Nonwoven Dry Wipe for Emergency, Industrial and Defense Applications

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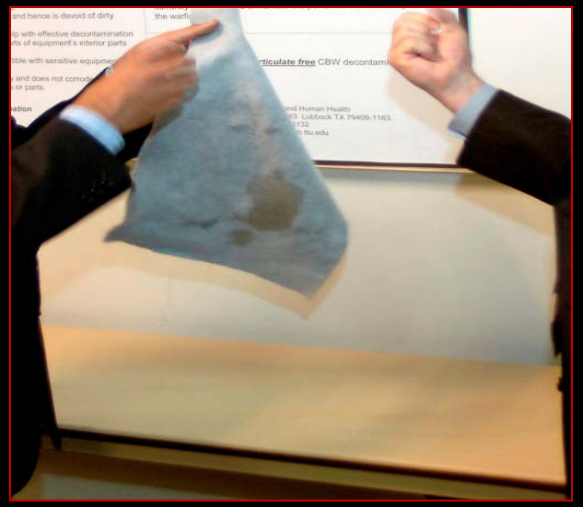
Fibrous Materials to Protect Human Life and Environment

Nonwoven Fabric Structures

a) Personal decontamination wipe for removing chemical warfare agents and toxic chemicals.



b) Breathable protective *inner liners* for chemical protective suit (work in progress).

Need for Hazard Mitigation

Attacks on civilians and civilian infrastructure with chemicals, such as the attack by Aum Shinrikyo in Japan with the military nerve gas illustrate the need for decontamination systems for both civil and military defense.

Ramkumar et al. 2008, Next Generation Non-particulate Dry Nonwoven Wipe for Chemical Warfare Agent Decontamination., *Ind. Eng. Chem. Res.,* 47, (24) 6885-6895.

Tu, A. T. 2007, Toxicological and Chemical Aspects of Sarin Terrorism in Japan in 1994 and 1945, *Toxin Rev.,* 26 (3), 231.

Personal Decon

Many of the world's military organizations have fielded a reactive liquid decontamination solution (RSDL) which contains some water.

Source: www.rkb.us

Ramkumar et al. 2008, Next Generation Non-particulate Dry Nonwoven Wipe for Chemical Warfare Agent Decontamination, *Ind. Eng. Chem. Res.,* 47, (24) 6885-6895.

Lukey, et al. 2004, Six Current or Potential Skin Decontaminants for Chemical Warfare Agent Exposure - A Literature Review. In *Pharmacologial Perspectives of Toxic Chem. and their Antidotes*, ed. S. J. S. Flora, J. A. Romano, S. I. Baskin and K. Sekhar, Narosa Publishing House, New Delhi, India, 13.

Particulate Technology

The M291 skin decontamination system is a particulate technology and consists of carbonaceous reactive powder in a nonwoven fabric matrix. The particulate decontamination material is a combination of adsorbent carbon, polystyrene polymer, and an ion-exchange resin.

Ref: Ramkumar et al. 2008, "Next Generation Non-particulate Dry Nonwoven Wipe for Chemical Warfare Agent Decontamination". Ind. Eng. Chem. Res., 47, (24) pp. 6885-6895.

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Particulate Problems

The particulate (loose particle) nature of the M291 kit's powder poses potential secondary exposure health risks by creating inhalable particles and leaving particulate residues that can potentially result in secondary contamination.

The powder can serve as an irritant to eyes, mouth or open wounds.

Ramkumar et al. 2008, Next Generation Non-particulate Dry Nonwoven Wipe for Chemical Warfare Agent Decontamination, *Ind. Eng. Chem. Res.,* 47, (24) 6885-6895.

Lukey, et al. 2004, Six Current or Potential Skin Decontaminants for Chemical Warfare Agent Exposure - A Literature Review. In *Pharmacologial Perspectives of Toxic Chem. and their Antidotes*, ed. S. J. S. Flora, J. A. Romano, S. I. Baskin and K. Sekhar, Narosa Publishing House, New Delhi, India, 13.

1st Generation LLNL Decon

Another two-part personal decontamination system first removes the bulk of chemicals from the skin by blotting with the dry sorbent pad.

It then removes residual chemicals by scrubbing with a liquid applicator (an open-cell polyethylene foam sponge) soaked with RSDL.

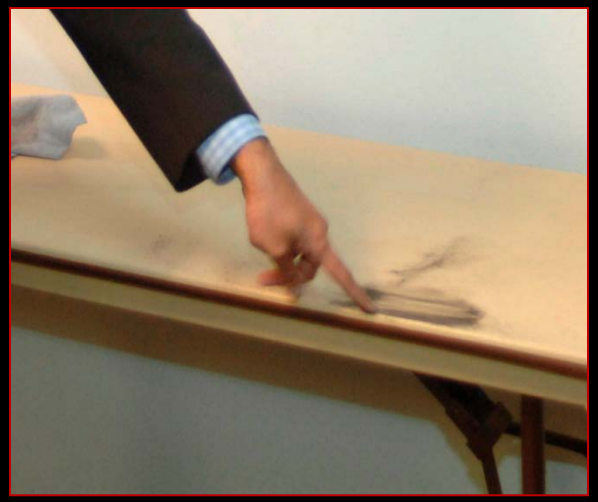
Ramkumar et al. 2008, Next Generation Non-particulate Dry Nonwoven Wipe for Chemical Warfare Agent Decontamination, *Ind. Eng. Chem. Res.,* 47, (24) pp. 6885-6895.

Smith et al. 2005, Evaluating the Efficacy of Low-Cost Personal Decontamination System (LPDS) Formulations for Sulfur Mustard and Assorted TICs. In *Proceedings of DECON 2005,* Joint Program Manager for Decontamination, Tucson, AZ, USA.

Decontamination
Need and National Priority

Development of:

Non-particulate, Non-corrosive and Environmentally Safe Decontaminating System for military personnel & equipment is an international priority research endeavor.



Wiping a surface using the M291 Kit.

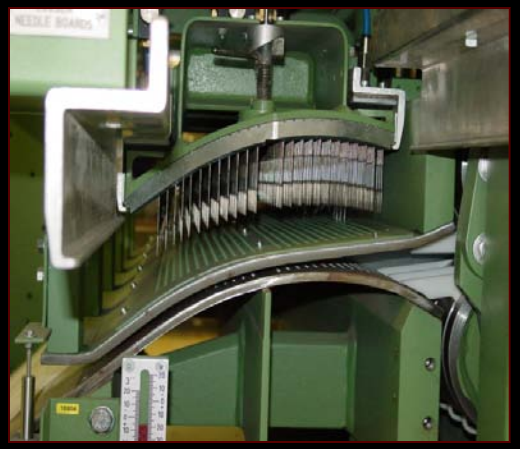
R&D in Sorbents, Catalysis, Membranes etc. is part of the Modernization Strategy of the CBD Program of US Department of Defense.*

* (Annual Reports from the US Department of Defense to the US Congress ’04 ’05 ’06 ‘07).

Objectives

1) DEVELOPMENT:

To develop fiber based Nonparticulate, Noncorrosive & Nontoxic chemical protective substrates for individual protection that could find following applications such as:



Next Generation Personal Decontamination Wipes.

2) EVALUATION:

To Quantify and compare the adsorption capabilities of the nonwoven composite sorbent fabric.

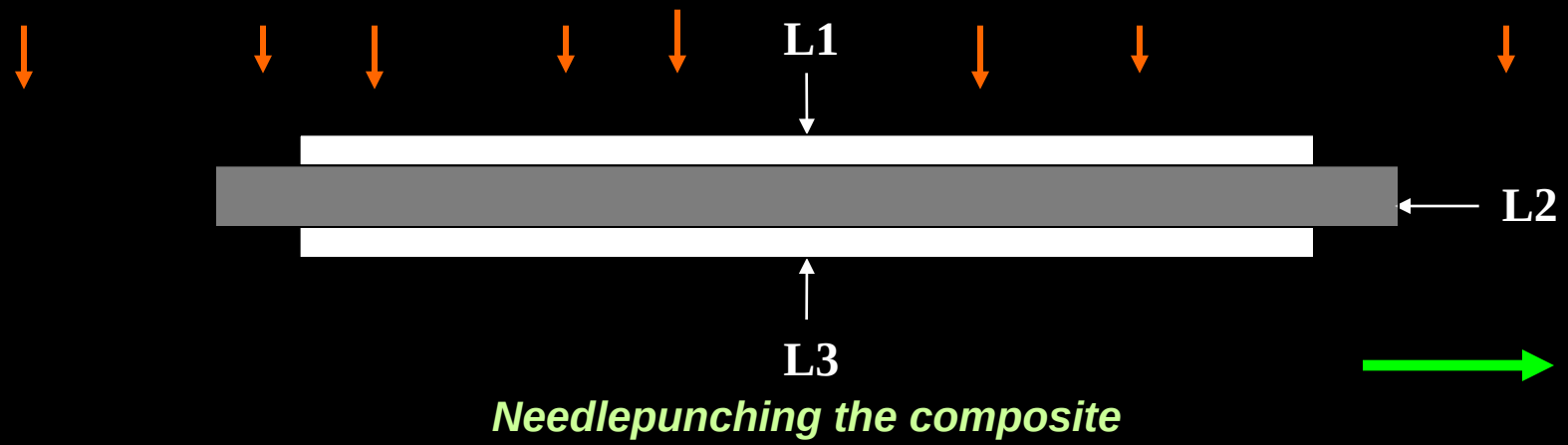
TTU Decon Wipe

Fibertect

Process for Making Chemical Protective Wipes and Such Wipes,US Patent #7516525

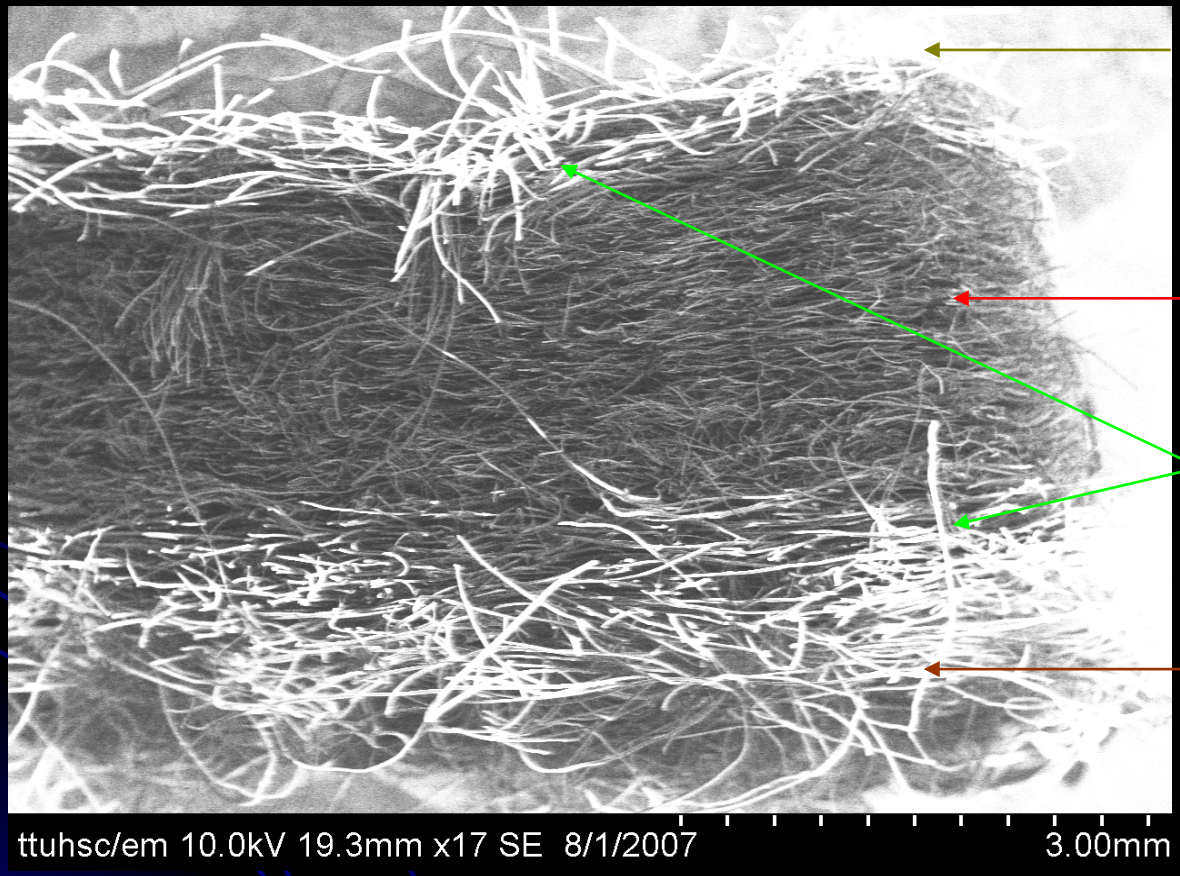
Three Layered Decontamination Wipe

L1 Pre-filter layer L2 Middle adsorbent layer L3 Next-to-skin layer



- L1 and L3 layers are cotton-based substrates which are hydrophilic in nature, and help with absorption of CW agents & simulants in liquid form.
- Many CW agents and their simulants can be volatile. It is important to adsorb the agents in vapor phase.
- The core adsorbent layer is entirely microporous & helps with vapor adsorption.

Cross-section of Absorbent-Adsorbent Nonwoven Composite Wipe



Top Needlepunched Fabric

Activated Carbon Nonwoven Fabric

Interlocking is only at the Interface

Bottom Needlepunched Fabric

(Interlocking takes place only at the interface)

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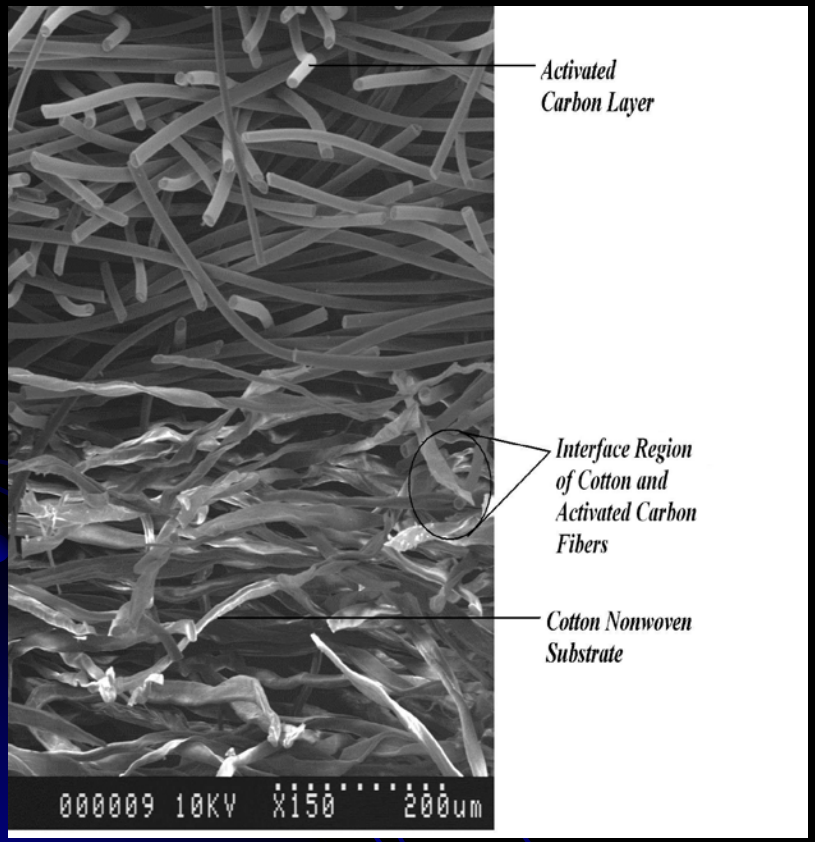
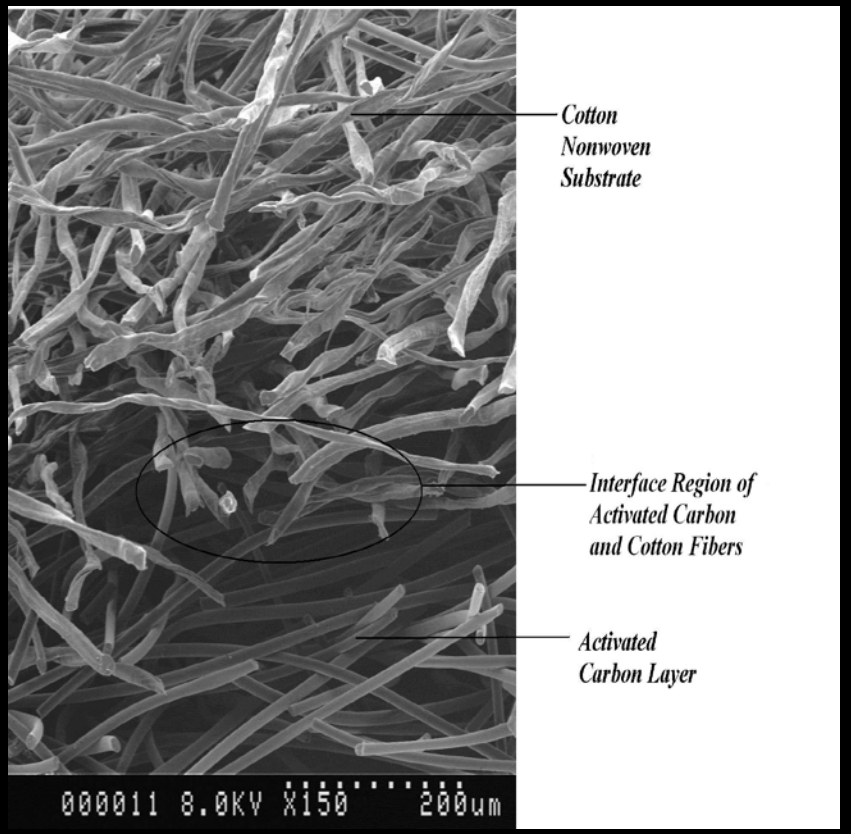
SEM Images of the Interlocking at the Interface





Next-to-Skin Friendly Decontamination Wipe

Three Layered Nonwoven Wipe

Patent - S. S. Ramkumar, “Process for Making Chemical Protective Wipes and Such Wipes,” US Patent 7,516, 525, April 14, 2009

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

Novel Features & Superior Characteristics of Nonwoven Decon Wipes

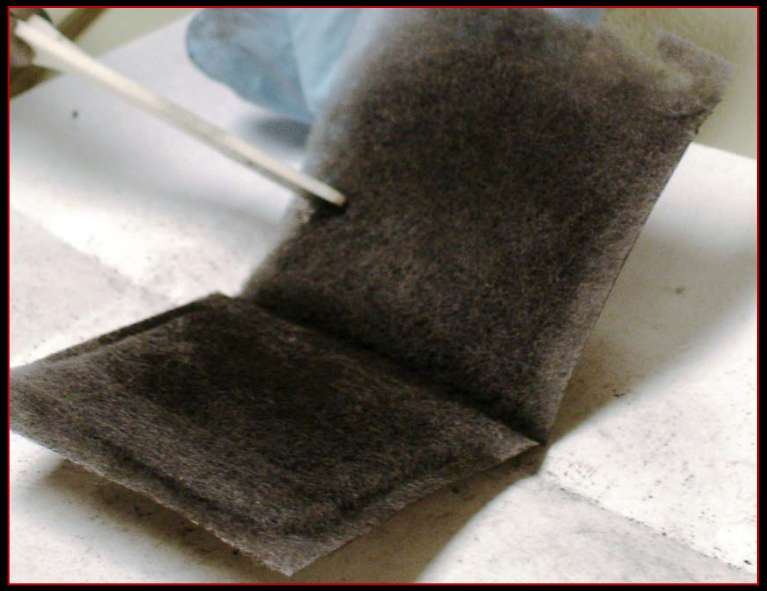
The important difference between the currently available rigid wipes and the nonwoven wipe is that the polymer films in rigid wipes mask the active adsorption sites of the middle activated carbon. This is NOT the case in flexible nonwoven wipe.

The three-layered structure allows to add functionality to the wipe such as topical antibacterial treatment, etc.

M 291 Skin Decon Kit

Currently fielded skin decontamination kit.

M 291 consists of a decontamination powder (Ambergard XE-555 resin) in an applicator pad.



The dry powder is a carbonaceous adsorbent, a polystyrene polymer and an ion-exchange resin.

Leaves a black powder on skin-this is a NEGATIVE aspect for DoD personnel use.
Forms a dust cloud (particles in eye/inhaled).

Experimental Study

Real Agent Sulfur Mustard (HD) Study

Ramkumar et. al. 2008. Next Generation Non-particulate Dry Nonwoven Wipe for Chemical Warfare Agent Decontamination *Ind. & Eng. Chem, Res. 47 , No 24 pp. 9889-9895*

Retention of Sulfur Mustard (HD) Adsorbed by Nonwoven Decontamination Wipe

Ramkumar et. al. 2008. Next Generation Non-particulate Dry Nonwoven Wipe for Chemical Warfare Agent Decontamination *Ind. & Eng. Chem, Res. 47 , No 24 pp. 9889-9895*

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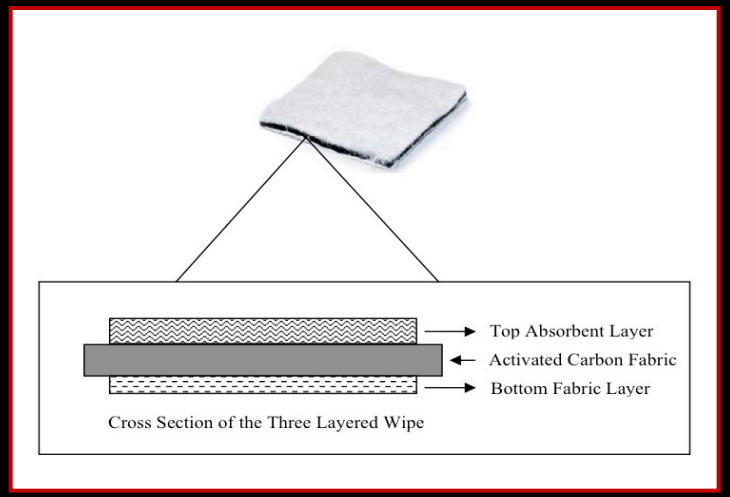


Details of Materials Used

Physical Properties	Type		
	Viscose Nonwoven Fabric	Polyester Nonwoven Fabric	Nonwoven Activated Carbon
Weight (g/m^2)	100	80	140
Fiber Denier	3	6	-
Fiber Staple Length (mm)	50.8	50.8	-
BET Surface Area (m^2/g)	-	-	1071*

*Surface area data for nonwoven activated carbon were obtained from Professional Analytical and Consulting Services.[22]
Viscose and polyester fiber details were provided by each manufacturer.

Figure & Table: Ramkumar et. al. 2008. *Ind. & Eng. Chem, Res. 47 , No 24 pp. 9889-9895*

Retention of Sulfur Mustard (HD) Adsorbed by Nonwoven Decontamination Wipe

GC/MS Peak Area for m/z 109 of Sulfur Mustard (HD)*

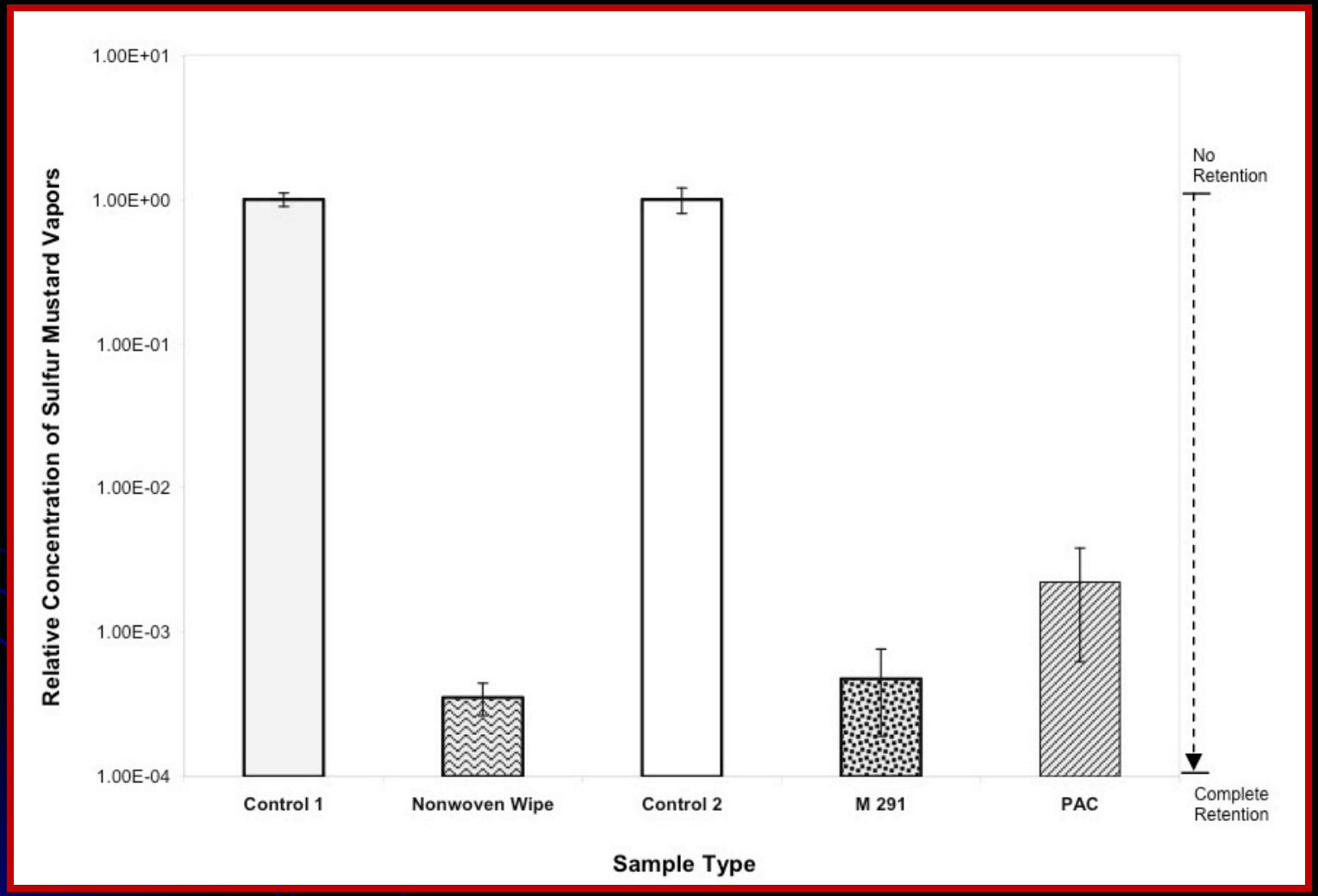
		Average Normalized Peak Area using Respective Mean Controls[a]	
Decon Type	Average Peak Area	Control 1	Control 2
Control 1	3.50E+07 (3.76E+06)	1.00E+00 (1.07E-01)	--
Nonwoven Wipe	1.24E+04 (3.12E+03)	3.55E-04 (8.92E-05)	--
Control 2	3.77E+07 (7.50E+06)	--	1.00E+00 (1.99E-01)
M 291	1.80E+04 (1.08E+04)	--	4.78E-04 (2.87E-04)
PAC	8.40E+04 (6.05E+04)	--	2.23E-03 (1.60E-03)

*Values within parenthesis indicate standard deviation which correspond to 3 repeats.

[a] Individual GC/MS peak areas associated with the vapor concentration of HD in the headspace of the vials containing decontaminant samples are normalized by their respective control peak area values which represent the v apor concentration of the agent in the headspace of the vials containing the CW agent HD and no decontamination sample.

Ramkumar et. al. 2008. *Ind. & Eng. Chem, Res. 47 , No 24 pp. 9889-9895*

Retention of Sulfur Mustard (HD) Adsorbed by Nonwoven Decontamination Wipe



Ramkumar et. al. 2008. *Ind. & Eng. Chem, Res. 47 , No 24 pp. 9889-9895*

Recommended as Next Generation Low-cost Personal Decontamination System

(LLNL Science & Technology Review, March 9, 2009)

<u>Two Components</u>

1) RSDL Lotion

2) Dry Wipe (Absorbent & Adsorbent)

Texas Tech's Fibertect Can Help Clean Up Gulf Coast Oil

Adsorption Studies Using TGA

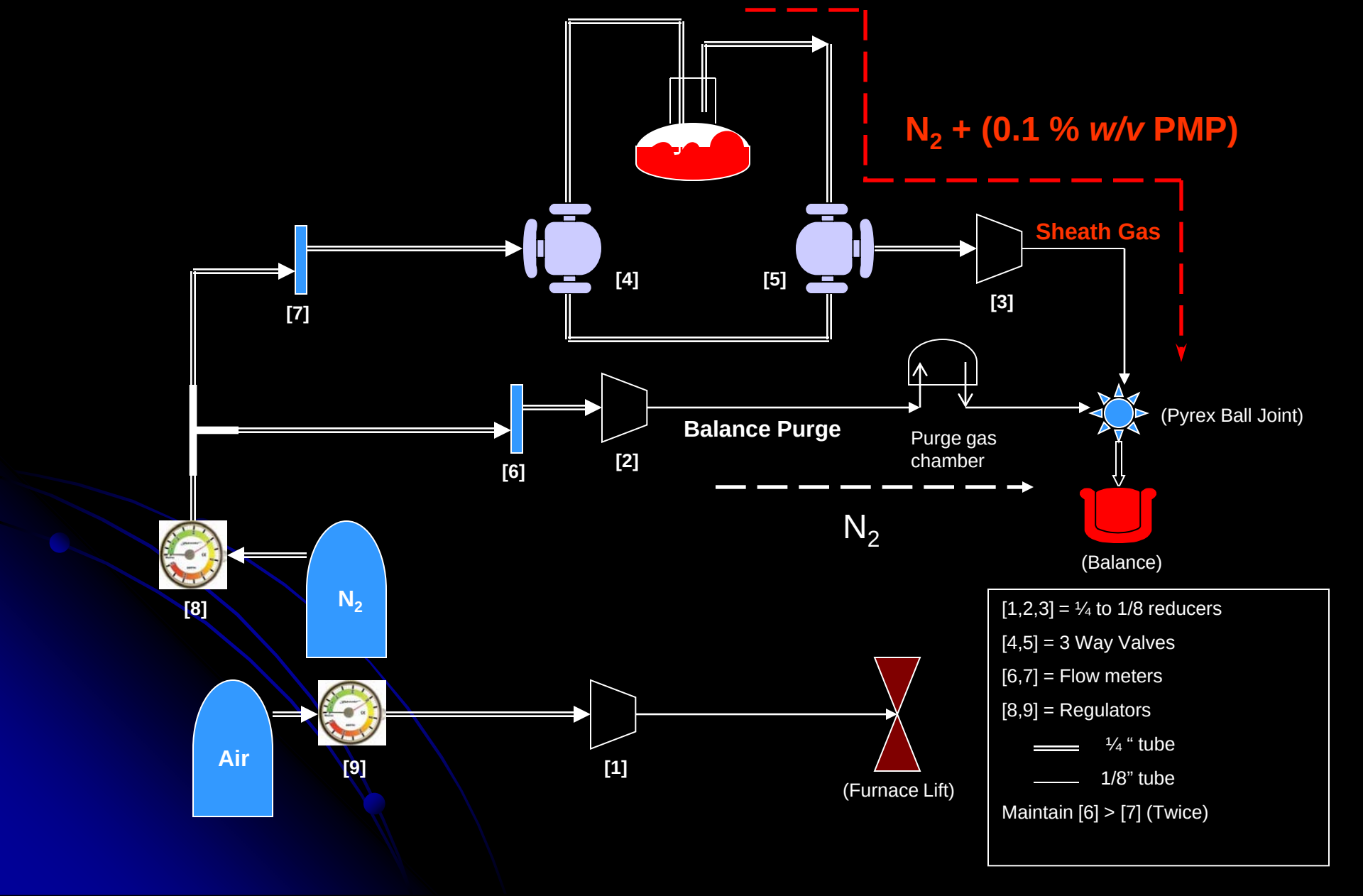
The adsorption of chemicals was characterized by gravimetric method using a thermo-gravimetric analyzer (Pyris 1 TGA Perkin Elmer) with a data collection software (Pyris Manager®).

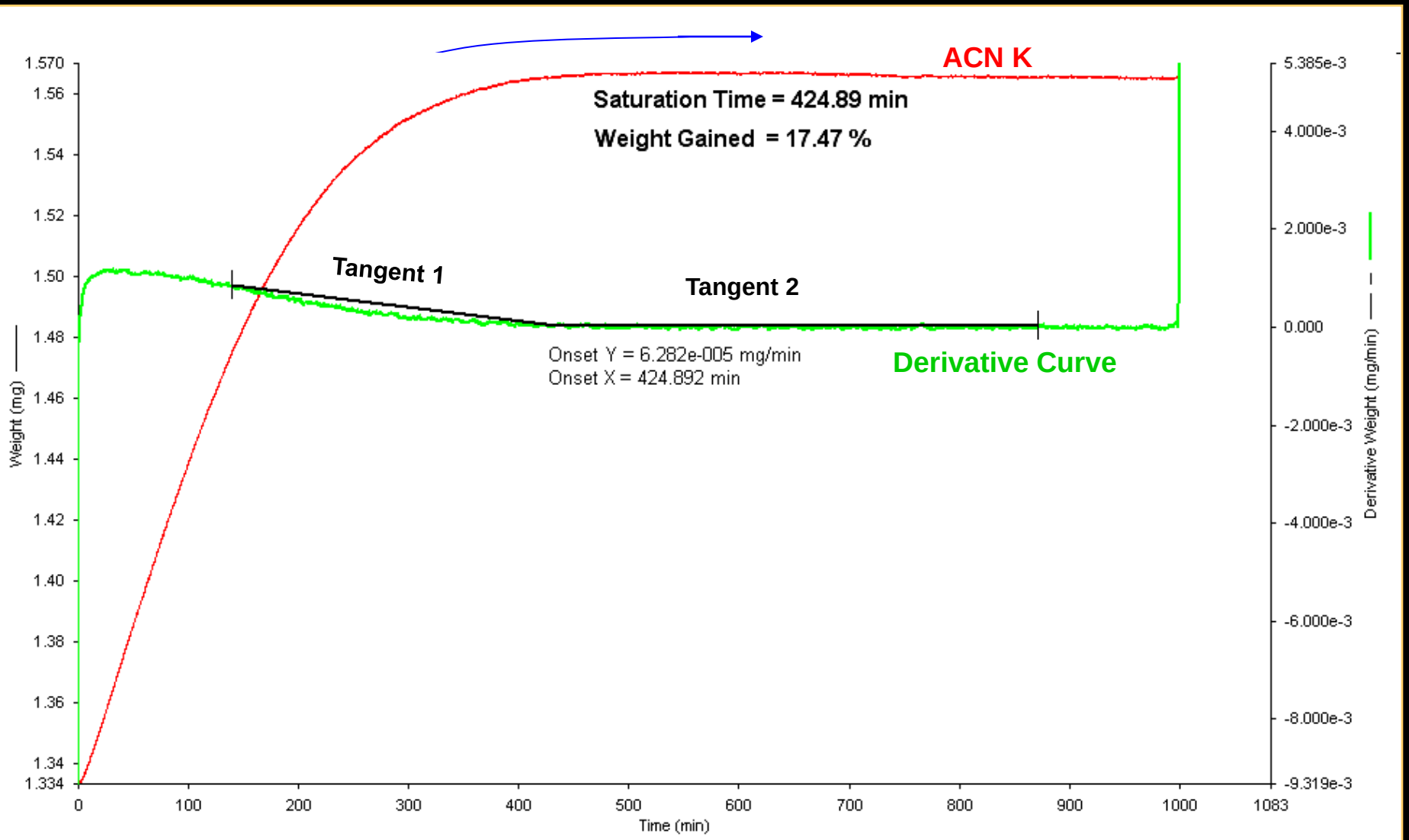
Challenger/Test Chemical

Pinacolyl Methylphosphonate (PMP)
(0.1 % w/v in butanol)

Simulant for SOMAN
Chemical Class: Organophosphorous agent
Mol Weight : 180.18
Specific Gravity : 1.032 g/mL @ 20ºC

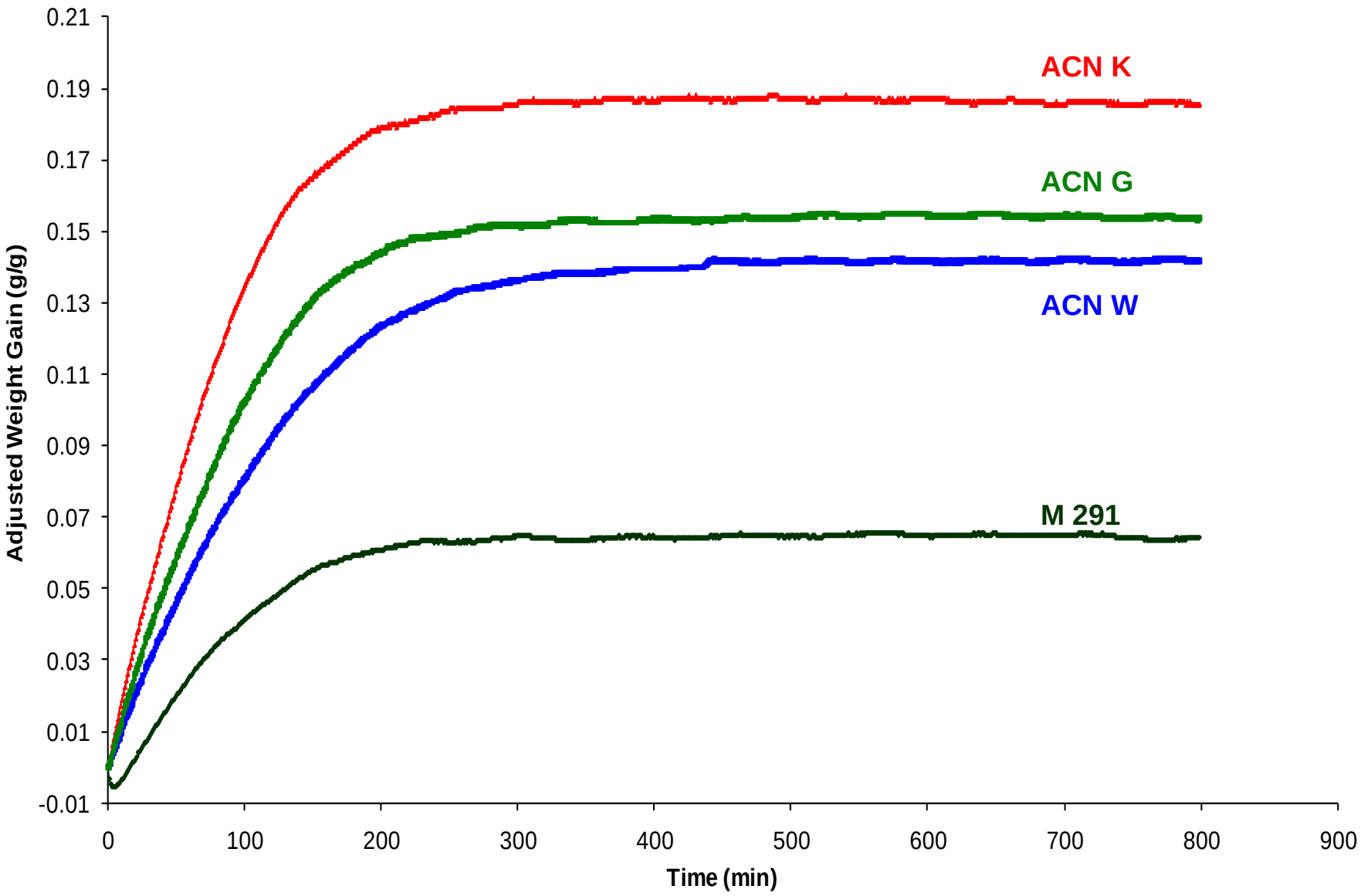
Schematic Representation of TGA Experimental Set up



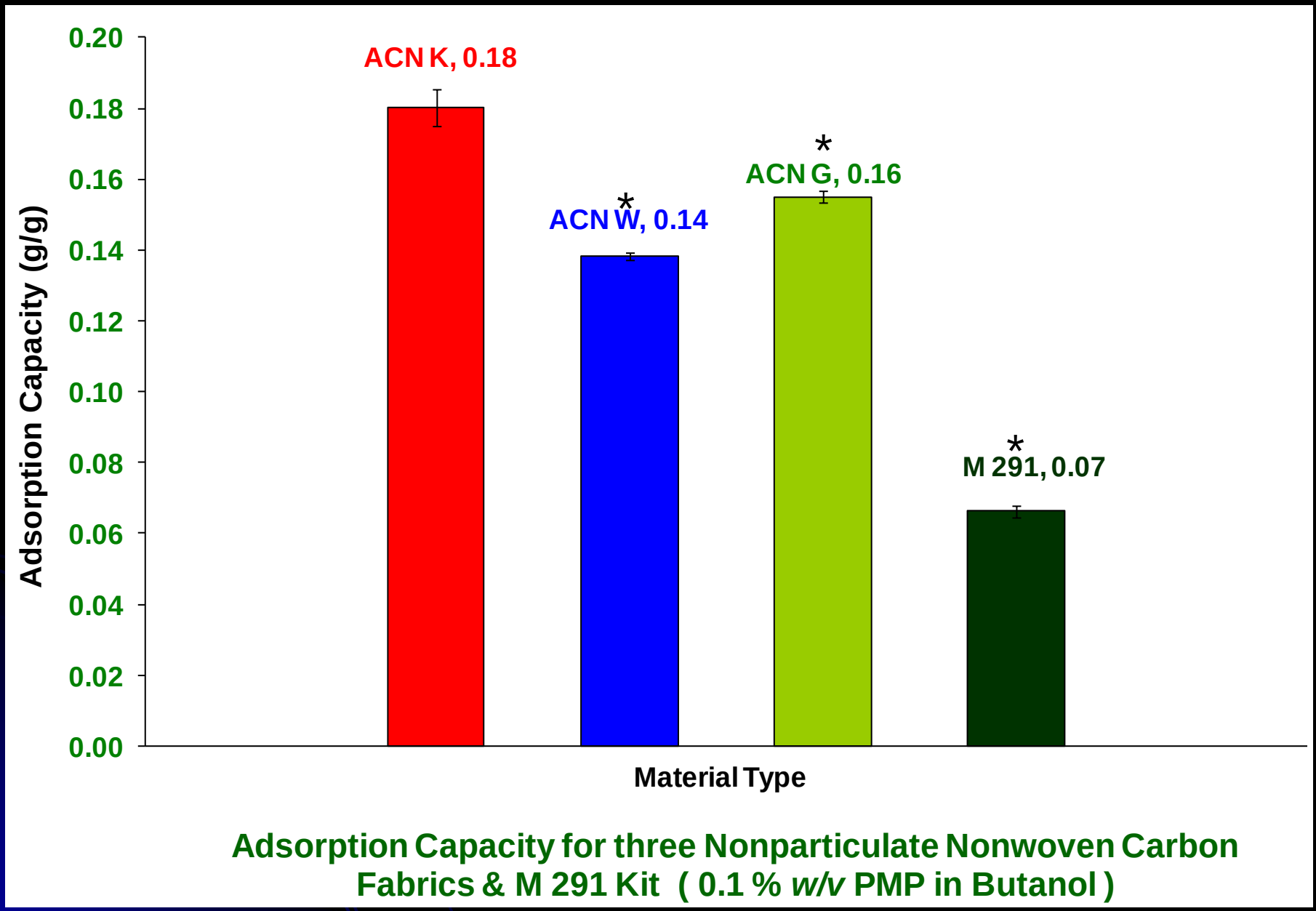


Nonwoven Sorbent Wipe Adsorption Curve

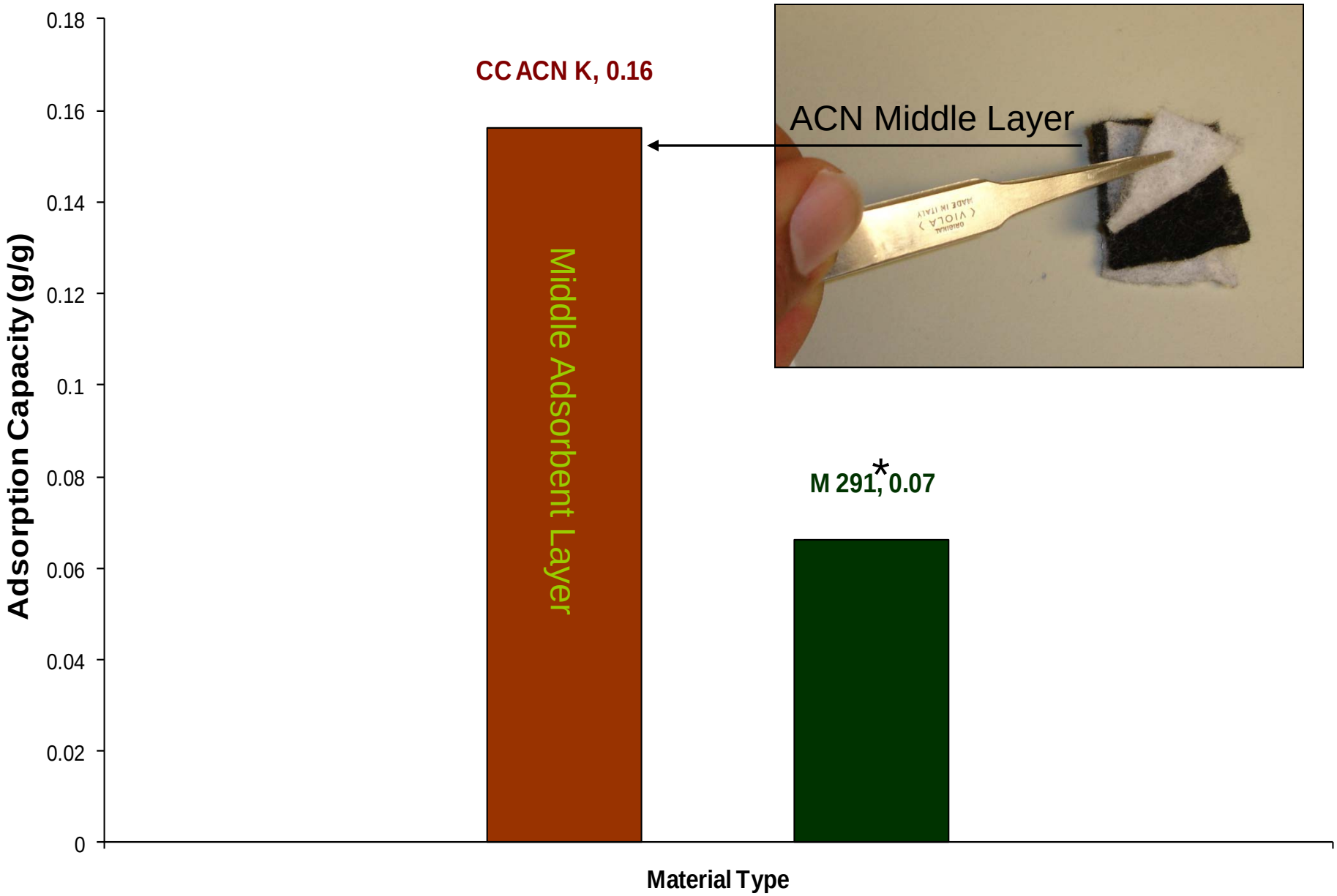
Weight Gain of ACN K for 0.1 % w/v Paraoxon in Butanol



ADSORPTION CURVES FOR NONPARTICULATE NONWOVEN ACTIVATED CARBON FABRICS & M 291 Kit Powder (Chemical = PMP - 0.1 % *w/v*)



Adsorption Capacity for three Nonparticulate Nonwoven Carbon Fabrics & M 291 Kit (0.1 % *w/v* PMP in Butanol)



Adsorption Capacity for M 291 & Activated Carbon (ACN K) in three-layered Cotton Composite

Conclusions

- The adsorption capacity of nonwoven nonparticulate activated carbon fabrics as well as the adsorbent layer of the three-layered skin friendly composite were higher than that of the currently used M 291 kit.

- Three-layered composite can serve as an effective adsorbent wipe against CW agents such as Sulfur Mustard (HD). The pad has affinity for, and capacity to adsorb and retain chemical vapor. These characteristics are important improvements over the existing technology for the military, the M291 kit.

Conclusions (Contd.)

- The multi-layered nonwoven material is devoid of loose particles and hence will be very effective to decontaminate open wounds and sensitive parts of military equipment.

- The cotton-based particulate material can also serve as inner layer for a chemical and biological protective suit.

- Thermo-gravimetric analyzer functions as a high precision balance in addition to providing isothermal conditions and controlled flow rates of gases.

Research Output

- Technology Transfer
- A novel non-particulate dry sorbent nonwoven wipe has been developed for decontamination of personnel and sensitive equipment.
- This technology has been licensed to Hobbs Bonded Fabrics of Waco, Texas.
- TTU's wipe technology has been recommended for the next generation low cost personnel decontamination system.

Acknowledgements

- **The work has been currently and continuously funded by the US Army Research, Development and Engineering Command, The CH Foundation, Lubbock, USA, The Cotton Foundation, Food and Fiber Grant Program of Texas and The International Cotton Research Center-TTU. Support for the preliminary part of the cotton composite study came from Cotton Incorporated. Additional support for the nonwoven laboratory comes from the NSIIC-USDA and the South Plains Foundation, Lubbock.**

- **Zumwalt Program at TIEHH for the continued support.**

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