

Exploration of Bone as a Natural Composite Material

Introduction

Growing up we were told to drink our milk so that our bones could grow to be strong. Milk and other food products provide us with the **calcium** our bones need for strength. In fact, about 99% of our body's calcium is found in bones. However, our bones also need a structural protein called **collagen** in order to provide added strength and flexibility. Bone can be thought of as a **composite material**; something made out of two materials with different properties, which when brought together produce a new material with new properties. In this laboratory you will play the role of a **polymer scientist** and explore the techniques that **engineers** use to test the strength properties of a composite material.

Composites

Composites can be found everywhere in our lives. Some examples of **engineered** and **natural** composite materials are:

- Concrete
- Plywood
- Fiberglass
- Bone
- Teeth
- Wood
- Shells

For polymer engineers making composite materials can be beneficial because they often times have properties **more valuable** than the materials they are made out of. Engineers often use **mechanical tests** to gain information about the the properties of a material. In this lab you will be conducting stress tests on bones that have had either the calcium or the collagen removed and **compare** the properties of these bones to a normal chicken bone.

Materials

Chicken Bones (leg, cleaned) 3 per student/group
Vinegar
Oven
500 ml beaker
5 gallon bucket
S hook or carabiner

2-3 feet of chain link

5 pound weights (at least 10 of them); or some equivalent weight material such as water, sand, bricks, gravel, etc.

Electronic mass

Ruler

Duct tape

Permanent Marker

Safety

For this lab either raw or cooked chicken bones may be used. If using raw chicken bones, be sure to wear gloves. Safety goggles must be worn during stress testing to protect from bone fragments that may fly into the air.

Pre-Lab Questions

1. What mechanical properties do you think are important for bones to have? Why?
2. How much weight do you think the “normal” chicken bone can hold? _____ lbs
How about the calcium deficient bone? _____ lbs
How about the collagen deficient bone? _____ lbs

Procedures

1. Place the “calcium deficient bones” in a beaker of vinegar so that the vinegar is covering all parts of the bone. Let this soak for 2-3 days.
2. Place the “collagen deficient bones” on a baking tray and bake at 250° F for 3 hours.
3. After treatments are complete, measure the three bones (control, calcium deficient, and collagen deficient) and use a permanent marker to make a mark on the middle part of the bone.
4. Observe properties of the three bones and record information in *Table 1*.
5. Set up the loading area as follows (this can be done as a whole class or per group depending on materials) for the untreated bone:
 - a. Move two tables together so that they are 2-inches apart.
 - b. Using either an S-hook or carabiner, hook a chain to the bucket handle.
 - c. Place the bone across the gap in the tables and secure each side with duct tape.
 - d. Hook the chain the bucket around the bone, making sure it is over the middle part of the bone.

- e. Add weight carefully in 5 lb increments to the bucket. Make sure to pause for at least 30 seconds in between each weight to assess for bone breaking.
 - f. Continue to add weight unless the bone cracks or breaks.
 - g. Record the breaking weight in the data table.
6. Repeat this procedure for the vinegar and baked bones. Record results in the *Table 2*.

Set-up



Data

Table 1

