Thermoresponsive Polymer with Added Cellulose as a Potential Cool Roofing Material

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The Problem – Urban Heat

The Urban Heat Island Effect explains how cities, including Philadelphia, disproportionately experience high temperatures compared to suburban or rural areas due to human infrastructure absorbing and trapping heat[1]. Mitigation strategies, in the form of cool infrastructure, are necessary to help reverse the risks that extreme heat poses on the human population.

Thermoresponsive Polymer Cooling

Preceding literature, "Thermoresponsive Polymer Induced Sweating Surfaces as an Efficient Way to Passively Cool Buildings," has outlined evaporative cooling employing a poly(N -isopropylacrylamide) (PNIPAM) layer as an effective cool roofing technology[2]. This project examines the effects of adding cellulose to this hydrogel structure as a potential cool roofing material. Cellulose presents many possible benefits due to its high natural abundance, tensile strength, and water retention capabilities.

Methods

Synthesizing Hydrogels

Three different hydrogels with varying amounts of added cellulose are synthesized by dissolving components in a solution of 1.1 wt% wood cellulose. The chosen concentrations of cellulose tested are pure (0%), 0.1%, and 1%.

Preparing Samples

After synthesizing 3mm thick layers of hydrogel, multiple squares of dimensions approximately 17.5 mm by 17.5 mm are cut from each sample for testing.

Testing

The cut hydrogels are tested by switching between water baths of temperature 23 degrees Celsius (cool) and 42 degrees (hot). Volume and mass are measured over time to measure water release when placed in the hot environment and recovery when placed in the cool environment.

Data

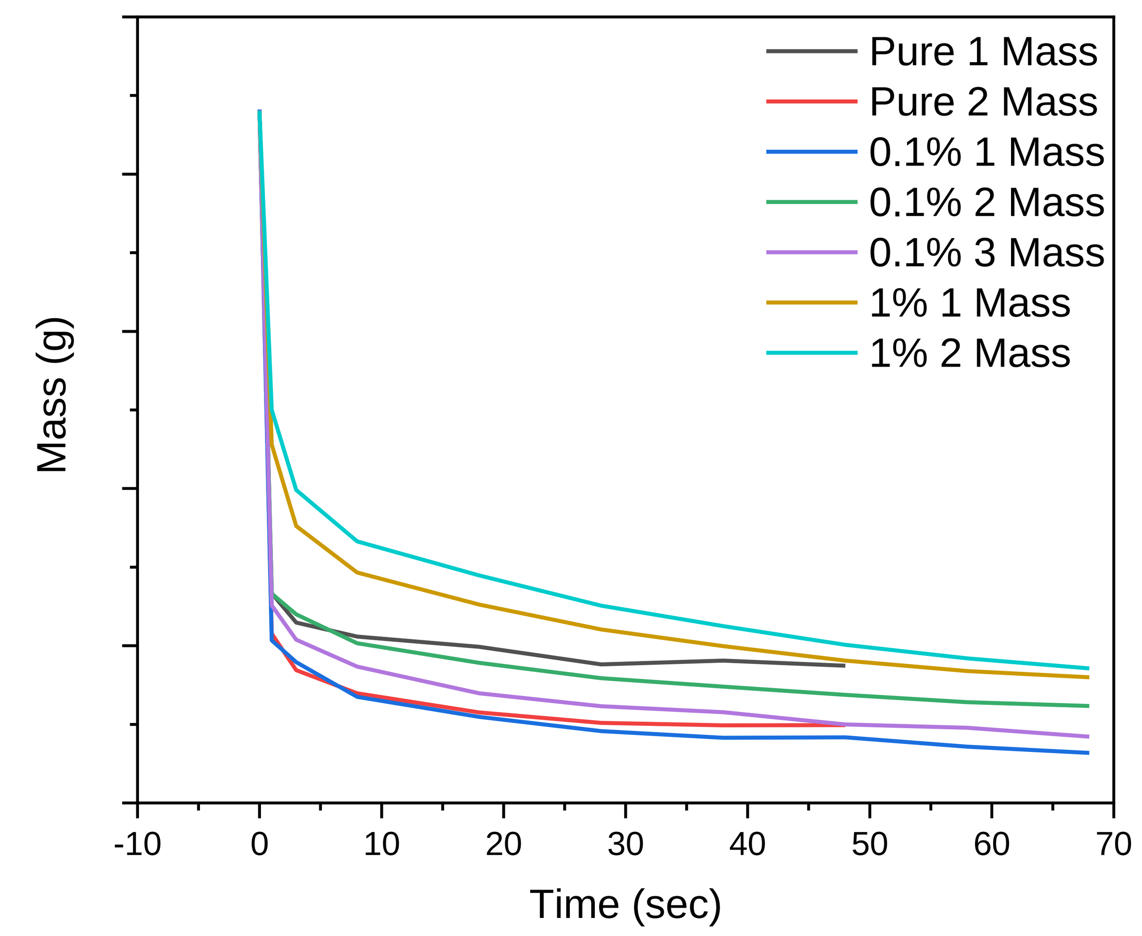


Figure 1: Mass of sample over time after being placed in hot water bath (hydrophobic environment)

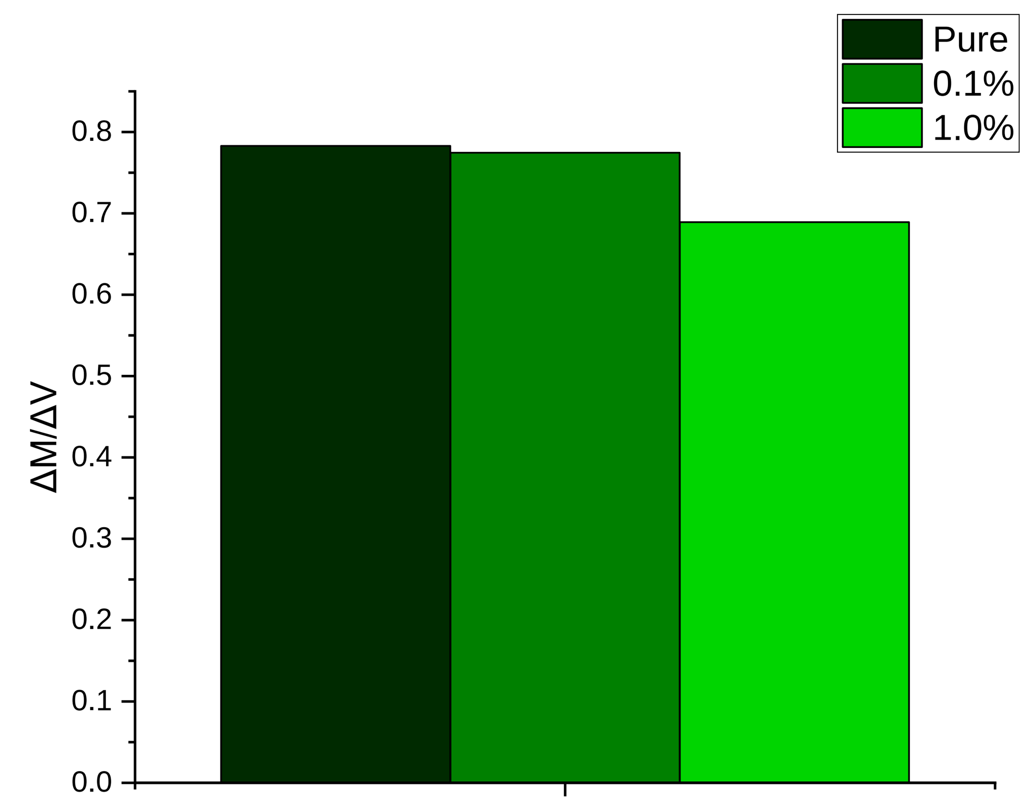
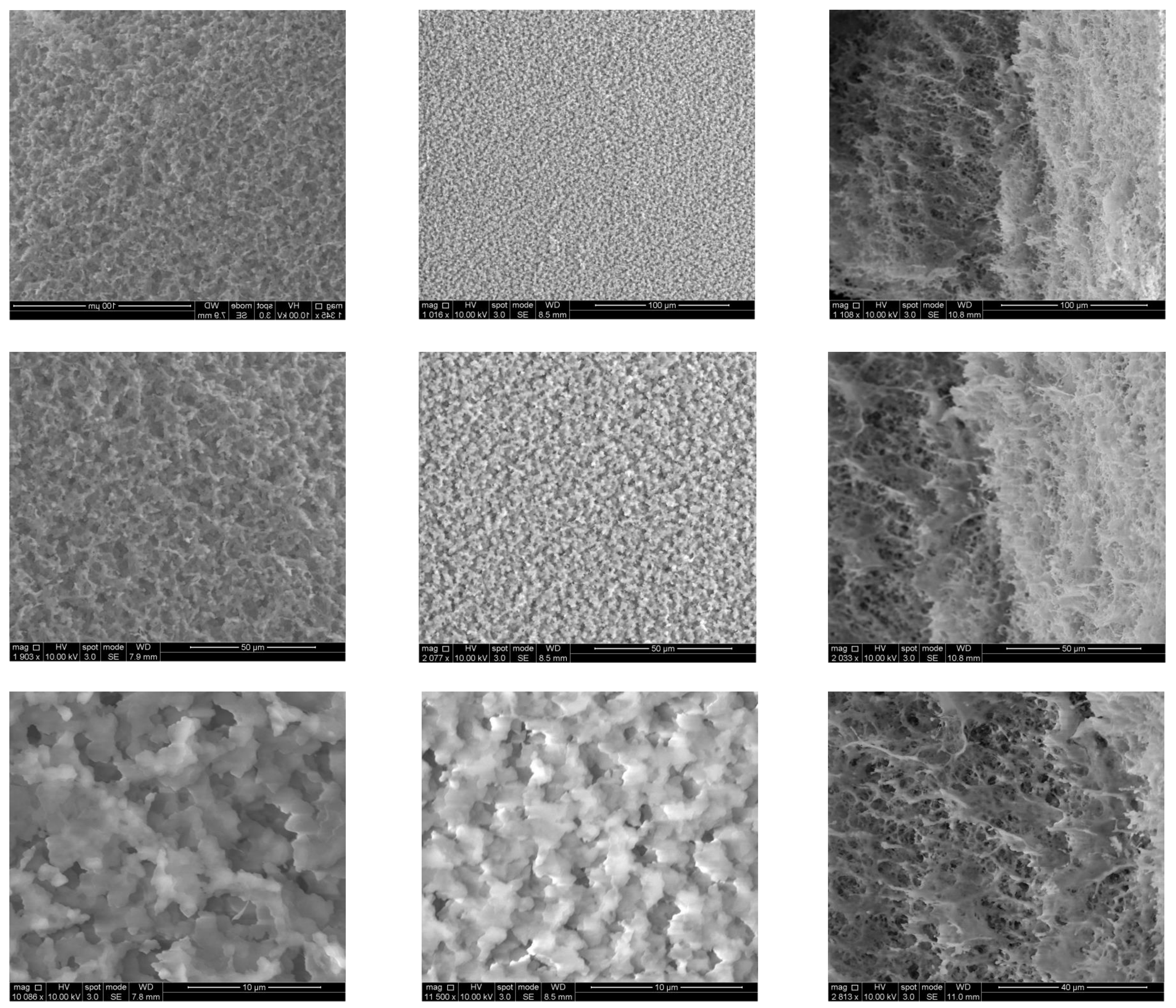


Figure 2: Measurement of water retention by dividing overall change in mass by change in volume

Images



Pure
top to bottom: scale bar 100 microns, 50 microns, 10 microns

0.1%
top to bottom: scale bar 100 microns, 50 microns, 10 microns

1.0%
top to bottom: scale bar 100 microns, 50 microns, 40 microns

Results and Discussion

Water retention capabilities decrease as the concentration of cellulose is increased. This can be attributed to cellulose fibers interlocking within the hydrogel structure. The rate of water dispelling also saw a decrease with the 1.0% cellulose sample. Additionally, differences in morphology can be observed between different concentrations of added cellulose. As for future testing, tensile strength should be measured as hydrogels with more cellulose seemed firmer. Measuring temperature upon exposure to heat/the sun is also important in determining viability as a cool roofing technology.

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References

[1]US EPA. (2014, June 17). *Learn About Heat Islands*. US EPA. https://www.epa.gov/heatislands/learn-about-heat- islands

[2]Rotzetter, A. C. C., Schumacher, C. M., Bubenhofer, S. B., Grass, R. N., Gerber, L. C., Zeltner, M., & Stark, W. J. (2012). Thermoresponsive Polymer Induced Sweating Surfaces as an Efficient Way to Passively Cool Buildings. *Advanced Materials*, *24*(39), 5352–5356. https://doi.org/10.1002/adma.201202574