A molecule from plants and trees could make our roads and roofs 'greener'

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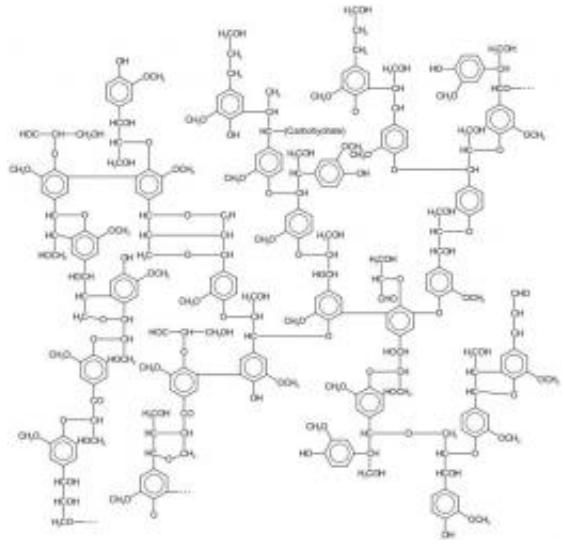

Lignin. Image: Wikipedia

Construction crews may someday use a plant molecule called lignin in their asphalt and sealant mixtures to help roads and roofs hold up better under various weather conditions. It also could make them more environmentally friendly, according to a researcher today at the 249th National Meeting & Exposition of the American Chemical Society (ACS).

Currently, a by-product of crude oil production called bitumen is the main sticky ingredient in asphalt and roof sealants. But oil is a nonrenewable resource. And fluctuations in the oil market have made it

more difficult to get high-quality bitumen, forcing manufacturers to look for alternatives, says Ted Slaghek, Ph.D. He is a senior scientist at TNO, a non-profit organization in the Netherlands that develops real-world applications for scientific and technological advances.

"In the long term, we have to move to renewable products that we can harvest every year," says Slaghek. "It should be logical to use natural organic raw materials instead of crude oil."

Slaghek explains that lignin is a renewable resource that makes up as much as a third of the dry material in trees, where it keeps out water and binds together other components of plant biomatter, like cellulose. Lignin is also plentiful—and therefore, inexpensive—because it is removed as a waste product during the paper-making process. More than 50 million tons are produced globally as waste each year. Most of this is burned to generate electricity to run the paper mills. Burning lignin is not only wasteful, it releases soot and other pollutants, he says.

Because lignin shares many characteristics with bitumen, it could become an environmentally friendly additive to help reduce the amount of bitumen needed for construction activities. Like bitumen, lignin is a large molecule with a number of carbon rings. The researchers first thought that this similarity meant that they could just add lignin to the bitumen, like other polymer additives that are already used to improve sealants. But Slaghek says that for the mixtures to work, lignin must be integrated into the bitumen on the molecular level, not just mixed into it. By integrating the lignin, he can reduce the amount of bitumen needed by as much as half, although he found that the best-performing mixtures required less.

As with other additives, lignin makes sealants perform even better—but those polymer additives come from petroleum sources, making them just as problematic as bitumen. Slaghek's team has developed a number of

lignin-bitumen mixtures that make the asphalt harder in warm weather, preventing rutting and adding a few years to a road's lifespan. "On the other hand, if you have roads where the temperatures tend to be lower, bitumen can become too hard and brittle, increasing the chance that rocks and pebbles will come loose and damage your car," says Slaghek. "We have also developed lignin-bitumen mixtures that keep the bitumen more tacky, so at lower temperatures it's still a good road." The mixtures contain differing amounts of lignin, as well as lignin with various chemical modifications.

To demonstrate how well these mixtures can work in the real world, Slaghek and partners are planning to build a 100-meter stretch of bicycle path this year using one of the lignin-based asphalt mixtures.

The advantages of lignin go beyond these quality, cost and performance benefits, Slaghek notes. It's also safe to handle—and consume. "You might be surprised to learn this, but you're eating lignin every day if you're eating vegetables," he points out.

More information: Sustainable bitumen, 249th National Meeting & Exposition of the American Chemical Society (ACS).

Abstract
Bitumen is the residue that remains after distillation of crude oil. This by-product of the crude oil industry is a complex mixture of hydrocarbons and is used in applications such as pavements including highways and for roof sealing. In a typical pavement application about 5% of the total road construction bitumen is used as a binder next to other components such as gravel and sand. About 83% of the bitumen used is applied in pavement applications. For roof application the amount of bitumen is much higher (50 - 70%). Usually bitumen for roof applications contains additional polymers such as SBS (styrene-butadiene-Styrene) or APP (Atactic Poly Propylene). They are used to modify the bitumen mixture

and create desirable properties. Since a couple of years the prices for bitumen have increased while the quality of bitumen is fluctuating. Therefore the market is looking for alternative sources preferably combined with a reduction in carbon dioxide emissions (e.g. natural polymers).
The paper describes the use of lignin and chemically modified lignin as a 'green' additive in bitumen mixtures. Lignin is one of the most abundant natural polymers on earth and au contraire to carbohydrates is hydrophobic. The focus of the research is aimed at applying (chemically modified) sulfur free lignin (e.g. organosolv or lignin obtained through hydrolysis of the carbohydrates) as an additive instead of a filler in bitumen applications. Chemically modified lignin show properties similar to SBS and APP. The paper will describe the use of lignin and chemically modified in bitumen and the potential that lignin has in this field of application including construction of lab samples of pavement. Up to 50% of the bitumen is replaced by lignin.

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