A one-step method for generating antimicrobial nanofibre meshes via coaxial electrospinning

Fangyuan Zhang[1], Maximillian Woodall [2], Claire Smith[2], Karolina Dziemidowicz[1] and Gareth Williams[1]

[1]UCL School of Pharmacy, 29-39 Brunswick Square, London, WC1N 1AX, United Kingdom; [2]UCL Great Ormond Street Institute of Child Health, 30 Guilford Street, London, WC1N 1EH, United Kingdom

Background: Respiratory diseases, ranging from influenza and infectious pneumonia to severe acute respiratory syndrome (SARS), are an ever-present threat to human health. The recent COVID-19 pandemic has claimed over 6.9 million lives worldwide since the outbreak began in December 2019 (World Health Organization, 2023). Fortunately, the number of reported cases and associated deaths has dropped significantly, but there remains the need to develop antimicrobial mesh materials for personal protective applications, masks in particular. There is much work reported in which electrospinning is used to this end. However, most of the reported approaches are relatively complex and expensive, and/or waste material by distributing antiviral agents throughout the mesh despite the fact they can only be active if at the fibre surface. Most researchers have tended to load the fibres with metal particles (Karagoz *et.al*, 2021). Here, differently, a cost-effective and efficient one-step method to produce nanofibre meshes with antimicrobial activity, including against SARS-CoV-2, was proposed.

Methods: In our work, cetrimonium bromide (CTAB) was coated directly onto the surface of polycaprolactone (PCL) fibre by modified coaxial electrospinning, in a single step. As a cationic surfactant, the presence of CTAB was expected to lead to finer and more uniform nanofibres, resulting in denser meshes with smaller pore size. Thus, the CTAB-coated fibres should show improved physical filtration and electrostatic adsorption of viral particles. Further, the amphiphilic nature of CTAB can result in disassembly of the viral particles, which in turn should lead to antiviral activity.

Results: Five concentrations of CTAB ranging from 0 mg/mL to 100 mg/mL (S0-S4) were used to coat PCL fibres. Scanning electron microscopy images showed that CTAB-coated samples (S1-S4) had smaller (mean diameters: ~300 nm) and denser (pore sizes: ~300 nm) nanofibre meshes compared to the blank sample S0 (average diameter of ~900 nm with ~600 nm pore size). Besides, all CTAB-coated formulations had over 90% encapsulation efficiency and a corresponding maximum of 5 % w/w loading. We observed 50%-80% drug release within 15 minutes, which ensures that the mesh is able to release the CTAB in response to fluids such as cough droplets and viral aerosols in a short time. To test the antiviral activity of the meshes, median tissue culture infectious dose (TCID50) and plaque assays were employed and both methods showed positive results.

Conclusions: In summary, we present an economical and simple one-step method to produce CTAB-coated nanofibre mesh with antimicrobial activity. Meanwhile, we are exploring the activity of the formulations against other viruses and bacteria.