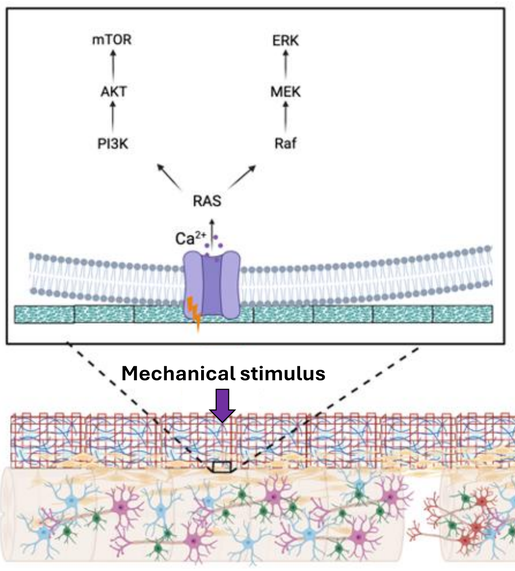
Porous Hybrid Piezoelectric Scaffolds for Neural Regeneration

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Introduction

Piezoelectric stimulation activates regeneration pathways

CNS injuries are often **permanent** and difficult to treat



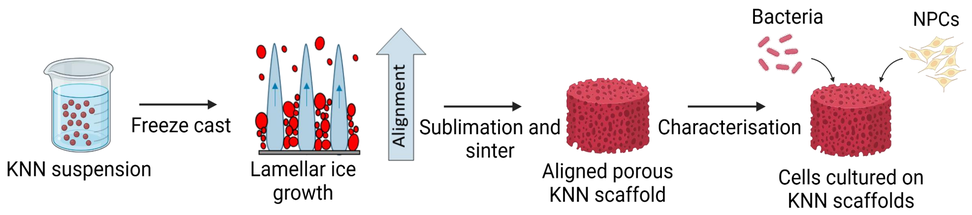
Activation of these pathways
Promotes:
- Cell survival
- Cell growth
- Cell proliferation
- Neuronal differentiation
- Migration of neural progenitors
- Axonal sprouting
- Regeneration

Inhibits:
- Excitotoxicity

KNN is a promising **piezoelectric** material for neural regeneration:
- Biocompatible
- Support NSC differentiation
- Provide topological guidance [1, 2]

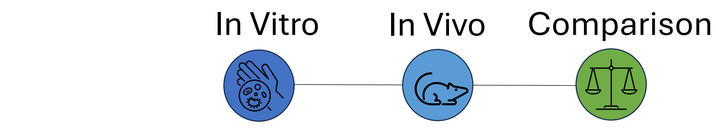
Aim: Develop a hybrid piezoelectric material that supports NSC transplantation and promotes neural regeneration following SCI.

Methods



Analysis

Follow standardised analytical framework for assessing piezoelectric material-driven CNS neural regeneration[2]

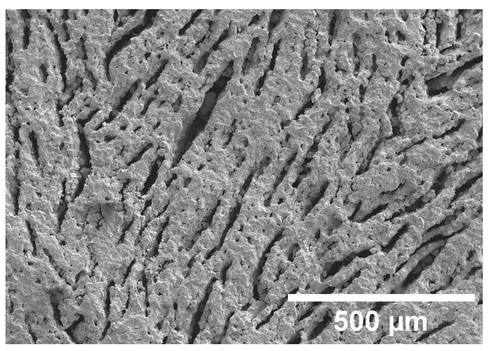


Same methods → Comparable results → Better material selection

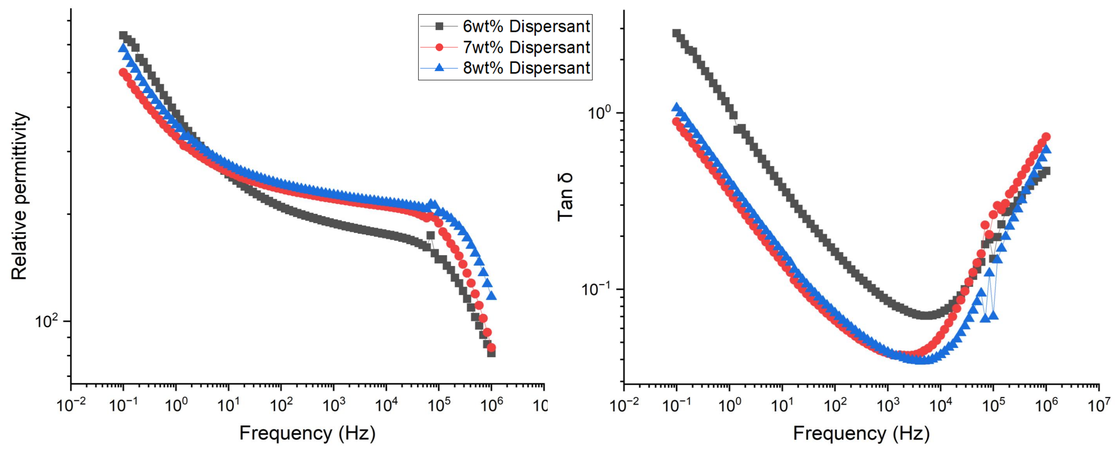
Potassium sodium niobate piezoelectric scaffolds for neural regeneration

Morphology and dielectric characterisation

SEM images of freeze-casted KNN surface prepared with 7wt% dispersant displaying aligned lamellar porosity



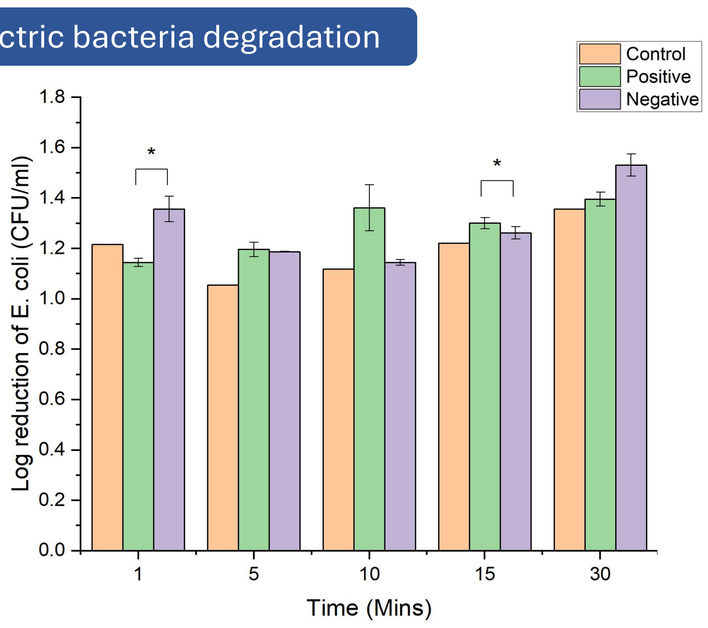
Surface at x100 magnification



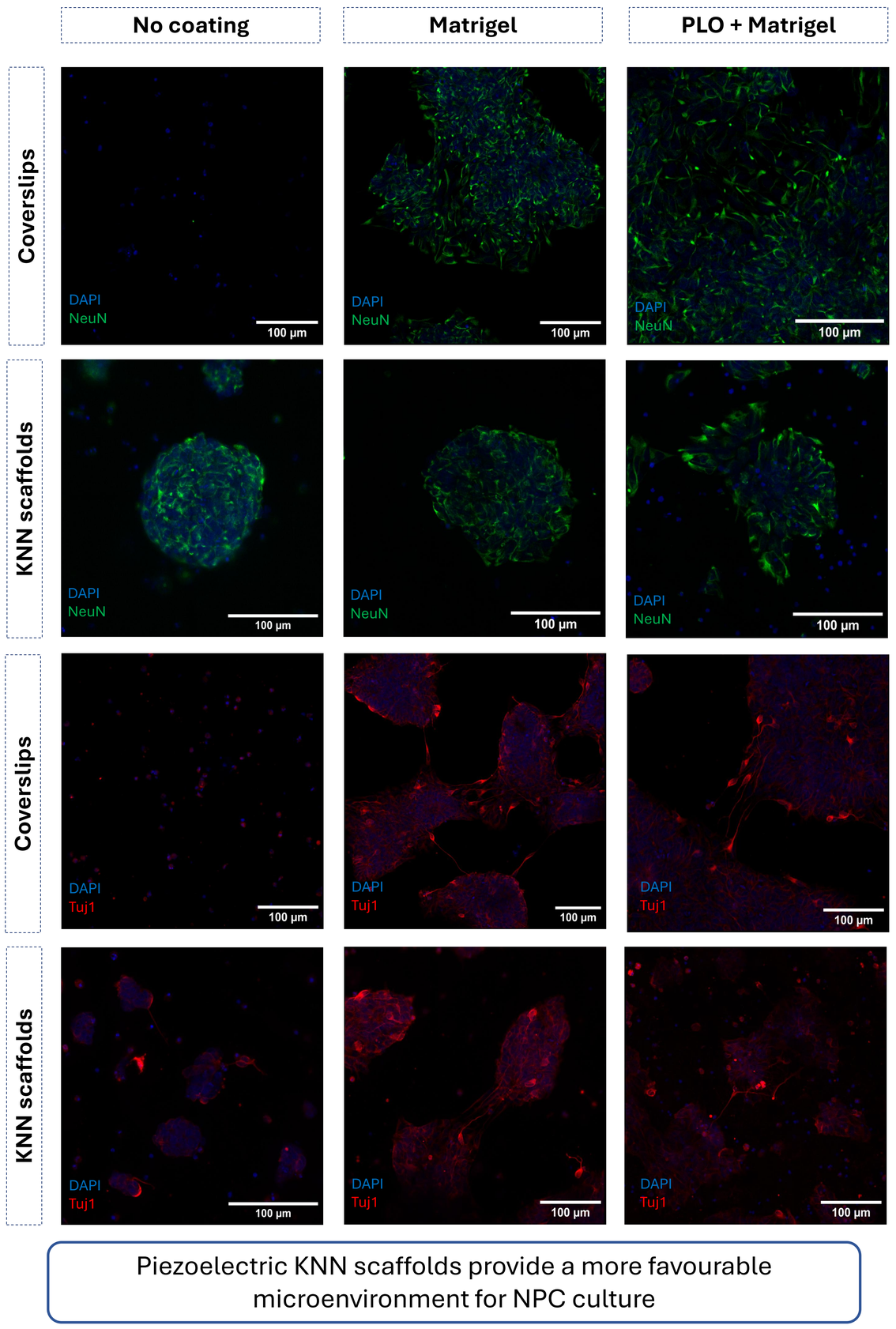
- High solid loadings required ≥6wt% dispersant to form stable slurries
- 7wt%: enhanced processability with strong dielectric performance

Piezoelectric bacteria degradation

Both positive and negative KNN piezoelectric surfaces significantly reduced E. coli viability relative to the control



Cultured NPCs on piezoelectric KNN scaffolds



Piezoelectric KNN scaffolds provide a more favourable microenvironment for NPC culture

Conclusion

Piezoelectric KNN scaffolds support **NPC adhesion** and early **neuronal differentiation** across all coating conditions compared to coverslips, showing KNN provides a more **favourable microenvironment** for NPCs. These findings support the development of self-powered scaffolds for clinical neural repair.

Future Directions

- Fabricate **hybrid** piezoelectric scaffold for neural regeneration
- Determine **optimal piezoelectric coefficients** (d_{33}, g_{33}) for neural repair and antibacterial effects
- NPC culture on **3D-printed KNN** scaffolds

Acknowledgements

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References

[1] Jarkov, V., Califano, D., Tsikriteas, Z.M., Bowen, C.R., Adams, C. and Khanbareh, H., 2025. 3D piezoelectric cellulose composites as advanced multifunctional implants for neural stem cell transplantation. *Cell Reports Physical Science, 6(1), p. 102368.*
[2] Titterton, H.F., Bowen, C.R. and Khanbareh, H., 2026. Piezoelectric Stimulation of Neural Cells: Exploring the Synergistic Potential of Hybrid Scaffolds for Enhanced Regeneration. *Advanced Materials Interfaces, 13(6), p. e00552.*
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