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

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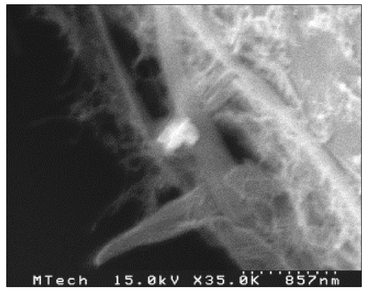
Will Carbon Nanotubes Strengthen Kevlar Body Armor?

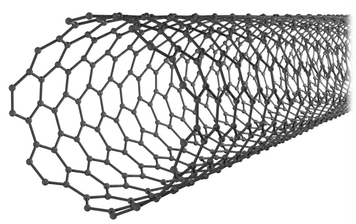
Hypothesis: Carbon nanotubes (CNTs) will greatly increase the strength of Kevlar body armor if chemically bonded directly to the fabric

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 body armor that was lighter but offered the same protection as heavier vests.

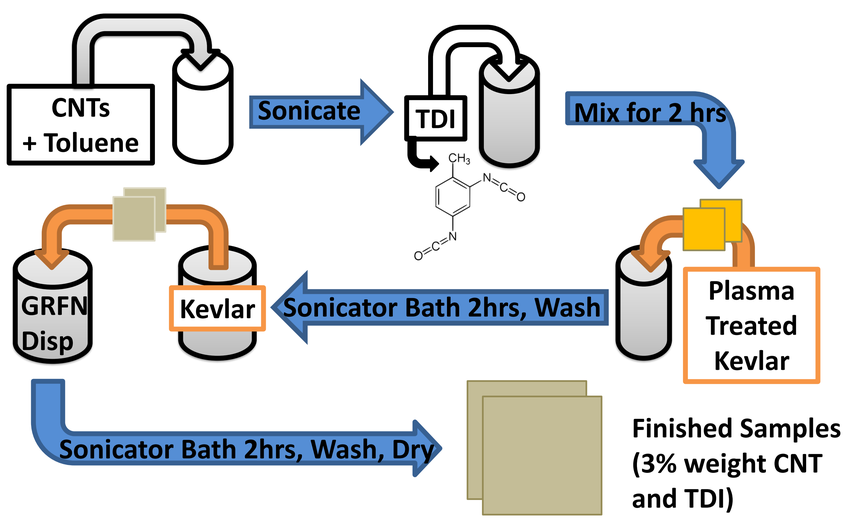


SEM photo of CNTs on the surface of a Kevlar fiber



Single wall carbon nanotube[1]

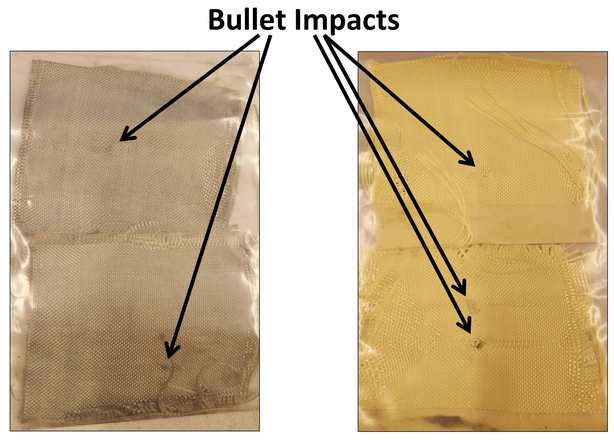
Methods



Finished Samples (3% weight CNT and TDI)

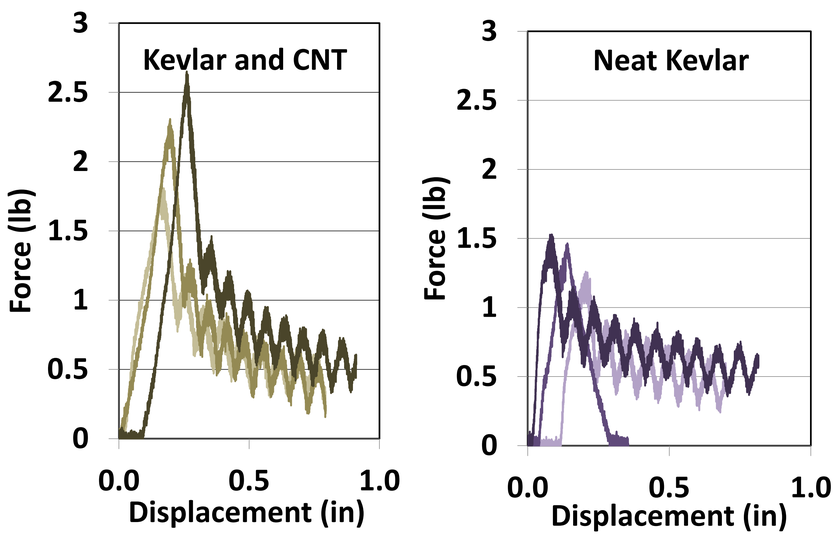
Results

- 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



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

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

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

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