HYDRA – Hydrogels for Aerosol Capture

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1. Motivation

- Airborne pathogens are a major issue for animal and plant survival and flourishment.[1 2]
- Hence, we need more sensitive, autonomous and integrated collection and detection methods.
- Electrostatic Precipitator (ESP) aerosol samplers meet the needs given above, but sometimes suffer from low collection efficiencies.[3]

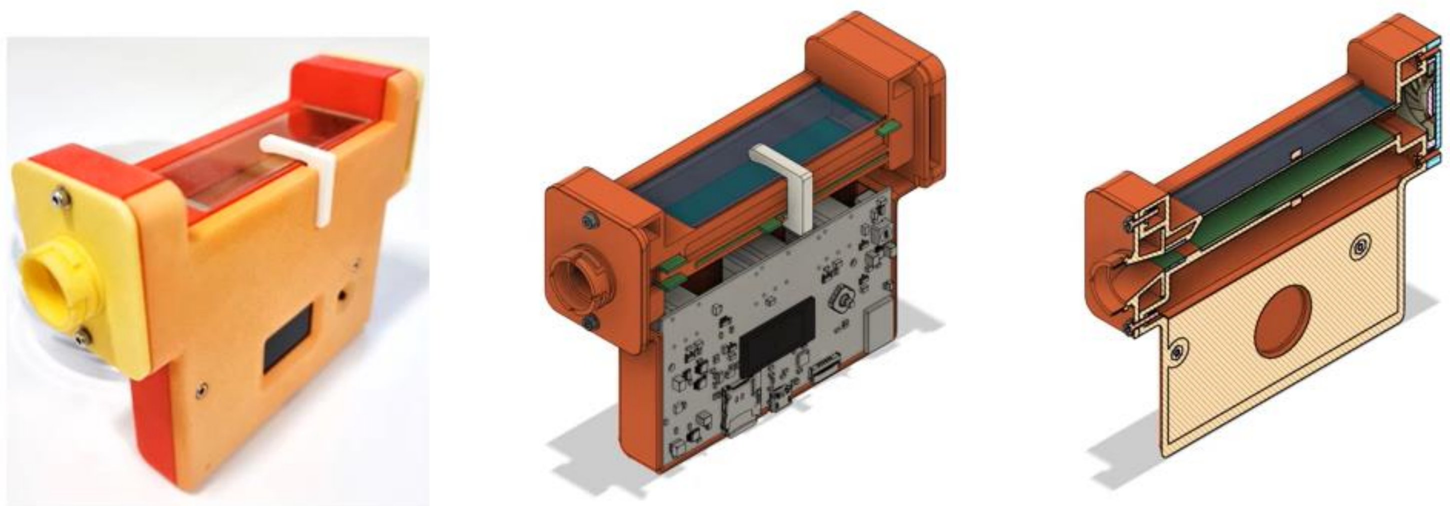

Figure 1: A portable electrostatic precipitator aerosol sampler in development at The University of Hertfordshire

2. Hypothesis

Inspired by the ability of mucus to capture and sustain some airborne pathogens,[4] this project aims to quantifiably test the hypothesis that hydrogels can be applied to develop a novel collection plate for an ESP to:

1. Enhance their collection efficiency.
2. Better protect the sample from factors that would result in pathogen death, such as osmotic shock.

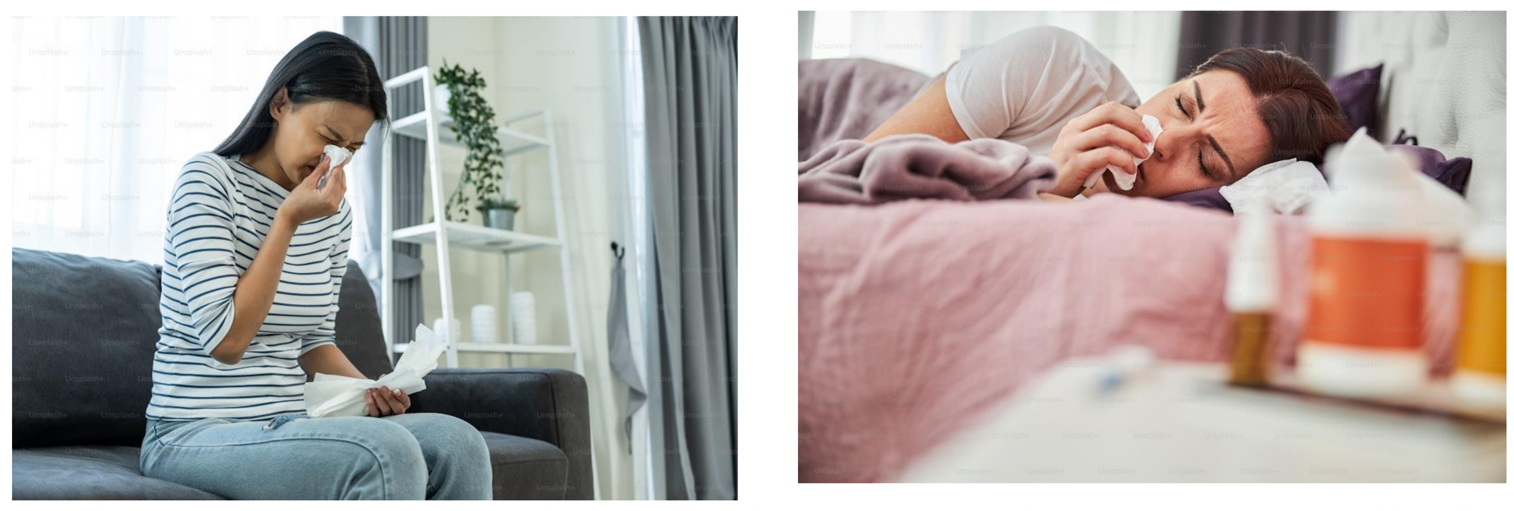

Figure 2: Public domain images of persons suffering from excessive mucus production.

3. Objectives

1. To synthesize a library of acrylate- and methacrylate-based hydrogels (figure 3, left) that is diverse with regards to conductivity, charge and acidity.
2. To evaluate the ability of these hydrogels to capture aerosols and identify the properties that result in optimal capture.
3. To develop a library of sustainable hydrogels (e.g. saccharide-based hydrogels – figure 3, right) that are optimised for aerosol capture.
4. To develop and evaluate an ESP incorporating a sustainable hydrogel collection plate (figure 4).

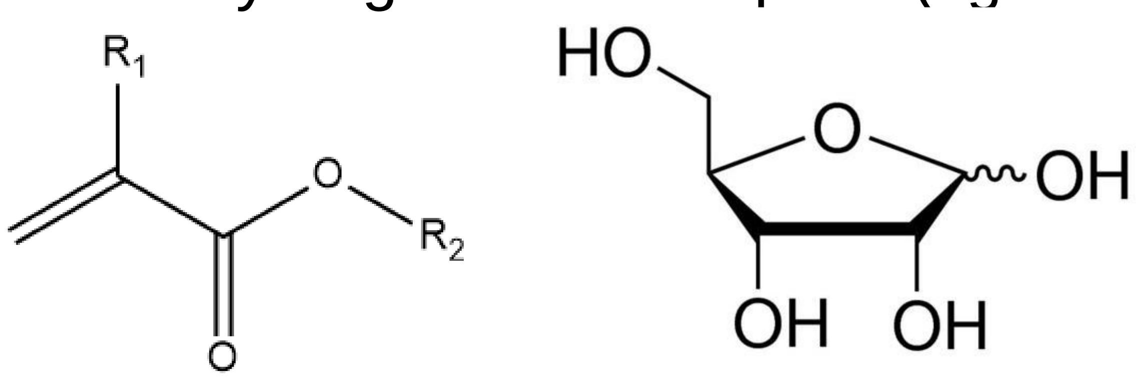

Figure 3: Chemical structure of acrylate (left, R_1 = H, R_2 = sidegroup), methacrylate (left, R_1 = Me, R_2 = sidegroup), and saccharide (right) monomers.

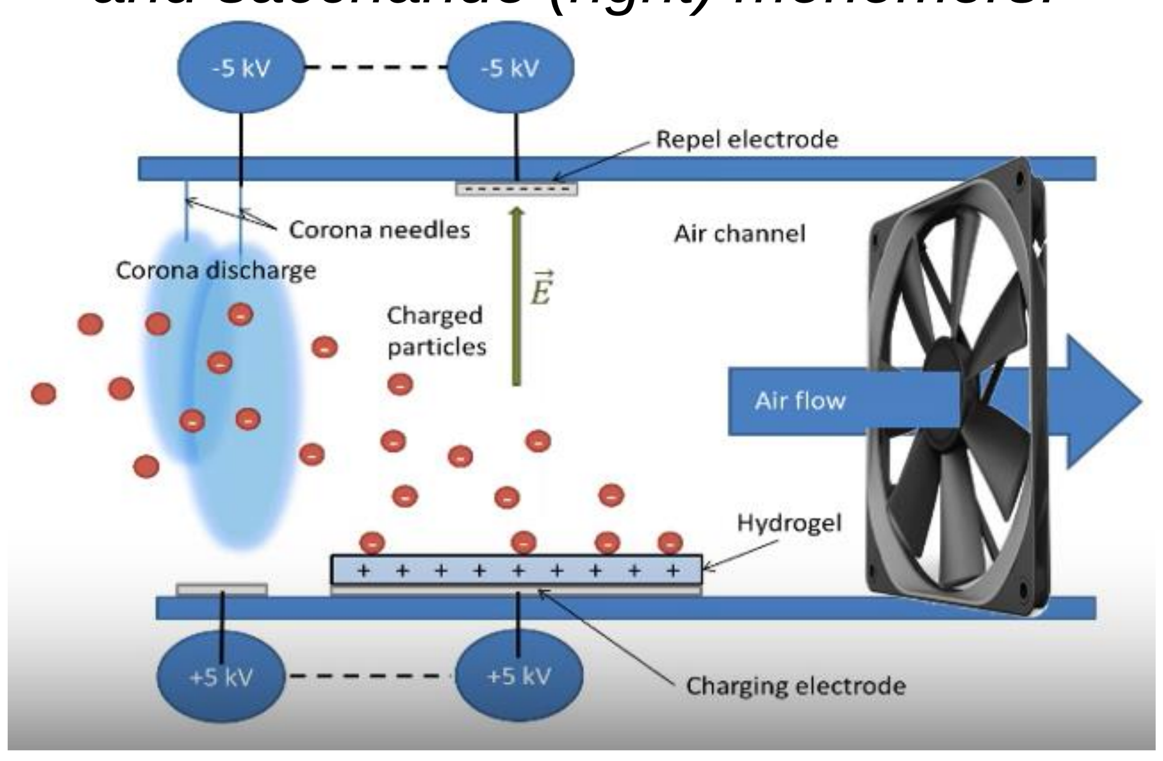

Figure 4: Proposed structure of portable electrostatic precipitator aerosol sampler incorporating a novel hydrogel collection plate.

4. Methods

This project aims to develop novel aerosol capture materials through use of the following main experimental techniques:

1. Synthesis
   a) Photo-initiated free radical polymerisation.
2. Characterisation
   a) Infrared Spectroscopy.
   b) Solid-state Nuclear Magnetic Resonance spectroscopy.
   c) Oscillatory rheology.
   d) Pycnometry.
   e) Volumetric analysis.
3. Evaluation of Aerosol Capture Efficiency
   a) Fluorescent microscopy.
   b) Solid-state Nuclear Magnetic Resonance spectroscopy.

5. Challenges

1. Determining the best method to evaluate aerosol capture given that microscopy of aerosol within a hydrogel substrate may be difficult.
2. Determining the optimal conditions inside the adapted ESP given that the high electrical current (10 kV) and flow rate (10 L/min) may have ramifications for hydrogel state and hydration, respectively.

6. References

1. O. f. N. S. G. Britain, Deaths due to COVID-19 registered in England and Wales. 2021, Office for National Statistics: Newport.
2. Hemadri, D., et al., Emergence of a new strain of type O foot-and-mouth disease virus: its phylogenetic and evolutionary relationship with the PanAsia pandemic strain. Virus Genes, 2002. **25(1)**: p. 23-34.
3. Coudron, L., et al., Fully integrated digital microfluidics platform for automated immunoassay; A versatile tool for rapid, specific detection of a wide range of pathogens. Biosensors and Bioelectronics, 2019. **128**: p. 52-60.
4. Reid, J. P., et al., Mucin transiently sustains coronavirus infectivity through heterogenous changes in phase morphology of evaporating aerosol, Viruses, 2022, **14(9)**, p. 1856.