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Supporting Material

Curvature generation and pressure profile modulation in membrane by lysolipids: insights from coarse-grained simulations

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Table 1: Length and number of LPC molecules in different simulations

System	LPC144	LPC192	LPC240	LPC288	LPC336	LPC384	LPC480
LPC (upper leaflet)	144	192	240	288	336	384	480
DOPC (each leaflet)	1824	1824	1824	1824	1824	1824	1824
Simulation time[a] (nsec)	100	100	200	210	230	220	300[b]

[a] The reported simulation times have not been scaled by any factor. [b] The simulation has been extended by another 1 μs after the wall potential (Eq. 1 in main text) is removed.

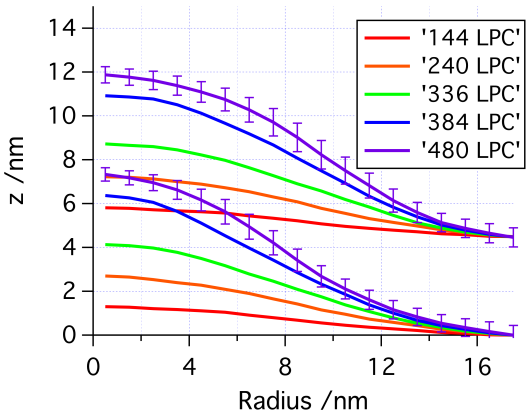

Figure 1: The shape of the final membrane interface (averaged last 100 ns) from different simulations with varying LPC concentrations. The shape, $h(r, z)$, represented in the cylindrical coordinate, indicates that the height of the mound structure rises steeply as more LPC molecules are incorporated into the upper leaflet. For the LPC480 system, error bars in $h(r, z)$ are shown, which illustrate the thermal fluctuation and instantaneous axial asymmetry of the mound structure.

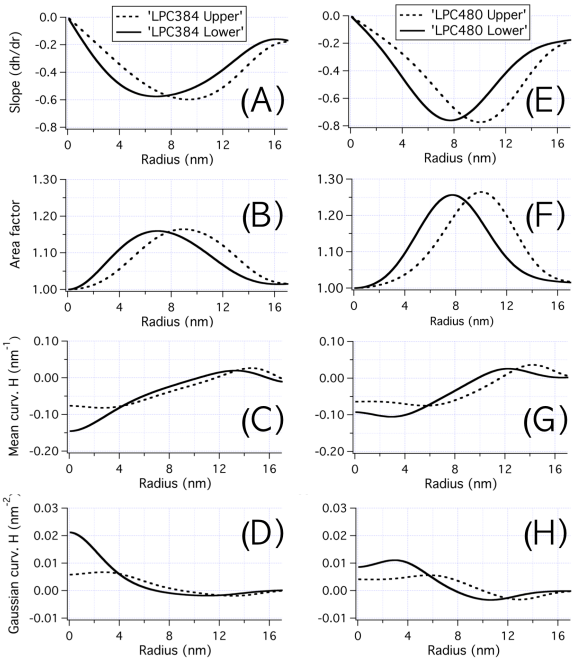

Figure 2: Geometrical properties of the mound structure for LPC384 (A-D) and LPC480 (E-H) systems (averaged over last 100 ns). These include slope, area factor (Eq.4 in main text), Mean curvature (Eq.2 in main text) and Gaussian curvature (Eq.3 in main text).

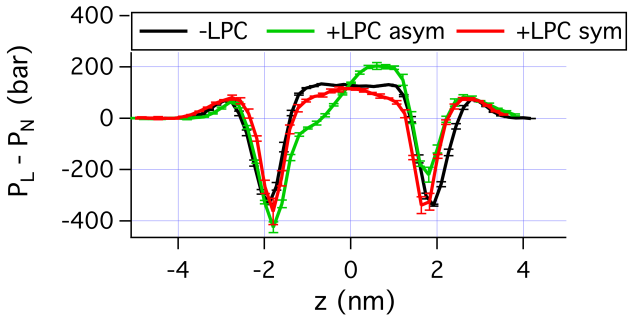

Figure 3: Pressure profiles of flat bilayers with 100 LPC added to only the upper monolayer ("asymmetric" case, in green) or both monolayers ("symmetric" case, in red). The number of DOPC is 320 for both cases. The numbers are chosen so that LPC:DOPC ratio is similar to that in the LPC480 system. The pressure profile of a flat bilayer that contains 1152 DOPC molecules is also shown for comparison (black). NPγT simulations with zero surface tension are carried out in all cases. Surface tensions of the upper and lower leaflets are -22.0 and 23.0 dyne/cm, respectively, in the asymmetric case, while they are 0.5 and 0.2 dyne/cm, respectively, for the symmetric case. In the symmetric case hydrocarbon density is less than that of a pure DOPC bilayer because LPC has only a single tail while its head group is identical to DOPC; this leads to downward shift of the pressure profile in the hydrocarbon region of the bilayer. In the asymmetric case the upper leafet with additional LPC tends to expand due to the higher density while the lower one resists against the expansion. Thus the flat but heterogeneous membrane finds equilibrium by dilating the lower leaflet while compressing upper one. The asymmetric pressure profile clearly shows the consequence: upward shift in the upper monolayer (compression) and downward shift in the lower one (dilation). The results shown in this figure further support the findings discussed in the main text that local pressure profile and surface tension are most directly related to the distribution of lipids rather than curvature, although the distribution of lipids for a curved membrane is not straightforward to predict *a priori* without detailed calculations.

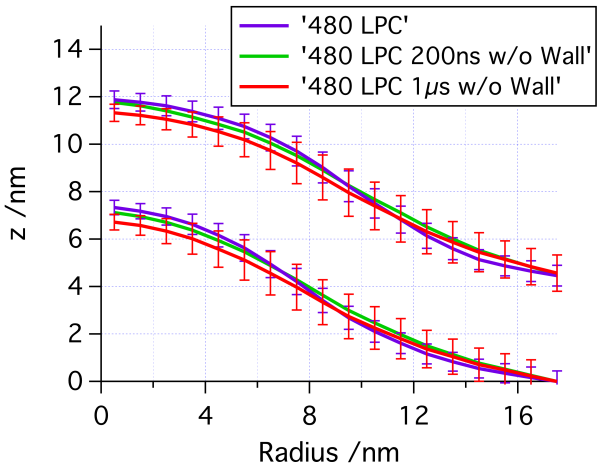

Figure 4: Shape change in the membrane mound induced by the removal of wall potential in the LPC480 system; original LPC480 system in purple; the 220 ns and the 1 μs extenstions without the wall potential in green and red, respectively. In the absense of the wall-potential, the dome shape collapses only slightly at small r.

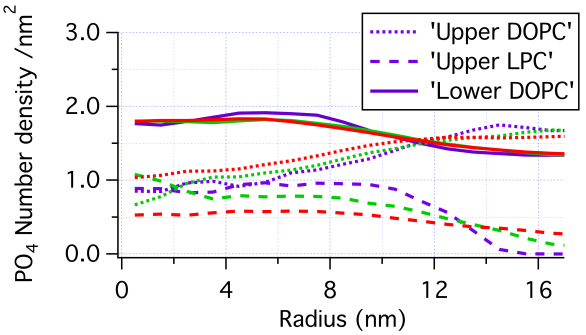

Figure 5: Comparison of phosphate group number density between the original LPC480 system (in purple) and its 220 ns (in green) and 1 μsec (in red) extensions without the wall potential. Note that LPC diffuses gradually out of the dome shape in the absence of the wall-potential.

Movie 1

Behavior of the LPC480 system during the 280 ns molecular dynamics simulation. Note that there is substantial axial asymmetry and horizontal fluctuations in the mound structure at the equilibrated stage of simulation. Color scheme: choline, blue; phosphate, orange; hydrocarbon tail, green (saturated) and white (unsaturated); glycerol, white; LPC, red.

Movie 2

Behavior of the LPC384 system after replacing all LPC molecules with cholesterol in the mound structure. The fast collapse (<20 ns) of the mound structure indicates that the curved membrane is unstable with cholesterol. Color scheme is the same as Movie 1; cholesterols are in red.