Varnish And Polyurethane Finishes

At our last meeting of the Pikes Peak Woodturners, there seemed to be a little confusion about polyurethane finishes and varnishes. So here is the unvarnished truth. All of the segmented bowls I showed at the meeting were finished in polyurethane using a brush. Eh? What is that supposed to mean? Unfortunately, it doesn't mean the same thing to everyone. So let's take a look at the polyurethane finishes.

Varnish

First comes the term "***varnish***". What does that mean? Wow! What a mess. Real confusion here. Shellac, lacquer, varnish, nitrocellulose, polyurethane, water based, conversion coatings, reactive coatings, "two can" finishes, acrylic. A lot of folks add to the confusion by calling some lacquers "*varnish"* just to indicate a transparent glossy coating. Then varnish, for example, *Japanese lacquer,* get called lacquer when they aren't. Then water-based stuff gets called varnish when it is really not varnish at all. So what is the true scoop? Shellac and lacquers are dissolved in a solvent. When the solvent evaporates, there is a coating left which is a lacquer. It does not undergo any chemical changes. Varnishes are coatings dissolved in a solvent. When the solvent goes away, the coating then undergoes a chemical change to make it harder and more durable. So generally lacquers are in solvents like acetone, alcohol, methyl ethyl ketone, and stuff like that. Varnishes are typically in oil based solvents like paint thinner. When exposed to air or moisture, the varnish reacts.

Consider the horrible example of not cleaning the rim of the can before you put the lid back on. The lid does not seal tightly and air gets in. For a lacquer, the paint dries out, but can be re-dissolved by adding more solvent and stirring. NOT SO for a varnish. A month later, you take the lid off and find a tough rubbery layer on top of the varnish. Some of the chemicals have reacted with air or moisture to form giant molecules. You cannot re-dissolve that gunk by adding solvents and stirring.

Varnishes are slow to "dry". For some of these, you can allow them to dry for a couple of hours and paint the next coating on top. However, if you wait for a day or two, you have to sand before you can recoat. With lacquer, the solvent in the second coat will dissolve the surface of the first coat and give you a continuous coating. In a varnish, this dissolving does not take place and you have to sand to provide tiny scratches for the second coat to stick to mechanically.

Varnish History

DO NOT READ THIS PARAGRAPH. This paragraph is about a Queen of Egypt and how she got her name on "varnish". A long time ago there was this kid named Alexander the Great. Well, he wasn't really named "the great" folks just called him that. He conquered the civilized world as far as anyone knew at the time. Alex died and the generals of his army divided the territory. A general named Ptolemy got Egypt as his share of the spoils. He became the king, the Pharaoh, an Egyptian god, and immortal. Not bad work if you can get it. His dynasty continued to rule Egypt on down to the last Ptolemy, a young lady named Cleopatra. Anyway, along the line was King Ptolemy III.

His wife was named Berenice. Berenice was a real looker with long amber colored hair. Her husband was at war with Iraq and Iran and Syria (similar to George W. Bush). While the King was away to war, Berenice cut off the long amber hair and gave it to the gods if her guy would return in one piece. The gods glommed onto the hair and stuffed it into the sky as constellation stilled known today as *Coma Berenice,* or *Berenice's hair* in English. Her hubby returned safely home. The golden amber color of varnish reminded folks of her hair, so they called the paints *Bernice* in honor of her sacrifice. Due to some sloppy spelling 500 years ago, it became known as *Vernice* and eventually in England it became *Varnish*. Now you know and you can see why I warned you not to read this paragraph.

Anyway, back in 1500, people did not know how to make polymers like polyurethane. So, they made varnish by dissolving natural resins in solvents. Stuff like resin off of pine trees and amber (fossil pine tree gunk) were dissolved and used. The amber varnishes were a lot harder because they had been "drying" for thousands of years. Then along came chemists who created the chemicals that are now used to make superior varnishes. Superior means excellent resistance to wear, heat, acid, alkali, water, alcohol, and Coors Light. On a trip to Scotland, I saw a varnished segmented vase that was hundreds of years old and the finish still looked great. The 300 year old marquetry table on which it sat was shellacked and was split, cracked and warped. Could have been expansion of the veneer, but I really think it was mostly the poor protection of shellac.

Polyurethane

I was a lot younger years ago when I was a kid. Well, DUH. Anyway, a lot of birthday parties were held at the local roller skating rink. The oak floors there took a terrible beating as millions of little wheels ran over them. However, the finish held up amazingly well. I asked the owner what they did to keep the floors from getting worn out. He told me they used "polyurethane". Here I am some years later still using polyurethane coating on the oak floors in my house. Segmented bowls take a long time to make, so I want to give them the best protection I can. I use the same kind of solvent-based polyurethane varnish that the roller skating rink used.

Great, so what is a polyurethane? Oooops. That is an ugly question. The simple answer is that it is any polymer based on isocyanate cross-linking. Gee, the simple answer is not so simple. First off, a polymer is any giant molecule. It turns out to be a chemists' inside joke. Someone was drawing a particular giant molecule with dozens of carbon atoms, each of which is represented by the letter "C". So the drawing looks like this

C-C-C-C-C-C-C-C-C-C-C-C-C-C-C-C-C-etc.

Someone quipped, "Oh, it is a poly-mer." Every one had a laugh as *"poly"* means "*many"* and *"mer"* is French for *"sea"*. Everyone had a good laugh at the pun, but the name stuck. ***Isocyanate*** is not so funny. Isocyanate is a particular little group with one atom each of carbon, nitrogen and oxygen. It is the basis of stuff like crazy glue, gorilla glue, and polyurethane. Isocyanate is a reactive little dude and gets stuck on here and there on active spots along another polymer. Then on command, the isocyanate links up with other active groups to make a gigantic molecule strung all over the place. This is called cross-linking. Basically we take one big molecule, or polymer, and use isocyanates to hook a bunch of them together. The isocyanate cross-linking is like taking some pieces of string and making them into a net. The net has a lot different properties than the loose strings. This net-like structure of molecules is what gives polyurethanes their strength, flexibility, heat resistance, solvent resistance, water resistance, and all the other properties that we know and love. One reason that polyurethanes are so tough is that they are tough. Well, that is a "strength of materials" thingy. Material scientists use a term "the modulus of toughness". To them "tough" is a combination of "stress" and "strain". ***Stress*** is how hard you can pull on something before it breaks. ***Strain*** is how far it stretches before it breaks. If you graph the stress vs. strain, the area under that curve is the modulus of toughness. Big deal. What it means to you is easy. Some stuff may be strong, but shatters like glass if you pull on it. It doesn't stretch. Other things, like a rubber band, are soft and not very strong, but stretch a lot. Neither has toughness. So, we have coatings like nitrocellulose lacquer that are hard and make very beautiful finishes, but are not very tough. They do not have much wear, water resistance, alcohol resistance, etc. They are strong but on the shatter end of the spectrum. The polyurethanes are not quite as strong, but they have a LOT more stretch. They are "tough". As wood shrinks and expands with humidity changes, the urethanes are stretchy enough to go along without developing cracks.

So now you are a technical expert on polyurethanes. Right? Wrong. You know how the stuff works, but as you stand in front of the paint section at Woodcraft looking at all the stuff labeled "polyurethane", which one do you pick? All that book learning is not much help. The unvarnished truth is that "polyurethane" can mean a lot of different stuff. The chemist started with some backbone polymer and stuck some polyurethane linkages on it. However, the big question is "with which backbone polymer did he start?" Well, he picked a backbone based on a lot of stuff like the end use of the coating, the price of the polymer, compatibility with the solvent system to be used, availability of active sites on which to stick the isocyanate, etc. As if that is not bad enough, varnishes are usually polymer mixed with other stuff. For example, the spar varnish and marine varnishes have a lot of "oil" mixed with them, along with ultraviolet blocking agents and other stuff. (These finishes are called "long oil" varnishes.) The polymer used has to be compatible with all that other stuff. There are also some "drier" or drying agents. These are usually heavy metal stuff with things like manganese, zinc, cobalt, etc. They accelerate the cross-linking reaction. The polymer has to work properly with these driers. (You can buy driers separately, e.g, Japan drier. The chance of your adding this to get better cross-linking is very unlikely. You will mostly just screw up a system that some skilled chemists spent months developing.) No two chemists will pick the same starting stuff so no two polyurethane varnishes are the same. You have to depend on them to do the right thing. In general, you wind up trying several products then sticking with the one that works best for you. As a paint chemist, I use Varathane premium polyurethane interior varnish.

Water Based Polyurethane Varnish

Answer this. Four individuals are standing on opposite corners as a Brinks truck rolls through the intersection. The back door flies opens and $1,000,000 falls out. The four individuals are you, Santa Claus, the Easter Bunny, and an honest lawyer. Who gets the million bucks? You do. The other three don't exist — neither does water based polyurethane varnish. There ain't no such animal. There is stuff in a can that the sales department labeled “water-based polyurethane varnish” but it is the same as the department store Santa Claus. He is not the REAL Santa and the water-based urethane varnish is not a REAL varnish. IF you had a water-soluble varnish, you could wipe it away with a wet rag. So how did this whopper of a lie start. Turn the pages back to Los Angeles and smog. Most of the smog develops by ozone in the air reacting with organic stuff, like gasoline. When you filled your tank with 20 gallons of gas, you pumped 20 gallons of gasoline vapor out into the environment. When the tank truck replaced that 20 gallons, another 20 gallons of vapor went out. When they filled the truck that dumped another 20 gallons out into the air. Refilling the tank from which they pumped filled the truck dumped another 20 gallons of vapor out. When the refinery filled the tank, it dumped another 20 gallons of vapor out. So, for every 20 gallons of gasoline sold, about 100 gallons of saturated vapor went into the atmosphere. In L.A, many millions of gallons of saturated vapor was pumped out into the air every day. So logically, the environmental agencies came down hard on solvent-based paints. Logically? Yes. If the politicians came down on use of gasoline in L. A., the voters would kick them out. There were millions of gasoline users, but only a few painters. From this the so called “water-based finishes” were developed to comply with Reg 66 in Los Angeles. If L. A. politicians do something dumb, San Francisco feels behind the times. So they developed the Bay Area Air Pollution Control agency, BAAPCD. These regulators pushed the water-based paints. Now no one could develop a paint to sell in LA and SFO, but not San Diego and Sacramento an Yreka. Effectively, the paint became a “California” paint. But that is the largest paint market in America, so the tail started to wag the dog. We now have federal EPA and 50 state EPA and hundreds of local EPA agencies. The water-based paints took over.

Now what? “Water-based” polyurethane varnish is not based on water. Well, DUH. When you open that can of latex paint and start to do the kids bedroom, what is that funny smell? Why does the label say you have to have good ventilation? That is the smell of the solvent used. They use solvents just like solvent-based paints. They use some stuff called glycol ethers. Glycol ether is just a catch all term for all kinds of crap, just like the varnish that says “petroleum distillates” for thousands of different chemicals all of which came from distilling petroleum based chemicals. Chemically speaking the glycol ethers come in two groups, ethylene glycol butyl ether, often sold as “butyl cellosolve”. Even that stuff is not so pretty good for you to breathe, so the manufacturers are starting to use propylene glycol butyl ethers which is less poisonous. IF YOU HAVE A CHOICE, always use the propylene glycol butyl ether based stuff. Most often the can label will only read “glycol ethers”. Sometimes the manufacturers web site will have a chemical safety data sheet for the product which will tell you which glycol ether is used.

All that and we still have not gotten to what this stuff is. Back to step one. The chemist takes some chemicals and dissolves or disperses it into the glycol ether of his choice. He then does isocyanate thing and makes a “latex” a milky looking suspension of little blobs of plastic. (If it were a water varnish, the stuff would be dissolved and clear, not milky looking.) Now the reaction is going along and the polymers are growing. Eventually, it will become one giant glob and settle to the bottom. Wait. We gotta stop these polymers before they get too big. So, when things are just right, he dumps in some stuff (called chain enders) that stops the polymer from growing. Now we have nice little balls of stuff like tiny little marbles coated with a coating of stuff that is different than the middle of the marble. In the suspension are things to keep the little balls from sticking to each other. Now the latex could be any of a lot of different plactics. If the plastic is based on isocyanate, then it is a polyurethane latex. Now the problem comes when you use the stuff. Easy to paint, easy to spray, easy to clean up. However, you have a coating that is a bunch of little balls, like a pile of marbles, with holes between them. It does not have the water resistance, alcohol resistance, solvent resistance, heat resistance that polyurethane varnishes offer because fluids can get through these microscopic holes. Although some folks think they get the same clarity with water based clear finishes, I have not found that to be true. The water bases stuff has a milky appearance even when dry.

So, I use the water-based polyurethanes around the shop when I can, but only where the finish does not show or where protection of the piece is of secondary importance. I NEVER use them on segmented bowls.

Using Polyurethane varnish

Varnish can be applied by brushing, spraying, or wiping. However, I prefer to use brushing. In the hands of a really good paint chemist, the stuff in the varnish can gives beautiful results IF you follow a few simple tips.

1) . You should get a good book on painting technique instead of reading this hit and miss bunch of tips.
2) There ain't no such thing as a cheap brush. IF you expect to do high quality finishing, you need a high quality brush. Look for words like Chisel edged, tapered bristle, flagged double or triple brushes. These cost money, but you can get a superb finish with them. (But, pssst, hey buddy, Home Depot has a sale on brushes this week for only $1.99 for a 1 inch sash brush. With it you can fight brush marks on a bowl that took you many hours to make.) Get a good brush and take good care of it.
3) Clean up your act. No dust, no dirt. If at all possible do your varnishing away from sources of dust and sawdust, as in your shop. Japanese turners have a separate room for lacquering their work.
4) That didn't sell. You don't have a spare room and neither do I. So after your final sanding of the bowl, clean your shop, sweeping and vacuuming. Then damp mop the floor, work surfaces where you will varnish. Now let the shop stand overnight to let any dust settle. With a minimum of activity the next day, clean your bowl with a tack cloth. (Do NOT put on that dusty apron you wear when you are turning.) Cover the paint area with a clean sheet of paper. Ready to paint?
5) Open your can of Varathane. Take out the amount you will use by dipping it out with a stainless steel gravy ladle (Wal Mart, $3) into a stainless steel measuring cup (Wal Mart $5). Immediately clean the rim of the paint can with a Q-tip. Replace the lid on the paint. Do not allow any time for stuff to get into your paint. Never dip your paint brush into the can of paint. Don't let ANYTHING get into your can of paint.
6) First coat? Well you probably should dilute the varnish with some clean paint thinner. Maybe as much as 50/50. The dilute "primer" gives a thinner first coat

and will be easier to sand before the second coat. (Most sanding sealers are diluted and have a “metal soap” added (mostly metal stearates). The soap helps in sanding. Do not use sanding sealer like Deft and then use a varnish like Varathane. They may not stick to each other.)

7) Brush on a coat of the dilute varnish, being careful to avoid thick spots or runs. Allow this to stand until tomorrow. I paint in the morning and then move the painted bowls into another room to dry.
8) The next morning, sand the first coat with 400 grit wet or dry sandpaper. Carefully remove the dust and wipe the bowl clean with tack cloth. When all is ready, open the can and ladle out enough paint to do the job into the stainless measuring cup. Give the bowl the second coat of clear gloss Varathane. Even if you want a satin finish, only use clear gloss until the last coat. If all goes as it should, you can apply a third coat in about 4 or 5 hours **without sanding**. You can apply the fourth coat that evening without sanding. Then let the bowl dry for a couple of days.
9) With Varathane, you will be amazed at how the surface levels with no brush marks showing. So after the fourth coat is thoroughly dry, try sanding with 600 grit 3M wet or dry sandpaper. Try wet sanding with 99% isopropyl alcohol (Safeway Stores, $2). Sand thoroughly as the Varathane can take it. If the alcohol dries, it will leave a white powder adhered to the bowl, your fingers and clothes. Clean it off thoroughly with a lint free shop towel and alcohol. Wet sanding should generate no dust in the air, so you can ladle out the varnish and give it coat five and in a few hours coat six.
10) IF you want a satin finish, use a satin finish Varathane for the final coat.
11) OR if you want a really fine finish, let the bowl dry for 4 to 6 weeks. Then do the polishing step with 800 grit wet sanding, then pumice in oil and rottenstone in oil. Yes a lot of books say you can’t do this. With Varathane INTERIOR varnish it works well enough. Deft lacquer will give a higher gloss finish by a little bit, but you are buying into the other problems of nitrocellulose lacquers.

ENOUGH Already.

So, our last Pikes Peak Woodturner’s meeting had a little confusion about polyurethane finishes. I hope that this rather long discussion of polyurethane has removed that little confusion and left total chaos in its place.

Bibliography

There are a number of very lengthy books on the subject of finishes for wood. I highly recommend that you ignore most of these. They do not even agree with each other. Instead, read

Alice in Wonderland,
Grimms’ Fairy Tales
Winnie the Pooh

As with these three books, the authors KNEW they were weaving fairy tales.

Somewhat respectfully submitted,
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