Design of a mask insert for transmission-based detection of SARS-CoV-2.

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Introduction: The use of face masks to reduce person-to person spread of infectious diseases has become increasingly apparent and significant in light of the recent COVID-19 pandemic. Molecular based PCR detection techniques generally use samples that come from respiratory track fluids such as saliva or nasal swabs. The sensitivity of these testing methods along with the known consideration that respiratory droplet carry the virus suggests that detection within a used mask is achievable.[1] We seek to develop a mask insert and test the hypothesis that exhaled respiratory droplets contain detectable biological materials and may be useful for monitoring asymptomatic infection in masked individual, particularly for SARS-CoV-2.

Methods: Because poly(vinyl alcohol) (PVA) fibers are readily dissolved in water during processing, we focused on development using this material. In some designs, we also incorporated micro-scaled magnetic beads to ensure high efficiency collection of genetic material.[2] PVA of different molecular weights (MW) and degree hydrolysis (DH) were dissolved in H_2O with or without suspended Dynabeads magnetic beads and processed by electrospinning to form a large array of randomly aligned nano-scaled fibers. They were then cut into individual 1”x1” squares for use as mask inserts. Deposition patterns were imaged by SEM and quantitatively assessed with ImageJ for fiber diameter and pore area. Complete solubility of the substrates in an aqueous solution was measured. Inserts were worn in masks for 30 minutes and exhaled droplet deposition was subsequently quantified by extraction and PCR detection of biomarkers RNaseP and *S. Mitis*; both of which are present in saliva and other regions of the respiratory tract.

Figure SEQ Figure * ARABIC 1. Scanning electron microscopy images of electrospun PVA with embedded magnetic beads (circled in red.)

Results: PVA with and without embedded magnetic beads was successfully electrospun to produce a fibrous microstructure ideal for capturing respiratory droplets (**Figure 1**). PVA with a MW of 126-146 kDa and 88% DH electrospun at 15% (w/v) in water resulted in promising substrates. The inserts readily dissolve in aqueous extraction buffers in under 2 minutes, show great fiber formations with a diameter of 389 ± 68 nm and a pore area of 1.29 ± 0.56 μm^2. Preliminary PCR tests detecting the biomarkers found 7,670 copies of RNaseP when worn in a mask and 86% recovery when directly dosed onto substrates and.

Conclusion: The combination of successful incorporation of magnetic bead in electrospun PVA substrates and detection of reparatory droplet biomarkers by PCR indicates a promising outlook for a mask-based surveillance method of respiratory diseases such as COVID-19.

References: [1]Morozov, V. N., et al. (2017). Non-invasive lung disease diagnostics from exhaled microdroplets of lung fluid: perspectives and technical challenges. *Journal of breath research*, *12*(1), 017103. [2]Muir, P., et al. (1993). Rapid Diagnosis of Enterovirus Infection by Magnetic Bead Extraction and Polymerase Chain Reaction Detection of Enterovirus RNA in Clinical Specimens. *Journal of clinical microbiology*.