

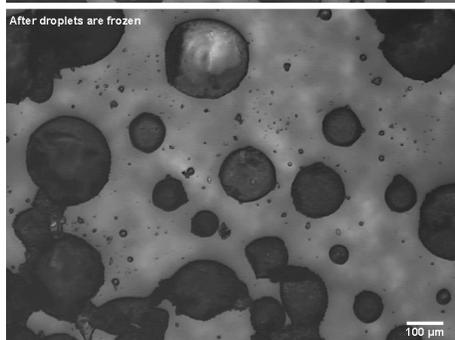
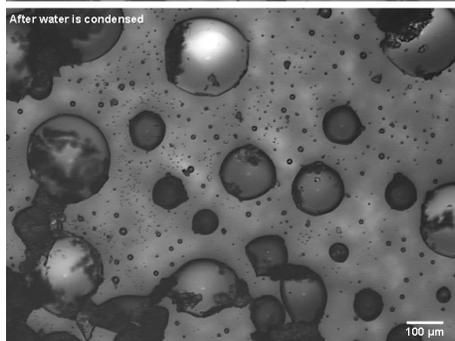
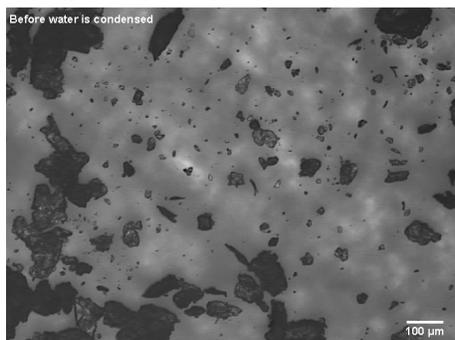
Electronic Supplemental Information

Table S1. Summary of present experimental results (all DFT experiments except as noted for IS, CRAFT, and CFDC)

Experiment	Fatty Alcohol or Acid	Blank freezing T	Detected Ice nucleation freezing T
(Monolayers) + CHCl ₃	Docosanol (1.6)	T _{50%} = -26.3 ± 0.3 °C	T _{50%} = -13.9 ± 0.3 °C
	Docosanol (1.6) refreeze	T _{50%} = -25.8 ± 0.4 °C	T _{50%} = -10.6 ± 0.3 °C
	Docosanol (0.5)	T _{50%} = -26.7 ± 0.3 °C	T _{50%} = -22.7 ± 1.3 °C
	Docosanol (0.5) refreeze	T _{50%} = -26.1 ± 0.2 °C	T _{50%} = -14.0 ± 0.4 °C
	Palmitic acid (1.5)	T _{50%} = -25.6 ± 0.8 °C	T _{50%} = -25.3 ± 1.0 °C
	Palmitic acid (268) - IS	T _{50%} = -20.7 ± 1.8 °C	T _{50%} = -21.1 ± 1.1 °C
	Palmitic acid on seawater (1.0)	T _{50%} = -20.7 ± 1.8 °C	T _{50%} = -21.0 ± 1.1 °C
	Stearic acid (8.4)	T _{50%} = -24.2 ± 3.1 °C	T _{50%} = -26.9 ± 0.5 °C
	Stearic acid (1.5)	T _{50%} = -26.5 ± 0.6 °C	T _{50%} = -26.1 ± 0.7 °C
	Stearic acid (1.0)	T _{50%} = -27.0 ± 0.8 °C	T _{50%} = -25.0 ± 0.9 °C
	Stearic acid on seawater (1.5)	T _{50%} = -21.6 ± 1.0 °C	T _{50%} = -23.3 ± 0.5 °C
	Stearic acid (1.0) pH 2.7	T _{50%} = -29.3.0 ± 1.7 °C	T _{50%} = -25.6 ± 1.4 °C
	Stearic acid (1.5) pH 2.7	T _{50%} = -24.5 ± 2.0 °C	T _{50%} = -26.7 ± 0.5 °C
	Stearic acid (2.0) pH 2.7	T _{50%} = -28.1 ± 0.7 °C	T _{50%} = -27.0 ± 0.5 °C
	Stearic acid (2.0) pH 1.4	T _{50%} = -26.7 ± 1.4 °C	T _{50%} = -24.9 ± 1.6 °C
Stearic acid (1.0) – CRAFT	T _{50%} = -31.0 ± 0.5 °C	T _{50%} = -30.6 ± 0.5 °C	
Solid Particles	C16 Alcohol	T _{10%, sub-phase} = -35.0 °C	T _{10%} = -11.8 ± 0.3 °C; T _{50%} = -12.6 ± 0.2 °C
	C17 Alcohol	T _{50%, sub-phase} = -36.5 °C	T _{10%} = -11.2 ± 0.7 °C; T _{50%} = -13.1 ± 0.8 °C
	C18 Alcohol		T _{10%} = -12.8 ± 0.5 °C; T _{50%} = -14.1 ± 0.3 °C
	C12 Acid		T _{10%} = -31.6 ± 3.2 °C; T _{50%} = -35.4 ± 0.9 °C
	C14 Acid		T _{10%} = -31.7 ± 1.9 °C; T _{50%} = -36.0 ± 0.1 °C
	C16 Acid		T _{10%} = -32.6 ± 2.0 °C; T _{50%} = -35.5 ± 0.7 °C
	C18 Acid		T _{10%} = -29.5 ± 1.6 °C; T _{50%} = -33.7 ± 0.5 °C
	C19 Acid		T _{10%} = -28.8 ± 0.5 °C; T _{50%} = -30.6 ± 0.4 °C
C20 Acid		T _{10%} = -32.1 ± 1.5 °C; T _{50%} = -36.3 ± 0.3 °C	
Aerosolized particles*	Palmitic acid - CFDC	N/A	Not significant (T _{0.0001%}) at -30.5 °C

*phase state of particles undetermined, see Section 2.

Sample images from an experiment using **stearic acid** particles



Sample images from an experiment using **myristic acid** particles

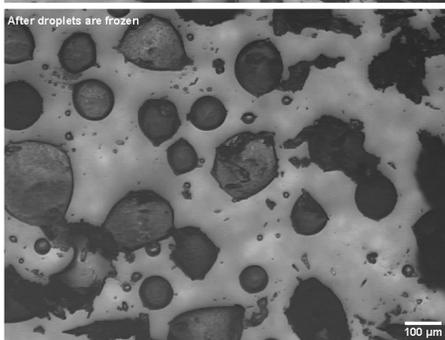
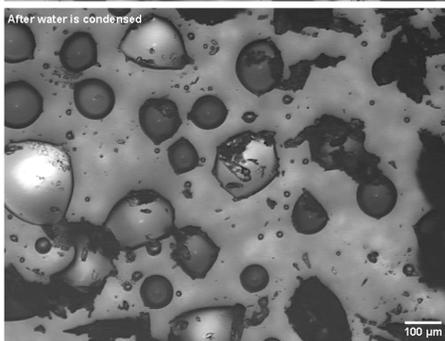
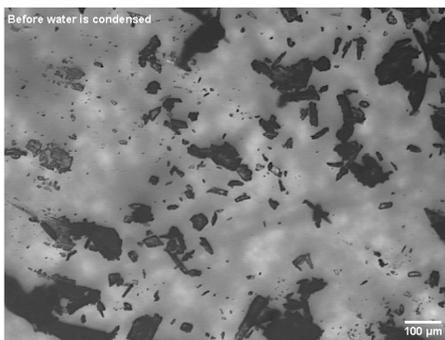


Figure S1. Images from C-series of pure nL droplet on crystalline fatty acid experiments in the DFC device. Stearic acid (C18) and myristic acid (C12) results are shown in the left and right columns, respectively. Dry particles on glass cover slips are shown in the top panels, images following condensation of nL drops are shown in the middle panels, and images following freezing at the lowest temperatures are shown in the bottom panels. The small white scale in the lower right of the images is 100 μm , indicating that a range of particle sizes up to this size are present in these experiments and that droplet sizes range from about 40 to 150 μm diameter, sometimes encapsulating more than one particle. It is also clear that most particles remain undissolved following condensation and freezing. Finally, we may note that image analysis of the stearic acid view above gave a total surface area estimate of $1.6 \times 10^{-3} \text{ cm}^2$ on the basis of ascribing spherical equivalent diameters to particles and assuming an exposed hemispheric area in each case. Active site density was then estimated by then dividing the number of frozen particles by the total surface area.

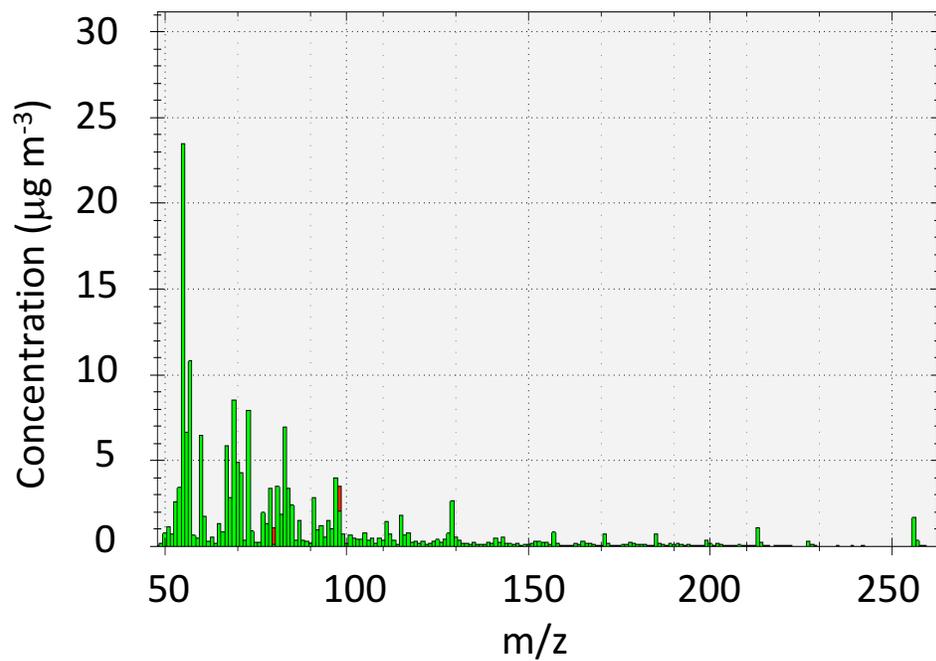


Figure S2. AMS verification mass to charge spectrum of 100 nm palmitic acid particles generated by nebulizing palmitic acid dissolved in methanol followed by diffusion drying of the particles, for use in the CFDC experiment. The chemical spectrum shown was confirmed with a NIST reference spectrum of palmitic acid; unique mass to charge ratios (m/z) for palmitic acid were determined to be $m/z = 256$, $m/z = 129$, and $m/z = 213$.

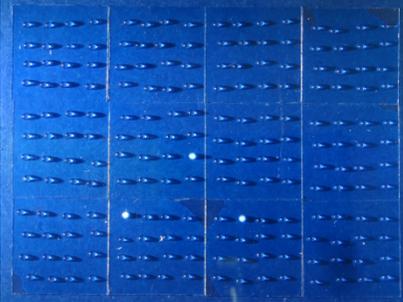
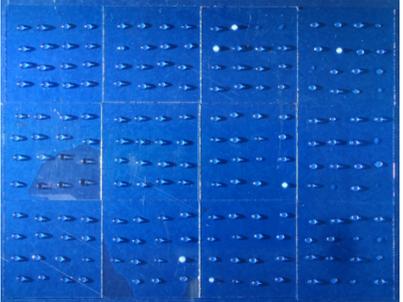
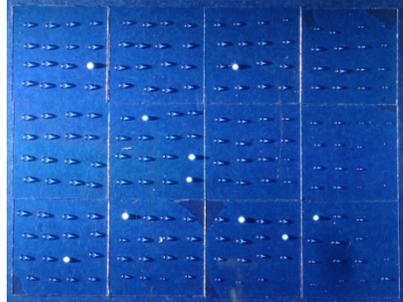
Time	Control	Sample
0 min		
120 min		
180 min		

Figure S3. Table showing the freezing evolution of 192 droplet arrays held at $-23\text{ }^{\circ}\text{C}$ for an extended period while passing dry N_2 over the arrays. The control array (no acid added) is on the left and an array with nonadecanoic acid (C19) monolayers added appears on the right panels. Fatty acid residue is visible for many of the C19-treated drops after evaporation. No enhancement of freezing over the control situation is noted over the 3-hour period shown.

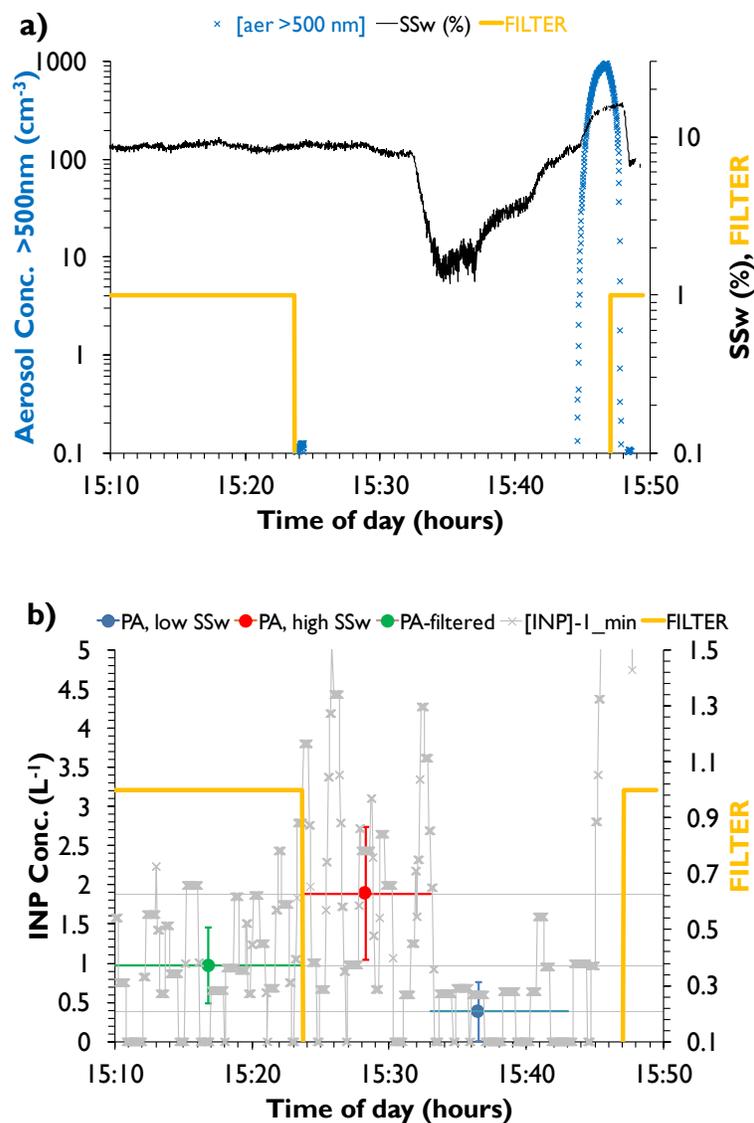


Figure S4. INP data collected from the CFDC instrument during operation at $-30.5\text{ }^{\circ}\text{C}$ while sampling 1000 cm^{-3} , 100 nm size-selected palmitic acid (PA) particles. Panel **a** shows the 1 Hz aerosol particle concentration at sizes larger than 500 nm and the SS_w . At very high SS_w , water droplets grown on the PA particles are not evaporated back to their equilibrium sizes in the CFDC evaporation regions, as shown by the sudden onset of $>500\text{ nm}$ aerosols at $15:45$, thus validating total particle concentrations. FILTER refers to passing the aerosol sample stream through a HEPA filter prior to measurement in the CFDC, to detect background frost. One-minute and period-averaged INP concentrations are shown in panel **b** during three integrated sample periods, which show a small positive freezing signal under conditions favoring immersion freezing (red period), as discussed in the manuscript. Low SS_w conditions also represent background conditions, akin to the filter period.

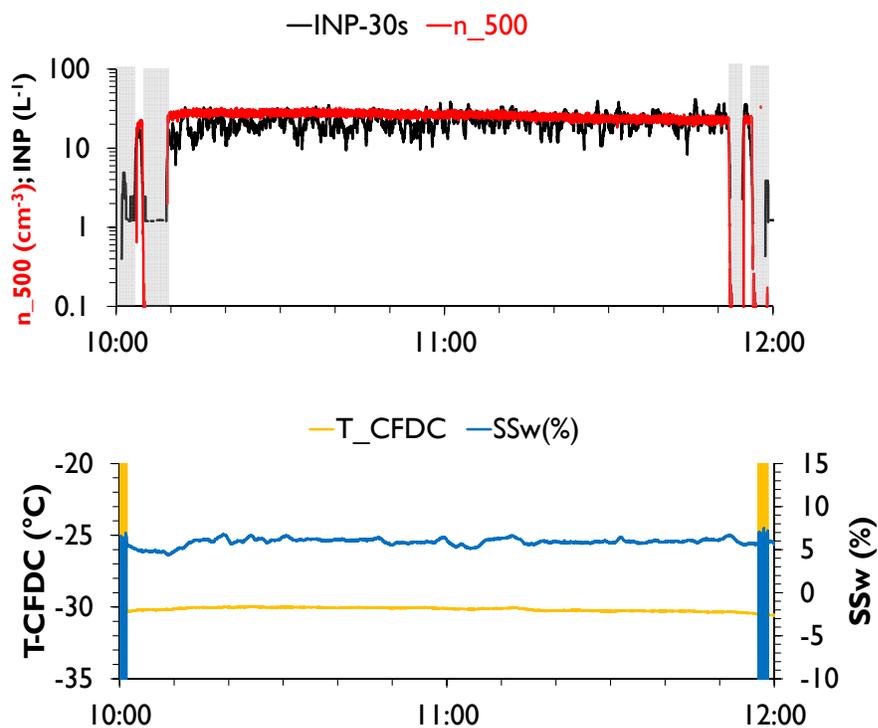


Figure S5. CFDC timeline of data from January 26, 2014 Marine Aerosol Reference Tank experiment from which 75% of collected INPs (residuals of ice crystals impacted from CFDC outlet flow) were of a composition most similar to hexadecanoic acid on the basis Raman spectroscopy measurements¹¹. In contrast to the data in Fig. S4, activated INPs were present at 20 L^{-1} , significantly greater than the instrument background noted in gray-shaded areas. Also shown are the concentrations of aerosols at diameters larger than 500 nm (cm^{-3}), CFDC lamina temperature and CFDC lamina average supersaturation. Total particle concentrations at all sizes were nearly steady at 1000 cm^{-3} , with a number size mode at about 150 nm. Total surface area was $930 \mu\text{m}^2 \text{ cm}^{-3}$, predominately from particles at sizes $>500 \text{ nm}$.