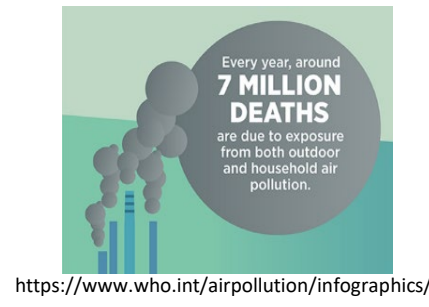


# Development of an Engineered Face Mask with Optimized Nanoparticle Layering for Filtration of Air Pollutants and Viral Pathogens

## Research Problem

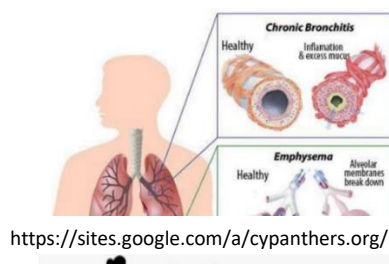
Air pollution is a major contributor to global deaths

7 million deaths every year due to air pollution, 99% of people live in places exceeding air quality limits



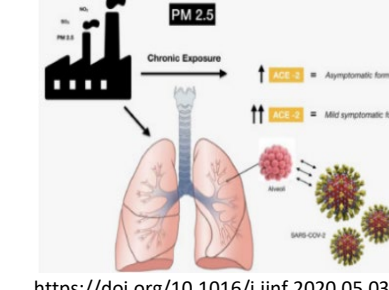
PM<sub>2.5</sub> causes several health disorders

PM<sub>2.5</sub>, a major pollutant, can cause cardiovascular and respiratory diseases



COVID-19 cases are strongly correlated to air pollution

11% increase in mortality from COVID-19 infection for every 1µg/m<sup>3</sup> increase in air pollution

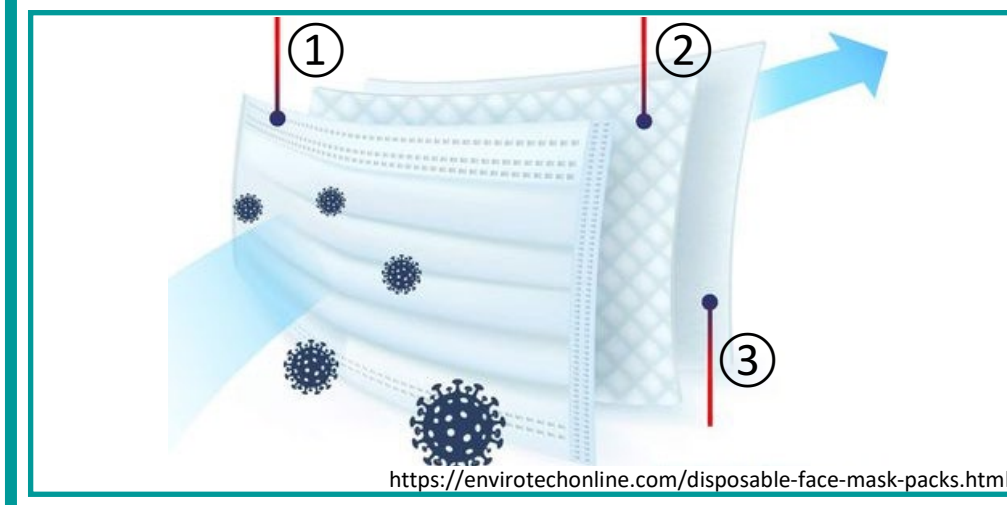


Face masks are critical, but contribute to plastic pollution

>8 million tons of pandemic-associated plastic waste have been generated globally

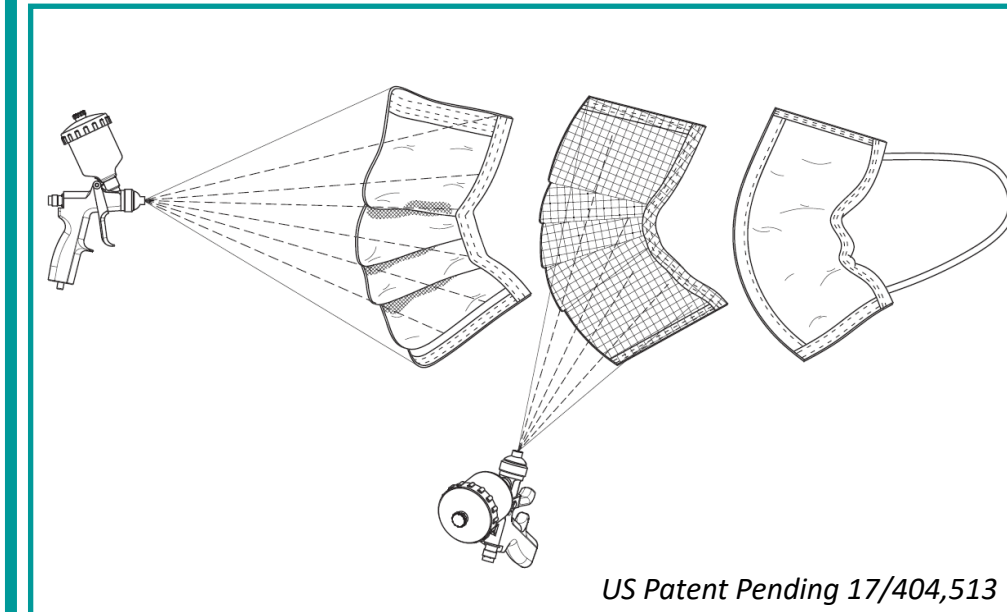


## Solution Concept



Typical Masks have 3 layers:

- Outer non-woven fabric ⇒ moisture absorption
- Middle melt-blown electret layer ⇒ adsorption
- Inner soft non-woven layer ⇒ vapor/mist absorption

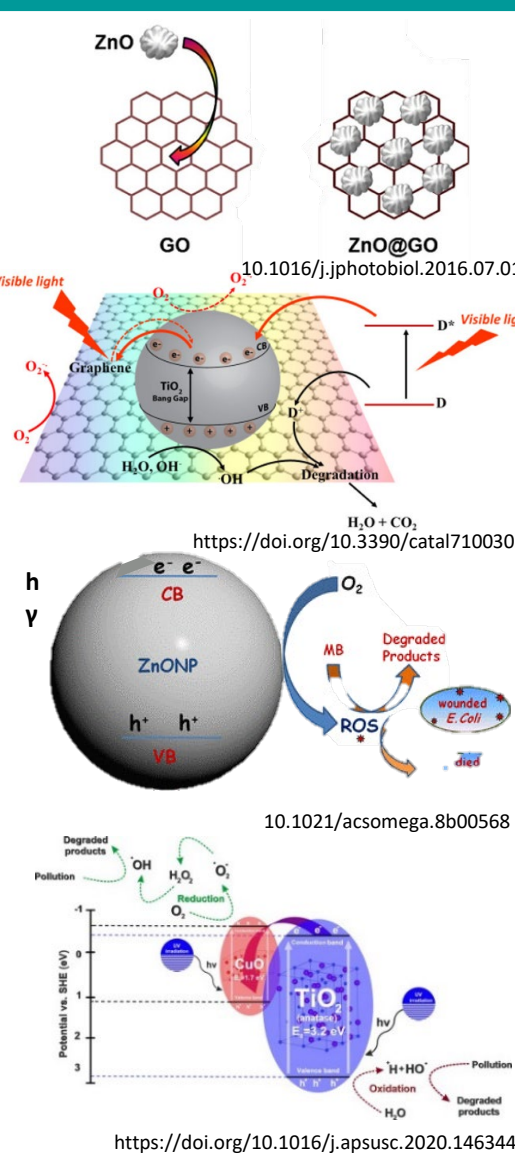


Dual layer nanoparticle coating

Outer Layer	SiO <sub>2</sub> Desiccant, Adsorption
Middle Layer	Gr., ZnO, TiO <sub>2</sub> , CuO Adsorption, Filtration, Virucidal

## Nanoscience

- Graphene:** Hexagonal lattice structure, promotes adsorption and platform for other nanoparticles
- TiO<sub>2</sub>:** Antibacterial and photo-catalytic properties with low toxicity, not susceptible to photo-corrosion
- ZnO:** Generates Reactive Oxygen Species (ROS), low toxicity, used in pill coatings and cosmetics
- CuO:** Enhances photo-activity by lowering band-gap. Slow release of Cu<sup>2+</sup> → long-lasting virucidal activity
- SiO<sub>2</sub>:** Desiccant & adsorption capabilities with large specific area, increased virucidal property

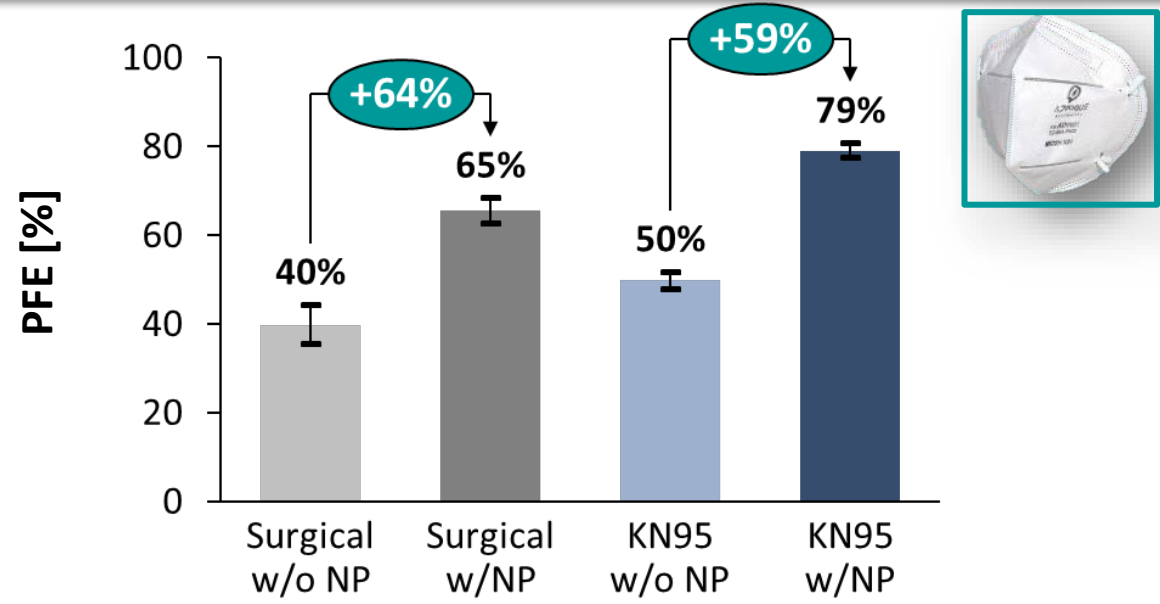


## Applications

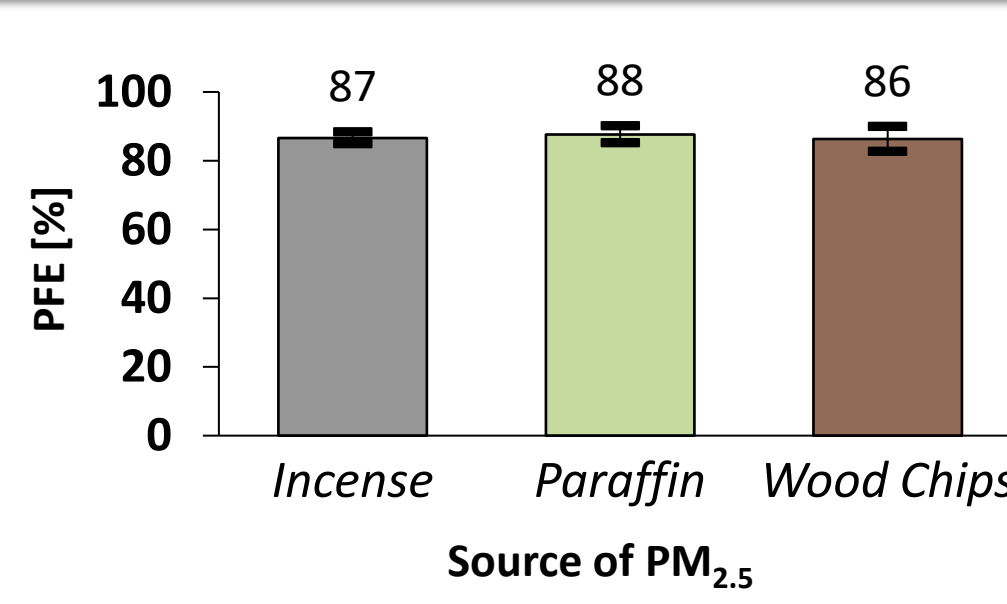
- Anti-viral and anti-bacterial:**
  - PPE for frontline medical personnel
  - PPE for airborne viruses / allergies
  - Air filters for medical facilities
- Air pollution protection for:**
  - Heavily polluted cities
  - Forest fire prone areas
  - Firefighter equipment
- Indoor air filters and car cabin filters**
- Industrial pollution control systems**



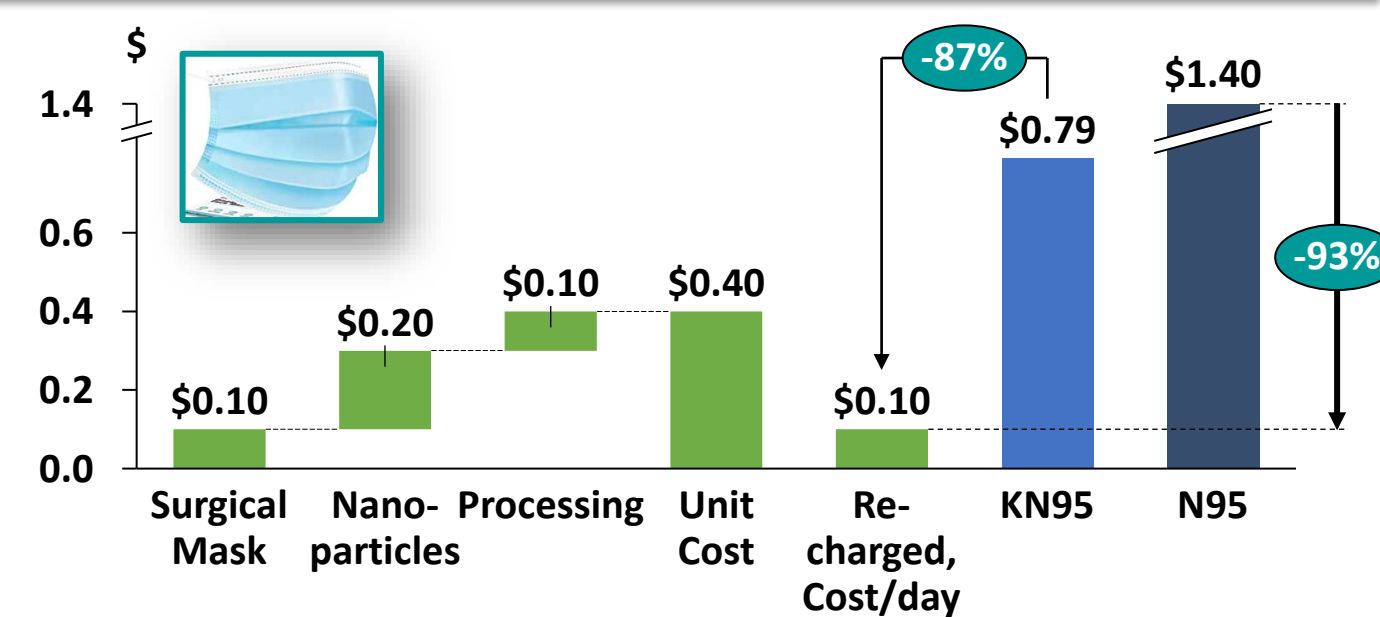
## Results



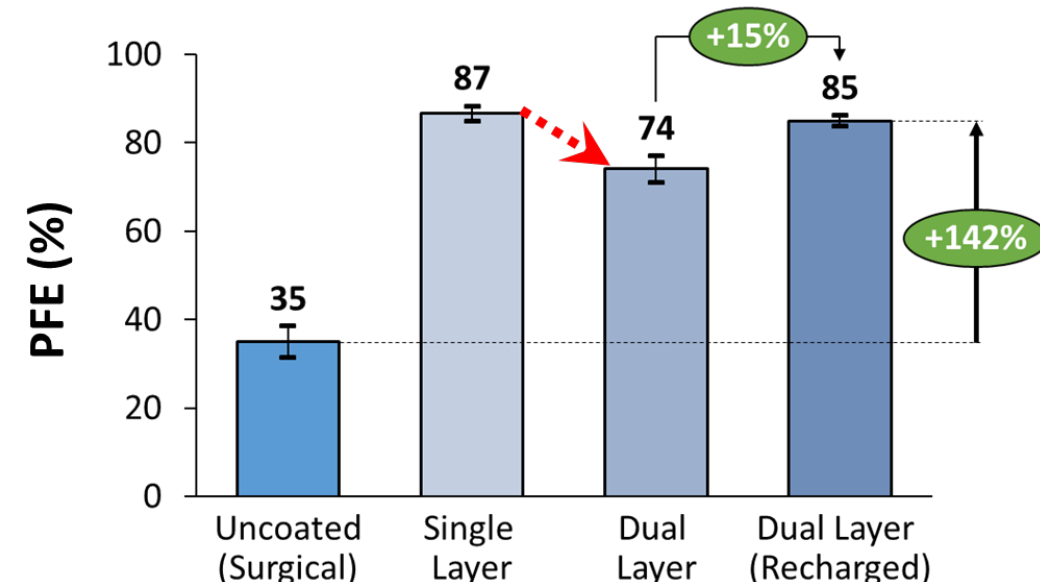
Filtration efficiency improved by ~60% with nanoparticle coatings on masks



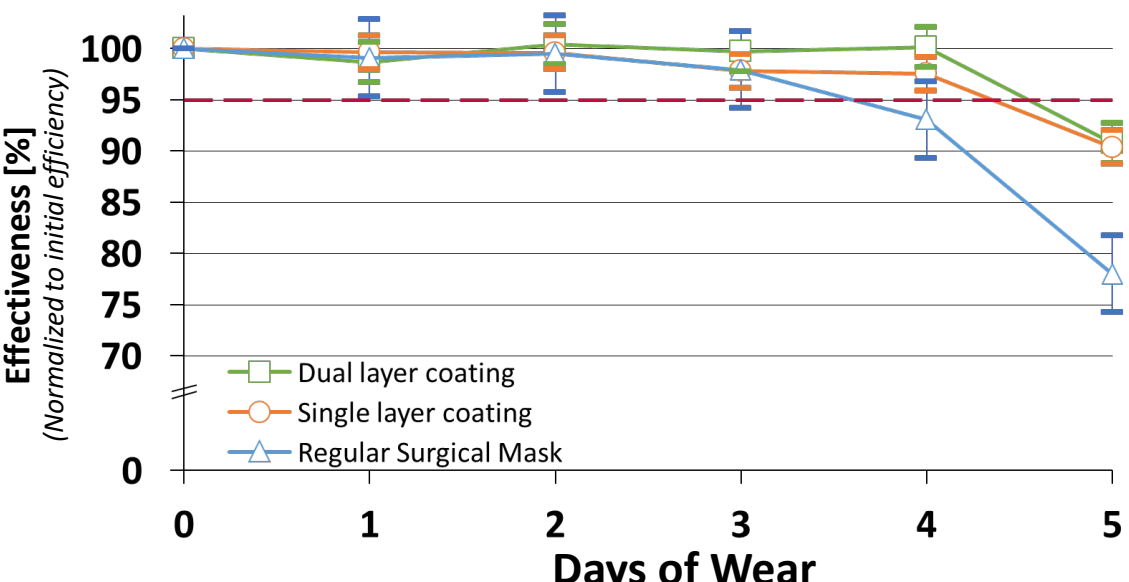
PFE was independent of the source of PM<sub>2.5</sub>, demonstrating versatility



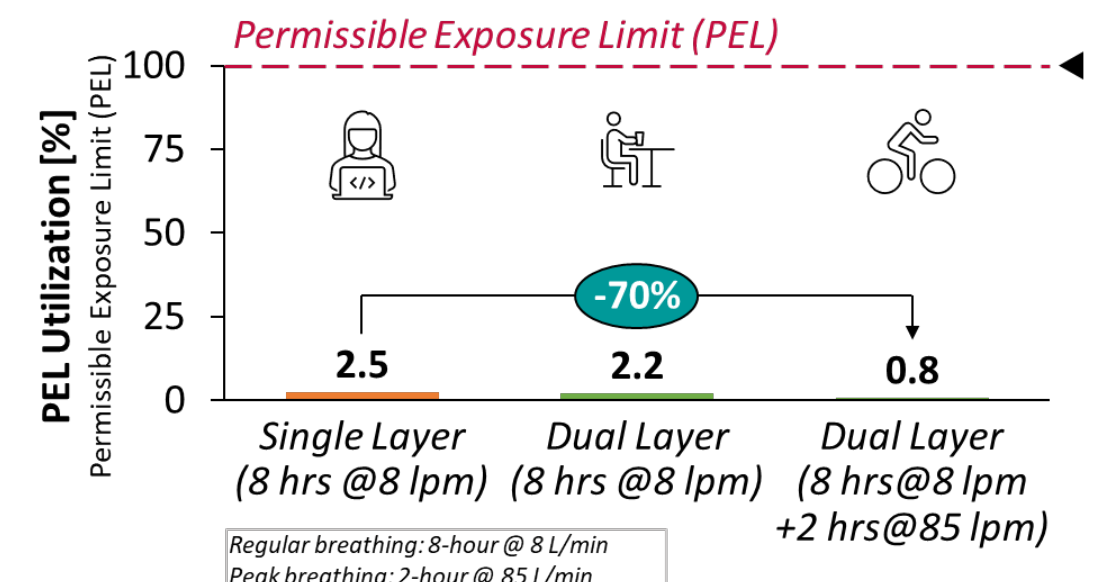
Nanoparticle coated surgical masks are ~90% less expensive than an N95 mask



Recharging the mask restored filtration efficiency by 15%



~95% effectiveness maintained over 4 equivalent days of mask wear



Nanoparticle coated masks well within OSHA specified exposure limits

Nanoparticle coated 'Engineered Masks' are Efficient, Versatile, Cost-effective, Rechargeable, Durable & Safe