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Temperature Control in Textiles Made of Colored, Infrared-Transparent Polyethylene

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Description

In addition to improving human health and comfort, wearables with effective temperature regulation hold great promise for energy savings. According to recent reports, infrared-transparent polyethylene textiles had a passive cooling effect by allowing the body's thermal radiation to pass through, but they were not color-tunable. In this work, we show for the first time how to color infrared-transparent polyethylene textiles for radiative cooling with unique inorganic pigment nanoparticles. This work will enable us to move one step closer to the practical application of energy-efficient and cost-effective radiative cooling textiles for personal thermal management thanks to the demonstrated scalable fabrication processes and good washability. Reducing the amount of energy used in a building can be accomplished in a novel and potentially cost-effective way by effectively regulating heat flow between the body and its surroundings. Textiles with infrared properties have been shown to effectively cool and warm the human body by passively regulating radiative heat loss. However, a major obstacle to the commercialization of textiles remains the absence of dyes that can adjust the color of the fabric without compromising its infrared properties. For scalable brightly colored, infrared-transparent textiles, we present a novel method that makes use of inorganic nanoparticles as a coloring component. The composite textiles as they were made not only have a high infrared transparency of 80% and a passive cooling effect of 1.6°C–1.8°C, but they also have vivid visible colors that hold up well to washing. This straightforward coloration strategy will encourage the commercialization of radiative cooling textiles for effective energy savings in temperature-regulating wearable applications [1].

The utilization of wearable technology for heat flow management has the potential to enhance human comfort and health. Personal thermal management is a more cost-effective and efficient alternative that aims to provide localized heating and cooling to the human body and its immediate environment. This is in contrast to building-level temperature regulation, where the majority of the energy is wasted on unoccupied space. Additionally, heat-managing wearables can result in substantial energy savings, as space heating and cooling consume a significant amount of energy (for example, more than 10% of the total energy consumption in the United States). Controlling garment textiles' infrared (IR) optical properties can have a significant impact on the body's local cooling and heating, according to recent research. The human skin has a high emissivity (=0.98) and acts like a black body, strongly emitting thermal radiation in the IR wavelength range of 7–14 m with a peak intensity at 9.5 m. This is due to the fact that the human skin has a high emissivity (=0.98) and acts like a black body. It was demonstrated that IR-transparent nanoporous polyethylene (nanoPE) can passively cool the body by 2 Since thermal radiation accounts for more than half of heat loss in indoor environments, it is essential for the body to dissipate heat. Because conventional textile materials lack the ability to control infrared radiation, these findings provided a new direction for personal thermal management [2].

However, controlling textiles' visible color while simultaneously using effective infrared management is challenging. Because color selection is one of the most important factors governing the wearable market, this remains the main obstacle that prevents infrared-engineered textiles from being used in real life. C-O stretching (7.7–10 m), C-N stretching (8.2–9.8 m), aromatic C-H bending (7.8–14.5 m) and S=O stretching (9.4–9.8 m) are examples of chemical bonds that strongly absorb human body radiation in the mid-IR wavelength range. Organic dyes can therefore have low IR transparency and high IR emissivity, rendering them unsuitable for radiative cooling or heating effects. Chemical dyes cannot adhere to polyethylene's surface because it lacks polar groups and is chemically inert, making it an ineffective base material for radiative cooling and heating textiles. We present the first demonstration of colored polyethylene textiles with high IR transparency for radiative cooling and propose a possible solution to the conflict between visible and infrared optical properties. This is made possible by successfully locating and making use of one-of-a-kind inorganic pigment nanoparticles that reflect certain visible colors in an optimal concentration and size while exhibiting negligible IR absorption. In contrast to the surface-adhesion method, which was previously reported to have difficulty achieving stable coloration for polyethylene, the compounding of the inorganic pigment nanoparticles into the polyethylene matrix produces a uniform composite for stable coloration. We also show that scalable processes can be used to easily extrude colored polyethylene composite into mechanically strong, continuous fibers for knitting interlaced fabrics. Not only do the knitted fabrics have a good radiative cooling performance of 1.6°C–1.8°C and a high IR transparency of 80% but they also maintain their color well after more than 100 washes. This work lays the groundwork for the practical use of radiative cooling textiles to improve personal thermal management and make better use of energy [3-5].

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Conflict of Interest

None.

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