Sprayable Hydrogels for Preventing the Rekindling of Wildfires

Abstract

The goal of this project was to find a hydrogel product capable of keeping wildfires from reigniting. The first test we did to identify the best hydrogel was to take 9 different hydrogels and test how well they retained water in an oven. We then took the most successful hydrogels and tested how well they stuck to a vertically hung leaf. We also tested how fast they hydrated, then measured the cooling capability of different hydrogel-water mixtures using hot coals. We found that 100% sodium polyacrylate was the optimal hydrogel for keeping wildfires from rekindling.

We then designed and tested 8 different iterations of a water hose attachment that can be used to spray hydrogel on recently burned areas. Our final iteration uses Bernoulli's principle, the Venturi effect, and entrainment to suck the dry hydrogel into the water stream.

Introduction

Wildfires have been an increasing problem in California due to climate change. The recent Palisades fire was one of the most expensive on record, costing an estimated $250 billion dollars. The Palisades fire was caused when an earlier fire, the Lachman's fire, was extinguished above ground but still smoldered underground. 6 days later, strong winds pushed the fire above ground into vegetation and started the Palisades fire.



Figure 1. Houses engulfed by flames during the Palisades Fire. (1)



Figure 2. The damage to a neighborhood after the Palisades Fire was extinguished. (2)

Out of the many types of fires, the hardest types to extinguish are zombie fires (such as the Lachman's fire), rekindling, and spot fires. Zombie fires occur when a fire is extinguished above ground but remains burning below ground. Rekindle fires are when the inside of a burned material still has enough heat that it can reignite in strong wind. Finally, spot fires are fires caused by embers, pieces of extremely hot floating material that can travel for miles and cause a new fire, spreading the fire dramatically. All of these have one thing in common: they require a lot of time and effort to stop. This means that usually the best firefighters can do is spray them with water before leaving to combat other parts of the fire. This creates a challenge for firefighters, who need to prevent re-ignition while also fighting the active fire.

Process

1. Select optimal hydrogel
   - Test moisture retention under applied heat
   - Test adhesion to vegetation
   - Test hydration speed
2. Determine rekindling prevention capabilities
   - Test re-ignition prevention of hot coals
3. Design, test and iterate spray methods
   - Hydrogel distribution method
   - Suction generation
   - Feeding
   - Hydrogel container
   - Anti-clogging measures

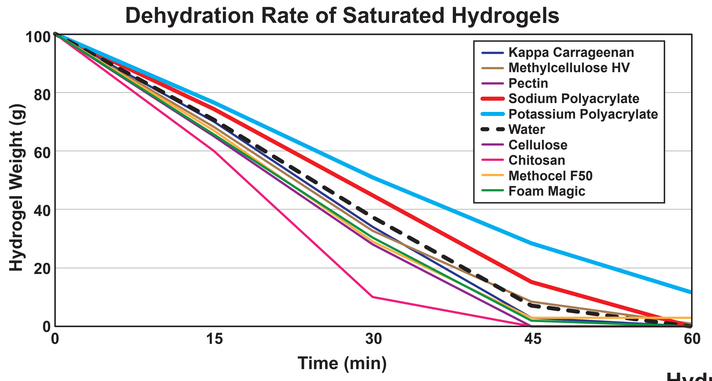
Functional Prototype

(3)

Graphical References

(1) Soucy, Jon, Sgt.1st Class Jon Soucy, US Army (2025, January 15). Homes Destroyed in the Palisades Fire. Wikimedia. https://commons.wikimedia.org/wiki/File:Homes_destroyed_in_the_Palisades_fire_(54272193113).jpg (public domain)
(2) CAL FIRE (2025, January 8). Palisades Fire. Wikimedia. https://commons.wikimedia.org/wiki/File:Palisades_Fire_(54254471791).jpg (public domain)
(3) Graphic made by finalists using Adobe Illustrator with icons adapted from The Noun Project, https://thenounproject.com, 2026.
(4) Graph made by finalists in Google Sheets, 2025. Right: photographs taken by finalists, 2025.
(5) Graph made by finalists in Google Sheets, 2025.
(6) Graph made by finalists in Google Sheets, 2025.
(7) Photographs taken by finalists, 2025. Graph made by finalists in Google Sheets, 2025.
(8) Photographs taken by finalists, 2025.
(9) 3D model by "bqzero" (2015, January 18). Venturi / Water-Jet Pump. Thingiverse. https://www.thingiverse.com/thing:641103
(10) Photographs taken by finalists and edited in Canva to remove backgrounds, 2025.
(11) Photograph taken by finalists, 2025.
(12) Photograph taken by finalists, 2025.
(13) Graphic made by finalists using Adobe Illustrator with icon adapted from The Noun Project, https://thenounproject.com, 2025.

Results 1. Selecting Optimal Hydrogel



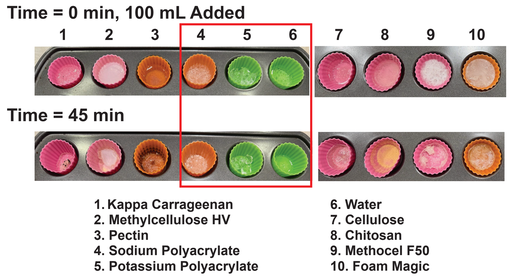


Figure 3: A test of 9 saturated hydrogels at 200 degrees Celsius and their mass measurements over 1 hour. Left: Mass of hydrogels over time. Above: Images of hydrogels before (top) and after (bottom) 45 minutes in the oven. Red box shows polyacrylates and water. (4)

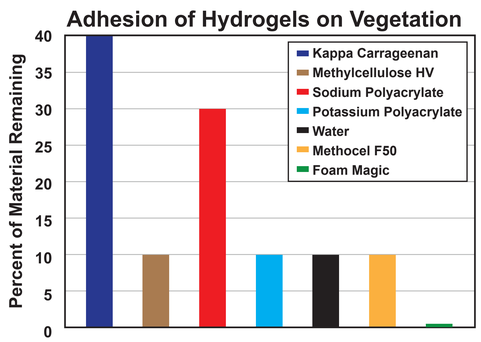


Figure 4: A test of hydrogel adhesion to a hanging leaf. 1 g of hydrogel hydrated in 100 mL of water, let sit for 30 min. Solid hydrogels strained before applying to leaf. (5)

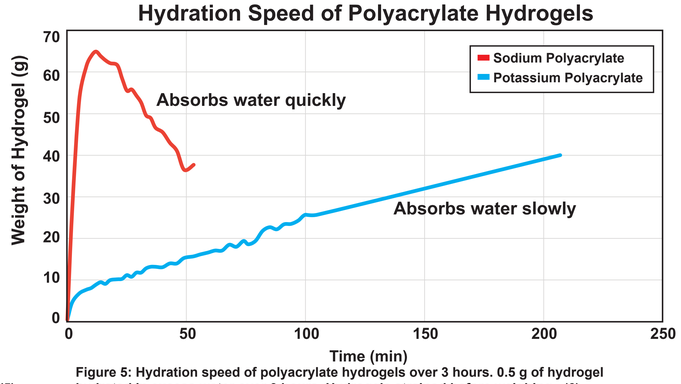
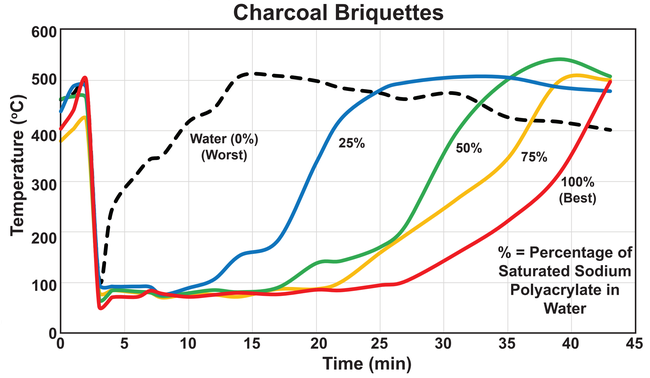


Figure 5: Hydration speed of polyacrylate hydrogels over 3 hours. 0.5 g of hydrogel hydrated in excess water over 3 hours. Hydrogels strained before weighing. (6)

2. Determining Rekindling Prevention Capabilities



Figure 6: Above: Normal and thermal images of hot charcoal briquettes treated with 0%, 25%, 50%, 75%, and 100% mixtures of hydrogel in water. Right: Charcoal briquette temperatures after adding 10 g of different hydrogel and water mixtures. (7)



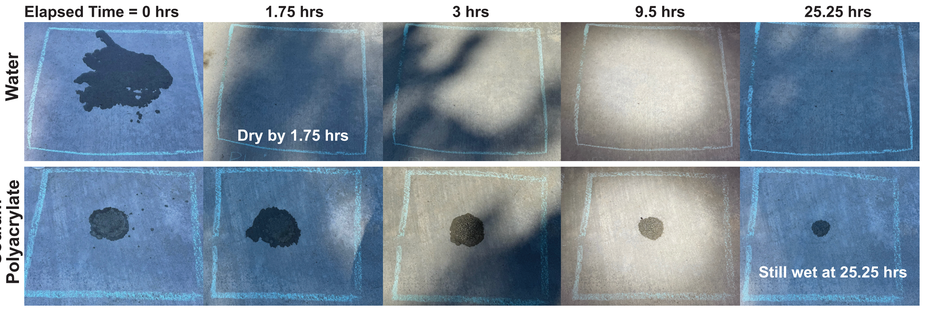
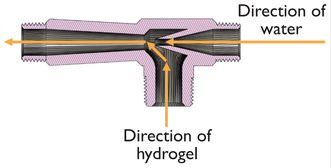


Figure 7. Images of plain water and a hydrogel-water mixture applied to a concrete driveway, comparing how long they last before evaporating away. Equivalent volumes of water were applied to both squares. Wet hydrogel is still visible over 25 hours later, while plain water evaporated after only 1.75 hours. Outside temperatures ranged from 16-23 °C. (8)

3. Iterative Design and Testing of Hydrogel Sprayer

Bernoulli's principle:
$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$



Venturi effect: as an incompressible fluid moves through a narrow point in a tube, the speed increases as the pressure decreases.

Figure 8: Cross-sectional view of spray nozzle. (9)

Entrainment: a physics principle in which a fast moving jet of water sucks in nearby matter and transports it with the stream, leaving behind a zone of localized suction.

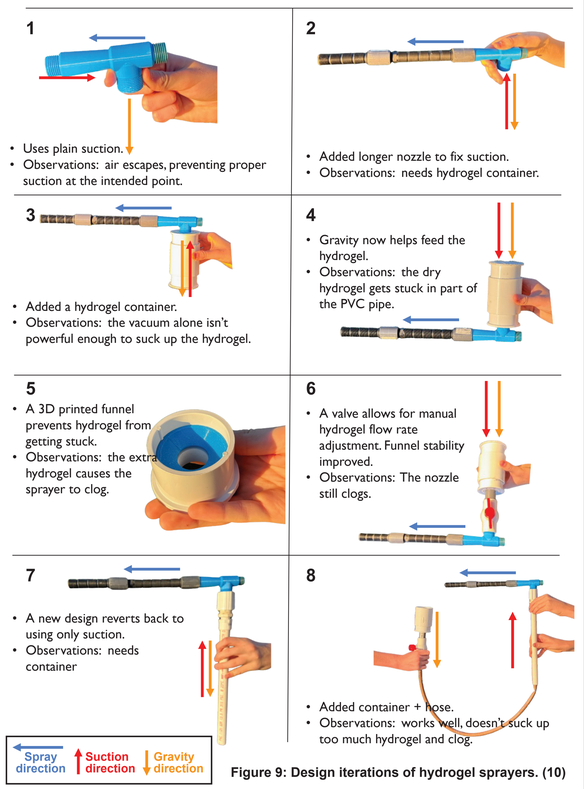


Figure 9: Design iterations of hydrogel sprayers. (10)



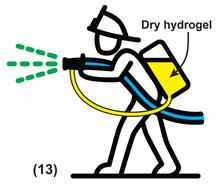
Figure 10: Concrete after being sprayed with our final iteration hydrogel-dispensing hydrogel sprayer. (11)



Figure 11: Tumbleweed after being sprayed with our final iteration of a hydrogel-dispensing hose attachment. (12)

Conclusions

We have successfully shown that sodium polyacrylate hydrogel outperforms plain water in preventing wildfire rekindling, and demonstrated a simple hose attachment that can be used by firefighters to spray hydrogel.



(13)

General References

1. Vincent, R. (2025, January 24). Estimated cost of fire damage balloons to more than $250 billion. Los Angeles Times. https://www.latimes.com/business/story/2025-01-24/estimated-cost-of-fire-damage-balloons-to-more-than-250-billion.
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4. Khan, S. (nd) Finding flow rate from Bernoulli's equation. Khan Academy. https://www.khanacademy.org/test-prep/mcat/physical-processes/fluids-in-motion/v/fluids-part-12.
5. Wait, T. (2025, October 8). How an underground fire turned into the Palisades Fire. CBS Los Angeles. https://www.cbsnews.com/losangeles/news/holdover-ground-fire-palisades-los-angeles.

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