Biomass-derived 3D Evaporator with Hierarchical Pore Structures for Effective Evaporative Cooling

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We developed a 3D solar steam generator with the highest evaporation rate reported so far using a carbonized luffa sponge (CLS). The luffa sponge consisted of entangled fibers with a hierarchically porous structure; macropores between fibers, micro-sized pores in the fiber-thickness direction, and microchannels in the fiber-length direction. The microchannels in the fiber-length direction transported water to the top surface of the CLS by capillary action, and the micro-sized pores in the fiber-thickness direction delivered water to the entire fiber surface. The water evaporation rate was 14.5 kg m^{-2} h^{-1} under 1-sun illumination and 2 m/s wind that corresponded to the highest evaporation rate ever reported under the same condition. In addition, it was found that the air temperature dropped by 3.6 ℃ when the wind passed through the CLS because of the absorption of the latent heat of vaporization. The heat absorbed by the CLS during water evaporation was calculated to be 9.7 kW/m^2 under 1-sun illumination and 2 m/s wind, which was 10 times higher than the solar energy irradiated on the same area (1 kW/m^2).