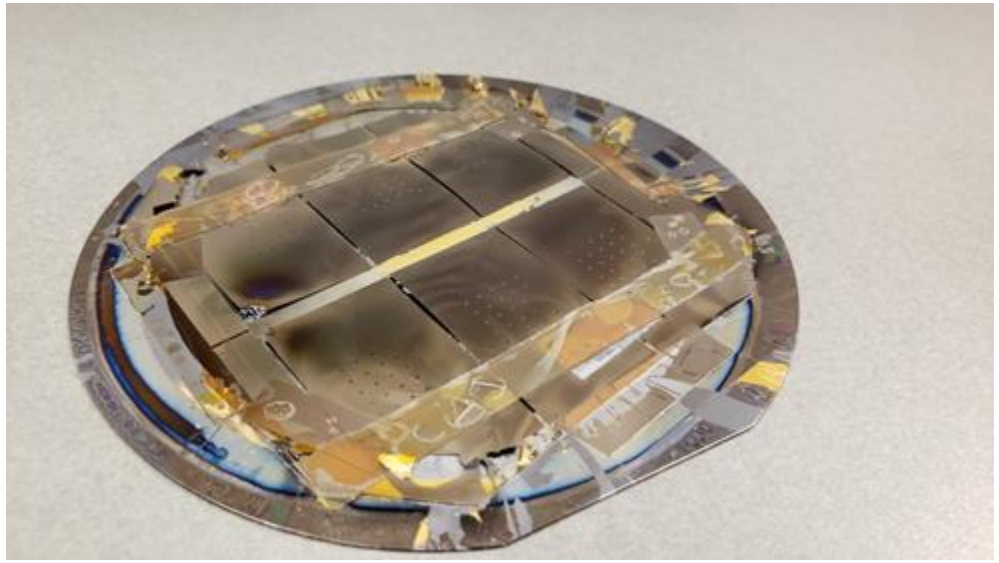
GEORGETOWN UNIVERSITY

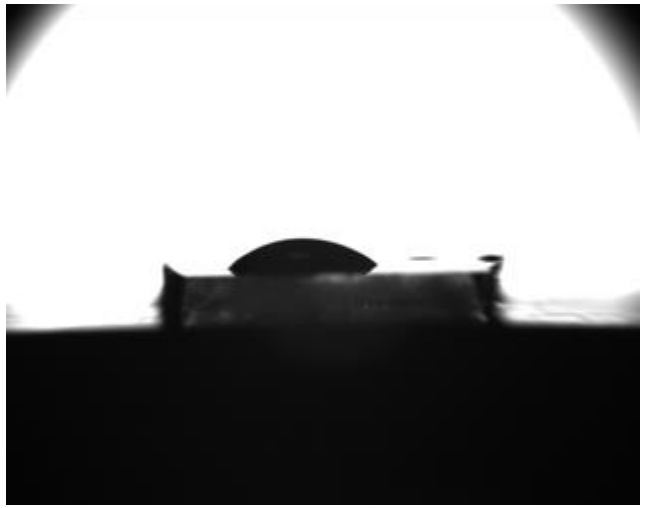
Testing the Mechanical Properties of Polydimethylsiloxane (PDMS)

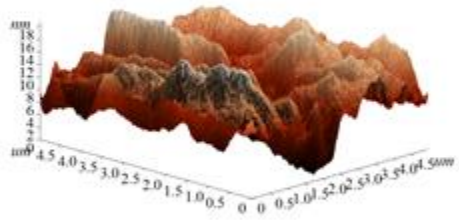
Maya Lall
Georgetown University Nanoscience and Microtechnology Laboratory
Mentor: Makarand Paranjape, PhD

Dr. Paranjape's Lab

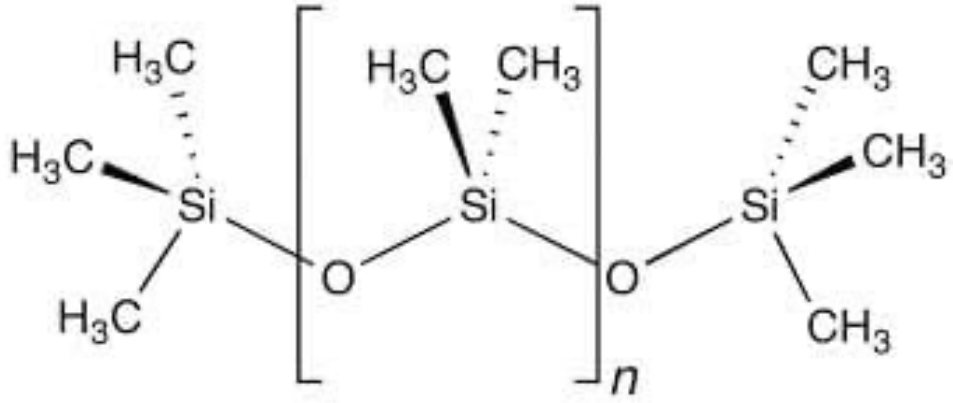
- Nanotechnology and biomedical engineering
- Creating biomedical sensors
- Purposes
  - Transdermal glucose sensing
  - Drug delivery
  - Tissue engineering
  - Cell isolation







PDMS



- Organosilicone compound
- Elastomer
- Two parts: silicone base & curing agent
- Often used in microfluidics & biomedical applications
- Hydrophobic

Chronology of My Internship

February 21: Began researching & joining weekly Zoom meetings

June 20: First day in-person, began working on the first project

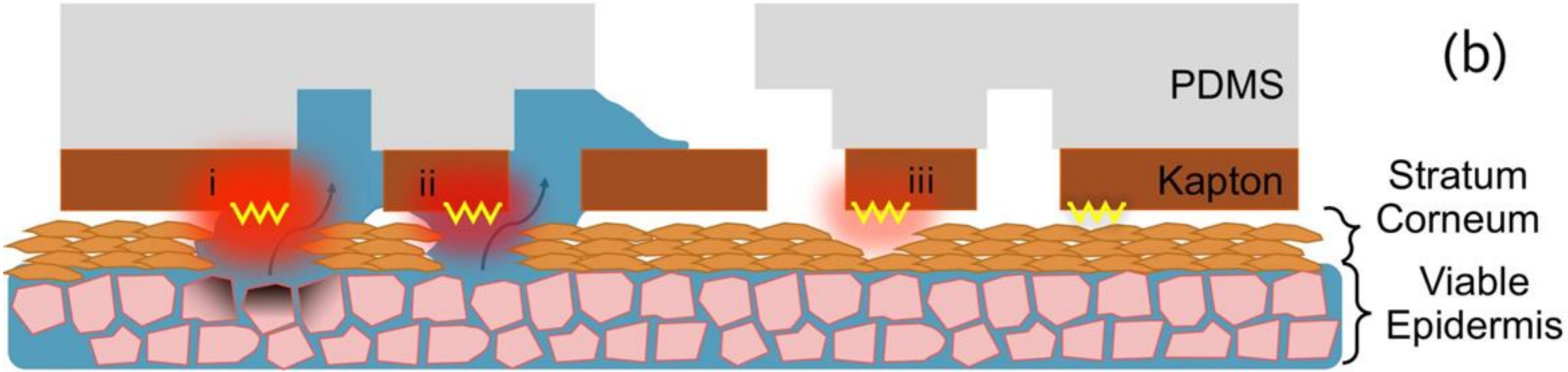
July 29: Began working on the second project

August 17: Final day

Part One

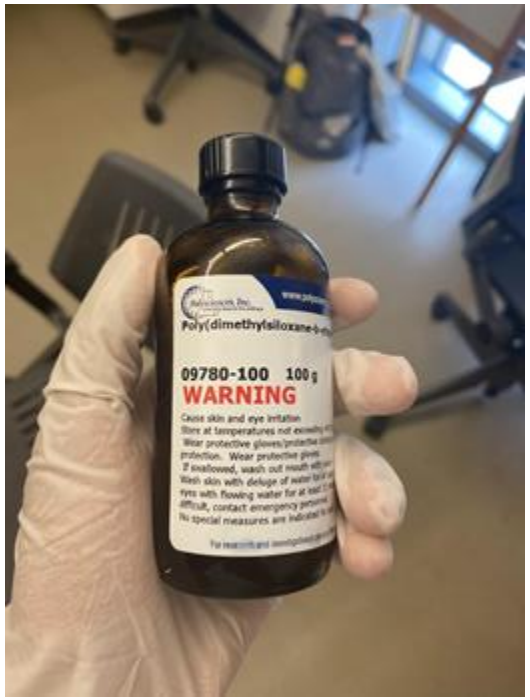
Determining the elasticity of PDMS with different concentrations of surfactants

Transdermal Skin Patch



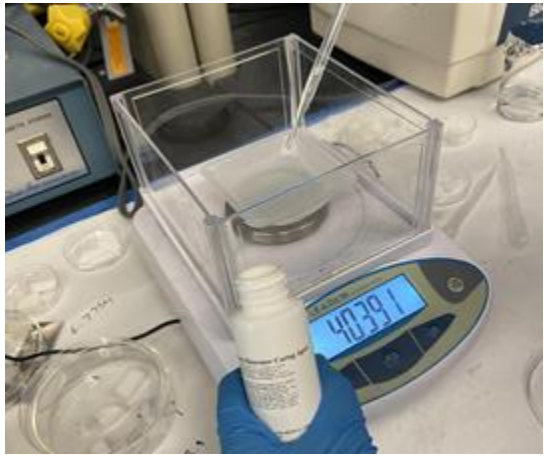
My Role

- PDMS is hydrophobic - want it to be hydrophilic for the skin patch
- Surfactants make PDMS hydrophilic
- Question: Does adding surfactant to PDMS change its elasticity?

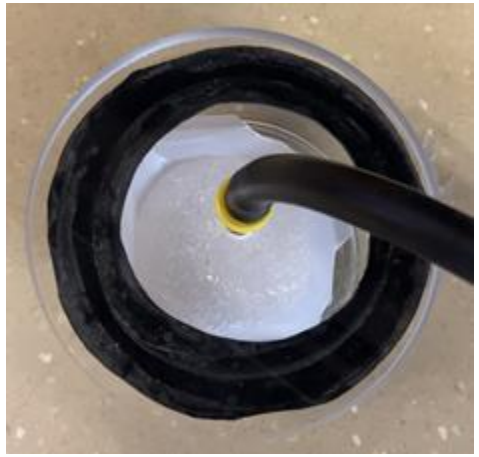


Methods: Preparing PDMS Samples

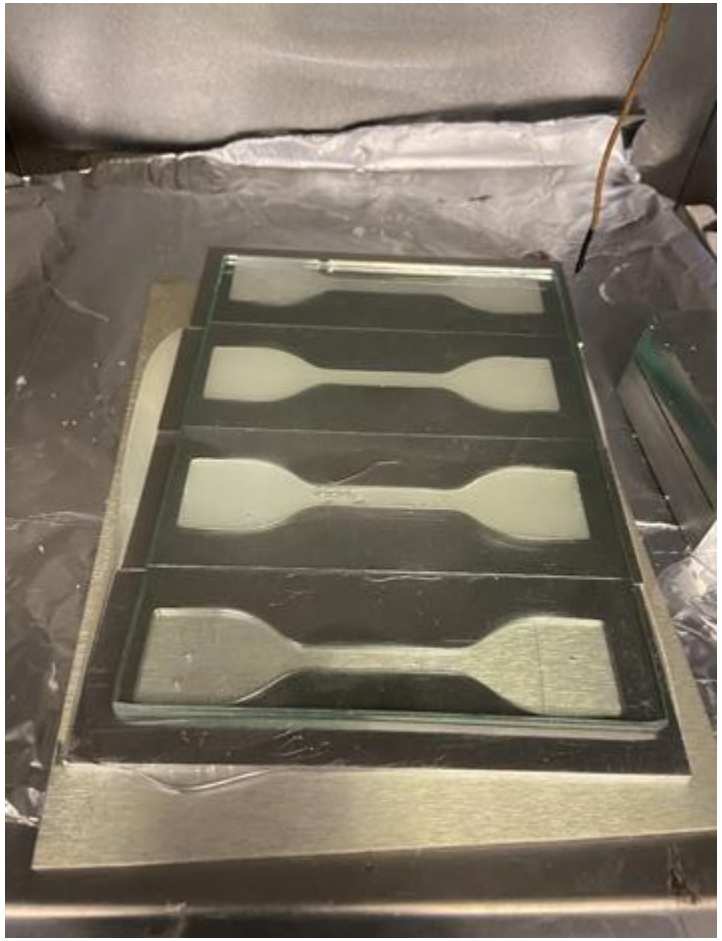
- Made PDMS with 2 types of surfactant: Triton X-100 & PDMS b-PEO
- At least 3 trials of each type
- Samples were in the oven for 24-72 hours at 65°C



Step 1



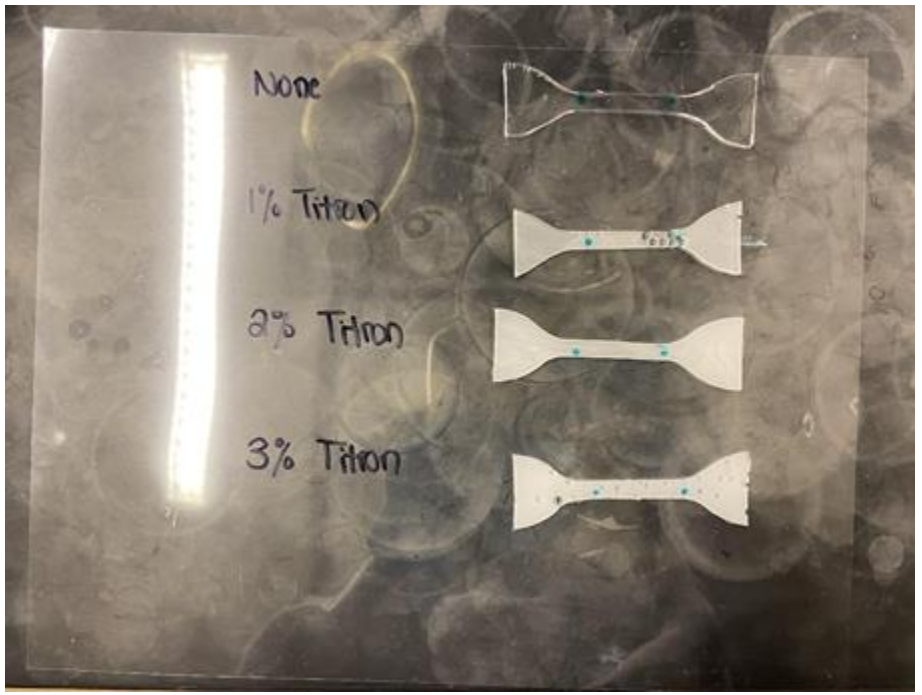
Step 2



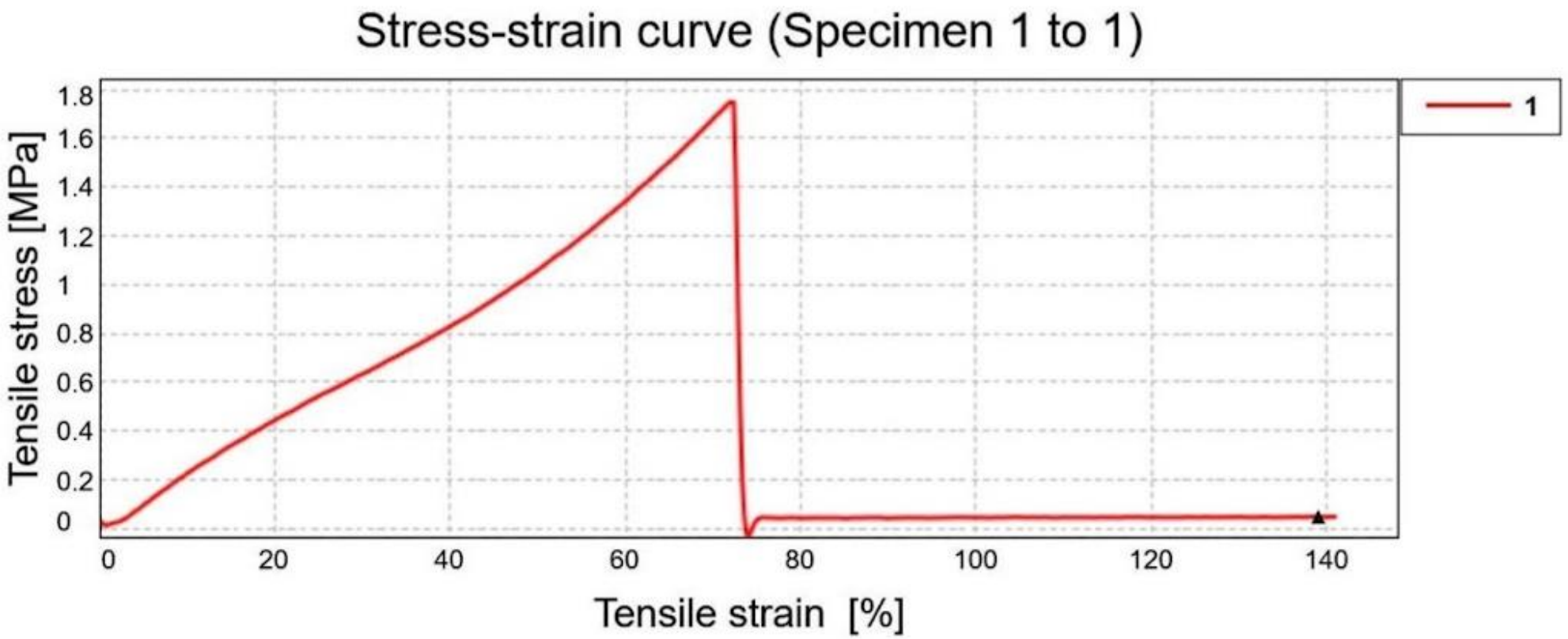
Step 3

Methods: Testing PDMS Samples on Instron

- Instron measures mechanical properties
- My focus: Young's Modulus (elasticity)

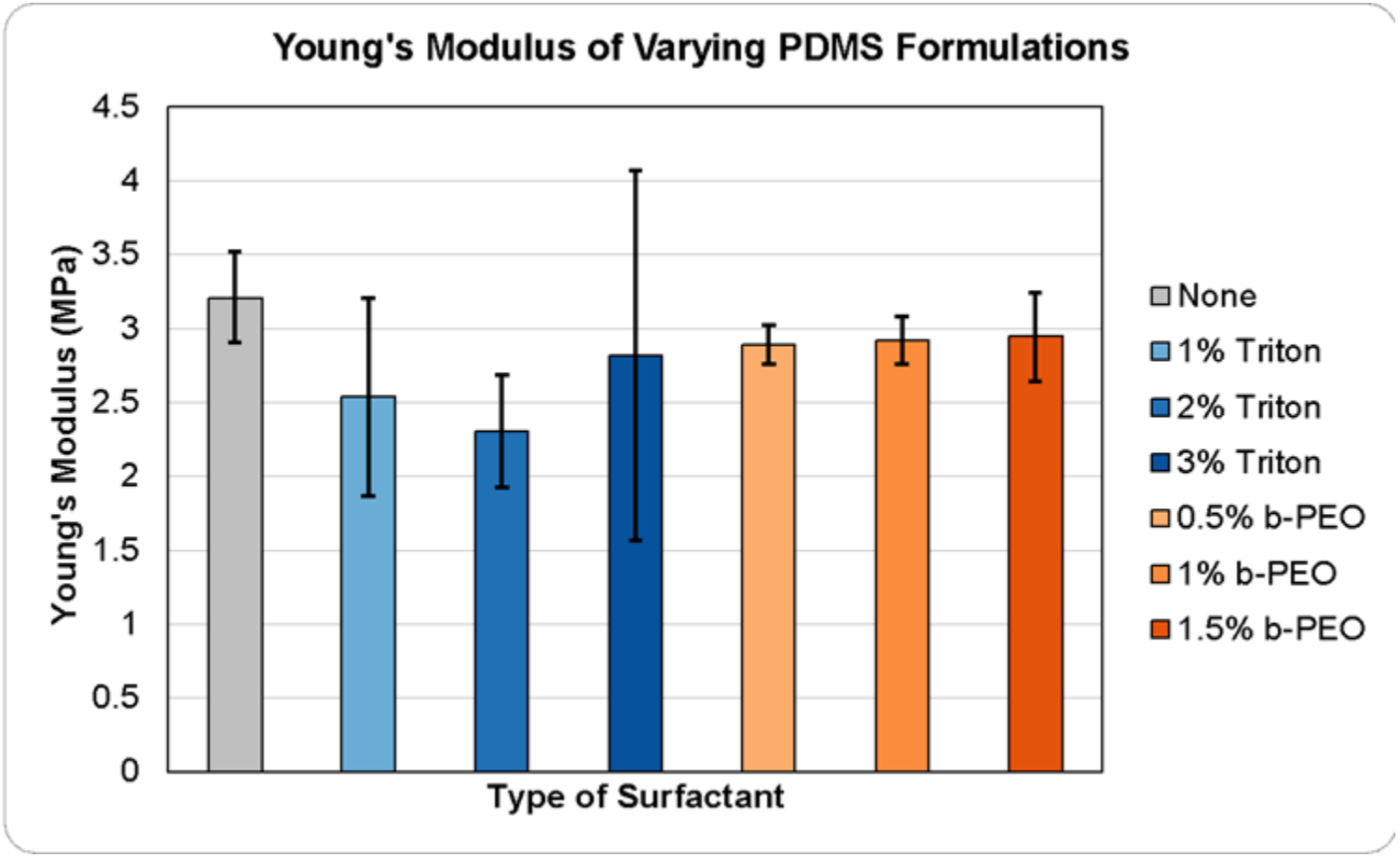


Results



Stress-strain curve of PDMS b-PEO trial 1

Results

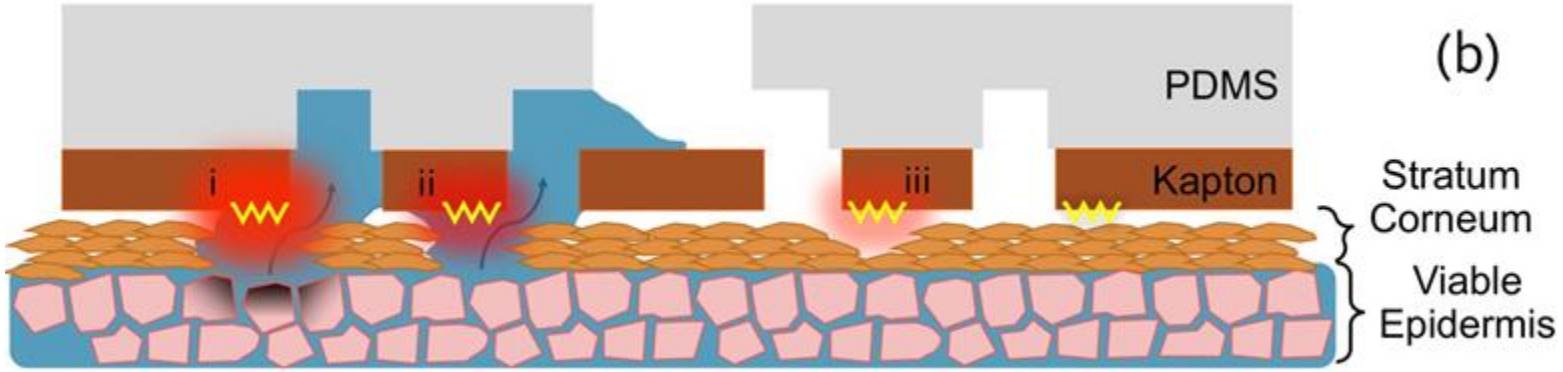

Young's Modulus of Varying PDMS Formulations
Young's Modulus (MPa)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Type of Surfactant
None
1% Triton
2% Triton
3% Triton
0.5% b-PEO
1% b-PEO
1.5% b-PEO

Part Two

Determining the gelation point of PDMS with different concentrations of surfactants

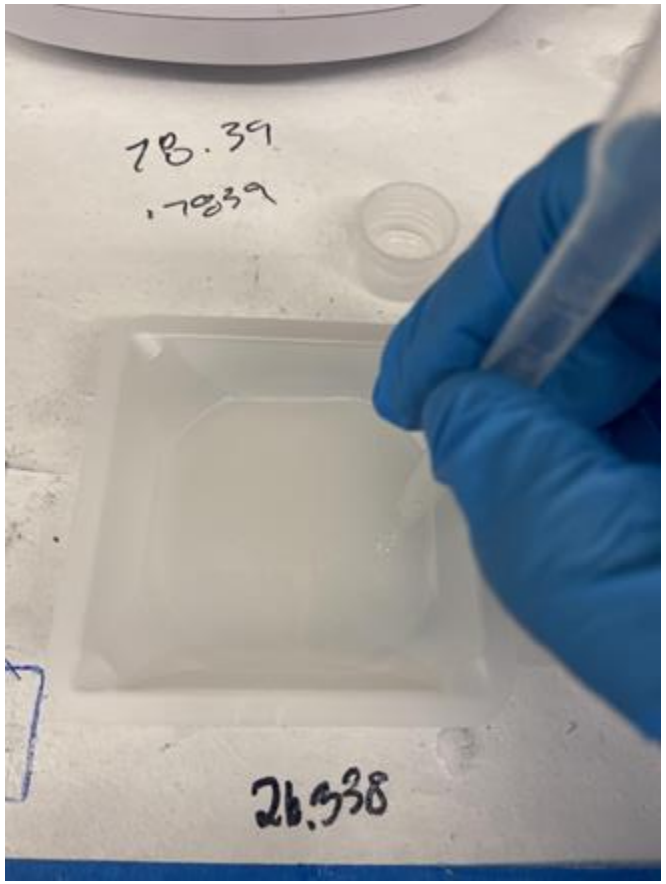
My Role

- Question: What are the gelation points of PDMS with different surfactants?
- Useful to know because PDMS is used to make the transdermal skin patch



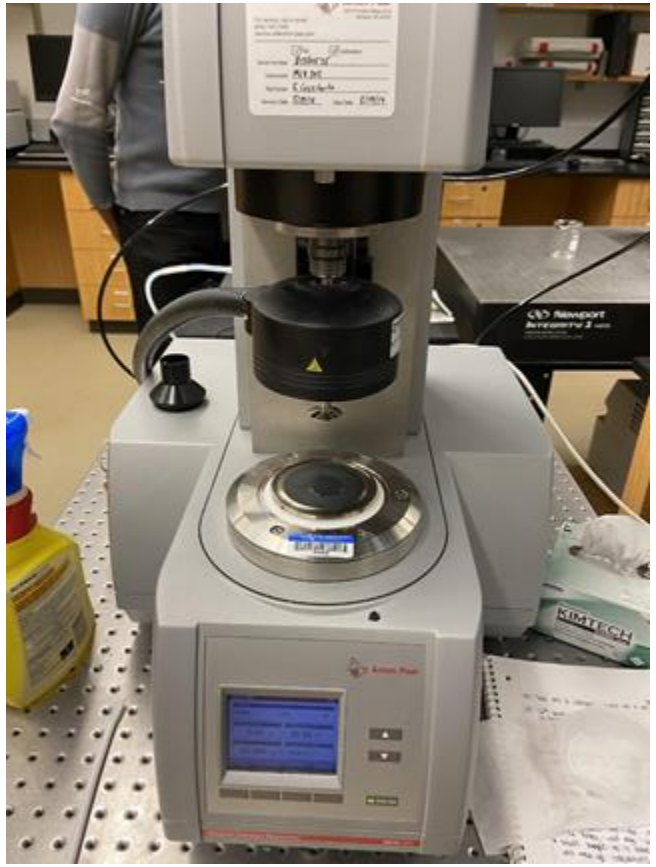
Methods: Preparing PDMS Samples

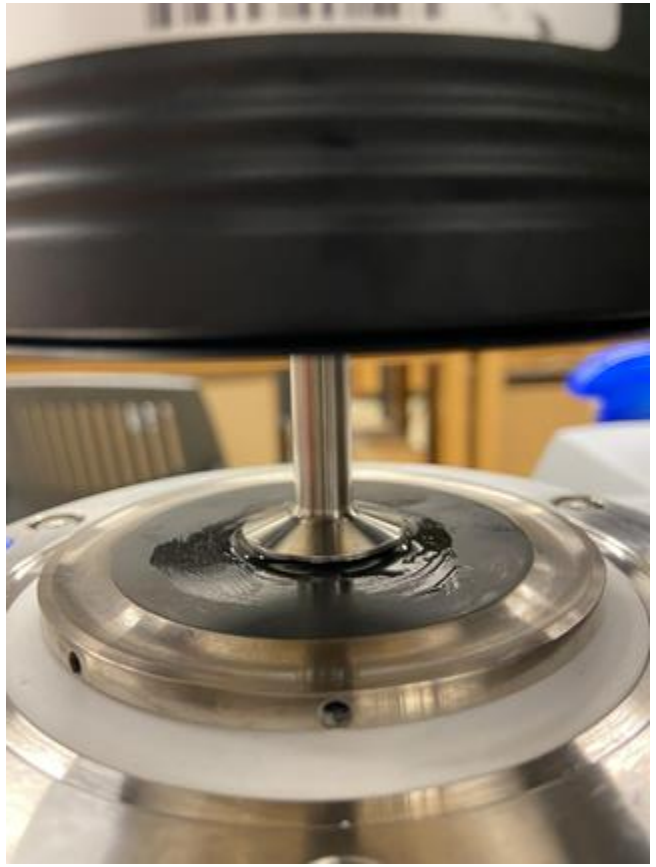
- Same process as in part one except samples did not go into the oven
- Made PDMS with 2 types of surfactant: Triton X-100 & PDMS b-PEO



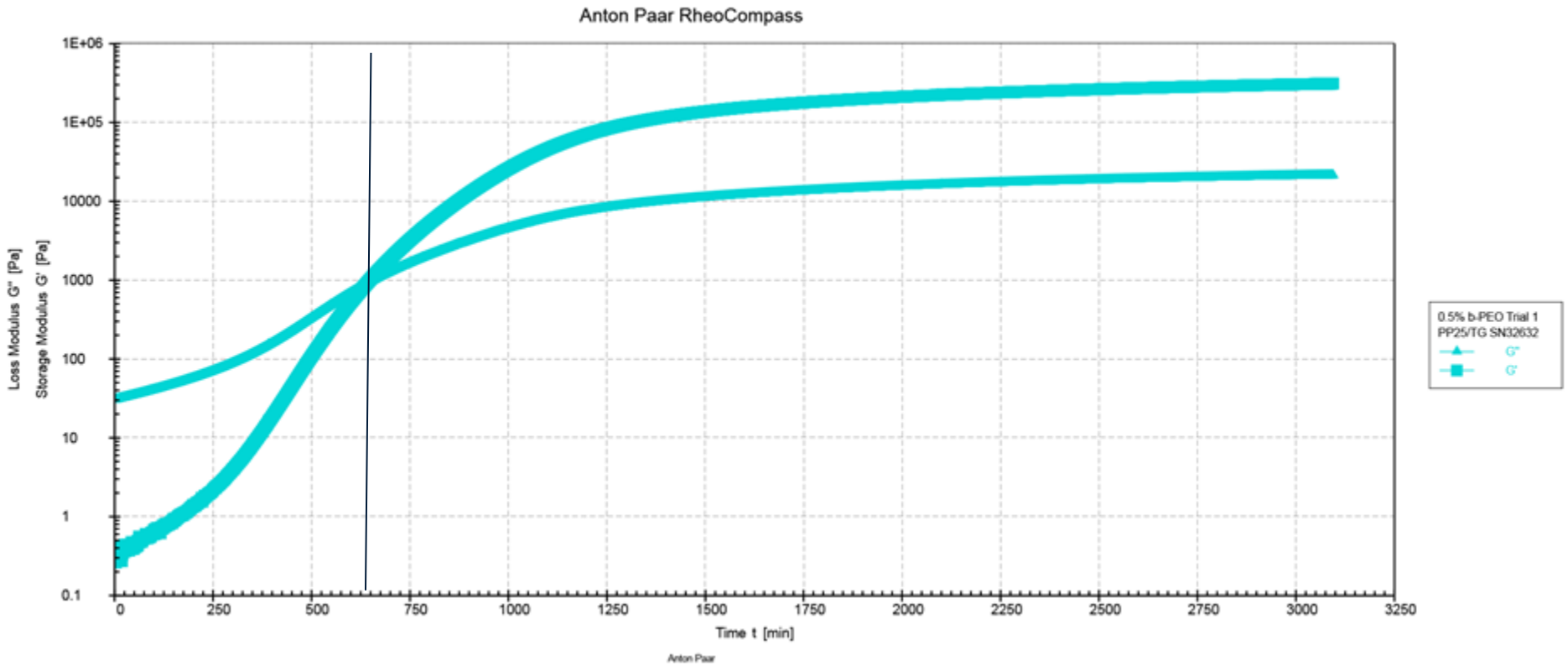
Methods: Testing PDMS Samples on Rheometer

- Rheometer measures gelation point of PDMS
- Samples were in the Rheometer at 25°C (room temperature) for 48-72 hours

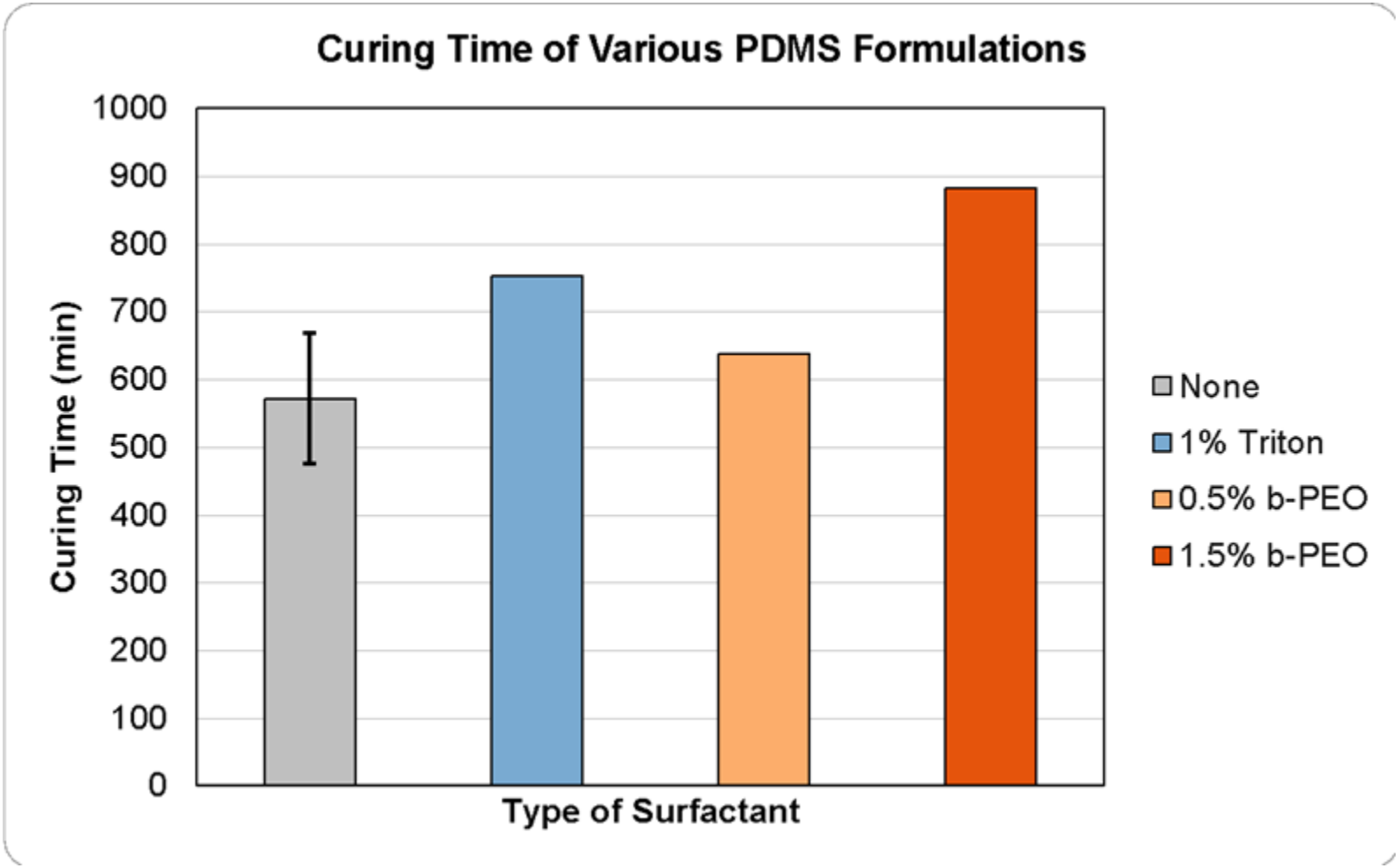




Results


Anton Paar RheoCompass
1E+06
1E+05
10000
1000
100
10
1
0.1
Loss Modulus G'' [Pa]
Storage Modulus G' [Pa]
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
Time t [min]
Anton Paar
0.5% b-PEO Trial 1
PP25/TG SN32632
G''
G'

Results


Curing Time of Various PDMS Formulations
Curing Time (min)
1000
900
800
700
600
500
400
300
200
100
0
Type of Surfactant
None
1% Triton
0.5% b-PEO
1.5% b-PEO

Takeaways

- Trial and error is key
- Be open to collaboration
- Take detailed notes!

Acknowledgements

A huge thank you to:

- Dr. Mak Paranjape
- Dr. Xinran Zhang
- Dr. Jasper Nijdam
- Leon Der
- Daniel O’Brien
- Darrian Mills
- Other lab researchers: JoJo Farina, Aroosha Soloman & Chelsea Hu
- Dr. Krug & the Science Research Program

GEORGETOWN UNIVERSITY

Thanks for listening!

Questions?

Citations

Pictures:

1. https://www.elveflow.com/microfluidic-reviews/general-microfluidics/the-polydimethylsiloxane-pdms-and-microfluidics/
2. https://simpore.com/product/pdms-sheet/
3. http://maklab.georgetown.domains/photos/
4. https://www.researchgate.net/figure/Schematic-of-the-microfluidic-device-dimensions-not-to-scale-A-Top-view-and-B_fig3_314020368
5. https://www.researchgate.net/figure/Microfluidics-based-force-sensor-A-Schematic-of-the-novel-microfluidics-based-force_fig1_350522461
6. https://www.thermofisher.com/order/catalog/product/85112

Websites:

1. http://maklab.georgetown.domains/research/
2. https://www.sciencedirect.com/topics/engineering/polydimethylsiloxane
3. https://www.elveflow.com/microfluidic-reviews/general-microfluidics/a-general-overview-of-microfluidics/
4. https://www.sciencedirect.com/topics/chemistry/organosilicon
5. https://www.instron.com/en-us/resources/glossary/m/modulus-of-elasticity
6. https://www.sciencedirect.com/topics/engineering/youngs-modulus
7. https://www.dupont.com/electronic-materials/kapton-polyimide-film.html
8. https://wiki.anton-paar.com/en/basics-of-rheology/