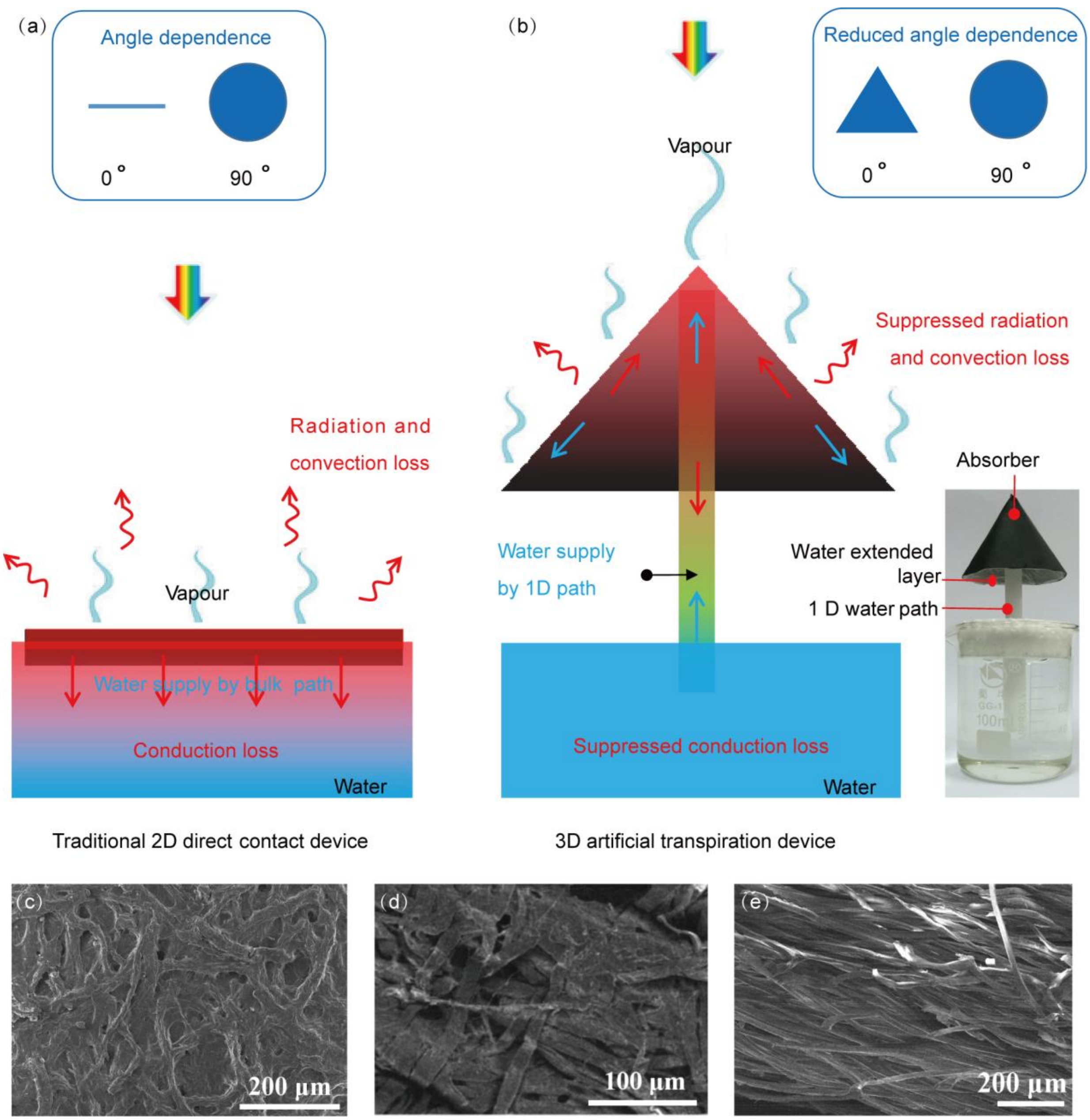
Artificial transpiration for solar water purification

June 2 2017



(a) This is a schematics of traditional two dimensional solar steam generation with direct water contact. (Here, the conduction loss means the heat from the absorber to bulk water. The convection and radiation loss mean the heat from absorber to environment) (b) Schematics of three dimensional artificial transpiration device with suppressed heat loss. (The red straight arrows represent the direction of heat conduction. The red crooked arrows represent the direction of heat convection and radiation. The blue straight arrows represent the direction of water supply.) Credit: ©Science China Press

Recently, solar steam and vapor generation has attracted attention as a promising prospect in desalination, sterilization and chemical purification. Tremendous progress has been achieved in absorber designs and thermal management. However, in all the previous designs, because of the minimized optical loss and heat conduction loss, losses related to convection and conduction start to dominate. Therefore, it becomes critical to simultaneously minimize the losses related to radiation, convection and conduction simultaneously in order to achieve optimum solar steam performance and enable widespread applications.

In research reported in the *National Science Review*, the Zhu group at Nanjing University, China, has developed a new concept of "artificial transpiration" with a graphene oxide-based 3-D hollow cone structure (Fig. 1). In this unique 3-D artificial transpiration device, a 1-D water path was used to obtain efficient water supply and suppressed conduction loss at the same time. The radiation and convection losses were also minimized by lowering the absorber temperature via increased evaporation surface area and carefully designed morphology. As a result, this device enable over 85 percent solar vapor efficiency under one sun irradiation without external thermal insulation and optical supporting systems.

Another feature in this 3-D artificial transpiration device is the ability to collect more sunlight throughout the day, compared with a 2-D flat horizontal device. In contrast to the fixed, simulated sun light used in the lab, the sun is constantly changing its position in the sky. Furthermore, large portion of the sunlight (10 to 50 percent) is diffusive, arriving to the receiver from all directions. The results show that 3-D absorption structures can absorb more light (about ~24 percent) than 2-D devices, which is beneficial to real world applications.

It is also demonstrated that the artificial transpiration device can enable effective water treatment through two pathways, producing clean water condensed from vapor and recycling heavy metals. The extracted water from the condensed vapor is pure enough to meet WHO drinking water standards, even starting with waste water containing high concentrations of Cu^{2+}, Cd^{2+}, Pb^{2+} and Zn^{2+} (5000 mg/L, 5000 times higher than WHO drinking water standards). Meanwhile, heavy metals such as Au and Cu can be recovered.

Therefore, this artificial transpiration device provides a complementary approach for efficient, effective and portable solar water treatment.

More information: Xiuqiang Li et al, Three-dimensional artificial transpiration for efficient solar waste water treatment, *National Science Review* (2017). DOI: 10.1093/nsr/nwx051

Provided by Science China Press