SUPPLEMENTARY MATERIAL

ELECTRIC FIELDS ENHANCE ICE FORMATION FROM WATER VAPOR BY DECREASING THE NUCLEATION ENERGY BARRIER

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Video S1: Needle and dendrite formation and change using the set-up shown in Figure 2a. Image acquisition was done using a digital video microscope.

Video S2: Sudden appearance of ice needles floating in the air.

Video S3: Sudden appearance of thin ice needles adjacent to a surface.

Video S4: Vertical and lateral growth of dendrites exposed to cooled water vapor.

Video S5: Dendrite growth on the top and around isolated needles.

Video S6: Collapse of needles and dendrites in the absence of an electric field, when the aluminum plate is grounded.

Video S7: Small changes in the porous packed ice network triggered by the electric field.

Video S8: The dendrites collapse forming packed ice, under nil electrode voltage.

Video S9: Removal of dendrites and packed ice.

Supplementary Calculations and Equations:

Estimates of needle charge, based on the minimum force required for ice extraction from the substrate.

The frequent observation in the videos of needles, dendrites, and aggregates flying from their grounded or ungrounded substrates toward the biased electrode allows an estimation of ice charge by calculating the minimum electric force required to surpass the needle weight. The following example was calculated for a needle attached to a dendrite as shown in Figure S1:

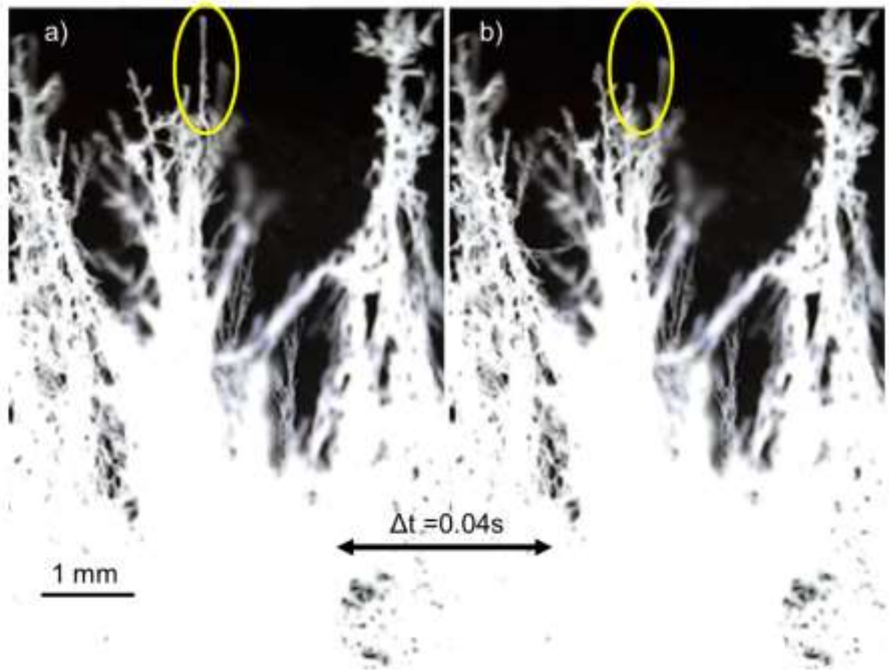

Figure S1. Needle extraction from a dendrite. The yellow ellipse in **(a)** encloses a needle (height h = 0.001 m and diameter $2r$ = 0.0001 m), that flew from a dendrite top, and is no longer seen in **(b)**.

a) volume of a needle with height h = 0.001 m and diameter $2r$ = 0.0001 m:

$$V_n = \pi r^2 h = 3.1416 \times 0.25 \times 10^{-8} \times 10^{-3} = 7.85 \times 10^{-12}\ \text{m}^3$$

b) needle area: $s_n = 2 \times 3.1416 \times rh = 3.14 \times 10^{-7}\ \text{m}^2$

c) needle weight $w_n = v_n \rho$ (density) = $7.85 \times 10^{-12}\ \text{m}^3$. 900 kg.m^{-3} = 7.07×10^{-9} kg = 7.07×10^{-8} N.

d) number of water molecules in a needle: $n_w = (w_n/0.018\ \text{kg.mol}^{-1})$ x Avogadro number = 2.36×10^{17}.

e) minimum modulus of the vertical component of the electrical force F_{el} required to levitate the needle, $F_{el} = 7.07 \times 10^{-8}$ N.

f) minimum needle charge q_{min} required to obtain $F_{el} = 7.07 \times 10^{-8}$ N under 180 kV.m^{-1} potential gradient: $q_{min} = 7.07 \times 10^{-8}$ N/ 1.8×10^5 V.m^{-1} = 3.93×10^{-13} Coulombs.

g) needle surface charge density = 3.93×10^{-13} Coulombs/3.14×10^{-7} m^2 = 1.25×10^{-6} C.m^{-2}

h) mol number N of monovalent ions equivalent to the needle charge: $n_i = q_{min}$ x Avogadro number / Faraday electrochemical equivalent: $n_i = q_{min} \times 6.02 \times 10^{23}/ 96485 = 2.45 \times 10^6$ ions per needle.

i) mol fraction of ions in needle, $x_i = n_i$/number of water molecules: $x_i = n_{i/}\ n_w$ = 2.45 x 10^6/ 2.36 x 10^{17} = 1.07 x 10^{-11}.

Assuming that ions are exclusively located in the ice needle surface monolayer:

j) number of water molecules in the needle surface, $n_{ws} = s_n$/area occupied by a molecule with radius 0.275 x 10^{-10} nm: n_{ws} = 3.14 x 10^{-7} m^2/ (3.1416 x r^2) = 1.32 x 10^{14} water molecules.

k) mol fraction of ions in the needle surface, $x_{is} = n_i / n_{ws}$ = 2.45 x 10^6 ions/1.32 x 10^{14} water molecules = 1.85 x 10^{-8}.

Summing up, the large number of ionic charges required to have an ice needle pulled out of the supporting surface under the potential gradients used in this work is a small fraction of the number of water molecules at the needle surface: 18 ions per billion surface water molecules. That is a slight departure from stoichiometry and water electroneutrality. Dividing the surface charge density σ by the air permittivity ε, as in the Poisson equation, yields the electric potential gradient E:

l) $E = \sigma/\varepsilon$ = 1.25 x 10^{-6} C.m^{-2} / 0.085 x 10^{-10} F.m^{-1}= 1.47 x 10^5 V.m^{-1}

Similar calculations using needle height and radius data from other needle fluctuation events allows the calculation of the charge density and electric fields shown in Table S1.

Table S1. Height, radius, surface charge density and electric field of charged needles extracted from the ice surface.

Events	Height (m)	Radius (m)	Surface charge density (C.m^{-2})	Electric field (V.m^{-1})
1	0.3 x 10^{-3}	2.7 x 10^{-5}	6.8 x 10^{-7}	7.9 x 10^4
2	1.1 x 10^{-3}	3.3 x 10^{-5}	8.3 x 10^{-7}	9.8 x 10^4
3	0.3 x 10^{-3}	3.7 x 10^{-5}	9.4 x 10^{-7}	1.1 x 10^5
4	0.4 x 10^{-3}	3.3 x 10^{-5}	8.3 x 10^{-7}	9.8 x 10^4
5	1.0 x 10^{-3}	3.8 x 10^{-5}	9.6 x 10^{-7}	1.1 x 10^5
6	0.4 x 10^{-3}	4.8 x 10^{-5}	1.2 x 10^{-6}	1.4 x 10^5

7	0.5×10^{-3}	3.1×10^{-5}	7.8×10^{-7}	9.2×10^{4}
8	0.6×10^{-3}	3.4×10^{-5}	8.6×10^{-7}	1.0×10^{5}
9	0.9×10^{-3}	4.4×10^{-5}	1.1×10^{-6}	1.3×10^{5}
10	0.6×10^{-3}	3.8×10^{-5}	9.6×10^{-7}	1.1×10^{5}
11	0.8×10^{-3}	4.6×10^{-5}	1.1×10^{-6}	1.3×10^{5}
12	0.2×10^{-3}	2.5×10^{-5}	6.4×10^{-7}	7.5×10^{4}
13	0.7×10^{-3}	3.3×10^{-5}	8.2×10^{-7}	9.7×10^{4}
14	0.4×10^{-3}	2.5×10^{-5}	6.2×10^{-7}	7.3×10^{4}