Reactive Materials Research for Self-Detoxifying CB Protective Clothing

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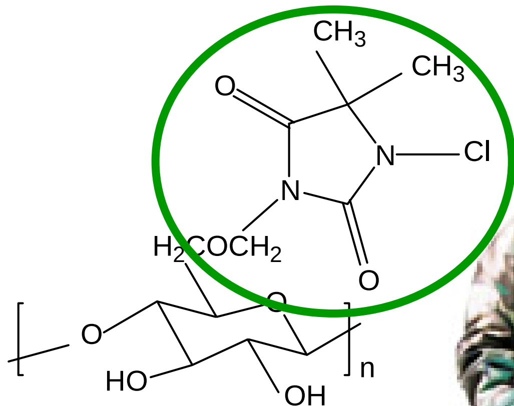
Concept

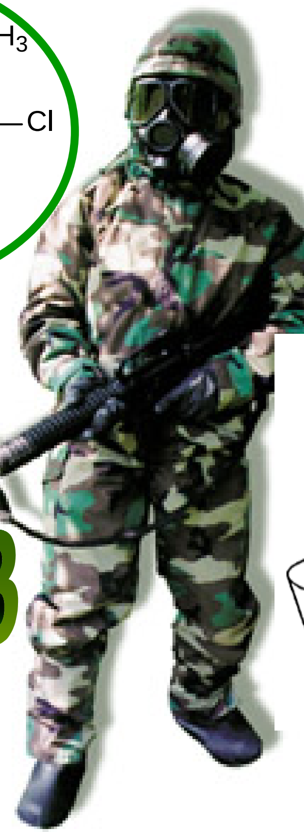
Place reactive materials in fabrics that detoxify Contaminants on clothing within hours of exposure.

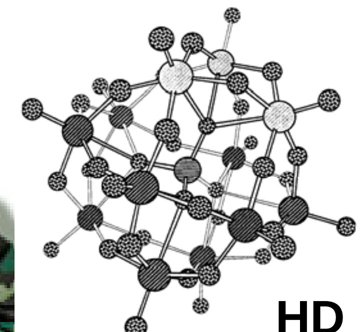


CHLORAMINE

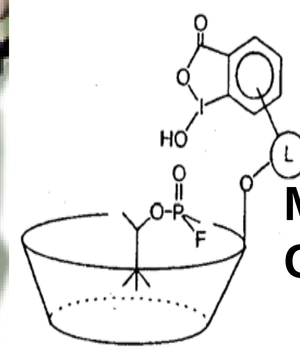
Bactericide, Agent Decon

Nano Al2O3



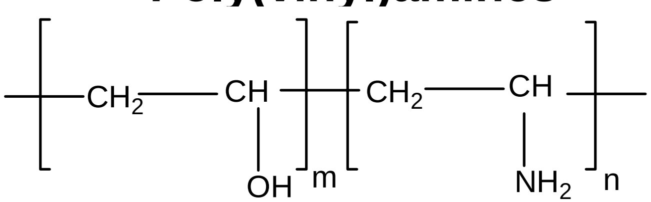


HD Catalyst



Modified Cyclodextrins

Poly(vinyl)amines



Approach

Chloramides & Quats -Shell Fabric

Bio, HD, VX

Sporicide and Agent Decon, Water Repellancy

POM Catalysts – Liner Materials

HD Carbon Surfaces

Polymer Film Surfaces

Nanoparticles – Attached to Fabrics,

HD, VX Blended into Fibers

Particulate Absorbants

Reactive Permselective Membranes - Liners

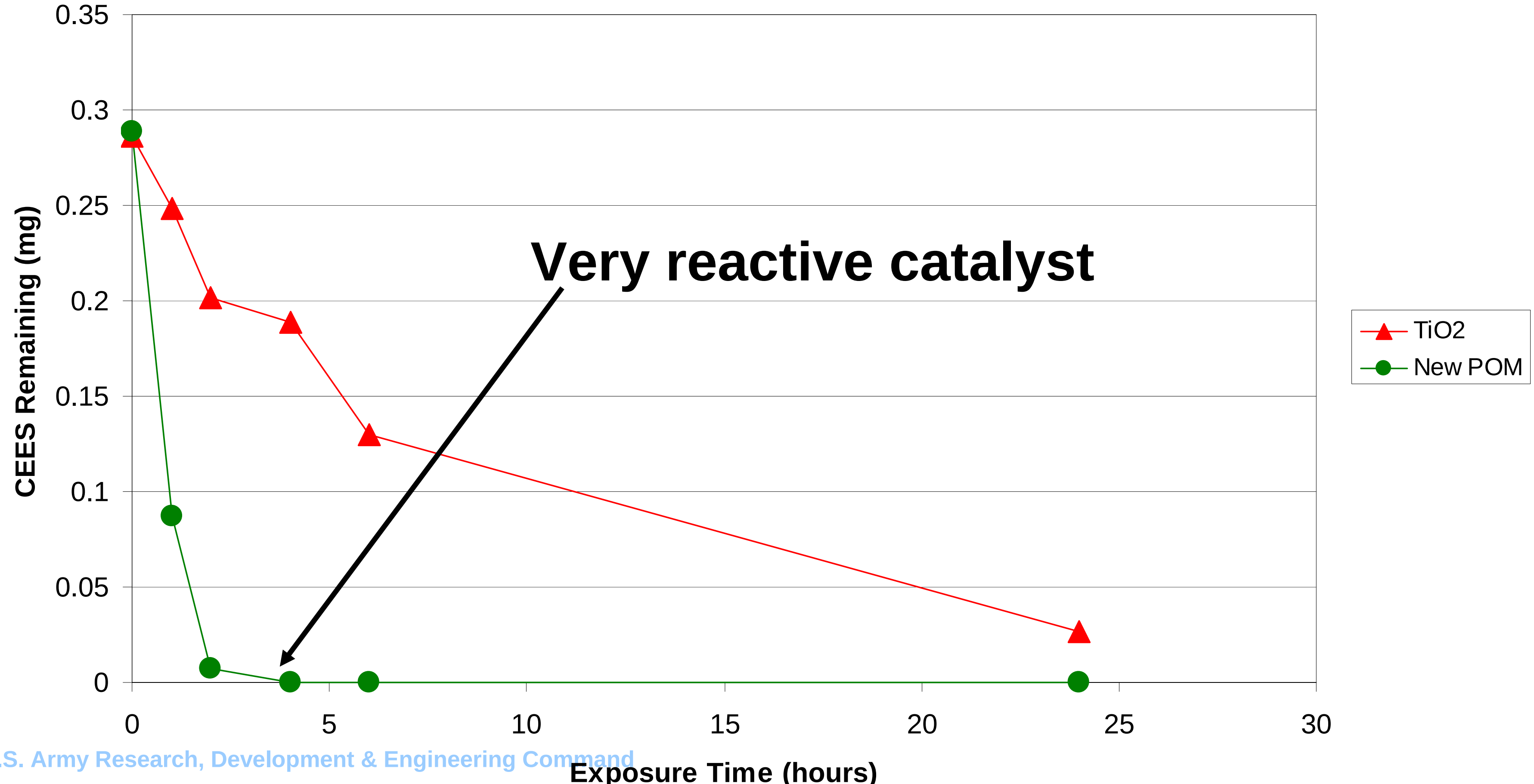
G, VX

Nanoparticle Reaction Rate Studies

Depletion of 2-CEES
- In Solution
- In Vapor

Solution Depletion of 2-CEES

Nanoparticle TiO_2 vs POM Catalyst

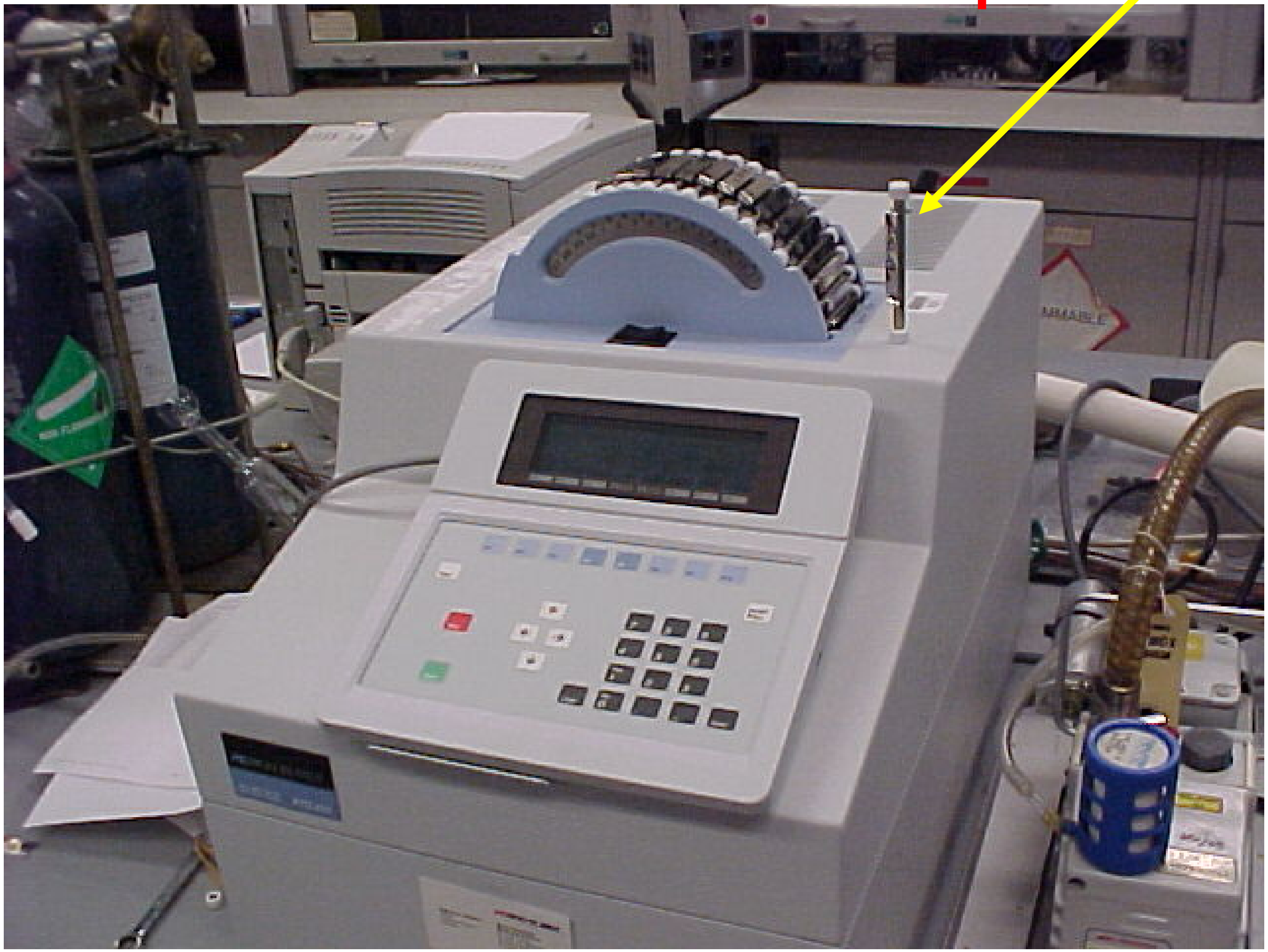


Equilibrium Vapor Adsorption Measurements

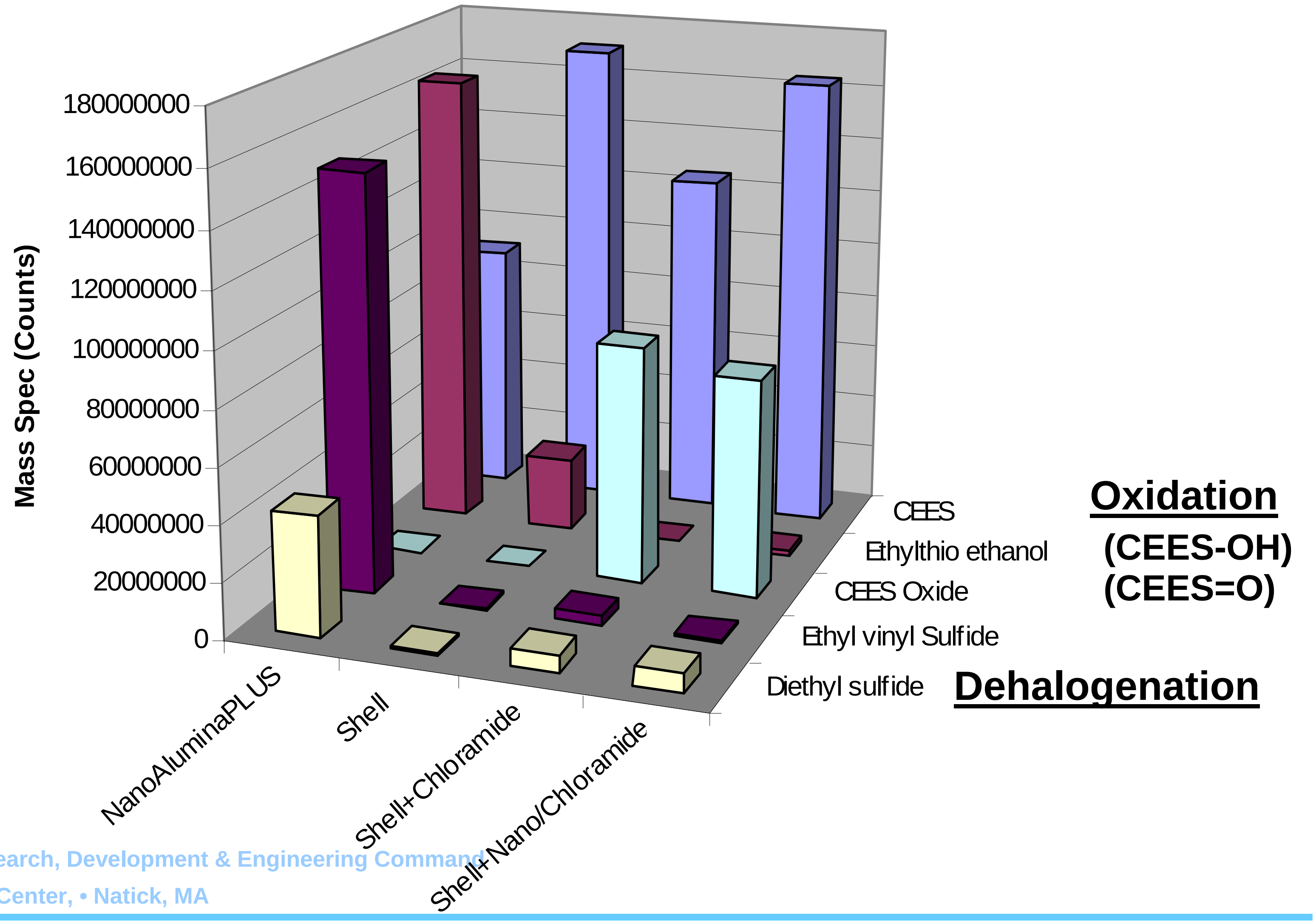
ADSORBANT	% CEES Vapor Uptake
Carbon Spheres	56
NanoAl_2O_3 - PLUS	99
NanoAl_2O_3	10
NanoTiO_2	17

Thermal Desorption GC/MS

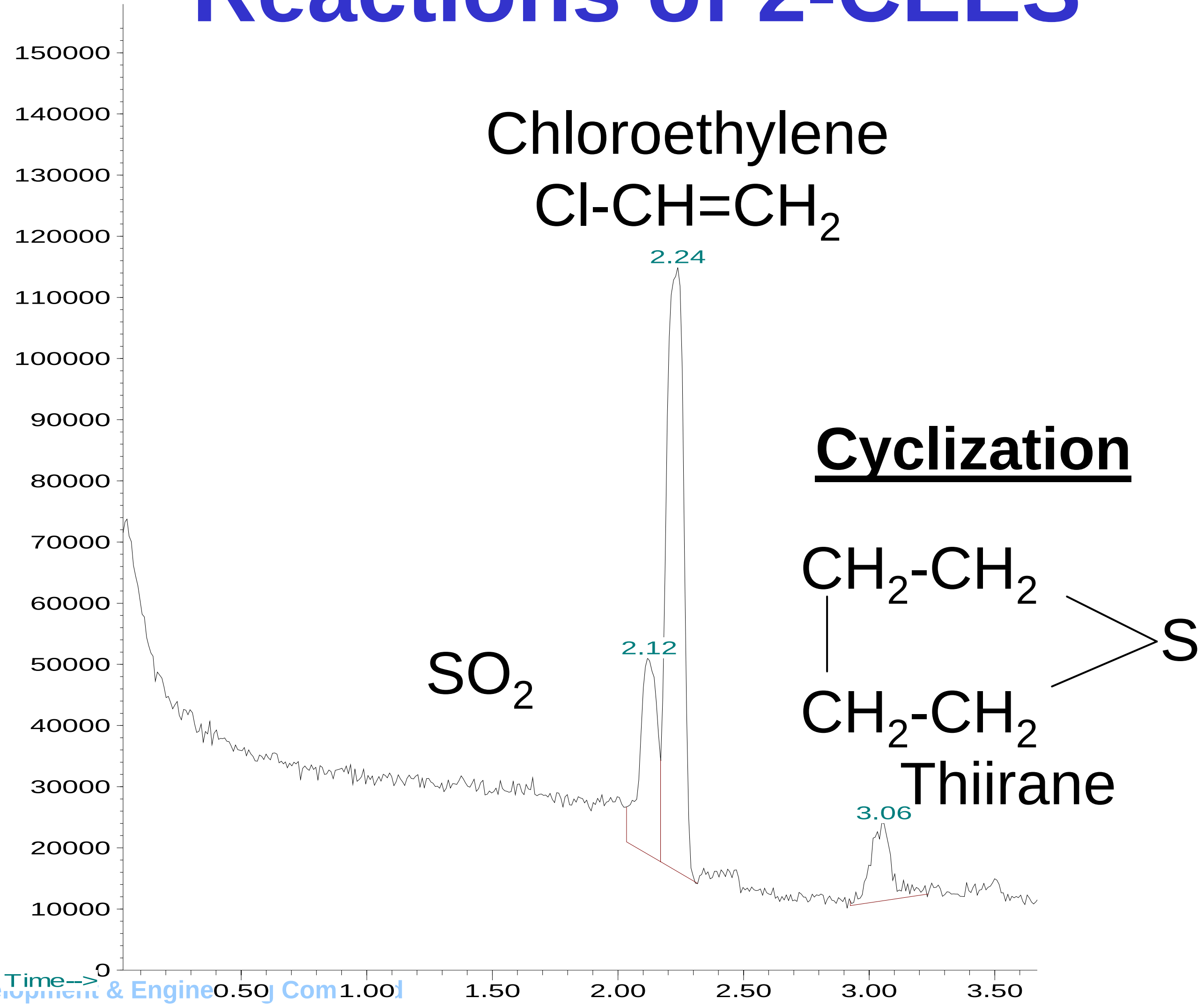
Sample in Tube



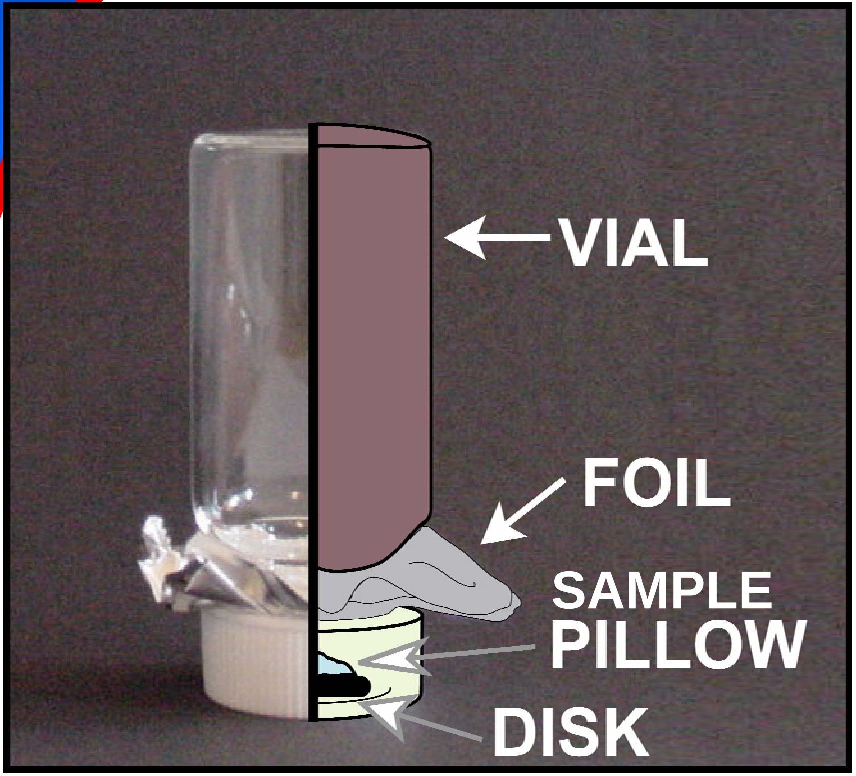
Depletion of CEES
Formation of Products



Some Products from Oxidation Reactions of 2-CEES



NMR (HRMAS)
Sample preparation

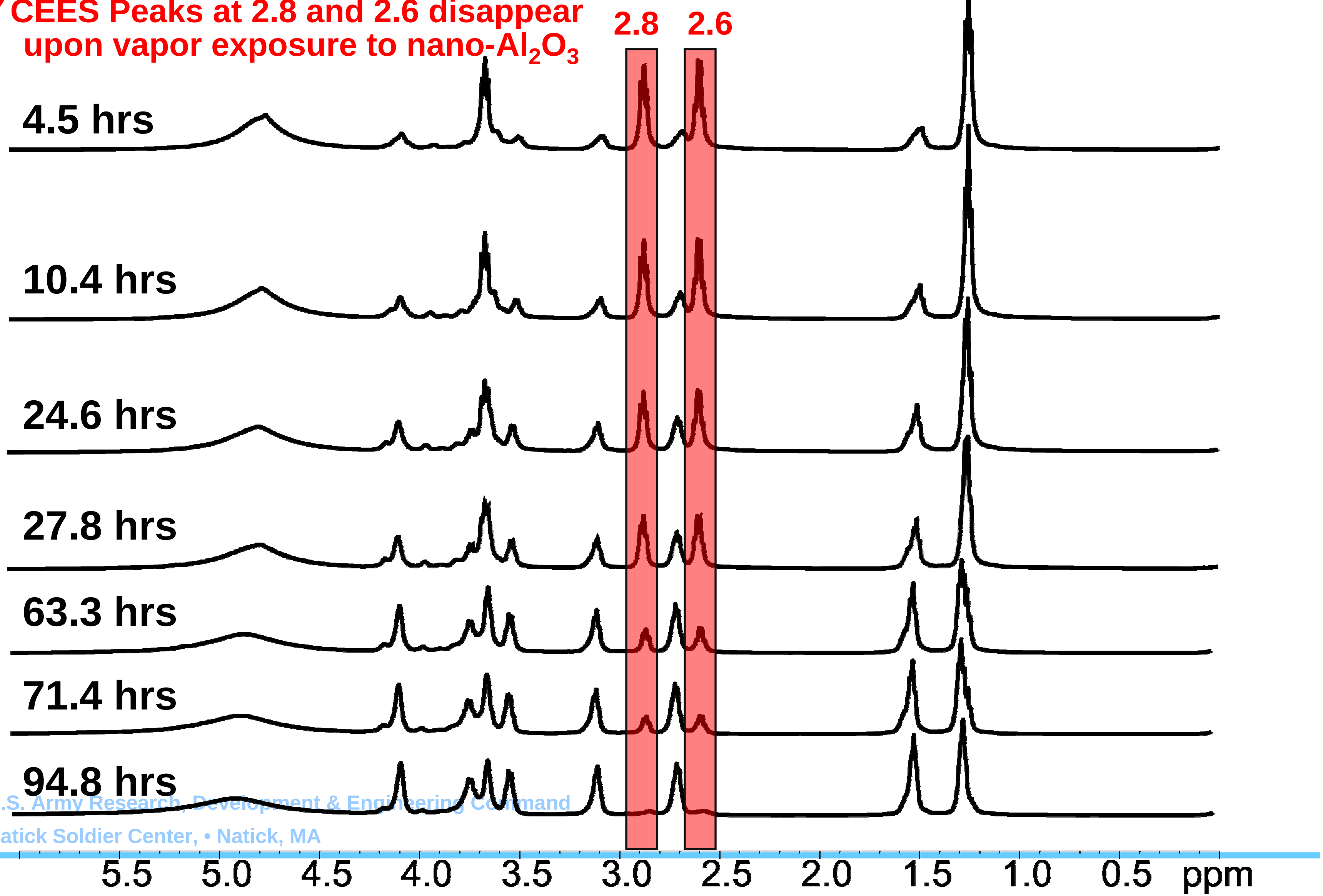


Vapor chamber for exposing catalyst to vaporous agent/simulant

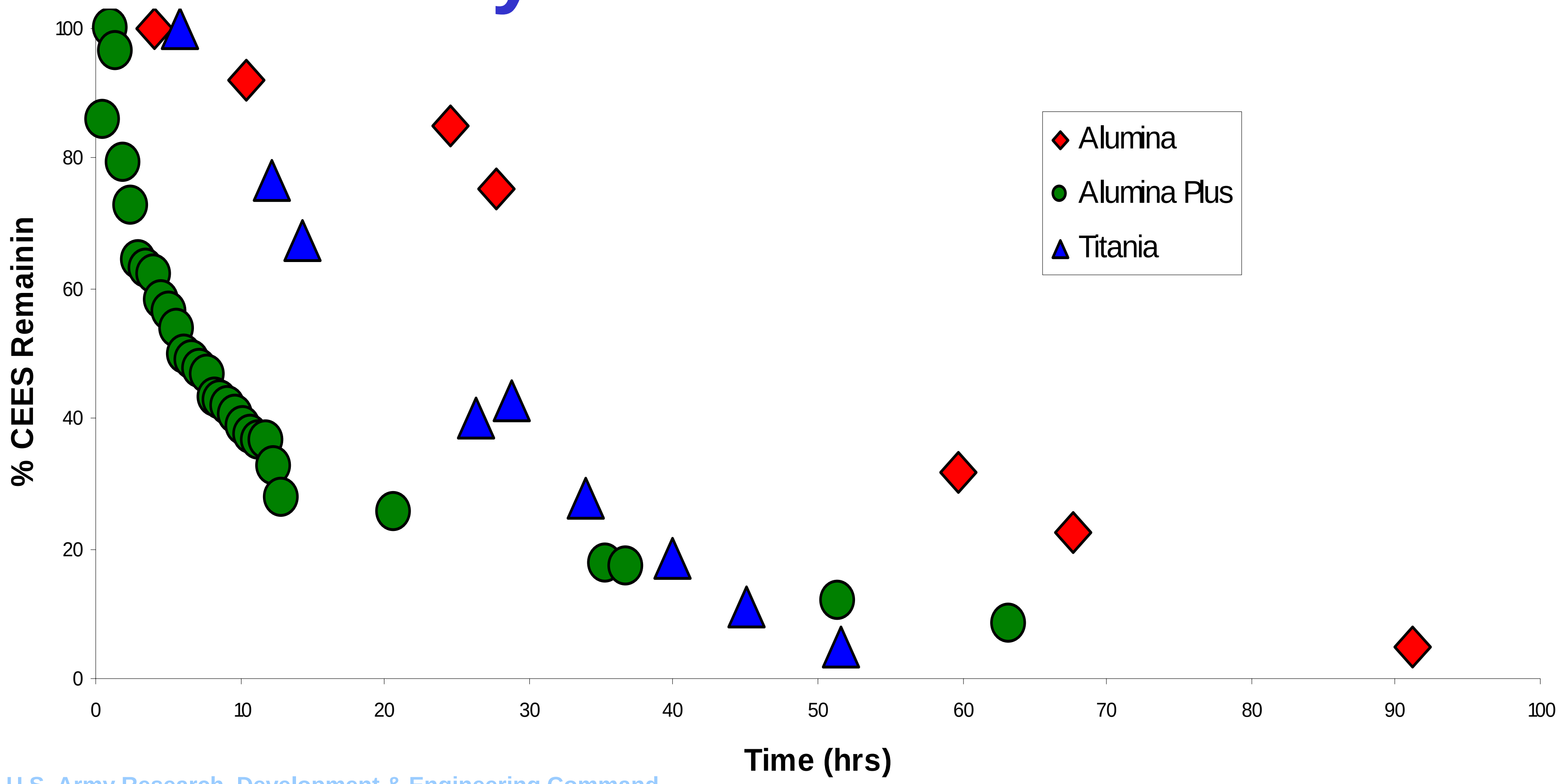
4 mm HRMAS rotor for examining small volumes of sample (< 100 µl)

^1H 1D Spectra Reaction Kinetics

CEES Peaks at 2.8 and 2.6 disappear upon vapor exposure to nano-Al_2O_3



Normalized 2-CEES Degradation Kinetics By Solid State NMR



Rate of CEES Vapor Depletion in HRMAS NMR Studies

	Rate	**Activity**
	% CEES/hr	mgCEES/24hr / mgNanoparticle
NanoAl_2O_3	0.83	0.020
NanoTiO_2	2.3	0.094
NanoAl_2O_3-PLUS	3.1	**0.74***

***30 g/m^2 of nanoAl_2O_3-PLUS needed to meet current protection requirements. 100 g/m^2 of nanoTiO_2 needed.**

POM Catalyst Reactions with 2-CEES

- POM on Carbon Surface
- Effect of Copper Content

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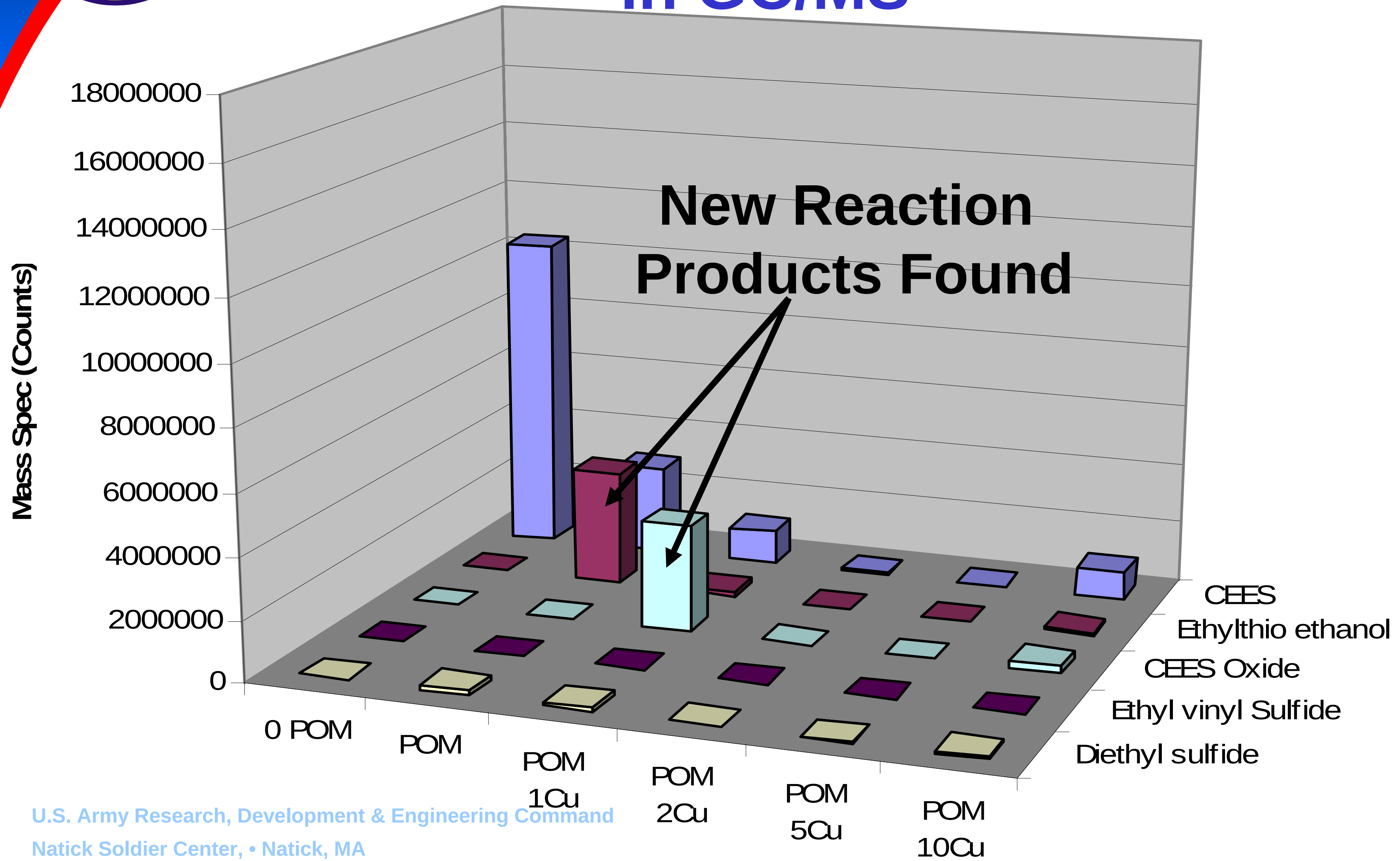
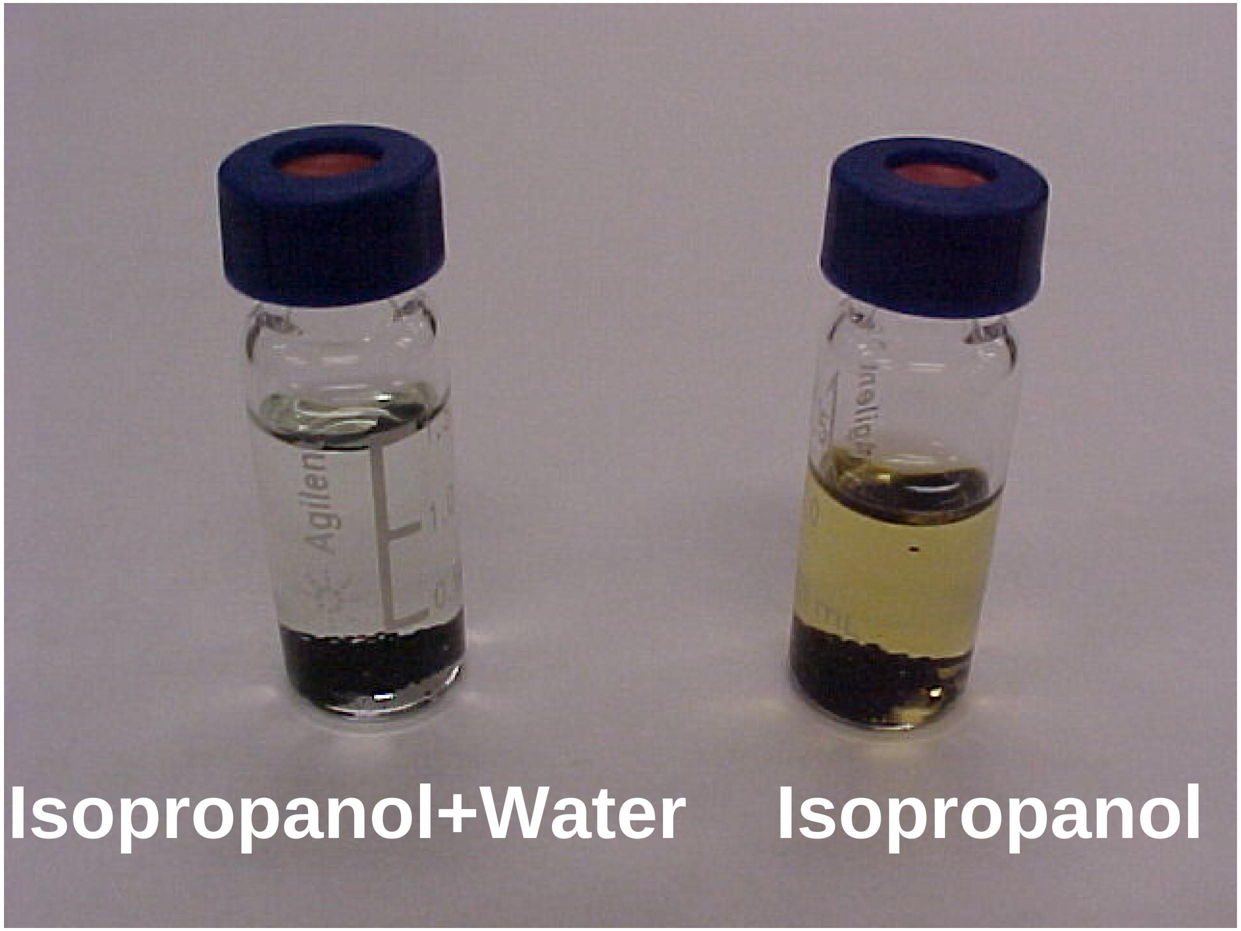
Natick Soldier Center, • Natick, MA

POM/Carbon Reduces 2-CEES in GC/MS

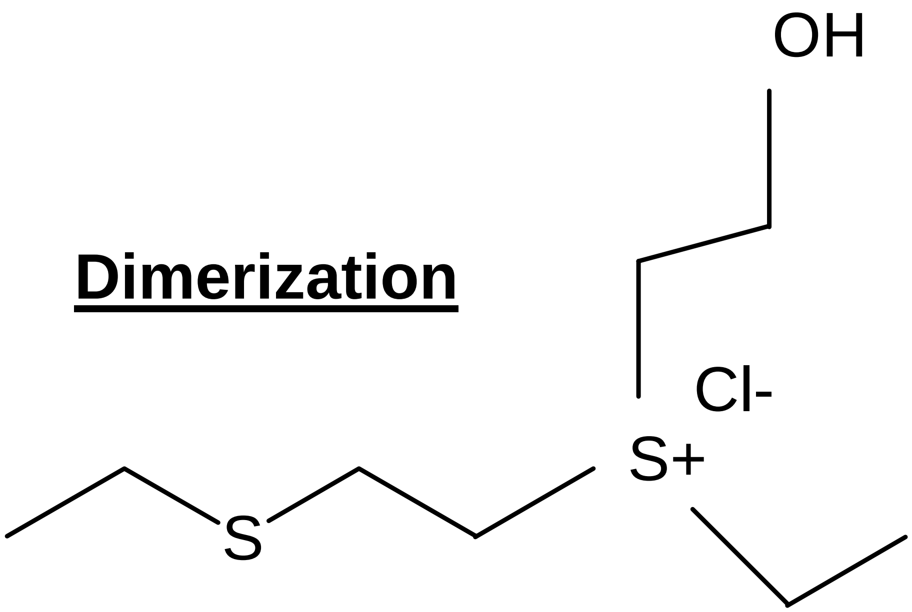


Reaction Product from Carbon/POM + 2-CEES



Dimer of 2-CEES from Oxidation Reaction

Dimerization



CEES
Vapor Diffusion Studies

Thick vs Thin Supported Selectively Permeable Films

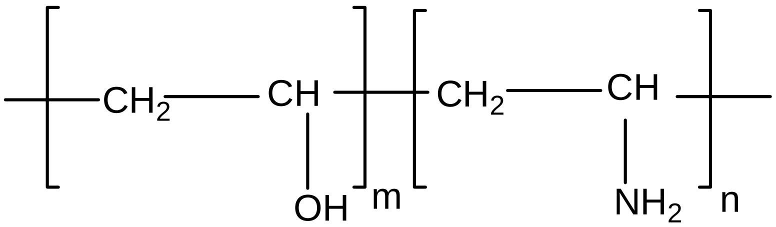
<u>Reactive</u>

PVAM (polyvinyl amine-co-vinyl alcohol)

<u>Non-Reactive</u>

Nafion, Membrane C, Membrane T

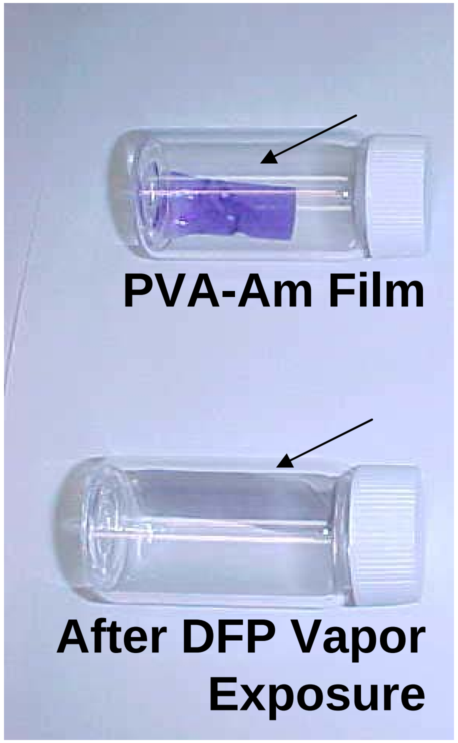
Reactive Selectively Permeable Membranes



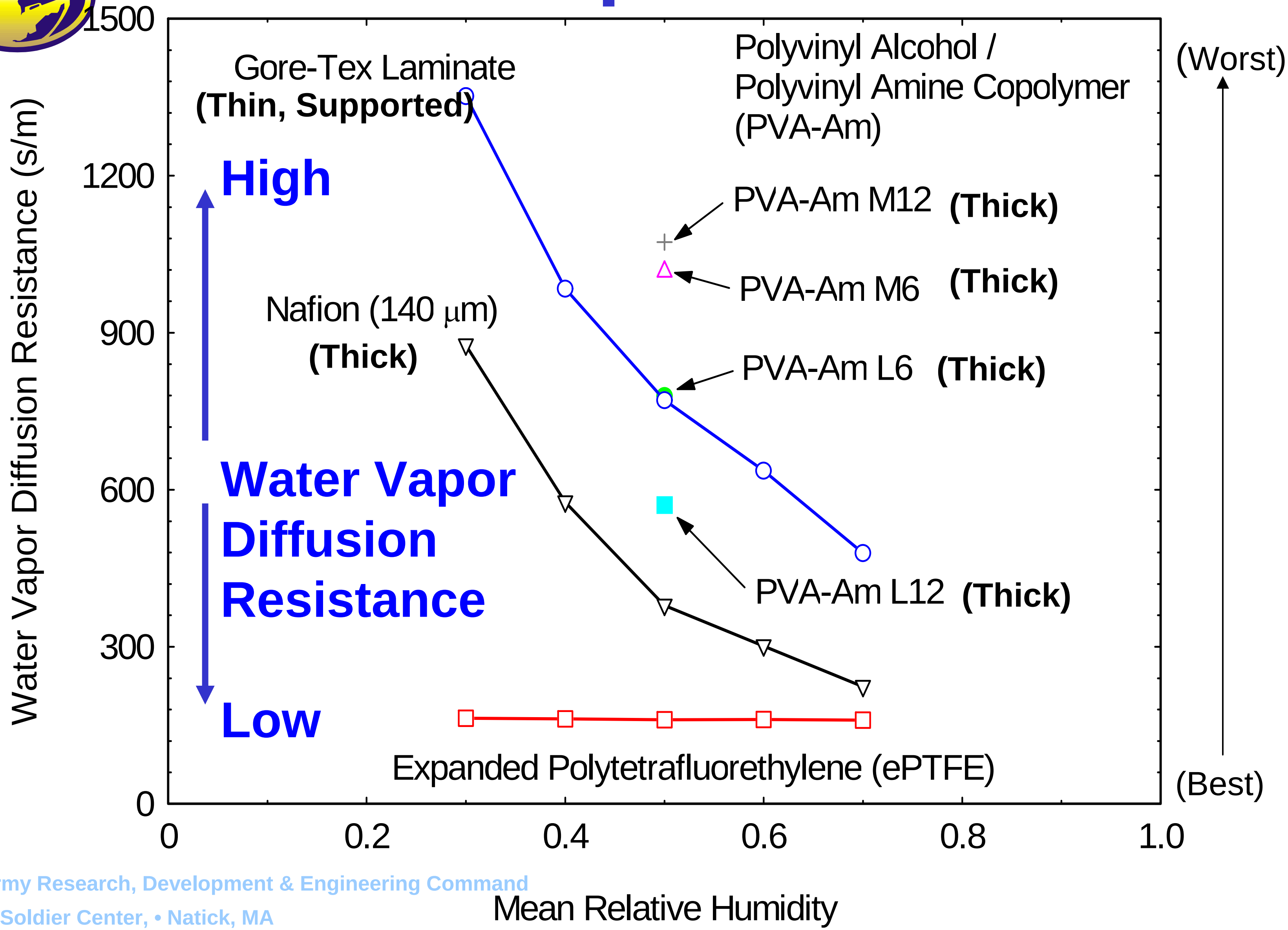
Polyvinyl alcohol-co-amine, PVA-Am

PVA-Am Film Hydrolyzes DFP, G-agent Simulant

(Seen by pH indicator).

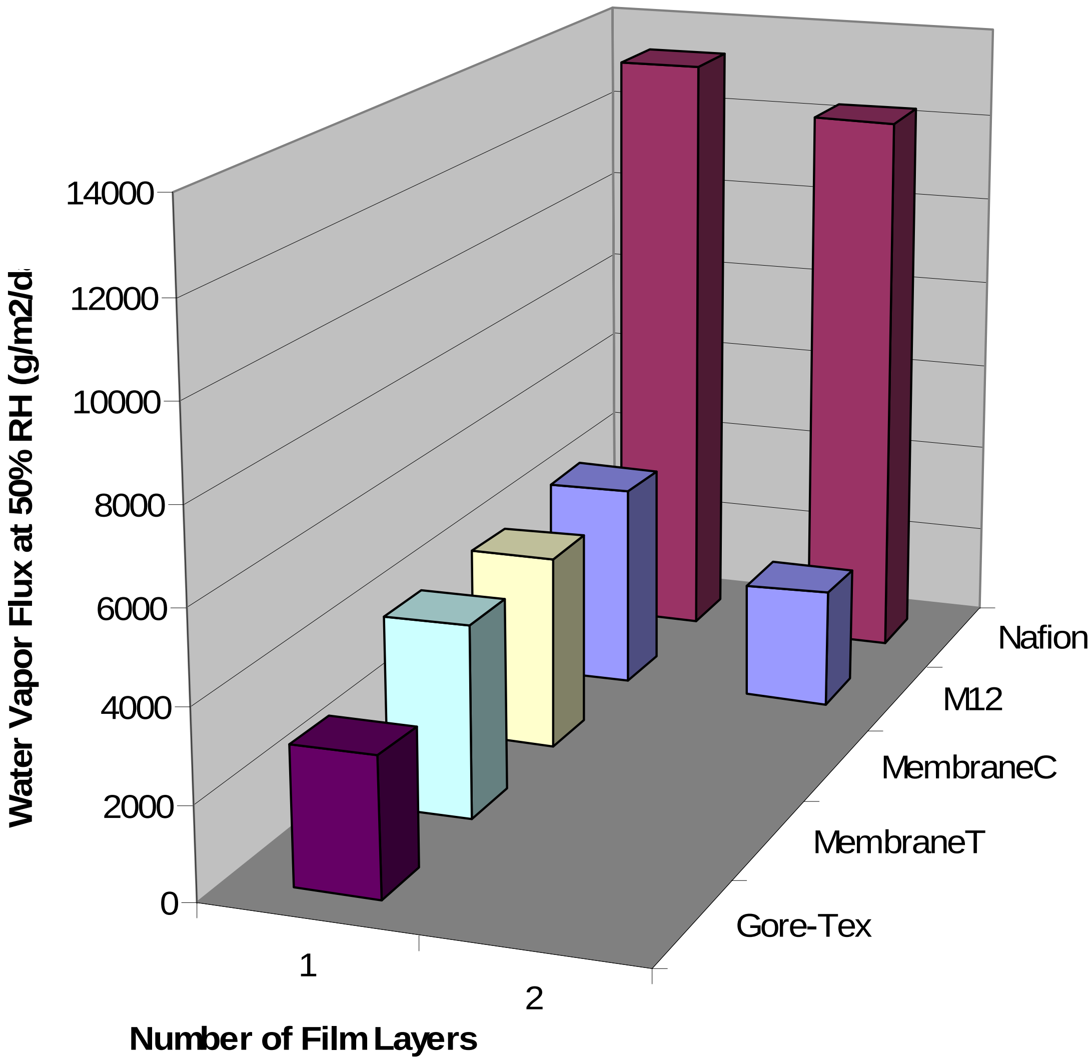


Water Vapor Diffusion



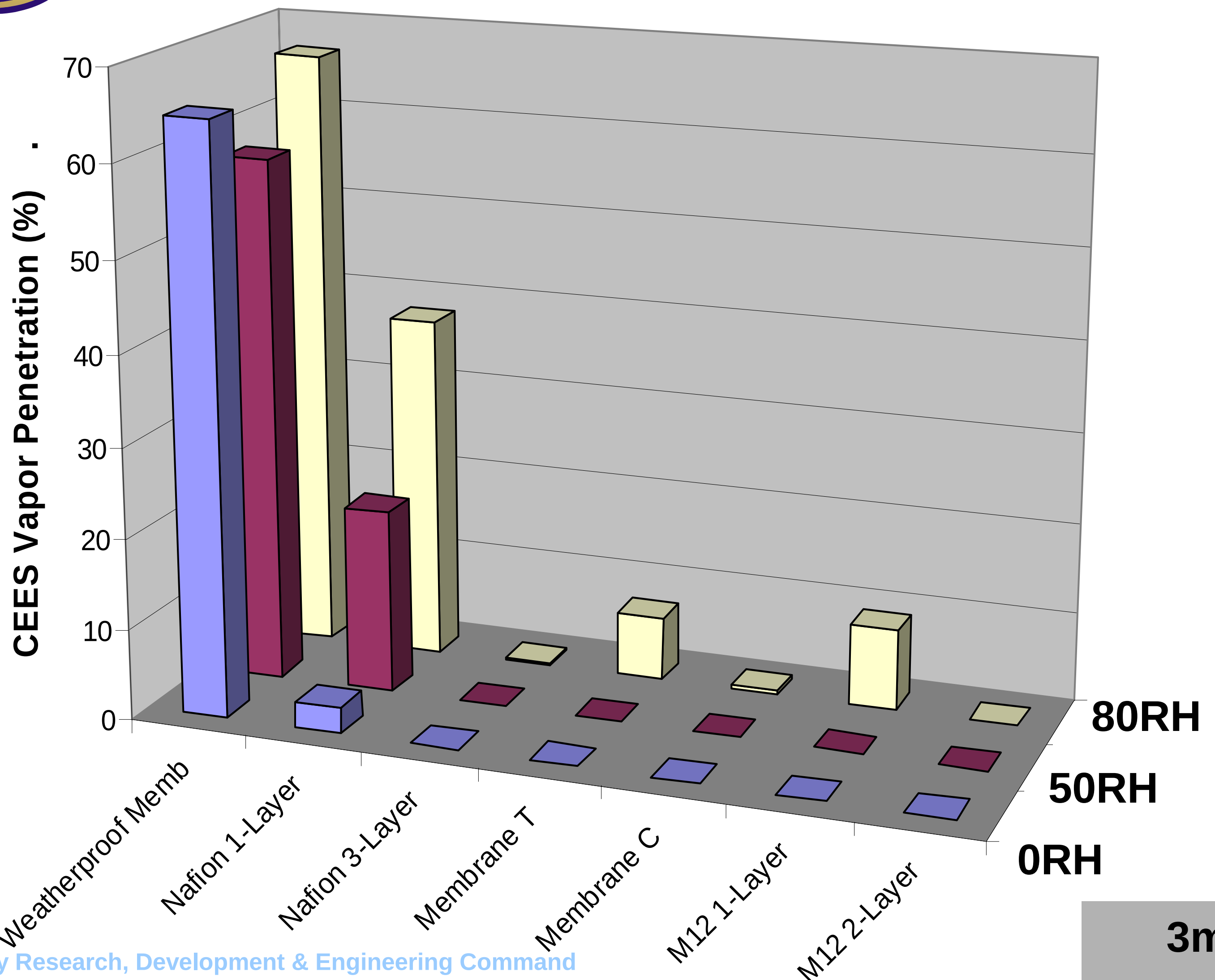
Water Vapor Diffusion

Thin, Supported Films



CEES Vapor Diffusion

Thin, Supported Films



3mg CEES applied

Conclusions

Chloramide-treated fabrics break down 2-CEES in solution and in vapor challenge tests.

One of the major by-products was the nontoxic sulfoxide. Other by-products include dimers.

Chloramides bound to nanoparticles of alumina were reactive, but not as active as the chloramides alone.

Conclusions

NanoAl$_2$O$_3$-PLUS more adsorptive than activated carbon.

NMR found that NanoAl$_2$O$_3$-PLUS depleted 2-CEES at a rate of 0.74 mgCEES/mgNanoparticle/day.

A fabric weight of 1-33 grams per square meter of NanoAl$_2$O$_3$-PLUS needed to meet the 1mg/cm2/day protection requirement for clothing systems.

100 gsm of nanoTiO$_2$ would be needed for protective fabrics to meet Chemical Protection requirements.

Conclusions

Carbon-bound POMs faster than free POM in the decomposition of 2-CEES.

Carbon-bound POMs can be optimized with Cu to increase depletion of 2-CEES by 7x.

Copper-containing POMs completely neutralize 2-CEES in 30 min. Produce CEES-oxide (sulfoxide) product.

Conclusions

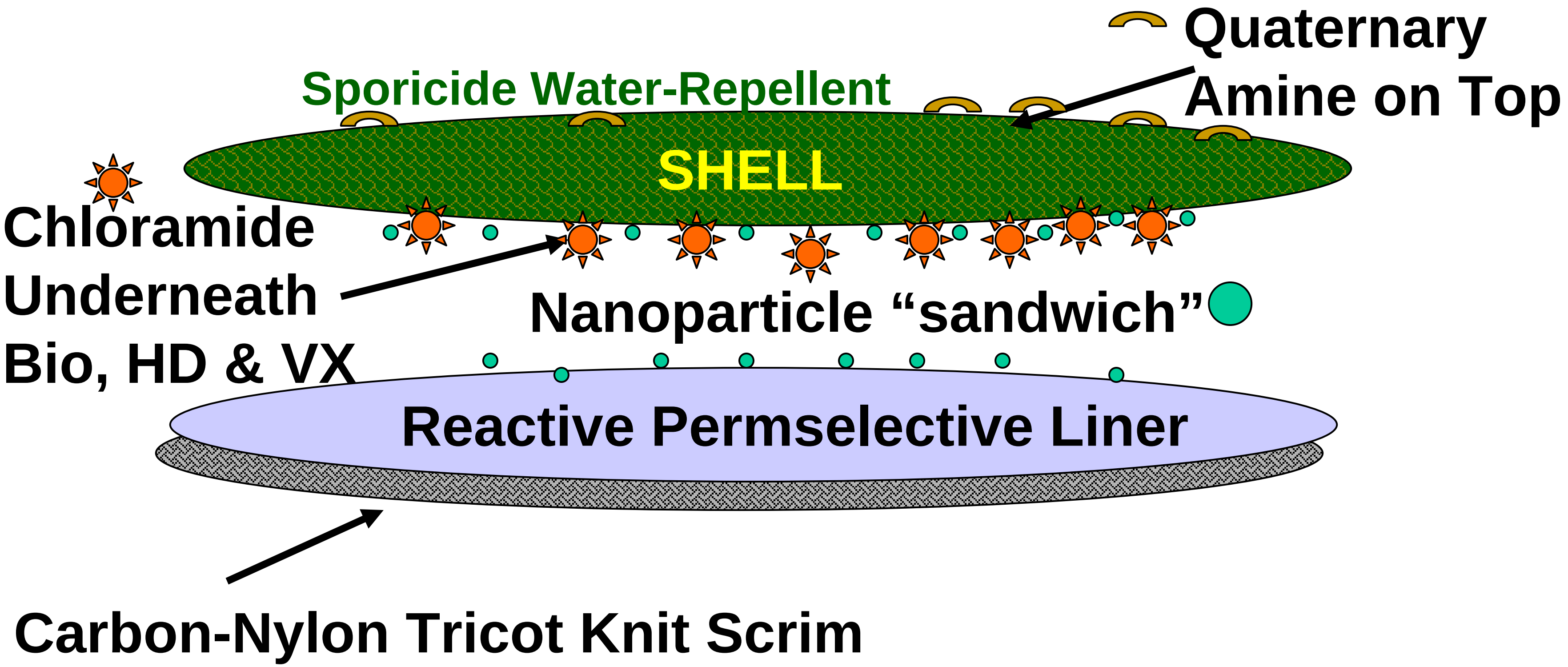
Thin supported PVAM films have high water vapor permeation, similar to commerical permselective membranes C and T.

Thin supported Nafion has the highest water vapor permeation.

Thin supported Nafion and MembraneC allow CEES penetration above 50RH

Thin supported PVAM films and MembraneT block CEES below 80RH.

Reactive Fabric System Design



Acknowledgements

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