Electronic Supplementary Material (ESI) for Materials Horizons.

Supporting Information

3D Organic Bioelectronics for Electrical Monitoring of Human Adult Stem Cells

Achilleas Savva,[1]* Janire Saez,[1,2,3,4] Aimee Withers,[1] Chiara Barberio,[1] Verena Stoeger,[1] Shani Elias-Kirma,[1] Zixuan Lu,[1] Chrysanthi-Maria Moysidou,[1] Konstantinos Kallitsis,[1] Charalampos Pitsalidis [5,6,1] and Róisín M. Owens.[1]*

[1]*Department of Chemical Engineering and Biotechnology, University of Cambridge, CB3 0AS Cambridge, United Kingdom*

[2]*Microfluidics Cluster UPV/EHU, BIOMICs Microfluidics Group, Lascaray Research Center, University of the Basque Country UPV/EHU, Avenida Miguel de Unamuno, 3, 01006, Vitoria-Gasteiz, Spain*

[3]*Basque Foundation for Science, IKERBASQUE, E-48011 Bilbao, Spain*

[4]*Bioaraba Health Research Institute, Microfluidics Cluster UPV/EHU, Vitoria-Gasteiz, Spain*

[5] *Department of Physics, Khalifa University of Science and Technology, P. O. Box 127788 Abu Dhabi, United Arab Emirates*

[6] *Healthcare Engineering Innovation Center (HEIC), Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates*

email: as3024@cam.ac.uk; rmo37@cam.ac.uk.

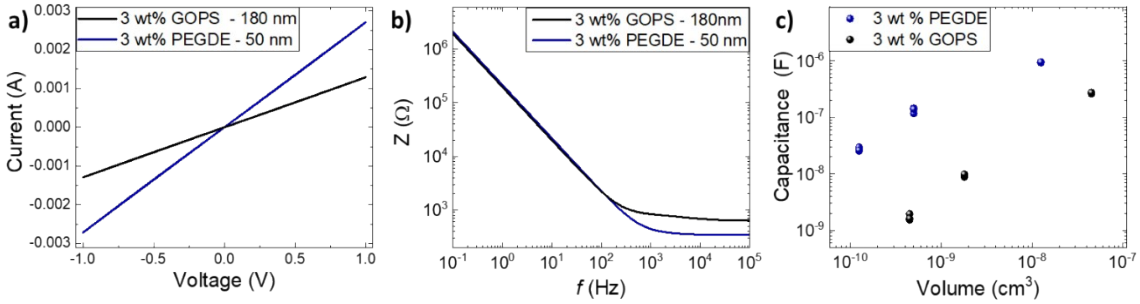


Figure S1: Electrical properties evaluation of PEDOT:PSS films crosslinked with 3 wt% GOPS (black symbols – thickness = 180 nm) and 3 wt % PEGDE (blue symbols thickness = 180 nm). **a)** Current vs voltage characteristics of PEDOT:PSS films cast between two gold electrodes of a fixed distance (100 µm). These data were used to extract the electrical conductivity of the thin films. **b)** Representative electrochemical impedance spectroscopy measurements of PEDOT:PSS films on micro-fabricated gold square electrodes with side = 500 µm. **c)** the capacitance of PEDOT:PSS films extracted from the impedance at low frequency (i.e 0.1 Hz)

for PEDOT:PSS casted on micro-fabricated electrodes with different sizes. All measurements were performed in the aqueous electrolyte PBS 1X.

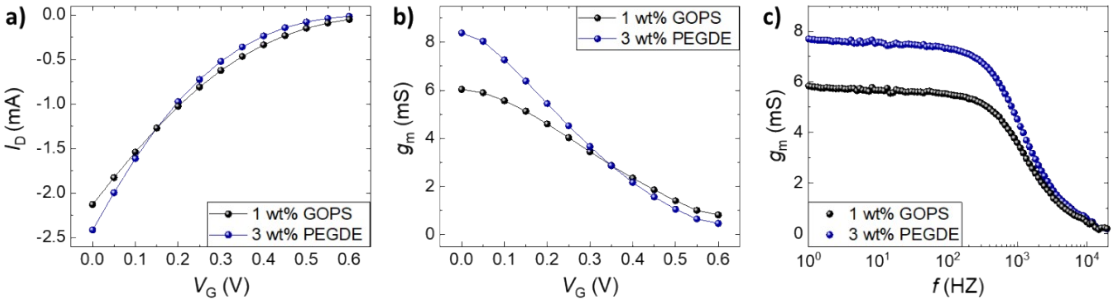


Figure S2: Organic electrochemical transistor characteristics of PEDOT:PSS crosslinked with 3 wt% GOPS (black symbols) and 3 wt % PEGDE (blue symbols). **a)** Transfer curves at V_D = -0.6V, **b)** transconductance (g_m) at V_D = -0.6V as a function of gate voltage (V_G) and **c)** transconductance (g_m) at V_D = -0.6 and V_G = 0 V as a function of frequency. The cut off frequency is calculated at ~850 Hz in both cases.

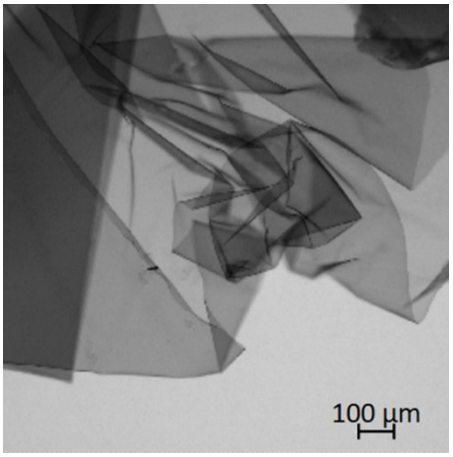


Figure S3: Bright field microscope image of delaminated PEDOT:PSS thin film crosslinked with 3 wt% PEGDE after 5 days immersed in cell media.

Figure S4: PEDOT:PSS-based scaffolds crosslinked with GOPS 3 wt% (right) and PEGDE 3 wt% (left) immersed in PBS for more than 6 months.

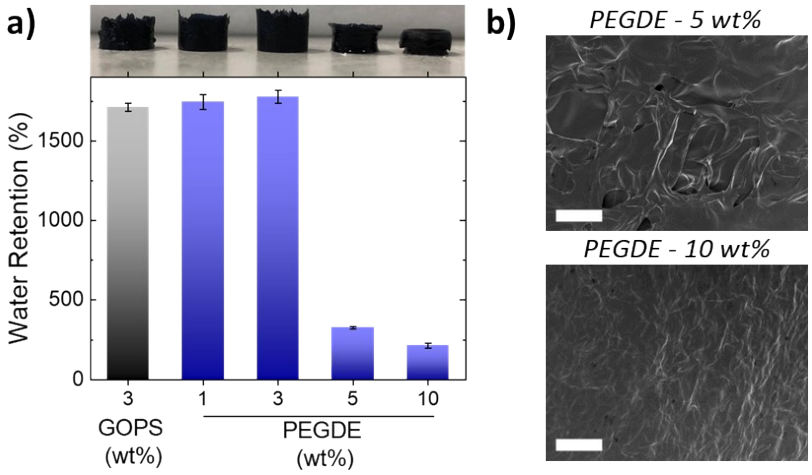


Figure S5: a) Water retention ability of PEDOT:PSS-based scaffolds crosslinked with GOPS 3 wt%, PEGDE 1 - 10 wt%. The digital pictures on top of the graph show the scaffolds for the corresponding concentration of crosslinker after been swollen in DI water (N=6). **b)** Scanning electron microscopy measurements of scaffolds prepared with PEGDE 5 wt% and PEGDE 10 wt%. Scale bars = 40 µm.

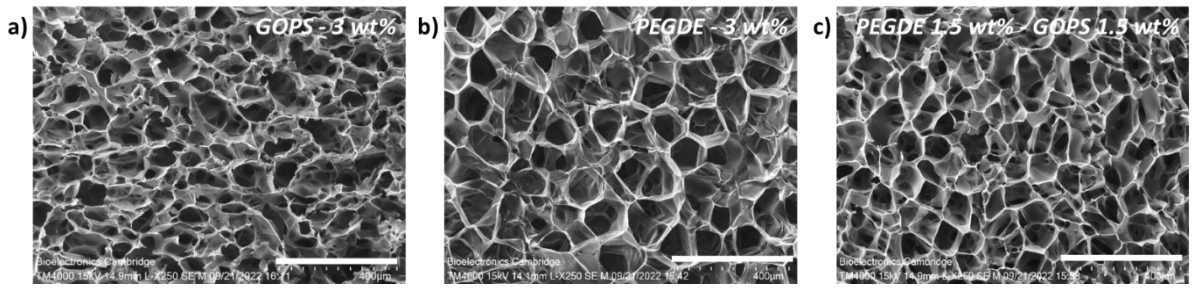


Figure S6: SEM measurements of PEDOT:PSS scaffolds crosslinked with **a)** GOPS 3 wt% , **b)** PEGDE 3 wt%, and **c)** a mixture of GOPS 1.5 wt%:PEGDE 1.5 wt%. Scale bars = 400 µm.

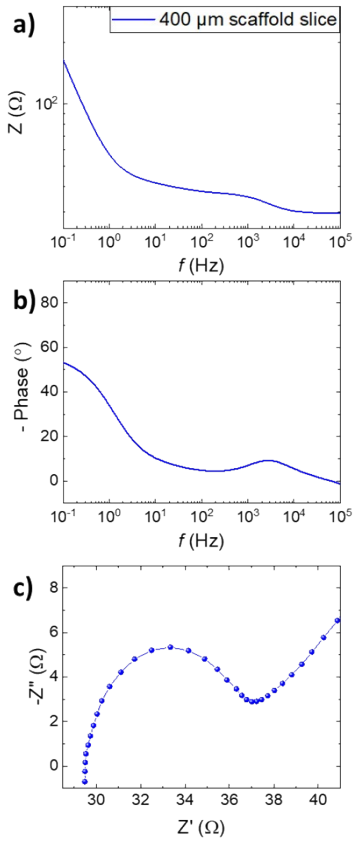
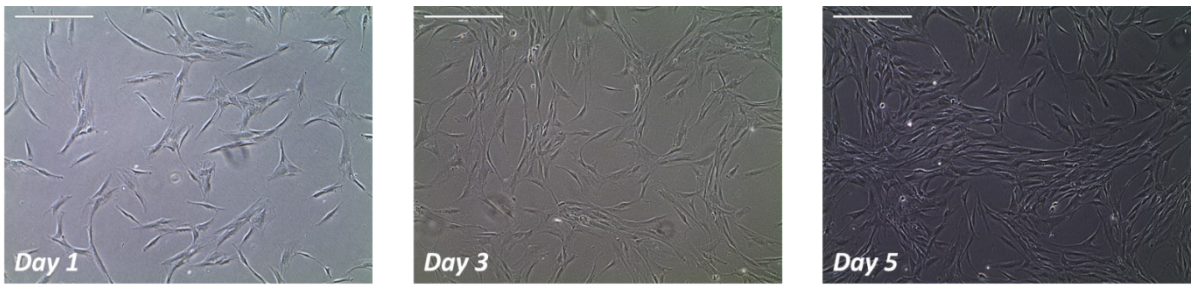


Figure S7: a) Impedance magnitude versus frequency **b)** Impedance phase and **c)** Nyquist plot for 3D devices made with a 400 µm thick scaffold slice.



<u>Figure S8</u>: Brightfield images of human adipose derived stem cell cultures in a flat petri dish. Scale bars = 400 µm.

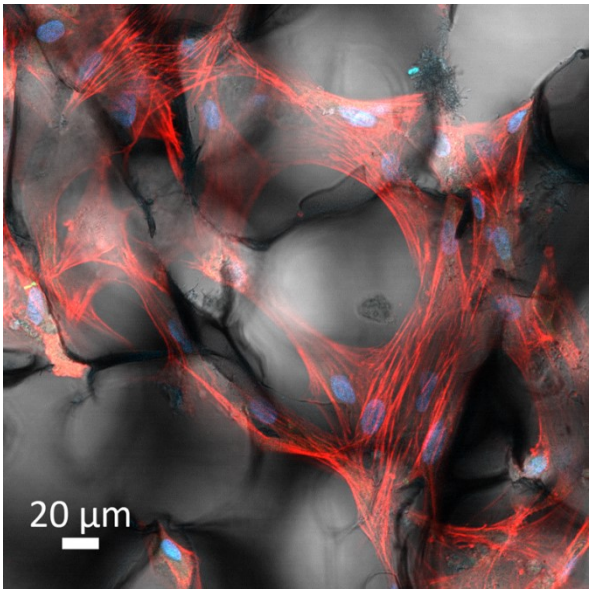


Figure S9: Combined bright field and fluorescent microscope image of hADSCs growing in a PEDOT:PSS-based conducting polymer scaffold.

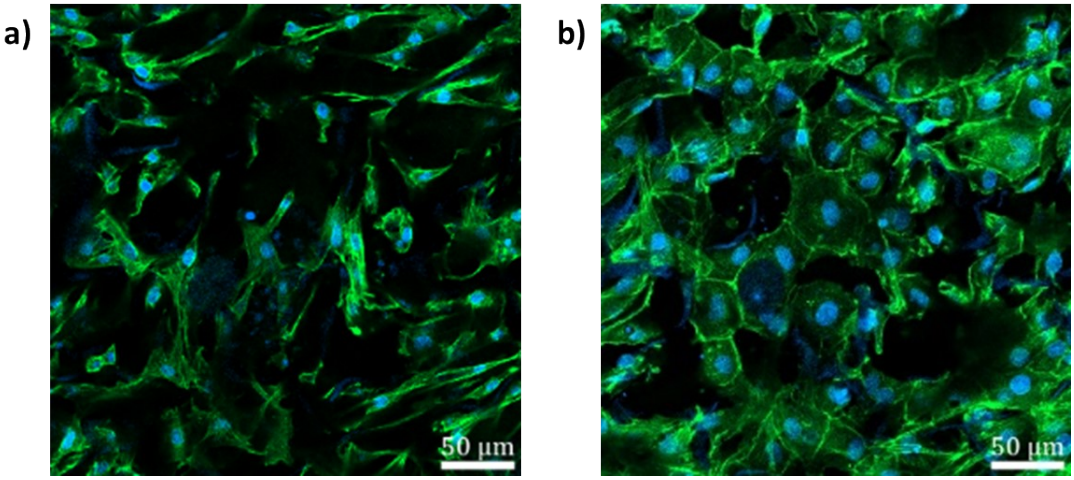


Figure S10: Immunofluorescence images of **a)** 3D Rat Fibroblast (ECACC, 85103116), and **b)** IEC-6, rat small intestine epithelial cells (ECACC, 88071401) cultures grown within 400 µm thick PEDOT:PSS scaffolds slices made with 3 wt% PEGDE. Stained for f-actin (green) and cell nuclei (blue).

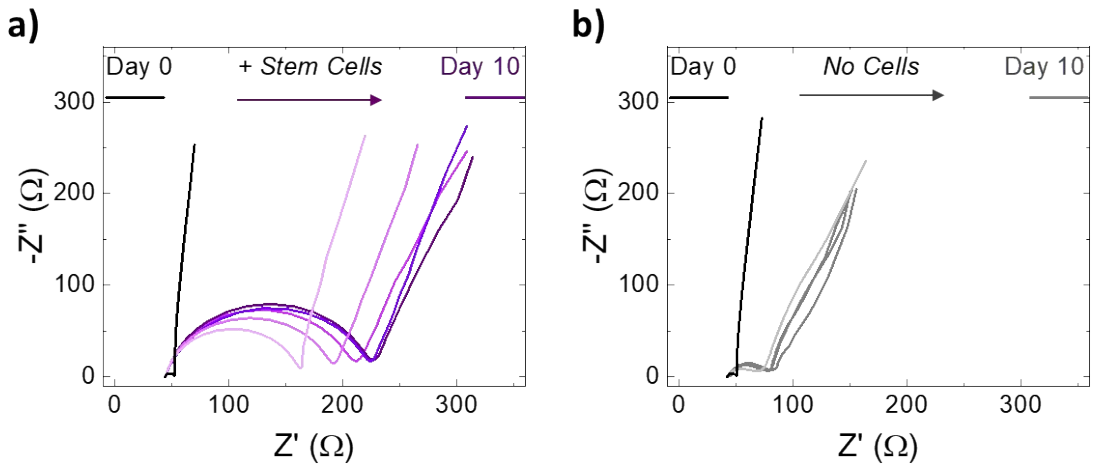


Figure S11: Nyquist plots for **a)** devices seeded with hADSCs and **b)** identically prepared devices not seeded with hADSCs.

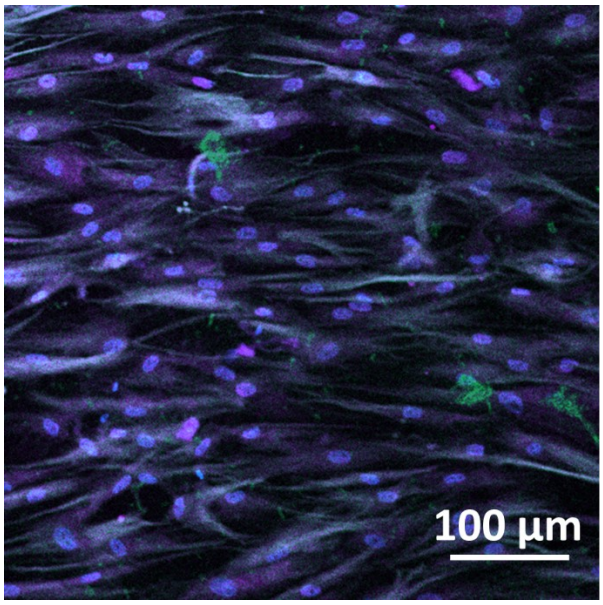


Figure S12: Immunofluorescence staining assay of undifferentiated hADSCs grown on a 2D PEDOT:PSS coated glass cover slip 6 days in culture. Stained for microtubule-associated protein 2 (MAP-2 - green), neuronal nuclear protein (NeuN - purple), and cell nuclei (HOECHST - blue).

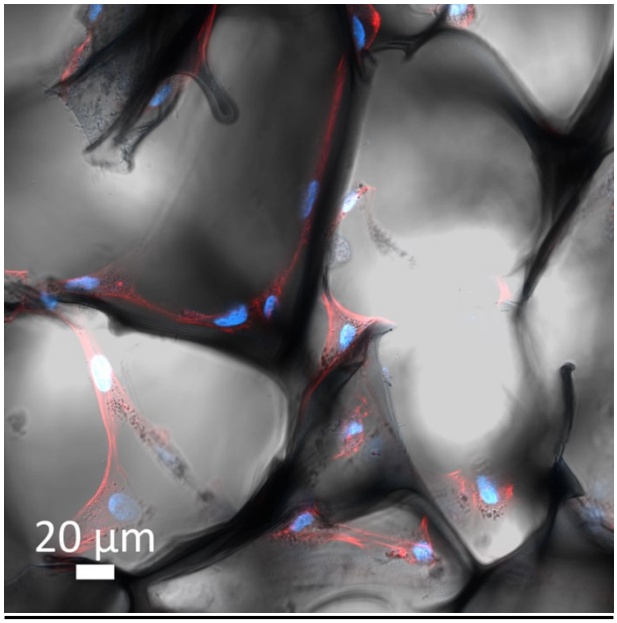


Figure S13: Combined bright field and fluorescent microscope image of neuron-like cells differentiated from hADSCs within a PEDOT:PSS-based conducting polymer scaffold.