

# Carbon Nanotube Reinforced Textiles: Advanced Personal Protection Technology for Firefighters

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Heat stress and exhaustion lead to an increased risk of injury and decreased performance for firefighters and first responders. This poster presents results of an initial evaluation of carbon nanotube (CNT) enhanced composite textiles as an advanced personal protection technology to reduce heat stress and fatigue in firefighters and first responders. The research method taken was to create a highly simplified Finite Element Analysis (FEA) model of a traditional textile fabric embedded with CNT and study its response to different ambient conditions. Nanotubes have several advantages related to improving protective gear for workers: they are very strong, light weight, and highly thermally and electrically conductive. To add to these amazing properties, from Molecular Dynamic (MD) simulations of the tubes, the tubes are thought to have anisotropic thermal conductivity. This property of CNT can allow the flow of thermal energy to be directed, in this case away from the firefighters and first.

Carbon nanotubes are grown as a vertically aligned forest on a silicon substrate. A CNT ribbon can be made by drawing a line of CNTs from the forest. The CNT ribbon is a mode in which the nano-scale CNTs can be constructed into a macro-scale product. Layering the ribbon forms a CNT sheet. Twisting the ribbon forms a CNT thread. Multiple threads can be plied together and twisted to form a yarn. The CNT structures mentioned are the potential building blocks to the new CNT enhanced composite textiles that will be tested for possible use as personal protective garments for firefighters and first.

An FEA model was constructed and it was subjected to arbitrarily selected ambient temperatures to determine how the embedded CNTs would affect the heat flux through the material into the body of the person “wearing” the garment. The model considered two different thermal conductivities of the thread. The first being the thermal conductivity of CNT reported in current literature. The second being the highest thermal conductivity reported in current literature of a CNT structure, to make a guess at the thermal properties we can expect of CNT thread upon further refinements.

Conclusions from this study indicate that CNT composite textiles may provide increased thermal protection for firefighters. The material may also have multi residual benefits, in that the CNT composite textiles would be strong and light. This would add to the abrasion resistance of the garment and further increasing the protection from heat-stress. The material may also have multifunctionality in that it could be dual purposed to also serve as an antenna, or sensor, or both. All of this combined points the notion that

CNT enhanced composite textiles have great potential to improve the safety for firefighters and first responders.

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