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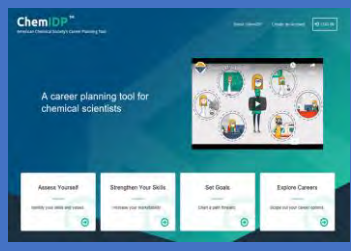

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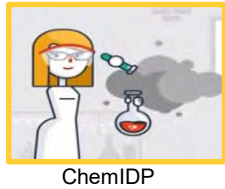
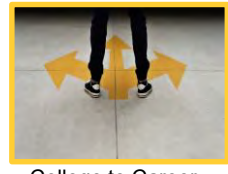

ChemIDP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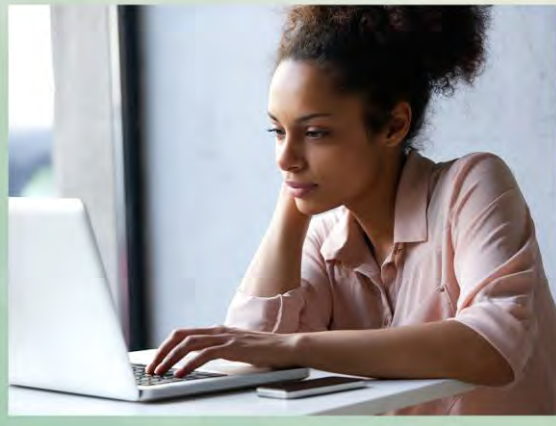

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Date: Thursday, June 17, 2021 @ 2-3pm ET
Speaker: Lee Polite, Axion Analytical Labs, Inc.
Moderator: Bryan Tweedy, American Chemical Society

Register for Free!

What You Will Learn:

- How to develop an HPLC method from scratch
- How to cut your analysis time in half, while preserving the quality of the results
- What are all those buttons for on your HPLC

Co-produced with: ACS Professional Education

Date: Wednesday, June 23, 2021 @ 2-3pm ET
Speakers: Carlonda Reilly, Kennametal / Serban Cantacuzene, AirLiquide / Kathleen Shelton, FMC
Moderator: Rebekah Paul, American Chemical Society

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- Lessons learned from three executives' rise to the top
- Insights on how you can succeed in today's changing job market
- Advice for charting your own career in the chemical enterprise

Co-produced with: ACS Industry Member Programs

Date: Friday, June 25, 2021 @ 2-3:30pm ET
Speaker: Sir Fraser Stoddart, 2016 Nobel Laureate in Chemistry, Board of Trustees Professor of Chemistry, Northwestern University and H.N. Cheng, ACS President
Moderator: Young-Shin Jun, Washington University in St. Louis

Register for Free!

What You Will Learn:

- How mechanically interlocked molecules (MIMs) are easily made and how they can be used inn the construction of artificial molecular machines (AMMs)
- How AMMs operate under kinetic control using energy ratchets in a manner similar to that employed by our many biomotors and are at odds with how machines operate in the macroscopic world: the difference could not be more stark!

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Polymers of the Pandemic

Antivirals and Decontaminating PPE

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ACS Chemistry for Life®

Polymers of the Pandemic: Antivirals and Decontaminating PPE

MICHAEL SCHULZ
Assistant Professor, Department of Chemistry, Virginia Tech

EMILIE REXEISEN
Advanced Product Engineering Specialist, 3M

TOMONORI SAITO
R&D Staff Scientist, Oak Ridge National Laboratory (ORNL) and Joint Faculty Associate Professor, University of Tennessee, Knoxville

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Polymers of the Pandemic

Antivirals

Michael D. Schulz
Department of Chemistry,
Macromolecules Innovation Institute,
Center for Emerging, Zoonotic, and Arthropod-borne Pathogens,
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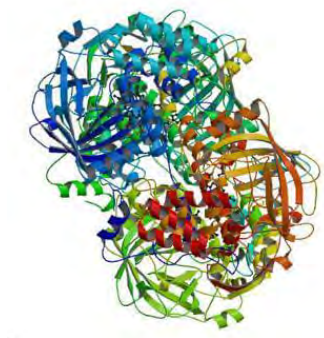
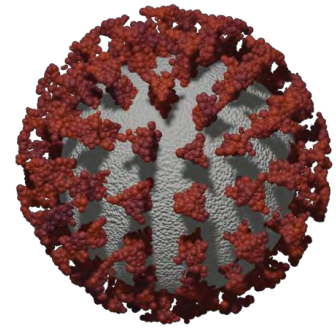
What is a polymer? What is a virus?

Polymer: A large molecule composed of many repeating units

Virus: A submicroscopic infectious agent that replicates only inside the living cells of an organism





How big is a polymer? How big is a virus?

RBC
10,000 nm

HIV
120 nm

Coronavirus
100 nm

Influenza
100 nm

Polymer
DP = 100
~ 25 nm

Polymer
Repeat Unit
~ 0.25 nm

NOT TO SCALE

Audience Survey Question

ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT

When were antiviral polymers discovered?

- 1930s
- 1940s
- 1950s
- 1960s
- 1970s

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Antiviral Polymers: Early History

In the course of investigations concerned with problems relative to the pathogenesis of primary atypical pneumonia, a study was undertaken on the effects of inoculating mice with both a virus and a bacterium. The virus employed in these experiments is known as pneumonia virus of mice, and will hereafter be designated PVM. The bacterium used is a non-hemolytic streptococcus, designated streptococcus MG.

When the first experiments were carried out, it was considered that either of two possible results might develop; first, that streptococcus MG would have no discernible influence on the course of an infection induced by PVM; or second, that it might, by contributing to the establishment of a complex infection, cause the results to be more severe than those of infections induced by PVM alone. Surprisingly, neither possibility evolved; instead, the inoculation of streptococcus MG in mice which previously had been inoculated with PVM resulted in a distinctly less severe infection.

Horsfall, F. L., Jr.; McCarty, M. *J. Exp. Med.* **1947**, 85, 623-646

20

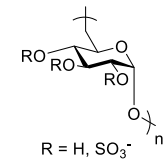
Antiviral Polymers: Early History

Subsequent studies in 1947 and 1948 directly tested various polysaccharides for antiviral activity against influenza and mumps. Some worked, others did not.

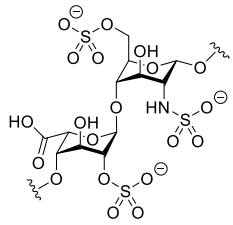
Green, R. H.; Woolley, D. W. *J. Exp. Med.* **1947**, *86*, 55-64.
Ginsberg, H. S.; Goebel, W. F.; Horsfall, F. L. *J. Exp. Med.* **1948**, *87* (5), 385– 410

Over a decade later, polyanionic character was recognized as key for antiviral activity.

Takemoto, K. K.; Liebhaber, H. *Virology* **1961**, *14* (4), 456
Takemoto, K. K.; Spicer, S. S. *Ann. N. Y. Acad. Sci.* **1965**, *130* (1), 365
Vaheri, A. *Acta Pathol. Microbiol. Scand.* **1964**, *60*, 1– 98



Dextran Sulfate



Heparin

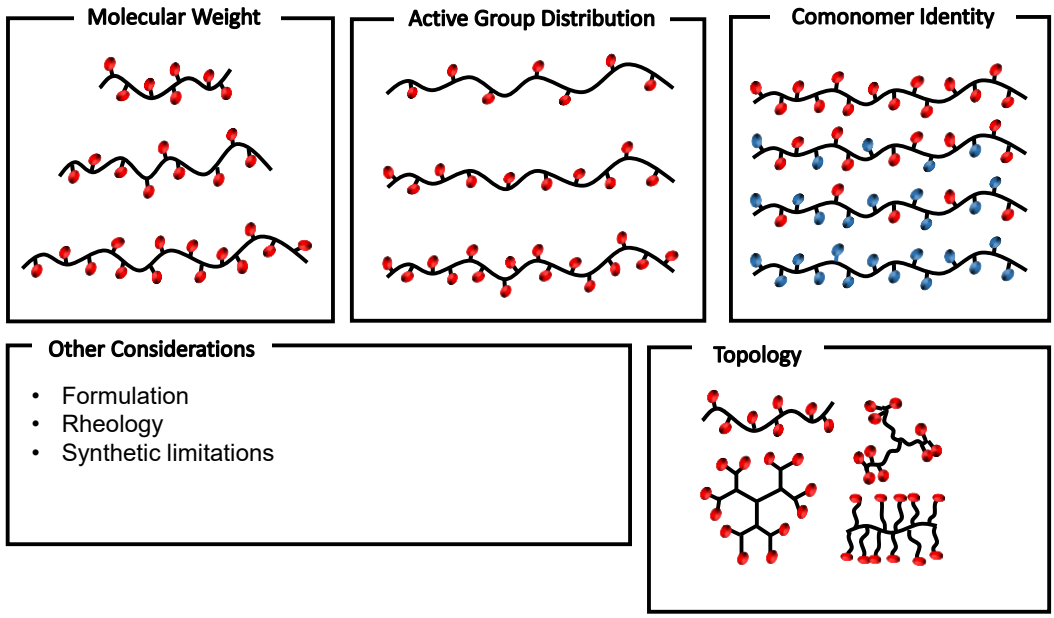
Antiviral Polymers: Early History

Polyanions continued to be developed
(especially in the context of anti-HIV materials)

Polymers were developed as interferon inducers

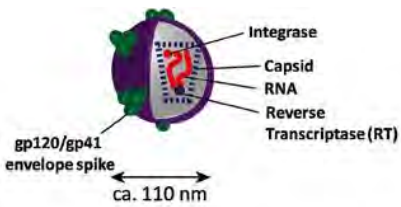
Polynucleotides and oligonucleotides were developed both as interferon inducers and as antiviral agents that would bind to viral mRNA

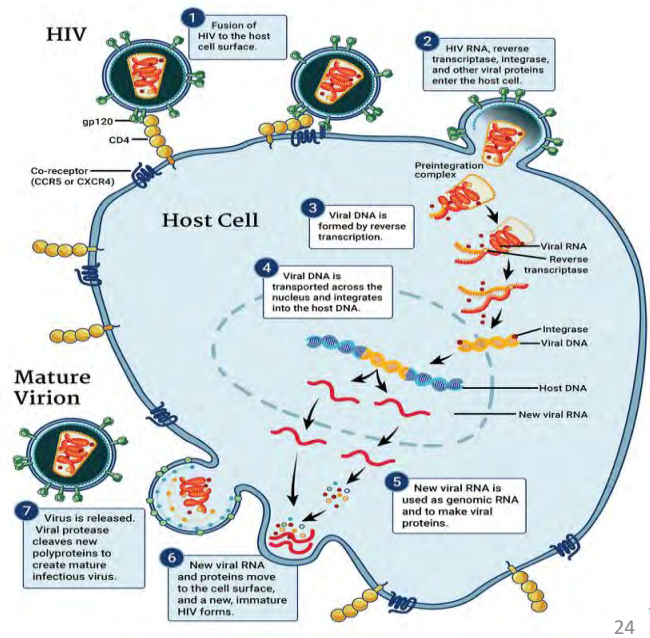
Polymer Parameters



Anionic Materials and Human Immunodeficiency Virus

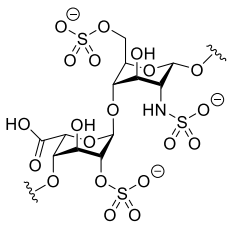
Anionic polymers were extensively investigated, including in clinical trials



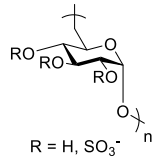


https://www.niaid.nih.gov/diseases-conditions/hiv-replication-cycle

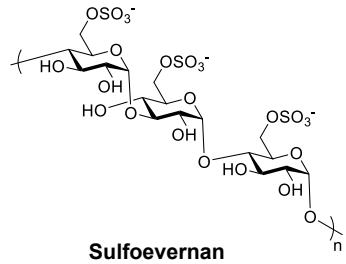
Anti-HIV Polymers



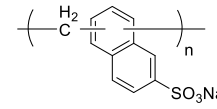
Heparin



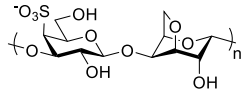
Dextran Sulfate



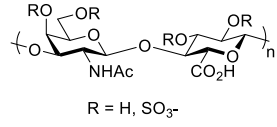
Sulfoevernan



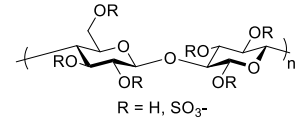
Napthalene sulfate (PRO 2000)



κ- or λ-carrageenan



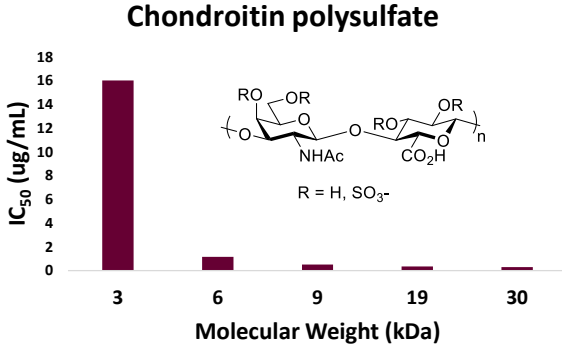
Chondroitin polysulfate

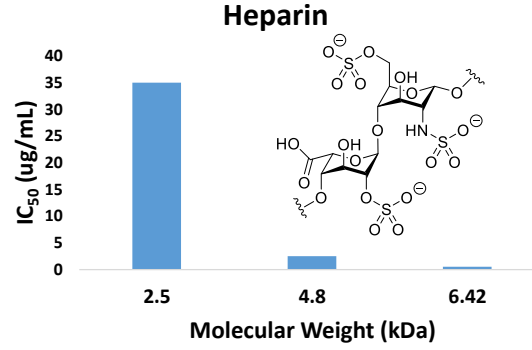


Cellulose sulfate

Bianculli, R. H.; Mase, J. D.; Schulz, M. D. *Macromolecules* **2020**, *53*, 21, 9158

Anti-HIV Polymers: Effect of Molecular Weight



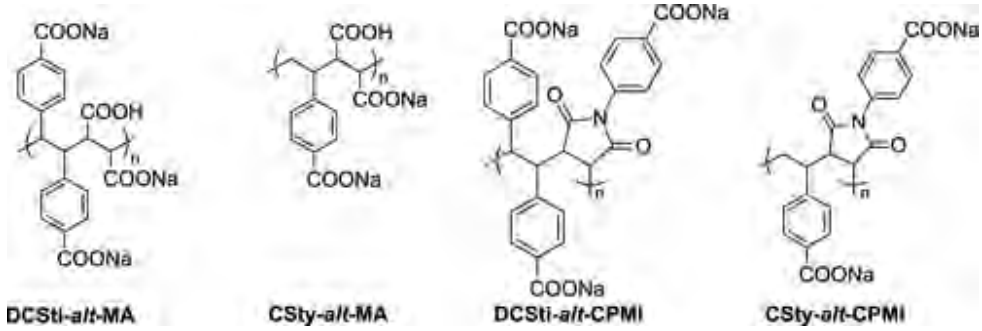


A polymer's molecular weight can be important in determining viral inhibition

- As molecular weight increases, the gains in antiviral potency begin to level off
- Polyvalency is a potential reason, though steric crowding of the virus may also play a role

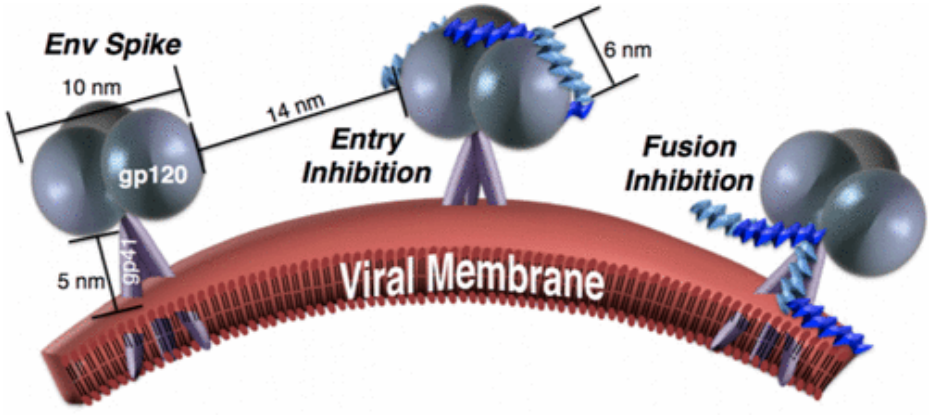
Jurkiewicz, E.; Panse, P.; Jentsch, K. D; Hartmann, H.; Hunsmann, G. *AIDS* **1989**, *3*(7), 423-427.
Baba, M.; Declercq, E.; Schols, D.; Pauwels, R.; Snoeck, R.; Vanboeckel, C.; Vandedem, G.; Kraaijeveld, N.; Hobbelen, P.; Ottenheijm, H.; Denhollander, F. *J. Infect. Dis.* **1990**, *161* (2), 208-213.

Rigid Polyanions against HIV



Savage, A. M.; Li, Y.; Matolyak, L. E.; Doncel, G. F.; Turner, S. R.; Gandour, R. D.
J. Med. Chem. **2014**, *57* (15), 6354– 6363

Rigid Polyanions against HIV



Savage, A. M.; Li, Y.; Matolyak, L. E.; Doncel, G. F.; Turner, S. R.; Gandour, R. D.
J. Med. Chem. **2014**, *57* (15), 6354– 6363

Anti-HIV Polymers: Some Concluding Thoughts

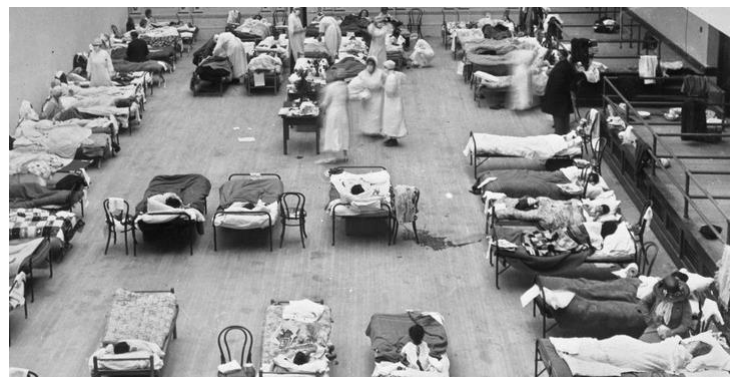
Antiviral polymers targeting HIV have been more extensively studied than for any other viral disease

Clinical trials have faced considerable challenges: some polymers possess limited strain effectiveness, can enhance HIV infectivity, or can cause acute reactions in patients

Danial, M.; Klok, H.-A. *Macromol. Biosci.* **2015**, *15*, 9–35

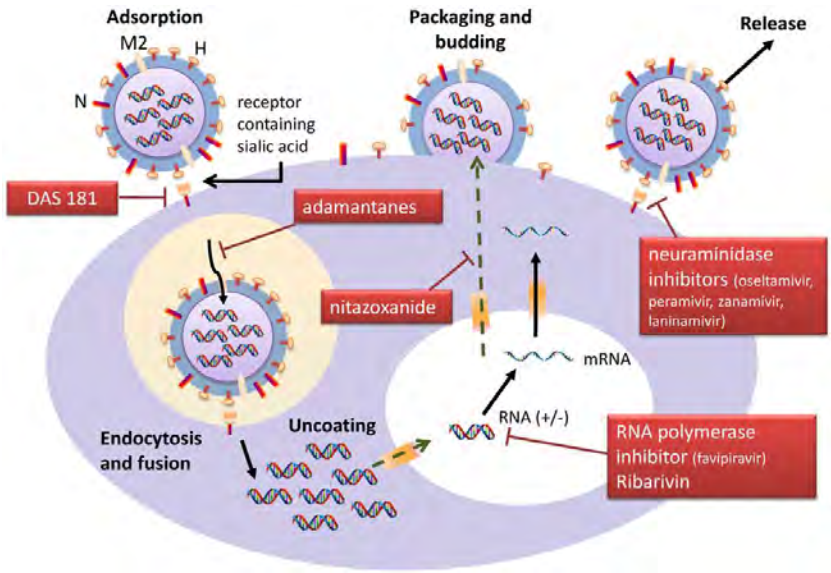
1918 Influenza: The Mother of All Pandemics

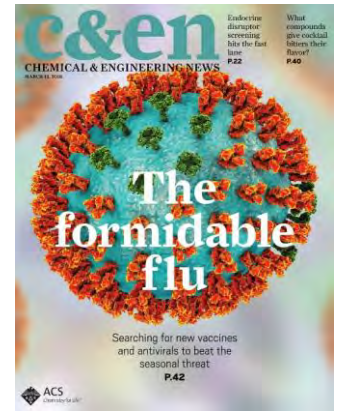
"An estimated one third of the world's population (or ≈500 million persons) were infected and had clinically apparent illnesses during the 1918–1919 influenza pandemic. The disease was exceptionally severe. Case-fatality rates were >2.5%, compared to <0.1% in other influenza pandemics. Total deaths were estimated at ≈50 million and were arguably as high as 100 million."



Taubenberger, J. K.; Morens, D. M. *Emerg. Infect. Dis.* **2006**, *12*, 15-22

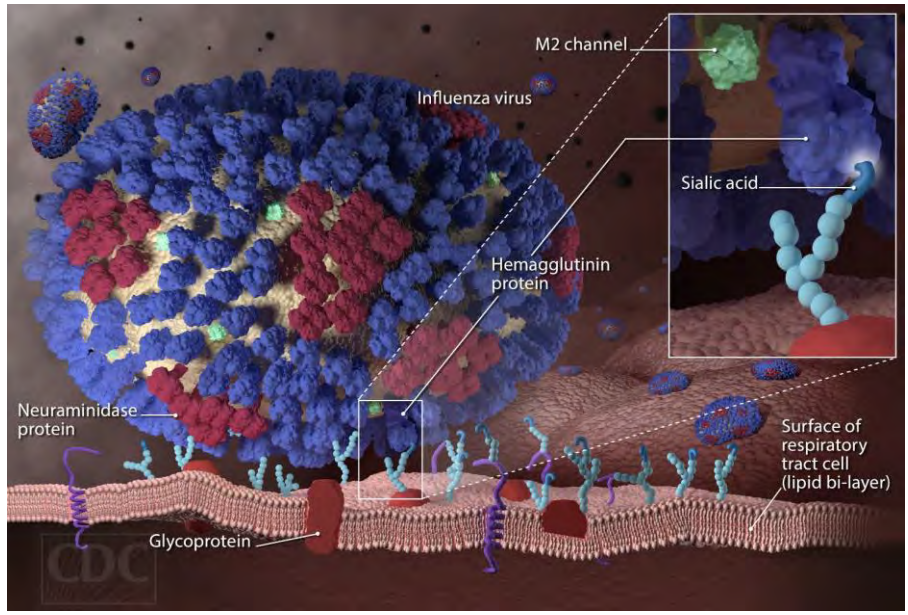
Influenza Virus





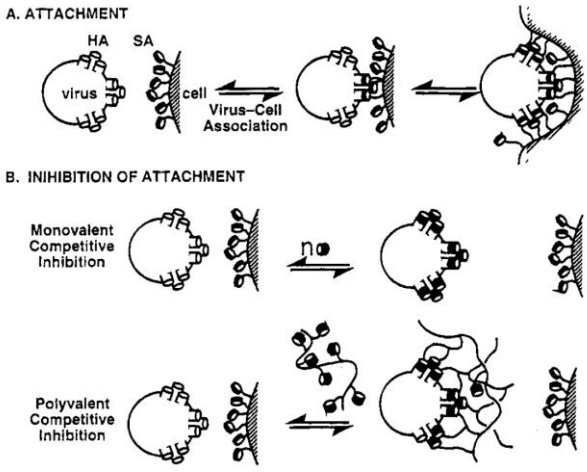
Li, T. C. M.; Chan, M. C. W.; Lee, N. *Viruses* **2015**, *7*(9), 4929-4944;

Influenza Infection

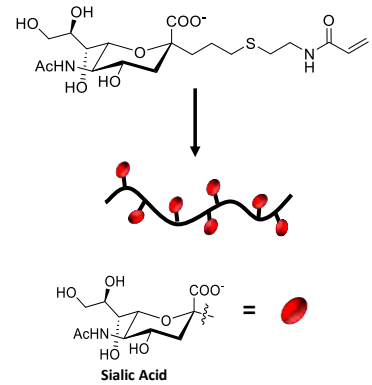


https://www.cdc.gov/flu/resource-center/freeresources/graphics/images.htm

Polymeric Influenza Inhibitors



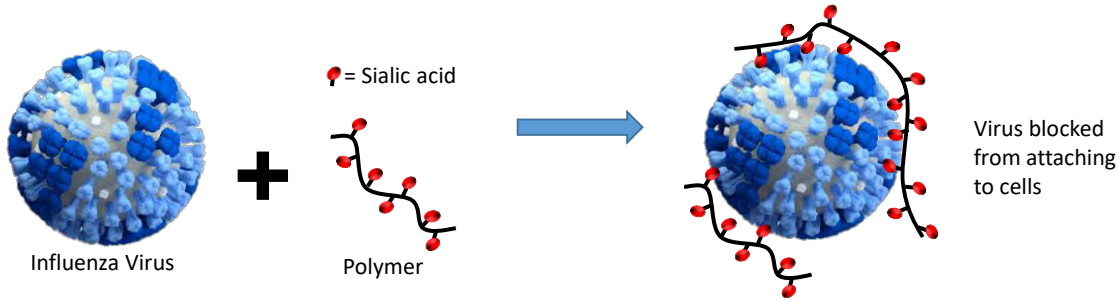
Polymers were found to be much more effective than the most effective synthetic small-molecular inhibitor at the time



Two theories of inhibition:
1. **Polyvalency** increases affinity of the polymeric inhibitor for the virus surface
2. **Sterics** prevent the virus from interacting with the cell receptors

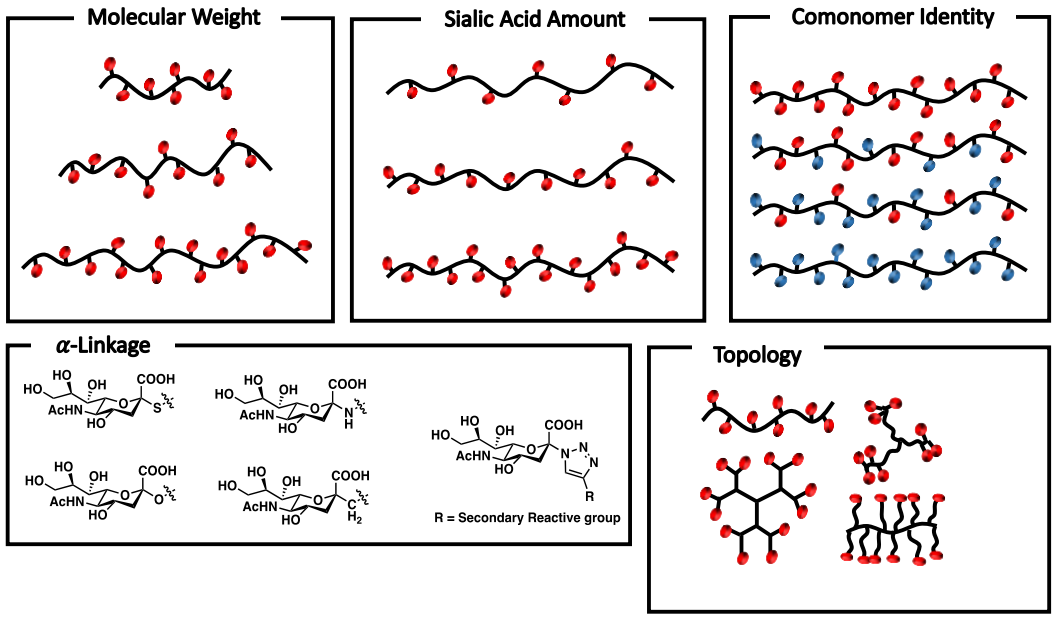
Mammen, M.; Dahmann, G.; Whitesides, G. M. *J. Med. Chem.* **1995**, *38*, 4179-4190.

The Basic Concept: Polyvalency

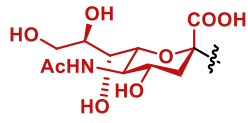


How do polymer parameters affect this interaction?

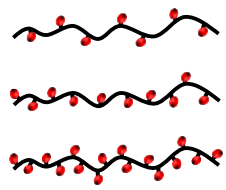
Anti-influenza Polymer Parameters



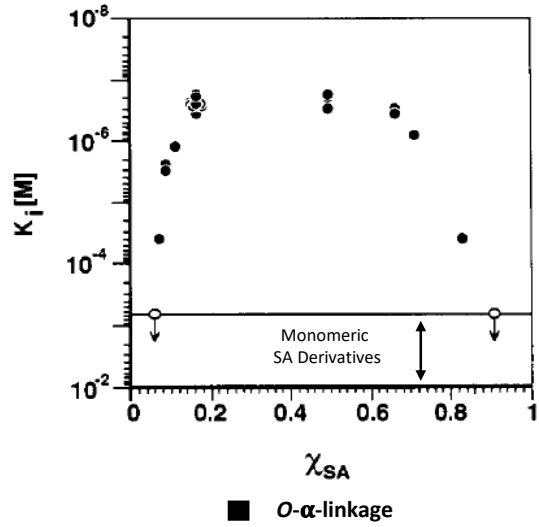
Sialic Acid Content



$K_i[M]$ = ~10^-3 M

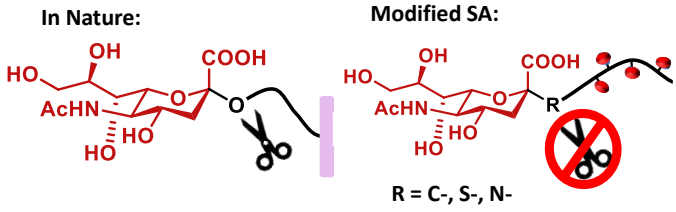


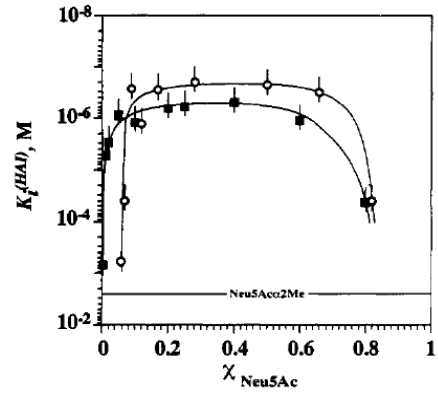
$K_i[M]$ = ~10^-6 M



Spaltenstein, A.; Whitesides, G. M., *J. Am. Chem. Soc.* **1991,** *113*, 686-687.

α-Linkage Identity and SA content

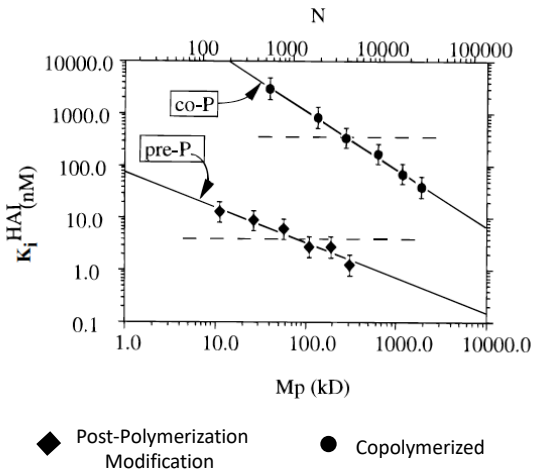




Synthetically modifying the SA to have a *C*-, *N*-, or *S*-α-linkages enhances inhibition.

Sparks, M. A.; Williams, K. W.; Whitesides, G. M., *J. Med. Chem.* **1993,** *36* (6), 778-783.

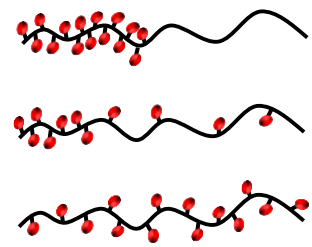
Molecular Weight and Polymerization Method



- Increase in molecular weight enhances inhibition
- Upper limit of this effect has not been determined

J. Am. Chem. Soc. **1996,** *118* (16), 3789-3800.

Copolymerization or Post Polymerization Modification?

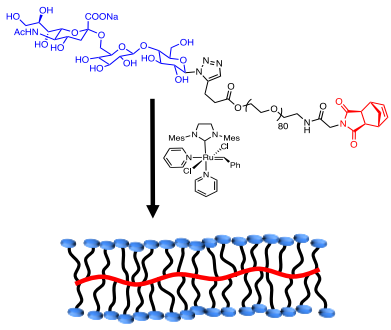


- Polymers produced by copolymerization of SA-containing monomers were less effective than those synthesized by post-polymerization modification.

J. Med. Chem. **1995,** *38* (21), 4179-4190.

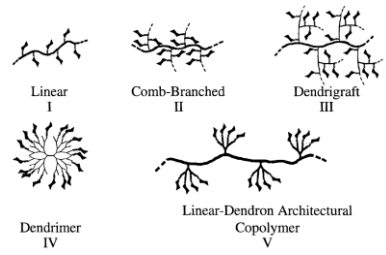
Topology and Backbone Identity

Poly(norbornene imide) Bottle Brush Polymers:
Polymers with high SA-lactose content, longer side chains, and higher DP had high antiviral activity. Bottlebrush topology mimics naturally occurring mucin.



ACS Macro Lett. **2016,** *5* (3), 413-418.

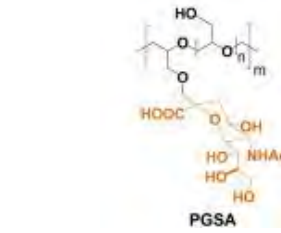
Dendritic Polymers
Dendritic polymers conjugated to sialic acid were investigated as inhibitors of viral adhesion and infection.



I, IV < V < II, III

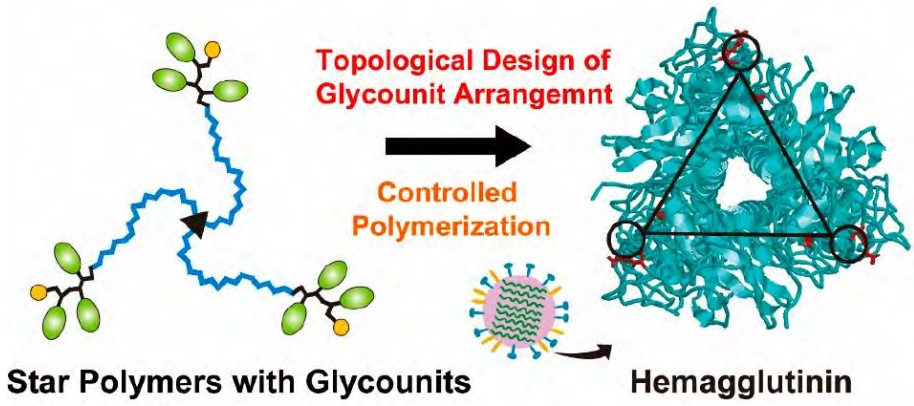
Bioconjugate Chem. ***1999,*** *10* (2), 271-278.

Polyglycerol – Linear and Dendritic
Linear polyglycerol polymers with *S*-linkage SA side chains were more effective inhibitors than similarly functionalized dendritic polymers *in vivo* and *in vitro*.



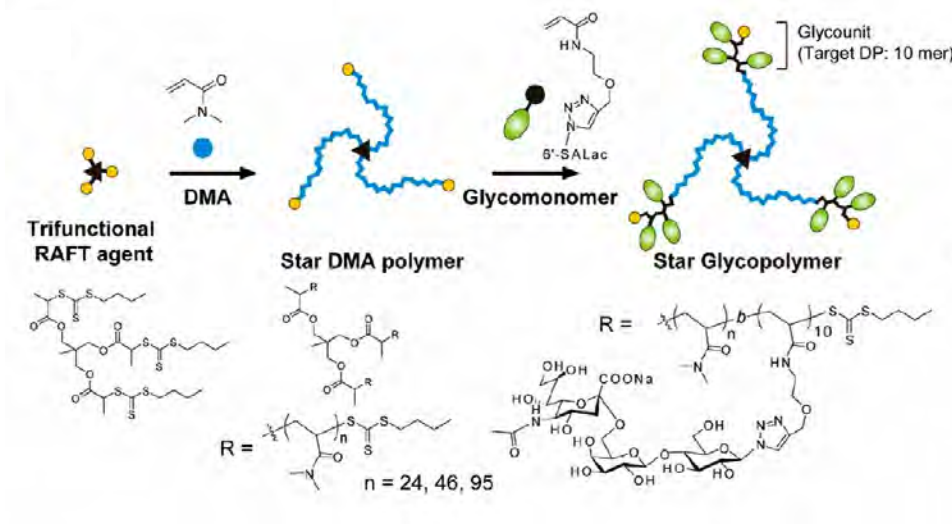
Biomaterials **2017,** *138*, 22-34.

Influenza: Targeting hemagglutinin



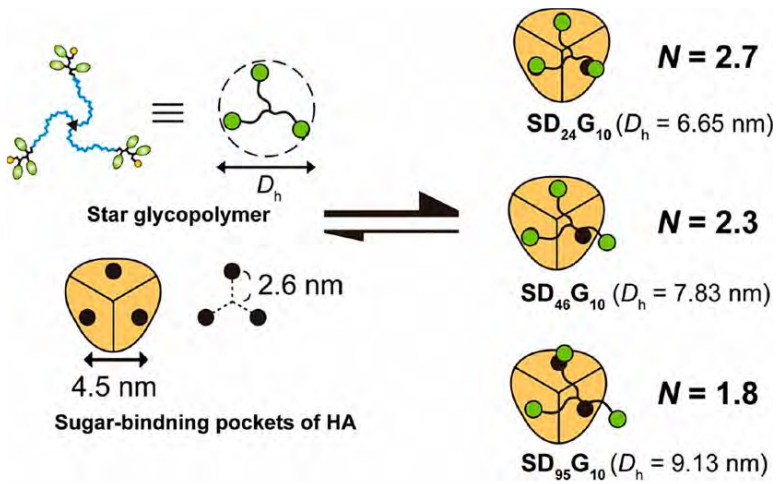
Nagao, M.; Matsubara, T.; Hoshino, Y.; Sato, T.; Miura, Y. *Bioconjugate Chem.* **2019**, *30*, 1192-1198

Influenza: Targeting hemagglutinin



Nagao, M.; Matsubara, T.; Hoshino, Y.; Sato, T.; Miura, Y. *Bioconjugate Chem.* **2019**, *30*, 1192-1198

Influenza: Targeting hemagglutinin

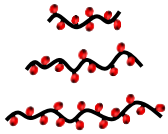


polymer	K_i (M)
$SD_{24}G_{10}$	2.1×10^{-5}
$SD_{46}G_{10}$	1.4×10^{-4}
$SD_{95}G_{10}$	8.3×10^{-4}

Nagao, M.; Matsubara, T.; Hoshino, Y.; Sato, T.; Miura, Y. *Bioconjugate Chem.* **2019**, *30*, 1192-1198

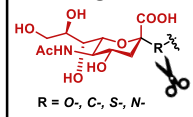
Anti-influenza Polymer Parameters for Enhanced Inhibition

Molecular Weight



- Increase in molecular weight enhances inhibition when SA remains constant
- Upper limit of this effect has not been determined
- Under-explored parameter

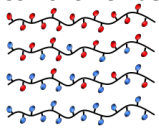
α-Linkage



R = *O-, C-, S-, N-*

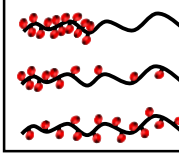
- Natural SA has α-*O*-linkages
  - Can be cleaved by NA
- Synthetically modifying the SA to have a *C-*, *N-*, or *S-*, α-linkages enhances inhibition

Comonomer Identity



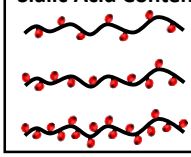
- Short (Sterics)
- Non-bulky (Sterics)
- Neutral (SA negatively charged)
- Hydrophobic (Interact with lipid envelope)

Sialic Acid Distribution



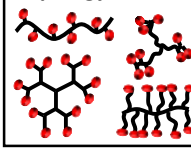
- Post-polymerization modification enhances inhibition over copolymerization
- Block copolymers are under-explored

Sialic Acid Content



- Midrange SA (20-70%) (Enough SA for polyvalent binding while avoiding excessive steric hinderance)

Topology



- Linear and dendritic polymers extensively studied
- Studies with branched or bottle brush polymers suggest that they may be more effective than linear

Bianculli, R. H.; Mase, J. D.; Schulz, M. D. *Macromolecules* **2020**, *53*, 21, 9158

In vivo studies

SA-functionalized polyacrylamide (DP~700, 10% SA content) **was tested against mouse-adapted influenza virus.**

Polymer was aerosolized and administered to mice by inhalation either 30 min before or 10 min after infection with the virus. Both groups had decreased mortality.

Subsequent studies produced similar results.

Gambaryan, A. S.; Boravleva, E. Y.; Matrosovich, T. Y.; Matrosovich, M. N.; Klenk, H. D.; Moiseeva, E. V.; Tuzikov, A. B.; Chinarev, A. A.; Pazynina, G. V.; Bovin, N. V. *Antiviral Res.* **2005**, *68* (3), 116– 23

Influenza: Concluding Thoughts

While influenza vaccines are effective, they also have significant limitations

Antiviral polymers targeting influenza have shown promise, but key questions remain

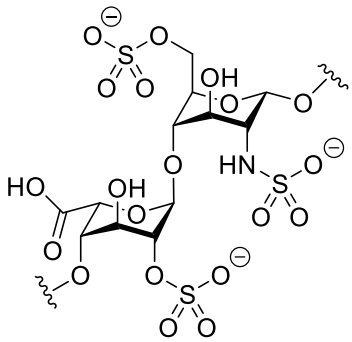
Other Viruses

Herpes Simplex Virus
Hepatitis
Norovirus
Respiratory syncytial virus
Sendai virus
Zika virus
Ebola

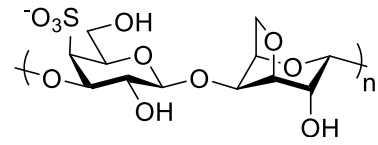
Antiviral polymers have been explored for each of these pathogens to some extent

COVID-19

Antiviral polymers are promising inhibitors of SARS-CoV-2



Heparin

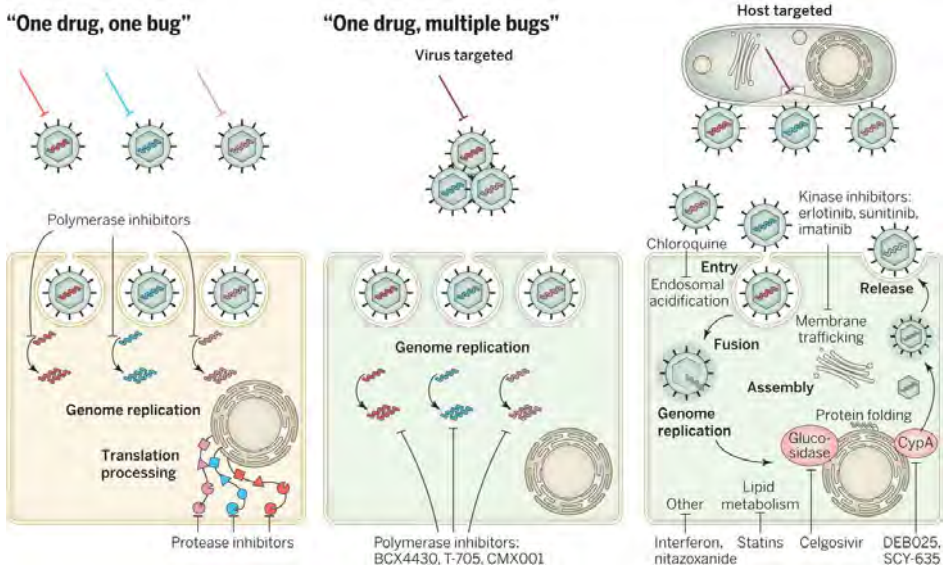


Carrageenan

Tandon, R.; Sharp, J. S.; Zhang, F.; Pomin, V. H.; Ashpole, N. M.; Mitra, D.; McCandless, M. G.; Jin, W.; Liu, H.; Sharma, P.; Linhardt, R. J.
J. Virol. **2021**, *95*, e01987. doi: 10.1128/jvi.01987-20

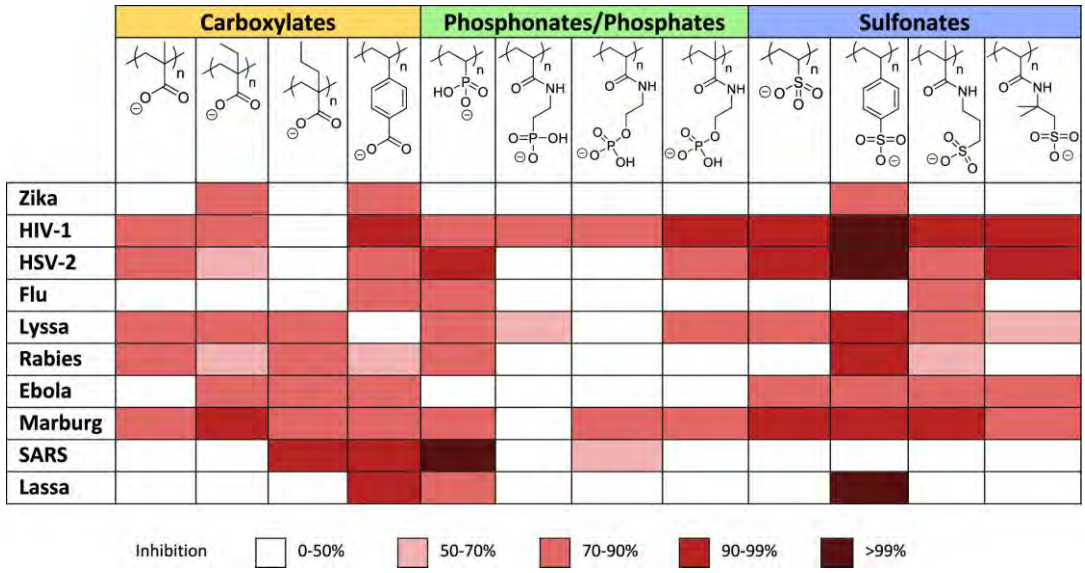
Moakes, R. J. A.; Davies, S. P.; Stamataki, Z.; Grover, L. M. *Adv. Mater.* **2021**, 2008304

Broad-Spectrum Antivirals



Bekerman, E.; Einav, S. *Science* **2015**, *348*, 282-283

Broad-Spectrum Antiviral Polymers



Schandock, F. et al. *Adv. Healthcare Mater.* **2017**, *6* (23), 1700748

Antiviral Polymers: Where do we go from here?

- **COVID-19 will likely dominate the research landscape in this area for the foreseeable future**
- **Broad-spectrum antivirals are underdeveloped (a challenge for small-molecule antiviral drugs as well)**
- **Common challenges in nanomedicine in general (biodegradability, metabolism, biodistribution, etc.) have received little attention in the context of antiviral polymers**
- **Assay development and refinement**
- **Potential applications in veterinary medicine, agriculture and other fields**

Conclusions

Modern polymer synthesis techniques enable control over key polymer parameters

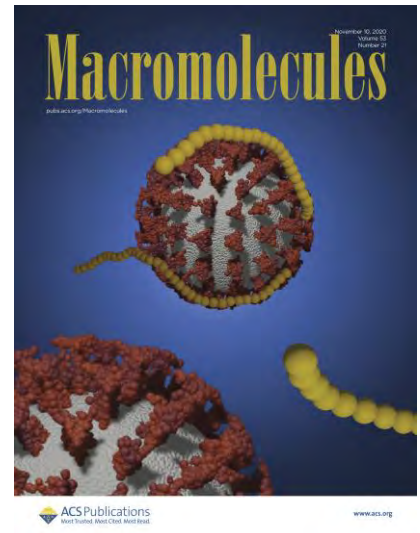
Antiviral polymers remain unexplored as approaches to treating most viral diseases

Cross-disciplinary collaboration is important

Opportunities abound

For More Information

"Antiviral Polymers:
Past Approaches and Future Possibilities"
Bianculli, R. H.; Mase, J. D.; Schulz, M. D.
Macromolecules **2020**, *53*, 21, 9158



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Andy Brenner
Agustin Fiorito
Andrew Bigelow
Samantha Scott
Grace Dinges
Alex Coley
Piper MacNicol
Javier Ortiz Alvarado

CDZAP Center for Emerging, Zoonotic, and Arthropod-borne Pathogens
NSF
ACS PRF
ARL

3M Science. Applied to Life.™

Polymers of the Pandemic: Detrimental Effects of Decontamination Methods on Polymers in Respirators

Emilie Rexeisen, PhD
Product Engineering Specialist, 3M

June 16, 2021

3M at a glance

- Sales in nearly every country
- $32.1 billion in sales
- Four business groups
- 96,163 3Mers globally
- 122,416 patents
- 100+ straight years of dividends
- One of 30 companies on the Dow Jones Industrial Index

3M

Our four Business Groups

Safety & Industrial

Transportation & Electronics

Health Care

Consumer

3M

3M Value Model

Vision

3M Technology Advancing Every Company
3M Products Enhancing Every Home
3M Innovation Improving Every Life

Strengths

- Technology
- Manufacturing
- Global Capabilities
- Brand

Priorities

- Portfolio
- Transformation
- Innovation
- People & Culture

Values

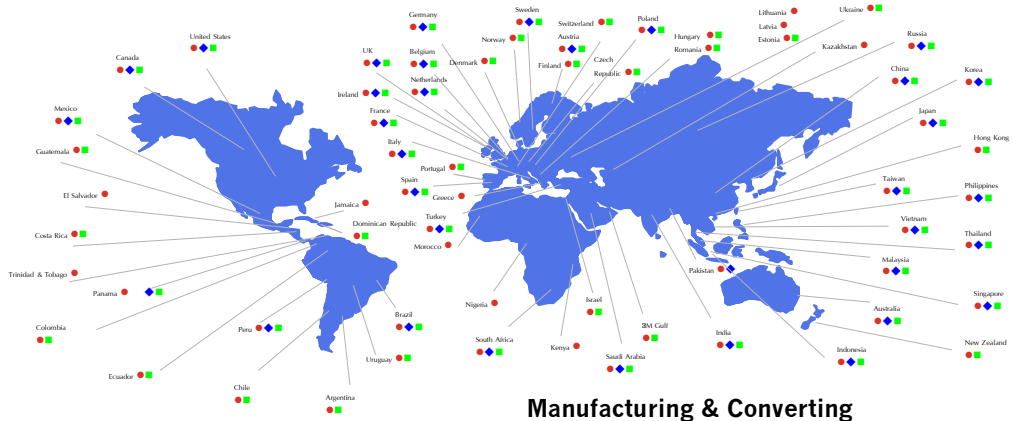
Inclusion
Diversity
Sustainability
Respect, encourage, challenge

3M

2021 Global Capabilities

Sales in 200 countries

Sales & Marketing Operations in 68 countries



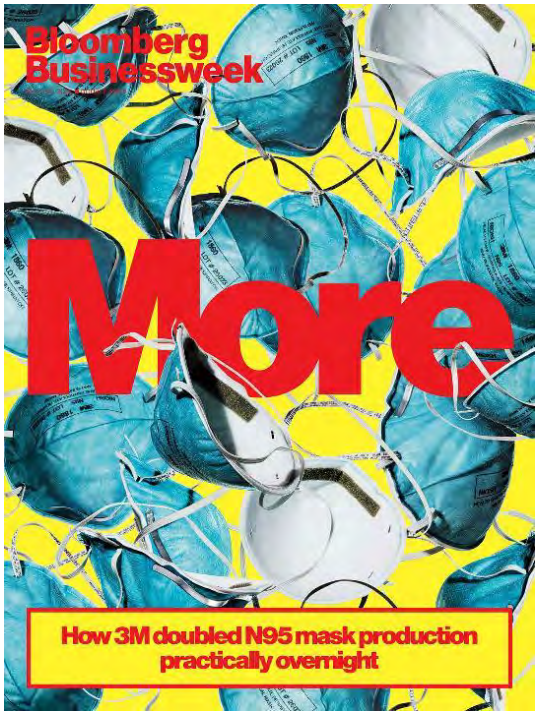
Laboratory & Application Engineering in 55 countries

Manufacturing & Converting in 34 countries

Key
- Sales & Marketing
- Manufacturing & Converting
- Technical Capabilities

V 1.15.2021

3M



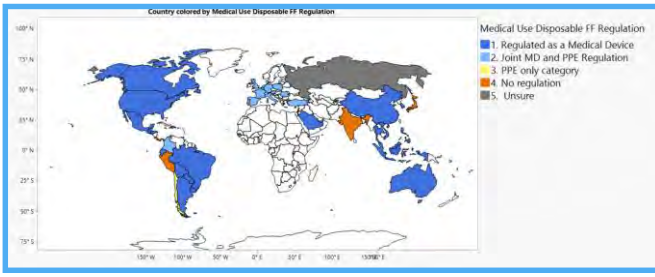
Challenge

Unprecedented demand for PPE far exceeding supply for the entire industry

- Manufactured 2B+ respirators in 2020 – more than tripling the volume in 2019 with goals to quadruple in 2021
- Producing over 95M respirators per month in US alone
- Plants running 24/7 making more respirators than ever before
- Resources from the entire corporation mobilized to scale-up new lines, qualify multiple raw material sources, commercialize new models, and meet all regional regulatory requirements
- Researched ways for hospitals to decontaminate, reuse, and extend the life of N95 respirators
- Working with governments to break down trade barriers and direct respirators to serve areas of the world most in need
- Launched a global effort to combat fraud and price gouging and help protect the public against those who try to exploit the unprecedented demand

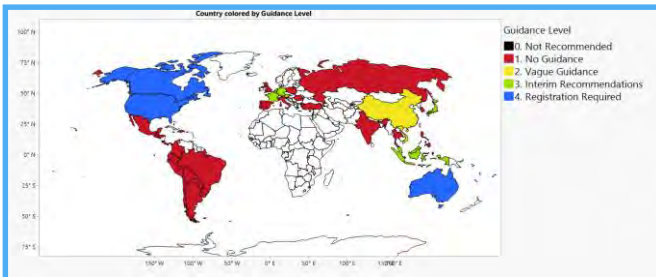
3M

Global Regulatory Landscape for FFRs and Decontamination



Regulation of FFRs in Health Care setting:

- Many countries regulated as Medical Devices or Personal Protective Equipment or both
- During COVID-19, Health Ministries were accelerating use of additional N95 level respirators into hospitals, including those most often used in industrial applications
- Opportunity to assess reusable respirators for broader use in health care settings



Guidance on Decontamination of FFRs as respirator conservation strategy:

- US CDC and FDA have established formal EUA process for decontamination systems with confirmation of efficacy and safety of decontamination method, and respirator fit and filtration performance.
- Japan, Canada, Australia have adopted elements of US approach
- Many countries allow health care providers to determine conservation strategies

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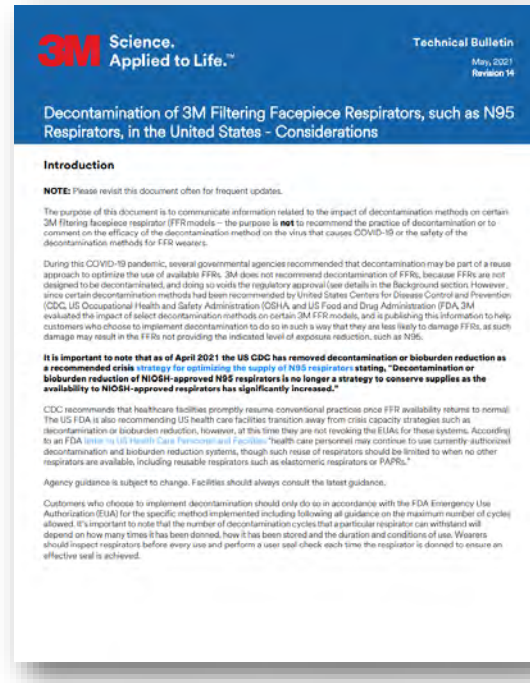
Can I decontaminate FFRs?

Per OSHA, decontamination of FFRs is only permissible for **healthcare** workplaces during certain crisis capacity circumstances.

As of April 2021, the US FDA has recommended workplaces to transition away from decontamination.

https://multimedia.3m.com/mws/media/1824869O/decontamination-methods-for-3m-n95-respirators-technical-bulletin.pdf

- 3M does not recommend decontaminating FFRs.
- Decontamination does not extend the service life of FFRs.



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Technical Bulletin
May, 2021
Revision 14

Decontamination of 3M Filtering Facepiece Respirators, such as N95 Respirators, in the United States - Considerations

Introduction

NOTE: Please revisit this document often for frequent updates.

The purpose of this document is to communicate information related to the impact of decontamination methods on certain 3M filtering facepiece respirator (FFR models – the purpose is **not** to recommend the practice of decontamination or to comment on the efficacy of the decontamination method on the virus that causes COVID-19 or the safety of the decontamination methods for FFR wearers.

During this COVID-19 pandemic, several governmental agencies recommended that decontamination may be part of a reuse approach to optimize the use of available FFRs. 3M does not recommend decontamination of FFRs, because FFRs are not designed to be decontaminated, and doing so voids the regulatory approval (see details in the Background section. However, since certain decontamination methods had been recommended by United States Centers for Disease Control and Prevention (CDC, US Occupational Health and Safety Administration (OSHA and US Food and Drug Administration (FDA, 3M evaluated the impact of select decontamination methods on certain 3M FFR models, and is publishing this information to help customers who choose to implement decontamination to do so in such a way that they are less likely to damage FFRs, as such damage may result in the FFRs not providing the indicated level of exposure reduction, such as N95.

It is important to note that as of April 2021 the US CDC has removed decontamination or bioburden reduction as a recommended crisis strategy for optimizing the supply of N95 respirators stating, "Decontamination or bioburden reduction of NIOSH-approved N95 respirators is no longer a strategy to conserve supplies as the availability to NIOSH-approved respirators has significantly increased."

CDC recommends that healthcare facilities promptly resume conventional practices once FFR availability returns to normal. The US FDA is also recommending US health care facilities transition away from crisis capacity strategies such as decontamination or bioburden reduction, however, at this time they are not revoking the EUAs for these systems. According to an FDA letter to US Health Care Personnel and Facilities "health care personnel may continue to use currently authorized decontamination and bioburden reduction systems, though such reuse of respirators should be limited to when no other respirators are available, including reusable respirators such as elastomeric respirators or PAPRs."

Agency guidance is subject to change. Facilities should always consult the latest guidance.

Customers who choose to implement decontamination should only do so in accordance with the FDA Emergency Use Authorization (EUA) for the specific method implemented including following all guidance on the maximum number of cycles allowed. It's important to note that the number of decontamination cycles that a particular respirator can withstand will depend on how many times it has been donned, how it has been stored and the duration and conditions of use. Wearers should inspect respirators before every use and perform a user seal check each time the respirator is donned to ensure an effective seal is achieved.

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Evaluation of Decon Method Compatibility with 3M FFRs

Efficacy
- Must inactivate target organism

Safety
- Must be safe for person wearing respirator

Filtration
- Must not damage respirator's filtration

Fit
- Must not negatively affect respirator's ability to seal to the wear's face

3M relied upon the decontamination method developer to confirm the germicidal efficacy of the method

If filtration is damaged or the respirator does not fit, it will not help reduce exposure to airborne particles at the level indicated

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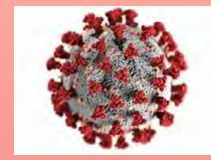
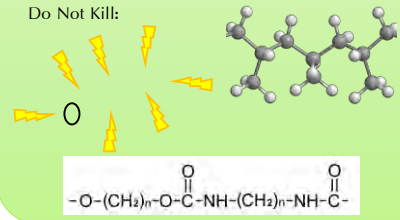
Kill:



Do Not Kill:



Potential Disinfection Methods:

- Soaps/Detergent
- Chemical Disinfectants
- Heat
- Ethylene Oxide (EO)
- UV-C
- H2O2 vapor
  H2O2 gas plasma
- Ozone
- Ionizing Radiation
- Chlorine Dioxide
- Plasma

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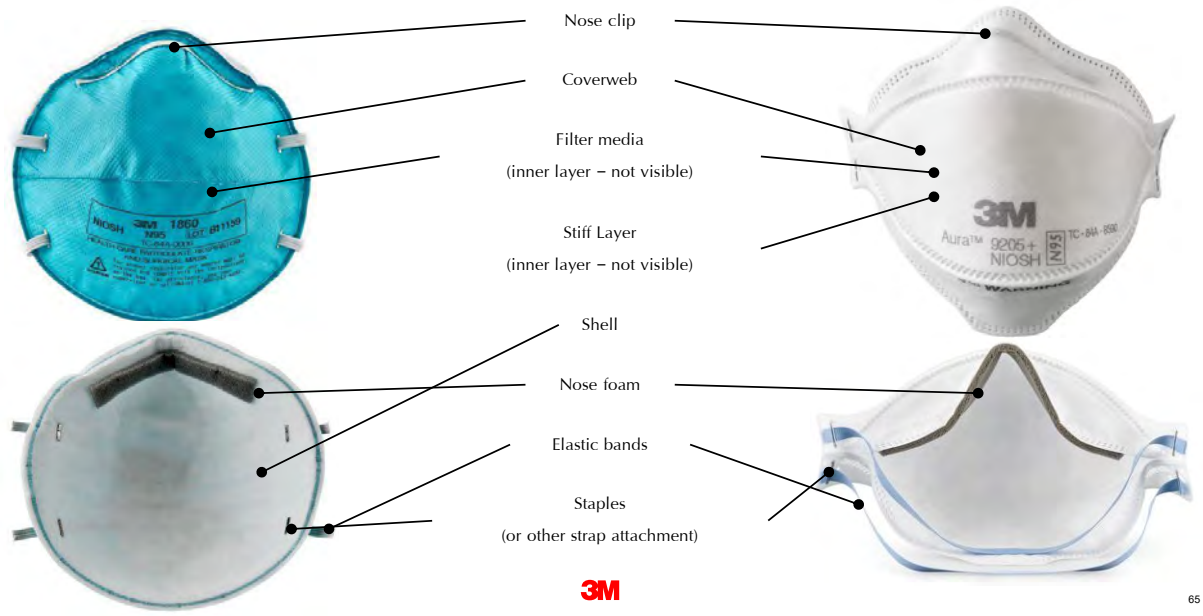
Respirator Components



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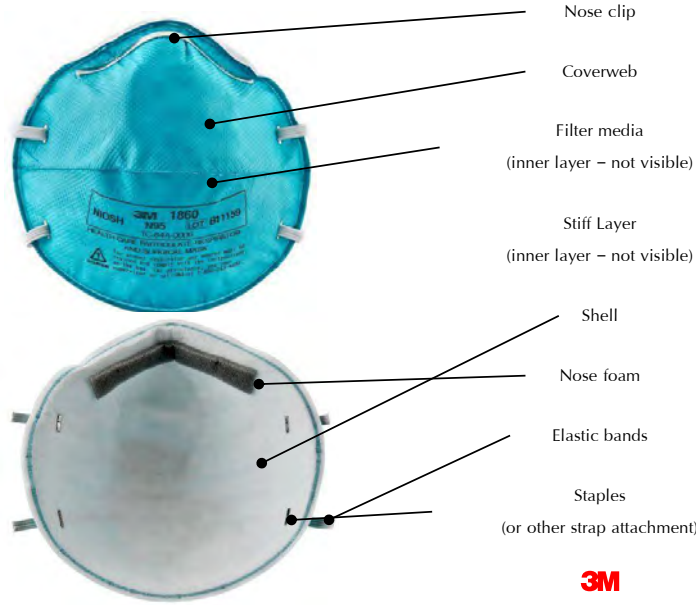
Respirator Components



Impact on filter

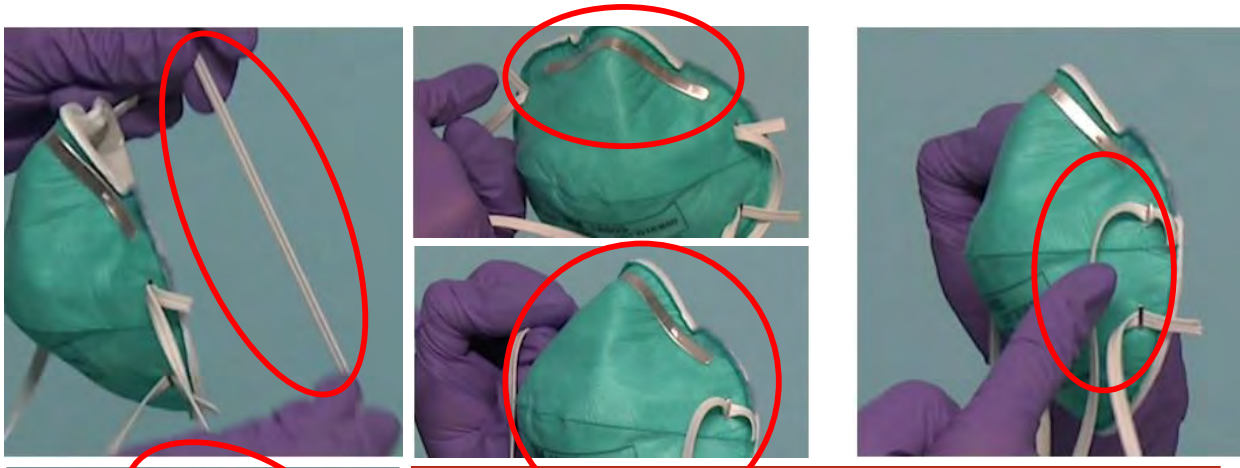
Validation conducted using automated filter tester such as the TSI Automated Filter Tester 8130, used in generating filter data for meeting NIOSH standard 42 CFR part 84, Respiratory Protective Devices or European standard EN 149.

Impact on fit

Assessments are made of:

- nosefoam
- headbands
- cup condition

66



Inspection for reuse

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Audience Survey Question

ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT

Which respirator component is adversely affected by heat?

- Noseclip
- Coverweb
- Filter media
- Shell
- Nosefoam

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*3M is not assessing residuals or decontamination efficacy.

UV, VHP, Heat Methods

Method	Filter Media	Elastic	Nose foam	Shell	Residuals	3M Conclusions
UV-C		Can degrade at high high cycles				Maximum 100J/cm2 total exposure
VHP (if VHP is used in combination with another with another method, refer to both lines) both lines)					***	Straight VHP ok. VHP+plasma needs to be tested
Low Temp Moist Heat (65°C)			Can delaminate			Ok. Process flatfolds flat
Dry Heat (90-100°C)	Slightly Degrades filtration filtration efficacy		Can delaminate	Cup-style shrinks above 90°C above 90°C		Temperature control is important. Filtration efficiency decreases with Temperature*Time Temperature*Time
Microwave Generated Steam				Melting near metal components – creates holes creates holes		No Not well controlled
High Temp Steam (121°C)	Degrades filtration efficacy filtration efficacy		Becomes sticky, loses loses elasticity w/ multiple multiple cycles	Shrinks – will lead to leaks in to leaks in cup style style		Only for Aura or VFlex-styles, only 1 cycle

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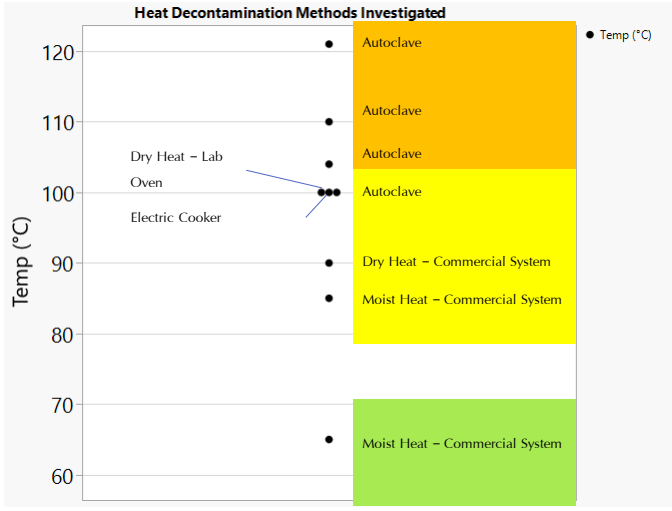
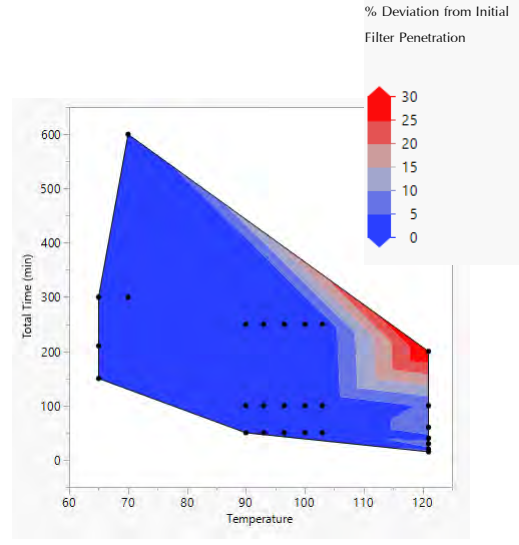
Heat Decontamination Methods





Filtration performance can be affected at high temperatures, especially at long exposure times.

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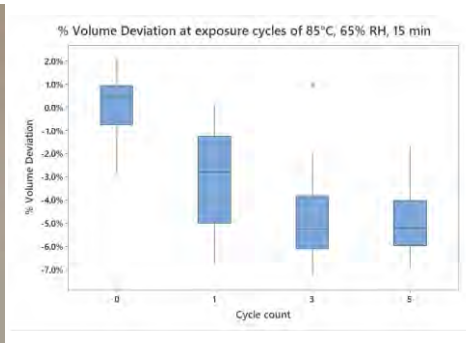
High temperatures cause shrinkage of shell.

At high temperatures, the respirator shrinks considerably, which compromises fit.



Even at moderate temperatures, a 5% shell shrinkage can be observed.

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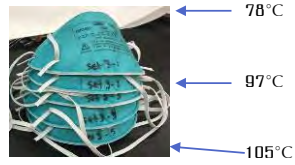
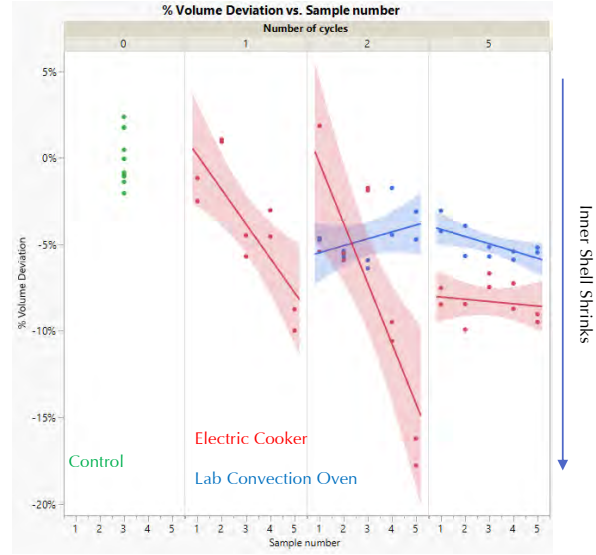
Electric Cooker provides inconsistent temperature profile, which leads to shell shrinkage.



Temperature varied significantly throughout the stack.



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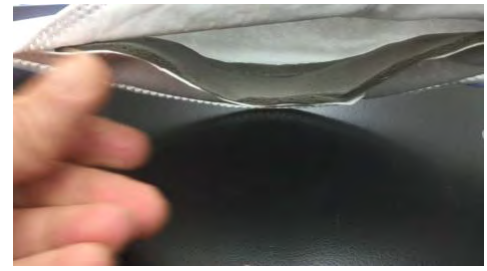
Effect of 121°C of PU foam

Control

2 cycles



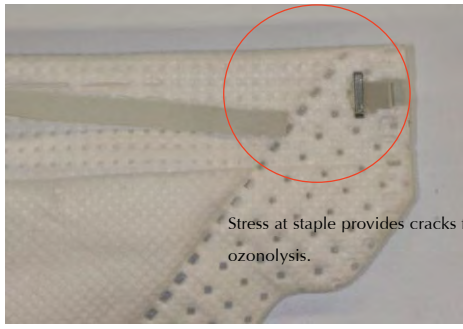
10 cycles

*3M is not assessing residuals or decontamination efficacy.

Other Chemical & Radiation Methods

Method	Filter Media	Elastic	Nose foam	Shell	Residuals	3M Conclusions
Ozone		Loses elasticity after 1 cycle	Loses elasticity after 1 cycle		***	No
Chlorine dioxide		Loses elasticity after multiple cycles	Loses elasticity after multiple cycles		***	Residuals unknown. Low cycle counts (≤1)
Plasma (chemical dependent)	Can degrade filtration efficacy	Can affect if creating ozone	Can affect if creating ozone			Test each individually
Ionizing Radiation (gamma, e-beam, X-ray)	Degrades filtration efficacy					No
Isopropanol	Degrades filtration efficacy filtration efficacy					No
Supercritical CO2	Degrades filtration efficacy filtration efficacy			Cup-style shrinks		No
Soaps/Detergent	Degrades filtration efficacy filtration efficacy					No
Quat solution	Degrades filtration efficacy filtration efficacy				***	No
Ethylene Oxide	N/A	N/A			***	No

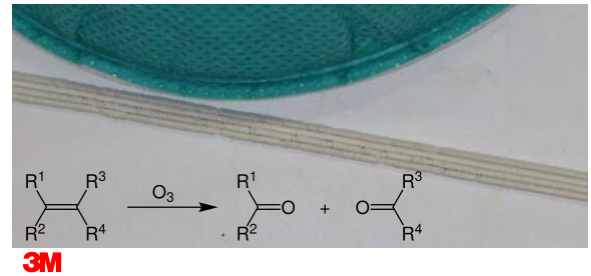
Rubbers are susceptible to ozone cracking.



Stress at staple provides cracks for ozonolysis.

Common phenomena in tires and natural rubber tubing.

By Pawelmok at English Wikipedia - Own work, Public Domain



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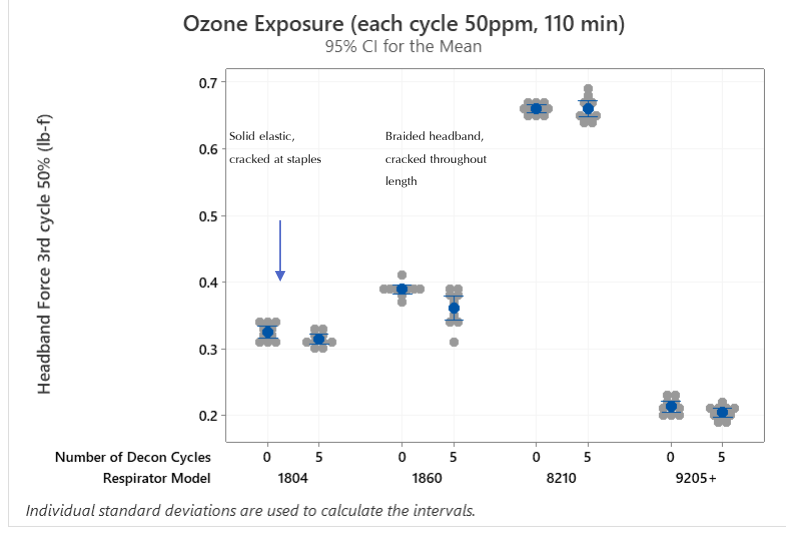
Changes in elastic band force with exposure to ozone.



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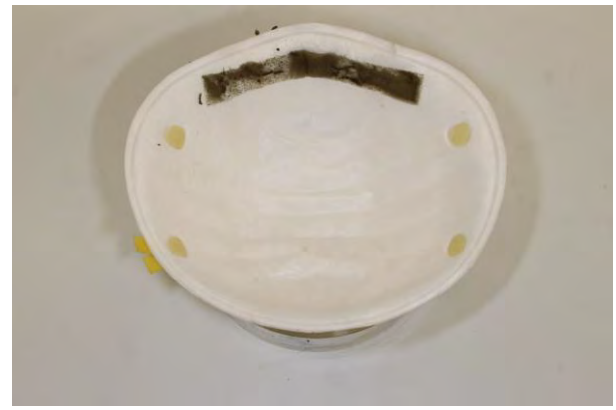
Ozone degradation of nosefoam

Nosefoam after 1 cycle loses ability to recover to full thickness, which compromises fit performance.



After multiple cycles, nosefoam degrades completely.

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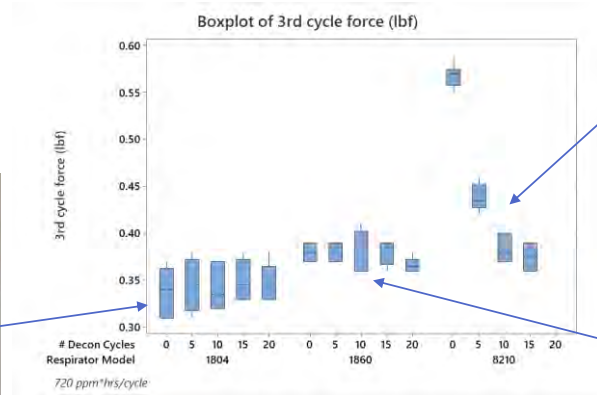
Chlorine Dioxide Decontamination

Different headband materials react differently to exposure to chlorine dioxide.



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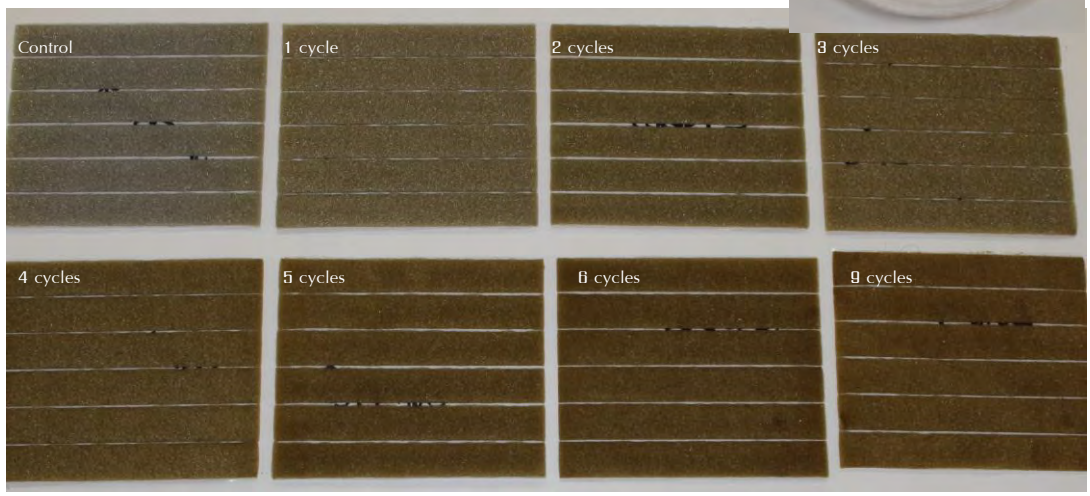
Chlorine Dioxide Yellowing of Nosefoam



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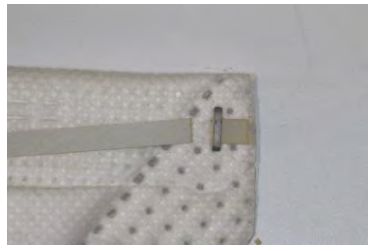
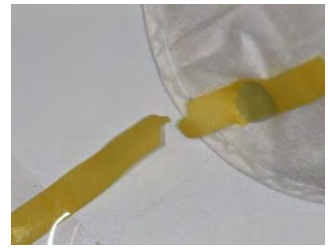
Plasma exposure effects are dependent upon chemical species created.

Treatment #1

Treatment #2





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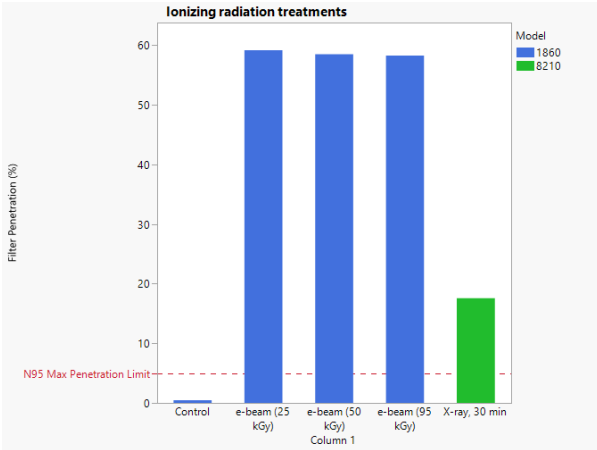
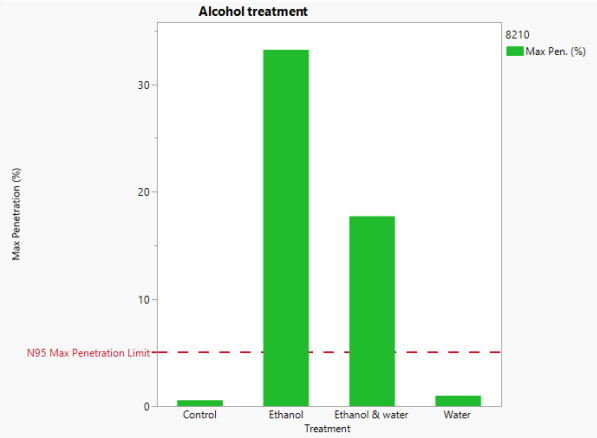
Ionizing radiation and chemical disinfectants destroy electrostatic filtration.





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Pandemic Lessons Learned

3M is sharing expertise on how to better prepare for future pandemics and emergencies with governments, customers, and stakeholders around the world.

- 3M rose to the challenge of COVID-19 drawing from our years of experience responding to other global challenges.
- COVID-19 has been a test of national preparedness plans and demonstrated how supply chains, governments, and health care systems can be stretched beyond their limits by the unexpected.
- 3M proudly partnered with governments around the world to expand N95 and other respirator production capacity including in North America, Europe and Asia to help those regions respond to the pandemic and build resiliency to face global challenges.

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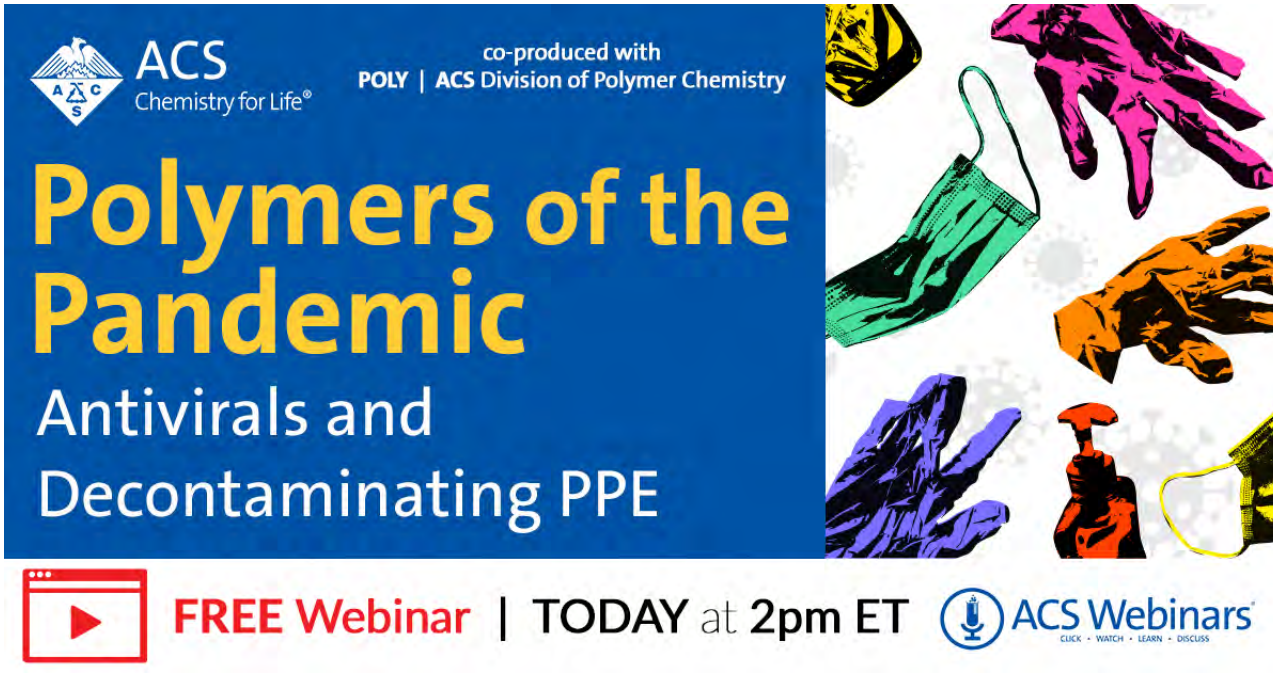

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