TECHICAL ASSISTANCE REQUEST

The MIST Team, led by Reactwell, L.L.C., seeks to develop a scalable micro-porous membrane layer coating methodology and a pilot-scale membrane module for solar-thermal distillation. Technical assistance to meet this task will be provided by the Oak Ridge National Laboratory (ORNL) where this technology was initiated [1,2,3]

The core technology of the MIST device is a superhydrophobic carbon-composite membrane coated on a porous graphite foam (GF) which helps to contain liquid water and allows a membrane distillation mechanism to work more efficiently than traditional distillation processes. The membrane was initially fabricated by a microparticle slurry coating, which was used to cover the open cells and pores of the top surface of a graphite foam, forming a microporous layer [Figure 1]. Nanoparticle slurry coating was then applied to further reduce the pore size to <500 nm, resulting in a nanoporous selective layer. Lastly, the nanoporous carbon surface was coated with superhydrophobic molecular coating to produce a superhydrophobic surface that will be more resistant to leaking under elevated pressure. The pore size, size distribution, and porosity of the carbon-composite membrane skin layer of graphite foam on the upstream side are all critical parameters for wetting resistance and liquid entry pressure. The hierarchical membrane-pore structure and superhydrophobic coatings will be further optimized to yield a scalable thermally durable membrane.

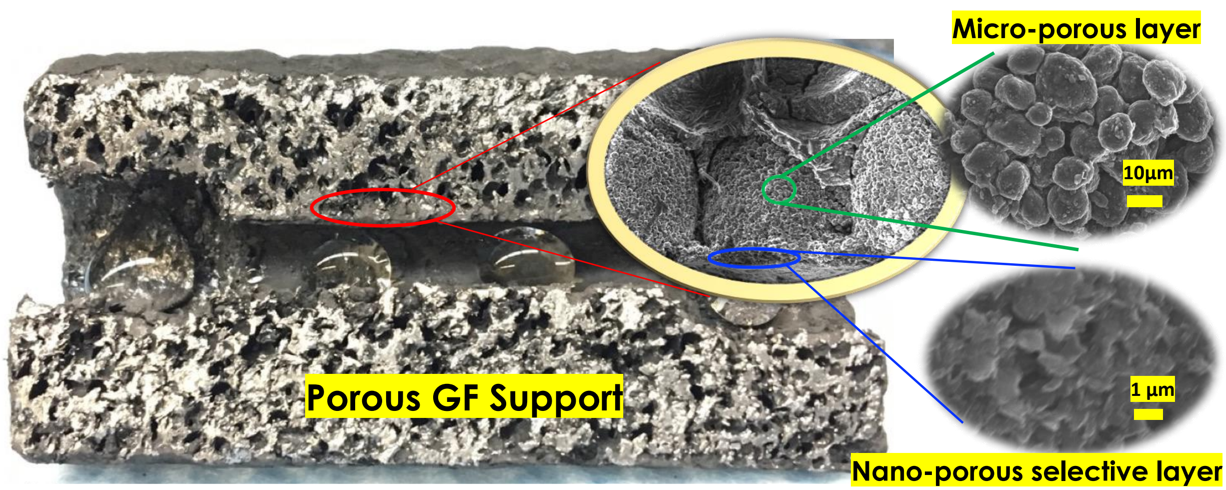

Figure 1. Superhydrophobic coated graphite foam tubular membrane.

Based on current solar-membrane performance data, the required membrane area as a function of concentrated solar intensity was determined [Figure 2]. Considering 3-4 suns solar intensity (e.g., 140–170 ºC heating) as the most suitable for the full-scale MIST system, the estimated membrane area required is 990–1870 m^2. Therefore, a multi-flow channel membrane module shall be designed to increase the membrane area within a limited volume, so that significant reduction in CAPEX and OPEX is achieved. The machining of base material (i.e., highly thermally-conductive GF) to a multi-channel module is doable; however, the membrane-layer coating of the internal walls of a large-scale system could be challenging. This challenge can be overcome at ORNL where various nano/micro-scale materials will be tested for forming thermally durable functional membrane layers and various advanced characterization tools will be employed to determine factors affecting pore structure. Through various measurements at user facilities of ORNL, such as the Center for Nanophase Materials Science, a correlation between pore structure and flux/thermal conductivity will be obtained. In parallel, a methodology will be developed and demonstrated for the fabrication of optimized membrane with a large-scale coating (e.g., 1.0 m^2 membrane area). Also, due to the unique material properties of GF, a seamless membrane module frame consisting of a glass tube and inlet and outlet ports will be investigated.

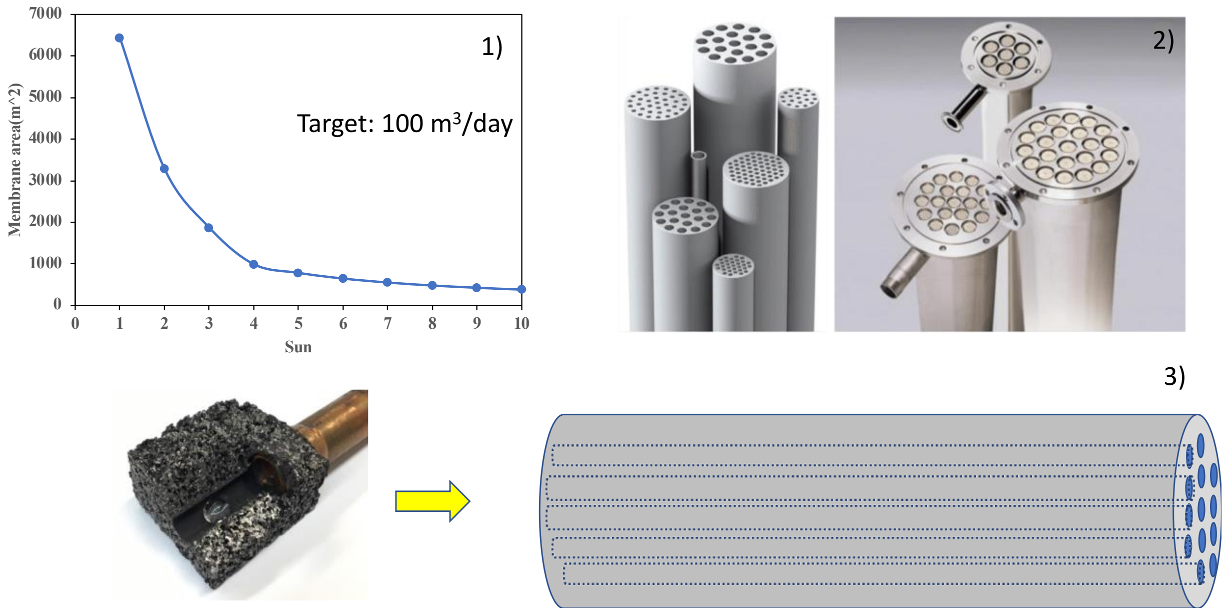

Figure 2 1) Solar Membrane area requirement as a function of solar intensity; 2) A commercial multi-channel inorganic membrane and module to pursue in MIST devices; 3) Proposed multi-channel GF membrane.

Reference

(1) G.G. Jang et al., “Efficient solar-thermal distillation desalination device by light absorptive carbon composite porous foam” *Global Challenges* 3 (2019) 1900003.
(2) G.G. Jang et al., “Superhydrophobic coated micro-porous carbon foam membrane and method for solar-thermal driven desalination” US20200101420A1.
(3) G.G. Jang et al., “Solar-Thermal Membrane Pervaporation for Dewatering Aqueous Organic-Acid Solutions,” *Separation & Purification Technology*, 267 (2021), 118232.