

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 (<i>n</i>) 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 <i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i>
☒	☐ 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. <i>F</i> , <i>t</i> , <i>r</i>) with confidence intervals, effect sizes, degrees of freedom and <i>P</i> value noted <i>Give P values as exact values whenever suitable.</i>
☒	☐ 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 <i>d</i> , Pearson's <i>r</i>), 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	Lumicks BlueLake (v1.6.11) was used for pMOT experiments. Micro-manager 2.0.0 was used for VPT data acquisition. FTIR spectra were collected using a Nicolet iS20 from ThermoScientific. TEM images were collected using a Leica EM ACE900 Freeze Fracture System.
Data analysis	Fiji-ImageJ (v1.53c), Adobe Illustrator CC (2019, v23.0). Python (v3.5) was used for data analysis. All custom-made python scripts are available in GitHub (https://github.com/BanerjeeLab-repertoire/Material-properties). All simulation results and the code for the computation of moduli are available via the Pappu Lab Github (see https://github.com/Pappulab/material-properties). LaSSI (https://github.com/Pappulab/LASSI) was used for the MC simulations, MATLAB (r2018a) was used for analysis of the simulations. Both LaSSI and the analysis tools are available through the Pappu lab repository (https://github.com/Pappulab). FTIR spectra were processed and analyzed using OriginPro 2023.

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 are available in the manuscript or the supplementary materials. All expression plasmids are available from T.M. under a material transfer agreement with St. Jude Children's Hospital or from Addgene.

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	Sample sizes are chosen based upon previously optimized experimental conditions developed by the Banerjee Lab, the Pappu Lab, and the Mittag lab, and cited in the text in appropriate sections. This was based on acquisition of statistically meaningful experimental dataset. For pMOT, the sample size of 20 condensates was chosen. VPT measurements was performed for at least 3 condensates containing more than 20 diffusing particles. All simulations were done in triplicates. All saturation concentration measurements were performed at least 3 times.
Data exclusions	No data were excluded from the current study.
Replication	All measurements were collected across different sample preparations by multiple individuals and different protein purification batches. The replication was successful. All simulations were done at least in triplicates.
Randomization	Randomization was not used in this study. Each system is homogeneous and studied individually therefore randomization is irrelevant.
Blinding	Blinding was not used in this study as it does not apply. This is because there is no information that can influence the outcome of the experiment and simulations.

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 |