Vance INDUSTRIAL STRENGTH WOODWORKING WWW ISWONLINE COM
WOOD & WOOD PRODUCTS

NEW ADHESIVE FLEXES ITS 'MUSSELS'

Oregon State University's Kaichang Li uses mussels as inspiration for a durable, soy protein-based wood adhesive.

By J.D. Piland

Kaichang Li was wading in the waters off the Oregon coast when he noticed a group of mussels gripping to a rock beneath the surface of the water.

Observing the mussels' unfaltering hold on the rock, despite crashing waves all around, Li, an assistant professor in Oregon State University's College of Forestry, set out to determine how they hang on so tightly.

Five years later, and having figured out that mussels get their super grip by secreting proteins known as byssal threads, Li and his colleagues are on the forefront of the woodworking industry's latest adhesive alternative, which Li says would work especially well in plywood manufacturing.

For the adhesive to work as imagined, it would have to mimic the properties of the byssal threads. Li learned that the mussels' threads are effective because they are strong, yet flexible, enough to absorb the energy caused by constant movement of the waves.

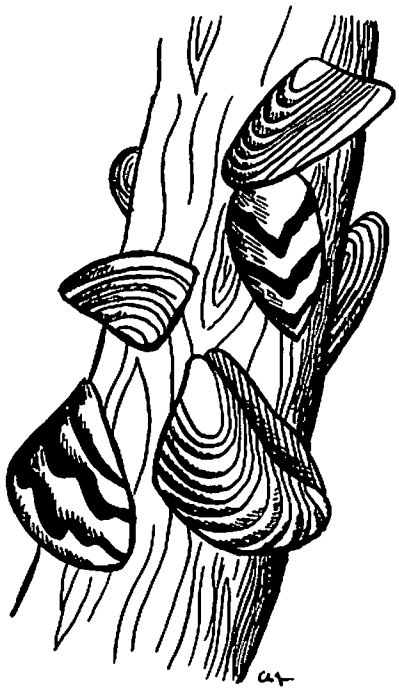
Li had to find a protein that had a similar effect, and he found it in soybean flour.

This main ingredient has been lauded by many in the industry because it is formaldehyde-free, giving companies another adhesive option. Formaldehyde remains under fire due to its widely debated health effects and its listing last year as a "known" carcinogen, given by the International Agency for Research on Cancer.

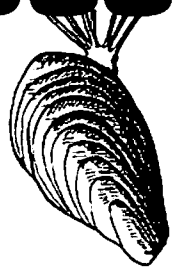
One of the companies in support of the soy protein-based adhesive is hardwood plywood manufacturer Columbia Forest Products, based in Portland, OR.

The company gained exclusive sub-licensing rights from Hercules Inc., a partner in development and which now has the licensing rights on the adhesive and its proprietary curing agent. Columbia soon will finalize a complete changeover of its three North American veneer-core and Woodstalk-core hardwood plywood manufacturing facilities to use the soy-based adhesive in place of urea formaldehyde resins (See June *Wood & Wood Products* for complete story). Columbia says the panels it produces with the adhesive are compliant with and earn one point toward the U.S. Green Building Council's LEED-EQ Credit 4.4 for Low-Emitting Materials: Composite Wood.

The adhesive is quite easy – and relatively cheap – to make, Li says. So easy, in fact, that *The Oregonian* newspaper reported Li can whip up a batch with soy flour and a kitchen mixer. The newspaper also reported that Li's phone has been ringing non-stop with interested consumers and manufacturing companies since the adhesive was unveiled.



Kaichang Li, an assistant professor at Oregon State University, says he was inspired to develop a wood adhesive by the abilities of mussels to grip to a rock or piece of wood. *Illustrations by Chris Nititham.*



The strength of a mussel's byssal thread proteins was the basis for development of the soy protein-based adhesive currently in production at Columbia Forest Products.

And all this because some mussels refused to let go of that rock.

Due to patent constraints on the adhesive, Li could not speak in-depth about its composition. He did, however, respond to a series of questions *Wood & Wood Products* posed to him.

Wood & Wood Products: The inspiration for a wood adhesive – of all things – came from a group of mussels. What was it about them that caught your eye?

Kaichang Li: I discovered the mussel phenomenon in 2000, and it was pure scientific research from there. I was curious why and how a mussel could stick to rock or a piece of wood so strongly in water. Then [my colleagues and I] began to work on it.

Basically, the mussels secrete a protein that is pretty unique. We mimicked the protein to investigate why and how the protein is so strong and water resistant. We graphed the key function of the mussel protein to a soy protein.

The soy protein was found to be very strong and very water resistant as well. We found that some of the pectin is directly related to the soy protein and to the mussel protein. We went ahead and found a good curing agent and basically crosslinked the soy protein to make it stronger. Then we tried to lower the price, simplify the recipe and make it really easy to use – not to mention make it cost competitive.

When you look at the chemistry of the adhesive, there are no volatile organic compounds released. In the soybean flour, all the oil is already extracted, so there is nothing that could be harmful. There is no ingredient in this that would be volatile.

W&WP: Were there any hang-ups while researching and developing the adhesive?

Li: Soy bean flour was used as a wood adhesive

since 1930 and into 1960. It was a commercial production at that time. So, soy protein – soy flour itself – is a good wood adhesive. Unfortunately, soy protein is not as strong or water-resistant as a synthetic resin. We needed to modify the soy protein itself and use our unique curing agent and some other ingredients to make it water resistant. In the beginning, it was just all the chemical modifications.

Basically, you can think of it this way: take soy flour, dissolve it in water, penetrate it into wood, then crosslink it. If you have something to cross soy flour – so the flour becomes like a 3-D network – it becomes water-insoluble. It's basically like putting a key in a lock and making a turn: You can't pull it out then. So the soy flour, when it gets into wood and you hot press it, it cures and you have the 3-D, water-insoluble material.

W&WP: What kind of tests did you run to determine the effectiveness of the soy protein for wood applications? How can you be sure it will work?

Li: For exterior-use wood composites, it is a standard to run a four-hour, two-cycle boil test. Basically, you take a wood composite, and boil it in water for four hours. Then you dry it and boil it again. If it doesn't eliminate, then it's really water resistant.

On one occasion, we boiled the wood composite one day, then let it soak in the water. The next day, we came back and turned on the heater and went through the test one more time.

That isn't the standard method to run the test, letting it soak. We were just curious [to see the results of soaking it]. It was still resistant to the water after the test.

[Other types of adhesives that went through the battery of tests reportedly would result in spongy material, while the soy adhesive would hold its tight grip.]

W&WP: What does the future hold for this adhesive? Will it only be marketed to woodworkers? Are there plans to expand its consumer base?

Li: One other adhesive has been licensed by Hercules. Hercules is the company that produces the curing agent. Hercules bought the license from Oregon State University. Hercules is not a forest product company. They will sell it to whoever wants to use it. For that patent, it is out of my hands. They still want me to do research and development work and determine if it can be used in different applications.

Basically, it's their stuff now. Columbia Forest Products also contributed research dollars, so I think they have some benefit there, too. Columbia told me they use it continuously now. At each mill, they have several production lines. I don't know exactly how many of them are using it, but [I know] at least two mills are using it regularly.

W&WP: You mentioned that the adhesive is going to be more cost-competitive. How so?

Li: Well, I'll phrase it this way: This adhesive is cost competitive to UF, urea formaldehyde. I can't tell you any price or numbers, but I think Columbia is happy about it, and they are satisfied with the prices.

W&WP: How gratifying is it for you to have developed an adhesive that is formaldehyde-free and seems to be catching on quickly in the industry?

Li: I get a lot of phone calls and people write e-mails. Actually, someone wrote me a letter.

People really like this product. One man said one of his friends is very allergic to formaldehyde and gets sick very quickly. So I'm happy I can make a difference for some people. It makes me feel really good.

W&WP: What's next for you and your colleagues? Will you continue to research the adhesive?

Li: Since we were successful with the hardwood plywood [application], we are going to [attempt to] make [adhesives for] particleboard, MDF and OSB. A number of companies in Oregon are really interested in exterior-use plywood, exterior-use products, laminating lumber and that kind of stuff. We still have a lot of work to do.

Each mill is unique and may want me to formulate an adhesive slightly different to meet their facility, so I'll be busy for the next couple of years.

One of the driving forces here is the petroleum oil. The oil price is going up and will probably remain high in the near future. With all these petro-chemical-based wood adhesives, like phenyl formaldehyde or urea formaldehyde, the price of them may remain high. Our adhesive is from a renewable resource – it should have some long-term benefit for sustainable growth. ⌘

"[Think of this adhesive] like a key in a lock: When you make a turn, you can't pull it out."

– Kaichang Li, Oregon State University