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Oils and Varnishes for Finishing Wood

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Like me, you have probably tried lots of different finishes on your projects, hoping to find something better and easier. Unfortunately, our product labelling regulations do not demand much information, so the manufacturers provide as little as possible. To understand what is in all these different products, I did some reading.

The chemistry of finishes is a complex subject, involving a lot organic chemistry and the understanding of polymers and catalysts. Underlying it all are some fairly simple concepts that I will attempt to explain. Having grasped these, I hope you will have a better understanding of how oils and varnishes work.

Oils. If you look around you will see that there are a large number of different oils. From a wood finishing point of view, oils can be grouped into non-drying and drying oils.

Non-drying oils remain unchanged after finishing. They coat and are absorbed into the wood surface, but they do not harden or bond to the wood. The application of non-drying oils is mostly reversible - a solvent such as mineral turpentine or thinners can be used to remove them. Non-drying oils have their uses – they can carry pigments to colour and protect the wood. When exposed to the weather, they remain flexible and can accommodate wood movement. However, they can wash off and may not prevent water from penetrating the wood. Most oils are non-drying oils - examples are motor oil, mineral oil, linseed oil, and most vegetable oils.

Drying oils undergo a chemical process after application that makes them become more viscous and bond to the wood. The drying process is explained by polymer chemistry. Polymers are long chain organic molecules. Heat or the right catalyst can cause the short molecules in the oil to form long chain molecules that cross-link. They effectively bond together to form a more viscous (stiffer) fluid or a solid film. Once the oil has dried, the change is not usually reversible. It will withstand some solvents such as water, turpentine, lacquer thinners, and some oils. The coating cannot be removed without chemical destruction of the film by a strong solvent or paint remover.

A good example is linseed oil, which is pressed from flax seed. Flax is used to make linen cloth. Linseed oil has been in use for many years. Raw linseed oil does not harden, or if it does, it takes many months, and remains sticky, attracting dirt. Before the action of catalysts was understood, to make linseed oil dry, it was boiled, which also had the disadvantage of making the oil rather dark. Nowadays, boiled linseed oil isn't boiled – it has a "drier" added, which performs the function of a catalyst. When boiled linseed oil is applied to wood, it is exposed to oxygen in the atmosphere, whereupon the catalyst causes the short chain molecules to link together into longer chain molecules and the oil stiffens up and forms a film, eventually hardening. This reaction is exothermic – it emits heat, which is not noticeable in a thin film. However, when rags are soaked in boiled linseed oil, the temperature rise can be significant, and even lead to a fire. Leave rags soaked in oil outside to dry or keep them in a fireproof metal container to avoid the risk of fire.

The key to the drying process is the "drier" or catalyst. (A catalyst is substance that accelerates the rate of a chemical reaction without being changed or consumed in the reaction.) The catalyst is carefully selected to affect the speed of drying and nature of the end product. Traditionally, organic lead salts were used, but these have been replaced with other substances based on cobalt, zirconium, zinc, calcium or iron. Cobalt and iron make blue and red pigments so are not used in clear finishes. When the varnish dries, the catalyst is bound up in the film in very small quantities so the varnish is chemically inert. Safety for furniture is not usually an issue. However for contact with food and for toys, no concentration of lead is acceptable, so you should assure yourself that the product is lead-free. The other metals listed are relatively safe, particularly in the small quantities used in the varnishes.

Boiled linseed oil remains flexible, and rather soft even when fully dry. There are other drying oils such as tung oil, walnut oil and so-called Danish oils which are better than linseed. Danish oils are usually blends of other oils, such as tung oil, sometimes diluted with mineral turpentine for ease of application and better penetration into the wood surface.
Tung oil is good but expensive, so the amount of tung varies in different products and influences the price.
Walnut oil can be purchased from health shops and is completely food safe (unless you have a nut allergy). It dries slowly, and forms a matt film – it also has a pleasant, nutty aroma.

There are many blends of oils on the market, and in times past, the compositions were closely guarded trade-secrets. A visit to a modern analytical laboratory will reveal product ingredients, so there is less secrecy now. Product differentiation is through price and marketing, as well as the ingredients.

Varnishes.
Basically, a varnish is comprised of three elements:

- A drying oil,
- a carrying solvent and various resins
- and oils/waxes that will depend on the end use.

1. The drying oil behaves as discussed last month.
2. The solvent assists the application and penetration of the varnish. It was traditionally natural turpentine that is distilled from pine trees, but nowadays mineral turpentine (white spirit) is used. Water based varnishes are becoming more common, as they have safety and environmental advantages, but they may not be organic solvent free.
3. Resins. What mostly differentiates varnishes from each other are the added resins and oils and waxes. As the varnish dries, and polymerisation takes place, these additives become chemically bound into the film. They modify the properties of the final film, providing a mixture of hardness and flexibility. Resins used include amber, copal, rosin and these days mostly alkyd and polyurethane.

    - **Amber** is a fossil resin that was once the gum of a tree that has been preserved for millions of years. It is not used much today.
    - **Copal** and **rosin** are resins obtained from trees such as pines.
    - **Alkyd** resins are created chemically using oils such as sunflower, safflower, soybean, fish, corn or tall oils. These are cooked with acid anhydrides to create

polyester molecules. They are widely used in paints and varnishes. There are a variety of sources and levels of quality that are chosen to suit the application.

- **Polyurethane** resins are also created chemically. There is a wide range of polyurethane resins, with some carefully designed for use in coatings. Single part polyurethane relies on air-drying in common varnishes. There are also two part paints that require mixing before use, but are exceptionally hard and durable.

By selecting the ratios of oil and resins, the final properties of the finish can be determined. So-called “long-oil” varnishes contain more oil and are more flexible and weather-resistant when set. “Short-oil” varnishes contain more resins to give a higher gloss, but are less elastic and better suited to interior applications. For outdoor applications, resistance to ultra-violet light is important, so an inhibitor can be added, however this is only partially effective. Pigments are the only really effective UV protection, and then we are talking about a proper paint! Plan on regular recoating of varnished wood that lives outdoors, various adverts notwithstanding.

Most varnishes contain alkyd and/or polyurethane resins. Alkyd varnishes are clear and dry to a flexible film that can be easily over-coated, whereas polyurethane varnishes are much harder and more durable. With polyurethanes, you need to be careful about over-coating – if you don’t follow the instructions, you can have adhesion problems between layers.

The alkyd or alkyd/polyurethane varnishes are good general-purpose varnishes, combining strength, flexibility and ease of recoating. The polyurethane varnishes are more suitable for high-wear surfaces, such as counter tops and floors, but can be inclined to crack and peel. Adhesion is not as good, and careful application is required to avoid problems.

After application varnish will tend to smooth out or “flow” to level out brush marks and form a smooth, shiny surface. Some varnishes have additives to enhance this. If a shiny finish is not desired, silica is added to give a matt finish. This is inclined to settle out, so be sure to stir matt varnishes properly before application.

Spirit Varnishes and Lacquers are finishes that are carried in a solvent and don’t usually set irreversibly on application. Examples of these are **shellac** and **nitrocellulose lacquer**. Shellac contains a resin that is dissolved in alcohol (what we would call methylated spirits in South Africa). Shellac is used for so-called French polish. Both set after evaporation of the solvent, which is rapid, so application is fast, and suits production well. However, both can be removed by applying the carrying solvent. This is in contrast to varnish, which is immune to turpentine once set.

Some lacquers are derived from natural sources such as the lacquer tree. More commonly, nitrocellulose lacquer is made from cotton reacted with sulphuric and nitric acids, and dissolved in lacquer thinners. It is used in sanding sealer. Shellac and lacquer can produce wonderfully clear, polished finishes, which is why they are popular. However, for general use they are not as durable as varnish.

There are some lacquers that do set. **Pre-catalysed lacquer** has a drier added that causes hardening after application. Drying is slow but the resulting finish can be quite durable. C**atalysed lacquer** is a two-part mixture. It is mixed with a hardener before application. Once dry, it is hard and durable, as well as having the clarity of a lacquer. It is impervious to most solvents. It is very popular for commercial furniture, and is usually sprayed on.

Wax is a solid at room temperature, but it can be softened by heating or adding solvents, to make it easier to apply. There are a large number of natural and synthetic waxes. In woodworking, we usually encounter beeswax, carnauba and paraffin waxes. Furniture polish and shoe polish are blended from a combination of these waxes and a solvent added to soften them. Beeswax is soft, paraffin wax is firm and carnauba wax is hard, so by blending these, the right properties for the application can be realised. After application, the solvent evaporates and soaks into the material such as leather, so the wax becomes harder. Wax can be removed by applying the same solvent, so it is reversible finish. This means that for antique preservation, wax is OK. Applying the wax may modify the existing finish (including all the accumulated grime) if it is not resistant to the solvent used in the wax, but otherwise, it is very safe. Wax is not a very durable finish – it is water resistant, but not water proof. To remain effective, wax needs to be reapplied periodically. To prevent rust on tools and machinery, cheap floor wax works really well. It is easy to apply and completely reversible, so even for antique tools, you need have no worries.

Some consumer furniture waxes contain silicone for a nice shine, but avoid these, as silicone can contaminate finishes causing non-adhesion, and it is very difficult to remove. Don’t use oils and waxes that contain silicone on your tools and machinery as they may contaminate you work pieces and cause finishing problems.

(Sources: Wikipedia, Fine Woodworking articles, American Woodworker article, Practical Woodworking article.)