Development of A Photo-Responsive Moisture-Absorbent Composite for Atmospheric Water Extraction

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Abstract

Poly(*N*-isopropylacrylamide) was chosen as water reservoir, which is one of the component of the photo-responsive moisture-absorbent composite for Atmospheric Water Extraction technology. Demonstrated that the saturated water content of poly(*N*-isopropylacrylamide) hydrogel network reaches the 22 g/g at room temperature and effectively released approximately 18 g/g at 40 ˚C within 30 minutes by tuning synthesis compositions. Preliminary copolymerization synthesis of hygroscopic materials with PNIPAAm hydrogel were also tried.

Background

Atmospheric Water Extraction (AWE) technology can provide fresh water using thermo-responsive adsorbent composite to capture the gaseous water from the air and efficiently release it in liquid form [1]. Such materials holds promise but currently suffers from energy intensiveness. A photo-responsive hybrid gel consisting of a hygroscopic material to extract atmospheric water, a hydrophilic hydrogel as a water reservoir, and a light sensitive agent to realize photo-responsive for the Atmospheric water extraction technology will be developed.

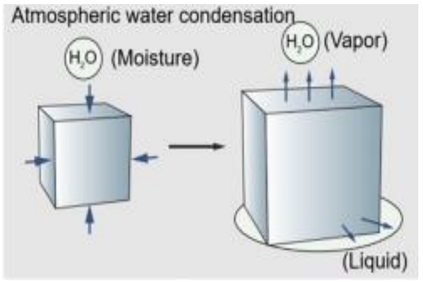

Fig. 1 The atmospheric water capturing and releasing processes via moisture absorbent [1]. The process of moisture from the air will be release in liquid form through the condensation. The hydrophilic polymer-based hydrogel network works as a platform to store gaseous water.

Materials and Methods

- The PNIPAAm hydrogel synthesis: N-isopropylacrylamide monomer, N,N,N′,N′-Tetramethylethane-1,2-diamine(TEMED) as accelerator, N,N‘-Methylenebisacrylamide (MBAA) as crosslinker and apersulfate (APS) as initiator.
- The water uptake tests were done by monitoring weight change of hydrogel as a function of time at room temperature and elevated temerpatures at 40 celsius degree in water bath.

Testing Results and Discussion

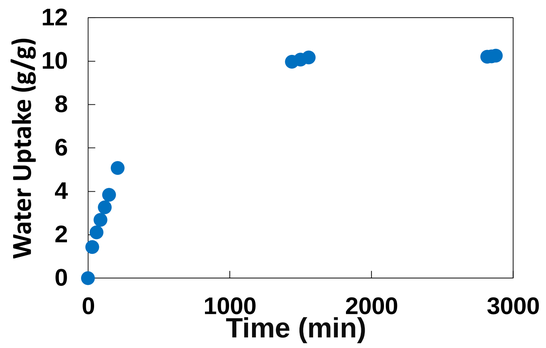

Fig. 2 The water uptake of PNIPAAm hydrogel at room temperature

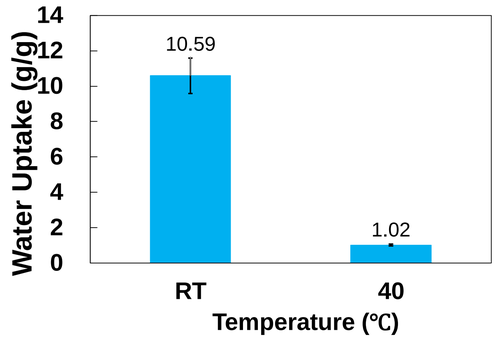

Fig. 3 The water uptake of PNIPAAm hydrogel at 40 ℃.

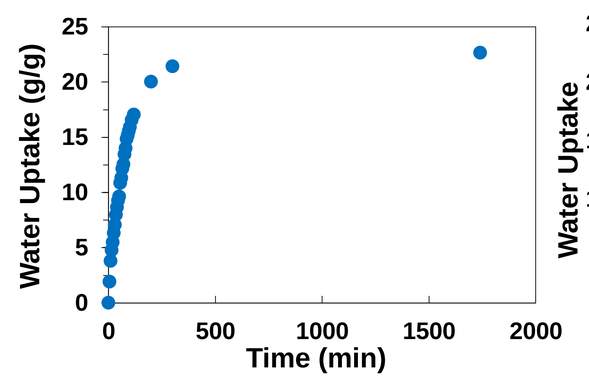

Fig. 4 The water uptake of optimized PNIPAAm hydrogel at room temperature.

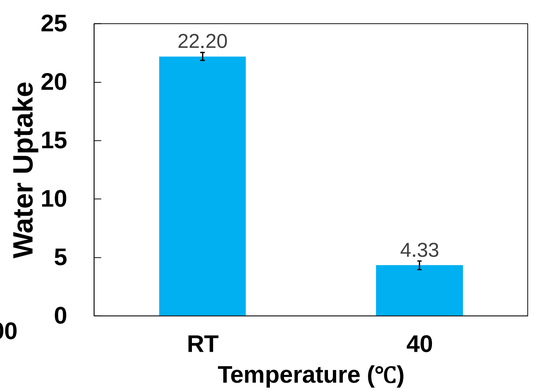

Fig. 5 The water uptake of optimized PNIPAAm hydrogel at 40 ℃

- Fig.2 and Fig.3 are about the PINIAAm hydrogel's water uptake capability at room temperature and at 40 ˚C
- Fig.4 and Fig.5 are about the optimized PINIAAm hydrogel's water uptake capability at room temperature and at 40 ˚C
- PNIPAAm hydrogel's water uptake capability is around at 10 g/g.
- PNIPAAm hydrogel released 9 g water/g gel at 40 ˚C within 30 minutes.
- By lowering the crosslinker mass fraction from 8.5 wt. % to 3 wt. %, the synthesized PNIPAAm hydrogel proved an improvement in water uptake at room temperature form 10 g/g to 22 g/g.
- Optimized PNIPAAm hydrogel released 18 g water/g gel at 40 ˚C within 30 minutes.
- Tuning the crosslinker compositions, the mechanical properties of hydrogel such as swelling ratio would be changed accordingly.

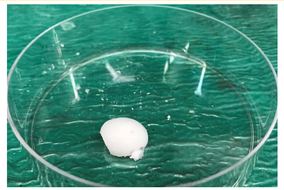

Fig. 6 PNIPAAm hydrogel at RT.

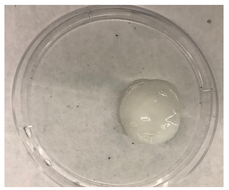

Fig. 7 Optimized PNIPAAm hydrogel at RT

Conclusion

PNIPAAm hydrogel is an ideal reservoir selection for developing the photo-responsive moisture-absorbent composite.

Future Work

1) Functionalization of the photosensitive agent, spiropyran
2) Survey for the suitable hygroscopic material
3) Develop a photo responsive hybrid gel consisting of a hygroscopic material, PNIPAAm hydrogel and photosensitive agent, spiropyran
4) Test the absorption and desorption of such photo-responsive hybrid gel

Acknowledgements

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References

[1] Liu, Xinyue, et al. "Hydrogel Machines." *Materials Today* (2020): 102–24.

[2] Zhao, Fei, et al. "Super Moisture-Absorbent Gels for All-Weather Atmospheric Water Harvesting." *Advanced Materials* 31, no. 10 (2019): 1806446.

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