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The greening of coatings

Is the roofing industry on the verge of a biobased boom?

*by **Grant Grable, LEED A.P.***

These days, roofing contractors are confronted by many options when it comes to the rapidly growing market for green buildings and their roof systems. Typically, the question for most building owners, specifiers and architects desiring an environmentally friendly roof system is whether it will be a living green roof system or a highly reflective one. But there is another option, which comes in the form of biobased roofing products such as reflective roof coatings, adhesives and sealants.

What they are

Biobased roofing products are derived from rapidly renewable plant oil polymers designed not only to replace but outperform petroleum-based products. Currently, building products such as roofing materials, adhesives, caulks, stains, paints, insulation and sealants primarily come from petroleum. In fact, according to research conducted by the United Soybean Board (USB), one-third of all foreign oil consumption in the U.S. is tied to the polyurethane product industry. These products start out as extracted crude oil, and it takes an incredible amount of processing to convert crude oil into the petroleum chemistries commonly used in the roofing industry. These processes—not the finished products—are the real offenders when it comes to environmental pollution.

On the other hand, agricultural oils have been called nature's perfect chemistry. Oil that can end up on a consumer's dining room table as salad dressing, for instance, also could be taken directly to a polymer reactor and used to create a host of industrial polymer-based products. For instance, processing agricultural oils for industrial building product use as urethanes or polyurethanes takes less than 20 percent of the inherent energy and subsequent environmental effect needed to produce comparable petroleum-based industrial building products, according to USB research findings.

Many plant-based seed oils, such as soybean, linseed and corn oils, can be used to replace petroleum building products. These oils are rapidly renewable and readily available in abundant supply.

During the past 10 years, many innovations in biobased chemistry have been brought to the marketplace but gained limited exposure until the explosion of green building practices, government mandates and rising cost of petroleum-based products.

A short history

Biobased chemistry is not new. Biobased products, such as linoleum, have been around since 1863 and are made from clay, cork, wood flour, linseed oil and pigments—both organic and synthetic. It is linseed oil that gives linoleum its name.

The use of biobased oils for industrial applications can be traced to the work of scientist George Washington Carver. Carver's studies proved that peanuts, soybeans and sweet potatoes not only provide cash crops for farmers but also replenish soil with needed nutrients and nitrogen, leading to the common practice of crop rotation that helped save the U.S. farming base. However, Carver knew these agricultural products could provide offerings beyond simple food staples and set out to discover a host of industrial uses for the versatile oils these products possess.

Having the quickest gestation period and being the most cost-effective oil product for reproduction, soybeans were the focal point of Carver's quest to replace industrial petroleum products with oil derivatives. As Carver's research became published, it caught the eye of Henry Ford. Ford, though best known for inventing the assembly line and being an automobile industry pioneer, also was an environmentalist and soybean farmer. Carver and Ford's collaboration launched an industry originally called the Chemurgy Movement.

Ford established a research lab at his Dearborn, Mich., facility to research the many petroleum replacements that could be created using soybean polymers. Ford and Carver collaborated to develop biobased plastics, lubricants and insulations that eventually made their way into Ford automobile production. By the 1930s, Ford automobiles were rolling off assembly lines with more than a bushel of soybeans used to create each automobile's trunk, steering wheel, foot pedals and horn.

This was the beginning of the biobased movement, which ultimately resulted in biobased roofing products.

Biobased roofing

The development of biobased roofing products can be tied directly to the increased use of soybeans in the food industry. If you read the ingredients of many processed foods, you will see soybeans have become a common protein and oil substitute.

However, even with the multitude of uses for soybean oil in the food industry, there was a tremendous glut of the oil available during the early 1980s. This excess oil was treated as a waste product and disposed of by large producers. The U.S. Department of Agriculture (USDA) and USB were cognizant of soybean oil's history and many industrial uses and set out to fund industrial research to bring this chemistry to the forefront as a viable alternative to petroleum products.

As a result, during the late 1980s and early 1990s, research grants were established to help fund the creation of biobased industrial products. Some of the first products approved for research grants were biobased roofing and masonry coatings. Other products included insulating foams, sealants and adhesives. Early in the process, most of these products were created at universities and in small laboratories with limited production and usage. However, over time, these products—many comparable to urethane and polyurethane chemistries—have been recognized to possess excellent physical properties and, in some cases, outperform the comparable petroleum products they were created to replace.

One product category that has attracted a lot of attention in the roofing industry is reflective, soy-based roof coatings. During the early 1990s, the first soy polymer coatings were designed to provide exceptional adhesion, pigment retention and low permeability, as well as reflective and emissive properties, to coincide with research being conducted at the time.

Photos courtesy of Green Products LLC, Romeoville, Ill.
Photo of a roof system restoration before a biobased coating was installed on Baptist Medical Center's surgical wing in San Antonio

Photo of a roof system restoration after a biobased coating was installed on Baptist Medical Center's surgical wing in San Antonio

During this time, the U.S. Environmental Protection Agency's ENERGY STAR® program was in its beginning stages and research was being conducted by Lawrence Berkeley National Laboratory, Berkeley, Calif., in conjunction with Oak Ridge National Laboratory, Oak Ridge, Tenn., regarding the benefits of reflective and emissive surfaces and their capabilities to reduce solar heat gain in low-slope roofing applications.

Because low-slope roofing seemed to have the greatest potential for cool roof technologies, products that would be best-suited for asphalt-based roof systems were produced first. Adhesion to asphalt was key because existing cool roof coating technologies experienced adhesion issues with low-slope asphalt-based roof systems, especially in areas that had experienced ponding water conditions for longer than 48 hours.

ASTM D6083, "Standard Specification for Liquid Applied Acrylic Coating Used in Roofing," has been established as the benchmark for products in the acrylic elastomeric family. The standard calls for an acrylic elastomeric roof coating to be less than 50 perms (at 20 mils thick) and have a maximum of 20 percent water absorption by weight. Many traditionally made products, when subjected to ponding water conditions in excess of 48 hours, tend to delaminate from the substrate. Soy-based coatings were created not only to adhere to substrates but to resist ponding water with a less than 1 perm rating tested under ASTM E96, "Standard Test Methods for Water Vapor Transmission of Materials," and less than 1 percent of water swelling under ASTM D471, "Standard Test Method for Rubber Property-Effect of Liquids."

The modern marketplace

The first products for bituminous applications were produced to increase adhesion, protect against asphalt bleed-through and provide a waterproof surface that could handle long-term latent water.

As time passed, multiple biobased polymer blends were created to provide solutions for the multitude of roof substrates available. Versions were created that could handle the increased elongation and tensile needs of metal roof systems, as well as single-ply roof systems such as EPDM and PVC. With performance in mind, all constituents of the products were chosen for their abilities to handle long-term exposure to ultraviolet (UV) rays, ponding water and biological growth.

Because the products needed to meet ENERGY STAR requirements and still be high-performance, naturally mined minerals such as cosmetic-grade talc and zinc oxide were used in addition to titanium dioxide not only to make these coatings reflective and emissive but for their excellent UV protection capabilities and natural protection against biological growth.

Biobased coatings have been third-party tested for reflectivity and emissivity by the ENERGY STAR program and Cool Roof Rating Council's reflective roof program and exceed their recommendations. Biobased roof coatings have a reflectivity range from 0.83 to 0.85 with an emissivity rating of 89 for a combined range of 103 to 105. These ratings exceed the required 78 combined value listed under the U.S. Green Building Council's Leadership in Energy and Environmental Design® (LEED) Green Building Rating System.™

During the 1990s, EPA and California codes began to reduce volatile organic compound (VOC) level approvals in construction products to aid in the reduction of ozone depletion and the incidence of smog levels. As a result, solvents, such as California Rule 66 mineral spirits (an aliphatic solvent that doesn't contribute to ozone depletion), and biobased solvents, such as methyl soyate made from soybeans; ethyl lactate made from corn esters; and Turpentene made from pine resin esters; were used to minimize environmental damage. However, the high solids content of such products (in some cases greater than 80 percent) resulted in coatings that did not flash off like toluene and zylene used in conventional urethane coatings, as well as increased cure times.

Biobased roof coatings were created to be applied in single-coat applications of up to 40 wet mils so contractors could apply these products in a single coat in 90 percent of applications. These solvent blends also have low odors. Another benefit of using biobased solvents is that unlike water-based products, applications in temperatures below 40 F still are possible with dry, properly prepared substrates. Many of these products can be applied in temperatures below 30 F if the products are heated and surface temperatures are above freezing and absent of moisture or frost.

This smooth 2,600-square-foot built-up roof system on KV Pharmaceutical's building in St. Louis was restored with a biobased coating.

Because biobased polymers are created with adhesion in mind, their application requires surface preparation through power washing and removal of loose and latent materials on the substrate. However, no surface primers are necessary. Greases or oils must be removed using mild degreasing agents, but surfactants are not necessary if effluents are nonexistent. A typical biobased coating application requires 2 gallons per 100 square feet for smooth, nongranulated substrates such as those used for the following roof systems: smooth built-up, smooth modified bitumen, aged single-ply and metal.

Substrates used for granulated modified bitumen and alligatored smooth asphalt built-up roof systems require an average single-coat application of 2 1/2 gallons per 100 square feet.

Unaged PVC roof systems containing plasticizers and coal-tar pitch roofs are not acceptable substrates for use with these products.

Soy-based roof coatings can be rolled, sprayed, or brush- or squeegee-applied in a similar fashion as conventional high solids urethane roof coating products. When spraying these products, it is necessary to back-roll the products into the substrate because of their high solids content. However, back-rolling can be done in tandem with spray application so efficiencies of scale are achieved.

One drawback of biobased coatings is their oil-based compositions can increase cure times compared with conventional solvent- or water-based roof coatings. Another drawback is these products tend to be more expensive than conventional roof coatings. However, with higher performance values and single-coat applications, the applied cost to a customer can be competitive with conventional roof coatings.

Growth ahead

As the green building movement has grown, so has the notoriety of biobased soybean polymer coatings. Although these coatings primarily are used for roof system restoration, many conventional roofing product manufacturers have seen the advantages of using biobased coatings in combination with conventional roofing materials for new construction and retrofit solutions.

Such coatings also provide many point opportunities under LEED construction guidelines. Although reflective conventional acrylic and urethane coatings can provide point opportunities in regional manufacturing, urban heat island reduction and even low VOCs, biobased coatings have the additional advantage of being made from rapidly renewable biobased oils and also are regionally extracted, harvested and manufactured, which can contribute to additional LEED point opportunities for projects within 500 miles of the product manufacturers' plants.

In addition, the Farm Security and Rural Investment Act was signed into law in 2002 and established the Federal Biobased Product Preferential Procurement Program (FB4P). A goal of the legislation was to increase the government's purchase and use of biobased products. In addition to decreasing the country's dependence on foreign oil, use of biobased materials promotes economic development by creating new jobs in rural communities and provides new markets for farm commodities.

Under the act, federal agencies must establish procurement preference programs for USDA-certified biobased products that meet the required levels of biobased material content. Under this program, federally funded agencies and projects are mandated to purchase biobased products if they are reasonably available, meet performance standards and are reasonably priced. One of the first six categories established by USDA for the FB4P program was biobased roof coatings.

Because the federal government has a mandate for LEED certification, as well as a mandate for the use of biobased products, biobased roof coatings provide many opportunities for federal projects to achieve their environmental goals.

Products to consider

Biobased solutions for adhesives, insulation, sealants, caulks and solvents, as well as specialty coatings and two-component epoxy formulations, are being researched and developed or already are on the market. For more information about biobased roofing and construction products, as well as FB4P, visit USDA's BioPreferred^{SM} Web site at www.biobased.oce.usda.gov/fb4p.

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