

## Electronic Supplementary Information

### Nanoparticle-Induced Structural Changes in Lung Surfactant Membranes: An X-ray Scattering Study

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**Table S1.** Physical Characteristics of the Silica NPs.

Particle type	Hydrodynamic diameter (Å)	Zeta potential (mV)
Cationic NPs (Levasil)	240 ± 70	+43 ± 1
Anionic NPs (Bindzil)	170 ± 50	-12 ± 4

**Table S2.** The maxima of the fitted Bragg peaks  $Q_{xy}$  and Bragg rods  $Q_z$ , for DPPC, DPPC:DLPC (7:3), DPPC:POPG (7:3), and Infasurf on subphases of water, 0.001 wt% anionic silica NPs, and 0.001 wt% cationic silica NPs at 35 mN/m and 22.0 ± 0.5 °C.

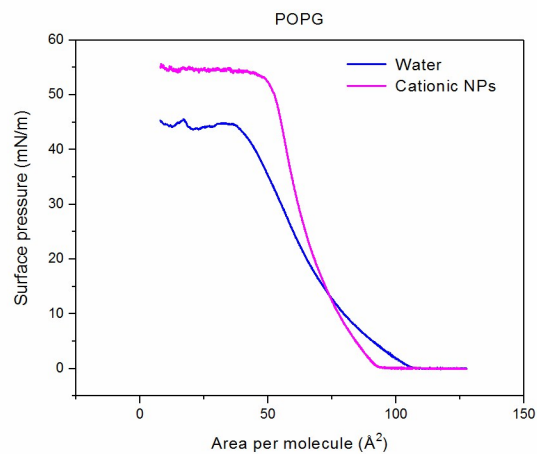
System	Subphase	(10) [Å <sup>-1</sup> ]		(01) [Å <sup>-1</sup> ]		(1±1) [Å <sup>-1</sup> ]	
		$Q_{xy}$	$Q_z$	$Q_{xy}$	$Q_z$	$Q_{xy}$	$Q_z$
DPPC	Water	1.367	0.637	1.405	0.556	1.468	0.0808
DPPC	Anionic NPs	1.324	0.740	1.351	0.692	1.465	0.0488
DPPC	Cationic NPs	1.333	0.709	1.365	0.664	1.465	0.0450
DPPC:DLPC	Water	1.351	0.629	1.367	0.606	1.465	0.0232
DPPC:DLPC	Anionic NPs	1.359	0.623	1.407	0.545	1.465	0.0776
DPPC:DLPC	Cationic NPs	1.331	0.599	1.356	0.621	1.465	0.0218
DPPC:POPG	Water	1.408	0.476	1.434	0.394	1.473	0.0826
DPPC:POPG	Anionic NPs	1.394	0.541	1.419	0.446	1.467	0.0940
DPPC:POPG	Cationic NPs	1.475	0.0885	1.444	0.177	1.475	0.0884

**Table S3.** The maxima of the fitted Bragg peaks  $Q_{xy}$ , Bragg rods  $Q_z$ , chain tilt (t), and projected area per chain ( $A_{xy}$ ) for POPG on the subphase containing 0.001 wt% cationic silica NPs.

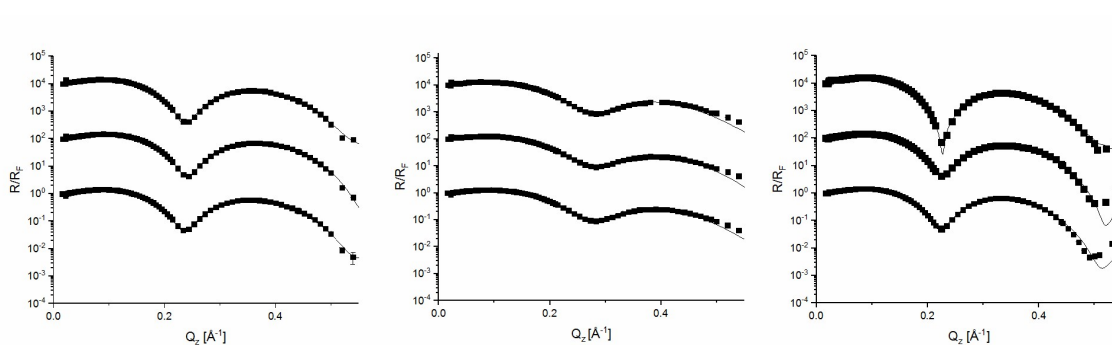
System/subphase	(10) [Å <sup>-1</sup> ]		(01) [Å <sup>-1</sup> ]		(1±1) [Å <sup>-1</sup> ]		t [°]	$A_{xy}$ [Å <sup>2</sup> ]
	$Q_{xy}$ [Å <sup>-1</sup> ]	$Q_z$ [Å <sup>-1</sup> ]	$Q_{xy}$ [Å <sup>-1</sup> ]	$Q_z$ [Å <sup>-1</sup> ]	$Q_{xy}$ [Å <sup>-1</sup> ]	$Q_z$ [Å <sup>-1</sup> ]		
Pure POPG-cationic NPs	1.455	0.000	1.455	0.000	1.455	0.000	0.0	21.53

**Table S4.** Fitted parameters for the XR data of DLPC and POPG monolayers on subphases of water, 0.001 wt% anionic silica NPs, and 0.001 wt% cationic silica NPs at a surface pressure of 35 mN/m and temperature of  $22.0 \pm 0.5$  °C.

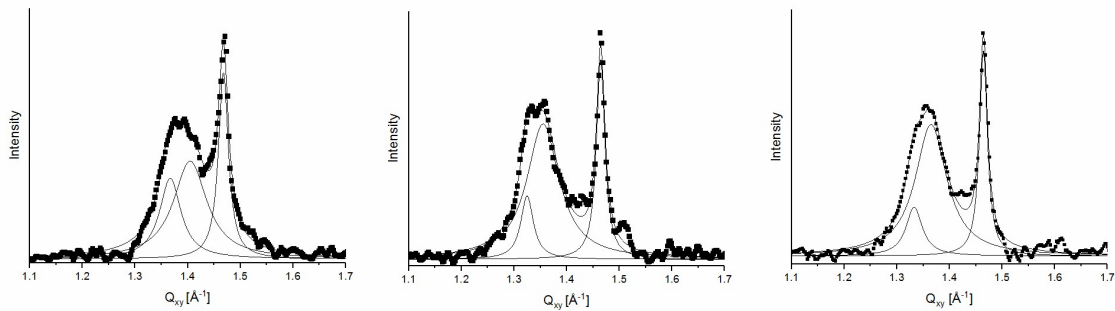
System	Subphase	Tail		Head group		Nanoparticle		$\sigma$ [Å]
		Thickness (Å)	$\rho$ (e <sup>-</sup> /Å <sup>3</sup> )	Thickness (Å)	$\rho$ (e <sup>-</sup> /Å <sup>3</sup> )	Thickness (Å)	$\rho$ (e <sup>-</sup> /Å <sup>3</sup> )	
DLPC	Water	10.2	0.295	8.6	0.433	--	--	3.37
DLPC	Anionic	10.2	0.295	7.9	0.441	150.5	0.336	3.39
DLPC	Cationic	9.7	0.289	8.9	0.428	236.6	0.335	3.28
POPG	Water	16.9	0.314	6.3	0.507	--	--	3.78
POPG	Anionic	17.0	0.329	5.4	0.512	153.4	0.335	3.95
POPG	Cationic	15.5	0.310	9.2	0.531	199.8	0.345	3.57



**Figure S1.** Surface pressure-area isotherms of POPG on subphases of water and 0.001 wt% cationic NPs at  $22.0 \pm 0.5$  °C.



**Figure S2.** XR data for DPPC (left), DPPC:DLPC 7:3 (middle), and DPPC:POPG 7:3 (right) on subphases of water (bottom), 0.001 wt% anionic silica NPs (middle), and 0.001 wt% cationic silica NPs (top) at 35 mN/m and  $22.0 \pm 0.5$  °C. Experimental data is shown as dots and the fits are shown as lines. For clarity the reflectivity curves have been shifted along the ordinate.



**Figure S3.** Bragg peaks from GIXD data analysis for DPPC on subphases of water (left), 0.001 wt% anionic silica NPs (middle), and 0.001 wt% cationic silica NPs (right) at 35 mN/m and  $22.0 \pm 0.5$  °C. Experimental data is shown as dots and the fits are shown as lines.