Porous Cellulose Thin Films as Sustainable and Effective Antimicrobial Surface Coatings

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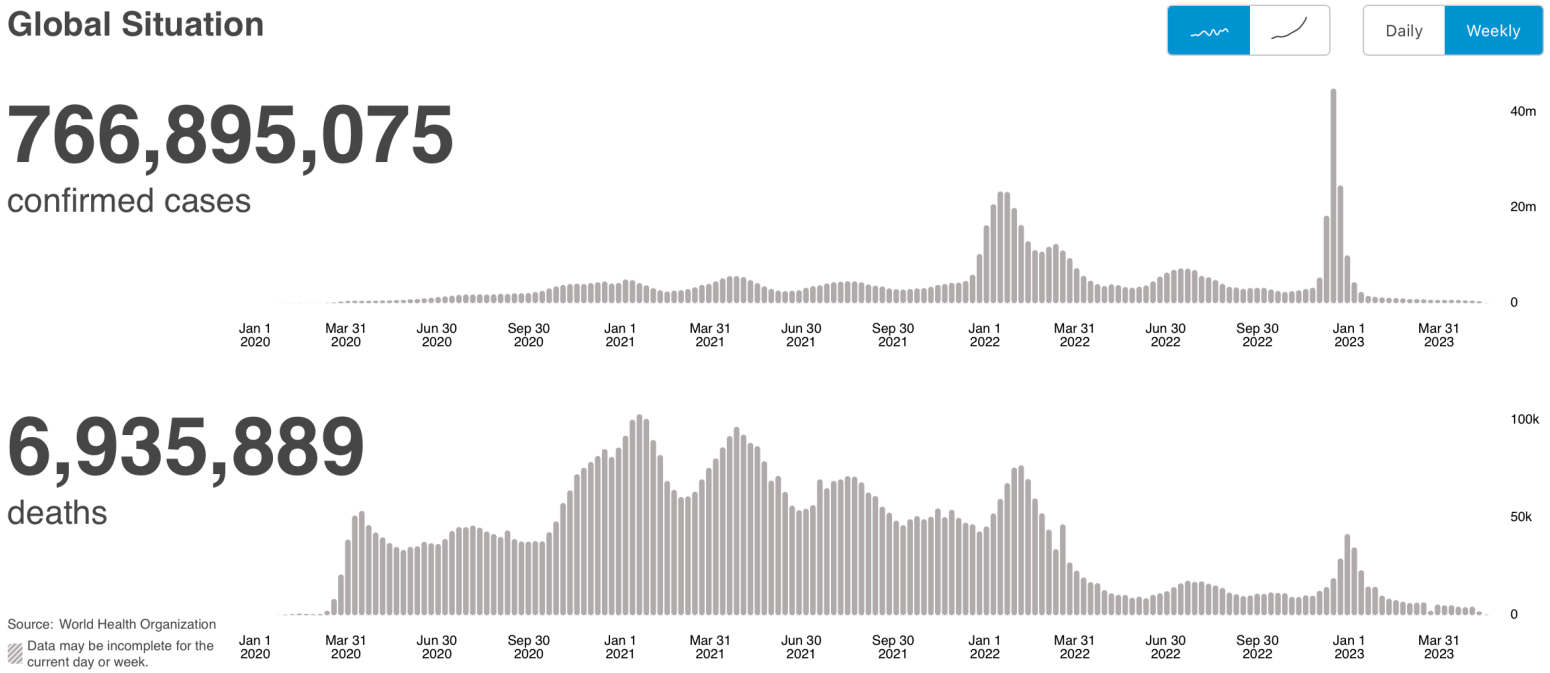
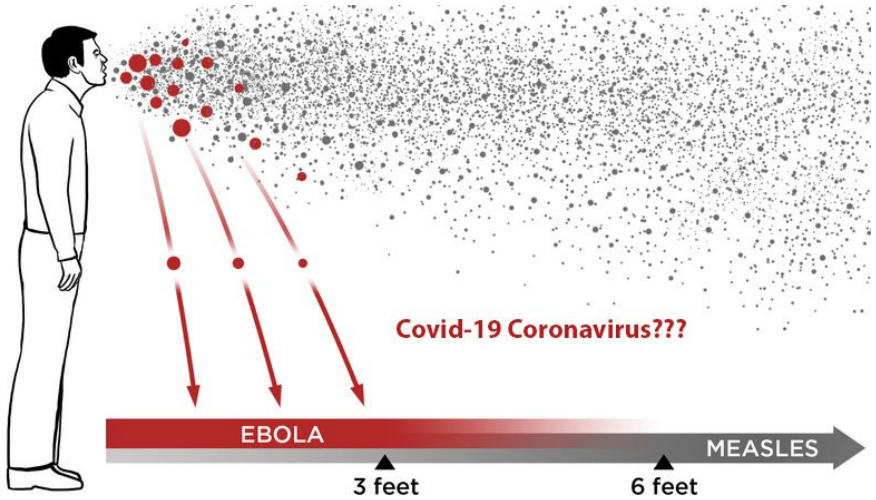
It has been more than three years!!



https://covid19.who.int

All started with the COVID-19



- SARS-CoV-2 transmits mostly between people at close range through inhalation
  - More likely by inhaling it than having it fly through the air in large droplets to land on their eyes, nostrils, or lips
- Surface transmission is correlated with transmission, too!

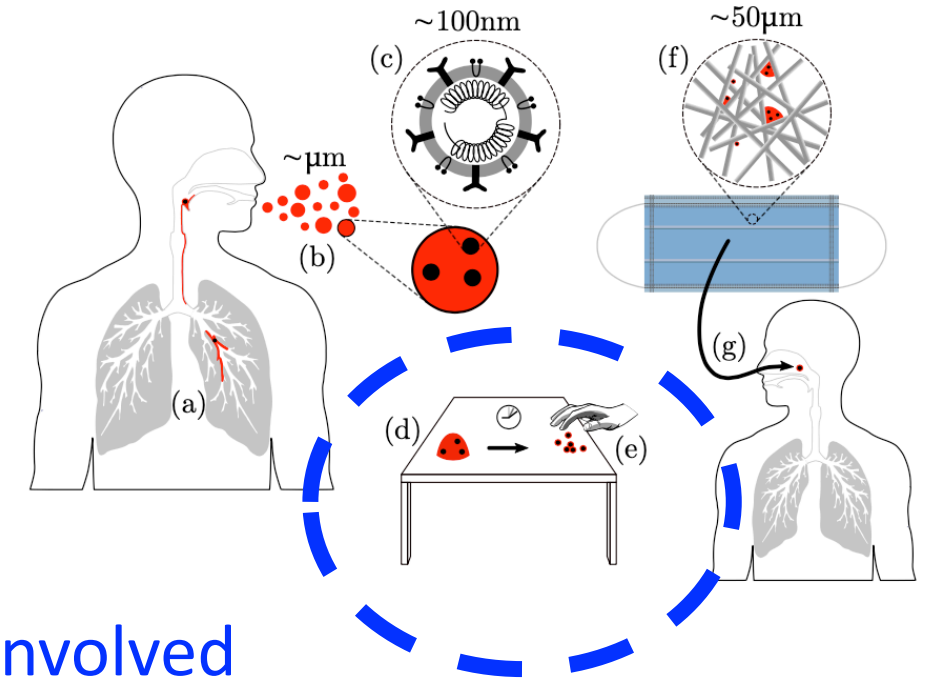
Tang et al. *BMJ* 2021

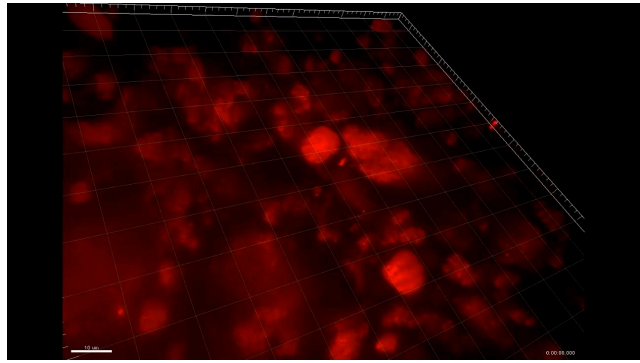
Derqui et al. *Lancet Microbe* 2023

Interpretation Presence of SARS-CoV-2 RNA on primary cases' and contacts' hands and on frequently-touched household surfaces associates with transmission, identifying these as potential vectors for spread in households.

The indirect transmission pathway

- Indirect transmission
  - High traffic surfaces
  - Cold chain
- Droplet *vs* nuclei
- Size?
- Surface
  - Chemistry
  - Topography
  - ……..





Multi-steps involved

Ejection
Deposition
Evaporation
Adsorption
Contact transfer

What is the role of surfaces?
Which is our target?
How can we help?

Poon et al. *Soft Matter* 2020

Antimicrobial coating

- A research topic with extensive work prior to the pandemic
- Grand challenge with complex nature: microbe, surface characteristics, environmental conditions, transmission route, regulatory requirement, sustainability – no one-size-fits-all solution.

Strategies

- Chemical disinfectants: Chlorine bleach, phenolics, QACs, etc.

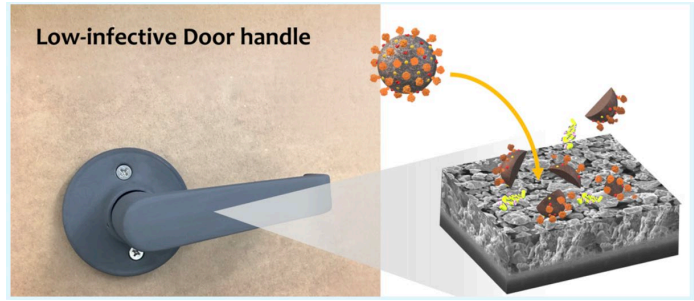
  Environmental concerns

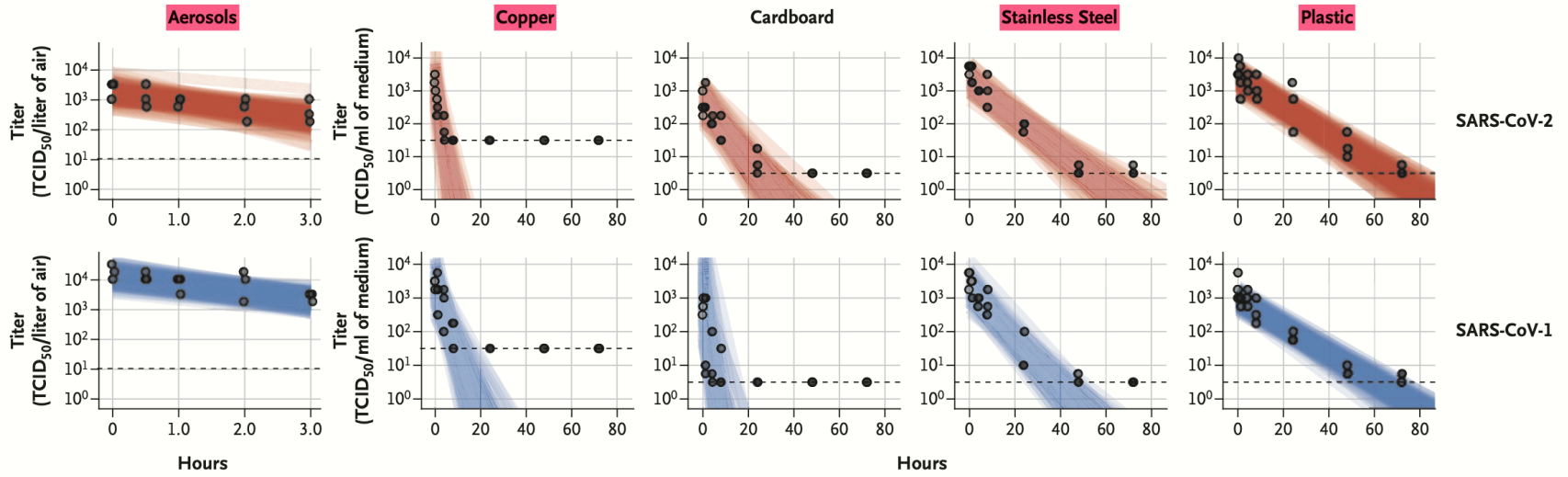
- Non-contact disinfection: Heat, UV, sunlight, etc.

  Not always accessible

- Surface coatings: Silver, copper, etc.

  Technical barriers. Equipment, skill, etc.



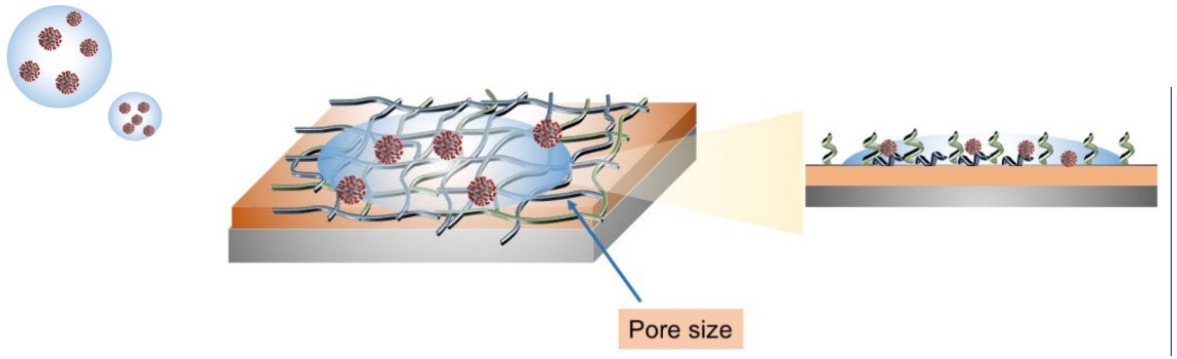


Doremalen et al. *N. Engl. J. Med.* 2020

Hosseini et al. *ACS Appl. Mater. Interface* 2021

What if?

- Produce a porous coating
- Capture respiratory droplets
- Disrupt the complex fluid
- Inactive the virions



What is the role of surfaces?
Which is our target?
How can we help?

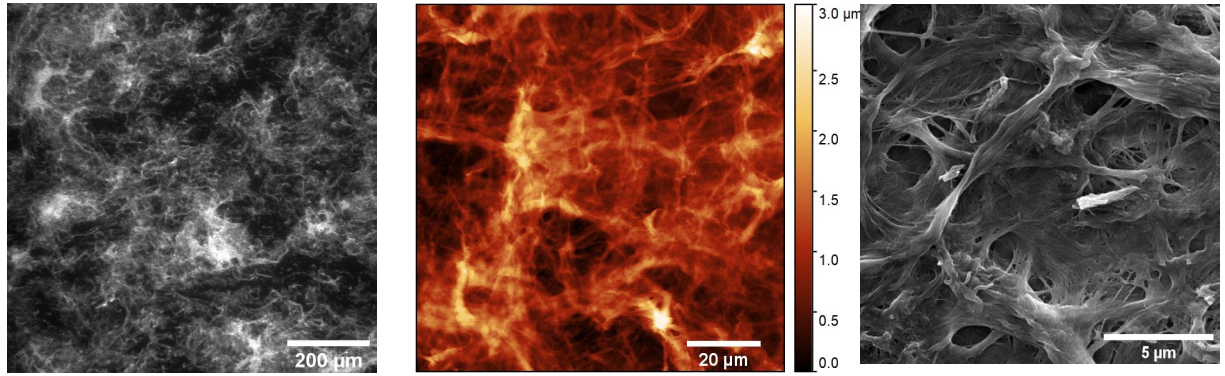
Practical
Sustainable

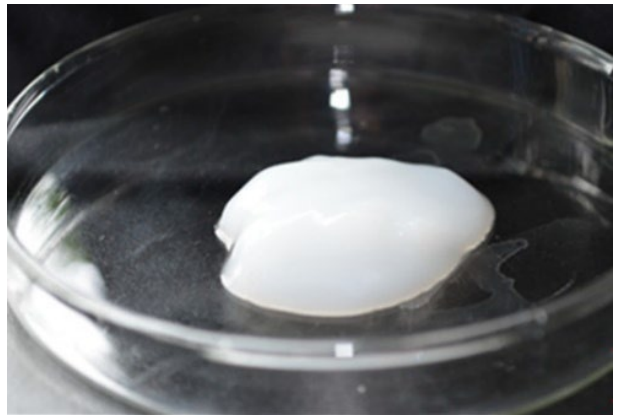
Immobilise
Trap

Wicking
Spreading
Breakdown

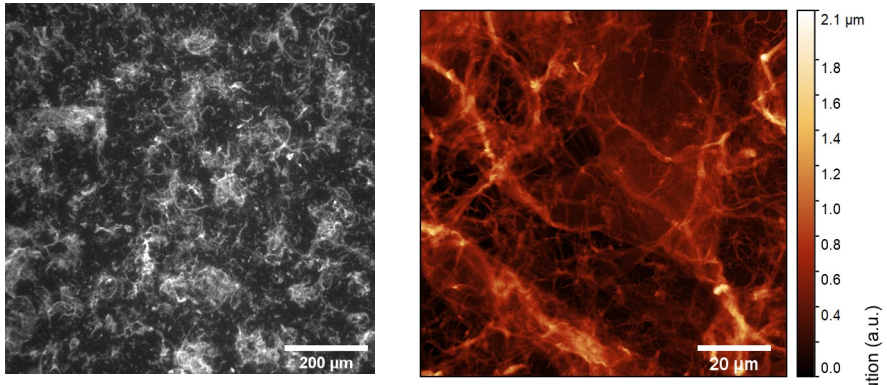
MFC coating

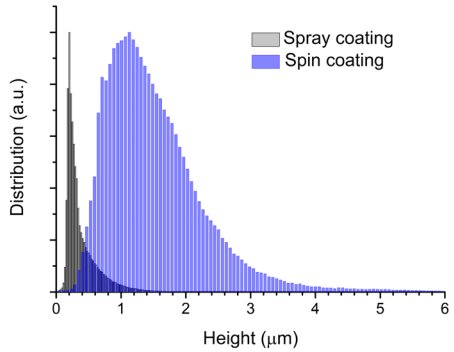
Spin coating





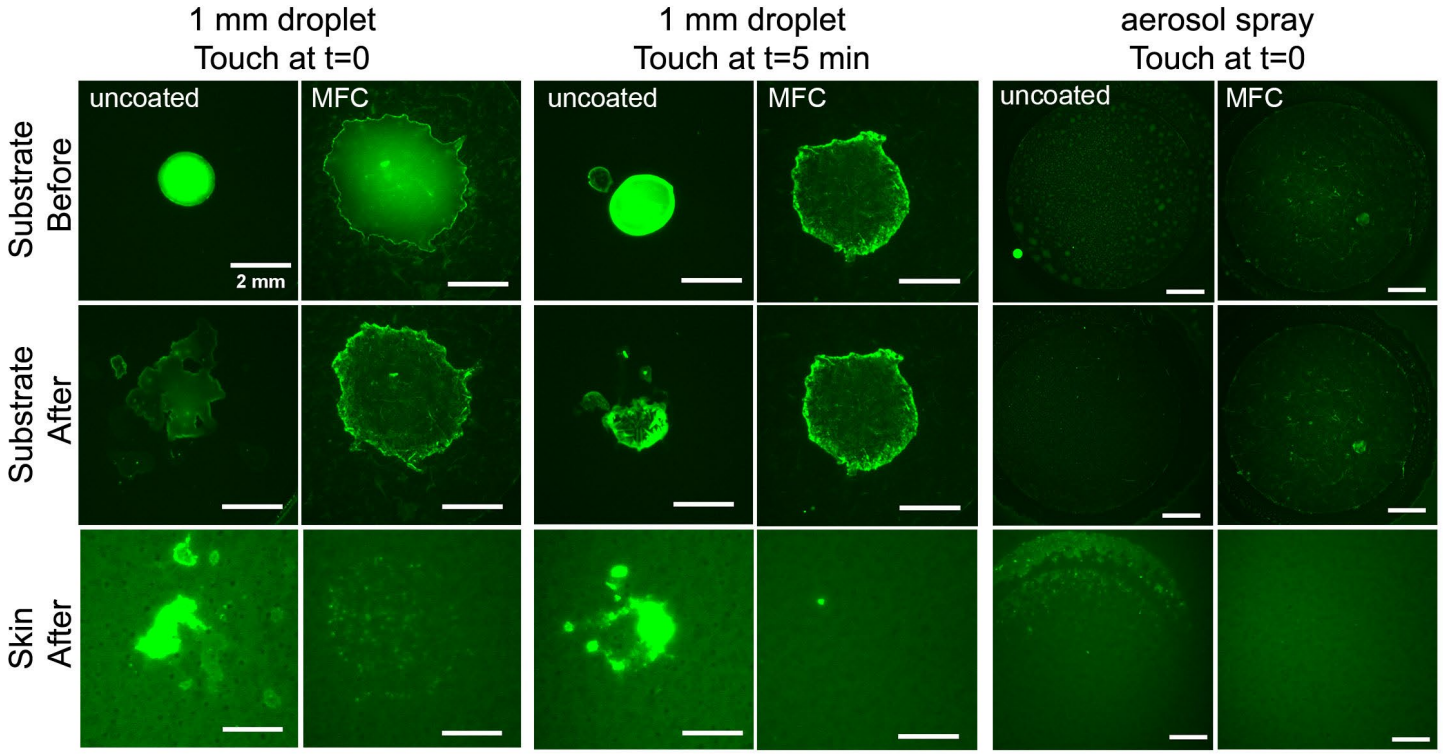
Spray coating



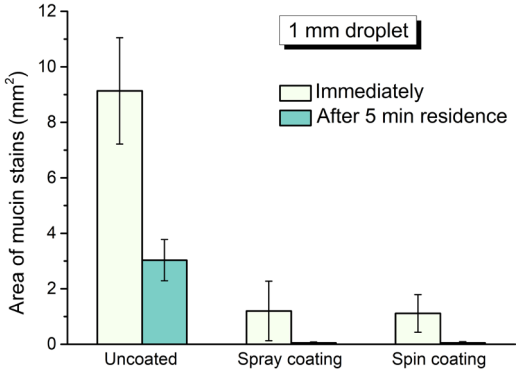


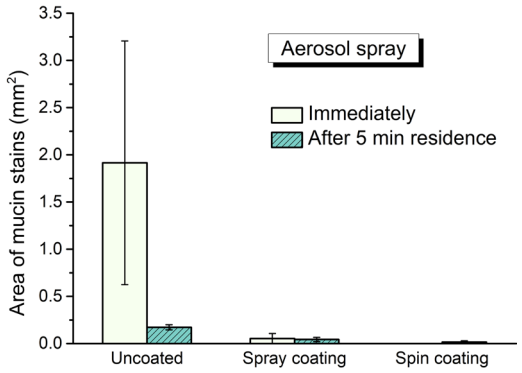
Both deposition methods worked

Can it capture droplets loaded with virus?



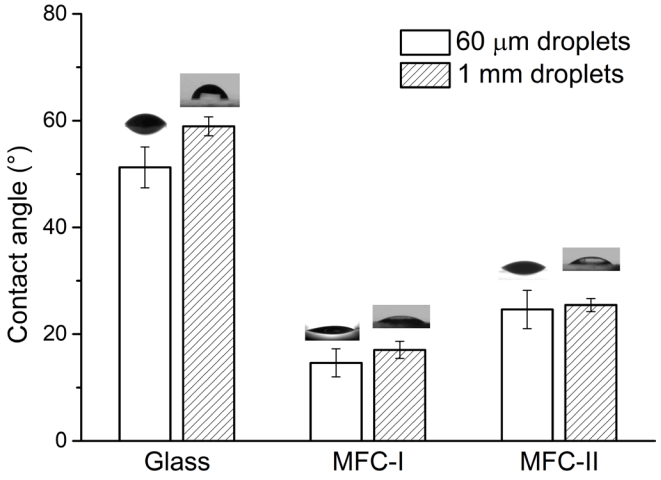
- Ability to hold the artificial saliva
- Both droplet and aerosol
- Minimal transfer

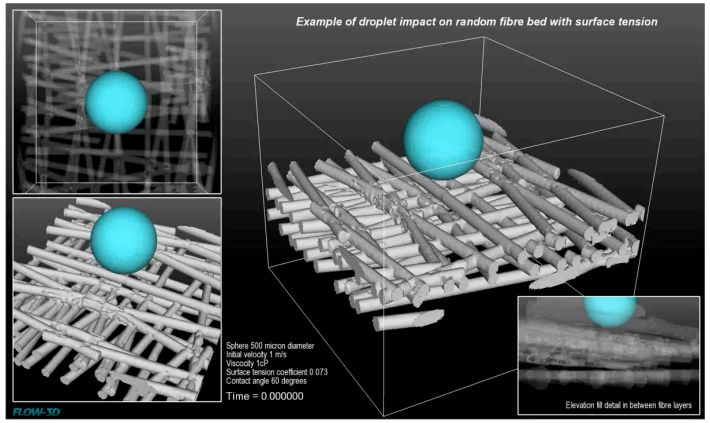




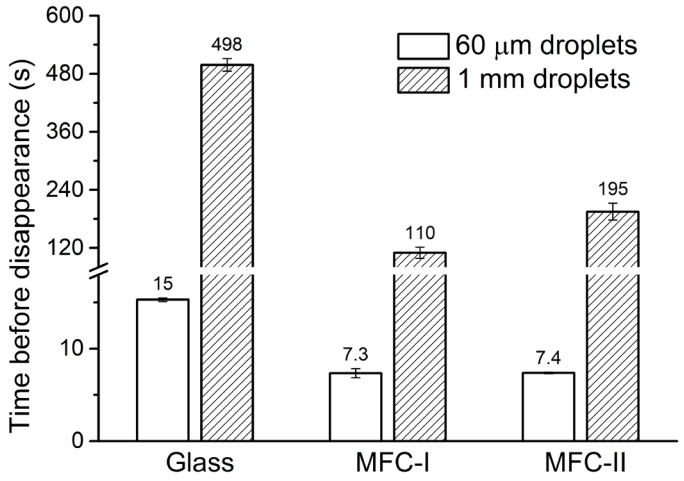
Wicking and spreading

- Spread the droplet quickly
- Fast wicking kinetics



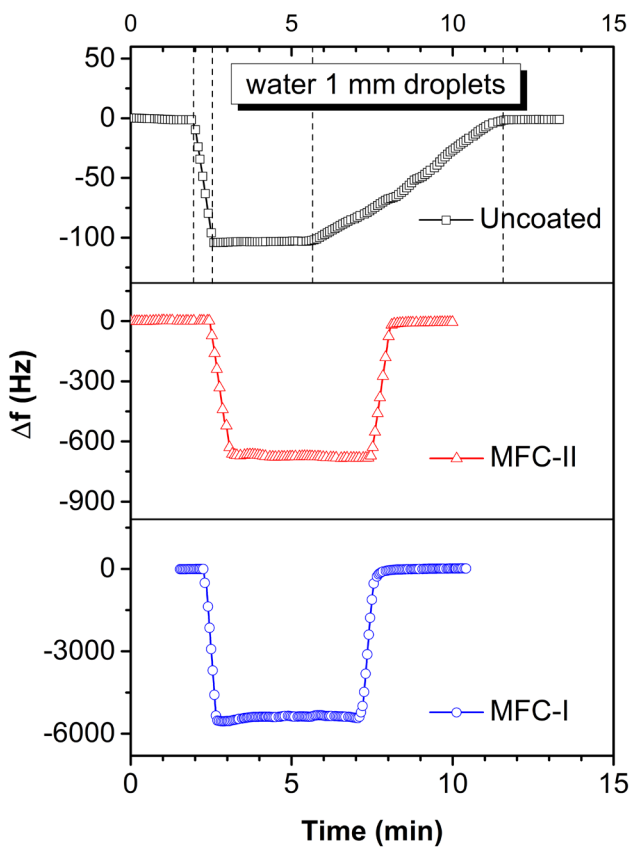


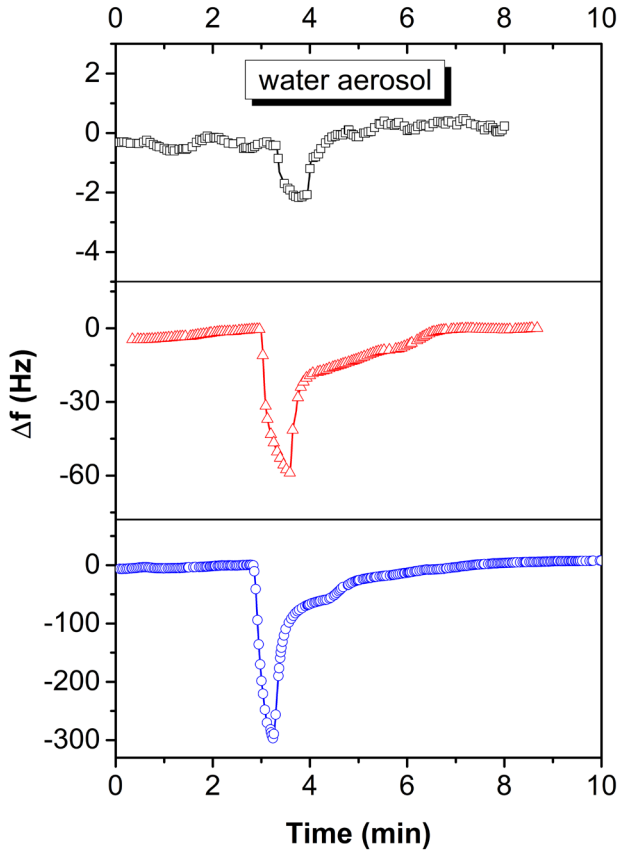
- Controlled porosity
- Adjustable cellulose fibre diameter
- Changeable fibre chemistry
- Surface contact angle on single fibre

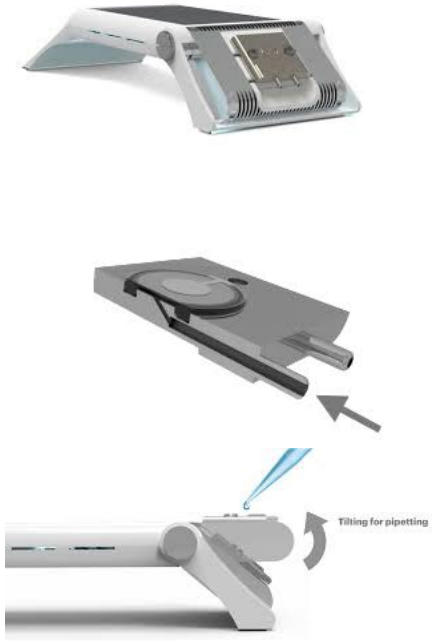


Evaporation kinetics

- Used Quartz Crystal Microbalance to study the evaporation kinetics
- Accelerated evaporation

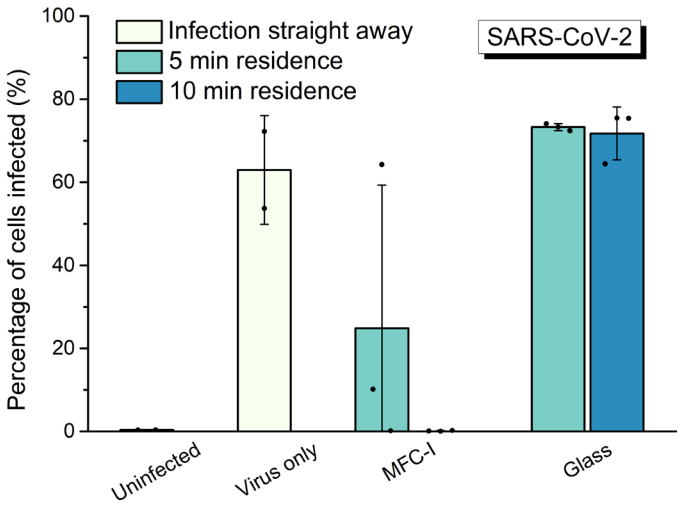


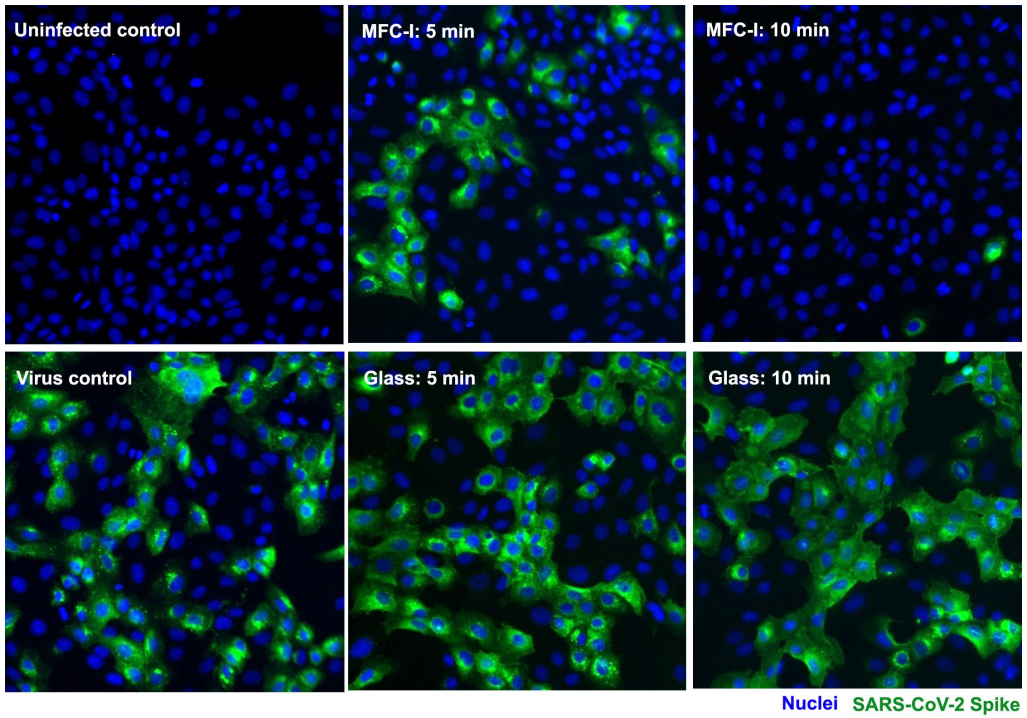


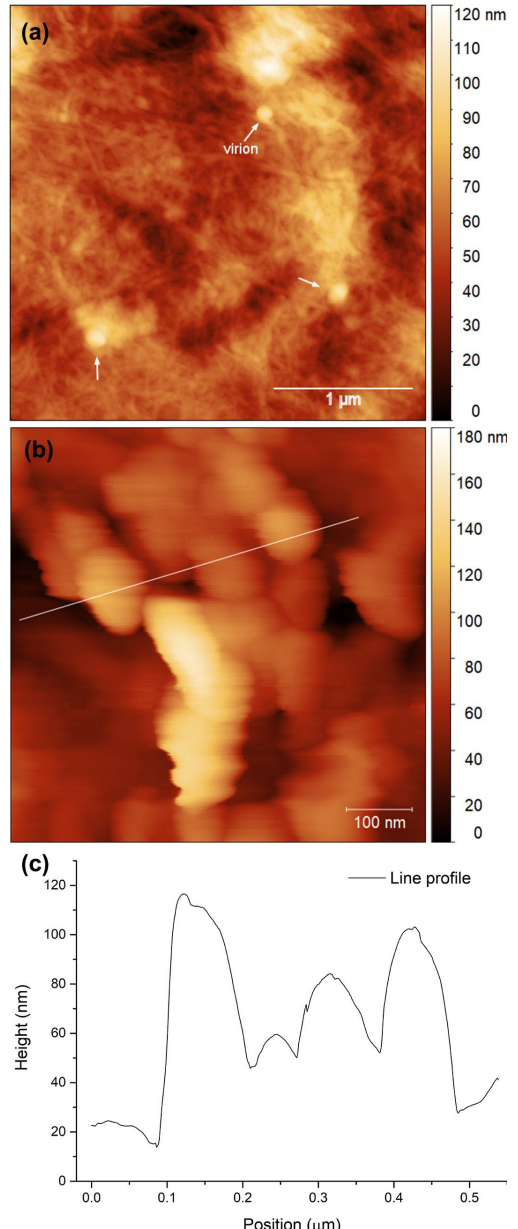


Ability to inactivate virus

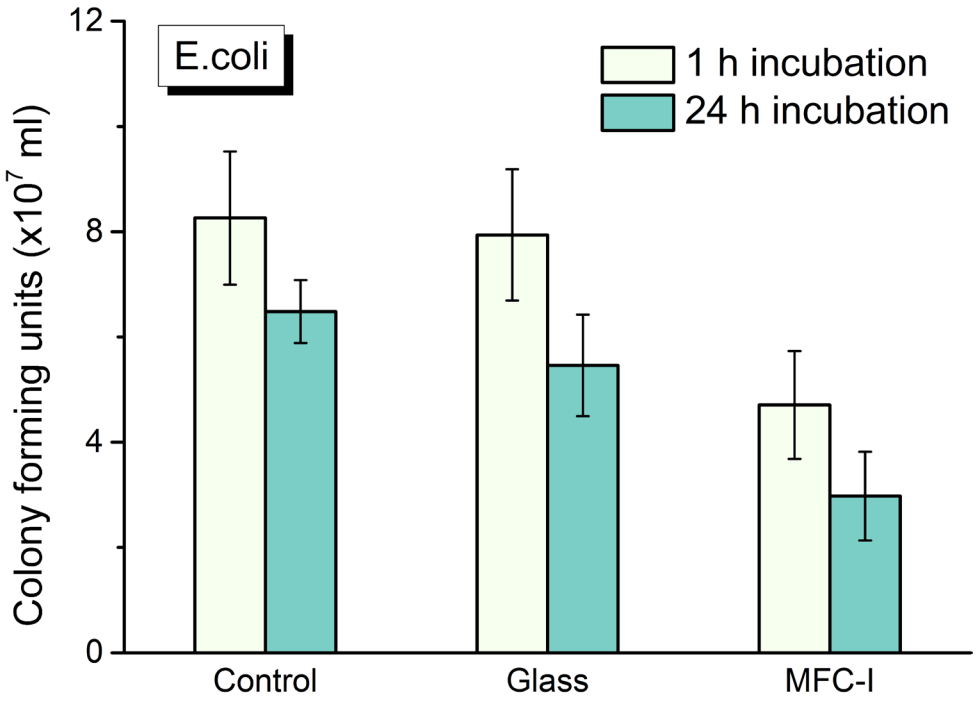
SARS-CoV-2 virus England 2 stock 106 IUml−1 (kind gift from Christine Bruce, Public Health England) diluted 1/150 in culture media.

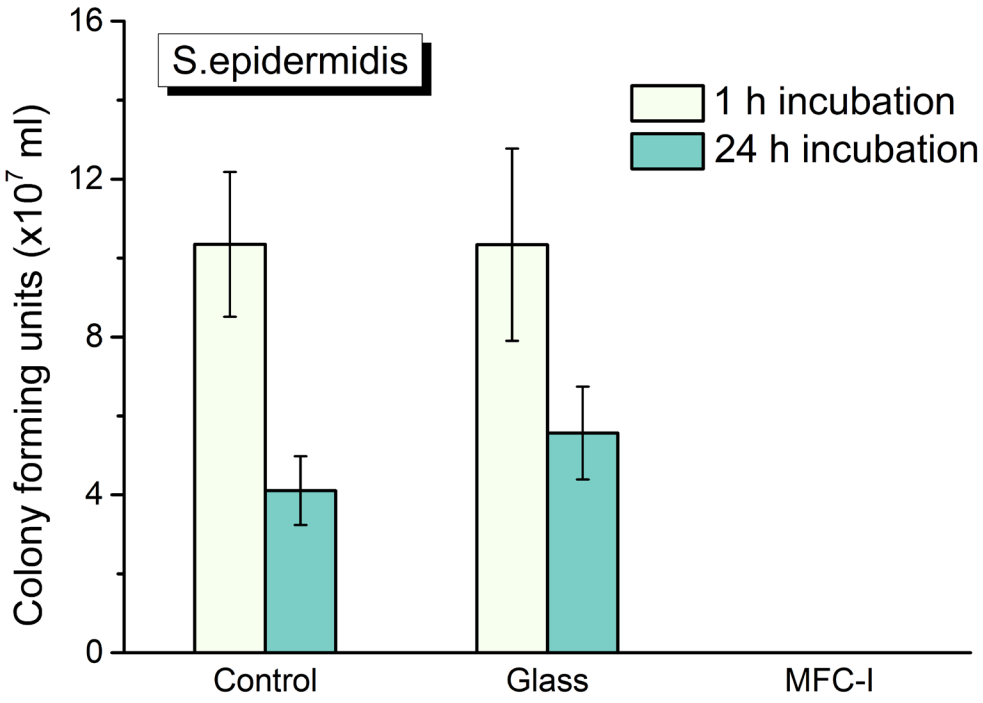






How about bacteria?



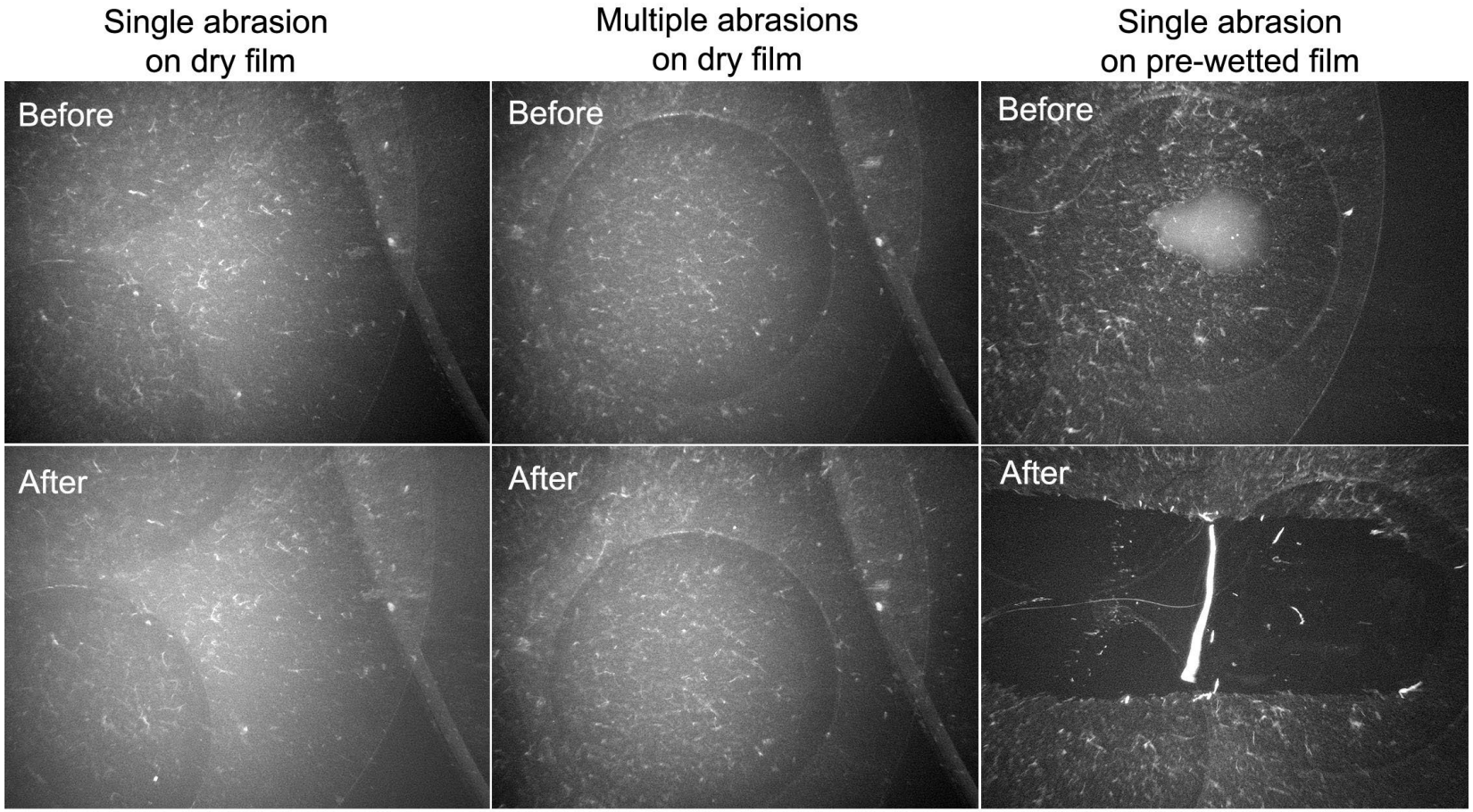


Shows effectiveness against representative gram-negative and gram-positive strains – a physical Mode of Action to disrupt cell membrane.

Stability & Durability

Permanent coating or not?

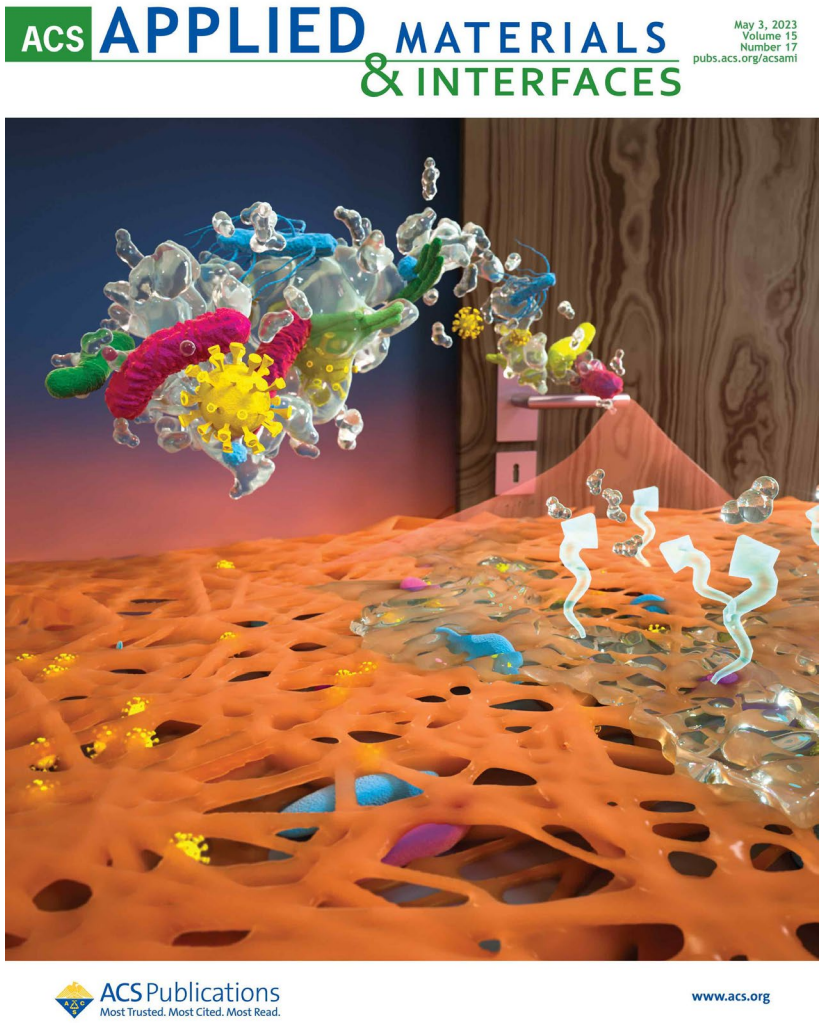
Weakness of porous coating?



Conclusion

- Porous bio-degradable coating
  - Sustainable / safe
- Minimal surface fomite transfer
- Fast evaporation kinetics
  - Reduces the transmission window
- Anti-viral effectiveness
  - Physical disruption

  - Balance fibre chemistry and porosity
  - Incorporate actives into the porous network
  - Sustainable resource for fibres
  - Controlled hydrophobicity & porosity *vs* evaporation kinetics



Qi et al. *ACS AMI* 2023

Acknowledgement

EPSRC
Engineering and Physical Sciences Research Council

EPSRC ‘SUrfaCe Characteristics Enabled StrategieS against virus transmission (SUCCESS)’

University of Birmingham
Dr Shaojun Qi
Dr Alexandros Kosmidis
Dr Ophelie Squillace
Dr Ioannis Kiratzis
Dr Zania Stamataki
Prof. Peter Fryer

Cambridge University
Prof. Stuart Clarke
Dr Graham Christie
Dr Ljiljana Fruk

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