Photo courtesy of Rohm and Haas Company.

Cool Roof Coatings Market Heating Up

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Rising oil and natural gas prices have resulted in shrinking margins and lower profits for many in the coatings industry. However, the roof coatings market—more specifically, the cool roof coatings market—seems to be one sector that will ultimately benefit from the energy increases, particularly in the U.S. Reducing energy consumption has become a primary goal of the U.S. federal and state governments. In hotter areas of the U.S., the use of cool roofing technology is now seen as a practical means of lowering energy consumption and many states have or are planning to adopt corresponding building/energy codes requiring minimal performance levels for roofing materials. Coating, resin, and pigment producers are responding to the challenge and developing cool roof coatings to meet these requirements and those anticipated for the future.

"The cool roof coatings market is a very dynamic segment that is evolving quite rapidly," says Dan Murad, president and CEO of The ChemQuest Group. The consulting firm pegs the value of the cool roof coatings market at $430 to $440 million, with white elastomeric products accounting for $290 million and colored coatings containing infrared (IR) reflective pigments making up the remainder. According to Michael Crowney of Kusumgar, Nerlli & Crowney, the overall roof coatings market is valued at $750 million. "Cool roof coatings account for more than half of the roof coatings market in the U.S. and, in general, are growing faster than the roof coatings market overall," he notes.

White coatings, which are largely acrylic-based materials that are field-applied on flat commercial roofs, have been employed for about 10 years and are growing at a rate of 11–12% annually, according to The ChemQuest Group. In the past few years, coil coatings containing IR reflective pigments that are applied to metal roofs have been developed in a range of shades

that are attractive for residential applications. These factory-applied coatings are growing at the more rapid rate of 15–17% per year.

There appear to be two key drivers for the cool roof coatings market, both of which relate to reduced energy consumption. The first driver originates with consumers who are looking to lower air conditioning costs and be more environmentally conscious. The second is regulatory based, as several states and cities in the U.S. have passed, or are planning to incorporate, requirements for cool roof performance in their building codes.

Cool roof coatings provide numerous benefits. The high solar reflectivity and emittance of cool roofs help reduce the heat build-up within buildings and therefore reduce reliance on air conditioning, which in turn lowers the demand for electricity and the amount of air pollution generated. Asphalt shingles are the most common type of roofing material in the U.S. but are the poorest at reflecting energy (about 5%). Cool roofs can in fact be as much as 100°F cooler than roofs covered with traditional dark-colored roofing materials, according to the U.S. EPA. In addition, energy savings have been demonstrated to be as much as 20–70% with cool roofs.

The actual level of energy savings is dependent on a number of different factors. The increase in solar reflectance and emittance is critical, as is proper application of the coating. The local climate and the microclimate of the building is important as well. Use of insulation and the location and efficiency of heating/cooling systems also plays a role.

Because cool roof coatings limit the amount of absorbed solar energy, they also reduce the amount of damage caused by ultraviolet radiation and the repeated contraction and expansion (especially for metal) that occurs as a result of daily temperature fluctuations. These coatings can also protect roofs against water, chemicals, and other physical damage. All together, these attributes help prolong the life of the roof system.

Buildings with cool roofs can also help reduce smog levels in cities. In the summer, urban areas become "heat islands" with temperatures 4°T–8°T higher than surrounding areas. The higher temperatures result in increased ozone levels and contribute to smog and haze. Cities with buildings possessing reflective roofs will not experience this heat island effect as strongly. According to a study by the Lawrence Berkeley National Laboratory's (LBNL) Heat Island Group, Los Angeles could save $35 million per year in energy costs if buildings within its limits were modified with reflective roofs.

Solar reflectance is the percentage of solar energy that is reflected by a surface. Thermal emittance is defined as the percentage of energy a material can radiate away after it is absorbed. Cool roofs reflect heat well across the entire solar spectrum, especially in the infrared and visible wavelengths. The less solar radiation materials absorb, the cooler they are. In addition to absorbing less heat, the coolest roofing materials radiate away any absorbed heat.

The amount of desired solar reflectance depends on the type of roof. For low-sloped roofs, which are found on most commercial and industrial buildings, solar reflectivity is the critical factor in reducing the amount of heat transferred internally. White cool roof coatings are elastomeric acrylic or sometimes polyurethane-based materials that can be applied over most roofing substrates (sprayed polyurethane, metal, singly-ply rubber, modified bitumen, some types of asphalt, etc.). They typically last for 10–20 years, losing up to 20% of solar reflectivity during their lifetime, with the greatest portion lost during the first year when the coating picks up dirt and grime.

Other options for low-sloped roofs include reflective tiles (they contain reflective pigments) and white, single-ply membranes made of ethylene-propylene-diene-terpolymer (EPDM), polyvinyl chloride (PVC), thermoplastic polyolefin (TPO), or other similar materials.

Residential roofs typically are steep-sloped and have, due to their design, a lower requirement for solar reflectance. The ideal cool roof material for residential applications is metal roofing coated with cool roof coatings containing infrared reflecting pigments. Two different materials are used for cool metal roof coat-

Definitions

Solar Reflectance: The fraction of the solar energy that is reflected by a roof, expressed as a number between zero and one. The higher the value, the better the roof reflects solar energy. For example, white reflective coating or membrane has a reflectance value of 0.85 (reflects 85% of solar energy hitting it and absorbs the remaining 15%), while asphalt has a value of 0.09 (reflects 9%).

Emittance: The amount of absorbed heat that is radiated from a roof, expressed as a number between zero and one. The higher the value, the better the roof radiates heat.

Solar Reflectance Index (SRI): Indicates the roof's ability to reject solar heat, and is the combined value of reflectivity and emittance. It is defined so that a standard black is zero (reflectance 0.05, emittance 0.90) and a standard white is 100 (reflectance 0.80, emittance 0.90). Because of the way SRI is defined, very hot materials can have slightly negative SRI values, and very cool materials can have SRI values exceeding 100.

Source: http://www.hypower.org/res/tools/products_results.html?id=100123.

Voluntary Cool Roof Programs

Agency	Location	Program Name	Reflectance	Emissivity
Environmental Protection Agency/ Department of Energy	Federal	Energy Star	Low-slope 0.65 (0.50 aged). Steep-slope: 0.25 (0.15 aged)	None
U.S. Green Building Council	International	LEED™ Green Building Rating System for New Construction	Solar Reflectance Index (SRI) of 78 for low-slope and 29 for steep-sloped roofs.	

Source: Cool Roof Rating Council, www.coolroofs.org/.

ings. One is composed of a blend of polyvinylidene difluoride (PVDF) and acrylic resins (70:30 ratio). The other type of coating is based on silicon-modified polyester resins (SMP). The PVDF coatings are considered to be the premier technology, but SMP coatings technology is rapidly advancing and performance is improving dramatically.

As part of its Energy Star® Roof Product Program, the U.S. EPA has established criteria for solar reflectance for coatings applied to low- and high-sloped roofs. Under the program, low-sloped roofs (surfaces with a slope of 2:12 inches or less) must have an average initial albedo (reflectance) of at least 0.65, and the material must maintain a level of at least 0.50 after three years of installation under normal conditions. Sloped roofs (surfaces with a slope of 2:12 inches or greater) must have an average initial albedo of 0.25 or more. These materials must maintain a level of at least 0.15 after three years of installation under normal conditions. While thermal emittance is not a qualifying criterion for the Energy Star label, a rating of 80% or more further reduces heat transfer to the indoors. Energy Star-qualified reflective roof products can reduce peak cooling demand by 10–15% and can reduce building energy use by up to 50%, according to the EPA.

Industry groups have been formed to help manage information related to cool roof materials and to promote their use. The Cool Roof Rating Council (CRRC) is a non-profit association comprised primarily of roofing product manufacturers and distributors and their trade associations. The Council was established in 1998 to implement and promote "fair, accurate, and credible radiative performance rating systems for roof surfaces." The centerpiece of the CRRC is its third-party testing and rating program that provides credible reflectance and emissivity data on roof surfaces to help improve the energy efficiency of buildings while positively impacting the environment.

The Roof Coatings Manufacturers Association (RCMA) is the national trade association representing the manufacturers of cold-applied coatings and cements used for roofing and waterproofing, as well as the suppliers of products, equipment, and services to and for the industry. The RCMA White Coatings Council serves the producers and suppliers of acrylic or elastomeric (non-bituminous) coatings. The Council has already implemented an industry promotional campaign, and is actively planning programs to respond to targeted governmental and regulatory issues, technical matters and activities, and membership services and programs.

Two national labs are investigating cool roof materials, working with raw material suppliers, coating formulators, and coating applicators to test various products and establish standards. The aforementioned LBNL is looking at the positive health benefits and implications of reduced pollution. Oakridge National Laboratory is investigating the potential energy savings of cool roof technology based on reduced consumption of fossil fuels.

COOL COATINGS FOR LOW-SLOPED ROOFS

Roof coatings have been available for decades in white and various shades of tan and gray. Originally, reflective coatings were formulated like traditional paints, but performance was poor under the severe weathering conditions present on roof tops. Manufacturers also have a long track record of providing aluminized roof coatings, according to Dan White, technical product manager with APOC. "For many years these systems were the coolest coatings available. Then roof coatings formulators began offering white coatings as a natural extension and expansion of their coating lines."

The durability of white roof coatings was dramatically improved with the introduction of products based on elastomeric acrylic resins. "Conventional architectural coatings do not have the inherent performance attributes to withstand rugged rooftop conditions such as wet adhesion and wide temperature fluctuations," states Colin Couveia, North American marketing direc-

tor for Rohm and Haas Company's Industrial and Construction business. "Rohm and Haas has made significant investments in product research and continues to develop innovative technology that meets the demanding requirements of the roofing industry."

APOC has manufactured white and light colored coatings for decades and currently offers a full line of reflective roof coatings. Its APOC #252 is a white acrylic roof coating with reflectivity and emissivity properties that exceed Energy Star and California Title 24 requirements, according to White. "This coating can be sprayed or roller-applied and is available through roofing distributors nationwide." APOC has two plants dedicated to manufacturing white reflective coatings. Its eastern U.S. facility will be tripling its capacity to produce its white and light-colored line of roof coatings with a new plant opening in late 2007.

Elastomeric acrylic coatings still have their limitations, though. "One of the key issues with the current technology is associated with the level of preparation required before the coating can be applied," notes Murad. "The failure of these elastomeric roof coatings can often be traced back to poor preparation. As with many industrial maintenance coatings, advancements in resin and coating technology that will provide high performance without the need for extensive preparation are a focus area for manufacturers."

Many acrylic coatings do still suffer damage due to water ponding and often lose adhesion. Discoloration, fading, and chalking are also issues with these systems. "Dirt pickup and mildew growth are specific problems faced by elastomeric acrylic coatings," says John Linell, technical director with BaySystems. He also notes that plasticizer migration in coating applications over PVC roofing can be another issue. According to the EPA, traditional acrylic coatings typically lose about 20% of their total solar reflectivity, and much of this is lost just in the first year. Reflectivity generally drops to 55% after three years.

The industry is working to overcome these limitations. "Technologies based on fluorine are just arriving that will retain reflectivity of over 80% for more than 10 years while remaining flexible, mildew resistant, and color fast," states Linell. "These products cost more but the long-term energy savings would be dramatic." Both BaySystems and Arkema Inc. are introducing such products to the market.

Kynar Aquatec®, a water-based fluoropolymer latex resin, was launched by Arkema at ICE 2006 in New Orleans. This resin can be formulated into coatings that can be field applied onto a variety of roof surfaces. "Most importantly," asserts Jerry Petersheim, senior business development engineer for technical polymers with Arkema, "the fluoro component of the Kynar Aquatec resin enables coatings to retain total solar reflectance longer than any conventional coating. Panels exposed in Florida continue to yield total solar reflectance greater than 0.80 after six years with no yel-

Cool Roof Codes and Standards

Location	Agency	Policy	Description	Requirements	
				Reflectance	Emissivity
United States	ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.)	90.1 (Commercial Buildings and 90.2 (Residential Buildings	Absorptivity Ratio: considering proposal to include CRRC in cool roof component	0.7	0.75
California	California Energy Commission	Title 24	Performance credits for inclusion of cool roofs in buildings; CRRC named as supervisory entity	0.7	0.75
Chicago, IL	Department of Buildings	Energy Conservation Code (pdf)	Adoption of Energy Star as part of Energy Code, which is now part of the city's Building Code	0.25 before 12/21/08; Energy Star after	None
Florida	Department of Community Affairs	Florida Energy Code	Performance-based	0.65	0.8
Georgia	Department of Community Affairs	Georgia Energy Code; Georgia White Roof Amendment	Requires use of additional insulation for roofing systems whose surfaces do not have test values of 0.75 or more for both solar reflectance and emissivity	0.75	0.75
Texas	—	—	Developing code; considering ASHRAE	—	

Source: Cool Roof Rating Council (www.coolroofs.org) and internal research.

lowing of the film even at much thinner film thicknesses (2 -3 mils of topcoat as compared to 10 -15 mils of topcoat for traditional elastomeric acrylic coatings)." Weathering data demonstrates that the Kynar Aquatec based coatings experience very little erosion, exhibit excellent toughness, durability, and color and gloss retention, and are resistant to dirt pickup, staining, and water damage.

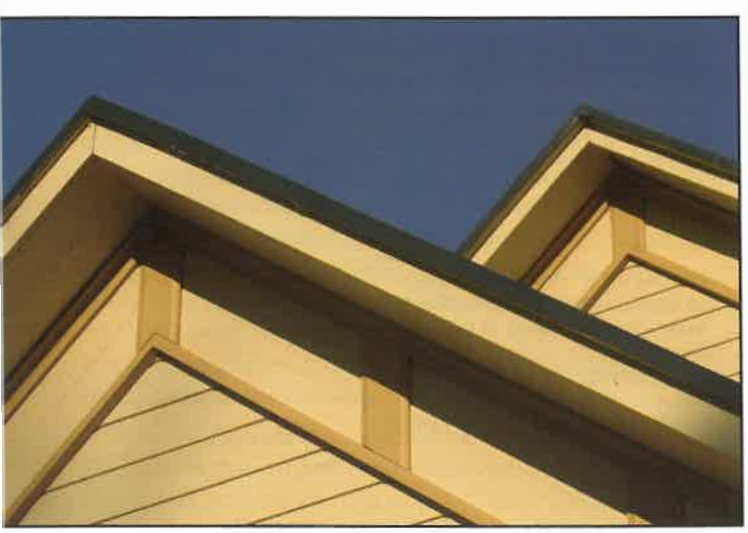
ER Systems and United Coatings are other companies introducing cool roof coatings based on the Kynar Aquatec resin.

BaySystems is introducing a fluoropolymer coating based on this technology that exhibits resistance to dirt pickup, mildew, and algae, and is designed to remain colorfast much longer than current technologies. Typically, dirt-resistant coatings have low flexibility, however this fluoropolymer will reportedly handle significant substrate movement.

Developments in pigment technologies are also making it possible to expand color options beyond white or very light shades. "With the development of solar reflective pigments such as Ferro Corporation's Cool Color and Eclipse line, colors can now be formulated to meet 65% reflectivity," says Kenneth Loye, market development manager with Ferro Corporation's Performance Pigments and Colors Group. "Without these new pigments, white would be about the only answer," he adds. The technology for infrared reflecting pigments is an offshoot of projects completed by Ferro for some U.S. military applications.

COOL COATINGS FOR HIGH-SLOPED ROOFS

Advancements in coating technology for metal roofing have focused around the development of darker shades of pigments that retain the ability to provide the desired level of solar reflectivity and emittance.



"For residential applications, consumers continue to gravitate toward the aesthetic appeal of the darker shades and designs, despite urging by governmental and architectural bodies for the industry to achieve higher reflectivity values," notes David Story, cool coatings specialist with BASF Corporation's Cool Color Concepts Group.

Current limitations of the metal roof coatings technology are "reflectivity for color space" and the laws of physics, according to Loye. "If you study the chart of solar flux striking the earth, you can determine that a black color can only achieve a maximum reflectivity of around 50%. Currently, black color commercial products can achieve as high as about 32%," he explains. Ferro recently introduced V-775 Cool Color IR Black, the company's darkest IR Black with 24% solar reflectivity. Eclipse 10202 is Ferro's almost-black pigment and it has a solar reflectance of 32%

In mid-January 2007, the Shepherd Color Company added Brown 10C873 to its Arctic® range of infrared reflecting pigments. The new product is a dark brown manganese antimony titanate pigment with high solar reflectivity. Arctic Brown 10C873 is complementary to Arctic Black 10C909, introduced in 2004.

The use of infrared reflective pigments for metal roofing has only been practiced for the past several years. BASF's Industrial Coatings Solutions Group became the first to supply solar reflective coatings to the metal roofing market, according to Story. The company currently offers three premium Ultra-Cool® coatings for metal substrates: Fluoroceram® and Ultramet® (metallics), which are PVDF technologies, and Superl® SP IITM Ultra-Cool Siliconized Polyester.

"We are currently working on technology improvements to increase the reflectance of deeper shades of brown, blue, and green colors (currently in the 25%–27% SRV range) to above 30% reflectance, which will make them LEED 2.2 compliant," Story says. In addition, BASF has been invited to be an industry partner in the Lawrence Berkeley Laboratory "Phase Two" study, sponsored by the California Energy Commission. Representatives from BASF will be part of a team focused on working with utilities and other public groups, promoting cool roof materials and improving the reflectance of non-white coatings.

Akzo Nobel and BaySystems also offer lines of roof coatings that contain IR reflective pigments for high slope metal roof applications. Akzo Nobel's Cool Chemistry® series of coatings meet the requirements for all of the current codes and standards. The company also offers a silicone modified polyester product with superior UV resistance that it believes is the most durable non-Kynar coating on the market, according to David Cocuzzi, manager of market and technology development for Akzo Nobel.

A Sampling of Rebate Programs

Location	Agency	Program Name
Federal	Energy Policy Act of 2005	Federal tax credit of up to $500 for cool metal roofs
Austin, TX	Austin Energy (City of Austin's municipal utility)	Building envelope rebates
California	Pacific Gas & Electric	Residential Cool Roof Rebate
Los Angeles, CA	Los Angeles Department of Water and Power	Cool Roof Retrofit Program (CEC)
San Diego, CA area	San Diego Regional Energy Office	Cool Roof Retrofit Program (CEC)
Idaho	Idaho Power	Building Efficiency for Commercial Construction
Florida	Florida Power & Light Company	Rebates for reflective roofs and roof coatings under "Residential Building Envelope"

Source: Cool Roof Rating Council (www.coolroofs.org/) and internal research.

WHAT'S NEXT?

The pace of development in cool roof coating technology has been very dramatic over the last decade. Can the industry sustain such levels? "I expect that the rate of development will slow, but advancement in capabilities for providing darker colors with higher solar reflectance values will still be achieved," states Cocuzzi. In the long term, as demand for cool roof coating technology increases, he also believes that improvements in durability will also be addressed, such as resistance to UV radiation.

A greater understanding of the interaction between roof coatings and other aspects of building construction and operation might play a role in improving performance as well. "I think advances will take place with synergies among various suppliers to the industry, like the use of insulation along with reflective pigments on the surface to get the benefit of both technologies," says Loye. He goes on to note that "some work suggests air spaces underneath roofing along with reflective pigments shows improvements in heat flux getting into the building envelope."

These issues will receive more attention as demand for cool roof coating technology grows. And demand is expected to rise significantly. "The prediction is that we will see increasingly more municipal as well as state requirements for cool roofs. Translated, that means more coating products will be produced to meet demand for new as well as existing low-slope roofs," White explains. "A wider range of products dedicated to each substrate type will be formulated as a result. Building codes will also likely dictate sufficiently sloped roof designs, which will benefit the entire roof coatings industry," he continues.

Growth will in part depend on a greater awareness of, and compliance with, regulations. "Currently, there is poor knowledge and enforcement of the Title 24 reflectivity requirements in California," notes Linell. "Once the market truly meets the requirements of Title 24, and the same issues are resolved in the other states, the market will truly be enormous. We believe this market is a major opportunity for suppliers that manufacture a premium product and have a qualified applicator network."

To date, the interest in cool roof coatings has largely been generated in the warmer climates of the United States. Outside of the U.S. there has not been much demand for these products yet. "Anyone that has cooling demands will eventually be interested in cool roof technology, though," comments Cocuzzi. He expects that countries located in the Southern Hemisphere—Australia, parts of Asia, and Central and South America—will likely be interested in cool roof coatings eventually, adding to the tremendous potential of the market.

Even without expansion beyond the U.S. market, the potential is significant. "A key point to remember about cool roof coatings is that these products can take market share away from asphalt roofing. This situation presents an extremely rare opportunity for the coatings industry," Murad asserts. "With the development of cool roof coatings for metal roofs, coatings producers and their suppliers have a new surface area to coat that was not available just 10 years ago. The value of that opportunity is approximately $10 billion." He adds that there is further potential for cool coatings as they take on the challenge to expand to other surfaces such as pavements and siding.

It looks like it will be a hot market for cool roof coatings, indeed. CT