Supporting Information for

Focal Opening of the Neuronal Plasma Membrane by Shock-induced Bubble Collapse for Drug Delivery. A Coarse-Grained Molecular Dynamic Simulation

Mi Zhou,[a,b] Tong Wei,[b] Lingzhi Gu,[b] Hong Yang,[b] Ming Li,[b] and Yang Zhou[b,]*

[a] School of Materials Science & Engineering, Beijing Institute of Technology, 100081 Beijing, China;

[b] Institute of Chemical Materials, Chinese Academy of Engineering and Physics, 621900 Mianyang, China.

AUTHOR INFORMATION

Corresponding Author

*Yang Zhou. E-mail: zhouy@caep.cn

Captions

Table S1. The composition of plasma membrane.

Figure S1. Distribution of three characteristic components (SM lipid are red, Cere are orange, CHOL are blue, other lipid molecules are silver).

Figure S2. Illustration of the momentum mirror boundary condition.

Figure S3. Time dependence of the pressure normal to the membrane surface (pressure profile at the membrane position) with u_p = 0.8 km·s^{-1}. The gray area represents pressure space generated by bubble collapse. The "a" is the pressure of the shock wave front passing through the membrane interface, and "b" represents the jet begins to generate pressure on the membrane after the bubble collapses.

Table S2. Details of all simulation systems in this work.

Table S3. The pore area (nm^2) of different SM content at the u_p = 0.6 km/s and D = 40nm.

Table S4. The pore area (nm^2) of PM at different bubble diameters (nm) and shock velocity (km/s).

Table S1. The composition of plasma membrane.

Composition name	**Number of lipids**		**Total**
	Outer leaflet	Inner leaflet	
Phosphatidylcholine (PC)	2412	1288	3700
Phosphatidylethanolamine (PE)	1093	2017	3110
Sphingomyelin (SM)	892	219	1111
Phosphatidylserine (PS)	0	930	930
Glycolipid (GM1)	135	0	135
Glycolipid (GM3)	135	0	135
Cerebrosides (CERE)	742	0	742
Phosphatidylinositol (PI)	0	484	484
Phosphatidic acid (PA)	0	38	38
Phosphatidylinositol phosphates (PIPs)	0	132	132
Ceramide (CER)	56	55	111
Lysophosphatidylcholine (LPC)	30	15	45
Lysophosphatidylethanolamine (LPE)	15	30	45
Diacylglycerol (DAG)	38	38	76
Cholesterol (CHOL)	4431	4222	8653
Total lipids	9979	9468	19435

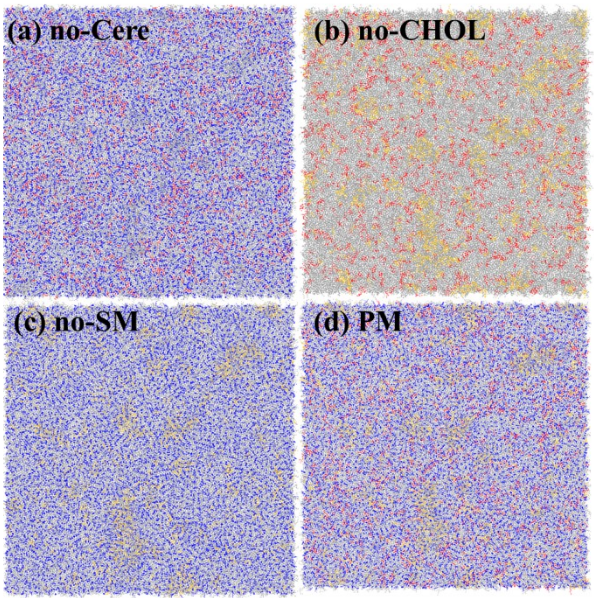

Figure S1. Distribution of three characteristic components (SM lipid are red, Cere are orange, CHOL are blue, other lipid molecules are silver).

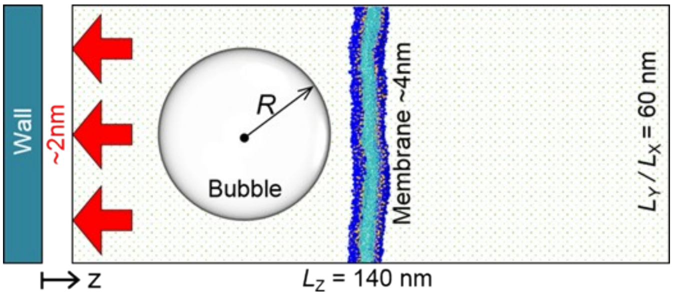

Figure S2. Illustration of the momentum mirror boundary condition.

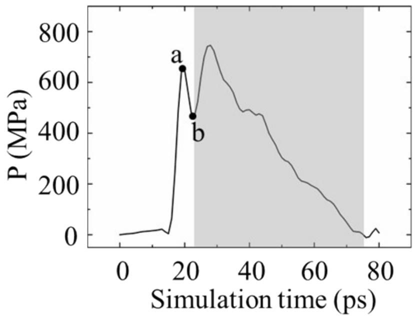

Figure S3. Time dependence of the pressure normal to the membrane surface (pressure profile at the membrane position) with u_p = 0.8 km·s^{-1}. The gray area represents pressure space generated by bubble collapse. The "a" is the pressure of the shock wave front passing through the membrane interface, and "b" represents the jet begins to generate pressure on the membrane after the bubble collapses.

Table S2. Details of all simulation systems in this work.

Systems	Bubble diameter (*D*)	Shock velocity (km/s)	Shock simulation time (ps)
PM	20	0.7	100
	20	0.8	100
	20	0.9	100
	20	1.0	100
	20	1.1	100
	40	0.6	150
	40	0.7	100
	40	0.8	100
	40	0.9	100
	40	1.0	100
	40	1.1	100
	40	1.2	100
	50	0.7	100
	50	0.8	100

	50	0.9	100
	50	1.0	100
	50	1.1	100
no-CERE	20	0.7	100
	20	0.8	100
	20	0.9	100
	20	1.0	100
	20	1.1	100
	40	0.6	150
	40	0.7	100
	40	0.8	100
	40	0.9	100
	40	1.0	100
	40	1.1	100
	40	1.2	100
	50	0.7	100
	50	0.8	100
	50	0.9	100
	50	1.0	100
	50	1.1	100
no-CHOL	20	0.7	100
	20	0.8	100
	20	0.9	100
	20	1.0	100
	20	1.1	100
	40	0.6	150
	40	0.7	100
	40	0.8	100
	40	0.9	100
	40	1.0	100
	40	1.1	100
	40	1.2	100
	50	0.7	100
	50	0.8	100
	50	0.9	100
	50	1.0	100
	50	1.1	100
no-SM	20	0.7	100
	20	0.8	100
	20	0.9	100
	20	1.0	100
	20	1.1	100
	40	0.6	150
	40	0.7	100

	40	0.8	100
	40	0.9	100
	40	1.0	100
	40	1.1	100
	40	1.2	100
	50	0.7	100
	50	0.8	100
	50	0.9	100
	50	1.0	100
	50	1.1	100
SM:DOPC (1:9)	40	0.6	150
SM:DOPC (3:7)	40	0.6	150

Table S3. The pore area (nm^2) of different SM content at the u_p = 0.6km/s and D = 40nm.

Models	Area at 60ps	Area at 80ps	Area at 100ps
10%SM	0.0	3	7.75
30%SM	0.25	4	13

Table S4. The pore area (nm^2) of PM at different bubble diameters (nm) and particle velocity (u_p, km/s).

D \ u_p	**0.6**	**0.7**	**0.8**	**0.9**	**1.0**	**1.1**	**1.2**
20	-	18	114	86.25	97.75	100.25	-
40	5.5	296.75	745	498	409.25	317	299
50	18.5	318.75	795	714.75	464	354.5	-