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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	Optical images were performed on a Leica DMi8 manual inverted fluorescence microscope at 40× magnifications. Image J software was employed to measure the diameters of the coacervates. Confocal fluorescence images were performed on a Leica SP8 Laser scanning confocal microscope. Scanning electron microscopy (SEM) image of dried samples was obtained with a SU8000 instrument. 1H NMR spectra of monomer/polymer solutions were measured on a Bruker Avance-400 MHz NMR spectrometer using D2O as the solvent and DMF as the reference. The test result was analyzed using MestReNova. UV-vis spectrum measurements were measured on a PerkinElmer spectrophotometer (Lambda 750S, USA). Zeta potential measurements were performed using Malvern Zetasizer Nano-ZSP at 25°C. Agarose gel electrophoresis was conducted at 100V using TAE buffer as running buffer. The samples were loaded by mixing 4 μL of sample, 1 μL of 6× loading buffer, with 1 μL of SYBR Green I. Drop adhesion force (DAF)/contact angle (θ) were performed on an Optical Surface Analyzer (OSA 100S-M, NBSI). Density functional theory (DFT) calculations were performed by Gaussian 09 software with DFT-D3 (BJ) corrected B3LYP functional (B3LYP-D3 (BJ)). Geometry optimizations were carried out at B3LYP-D3 (BJ)/6-311G (d, p) level coupled with IEFPCM solvent model (water).
Data analysis	The fluorescent intensity profile was carried out using Image J. Data process was conducted using Origin 2021.

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 other experimental data supporting the findings of the study are available within the manuscript and its Supplementary Information. Source Data file has been provided.

Human research participants

Policy information about studies involving human research participants and Sex and Gender in Research.

Reporting on sex and gender	Not applicable in this study.
Population characteristics	Not applicable in this study.
Recruitment	Not applicable in this study.
Ethics oversight	Not applicable in this study.

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	Image J is performed to measure the diameter of coacervates.
Data exclusions	No data are excluded from the analysis.
Replication	Each experiment was carried out more than three independent replications.
Randomization	The coacervate droplets are freshly prepared for use. The coacervate droplets are randomly grouped for experiments.
Blinding	Blinding is not involved in this study.

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

Methods

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