Supplementary materials

An efficient self-driven fog harvesting system based on Kelvin waterdrop generator

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Supplementary Text

Working principle of the Kelvin waterdrop generator

The working principle of Kelvin waterdrop generator is the electrostatic induction effect and positive feedback regulation. As Figture S1 shows, as the water drops, the generator obtains stray charges from the surroundings at a certain moment.[1-3] Assuming that the waterdrops at the left side obtains negative charges (Fig. S1a), metal drum D and metal ring C will be negative charged as them falling into metal drum D and then the waterdrops at the right side are positive charged due to the electrostatic induction effect (Fig. S1b). Metal drum B and metal ring A will be positive charged when the right drops fall into B, and then the left waterdrops induce negative charges (Fig. S1c). As water drops continuously, the negative charges in D and positive charges in B accumulate explosively (Fig. S1d), which enables positive feedback regulation.

Calculation of the dielectrophoretic force applied on the droplets

Fog droplets are composed of H_2O molecule, which is a polar molecule. When an electric field is applied, the positive charges inside the droplets move to one end along the direction of the electric field, and the negative charges move to the other end along the opposite direction of the electric field, which is called polarization[4]. The opposite charges on the fog droplets' two ends will be subjected to electrostatic force with opposite direction, and the net electrostatic force on the fog droplets is called dielectrophoretic force (*F*).

The equation for *F* is: $F=2\pi d^3\varepsilon_m \mathrm{Re}[K(\varepsilon_p^*, \varepsilon_m^*)]\ \nabla|E|^2$. d is the diameter of droplet, m. ε_m is dielectric constant of continuous phase, $F\cdot m^{-1}$. $\mathrm{Re}[K(\varepsilon_p^*, \varepsilon_m^*)]$ is real part of Clausius-Mossotti coefficients, and $\mathrm{Re}[K(\varepsilon_p^*, \varepsilon_m^*)] = (\varepsilon_p - \varepsilon_m)/\ \varepsilon_p + 2\varepsilon_m$. ε_p is dielectric constant of the dispersed phase, $F\cdot m^{-1}$. When $\mathrm{Re}[K(\varepsilon_p^*, \varepsilon_m^*)] > 0$, the dielectrophoretic force of the droplet points to the direction of the higher field. When $\mathrm{Re}[K(\varepsilon_p^*, \varepsilon_m^*)] < 0$, the dielectrophoretic force of the droplet points to the direction of the lower field.[5]

In the fog harvesting experiment, the fog droplets are consisted of water, with $d \sim 25$ μm, $\varepsilon_m = \varepsilon_0 = 1$ and $\varepsilon_p = 81$. So $\mathrm{Re}[K(\varepsilon_p^*, \varepsilon_m^*)] = 0.96 > 0$. When it is in the uniform electric field, $\nabla|E|^2 = 0$, so $F = 0$, the motion of the mist droplets is not affected by the electric field. When it is in the nonuniform electric field, $\nabla|E|^2 > 0$, and $F > 0$, the dielectrophoretic force of the fog droplets points to the direction of the higher field.

Supplementary Figures

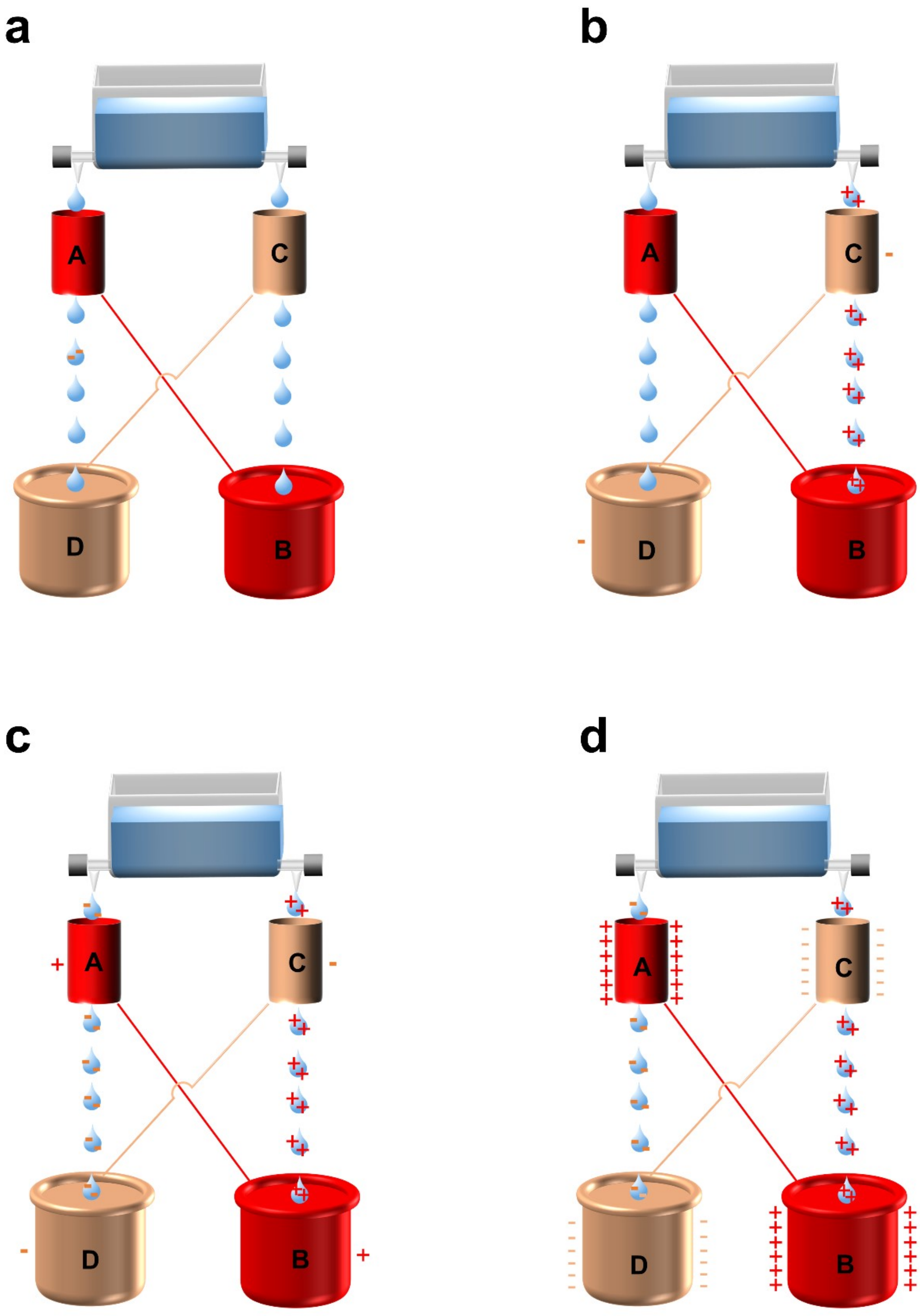

Figure S1. Working principle schematic diagram of Kelvin waterdrop generator, A and C are metal rings, B and D are metal drums, AB and CD are crosslinked by wires.

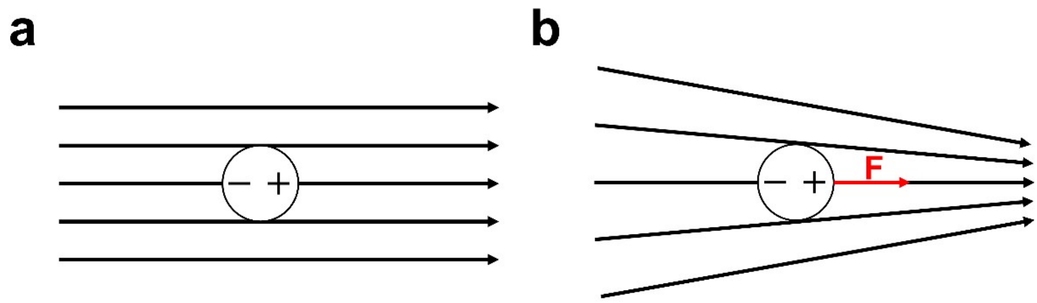

Figure S2. Schematic image for the dielectrophoretic force of the fog droplet in different electric fields. (a) The fog droplet in uniform electric field. (b) The fog droplet in nonuniform electric field.

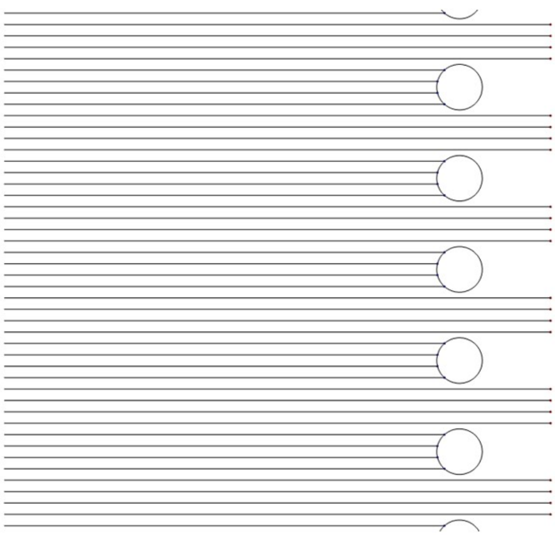

Figure S3. Simulation of the trajectory of the fog droplets without applying the electric field.

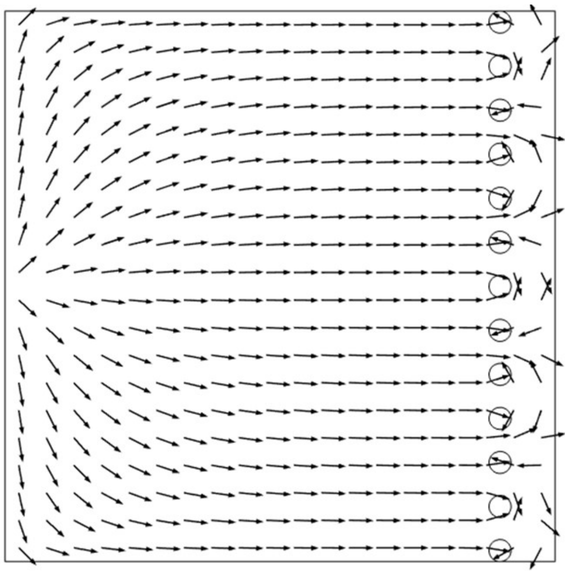

Figure S4. Simulation of the electrostatic force applied on the fog droplets by discharge.

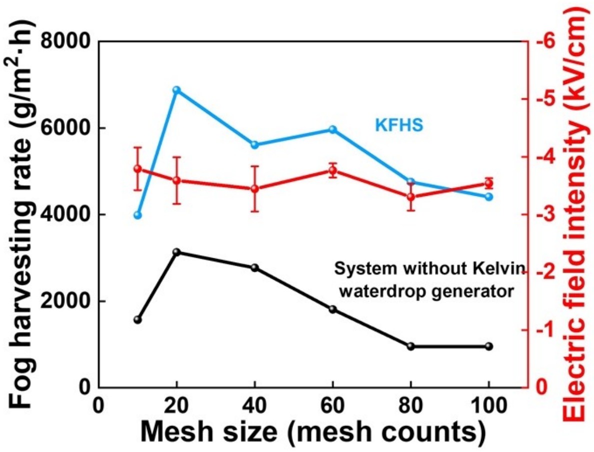

Figure S5. The fog harvesting rate and the electric field intensity of the KFHS and the system without Kelvin waterdrop generator with different mesh size.

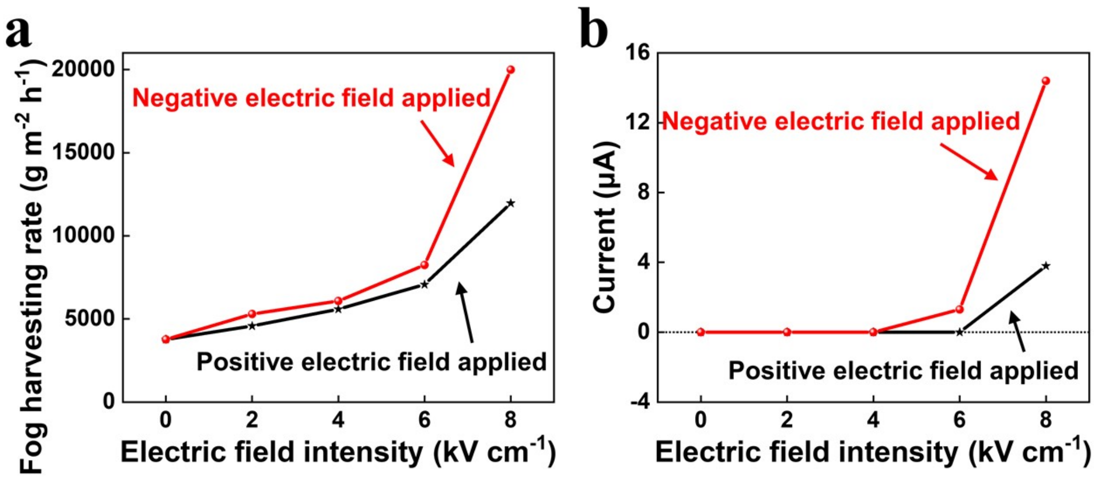

Figure S6. (a) Fog harvesting rate with different electric field intensity. (b) Discharge current of the probe tip.

Supplementary references:

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