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Cool-colored coatings fight the urban heat-island effect

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Replacing conventional pigmented coatings with specialized ones that reflect more near-infrared radiation lowers surface temperatures.

The urban heat island effect is becoming increasingly more intense. Among its causative factors are the lower albedo (reflective power) of urban surfaces and the replacement of vegetation by buildings.[1] Absorption of solar energy by concrete and paved structures raises their surface temperature several degrees over that of the ambient air, which also then increases. Apart from causing thermal discomfort, heat islands precipitate greater consumption of cooling energy. They also drive up energy demand and costs,[2–4] and accelerate the formation of harmful smog.[5]

Mitigating the urban heat island phenomenon requires cool materials that are characterized by high solar reflectance (SR) and IR emittance values.[6] Increasing either reflectance or emittance lowers the surface temperature of the building envelope, which in turn decreases the heat penetrating the structure. These techniques also work by lowering the temperature of the ambient air, because the cooler the surface, the lower the heat convection intensity. A number of cool materials are currently available commercially for buildings and other surfaces of the urban environment, These including cool surface coatings, reflective tiles, and so on: however, they are all white or light colored.[7–10] There is a need for cool, nonwhite products for situations where darker colors are preferred or where white products introduce glare. For this reason, new materials that are dark but still reflect more sunlight and stay cooler are being developed using specialized pigments.

A cool non-white coating absorbs in the visible range to give the appearance of a specific color. Considering that about half of all solar power arrives as invisible near-IR (NIR) radiation, such a coating should be highly reflective in the NIR part of the spectrum to maintain high solar reflectance. This is achieved by replacing conventional pigments that absorb in the NIR with novel ones that have the desired properties.[11,12]

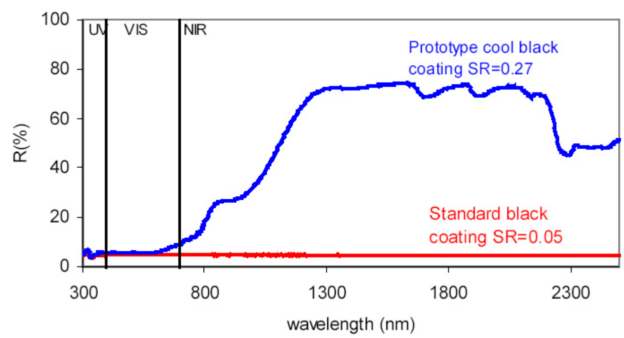

Figure 1. *Spectral reflectance of cool and conventional black coatings.*

We have developed ten prototype coatings using NIR-reflecting pigments and compared them with color-matched, conventional counterparts. The difference in the solar reflectance observed between old and new coatings ranges, according to color, from 0.06 to 0.22, the highest being for the black coating (440% increase in SR, see Figure 1). The reflectance curves for each conventional coating and its corresponding cool equivalent coincide in the visible range. These results indicate that although the colors are similar, the conventional coatings exhibit low or modest reflectance in the NIR range, while the cool-colored coatings display a more selective absorption band and significantly reflect NIR radiation.

Measurements for the summer period show that during the day, the cool-colored coatings consistently had surface temperatures lower than the matched ordinary ones. The highest difference was observed between cool and standard black and was equal to 10.2°C, corresponding to a difference in solar reflectance of 0.22 (see Figure 2).

Although both coatings absorb in the visible range, the cool version reflects NIR radiation. Consequently, less solar energy is absorbed and converted to heat energy, resulting in a smaller increase in surface temperature for the cool coating. During the night, when there is no solar radiation, the surface temperature of the samples was found to be quite uniform: all the coatings have an emissivity of about 0.88 (see Figure 3).

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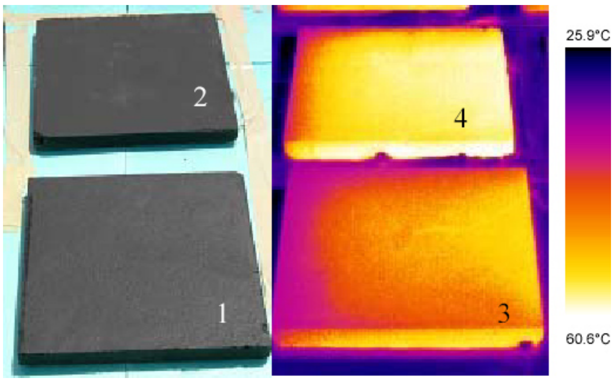

Figure 2. *Visible and IR images of cool (1, 3) and conventional (2, 4) black coatings.*

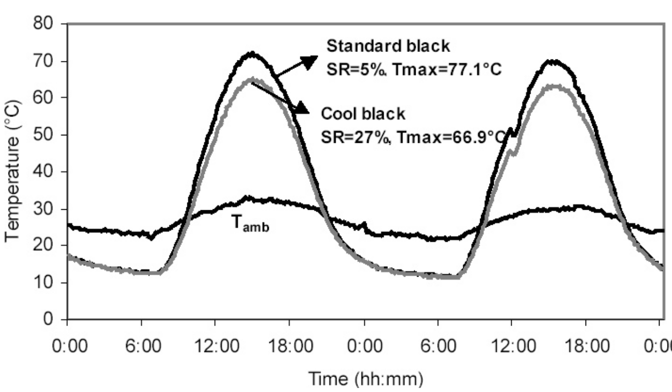

Figure 3. *Forty-eight-hour distribution of surface temperatures of cool and standard black coatings, and ambient temperature (T_{amb}).*

Cool-colored coatings are an inexpensive and passive solution that can help to reduce cooling loads and improve indoor comfort at the level of buildings. At the city level, the materials could provide a means to alleviate air temperature due to heat-transfer phenomena, ultimately improving outdoor thermal comfort and reducing the heat-island effect. Aside from these applications, the pigments could also be used to create other cool-colored materials, as well as automotive topcoats and coatings for oil rigs and military applications.

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