Non-Traditional Textiles

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US ARMY RDECOM

US ARMY NATICK SOLDIER RD&E CENTER

Non-Traditional Textiles

Encompasses two ongoing research efforts at US Army NSRDEC:

- ***Stable, Multifunctional and Reactive Textile Coatings* (SMaRTeC)**
- ***Process Development for Electrospun Nanofibers***

• These efforts are designed to utilize novel methodologies to make new textiles and membranes, and modify commercially available fabrics.
• Simple, eco-friendly techniques are being used to coat textiles with thin layers of materials such as oxides in order to impart multiple functionalities including sensing, decontamination, and flame and thermal protection.
• The process development research on electrospinning of nanofibers through modeling and experimentation will develop methodologies to produce controlled micro/nanostructures in electrospun membranes, with enhanced durability and using environmentally friendly solvents.
• These efforts will lead to enhancements in uniform materials that will decrease Soldier load by providing multiple capabilities in a single fabric treatment.

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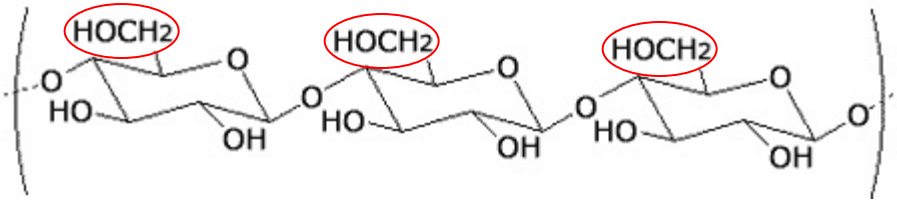
Stable, Multifunctional and Reactive Textile Coatings (SMaRTeC)

Woven and Non-Woven Textile Treatments

- Physical/chemical treatments of textiles are frequently performed to impart certain properties not inherent to the material
- Rarely do these treatments address more than one need or weakness
- Needs addressed are generally physical in nature
- Multi-step process required to address more than one need

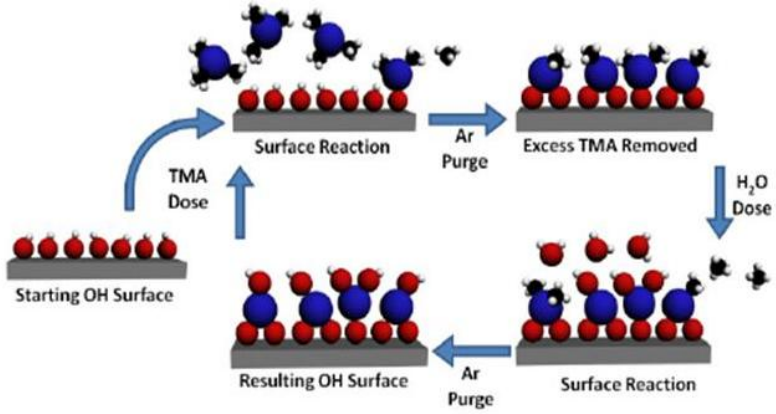
Templating onto Textile Surfaces

- Previous studies have demonstrated biomimetic surfaces can precipitate metal oxides with some control
- The procedures are “environmentally benign” (aqueous, neutral pH, ambient temperature and pressure)
- Bulk precipitations from solution and coatings onto surfaces are possible
- Natural fibers (*e.g.* cotton) have functional groups amenable to modification, resulting in active biomimetic surfaces



Atomic Layer Deposition on Textiles

- This research plan focuses on a green coating method for metal oxides called Atomic Layer Deposition (ALD) to impart flame resistant, electronic and optical capabilities to common textiles used by the military
- ALD is a unique, highly conformal coating fabrication technique.
- The contouring of the ALD coating preserves porosity of the fabric so original moisture vapor transport properties are maintained.
- ALD, used mostly in the electronics industry has only recently has been used on textiles to impart multifunctional properties in the areas of FR, electronic and optical research



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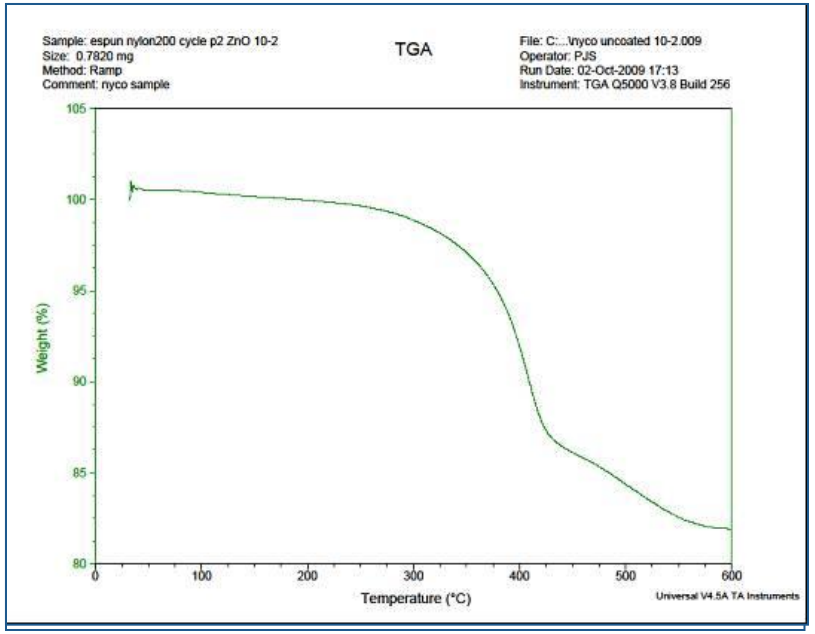
Stable, Multifunctional and Reactive Textile Coatings (SMaRTeC): ALD

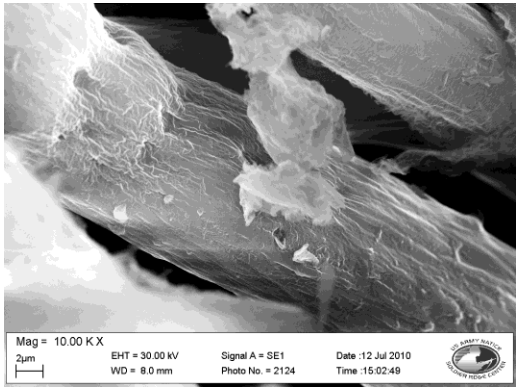
Thermo gravimetric analysis

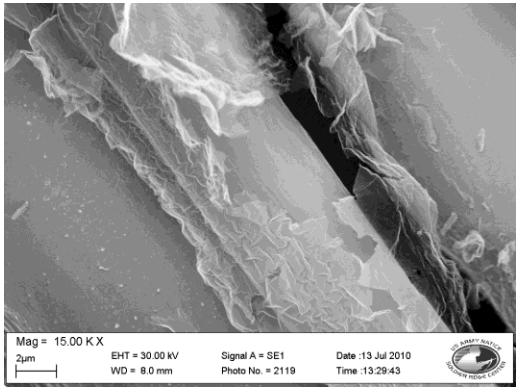
- Commonly used by FAA to simulate burning events
- ZnO coating on nylon nanofibers
- 100, 200, and uncoated fibers
- 100 cycle coating leveled off at ~65 wt%
- 200 cycle coating leveled off at ~82 wt%
- Uncoated fibers completed burned



SEM images of Aluminum oxide coating on textiles following TGA up to 600˚C

Note how the coating is protecting the fibrous structure of the textile





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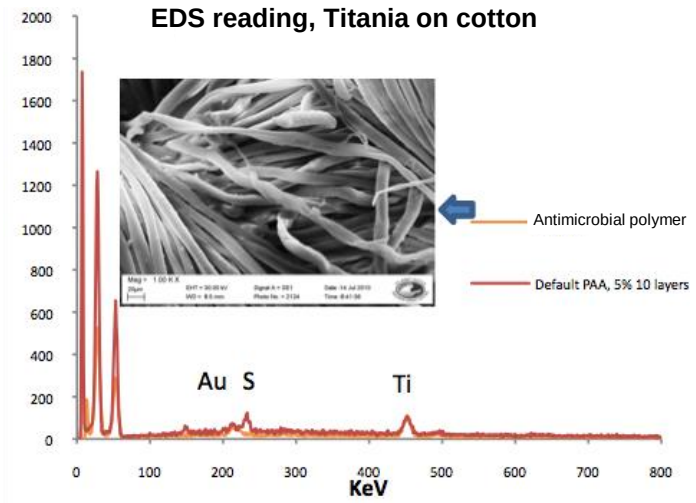
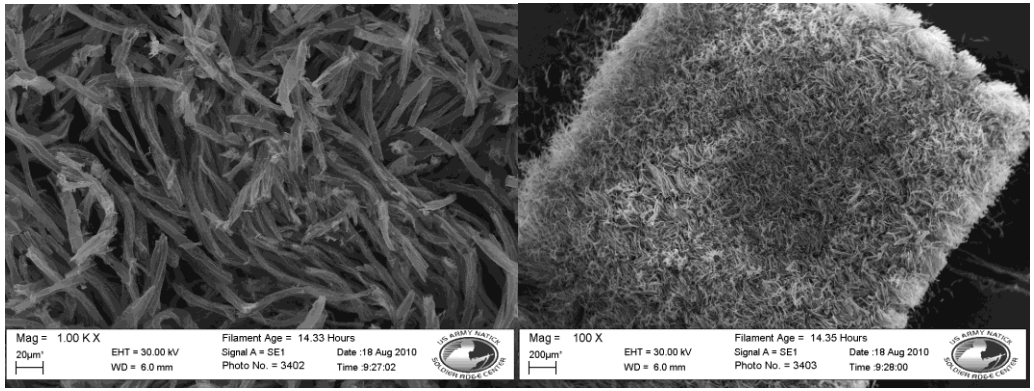
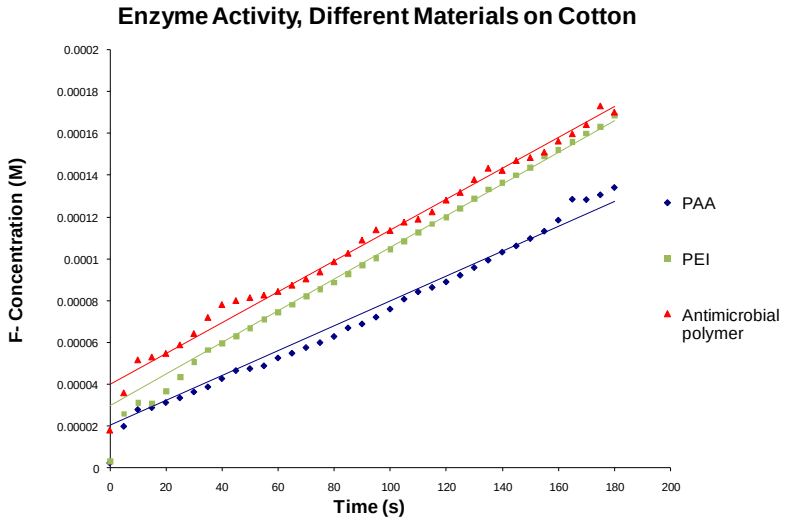
Stable, Multifunctional and Reactive Textile Coatings (SMaRTeC): Solution

- Successfully precipitated titania on cotton and NyCo
- Used electrostatic and covalent attachment
- Encapsulated enzyme while retaining activity
- TGA with antimicrobial polymer shows char of conformal titania coating







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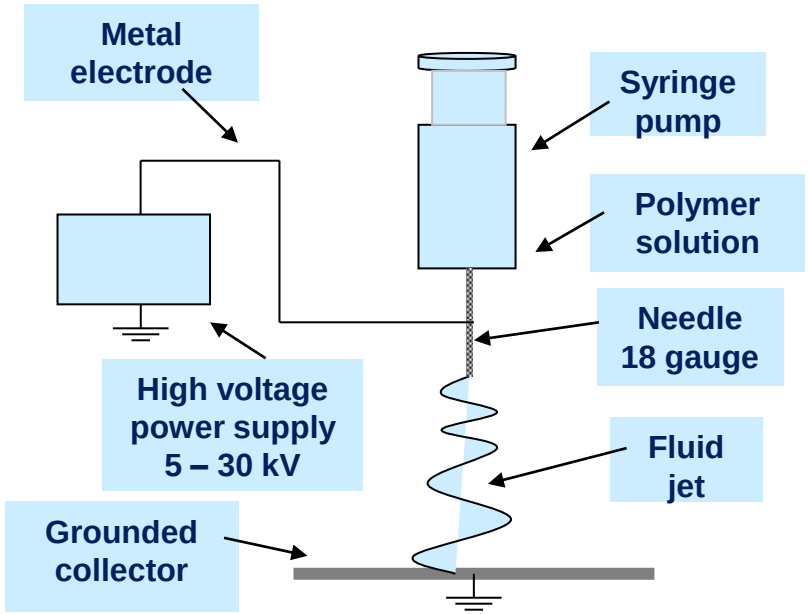
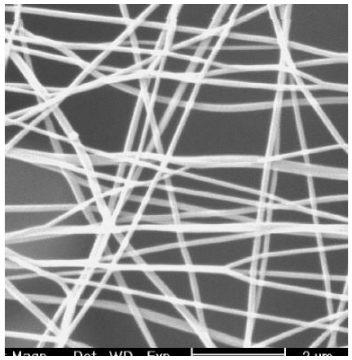
Electrospinning



- Drops of polymer solution emerge from capillary end (controlled by surface tension and viscosity)
- Polymer solution jet at capillary end, splaying and/or stretching controlled by viscosity, conductivity and applied electric field
- Dried nanofiber non-woven mats are deposited at the collector

- Ultra thin non-woven mat
- Conformable Net-Shape Manufacturing
- High surface area and porosity
- Membrane like textile material
- Potential for reactive surface
- Potential for stimuli response



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Army and DOD Applications for Polymer Nanofibers

Protective Clothing
- Air Permeability
- Aerosol Particle Filtration
- Good “Breathability”

Filter Media
- Liquid filtration
- Gas filtration
- Molecule filtration

Nanosensors on clothing
- Thermal sensor
- Piezoelectric sensor
- Biochemical sensor
- Fluorescence optical chemical sensor

Other Applications
- Nano electronic devices
- Electrostatic dissipation
- Electromagnetic interference shielding
- Photovoltaic devices (nano-solar cells)
- LCD devices
- High efficiency functional catalysts
- Nanocomposites

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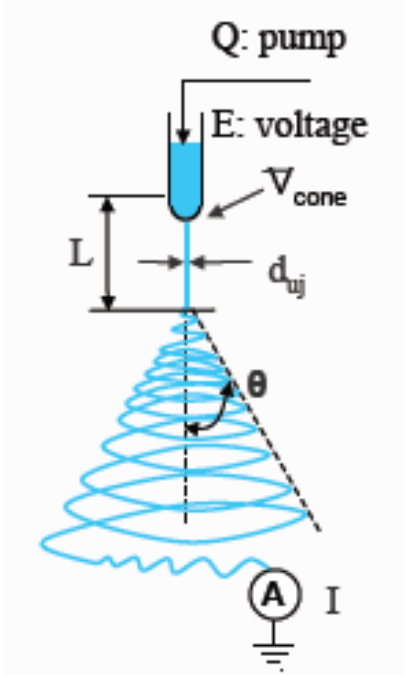
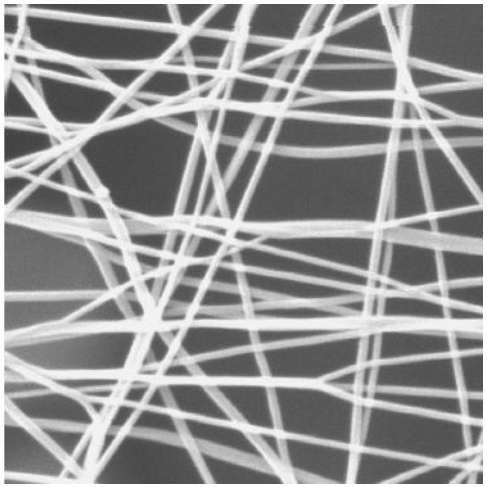
Critical Process Development Challenges

- Process control to generate nanofibers of controlled size and non-woven mats of controlled porosity
- Mechanical strength and durability of the nanofibers and nanofiber mats
- Current use of solvents that are not conducive to protecting the environment





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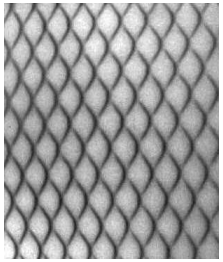
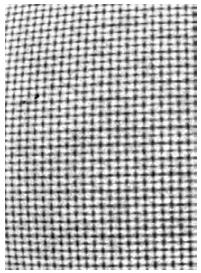
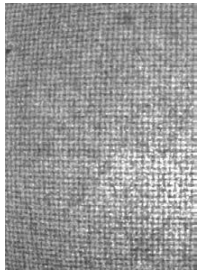
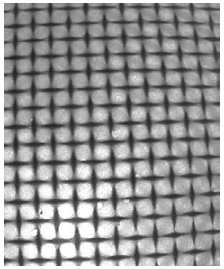
Mechanical strength and durability of the nanofibers and nanofiber mats

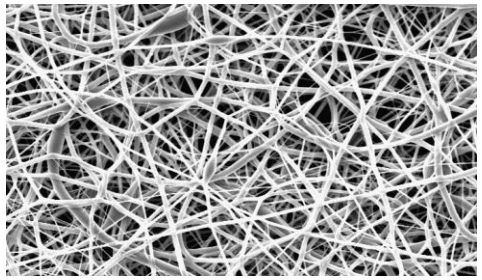
In-house R&D at NSRDEC with potential academic/industrial collaborations to investigate nanofiber cross-linking, deposition of oriented or aligned nanofiber mats, core-shell fibers

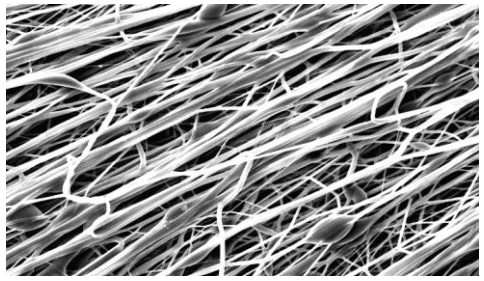












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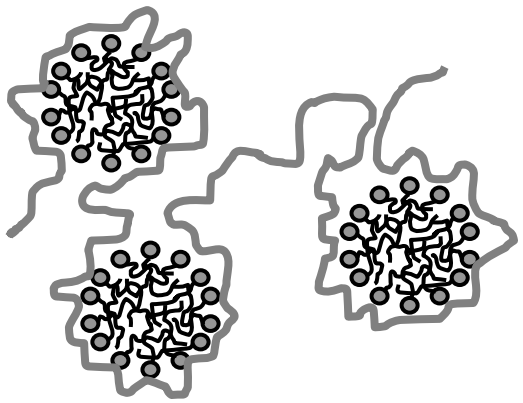
Current use of solvents that are not conducive to protecting the environment

Use of aqueous solution of polymer-micelle complex as the universal carrier for all polymers that need to be made into electrospun nanofibers – In-house R&D at NSRDEC



- Control viscosity of spin formulation
- Control surface tension of spin formulation
- Control conductivity of spin formulation
- Facilitate water based electrospinning by creating stable emulsion or dispersion of polymers, nanoparticles, catalysts, enzymes (main components in the spin formulation) by adding polymer-micelle complex as minor component