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Marine Gut Impaction & Alternative Plastic

Noelle Clark, Sebastian Myhr, Ishan Sharma, Zoë von Allmen

Abstract

The growing number of plastic bags being introduced to ocean systems is causing marine animals to accidentally consume harmful plastics, eventually leading to gut impaction and death. Traditional plastic bags do not degrade and rely on individuals to recycle them to prevent permanent pollution. Current biodegradable plastic bags require industrial composting and are not digestible in many marine gastrointestinal (GI) systems. Using algae agar, we synthesized a bioplastic material that can digest in marine GI systems with the structural integrity to hold common grocery items. Our novel solution does not rely on the consumer to recycle their plastic, avoids the use of industrial composting, and breaks down in marine GI systems.

Introduction

Plastic Bags:

- Are considered the most harmful waste to marine ecosystems.[3]
- Negatively affect marine animals that ingest them.

Marine Animal Digestion:

- Standard polypropylene plastic bags and biodegradable plastic bags are not able to be digested in the GI tracts of marine animals, mostly affecting sea turtles.[1]
- Sea turtles often mistake plastic bags for jellyfish, and ingesting causes gut impaction, leading to malnourishment, and in the worst case, death.[2]

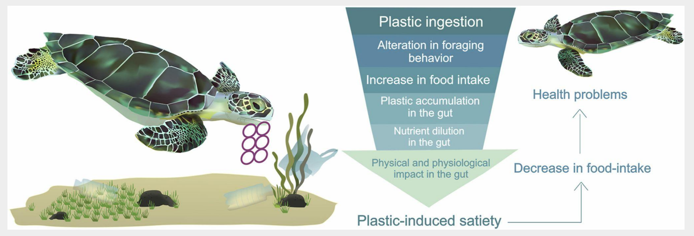

Figure from Santos et al. 2020

Our Solution:

- Create a desirable bioplastic material from seaweed agar, glycerol, and water to replace traditional plastic bags which could:
  - Degrade naturally in the environment
  - Be digested under GI conditions
  - Decrease the amount of traditional plastic bags entering our oceans

Knowledge Gaps:

- How does strength compare between bioplastic and traditional plastic?
- Will a marine animal be able to eat and digest the bioplastic without harm?

Results

Through our trials, we were able to synthesize multiple plastic types with different concentrations of glycerol and algae agar in water. The optimal combination of materials was determined via a series of trials to be a 1:2.6:168 ratio of glycerol to algae agar to water. This balanced our desired properties of tensile strength, water absorption, and dissolution in HCL, making it a viable alternative to traditional plastic bags.

Figure 1

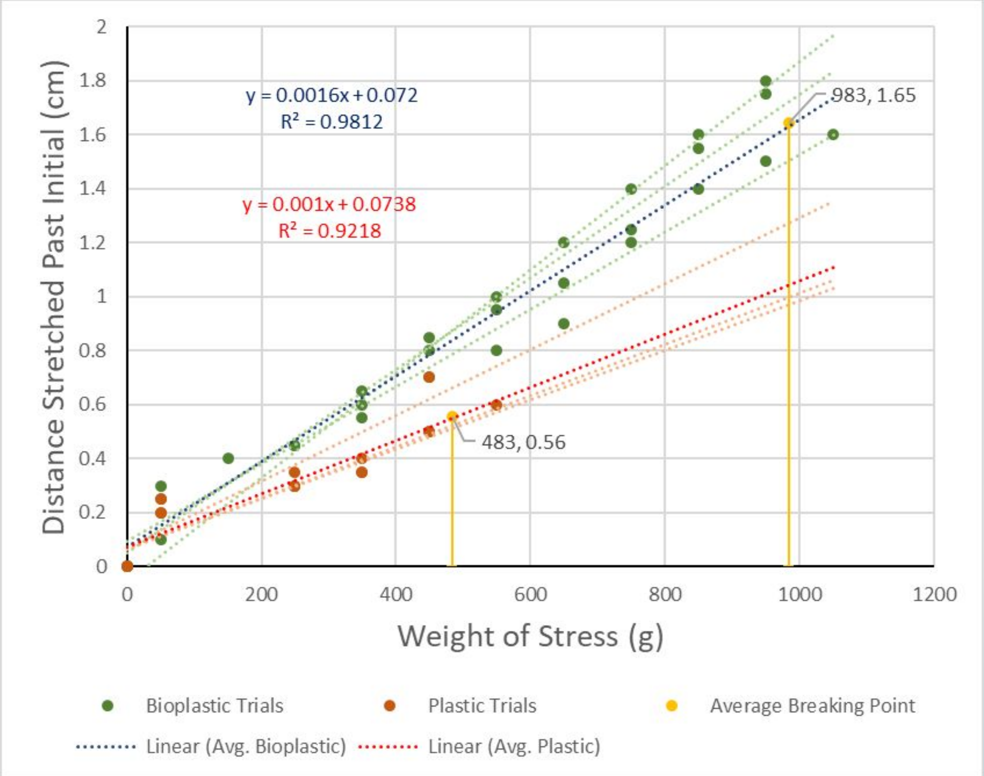

Figure 1: Comparison of the distance (cm) that plastic sheets stretched against added weight (g) before breaking. Bioplastic on average held 500 grams more than plastic before reaching the breaking point.

Figure 2

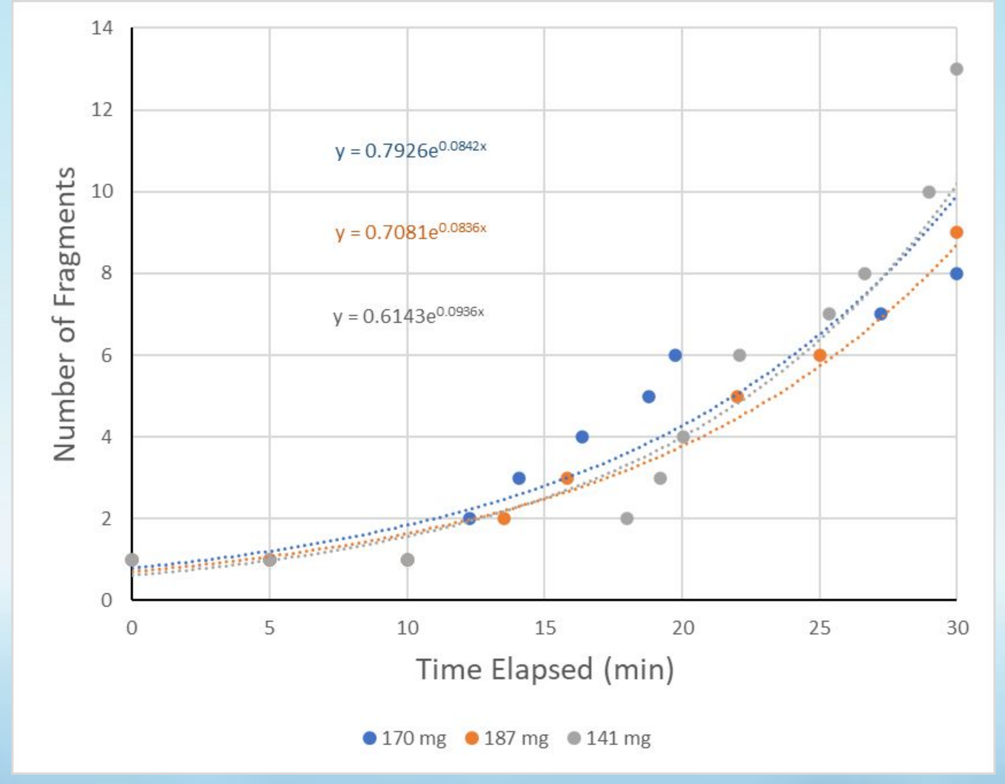

Figure 2: Simulation of GI movements to test plastic digestibility. Each trial showed results of fragmenting within 30 minutes, which would make the plastic easier to pass through GI tract.

Figure 3

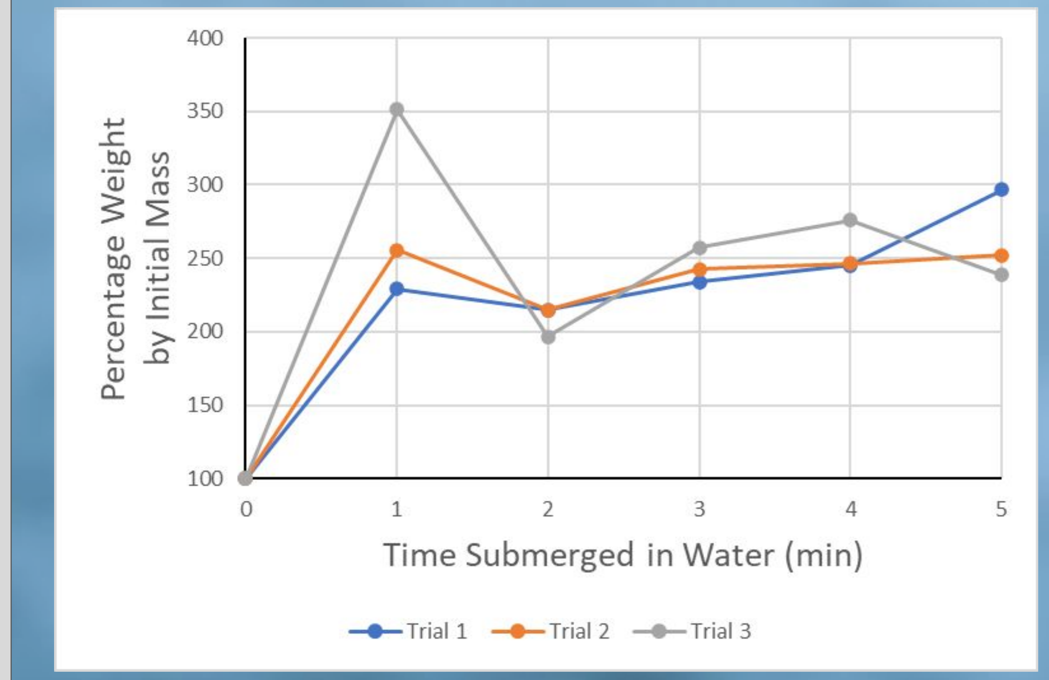

Figure 3: Measurement of the plastic's water absorption as a percentage of its original weight. All trials had similar end result and gained mass before losing it at around 2 minutes. Trial 2 was the most consistently low.

Figure 4

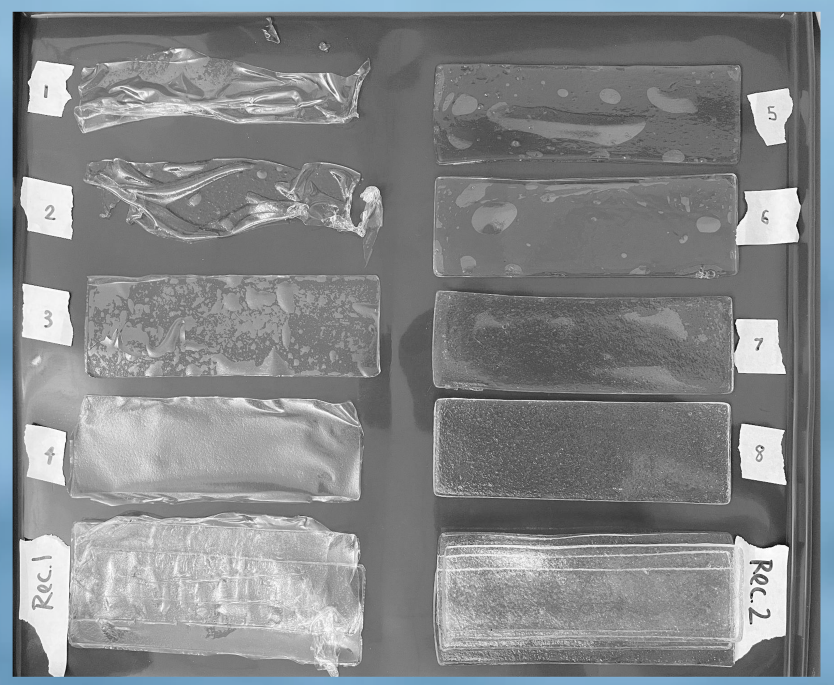

Figure 4: Different plastic types created with varying concentrations of algae agar. The bioplastic labeled "rec 1" was determined to be the best combination of materials.

Methods

To achieve a material that can effectively serve as a plastic alternative, algae agar, which provides structural stability, was combined with glycerol, which provides flexibility.

1. Using a hot plate, the solution was brought to 95° F under continual stir bar agitation.
2. The prepared mixture was poured into silicone molds to set with 1.5 mL of solution per square centimeter.
3. After 72 hours of room temperature drying, the sheets were removed and coated lightly with cornstarch to prevent sticking.

Strength and Degradability Tests

1. Tensile Strength (Figure 1)
   - Weights were added to one end of the material and the maximum elongation prior to breakage was measured.
2. Gastrointestinal Simulation (Figure 2)
   - Plastic was soaked in HCl solution,
   - Heated to 27 °C (average sea turtle body temperature)
   - Timed to see how long it would take to degrade a piece of the material into 50 pieces
3. Water Absorption of Material (Figure 3)
   - Weight of the strip was measured at one minute intervals of submersion until a plateau was reached.

Conclusions

- Plastic can be synthesized at a structurally sound level using algae agar.
- Our plastic has potential to be a viable replacement to traditional plastic bags with further research on construction methods
- The plastic bag we synthesized will allow marine animals to consume bags safely[1]
- Our approach is novel and creates precedent for the creation of similarly synthesized plastic bags for mass production

Remaining Gaps in Our Knowledge

- How to form our plastic into a bag shape
- How fast the plastic material would break down in a natural environment
- How to mass produce the "plastic" bags

Acknowledgements

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References

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