COVID-19 PPE Research Activities at NIST: *Update June 9 2020*

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National Institute of Standards and Technology
U.S. Department of Commerce

COVID-19 PPE Research Activities

NIST has been applying its measurement and standards expertise to problems with the emergency reuse and decontamination of PPE to assist with the COVID-19 response.

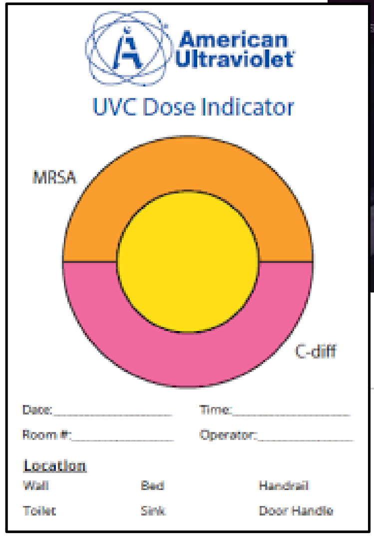
- UV measurements for decontamination
- Vapor Hydrogen Peroxide (VHP) for decontamination
- Measurement of particle escape from homemade face coverings
- Measurement of particle capture by homemade face coverings
- Measurement of trace gases released after decontamination
- Helping other agencies and American businesses respond to COVID-19

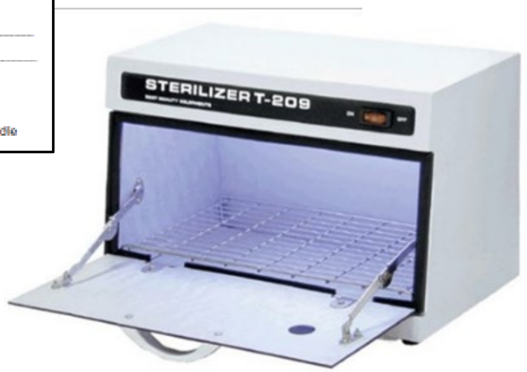
Background: UV Source Measurement Standards

Multiple standards in development with the Illuminating Engineering Society (IES):

- 5 Different Lamp Types
- Complete devices
- Irradiance measurements
- UVC radiometer calibration


Photo: Dimer LLC

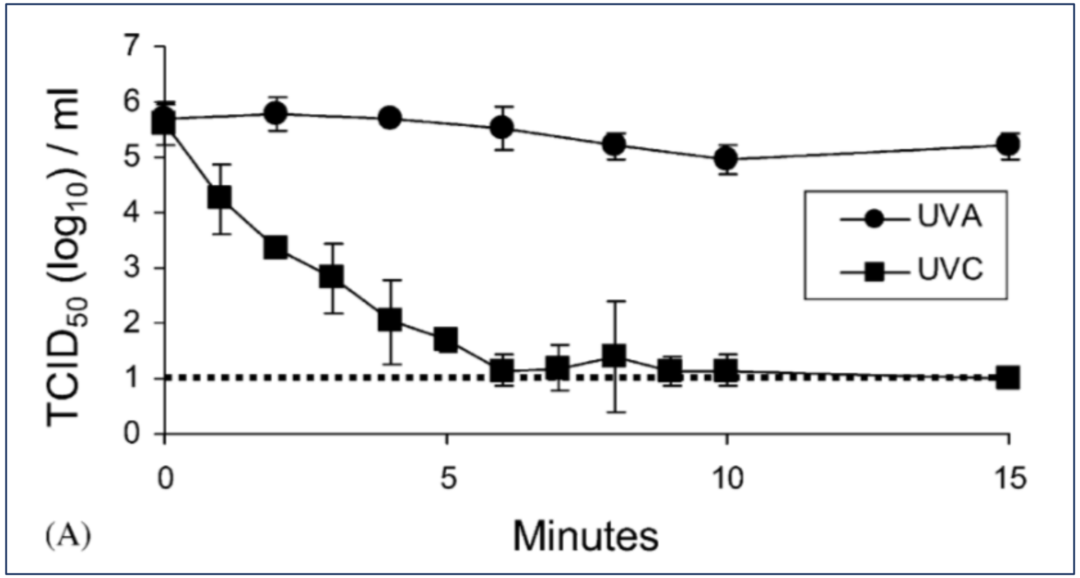




Photos of commercial products do not imply endorsement

PML

Background: SARS-CoV Response to UV



Previous studies of coronavirus response to UV in 2000's

Range of exposure conditions tested

UV-C was effective against SARS-CoV, UV-A was not

Duan SM et al. Biomed Environ Sci 2003;16:246
Darnell ME et al. J Vrifol Meth 2004;121:85
Kariwa H et al. Dermatology 2006;212 (Suppl 1): 119
Tsunetsugu-Yokota Y et al. Meth Mol Biol 2008;454:119

Now: SARS-CoV-2 and UV

NIST

- Working with **BSL-3 facilities** to measure the wavelength and dose dependent responsivity of SARS-CoV-2 Aerosols, Surfaces, & Biofilms
- Comparing results to **potential BSL-2 surrogates** to speed up testing in other facilities

222 nm lamps – safer?

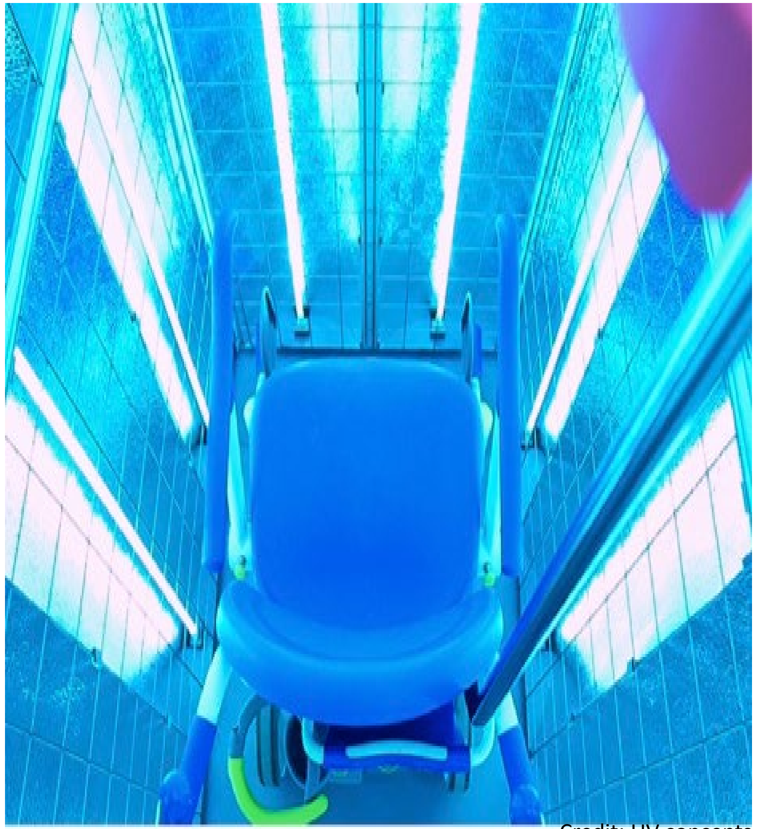
- Collaborating with Columbia University to establish a calibrated source
- Working with FDA to make sure measurements meet their regulatory bar

Image courtesy of Columbia University mouse facility

Cameron Miller, PML

UVGI Systems for emergency use

- Using existing commercial field-deployed UV-C enclosures
- Investigating material integrity, performance of N95 respirators after UV-C disinfection



Credit: UV concepts

NIST:
Andras Vladar (PML), high resolution SEM analysis
John Wright (PML), flow capacity assessments
Michael Riley (MML), tensile testing
Jennifer Carney (MML), off-gassing testing
Cameron Miller (PML), fluence assessments, sensor calibrations
Dianne Poster (MML Director's Office)

uvconcepts™ belief meets innovation

ResInnova

NIST Technical Note 2091

Tool for Evaluation of Vaporized Hydrogen Peroxide Disinfection of N95 Masks in Small Rooms

Inputs

1) Gassing Phase	
Duration, h	0.33
Mechanical Flow, $m^3\ h^{-1}$	1.00
Total Air change rate, λ, h^{-1}	0.15
a) In Room Source	
Emission source in room E, g h^{-1}	120
b) Injection Source	
Concentration in injected air, C_{inj}, g m^{-3}	0
Flow rate of injected air, Q_{inj}, $m^3\ h^{-1}$	0

2) Dwell Phase	
Duration, h	2.50
Mechanical Flow, $m^3\ h^{-1}$	1.00
Total Air change rate, λ, h^{-1}	0.15
a) In Room Source	
Emission source in room E, g h^{-1}	60
b) Injection Source	
Concentration in injected air, C_{inj}, g m^{-3}	0
Flow rate of injected air, Q_{inj}, $m^3\ h^{-1}$	0

3) Aeration Phase	
Duration, h	0.50
Mechanical Flow, $m^3\ h^{-1}$	200.0
Total Air change rate, λ, h^{-1}	9.36

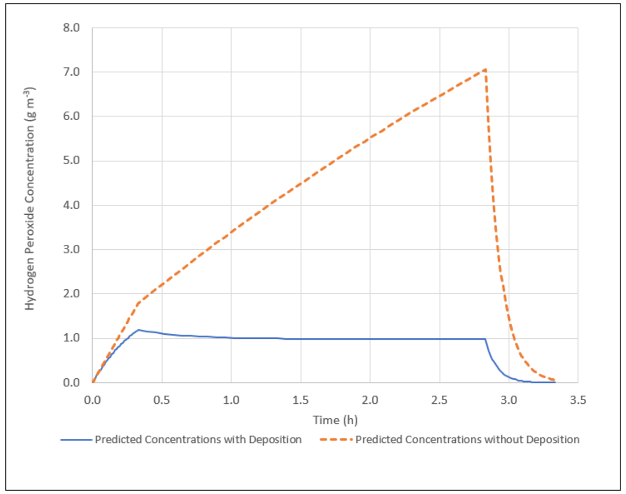
Masks	
Diameter, m	0.15
Number	50

Room	
Length, m	3.6
Width, m	2.4
Height, m	2.5
Initial Concentration, $C_{initial}$, g m^{-3}	0
Infiltration rate, λ, h^{-1}	0.1

Surfaces	Surface adsorption area, A, m^2	Surface material	Deposition Velocity, V_d, cm h^{-1}	Vd*A/V, h^{-1}
Walls	30	Metal File Cabinet	100	1.4
Ceiling	8.64	Metal File Cabinet	100	0.4
Floor	8.64	Metal File Cabinet	100	0.4
Masks	1.8	Paper/HVAC Duct	600	0.5
Other Surfaces with Large Areas	0.0	-	0	0.0

Results

Maximum predicted room concentration with surface losses, g m^{-3}	1.19
Maximum predicted room concentration with no surface losses, g m^{-3}	7.06
Ratio of maximum predicted room concentration with surface deposition and predicted room concentration with no surface deposition	17 %
Cumulative predicted disinfectant dose with surface losses (g m^{-3} h)	2.76
Percent of disinfectant mass injected/emitted into room deposited onto masks	15 %
Percent of disinfectant mass injected/emitted into room deposited onto room surfaces	68 %

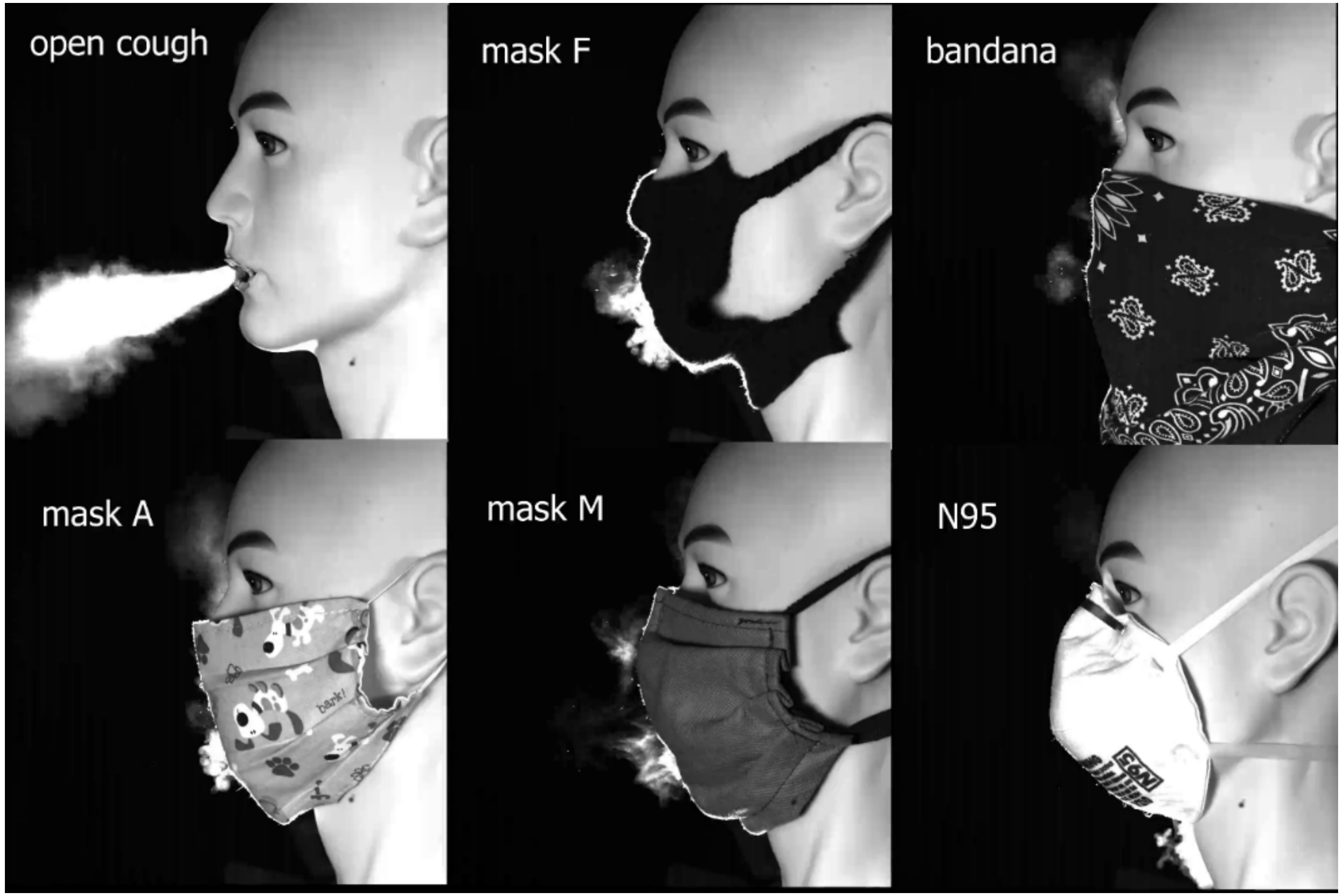


- Estimates the VHP concentration in air of a room being used to disinfect masks
- Accounts for room size, surface losses and air change rate using a mass balance approach
- Does not describe or provide guidance on VHP disinfection applications, does not address safety considerations
- Exploring collaborations with Batelle, EPA, UT Austin

Dustin Poppendieck, EL

Flow Visualization of Droplet Collection from Face Coverings

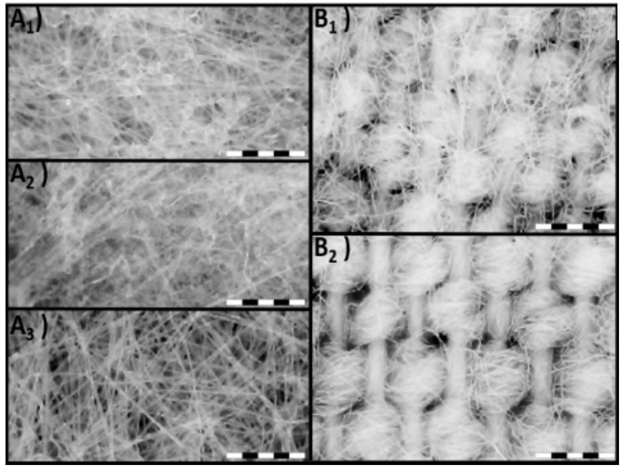
- High speed videography and backscattered lighting techniques
- Qualitative effectiveness of aerosol droplet capture with common face coverings
- Realistic human cough, fog droplets (~1-5 µm in diameter)
- Dramatic reduction of aerosol transport using basic face coverings
- Visualization shows the importance of a snug fit by the nose



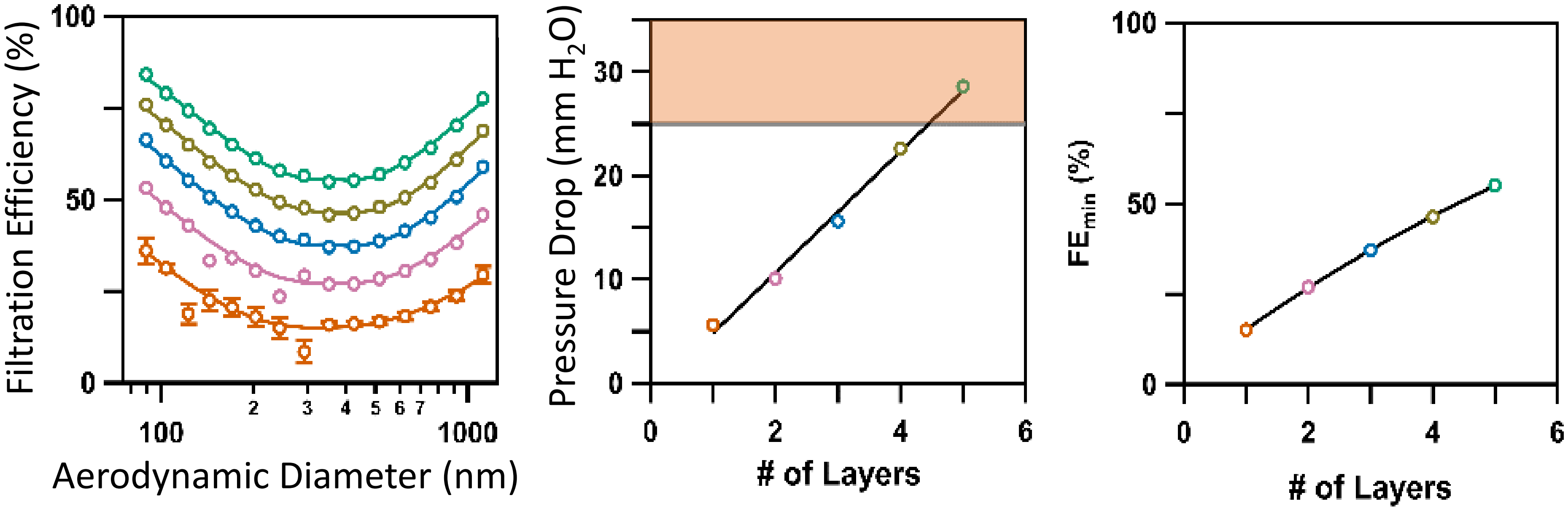
Credit: M. Staymates

Matt Staymates, MML

Filtration Efficiencies of Cloth Face Coverings



Transmitted light images.
Scale bars are 1 mm.



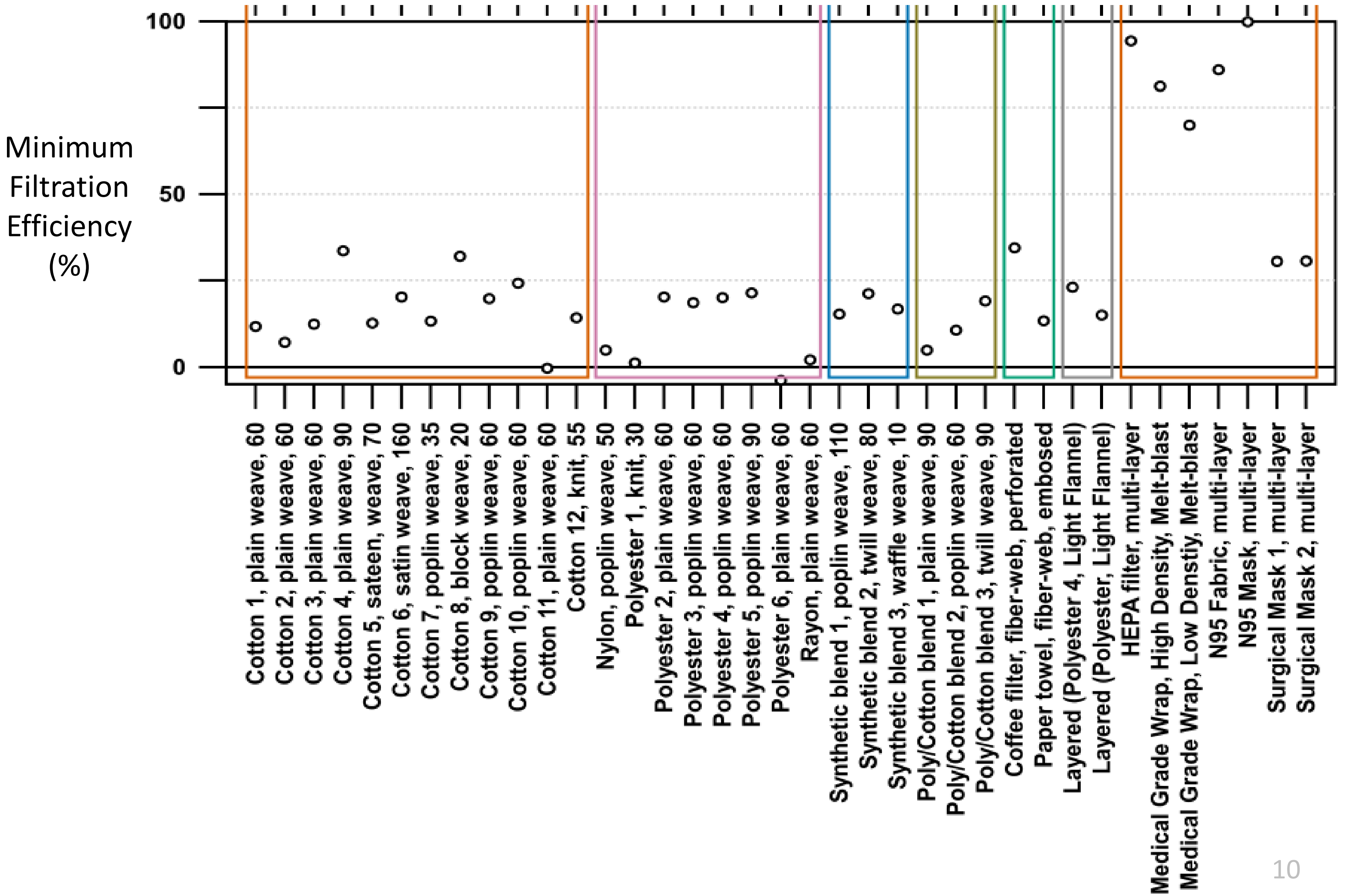
Filtration efficiency and pressure drop as a function of layers of material (one to five layers)

Christopher D. Zangmeister[1], James G. Radney[1], Edward P. Vicenzi[1,2], and Jamie L. Weaver[1,2]
[1] NIST MML; [2] Museum Conservation Institute, Smithsonian Institution

Filtration Efficiencies of Cloth Face Coverings

NIST

- Tested wide variety of fabrics tested
- Best performance from 100% cotton, with nap
- Compared No. of layers, pressure drop, mixed materials
- Publication submitted



Standards and Coordination

NIST

Standards Coordination Office

- NIST SCO has been able to arrange access for NIST staff and other agencies to PPE and ventilator-related standards

Interagency Coordination

- Participating in a variety of interagency calls and working groups to identify needs and connect NIST staff and resources
- Includes DHS, NIOSH, FDA, FEMA, DOE, DOS, DOJ