

Title:

One-step electrospray deposition of carbon materials to construct scalable photoactive membrane for solar membrane desalination

Authors & affiliations:

*Ting-Hsun Chou^{*1}, Kuo-Lun Tung¹*
¹Department of Chemical Engineering, National Taiwan University, Taiwan

Abstract:

Solar energy, with its inherent advantages of clean and renewable, has been used worldwide for generating electricity or desalting seawater. Nanophotonics-enabled solar membrane distillation (NESMD), an emerging thermal-driven process for seawater desalination, combines interfacial heating via photothermal nanomaterials with conventional membrane distillation technology to achieve high solar utilization efficiency as well as vapor-to-distillate conversion efficiency. However, it's still a grand challenge thus far to develop a cost-effective and potentially commercializable membrane utilizing low-cost materials along with scalable fabricating techniques. Herein, a dual-layer carbon black (CB)/PVDF membrane was prepared based on a one-step electrospray method. With the introduction of a functional layer, photothermal effect was imparted to the bare membrane, thus significantly boosting the water production rate and solar utilization efficiency (SUE) when exposed to the artificial sunlight (~57% enhancement and 72% SUE under 1 sun). In addition to the outstanding photothermal property, hierarchical structures on the substrate, constructed by the entanglement of PVDF polymers and the re-entrant shape of CB nanoparticles, endowed the as-prepared membrane with a slippery surface and therefore retarded the heterogeneous crystallization of inorganic salts, which commonly resulted in the deterioration of membrane performances. Hence, when treating hypersaline feeds composed of 10 wt% of NaCl or 20 mM gypsum, the electrospray-engineered membrane demonstrated a scaling mitigation behavior (<5% flux reduction) during a 24-hr operation compared with the original membrane. This multifunctional coated membrane along with a fast-growing solar desalination technology provided a promising solution to water crisis, especially in the off-grid areas where energy and resources are both relatively insufficient.