Composites: Bioresins? Natural Fibers?

feedstocks	processes	uses
Crops/residue	Mechanical – extraction/separation Chemical conversion Mechanical – blending and extrusion	Composites

Background

What are composites? What everyday products contain composites? What key performance characteristics make them useful?

Composite materials are formed by combining two or more materials. Reinforced concrete, plaster casts used to repair broken bones, and wire reinforced tires are everyday examples of composites. Plywood is another composite. Humans have been creating composite materials for thousands of years in an attempt to build stronger and lighter materials. The ancient Egyptians added straw to mud for strength and stability when making bricks for building and construction.

In the mid-20th century, fiber reinforced polymers became widely used to create lightweight, yet very strong, materials. These newer composite materials are used to enhance the performance of everything from boats and racing bikes to automobiles and airplanes. You may be familiar with fiberglass.

Today, research includes development of biocomposites, materials in which either the fiber material or the resin is derived from an agricultural product. Each combination of biobased fiber and resin yields a product with unique physical properties, such as tensile strength, rigidity or weight. The automotive and decking industries have been very successful integrating biocomposite materials. Biocompatibilty and biodegradability have made research in biocomposites of real interest to much broader markets, even those in biomedical materials research.

Materials

For the classroom:

- Microwave
- Gram scale & plastic boats (to weigh solids)
- 25 mL graduated cylinder (to measure water)

Station 1: per pair of students

- 1 tube Bondo resin and hardener
- 1 piece fiberglass cloth
- 2 pairs of safety goggles
- 2 pairs of latex/rubber gloves
- Mixing stick
- 1 aluminum tub (to mix Bondo resin and hardener; may be provided in the Bondo kit)
- Material with hole to be patched (cardboard, plastic, wood, etc.)

Station 2: per pair of students

- Handful of natural fibers (fur, feathers, wood, plant material, etc)
- 1 piece fiberglass cloth
- 2 pairs of safety goggles
- 2 pairs of latex/rubber gloves
- Resealable sandwich plastic bag
- 1 pipette
- .5 mL corn oil
- 15 mL water
- 15 gm cornstarch

Objective:

Discover how a variety of biomass feedstocks can be used to improve the characteristics & performance in composite materials.

Keywords:

- Composites
- Biocomposites
- Matrix or binder
- Reinforcement materials
- Natural fibers
- Polymers

21st Century Skills Represented:

- Environmental Literacy
- Creativity & Innovation
- Critical Thinking & Problem Solving

National Science Education Standards:

- Physical Science: Matter & its Interactions
- Engineering Technology & Applications of Science: Engineering Design; Links Among Engineering, Technology, Science & Society

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Pre-Lab Preparation

Hold a class discussion on the following questions:

1. What is a composite?
2. How are composites used?
3. What are examples of composites?

Lab Procedures

Two stations are presented, one that uses a familiar, over-the-counter 3M product, Bondo, to illustrate the two components of a composite: the binder and the reinforcement material. The second is a make-your-own, biobased binder from corn starch and corn oil and a variety of natural fibers which can be used as reinforcement materials.

Station 1: Bondo resin and fiberglass

1. Students should wear safety goggles and gloves while mixing and working with Bondo. Be certain to work in a well-ventilated or hooded area.
2. Read the instructions on the Bondo box and the supplemental instructions below before beginning.
   a. Instructions: http://www.ehow.com/how_4545701_use-bondo.html
3. Give students various materials with holes that need to be patched (e.g. cardboard, clay pottery, wall board, wood, or cracks in a sidewalk that need to be evened out for successful skateboarding).
4. Have students prepare the Bondo, per the instructions on the kit, and fix the holes.
5. In between steps, students should record their answer to the following question:
   a. What performance characteristics are necessary for successful composite use in this project?

Station 2: Biobased Composite with natural fibers

1. Working in groups of two or three, students can make their own bioplastic using the following instructions.
   a. Add 15 grams of cornstarch to a resealable plastic bag.
   b. Use a pipette to add 0.5 mL of corn oil to the bag.
   c. Add 15 mL of water to the bag and mix well.
   d. Microwave the mixture for 25-30 seconds. Be sure to vent the bag by leaving it slightly open.
2. Ask students to list as many uses for their bioproduct as they can.
3. Review the use of the fiberglass as a reinforcement used with the Bondo resin in the Station 1 experiment.
4. Explain that students will make a bioplastic composite by adding a natural fiber to the bioplastic recipe.
5. Provide several samples of natural fibers such as hemp, wool, cotton, feathers, hair, etc. Grinding, pulverizing, weaving or otherwise changing the physical characteristics may also add to its performance.

6. Have the groups use the following steps to create their own bioplastic composite:
    a. Add 15 grams of cornstarch to a re-sealable plastic bag.
    b. Use a pipette to add 0.5 mL of corn oil to the bag.
    c. Add 15 mL of water to the bag. Add one type of natural fiber to the bag and mix well.
    d. Microwave the mixture for 25-30 seconds. Be sure to vent the bag by leaving it slightly open.
7. Each group should compare and contrast the characteristics of the bioplastic composite to that of their original bioplastic.
8. Each student should record the fiber chosen as well as the similarities and differences of the composite and bioplastic.
9. As time allows, have students repeat steps 6-8 using different natural fibers.

Post-Lab Discussion/Questions

Have the students record their answers to the following questions:

1. What were the strengths and weaknesses of each of the two types of composites?
2. What are the pros and cons of working with each of the composites?
3. Did different natural fibers produce different results? How so?
4. What natural fibers do you think would make the most effective reinforcement materials?

Expansion Ideas

- Design a contraption to test insulation abilities and other characteristics of natural fibers versus fiberglass.
- Design tests to check for weight, stiffness, tensile strength, and cost to compare the natural fibers used.

Evaluation of Learning

- Find real-world examples of composites in use today. Use categories such as construction materials, medical devices, high performance recreation materials, aircraft/aerospace, defense, marine based materials, and others.
    - Which composites use natural fibers? In what cases does a biobased composite work best?
- Choose a biomass and invent a plan for its use as a composite material. Include the characteristics, the benefits, the concerns and the targeted users of the materials.

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Resources

- Videos
  - What are Composites from YouTube by Wichita State
  - What are Composites from YouTube by Maine Composites Careers – a series of videos on careers related to composites, including an excellent introduction
  - Why Natural Fibers from YouTube - an animated review from nameteco.com
  - Creating composite materials from plant derived fibers from YouTube by The Ohio State University-OARDC
  - Natural Fiber Composites Corporation from YouTube by the Ohio BioProducts Innovation Center

- Websites and Articles
  - What are Composite Materials by wiseGEEK
  - Overview of composite materials by American Composites Manufacturers Association
  - Overview of composite process by American Composites Manufacturers Association
  - Composites and Advanced Materials by U.S. Centennial of Flight Commission
  - SEM of a nanofiber by Gizmag
  - High Performance Natural Fiber Composites Poised for Progress by Ohio State's Industry Liaison Office
  - Advanced Natural Fiber Composites by PolymerOhio, Inc.

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Project supported by a Secondary Education/2-Year Postsecondary Education/Agriculture in the K-12 Classroom grant from the United States Department of Agriculture - National Institute of Food and Agriculture under Award No. 2010-38414-21028. Any opinion, findings, conclusions or recommendation expressed in this publication are those of the author and do not necessarily reflect the views of the U.S. Department of Agriculture.