nature portfolio

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Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our Editorial Policies and the Editorial Policy Checklist.

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed	
☐	☒	The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒	A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☒	☐	The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☒	☐	A description of all covariates tested
☒	☐	A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒	A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☒	☐	For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	EIS, OCP and CV with commercial software EC-Lab version V11.60 OECT characterizations with LabView code Version 2022 Q3 22.3.5f9 e-QCM-D with commercial software QSoft401 Version 2.8.6.953
Data analysis	EIS data fitting with commercial software EC-Lab version V11.60 All the remaining data analysis with OriginPro 2022b

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

All data generated in this study are provided within the main text and in the Supplementary Information. Source data are provided in this paper as an additional supplementary file.

Research involving human participants, their data, or biological material

Policy information about studies with human participants or human data. See also policy information about sex, gender (identity/presentation), and sexual orientation and race, ethnicity and racism.

Reporting on sex and gender	N/A
Reporting on race, ethnicity, or other socially relevant groupings	N/A
Population characteristics	N/A
Recruitment	N/A
Ethics oversight	N/A

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☒ Life sciences ☐ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Life sciences study design

All studies must disclose on these points even when the disclosure is negative.

Sample size	No sample size calculation was performed. A sample size of 37 was used to characterize the reproducibility of the OECT channels. This number was obtained from four independent OECT arrays, each containing 16 channels, corresponding to a total of 64 fabricated OECT channels. The 64 channels were visually inspected by optical microscopy to assess the quality of the semiconductor deposition. Channels exhibiting visually suboptimal coating were excluded, resulting in a final sample size of 37. For the remaining characterizations, a sample size of n = 3 was selected because larger sample sizes were not considered necessary for the purpose of this study. Specifically, we employed model electrodes with stable and readily tunable electrochemical properties. The electrochemical potential correlated linearly with the logarithm of ion concentration, as described by the Nernst equation and Supplementary Figure 2, while the capacitance correlated linearly with the electrode area as show in Figure 4a. These properties were also measured in parallel throughout each experiment to ensure maximum accuracy. In addition, the device was operated within a highly stable voltage window to minimize parasitic degradation and, consequently, experimental variability. For these reasons, a sample size of n = 3 was considered sufficient for this study.
Data exclusions	Data shown in Fig. 8c-iii and Fig. 8c-iv were obtained from the analysis of 64 independent OECT channels. Channels exhibiting suboptimal spin coating, as determined by visual inspection of optical micrographs, were excluded, resulting in a final dataset of 37 instrumentally analyzed channels. No other data/samples were excluded.
Replication	Measurements were repeated at least three times, as indicated in each figure caption reporting standard deviation values and specified in the Methods section.
Randomization	No randomization was required for the experiments performed, as these studies were designed as proof-of-concept demonstrations.
Blinding	No blinding was performed, as it was not required for the type of experiments conducted in this work.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☐	☒ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☒	☐ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Antibodies

Antibodies used: Nanobody–SpyCatcher fusion proteins were designed based on available structures (Ty1 nanobody:6ZXN; SpyCatcher:PDB 4MLI; https://doi.org/10.1038/s41467-020-18174-5)
The SpyCatcher/Ty1-nanobody was produced in our lab and used for the electrode functionalization at a concentration 20E-6 M.

Validation: Validation data are provided in our previous study (https://doi.org/10.1038/s41551-021-00734-9) in the Supplementary Information (SPR characterization).

Plants

Seed stocks: N/A

Novel plant genotypes: N/A

Authentication: N/A