Influence of Chemical Composition on the Adhesion of Hydrogels in Dry and Underwater Conditions

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Motivation

In the production and use of biomedical devices, wound dressings, and bone regeneration, underwater adhesion is essential to its effectivity. However, adhesion is limited in underwater environments because water molecules will penetrate and create gaps between surfaces and cause debonding at the interface. Hydrogels have demonstrated superior adhesion in underwater environments, despite their chemical composition, which is surprising. [4,5] To investigate this, polyethylene-glycol dimethacrylate (PEGDMA) and 2-hydroxyethyl methacrylate (HEMA) hydrogels were synthesized. Adhesion measurements were done using JKR geometry to test the adhesion of hydrogels in dry and wet conditions. Sum Frequency Generation Spectroscopy (SFG) was used to examine interaction strength and chemical composition at the interface. Our results will provide insights into designing hydrogels for wet adhesion applications.


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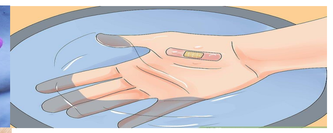


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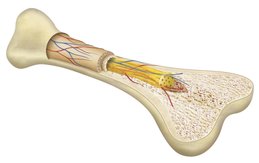
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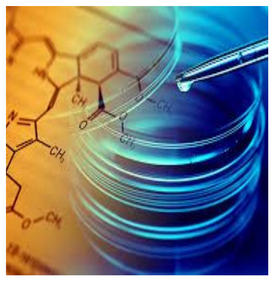
Background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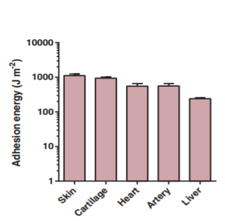
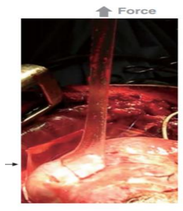
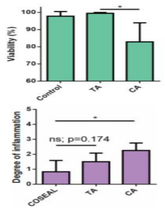
Hydrogels are composed of over 80% water.[4] This causes their superior underwater adhesion to be surprising, as water interferes with bonds between adhesive and substrate. However, numerous studies have indicated increased adhesion in underwater environments. [3,4]

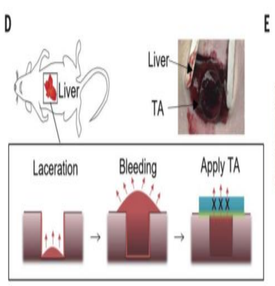
Hydrogels Show Promise in Tissue Repair and Wound Dressings[3]

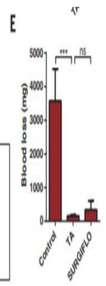
Alginate-polyacrylamide hydrogels were synthesized with various bridging polymers and analyzed for their potential in tissue repair and wound dressings.









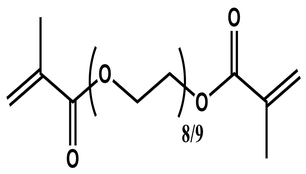


Results indicate hydrogels maintained high adhesion to various tissues in wet environments, were biocompatible, and diminished blood loss in wound dressing simulations.

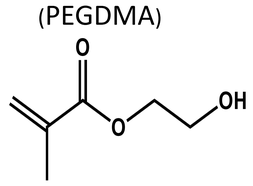
Experimental Design

Synthesis

Photopolymerization by UV irradiation was utilized to create the following hydrogels:

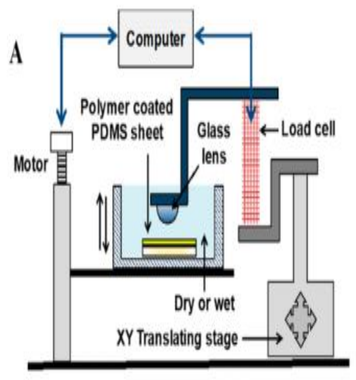


(PEGDMA)



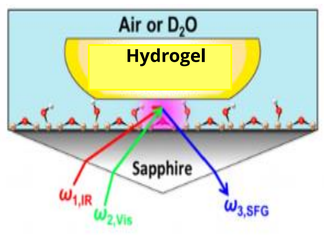
(HEMA)

Adhesion

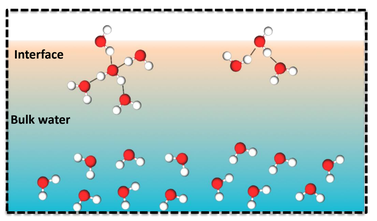


Kaur, et al. ACS Central Science 2018,4,1420-1429
Johnson Kendall Roberts Geometry (JKR)

Spectroscopy

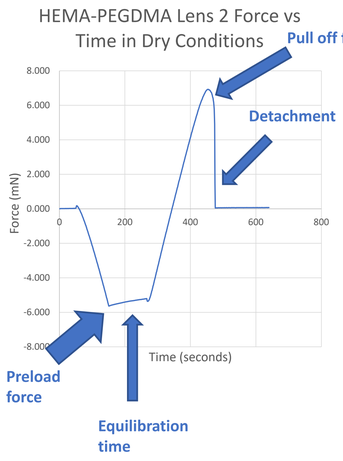


Kaur, et al. ACS Central Science 2018,4,1420-1429

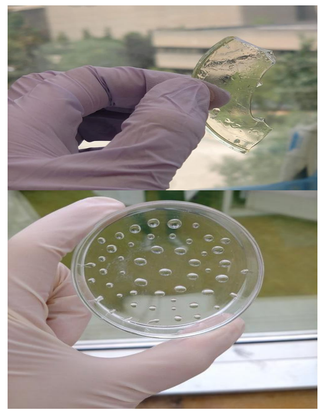


Results and Discussion

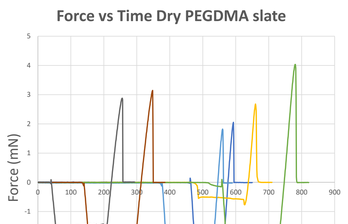
Hydrogels Demonstrate Significantly Decreased Underwater Adhesion

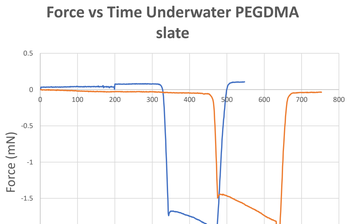


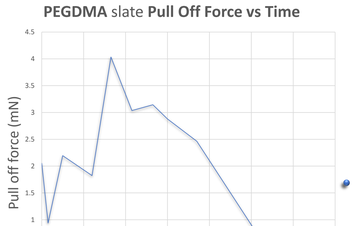
Maximum **pull off force** was measured to indicate adhesive strength of the hydrogel in slate and lens form.

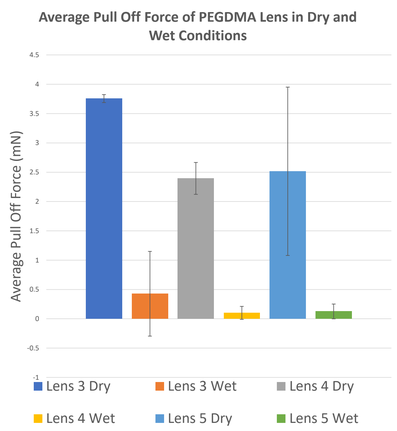


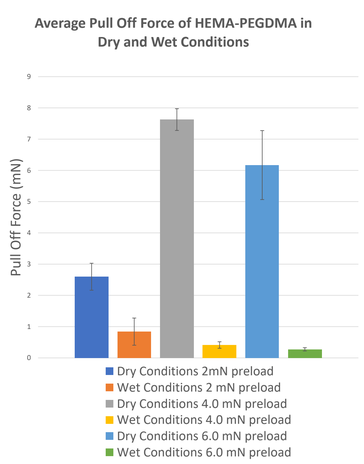
Hydrogel slates were difficult to cut and obtain a flat surface. Lens work better.



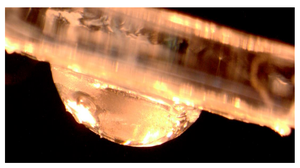




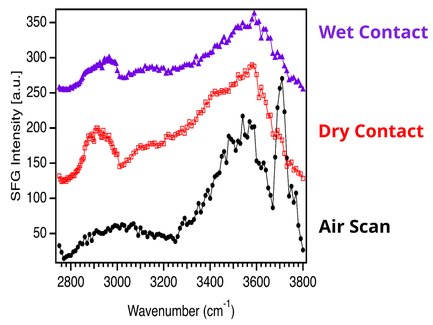




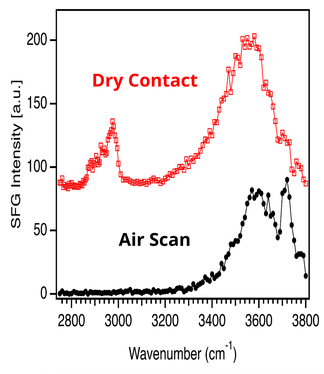
The radius of each lens was measured to provide similar sized lens in each adhesion test performed.

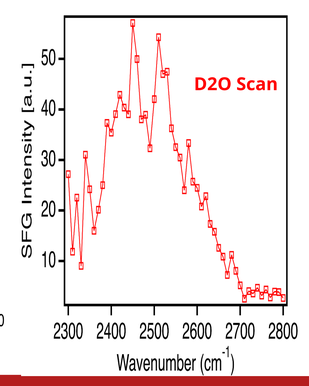


Spectroscopy



PEGDMA Lens were analyzed in dry and wet contact. Further experiments were performed utilizing deuterium oxide to differentiate the water signals from sapphire surface OH groups.





Conclusions and Future Work

1. Hydrogels demonstrated significantly lower adhesion in underwater environments, regardless of chemical composition.
2. HEMA-PEGDMA contained increased dry adhesion through pull off force values when compared to PEGDMA.
3. SFG analysis indicated presence of hydrocarbons as well as hydroxyl signals at the interface.
4. Future work will be focused on conducting additional SFG scans, as well as studying the mechanical properties of the hydrogel utilizing rheology measurements.

References

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Acknowledgements

We would like to thank the National Science Foundation (DMR# 1659531) for the generous financial support. Many thanks to my laboratory instructors Saranshu Singla, Amal Narayanan, Dr. Ali Dhinojwala and all colleagues in Dr. Dhinojwala's group for their helpful advice.