Development of a Multifunctional Laser Hair Removal Patch

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Introduction/Background

Laser hair removal enables permanent hair removal and is among the most commonly practiced laser procedures in all of medicine. This procedure improves the quality of life for patients by permanently removing excessive hair and increasing. Unfortunately, there are many challenges with the current laser hair removal technology today. Some of these challenges include:

- Burning and ulcerations from the heat of the laser pulse
- Pain
- Plume
  - inhalation risk, containing very high levels of particulate matter and volatile organic compounds that are carcinogenic
- Difficult to determine where the laser was fired

The multifunctional laser patch aims to address these challenges.

(a) (b) (c)

Fig 1. (a) Patient receiving laser hair removal in the armpit area. **(b)** Images of a patient's treated back areas before and after laser hair removal. **(c)** The burning and ulcerations that can be caused by laser hair removal.

Goals

The purpose of this project is to create a device that can mitigate challenges of laser hair removal without compromising efficacy. Functions of the device include:

- Epidermal Cooling/Protection
  - Prevents burning and ulcerations
- Pain Mitigation
  - Provides pain relief before, during, and after laser pulse
- Plume Control
- Indicator function
  - Acts an indicator of where the laser was fired

Structure and Function

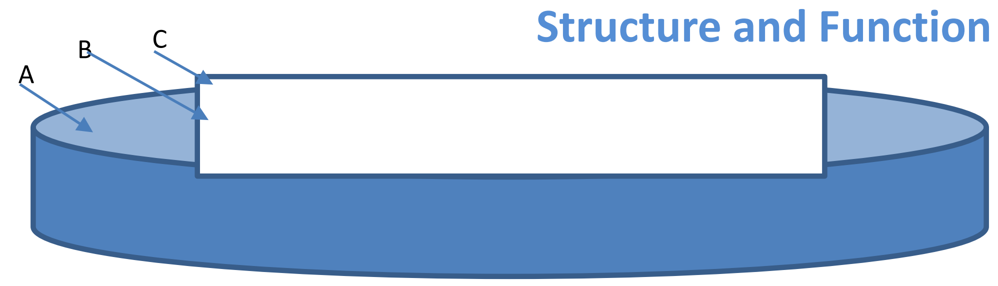
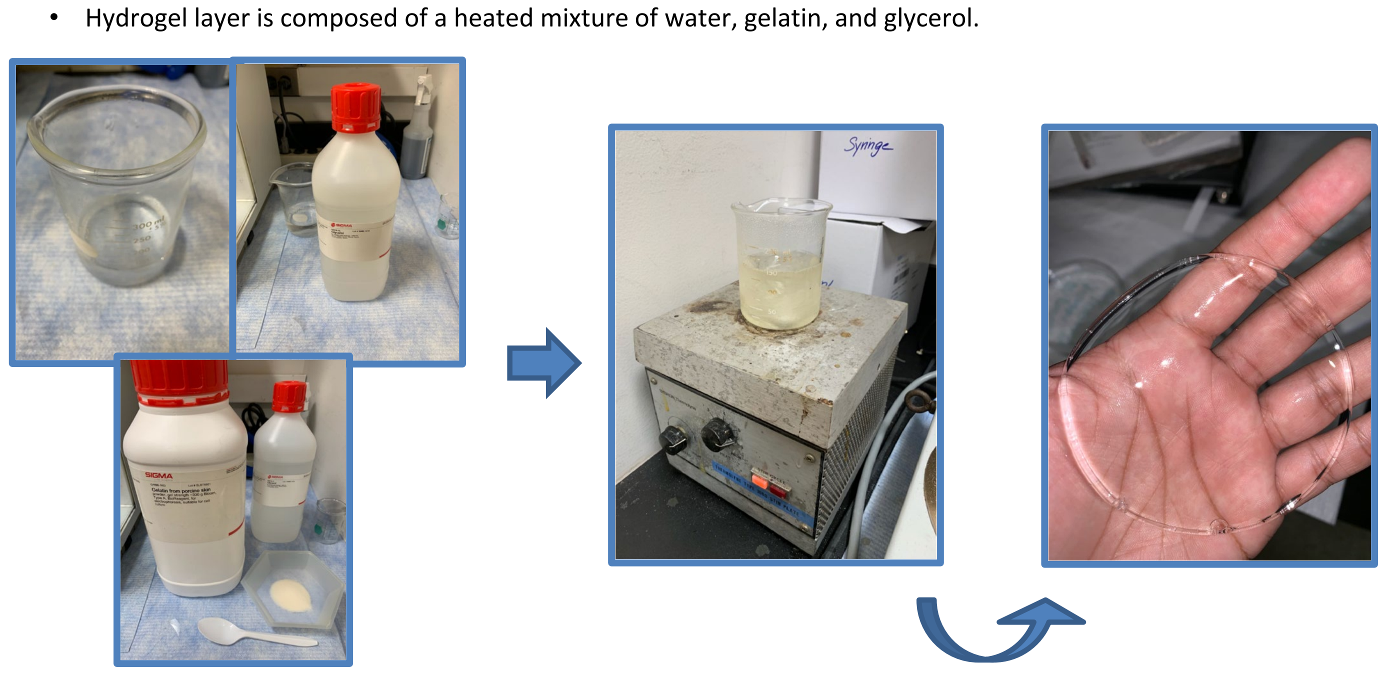


Fig 2. Diagram of the multifunctional laser hair removal patch (optically transparent).

- "A" refers to the hydrogel layer.
- "B" refers to the plastic film serving as the indicator sheet.
- "C" refers to the ink particles on the indicator.

Hydrogel Layer (Optically Transparent)
- Hydrogel layer is composed of a heated mixture of water, gelatin, and glycerol.



(a) (b) (c)

Fig 3. Ionized water, glycerol, and gelatin powder, pictured on the left (a), are mixed while being heated (b) to turn into the hydrogel seen on the very right.

Indicator Sheet (Optically Transparent)
- Contains ink particles which serve as the indicator function
- Bonded to hydrogel with glue

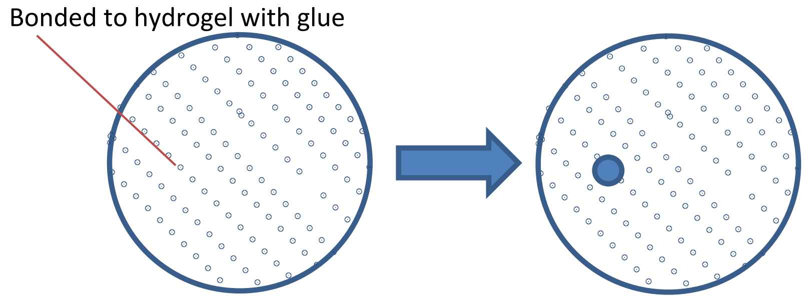
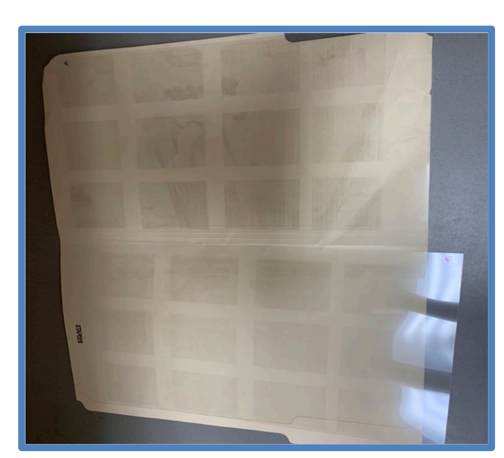


Fig 4. View of the indicator sheet from above. The ink particles on the plastic film (Left) are heated by the pulse from the laser. Area hit by the laser became opaque (right).



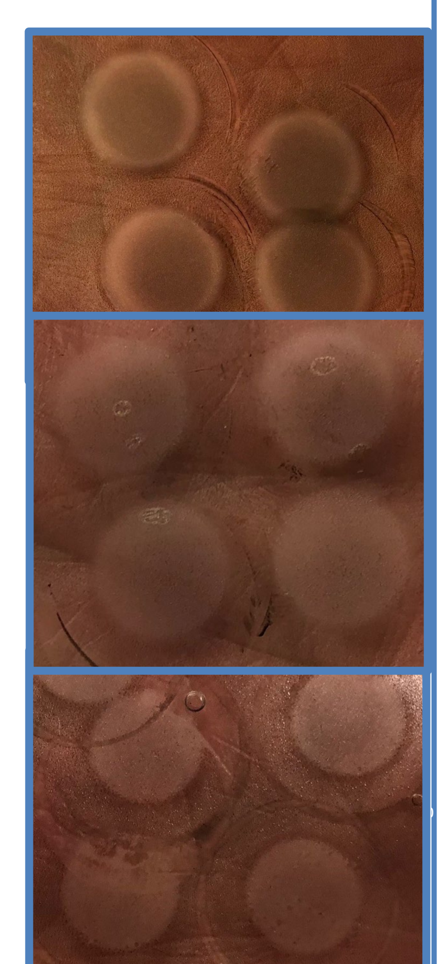


Fig 5. Before and after of ink particles being hit by the 755 nm laser. Left: Freshly printed ink particles on plastic film. Right: Ink particles after being hit from the laser

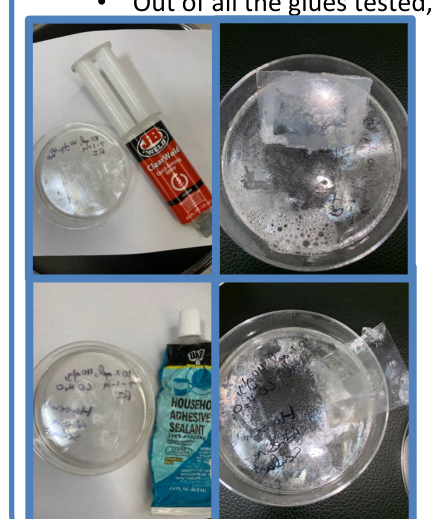
Optimization of the Multifunctional Patch

Several tests have been conducted to optimize the hydrogel and its indicator function. These tests include finding the optimal gel concentration and and adhesion tests.

Optimizing Gel Concentration
- Multiple gels with different concentrations were produced to find the gel that could be formed with the least amount of materials and placed in -20º C without freezing.
- It was found that after ample testing, 3% gelatin powder, 70% water, 30% glycerol produced the best results.

Fig 6. Optimal gel pictured above.

Adhesion Tests
- Peeling tests of the plastic film were conducted to measure the strength of the glue between the hydrogel and indicator.
- Out of all the glues tested, Caliber Super Glue produced the best results.



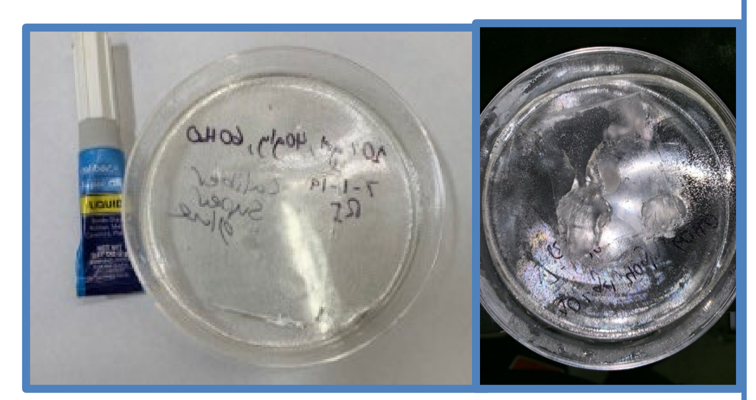


Fig 7. All glues used within the experiment pictured above. Caliber Super Glue pictured on the right.

Results

The multifunctional patches were tested at the laser clinic and analyzed with a plate reader to find the optical transmission.

Photometer

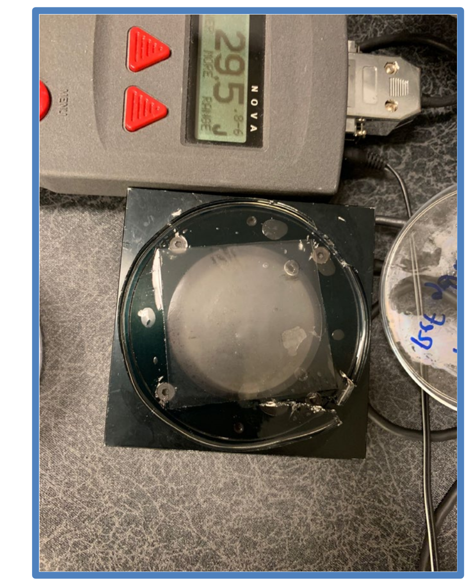
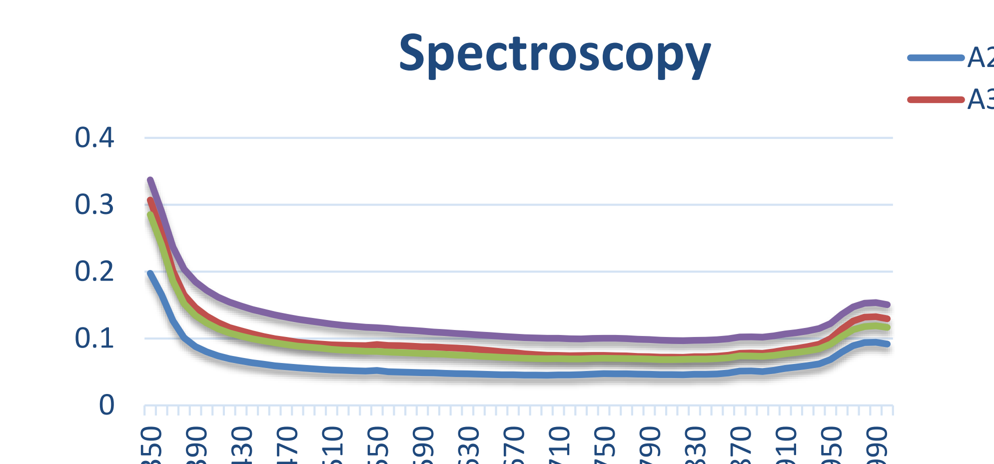


Fig 8. Pictured above is a photometer.

100% Water	Baseline	70% Water and 30% Gly
2.37	3.93	3.17
2.56	3.9	3.62
2.46	4.08	2.83
2.83	3.97	3.08
2.59		2.94
2.61		2.81
2.77		2.51
2.8		2.77
2.72		2.72
2.48		2.7
2.73		2.82
2.77		2.51
2.64083333 (average)		2.87333333 (average)
66% transmission		72% transmission
0.17704951 absorbance		0.1404045 absorbance

- The results show the transmission and absorbance of light by the laser patches. The patch with the concentration of 10% gelatin, 30% glycerol and 70% water was found to transmit more light in comparison to the patch with just water.

ELIZA Spectrophotometer



- The results show the amount of light that was absorbed by the patches with just the: gel (A2), gel + plastic(A3), gel + plastic + ink (A4), gel + plastic + ink + glue (A5)
- At 755 nm, there is absorbance is 0.1 of light by the patch A5. Even with the addition of glue, plastic sheet and ink to the gel, absorbance increases by only 0.05.
- Enough light can be transmitted to reach the skin.

Conclusions

Several parameters of the two-layer multifunctional laser patch have been optimized.

Future Work

- One layer patch
- Indicator function as liposomes within the single layer
- Indicator will change color when stimulated by laser light
- Testing will be done on patients in the future

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References

[1] "Laser Hair Removal: Benefits, Side Effects, and Cost." *WebMD*, WebMD, www.webmd.com/beauty/laser-hair-removal#2.
[2] Anderson, R R, and J A Parrish. "The Optics of Human Skin." The Journal of Investigative Dermatology, U.S. National Library of Medicine, July 1981, www.ncbi.nlm.nih.gov/pubmed/7252245.
[3] "Laser Hair Removal Can Cause First-Degree Burns." Gulf News – No.1 in UAE and Dubai for Breaking News, Opinion and Lifestyle, Gulf News, 7 Nov. 2018, gulfnews.com/uae/health/laser-hair-removal-can-cause-first-degree-burns-1.2271344.
[4] Cruel, Jessica. "Is Laser Hair Removal Right for You? How to Find Out." SELF, SELF, 22 Aug. 2018, www.self.com/story/the-pros-cons-of-laser-hair-re.
[5] "Laser Hair Removal - Skinologie Beaumont." Skinologie Medical Spa, www.skinologie.com/laser-hair-removal2.html.

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