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

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

Desired Improvements in Select Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Carbon Bead Laminata</th>
<th>NanoScale Proposed Laminata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Weight (g/m²)</td>
<td>402</td>
<td>350</td>
</tr>
<tr>
<td>Sorbent: Fabric Weight (g)</td>
<td>250:152</td>
<td>250:100</td>
</tr>
<tr>
<td>Air Permeability (cm³/cm².s)</td>
<td>63</td>
<td>≥63</td>
</tr>
</tbody>
</table>

Configurations of Compared Laminates

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fabric</th>
<th>Nano material/Adhesive</th>
<th>Fleece material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Bead Laminata</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Layer Laminata-NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Layer Laminata-NS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Physical Characteristics and Permeation Data

<table>
<thead>
<tr>
<th>Sample</th>
<th>Total Weight (g/m²)</th>
<th>Sorbent: Fabric (g)</th>
<th>Air Perm (cm³/cm².s)</th>
<th>Chemical Permeation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2-CEES</td>
</tr>
<tr>
<td>Carbon Bead Laminata</td>
<td>402</td>
<td>250:152</td>
<td>63</td>
<td>23</td>
</tr>
<tr>
<td>2 Layer Laminata-NS</td>
<td>338</td>
<td>250:88</td>
<td>60</td>
<td>6.6</td>
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<tr>
<td>3 Layer Laminata-NS</td>
<td>377</td>
<td>250:127</td>
<td>45</td>
<td>5.9</td>
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</tbody>
</table>

Evidence for Destructive Adsorption

<table>
<thead>
<tr>
<th>Sample</th>
<th>% Recovered 2-CEES</th>
<th>% Recovered DMMP</th>
<th>% Recovered HCN</th>
<th>% Recovered NH₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Bead Laminata</td>
<td>92</td>
<td>0</td>
<td>1</td>
<td>Absent</td>
</tr>
<tr>
<td>2 Layer Laminata-NS</td>
<td>1.4</td>
<td>18</td>
<td>3.2</td>
<td>Present</td>
</tr>
<tr>
<td>3 Layer Laminata-NS</td>
<td>1.3</td>
<td>15</td>
<td>3.3</td>
<td>Present</td>
</tr>
</tbody>
</table>

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 DOI and civilian products
- Refining to meet the demands of the 21st century

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