Thermally conductive h-BN/polymer composites for textiles thermal management

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Abstract

Textile materials with high thermal conductivity are ideal for personal cooling by accelerating the heat dissipation between the human body and hot atmosphere via thermal conduction. Current works on advanced textiles for thermal management adopted thermally reinforced composites to form nanofibers using carbon-based or boron-based nanofillers, achieving an in-plane and out-of-plane thermal conductivities (κ) of 13.1 W m^{-1} K^{-1} and 1.9 W m^{-1} K^{-1}, respectively (1). However, the complex fabrication and the insufficient thermal conductivity of nanofiber composites impede their use in applications such as sportswear which requires more efficient transfer ability of heat flux to surroundings. Hexagonal boron nitride (h-BN) is a promising candidate as thermal conductive filler with an in-plane thermal conductivity value of up to 370 W m^{-1} K^{-1} (2). It can be exfoliated into single layer form achieving a value up to 751 W m^{-1} K^{-1} (3). In this work, we demonstrate a thermally conductive composite embedded with exfoliated h-BN, achieving κ ~ 21.7 W m^{-1} K^{-1}, (figure 1) about 5-fold higher than bulk h-BN embedded composites (κ ~ 4.5 W m^{-1} K^{-1}). Exfoliated h-BN were produced via probe sonication of bulk h-BN with carboxymethyl cellulose (CMC) in water and subsequently purified via centrifugation. Atomic Force Microscopy characterisation revealed the average thickness of the exfoliated h-BN flakes is around 6 nm. The h-BN/CMC aqueous composite is then drop-casted onto a non-woven fabric and dried in the air to prepare a thermally conducting textile. Comparative temperature measurements at the thermal equilibrium between the h-BN/CMC coated textile and the uncoated textile shows that the coated textile reaches a higher temperature than the uncoated textile by 1 ℃, indicating that the exfoliated h-BN-assisted composite improved the heat amount dissipated from the heater to the environment. The cooling effect of the exfoliated h-BN-assisted composite textile is calculated to be 5.5% greater than the commercial textile under natural air convection (4, 5), which displays a better thermal management capacity of the textile for applications in active thermal management clothing for sportswear, aerospace, or heavy-duty industries.

References

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Figures

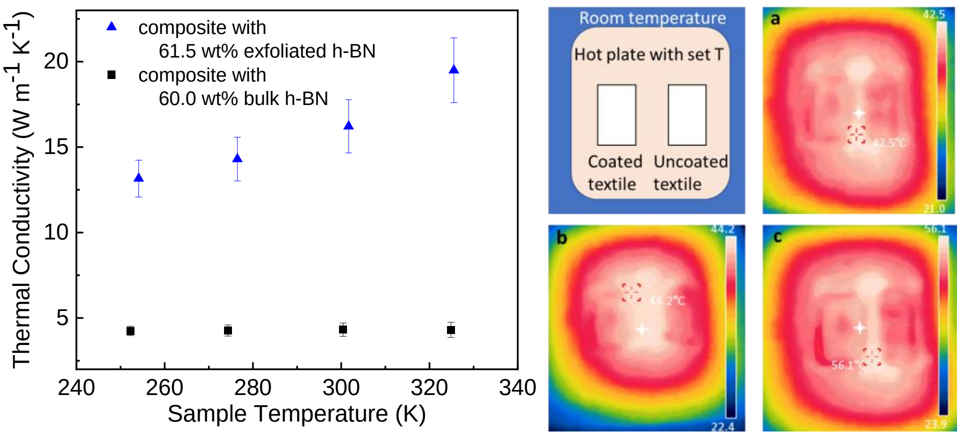

Figure 1: Left: Thermal conductivity of the exfoliated and bulk h-BN assisted composites; Right: Comparative temperature measurements between the coated textile and the uncoated textile.