

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

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During the COVID-19 pandemic, face masks have become a critical part of the personal protective equipment for front-line workers and the public, resulting in an acute shortage of effective and affordable masks. Recent studies also indicate a strong correlation between ambient air pollution and COVID-19 cases. Air pollution from particulate matter less than 2.5 microns (PM<sub>2.5</sub>), is a significant contributor to cardiovascular and respiratory diseases. This project's goals are to develop an engineered face mask with an optimized layering of nanoparticles to filter PM<sub>2.5</sub> and viral pathogens. Furthermore, the objective is to develop a cost-effective solution for face masks that are reusable and clinically safe. The nanoparticles were selected based on their filtration, virucidal, and non-toxic properties. Particle filtration efficiency (PFE) was tested with PM<sub>2.5</sub> from incense sticks measured by laser particle detectors. Virus Filtration Efficiency (VFE) was tested using nebulized NaCl particles as a virus surrogate. Both PFE and VFE improved by ~140% with nanoparticle coatings. The filtration efficiency was independent of the source of PM<sub>2.5</sub>, demonstrating versatility. PFE for engineered masks, with dual-layer nanoparticle coatings, initially declined but was restored by recharging the mask. The nanoparticle retention efficacy, improved by 70% with the dual-layer coating, was well within the permissible exposure limits per OSHA standards. An accelerated durability test demonstrated ~95% effectiveness maintained over 4 equivalent days of wear. This rechargeable and multi-purpose mask can be effective in polluted cities, in fire-prone areas and can protect people against the deadly effects of viruses in a cost-effective way.