Waterborne Finishes: Friendlier Than Ever

Simple shop tests help rate a new generation of clearcoatings

by Chris A. Minick

Finishes that use water as a carrier— *Waterborne finishes go by many names, such as lacquer, acrylic, urethane and conversion-varnish. But they all use water as a delivery medium. The waterborne finishes compared in this article (with their test panels below left) include both hardware-store and commercial-grade varieties.*

A cigarette advertising campaign gained fame, if not fortune, by telling women, "You've come a long way, baby." The ads are in bad taste. But that corny slogan would be perfect for describing products I'm sure advertising copywriters didn't have in mind—waterborne wood finishes.

Almost universally, the latest wave of clear, waterborne finishes (see the photo above) shows a dramatic improvement over those of just five years ago. Gone are the poor-performing, hard-to-use coatings that looked more like plastic wrap than furniture finish. They've been replaced by friendlier finishes, some of which out-perform nitrocellulose lacquer.

Waterborne finishes are not toxic to the environment. They meet the most recent limits for volatile organic compounds (VOCs) in finishes. The newest waterborne finishes adhere better and raise the grain less than the old formulations did. They are easy to use, dry fast, clean up with water and, generally, level out well. If you have good ventilation, you can set up a simple finishing area to spray waterborne finishes. You don't need an explosion-proof booth. If you're brushing, keep in mind that the coats dry quicker than solvent-based varnish (see the story on p. 52).

To see how the new field of waterborne finishes has changed, I chose 15 popular brands—eight over-the-counter finishes found at hardware stores and seven professional-grade finishes found at woodworking supply stores.

I picked gloss finishes because they're the most difficult to get right. I couldn't

evaluate every transparent waterborne finish on the market, but if the brand you're using isn't on the chart on pp. 50-51, some simple shop tests will tell you how good your finish is (see the box at right).

Choosing a finish depends on many factors (see *FWW* #104, pp. 85-89). Because different waterborne finishes excel at different things, you can use the results summarized in the chart (or your own test results) to select the right finish. First, though, a brief discussion of the chemistry of waterborne finishes is in order.

Waterborne finishes have complex formulations

By definition, a lacquer always is soluble in its own solvent. That's why even dried nitrocellulose lacquer can be cleaned from a brush with lacquer thinner. It might surprise you that most waterborne finishes are lacquers. They're sold under every finish name under the sun, including acrylic and urethane.

But don't expect to clean up any of these dried waterborne finishes with water. Water is merely a convenient, nonhazardous

Photos: Alec Waters

Six finish testing methods

There is no magic to testing finishes. For the test panels, I used ½-in. medium-density fiberboard (MDF) veneered with birch. I stained half of each panel with Glidden's walnut, oil-based stain and let the panels dry for a week.

To apply the finish uniformly, I used a draw-down bar (a rod wrapped with #40 wire). I applied a swath of finish on one end of the panel and used the wire-wrapped bar to drag the finish across the panel. (You could make your own bar by spiral-wrapping 20-gauge wire around a length of pipe.) I applied three consistent coats of finish, 3 mils thick, allowing each coat to dry four hours. I cured the panels in the shop for 10 days. —*C.M.*

Adhesion

Slice an X on the finish with a razor or sharp knife guided by a straightedge (on the stained side of the panel). Apply a piece of duct tape over the cut area, and rub down well.

After a few minutes, yank off the tape. The finishes that pass will show no delamination. Finishes with marginal adhesion will have ragged edges along the cut. And failed finishes will have chunks missing.

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carrier liquid that transports the resin from the can to the work. Special resin-soluble/water-soluble solvents, usually glycol ether (similar to lacquer retarder), are added to waterborne finishes. These solvents are critical to film formation. They also dissolve the dry film.

Besides solvent, water and resin, a myriad of other chemicals are needed to complete a waterborne finish formulation. Among the most important are surfactants, compounds which are added for stability, proper flow and leveling.

Defoamers minimize bubbles during application, and thickeners maintain proper viscosity. Flatting agents control finish sheen, and mar-aids protect the film from damage while curing. The formulation is a delicate balance of all these parts, plus some other minor ones. Over-thinning a waterborne finish will destroy this balance, resulting in finishing defects.

How waterborne finishes work

Waterborne finishes contain about 30% resin—much more than nitrocellulose lacquer, which has about 12% resin. That's why it's easy to apply too heavy a coat the first time you spray a waterborne finish. It's common to get sags and runs until you get used to spraying these finishes.

Waterborne finishes differ from solvent-based finishes not only in composition but also in the way a film is formed. If you could look into a can of waterborne finish with a powerful microscope, you'd see billions of tiny spheres of resin dispersed in water. Each resin ball contains solvent, which makes the ball sticky, and is surrounded by a protective layer of surfactant. The surfactant layer keeps the sticky balls from becoming one giant agglomeration in the can.

As the finish begins to dry, water evaporates from the emulsion. At the same time, the viscosity of the finish increases, and the resin balls start to bunch together, much like golf balls packed in a bucket. When enough water has evaporated, capillary action within the film deforms the balls into stacked, overlapping discs, called platelets. Residual solvents, called tail solvents, weld the discs together to form a continuous film.

The tail solvents also allow successive coats to burn into one another. The solvents gradually evaporate to complete the curing. One exception is Kemvar W made by Sherwin Williams. Because it is a conversion varnish, it's possible to get "witness lines" between coats if the directions aren't followed. Witness lines result when successive layers of finish don't melt into each other and are rubbed out unevenly.

The whole film-forming process is known as coalescence. The makers of waterborne finishes often have "polymerized" written on the can because it's a sexy chemical term that attracts consumers. Some cans of waterborne finish also have "catalyzed" on the label, which means that a chemical (catalyst) is added to trigger the polymerization process. Finish polymerization, in theory, means that billions of tiny molecules link into one big one.

Comparing waterborne finishes

Manufacturer	Product	Adhesion over oil stain	Stain Resistance (22 max.)	Heat resistance (200°F)	
Amity (800) 733-1776	Gloss	Fail	22	OK	
Behlen (518) 843-1380	Water-based urethane	Pass	17	Slight print	
Behr (714) 545-7101	#630 polyurethane	Fail	22	OK	
Carver Tripp (508) 679-5938	Safe & Simple	Fail	22	OK	
Crystalac (615) 727-6425	CL90	Marginal	14	Slight print	
Deft (714) 474-0400	Safe & Easy	Marginal	20	Slight print	
Fabulon (716) 873-6000	Crystal	Marginal	16	OK	
Eclectic Products (800) 288-4667	Famowood Super Lac	Pass	19	OK	
General Finishes (800) 783-6050	EF poly-acrylic blend	Pass	16	OK	
Hydrocote (800) 229-4937	Equal	Marginal	6	Fail	
McCloskey (800) 845-9061	Heirloom	Marginal	17	OK	
Minwax (201) 391-0253	Polycrylic	Fail	15	Slight print	
M.L. Campbell (716) 873-6000	Ultrastar	Marginal	20	OK	
Sherwin Williams (216) 566-2000	Kemvar W	Pass	20	OK	
Wood-Kote (503) 285-8371	Liquid plastic	Pass	22	OK	
Two benchmark finishes					
Solvent-based nitrocellulose lacquer		Pass	21	Fail	
Solvent-based polyurethane varnish		Pass	22	OK	

Nitrocellulose lacquer and polyurethane varnish are considered the solvent-based standards in the finishing industry. Because you may be more familiar with these two finishes than you are with waterborne finishes, we've included them here as a point of reference.

Testing the finishes and interpreting the results

I'm a sucker for new finishes. But experience has taught me that the worst way to select a new finish is by reading manufacturer's advertisements or what's listed on the label. Most of the product literature reads something like "Our finish is great on everything." The only way to tell whether those assertions are true is to test the finish. That's how this article was born. Half the waterborne finishes I tested are

	Solvent resistance (30 max.)	Sanding	Appearance	Best applicator	Remarks / Dry time
	3	Moderate	Fair	Spray	Good color/ 2 hours
	1	Difficult	Fair	Spray or brush	Very thin / 2 hours
	10	Difficult	Poor	Brush	Looks plastic-coated / 3-4 hours
	16	Moderate	Poor	Brush or spray	Blue tint / 45 minutes
	2	Easy	Very good	Spray	Lacks color / 30 minutes
	8	Very difficult	Very poor	Brush	Severe fish-eyes / 1 hour
	2	Moderate	Fair	Brush	Low gloss / 1 hour
	9	Easy	Excellent	Spray	Looks like nitro-cellulose / 30 minutes
	8	Easy	Very good	Brush or spray	Easy to brush / 2 hours
	0	Easy	Excellent	Spray	Cold water destroyed film / 30 minutes
	12	Difficult	Fair	Brush	Good color / 1-2 hours
	16	Moderate	Good	Brush	Lacks color / 2 hours
	6	Moderate	Good	Spray	Rubs out nicely / 45 minutes
	30	Moderate	Very good	Spray	Off-gasses formal-dehyde / 45 minutes
	18	Difficult	Poor	Brush	Poor leveling / 2-4 hours
	9	Moderate	Excellent	Spray	Industry standard
	27	Difficult	Very good	Brush	Very durable, but looks yellow

The areas on the chart in this color indicate professional-grade finishes designed for spraying. Unshaded areas indicate over-the-counter, hardware-store finishes designed for brushing. There are three finishes that are recommended for both spraying and brushing.

recommended for spray application. The other half are suitable as general-purpose, brush-on finishes.

Adhesion is the most important consideration—Many projects are stained, so it's critical that a waterborne finish adhere to oil-based stain (see the photo at right on p. 49). After all, the main job of a finish is protection. If a finish doesn't stick, the rest of its attributes are meaningless. I avoid any finish that fails in adhesion. If a finish adheres marginally, I would seal stained areas with fresh, de-waxed shellac before I used that particular topcoat.

Resistance to stains, solvents and heat depends on the project—Not all finishes are appropriate for all projects. Tabletop finishes should provide good resistance to food stains and should be washable with standard cleaners. I used a stain-resistance test to determine how well each waterborne finish withstood 11 com-

Stain resistance

Place one drop of the following household products on the panel: milk, mustard, grape juice, lemon juice, olive oil, Windex, Fantastik, Spic and Span pine cleaner, ammonia, black shoe polish and hot water (140°F). After one hour, wash the panel with water, and inspect the finish. If a patch shows no stain or damage, it receives two points; if it has slight dulling, it gets one point; if it has severe damage or a stain, it gets no points. Add up the points (22 is the maximum).

Heat resistance

Heat several large flat-head bolts in boiling water. Set a bolt (about 200°F) on each panel, and allow them to cool to room temperature. Then remove the bolts.

Rate the finish "okay," if a bolt shows no sign of damage. If the bolt leaves a slight impression or sticks to the finish, the finish fails the test.

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Solving waterborne finish problems

Although it's true that waterborne finishes are easy to use, they are not problem-free. However, by knowing a few corrective tricks, you can overcome most of their shortcomings.

When you first apply a waterborne finish, don't be alarmed if the finish looks milky. As it dries, and the water evaporates, a clear film of finish will form.

Reducing bubbles and micro-bubbles: Bubbles are the most common drawback to using waterborne finishes. Bubbles are caused by the surfactants (compounds added for stability, flow and leveling). Manufacturers try to counteract the bubbles by mixing in defoamers, but the defoamers deactivate over time. The older the finish, the more bubbles. To control bubbles in old (one year or more) cans of finish, I add a small amount of solvent (no more than 1½ oz. per gallon). I use lacquer thinner, mineral spirits or even

Watch the humidity—*Applying waterborne finishes in high humidity and low temperatures can interfere with proper film formation. That was the case with this finish.*

milk. (Fats in milk are chemically similar to defoamers.)

Another bubble problem, micro-bubbles, is particular to certain fast-drying waterborne finishes designed for spray application. Micro-bubbles form when high-pressure air from a spray gun is forced into the liquid finish. This trapped air forms tiny voids in the film. Micro-bubbles are not so noticeable in a dull or semigloss finish, but they show up as a white haze in high-gloss finishes. To eliminate micro-bubbles, reduce the atomization pressure. Lowering the pressure can cause another problem—orange peel (poor leveling). Eliminating both micro-bubbles and orange peel is a balancing act. Sometimes, I add a waterborne finish retarder (in a pinch, you can use a 50:50 mix of lacquer retarder and water) to minimize micro-bubbles.

Applying level, blemish-free coats: When brushing on a waterborne finish, use long, even strokes, as you would with shellac. Keep the brush angle at about 30°. Avoid back-and-forth motions—they're more suited for house painting. Use a long-bristled, tapered-and-tipped nylon brush or a good foam applicator. Work quickly as you brush, and maintain a wet edge. This should reduce sanding.

In preparation for a waterborne finish, don't use a tack cloth. It contains an oily substance that will cause fish-eyes (so will some stearate-coated sandpapers). I wipe down my projects beforehand and between sanding stages with a cloth dampened with mineral spirits. If you're spraying, make sure you have a de-oiler. Also, don't use steel wool between coats. Small metal shards left by the steel wool will rust and ruin your finish.

Eliminating grain raising: Grain raising, though still a problem with waterborne finishes, is not as bad as it once was. One way to get around the problem is to wet the wood and then knock down the fibers with sandpaper before you finish. But there is an easier way. Waterborne-finish manufacturers have introduced non-grain-raising (NGR) sealers. Apply a thin sealer coat, let it dry and then scuff-sand the surface. Nearly all the finishes in this article have accompanying sealers.

I almost always use a sealer with waterborne finishes. Compared to nitrocellulose lacquer, waterborne finishes usually are colorless and without depth. Sealing (I like super-blond shellac) before you apply the waterborne finish can dramatically improve the appearance. Tinting with NGR stain is another option.

Watching the temperature and humidity: The ideal application condition for most waterbornes is around 70°F and 50% relative humidity (RH). Temperatures below 50°F and/or humidity above 85% RH can severely compromise film integrity (see the photo above). In fact, either condition can prevent the finish from forming a film at all. Heating or dehumidifying your shop will cure both problems. Or you can wait for a better day. —*C.M.*

mon chemicals (see the top photo on p. 51). The higher the number, the better the stain resistance. Finishes with a rating of 15 or higher should stand up well to everyday use. If you have a house full of teen-agers, you may want to use a finish with a higher rating.

Heat resistance also is important for dining-table finishes. While it's probably not a good idea to take a hot casserole dish from the oven and place it on the table, it happens all the time. Heat-damaged finishes are very hard to repair. A simple test using a hot bolt (see the bottom photo on p. 51) can save you a lot of work later on.

The solvent-resistance test (see the top right photo on the facing page) is tedious. But it's worth checking out a finish's solvent resistance ahead of time. This is especially true for dressing tables or bar tops because perfume, nail-polish remover and drinks with alcohol in them contain solvents that can damage a finish. This test is standard in the kitchen cabinet industry.

How it sands and looks may or may not be a concern—Sanding is an important step toward getting a nice finish. But I don't like to sand. Who does? If a finish is hard to sand (meaning that globs of finish accumulate on the sandpaper), I usually get frustrated, stop sanding and hope that the next coat will cover up the problem. It rarely does. That's why I select finishes that sand as painlessly as possible. It's rather tricky for a finish to be both durable (not brittle) and have the right feel (friction) for sanding. A good finish is neither too soft nor too hard.

Grading the look of a finish is subjective. I'm a nitrocellulose lacquer fan. As far as appearance goes, no finish can match it. I can't help but compare any finish to nitrocellulose lacquer, and the waterborne finishes were no exception (see the bottom photos on the facing page). Appearance rankings on the chart, as well as those for sandability, relate more to my preferences than to hard data or measurements. Take them with a grain of salt.

The good, the bad and the ugly

I've tested a lot of waterborne finishes in the last 15 years, and most have been pretty mediocre. I expected the same kind of results from this round of tests, too. What I found was quite different. The latest waterborne finishes have some real winners and a few big losers.

The real surprise was Hydrocote Equal. Although it was one of the best-looking finishes, it tested last overall. I even ran the tests twice to confirm my initial results. And then I used the same procedures to compare this finish to an acrylic floor polish made by Johnson Wax. The floor polish

Strikes against them—*No finish was perfect, but some of them had serious faults (from left): Amity (poor adhesion), Carver Tripp (poor appearance), Deft (excessive fish-eye), Wood-Kote (poor leveling) and Hydrocote (poor stain and solvent resistance).*

Author's favorites—*Based on the tests, Minick liked three finishes (from the left): Sherwin Williams (most protective), General Finishes (best brush-on), and Wood-Tex, which is now sold as Famowood Super Lac (best to spray, best looking and best value). Sherwin Williams is shown with its catalyst.*

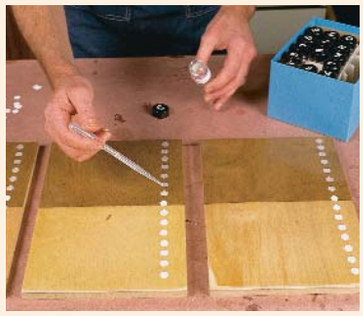
scored higher. Hydrocote does make another more expensive, more durable waterborne finish called Resisthane. This finish performed much better than the Equal. The waterborne finishes made by Amity, Carver Tripp, Deft and Wood-Kote had their share of problems, too (see the top photo). They may or may not be appropriate for your next finishing project.

But three finishes really impressed me (see the bottom photo). Kemvar W had the highest gross score. For sheer protection value, this finish is practically bulletproof. In terms of formulation, it's quite different from the others in the field because it has two parts. It's actually a spray-on, acid-catalyzed, waterborne conversion varnish designed as a kitchen-cabinet finish.

A word of caution, though. Kemvar W releases small amounts of formaldehyde gas as it dries. This finish should only be sprayed in a booth that has good intake and exhaust air flow. And it's a good idea to wear gloves and protective clothing. I also use a carbon-filter respirator.

General Finishes' EF polyurethane and acrylic blend applies easily, has excellent leveling properties, good vertical cling and looks great—a pleasant surprise in a brush-on finish. Of all the finishes, I was most impressed with Eclectic Product's Famowood Super Lac (previously available as Wood-Tex Super Lac; the manufacturer assures me that the finish in the can remains the same). This finish's color is virtually indistinguishable from nitrocellulose lacquer. It rubs out beautifully, has decent resistance properties and, best of all, has a depth not usually associated with waterborne finishes. □

Chris Minick is a finishing chemist and a contributing editor to Fine Woodworking. *He works wood in Stillwater, Minn.*



Solvent resistance

Apply three solvents to the panels. I blended water, ethyl alcohol (ethanol) and methyl ethyl ketone (MEK) in 15 different ratios, starting with a 50:50 mix of water and ethanol and ending with 100% MEK. Space 15 dots of bond paper on the panels. Place a drop of each solution on the dots, and dry two hours. Remove the dots. A spot with no damage receives two points; slight damage or dulling of the finish gets one point; dots that stick to the finish get no points. Add up the points (30 is the maximum).

Sandability

Wrap a ¾-in.-wide strip of 400-grit sandpaper around a piece of scrap. Abrade a spot of the panel. Easy-to-sand finishes form a powder and do not load the paper. Difficult-to-sand coatings require force and gum up the paper. Moderate-to-sand finishes fall in between.

Appearance

Compare the finishes to nitrocellulose lacquer. Note the clarity, depth, color and luster. I rated finishes "excellent" and "very good" if they looked three-dimensional and warm (amber). I used "good" and "fair" for finishes that lacked color or appeared cloudy or blue. I rated ugly finishes "poor."