Synergistic Approach for Efficient Water Harvesting using LiCl-PVA Hydrogel and Nanofiber membrane

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Demand for fresh liquid water continues to rapidly compared with the available supply as the global population is growing fast. In several megacities of developing countries, fresh water will outstrip supply by 2035[1]. The development of sorbents for atmospheric water harvesting could be one of the sustainable technologies to address water scarcity, particularly in the semi-arid region. This approach has the potential to reduce the burden on conventional freshwater production, as self-supply becomes feasible. LiCl salt exhibits significantly higher water absorption characteristics among sorbent materials[2]. Hydrogel, with hydroxyl groups on its porous surfaces, synergizes with lithium chloride in the hydrogel for water harvesting applications, extracting drinkable water from unsaturated vapor. Particularly, the abundant hydroxyl groups between polyvinyl alcohol (PVA) chains lead to the formation of a hydrogel structure through physical cross-linkage during the cyclic freeze-thawing method, without using a chemical crosslinker[3]. The LiCl-containing PVA hydrogel, produced via the freeze-thawing method, enables a sustainable structure and serves as a non-toxic sorbent for producing drinkable water. However, excessive lithium ions can collapse the hydrogel structure in vapor-saturated conditions. The vapor kinetics in the hydrogel are slowed in the cyclic water harvesting process. Here, we introduce a novel sorbent structure based on the hygroscopic nature of lithium chloride (LiCl) to enhance the efficiency of water harvesting from the atmosphere. a nanofiber membrane is applied to reinforce the structure of the LiCl-containing PVA hydrogel and enhance the vapor sorption and desorption kinetics. The porous membrane has a pore distribution within the 1 to 10 μm range, improving the sorption kinetics of the LiCl-PVA hydrogel. For water molecules, the sorption kinetics of vapor from the air to the porous structure of the hydrogel, bonded with the nanofiber membrane, is higher than that of the hydrogel without the nanofiber membrane. The required time to reach 80% of the equilibrium mass for water saturation in the hydrogel decreased by more than 6 times. The shortened vapor saturation cycle is expected to accelerate the total water collection ratio from semi-arid air.

References:

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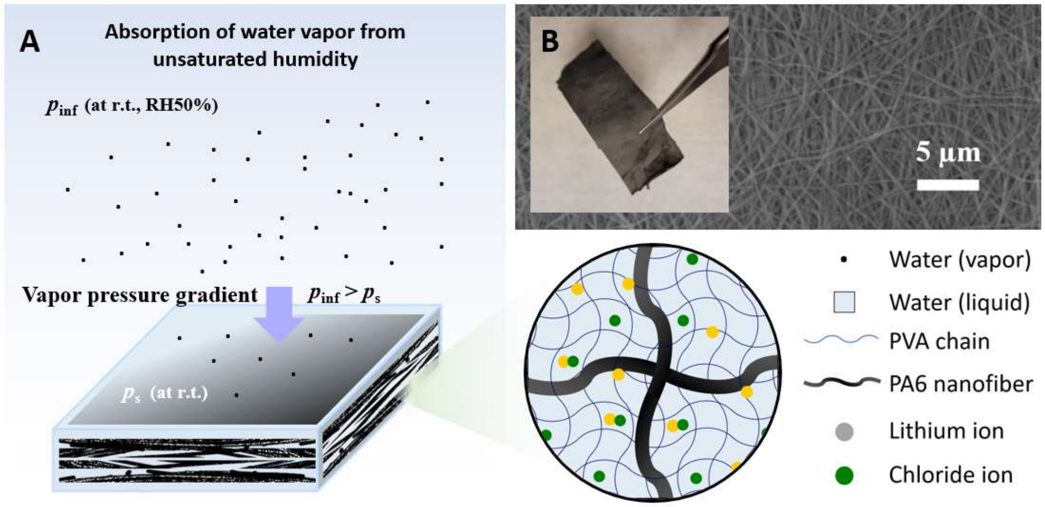

Figure 1. (A) Schematic of the sorbent: PA6 nanofiber membrane embedded LiCl-PVA hydrogel for water harvesting under unsaturated humidity conditions (B) Images of the carbon black-decorated PA6 nanofiber membrane.

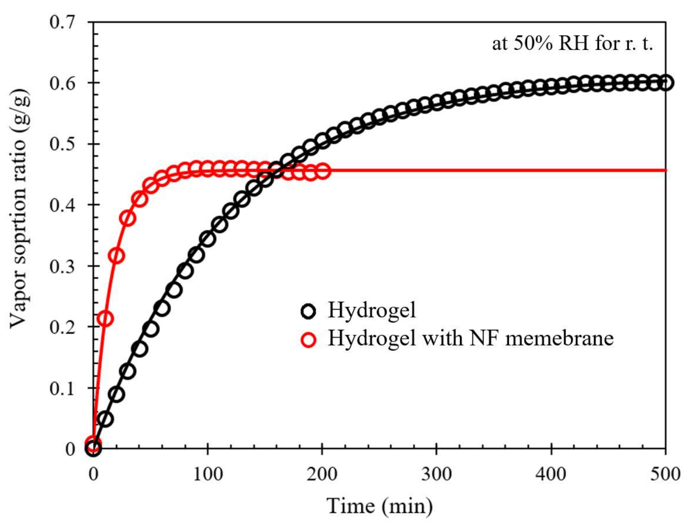

Figure 2. Vapor sorption ratio of the PVA hydrogel containing 8 wt% of LiCl with and without nanofiber membrane structure at 50% relative humidity under room temperature conditions. Water vapor saturation in the nanofiber membrane with the PVA hydrogel structure occurred within 26 minutes, representing over 80% of equilibrium mass ratio of the sorbent.

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