Interaction of SARS – CoV2 and Influenza Viruses with Particulate Matter Air Pollution

Erin Kiely
Prof. Alexandra Porter

IMPERIAL

EPSRC Engineering and Physical Sciences Research Council

There is evidence of higher transmission rates and worsening of disease outcomes for viral infection in more heavily polluted areas[1]. We hypothesise that fine and ultrafine Particulate Matter (PM) and viruse coinfection, increases viral infectivity and boosts the cellular inflammatory response, with varying PM chemistries triggering different inhibitory or protective immune responses.

1. Background

PM in our environment

Pollutant concentrations of Black Carbon (BC), PM 10, 2.5 and 1 (<10, 2.5 and 1µm) across 4 different London microenvironments[1]:
Park (**PK**), Indoor (**IN**), Traffic Intersection (**TI**), Street Canyon (**SC**)

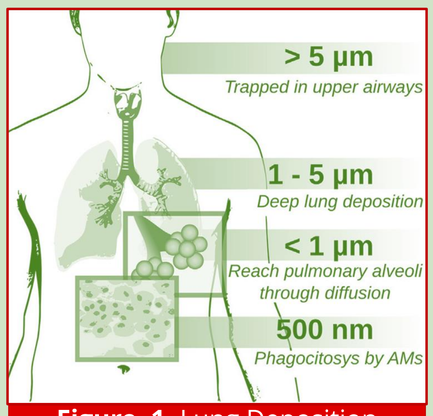


Figure. 1. Lung Deposition based on particle size [2]

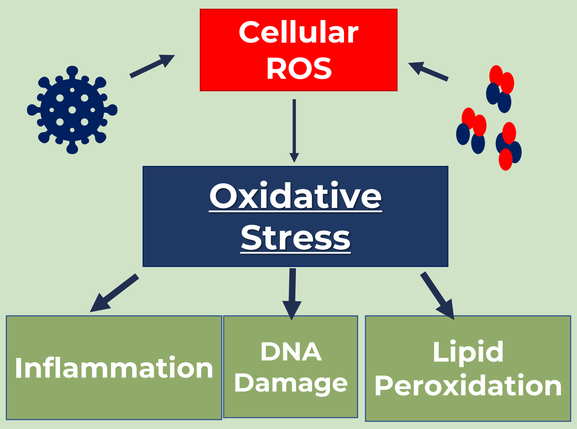
- **Sizes:** $PM_{2.5}$, PM_{10} and particle number counts were **TI > SC > PK > IN**. PM1 and BC was higher indoors.
- **Potentially toxic** trace transition metals including **Fe, Ti, Cr, Mn, Al and Mg** were detected at all sites.
- Same potentially toxic metals in the IN site as at the TI site- **Transport of PM indoors**
- Pollutant concentrations indoors followed the office time and work pattern
- Air quality **variation** at different MEs and reveals the **exposure inequalities** around the city

PM effect on viral infection

Virus Survival: Evidence that influenza can be deactivated by diesel emission particles[3]

Viral Cell Entry: PM known to upregulate expression of SARS-CoV-2 receptor, ACE-2. PM may also inhibit protective proteins in lung secretions[4]

Inflammatory Response: Persistent inflammation from chronic PM exposure, weaken immune response to viral infection. Overstimulation of immune response may occur through reactive oxygen species (ROS) and oxidative stress



2. Statement of The Problem

- Direct visual evidence of interactions between virus and PM is yet to be demonstrated, as is the cellular inflammatory response to virus and PM acting together.
- The effects of specific PM chemical components on viral infectivity could be delineated.

3. Objectives

- To determine whether PM effects viral cell entry and intracellular trafficking
- To visualise virus and PM interactions within lung secretions
- To determine how PM affects viral cell entry and cellular inflammation in *in vitro* cell culture

4. Significance

- The outcomes will provide guidance around which polluted microenvironments are potentially most unsafe for infection
- Could shed light on new therapeutic interventions.

5. Methodology

- **PM** will be extracted from polyurethane foams and mixed with surrogate virus, **Psuedovirus,** to look for interactions using **Transmission Electron Microscopy (TEM)**
  - Developing and adapting new ***in situ*** **Liquid TEM** protocols (Fig.2) to image the mixtures of virus and PM in these media **real time**
- Using *in vitro* cell culture techniques, **human airway epithelial cells will be exposed to both PM and Pseudovirus** to measure:
  - **Virus/PM localisation and intracellular trafficking** (TEM)
  - **Cell death** (flow cytometry, plaque assay)
  - **Biomarkers of oxidative stress and inflammation** (Immunofluorescence, Reverse Transcription Polymerase Chain Reaction)
- **TEM** will be used to visualise virus and PM localisation within pre-prepared samples of **VeroE2 cells exposed to SARS-CoV-2 and PM from various sites .**

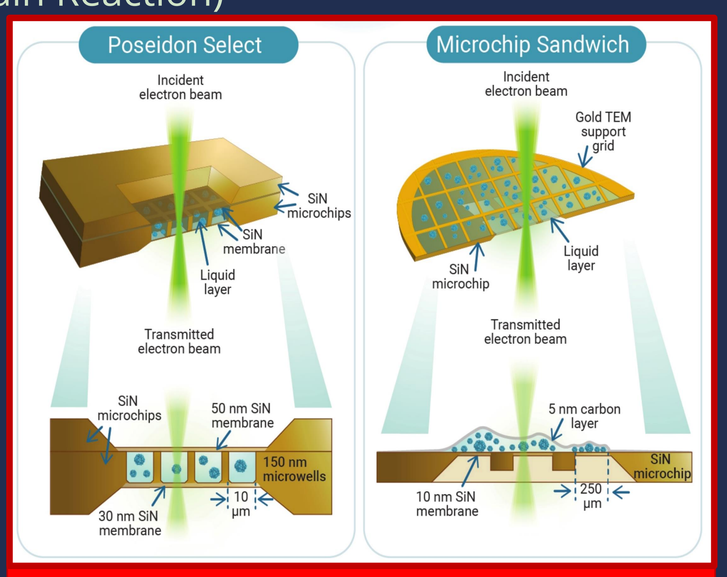
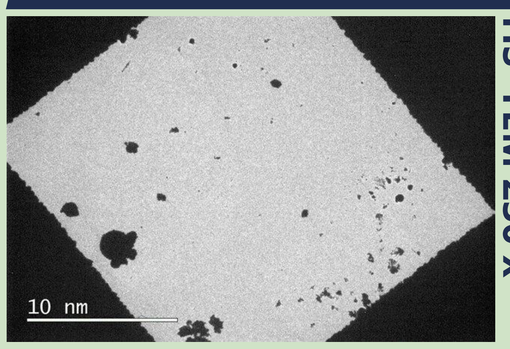


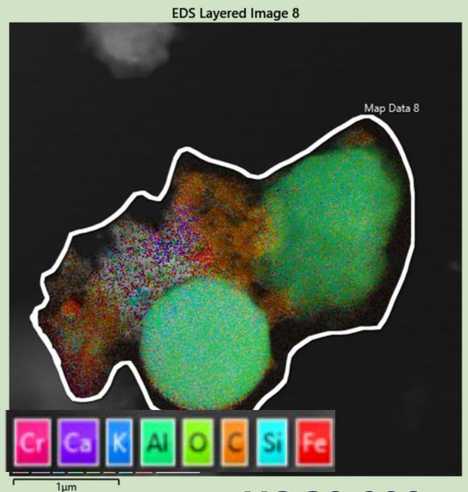
Figure 2. *Liquid TEM techniques. From* [5]

6. Year 1

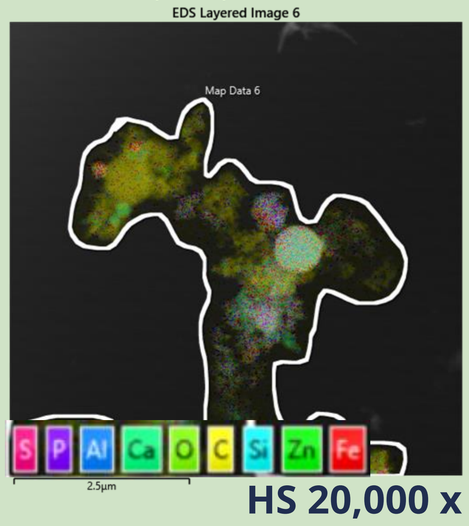


HS TEM 250 x

- TEM characterisation of PM10 collected at Marylebone Highstreet (HS) and Baker Street Tube station.
- Ongoing extraction of PM2.5 and PM1 from PUF collected IN, PK, GI and LU



HS 30,000 x



HS 20,000 x

STEM EDS layered Map Images

7. Responsible Innovation

- What research avenues should future work follow?
- How can the outcomes of these become entangled politically?

1. Tomson M, Kumar P, Kalaiarasan G, Zavala-Reyes JC, Chiapasco M, Sephton MA, et al. Pollutant concentrations and exposure variability in four urban microenvironments of London. Atmospheric Environment. 2023;298:119624
2. Costa A, Pinheiro M, Magalhães J, Ribeiro R, Seabra V, Reis S, et al. The formulation of nanomedicines for treating tuberculosis. Advanced drug delivery reviews. 2016;102.
3. Hsiao T-C, Cheng P-C, Chi KH, Wang H-Y, Pan S-Y, Kao C, et al. Interactions of chemical components in ambient PM2.5 with influenza viruses. Journal of Hazardous Materials. 2022;423:127243
4. Paital B, Agrawal PK. Air pollution by NO(2) and PM(2.5) explains COVID-19 infection severity by overexpression of angiotensin-converting enzyme 2 in respiratory cells: a review. Environ Chem Lett. 2021;19(1):25-42.
5. Jonaid GM, Dearnaley WJ, Casasanta MA, Kaylor L, Berry S, Dukes MJ, et al. High-Resolution Imaging of Human Viruses in Liquid Droplets. Advanced Materials. 2021;33(37):2103221.

Erin Kiely
ejk22@ic.ac.uk
ca22273@bristol.ac.uk