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Application of Carbon Nanotubes to Kevlar Fabric for Use in Body Armor

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Application of Carbon Nanotubes to Kevlar Fabric for Use in Body Armor

Will Carbon Nanotubes **Strengthen Kevlar Body Armor?**

Hypothesis: Carbon nanotubes (CNTs) will greatly increase the strength of Kevlar body armor if chemically bonded directly to the fabric

Background and Theory

- **CNTs have immense tensile strength but are** extremely brittle
- If CNTs were bonded to Kevlar, they would entangle the fibers and make it more difficult for a bullet to pass through.
- This could allow armor makers to design \bullet body armor that was lighter but offered the same protection as heavier vests.





SEM photo of CNTs on the surface of a Kevlar fiber

Single wall carbon nanotube¹



Curtis Baker (Montana Tech) and Dario Prieto (Montana Tech)

Results

- The Kevlar with CNTs was more intact after being shot with a .177 caliber air rifle The yarn was significantly more difficult to
- pull out of the weave
- The fabric had less back-face deformation

Bullet Impacts



Kevlar after being shot with .177 caliber air rifle. Left: Kevlar with CNTs Right: Neat Kevlar

Yarn Pullout Test



Ballistic and Tensile Test

	ΔE (J)	σ (ksi)
Neat	6.2	85.5
Treated	7.4	90.2
Percent Increase	19.3%	5.5%
Standard Deviation	0.5,0.5	3.7 , 2.9

and TDI)



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Conclusions The CNTs did improve the Kevlar's performance in ballistic tests The weave of the fabric didn't break up as much as in normal Kevlar This leads to less back-face deformation and increased protection for multiple high velocity impacts



Future Work

- **Continue ballistic testing using .22** caliber subsonic rounds.
- **Try different weaves of Kevlar Analyze different treatments of Kevlar** oxidation
- **Produce larger panels of Kevlar for use** in hard armor plates

Acknowledgements

This research was sponsored and inspired by Hugh Craig. Huge thanks to Dr. Dario Prieto who designed much of the experimental methods.

Photo References **1.** Suraj.viswanathan. "Carbon Nanotubes Better than Carbon Fiber." *Motoroids*. N.p., 18 Mar. 2015. Web. 28 July 2017

Kevlar after being shot with .177 caliber air rifle still in sample holder. Note: lack of damage to weave