Figure S1: Horizontal scattering vector, $q_{\text{hor}}$ 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
Figure S5. Surface viscosity of DMPE (nNs/m) monolayer vs. molecular area (Å²).
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.