Synthetic Hagfish Slime: Mechanical Characterization

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Background

Hagfish are ancient animals that eject a strong slime when attacked by predators. This slime is composed of protein strands that cause it to have incredible strength (Fig. 1 & Fig. 2).
To defend against foes, the Navy launches plastic ropes into the propellers of enemy warships in order to decrease the thrust of the motors. In a push to find a more biodegradable solution, the utilization of hagfish slime has shown great promise in stopping propellers (Fig. 3).
We hope to understand how the slime withstands the impact of a quickly rotating propeller, while simultaneously reducing the propeller's thrust. What specific mechanical properties allow for this phenomena? From this research we can maximize the capabilities of this incredible biomaterial.

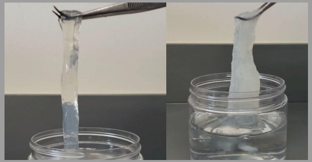


Fig. 1 (left): FW slime example
Fig. 2 (right): SW slime example

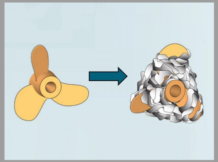


Fig. 3: Hagfish slime affecting a propeller

Methods

- Recombinantly produced alpha protein (α), gamma protein (γ), or an equal mixture of the two (M) are dissolved in 3 mL of formic acid
- After 24 hrs, centrifuged and transferred to a 26 gauge syringe
- Extruded into strands in freshwater (FW) or a saltwater solution (SW)
- FW and SW slimes are tested in a tank of freshwater or saltwater (12 conditions)
- Mechanically tested using the MicroTester from CellScale (Fig. 4 & Fig. 5) for force and elongation

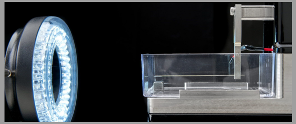


Fig. 4 CellScale MicroTester: Strand secured horizontally and beam slowly compresses the fiber

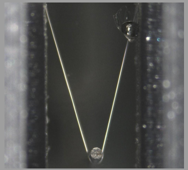


Fig. 5: Tension Test Example

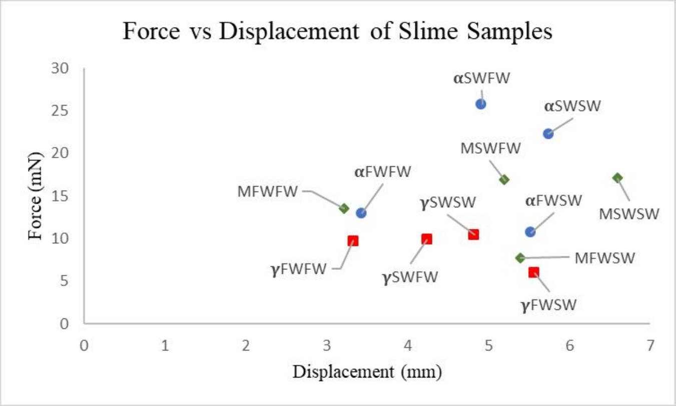
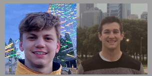


Fig. 6: Results indicate that SWSW and α slimes are much stronger and can elongate much more than other conditions



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Results

Results are graphed in Fig. 6. Key findings include:

- FWFW samples performed the lowest for strength and elongation
- The SWSW slimes tended to perform the best with respect to strength and elongation
- FWSW samples performed better regarding elongation compared to FWFW, but had lowered force values
- Force and elongation of SWFW slimes were highly variable, but the alpha SWFW recorded the highest force value for all conditions.
- Alpha protein slimes generally outperformed the other two protein ratios
- Gamma protein slimes performed relatively poorly in all conditions

Future Work

Beyond continued replications using current methods, future goals included analyzing the effects of:

-Fiber diameter
-Lyophilization
-Adding Salts to Dope
-Time Specific Testing

Due to the measured properties and the composition of the fibers, which closely mimic native tissues, biomedical and applications and research are also a viable research direction.