

# Nanotechnology Education - Engineering a Better Future

### **Teacher's Guide**

## Title of Activity/Lesson: Plants to Replace Plastic - Cellulose Films Lab Activity

**Grade Level**: 9<sup>th</sup>-12<sup>th</sup> **Subject area(s)**: Chemistry, Physical Science, Environmental Science

**Time required**: Two 50-minute class periods\*; \*There is a 2-3 day wait time for the films to dry. The first day students will measure/create solutions and then 2 days later come back to observe resulting films.

Learning objectives: Explore solutions to real-world problems involving sustainable polymers; Engineering/Experimental design **Summary or Description**: Cellulose (a polymer found in the cell walls of plants) can be used to create more renewable films to replace plastic films in packaging. This lab will allow students to design and conduct an experiment to solve real-world problems.

**Lesson Background:** (Information with sources) This lab can be used to teach students about calculating concentration, scientific method, or in conjunction with sustainability. Students can read articles/view images about plastic waste such as:

- <u>https://greenly.earth/en-us/blog/ecology-</u> <u>news/why-is-plastic-bad-for-the-environment</u>
- <u>https://www.nationalgeographic.com/photogra</u> <u>phy/article/animals-wildlife-plastic-pollution</u>

#### Pre-requisite Knowledge:

- Plastics are made up of long polymer chains. While plastic has many beneficial qualities such as its malleability and ability to act as a water and oxygen barrier in packaging, the sourcing and discarding of plastics has a largely negative impact on the environment.
- Cellulose is a polymer found in the cell walls of plants.
- Concentration by mass percent is calculated using the formula:

 $\mathrm{Mass\ Percent} = rac{\mathrm{Mass\ of\ Solute}}{\mathrm{Mass\ of\ Solution}} imes 100\%$ 

#### Materials:

- Carboxymethyl Cellulose (CMC) Powder
- Water
- Scales/Balances (that read to 0.01 grams)
- Graduated cylinders
- Beakers
- Petri dishes
- Tweezers/forceps
- Pipettes
- Scoops/Scoopulas/Plastic Spoons
- Weigh Paper/Weigh Boats

#### Safety Information:

- All chemicals in this lab are kitchen-friendly and not hazardous. General lab safety rules should be followed such as:
  - No horseplay or rough housing.
  - $\circ$   $\,$  Do not eat or drink in lab.
  - Maintain an clean work area.
  - Gloves, aprons, and eye protection should be worn when working with glass and chemicals\*. (\*All chemicals used in this lab are kitchen-friendly and not hazardous.)
  - Any broken glass should be disposed of in sharps box.

#### Vocabulary and Definitions:

- **Polymer**: a long molecule made up of many small, repeating subunits called monomers
- <u>Cellulose</u>: a polymer that is the main substance of plant cell walls and vegetable fibers such as cotton; a polysaccharide (carbohydrate) made up of long chains of monosaccharides
- <u>Solution</u>: When compounds mix completely to become a uniform mixture, the mixture is called a solution.
- **<u>Solute</u>**: A solute is the substance dissolved in a solution.
- **<u>Solvent</u>**: A solvent is the substance that dissolves a solute in a solution.
- <u>Mass Percent</u>: one way of representing the concentration of an element in a compound or a component in a mixture. Mass percent is calculated as the mass of the solute divided by the total mass of the solution, multiplied by 100%.

**Advance Preparation**: Will need at least 4 days to complete lab (2 active days and 2 waiting days). Great lab to start on a Friday and come back to see results on Monday after the weekend. Will need to order CMC powder.

# Suggested Teaching Strategies or Troubleshooting Tips: (may also include Suggested Instructional Procedure)

- Have students read <u>Why is Plastic Bad for the Environment</u> Article as a hook. Students can complete a 3-2-1 Graphic Organizer (3 Things I Learned, 2 Things I Found Interesting, 1 Question I still have), annotate/highlight facts that surprised them, or just discuss with a partner/group.
- Give students <u>Cellulose Films Lab Student Handout</u>. In lab groups, students will choose 3 different concentrations they want to test to create the best film.
- Films are clear and may be hard to see after drying. Use tweezers to try and find edge of film at edge of petri dish and peel away. Can watch this video: <u>How to create Cellulose</u> <u>Films \*Video\*</u> to see how to peel films from petri dish using tweezers @6:10min.
- 4. May need to lead class discussion on what other properties are desired in packaging materials.

**Procedure or Directions for the Activity:** (This can also go in the Student Guide with answers with additional information for the teacher; refer teacher to this section which is at end to the TG)

- <u>Cellulose Films Lab Student Handout</u>
- <u>Cellulose Films Lab Teacher Handout WITH ANSWER KEY</u>

Assessment: Can grade questions on Cellulose Films Lab – Student Handout

#### Additional Resources:

- Link to buy CMC from Amazon
- <u>Why is Plastic so Bad for the Environment?</u> (Article)
- <u>Plastic v. Cellophane</u> (Article)
- <u>How to create Cellulose Films \*Video\*</u> (can see how to peel films from petri dish using tweezers @6:10min)
- <u>PBS Student Inventors to Solve Plastic Problem</u> (Lab as an extension)

#### Standards:

NGSS

- <u>HS-ETS1-1 Engineering Design</u>: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- <u>HS-ETS1-2 Engineering Design</u>: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

#### **Optional Extensions**:

- Additional Lab: <u>PBS Student Inventors to Solve Plastic Problem</u>
- Could design or conduct additional tests like soaking Ziploc bag and Cellulose films made in water to observe water barrier properties brainstormed in #5 of Conclusions section on Student Handout:
  - o <u>Cellulose Films Lab Student Handout</u>
  - o <u>Cellulose Films Lab Teacher Handout WITH ANSWER KEY</u>

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Supporting Programs: GeorgiaTech RET, IEN, NNCI

Teacher Key: Teacher Worksheet with answers in red