Carbon Nanotube Textiles to Provide Advanced Personal Protection for Firefighters and First Responders

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Heat stress and exhaustion lead to decreased performance and increased risk of injury for firefighters and first responders. This poster presents results of an initial evaluation of carbon nanotube textiles as advanced personal protection technology to reduce heat stress and fatigue in firefighters and first responders. The research method taken was to integrate carbon nanotube yarn into a cotton swatch from the inner layer of a firefighter garment and use the nanotube yarn to pipe heat away from the cotton fabric to a cold sink. Nanotubes have several advantages related to improving protective gear for workers. Carbon nanotubes are grown as a vertically aligned forest on a silicon substrate. Nanotube ribbon is made by drawing a line of nanotubes from the forest. Layering the ribbon can form a sheet. Twisting the ribbon would form a thread. Multiple threads can be plied together and twisted to form a yarn. Ribbon, thread, yarn, braid, and sheet forms of nanotube textile materials are being tested for possible use as personal protective garments for firefighters, first responders, and soldiers.

Experiments were performed to measure thermal conductivity of cotton fabric alone and then with carbon nanotube yarn sewn in. The yarn was run from the fabric to a cold sink. Initial results indicate the nanotube yarn conducts heat away from the fabric to the cold sink. Improvements in the design of the heat path could be made by integrating the nanotube yarn into the fabric without stitching to reduce transverse heat conduction from the outside of the swatch (representing the hot outside surface of the garment) to the cooler inside layer of the garment. The improved approach will integrate a layer of nanotube sheet in between layers of the firefighter garment to pipe heat along the axis of the nanotubes to a cold area. Then transverse heat conduction from the outside of the garment to the inside would be reduced because the nanotube sheet does not easily conduct heat laterally. NFPA standards outline all the design and performance requirements and test methods for these garments and accessories. The standards will be used to guide the testing of nanomaterial fabric.

Conclusions from this study indicate nanotube textiles may provide cooling, lighter weight, and abrasion resistance when used as a layer in firefighter garments. Designing the interface between the nanotube material and adjacent layers of the garment is a key factor in the performance of the cooling layer. Nanotube textiles may also be useful in reinforcing firefighter gloves, helmets, and shoes.

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