Polymeric Photothermal Membranes for Interfacial Solar Heating

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Abstract

Water evaporation under the solar light irradiation plays a critical role in both the global water cycle and many industrial processes. In some remote and rural areas where access to centralized drinking water supply is unavailable, solar distillation is used to produce freshwater, which uses solar energy to heat and evaporate seawater or brackish water. However, the relatively slow evaporation rate of the conventional solar evaporation limits their performance and applications, as in the conventional solar evaporation bulk water is heated up and thus it would unavoidably result in unnecessary heat/energy loss due to the energy transfer to the non-evaporative portion of the bulk water. Therefore, targeting at enhancing only the local temperature of the interfacial water is more meaningful and energy-efficient for a high evaporation rate. Aiming at enhancing the solar-driven water evaporation rate, we rationally designed and fabricated a photothermal polymer-based interfacial heating membrane, which spontaneously stayed at the water–air interface due to its hydrophobicity, collected and converted solar light into heat with high efficiency, and locally heated only water near the air/water interface. Moreover, given the likelihood of losing its hydrophobicity during application, a self-healing capability was readily introduced to the polymeric membrane due to the relatively large free volume of polymeric materials. The hydrophobicity self-healing capability ensures the long-term stability of the photothermal membrane for practical applications. Furthermore, we also prepare bi-layered photothermal membranes, which effectively prevent the heat loss from the photothermal materials to the bulk water due to the conduction. This kind of the bi-layered structures exhibits great potential for the practical applications in solar driven evaporation. This work provides a new concept for next-generation solar-driven water desalination.

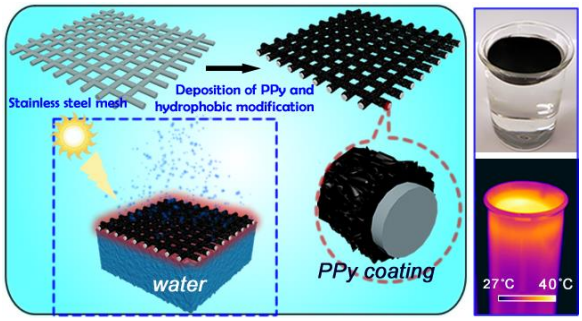


Figure 1. Polymeric light-to-heat conversion membranes for interfacial solar heating are fabricated by deposition of light-to-heat conversion material of polypyrrole onto porous stainless steel mesh, followed by hydrophobic fluoroalkylsilane modification. The mesh-based membranes spontaneously stays at the water-air interface, collects and converts solar light into heat, and locally heats only the water surface for an enhanced evaporation.

Recent Publications

1. Zhang LB, Wang P (2016) Smart Materials for Advanced Environmental Applications, Royal Society of Chemistry (RSC) Publishing.
2. Jin Y, Zhang LB, Wang P (2017) Atmospheric Water Harvesting: Role of Surface Wettability and Edge Effect. Global Challenges 1: 1700019.
3. Li RY, Zhang LB, Shi L, Wang P (2017) MXene Ti3C2: an Effective 2D Light-to-Heat Conversion Material. ACS Nano 11: 3752–3759.
4. Zhang LB, Li RY, Tang B, Wang P (2016) Solar-thermal conversion and thermal energy storage of graphene foam-based composite' Nanoscale 8: 14600-14607.
5. Zhang LB, Tang B, Wu JB, Li RY, Wang P (2015) Hydrophobic Light-to-Heat Conversion Membranes with Self-Healing Ability for Interfacial Solar Heating" Advanced Materials 27: 4889-4894.



Biography

Lianbin Zhang is currently a full professor in school of chemistry and chemical engineering of Huazhong University of Science and Technology, China. He received his B.Sc. degree in polymer material and engineering in 2005 and Ph.D. degree in polymer chemistry and physics in 2010, both from Jilin University, China. He then conducted postdoctoral research studies in Hong Kong University of Science and Technology in 2010 and at King Abdullah University of Science and Technology from 2010 to 2012. He also worked a research scientist in King Abdullah University of Science and Technology from 2012 to 2016, after which he joined in the Huazhong University of Science and Technology as a full professor. His scientific interests are focused on functionalized interfacial materials, stimuli-responsive nanomaterials, and their applications in environmental and biological fields.

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