Quick Fabrication of Highly Porous Dual Tissue Scaffolds using Textile Techniques

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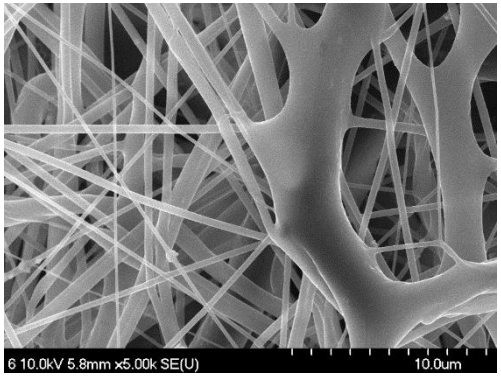
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College of Engineering and Computer Science, University of Texas Rio Grande Valley, USA

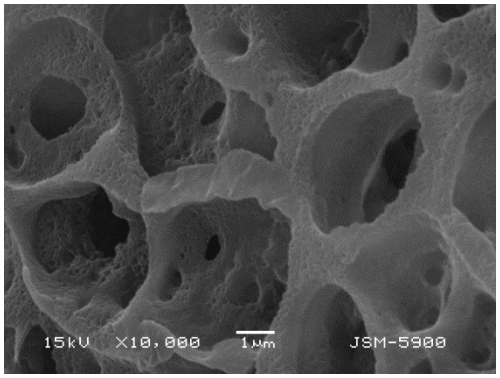


Novelty

- We introduce a novel technique for fabrication 3D structures (nanofibers and porous structure

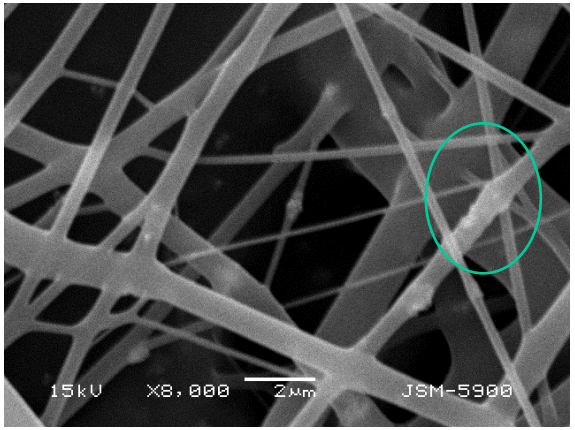
Nanofibers



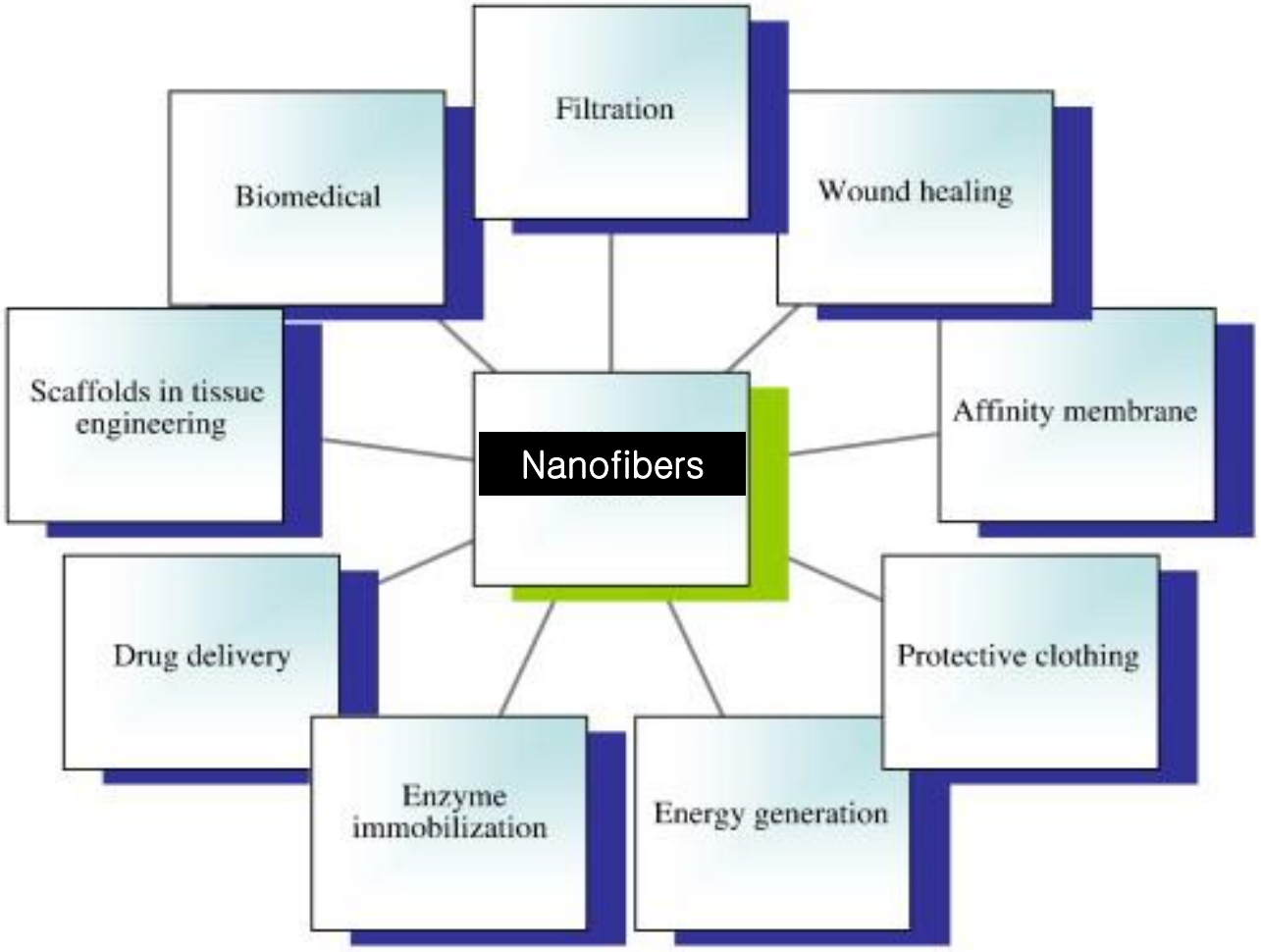


Porous structure

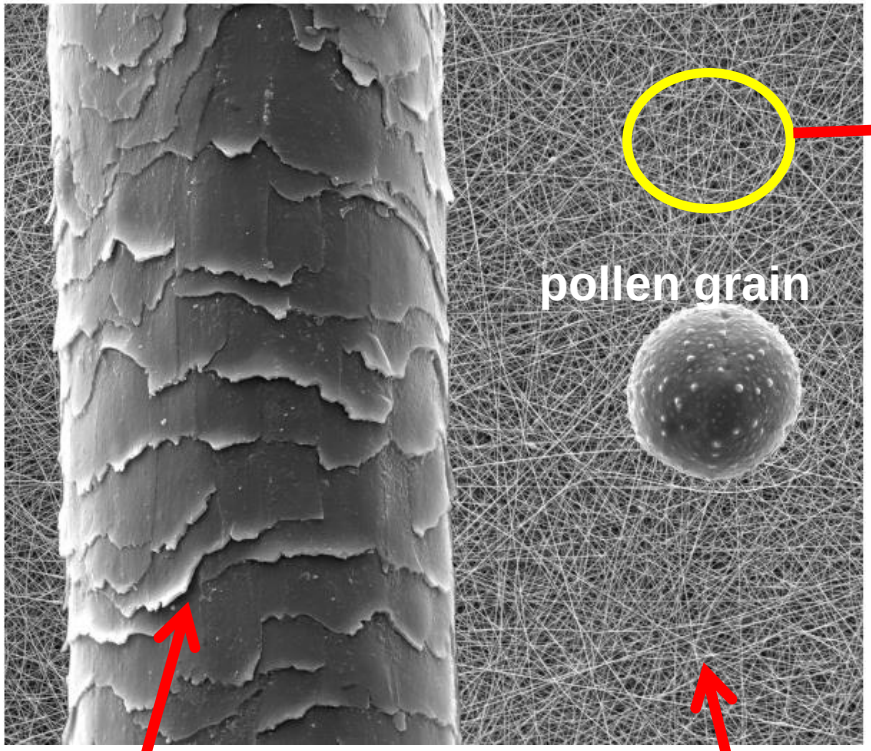
Composites

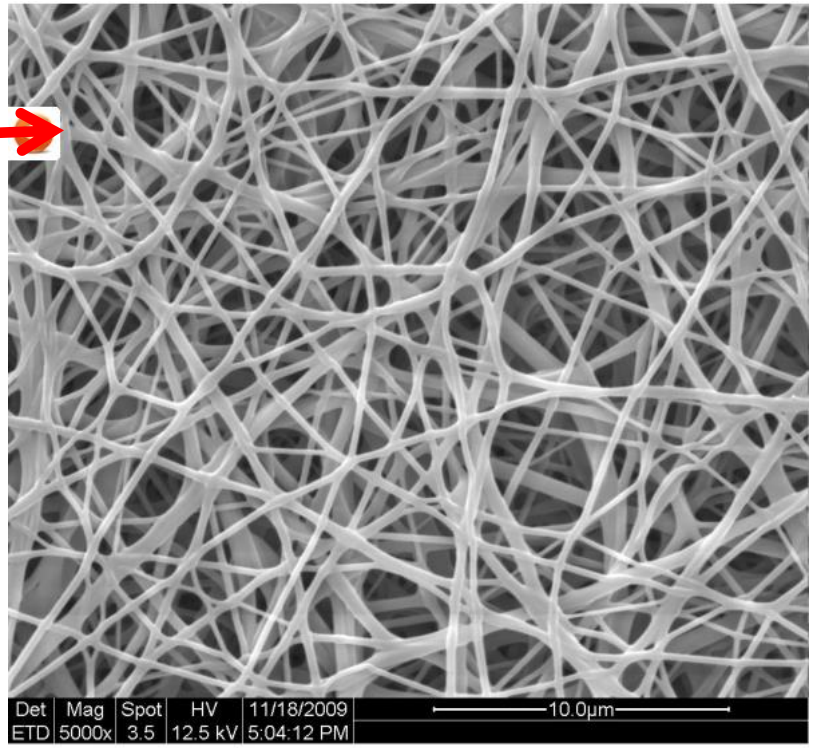


Uses of nanofibers



Nanofibers morphology



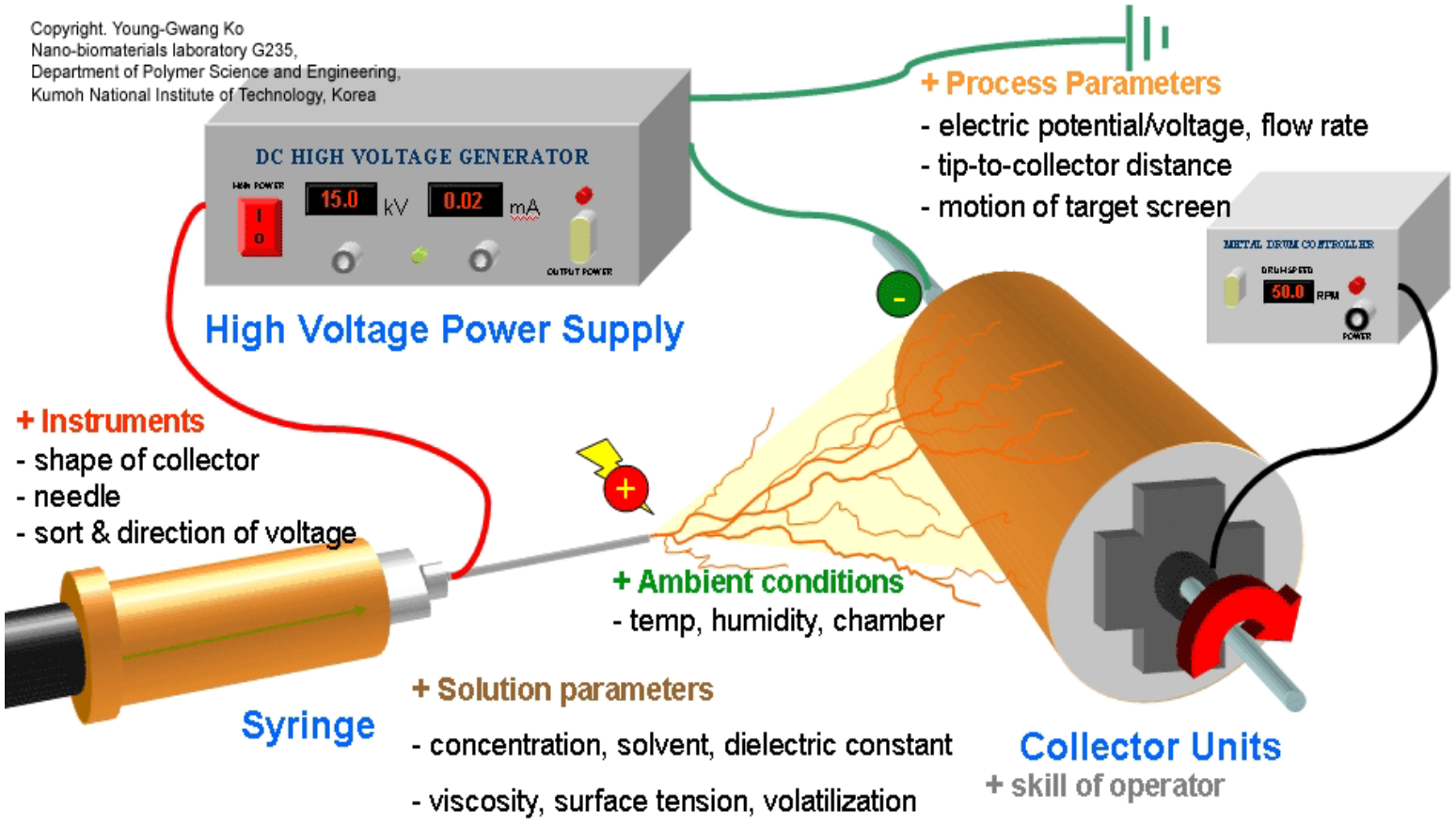


Why Nanofibers?

- High surface area - increased reactivity
- Small pore size →more contaminant capture
- High pore volume (porosity) → less energy

  = lower cost of use
- More cell attachment and proliferation

Common fabrication method of polymer nanofibers



Electrospinning process

Disadvantages of electrospinning

- High initial cost
- High running cost
- Not safety
- Very low production rate
- Limited (not versatile)
- The solution type
- Viscosity

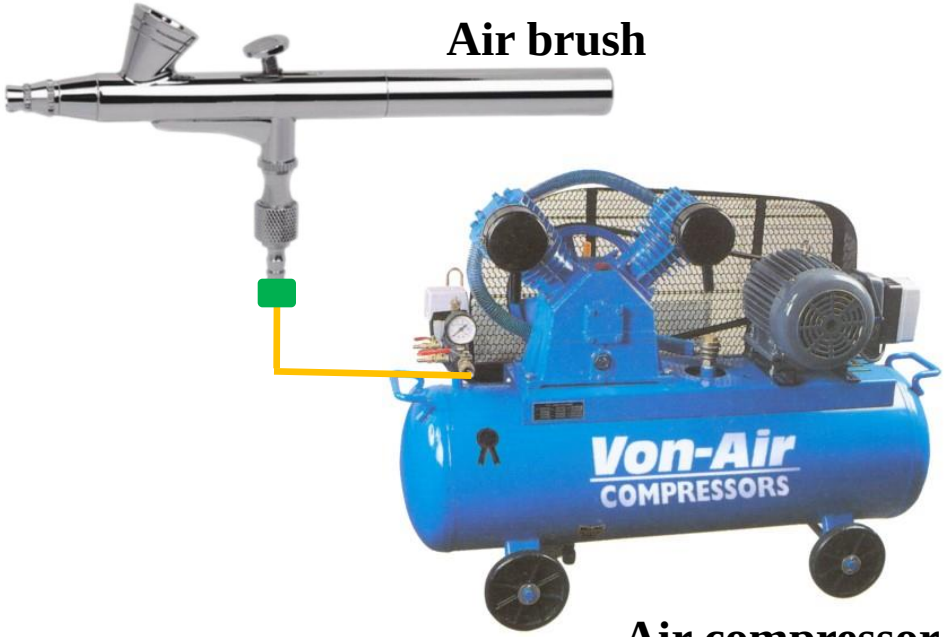
Our developed strategy



Air Jet Spinning (AJS)

Air Jet Spinning (AJS) and its component

Polymer Solution



Pure polymer



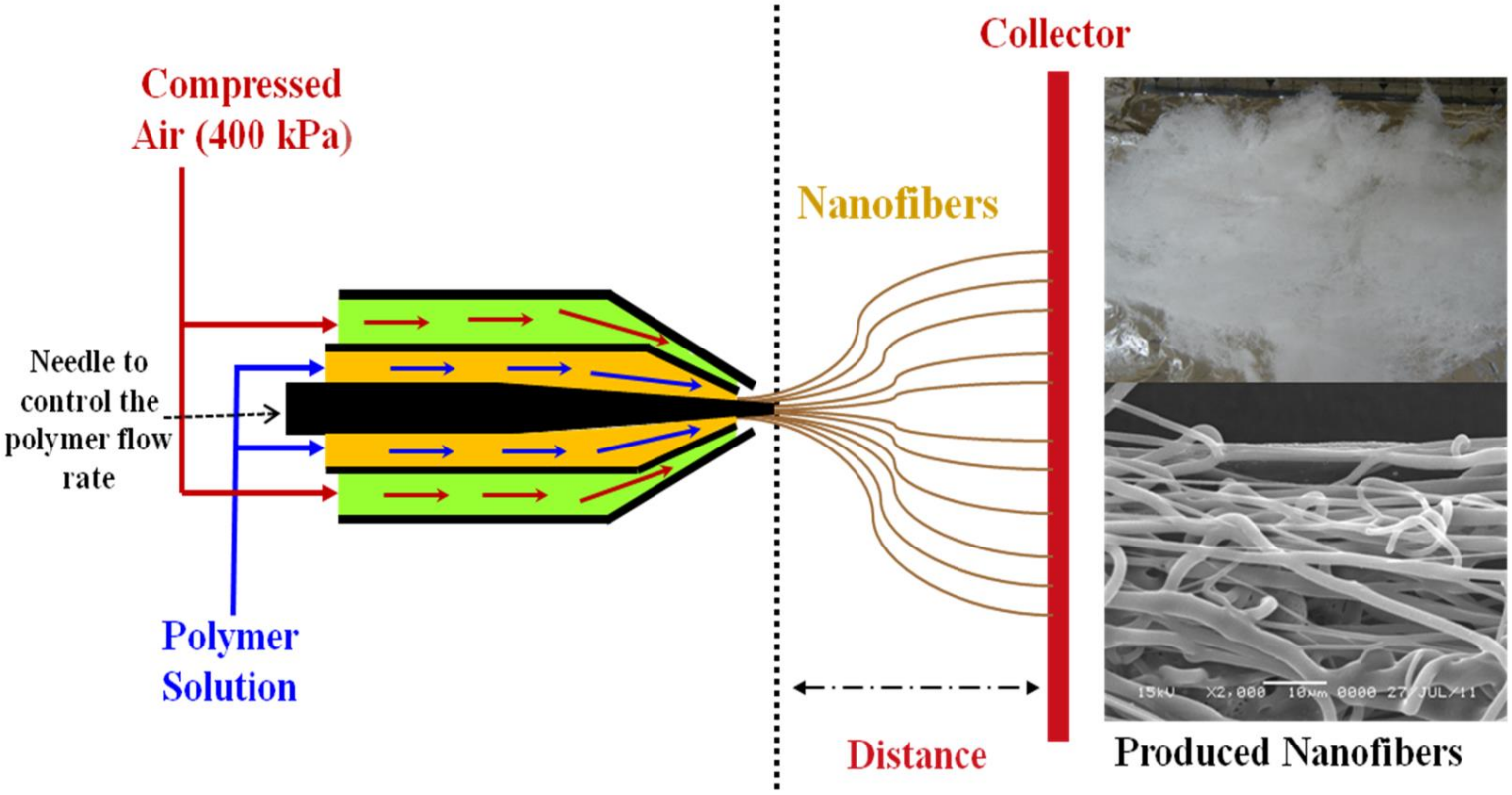
After few seconds



After 1.2 min

Pure polymer

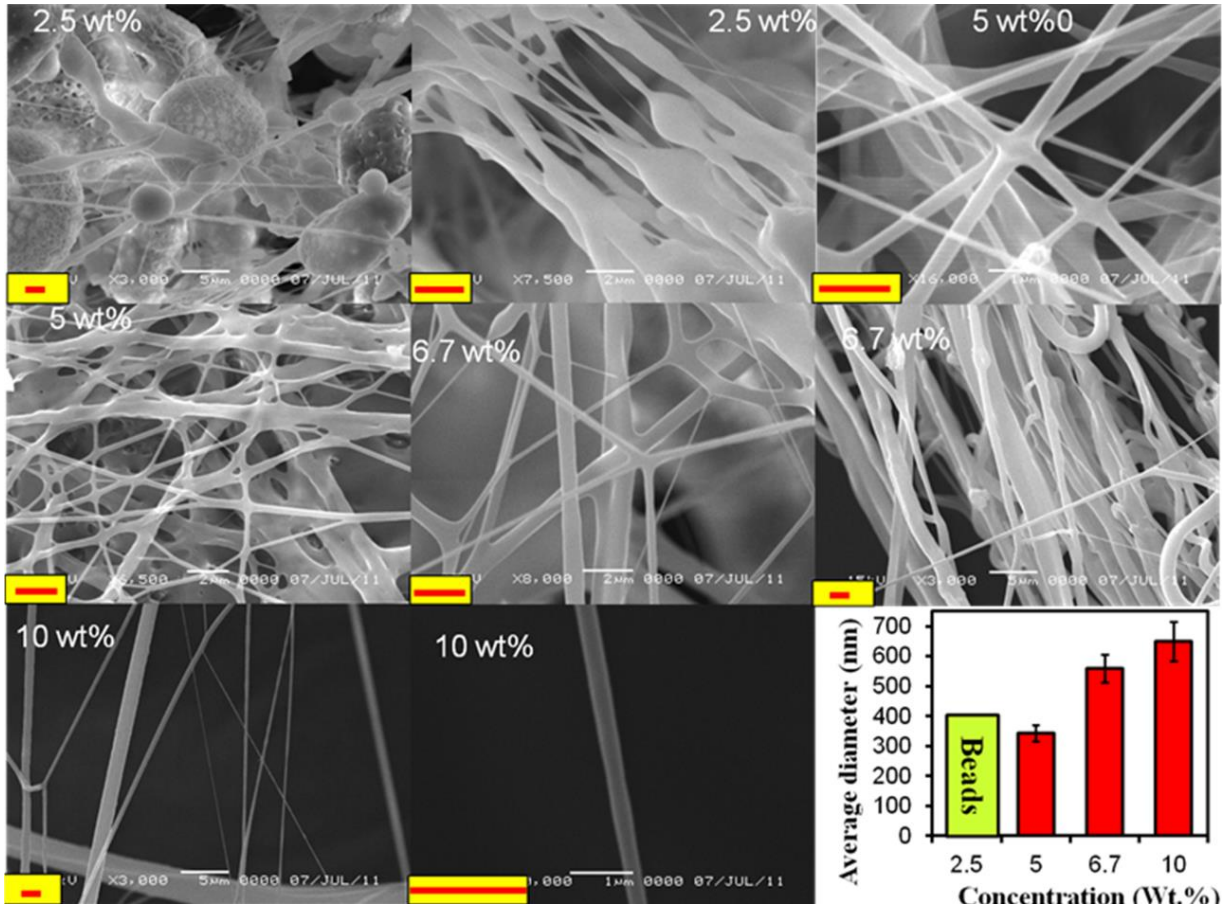
1. Fabrication of nanofibers by AJS



Schematic diagram illustrates the fabrication process

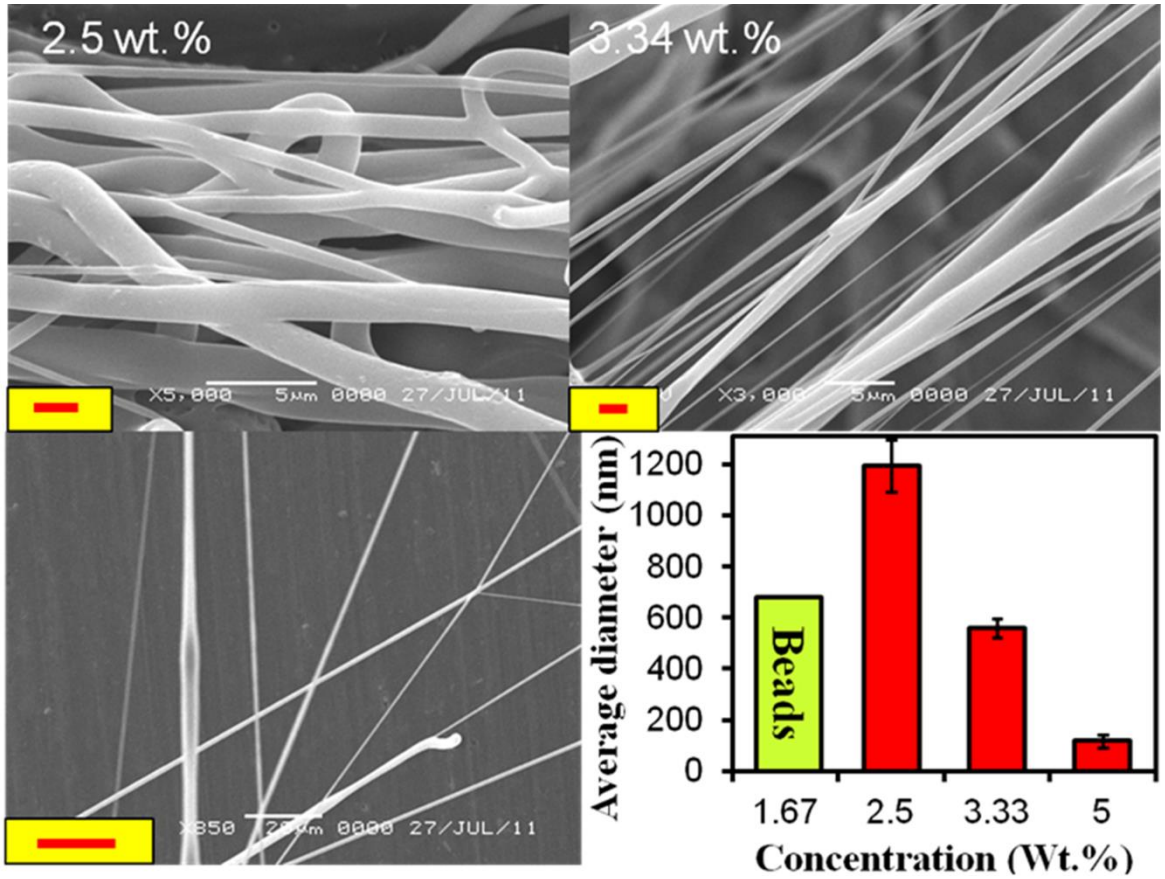
Pure polymer

Fabrication of PLA nanofibers by AJS



Effect of polymer concentration on the nanofibrous morphology in case of PLA.

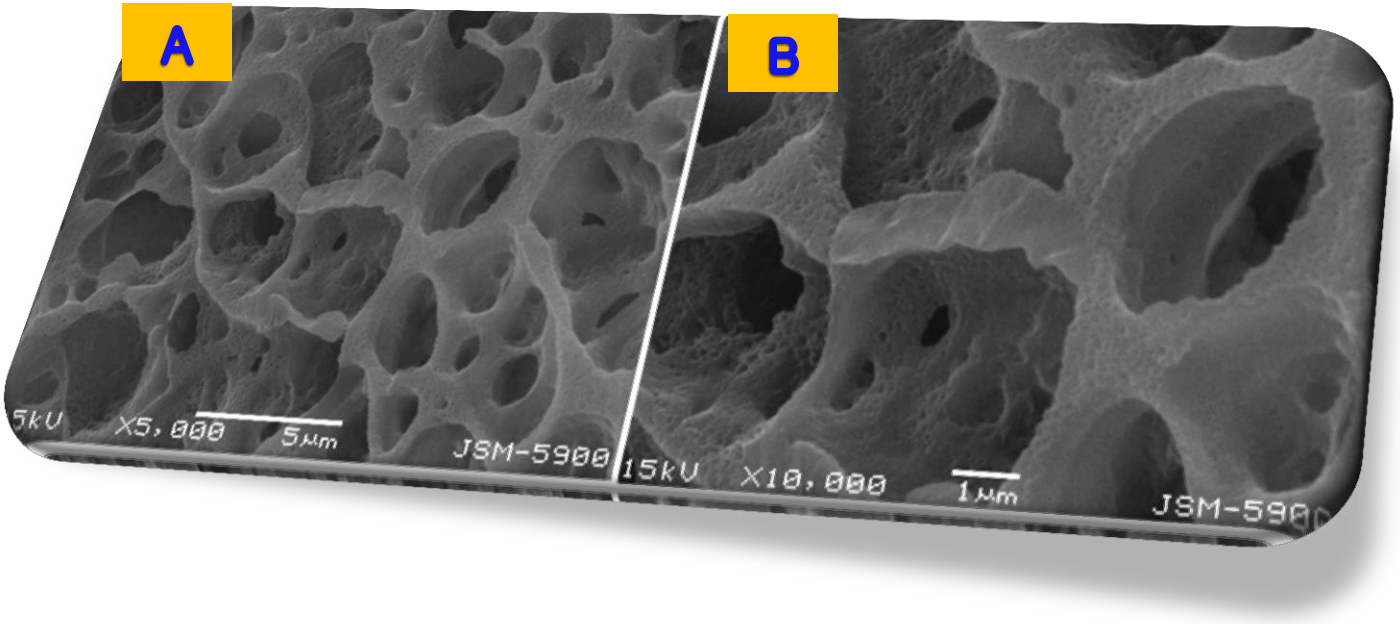
Fabrication of PVAc nanofibers by AJS



Effect of polymer concentration on the nano fibers morphology in case of PVAc

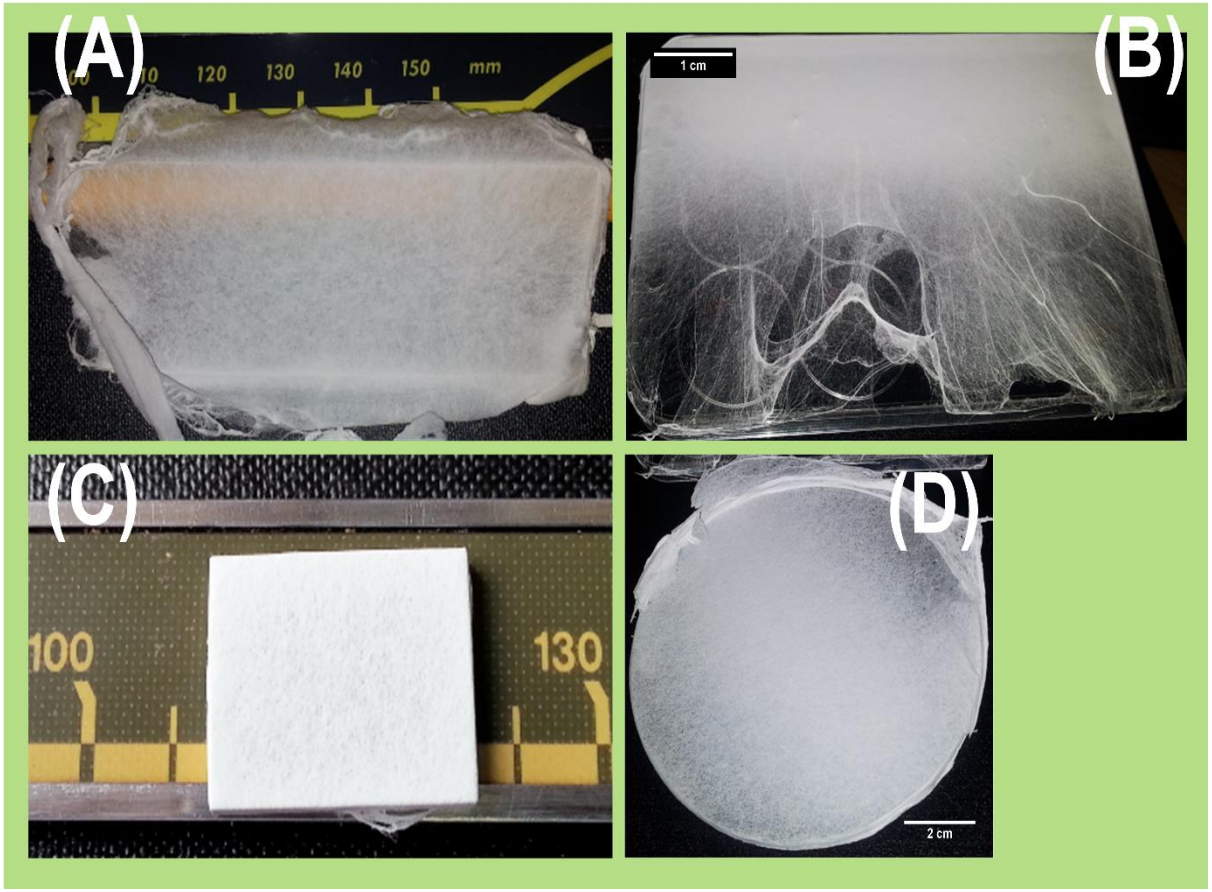
Pure polymer

- Porous structure observation due to the solvent evaporation rate ((i.e., high boiling point)



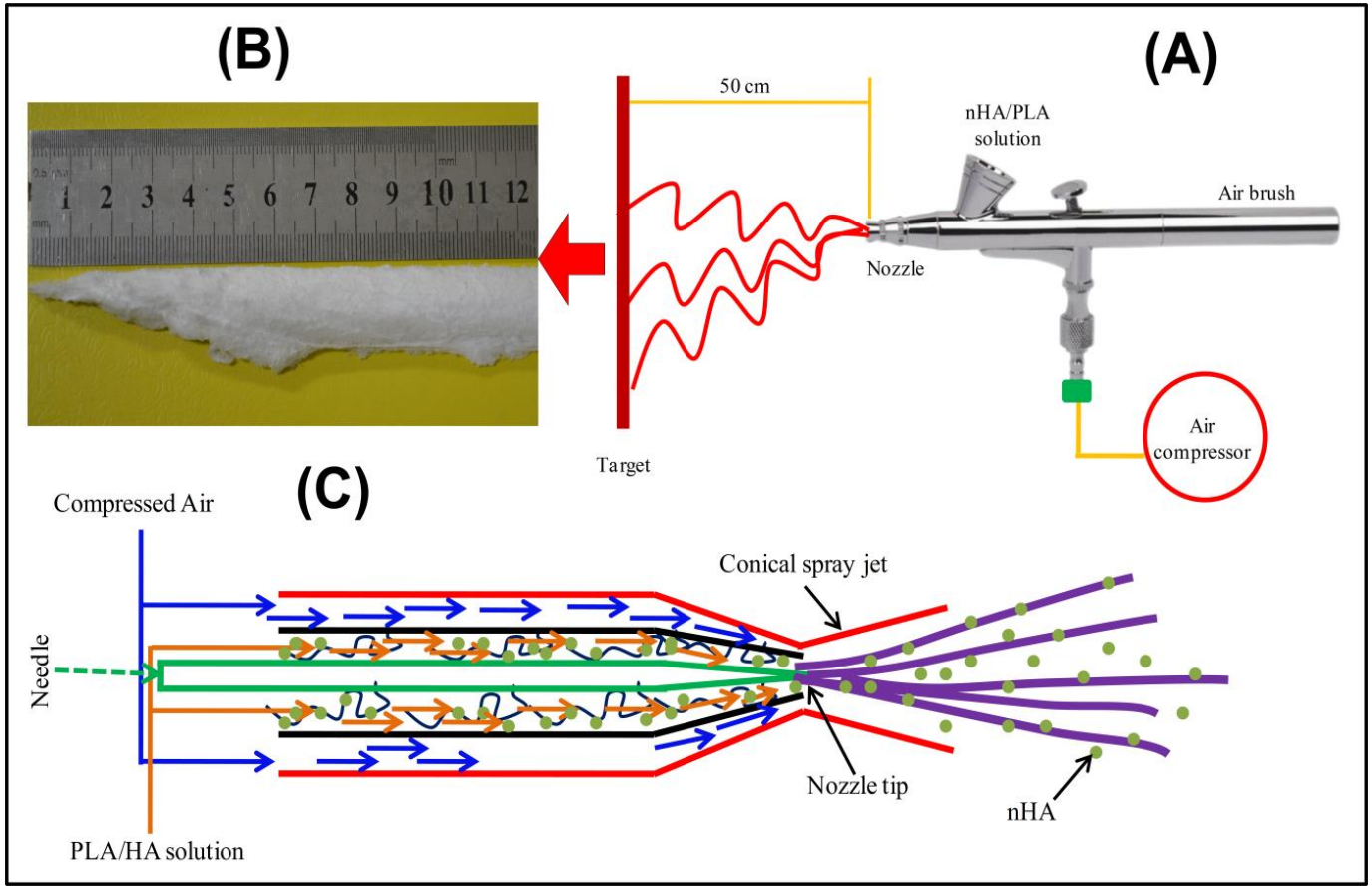
SEM images of air jet spray fabrication of membrane at (A) 7 wt% and (B) 14 wt% of nylon 6 dissolved in acetic acid and formic acid

AJS fibers deposited on different targets



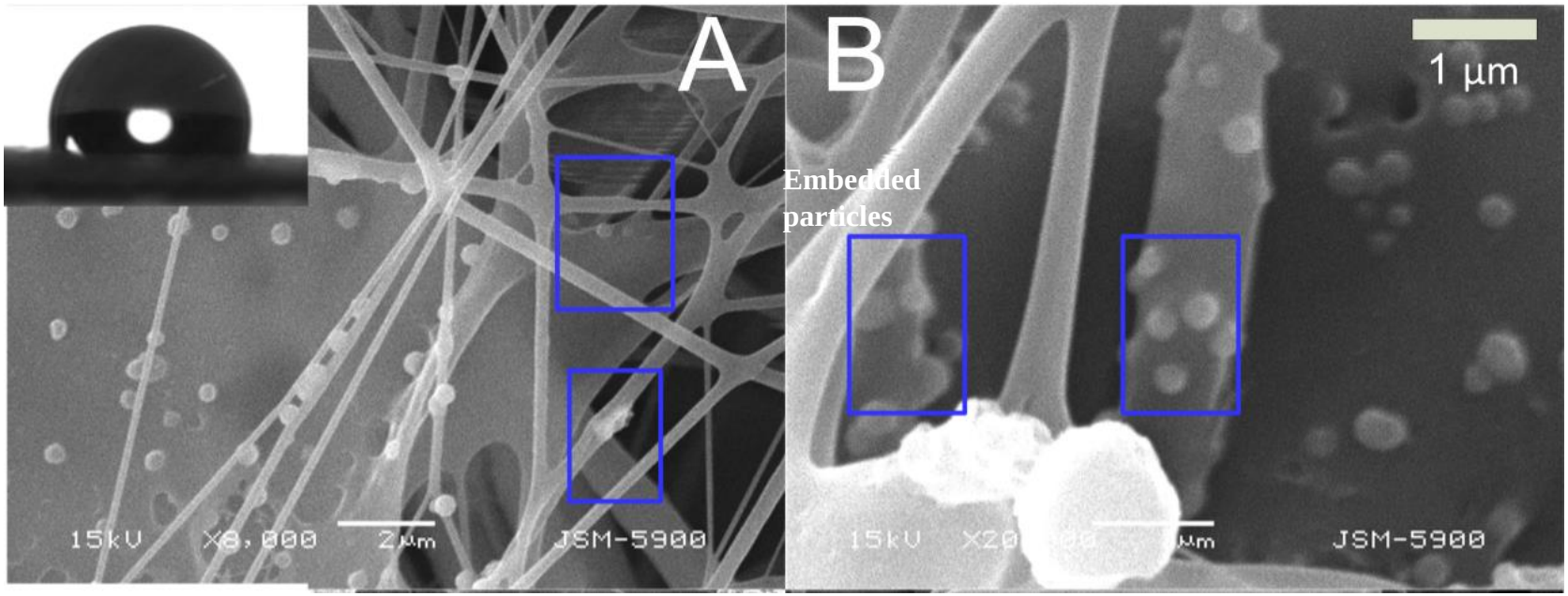
A. Membrane scaffold, B. on plastic, C. on metals and C. glass

2. Composite nanofibers (HAp/PLA) by AJS



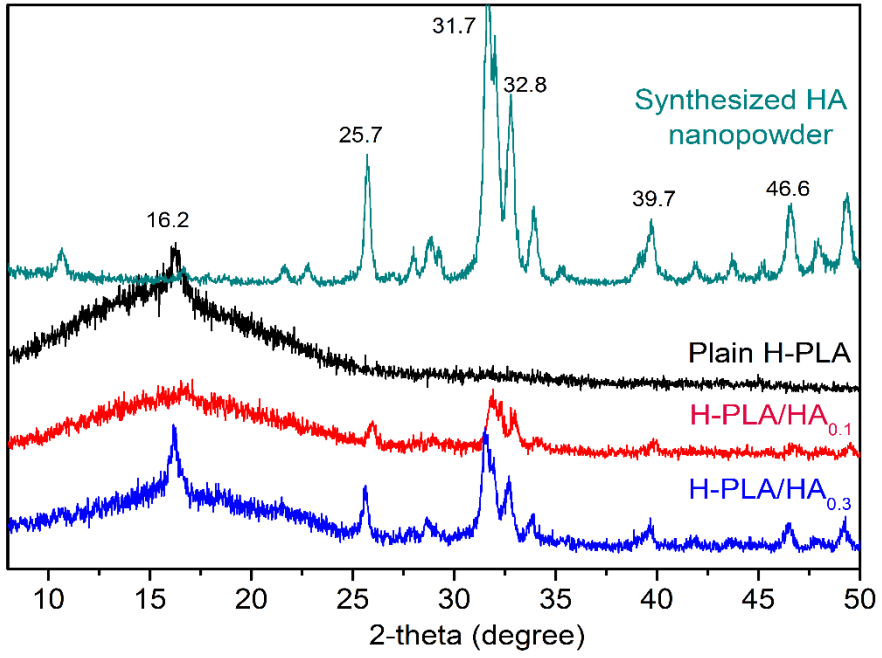
Schematic diagram of the air jet spray apparatus

Composite Nanofibers (HAp/PLA) by AJS

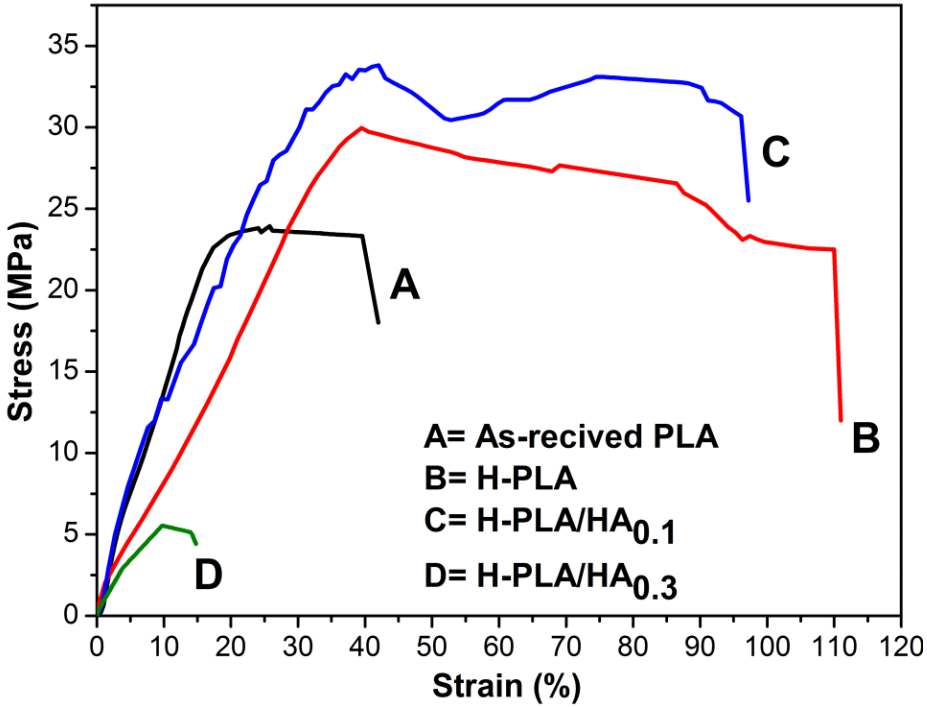


Typical SEM images observation of H-PLA/nHA0.3

Composite Nanofibers (HAp/PLA) by Air Jet Spinning

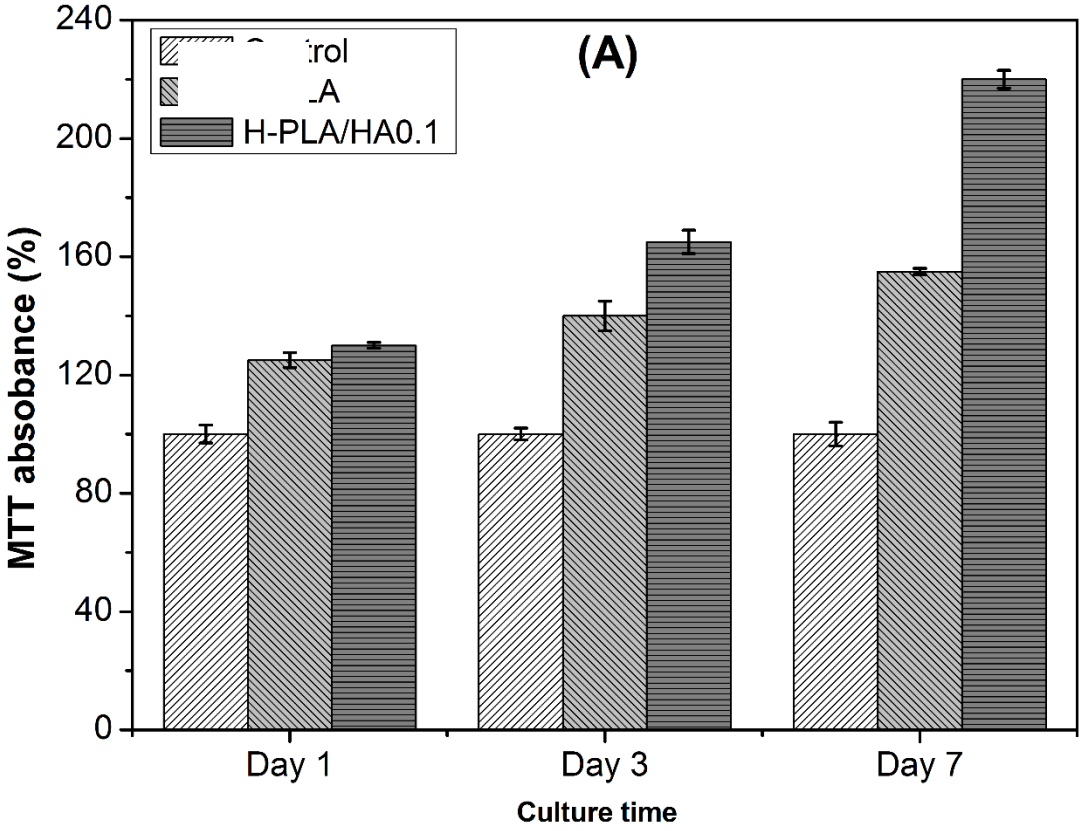


XRD spectra of PLA and PLA/HA membrane samples



Representative stress- strain curves obtained from tensile tests of composite membrane polymer mats

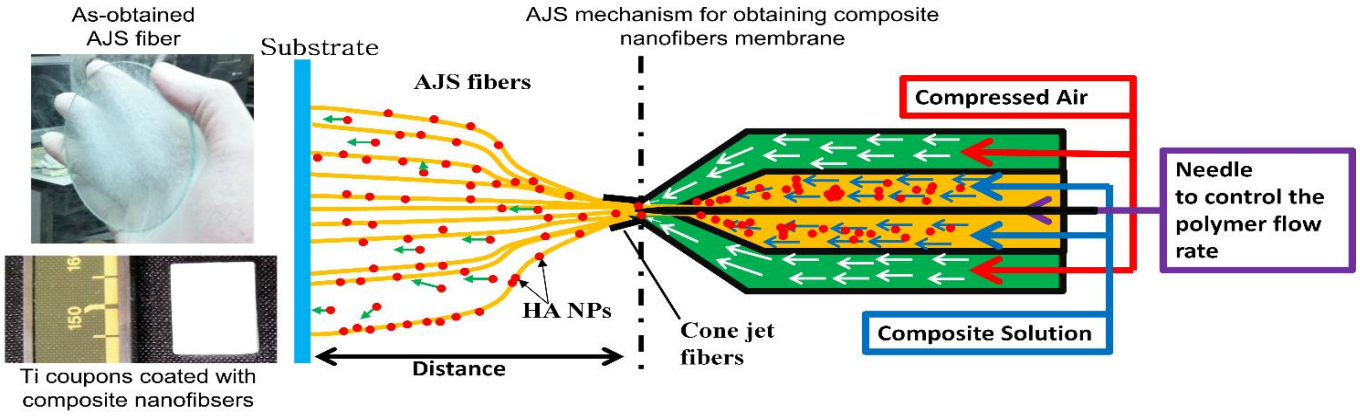
Composite Nanofibers (HAp/PLA) by Air Jet Spinning (Mechanical Properties)

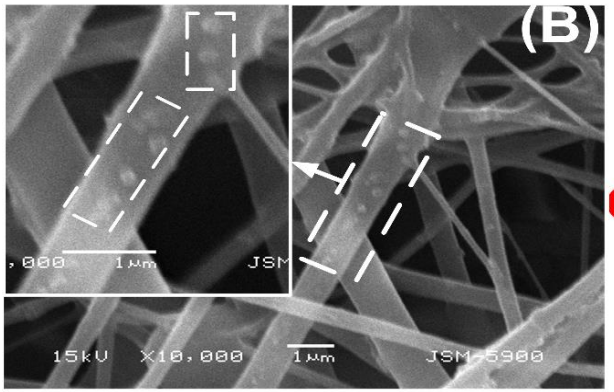


MTT cytotoxicity test of MC3T3-E1 osteoblast-like cells

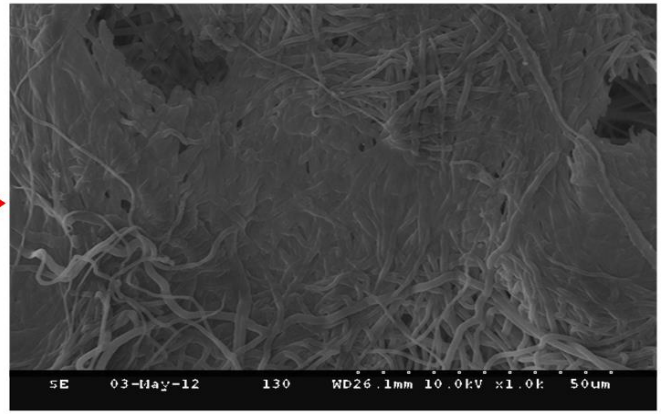
Composite Nanofibers

Composite Nanofibers (HAp/PVAc) coated on C.p.Ti



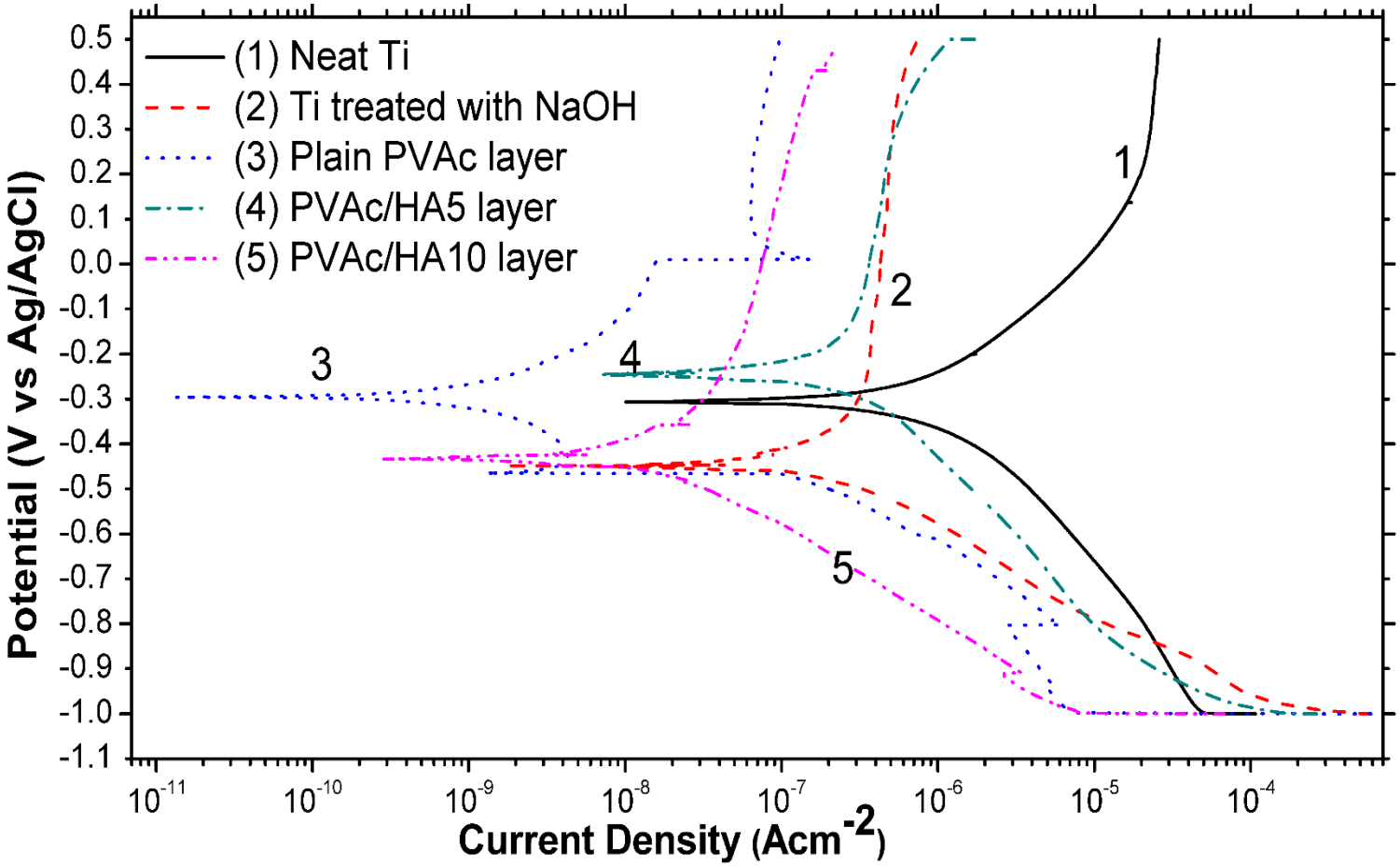


PVAc/HA composite mat



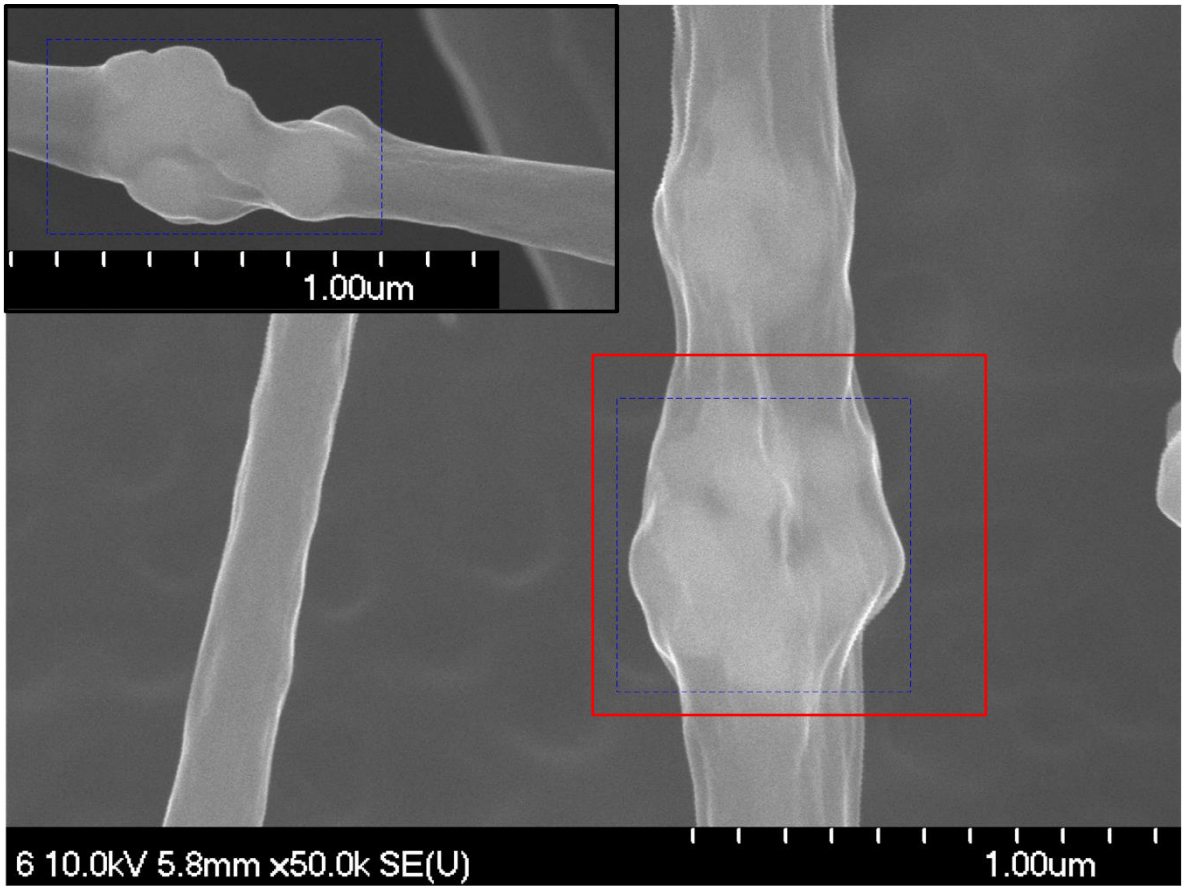
Cell culture

Corrosion behavior of C.p.Ti coated samples



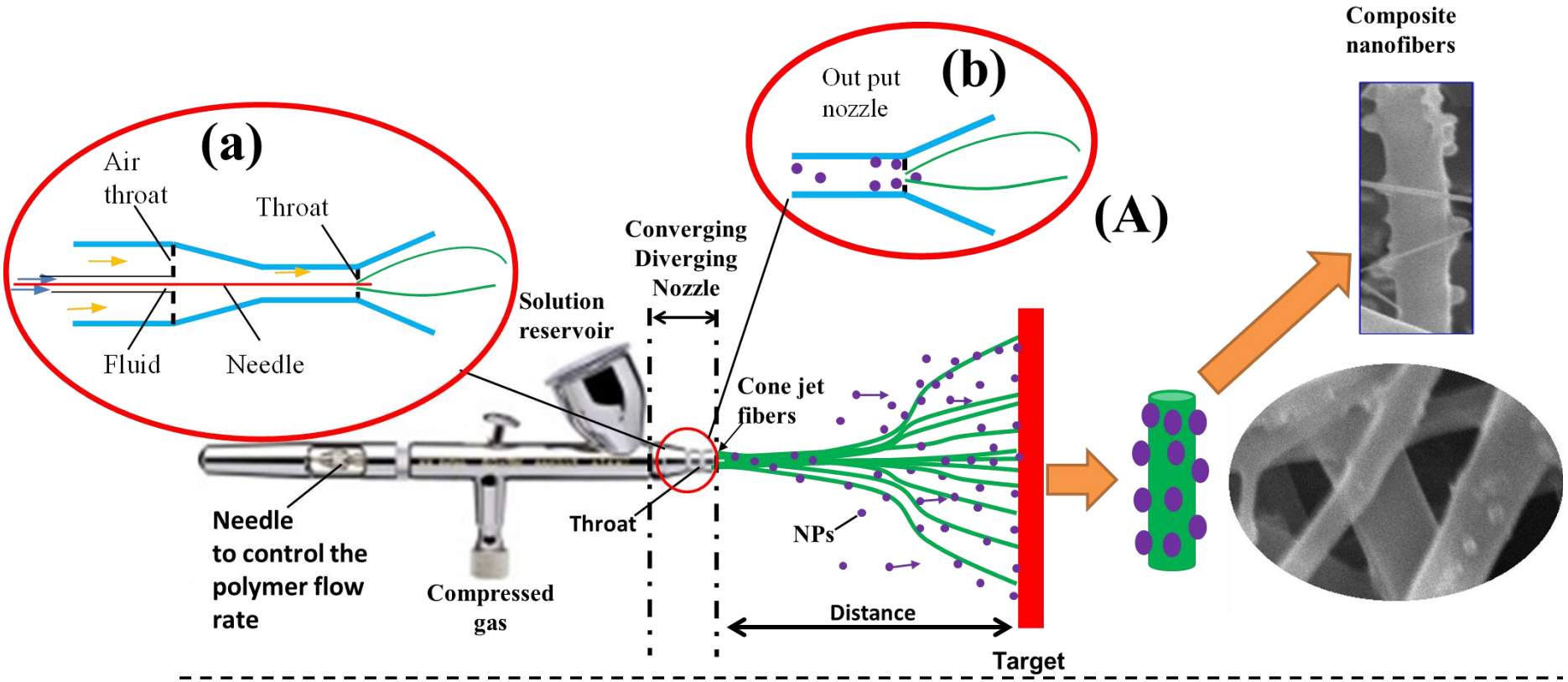
Composite Nanofibers

Mechanical interlocking



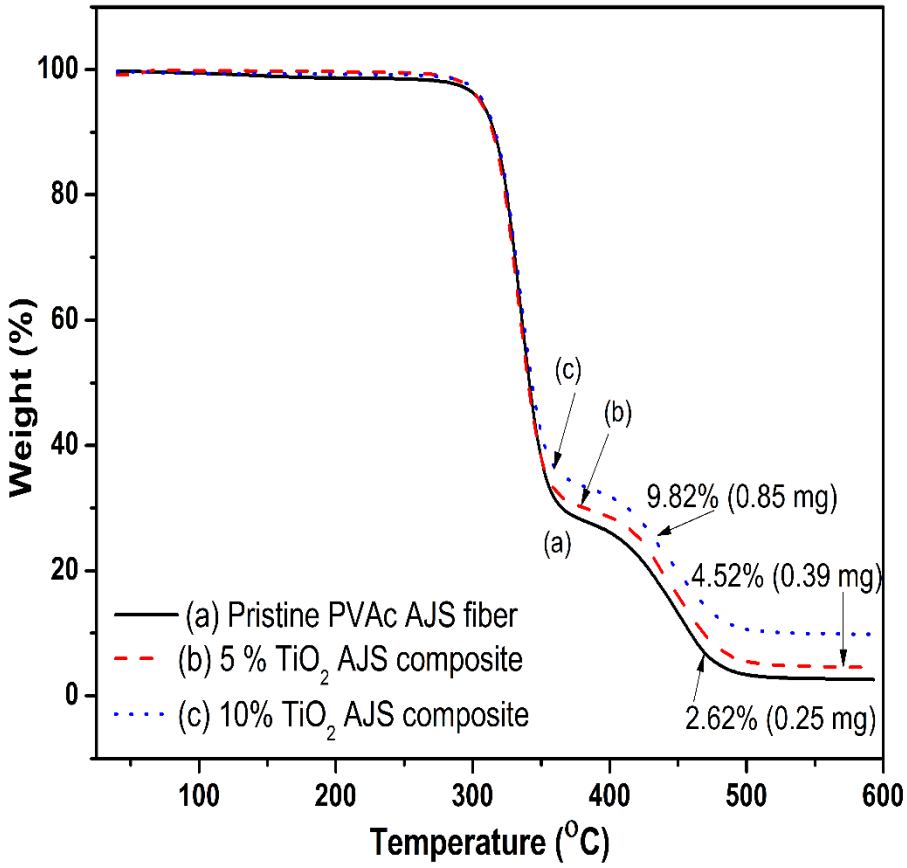
Composite Nanofibers

TiO2/ PVAc composite fibers for MB degradation

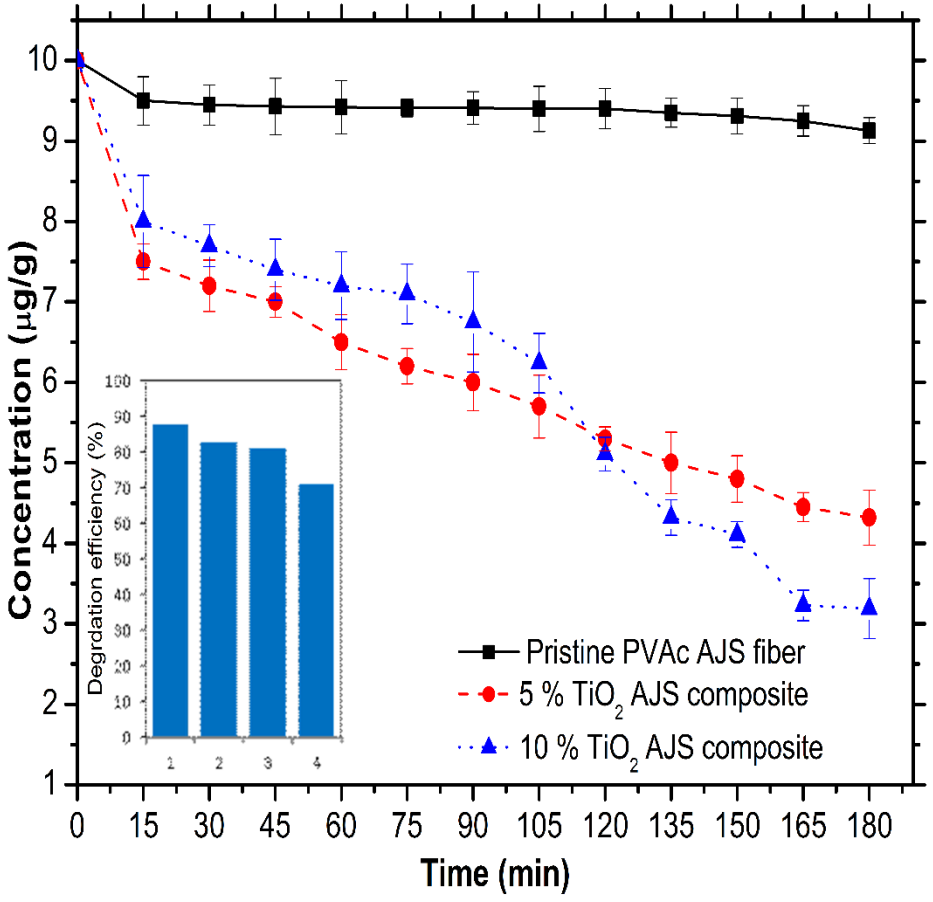


Composite Nanofibers

TGA



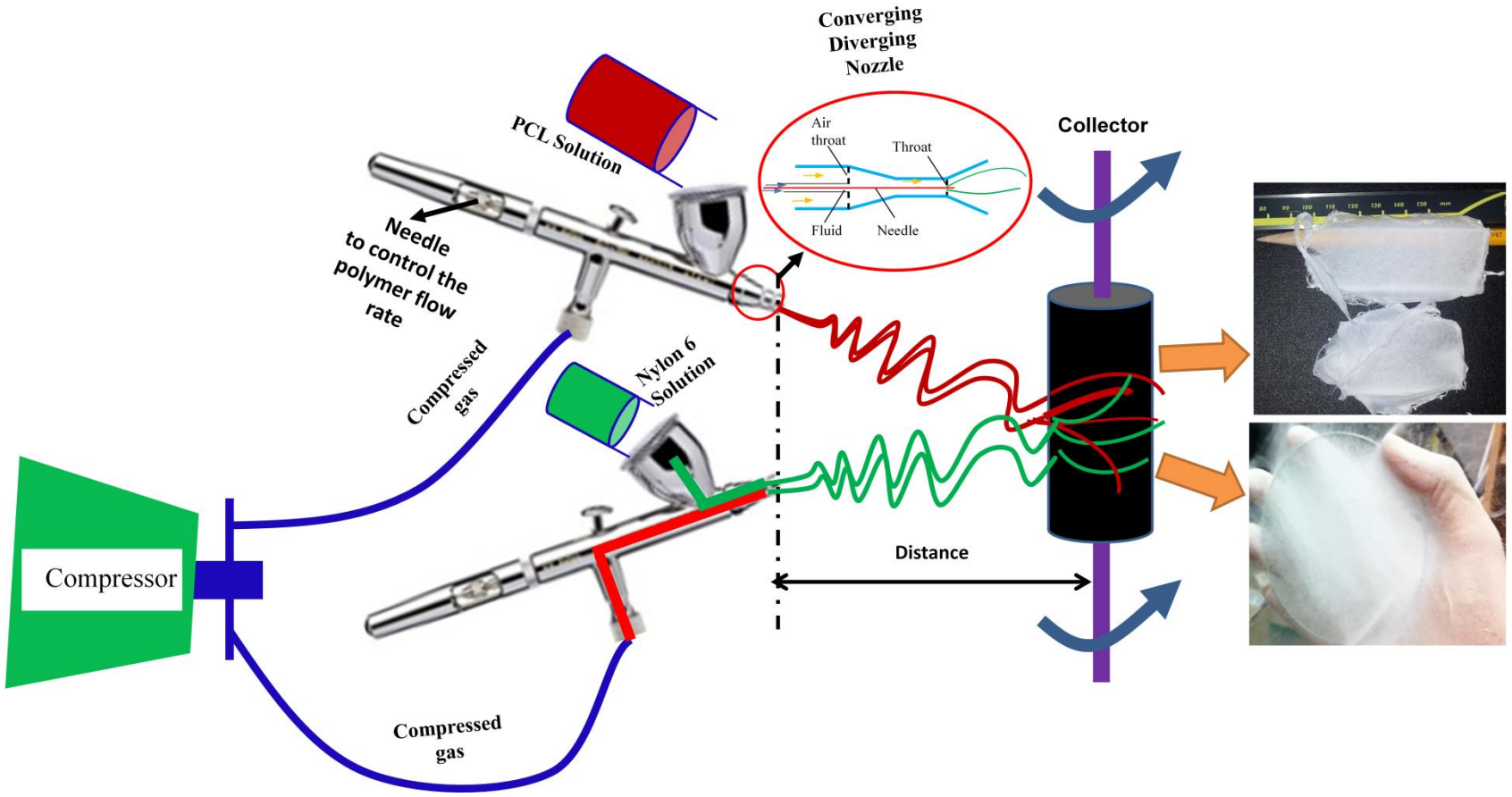
Photocatalytic degradation rate of MB



Dual Tissue Scaffolds

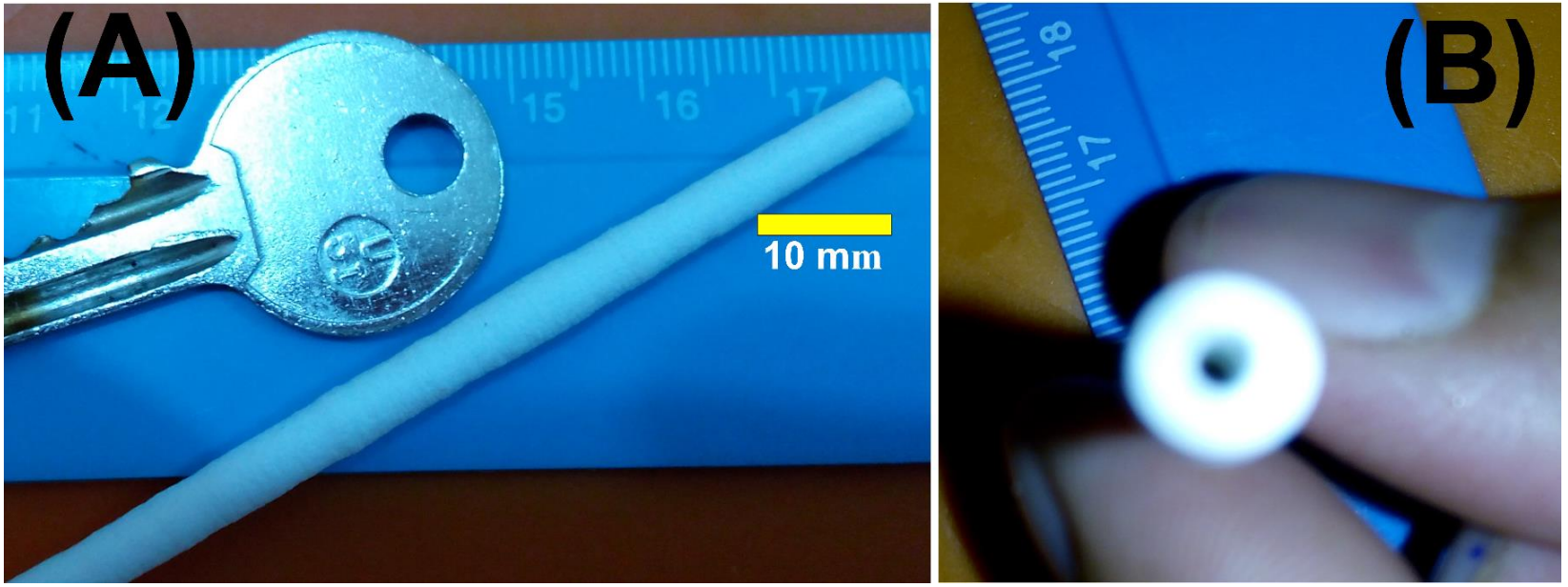
Dual tissue scaffold

Schematic diagram of dual air jet spinning fabrication process



Dual tissue scaffold

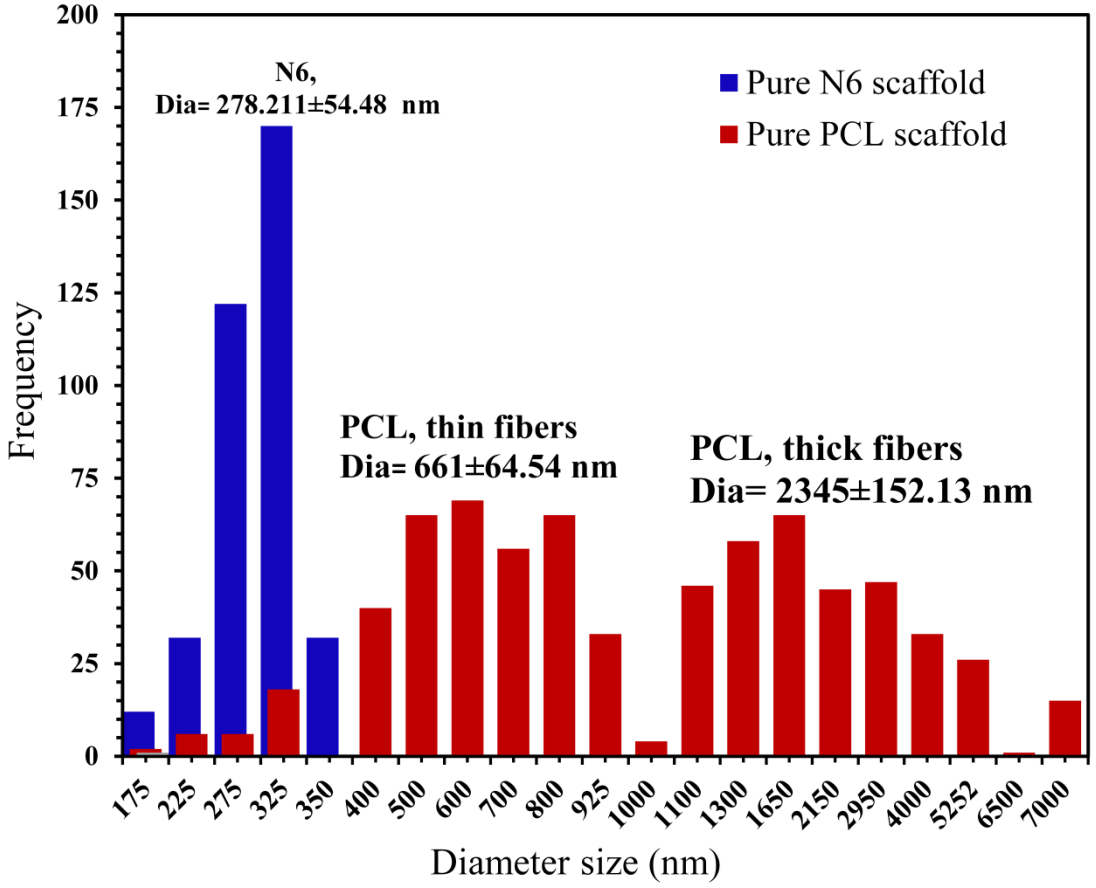
AJS fibers as blood vessel



2D optical images of blood vessel tubular structure: (A) horizontal view, (B) top view

Dual tissue scaffold

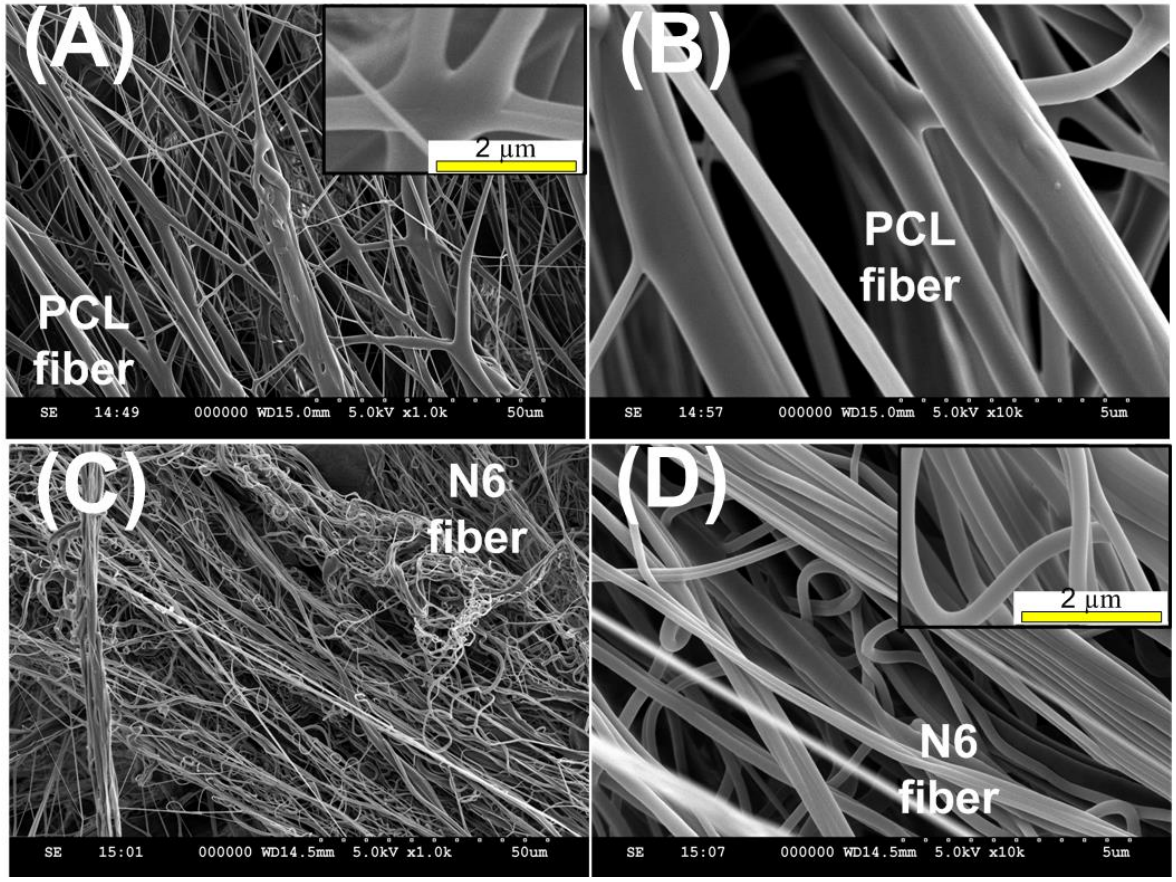
Cell culture: Indirect contact assay



TGA curves of pure and hybrid tissue scaffold

Dual tissue scaffold

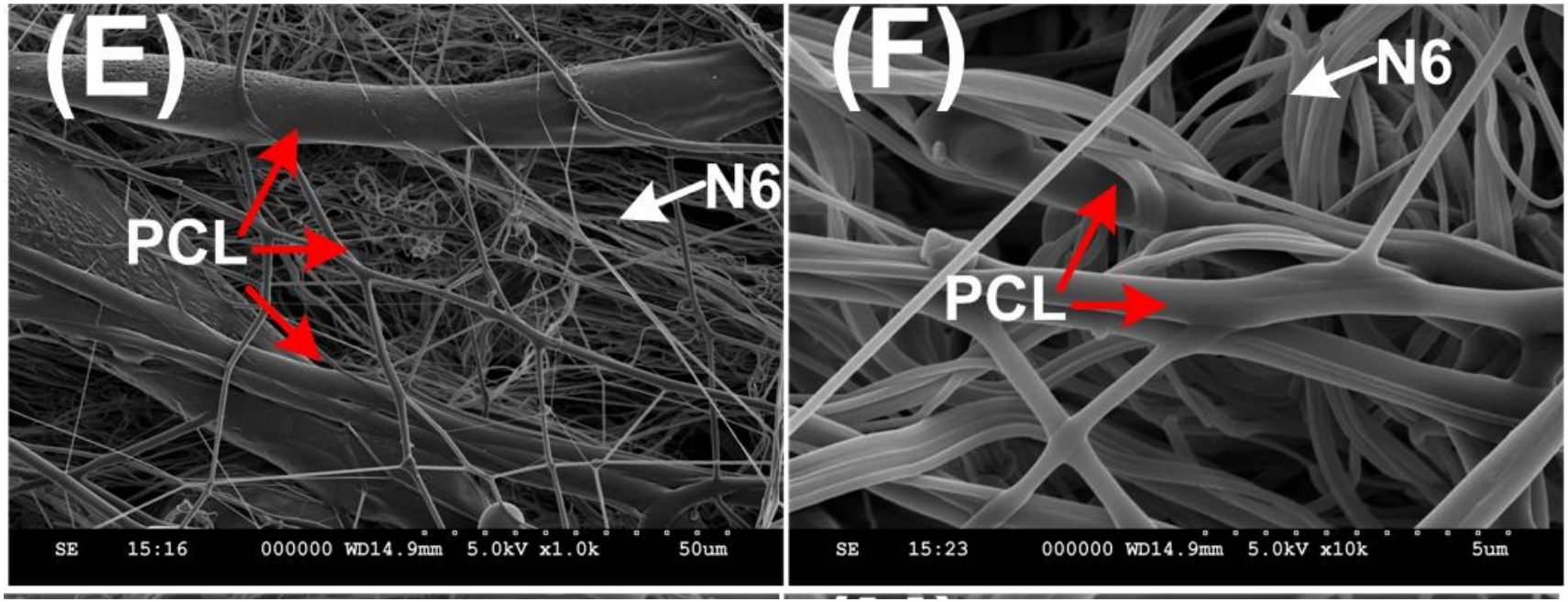
Morphology Observation



SEM images of pure PCL (A and B) and pure nylon 6 (C and D)

Dual tissue scaffold

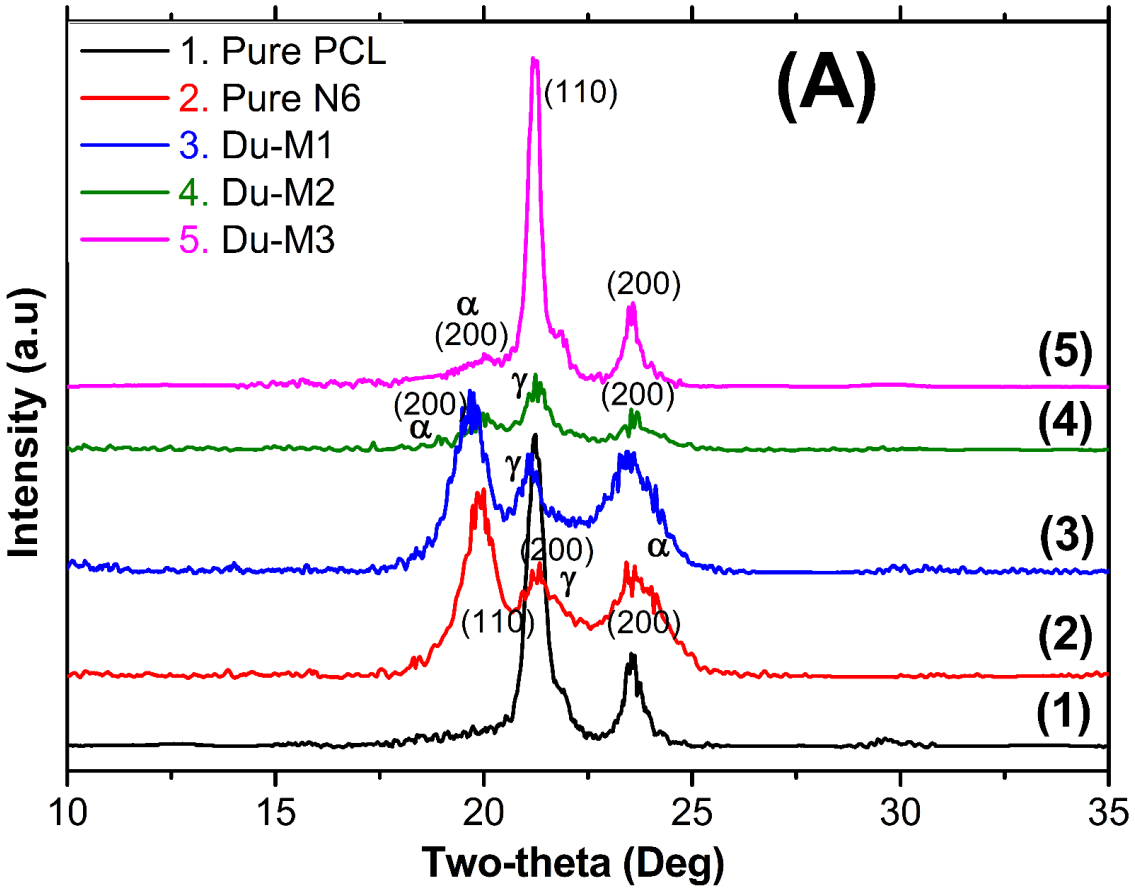
Morphology Observation: Cont



SEM images of N6/PCL (90/10) hybrid (dual) scaffold

Dual tissue scaffold

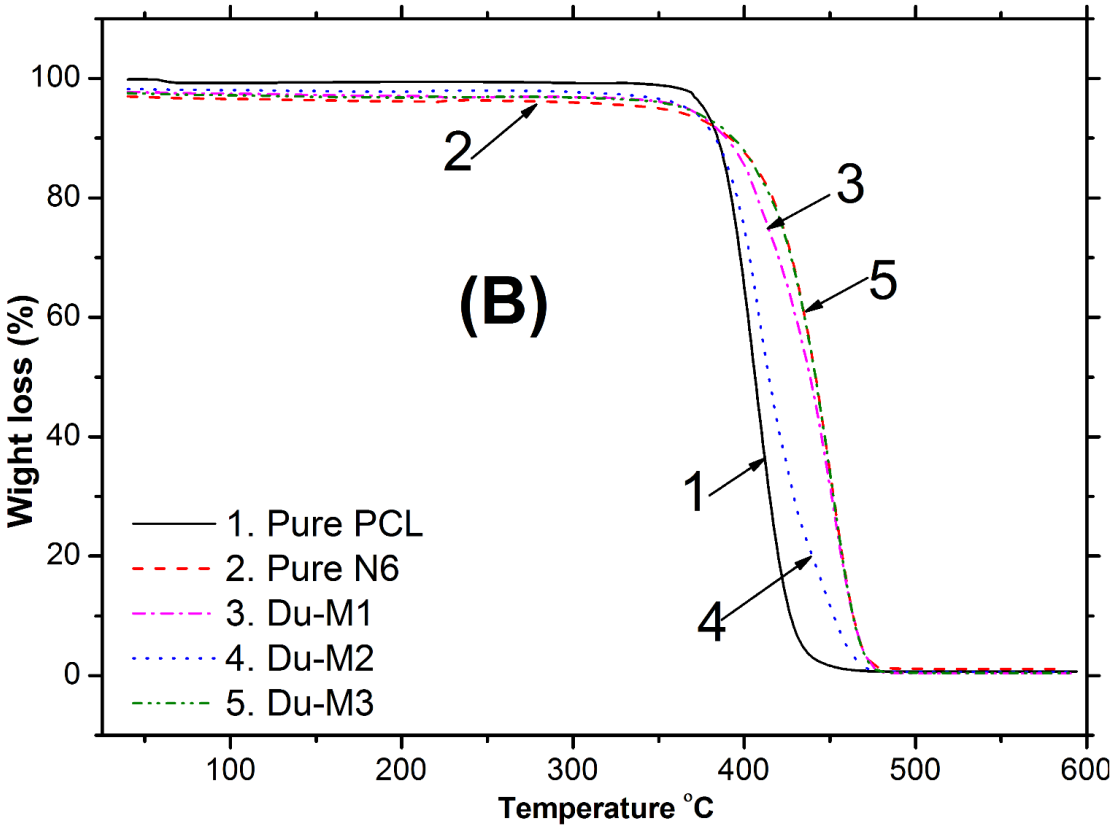
Physical properties



XRD profiles of pure and hybrid tissue scaffold

Dual tissue scaffold

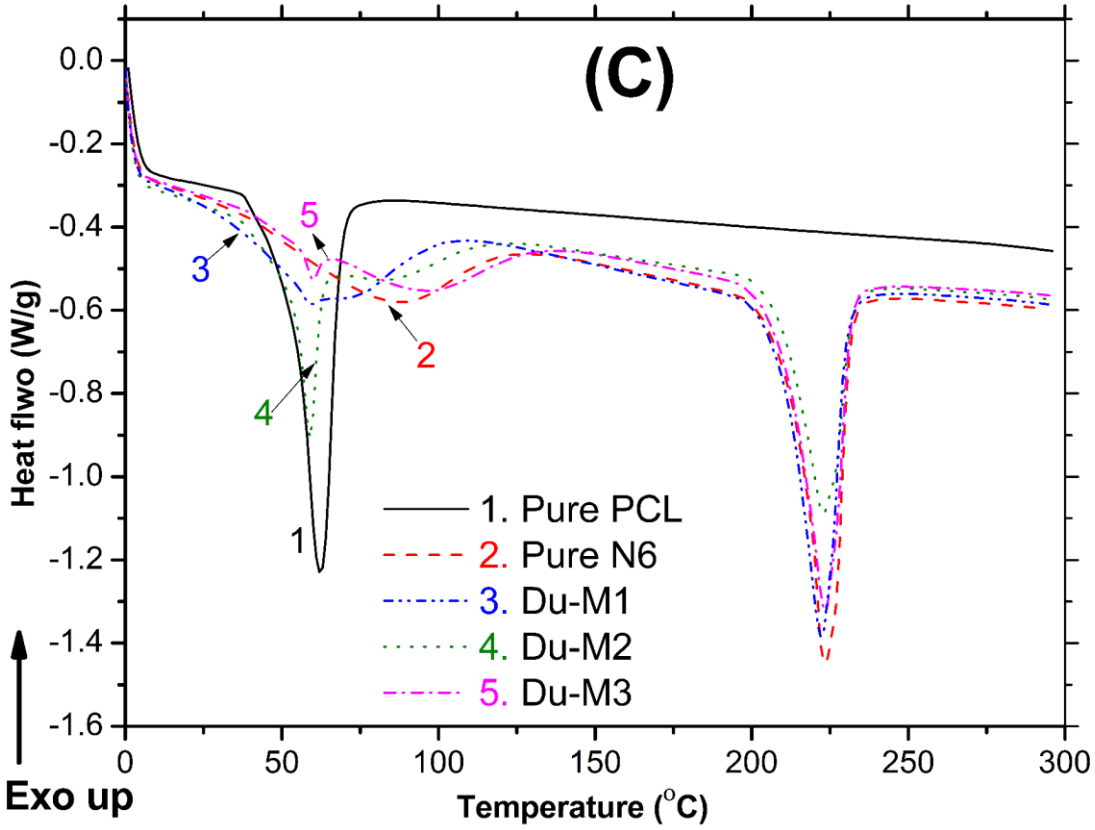
Physical properties: Cont



TGA curves of pure and hybrid tissue scaffold

Dual tissue scaffold

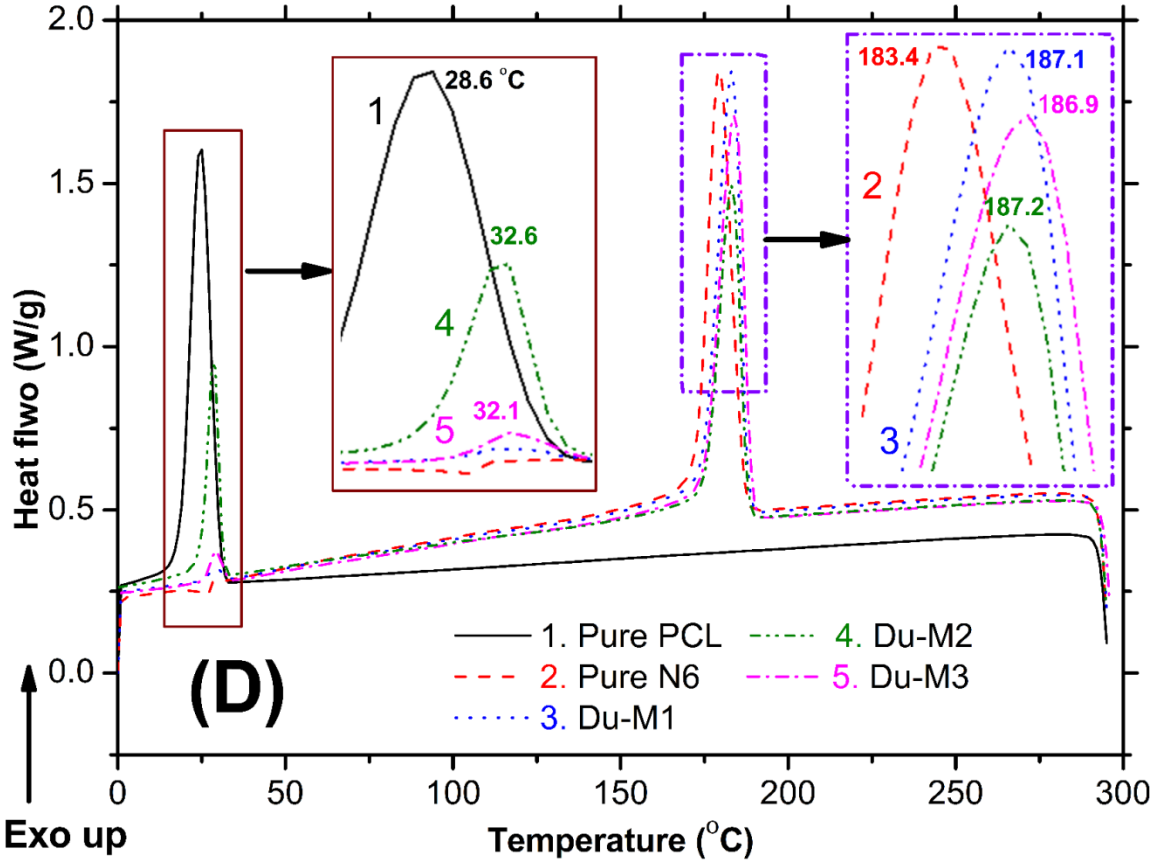
Physical properties: Cont



DSC curves of pure and hybrid tissue scaffold

Dual tissue scaffold

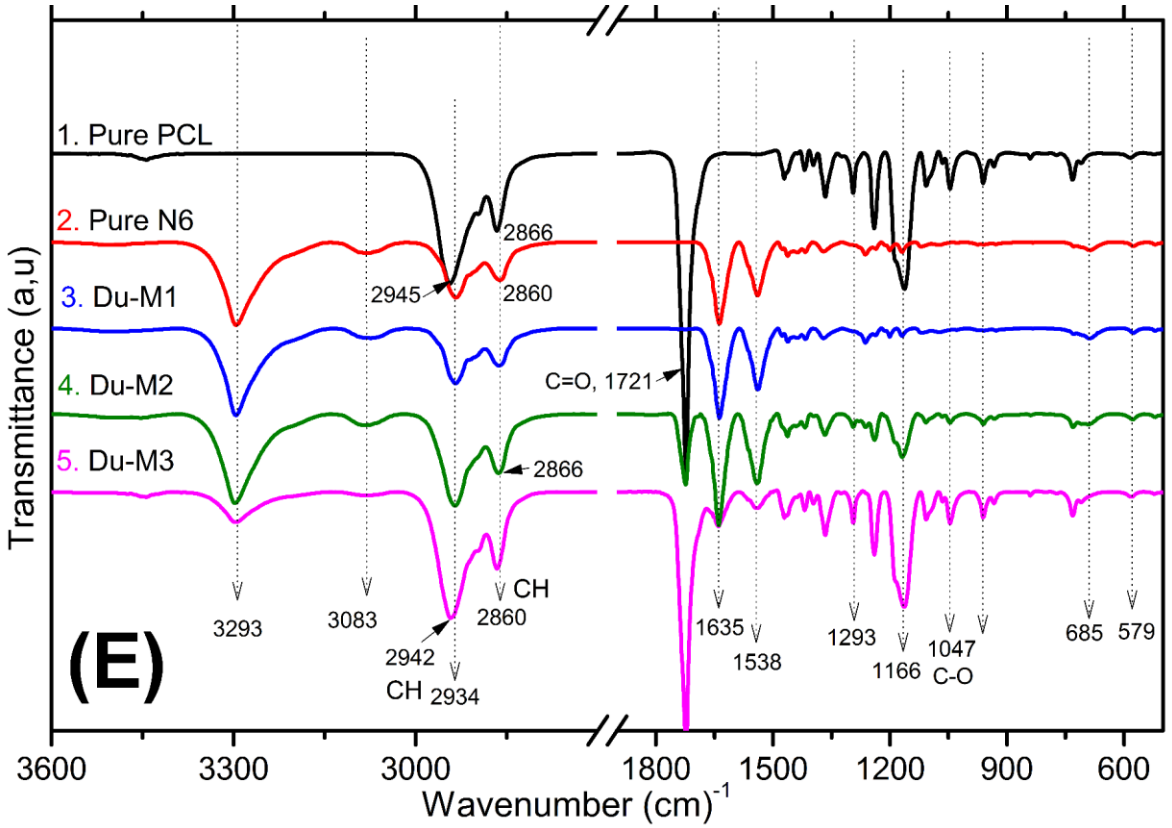
Physical properties: Cont



DSC curves of pure and hybrid tissue scaffold

Dual tissue scaffold

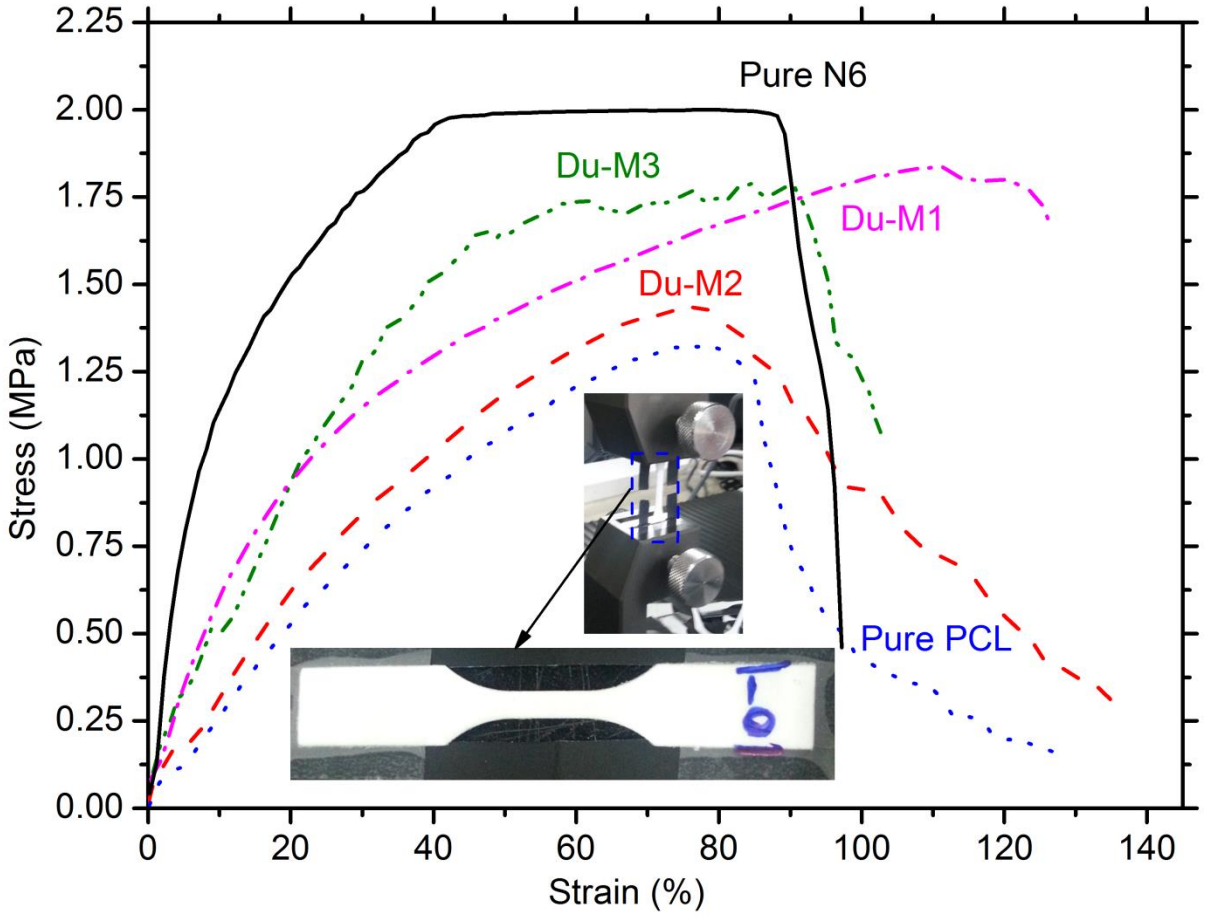
Physical properties: Cont



TGA curves of pure and hybrid tissue scaffold

Dual tissue scaffold

Mechanical properties



Typical stress-strain curves of the as-prepared samples using AJS strategy

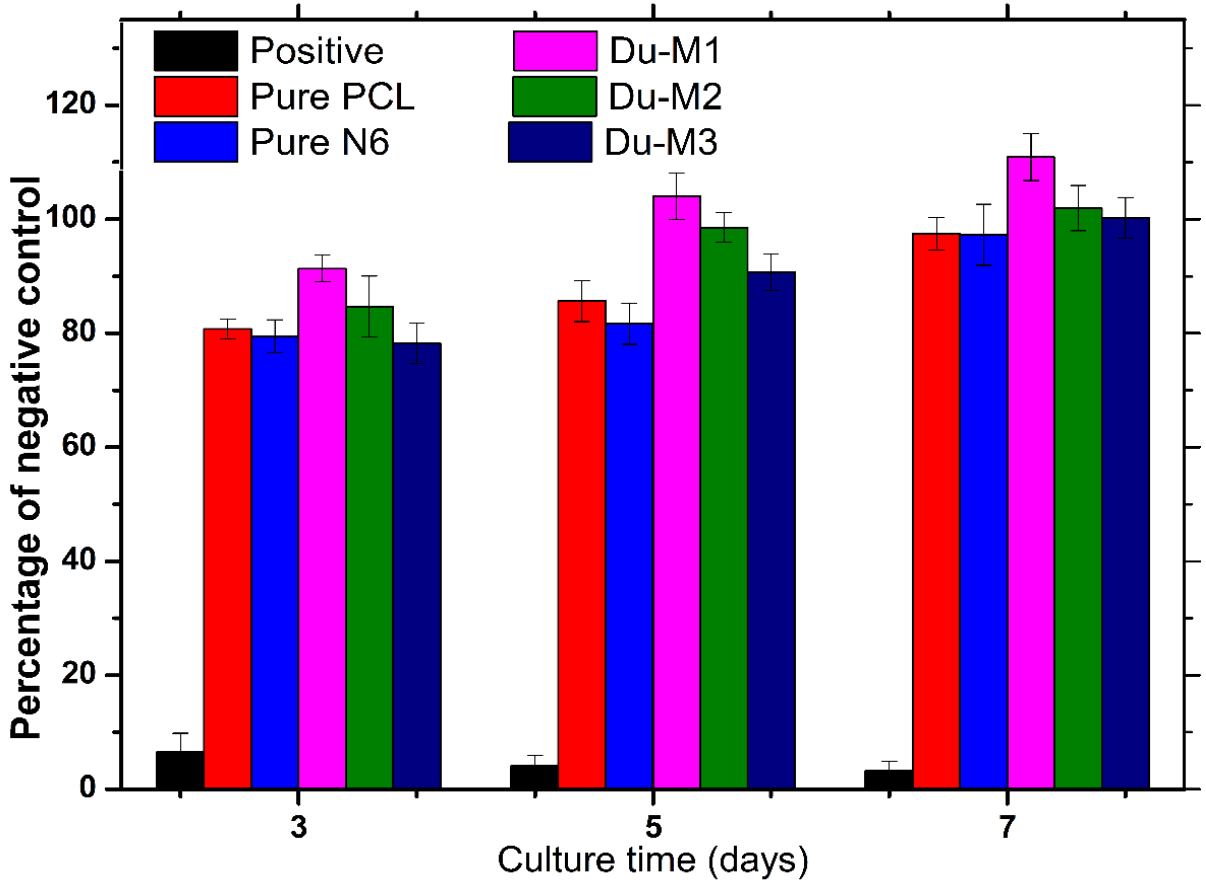
Dual tissue scaffold

Table 1. Tensile and pore size properties of AJS scaffolds

Sample	Tensile strength (MPa)	Young's modulus (MPa)	Breaking elongation (%)	Pore size (μm)
Pure N6	1.98±0.25	9.14±1.61	97.53±6.75	4.25±0.89
Pure PCL	1.28±0.38	4.15± 0.73	128.9±6.52	11.23±1.13
Du-M1	1.86±0.312	8.14±2.08	127.1±7.14	9.56±1.82
Du-M2	1.38±0.43	5.43±1.27	134.8±8.72	8.3±1.5
Du-M3	1.79±0.22	7.79±1.22	110.5±8.18	7.11±0.45

Dual tissue scaffold

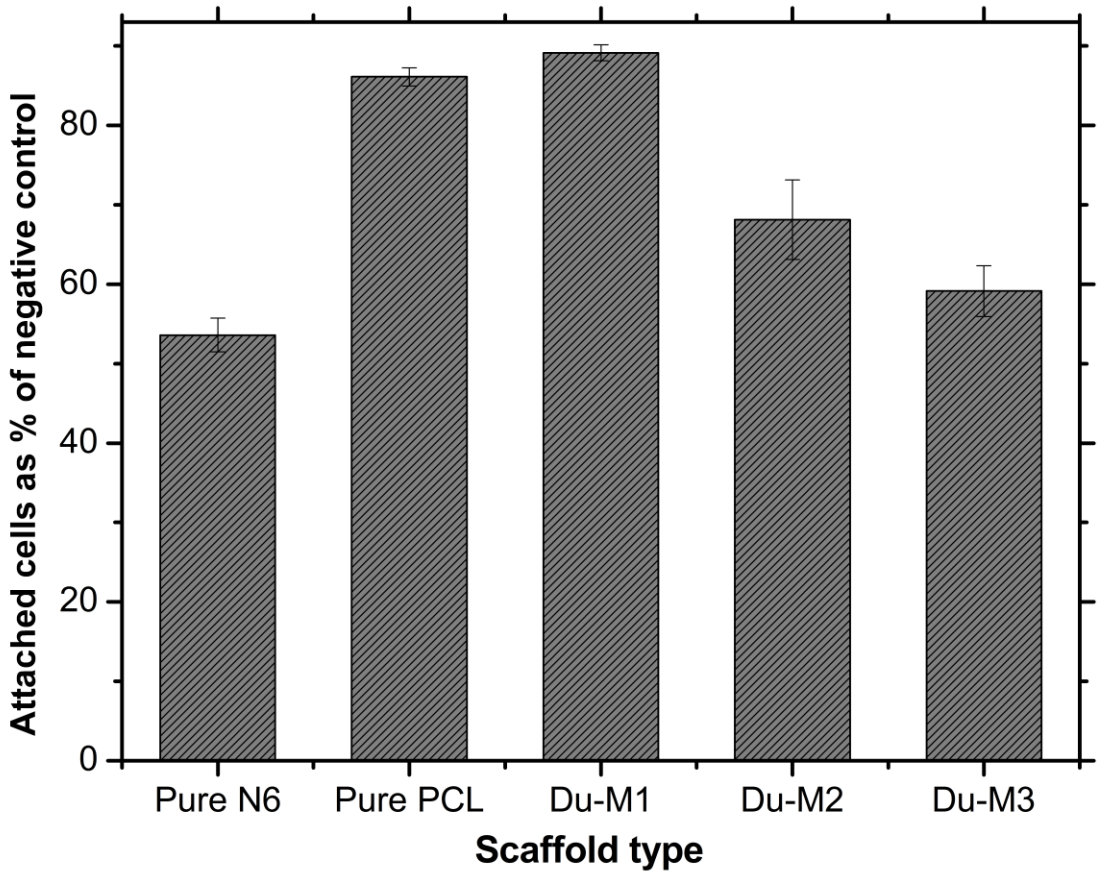
Cell culture: Indirect contact assay



MTT-assay for cell viability and proliferation after culturing EA.hy926 endothelial cells using preconditioned media prepared from pure PCL, N6, Du-M1, Du-M2, and Du-M3 scaffolds compared to the negative control after 3, 5 and 7 days of culture (n =3).

Dual tissue scaffold

Cell culture: Cell attachment assay

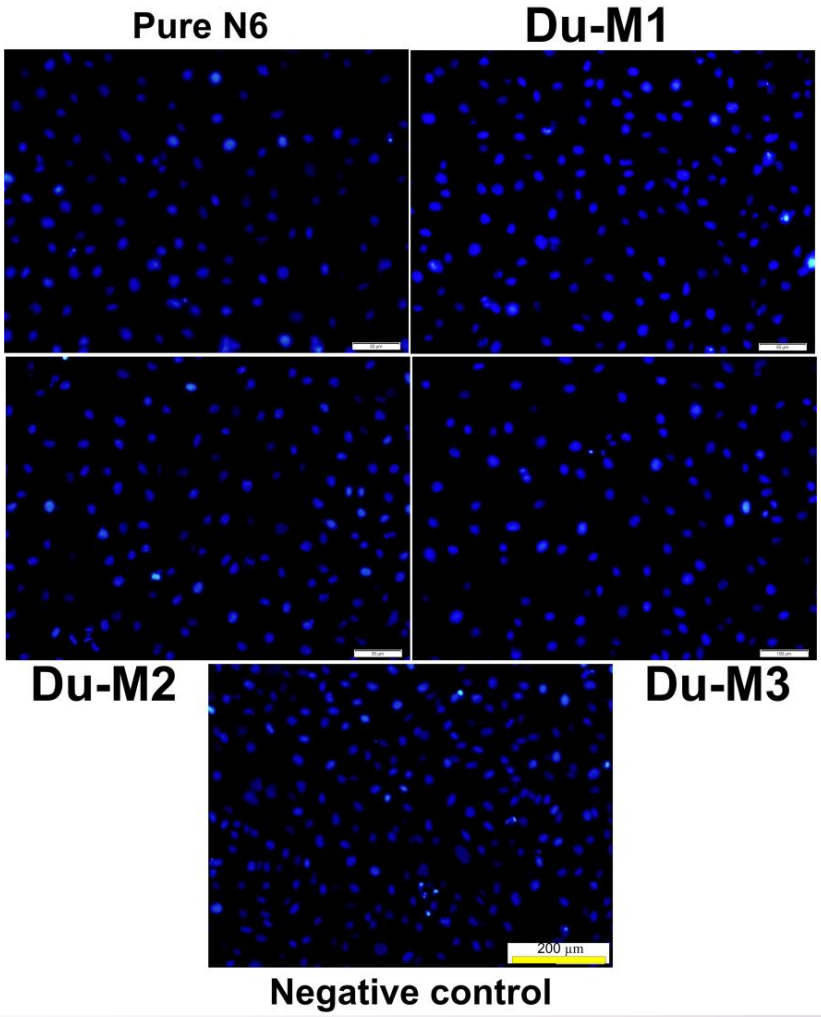


Cell attachment assay of EA.hy926 endothelial cells- MTT

Dual tissue scaffold

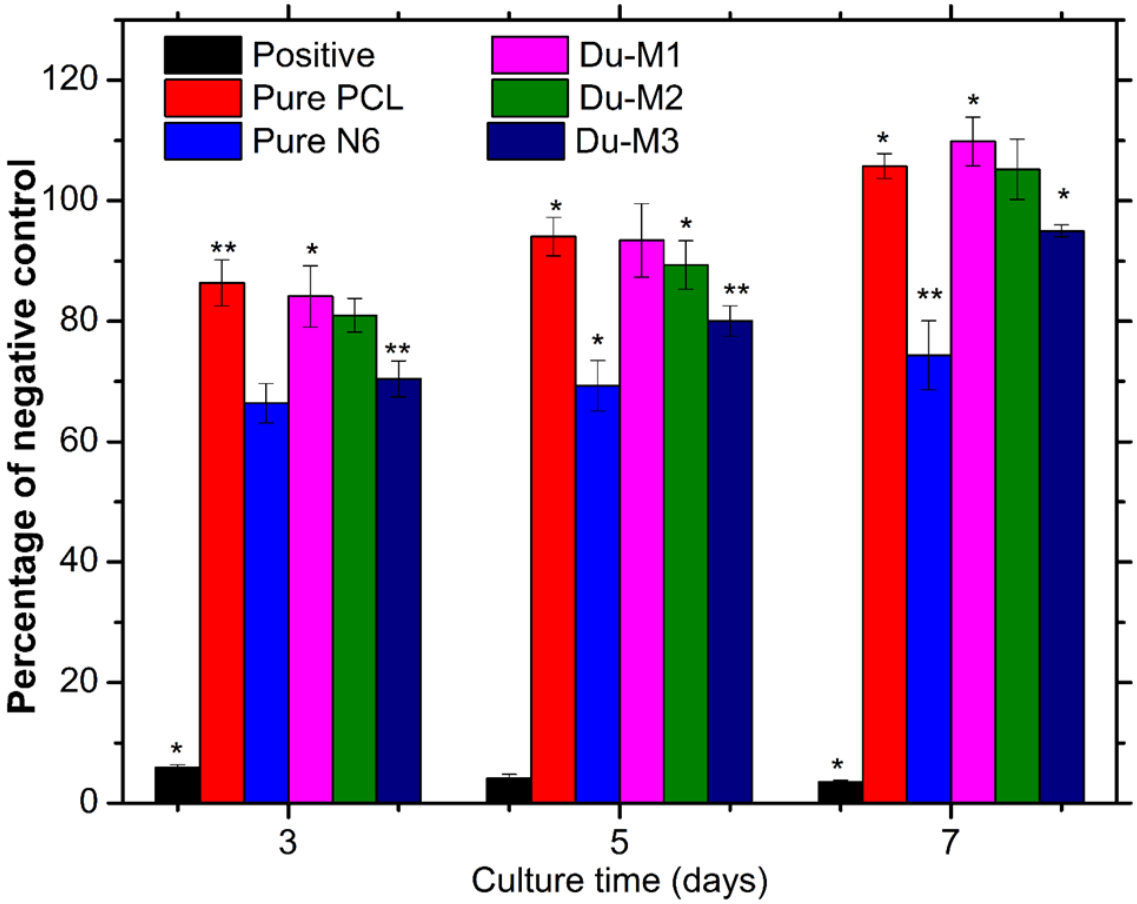
Cell culture: Cell attachment assay

Cell attachment assay of EA.hy926 endothelial cells -DAPI staining assay



Dual tissue scaffold

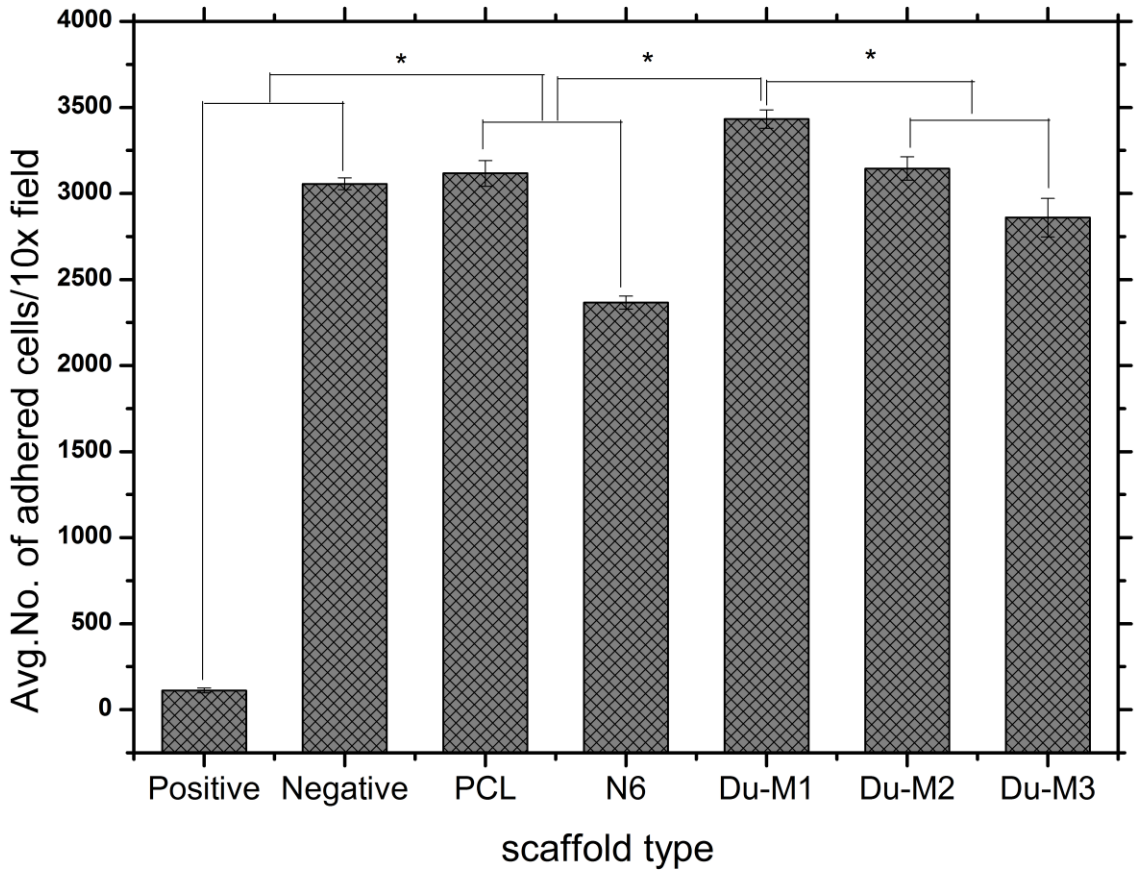
Cell culture: Direct contact assay



MTT-assay for cell proliferation of EA.hy926 endothelial cells cultured on surfaces of mats for 3, 5 and 7 days, compared with the negative control. Error bars represent means ± standard deviation (n=4).

Dual tissue scaffold

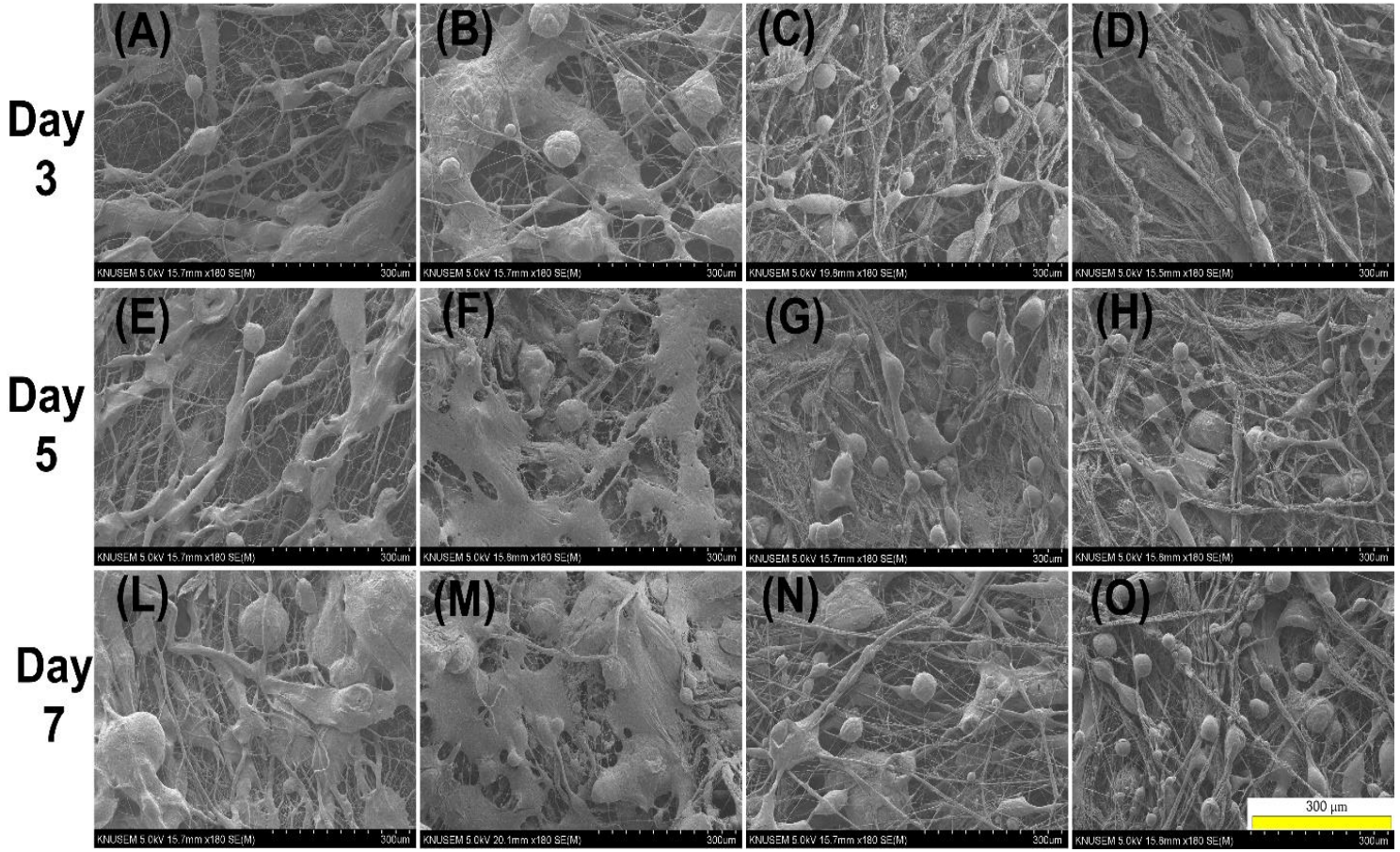
Cell culture: Direct contact assay



Attached DAPI stained EA.hy926 endothelial cells on PCL, N6, Du-M1, Du-M2, and Du-M3 hybrid fibrous scaffolds compared to that of negative control

Dual tissue scaffold

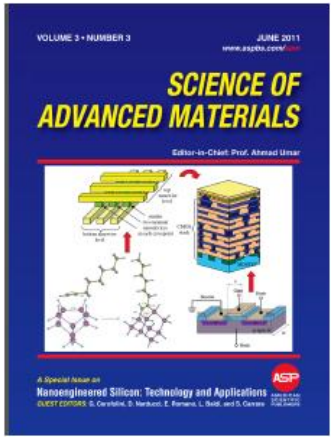
Cell morphology observation



SEM images for EA.hy926 endothelial cells cultured on the surface of pure PCL (A,E,L), Du-M1 (B,F,M), Du-M2 (C,G,n), and Du-M3 (D,H,O) hybrid fibrous scaffolds at 3,5, and 7 days of culture.

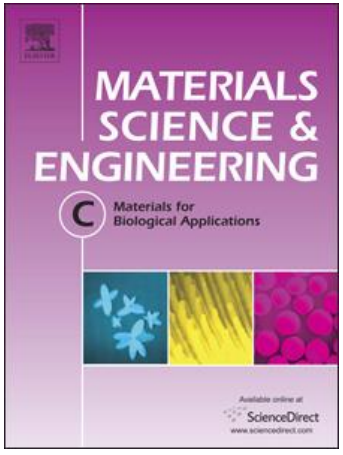
Selected Publications Related to the AJS











Conclusion

- We successfully designed a novel fibrous and porous membrane using a very simple, versatile, costless and effective technique.

- Nanocomposite membrane can easily be fabricated by this simple and effective technique

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