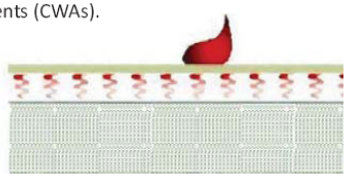
FROM NANOPARTICLES TO NOVEL PROTECTIVE GARMENTS

Shuvo Alam, Dennis Karote, Jane Langemeier, Cherry Leaym, and Shyamala Rajagopalan

1310 Research Park Drive
Manhattan, KS 66502

Our Approach

Highly reactive nanocrystalline metal oxide sorbents will be integrated with textile matrices to produce laminates that are suitable in the manufacturing of textiles for protection against toxic industrial chemicals (TICs) and chemical warfare agents (CWAs).



Specific Objectives

- Lightweight
- Air-permeable
- Comfortable
- Effective against liquids and vapors
- Engineered formulations for wide spectrum adsorption
- Destructive adsorption
- Increased and instantaneous protection
- Enable safe, effective, and comfortable operation by the wearer

Available Technology

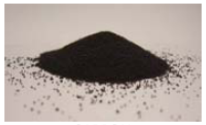
- Air-permeable materials
- Semi-permeable materials
- Impermeable materials
- Selectively permeable materials

Key Features of Available Air-permeable Materials

- Permeable to air, liquids, vapors and aerosols
- Consist of woven shell fabric
- A layer of activated carbon impregnated foam or carbon loaded non-woven felt
- Liner fabric

Limitations of Carbons

- Partial protection by physical entrapment of toxins
- Preferential adsorption of water
- Increased temperature results in off-gassing of adsorbed toxins
- No effect on acid or alkaline gases



CARBON

Uniqueness of NanoActive® Materials

Extraordinary Chemical Reactivity
- High porosity
- Small crystallite sizes
- Large surface area
- Unique morphologies

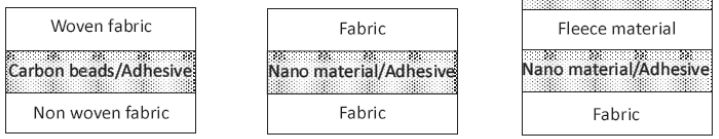
Proven Safe by Independent Testing
- Pulmonary
- Ocular
- Oral
- Skin sensitization and irritation

NANO MATERIAL

Desired Improvements in Select Properties

Property	*Carbon Bead Laminate*	*NanoScale Proposed Laminate*
Total Weight (g/m^2)	402	350
Sorbent: Fabric Weight (g)	250:152	250:100
Air Permeability ($cm^3/cm^2.s$)	63	≥63

Configurations of Compared Laminates



Carbon Bead Laminate | 2 Layer Laminate-NS | 3 Layer Laminate-NS

Physical Characteristics and Permeation Data

Sample	*Total Weight (g/m^2)*	*Sorbent: Fabric (g)*	*Air Perm ($cm^3/cm^2.s$)*	*Chemical Permeation*			
				Cumulative Permeation 1 hr $\mu g/cm^2$		*Maximum Permeation Rate $\mu g/cm^2/min$*	
				2-CEES	*DMMP*	*HCN*	*NH_3*
Carbon Bead Laminate	402	250:152	63	23	6.7	310	624
2 Layer Laminate	338	250:88	60	6.6	0.44	0	0.004
3 Layer Laminate	377	250:127	45	5.9	0.60	0	0

Evidence for Destructive Adsorption

Sample	*% Recovered*	
	2-CEES	*HEES*
Carbon Bead Laminate	92	0
2 Layer Laminate	1.4	18
3 Layer Laminate	1	13

Sample	*% Recovered*	
	DMMP	*MPA*
Carbon Bead Laminate	85	Absent
2 Layer Laminate	24	Present
3 Layer Laminate	20	Present

From Meritorious Material to Marketable Product

Key Conclusions/Near Term Plans

- Improved granule immobilization with significantly reduced shedding
- Weight reduction at the fabric level for excellent chemical protection
- Concept was proven at the laminate manufacturing level
- Exploring markets related to emergency, medical, military and industrial apparel
- Exploring use in other areas such as various DOD and civilian products
- Refining to meet the demands of the 21st century

This work was supported by NIOSH Phase II SBIR Grant No. 2R44OH007963-02A2.