Supporting Information

High-Efficiency Superheated Steam Generation for Portable Sterilization under Ambient Pressure and Low Solar Flux

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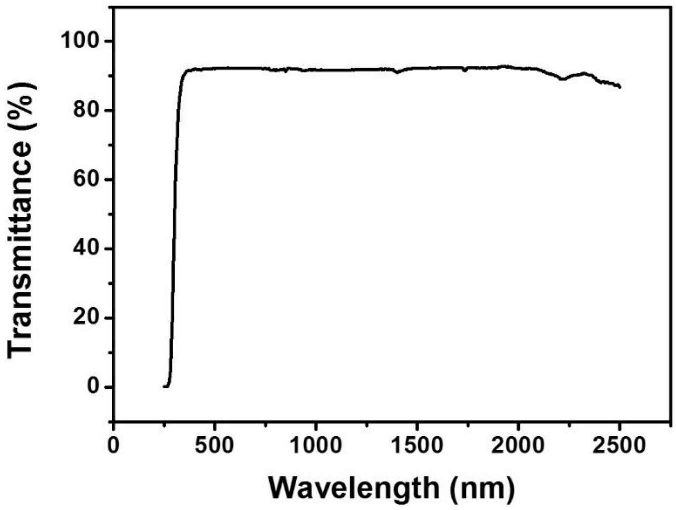

Figure S1. Transmittance spectrum of the outer glass for the solar vacuum tube.

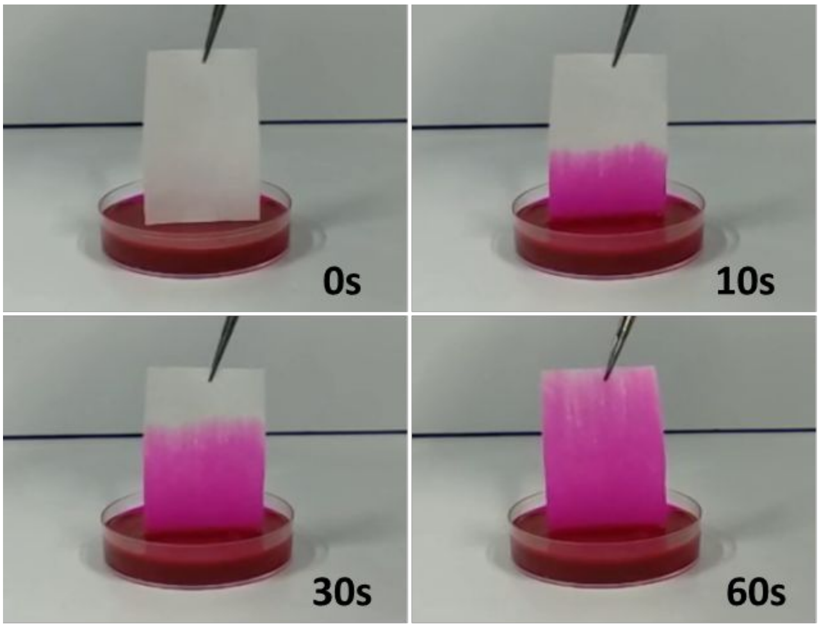

Figure S2. Wicking capacity test of the air-laid paper.

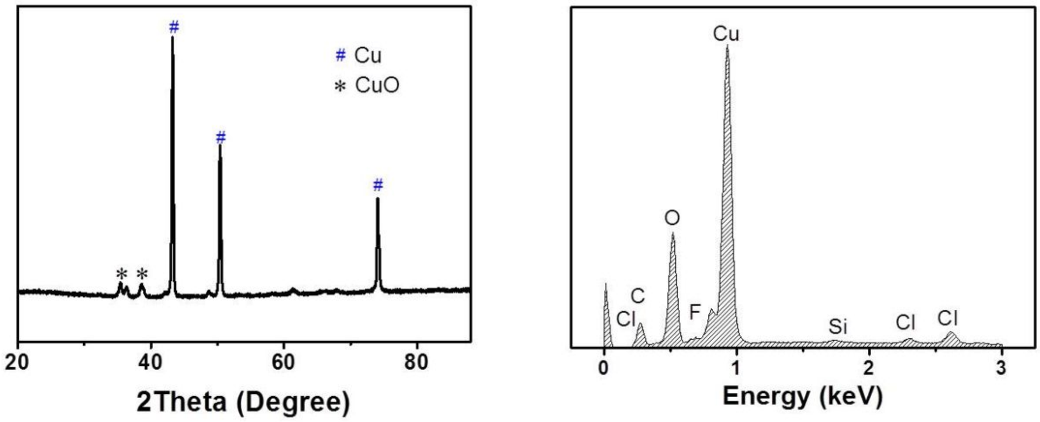

Figure S3. XRD spectrum (left) of treated hydrophilic and EDS analysis (right) of the hydrophobic copper mesh treated with fluorosilane.

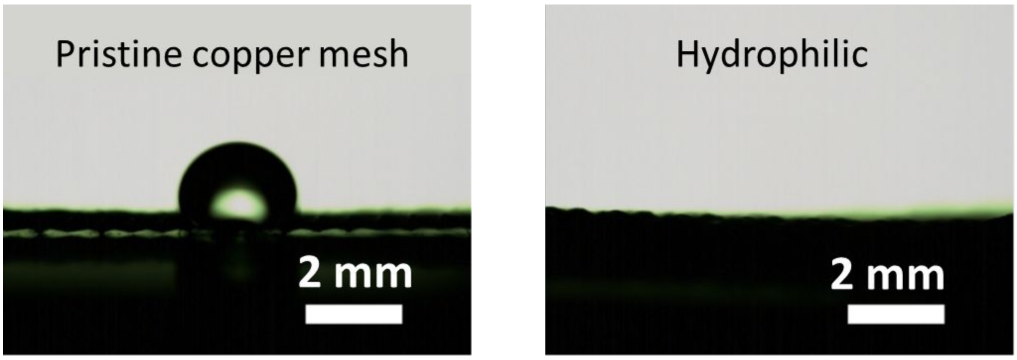

Figure S4. Contact angle measurements for the pristine copper mesh (left) and hydrophilic copper mesh (right).

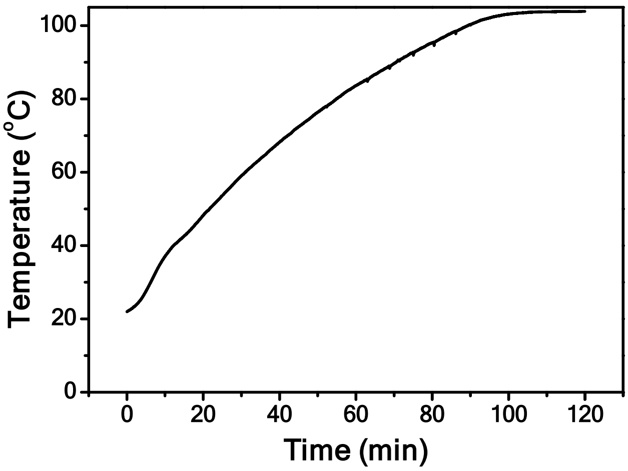

Figure S5. Temperature evolution of the non-illuminated side of the solar vacuum tube under one-sun illumination.

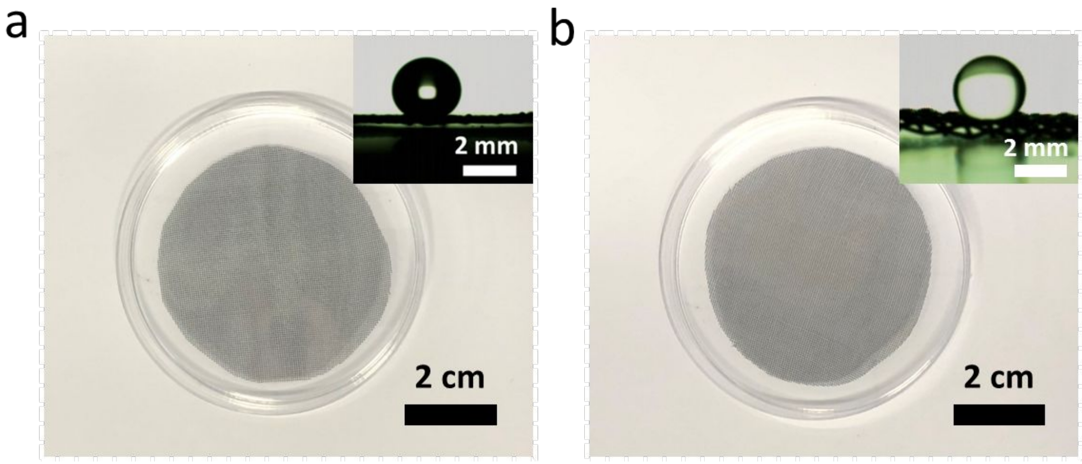

Figure S6. Comparison of the appearance and water contact angle of the hydrophobic copper mesh after continuous operation of the steam generator for 7 days: (a) before operation, (b) after operation.

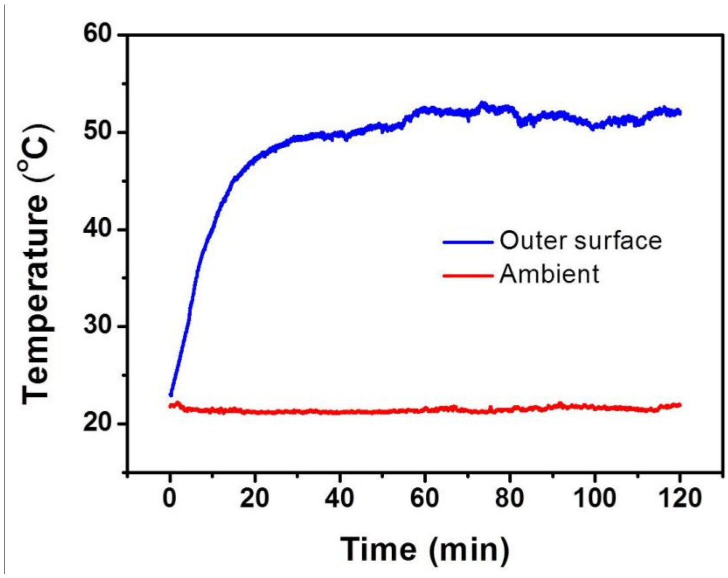

Figure S7. Temperature evolution of outer surface in the superheated steam generator with an evaporation occupation of 20%.

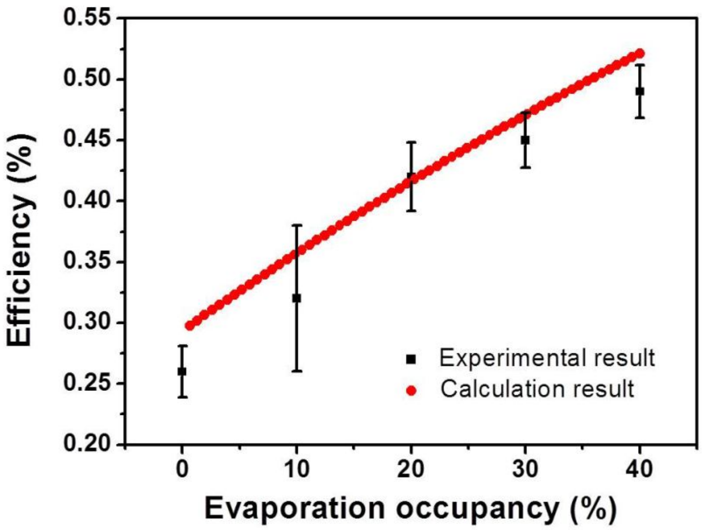

Figure S8. Evaporation efficiency of the superheated steam generator as a function of evaporation occupation.

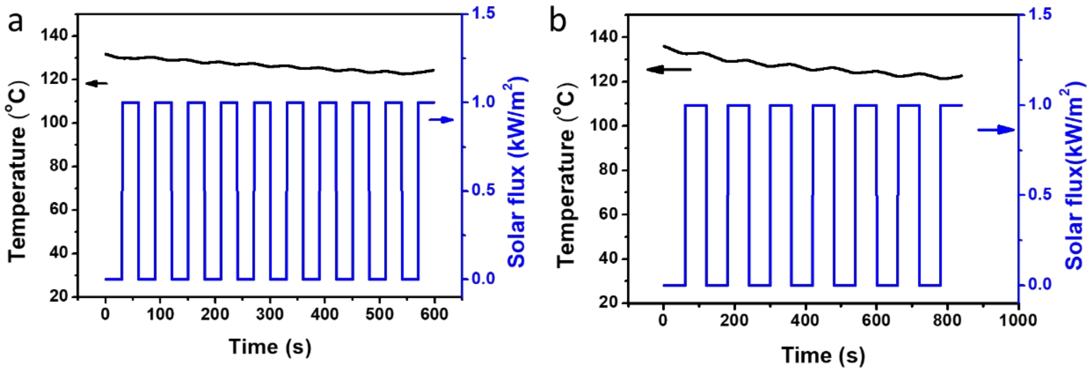

Figure S9. Steam temperature evolution under periodically switching-on and switching-off one-sun solar illumination: (a) 30 s (on) and 30 s (off), and (b) 1 min (on) and 1 min (off).

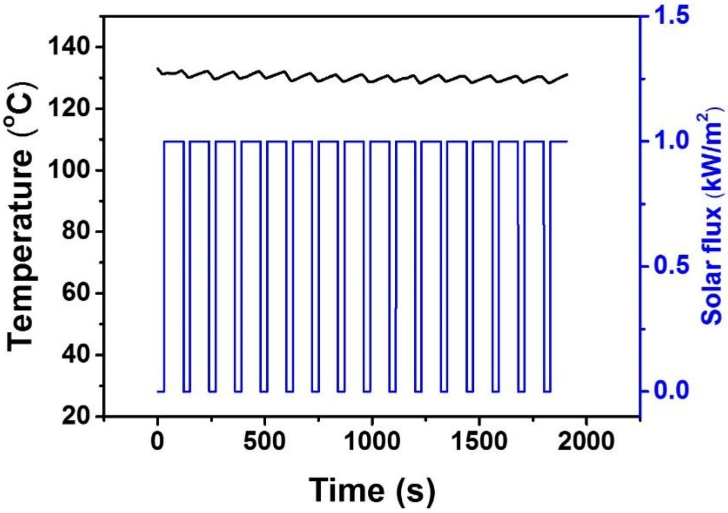

Figure S10. Steam temperature evolution under periodically switching-on and switching-off one-sun solar illumination: 90 s (on) and 30 s (off).

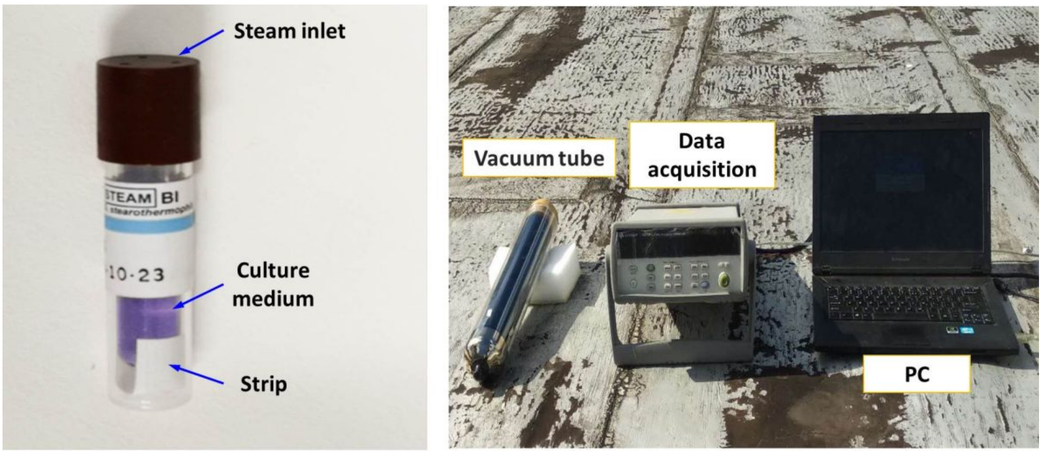

Figure S11. Schematic structure of the biological indicator (left), and the outdoor experimental setup (right).

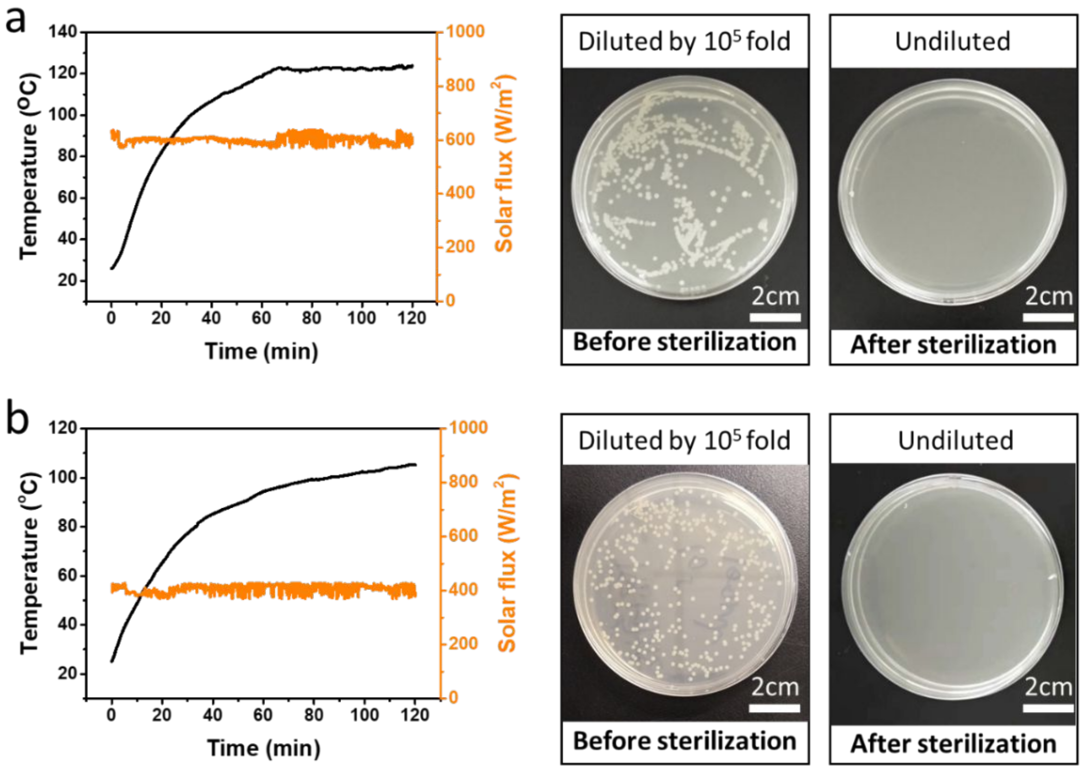

Figure S12. Steam temperature evolution of the steam generator and solar steam sterilization performance under (a) 0.6 sun and (b) 0.4 sun illumination.

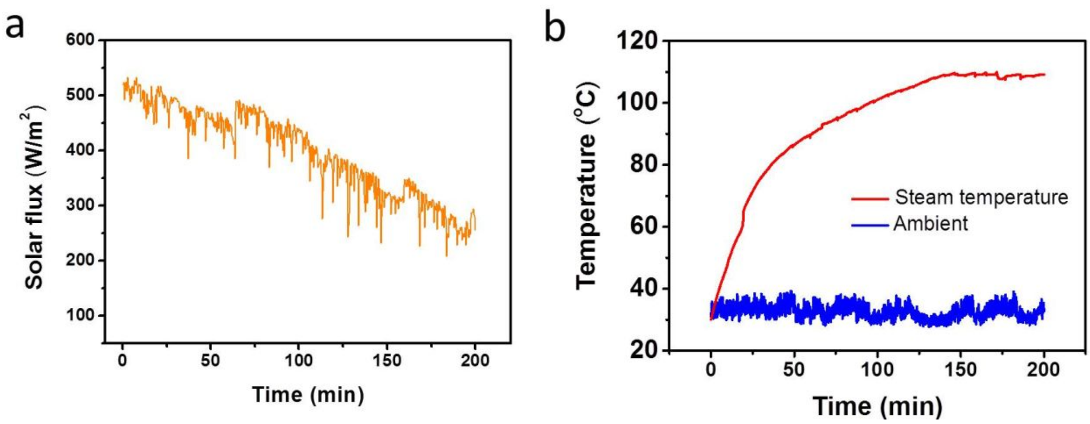

Figure S13. (a) Outdoor solar radiation on a cloudy day. (b) Steam temperature evolution over time for the superheated steam generator under the cloudy day.

Supplementary Note S1

Heat transfer analysis of the superheated steam generator

Besides driving water evaporation (q_{evap}), the incident solar energy is also lost to the environment through radiation (q_{rad}) and convection (q_{conv}). According to energy balance principle, the energy conservation equation can be described by:

$$q_{\mathrm{sol}} \cdot \tau_{\mathrm{glass}} \cdot \alpha_{\mathrm{abs}} \cdot A = q_{\mathrm{rad}} \cdot A' + q_{\mathrm{conv}} \cdot A' + q_{\mathrm{evap}}$$

where τ_{glass} is the transmittance of the outer glass (0.92), α_{abs} is the absorptance of the selective absorber (0.93), A is the effective solar absorption area (259.05 cm^2), A' is the heat-dissipating area (518.1 cm^2). The radiation heat loss q_{rad} and convection heat loss q_{conv} can be calculated by：

$$q_{\mathrm{rad}} = \varepsilon \cdot \sigma \cdot \left(T_{\mathrm{s}}{}^{4} - T_{\infty}{}^{4}\right)$$

$$q_{\mathrm{conv}} = h \cdot \left(T_{\mathrm{glass}} - T_{\infty}\right)$$

where ε is the emittance of the selective absorber (0.07), σ is the Stefan-Boltzmann constant (5.67×10^{-8} $W/m^2\,K^4$), h is the convection heat transfer coefficient (5 $W/\,m^2\,K$), T_{s}, T_{glass} and T_{∞} are the temperature of the selective absorber, the outer glass and the ambient temperature, respectively. Based on the experimental temperatures, the convection and radiation heat losses can be calculated and then the evaporation efficiency is obtained.