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UCL MECHANICAL ENGINEERING

UCL Institute of Healthcare Engineering

1st International Electronic Conference on Pharmaceutics 2020

Advanced Manufacturing Research for Healthcare

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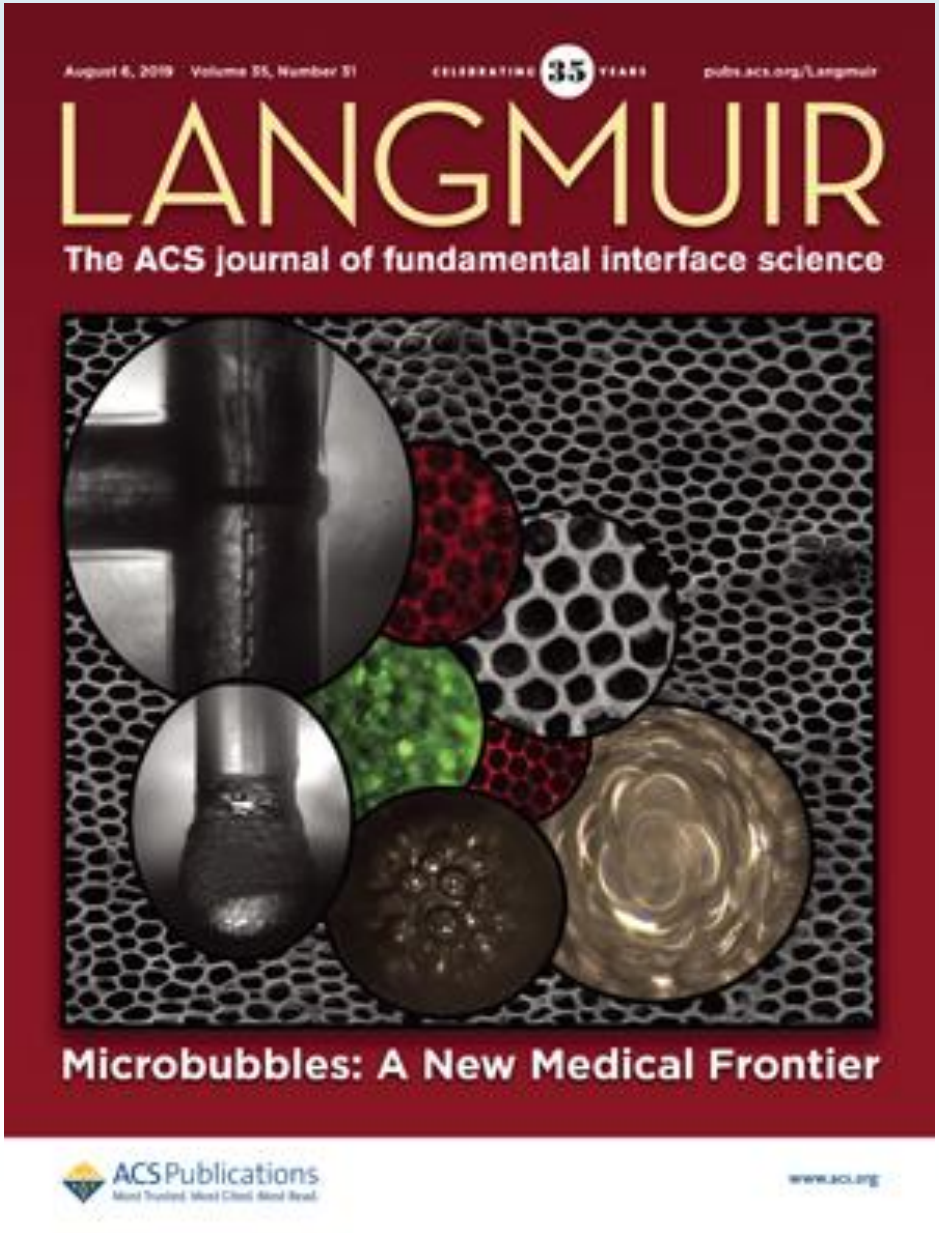
MICROFLUIDICS

Many EPSRC Grants (e.g. EP/E012434/1) and UCL doctoral studentships



Invited Special Issue

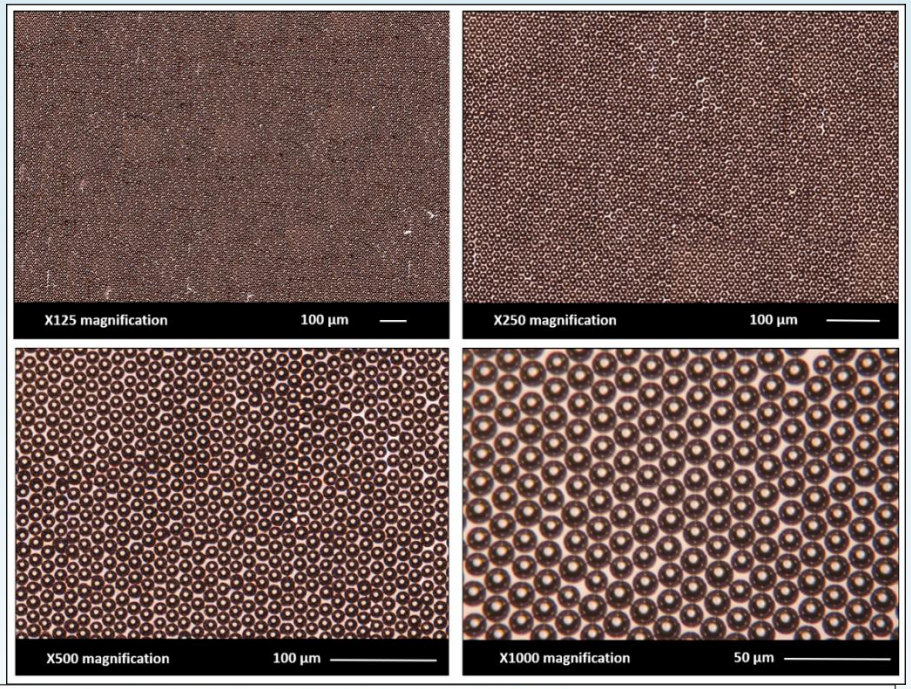
06th August 2019

24 key papers by key leading researchers covering every part of the world

Microbubble size reduction

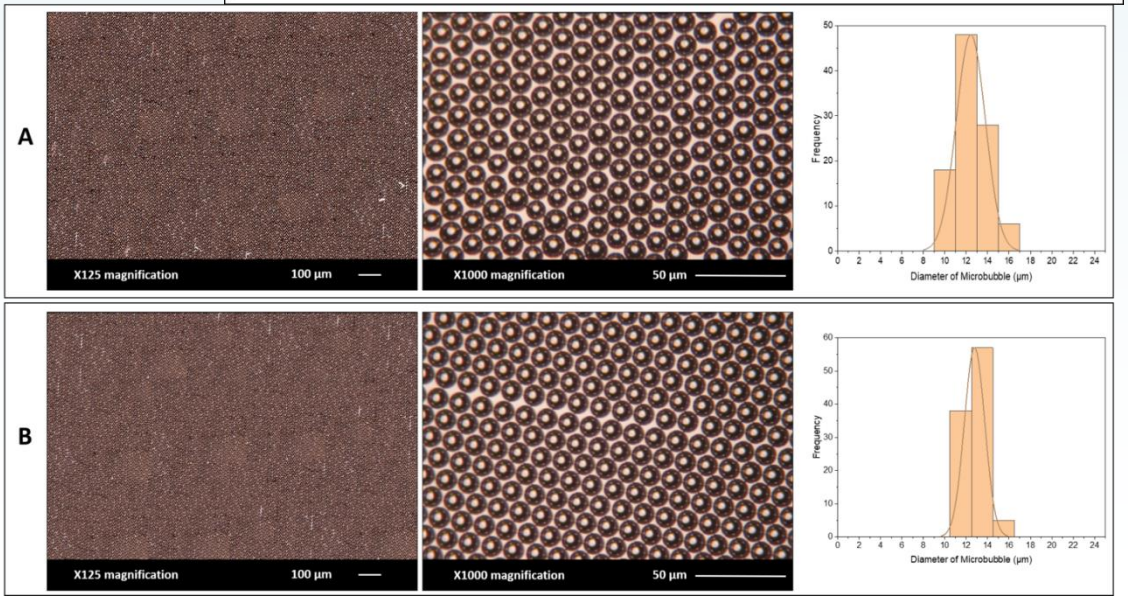
(A): **Triple (3)** T-junction
Capillary size: **65 µm**
Channel gap size: **65 µm**
Gas Pressure: **80 kPa**
BSA solution: **10 wt %**
Flow Rate: **650 µL / min**

The mean MB size is:
12.4 µm



(B): **Triple (3)** T-junction
Capillary size: **25 µm**
Channel gap size: **25 µm**
Gas Pressure: **80 kPa**
BSA solution: **5 wt %**
Flow Rate: **400 µL / min**

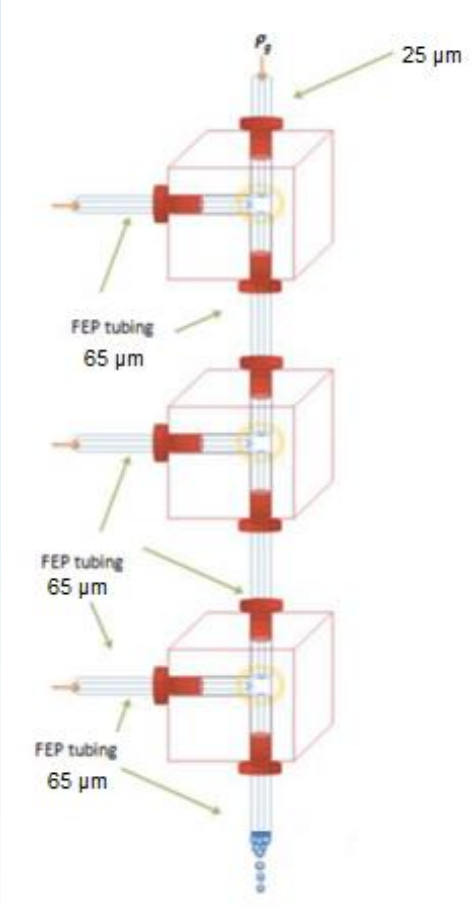
The mean MB size is:
12.8 µm



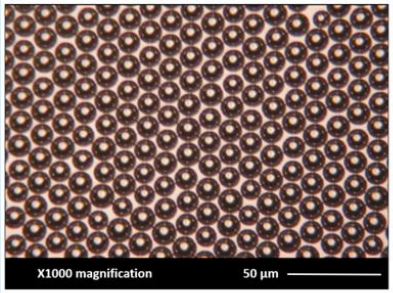
(C): Triple (3) T-junction

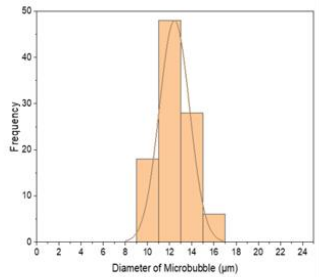
Capillary size: **25 µm (gas inlet) and 65 µm (rest)**
Channel gap size: **65 µm**
Gas Pressure: **80 kPa**
BSA solution: **10 wt %**
Flow Rate: **700 µL / min**

(C): The mean MB size is:
9.9 µm



(A):





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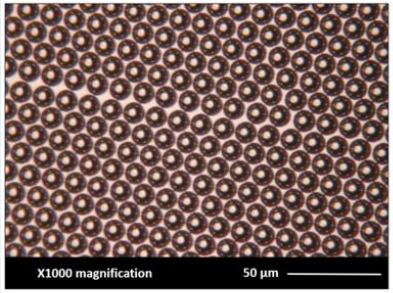
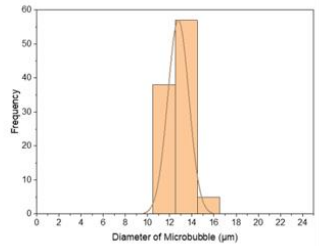
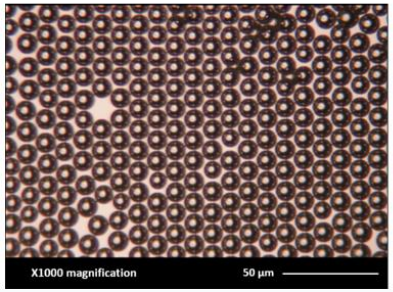
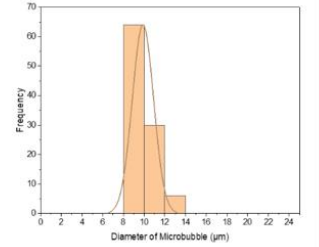




(C):



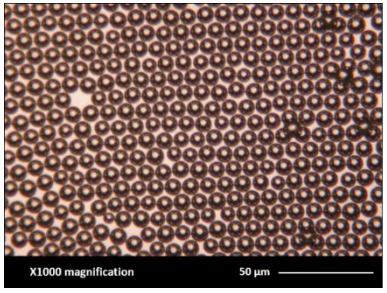


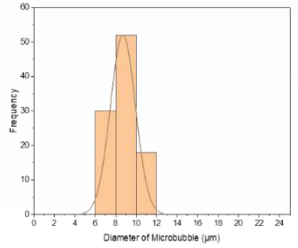
(D): Quadruple (4) T-junction

Capillary size: **100 µm**
Channel gap size: **100 µm**
Gas Pressure: **80 kPa**
BSA solution: **10 wt %**
Flow Rate: **700 µL / min**

The mean MB size is:
8.7 µm

(D):

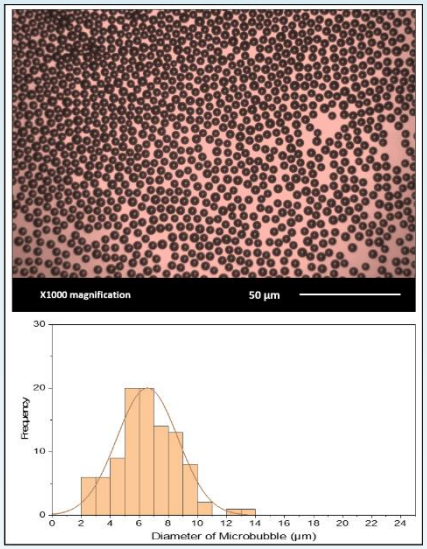


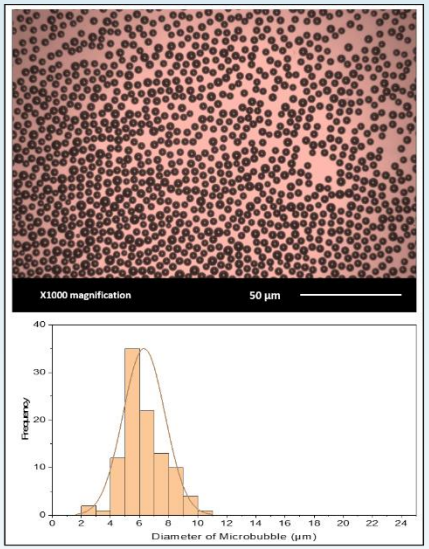


Microbubble size reduction with fission processes:

Quadruple (4) T-junction
Capillary size: **65 µm**
Channel gap size: **100 µm**
Gas Pressure: **80 kPa**
BSA solution: **10 wt %**
Flow Rate: **600 µL / min**

The mean MB size is:
6.6 µm



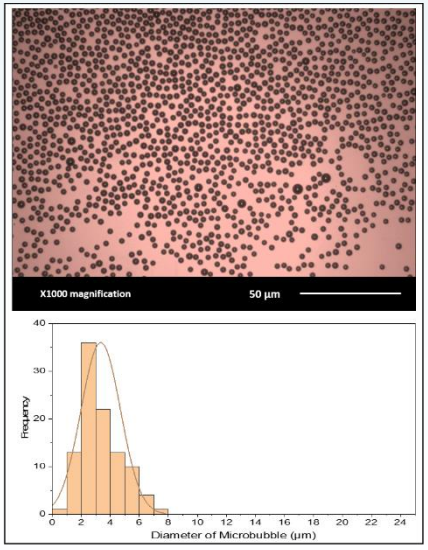


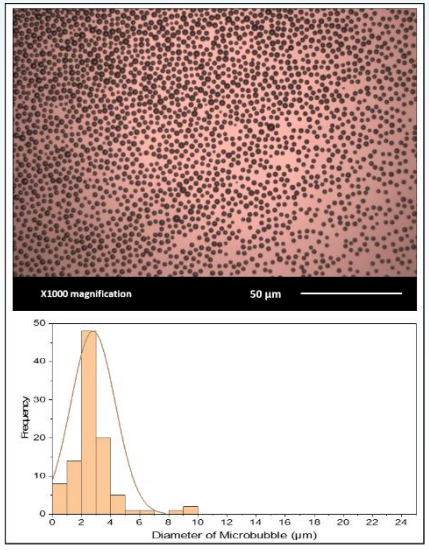
Quadruple (4) T-junction
Capillary size: **25 µm**
Channel gap size: **50 µm**
Gas Pressure: **80 kPa**
BSA solution: **15 wt %**
Flow Rate: **700 µL / min**

The mean MB size is:
6.30 µm

Quadruple (4) T-junction
Capillary size: **25 µm (gas inlet) and 100 µm (rest)**
Channel gap size: **150 µm**
Gas Pressure: **80 kPa**
BSA solution: **15 wt %**
Flow Rate: **700 µL / min**

The mean MB size is:
3.3 µm





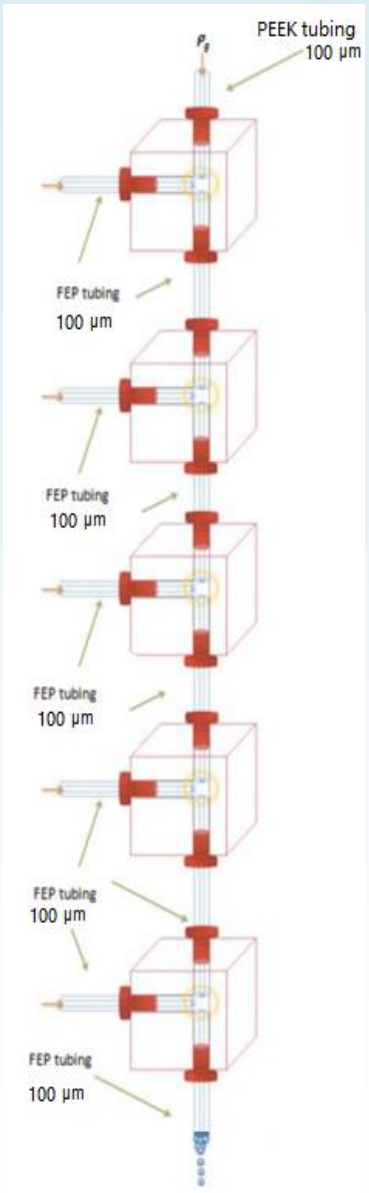
Quadruple (4) T-junction
Capillary size: **25 µm (gas inlet) and 65 µm (rest)**
Channel gap size: **100 µm**
Gas Pressure: **80 kPa**
BSA solution: **10 wt %**
Flow Rate: **650 µL / min**

The mean MB size is:
2.80 µm

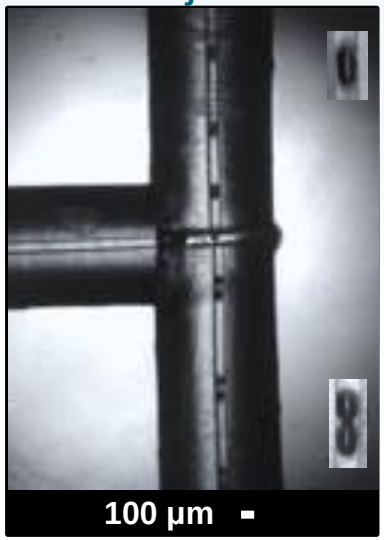
Fission processes:

- MB size can be further reduced by fission process. (But lose the monodispersity of MBs)
- When the channel gap size is greater than the diameter of capillary, fission process occurred

Quintuple (5) T-junction
Capillary size: **100 µm**
Channel gap size: **150 µm**
Gas Pressure: **80 kPa**
BSA solution: **15 wt %**
Flow Rate: **500 µL / min**

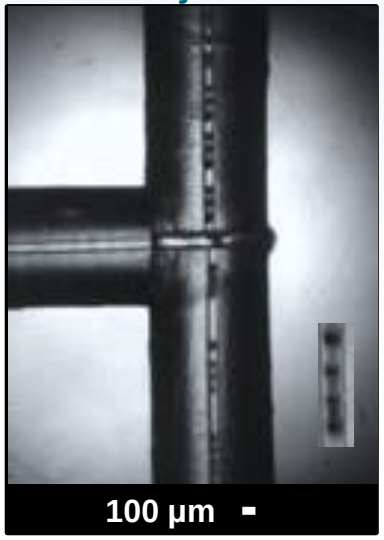


2nd T-junction

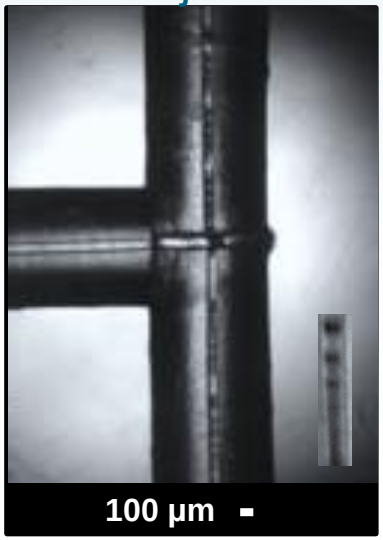


3rd T-junction

4th T-junction



5th T-junction



Comparison study:

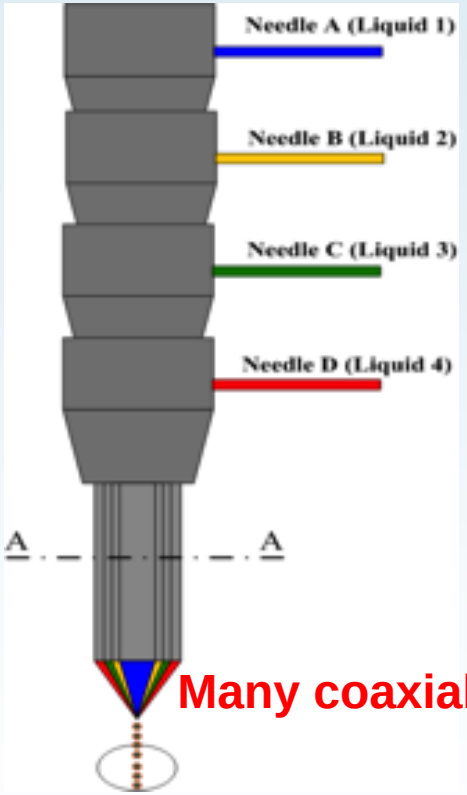
Capillary size:	100 µm	65 µm	25 µm	25 µm for gas inlet 65 µm for rest capillaries	
Channel gap distance:	**100 µm**	**65 µm**	**25 µm**	**65 µm**	
Fission Process	**Not occurred**	**Not occurred**	**Not occurred**	**Not occurred**	
The smallest MB size:	**22.8 ± 1.4 µm**	**12.4 ± 1.2 µm**	**12.8 ± 1.7 µm**	**9.9 ± 1.3 µm**	
The optimal conditions:	Triple (3) T-junction Gas Pressure: 80 kPa BSA solution: 15 wt % Flow Rate: 800 µL min^{-1}	Triple (3) T-junction Gas Pressure: 80 kPa BSA solution: 10 wt % Flow Rate: 650 µL min^{-1}	Triple (3) T-junction Gas Pressure: 80 kPa BSA solution: 5 wt % Flow Rate: 400 µL min^{-1}	Triple (3) T-junction Gas Pressure: 80 kPa BSA solution: 10 wt % Flow Rate: 700 µL min^{-1}	
lifetime of MBs (without adding SiQD):	40.0 ± 2.0 mins	25.0 ± 1.5 mins	5.0 ± 0.5 mins	25.0 ± 2.5 mins	
Capillary size:	100 µm	65 µm	25 µm	25 µm for gas inlet 100 µm for rest capillaries	25 µm for gas inlet 65 µm for rest capillaries
Channel gap distance:	**100 µm**	**100 µm**	**50 µm**	**150 µm**	**100 µm**
Fission Process	**Not occurred**	**Occurred**	**Occurred**	**Occurred**	**Occurred**
The smallest MB size:	**8.7 ± 0.8 µm**	**6.6 ± 2.1 µm**	**6.3 ± 1.4 µm**	**3.3 ± 1.4 µm**	**2.8 ± 1.5 µm**
The optimal conditions:	Quadruple (4) T-junction Gas Pressure: 80 kPa BSA solution: 15 wt % Flow Rate: 800 µL min^{-1}	Quadruple (4) T-junction Gas Pressure: 80 kPa BSA solution: 10 wt % Flow Rate: 600 µL min^{-1}	Quadruple (4) T-junction Gas Pressure: 80 kPa BSA solution: 5 wt % Flow Rate: 300 µL min^{-1}	Quadruple (4) T-junction Gas Pressure: 80 kPa BSA solution: 15 wt % Flow Rate: 700 µL min^{-1}	Quadruple (4) T-junction Gas Pressure: 80 kPa BSA solution: 10 wt % Flow Rate: 650 µL min^{-1}
lifetime of MBs (without adding SiQD):	35.0 ± 4.0 mins	20.0 ± 2.0 mins	5.0 ± 1.0 mins	20.0 ± 1.0 mins	15.0 ± 4.5 mins

EPSRC GRANTS: EP/C547055/1, EP/E045839/1, EP/J01334X/1

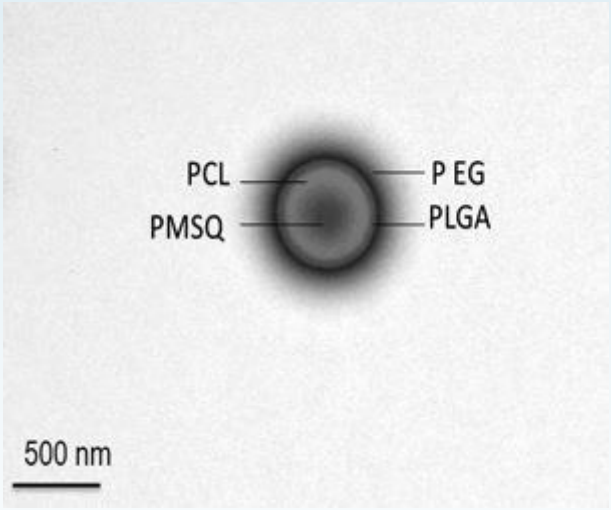
Multi-Layer Capsules

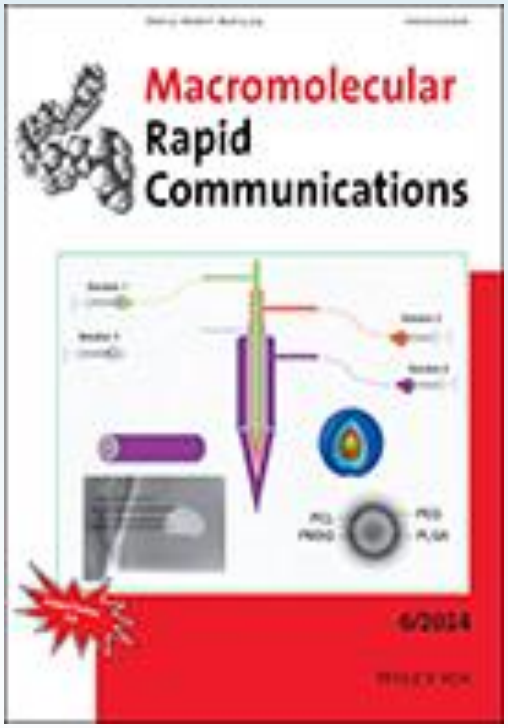
(prepared using electrohydrodynamics)

VENTURE PRIZE 2010



Many coaxial Needles





Labbaf S, Ghanbar H, Stride E, Edirisinghe M. Preparation of multilayered structures using a novel four-needle coaxial device. Macromolecular Rapid Communication 2014 35: 618-623 (front cover article)

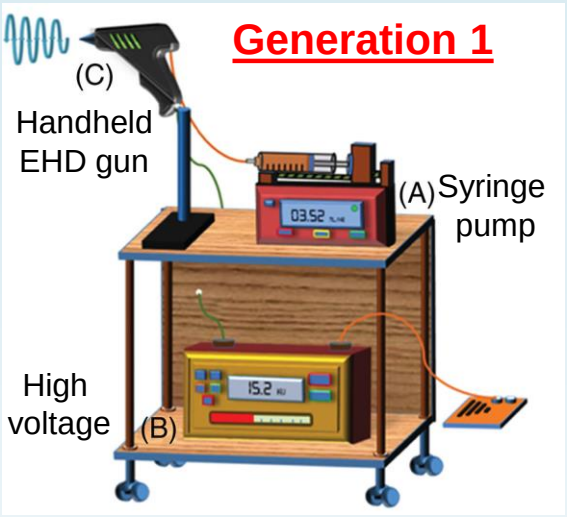
UK Patent Application No. 1102148.2 PCT filed: 08Feb 2012

USA Patent Application 13/984345

EPSRC GRANT : EP/P022677/1

Collaboration School of Pharmacy (Prof Duncan Craig) AND MECHANICAL ENGINEERING

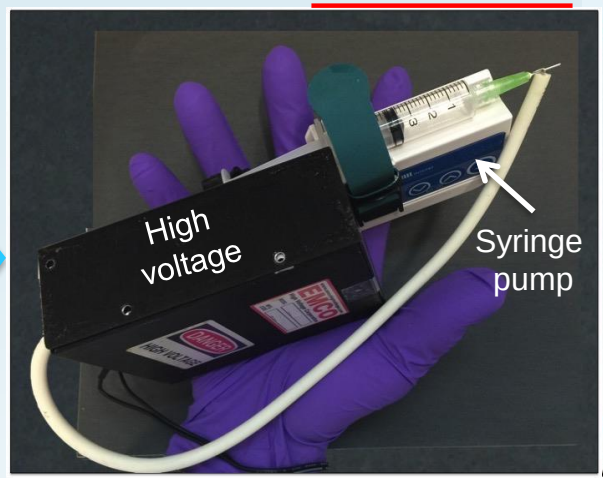
Generation 1

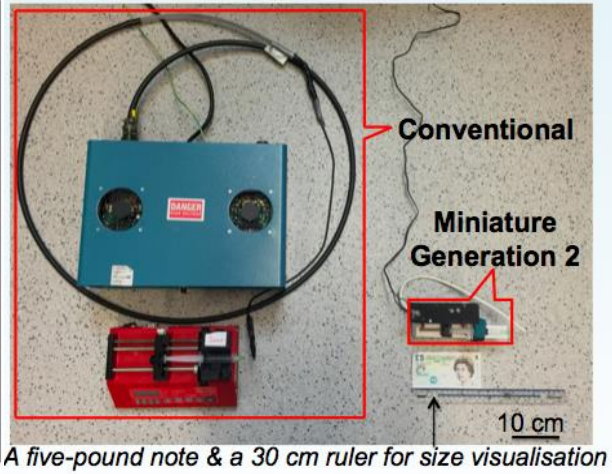


Sofokleous, P.; Stride, E.; Bonfield, W.; **Edirisinghe, M**. *Mater. Sci. Eng. C Mater. Biol. Appl.* **2013**, *33* (1), 213–223.

A

Generation 2



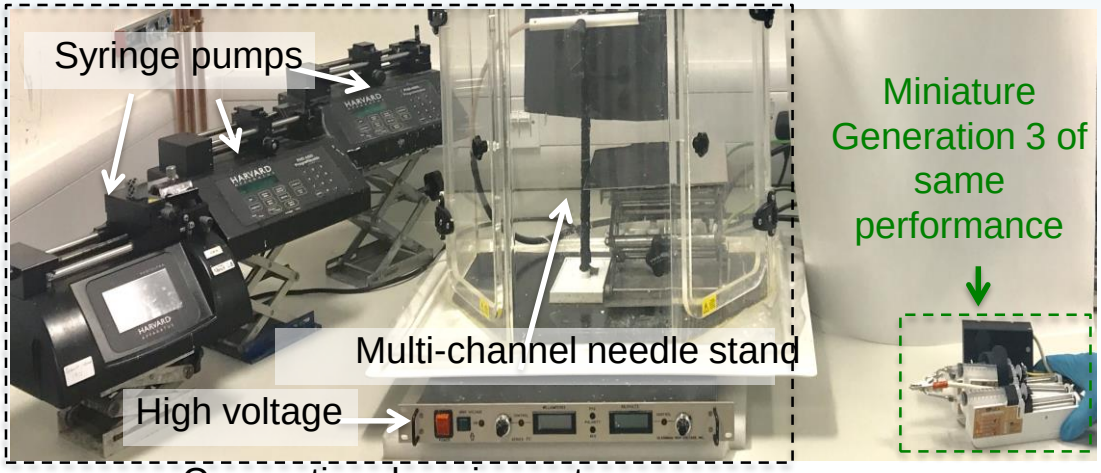


A five-pound note & a 30 cm ruler for size visualisation

F. Brako, C.J. Luo, D.Q.M. Craig, **M. Edirisinghe.** Macromolecular Materials and Engineering, **2018**, 303 (5), 1700586.

B

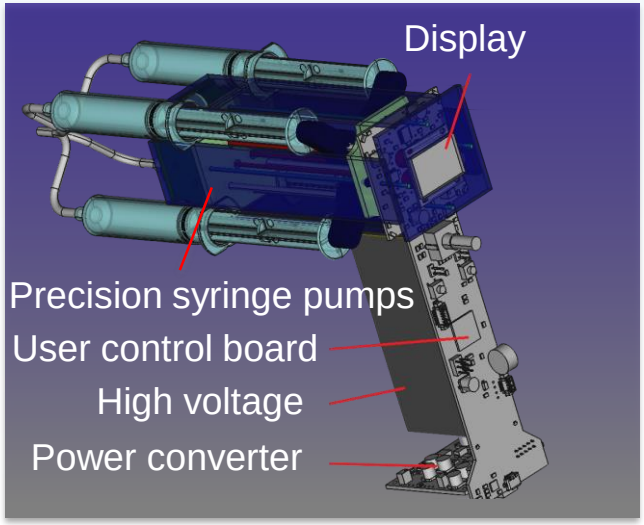
Generation 3



Conventional equipment

C

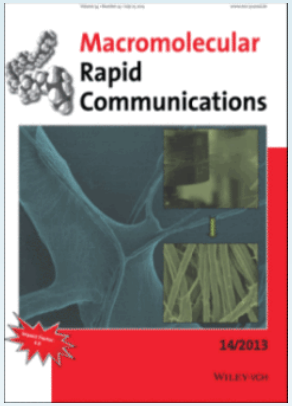
Generation 4

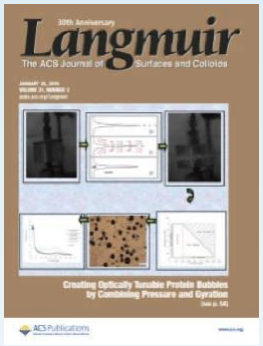


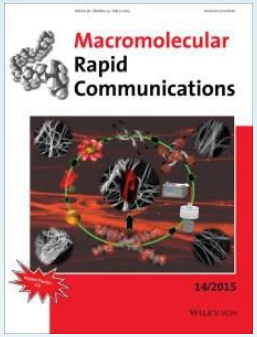
Pressurised Gyration & SISTER PROCESSES

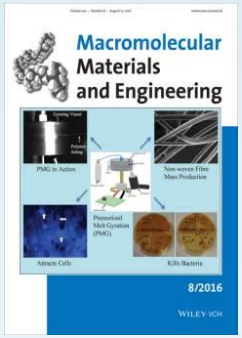
EPSRC grant EP/L023059/1: Exploitation of Pressurised Gyration as an Innovative Manufacturing Route for Nanofibrous Structures. Industrial Support: BASF, Astra Zeneca

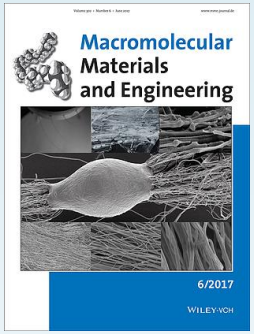
(Collab: Professor Duncan Craig, UCL School of Pharmacy)

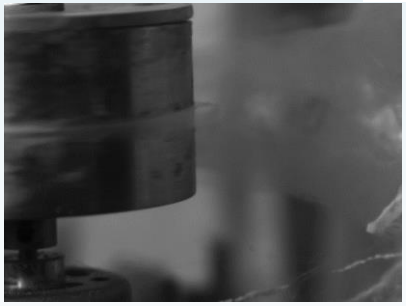


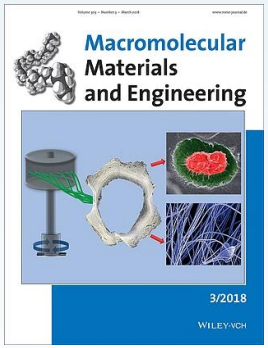


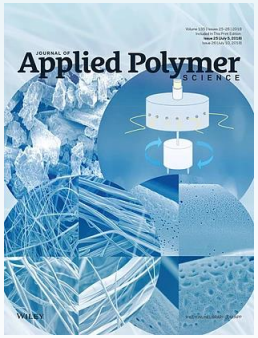


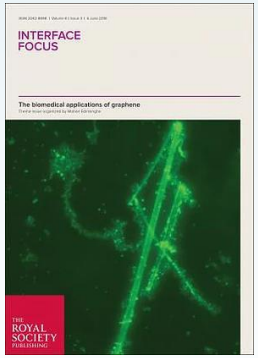


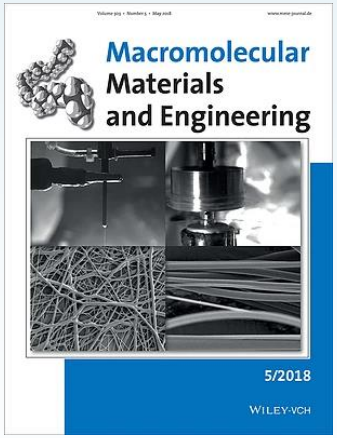


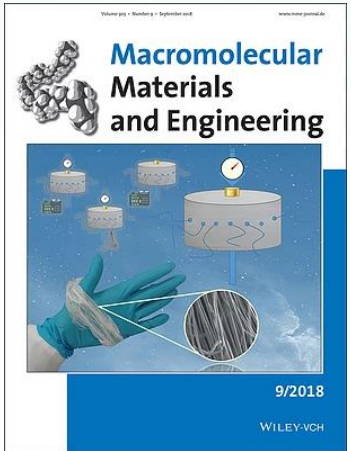












Invited Feature: 2018

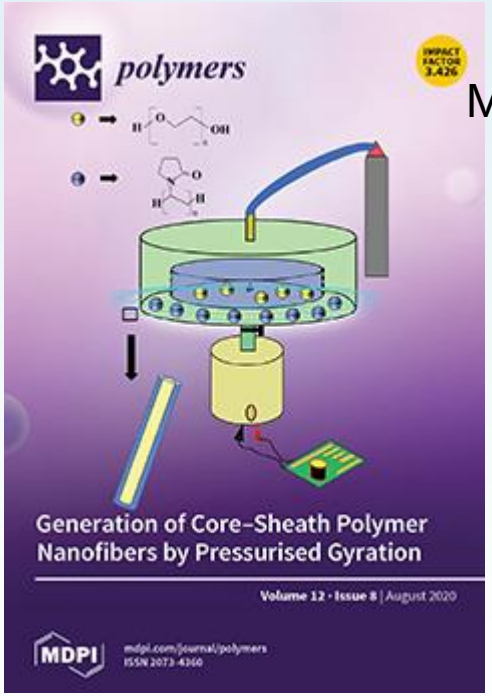
BEST OF MACROS 2018

Featured in Advanced Science News July 23rd 2018

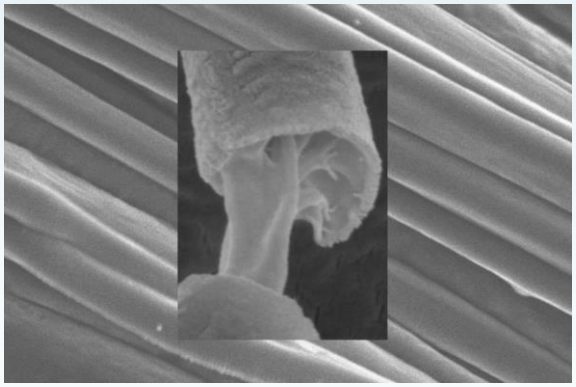
BEST OF MACROS 2019

EP/S016872/1:
Creation and Exploitation of Pressurised Gyration to Manufacture Core-Sheath Structures

Mahalingam, S; Homer-Vanniasinkam, S; Edirisinghe, M; (2019) Novel pressurised gyration device for making core-sheath polymer fibres. **Materials & Design** , 178 , Article 107846. 10.1016/j.matdes.2019.107846.



Polymers 2020, 12, 1709; doi:10.3390/polym12081709
Mahalingam, S; Huo, S; Homer-Vanniasinkam, S; Edirisinghe, M



UPI - SCIENCE NEWS
OCT. 14, 2020 / 9:17 AM
Layered hybrid fibers could be used to build anti-viral masks, researchers say

Current methodologies and approaches for the formation of core–sheath polymer fibers for biomedical applications
S. Mahalingam, *R. Matharu*, *S. Homer-Vanniasinkam* and *M. Edirisinghe*
Applied Physics Reviews **7**, 041302 (2020); https://doi.org/10.1063/5.0008310

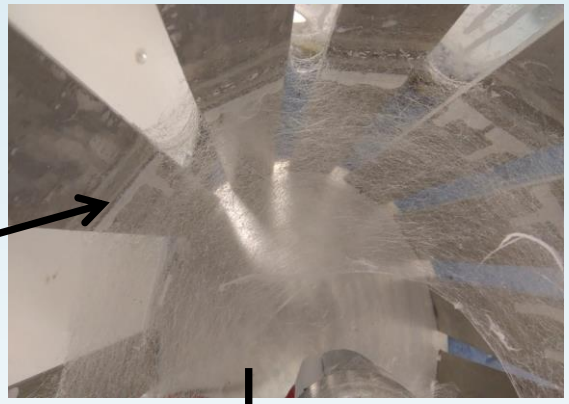
Altmetric

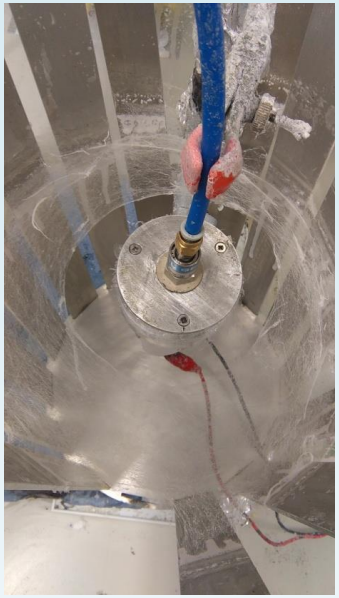
EPSRC Grants: EP/N034228/1 & EP/N034368/1

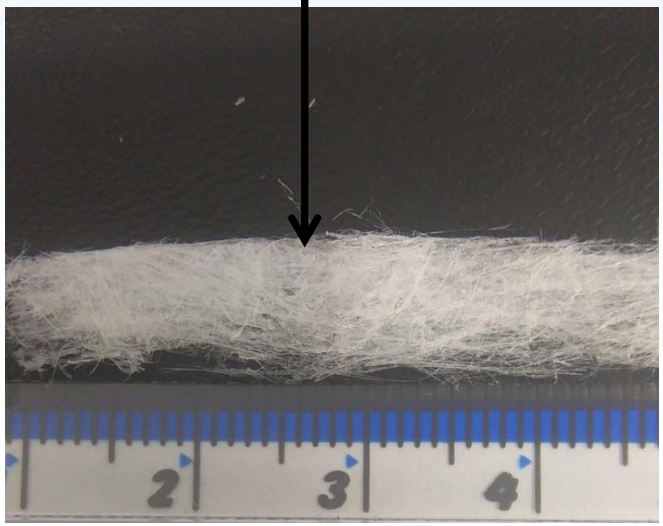
Antimicrobial filters for hospital air and water system

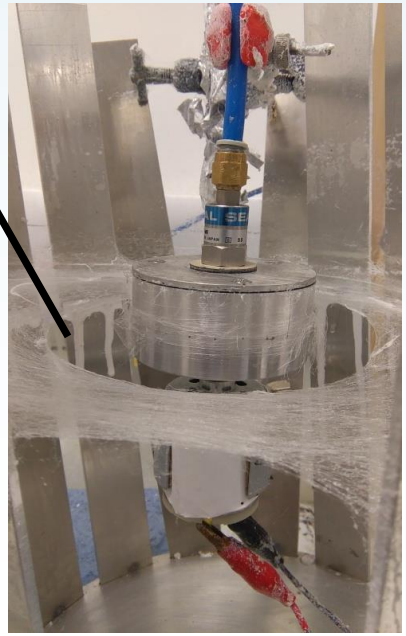
(Collab: Dr Lena Ciric UCL Eng Civil Eng. (microbiologist) & UoH Eng.)

Mark-II of device (2015-16)



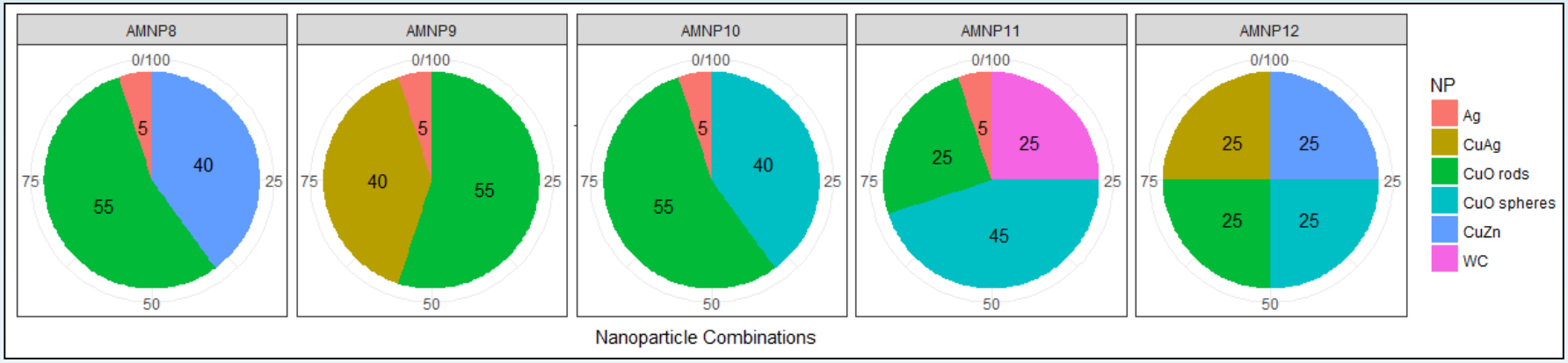




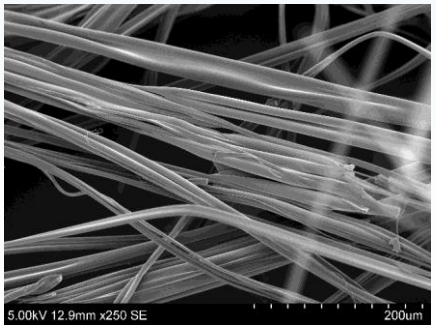


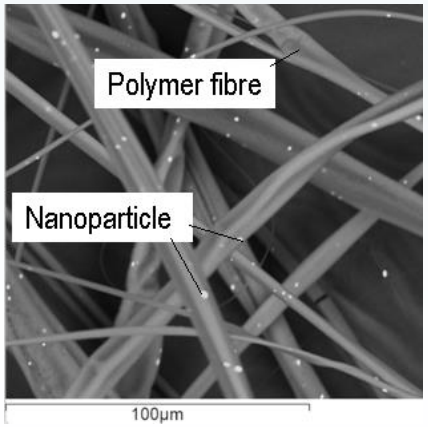
Novel Antimicrobial Filters

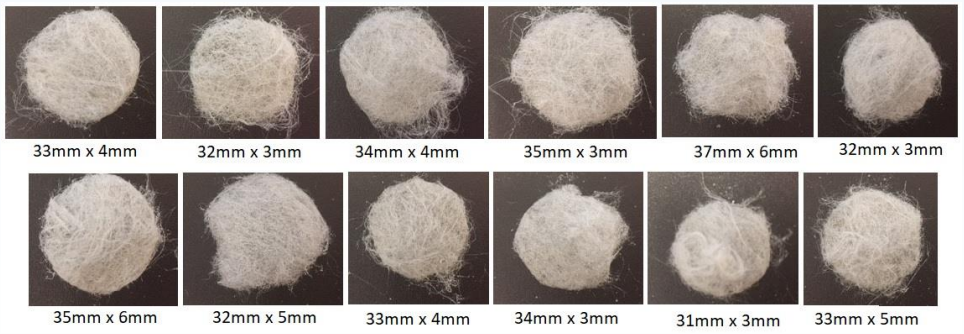
A number of nanoparticle preparations were assessed for their antimicrobial properties.



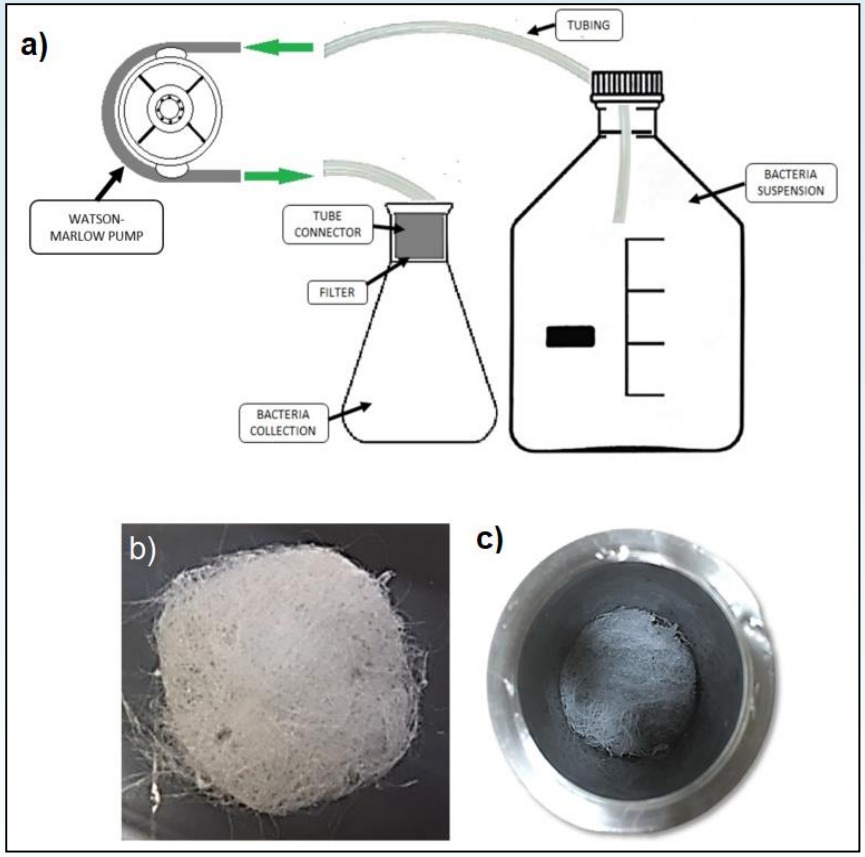
Nanocomposite filters were developed using pressurised gyration, during which poly(methylmethacrylate) (PMMA) solutions were loaded with **antimicrobial nanoparticles** and processed into nanofiber meshes.



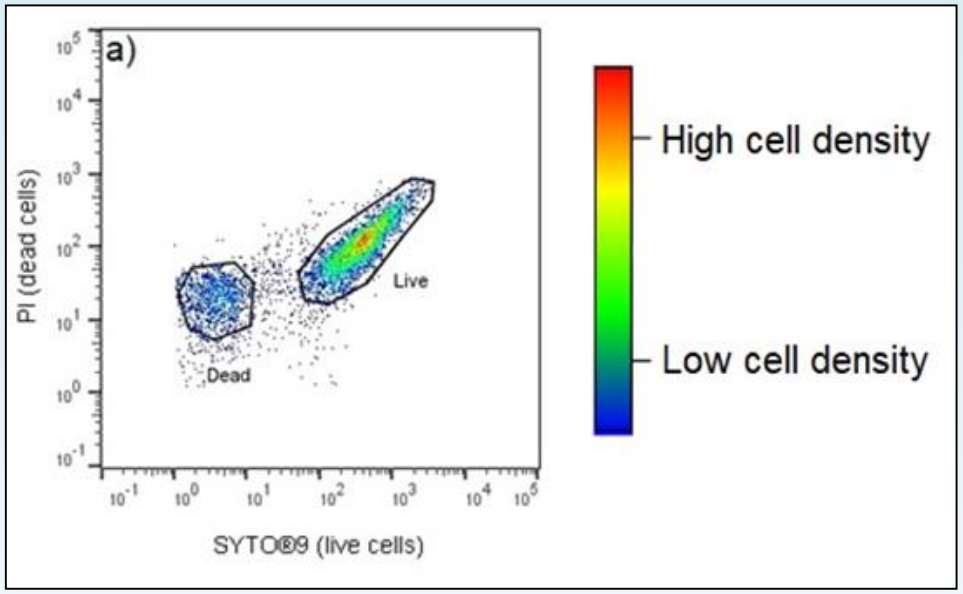




Novel Antimicrobial Filters



Filters were tested using phosphate buffered saline solution spiked with high concentrations of ***Pseudomonas aeruginosa*** and ***Staphylococcus aureus***. The bacterial suspensions were passed through a peristaltic pump at **500 mL min^{-1}** to simulate standard UK tap pressure.



The viability of bacterial populations were quantified and analysed using **flow cytometry** to determine live and dead cells after filtration.

Project Partners:

GAMA Healthcare Ltd

Intrinsiq Materials Limited

Pall Corporation

Pathogen Solutions

Professor John Oxford

Novel Antimicrobial Filters

AMNP8.1 filters showed reproducible results upon reuse every 30 minutes for 6 hours.

Project Partners:

GAMA Healthcare Ltd

Intrinsiq Materials Limited

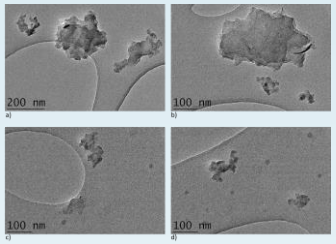
Pall Corporation

Pathogen Solutions

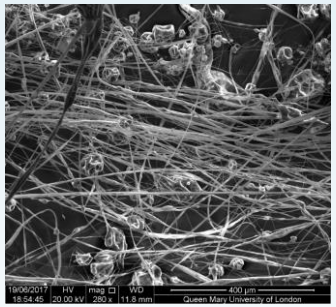
Professor John Oxford

The Effect of Graphene-Poly(methyl methacrylate) Fibres on Microbial Growth.

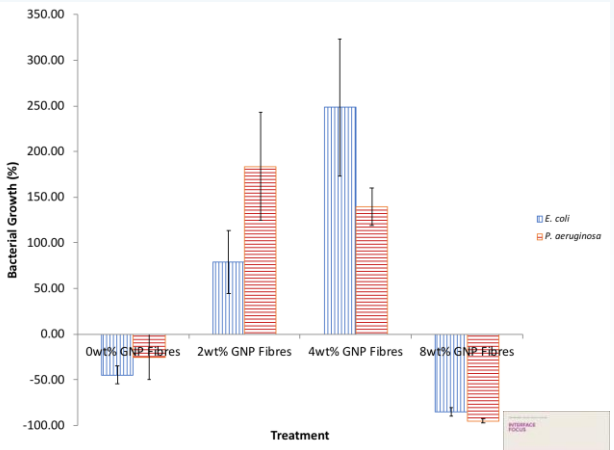
Graphene nanoplatelets (GNPs) are the most **recently discovered** carbon-based nanomaterial. They are the two-dimensional counterpart of carbon nanotubes and are composed of a **single layer of sp2 hybridized carbon atoms** arranged in a regular hexagonal lattice.



The microbial properties of a novel class of ultra-thin PMMA fibres containing **2, 4 and 8 wt% of (GNPs)** were studied. A series of polymer solutions loaded with GNPs were prepared and processed into continuous, tubular and smooth nanofiber meshes using pressurised gyration. As GNP concentration increased, the average fibre diameter increased from **0.75 µm to 2.71 µm**.

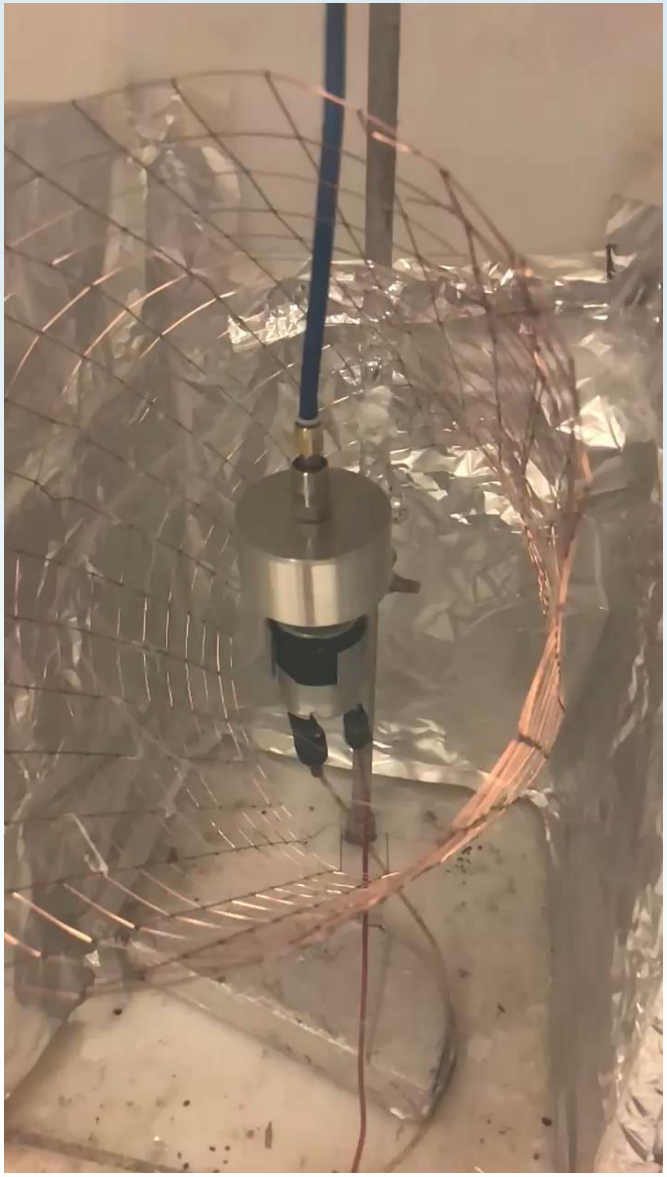


Gram-negative bacteria ***Escherichia coli*** and ***Pseudomonas aeruginosa*** were used to investigate the bacterial properties of the composite fibres. Pure PMMA fibres were used as the control. The presence of **2 and 4 wt% GNP loaded fibres promoted microbial growth**, whilst **8 wt% GNP loaded fibres showed antimicrobial activity**.

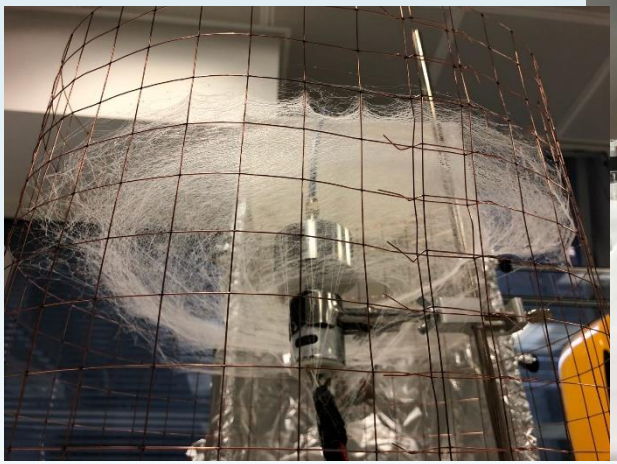


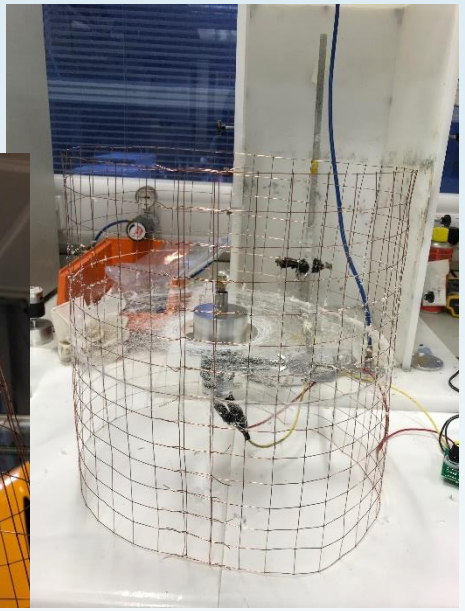
Matharu, R. K., Porwal, H., Ciric, L. and Edirisinghe, M. (2018). The Effect of Graphene-Poly(methyl methacrylate) Fibres on Microbial Growth. *Royal Society Interface Focus*, 8, 20170058; doi:10.1098/rsfs.2017.0058. (Special issue on graphene in Biomed. Eng.)

New project: Making a new generation of wound healing bandages



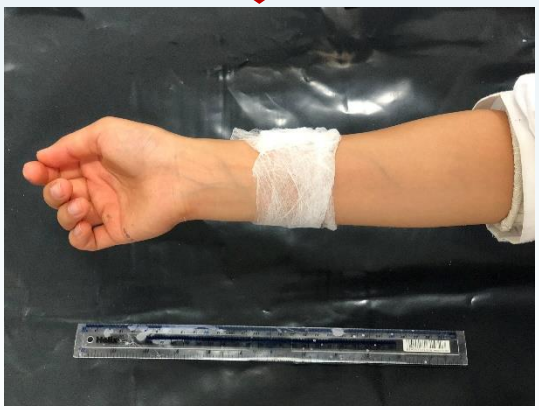
- Air Flow!!!
- Bigger Collector (from 150 to 300 mm in diameter)





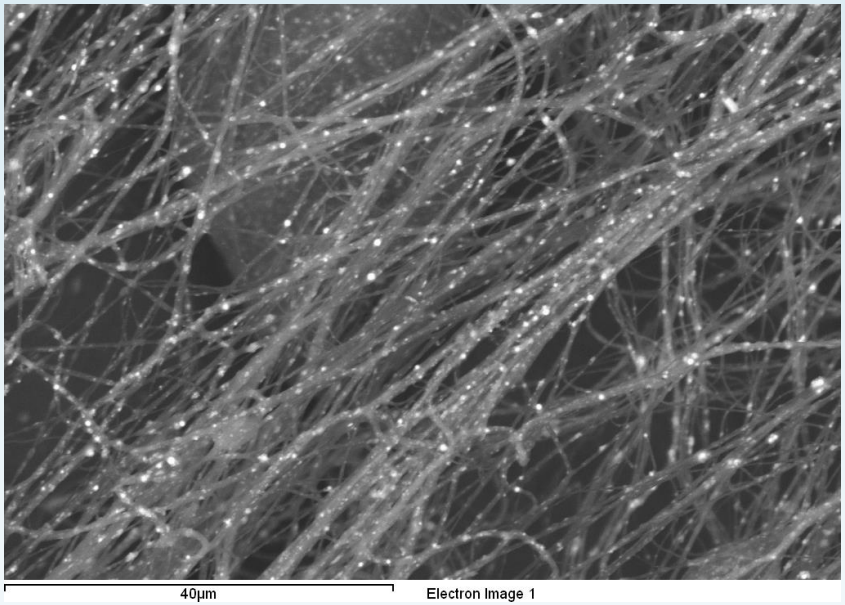
Sample Series	Relative Humidity (%)	Temperature (^{o}C)
100 PLA to 100 BC	41.4 - 45.3	23.1 – 24.8
100 PCL to 100 BC	42.6 - 45.7	22.2 - 23.7
PLA:PCL	51.3 – 54.5	21.3 – 25.8
PLA+PCL : BC (70:30 wt ratio)	48.5 - 51.9	20.1 – 23.6

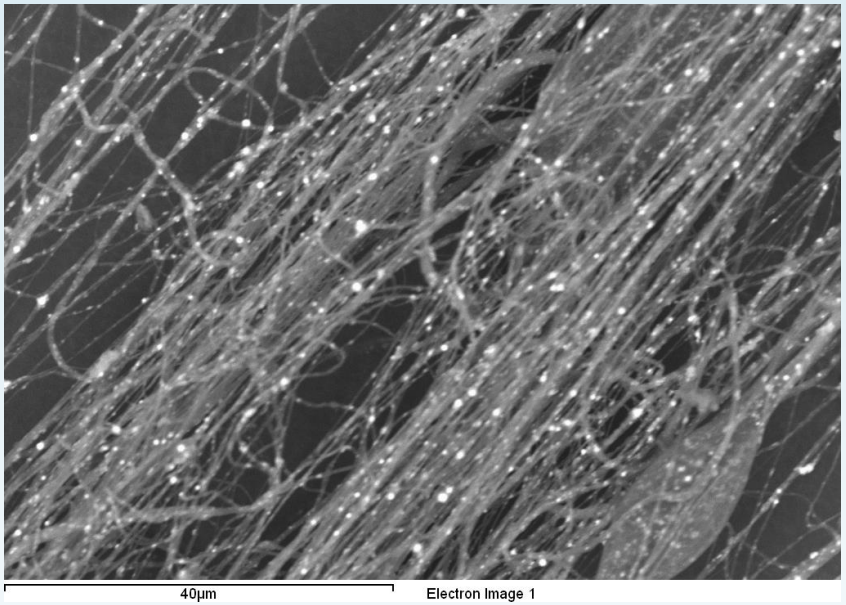
New project: Making a new generation of wound healing bandages

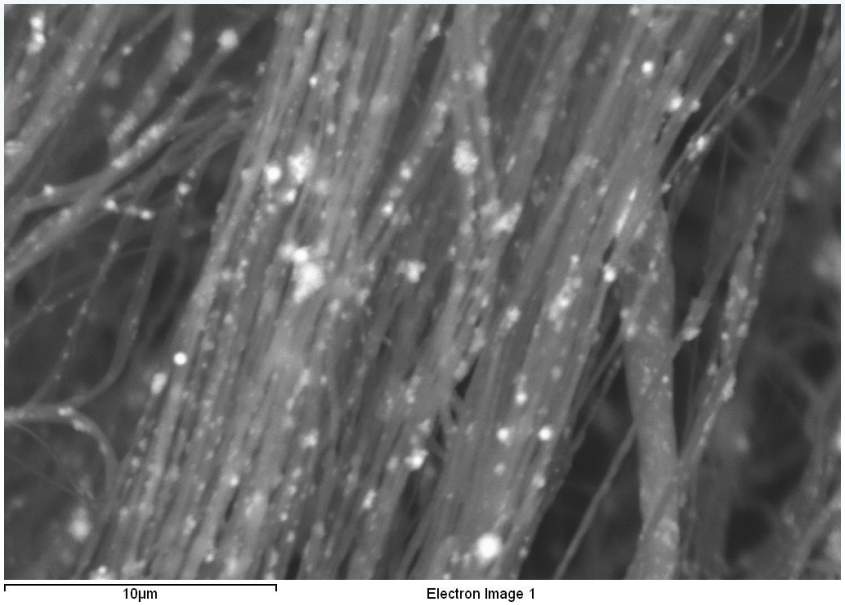


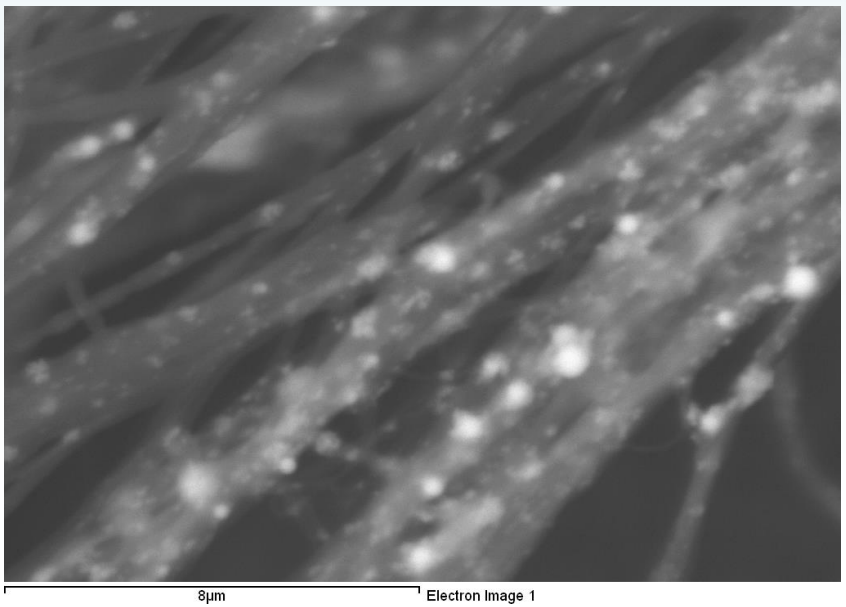
PLA:PCL samples from collector to bandage form

PEO 15 wt.% + HA 30 wt.% at 36000 rpm and 0.3 MPa



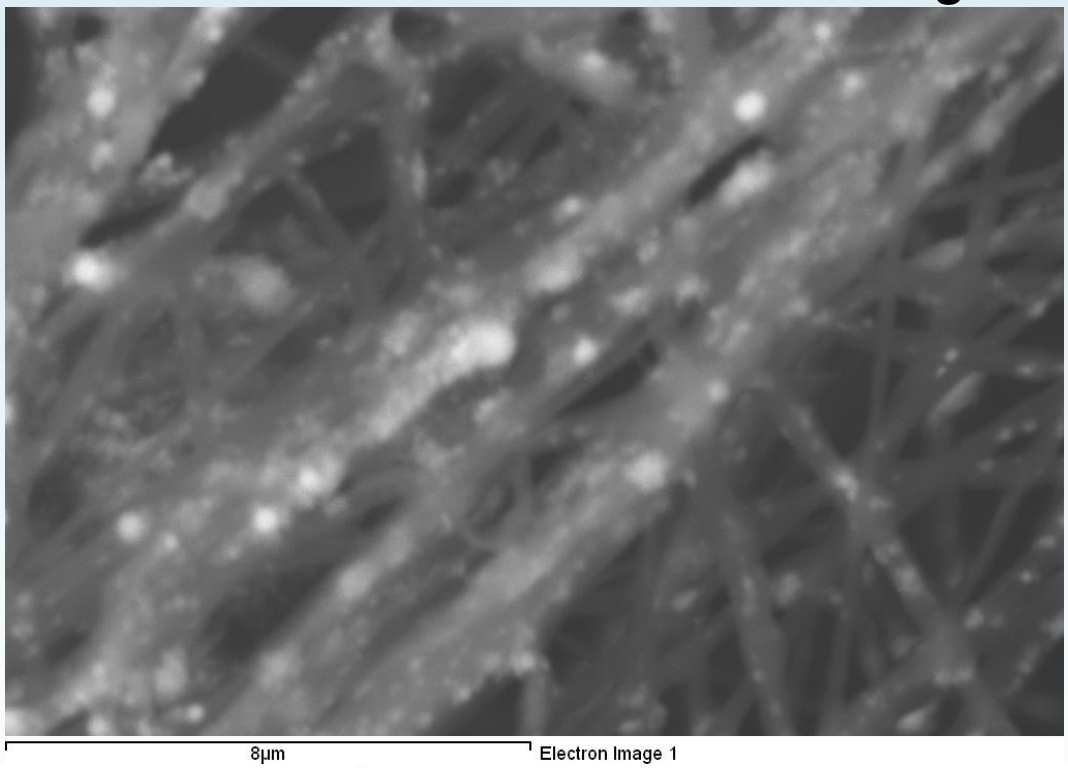


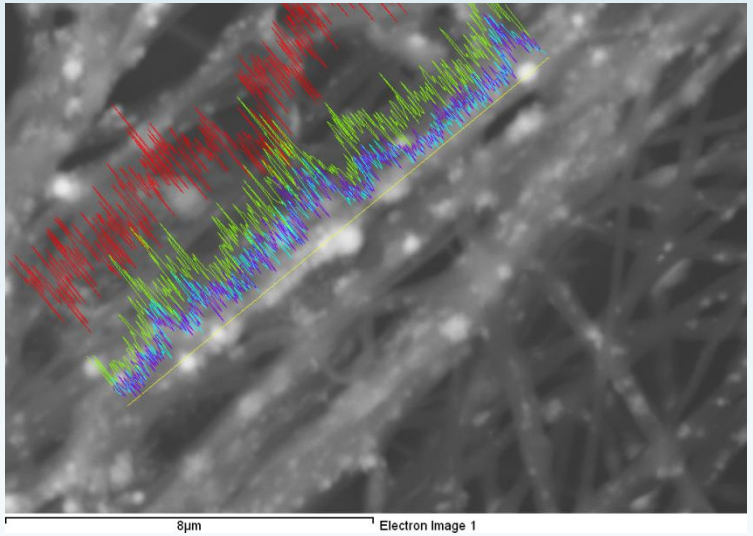


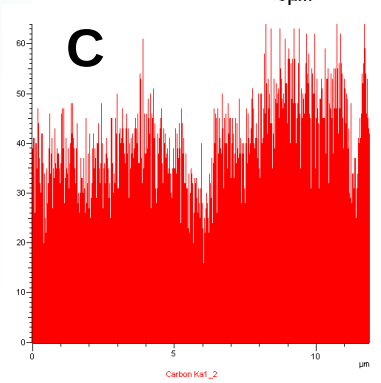


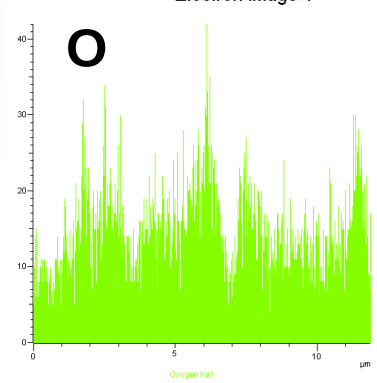
PEO 15 wt.% + HA 30 wt.% at 36000 rpm and 0.3 MPa

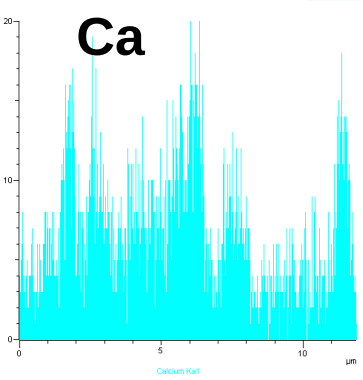
- EDS line scan along a fibre

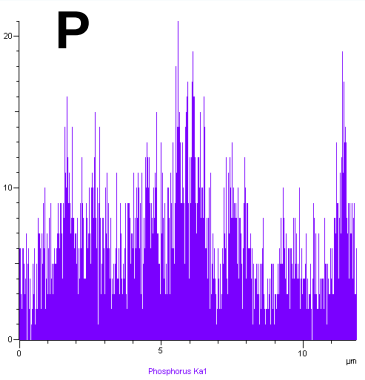


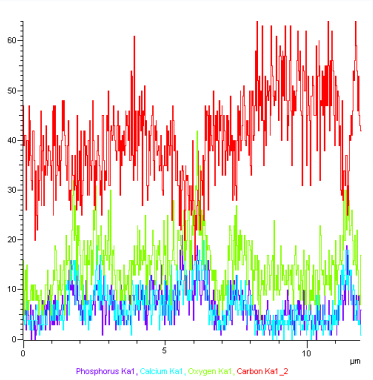




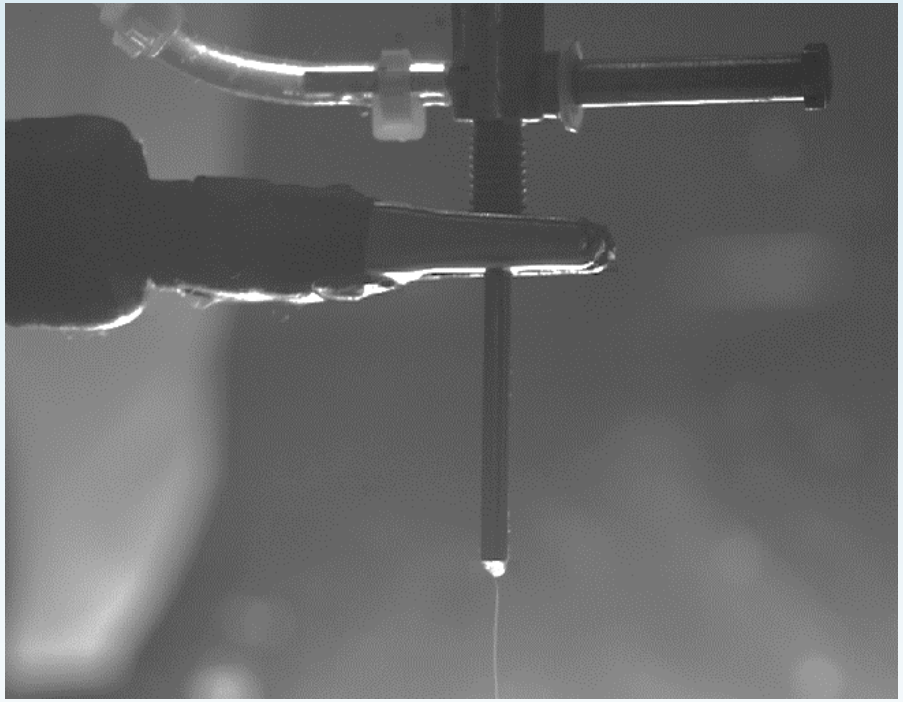






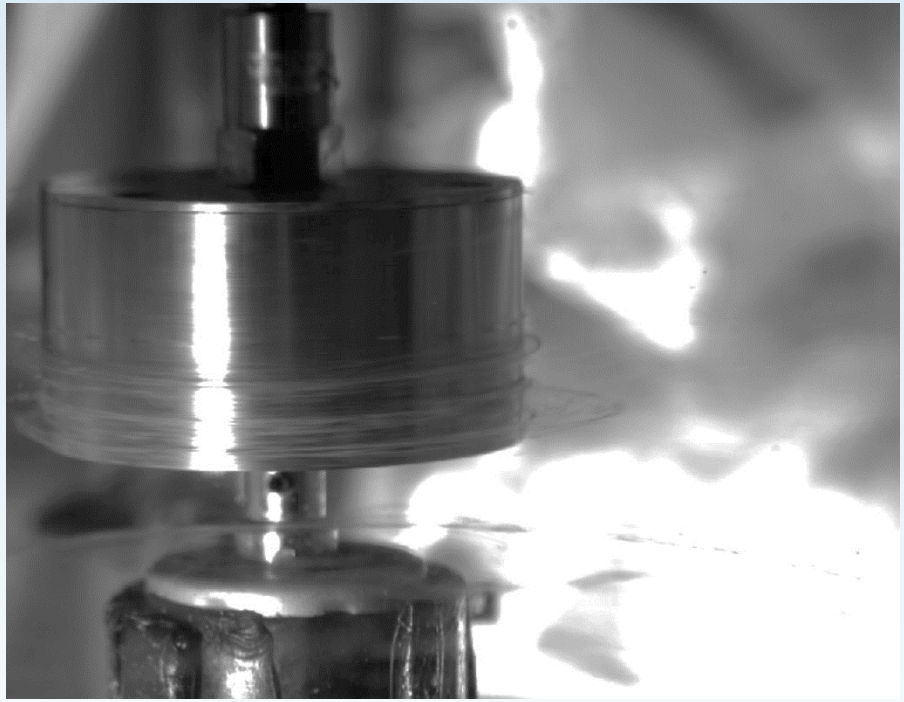


Electrospinning



- Electric field overcomes surface tension of polymer solution which allows for a highly tuneable fibre production (voltage increase very incremental)
- Can create very fine fibres with wide range of biomedical applications
- Due to electric field, polymer solution must be conductive, which limits usage of various polymer systems

Pressurised Gyration



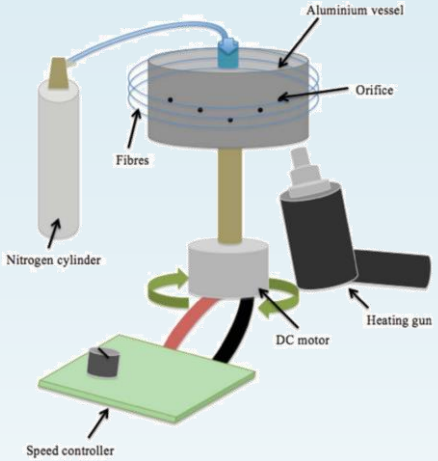
- Centrifugal force and applied gas pressure overcome surface tension of solution which allow for a large range of materials to be used, in solution form or otherwise
- Very rapid fibre production rate with great potential for scale-up
- The full potential of this technology has not yet reached

Differences in Polymer Preparation

Electrospinning

- Polymer solution must be prepared by dissolving a polymer within a solvent
- Polymer solution must be conductive in order to form fibres
- Solution must be homogenous otherwise it can effect the fibre formation
- Non-dissolved solutions can cause needle and pipe clogging and potentially damage setup

Pressurised Gyration

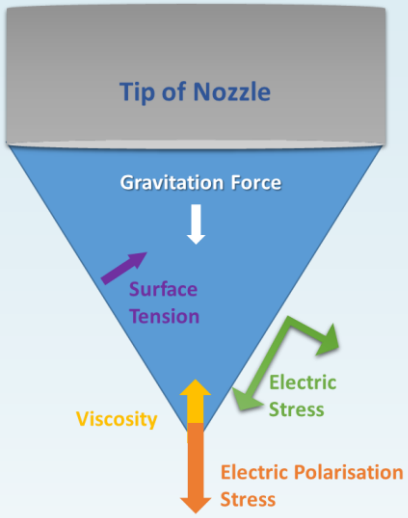


- Polymer solution can be prepared just like with electrospinning
- Non-homogenous solution can be spun as vessel is large and creates mixing during spinning
- Polymer melts can also be spun using melt gyration
- Materials in vessel can be in different phases, but can still form fibres
- Thick and viscous solutions can be spun which can be a problem with EHD

Xu, Z., et al., *Making Nonwoven Fibrous Poly(ε-caprolactone) Constructs for Antimicrobial and Tissue Engineering Applications by Pressurized Melt Gyration.* Macromolecular Materials and Engineering, 2016. **301**(8): p. 922-934.

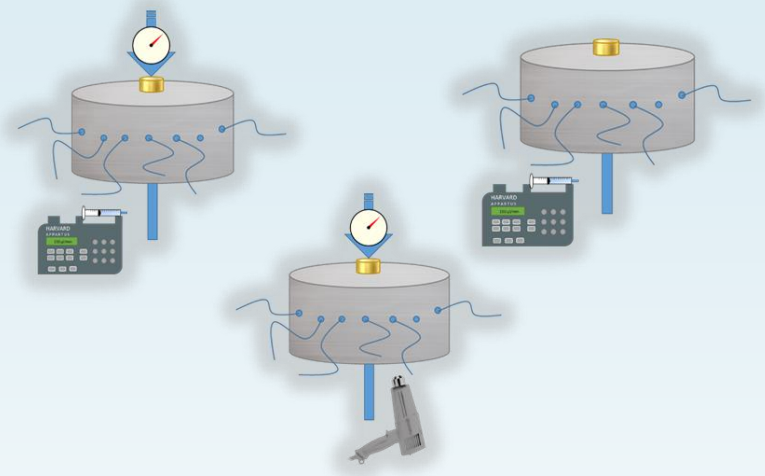
Differences in Process Control

Electrospinning



- Voltage can be adjusted very incrementally to give great control over final fibre morphology
- Flow rate is carefully governed to suit desired application and fibre size
- Collection distance can be altered to optimise fibre production by controlling fibre drying times
- Needle size can also have an effect on fibre production and morphology

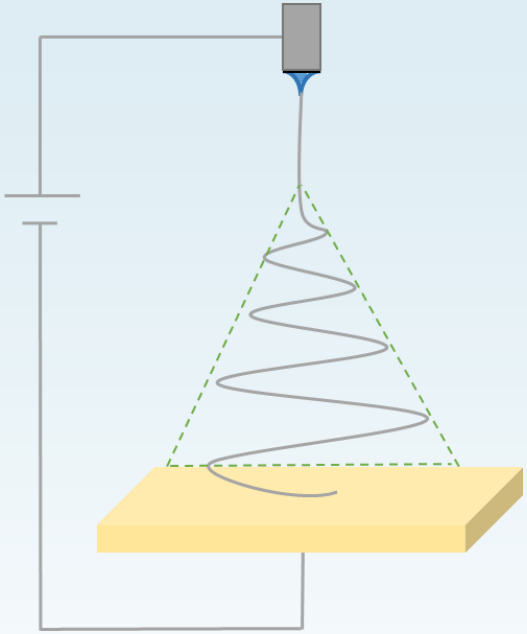
Pressurised Gyration



- Rotation speed influences centrifugal force and can be adjusted to control fibre morphology
- Applied gas pressure can also be increased to reduce fibre diameter, and control bead production
- Collection distances and setups do influence fibre structure
- Relative humidity can be used to regulate drying times and thus fibre morphology
- Melt temperature and infusion rate can further used to regulate fibre production

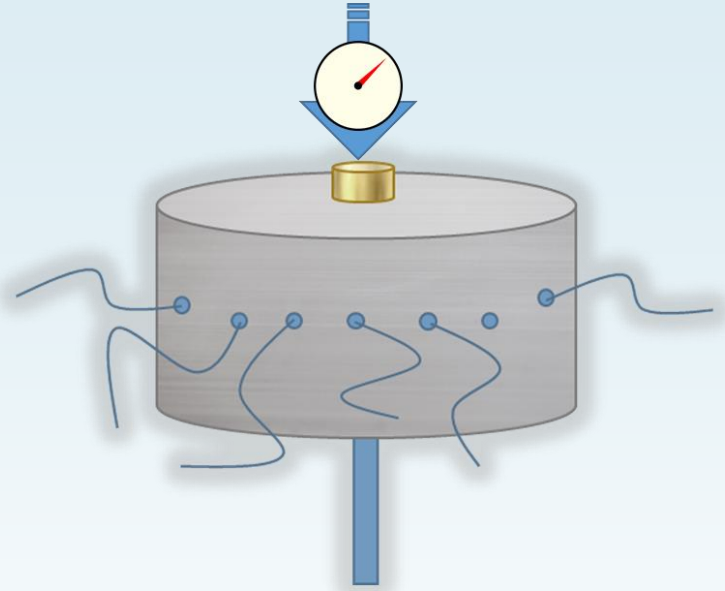
Differences in Fibre Production Rate

Electrospinning



- Typical flow rates are 50-150 µL/min in a single needle setup
- Typical fibre production in 1 hour is approximately **0.6 grams** of fibre for normal single-needle nanofibre setups
- Can be scaled up with multiple needle set-ups and advanced needle and collector devices which minimise solution-related problems

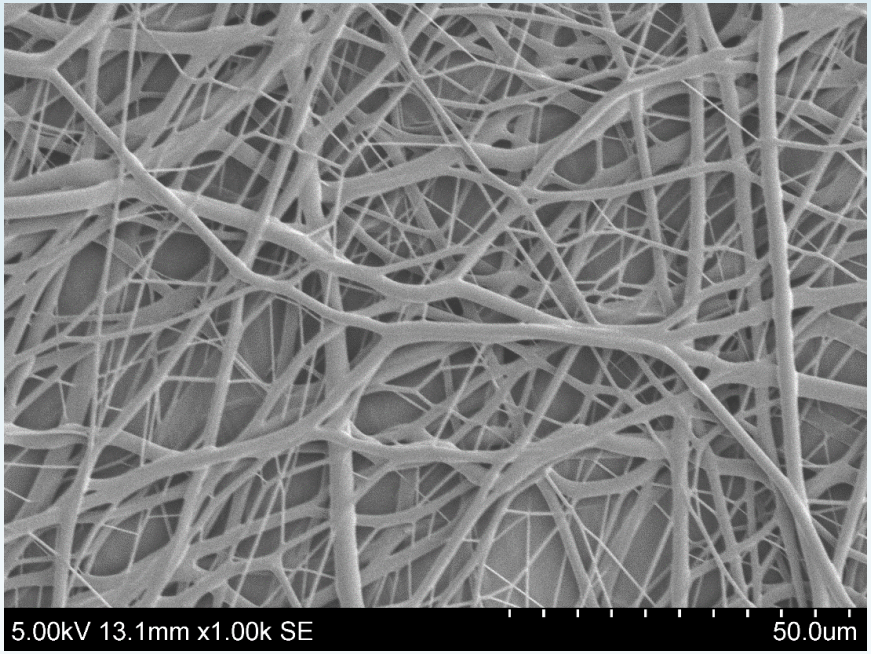
Pressurised Gyration



- 5mL of polymer solution can be produced into fibres in 15 seconds
- Typical fibre production rate in 1 hour is approximately **120 grams**
- Infusion gyration can further increase production rate to exceed 6 kg/hour
- Just like electrospinning, multiple gyration pot setups can be created to increase production rate

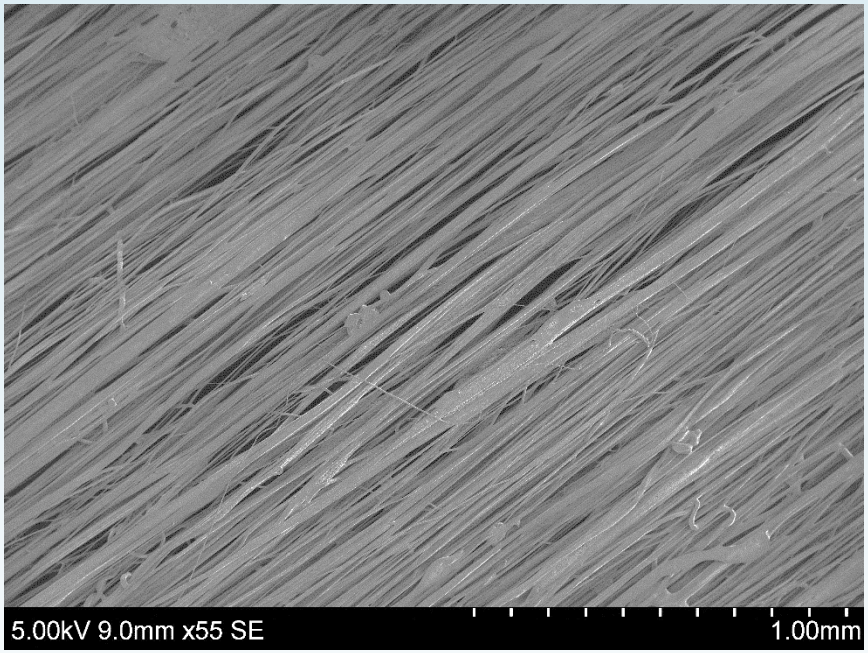
Differences in Fibre Morphology

Electrospinning



- Without a modified collector electrospun fibres form mesh-like fibres useful in mimicking the ECM
- Increased collection times allow for stacking up of layers to create 3D structures
- Very low fibre diameters can be achieved as low concentration polymers can be used

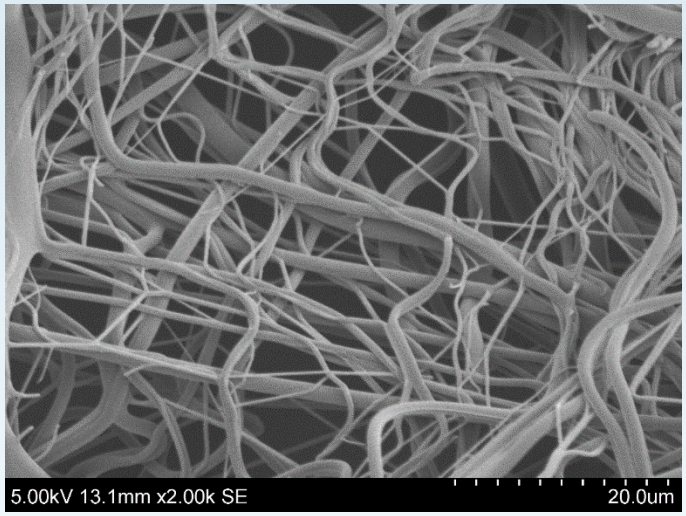
Pressurised Gyration



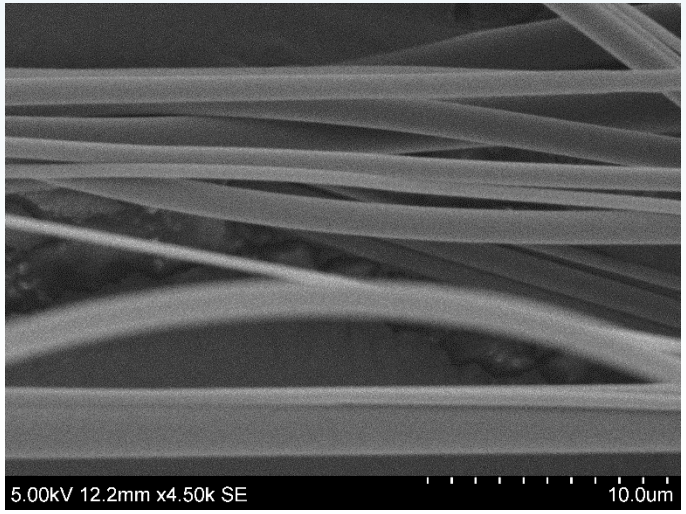
- PG fibres can easily form highly aligned structures suitable for use in neural tissue engineering
- The fibres can be collected into mats, bandages and other shapely materials and used directly as bandages without an additional step
- High production capable of fulfilling demand in medical scenarios

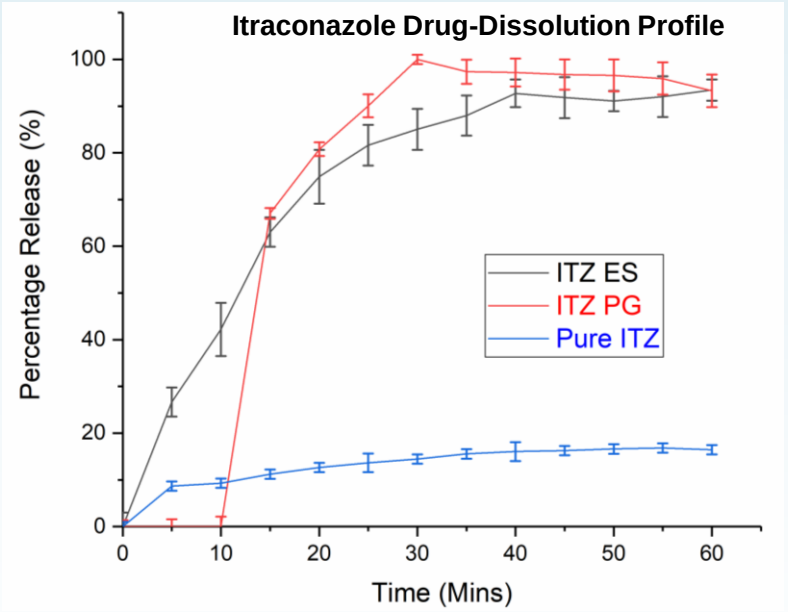
Pressurised Gyration Vs. Electrospinning for Drug Delivery

Electrospinning
PVP-Itraconazole
Average Fibre Diameter:
(0.94 µm ± 0.34)



Gyration
PVP-Itraconazole
Average Fibre Diameter:
(1.60 µm ± 0.87)

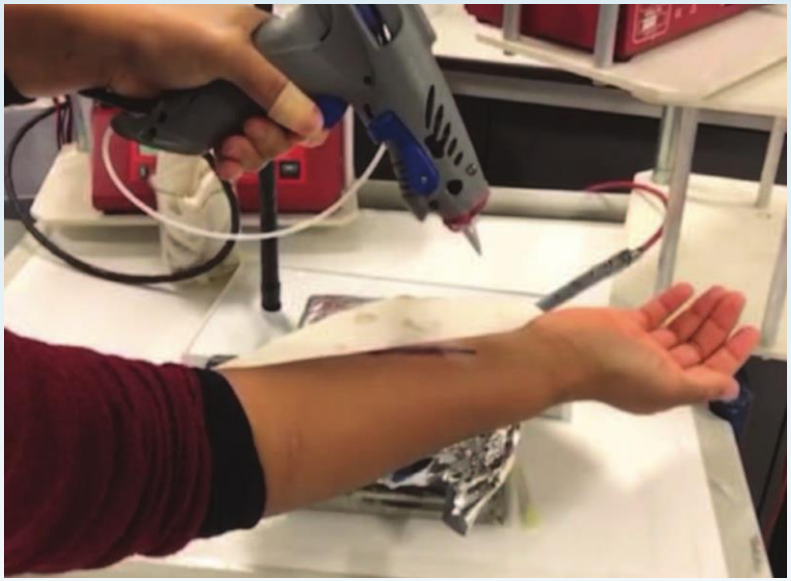




Ahmed, J., R. K. Matharu, T. Shams, U. E. Illangakoon and M. Edirisinghe (2018). "A Comparison of Electric-Field-Driven and Pressure-Driven Fiber Generation Methods for Drug Delivery." *Macromolecular Materials and Engineering*, 1700577.

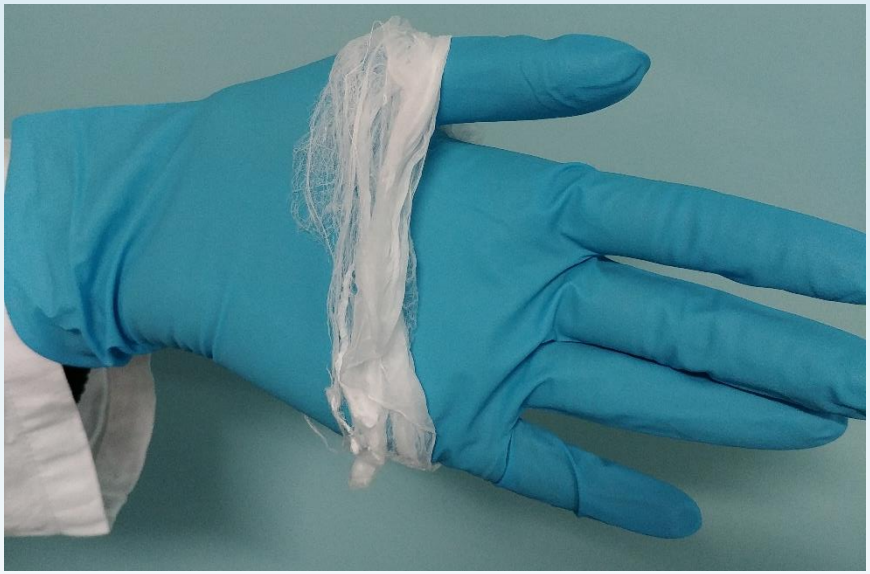
Differences in physical applications

Electrospinning



- Can be used to create filters with small mesh sizes that are capable of trapping microbes
- Portable EHD gun can be used to coat a layer of protective fibres directly onto the wound site in an emergency state

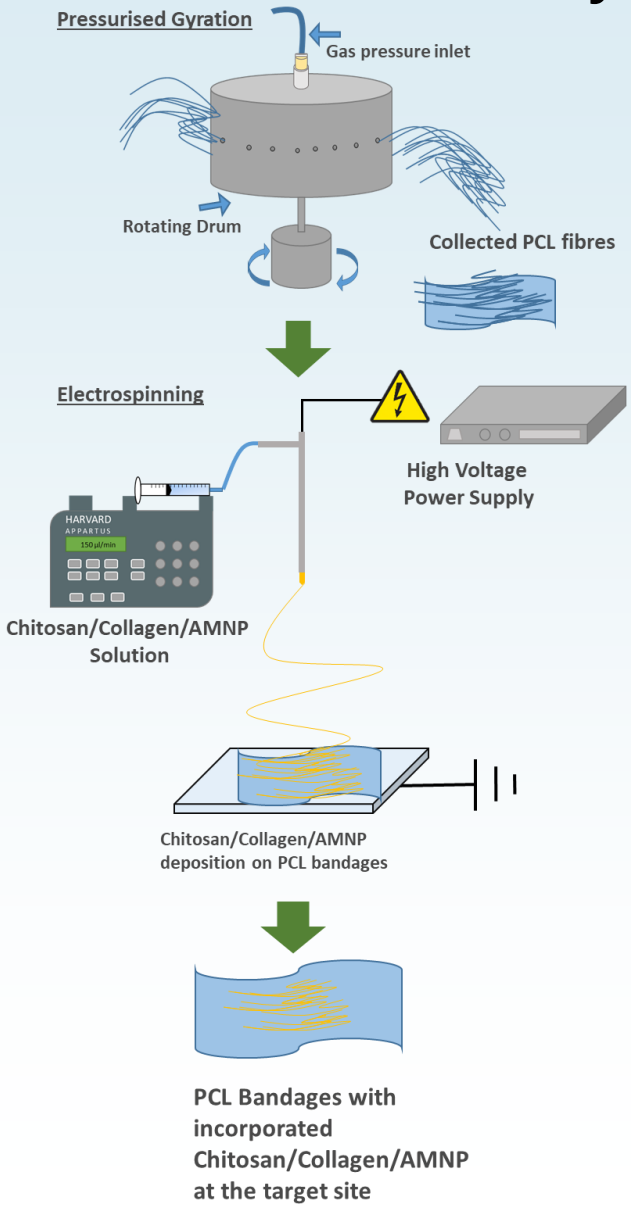
Pressurised Gyration



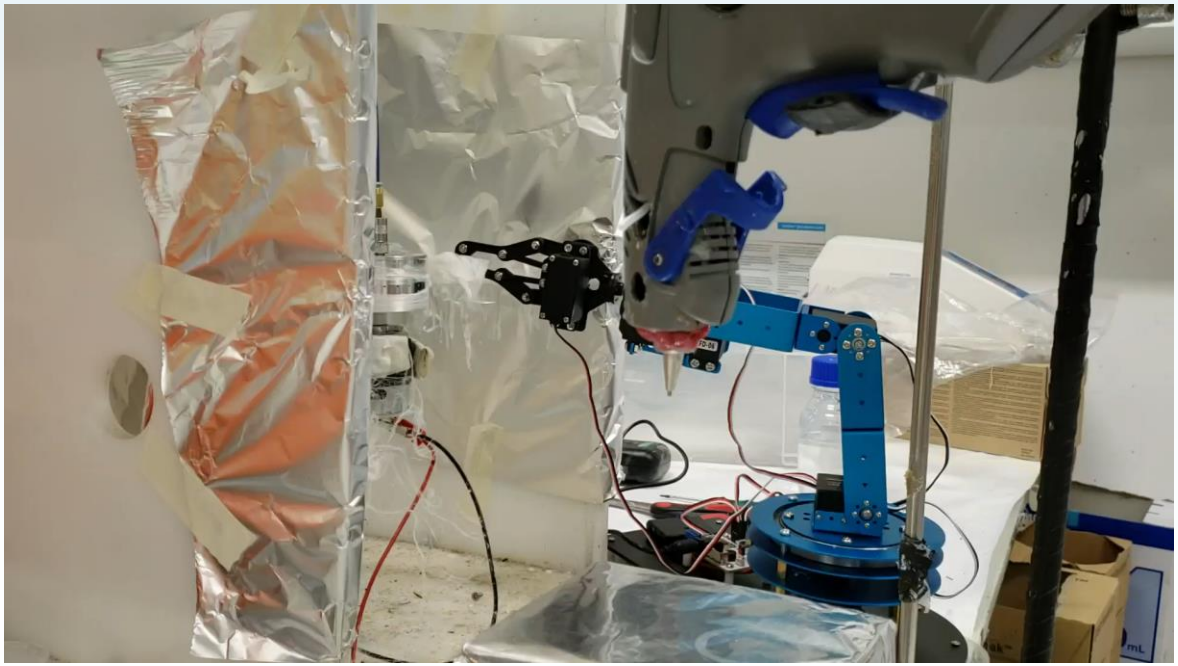
- Rapid spinning process allow for macro-scaled materials to be produced fast allowing for use in more physical applications such as wound dressings
- As the spinning material does not have to be in a solution, a wide range of antimicrobial and pro wound-healing additives can be incorporated into the bandages

Aydogdu, M.O., et al., *Cellular interactions with bacterial cellulose: Polycaprolactone nanofibrous scaffolds produced by a portable electrohydrodynamic gun for point-of-need wound dressing.* International Wound Journal, 2018. **15**(5): p. 789-797.

Combination of Gyration and Electro-spinning/spraying



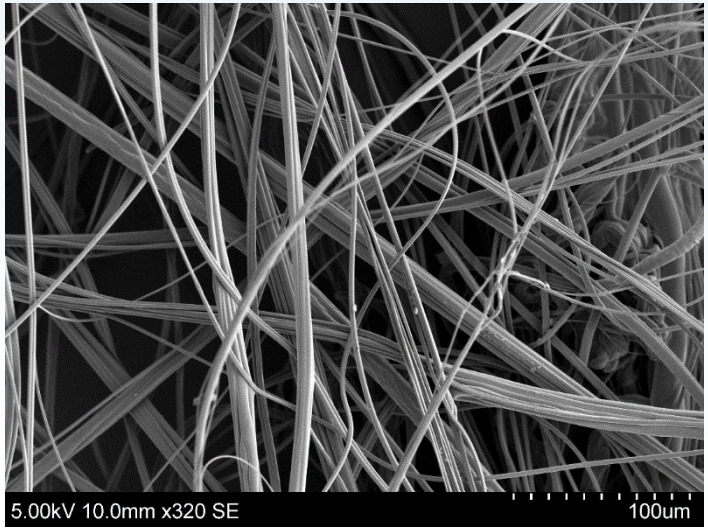
- PCL high-yield fibres produced by gyration which can be collected as bandage-like sheets
- Fibrous ring is cut into pieces and robot transfers bandage to the electrospinning site
- Electrospinning of active nano-fibrous patches made of materials such as collagen and chitosan can be accurately printed onto the bandage



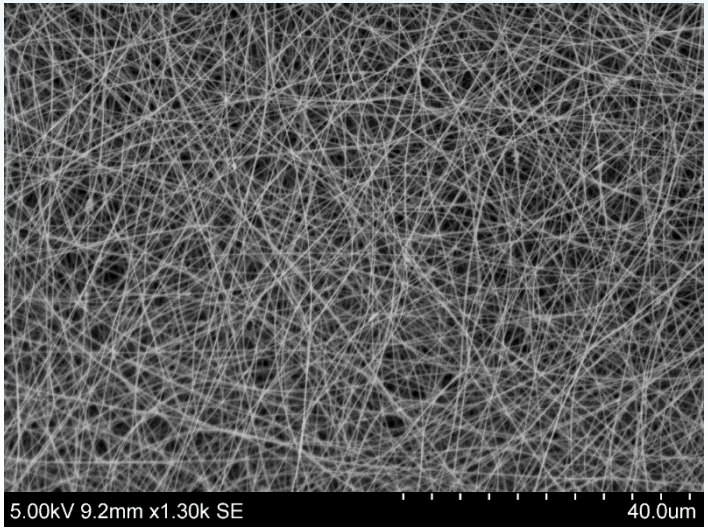
Production of Bioactive Bandages & Patches

- PCL fibres produced via pressurised gyration which act as the bandage
- Collagen and Chitosan solutions are electrospun onto the bandages to provide a bioactive patch which both protects the wound site from bacterial infections and accelerates the wound healing process.

Bandage with patch on 90 mm Petri dish



Gyration (1.71 ± 0.47 μm)

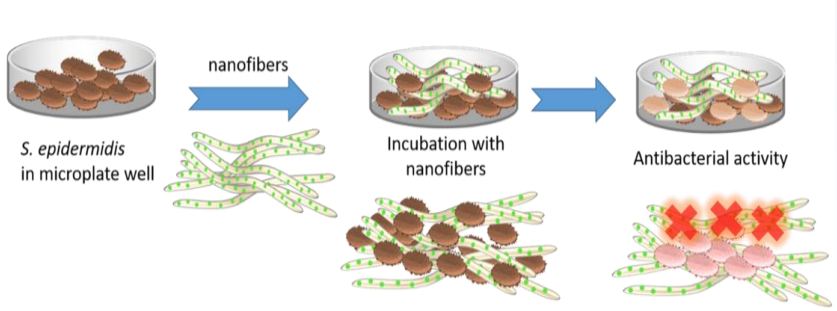


Electrospinning (142 ± 31 nm)

Collaboration with University of Kansas (Prof Candan Tamerler) - paper just accepted in Med. Devices & Sensors

Next generation wound dressing made of nanofibers incorporated with antimicrobial peptides (AMPs).

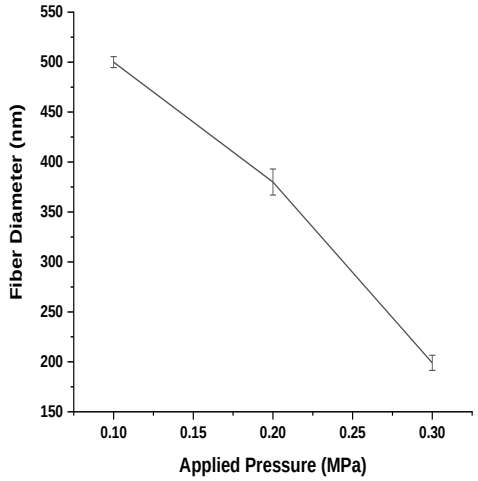
- Materials including hydrogels, decellularized dermal porcine dermal matrix and freezing dried or gas foaming scaffolds have been studied for wound healing applications, however, lack the ability to recapitulate the architecture of the skin's extracellular matrix (ECM)
- A new generation of wound dressing materials is anticipated to have a higher moisture level, and thereby provide sustained release results, which will enhance the healing of wounds due to the distinctive biological and non-sterile wound environment and to the difficult process of wound healing [1-3].
- Pressurised gyration is selected in this research because of its ability to mass produce bandage like meshes with simple separation and enhanced process control [4].
- A wound dressing material is created by loading peptides into water-soluble polymers that are proficient of efficient release. Thus, the growth of microorganisms is regulated by the antibacterial agents embedded in the structure of the fiber [5].
- A series of PEO integrated AMP nanofibers are prepared using GH12-COOH-M2 and AMP2 antimicrobial peptides, which are synthesized by solid phase peptide synthesis (SPPS) using an AAPPTec Focus XC peptide synthesizer, supplied by Kansas University (USA).



Schematic illustration of the antibacterial assessment of AMP integrated PEO nanofibers

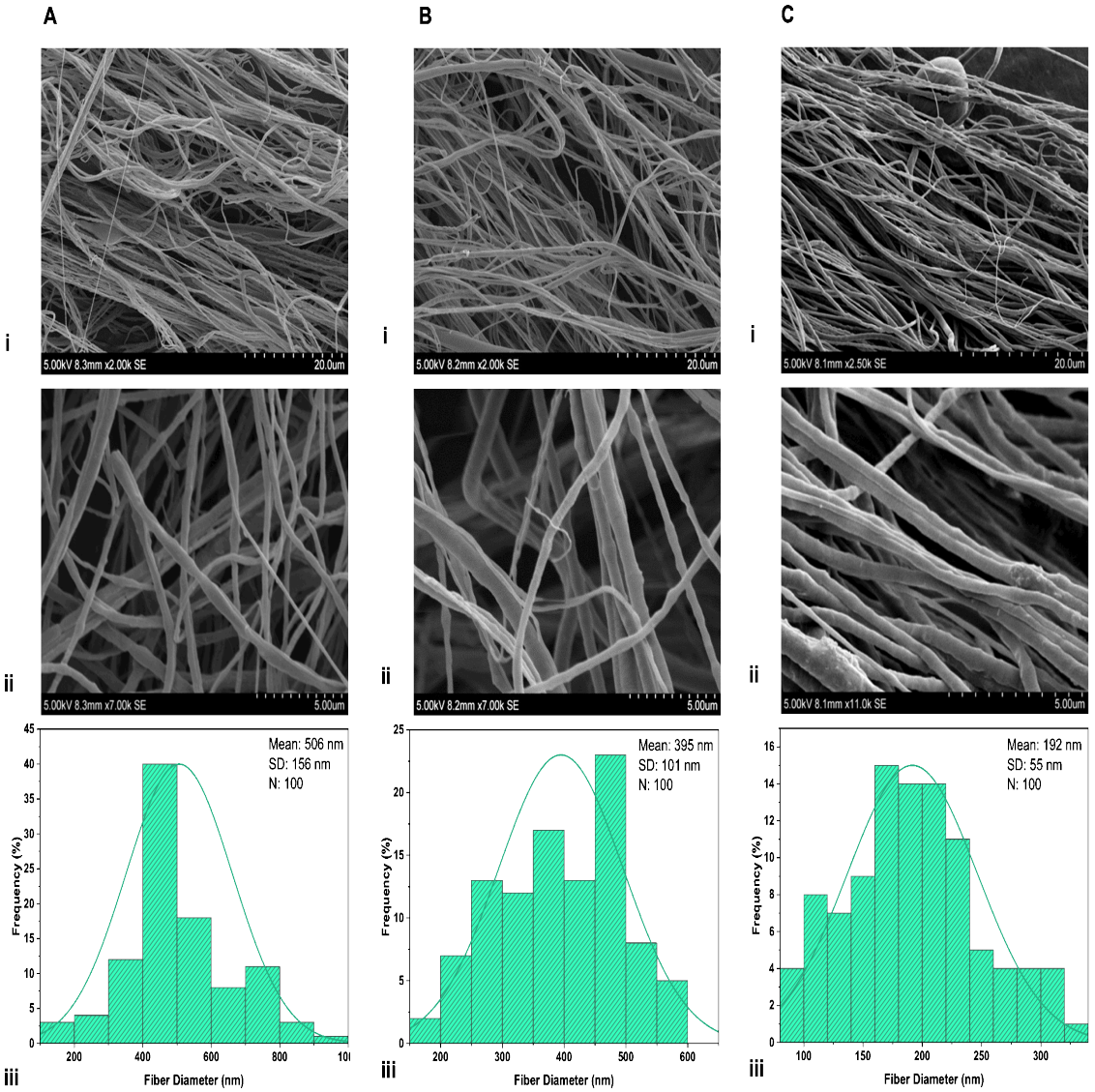
1. Georgescu, M.; Chifiriuc, M. C.; Marutescu, L.; Gheorghe, I.; Lazar, V.; Bolocan, A.; Bertesteanu, S., Bioactive Wound Dressings for the Management of Chronic Wounds. 2017.
2. Sood, A.; Granick, M. S.; Tomaselli, N. L., Wound Dressings and Comparative Effectiveness Data. 2014.
3. Gizaw, M.; Thompson, J.; Faglie, A.; Lee, S.-Y.; Neuenschwander, P.; Chou, S.-F., Electrospun Fibers as a Dressing Material for Drug and Biological Agent Delivery in Wound Healing Applications. 2018.
4. Alenezi, H.; Cam, M. E.; Edirisinghe, M., Experimental and theoretical investigation of the fluid behavior during polymeric fiber formation with and without pressure. 2019.
5. Morais, D. S.; Guedes, R. M.; Lopes, M. A., Antimicrobial approaches for textiles: From research to market. 2016.

Preliminary testing



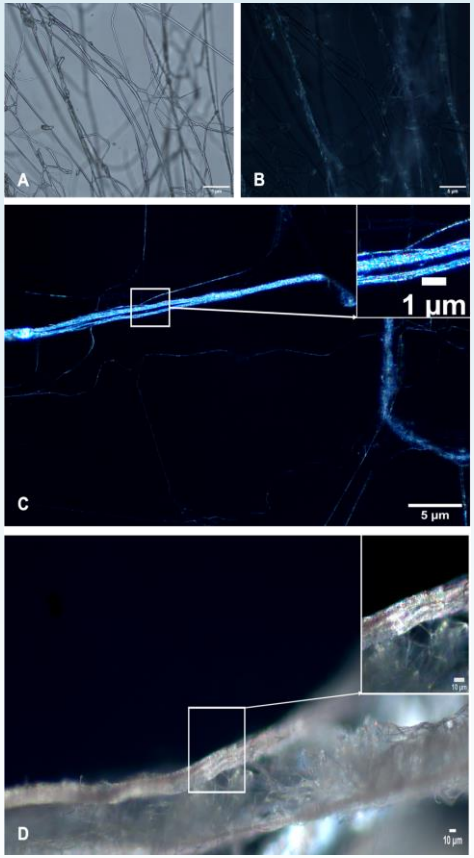
Average fiber diameters using M2 peptides at 35 µg/ mL at 0.1 – 0.3 MPa

- Average fiber diameter at 0.1 MPa – 0.3 MPa: 506 nm ± 155, 395 nm ± 101 nm and 191 nm ± 55 nm respectively.



Scanning electron microscopy (SEM) images and size distribution graphs at 15% PEO/ water using M2 35 µg/ mL, a) 0.1 MPa, b) 0.2 MPa, c) 0.3 MPa

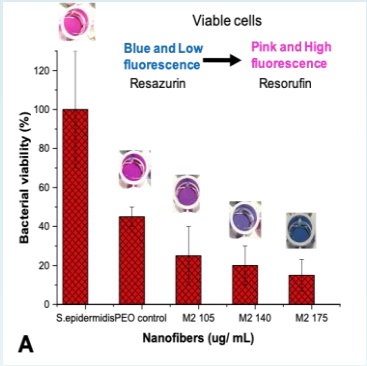
AMP characterisation using fluorescence microscopy



Polarisation contrast images captured on a Zeiss Axioplan2 microscope, with a 20xNA0.5 objective, a) PEO control without polarisation contrast, b) with polarisation contrast, c) PEO incorporated M2 Peptide, and d) PEO incorporated AMP2 polarization image

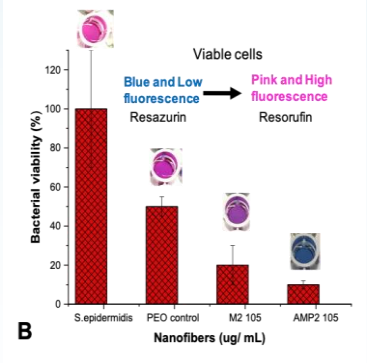
- Fluorescence microscopy was used to produce brightfield and polarisation contrast images
- Brightfield image A, and polarisation image B both serve as PEO control fibers. Images display fibers without attachment, this confirms samples are pure PEO fibers only
- Both polarisation images C and D display attachment of peptides (M2 and AMPs at 105 µg/mL) dispersed evenly inside and along fiber surface, illustrated as dots
- AMPs are embedded in the polymer matrix and fiber surface.

Bacterial viability



Antimicrobial effect of PEO fibers loaded with M2 peptides (105 µg/mL – 175 µg/mL) against S. *epidermidis* evaluated with AlamarBlue cell viability assay

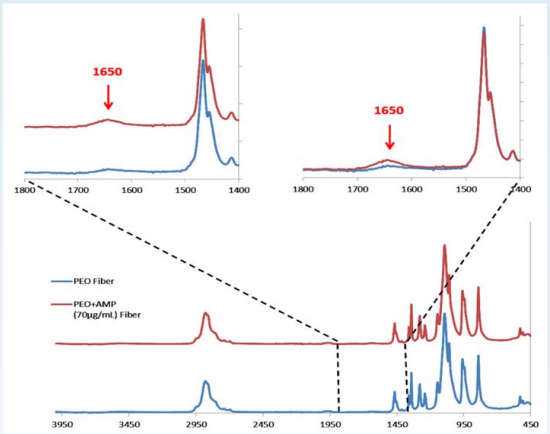
- Bacterial viability was assessed at various concentrations using only M2 integrated PEO nanofibers
- An increase in the M2 content has produced greater antimicrobial activity.



Comparison of antimicrobial effect of PEO fibers loaded with M2 and AMP2 at 105 µg/ mL against *S. epidermidis*

- Comparison of bacterial viability at 105 ug/mL using M2 and AMP2 suggest that antimicrobial activity was significantly higher using AMP2, indicating a greater release rate when tested against *S. epidermidis.*

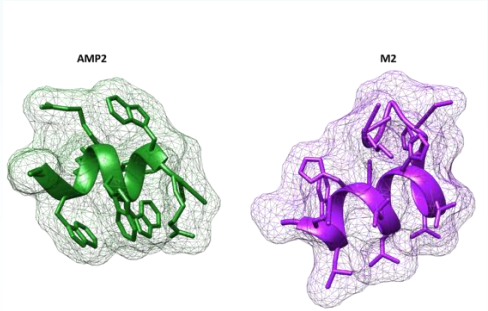
Fourier-transform infrared spectroscopy



FTIR spectra of the nanofiber samples

- FTIR depicts that characteristic peaks of PEO observed at 2900 cm $^{-1}$ (methylene group CH 2 molecular stretching), and at 1100 cm $^{-1}$ and 960 cm $^{-1}$ (C O C group stretching)
- FTIR results showed that there was no change in chemical structure as a result of M2 integration to fibers
- FTIR of M2 samples integrated with PEO in two different concentrations did not reveal new chemical bonds
- Therefore, FTIR peaks of PEO fiber and fiber samples containing M2 are similar.

Antimicrobial peptide structures



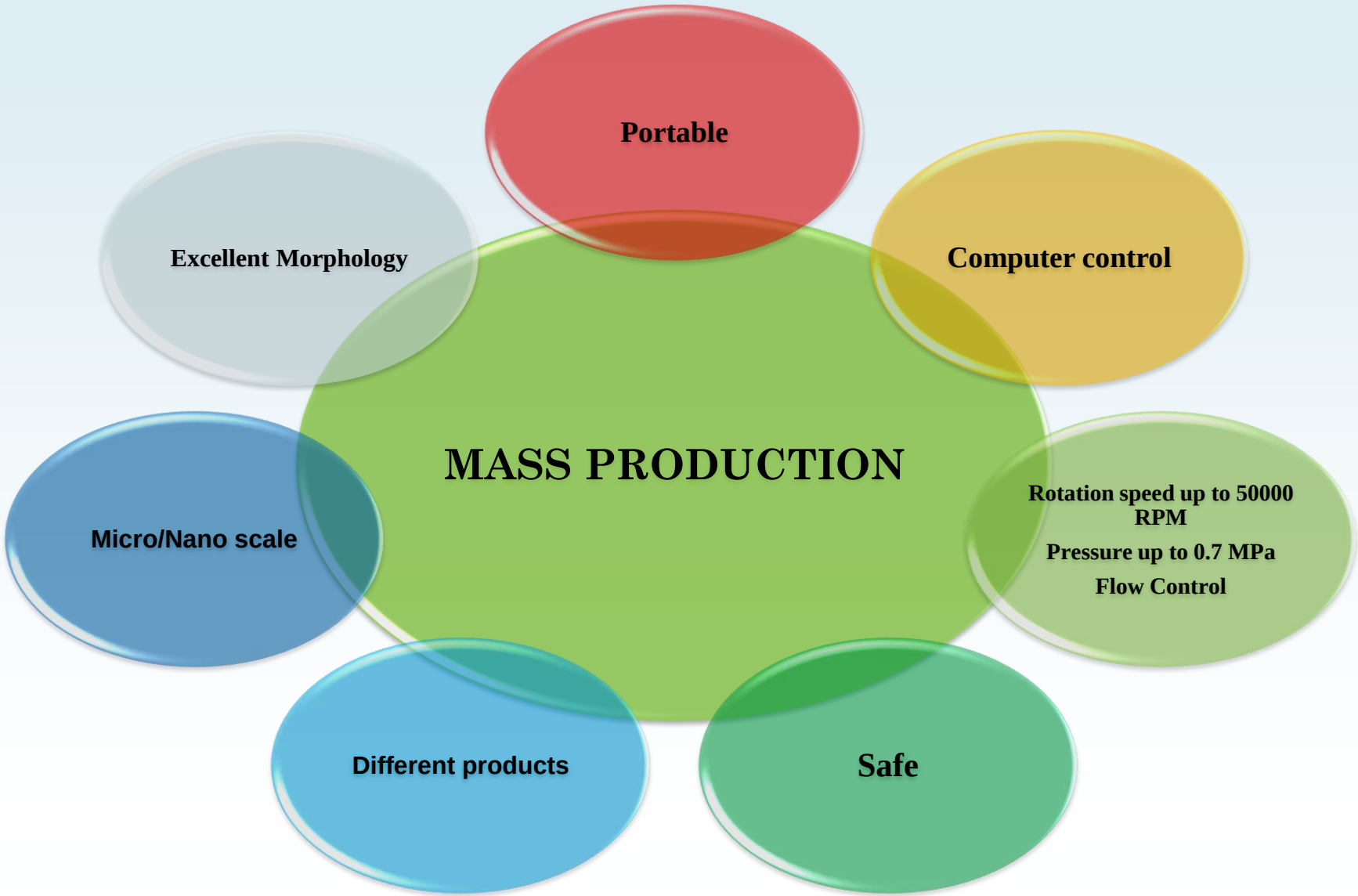
Secondary structure models for AMP2 and M2 peptides

- Secondary structure models of the peptides were obtained from the amino acid sequences using PEP-FOLD 3.5.8
- Chimeric peptides with AMP2 incorporated demonstrated effective antibacterial function against *S. epidermidis* bacteria.

Conclusions

- The novel PEO nanofibers incorporated with M2 and AMP2 peptides generated an effective antibacterial activity against *S. epidermidis* to enhance wound healing applications
- The nanofibers created a high efficiacy against *S. epidermidis* which is a common bacteria accociated with wounds
- AlamarBlue assay confirms that AMP2 (105 µg/ mL) performed the greatest antibacterial activity
- Therefore, loading antibacterial peptides with water soluble polymers such as PEO is an effective delivery method for the easy release of antimocrobial agents into a wound site
- Using water-based systems also allows to be more environmentally friendly whilst also ensurng maximum biocompatability in an open wound scenario.

NEW PORTABLE GYRATOR DEVICE – VERY HIGH SPEED/PRESSURE



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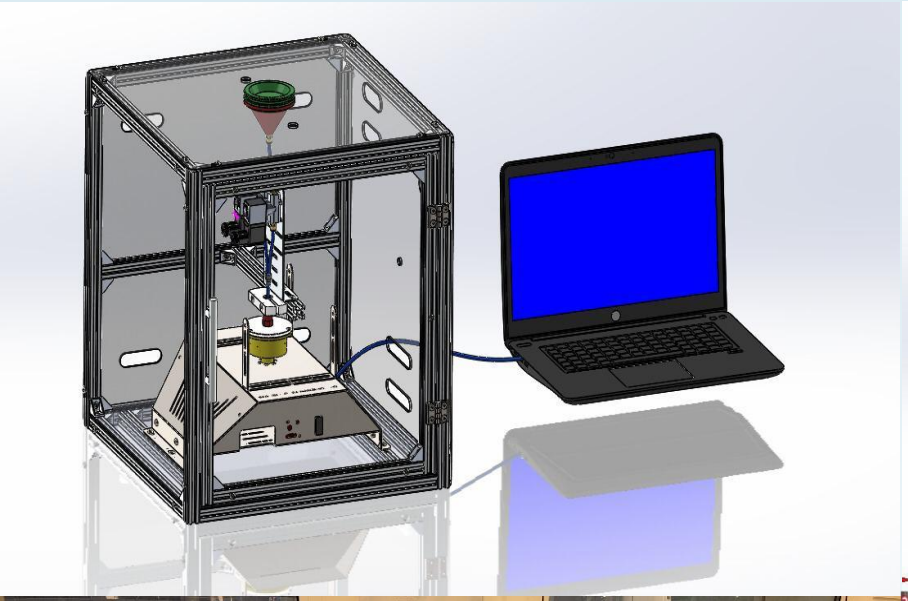
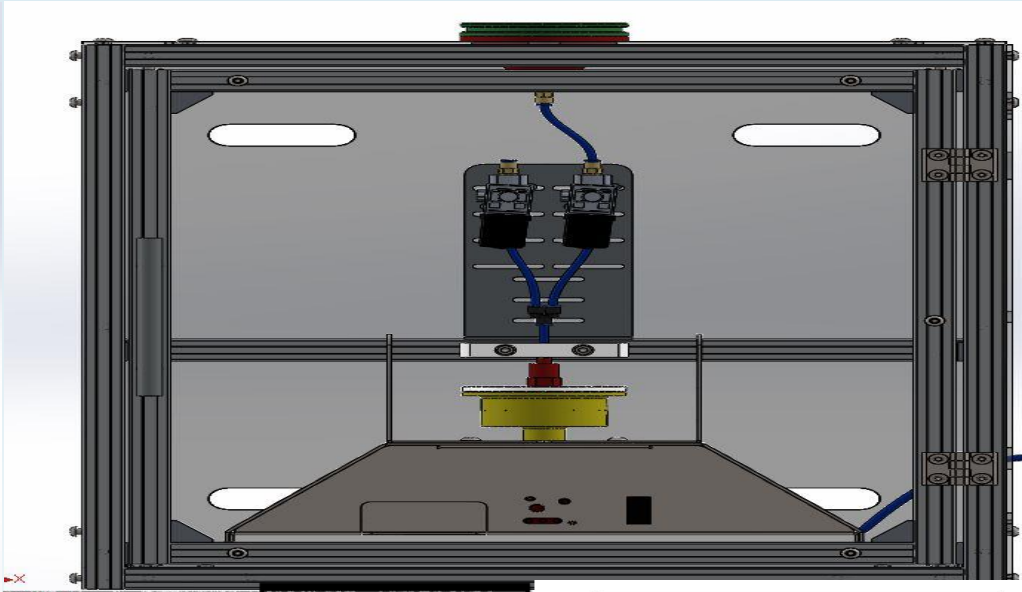
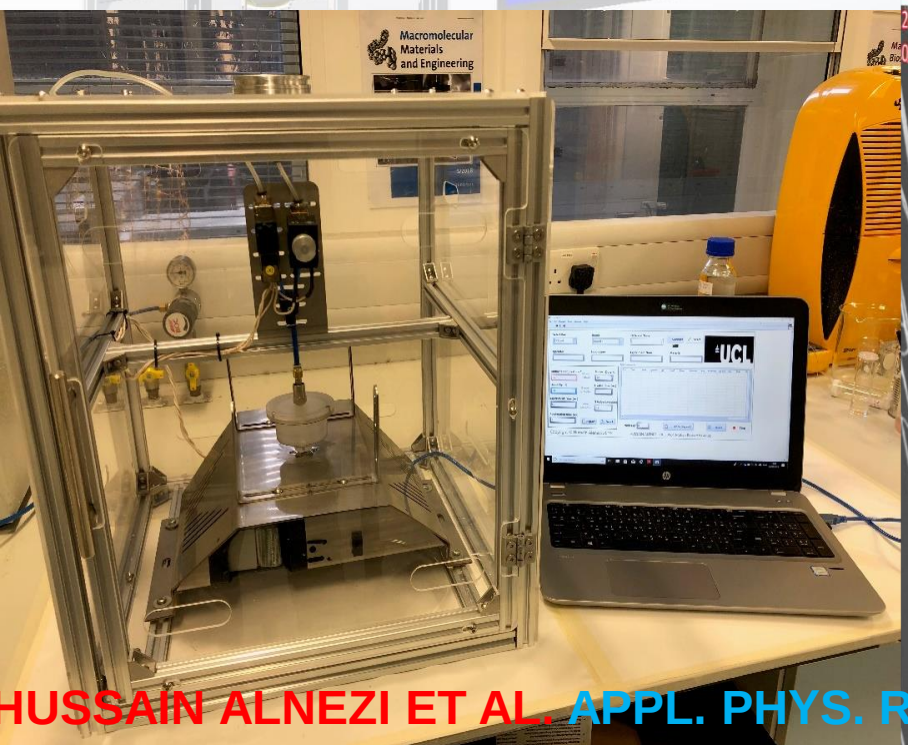
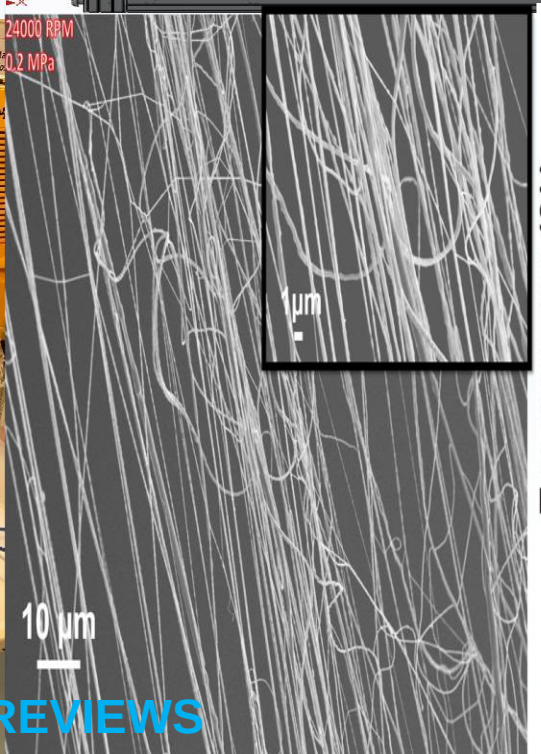
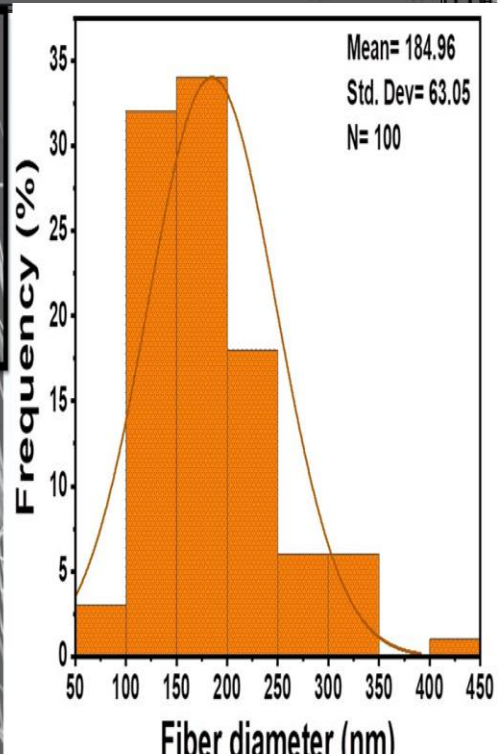






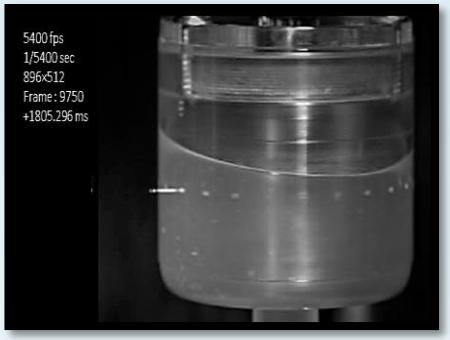


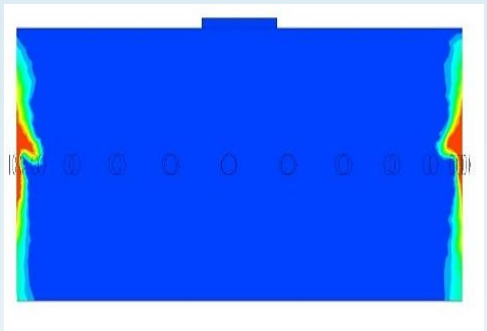


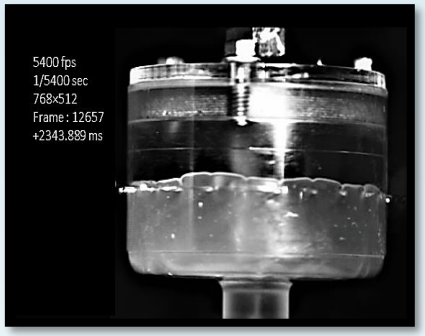
HUSSAIN ALNEZI ET AL. APPL. PHYS. REVIEWS

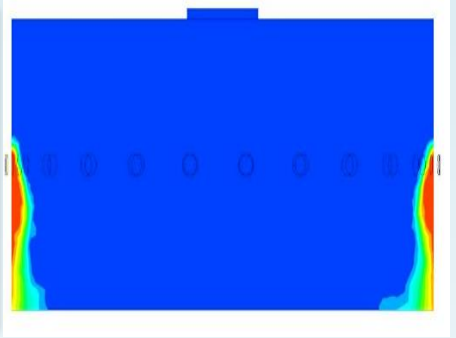
Experimental and theoretical investigation of the fluid behavior during polymeric fiber formation with and without pressure

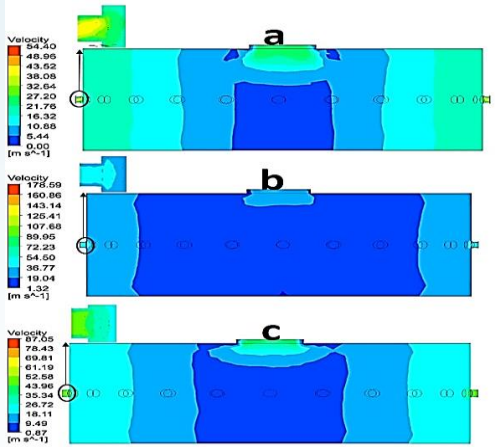
C.S at 7000.8500 and 10000 rpm no pressure **VS** ***P.G at 10000 rpm at 0.1,0.2 and 0.3MPa***

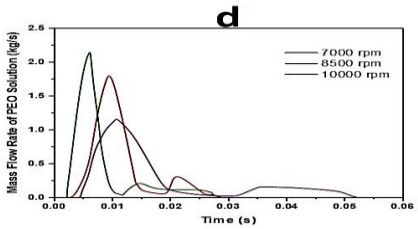


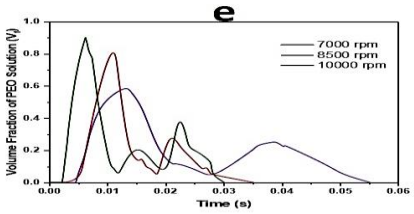


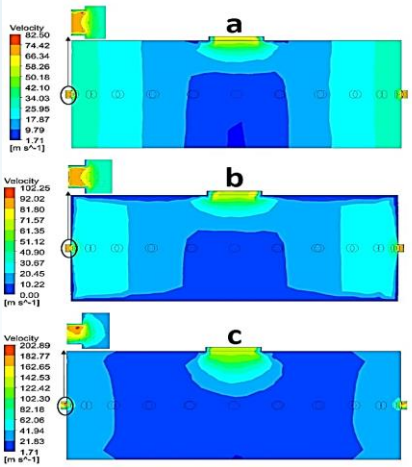


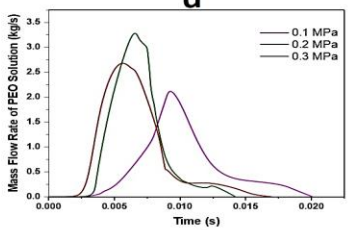


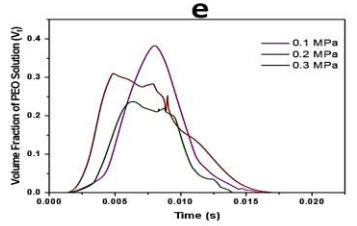


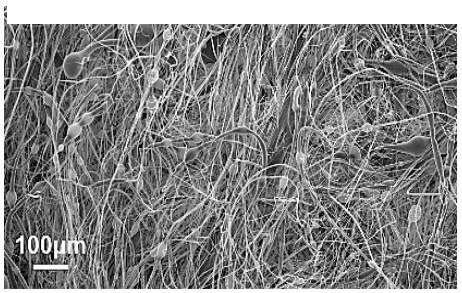


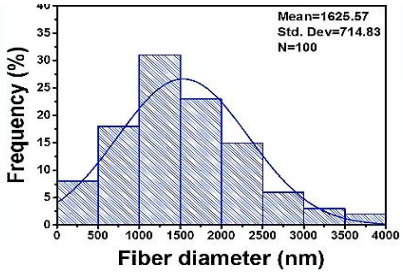


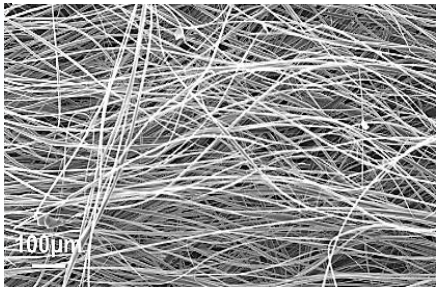


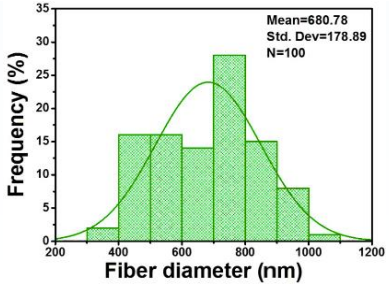












Groundbreaking Research on Polymeric Fibers

Creating Miracles with Polymeric Fibers

Amer Inst Phys News 15th October 2019

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https://phys.org/news/2019-10-fabrication-polymeric-fibers-advanced-health.html

https://www.sciencedaily.com/releases/2019/10/191015131616.htm

https://www.parallelstate.com/news/researchers-studied-the-fabrication-of-polymeric-fibers-for-use-in-advanced-health-care/175626

https://www.eurekalert.org/multimedia/pub/213920.php

Experimental and theoretical investigation of the fluid behavior during polymeric fiber formation with and without pressure
Applied Physics Reviews 6, 041401 (2019); https://doi.org/10.1063/1.5110965

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