

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

The sizes and morphologies of nanoparticles were observed using an HT-7700 transmission electron microscope (Hitachi, Japan) with an accelerating voltage of 120 kV. Elemental compositional mapping was performed using energy-dispersive X-ray spectroscopy (EDS) in high angle annular dark field scanning transmission electron microscopy (HAADF-STEM) mode. The hydrodynamic size and zeta potential were measured with a Zetasizer Nano ZS90 (Malvern, UK). Changes in elemental valence states were assessed using ESCALAB 250Xi X-ray photoelectron spectroscopy (XPS, Thermo Fisher, UK). Powder X-ray diffraction (XRD) was conducted using a D8 Advance (Bruker, Germany). Confocal images were obtained from an 880 confocal laser scanning microscope (Carl Zeiss, Germany). Chlorophyll fluorescence yield (FV/FM) was measured using an imaging pulse amplitude-modulated fluorimeter (IMAG-MAXI; Heinz Walz, Effeltrich, Germany). Absorption spectra were acquired using a UV-3600Plus UV-vis-NIR spectrometer (Shimadzu, Japan). Fluorescence spectra were measured with an FLS1000 fluorescence spectrometer (Edinburgh, UK). Visible and NIR-I fluorescence imaging was performed using an IVIS Spectrum platform (Perkin Elmer, USA). NIR-II imaging was conducted with a custom imaging system equipped with a 640 × 512-pixel 2D InGaAs NIRvana-LN CCD camera (Princeton Instruments, USA). Plants were cultivated under controlled conditions in an RLD-350C-4 artificial climate chamber (Ningbo Ledian Company, China).

Data analysis

Fluorescence images were acquired using LightField imaging software and quantitatively analyzed with Image J software. Data analysis was conducted using OriginPro 2018 and GraphPad Prism 9.5. All training models were constructed using Python (v.3.9).

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](#)

The data supporting the findings of this study are available within the article and its supplementary files. Any additional requests for information can be directed to and will be fulfilled by, the corresponding authors. Source data are provided in this paper.

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	NA
Reporting on race, ethnicity, or other socially relevant groupings	NA
Population characteristics	NA
Recruitment	NA
Ethics oversight	NA

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](https://www.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	For the in vivo plant evaluation of the nanosensors, we selected at least three independent plant samples in each set of experiments. They have been explicitly indicated in the respective table and figure legend.
Data exclusions	No data were excluded from the analysis.
Replication	Experiments were repeated in at least three independent experiments with similar results. All experiments were reproduced to reliably support the conclusions stated in the manuscript.
Randomization	All plant samples were randomly selected from healthy plants in the same growth conditions. For different batches of plants, the plants are measured at the similar growth stage/age.
Blinding	The investigators were blinded to group allocation during data collection and analysis.

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	Involvement 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	Involvement in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Dual use research of concern

Policy information about [dual use research of concern](#)

Hazards

Could the accidental, deliberate or reckless misuse of agents or technologies generated in the work, or the application of information presented in the manuscript, pose a threat to:

No	Yes
☒	☐ Public health
☒	☐ National security
☒	☐ Crops and/or livestock
☒	☐ Ecosystems
☒	☐ Any other significant area

Experiments of concern

Does the work involve any of these experiments of concern:

No	Yes
☒	☐ Demonstrate how to render a vaccine ineffective
☒	☐ Confer resistance to therapeutically useful antibiotics or antiviral agents
☒	☐ Enhance the virulence of a pathogen or render a nonpathogen virulent
☒	☐ Increase transmissibility of a pathogen
☒	☐ Alter the host range of a pathogen
☒	☐ Enable evasion of diagnostic/detection modalities
☒	☐ Enable the weaponization of a biological agent or toxin
☒	☐ Any other potentially harmful combination of experiments and agents

Plants

Seed stocks	Arabidopsis thaliana seeds ecotype Columbia (Col-0) and rbohD (CS95555) were obtained from the Arabidopsis Biological Resource Center at The Ohio State University (Columbus, OH). Lettuce seedlings were purchased from Danong Agricultural Technology Company (Suzhou, China). Spinach seeds and pepper seeds were purchased from Hezhiyuan Seed Industry Company (Hunan, China).
Novel plant genotypes	NA Tobacco seeds (K326) were obtained from Yuxi Tobacco Company (Yunnan, China)
Authentication	NA