Developing a Simple and Universal Method to Manufacture High Performance Radiative Cooling Fabrics

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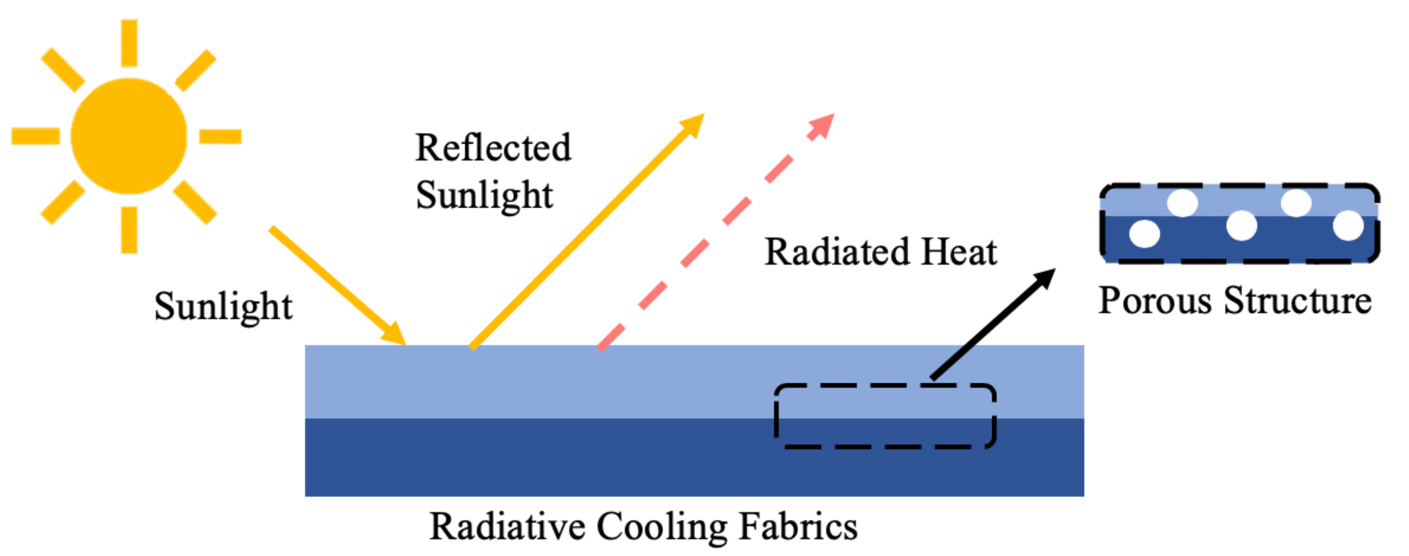
Background and Motivation

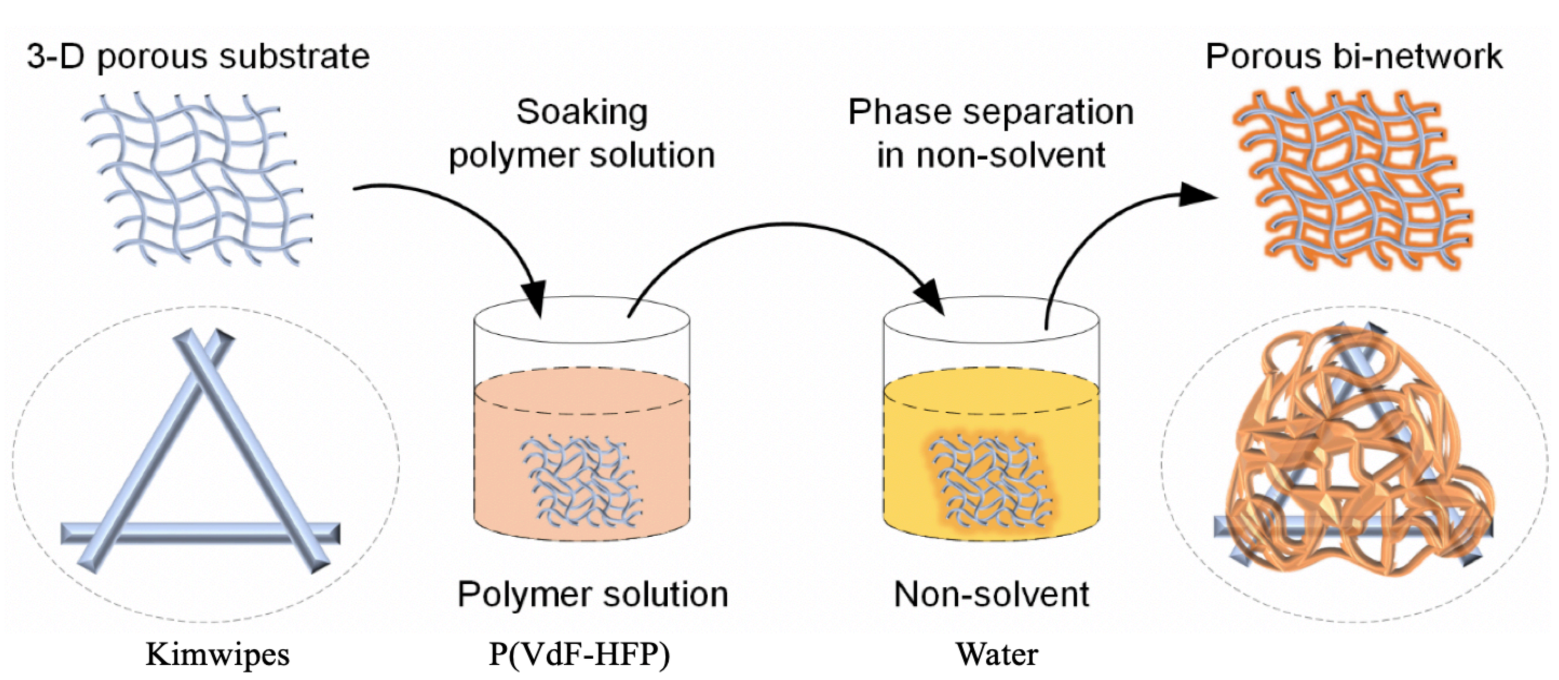
Cooling has been extensively examined as the main driver of peak electricity demand and an energy-efficient cooling strategy is desired. Now, radiative cooling as a means of cooling objects without additional electricity input has attracted widespread attention and has a considerable impact on global energy consumption. The principle of the radiative cooling uses the human-made structures reflect sunlight and radiate heat into outer space, considered as ultimate heat sink, in the form of electromagnetic waves through the atmosphere.

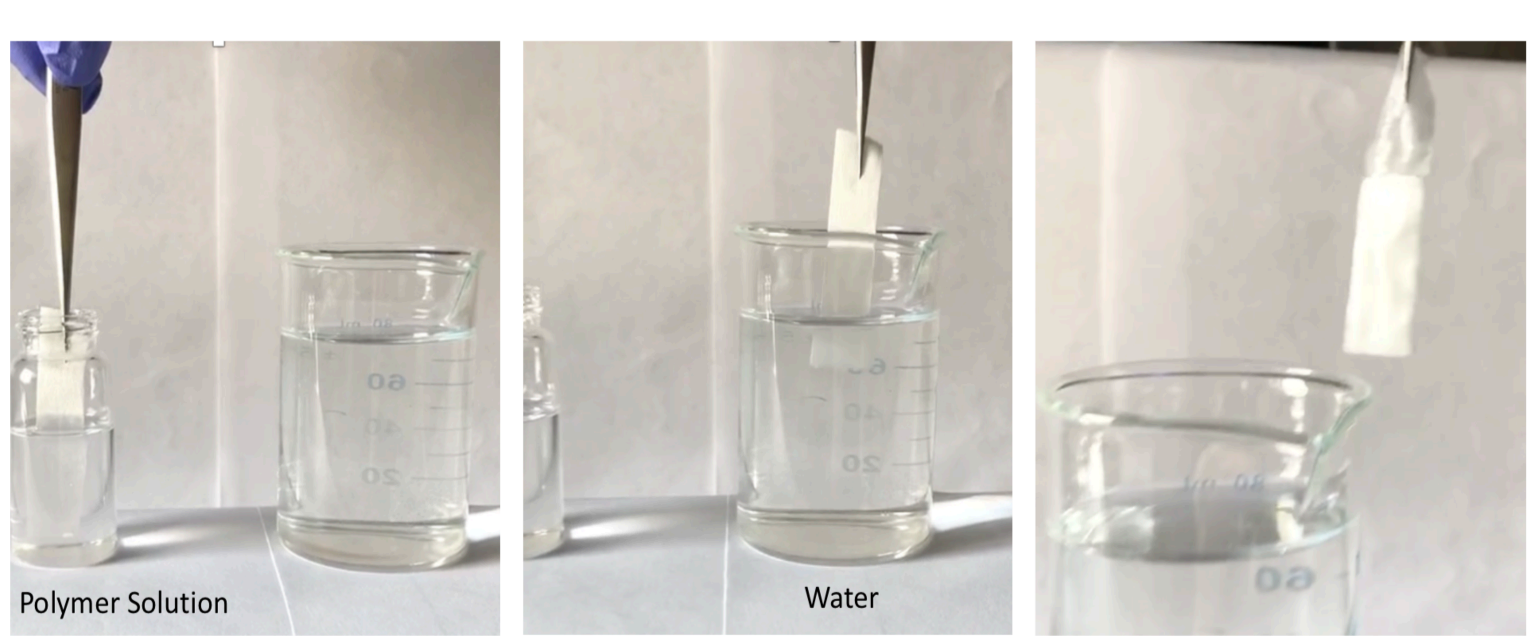
In the previous studies, our group has reported porous P(VdF-HFP) coating obtained by a controlled evaporation based phase inversion method could achieve an impressive high performance. However, under the premise of moderate polymer solubility, an effective solvent/non-solvent combination is required, which is difficult to achieve for various types of polymers. This process also has strict requirements on environmental temperature and humility.

Our objective is to develop a simper and universal method to manufacture high performance radiative cooling fabrics.



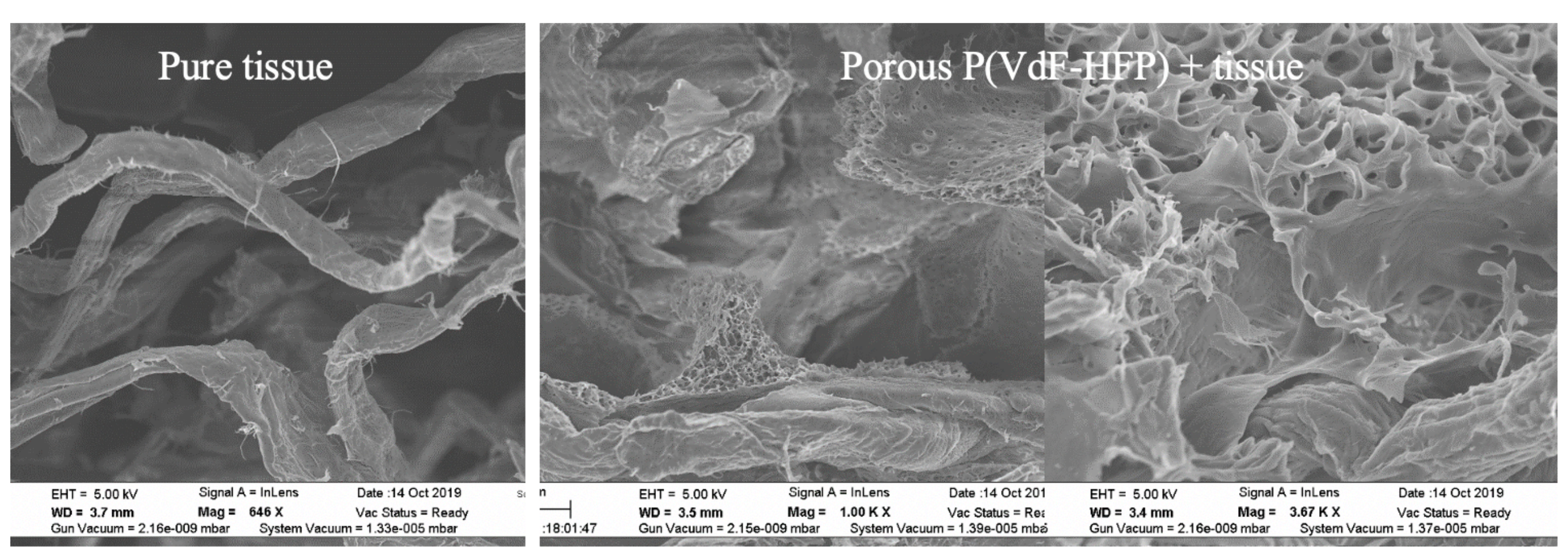
Experimental Setup

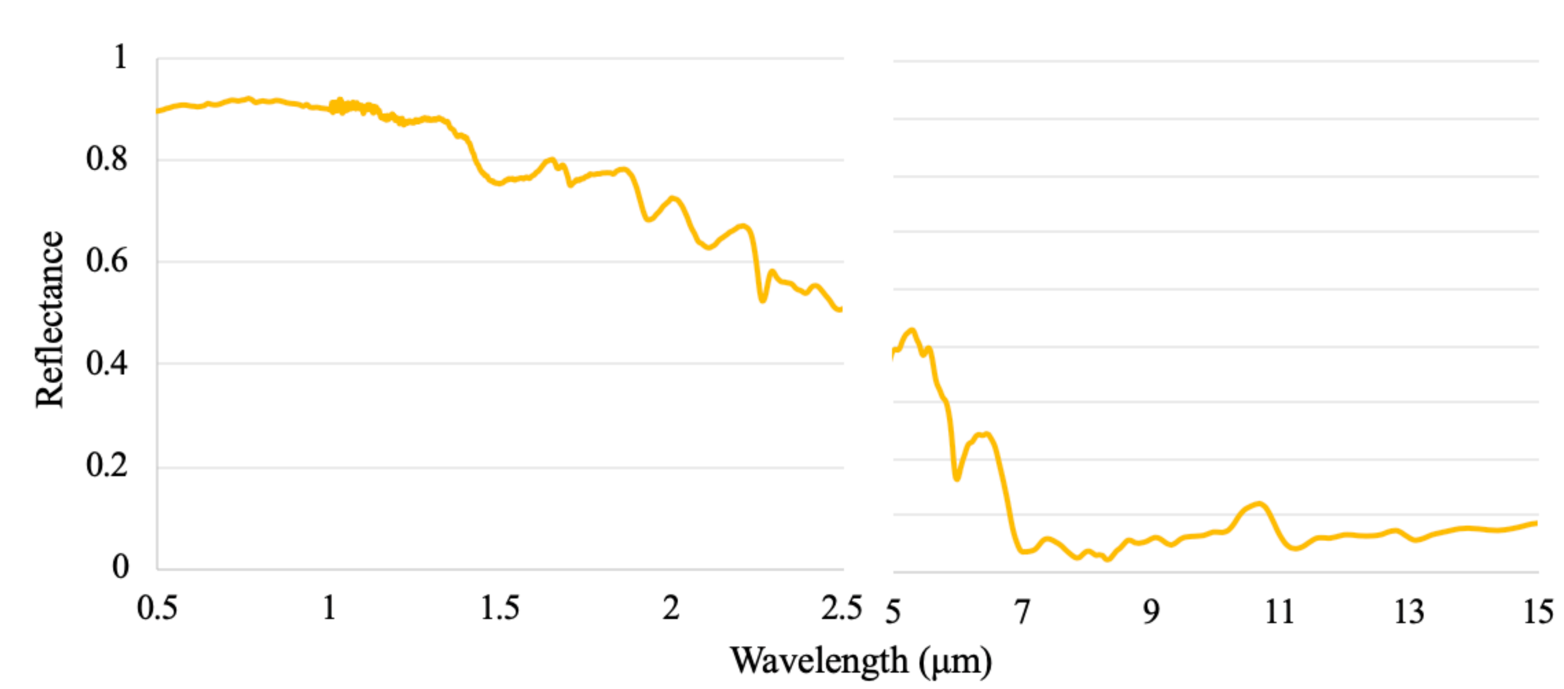


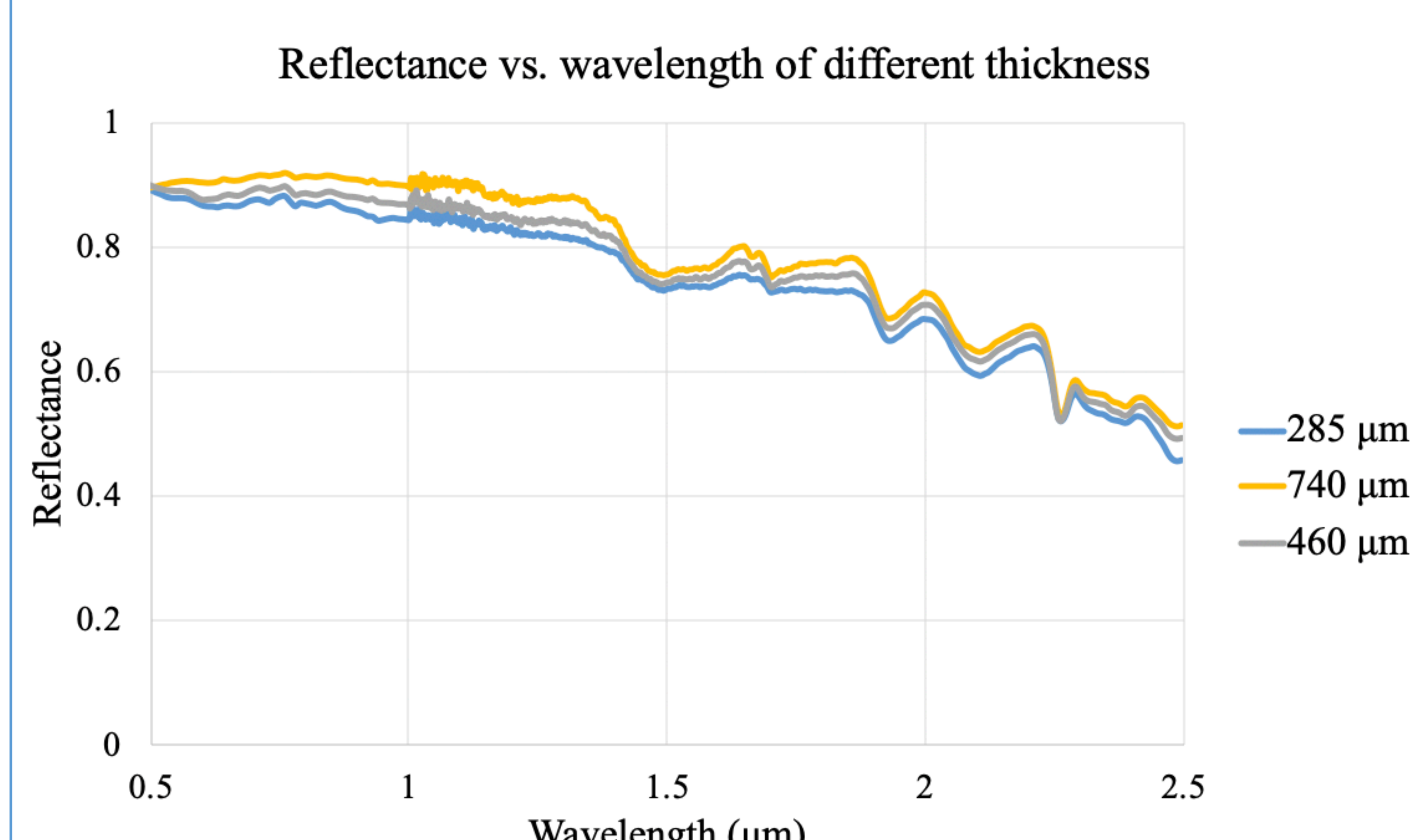


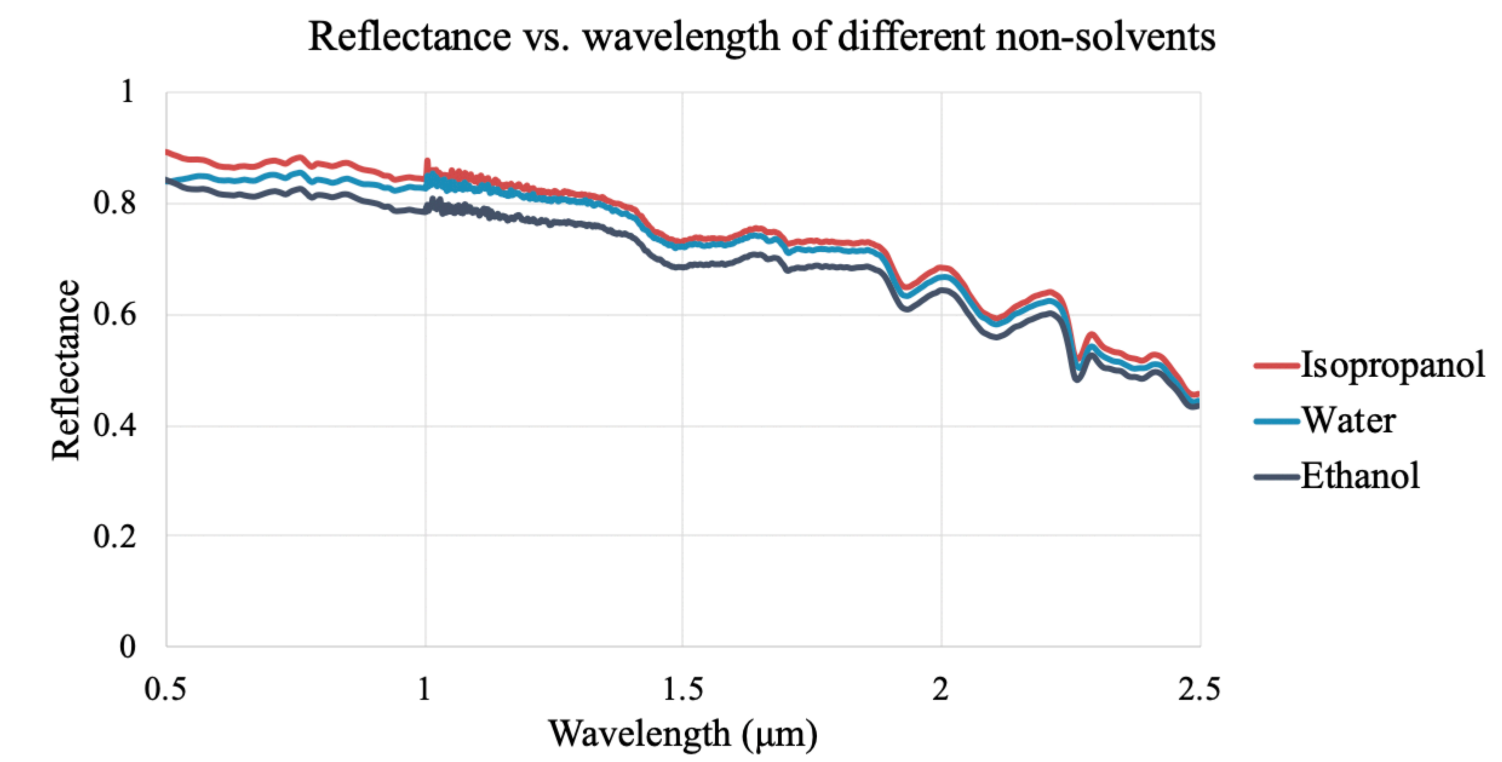
The 3D porous substrate (e.g., Kimwipes) was completely immersed in a beaker filled with polymer solution. Then the Kimwipes was vertically dipped into another beaker containing non-solvent (such as water) to induce phase separation. After drying, a porous polymer-substrate intertwined network was formed. Then a SEM was used to examine the microstructure characterization of the Kimwipe. A reflectance test and a mechanical performance test were conducted to examine the performances of the radiative cooling fabric. To produce a uniformly colored fabric, the colorant was putted in the polymer solution and a magnetic hot plate was used to completely mix the solution.

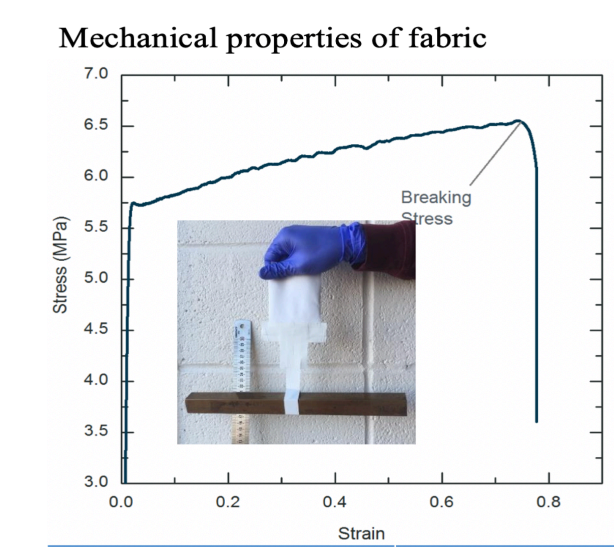
Results



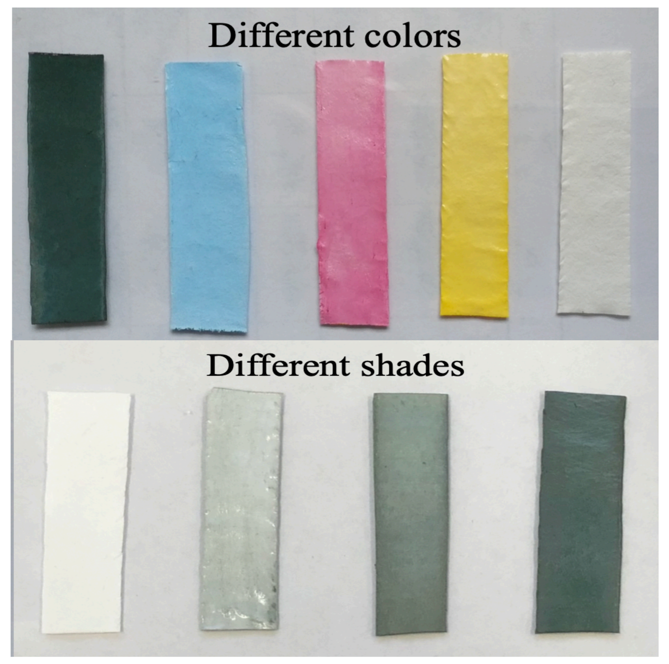








	P(VdF-HFP) sheet
Ultimate tensile strength	6.5 MPa
Young's modulus	8.7 MPa



Conclusions

Comparing the results with the suggested reflectance of various materials, we can conclude that the formed porous polymer-substrate intertwined network can effectively reflect the sunlight so that the fabrics can cool the object without any additional energy input.

Moreover, the reflectance under different thickness and different non-solvent also suggest that the "3D" method ("Dip-Dip-Dry" method) is applicable for wide range of polymers and it also can be customized for multi-scenarios with specific requirements

Further Work

1. Further improve the reflectance by varying substrates and polymer solutions
2. Conduct thermal tests to investigate the cooling performances under direct sunlight

References

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3. Raman, Aaswath P., et al. "Passive Radiative Cooling below Ambient Air Temperature under Direct Sunlight." *Nature*, vol. 515, no. 7528, 2014, pp. 540–544., doi:10.1038/nature13883.

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