## Supplementary information

## Biohybrid plants with electronic roots via *in-vivo* polymerization of conjugated oligomers

Daniela Parker<sup>1</sup>, Yohann Daguerre<sup>2</sup>, Gwennaël Dufil<sup>1</sup>, Daniele Mantione<sup>3</sup>, Eduardo Solano<sup>4</sup>, Eric Cloutet<sup>3</sup>, Georges Hadziioannou<sup>3</sup>, Torgny Näsholm<sup>2</sup>, Magnus Berggren<sup>1,5</sup>, Eleni Pavlopoulou<sup>6</sup>, Eleni Stavrinidou<sup>1,2,5</sup>\*

## **UV-VIS spectroscopy on roots**

16 mg of freeze-dried root material, treated with ETE-S for 72 h and without treatment (control roots) were placed in a mortar with 3 mL of DMSO. The samples were mechanically crushed for 10 min until the root samples were homogenized in DMSO. Treated root extract exhibits a pale rose color while the control root shows no specific coloration after the extraction. The solutions were then left to settle for 6 h and the supernatant was collected for UV-Vis spectroscopy measurements. The spectra were acquired using a Lambda 900 Perkin Elmer Absorption spectrometer with a resolution of 5 nm from 300 to 900 nm. To obtain the ETE-S contribution on the treated root extract we subtracted the spectra of the untreated root extract from the treated root extract. The characteristic peaks of the ETE-S and undoped p(ETE-S) are observed showing that the root contains both polymer and monomer after ETE-S treatment.



**Figure S1:** UV-Vis spectra of p(ETE-S) root homogenized in DMSO (tissue contribution subtracted) in red, in vitro enzymatically polymerized p(ETE-S) dissolved in DMSO in blue, and ETE-S dissolved DMSO in black.



**Figure S2:** Schematic of the experimental set-up for monitoring in-situ the ETE-S polymerization on the root that is still attached on the plant using timelapse microscopy. Created with BioRender.com



**Figure S3:** Selected micrographs of root during ETE-S polymerization at different times converted to greyscale. Red square shows the selected region of interest (ROI) for analyzing the ETE-S polymerization kinetics as shown in Figure 1C, (scalebar 100mm).



**Figure S4:** Temporal evolution of p(ETE-S) amount on the root with an overall sigmoidal trend, and a linear trend from 100 to 250 min. Linear fit has a  $R^2 = 0.9898$ . For the Sigmoidal fit: A1= -0.072±0.021, A2= 0.899±0.0120, x0=152.345±2.977, dx=65.199± 3.329 with  $R^2 = 0.9977$ .



**Figure S5:** a) Transversal cross section of p(ETE-S) root. Transversal cross sections of wounded roots with p(ETE-S) on ground and vascular tissue b) on the cortex, c) on the pericycle, d) on the cortex and xylem. (Scalebar 100µm)



Figure S6: Root functionalized with 2 mg ml<sup>-1</sup> of ETE-S for 3 days. A) Schematic of root anatomy indicating the various tissues and developmental zones (created with BioRender.com). p(ETE-S) fixed root micrographs for B) plane view (scalebar 500µm) C) longitudinal cross section, (scalebar 100µm) and D) transversal cross (scalebar 100µm). In B-D first column corresponds to meristematic/elongation zone while second and third column to the maturation zone of the root.



**Figure S7:** Longitudinal cross sections of functionalized bean root for 3 days in 2mg ml<sup>-1</sup> ETE-S fixed with PFA. The micrographs show that the root hairs are coated with P(ETE-S).



**Figure S8:** A) IV curve of untreated bean root with 20mm interelectrode distance (red) compared with the electrolytic contribution measured with and carbon fiber probes (black). B) IV curves of p(ETE-S) roots treated with 1 and 2mg/ml ETE-S.



**Figure S9:** A) Plane view and B) cross section of a Pea plant (Pisum sativum) root functionalized with 1mg ml<sup>-1</sup> ETE-S solution. ETE-S polymerized on the root forming a polymer coating on the root epidermis. For the functionalization the same methodology was used as for bean plant roots (see methods section). Scale bar 100 $\mu$ m.

Current (µA)	Capacitance (mF)	ESR (KΩ)
5	8.07	1.8
10	6.54	1.75
20	5.34	1.89
30	4.89	1.8
40	4.36	1.5
50	3.95	1.3

**Table S1:** Capacitance and ESR values calculated form galvanostatic charge/discharge measurements on root supercapacitor.