Fabrication, measurements, and applications of thermoresponsive and double network hydrogels

Yvonne Yeh, Shuang Cui, Professor Renkun Chen

The Department of Mechanical and Aerospace Engineering, University of California San Diego, 9500 Gilman drive, La Jolla, California

Introduction
Hydrogels are cross linked polymers with hydrophilic groups that are highly absorbent. They are used in coatings and stimuli-responsive hydrogels have applications as adaptive lenses, artificial muscles, vehicles for drug deliveries, scaffolds or matrices for tissue engineering, and sensors and actuators for soft robotics and soft machines.

Double network hydrogels (tough hydrogel) crosslink the polymers with covalent bonds and ionic bonds. Ionic bonds break under stress, and it reforms that help hydrogel recover. This structure of double network hydrogel yields greater strength and better mechanical properties than single network hydrogel, and extend the application field for hydrogels.

Thermoresponsive hydrogels based on NIPAM can transition across the lower critical solution temperature (LCST). With a low LCST, the properties of the gel can be changed with temperature, which further widen the application to temperature based actuators, robotics, self-folding structures, and pattern formation.

Fabrication
Materials: Alginate, Acrylamide, CaSO₄·2H₂O Ammonium persulfate (AP), N - Isopropylacrylamide (NIPAM), Tetramethylenediamine (TEMED), N, N'-Methylenebisacrylamide (MBAA)
Syringe 1: Dissolve the materials in a beaker and cover the beaker with aluminum foil. Stir the solution for 1 hour at 450 rpm. Degas the resulting solution until there is no bubbles.
Syringe 2: Dissolve the materials in another beaker and place it in ultrasonic cleaner for 5 minutes until it is well-mixed.

Syringe 1 : Syringe 2 = 1 : 0.16 by volume
Pour the solutions into respective syringes until the tip of open end is filled. Connect the two syringes and quickly mix the solution 10 times. Pour the solution into petri-dish and place the dish on a hot plate at 50°C. Shine UV light (254 nm) on the dish and cover with box for 1 hour.
Put the hydrogel in the petri-dish into a humid box for 24 hours. Put the humid box in fume hood.

Double Network Hydrogel

Tensile Test

Temperature Sensitive Hydrogel

Thermoresponsive Test

Tough Hydrogel

Temperature Sensitive Hydrogel

Conclusion/Future Research
Tough hydrogel was fabricated that can withstand 490 KPa tensile stress and 18.5 uniaxial stretch. It demonstrated capability to reduce the surface temperature of wood roofs by 25-30 °C, and it is regenerative. Thermoresponsive hydrogel was also synthesized. We suspect the 6:1 ratio of NIPAM:Alginate made the thermoresponsive hydrogel brittle. For future research, we could alter the ratio for better results, and apply it to more effective roof cooling. Also, applications for hydrogels as preparation for aerogels can be further explored.

Acknowledgements
I would like to thank Dr. Komives for organizing this program and giving me the opportunity to work in UCSD. Special thanks to Leonard Chen for helping me throughout the project and thanks to Melissa Averina and Brianna Fernandez for the help with experiments.

Nykäne, et. al. Soft Mat, 2011, 7, 4414-4424