REFINING LINSEED OIL – January 2017

This material is excerpted from Living Craft, copyright 2011-17 by Tad Spurgeon. There are now several different refining procedures, including a specific bulk oil procedure. Have fun, make great paintings, and please ask me any questions. Also, please note that the flax oil used ***must be pure.*** *Recently, flax oil has been marketed with an "anti-oxidant mix" that contains sunflower oil. This oil* ***cannot*** *be made to dry quickly.*

Introduction

The goal of the refining process is to make an oil that dries hard, and yellows as little as possible. While any drying oil creates a stronger paint film if its non-polymerizing components are removed, this process also makes the oil less prone to yellowing, and is especially important to modify the behavior of linseed oil, whose high proportion of linolenic acid (Omega 3) can cause yellowing, wrinkling and drying from the top. Eastlake typically explores many technical avenues based on older practice, but offers succinct direction with regard to 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 the need to begin with a quality oil, or the long term potential of the non-polymerizing components or incautious processing to darken the paint film. In part this may be because the oil used for painting was, during most of the 20th century, commercially refined, and often hot-pressed. 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, for example, that modern paint manufacturers do not refine their own oil, this situation may have created unavoidable yellowing issues at certain times simply due to the unavailability of higher quality oil. The significant change in this crucial department 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 in fact the focus of the entire text of Abendschein's *The Secret of the Old Masters* (1909). Despite obvious ongoing difficulties with modern oil, an attempt to reconstruct the type of oil used in the 17th century was apparently not considered relevant by any author in English until Carlyle. This oil was known to be different: cold-pressed, and hand-refined. Perhaps the inconvenience of the procedure, or its unaesthetic drudgery, acted as a deterrent. Wehlte simply states that cold-pressed oil should be used, and that the addition of dried barium sulphate is helpful. (Although mild alkaline additions are fine in general, barium sulphate has shown a tendency to create yellowing and should be avoided.) Even Laurie, who is usually direct, and unique in his willingness to acknowledge that something important has been lost from older practice, gets somewhat vague about the oil.

It is unfortunate that Eastlake's distinction about refining the oil became overlooked, or submerged by the commodification of the oil, as it may provide the key to the seminal puzzle of why many older paintings known to have been made with linseed oil have remained bright over time. This type of oil 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, 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 comes under the painter's direct control.

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 was a revelation: it was finally possible to understand both the origin of certain more bravura techniques, and why linseed oil could have been preferred. 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. These tests, unless done within the singular context of technical art history, also ignore factors related to the way the oil has been processed that have long been known to play a significant role in the ultimate behavior of the oil. Salt-refined organic (SRO) linseed oil 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 SRO linseed oil for the paint and medium, resins – and solvents – become virtually unnecessary.

For painters working with more emphatic techniques, the behavior of SRO linseed oil provides straightforward access to older methods, and is especially focal if using the putty medium 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 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.

Please note that, to create a fast drying oil, the flax oil used ***must be pure****. Increasingly, "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 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 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. No drier, solvent, or additional medium component is necessary at any point in the process. The maze of commercial materials and its chorus of half-truths can be eliminated simply by using permutations of this oil and pigment alone. This provides quality and expediency built in at the root of the process.

Traditional Refining Procedures

There are three major sources of historical procedures in English. 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, and the third is Merrifield's *Medieval and Renaissance Treatises on the Arts of Painting* (1849). These establish the ingenuity and concern that older painters brought to the fundamental issue of refining the oil. An excellent summary of older procedures is also part of *Rembrandt and his Circle: Seventeenth-Century Dutch Paint Media Re-examined* by Raymond White and Jo Kirby (NGTB 15).

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. Older formulas are sometimes vague about whether a procedure is designed to simply clear the originally cloudy oil – a form of filtering – or actually refine it so that it will be non-yellowing and faster drying.

Six traditional refining approaches have been reconstructed:

1. Washing the oil in water over an extended period with or without salt
2. Introducing a metallic salt – usually, but not always lead – with or without heat
3. Removing impurities via ethanol
4. Boiling the oil in water to destroy the mucilage
5. Allowing the oil to age over extended periods in glass in the light
6. 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. This may explain to some extent the 20th century doubt in print about the usefulness of older procedures: the commercial oil of the period could not be transformed by them. 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 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 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 SiO2) is often thought of as inert, but it is coated with silanol (SiH3OH), 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 literally 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.

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 variety of 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 beforer auto-oxidizing it minimizes this.

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 are anxious to avoid lead if possible. Using the faster drying oil created by the water, sand, and salt procedure, as opposed to commercial linseed oil, this can be done readily. The fastest drying system uses SRO linseed oil for the paint and medium, although this may dry too quickly in some situations. The system also works well with quality commercial paint, using variations of SRO oil as the medium.

Refining Overview

The washing procedure is very sensitive to the type and amount 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. 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, *no qualitative difference results* from the use of the more expensive oils, the behavior of the final oil at the easel is the same. 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.

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, available at about one third the price of pickling salt 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.

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. This is part of working with a complex organic substance.

Water, Sand, and Salt Method

The six week procedure in Eastlake led to a search for a similar non-invasive way to remove impurities that would take less time. The following factors emerged as significant to what can admittedly be of interest in this case, increased production speed. First, that the water is hot to begin with, hot tap water is sufficient and poses no risk of cracked jars. Second, that the quality of the sand is important. The most efficient sand found for hand processing is commercial pool sand. This is the relatively coarse, angular silica used in swimming pool filters, *not* calcined diatomaceous earth, which tends to entrap oil and is a significant toxic dust hazard. (If looking for sand alternatives, look for pure, clean, coarse silica.) Third, that the oil be shaken until it is emulsified, then put through this procedure again *several times* while the water is still warm. This is relatively aerobic but maximizes the amount of oxygen available to the oil when the interface between oil and water is most intimate. The wash is complete when the emulsion has fully separated, this takes from half an hour to an hour depending on the specific ingredients and ambient temperature. Three washes are needed, followed by a final water-only rinse. This means that the former six week process can be completed, if need be, in a day or two. The oil always remains turbid during the process. It is clarified at the end either by aging it in the light for an extended period, or by heating it slightly and carefully to remove any remaining water. This is the fastest method for generating a quick-drying oil without an added drier, and leads to a unique set of pre-polymerized oils based on it.

Salt, Sand, and Hot Water (SRO) Method

First wash: Place into each half gallon canning jar 0.50 liters (2 cups) of oil, along with 160 g (1/2 cup) of pool sand. In a second jar, salt in the amount of 120 g (¾ cup) is dissolved in 1 liter (1 quart) of hottest tap water, then added to the first jar. For cold weather processing, warming the jars with warm tap water first is recommended to avoid any danger of a jar cracking along the bottom. The oil-sand-salt mix is lidded tightly and shaken until it has emulsified, then allowed to rest, then shaken again for about five cycles over a period of ten minutes. The mix will emulsify more quickly as it cools slightly, but it is important not to skimp on shaking in the first wash especially as this is how the deeper cleaning is accomplished by creating an extremely fine interface between the hot salt water and the oil. After five rounds of shaking, clearing, and shaking again, the resulting bright yellow emulsion will slowly separate into a layer of orange oil on top, with the mucilage trapped in the sand on the bottom, and some impurities possibly hanging in a loose skein from the oil in the water between. 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. At this point most of the oil can be removed to a new jar using a bulb baster or large syringe. Cold water is then added gently to the first jar, bringing the remaining oil to the top. This may cloud temporarily but will clear again quickly. It can then be removed to the new jar with a small ladle, a bent spoon, or a large – veterinary – syringe. Impurities may be brought over to the second wash, this if fine. If processing several jars at once, it is helpful to consolidate all the leftover small amounts of oil first into one jar. Alternatively, this end bit of oil can be added to the first washing of the next batch of oil, if that will be occurring 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 oil will not emulsify fully with the water, 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 again be consolidated and recovered, or incorporated into a washing cycle in the near future. About 10 to 15 percent of the oil by volume is again removed.

Third wash: This again repeats the ingredients and procedure of the first wash. The oil is then transferred to a clean jar. About 10 to 15 percent of the oil is removed.

Rinse: The final rinse is up to 0.50 liters of oil (2 cups) shaken with 1 liter (4 cups) of water and 80 g (1/4 cup) of sand. This is done at least three times, with at least three changes of water. The exchange from jar to jar does not have to be exacting. The oil is turbid after this, clarifying somewhat overnight. A fine line of light yellow break is usually discernible at this point between the oil and the water. The oil can now be 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 wants to be as clean as possible. Again, small amounts of leftover oil can be consolidated, making it easier to salvage. Transfer may cloud the oil, but it clears overnight.

Clearing and Storing

The resulting oil is somewhat lighter in colour, but is cloudy when it is finished due to significant residual water in the oil. Allowing it to rest a few days to a week after the final rinse, in the light, before decanting, lets the majority of the trapped water to fall out. To clear it, heat it – **very slowly and carefully, using very low heat!** – to just at or slightly above the boiling point of water, 100C°. 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. The situation to avoid is a large amount of water first accumulating at the bottom of the pan, then building steam pressure, causing the oil on top of it to eventually erupt in volume. Because freshly rinsed oil is the most volatile and unpredictable, the calmest approach is to wait at least a few days before heating. If, after heating a few minutes, a large amount of water is seen on the bottom of the pan, most of it can be removed with a bulb baster by tilting the pan. Boiling chips in quantity – as simple as large clean gravel – can also be helpful but should not be overly relied on. Alternatively, the majority of the oil can be poured into a different pan, the remaining oil and water placed in a glass jar or beaker and separated. Small amounts of impurities carried over remain in the water and go to the bottom of the pan. An oil that is still turbid after heating can be put in the freezer overnight, then put in the light. One or two rounds of this typically clarifies it. Oil that is aged in a temperate climate on a windowsill clears naturally over the winter.

If the oil is not heated, but stored in the light a few days after the rinse step, a further microemulsion refining system is eventually created. In this situation, a microscopic amount of water remains dispersed in the oil, so small that the water molecules and their complement of ions do not fall out to the bottom of the jar, but remain suspended and enter into an ongoing reaction with light. In this case, succeeding waves of aggregate particles are generated in the oil, a phenomenon called flocculation. These particles eventually fall to the bottom of the jar, but because the water itself remains in suspension, a new wave soon forms, and the oil slowly becomes more refined. The microemulsion can be stopped at any time by slowly heating the oil, or by transferring the oil to an open tray for a week or so in a low humidity environment. A small amount of water remains in the oil, and oil stored this way continues to react with water and light, often throwing large and consistent precipitate flakes over time. This oil is then dried before use, either through gentle heat or prolonged exposure in a thin layer.

The oil can also be aged in the light with a small addition of alkaline stone dust to help neutralize any developing acid and further clean the oil of impurities. 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 is used for this at 0.125 g (1/8 t) per 0.25 (1 cup) liters of oil. Natural chalk is also added at 9 g (1T) per 0.25 liters (1 cup) of oil. While lead is not necessary to make the oil dry well, a small addition of litharge – 10 g (1t) per 0.25 liters of oil, shaken well – creates an oil that is slightly more dense or gelatinous over time as it ages in the light. Lime is not used in conjunction with litharge as the oil will darken. Laurie also recommends an addition of white lead; 4 g (1t) per 0.25 liters of oil can be used with chalk and lime. However, SRO oil dries quickly without the use of any lead, so quickly that in warmer weather it may need to be cut with a slower-drying oil for some techniques. When incorporating these additions, it is best to stir them in, rather than shake the jars, as shaking tends to cause the jar lids to become glued tightly closed over time by small amounts of polymerized oil. The oil temporarily clouds from any of these additions, and may throw a precipitate. The oil is stored in a sunny windowsill in relatively full glass jars. These are not made too full, though, as the oil expands in summer in the heat. The oil in a half full jar, on the other hand, slowly begins to thicken, which may or may not be desired. Jars left half full for long periods need to have their lids left slightly loose as the polymerizing oil creates a surprisingly strong vacuum over time. Wehlte warns that this can literally cause a jar to implode. While this has not actually happened in practice, lids have needed to be punctured to break the vacuum before the jar could be opened. Occasionally a given jar of oil clouds again as it ages. This can be cleared by putting it in the freezer overnight, then back in the light.

Another possibility before final storage is exposing a large surface area of the oil to oxygen for approximately two weeks, this situation is temperature sensitive and may go faster in summer, slower in the winter. If the layer of oil is thin – 250 ml in a 12x12 inch glass baking dish – almost all colour is removed through this method, and the oil develops a bit more body, suspending the pigment more and drying with a gloss. The oil becomes just perceptibly thicker through this method, and dries a bit faster. Longer exposure in the tray produces the highly useful *Studio Oil* (section 5.24.3), best used in small amounts. Variations of this method using a lead tray are covered in *Unsun Oil*, (section 5.24.5.1)

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.

Adjustments and Fine Points

The ionic content of the water is an important factor in how the refining proceeds. Most tap water contains relatively large amounts of calcium ions that help remove impurities. If the tap water is known to be soft, very small amounts of **coarse** marble dust can be added to the washes. Fine marble dust will entrain or capture oil into a yellow layer between the oil and the water. It is best to use marble dust only with linseed oil, with walnut oil even a small amount has a strong tendency to entrain the oil. Captured oil releases if washed in pure water and set in the light. While physically sturdy, canning jars are sensitive to thermal shock and need to always be heated or cooled slowly. Putting a cold jar in hot water, or water hotter than tap water in a particularly cold jar, can result in cracking. Even being careful, jars need to be inspected periodically for cracks at the base, any cracked jar discarded. Canning jar lids need to be replaced from time to time as they build up enough residue to not close quite tightly enough for leak-free shaking. A gasket of thin plastic can be used to make a firmer seal temporarily. Jars are most easily cleaned with vegetable soap and sodium carbonate – washing soda – before the oil and fatty-acid residue in them has dried. Jars with dried residue can be soaked in water and sodium carbonate and can eventually be scrubbed clean again. A separatory funnel can be used as an alternative to canning jars for small tests. These also work well for the final water-only rinse. There are also several different types of culinary fat separator that can be used to remove water from the oil.

Possible Further Refinements

The process can be done quickly, but does not have to be. If each wash is allowed to rest in the light for several days before proceeding to the next one, the salt and water in the oil continue to refine it. This can also be done by allowing the third wash to rest in the light for a week or two before the final rinse. In this case, more oil is lost, but the oil is also arguably cleaner, and ready for more demanding use that much more quickly. The sand must be silica. Other silica sands exist, such as sea sand for aquariums, and the sand used in urns for extinguishing cigarettes. These work in small amounts as adjuncts to the pool sand, but are too fine on their own, capturing oil in globules on the bottom of the jar. This is not a major issue, the globules can be spun free.

In modern oil refining, the first phase of the process is called degumming. This has typically been done with a mild acid, both phosphoric and citric acid are common, but more recent procedures have introduced enzymatic degumming using EDTA or other proprietary enzymes. The purpose of degumming is to eliminate the phospholipids. Water is recognized as taking care of a large proportion of the phospholipids, so the original process does accomplish this to a large extent. But there are also phospholipids which are not soluble in water unless treated with acid first. The question of whether this matters to the final quality of the oil for painting would be difficult to answer without significant testing. No modern information on it has been encountered, and no older recipes which incorporate the concept of an initial acid wash. It may be that, because the function of the phospholipids, along with the tocopherols, is anti-oxidant, their elimination leads to a faster drying oil. But, since a SRO linseed oil dries very quickly in any event, the difference involved in getting all of the phospholipids out may be immaterial in practice. However, a preliminary wash with sand and raw apple cider vinegar reduced to approximately one percent acidity (one part five percent vinegar to three parts water) in hot water did act on the oil more noticeably than a similar wash of citric acid, and might be considered if emulating the steps of the modern process in a milder manner is of interest. EDTA itself can also be tried, as well as the enzyme treatments available for aquarium water.

Finally, it is important to note that the oldest agent for refining the oil was simply water, and that the final water-only rinse can be extended, especially if the oil will be used without preheating or a period of aging in the light. Distilled water may be the best agent for this, as it has no initial ionic content, but may be too aggressive in some cases.

Integrating the Process

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

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 has separated, it can be 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. The sand is rinsed three times with clean warm water, and is then ready for the next wash. 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 has proven significantly more efficient than one long mix that is then allowed to separate. Mechanized rinsing takes longer to clear than handheld rinsing because the oil has been more closely mixed with the water, but the oil is also arguably cleaner as a result. 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.

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 (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 SRO 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 in 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 triaglycerols* by Jorrit D.J. Van den Berg, Nicoletta D. Vermist, Leslie Carlyle, Michal Holèapek, Jaap J. Boon.)

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.

Initial Ethanol Wash

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.

Ethanol Refining Formula: 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 an opaque 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 SRO 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 SRO procedure.

Marciana (Boiling Water and Sand) Refining Formula: 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 100C° 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 100C 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. 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, making it an efficient process for producing a quick drying oil.

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.

Snow Refining Formula: 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 SRO linseed oil. Larger amounts of oil can be processed by cutting the tops off of empty 2.5 gallon spring water containers and draining the melted snow through their spigots.

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 7µ cristobalite, will create a denser and more intimate emulsion – refining more and adding more oxygen – and also separate 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 salt, results in a moderately fast drying oil. Washing with spring water alone is simple, but takes a long time. An initial ethanol wash is efficient, 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 the entire SRO system, 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 less effort but more time to produce a moderately fast drying oil.