 190 g (135cc or 9T) plain or sea salt to the oil in the jar. Blend on low or medium speed for fifteen seconds, wait five minutes, then blend again for fifteen seconds. Allow the oil-water mix to separate; this takes an hour or two. There will be a yellow layer of break between the water and oil. Insert a long handled wooden spoon into the mix and stir it gently but thoroughly for a minute. Wait an hour for more impurities to emerge. Now insert a small ladle into the top of the jar, just above the oil level, and gently add 175 ml distilled water. This water falls below the oil, between the break and the salt water. Globules of oil then begin to seep out of the break, rising to the main oil mass. Let this sit overnight; the break loses its yellow colour and may detach and fall into the salt water. Then syphon both the salt water and the break out of the oil, being careful at the end not to pick up oil.

Second Wash: This repeats the procedure of the first wash.
Third Wash: In the third wash, add 750 ml distilled water to the oil, but now add 200cc pool sand or coarse silica sand. Stir this thoroughly with a long wooden spoon, then wait a few minutes, three times: three cycles of stirring and waiting. Then add 200cc salt and stir well with the wooden spoon. After an hour a large amount of gray break has separated from the oil. Again, insert a small ladle into the top of the jar, just above the oil level, and add 175 ml distilled water gently to separate the oil from the salt water and break. This time remove the oil from the top with a baster or ladle, and place it in a new half-gallon jar. Note: The third wash is not necessary when using high quality, extra-fresh branded oil, or any of the pre-washes, see the Refinements heading below.

The Immersion Blender Rinse Cycle: The rinse cycle can be done with distilled water, spring water, or filtered tap water if the tap water is relatively soft. Add water to the jar to the level of 1500 ml, then stir gently but thoroughly with a long handled wooden spoon for a minute. Allow the water and oil to separate, then repeat this cycle two more times for a total of three rinses. The rinses can be done one after the other, but clean the oil further if one rinse is done per day. Larger amounts of oil can be rinsed in 2.5 gallon spring water containers with spigots. The oil is always turbid after rinsing. About one third of the original oil volume is lost with this method.

THIRD METHOD: WATER EMULSION PREWASH

Prewash: (See also Emulsion Prewash, page 15). Place 0.75 liters (3 cups) of refined cold-pressed linsed oil in a half gallon jar. Add 150 ml (10T, 5 ounces) distilled water in 30 ml (2T, 1 ounce) increments, shaking well after each addition. This emulsion is re-shaken every 2-3 hours. It may break slightly overnight. Hold this emulsion for at least 24 hours before proceeding, an extra day or two shortens the oil’s drying time slightly.

First Salt Wash: After a day or more, add 600 ml (2 cups + 3.5 ounces) distilled water, spring water, or rural rainwater, 135 cc (9T) salt and 120 cc (1/2 cup) coarse silica sand. Shake for two minutes. Let sit five to ten minutes, then shake again for two minutes. Repeat this cycle a total of three times. After a few hours or overnight, the oil rises out of the salt water, and the mucilage has fallen away from the oil. Due to the water prewash, the mucilage separates in shards or rag-like clumps. Once the oil has separated, gently add 60-90 ml (4-6 T) distilled water using a bent spoon or small ladle sitting on top of the oil to soften the entry speed. Due to differences in specific gravity, this water falls below the oil, but remains above the salt water and silica. This allows the oil to be removed from above with a bulb baster, or from below using a syphon.

Second Salt Wash: The procedure is the same as the first salt wash but uses 750 ml distilled water to begin with, and 180 cc (12T) salt. A third salt wash is not necessary because of the emulsion prewash.

Rinse Cycle: This follows the Standard Rinse Cycle of Formula 18, Method 1, above.

CLEARING THE OIL AFTER RINSING

Method 1- Waiting: Simply let the oil sit on the final rinse water until it clears, then remove it. This can take anywhere from three days to a week, a sunny windowsill and low humidity conditions are helpful.

Method 2 - Low Oven: Small amounts of oil can also be cleared by placing the jars on a baking sheet in a low oven (95°C-200°F) for a few hours. A gas oven with a pilot light typically clears the oil in two or three days.

Method 3 - Sunny Windowsill: The jar of turbid oil is covered with cheesecloth or gauze, secured with string, or the band of a canning jar lid, and placed in a sunny windowsill until it clears, usually in a few days.
Method 4 - Very Low Heat: Heat the oil—very slowly and carefully, using very low heat!—to just at or slightly above the boiling point of water, 100°C (212°F). Because freshly rinsed oil contains the most water, the best approach is to wait a few days before heating. After heating a few minutes, the oil will become clear. If a large amount of water is seen on the bottom of the pan, remove most of it with a bulb baster by tilting the pan. If the water in the oil begins to pop, crackle or erupt as it exits, remove the pan temporarily from the heat source and turn the heat down. Boiling chips—as simple as large clean gravel—are helpful but should not be depended upon to tame high heat. Please note! When heating, avoid a large amount of water first accumulating at the bottom of the pan, then building steam pressure: this will cause the oil on top of it to eventually erupt in volume. Any impurities carried over remain in the water are gently fried, and go to the bottom of the pan. An oil that remains turbid after heating can be frozen overnight, then put in the light. A few rounds of this will typically clarify it.

⚠️ Heating oil that is turbid (still contains water) must be done slowly, on low heat, to avoid creating steam pressure below the oil that can cause an eruption of the hot oil above it. If the temperature of the oil is at or near 100°C (212°F) this does not happen.

STORING AND AGING THE OIL
The oil can be aged in the light with a small addition of alkaline stone dust to help neutralize any developing acid and further clean the oil. Both chalk and lime are mentioned by Eastlake in a late 17th century reference. A small amount of lime is also recommended both by Laurie and Church. A powder of dried hydrated lime (pit lime, fresco plaster) or agricultural hydrated lime—not quick lime!—is used for this at 0.125 g (⅛ t) per 0.25 (1 cup) liters of oil. Natural chalk is added at 9 g (1 T) per 0.25 liters (1 cup) of oil. When incorporating these additions, stir them in, as shaking tends to cause the jar lids to become glued tightly closed over time. The oil temporarily clouds from any addition, and may throw a precipitate. The oil is stored in a sunny windowsill in relatively full glass jars. These are not made completely full, as the oil expands in summer. The oil in a half full jar, on the other hand, slowly begins to thicken. This is a simple way to thicken oil, although past a certain point, the various autoxidation protocols need to be observed with linseed oil, see section 6.2.1.1. Jars left half full for long periods need to have loose lids as a strong vacuum is created over time. Wehlte warns that this can literally cause a jar to implode. While this has not actually happened, lids may need to be punctured to break the vacuum before the jar can be opened. Occasionally a given jar of oil clouds as it ages. This can be cleared by putting it in the freezer overnight, then back in the light. For further modifications of the oil, see Oil Mediums, section 6.2.

Microemulsions: If the oil is stored in the light after the rinse step in a full, covered jar, a further refining system is created. A microscopic amount of water is dispersed in the oil, so small that the water molecules and their complement of ions remain suspended and begin to react with light. Succeeding waves of particles are generated in the oil, a phenomenon called flocculation. These particles eventually fall to the bottom of the jar, but because the water remains in suspension, a new wave forms, making the oil more refined. It is best not to allow microemulsions to go on indefinitely, as water can eventually degrade the oil. After a few rounds of flocculation, the microemulsion can be stopped by opening the oil, covering the top with cheesecloth secured by a rubber band, and placing it on a sunny windowsill for a few days.

REFINING DETAILS AND ADJUSTMENTS
The Water: The ions in the water have a strong effect on how the refining proceeds. Most tap water contains relatively large amounts of calcium ions. Hard water can capture oil in the
break layer, making it yellow instead of cream coloured. When in doubt, use distilled water. Clean rain water also works well if available. Captured oil is not lost, but releases over time, or if washed in distilled water and set in the light.

The Jars: Canning jars are sensitive to thermal shock and need to always be heated or cooled slowly to avoid cracking. Jars need to be inspected periodically for cracks at the base, cracked jars discarded. Jars are most easily cleaned with soap and sodium carbonate – washing soda – before the mucilage has dried. Jars with dried residue can be soaked in water and sodium carbonate and scrubbed clean again. Lye-based oven cleaner also works.

The 2.5 gallon plastic rinse container: For large amounts of oil, 2.5 gallon plastic spring water containers with spigots work well for the final rinse: the top is partially cut off, the water and oil added and agitated thoroughly: an immersion blender works well for this, or an electric drill with a stirring attachment. When separation occurs, the water is run out via the spigot. A culinary fat separator can also be used for smaller amounts of oil. Several readers have made separatory funnels from large plastic soda bottles. The top is cut off, the cap is drilled and fitted with a stopcock, the bottle itself is then inverted and secured.

Clearing a Persistently Cloudy Oil: Freezing a water-only wash or rinse can be used to clear a cloudy oil and is also an effective way to separate the oil. But make sure the jars are not so full that they crack when the water expands as it freezes. Also make sure that the jars are not so tightly closed that, even if they are not full, they crack. A roasting pan can be placed in the freezer under the jars to contain possible mishaps.

MAKING 4:150 PAINTING OIL
Alternatively, the fresh oil can be heated to 150°C for four hours. Again, it is important that the heat be low until the water has evaporated. This process makes it ready for use right away as a virtually non-yellowing medium. However, this means it cannot be used for making paint, and does change its working characteristics, making it just slightly thicker and more gelatinous, therefore less likely to run.

INTEGRATING THE PROCESS
The process can be done quickly, but does not have to be. A slower process allows the water to clean the oil more thoroughly, and can be helpful when using linseed oil with bright modern colour schemes. The behaviors in this process are subtle, it is easy to miss things that are cumulatively important. As such, it may be helpful to be patient and with learning how a given oil and set of ingredients responds. A step in the procedure can be taken each day, meaning four days from start to finish. Exploring the procedure moderately and consistently, allows it to become integrated into the working routine. If, for example, two quarts of oil are processed each month in four half gallon jars, this gives, at the end of a year, about four gallons of oil at a moderate expense per month. This provides a relatively effortless way to slowly accumulate aged oil. Eight half gallon jars are needed to process a gallon of oil. Once the procedure is familiar, this has proven to be a reasonable and economical manual scale of production. Wide mouth gallon jars are that much more efficient if they can be handled. An alternative is to increase the scale through mechanization. The oil, sand and salt mixture can be emulsified in quart jars with a small immersion blender. There are larger, heavy duty commercial versions of this appliance that work for larger jars, but these get expensive quickly.

LARGE SCALE REFINING METHOD
Larger scale processing can be done using an electric drill with a stirring attachment. A paint stirring attachment works, but stainless steel versions of these for mixing glazes are available from pottery supply stores, and are more efficient at emulsifying the oil-water mix.
This process is straightforward, but involves heavier lifting, and requires more space. The clear visual information given by the glass jar is gone, meaning more guesswork at first about when a wash has separated. Depending on the water temperature and the type of oil 1 to 2 hours is usually, and overnight is always, enough time. One gallon of oil (eight times the above amount) can be washed in a 5 gallon stainless stockpot or plastic bucket with 2.5 kilos (8 cups) of mixed sand – 4 cups pool and 4 cups fine aquarium sand – 2 gallons of water, and 1.8 kilos (6 cups, about 4 pounds) of salt. A small amount (100 g or 1/4 cup) of coarse (sand-like) marble dust can also be added to the first wash. It may take a few minutes before the emulsion forms. Once it does, the speed of the drill can be increased. Again, several cycles of emulsifying and clearing are done per wash. Once the oil separates, it is skimmed off in a handled cup measure. The salt water is poured off slowly, stopping when fine sand can be felt coming from the bottom. The mucilage-filled sand can be discarded, or recycled. To recycle the sand, a gallon of warm water and handful of washing soda are added to the bucket or stockpot, stirring repeatedly. This is then poured off, and repeated. It may not be completely free of mucilage, this is not necessary, but it absolutely needs to be free of washing soda. The final rinse is 1 gallon of oil in 3.5 gallons of water with 8 cups sand, agitated again until an emulsion is formed; without salt this will be less stable. A 2.5 gallon stockpot can wash half a gallon of oil at a time. This amount may be more manageable in a home kitchen. If working without a lid, regardless of the quantity, the drill needs to be run slowly and carefully at first, so that the level of agitation in the liquid is moderate while getting used to the procedure. The key is to create an emulsion, beat it well, then allow it to separate. The stirring time can be five intervals of a few minutes each, with an interval of ten minutes or so between each one. This is more efficient than one long mix that is allowed to separate. Mechanized rinsing takes longer to clear than handheld rinsing because the oil has been more closely mixed with the water. While motorized processing is a quick way to build up oil inventory, it is highly recommended that manual washing be experienced first with a given set of ingredients to see and understand specifics of their behavior better in glass.

**SPRING WATER AND SALT METHOD**

This variation uses room temperature spring water instead of hot tap water, and a longer, more traditional processing period in the light. Distilled water can be tried but may prove too aggressive in later washes.

**FORMULA TWO: SPRING WATER AND SALT METHOD**

For each half gallon jar, 0.75 liters (3 cups) of oil, 1 liters (4 cups) of spring water, and 190 cc (3/4 cup) of salt are used. The jars are shaken three times daily, and left in the light on a windowsill. The water is changed once a week. Two week-length washes with salt are followed by one week-length wash with spring water alone. The oil can then be heated gently and stored as above. Alternatively, it can stand in the light until it clears naturally (approximately two weeks), allowing the combined action of the water and light to continue for a longer period before it is processed further.

**SPRING WATER METHOD**

Eastlake discusses this method at the opening of his chapter X, *Preparation of Oils*, and the first written account of pure water washing still appears to be in the *Secreti di Don Alessio*, a miscellany of craft and medical recipes printed in Lucca in 1557. This procedure calls for a kind of separatory funnel, stirs the oil and water together, and directs that the oil be washed seven or eight times, until the water is clear. The washed oil, as Eastlake notes, is used as
the foundation for any further modification. The process surfaces again in 19th century manuals and a three week version of it was replicated by Carlyle in Molart Fellowship: Historical Reconstructions of artist's oil paint: an investigation of oil processing methods and the use of medium-modifiers (2000). This procedure is longer than the S&S method, but many of the older procedures are even longer. Eastlake's original procedure, for example, adds a small amount of salt to the water, resulting in less removal per week for six weeks. Using spring water alone about one third of the original oil volume is removed in three weeks. All washes are at least two parts water to one part oil. Increasing the proportion of water to three to one even the first wash makes the process more efficient. Sand can also be added to this method, in this case the very fine aquarium sand presents no issues. (More on the science of this method can be found in Effects of traditional processing methods of linseed oil on the composition of its triacylglycerols by Jorrit D.J. Van den Berg, Nicoletta D.Vermist, Leslie Carlyle, Michal Holéapek, Jaap J. Boon.)

**FORMULA THREE: SPRING WATER, LIGHT, & TIME METHOD**

*First wash:* The oil is shaken three times daily for a week. It is possible, but not necessary, to form an emulsion by extensive shaking. In this method, the action of the water and light over time is more important than physical removal. The water becomes increasingly cloudy over the week, although the amount of oil lost is small. At the end of the week, the oil is removed from the jar, the water changed, and the oil replaced. It is not necessary for the process to be careful — i.e. picking up only oil — until the final wash.

*Second wash:* One week. This wash shows cloudy water and a small amount of material removed at the oil-water interface.

*Third wash:* One week. This wash may go into emulsion readily, and more oil is removed. At the end, the original oil volume has been reduced by approximately one third. The oil can be dried at this point, or allowed to clear in the light (two to three weeks) before further processing.

**ETHANOL REFINING**

Several variations on the theme of refining the oil by ethanol exist in older texts. Eastlake mentions a method by Pacheco, as well as De Mayerne's record of Van Dyck's method of mixing ethanol and egg yolk with the oil to refine it. Ethanol has been shown by modern research to clean the oil thoroughly by itself, meaning that egg yolk or other ingredients do not to need to be involved. The ethanol wash does not enhance drying time of the oil, but it is an efficient way of removing impurities, and produces a limpid and flowing oil.

**FORMULA FOUR: ETHANOL REFINING**

An equal volume of oil and forty percent (eighty proof) ethanol are placed in the jar, filling it one quarter to one third full. The jar is then shaken thoroughly. The mixture emulsifies readily. The jar is shaken repeatedly over the course of a day, the more shaking, the better. At the end of the day, an amount of spring or distilled water equal to at least twice the volume of the ethanol and oil mixture is added, and the jar is shaken again. The following morning, the water-ethanol mixture is white, and the clear oil has risen to the top of the jar and can be removed. Any small amount of entrained oil remaining near the top can be recovered after adding more water to the jar.

The oil can then be heated slowly and lightly to 100°C dry it before storing in the light, or processed further. This can be aging it in an open tray in a thin layer for a few weeks, in or out of the sun. When thickened, this oil is still less viscous or adhesive than S&S linseed oil. It can also be washed twice with spring water alone for a week, or washed for a week...
with high level salt, then for a week with plain spring water. The ethanol wash has removed most of the impurities, and these subsequent washes entrain or capture little oil as a result.

Pure (200 proof) ethanol is available from chemical or lab supply sources. Inexpensive but real vodka works well as an ethanol source for small amounts of oil. For larger amounts, 190 proof ethanol for commercial purposes can be ordered through liquor stores in America. Other types of alcohol – methanol, isopropyl – do not work for this procedure.

**MARCIANA METHOD**

This is derived from a note in the 16th century Venetian *Marciana Manuscript* in Merrifield. The original calls for boiling the oil in water for four hours, then allowing it to cool. This is the same procedure used in modern refining to remove the polysaccharide mucilage from the oil. This revised method adds sand to the process, resulting in a cleaner and faster drying oil. This oil dries more quickly than spring water or ethanol refined oil, but not as quickly as the S&S procedure.

**FORMULA FIVE: MARCIANA (BOILING WATER & SAND) REFINING**

Add 1 liter (1 quart) of oil and 4-6 liters (4-6 quarts) of water to a large stainless steel stockpot and bring to a boil on high heat. More water in this case means more potential for oxygenation of the oil. When boiling well, turn the heat down and add 125 cc of pool sand and 125 cc of fine aquarium sand, mixing well. (Pool sand can be used alone but aquarium sand cannot unless the temperature is lowered to just below 100°C to avoid massive thudding in the pot. This temperature will still clean the oil thoroughly.) Keep the mixture boiling slowly for four hours, it may thud from time to time as steam escapes from the glutinous impurities trapped in the sand. At the end of this time, stir the hot mixture – carefully! – from the bottom so that the sand interacts closely with the oil. It may emulsify temporarily, this is fine. Stir this off and on for ten to fifteen minutes to create more physical interaction between the oil, water and sand. Then allow the pot to cool overnight before removing the oil with a ladle or baster. The oil can then be heated – slowly, on very low heat! – in a clean stainless pot to 100°C to dry it, or allowed to sit several days – during which most remaining water in the oil will go to the bottom of the jar – before the final heating process. If the oil remains slightly cloudy after heating, it clears after being frozen overnight and placed on a sunny windowsill.

**NOTES ON THE MARCIANA METHOD**

This procedure can also be done with salt added to the water at 80 grams per liter of water. This means an added final rinse step, but this oil dries faster, and is cleaner, making it better suited to bright modern colour schemes.

**SNOW REFINING**

The first mention of this appears to be in Tingry's *The Painter and Varnisher's Guide* (1804). Tingry's method involves encasing already cold oil in snow, and allowing it to sit outside as long as possible at the height of winter. Doerner also mentions snow refining as recommended by Professor Hauser. The prerequisite, of course, is a climate with fresh, clean snow, the crystals of which, in addition to their ionic content, have an extraordinary amount of surface area that is surrounded by atmospheric oxygen. On melting, snow releases both heat and electricity, the latter of which leads to a series of electrochemical reactions in the more reactive non-triglyceride portions of the oil. As such, interaction with snow both oxygenates the oil, and allows its impurities to easily be separated by rinsing in plain water.
FORMULA SIX: SNOW REFINING
Fresh snow is packed tightly into a half gallon glass jar. A series of small holes are made in the top with a brush tip, then 2 cups of unrefined organic linseed oil are poured slowly into the jar. As the snow melts, it is replaced, until the jar is full. The water below is then siphoned off, and the procedure is repeated two more times, simply packing snow in on top of the oil. Pieces of congealed mucilage will appear in the jar, but can be ignored. The oil is then washed in distilled water or spring water. Multiple jars can be consolidated so that 2 cups of oil is washed with 4 cups of water. The oil emulsifies easily, and the water becomes turbid as the oil separates. A complex skein may first be exhibited between the oil and water. Overnight, this resolves into a dense layer of mucilage. This can be spun out of the oil to some extent, and is a larger amount than it appears. The oil is removed from this water, and rinsed twice more in the same way. Alternatively, once three cycles of melting snow have occurred, the oil can be placed outside full of snow in freezing weather for a week or more. Using this procedure, the oil does not have to be rinsed; the mucilage falls to the bottom of a jar in fragments when the oil is decanted and left in the light. It can be left in the light with a small amount of water in it for several weeks. The slow heating procedure is then followed to rid the oil of all water. Snow refined oil dries more quickly than oil refined by the spring water or ethanol methods, but not as quickly as S&S linseed oil. Larger amounts of oil can be processed by cutting the tops off of empty 5 gallon spring water containers and draining the melted snow through their spigots.

THE EMULSION PRE-WASH
This technique was suggested by Dr. Roland Greimers of the University of Liege, the idea being that a more intimate interface between the oil and water will refine the oil more thoroughly. Over time this has proven to be an effective beginning for any method, but it is important to note that the refining time, or the number of washes involved in the process, can typically be shortened as a result. In the case of the S&S procedure, two washes are enough with an emulsion pre-wash. Also, please note that, if using an immersion blender, a small amount of time is enough! Long emulsifying times can result in a persistent emulsion that can take many days to break naturally.

DISTILLED WATER PRE-WASH
Emulsions are effective at loosening the bond between the oil and the water soluble mucilage. The simplest pre-wash uses distilled water at one part water to five parts oil, for example, 100 ml distilled water for 500 ml oil. This is shaken thoroughly for several minutes, or blended with an immersion blender for 30 seconds. The emulsion is then allowed to break naturally over an hour or two, perhaps longer using the immersion blender. Once it breaks completely, the water is syphoned off and any of the refining procedures can begin. Or, especially if working with older linseed oil (bulk, not branded oil) the broken emulsion can be re-shaken several times before syphoning the water. See Formula 19, Method 3 above.

Variations: Simple hydrocolloidal substances can be used to stabilize a longer pre-wash. A minute amount of glycerin can be used, or small amounts of methyl cellulose or gum arabic can be dissolved into the water for the emulsion. See Emulsion Refining, section 5.12.10.

RAW APPLE CIDER VINEGAR PRE-WASH
A raw apple cider vinegar pre-wash can precede any of the refining procedures or follow a distilled water or chlorophyll pre-wash. The proportions are 25 ml raw apple cider vinegar added to 75 ml distilled water for 500 ml oil. This is shaken well for 2 minutes; or, with an immersion blender on low or medium, blend for 30 seconds, wait five to ten minutes, then
blend again for thirty seconds. The emulsion is then allowed to break naturally over the next few hours. The vinegar and water are removed with a bulb baster, or syphoned off — with food-grade vinyl tubing, % to % inch diameter or similar, or larger diameter aquarium airline tubing — before beginning any of the refining procedures. The vinegar pre-wash “hardens” the mucilage, making it denser, less amorphous, and more likely to appear as a mass of bubbles of various sizes between the oil and water. This procedure may also lessen the refining time — for example, in the S&S procedure, two washes with salt and sand are used instead of three — but this is also dependent on the age of the oil: the mucilage in fresher oil separates easily compared to older oil.

The vinegar pre-wash is a version of the first phase of the process in modern oil refining called degumming. This has typically been done with a mild acid, both phosphoric and citric acid are common, but raw apple cider vinegar was found to act more on the oil than citric acid. More recent procedures have introduced enzymatic degumming. The purpose of degumming is to eliminate the phospholipids. Water is recognized as taking care of a large proportion of the phospholipids, so the older processes do accomplish this to a large extent. But there are also phospholipids which are not soluble in water unless treated with acid first. Because the function of the phospholipids, along with the tocopherols, is anti-oxidant, their elimination may make a faster drying oil. But, since S&S linseed oil dries quickly in any event, the difference in getting all of the phospholipids out may be immaterial in practice.

PROCESSING OLDER OIL
Oil that is more than a few years old may require a slightly different approach than new oil, especially if it has been aged in the light. Investigate older oil first with distilled water using Formula 21. If the water becomes significantly cloudy in the first few days, and the oil itself remains quite full of water, this may mean that introducing salt or sand is unnecessary, and may lead to a persistent emulsion. The amount of break between the water and oil layers may be less than usual. Freezing the oil-water mix can be help break the bond between the water and oxygen for the next round of washing. Make sure there is room in the jar for the water to expand when frozen; always put jars in a baking dish as they can (rarely) break for no reason. Ethanol refining, Formula 22, also works well with older oil.

PRIOR OXYGENATION
Oil processed by any of the above methods can be made somewhat faster drying by a period of oxygenation before processing. This can be done with an aquarium pump with an airstone. The addition of a small amount of water to the oil also helps the oil to absorb oxygen.

EXAMPLE PRIOR OXYGENATION METHOD
In a 2 liter (half gallon) jar, add 375 ml (1.5 cups) water and 1375 ml (5.5 cups) oil. Add the airstone on its tubing, making sure it is fully in the water, and let it run for two or three days before processing the oil. The mixture will emulsify, but this emulsion breaks down quickly when the pump action stops. While this process adds oxygen, it also begins to refine the oil. The addition of a small amount of fine silica, such as fine (7µ) cristobalite, will create a denser and more intimate emulsion — refining more and adding more oxygen — and also separates readily.

REFINING SUMMARY
When different approaches develop historically and remain operative over time, each one has strengths and drawbacks. Boiling is the quickest method, loses the least amount of oil, and, especially if done with sand and salt, results in a cleaner and moderately fast drying oil.
But boiling may still benefit from an extra water wash of a week for higher chroma applications. Washing with distilled or spring water alone is simple, but takes a long time. An initial ethanol wash is efficient, and relatively non-yellowing from the start, but ethanol adds expense, does not increase the drying rate of the oil, and results in an especially thin oil, which may or may not be desired. Washing with high level salt produces an oil that dries very quickly, and leads to an entire system of pre-heated, pre-polymerized, and auto-oxidized oils that dry even more quickly, but this oil may in fact dry too quickly for some techniques, or for making paint to be tubed. Where clean snow is available, snow refining involves more time but less effort but more time to produce a very clean and moderately fast drying oil.

**LINSEED OIL AND THE COLOUR SCHEME**

Linseed oil was used effectively by painters such as Velasquez and Rembrandt in an approach based on chiaroscuro, an opaque white light-transparent brown shadow modelling convention, and often maximized the chroma of earth colours by contrasting them with strong areas of pure black and white. This approach to value and colour ensured distinction in often low period light, and effectively minimized the perception of any darkening of the oil by placing the cool highlights in an overwhelmingly warm matrix. This approach is rarely used in modern realism, which tends to be based on the conventions of digital photography and a far brighter palette overall. The more the colour scheme depends on bright modern colour, the more non-yellowing the oil needs to be. A detailed PDF about the various factors that affect the yellowing of linseed oil is available [here](#). There are many simple ways to help avoid yellowing: painting with minimum functional saturation in an alla prima system, painting from lean to fat in layers, keeping the beginning layers as lean as possible given the system, minimizing the use of heavily polymerized commercial oils such as stand oil, using heat polymerized S&S linseed oil or S&S linseed sun oil instead of stand oil if possible, and minimizing the use of balsam or soft resin varnish in the medium. Pre-heating small amounts of walnut or pre-polymerized, not raw, poppy oil into S&S linseed oil also help minimize yellowing potential by altering the fatty acid ratios towards those of the less yellowing oils. Developing the system with awareness of these factors can add up to a significant difference in the way the paint film ages over time.

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