Electronic Supplementary Material (ESI) for Soft Matter.

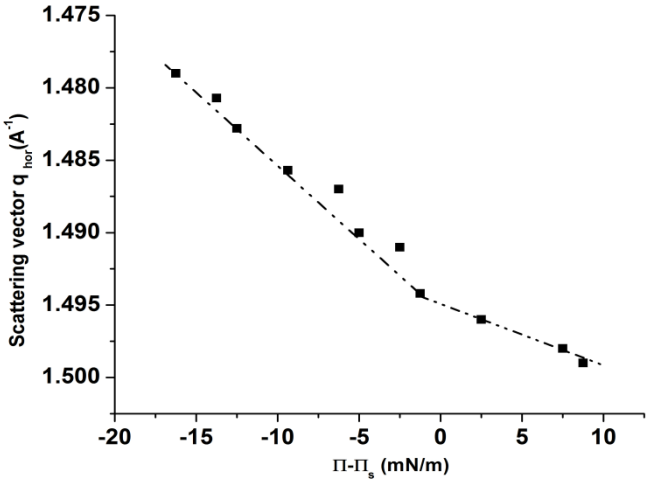

Figure S1: Horizontal scattering vector, $\mathbf{q_{hor}}$ of DMPE monolayer obtained from grazing incidence X-ray diffraction. At the LC-S transition, there is a change in slope, which is interpreted as a transition from a tilted to untilted molecular orientation; the continued decrease in **q** in the S phase is thought to be due to ordering and possible dehydration of the headgroups. Figure adapted from Helm et al. *Biophysical Journal* 1991 (Reference 5 in main text) with permission.

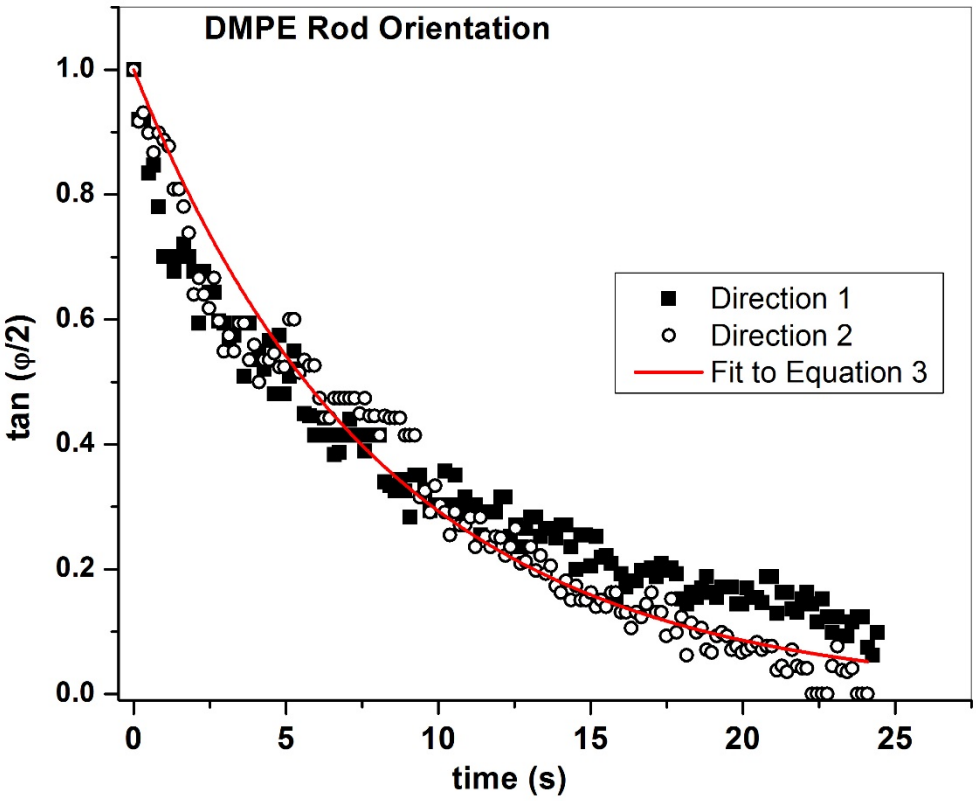

Figure S2: Rod reorientation as a function of time for two different perpendicular directions of the applied magnetic field. The red curve is a fit to Equation 3 in the main text.

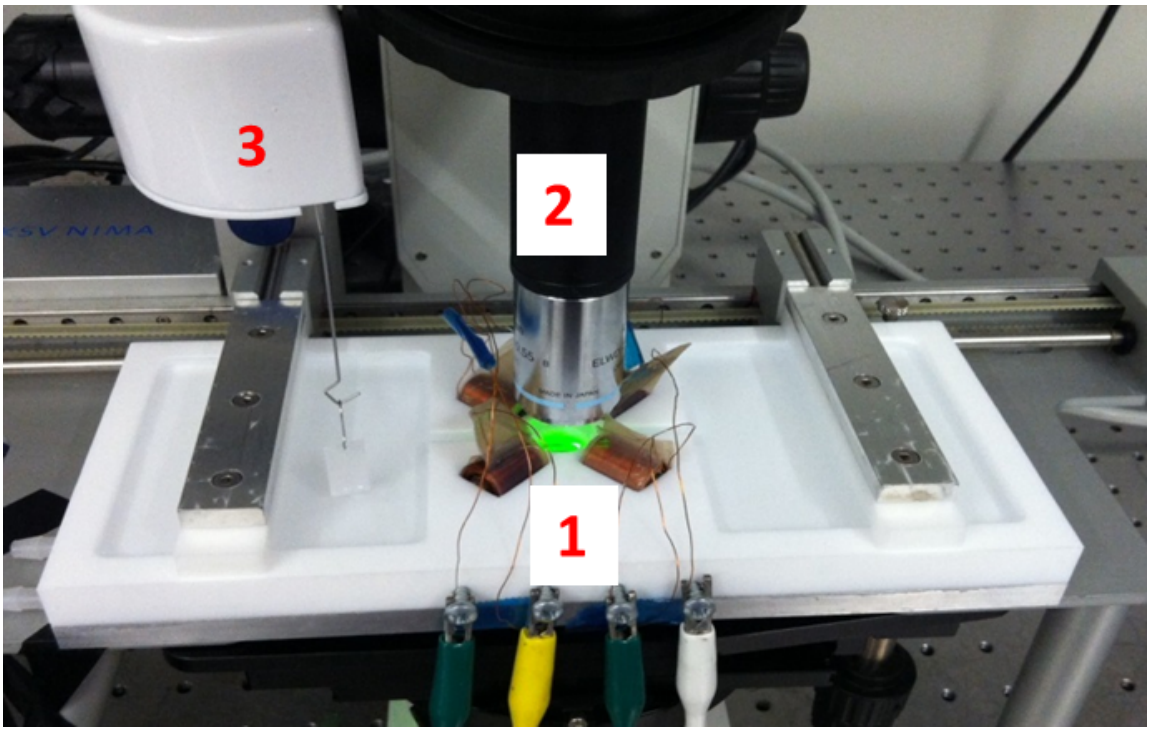

Figure S3: A custom-designed Langmuir trough with set of magnetic coils (1) mounted on a fluorescence microscope (2) to simultaneously visualize alterations in phospholipid packing and record reorientation of rods to measure interfacial rheological properties at different surface pressures measured using a Wilhelmy plate pressure sensor (3).

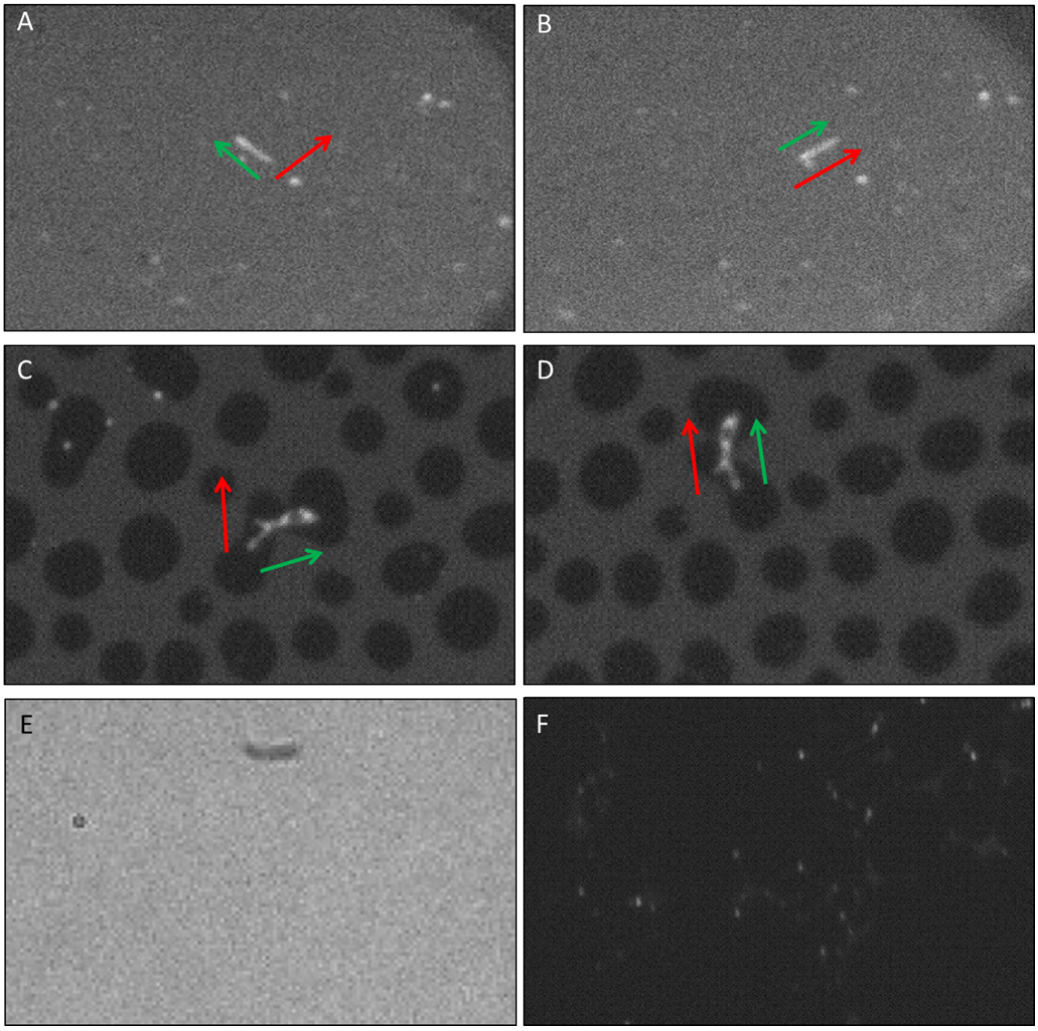

Figure S4. Representative fluorescence images of lipid monolayers with simultaneous monitoring of the reorientation of nanorods. Texas red-DHPE dye appears to attach to the nanorods in the LE (A-B) and LC-LE (C-D) coexistence phases, making them appear fluorescent. However, the nanorods could not be distinguished in the well-packed LC regions, where the interface appears dark. Image E is taken using visible light while image F shows the packing using fluorescent imaging in the LC region. The red and black arrows are representative

magnetic field direction and magnetic moment direction.

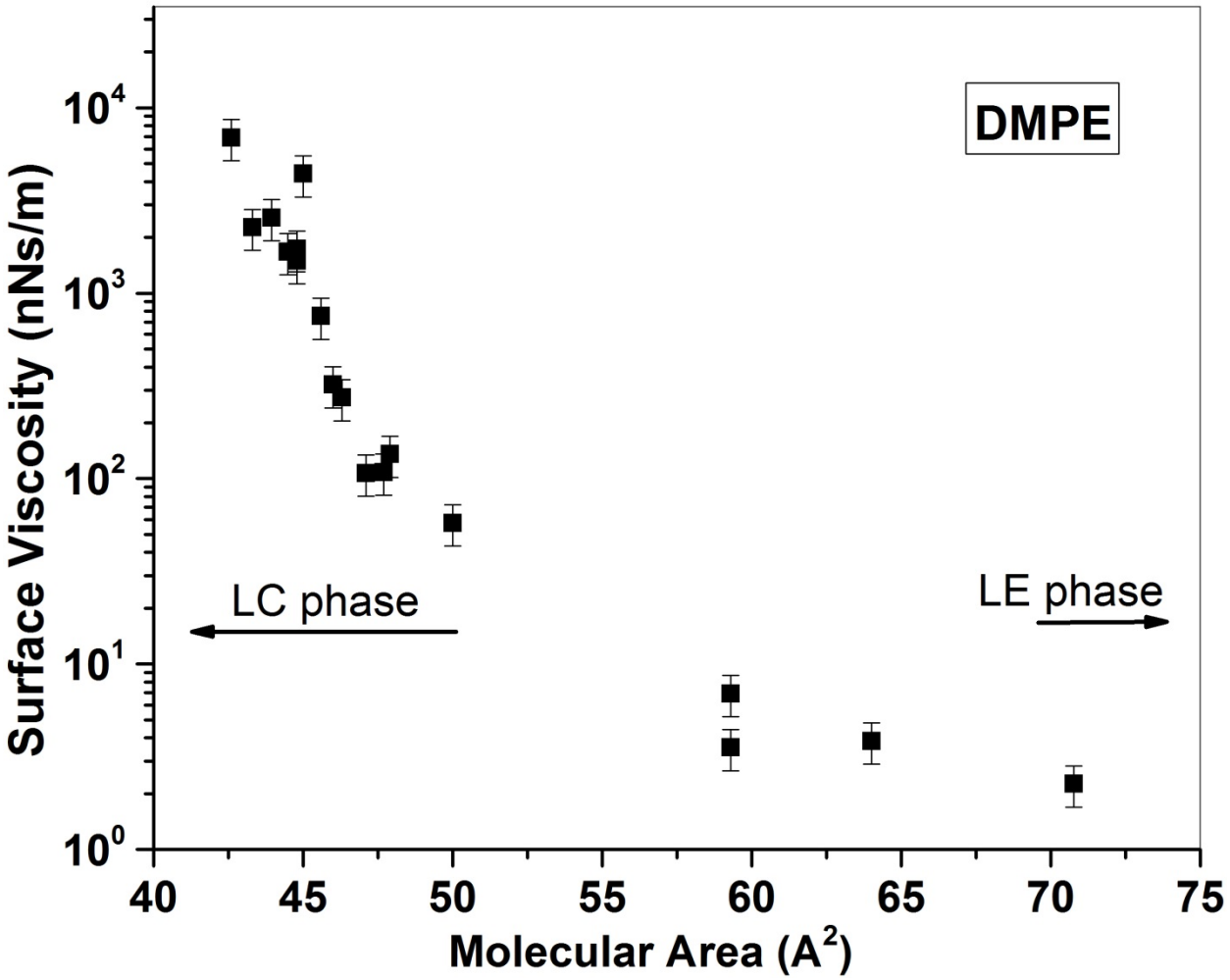

Figure S5. Surface viscosity of DMPE (nNs/m) monolayer vs. molecular area (A^2).

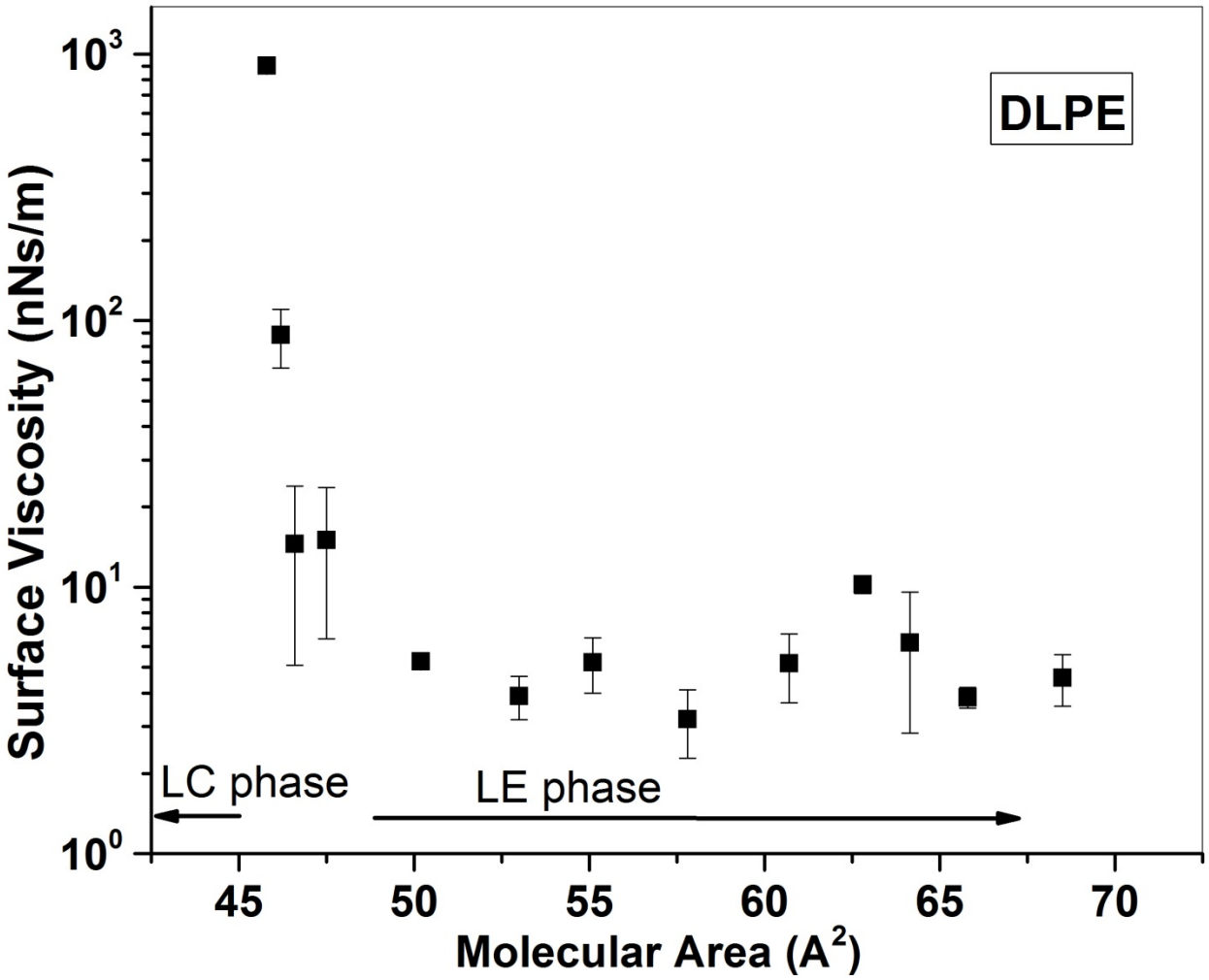

Figure S6. Surface viscosity of DLPE (nNs/m) monolayer vs. molecular area (A^2).

Details of Videos:

Video 1: Video of rod motion in LE phase using transmission mode.

Video 2: Video of rod motion in LE-LC phase using fluorescence mode, also showing the position of the rods with respect to phospholipid domains

Video 3: Video of rod motion in solid phase using transmission mode