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 (PM2.5), 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 PM2.5 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 PM2.5 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 PM2.5, 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.