

ORNL / UMaine

**SMART**

# Lobster Shell Composites

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# The need for temporary shelters: Refugees & the homelessness crisis



In 2023, the US experienced a record high of homelessness of over 700,000. **39.3 percent of these people experiencing homelessness were unsheltered**<sup>1</sup>

In 2023, the Institute for Economics and Peace (IEP) predicted **1.2 billion people could be displaced globally** by 2050 due to rise in extreme weather and natural disasters<sup>2</sup>



# Addressing the need for short - term, durable, and sustainable structures

## Should Wood be Used?

- Traditional wood-based solutions could be one answer
- Can last many years and often end up in landfill or burned
- Composite wood materials tend to be costly & require greater manufacturing and energy

**Should trees be cut down for temporary applications, decreasing amount of carbon capture, if there are possible alternative & available materials to be used?**

## What is an Ideal replacement material?

Designed for a temporary (3 year) lifespan and ability to be used with common construction connection, consistent and good mechanical properties, resistant to burning, biodegradable in water



# Turning waste into a Composite Material Solution

## Raw Materials

Gelatin → Byproduct of agricultural industry, >300,000 metric tonnes/yr produced globally<sup>3</sup>

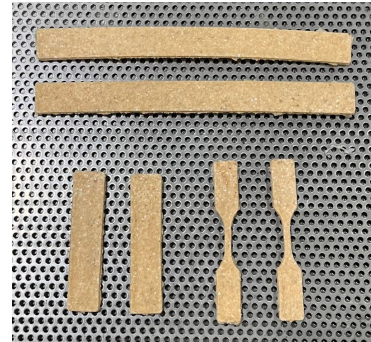


Lobster Shell → Waste product of seafood industry, ~ 50,000 tons / yr<sup>4</sup>



## Easy to Produce

Moldable with standard equipment



Typical injection molded composite specimens

1. Raw materials heated in water
2. Solution injection molded or open casted
3. Specimens dried to desired conditions prior to testing



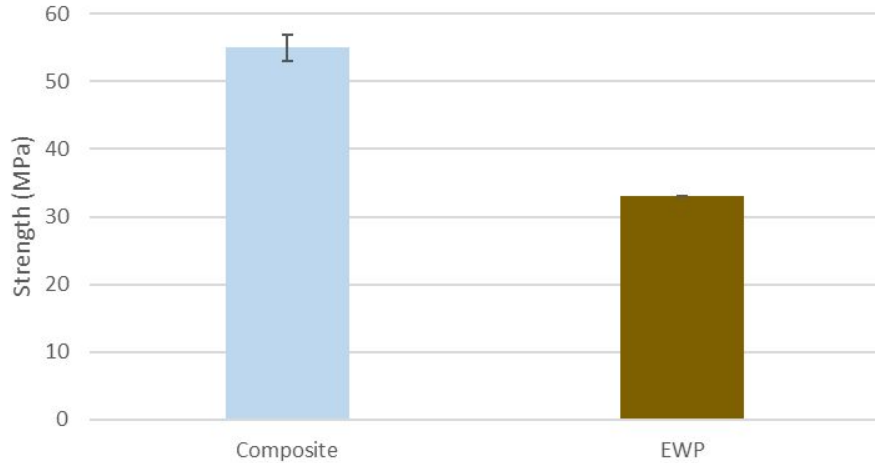
UMaine AMC custom built injection molder for test specimen manufacturing

## Objectives For Composite:

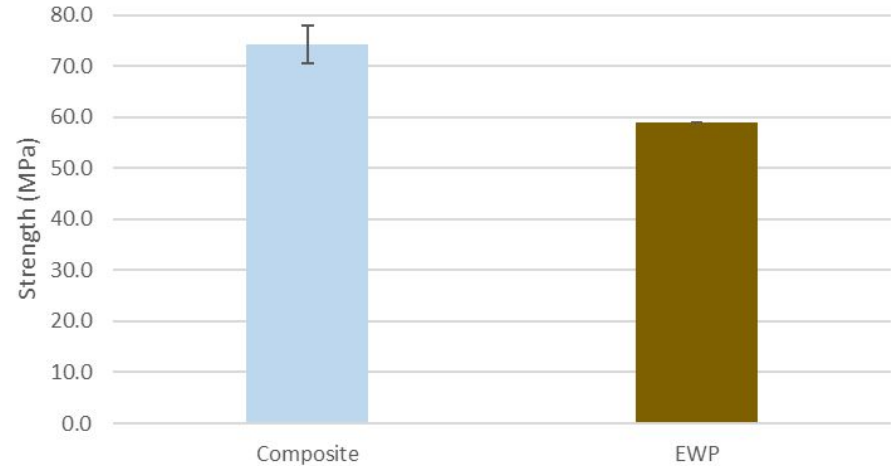
- Needs to exceed benchmarks for lumber in flexion, compression & shear strength
- Must be resistant to burning
- Must be biodegradable in soil
- Must be residually compostable
- Must be soluble in water
- Needs to be compatible with bio-based coatings
- Must be amenable to diverse and scalable production

# Mechanical Properties

## Compression Strength

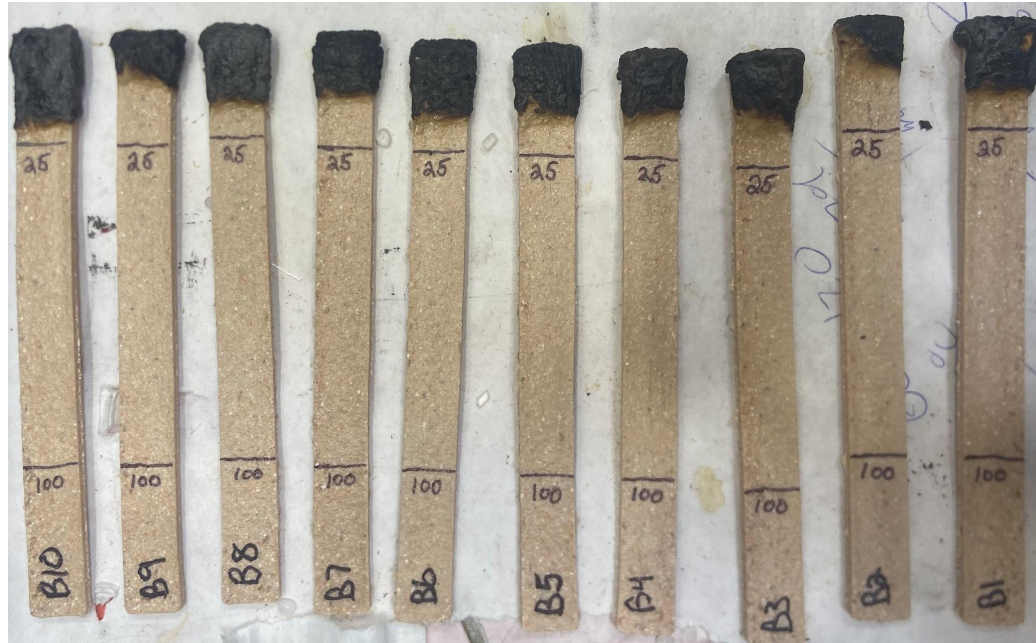


## Flexural Strength



**The composite exceeds the Eastern White Pine in compressive and flexural strength**

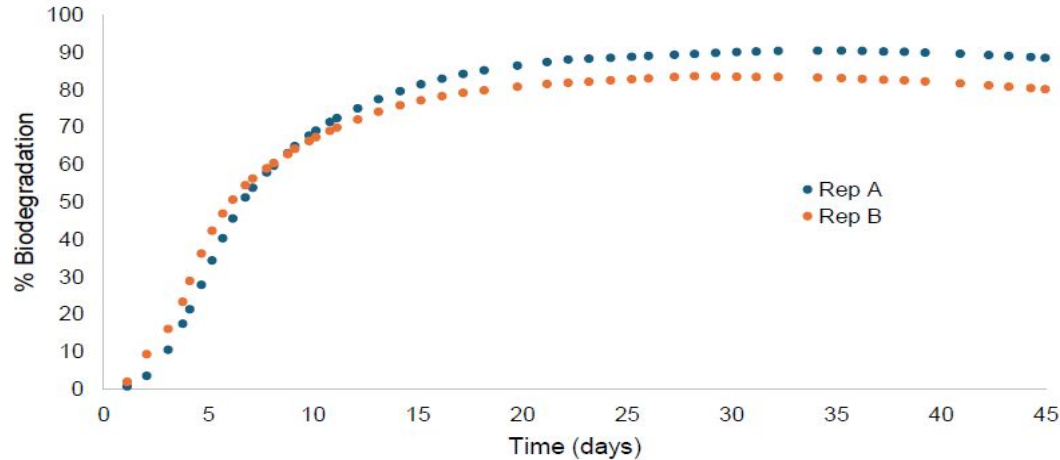
# Burn Evaluation



**LS composite self extinguishes in 2-3 seconds**

# Soil Biodegradation

**Figure 3.** Biodegradation (%) of test material as a function of time. CO<sub>2</sub>-C evolution from the test material was rapid for the first 10 days then slowed.



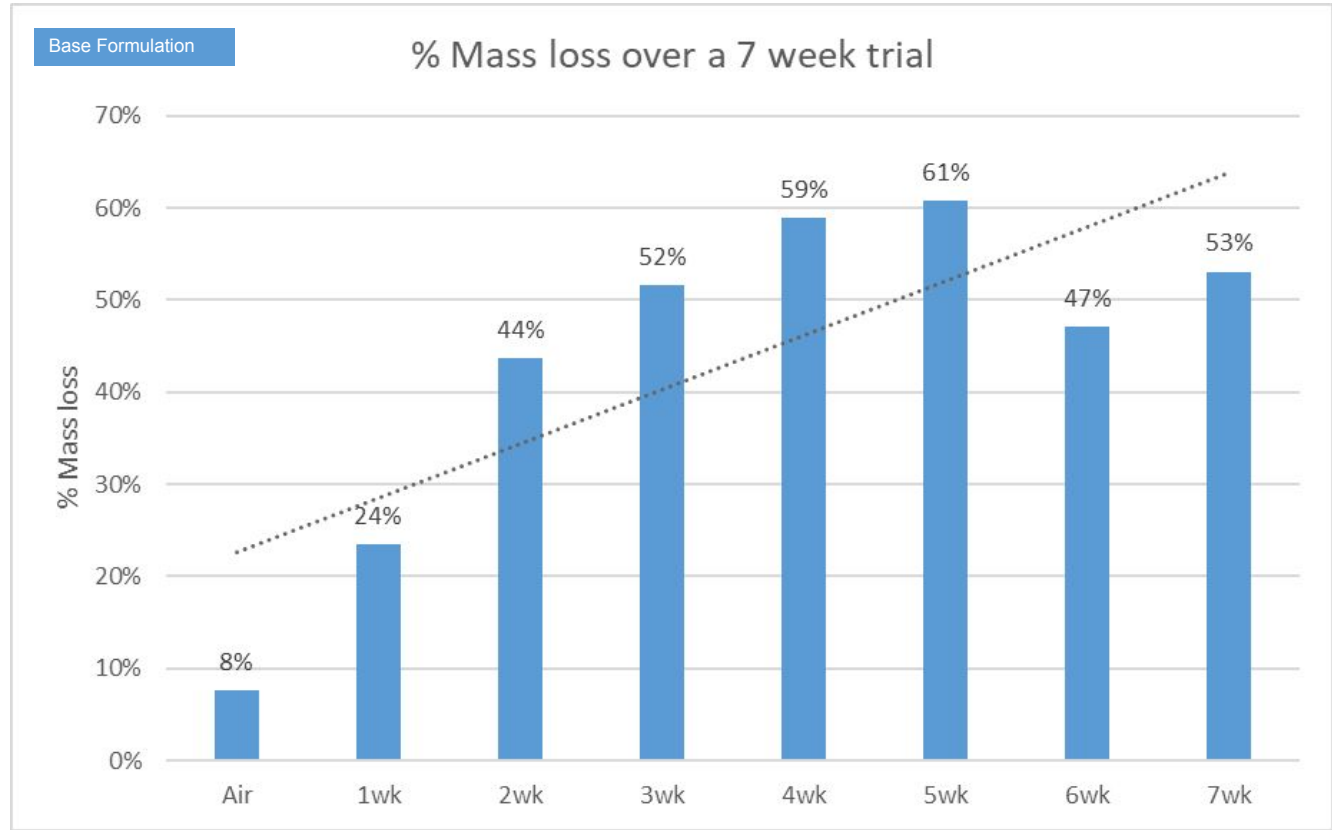
**An independent laboratory found that the LS composite meets the biodegradation standard in 31 of 91 test days & soil health is improved**



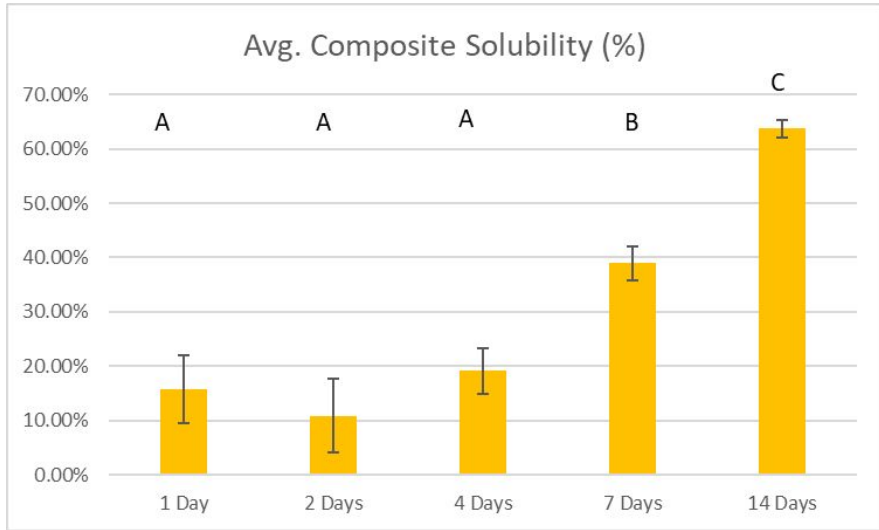
# Residential Composting



**Composite material composts in a residential setting**



# Water Solubility



**60% mass loss of the composite when submerged in water for 2 weeks**



# Biocompatible Coatings

## Linseed Oil

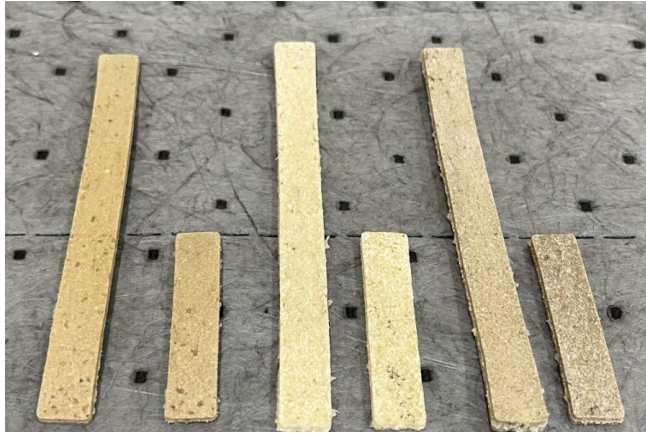


## Chitosan



**Exploration of bio-based coatings to increase lifespan without environmental concerns, may provide means of controllable dissolution**

# Diverse and Scalable Production



Left to right: Regular LS, Deproteinized LS, Green Crab Shell



3D Printing Evaluation



Top: Composite & EWP structures for carrying capacity testing  
Bottom: scaled lumber equivalent specimen

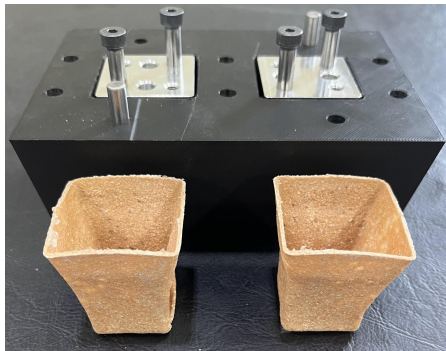
Successful manufacturing of composite with alternative filler materials

Scaling production for structural testing

# Commercial Opportunities



De-Risking the Business Model  
with golf tees through UMaine  
NSF I-Corps & MIRTAs



Not just Temporary Structures...

- Outdoor recreation (buoys, surf boards, targets)
- Soil stabilization & nutrient delivery
- Many other opportunities to displace petroleum derived plastics

Exploration of commercial prototypes

## Objectives For Composite:

- ✓ Exceeds benchmarks of lumber in flexion, compression & shear strength
- ✓ Resistant to burning
- ✓ Biodegradable in soil
- ✓ Residentally Compostable
- ✓ Soluble in water
- ✓ Compatible with bio-based coatings
- ✓ Diverse and scalable production

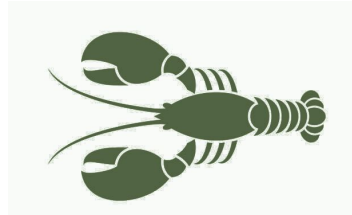
## The Problem

Increased need for sustainable and durable structural material for temporary structures and other applications.



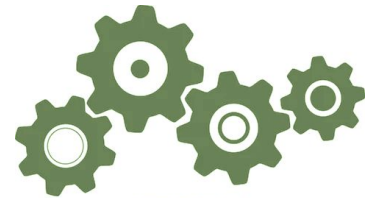
## Lobster Shell Composite Material

Prior and current work prove the LS - C composite exceeds its wood alternative in strength, biodegradability, solubility, and burn resistance.



## Ongoing & Future Work

Development of commercial opportunities, exploration of other material applications, and scaling production.



# Thank You!



Author affiliations: University of Maine.

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Woods End Laboratories is acknowledged for providing the soil biodegradation testing per ASTM D5988

## References

- 1)Soucy, Daniel, Makenna Janes, and Andrew Hall. *State of Homelessness: 2024 Edition*. National Alliance to End Homelessness, 5 Aug. 2024, [endhomelessness.org/state-of-homelessness/](https://endhomelessness.org/state-of-homelessness/).
- 2)Narayanan, B. K. B., Shipman, M. L., Foyle, L., Kharas, K., Livingston, B., Li, N. T., ... & Taguchi, L. Climate Crisis Induced Migration: A Global Framework to Minimize and Manage Large-Scale Climate Refugees and Migrants.
- 3)Ross, R. (2021). Wood handbook: Wood as an engineering material: Vol. 190.;GTR-190.; U.S. Dept. of Agriculture, Forest Service, Forest Products Laboratory. <https://www.fs.usda.gov/research/treesearch/62200>
- 4) Redacted to protect IP filling

# Questions or Comments?

## Connect With Us

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We are always looking to partner with those who have a unique application space that we have not considered.

# Meet the Team

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David Neivandt Ph.D. -  
Professor, Chemical and  
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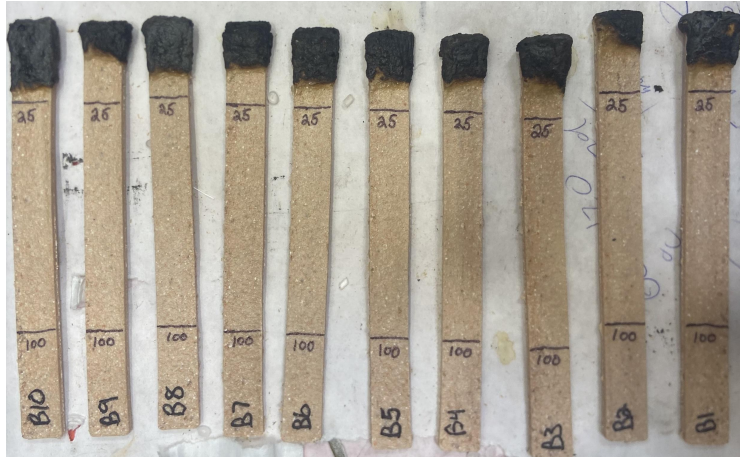


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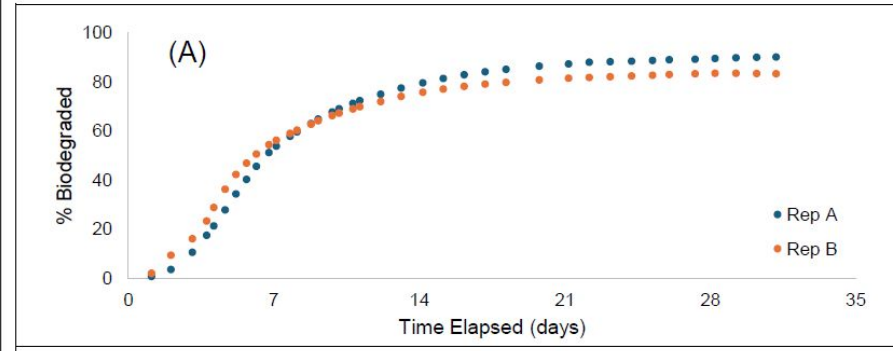
## ☐ Resistant to burning



Composite flames out within 2 -3 seconds  
→ Considered “non burning” per ASTM D635

## ☐ Biodegradable in soil

**Figure 3.** Percent CO<sub>2</sub>-C biodegraded in test chambers containing (A) test material in soil and (B) cellulose in soil. Data are corrected for background respiration of the soil.



Composite meets soil biodegradation standard within 31 days of a 90 day test (ASTM D5988)