This is the last of three articles exploring oils and oil-based finishes. In this article we will consider oil-based varnish; the most versatile and the most durable of the three...

Oil-Based Varnish

What comes after "oil"?

This is the third article in our series on Oils and Oil-Based finishes. In the last issue we looked at “oils” used in true *oil finishes*; both those derived from plants (vegetable oils) and those refined from petroleum (mineral oil). We examined the difference between drying oils (linseed and tung), non-drying oils (such as olive oil), and semi-drying oils such as soya (soybean) and walnut oil. We also made the point that oil finishes are not (marketing hype surrounding tung oil notwithstanding) very “durable”; they have virtually no resistance to heat, moisture, abrasion, and household chemicals. If you want greater “sheen” and better resistance to these common hazards, then varnish or an oil/varnish blend will be a much better choice. An oil/varnish blend (a.k.a. “Danish Oil”) is simply a mixture of more or less equal parts varnish, boiled linseed oil, and mineral spirits—make your own and save. While not as durable as varnish alone, oil/varnish blends are significantly more resistant than to the hazards listed above than oil finishes.

So, what is varnish, and if varnish isn’t oil (as so many seem to believe) then why do we talk of linseed, tung, and even soya oil in our descriptions of varnish? I’m glad you asked. You can’t make varnish without oil—oil is one of the primary ingredients in making varnish. But because varnish is *made from oil* does not mean that varnish is oil. Let’s consider a simple analogy. Bread is made from a number of ingredients; flour, salt, sugar, eggs, milk, yeast, etc. Each of these ingredients is easy to identify before all are combined, put into an oven, and baked. However, when the loaf of bread is removed from the oven it is much different than it was when it went in—it has been changed; modified if you will, by the cooking process. We can no longer identify the milk, flour, salt, sugar, or any of the other ingredients used by the baker. Each has combined with the others forming a new product that we call bread. Bread did not exist before the ingredients were combined and cooked. Bread is the product of the cooking process—the individual ingredients, while contributing to the end result, are gone; they were consumed or combined to form bread. It should also be pointed out that if one simply combines the ingredients but does not put them in the oven to bake, bread will not be produced.

Varnish was invented in the middle ages when the German monk, Theophilus Presbyter discovered that linseed oil, heated in a closed container, would combine with fossil resin (amber) to produce a polymer (though Presbyter did know what a polymer was) that we call varnish. Presbyter's varnish, precisely because it was a new compound (a polymer formed by the cross-linking of oil and resin molecules) was far more resistant to moisture, heat, solvents, and abrasion than was the oil from which it was made. Think about this last sentence for a moment. If varnish really is oil—just oil with a bit of resin mixed in—then it would be no more durable than the oil from which it is made. The resin would just be floating about in the oil. Returning to our bread analogy, just as combining flower and milk does not produce bread, neither does simply mixing oil and resin create varnish. Bread is produced only when the ingredients are *modified* at the molecular level by cooking. In the same way, varnish is not made by simply adding resin to oil. To make varnish, the oil and the resin must be *modified*; they must be *cooked* so that the molecules of each combine to form the new molecular structure that we call varnish. It is this cross-linking of oil and resin molecules that makes the varnish so much more durable than the oil from which it is made.

The oil used by Presbyter, and by far the most common drying oil still used today, was linseed oil. Other oils, however, can be used and each, like the choice of the flour used in baking bread, imparts its own unique properties to varnish. Tung oil, for example, is used in the manufacturer of most marine varnish because tung oil imparts superior moisture resistance compared to other oils. By itself however, tung oil has virtually no moisture resistance. In fact, the finish film produced by tung oil is virtually indistinguishable from the finish film produced by boiled linseed oil (BLO). It is only as an *ingredient* in the manufacturer of varnish that its moisture resistant properties are realized. An additional property of tung oil is that it is somewhat more color stable than linseed oil. However, over time tung oil, like linseed oil, will oxidize causing the finish to darken. The lightest color finish is achieved with varnish made from soya (soybean) oil. Varnish made from soya oil is lighter going on and darkens far less over time than either linseed oil varnish or tung oil varnish.

The Resin used by Presbyter was fossilized amber. Amber is mined from ancient deposits and then, as now, was frequently a component in "spirit varnish"—shellac to which other natural resins are added to improve various properties. The downside of amber is that the supply is limited, making it a very expensive ingredient.

The first man-made resin was phenolic resin. Phenolic resin is made by combining phenol and formaldehyde. Like amber, phenolic resin is a solid so it was easy to incorporate into the varnish technology of the day. Phenolic resin also produces a very hard varnish. This property makes varnish made from phenolic resin an excellent choice where hardness is desirable, for example for table tops, desks, floors, etc.

Alkyd resin appeared in the 1920's. Its name is derived from the two chemicals used in its production—alcohol and acid. Alkyd was the first liquid resin. In addition to its use in the manufacture of varnish, alkyd resin is used to make lacquer and oil-based paint. The primary attribute of alkyd resin is its superior clarity. This property, in my view, makes it an excellent choice, when combined with soya oil, as a finish for fine furniture. Alkyd resin varnish made from soya oil produces a very warm, clear finish that is quite color stable over time.

Finally, in the mid-1930s, urethane resin (polyurethane) was developed. Urethane resin, also a liquid, is very inexpensive to produce, making it the lowest price resin available for the manufacturer of varnish. Polyurethane's dominant property is its *extreme* abrasion (scratch) resistance making it the choice for children's furniture, kitchen tables, and other applications subject to having items pushed across the surface. (Please note; abrasion resistance and hardness are not the same thing! Logic tells us that it is much easier to scratch something hard than it is to scratch something soft and compliant.)

On the down side, polyurethane is somewhat cloudy when compared to the other varnish types. It also exhibits poor adhesion properties, polyurethane does not adhere well (even to itself) without a mechanical bond (sanding) and is highly susceptible to UV damage. It should also never be applied to shellac that contains wax. As a finish, polyurethane varnish did not see wide spread use until after WWII. Since then, lower production costs associated with shelf-space limitations and mass marketing have made it the most dominant varnish in the market place. By no means, the "best" varnish (in my view); but, certainly the cheapest and most commonly available.

At the risk of bogging down in unnecessary detail, let's take some time to see how these components are brought together to make varnish. It all begins with heating the oil. As the oil is heated in the absence of oxygen various sites along the oil's molecular chain are opened and made receptive to other oil molecules. The oil molecules begin to link with one another forming long chains of molecules in a process called polymerization (see drying oils in the last issue). When the oil reaches the optimum temperature, typically between 400° and 450°, resin is added to the oil. The molecules of resin also begin to attach themselves to the oil molecules, thus *modifying* the molecular structure of the oil. (Hence the term "oil modified resin" seen on many varnish labels.) Soon every oil molecule is linked at various locations to other oil molecules and to molecules of resin creating a great mass of interlocking molecular chains. We call this molecular structure varnish.

The varnish is not usable in this form. It is much too thick to be applied. Thinner is added to the varnish so that it can be spread. Flatting agents may also be added to reduce the sheen from gloss to semi-gloss, satin or dull. Color, in the form of pigment or dye, can also be added though this might more appropriately be added by the end user.

When the varnish is applied two things occur. First, the thinner evaporates leaving behind the finish film which consists of the solids; the actual varnish produced by cooking the oil and the resin. Second, when the varnish film is exposed to oxygen in the air the cross-linking of the molecules begun in the manufacturing process runs to completion; the varnish *cures* producing a durable finish film that is highly resistant to water, water-vapor, household chemicals, solvents, heat, and abrasion. In its cured state varnish, which we call a *reactive finish* because varnish cures by reacting with oxygen, can never again be softened, or dispersed in thinner.