COMMUNICATION
Water Harvesting
ADVANCED MATERIALS
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Super Moisture-Absorbent Gels for All-Weather Atmospheric Water Harvesting

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Paper presentation

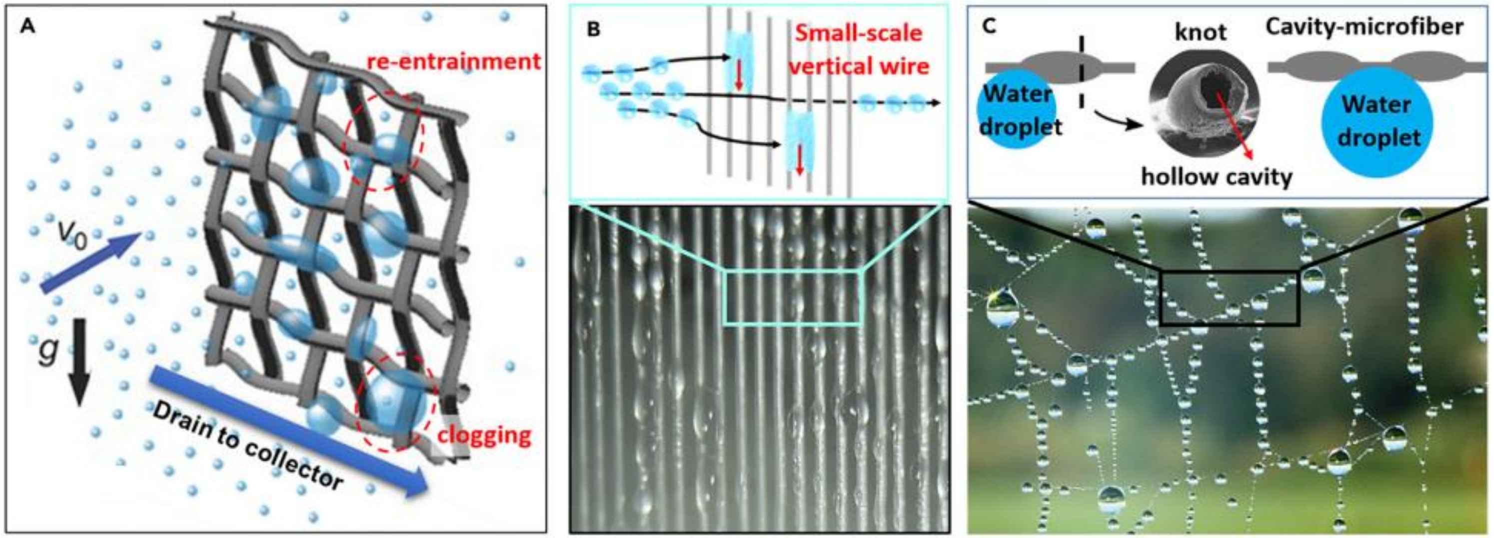
32nd Group Meeting

12-10-19

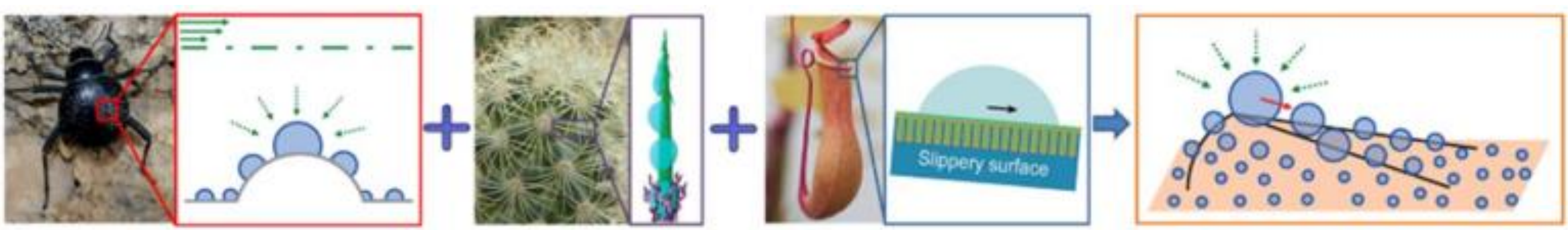
- Ankit Nagar

Background

Fog collectors



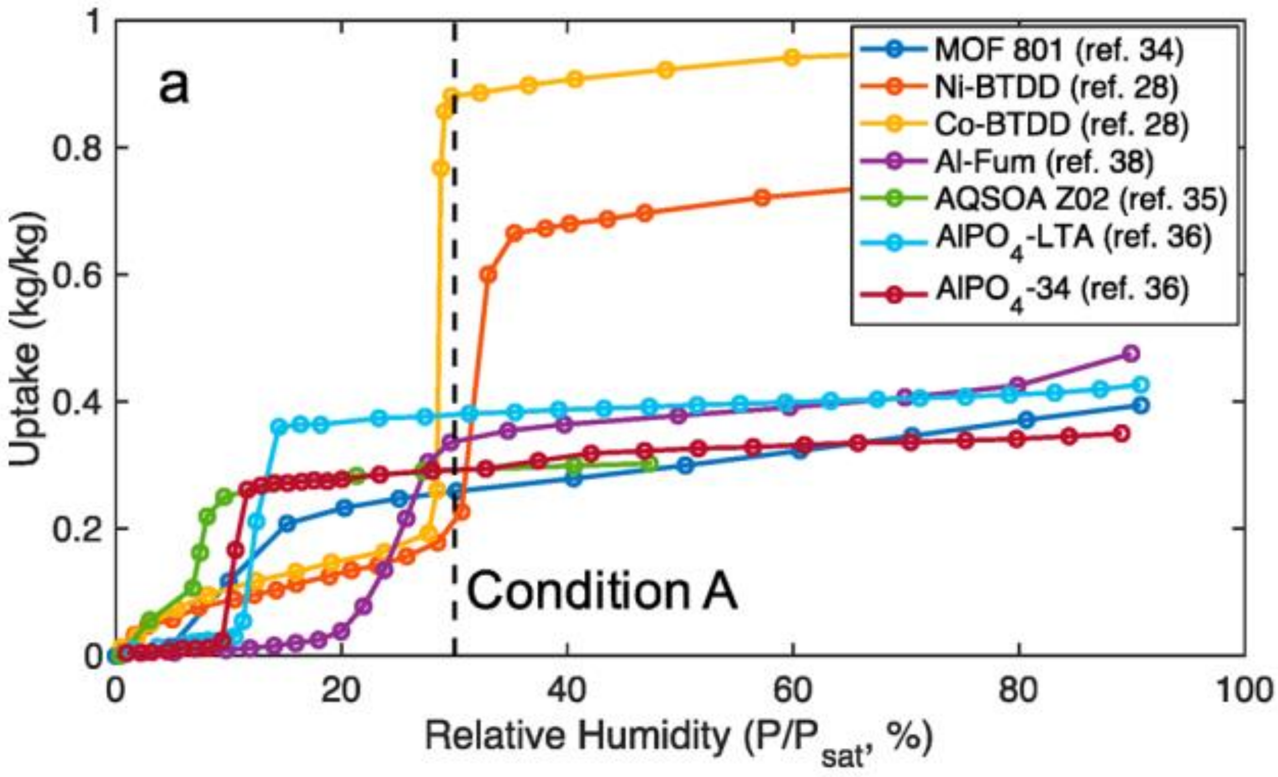
Condensation-enhancement surfaces



Tu, Y., et.al. 2018. *Joule*, *2*(8), pp.1452-1475

Background

Promising desiccants for sorption-based AWGs



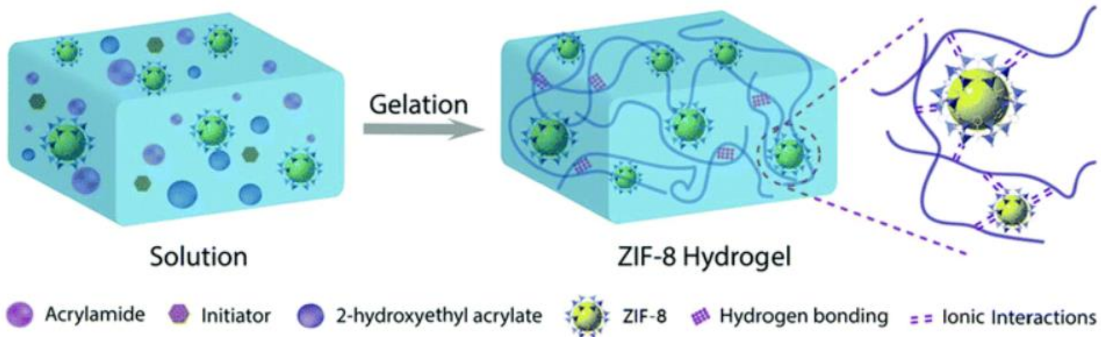
(regeneration temperature~ 65-95^{0}C)

LaPotin, A., et.al. 2019. *Accounts of chemical research*

Relevance

Super-elastic hydrogels

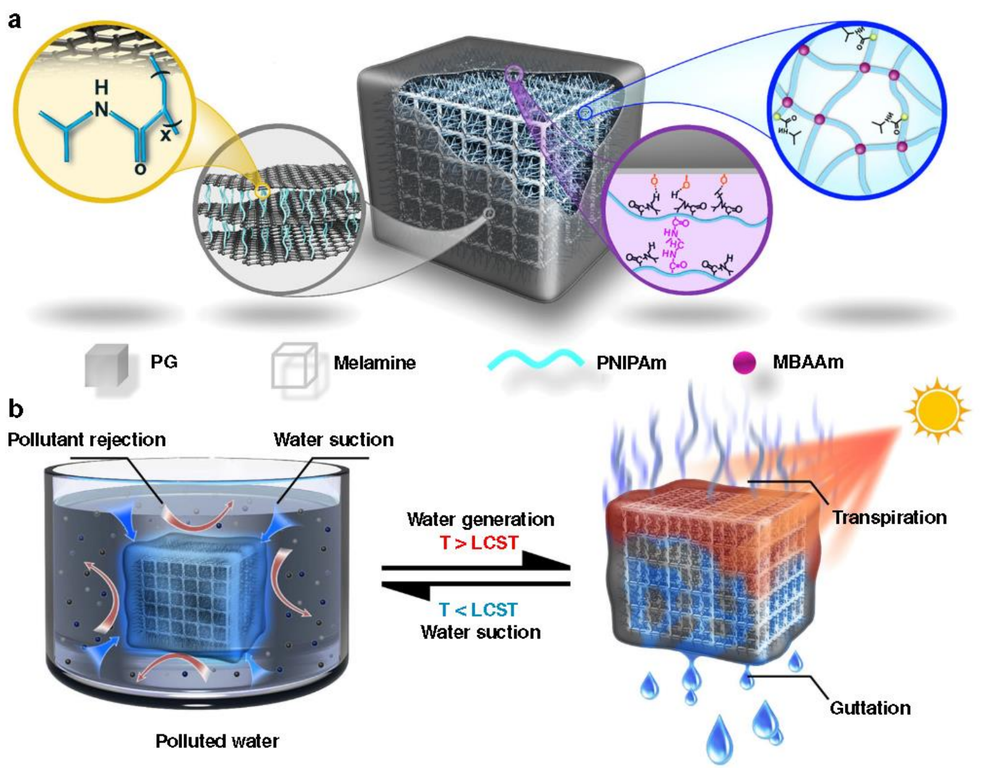
- MOFs capable of strengthening the hydrophilic networks by up to 2000%.
- Drug-delivery materials, biomedical devices, etc.



Liu, H., et. al. 2019. *Polymer Chemistry*, *10*(18), pp.2263-2272

Forward Osmosis

- Water collection rate up to 4.2 kg m^{-2} h^{-1}
- >99% ionic rejection
- PNIPAM-modified graphene- SPM, PNIPAM- draw agent



Geng, H., et.al. 2019. *Nature communications*, *10*(1), p.1512

Introduction

- A rationally-designed water harvesting material (moisture absorbing hygroscopic polymer + water-storing hydrophilic gel)

- Unlike active-surface-based vapor adsorption. Hence, exhibits highly efficient AWH in broad humidity range.

Super-moisture absorbent gel (SMAG)

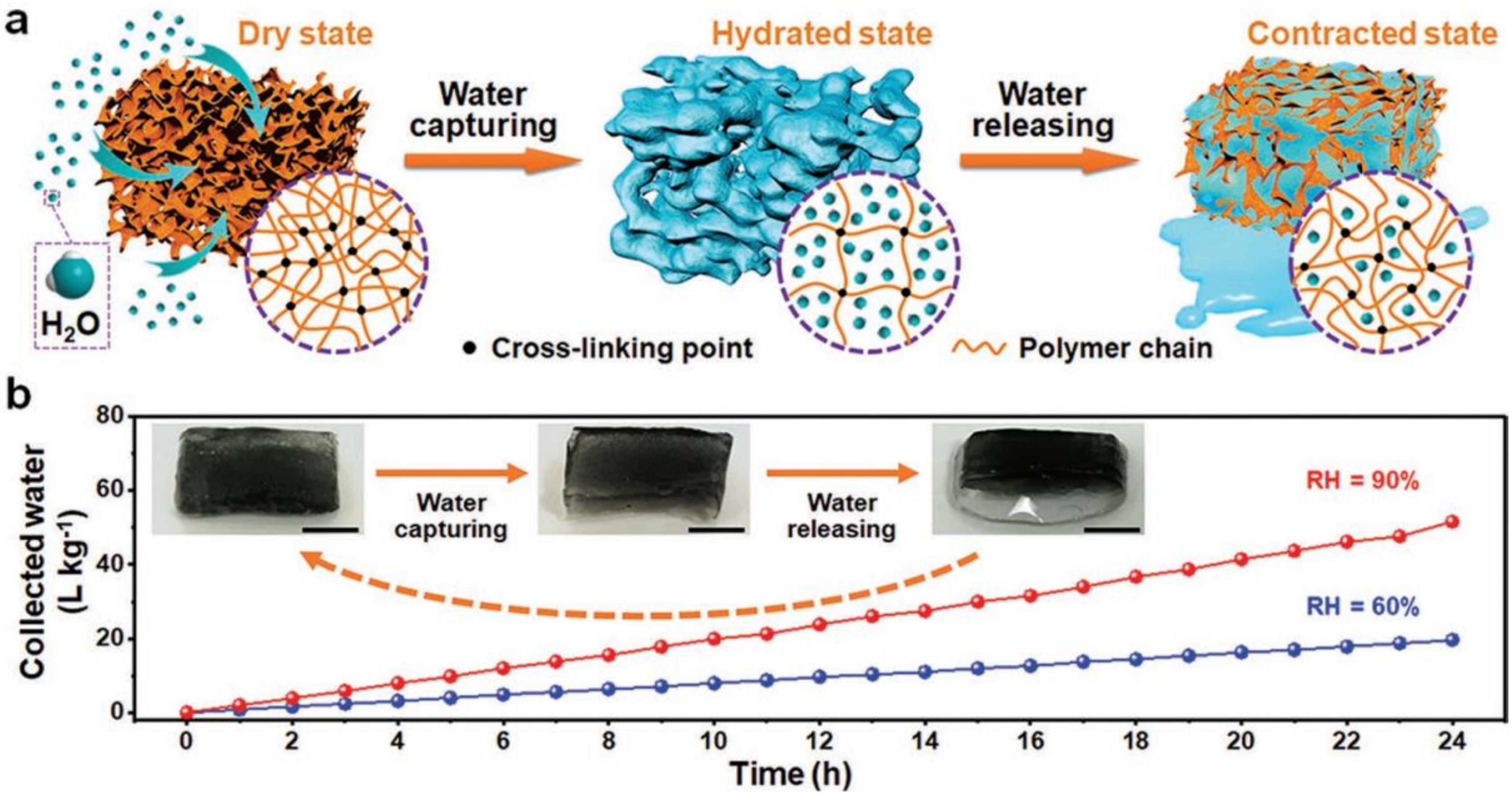


Figure 1. AWH based on SMAG. **a)** Schematic illustration of the AWH process. The water molecules are captured by SMAG and liquefied under room temperature (enabled by hygroscopic chloride-doped polypyrrole). The liquid water is absorbed by polymer network matrix of SMAG, realizing the swelling in moist air. Upon exposure to heat, the contained water is released via the thermal-responsive hydrophilicity switching (from hydrophilic to hydrophobic in poly-NIPAM). **b)** Water production from 24 h AWH at different RH levels. Insets of b): photographs of SMAGs during typical AWH cycles (50 min for water capturing and 10 min for water releasing), with scale bars of 1 cm.

Characterization

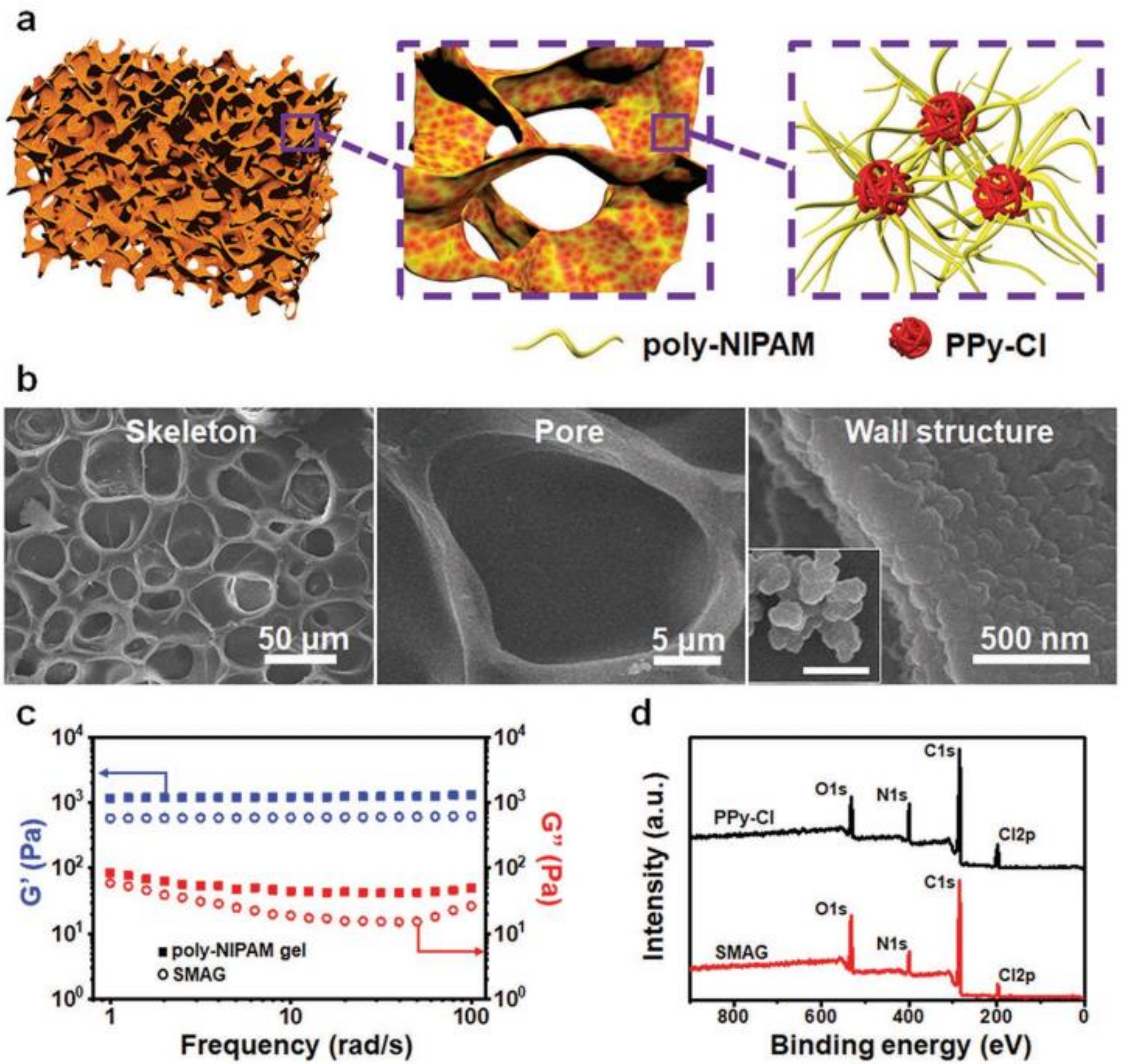


Figure 2. Characterization of the SMAG. **a)** Schematic of the skeleton, porous structure; **b)** SEM images of a dried SMAG. The rough surface of the wall structure evidences the inlay of PPy-Cl clusters in the poly-NIPAM matrix. The morphology comparison of pure PPy-Cl (inset of b) with scale bar: 500 nm) and the wall structure of the SMAG further confirms the interpenetration of PPy-Cl clusters and poly-NIPAM matrix. **c)** Dynamic mechanical analysis, including storage modulus (*G′*) and loss modulus (*G″*), demonstrates the interpenetration of PPy-Cl and poly-NIPAM in the SMAG. **d)** XPS of PPy-Cl and the SMAG confirm the retained chlorine dopant in obtained SMAG after purification process.

Results

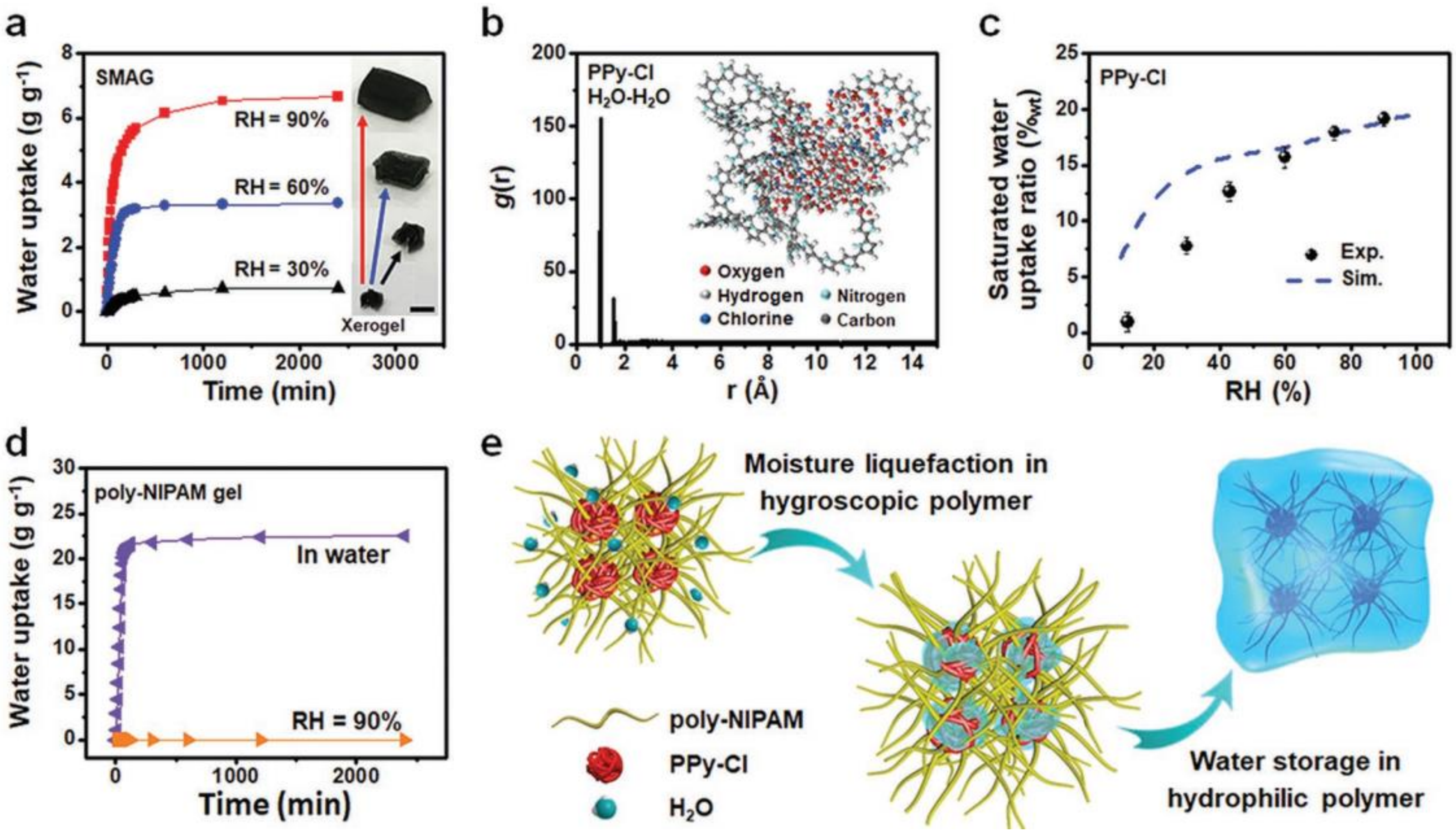
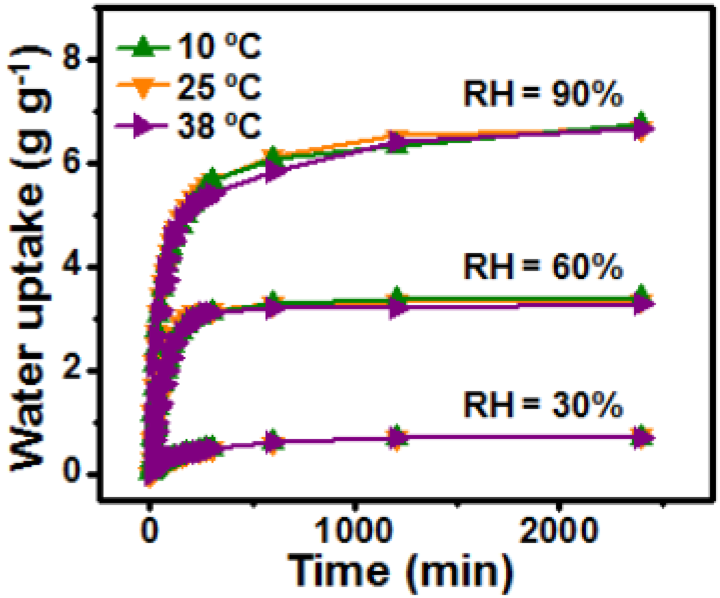


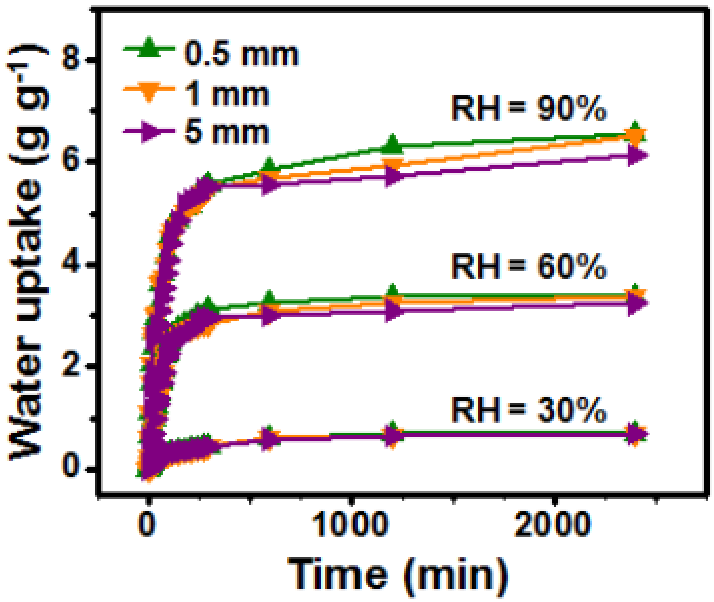
Figure 3. Water capturing with SMAGs. a) The water capturing the behavior of SMAG at RH of 30%, 60%, and 90%; Insets from bottom to top: corresponding dried and hydrated SMAG with equilibrated water uptake (scale bar: 1 cm). b) The PCF of water molecule pairs from molecular dynamic simulation; Inset: computing model of hydrated PPy-Cl shows the water aggregations in the central part of PPy-Cl clusters. c) The experimental (black points) and simulated (blue dash) data of moisture absorbing based on PPy-Cl at various RH. d), The liquid water (violet curve) and moisture (orange curve) absorption of the poly-NIPAM gel, revealing a superior liquid water absorption and poor moisture capturing of the poly-NIPAM gel. e) Schematic illustration of the moisture absorption enabled by SMAGs.

Results

Influence of temperature



Influence of size



- Swelling of SMAG is the RDS, instead of vapor permeation. Identical triggering of vapor liquefaction.

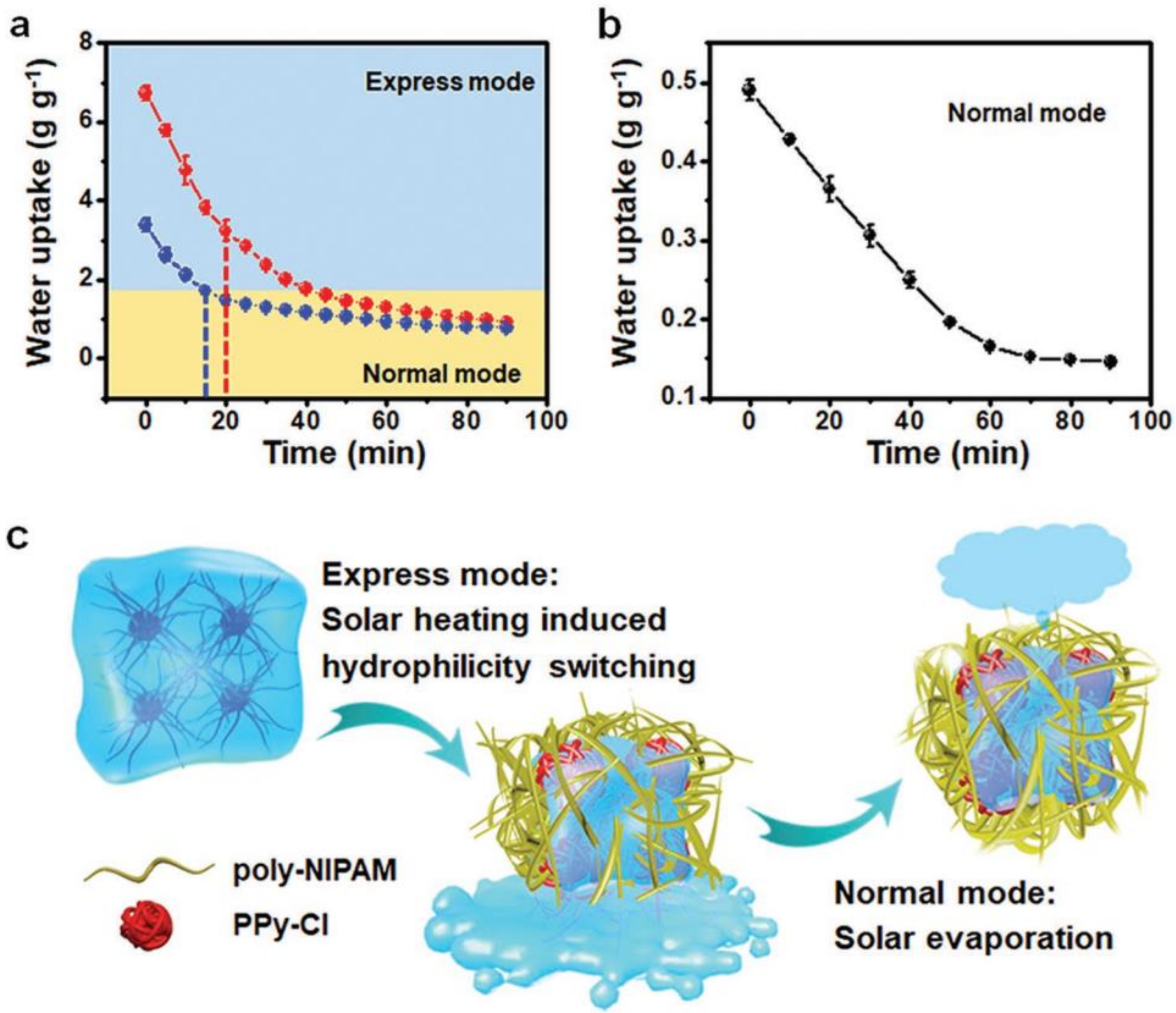


Figure 4. Water releasing with SMAGs. Water releasing modes of SMAGs with a) high and b) low water uptake. The water uptake threshold of the express mode is ≈1.7 g g^{-1}, showing that the SMAGs can rapidly release large amount of water and steadily produce water from the relatively dry air. c) Schematic illustration of express mode and normal mode for the water releasing powered by solar energy.

Results

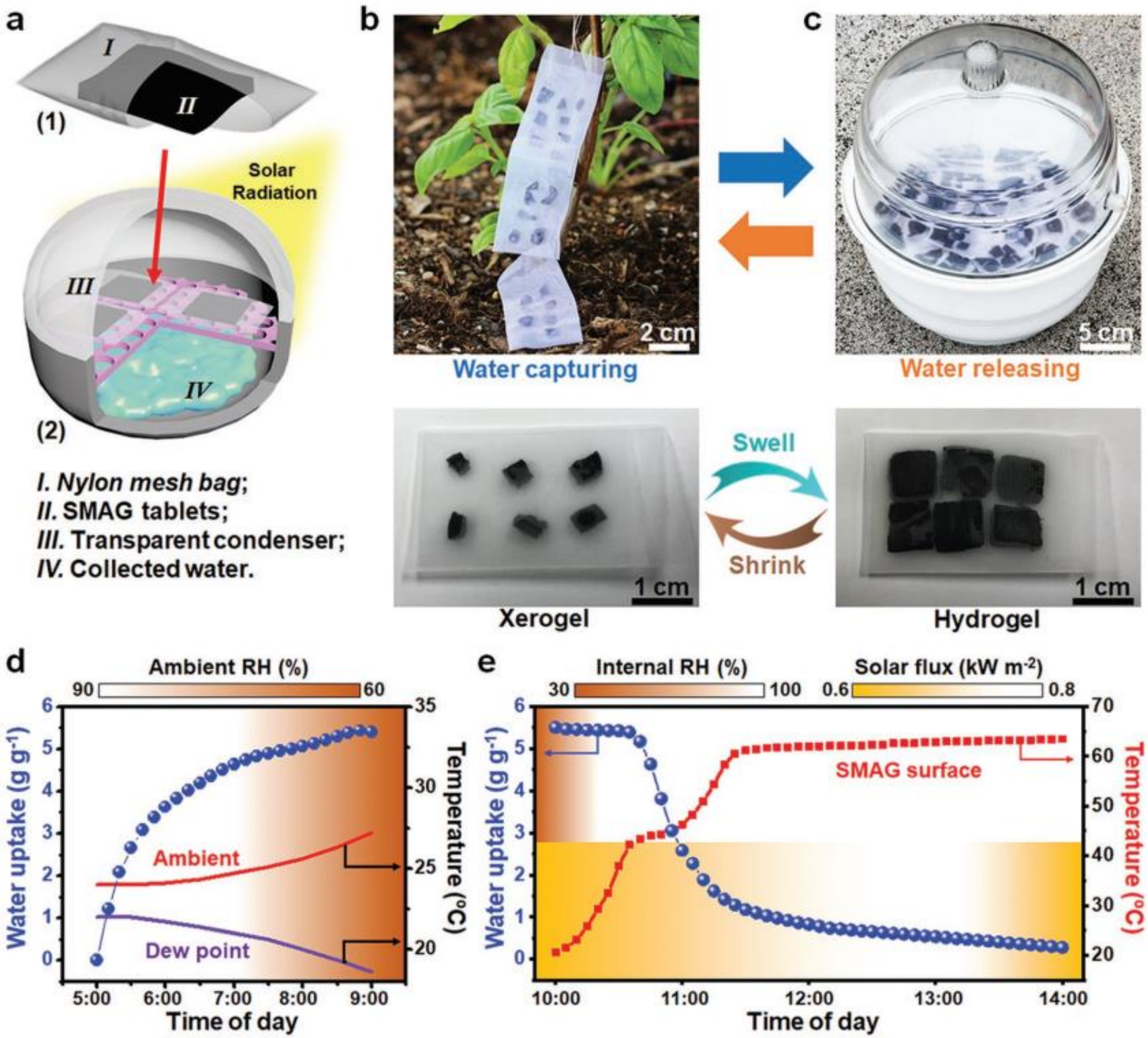


Figure 5. Outdoor AWH powered by natural sunlight.
a) Schematic illustration of 1) the water harvester based on SMAGs for 2) the water collector. Photograph of SMAG bags during b) water capturing in the natural environment and c) water releasing under solar radiation. The obvious volume change of SMAGs indicates a large water yield.
d) Representative outdoor water capturing process in the early morning (blue curve), where ambient temperature (red curve), dew point temperature (violet curve), and ambient RH (background color map) were presented.
e) Representative outdoor water releasing process in noontime (blue curve), where the surficial temperature of SMAG (red curve), internal RH (top background color map), and solar flux (bottom background color map) were presented.

Energy transfer during water capture

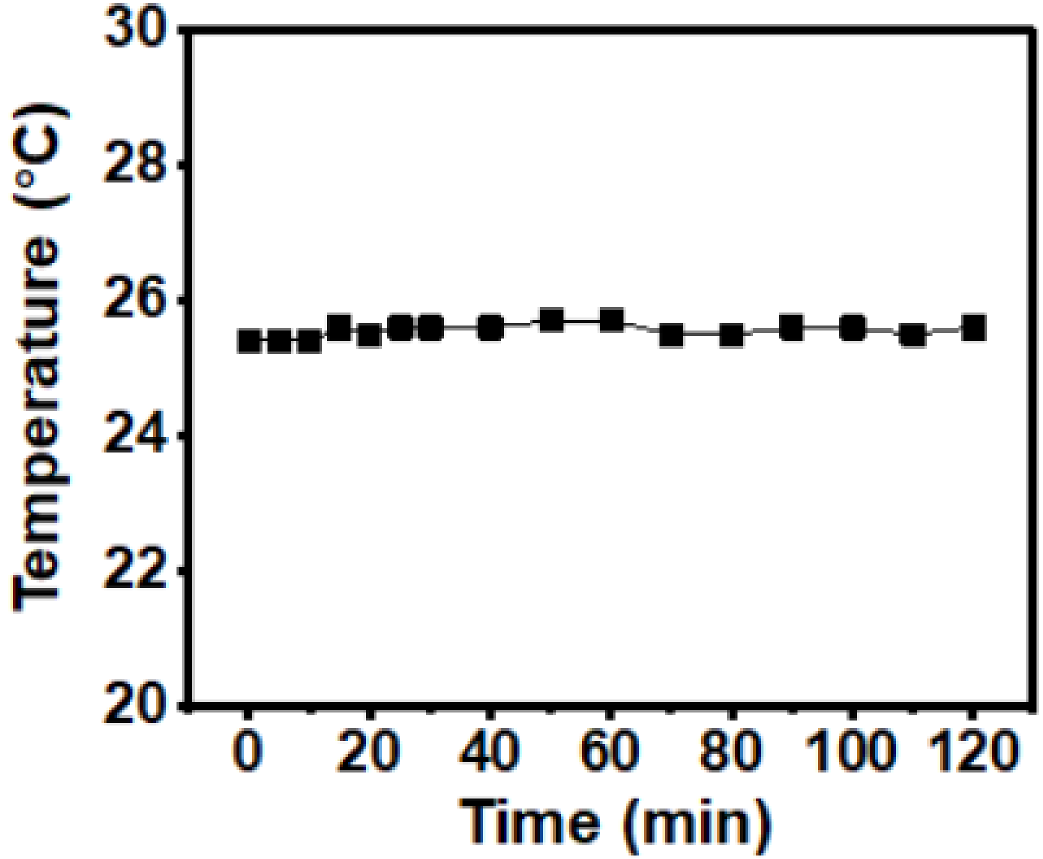


Fig. S13. The temperature of the SMAG during the water capturing process.

THANK YOU