Modified Wood

by Richard Jagels

COURTESY ACCSYS TECHNOLOGIES

Some chemically treated wood, like Accoya by Accsys Technologies, used in a load-bearing bridge constructed in The Netherlands, may hold promise for some uses in wooden boats.

Boatbuilder Arch Davis of Belfast, Maine, wrote to me a few months ago wondering about the possibility of using wood that has been either thermally or chemically modified for boat construction. In particular, he was intrigued by two products: PureWood, which is thermally modified; and Kebony, which is chemically modified.

I wrote about modified wood more than three decades ago (WB No. 21 in 1978). I did not discuss thermally modified wood at that time because it was off the radar screen. Even chemically modified wood was still in the experimental stages then, with no commercial plants yet in operation. I ended the column by stating, "One of the major stumbling blocks to the commercial use of chemically modified wood has been its cost. As the availability of quality woods continues to decline, inferior species and grades might be chemically modified to meet the demands and requirements of boatbuilders. It is not inconceivable that chemically modified wood could become the major boatbuilding material of the future."

Now that some modified woods are on the market, is it time for boatbuilders to embrace these new products? Keep in mind that modified woods have not been developed specifically for boatbuilding, so we need to investigate cautiously. The drivers that have brought these woods to market (first in Europe) during the past decade are threefold:

- Public concern about toxic wood preservatives,
- High cost and environmental concerns about using tropical woods (see my column in previous issue); and
- A rapidly expanding market for "outdoor" wood products like decks, docks, furniture, fencing, and siding.

Thermally modified wood has no added chemicals. The substances used to chemically modify wood become altered and strongly bound to cellulose molecules, so they leave no toxic residue. Both processes render wood more hydrophobic and less recognizable to decay fungi.

If these modified woods could be effectively used in boatbuilding, we would be able to abandon pressure-treated wood, with its toxic chemical components, and give up borates, which, although quite safe for mammals, readily leach out of wood with time. Perhaps even more important, boatbuilders would not be tempted, as some are now, to employ even riskier fixes like dumping ethylene glycol antifreeze into boat bilges. Just this past week, I had two more readers tell me they were considering using glycol to treat their boats. As I have warned previously, antifreeze is highly toxic to mammals including pets and children, both of whom are attracted to its sweet taste. In addition, glycol dumped in the bilge will slowly leach from the boat, adding this poison to the aquatic environment.

Thermal Modification

Heating wood to temperatures above those normally used for drying (generally less than 180°F or 82.2°C) produces modified wood that has reduced capacity to absorb water and hence shrinks and swells less. Temperatures between 200° and 600°F (93° and 315°C) have been used. These higher temperatures darken the wood and lead to loss in mechanical properties, particularly toughness and abrasion resistance. Wood heat-treated to produce a product that has a 40 percent improvement in anti-swelling/shrinking efficiency (ASE) will have toughness reduced to less than half that of untreated wood. The most recent version of the *Wood Handbook* (1999) states, "...because of the reduction in strength properties from heating at such high temperatures, wood that is dimensionally stabilized in this manner is not used commercially."

Clearly that situation has changed. Thermally modified wood products with market brands such as Thermowood, PureWood, Plato, Perdure, and Menz process are now on the market and being widely advertised.

Thermowood was developed in Finland for treating local softwoods. It is produced using temperatures that range between 300° and 464°F (150° and 240°C). Bending strength reductions of 30 percent can occur at the higher temperatures, and company data sheets state that it is not to be used in load-bearing situations. Reduction in shrinkage and swelling ranges between 50 and 90 percent. Decay resistance is increased, but it is not recommended for ground-contact use. Thermowood plants are now operating in the United Kingdom and Canada. I could not determine for certain, but PureWood, which is produced in the United States and is also based on a Finnish process, may be the same as Thermowood.

Plato, produced at temperatures between 320° and 374°F (160° and 190°C) has bending-strength reductions of up to 18 percent, improved ASE, and similar decay resistance variation as Thermowood.

Perdure (also known as Retification) uses temperatures between 410° and 464°F (210° and 240°C) in the presence of a nitrogen-enriched atmosphere that reduces oxygen to less than 2 percent. This produces a somewhat more decay-resistant wood but with strength losses of up to 40 percent.

The Menz process uses hot oil as a way of improving heat transfer to the wood and excluding oxygen. Spruce processed at 428°F (220°C) has greatly improved decay resistance, but with a 30 percent loss of bending strength. Paintability with acrylic waterborne systems is excellent.

As I have mentioned in previous columns, boats need to be strong not only in modulus of rupture in bending but also in impact resistance, or toughness. Unlike decking or outdoor furniture, boats are tossed about on the open sea and banged against dock pilings in port. Unfortunately, thermal treatments increase the brittleness of wood, which translates into losses in toughness that exceed the above-cited losses in bending strength.

Because of these significant strength losses, I do not recommend thermally modified wood for critical structural portions of boats. It may have some use in cabin siding and possibly decks where support framing has been beefed up considerably. The improved dimensional stability and decay resistance have value in these areas.

Chemical Modification

Myriad chemical wood modifications have been tested over several decades. Of the ones that have shown promise, a few are now on the market.

Furfurl Alcohol. This process was developed several decades ago and uses a renewable chemical from biomass waste from such crops as sugarcane. Heat, up to 284°F (140°C), is required during curing. So this is really a thermochemical process. Impact strength or toughness is reduced by 25 to 65 percent based on chemical weight percent gain. But stiffness is actually increased. Decay resistance is very good at high weight gains. Because of severe strength losses, I would rate this product the same as for thermally modified wood.

Acetic Anhydride. Acetylization of wood has been known for more than seven decades. Recently, Accsys Technologies has introduced acetylated wood to the market under the trade name Accoya. Decay resistance is very high, it has increased stability under ultraviolet light, high ASE, little color change from natural wood, and is about 50 percent harder than untreated wood. But best of all, strength properties are not reduced. In 2008 and 2009 this product was used to construct two load-bearing bridges in The Netherlands. The company recommends Accoya for boat decks and trim and says it is suitable for other freshwater applications. They do not recommend it for marine applications because marine borers may attack it, but proper bottom coatings may relieve this hazard. Accoya is sensitive to pH of 9 or above. Stainless or epoxy-coated fastenings are recommended. Paintability is good. For more information and sources, see www.accoya.com/availability.html.

Other processes that have been patented and seem to be close to commercialization use N-methylol (actually dimethylol dihydroxyl ethylene urea—a chemical with wide use in the textile industry as an anti-wrinkling agent). A thermochemical process using modified linseed oil has been patented by DSM Resins. This process is touted to produce high durability, high ASE, and no losses in strength under laboratory tests. Foreco, a company in The Netherlands, is scaling up the process, so we may see this product soon. (A WB No. 213 review addressed Fluted Beams, a different process that relies not on heat or chemicals but on steaming followed by compression.)

For now, the best thermally or chemically modified product I could find for boatbuilding applications was Accoya (and presumably any other acetylated wood products). But I suspect more products will be forthcoming—and some may have boatbuilding applications.

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