Impact of Nanofiber Physical and Chemical Properties on Immune Response

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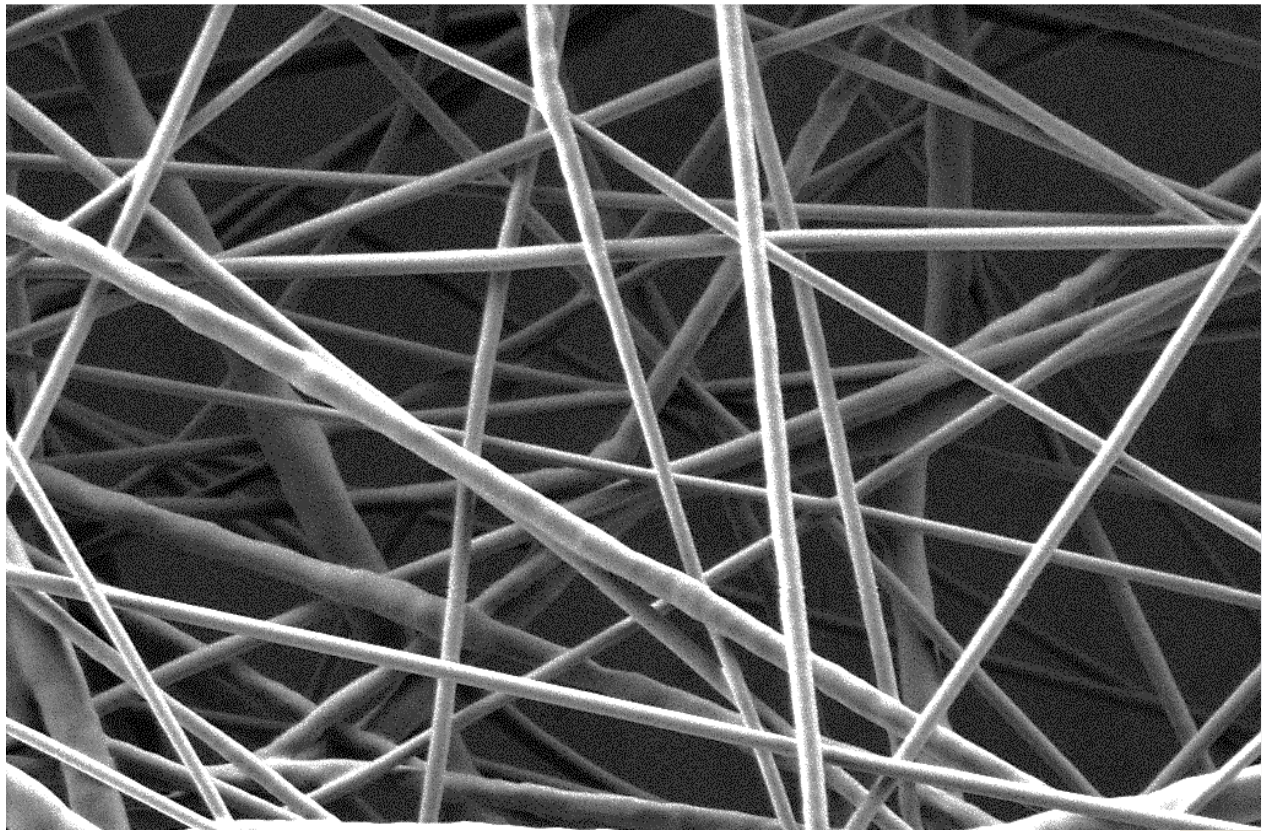
NEXT-GENERATION DELIVERY INNOVATIONS

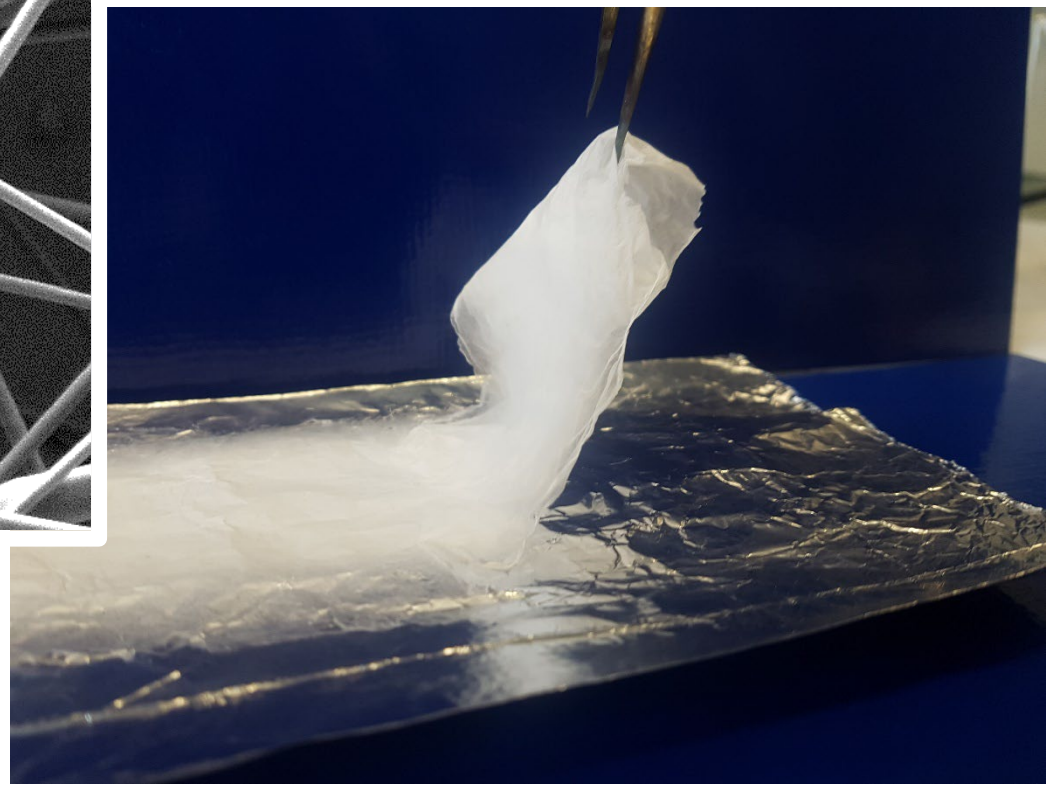
Nanofibers



Fibers with diameters in the nanometer range (typically, between 10 nm and 1 μm)

Delivery system

Tissue regeneration



Nanofibers and immunogenicity

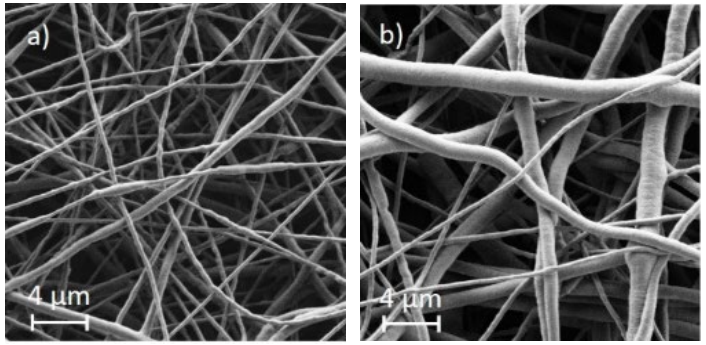
- Immune cells are present in mucosal membranes and skin.
- The immunological safety aspect related is often neglected.
- Properties of nanofibers dictate the interactions with immune cells.

Polymeric Nanofibers Investigated

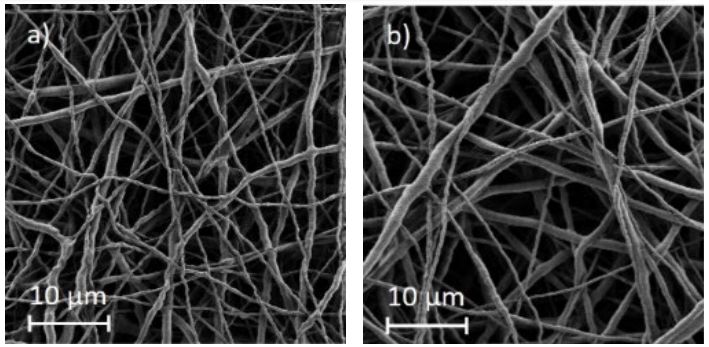
- **Polycaprolactone (PCL)**
  - Synthetic polymer – high hydrophobicity
- **Alginate + polyethylene oxide** (2 MDa) (ALG/PEO_{2MDa})
  - Natural polysaccharide – negative charge
- **Chitosan + polyethylene oxide** (900 kDa) (CS/PEO_{900kDa})
  - Polysaccharide – positive charge
- **Zein + polyvinylpyrrolidone** (zein/PVP)
  - Natural polypeptide – protein structure

Physical Properties of Nanofibers

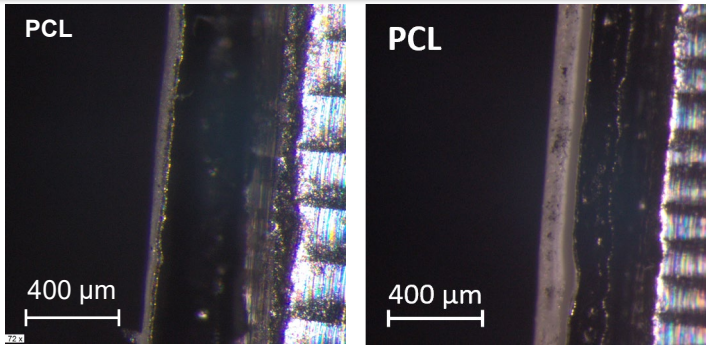
Nanofiber Diameter



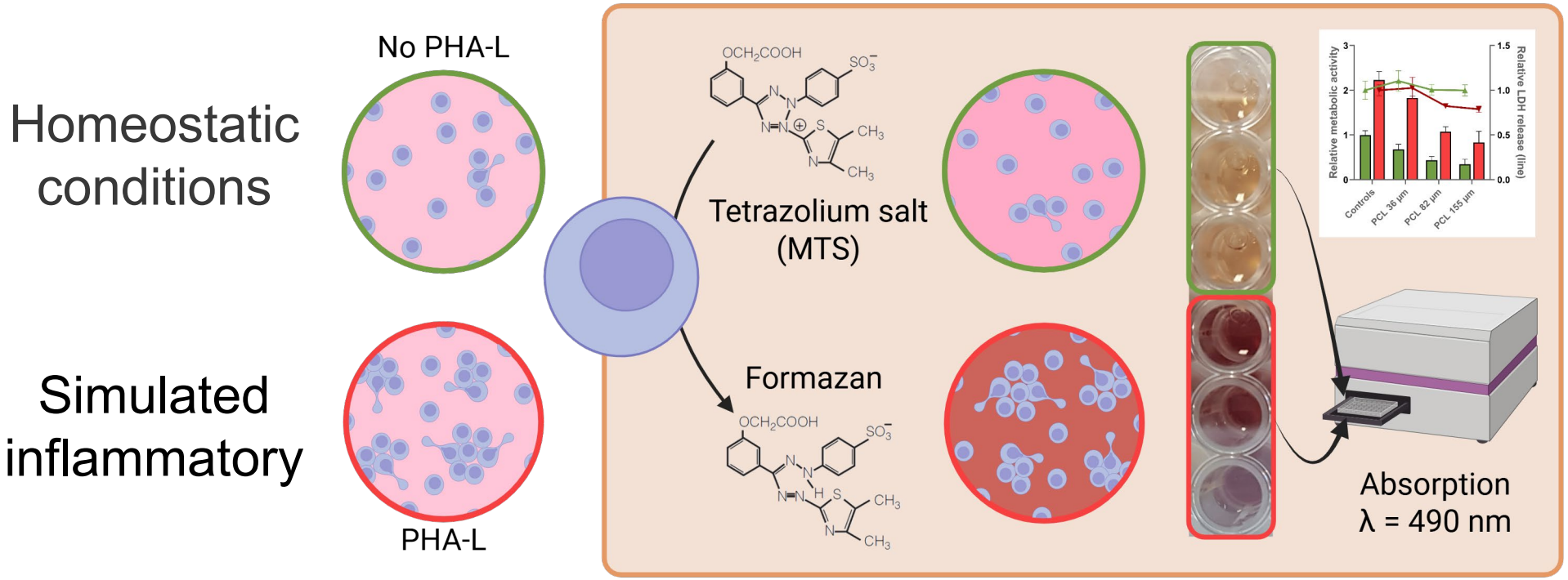
Pore Size



Membrane Thickness



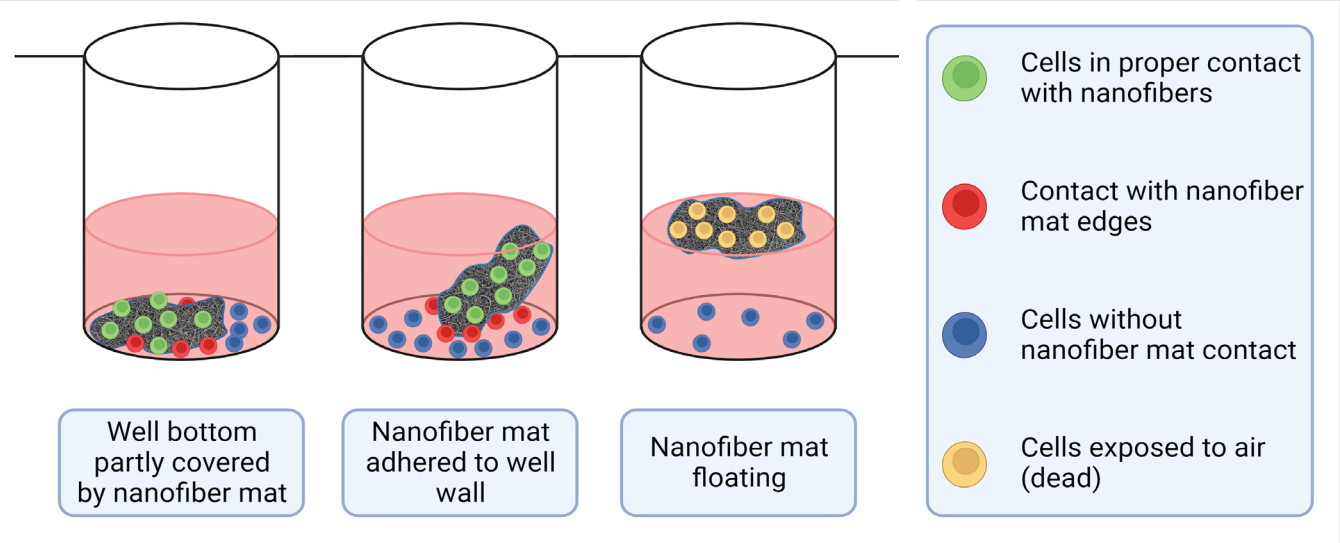
PBMC proliferation using MTS assay

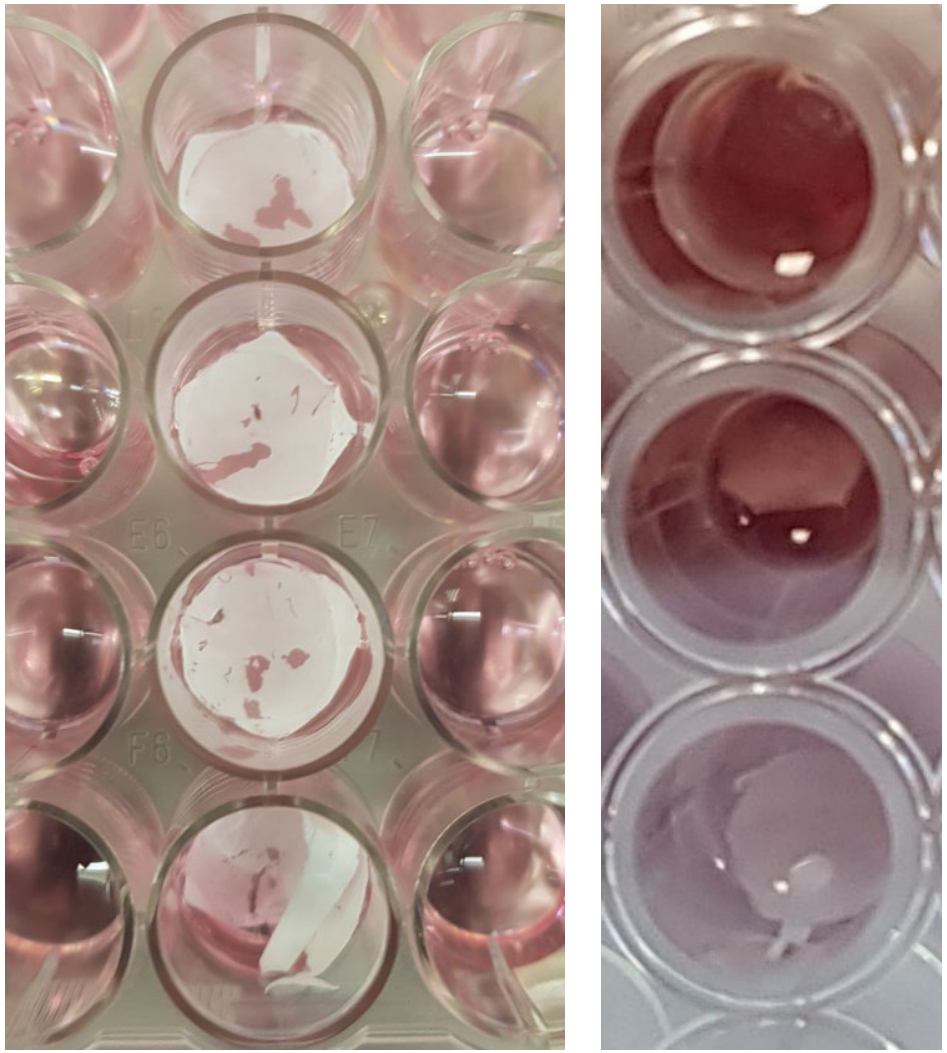


Peripheral Blood Mononuclear Cells (PBMCs) include lymphocytes (T cells, B cells, and NK cells), monocytes, and dendritic cells.

Conventional Model

Poor reproducibility and relevance

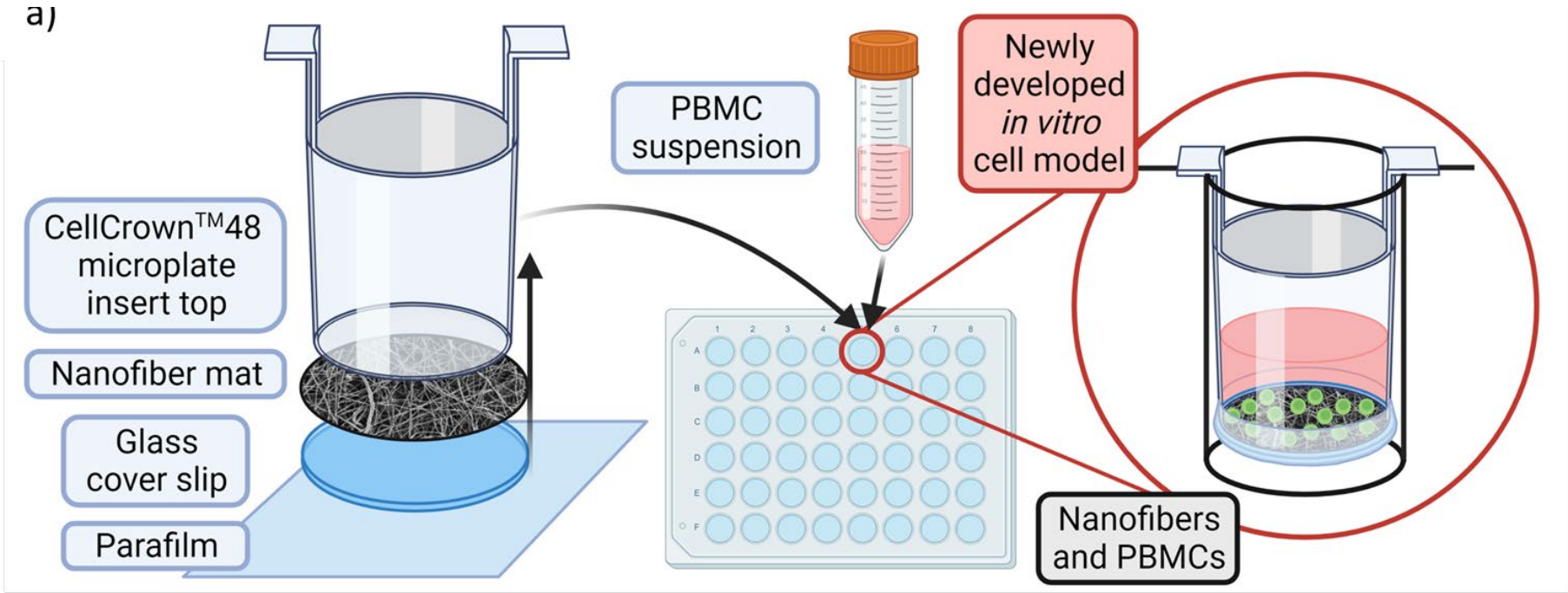




Zidar A, Zupančič Š, Kristl J, Jeras M. Development of a novel in vitro cell model for evaluation of nanofiber mats immunogenicity. Int J Pharm. 2024;650:123696.

New Model

- Enhanced reproducibility and better simulation of cell–nanofiber interaction



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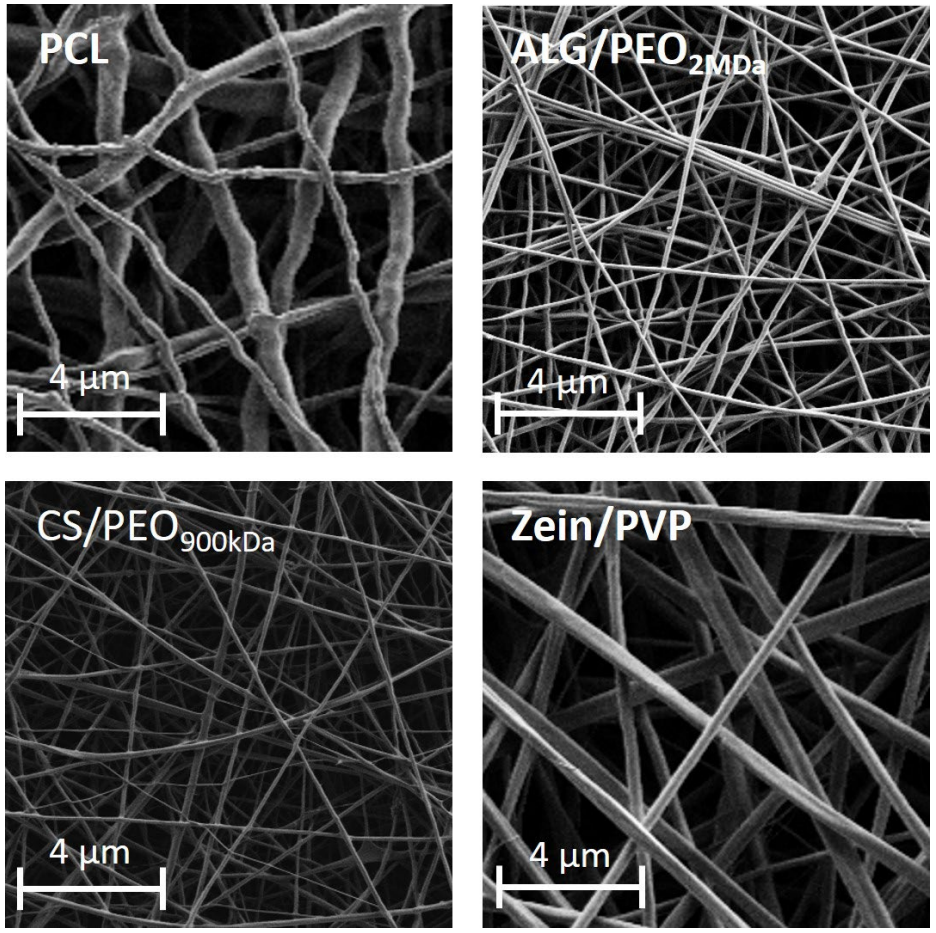
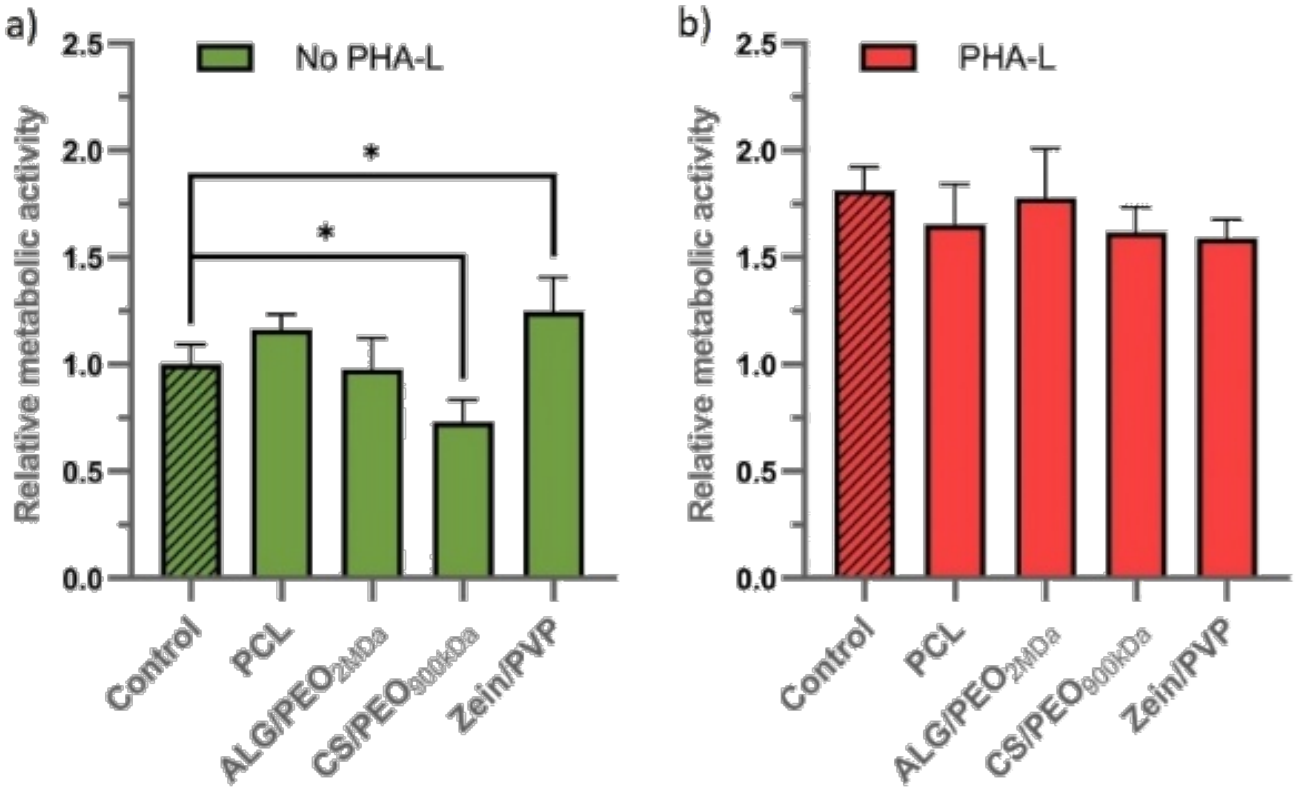
Chemical Composition Effects



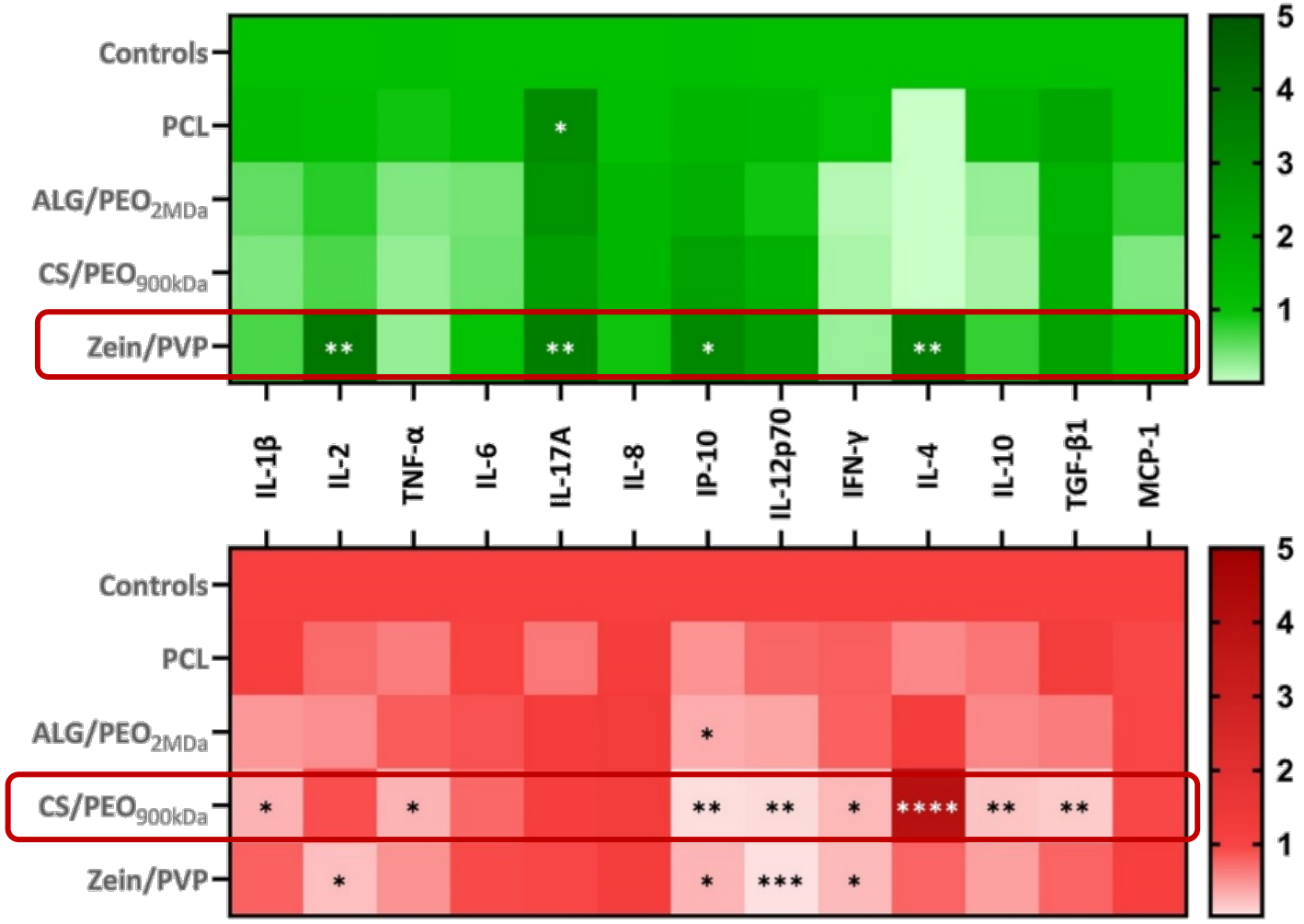
Metabolic activity



Chemical Composition Effects on PBMC Cytokine Release

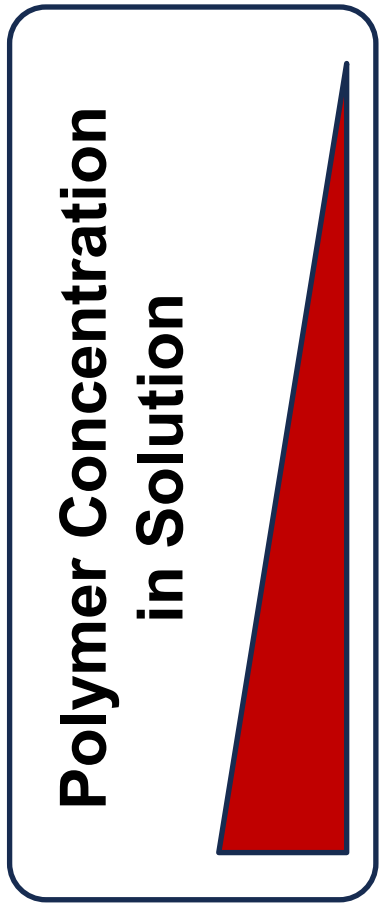
Homeostatic conditions

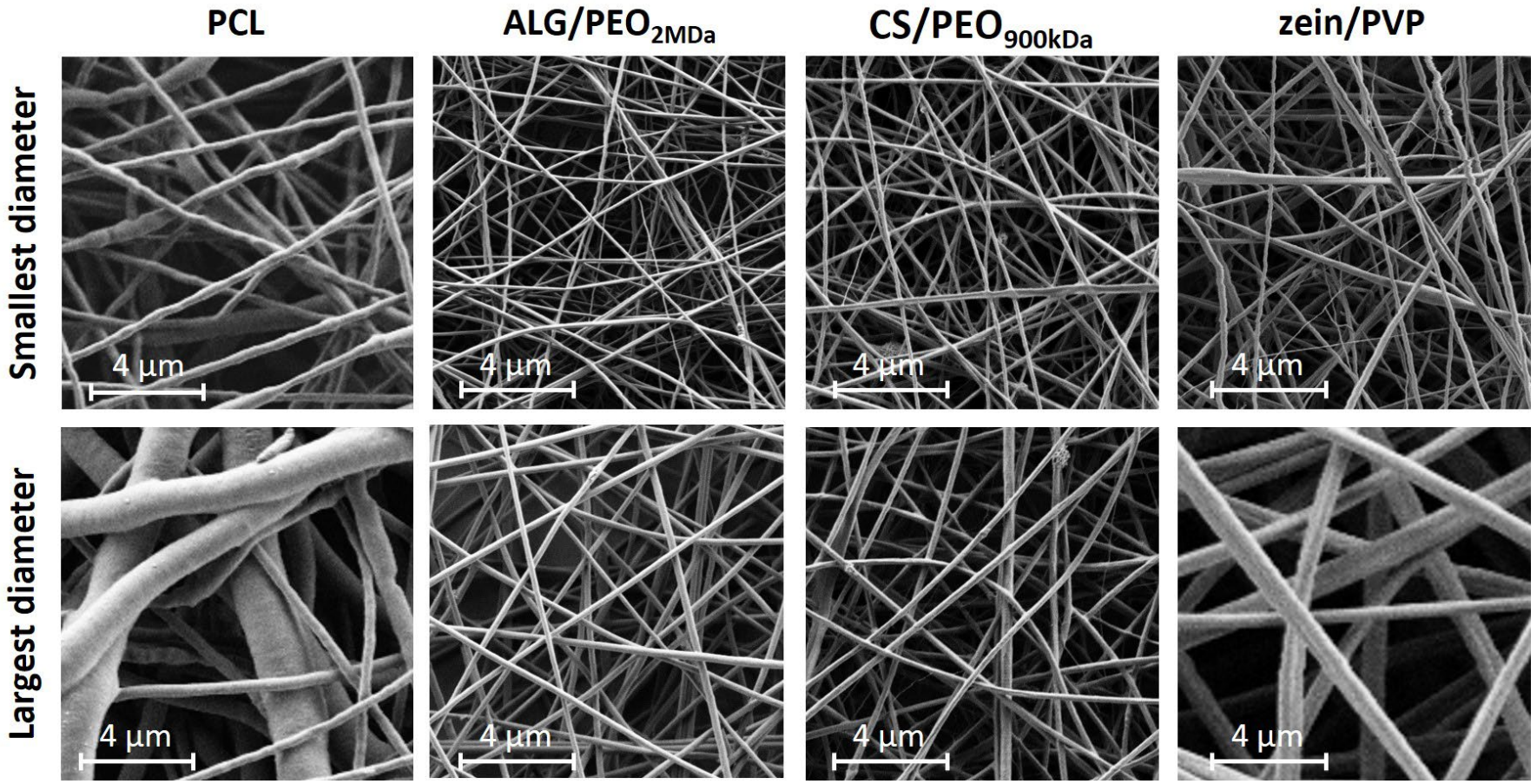
Simulated inflammatory



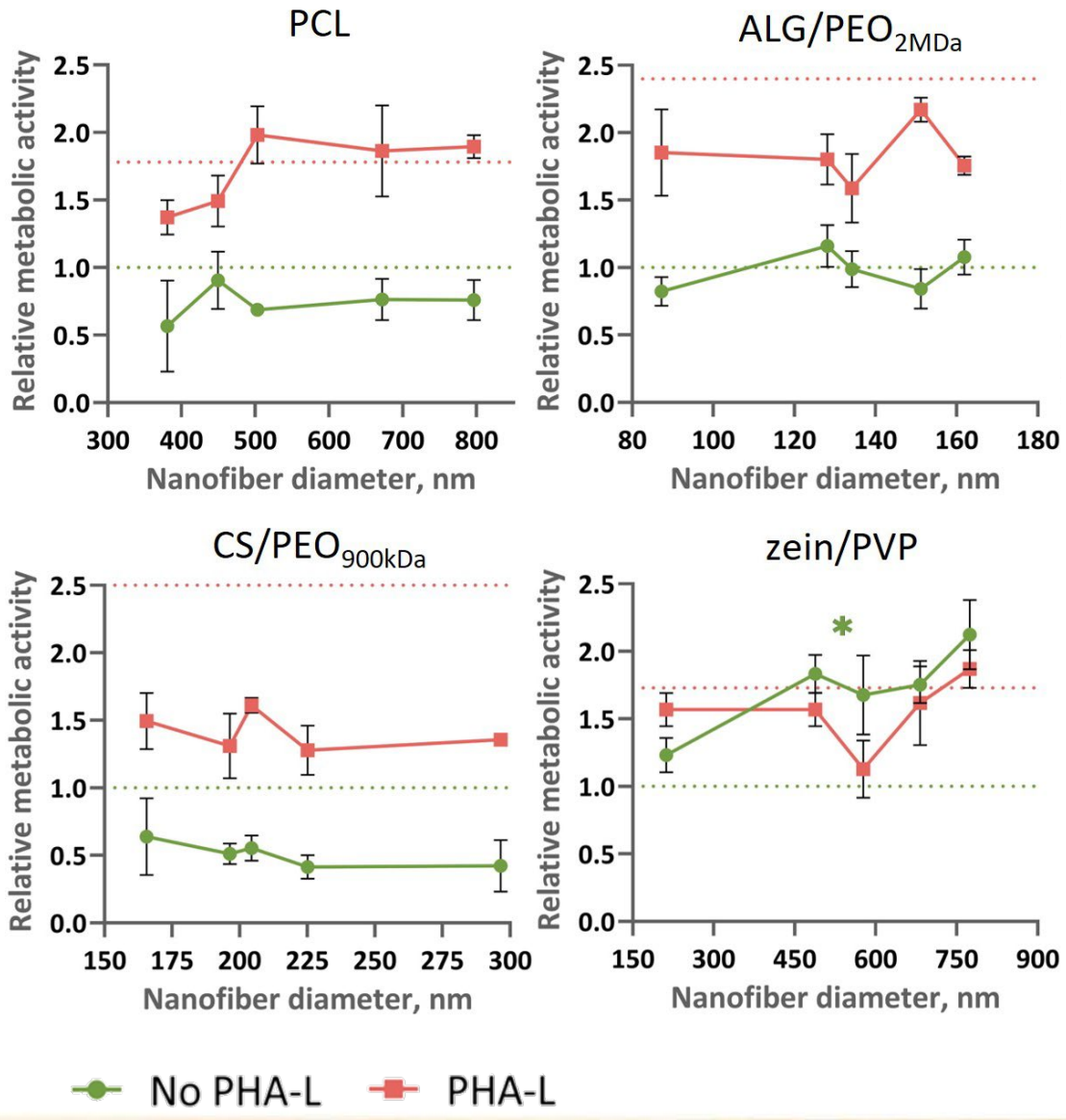
White Asterisks (*): Statistically significant **increase** vs control
Black Asterisks (*): Statistically significant **decrease** vs control

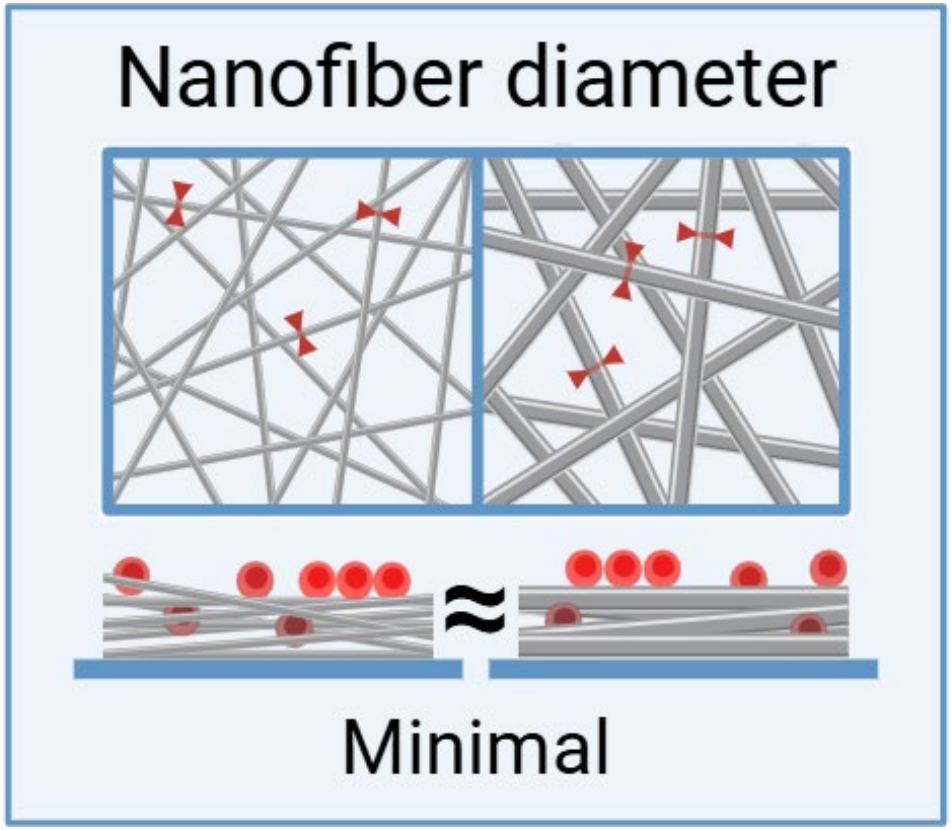
Nanofiber Diameter



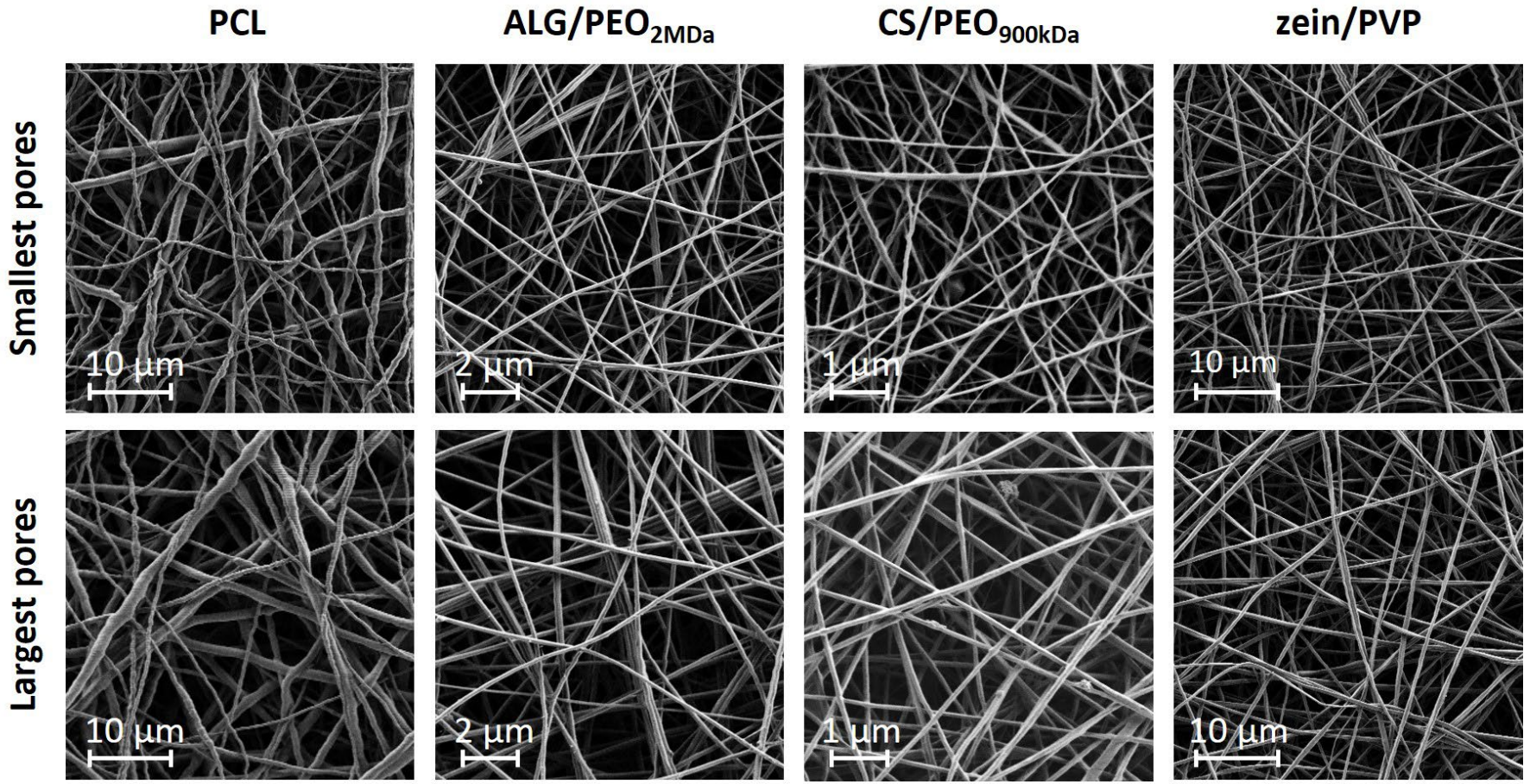


↑ Polymer concentration = ↑ Nanofiber diameter

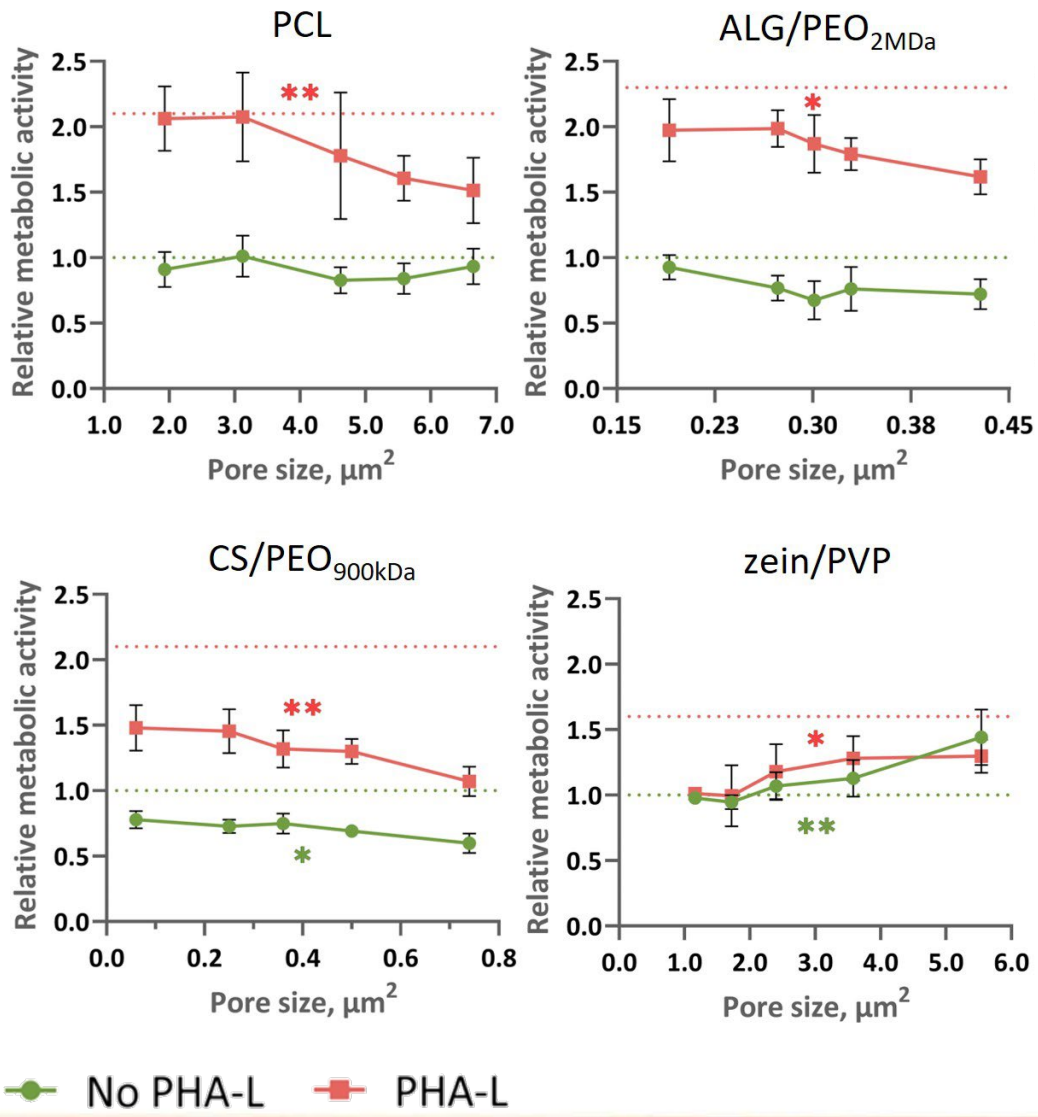

PCL
ALG/PEO2MDa
CS/PEO900kDa
zein/PVP
Relative metabolic activity
Nanofiber diameter, nm
*
No PHA-L
PHA-L


Nanofiber diameter
≈
Minimal

Pore Size



↑ Collector voltage = ↓ Pore size


PCL
ALG/PEO2MDa
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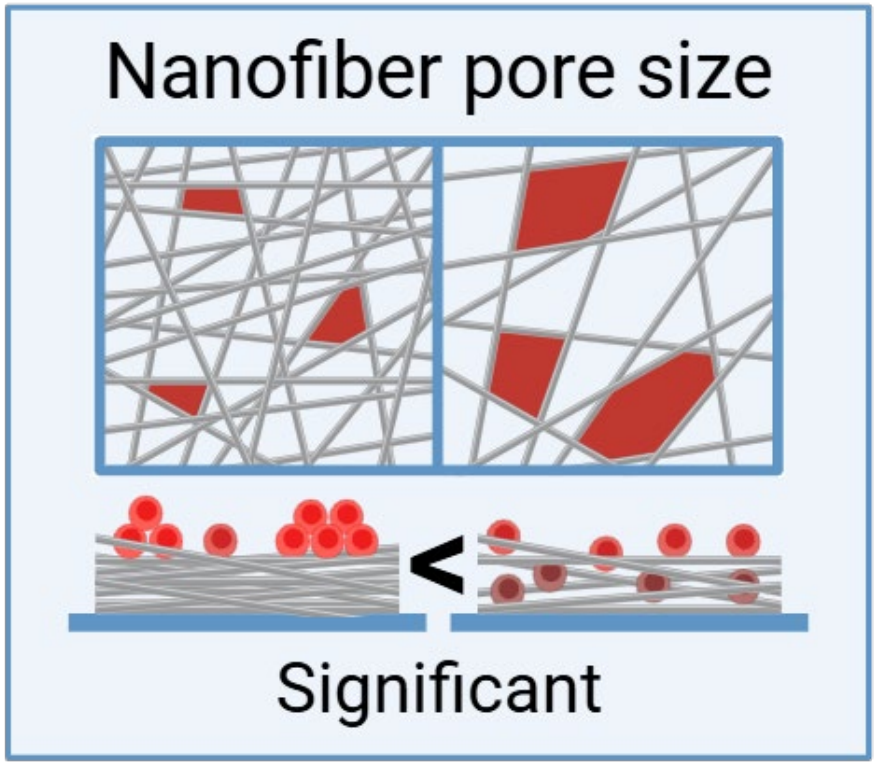
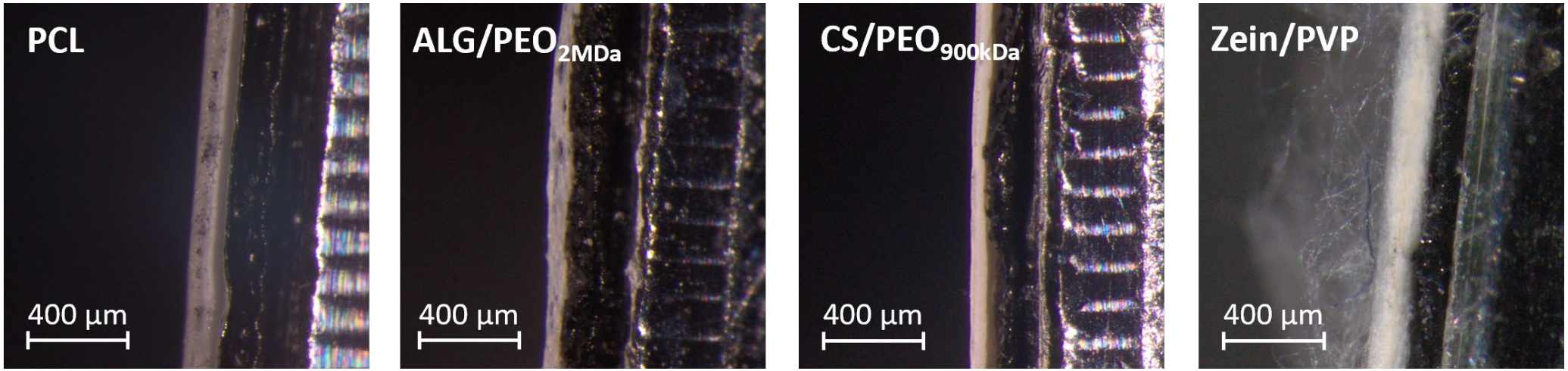
Relative metabolic activity
Pore size, µm2
No PHA-L
PHA-L

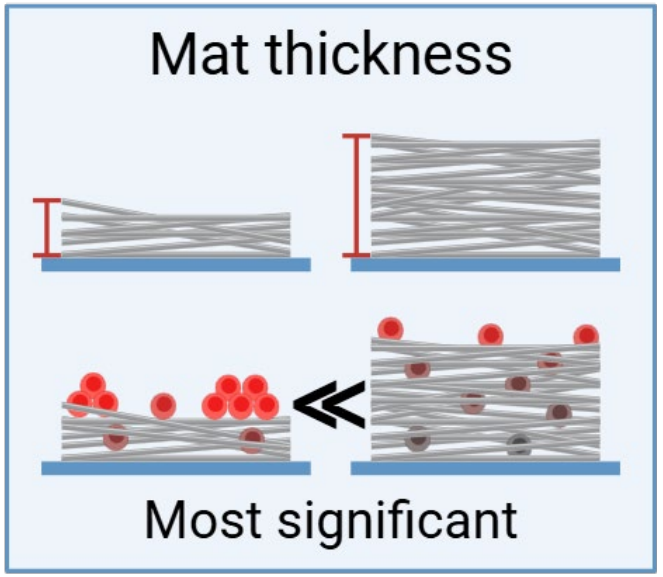

Nanofiber pore size
<
Significant

Membrane Thickness



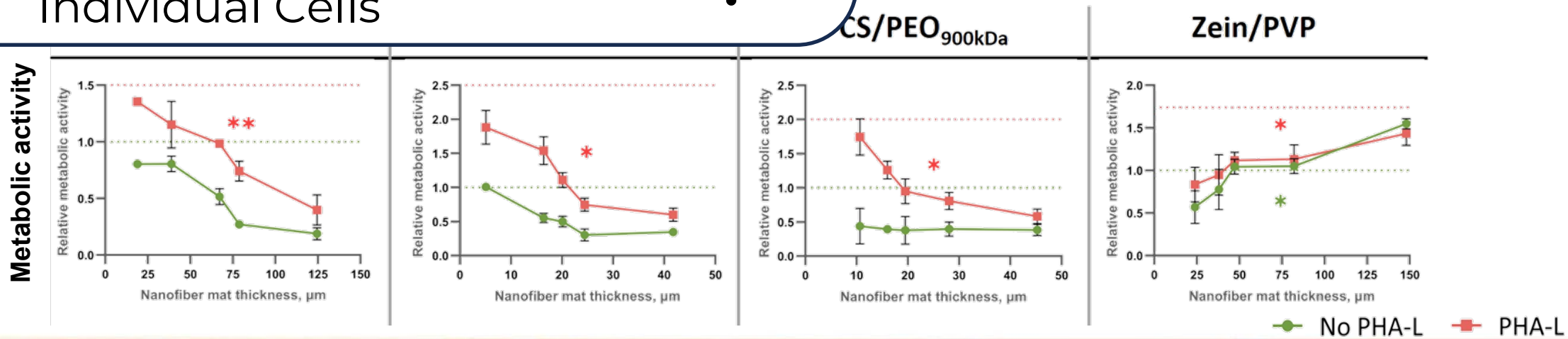
↑ Electrospinning time = ↑ Membrane thickness

Membrane Thickness



Change in Metabolic Activity:

- Cytotoxicity ?
- Proliferation ?
- Altered Metabolic Activity of Individual Cells ?



Membrane Thickness

Change in Metabolic Activity:

- Cytotoxicity ✗
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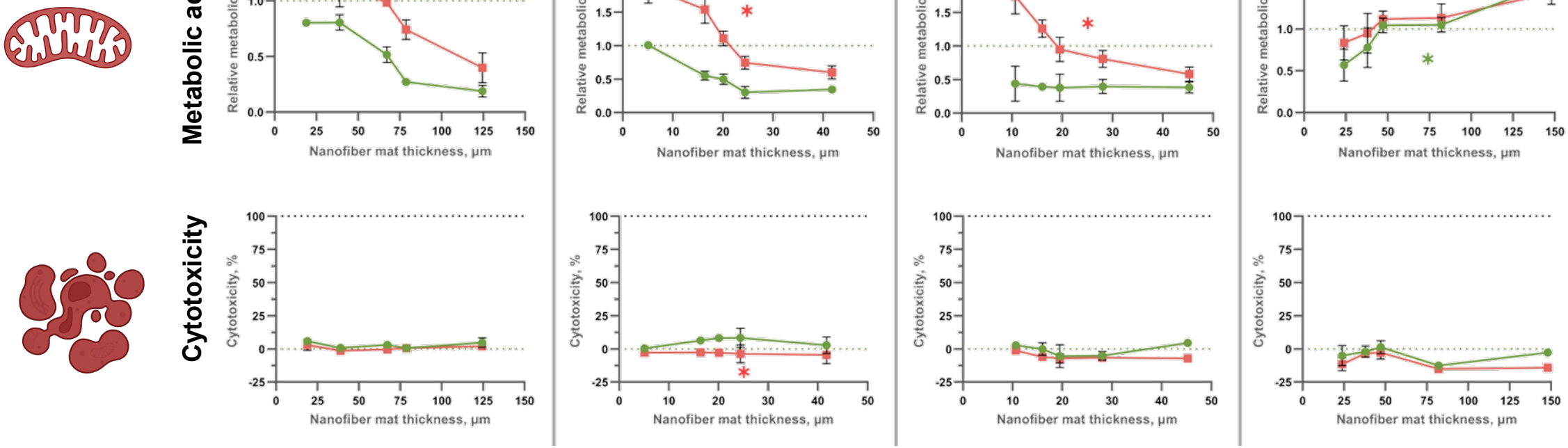
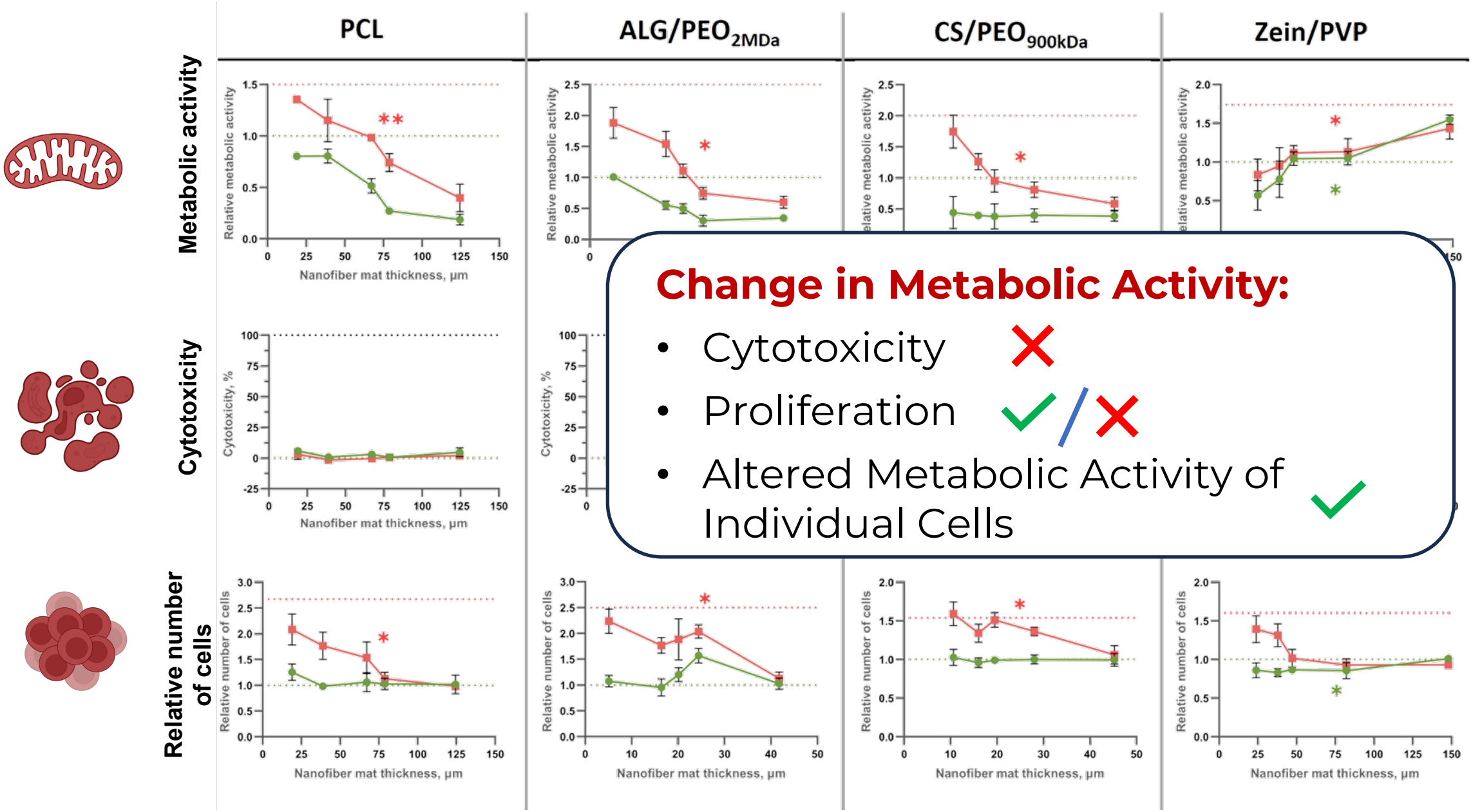
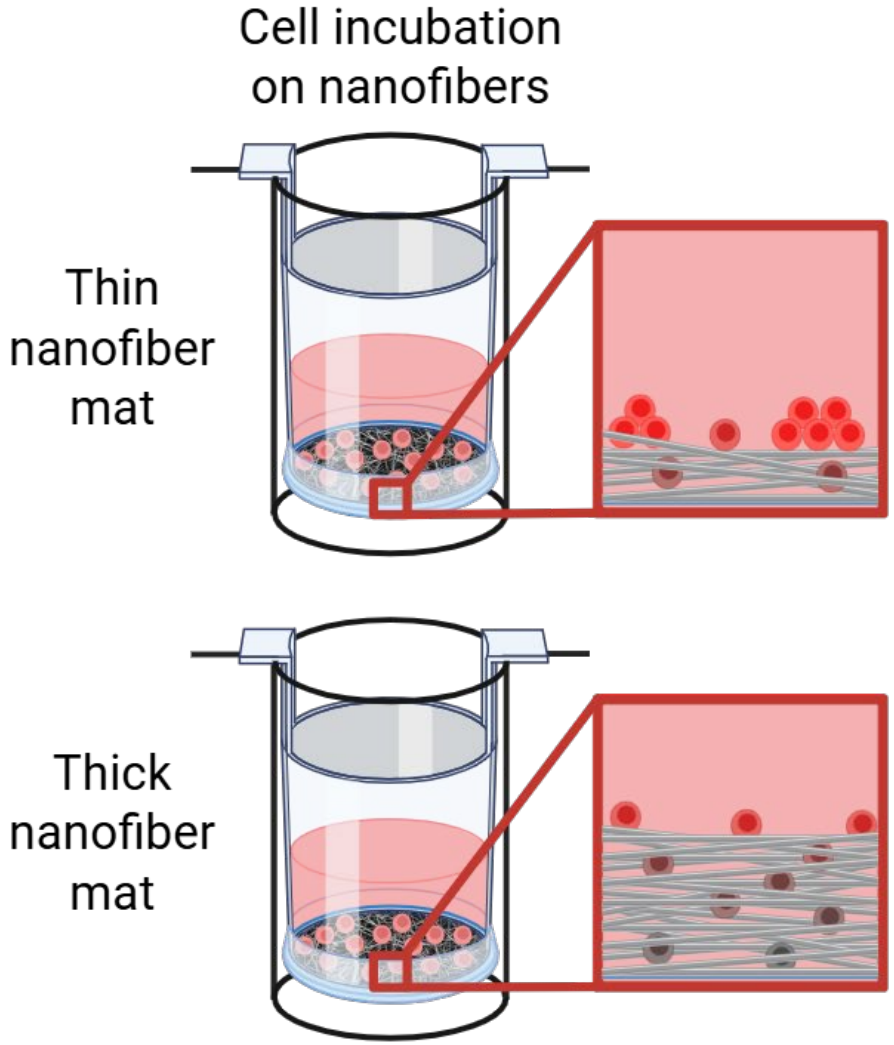


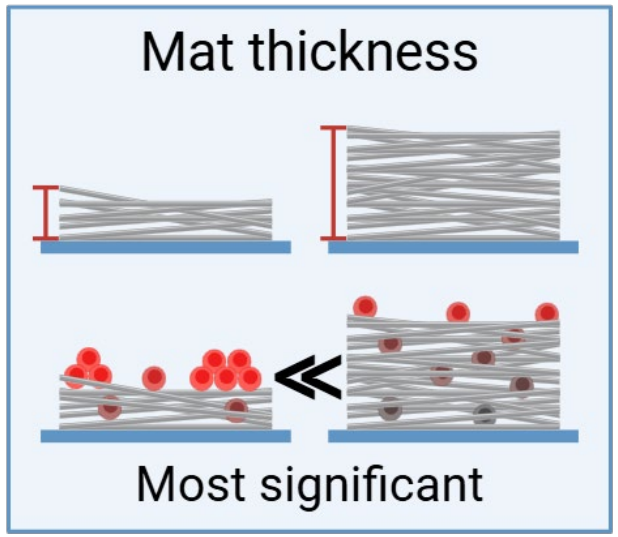


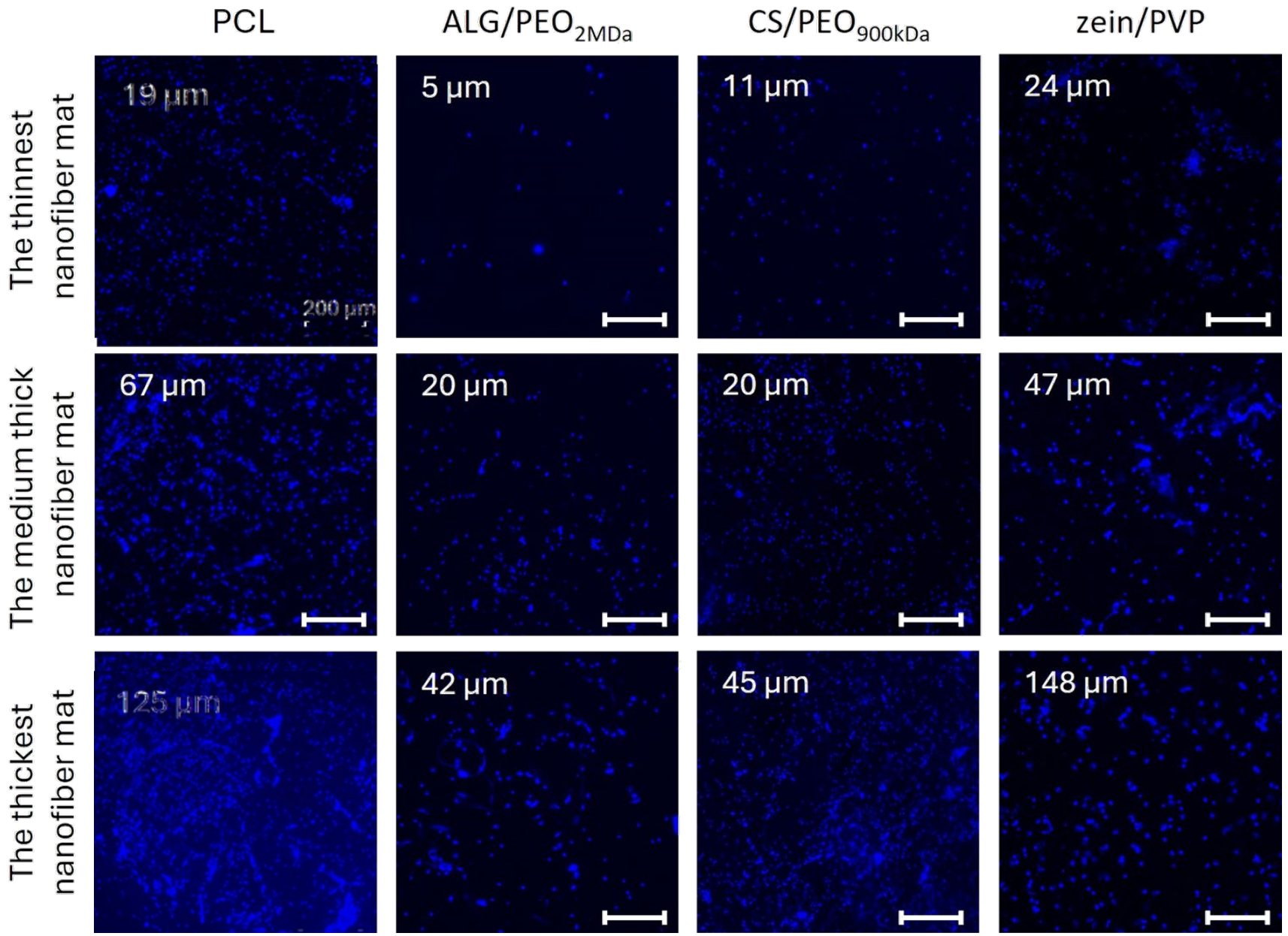
A. Zidar, Š. Zupančič, J. Kristl, M. Jeras, Impact of polycaprolactone, alginate, chitosan and zein nanofiber physical properties on immune cells for safe biomedical applications, IJBM, 282, 3, 2024,137029.

Cell penetration



Cell penetration





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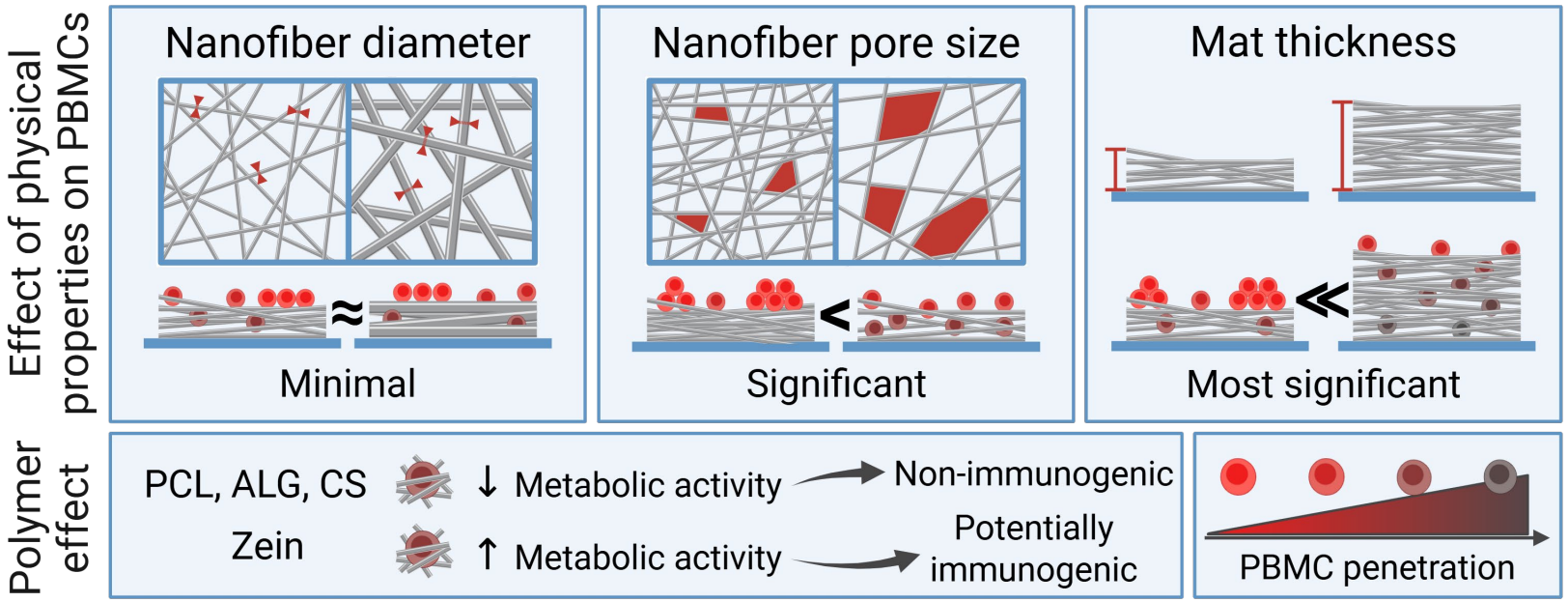
Conclusion



Publication

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Associate professor of Pharmaceutical nanotechnology ...

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