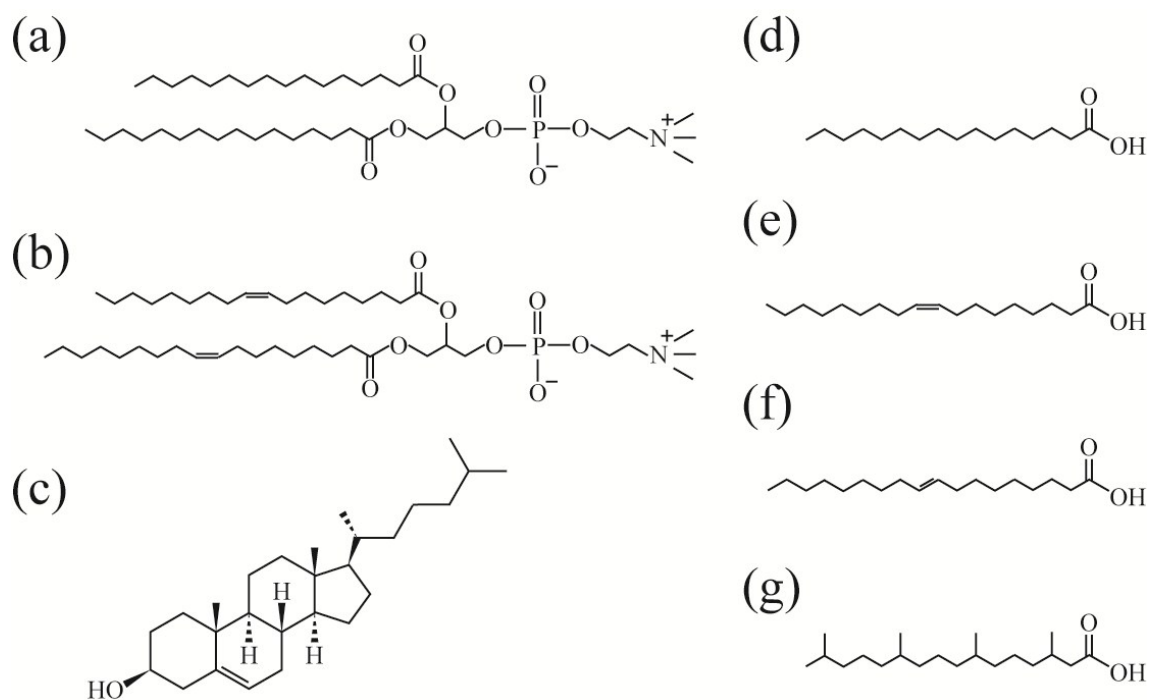


## **Electronic Supplementary Information**

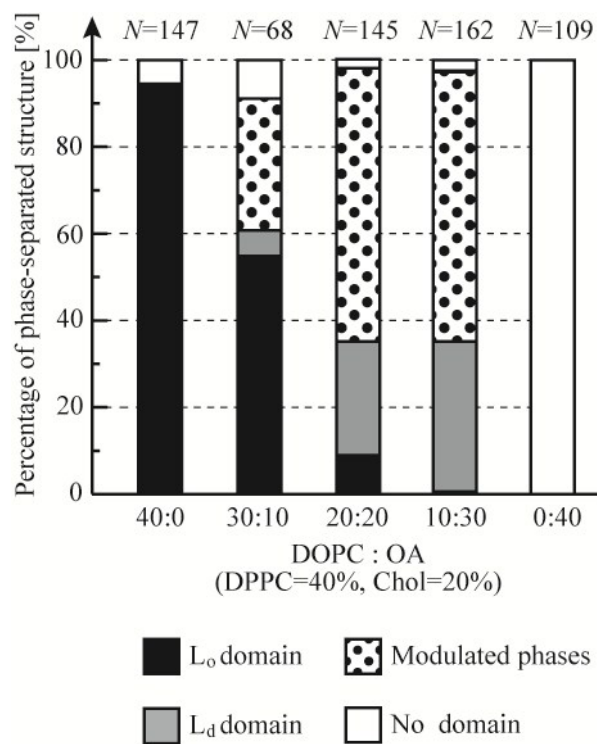
### **Formation of modulated phase and domain rigidification in fatty acids-containing lipid membranes**

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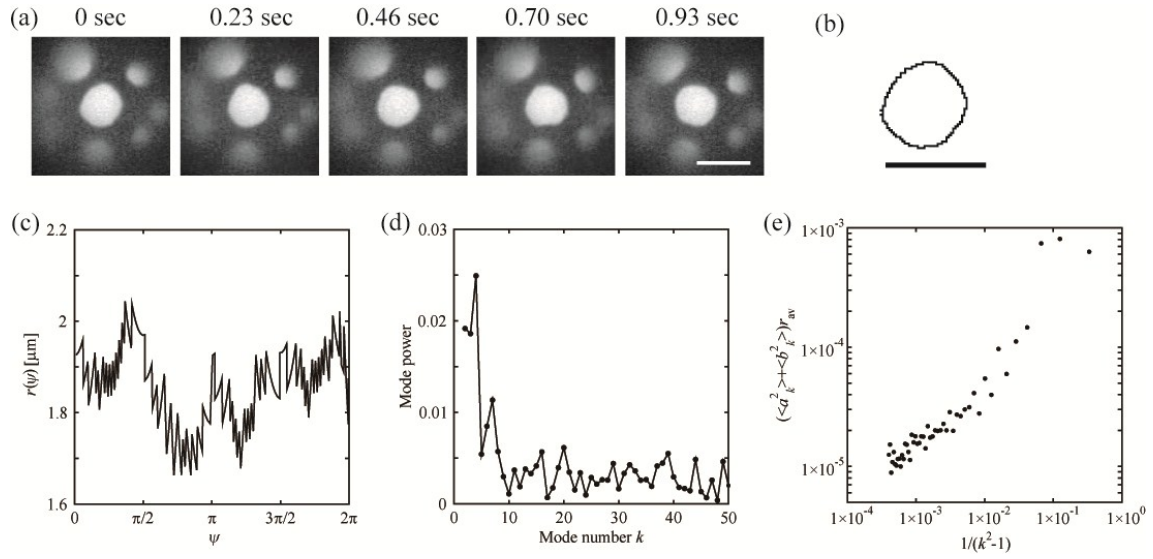
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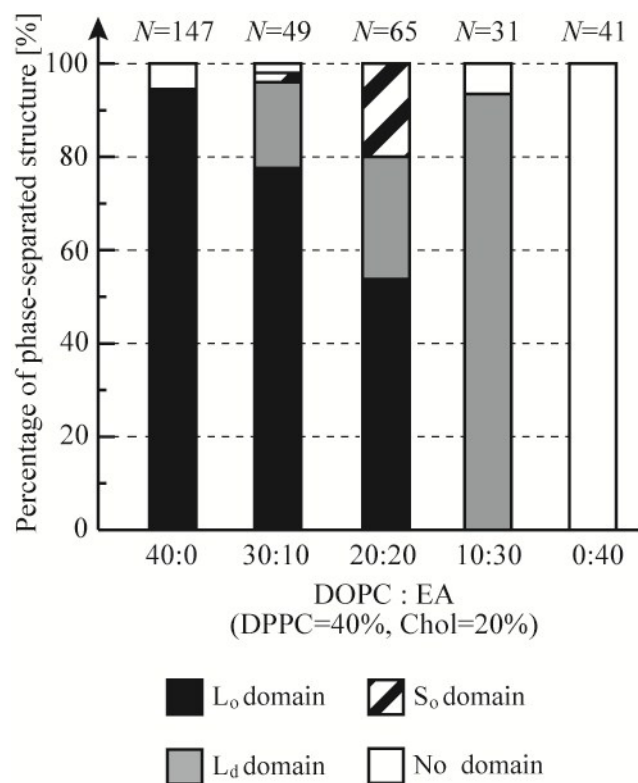
**Fig.S1** Chemical structures of lipids and fatty acids. (a) dipalmitoylphosphocholine (DPPC), (b) dioleoylphosphocholine (DOPC), (c) cholesterol (Chol), (d) palmitic acid (PA), (e) oleic acid (OA), (f) elaidic acid (EA), and (g) phytanic acid (PhA).



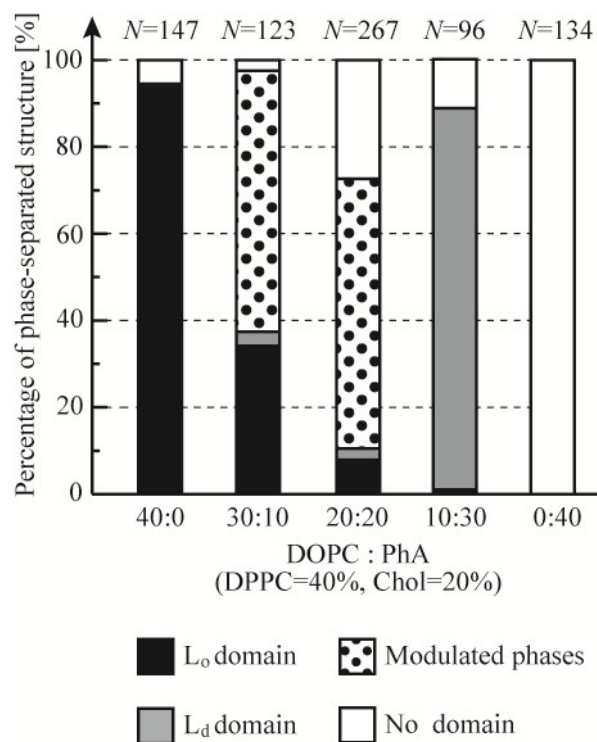
**Fig.S2** Percentage of phase-separated structures of a DOPC/DPPC/Chol/OA mixture with DPPC=40% and Chol=20%. Black, gray, black-dotted, and white regions indicate L<sub>o</sub> domain formation, L<sub>d</sub> domain formation (reverse domain), modulated phases, and a homogeneous phase, respectively.



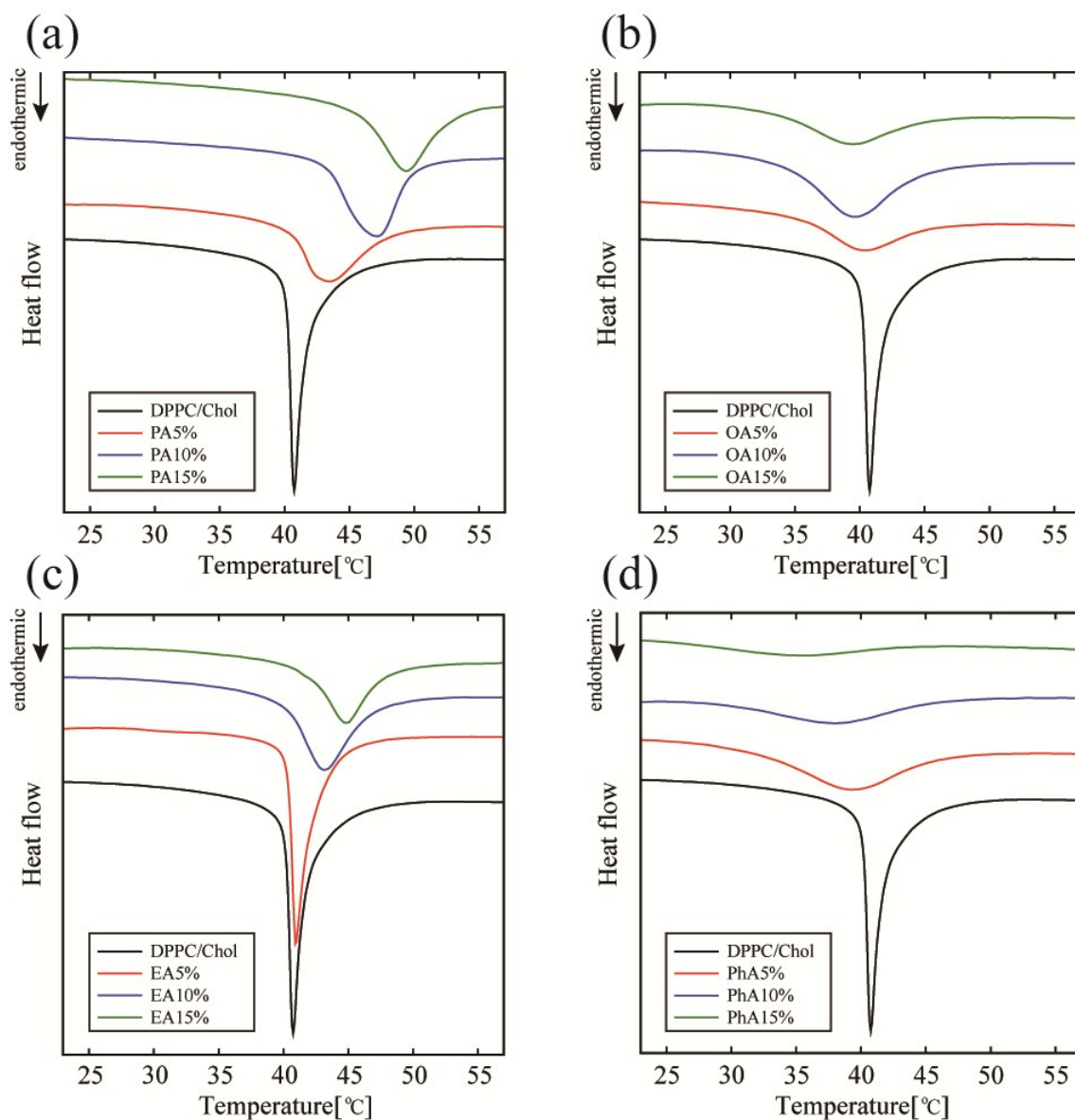
**Fig.S3** Analysis of line tension from domain boundary fluctuation. (a)Epi-fluorescence microscope images of a fluctuated domain in DOPC/DPPC/Chol/OA=10:40:20:30 (Scale bar: 10 μm). (b) Domain boundary trace of the image in (a) at 0 sec (Scale bar: 10 μm). (c) Radial fluctuation as a function of polar angle  $\psi$ . (d) Power spectrum calculated from (c). (e) Averaged Fourier coefficients obtained from 30 images plotted against  $1/(k^2-1)$ .



**Fig.S4** Percentage of phase-separated structures of a DOPC/DPPC/Chol/EA mixture with DPPC=40% and Chol=20%. Black, gray, shaded, and white regions indicate  $L_o$  domain formation,  $L_d$  domain formation (reverse domain),  $S_o$  domain formation, and a homogeneous phase, respectively.



**Fig.S5** Percentage of phase-separated structures of a DOPC/DPPC/Chol/PhA mixture with DPPC=40% and Chol=20%. Black, gray, black-dotted, and white regions indicate L<sub>o</sub> domain formation, L<sub>d</sub> domain formation (reverse domain), modulated phases, and a homogeneous phase, respectively.



**Fig.S6** Representative DSC thermographs of DPPC/Chol membranes including (a) PA, (b) OA, (c) EA, and (d) PhA. The lipid compositions are DPPC/Chol/FA=90:10:0 (black), 85:10:5 (red), 80:10:10 (blue), and 75:10:15 (green). The numbers of measurements are DPPC/Chol ( $N=10$ ), PA=5% ( $N=6$ ), PA=10% ( $N=8$ ), PA=15% ( $N=6$ ), OA=5% ( $N=6$ ), OA=10% ( $N=4$ ), OA=15% ( $N=3$ ), EA=5% ( $N=8$ ), EA=10% ( $N=3$ ), EA=15% ( $N=5$ ), PhA=5% ( $N=4$ ), PhA=10% ( $N=4$ ), and PhA=15% ( $N=3$ ).