Supplementary Information

Langmuir Films of Layered Nanomaterials: Edge Interactions and Cell Culture Applications

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Figure S1: Liquid cascade centrifugation diagram

As discussed in the Experimental Section, liquid cascade centrifugation is a useful technique to obtain fractions of an original dispersion with different nanomaterial sizes. Figure S1 illustrates the process of extraction and re-centrifugation of the supernatant fluid after each centrifugation step.

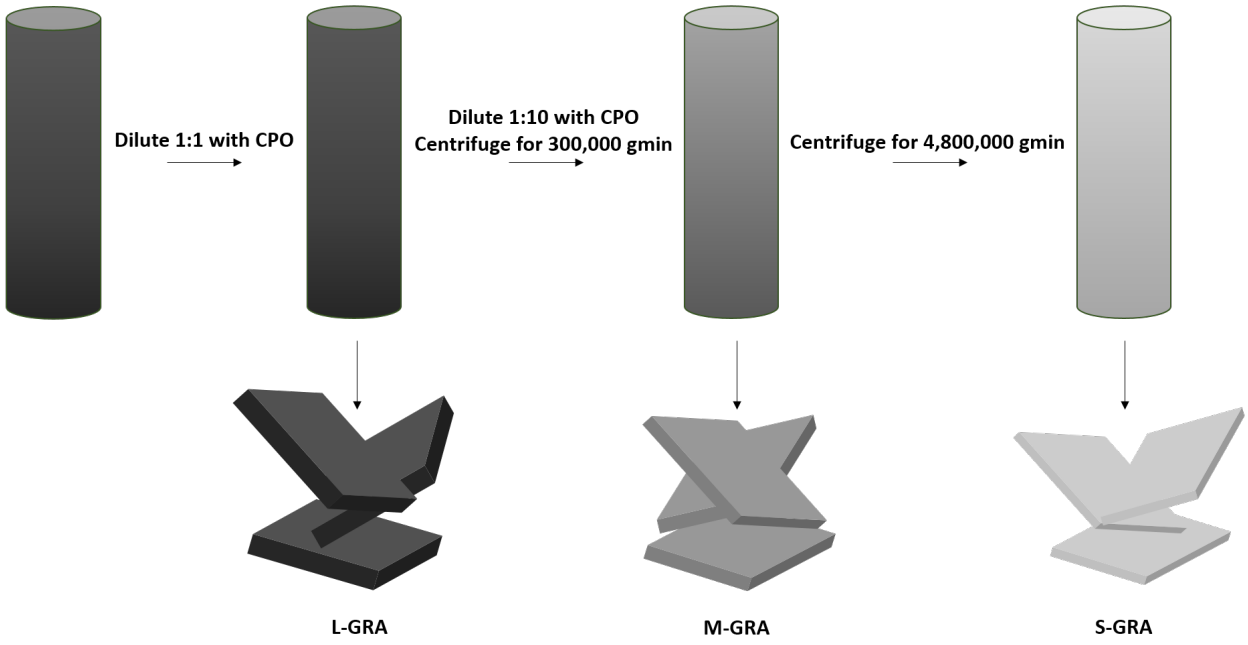

Figure S1: Diagram illustrating the liquid cascade centrifugation process, beginning with a graphene dispersion in cyclohexanone. This is described in more detail in the Experimental Section of the paper.

Figure S2: Example optical micrograph and threshold

As described in the Results and Discussion section, a simple, two-step post-processing method was used to determine the film surface coverage from the optical micrographs. Figure S2a shows a small section of a typical optical micrograph; Figure S2b shows the corresponding image once the threshold has been applied.

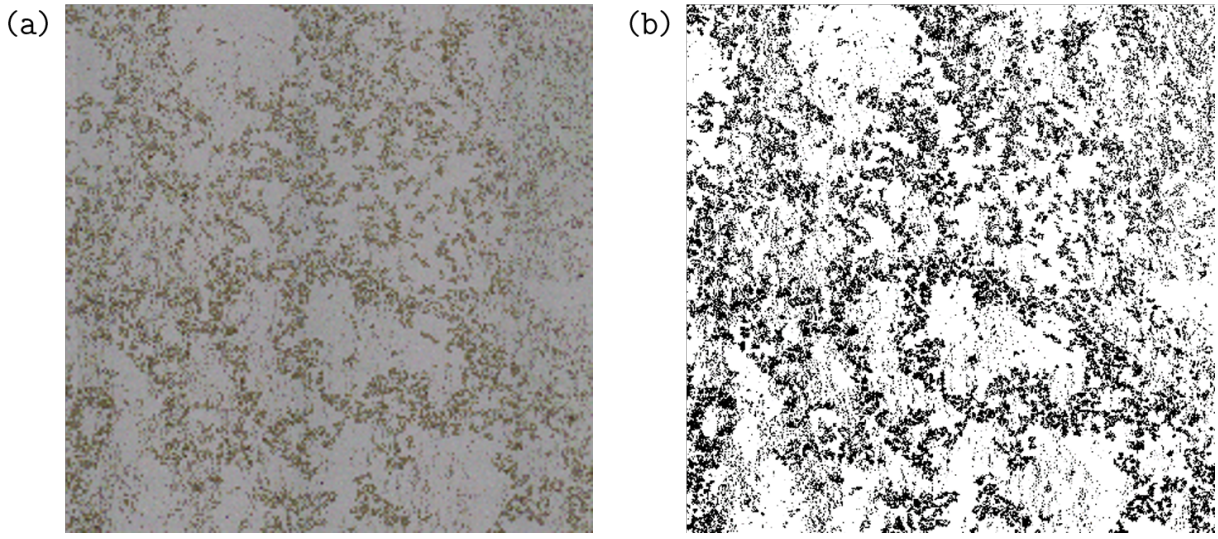

Figure S2: (a) Optical micrograph. (b) Optical micrograph after running binary threshold.

Figure S3: AFM images and statistics histograms

Below are included histograms of length, width, LW (length $\times$ width), and N (number of layers) obtained from AFM statistics for each material. Insets show example AFM image of a nanosheet; Figure S3f shows enlarged versions of these AFM images.

Figure S3a: L-gra histograms

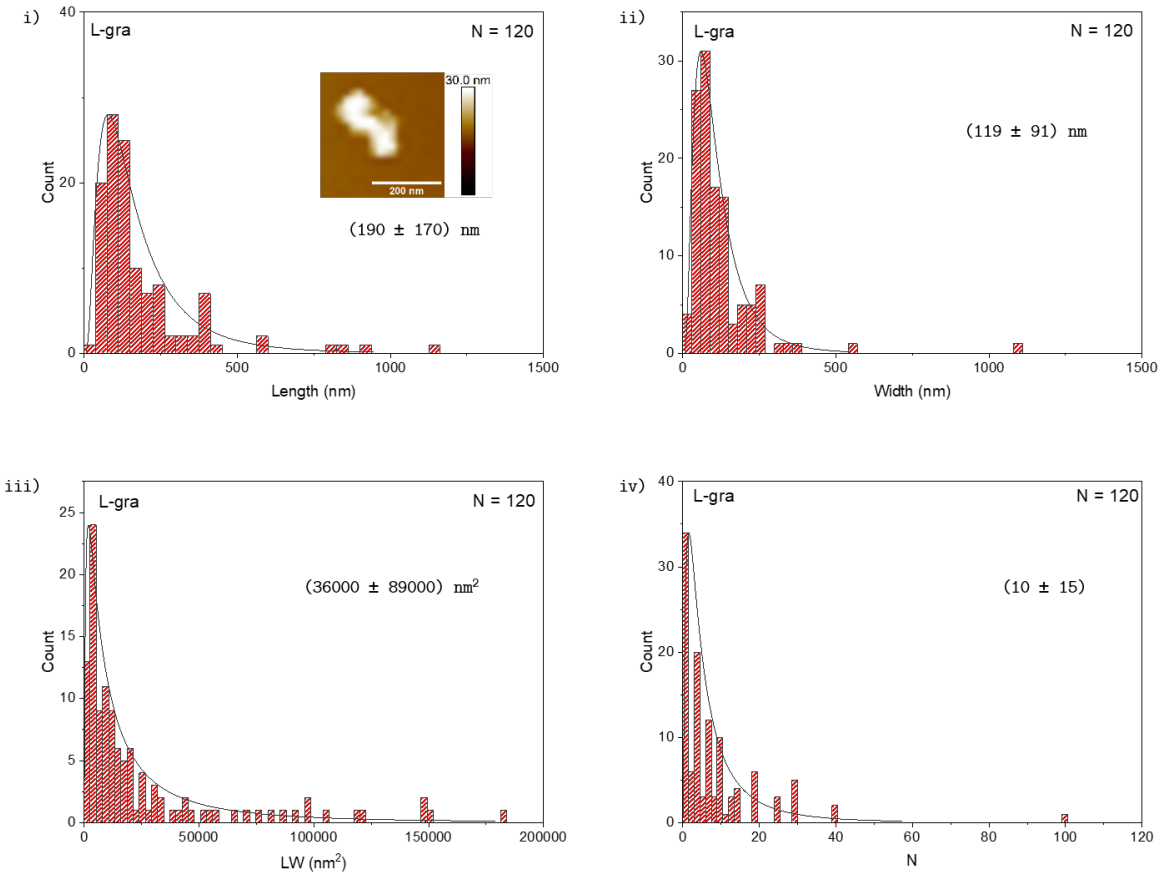

Figure S3a: Histograms of L-gra (i) length; (ii) width; (iii) LW; (iv) N.

Figure S3b: S-gra histograms

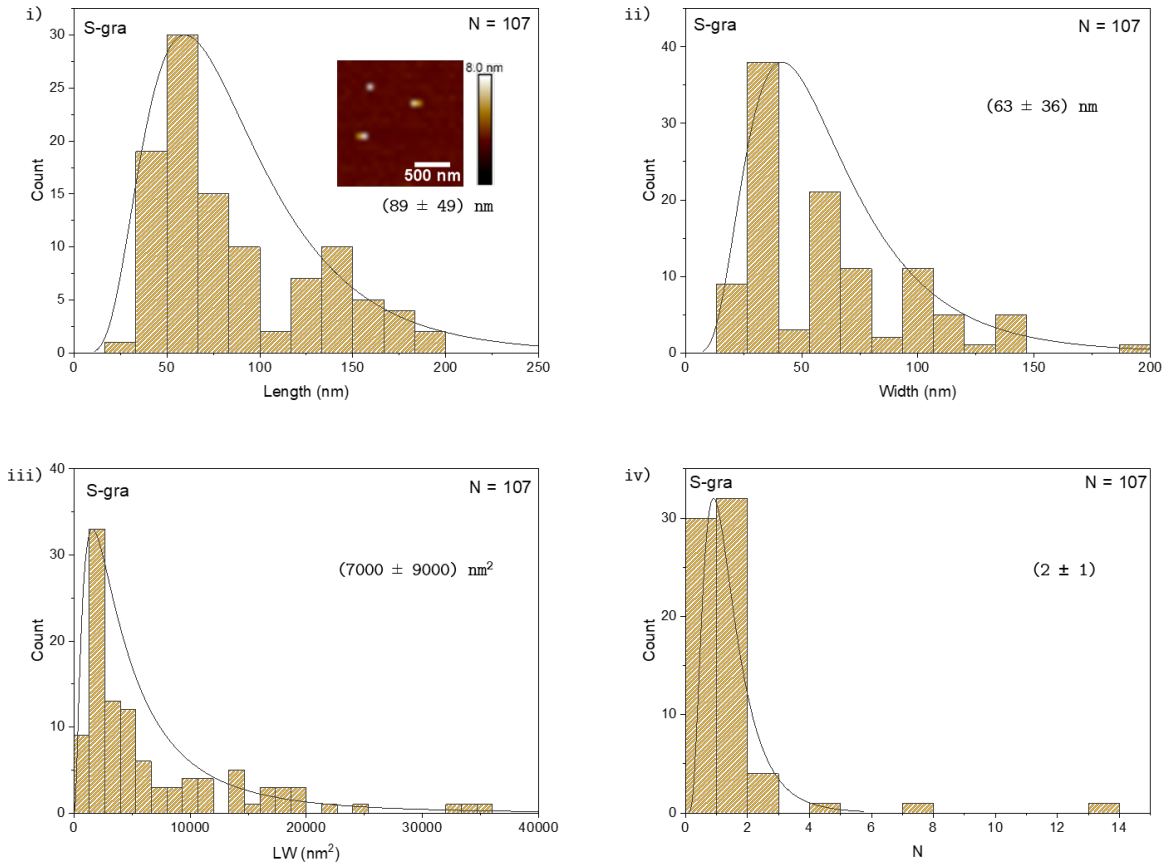

Figure S3b: Histograms of S-gra (i) length; (ii) width; (iii) LW; (iv) N.

Figure S3c: BN histograms

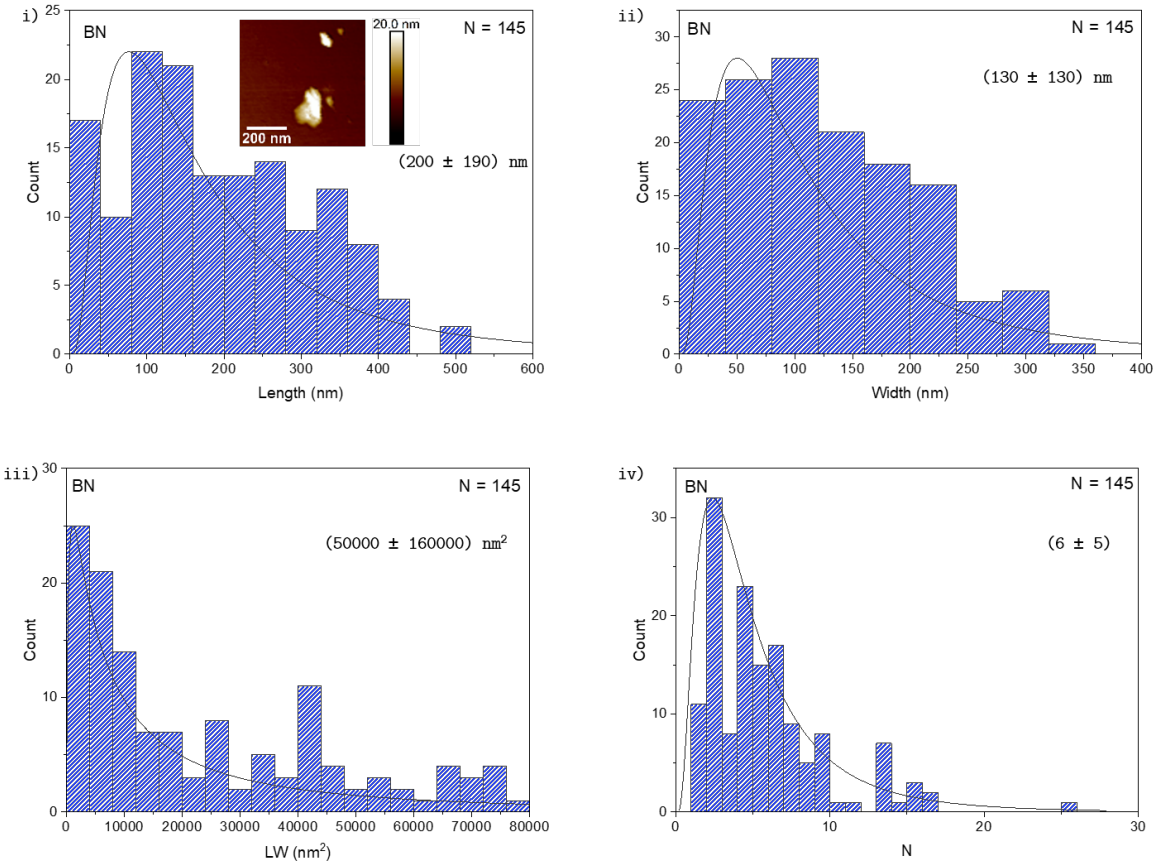

Figure S3c: Histograms of BN (i) length; (ii) width; (iii) LW; (iv) N.

Figure S3d: MoS_2 histograms

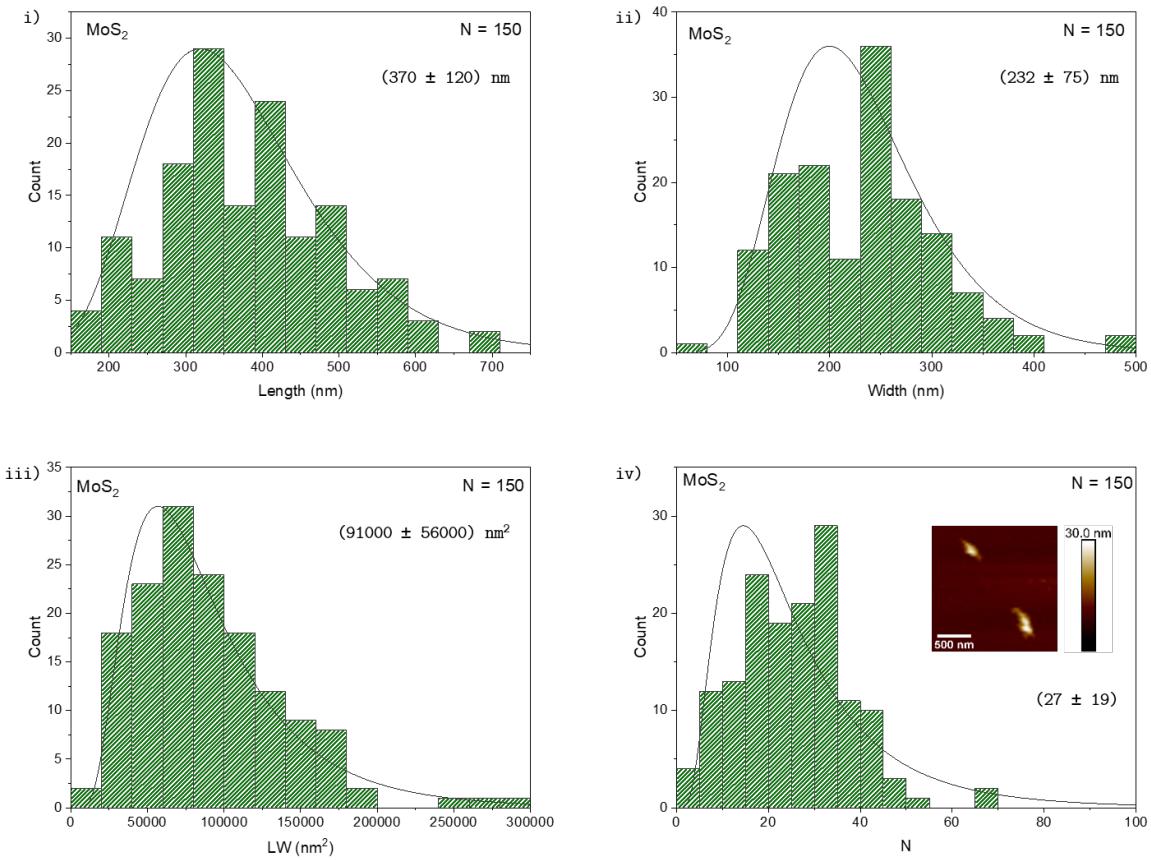

Figure S3d: Histograms of MoS_2 (i) length; (ii) width; (iii) LW; (iv) N.

Figure S3e: WS_2 histograms

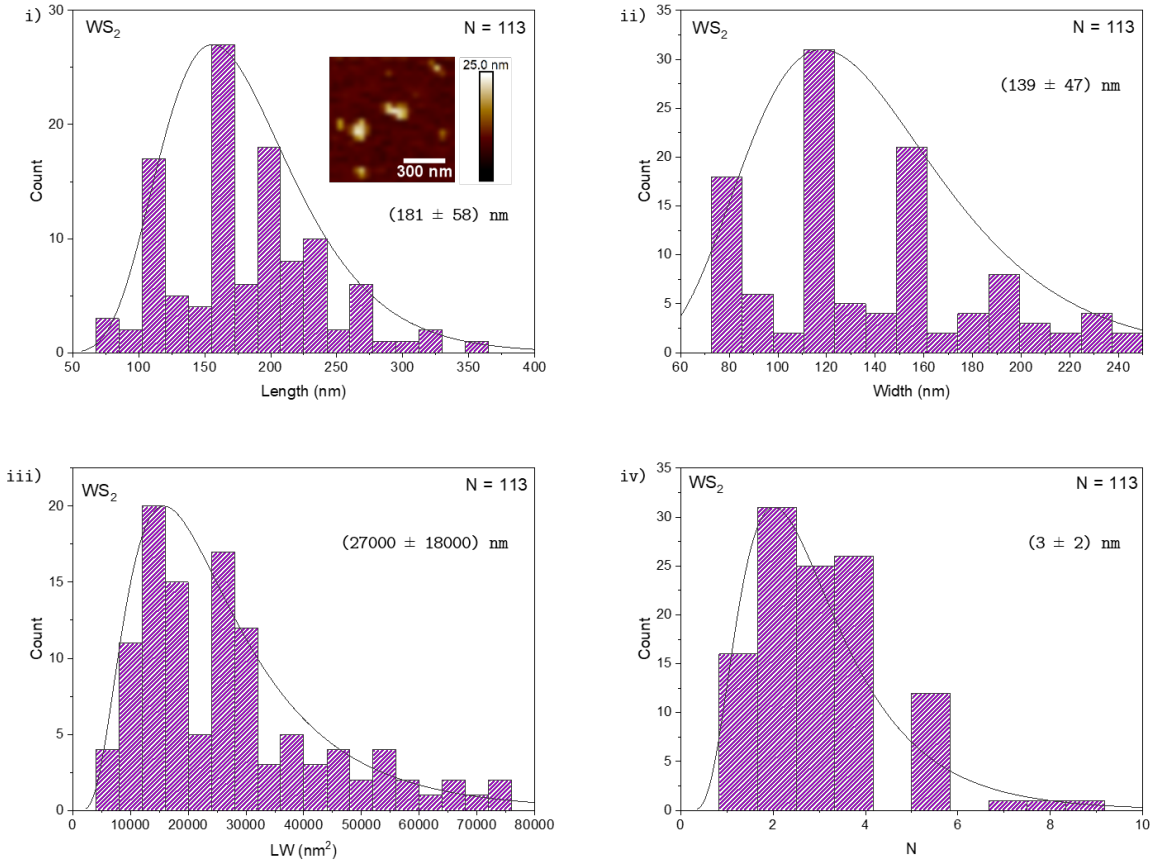

Figure S3e: Histograms of WS_2 (i) length; (ii) width; (iii) LW; (iv) N.

Figure S3f: AFM images

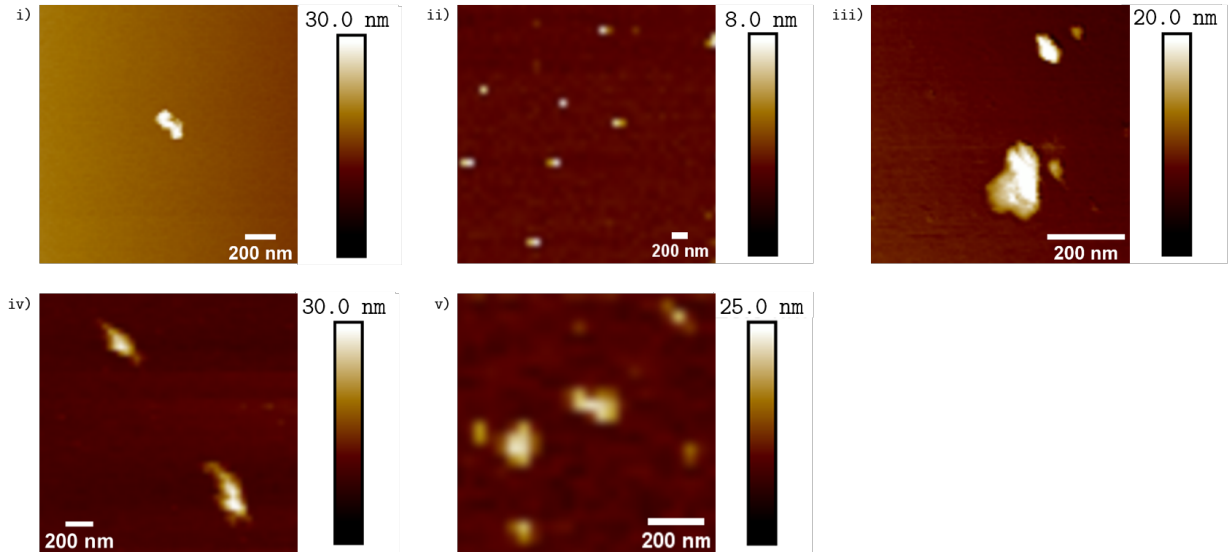

Figure S3f: AFM images of (i) L-gra; (ii) S-gra; (iii) BN; (iv) MoS_2; (v) WS_2.

Figure S4: $\langle L \rangle$ vs $\langle N \rangle$ plot

The average length and average number of layers, as obtained from fitting the histograms in Figures S3a–S3e, are plotted for each material.

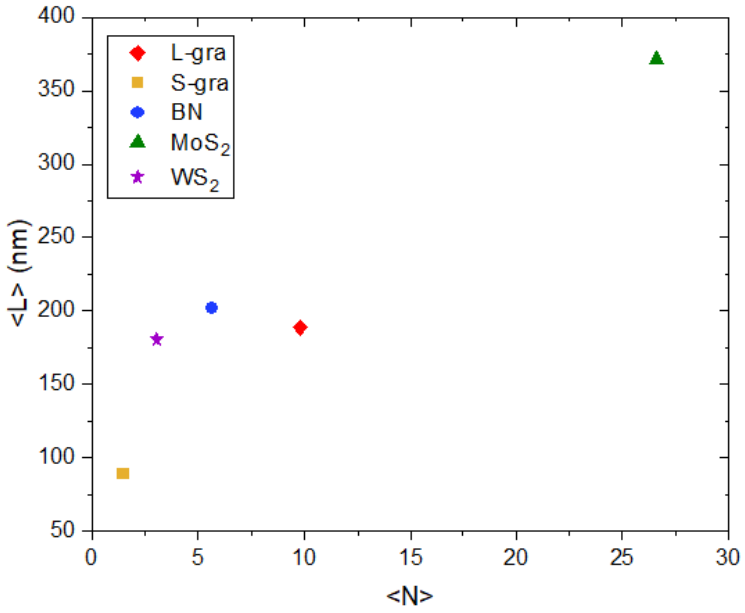

Figure S4: The average length is plotted against the average number of layers for each material.

Table S1: Aspect ratios for each material

The fit in Figure 2b, for L vs W on all materials, is provided as a guide to the eyes and demonstrates a common aspect ratio. Each material is additionally fitted individually, to obtain an aspect ratio for each material. Results for all cases are given in Table S1. As the plot is on a log 10 scale, the aspect ratio is calculated by 10^c, where c is the intercept of the fit.

Table S1: Fit results for L vs W plot for each material to gain values of aspect ratio.

Material	Intercept, c	Intercept std err, σ_c	Adj. R^2 values	Aspect ratio
L-gra	0.173	0.014	0.79	1.49
S-gra	0.153	0.014	0.59	1.42
BN	0.184	0.010	0.88	1.53
MoS_2	0.204	0.010	0.16	1.60
WS_2	0.116	0.009	0.46	1.31

Table S2: Results of fitting materials individually for LW vs N

The fit in Figure 2c, on all materials, is provided as a guide to the eyes. Each material is additionally fitted individually. Results for all cases are given in Table S2.

Table S2: Fit results for LW vs N plot for each material

	Material	Intercept, c	Intercept std err, σ_c	Gradient, m	Gradient std err, σ_m	Adj. R^2 values
Fitted independently	L-gra	3.577	0.062	0.958	0.072	0.65
	S-gra	4.030	0.043	0.301	0.163	0.06
	BN	3.882	0.121	0.424	0.172	0.03
	MoS_2	4.348	0.088	0.406	0.065	0.21
	WS_2	4.033	0.039	0.758	0.081	0.44
Fitted together	all	3.887	0.034	0.689	0.037	0.39

Table S3: R^2 values for surface pressure-surface coverage data fitting

Figures 3a, 3b fit the surface pressure-surface coverage data with a simple logarithm and with Equation 1, respectively. The R^2 values of these fits are provided in Table S3.

Table S3: R^2 values for simple logarithm and Equation 1 fitting of surface pressure vs surface coverage plots.

Material	Adj. R^2 values	
	Simple log	Fainerman (Eq. 1)
L-gra	0.90	0.94
S-gra	0.63	0.75
BN	0.18	0.55
MoS_2	0.80	0.56
WS_2	0.97	0.61

Appendix A: Derivation of interparticle distance variable

The system on the air–water interface can be approximated as shown in Figure A1. It is assumed that the film comprises uniformly distributed square nanosheets, and that the trough area, A, is also square.

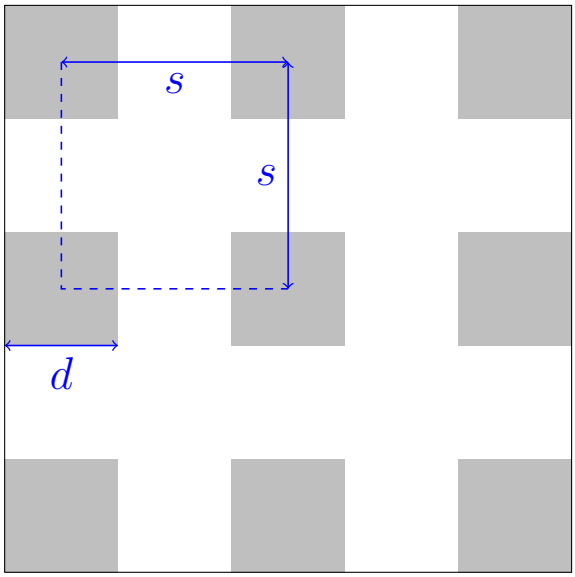

Figure A1: Top-down diagram of a Langmuir trough with a uniformly distributed film on the air–water interface.

The centre-to-centre interparticle distance, s, and the mean nanosheet diameter, d, are related such that

$$\frac{d^2}{s^2} = \frac{A_f}{A},$$

where A_f is the total film area. This is apparent when considering the square formed by s^2 (shown by the dashed blue line in Figure A1). As the total film area per trough area gives the surface coverage of the film, Φ, this ratio can be rewritten as

$$\frac{d^2}{s^2} = \Phi.$$

Since the area of a nanosheet has been approximated as $\langle LW \rangle$, the diameter can be taken as $\sqrt{\langle LW \rangle}$. Substituting in this value and rearranging, the interparticle distance can be written as

$$s = \sqrt{\frac{\langle LW \rangle}{\Phi}}.$$