

# Wood finishing

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**Wood finishing** refers to the process of refining or protecting a wooden surface, especially in the production of furniture where typically it represents between 5 and 30% of manufacturing costs.<sup>[1][2]</sup>

Finishing is the final step of the manufacturing process that gives wood surfaces desirable characteristics, including enhanced appearance and increased resistance to moisture and other environmental agents.

Finishing can also make wood easier to clean<sup>[3]</sup> and influence other wood properties, for example tonal qualities of musical instruments and hardness of flooring.<sup>[4][5]</sup> In addition, finishing provides a way of giving low-value woods the appearance of ones that are expensive and difficult to obtain.



A worker sprays a urethane finish onto a timber

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## Planning the finish (thinking ahead)<sup>[6]</sup>

Finishing of wood requires careful planning to ensure that the finished piece looks attractive, performs well in service and meets safety and environmental requirements.<sup>[6]</sup> Planning for finishing begins with the design of furniture.<sup>[6]</sup> Care should be taken to ensure that edges of furniture are rounded so they can be adequately coated and are able to resist wear and cracking. Careful attention should also be given to the design and strength of wooden joints to ensure they do not open-up in service and crack the overlying finish.<sup>[7]</sup> Care should also be taken to eliminate recesses in furniture, which are difficult to finish with some systems, especially UV-cured finishes.<sup>[8]</sup>

Planning for wood finishing also involves thinking about the properties of the wood that you are going to finish, as these can greatly affect the appearance and performance of finishes, and also the type of finishing system that will give the wood the characteristics you are seeking.<sup>[6]</sup> For example, woods that show great variation in colour between sapwood and heartwood or within heartwood may require a preliminary staining step to reduce colour variation.<sup>[9]</sup> Alternatively, the wood can be bleached to remove the natural colour of the wood and then stained to the desired colour.<sup>[10][11]</sup> Woods that are coarse textured such oaks and other ring-porous hardwoods may need to be filled before they are finished to ensure the coating can bridge the pores and resist cracking. The pores in ring-porous woods preferentially absorb pigmented stain, and advantage can be taken of this to highlight the wood's grain.<sup>[7]</sup> Some tropical woods, such as rosewood (*Dalbergia nigra*), cocobolo (*Dalbergia retusa*) and African padauk (*Pterocarpus soyauxii*), contain extractives such as quinones, which retard the curing of unsaturated polyester and UV-cured acrylate coatings, and so other finishing systems should be used with these species.<sup>[12][13][14]</sup>

Planning for wood finishing also involves being aware of how the finishing process influences the end result. Careful handling of the wood is needed to avoid dents, scratches and soiling with dirt.<sup>[6]</sup> Wood should be marked for cutting using pencil rather than ink; however, avoid hard or soft pencil. HB is recommend for face work and 2H for joint work.<sup>[6]</sup> Care should be taken to avoid squeeze-out of glue from joints because the glue will reduce absorption of stain and finish. Any excess glue should be carefully removed to avoid further damage to the wood.



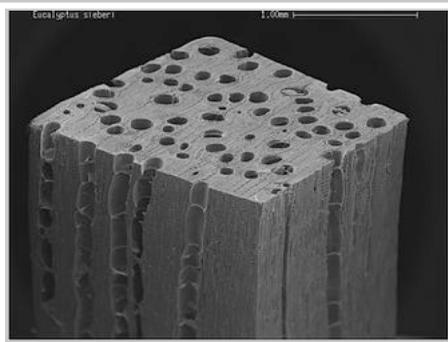
Wood's moisture content affects staining of wood.<sup>[15]</sup> Changes in wood moisture content can result in swelling and shrinkage of wood which can stress and crack coatings. Both problems can be avoided by stored wood indoors in an environment where it can equilibrate to a recommended moisture content (6 to 8%) that is similar to that of the intended end use of the furniture.<sup>[7]</sup>

Finally, consideration needs to be given to whether the finished wood will come into contact with food, in which case a food-safe finish should be used,<sup>[16]</sup> local environmental regulations governing the use of finishes,<sup>[17]</sup> and recycling of finished wood at the end of its life.<sup>[18]</sup>

## Sanding

Sanding is carried out before finishing to remove defects from the wood surface that will affect the appearance and performance of finishes that are subsequently applied to the wood.<sup>[7]</sup> These defects include cutter marks and burns, scratches and indentations, small glue spots and raised grain.<sup>[7]</sup> Sanding should not be used to eliminate larger defects such as gouges, and various forms of discolouration.<sup>[7]</sup> Other techniques are used to remove these defects (see below).

The key to preparing a defect free surface is to develop a sanding schedule that will quickly eliminate defects and leave the surface smooth enough so that tiny scratches produced by sanding cannot be seen when the wood is finished.<sup>[19]</sup> A sanding schedule usually begins with sandpaper that is coarse enough to remove larger defects (typically 80 or 100 grit, but sometimes higher if the surface is already quite smooth), and progresses through a series of sandpaper grades that gradually remove the sanding scratches created by the previous sanding steps.<sup>[19]</sup> A typical sanding schedule prior to wood finishing might involve sanding wood along the grain with the following grades of sandpaper, 80, 100, 120, 150 and finishing with 180 and sometimes 220



Large open 'pores' in *Eucalyptus sieberi*

grit.<sup>[7]</sup> The precise sanding schedule is a matter of trial and error because the appearance of a sanded surface depends on the wood you are sanding and the finish that will subsequently be applied to the wood.<sup>[19]</sup>

According to

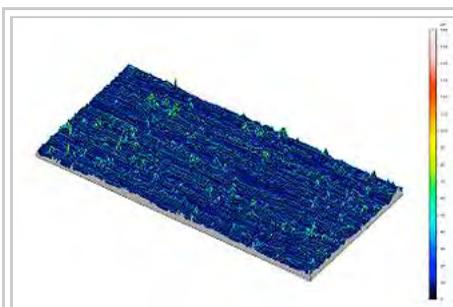
Nagyszalanczy,<sup>[19]</sup> coarse grained woods with large pores such as oak hide sanding scratches better than fine

grained wood and hence with such species it may be possible to use

180 or even 150 grit sandpaper as the final step in the sanding schedule.<sup>[19]</sup> Conversely, sanding scratches are more easily seen in finer grained, harder woods and also end-grain, and hence, they require finer sandpaper (220 grit) during the final sanding stage.<sup>[19]</sup> The sandpaper selected for the final sanding stage affects the colour of stained wood, and therefore when staining is part of finishing avoid sanding the wood to a very smooth finish.<sup>[7]</sup> On the other hand, according to Nagyszalanczy if you are using an oil-based finish, it is desirable to sand the wood using higher grit sandpaper (400 grit) because oil tends to highlight sanding scratches.<sup>[19]</sup>

Sanding is very good at removing defects at wood surfaces, but it creates a surface that contains minute scratches in the form of microscopic valleys and ridges, and also slivers of wood cell wall material that are attached to the underlying wood.<sup>[20][21][22]</sup> These sanding ridges and slivers of wood swell and spring-up, respectively, when sanded wood is finished with water-based finishes, creating a rough fuzzy surface. This defect is known as grain raising. It can be eliminated by wetting the surface with water, leaving the wood to dry and then lightly sanding the wood to remove the 'raised grain'.<sup>[19]</sup>

## Removing larger defects

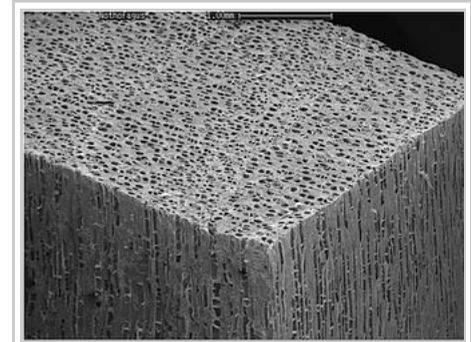


Profilometry image of Yellow birch after sanding

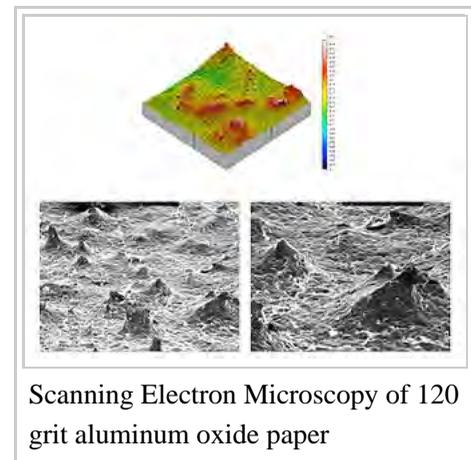
Larger defects that interfere with wood finishing include dent, gouges, splits and glue spots and smears.<sup>[7]</sup> These defects should also be removed before finishing, otherwise they will affect the quality of the finished furniture or object. However, it is difficult to completely eliminate large defects from wood surfaces.

Removing dents from wood

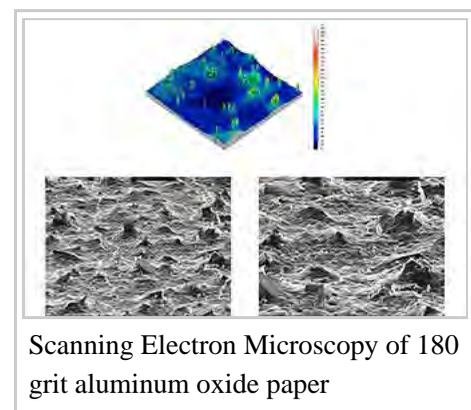
surfaces is quite straightforward as pointed out by Flexner.<sup>[7]</sup> Add a few droplets of demineralized water to the dent and let it soak in. Then put a clean cloth over the dent and place the tip of a hot iron on the cloth that lies



Pore distribution in southern beech



Scanning Electron Microscopy of 120 grit aluminum oxide paper



Scanning Electron Microscopy of 180 grit aluminum oxide paper



Profilometry image of Yellow birch after sanding and wetting

immediately above the dent, taking great care not to burn the wood. The transfer of heat from the iron to the wood will cause compressed fibres in the dent to recover their original dimensions. As a result the dent will diminish in size or even disappear completely, although removal of large dents may require a number of wetting and heating cycles. The wood in the recovered dent should then be dried and sanded smooth to match the surrounding wood.

Gouges and holes in wood are more difficult to repair than dents because wood fibres have been cut, torn and removed from the wood. Larger gouges and splits are best repaired by patching the void with a piece of wood that matches the colour and grain orientation of the wood

under repair.<sup>[7]</sup> Patching wood requires skill, but when done properly it is possible to create a repair that is very difficult to see. An alternative to patching is filling (sometimes known as stopping).<sup>[7][23]</sup> Numerous coloured fillers (putties and waxes) are produced commercially and are coloured to match different wood species. Successful filling of voids in wood requires the filler to precisely match the colour and grain pattern of the wood around the void, which is difficult to achieve in practice. Furthermore, filled voids do not behave like wood during subsequent finishing steps, and they age differently to wood. Hence, repairs to wood using fillers may noticeable.<sup>[7]</sup> Therefore filling is best used with opaque finishes rather than semitransparent finishes, which allow the grain of the wood to be seen.

Glue smears and droplets are sometimes present around the joints of furniture. They can be removed using a combination of scraping, scrubbing and sanding.<sup>[7]</sup> These approaches remove surface glue, but not the glue beneath the wood surface. Sub-surface glue will reduce the absorption of stain by wood, and may alter the scratch pattern created by sanding. Both these effects will influence the way in which the wood colours when stains are used to finish the wood. To overcome this problem it may be necessary to locally stain and touch-up areas previously covered by glue to ensure that the finish on such areas matches that of the surrounding wood.<sup>[7]</sup>

## Bleaching and Removal of Stains

Wood surfaces are occasionally affected by various organic and inorganic stains.<sup>[24]</sup> Sometimes such stains enhance the colour and appearance of wood.<sup>[24]</sup> For example, oak wood affected by the beef-steak fungus has a deep rich, attractive, brown colour<sup>[25]</sup> and there is no reason to remove the stain from the wood prior to finishing. The same applies to spalted wood whose attractive appearance is again caused by fungi. On the other hand some fungal stains and those caused by the reaction of iron with wood can disfigure wood.<sup>[24]</sup> These stains can be removed from wood using bleach.<sup>[26][27]</sup> Bleaches are also occasionally used to reduce the difference in colour between lighter sapwood and heartwood and also colour variation within heartwood.<sup>[7]</sup> Such bleaching make it easier to achieve a uniformly coloured wood when the wood is subsequently coloured with pigmented stains and



Macro photo of 120 grit sandpaper



Macro photo of 220 grit sandpaper



Macro photo of 320 grit sandpaper

dyes<sup>[7]</sup> (see below). Furthermore, the natural colours of wood fade when wood is exposed to sunlight, and more permanent colours can be created by bleaching wood to remove its natural colour and then re-colouring the wood using artificial, light-fast, stains.<sup>[7]</sup>

The bleaches used to remove unwanted fungal stains from wood include two-part peroxide bleach and solutions of sodium hypochlorite.<sup>[27]</sup> The former is particularly effective at removing the natural colour of wood before it is recoloured with pigmented stains or dyes.<sup>[27]</sup> Oxalic acid is particularly effective at removing iron stains from wood.<sup>[27]</sup>

## Colouring Wood

Wood can be stained to change its colour or left unstained before application of lacquer, or other types of top-coats. Staining should enhance the appearance of wood by reducing colour variation between and within sapwood and heartwood. It also provides a way of giving bland looking woods such as poplar, the appearance of prized furniture woods such as ebony, mahogany or walnut. Wood can be stained using dyes or pigmented finishes. These finishes are available in a wide variety of colours, many of which are not part of the natural colour palette of wood, for example, blues and greens. Pigmented stains tend to highlight the grain (and also sanding scratches), whereas dyes do not have this effect and are more transparent. Wood can also be coloured by exposing it to chemicals that react with the wood to form coloured compounds. Chemical staining of wood is rarely carried out because it is easier to colour wood using dye or pigmented stain, however, ammonia fuming is a chemical staining method that is still occasionally used to darken woods such as oak that contain a lot of tannins. Staining of wood is difficult to control because some parts of the wood absorb more stain than others, which leads to problems such as blotchiness and streaking. For this reason, as pointed out by Flexner, many people prefer to omit the staining step when finishing wood.

## Basic wood finishing procedure

Wood finishing starts with sanding either by hand, typically using a sanding block or power sander, scraping, or planing. Imperfections or nail holes on the surface may be filled using wood putty or pores may be filled using wood filler. Often, the wood's color is changed by staining, bleaching, or any of a number of other techniques.

Once the wood surface is prepared and stained, the finish is applied. It usually consists of several coats of wax, shellac, drying oil, lacquer, varnish, or paint, and each coat is typically followed by sanding.

Finally, the surface may be polished or buffed using steel wool, pumice, rotten stone or other materials, depending on the shine desired. Often, a final coat of wax is applied over the finish to add a degree of protection.

French polishing is a finishing method of applying many thin coats of shellac using a rubbing pad, yielding a very fine glossy finish.

Ammonia fuming is a traditional process for darkening and enriching the color of white oak. Ammonia fumes react with the natural tannins in the wood and cause it to change colours.<sup>[28]</sup> The resulting product is known as "fumed oak".

## Types of finishes

There are three major types of finish:<sup>[29]</sup>

- Evaporative
- Reactive
- Coalescing

Wax is an **evaporative** finish because it is dissolved in turpentine or petroleum distillates to form a soft paste. After these distillates evaporate, a wax residue is left over.

**Reactive** finishes may use solvents such as white spirits and naphtha as a base. Varnishes, linseed oil and tung oil are reactive finishes, meaning they change chemically when they cure, unlike evaporative finishes. This chemical change is typically a polymerisation, and the resultant material is less readily dissolved in solvents .

Tung oil and linseed oil are reactive finishes that cure by reacting with oxygen, but do not form a film.

Water based finishes generally fall into the **coalescing** category.

## Comparison of different clear finishes

Clear finishes are intended to make wood look good and meet the demands to be placed on the finish. Choosing a clear finish for wood involves trade-offs between appearance, protection, durability, safety, requirements for cleaning, and ease of application. The following table compares the characteristics of different clear finishes. 'Rubbing qualities' indicates the ease with which a finish can be manipulated to deliver the finish desired. Shellac should be considered in two different ways. It is used thinned with denatured alcohol as a finish and as a way to manipulate the wood's ability to absorb other finishes. The alcohol evaporates almost immediately to yield a finish that will attach to virtually any surface, even glass, and virtually any other finish can be used over it.



Linseed oil



Shellac



2:1 ratio of beeswax and carnauba wax



No finish



Molten bee wax



Shellac and linseed oil



Acrylic paint



Alkyd



Spar varnish



Tung oil



Tung oil and linseed oil



Acrylic varnish

	<b>Appearance</b>	<b>Protection</b>	<b>Durability</b>	<b>Safety</b>	<b>Ease of Application</b>	<b>Reversibility</b>	<b>Rubbing Qualities</b>
<b>Wax</b>	Dull, even sheen unless spit polished	Short Term	Needs frequent reapplication	Safe when solvents in paste wax evaporate	Difficult on bare wood	Difficult. Solvents thin wax causing it to penetrate deeper. Sanding creates heat. Scraping recommended	Needs to be buffed for low sheen, buffed with damp pad for high gloss
<b>Shellac</b>	From virtually clear (super blond) to a rich orange (garnet)	Fair against water, poor solvent protection	Durable	Safe when solvent evaporates, used as food and pill coating	Clogs spray equipment. Quick solvent flash time makes brushing difficult. Ox or badger/skunk hair brush recommended. Easy to pad, however French Polish is difficult	Completely reversible using alcohol	Excellent
<b>Nitrocellulose lacquer</b>	Transparent, good gloss	Decent protection	Soft and somewhat durable	Uses toxic solvents. Good protection is needed, especially if painted	Requires equipment.	Reversible with proper solvents	Excellent soft finish
<b>Pre-Cat lacquer</b>	Transparent, all sheens from 5% to 90%	Good general protection against wet and dry heat.	Meets UK and European standards for "general use".	Uses toxic solvents. Spray booth is needed.	Spray application only.	Non-Reversible after 5 days	Excellent general furniture finish used extensively outside USA
<b>Conversion varnish or Acid-Cat Lacquer</b>	Transparent, all sheens from 5% to Wet Look	Excellent protection against many substances	Meets UK and European standards for "severe use".	Uses toxic solvents, including toluene.	Requires spray equipment. Used in professional shops only	Difficult to reverse	Excellent hard finish
<b>Boiled linseed oil</b>	Yellow warm glow, pops grain <sup>1</sup> , darkens with age	Very little	Little	Relatively safe, metallic driers are poisonous, rags may spontaneously combust	Easy, but cure time can be upward of 30 days	Difficult. All saturated wood needs to be removed (planing/sanding /scraping)	Dries hard, can be buffed to high gloss
<b>Tung oil</b>	Warm glow, pops grain <sup>1</sup> , lighter than linseed	Water resistant	Poor	Relatively safe when fully cured. Pure tung oil contains no metallic driers. Many products labeled tung oil are oil/varnish blends	Difficult. Sanding is required between coats and a partial cure is necessary. Very long finishing schedule for sufficient amount of coats	Difficult. All saturated wood needs to be removed (planing/sanding /scraping)	Dries hard, can be buffed to high gloss
<b>Alkyd varnish</b>	Not as transparent as lacquer, yellowish/orange tint	Good protection	Durable	Relatively safe, uses petroleum based solvents	Brush or spray. Brushing needs good technique to avoid bubbles & streaks	Can be stripped using paint removers	Fair
<b>Polyurethane varnish</b>	Slight ambering, comes in a variety of sheen	Excellent protection against many substances, tough finish	Durable after approx. 7 day curing period	Relatively safe, uses petroleum based solvents	Very easy when thinned and wiped on. Also brushes and sprays well	Can be stripped using paint removers	Easy to rub out with steel wool or synthetic pads to reduce sheen.

							Because it is soft, it cannot be buffed to a high gloss
<b>Water-based polyurethane</b>	Transparent	Good protection. Newer products (2009) also UV stable when noted	Durable after approx. 10-day curing period	Safer than oil-based, fewer volatile organic compounds	Brush or spray. Fast drying demands care in application techniques	Can be stripped using paint removers	Excellent. Acrylic finishes are very hard and can be buffed to an extreme gloss. Use a release agent
<b>2-Part polyurethane</b>	Transparent	Stronger protection than regular polyurethane varnish	Durable once cured, generally less than an hour	low or free of VOCs, nonreactive when cured	generally sprayed, equipment must be cleaned of any mixed product immediately	Irreversible	Sands easily. Sanding not needed between coats
<b>Oil-varnish blends (i.e. Danish Oil, Teak oil, "tung oil finish")</b>	Enhances natural figure like a drying oil, but easier to apply and more protective.	Low, but more than pure oil finishes	Fairly durable but not recommended for heavy use items such as table tops	Relatively safe, uses petroleum based solvents	Easy, apply with rags and wipe off. Too many applications can result in sticky build up	Difficult. All saturated wood needs to be removed (planing/sanding /scraping)	Dries hard. can be buffed to a matte finish or to a gloss. Often top coated with paste wax for extra protection
<b>Epoxy resin</b>	Thick, high-gloss, and transparent. Some formulations can cloud or yellow with UV exposure	High level of protection	Flexible and durable	Safe when cured	Easy pour-on application for flat surfaces, difficult to apply evenly on more complicated shapes	Cleanable with acetone when liquid. Irreversible once cured	flexibility makes sanding difficult but possible

<sup>1</sup> accentuates visual properties due to differences in wood grain.

## Automated wood finishing methods

Manufacturers who mass-produce products implement automated flatline finish systems. These systems consist of a series of processing stations that may include sanding, dust removal, staining, sealer and topcoat applications. As the name suggests, the primary part shapes are flat. Liquid wood finishes are applied via automated spray guns in an enclosed environment or spray cabin. The material then can enter an oven or be sanded again depending on the manufacturer's setup. The material can also be recycled through the line to apply another coat of finish or continue in a system that adds successive coats depending on the layout of the production line. The systems typically used one of two approaches to production.

### Hangline approach

In the hangline approach, wood items being finished are hung by carriers or hangers that are attached to a conveyor system that moves the items overhead or above the floor space. The conveyor itself can be ceiling mounted, wall mounted or supported by floor mounts. A simple overhead conveyor system can be designed to move wood products through several wood finishing processes in a continuous loop. The hangline approach to automated wood finishing also allows the option of moving items up to warmer air at the ceiling level to speed up drying process.

### Towline approach

The towline approach to automating wood finishing uses mobile carts that are propelled by conveyors mounted in or on the floor. This approach is useful for moving large, awkward shaped wood products that are difficult or impossible to lift or hang overhead, such as four-legged wood furniture. The mobile carts used in the towline approach can be designed with top platens that rotate either manually or automatically. The rotating top platens allow the operator to have easy access to all sides of the wood item throughout the various wood finishing processes such as sanding, painting and sealing.

## See also

- Wood stain
- Refinishing
- Distressing
- Danish oil
- Xylotechnigraphy

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In this hangline approach, wood items being finished are moved through various finishing stages on a conveyor system



In this Towline method, mobile carts move large furniture through various finishing stages on a conveyor system.

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## External links

- Shellac Application ([http://www.frenchpolishes.com/application\\_information/shellac\\_polish\\_application.htm](http://www.frenchpolishes.com/application_information/shellac_polish_application.htm))
- Finishes on Antique Wood Furniture (<http://www.harpgallery.com/library/antiquefurniturefinishes.html>)
- To Refinish or Not to Refinish (Antique Furniture) (<http://www.harpgallery.com/library/refinish.htm>)
- Finishing for First-Timers (<http://www.popularwoodworking.com/features/finish5.html>)
- Oil Finishes (<http://www.popularwoodworking.com/features/finish2.html>)
- Homeshop finishes that work (<http://www.thewoodshop.20m.com/finishing.htm>)

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