NEXT STEPS IN MATERIALS ENGINEERING (Behind the Scenes Work)

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WHAT SHOULD BE THE NEXT STEPS IN MATERIALS ENGINEERING?

- Direction of Materials Development should be based on identification & closing of any known/potential “gaps” in performance, or needed improvements in PPE

- Gaps & improvements may include:
  - Comfort
  - Performance
  - Fit

MATERIALs ADVANCEMENTS HAVING POTENTIAL USE IN PPE (Others Exist)

- Shape Memory Polymers
- Amino-based Polymers containing anti-viral agent
- Crystallized Zeolites for Fabrics
- Nano-encapsulated urethane elastomers

SHAPE MEMORY POLYMERS
Potential Applications

- Potential means of achieving improved Comfort & Fit
- More Breathable Garment Material

SHAPE MEMORY POLYMERS

- May be composed of two polymer components phases, one with higher MP, & another with lower MP or Tg
- Have capability of changing their shape in response to temperature
- Material deformed to shape, but takes on different physical shape when heated to temperature above that of the lower softening/melting temperature component, (but below that of the higher melting point component)

SHAPE MEMORY POLYMERS
Use in PPE

- Potential use as membrane laminate to regulate garment cooling
- Laminate activated by thermal vibrations
- When body temperature rises above “preset temperature” (controlled by molecular structure & Mw), micropores are formed that permit heat & water vapor to escape
- Permeability increases as body temperature rises, helping to maintain wearer’s comfort
- When body temperature drops below specified temperature, the molecular structure “closes”, retaining heat of the wearer

SHAPE MEMORY POLYMERS
More Breathable Garment Material

- Shape memory fibers
  - "Open-ness" of fabric changes in response to temperature, possibly resulting in desirable thermal & moisture transport characteristics

- LLNL
- Georgia Institute of Technology
- Mitsubishi
- Dupont

MOLDABLE THERMOPLASTICS HAVING ANTIVIRAL CAPABILITIES

- Amino-based polymeric compounds containing Ag^{+} have been developed which are purportedly effective against viral agents
- Ions homogeneously distributed & “locked into resin matrix” of molded part
- Consequently, may provide protection for lifetime of molded component

MOLDABLE THERMOPLASTICS HAVING ANTIVIRAL CAPABILITIES

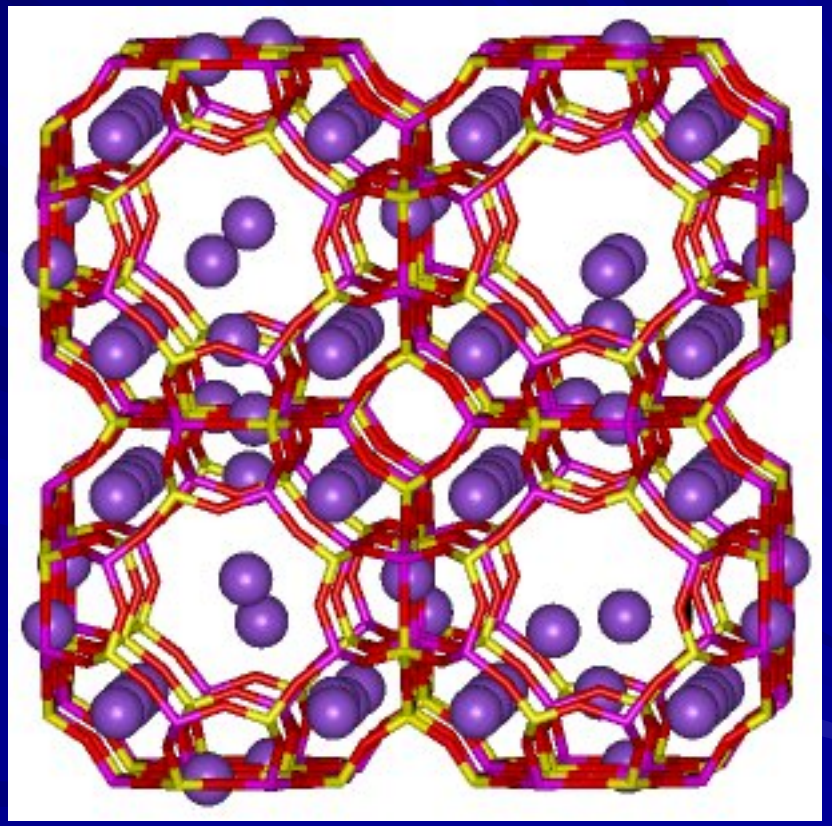
- Can this technology be exploited, & incorporated into other polymeric compounds & synthetic fabrics used in PPE?

ZEOLITE/COTTON BLEND FABRICS

- Zeolite/cotton blend complex has been developed which supposedly has ability to inactivate viral agents
- Positive ions within Zeolite held “loosely”, & can be readily exchanged for other ions having antimicrobial activity

ZEOLITE/COTTON BLEND FABRICS

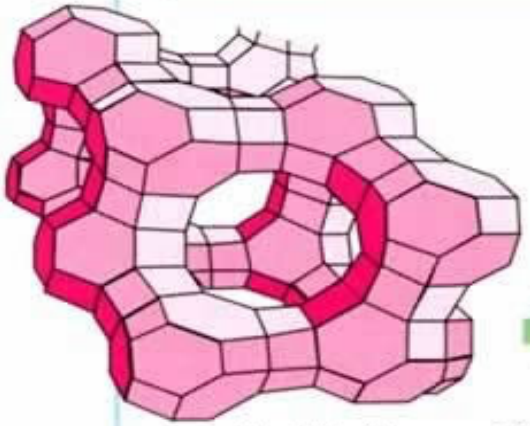
- "Open" structure of Zeolite
- Purple spheres represent loosely-bound" positive ions such as Na^{+}, K^{+}, Ca^{2+}, & Mg^{2+}

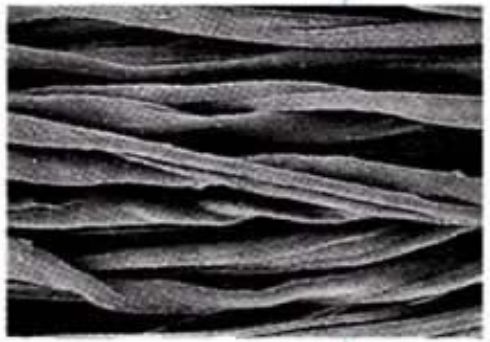


ZEOLITE/COTTON BLEND FABRICS

- Zeolite liquor crystallized within interior of cellulose fibers of cotton fabric
- Through ion-exchange process, metal ions (e.g., Ag^{+}, Cu^{2+},) introduced into Zeolite structure
- Claimed that 99% of bird flu virus inactivated after contact with treated fabric for 10 minutes

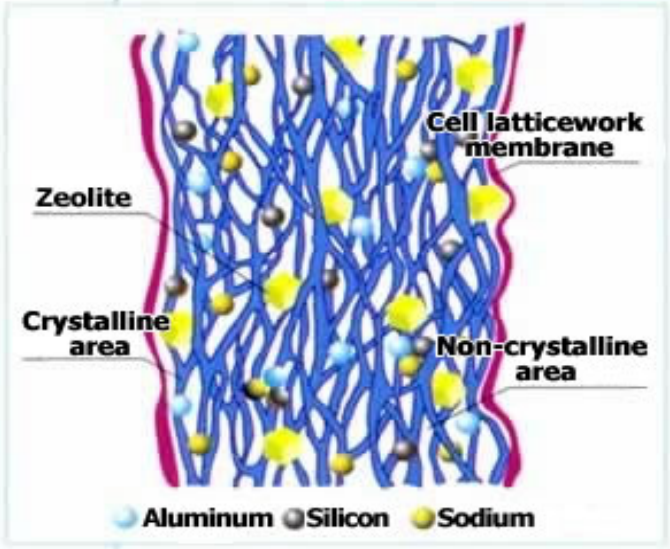
Zeolite synthesis occurs in-between cellulose molecules

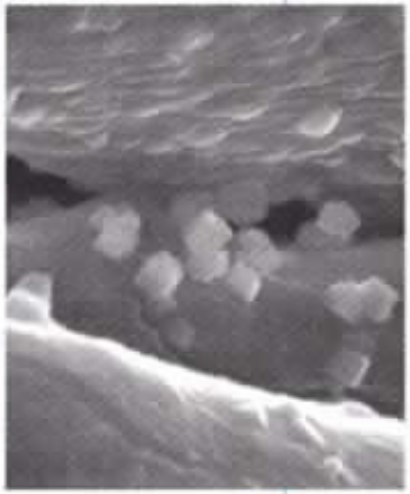




Zeolite (inorganic) Cotton (organic)

Inorganic cotton complex





How Does One Confirm the Effectiveness of Materials Technologies for Use in PPE to be Used Against Influenza?

DEVELOPMENT OF TESTING PROTOCOL

- No protocol exists to qualify/quantify effectiveness of filtering facepieces (possibly other garment material) against airborne droplets containing influenza related agents

- Standardized testing methods would enable materials researchers & manufacturers of PPE to confirm/compare effectiveness of each of these technologies

EXAMPLE OF TESTING PROTOCOL

- Challenge virus: Influenza or surrogate
- Size of droplet: $\leq 10\mu m$
- Concentration of droplets: TBD (literature states that as many as 40,000 virions can be dispersed into the air when an individual sneezes).
- Air flow rate: Adjusted to give a face velocity of approximately 229 cm/sec (equivalent to the peak air velocity through a respirator, when an individual is sitting in a relaxed state, breathing through a respirator at an air flow rate of 10 lpm)
- Relative humidity = $50 \pm 5\%$RH
- Temperature = $23 \pm 2^{o}C$
- Duration of exposure = 8 hours

OTHER MATERIALS CONSIDERATIONS

- Pose no respiratory or skin contact hazard (some antimicrobial particles may become airborne during fabrication of PPE. Could some of antimicrobial particles become dislodged from filter or garment during use)
- Cause no deterioration of physical properties/appearance of PPE
- Be odor-free
- Resistant to other chemical agents in workplace
- Remain in stable active state throughout the life of PPE
- Pose little or no hazard to environment
- Meet all relevant, if any, government standards, &
- Not cost prohibitive

CONCLUDING REMARKS

- Opportunities, through materials advancements, exist to improve the comfort, performance & possibly fit of PPE

- These technologies require further study, optimization & validation

CONCLUDING REMARKS

- Available information on aforementioned materials technologies suggests that they have some level of effectiveness against influenza-associated agents

- However, only limited or no data has been provided on their effectiveness when incorporated into media used for filtering facepieces or other protective garment applications

CONCLUDING REMARKS

- Over the years PPE manufacturers have developed & implemented new materials to meet user needs

- Such improvements are generally driven by market needs, and/or government requirements (certification standards)

CONCLUDING REMARKS

- Recommended that knowledgeable group of stakeholders-why we're here!
  - Review HCW needs
  - Identify potential "gaps", or desired improvements in PPE technology
  - Examine material advancements, &
  - Establish strategy which ultimately leads to PPE which provides HCW with needed level of protection

QUESTIONS?