Highly Efficient Nonwoven CW Decontamination Wipe

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Why is it important to develop lightweight and breathable chemical protective substrates?

Types of Agents:
- Nerve Agents
- Blister/Vesicant Agents
- Blood Agents
- Pulmonary Agents

Mustard gas victim
[www.firstworldwar.com]

All that body Suffocation??

[www.breathingequipmenthire.fsnet.co.uk]

Seeking protective clothing:
Abo Saad checks out a chemical suit for sale in the house wares department of a Kuwaiti market.
Research program utilizes needlepunching technology to develop chemical warfare protective substrates

Important characteristics for chemical protective substrates include:
- Toxic chemical adsorption
- "Next-to-Skin" friendliness
- Breathability

Characteristics conflict with each other - Nonwoven technology could be the solution
Needlepunching technology has been used to develop a three-layered chemical protective substrates that could find applications such as:

1. Flexible chemical warfare decontamination wipe
2. Protective inner lines for chemical protective suit

A US patent application entitled, “Method of producing Chemical Composite Substrate,” is pending

H1 contoured needle zone needlepunching technology has been used to develop nonwoven chemical protective substrates
H1 Technology Needlepunching

• H1 technology is the latest development in needlepunching from Fehrer-AG, Austria

• The needle zone is contoured unlike flatbed conventional needlepunching

• Texas Tech University is the first and only academic facility in the US to house the modern needlepunching line
H1 Technology: Characteristics

- Oblique angle needle penetration due to contoured needle zone

- Longer needle path results in better fiber orientation and fiber entanglement

- Higher needling speeds – maximum possible is 1300 strokes/min
H1 – Needle Loom
Novel Nonwoven Decontamination Wipe

The three-layered nonwoven decontamination wipe consists of:

1. Pre-filter (Top) Layer, L1
2. Middle Adsorbent Layer, L2
3. Next-to-Skin (Bottom) Layer, L3

Three layered structure was needlepunched at high speed to form a composite.
The three layered protective composite fabric which can effectively serve as a decontamination wipe was manufactured using H1 technology needle loom.
Nonwoven Line – Texas Tech University

Hopper Feeder

Opening – fine beating and tuft reduction

Double Cylinder Card

Web forming – removal of tufts; parallel orientation

Cross Lapper

Web formation - high loft, layered webs

H1 Needle Loom

Web consolidation – Interlocking of fibers
H1 Needlepunching Line
H1 Contoured Needle Zone
Next-to-Skin Friendly Decontamination Wipe

- Pre-filter Layer
- Middle Adsorbent Layer
- Next-to-skin Layer
Highly Efficient Flexible Decontamination Wipe

Decon Wipe Drapes Around the Arm

Decon Wipe Cleans the Elbow

Decon Wipe Cleans the Intricate Part of an Automobile

Decon Wipe Drapes Around the Corner of a Table
Adsorbent Medium: Activated Carbon Fabrics

Advantages of activated carbon fabrics include:

**Excellent adsorption capacity**: Better than the conventional GAC

**Easy in handling**: Fibrous form of activated carbon is favored

**Pore volume**: Slight presence of mesopore volume and a uniform distribution of micro pores
SEM Images of the Decontamination Wipe

Activated Carbon Layer

Interface Region of Cotton and Activated Carbon Fibers

Cotton Nonwoven Substrate

Cotton Nonwoven Substrate

Interface Region of Activated Carbon and Cotton Fibers

Activated Carbon Layer
SEM Image of Individual Fibers in the Decontamination Wipe

Surface Image showing no Surface Damage to the Cotton Fibers due to Needlepunching
Novel Features and Superior Characteristics of Nonwoven Wipes

- The three-layered decontamination wipe will be flexible, drapable and soft
- The decontamination wipe will be “next-to-skin” friendly, which is extremely important for personnel/human body decontamination
- The decontamination wipe due to its flexibility will be able to follow the shapes and contours of intricate parts of human body and equipments
- The top and bottom layers of the decontamination wipe provides the necessary structural coherence and enhanced strength
- The nonwoven adsorption wipes will have improved adsorption characteristics due to needlepunching which will also increase the overall porosity of the wipe
- The active adsorbing sites of the middle activated carbon adsorbent layers are not masked by the top and bottom layers as the three layers are needlepunched together which basically will enhance the porosity and surface area
Novel Features and Superior Characteristics of Nonwoven Wipes

- The use of needlepunched top and bottom layers enhances the adsorption and filtration efficiencies due to the availability of pores and free fibers.
- This is an important difference between the currently available rigid wipes that use polymer films that mask the active adsorption sites of the middle activated carbon.
- The decontamination wipe has phenolic resin based activated carbon as the middle adsorbent layer that has superior properties such as flame retardancy than the cellulosic activated carbons.
- The three-layered decon wipe will have improved mechanical strength and abrasion resistance.
- The nonwoven technology is highly productive that enables the mass production of wipes at reduced production costs.
Results and Discussion

The three-layered needlepunched nonwoven composite has been shown offer necessary adsorption and filtration to toxic chemicals.

A novel protocol has been developed to quantify the adsorption of toxic chemicals by the nonwoven wipe.

A thermogravimetric analyzer has been successfully adopted to quantify the adsorption characteristics of nonwoven wipes.
Thermogravimetric Analyzer

Pyris 1 TGA Perkin Elmer

Schematic Representation of TGA Exp. Set up
TGA Experimental Method

- **Fabric sample (TGA pan)**
  - Exposed to the resultant gas stream
  - Total flow rate 20cc/min + 45cc/min

- **Sample Exposed for 600 to 1000 min**
  - to confirm the saturation phenomenon

Change in mass of the fabric sample was recorded using “Pyris manager” data collection software until an equilibrium was reached.
Adsorption Curve for Nonwoven Wipe

Delta Y = 0.364

Weight gain at 300 min = 16.70%

300 min
2.509 mg

Final Weight = 2.514 mg
Saturation time Delta X = 497 min

X1 = 0.000 min
Y1 = 2.150 mg

Y2 = 2.343 mg
X2 = 100,000 min

Slope = 1.934e-003 mg/min
Inverse Slope = 517.155 min/mg
Four different adsorption parameters have been used to objectively quantify the decontamination efficiency of the wipe.

1. Rate of Adsorption
2. Saturation Time
3. % Weight Gain at 300 min
4. Adsorption Capacity
Details of Nonwoven Composites

Type I  Composite 5092-25 (basket weave)
Type II  Composite 507-25 (plain weave)
Type III Composite 507-15 (plain weave)
Type IV  ACF  5092-25
Type V  ACF  507-25
Adsorption Rate for Initial 100 Minutes

Adsorption Rate @ 100 min - Data for all runs for fabric Type I, Type II & Type III, Type IV & Type V

Number of Runs

Adsorption Rate (mg/min)

Type I
Type II
Type III
Type IV
Type V
**Significant Results**

*Rate of adsorption: All composite wipes performed more or less similar*

*Saturation Time: No difference among different composites (Type I – Type III)*

*Percentage Weight Gain: No difference among different composites (Type I – Type III)*
Toxic Clean-Up

A TIEHH research team has developed a nonwoven composite toxic chemical decontamination wipe using Fehner's HI needleloom technology.

Researchers at The Institute for Environmental and Human Health at Texas Tech University (TIEHH), Lubbock, Texas, have developed a flexible, drapable nonwoven composite substrate for a decontamination wipe that is effective in neutralizing toxic chemicals used in chemical warfare and pesticides. Seshadri Ramkumar, Ph.D., who heads up the research project, said a patent has been applied for in connection with this application. The research is supported by a grant from the US Army Research, Development and Engineering Command, Aberdeen Proving Ground, Md. Their composite was developed using Austria-based Fehner AG's HI needleloom technology. The HI system uses an oblique, asymmetrically curved needle loom and straight movement of the barbed needles, causing them to penetrate through the fiber mat at an angle, pushing from opposite sides to interlock the fibers in a criss-cross pattern. Ramkumar said the process requires fewer needle penetrations than traditional needleling processes and provides superior web properties, and the technology enhances the construction of composite and hybrid products. He also said the process is very practical and cost effective. "Needlepunch productivity is higher than weaving, plus intermediate processes such as spinning are eliminated, which lowers production costs," he explained.

The composite substrate developed for the wipes comprises a needlepunched profiler layer, an adsorption layer and a needlepunched base layer. The three layers are needlepunched together in a final interlocking. "The resulting fabric needs no other means of bonding, which would make it stiff. That is the beauty of needlepunching," Ramkumar said, noting that the fabric's drapability allows it to follow body contours and get into crevices of objects that must be decontaminated. He also said the fabric could become the inner layer of a protective suit.

The profiler and base layers contain a "skin-friendly" fiber such as cotton or polyester. Ramkumar said, "In the middle layer, I have used a special activated fiber, which gives adsorption and also is flame-resistant," he continued. "We have proved that the top and bottom layers do not affect the adsorption/adsorption characteristics of the middle layer. My Ph.D. student Utkarsh War Fata has worked under my supervision and proved this statistically." Ramkumar is using the HI technology to develop a variety of other fabrics as well. He is receiving support from the National Cotton Council, Cotton Incorporated and the Texas Food and Fibers Commission for the development of lightweight and ultra-lightweight cotton and natural fiber nonwovens for value-added products.
General Conclusions

- Three-layered composite can serve as an effective adsorbent wipe against toxic chemicals.
- Thermo-gravimetric analyzer is a good analytical tool for quantifying the adsorption characteristics.
- The needlepunching nonwoven technology is a viable method for developing flexible decontamination wipes.
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Quality Fabric Of The Month

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