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Development and testing of PCM doped cool colored coatings to mitigate urban heat island and cool buildings

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ABSTRACT

In this study the performance of organic PCMs used as latent heat storage materials, when incorporated in coatings for buildings and urban fabric, is investigated. Thirty six coatings of six colors containing different quantities of PCMs in different melting points were produced. Accordingly, infrared reflective (cool) and common coatings with the same binder system and of the same color were prepared for a comparative thermal evaluation. The samples were divided in six groups of different color and eight samples each: three PCM coatings of different melting temperatures (18 °C, 24 °C, 28 °C) each one of two different PCM concentrations (20% w/w, 30% w/w), an infrared reflective and a common coating of matching color. Surface temperature of the samples was recorded at a 24 h basis during August 2008. The results demonstrate that all PCM coatings present lower surface temperatures than infrared reflective and common coatings. Analysis of the daily temperature differences showed that peak temperature differences occur between PCM and common or cool coatings from 7 am to 10 am. Investigating the temperature gradient revealed that for this time period the values for PCM coatings are lower compared to infrared reflective and common. From 10 am to 12 pm, temperature gradients for all coatings have similar values. Thus coatings containing PCMs store heat in a latent form maintaining constant surface temperatures and discharge with time delay. PCM doped cool colored coatings have the potential to enhance thermal inertia and achieve important energy savings in buildings maintaining a thermally comfortable indoor environment, while fighting urban heat island when applied on external surfaces.

1. Introduction

Urban microclimatic conditions have a very serious impact on the energy consumption of buildings, outdoor comfort conditions and pollutants concentration. Urban heat island phenomenon in combination to the global climatic change deteriorate the microclimatic conditions that are characterized by increased ambient temperatures, longer duration of hot spells and more frequent heat waves [1,2].

Urban heat island refers to increased temperatures in cities compared to the surrounding environment because of the positive urban thermal balance [3–5]. It is the most documented phenomenon of climatic change, and is associated with a very important increase of the cooling energy demand of buildings and a global deterioration of the local environmental conditions [6–8]. Various studies performed have shown that urban heat island may increase the cooling energy demand of urban buildings between 20 and 100% [9–13].

Mitigation techniques aiming to counterbalance the heat island phenomenon deal with the intensive usage of green spaces, application of highly reflective materials, decrease of the anthropogenic heat, solar control of open spaces, use of environmental heat sinks and increase of the wind flow in the canopy layer [14–18]. In particular the use of materials presenting a high reflectivity in solar radiation and a high emissivity value, cool materials, have gained an increasing acceptance [19–21]. Both properties contribute to a lower surface temperature of the materials which may be applied in roofs, walls and pavements [22,23]. Lower surface temperatures of external roofing coatings decrease the heat penetration through the building envelope and reduce the cooling load of buildings [24], while when applied in pavements and other urban surfaces contribute to decrease the ambient temperature as the heat convection intensity from a cooler surface is lower [25,26].

Research on new generation cool materials aims either to decrease the penalty of low absorptivity during the winter period,

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