5E STEM SHADE ADSORPTION SPHERES

(2 weeks)

Authors

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SUBJECT/GRADE LEVEL

Subject Area: Physical Science

Grade Level: Middle and High School 7th-9th

Materials

Engage: You Tube Video Link:

Long Story Shorts: What Causes Red Tides?

Sketch Paper, Colored Pencils

Explore: Graphene Sheets: 0.2 mm, 0.5mm, 0.7 mm in thickness, thermometers, heat lamps, graphene bead coating spray, lamps, plastic tubes, plastic beads (uncoated), funnel, food coloring, beakers, stopwatch, gloves and goggles, Secchi disk/turbidity tube

Graphene_Heat_Transfer_Student_Lab.docx

Graphene_Heat_Transfer_Teacher_Guide.docx

Graphene Column Filtration Inquiry Lab: Stude…

Graphene Column Filtration Inquiry Lab: Teach…

Explain:

Presentation Slides_ Conductivity, Absorption,…

Student Note Sheet: Exploring Conductivity, A…

Exit Ticket Worksheet

Heat Conductivity – Spoon Test

Elaborate:

Elaborate: Shade Ball Prototype.docx

black ball pit balls, Carbon Black paint, brushes

Activated Charcoal powder, Adhesive spray glue, fish bowls, algae samples, Secchi disks, thermometers, heat lamp, tweezers, gloves,

Evaluate:

Shade Ball Choice Board

Evaluation: Shade Ball Advertisement Rubric

Computer or Posterboard, art supplies

STANDARDS

Next Generation Science Standards

- HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions.
- HS-PS3-4: Plan and investigate to determine the relationships among energy transferred, type of matter, mass, and the change in the average kinetic energy (temperature).
- HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
- MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Mathematics Standards | Common Core State Standards

- 7.RP.A.2: Recognize and represent proportional relationships.
- HSN.Q.A.1–3: Use units to understand problems and guide the solution.

English Language Arts Standards | Common Core State

- SL.6.5 / SL.8.5: Include multimedia components and visual displays in presentations.

LESSON OBJECTIVE(S)

Students will design, build, and evaluate the findings resulting from constructing a shade ball that uses a coated material of their choice to help mitigate temperature changes and algae growth.

Students can choose how to share what they learned—through a pitch, flyer, video, or review—and use evidence from the experiment to support those ideas.

CAREER CONNECTION(S)

Mentor Background: My name is Dr. Jesse Roberts, I'm a research chemical engineer within the Environmental Laboratory at the U.S. Army Engineering Research and Development Center (ERDC) in Vicksburg, MS. We provide solutions for tomorrow's environmental challenges by finding new ways to clean water and remediate environmental contaminants. My role focuses on developing and characterizing new materials for synthetic biology and environmental applications. Specifically, I work with graphene nanomaterials to remove harmful cyanotoxins from water sources that pose a significant risk to human health. I have my PhD in chemical engineering from the University of Arkansas



where I focused on biomaterial development for tissue engineering and biosensing applications. My team serves to make the world better by developing and utilizing materials to provide sustainable water infrastructure through clean and safe water.

STEM Careers: entomologist, structural engineer, geneticist, chemical engineer, zoologist, ecologist

ENGAGEMENT

Brief Description: Students will watch a short video introduction about the science and problems associated with harmful algal blooms, followed by a short discussion and a possible sketch.

Long Story Shorts: What Causes Red Tides?

Procedures:
Time Frame: 20 minutes- 1 Hour (if sketch is completed)
The teacher will show this 1:43-second video to the class and ask the following question beforehand:
"Have you ever noticed a lake or pond that looks unusually green or scummy? What do you think causes that?"
Key Vocabulary: Algae, bloom, toxins, eutrophication, cyanobacteria.
After the video, ask these guiding questions to lead the class in a whole-group discussion:

- "What did you observe in the video?"
- "Why do you think the water changed color?"
- "What might be the consequences of such blooms?"

Activity Suggestion**:** Have students sketch what they think a harmful algal bloom looks like and label potential causes and effects. Then have the students do a gallery walk to share or compare/contrast with others around them.

This can be linked to the following content connections:

Ecosystem Dynamics: Nutrient imbalances can disrupt aquatic ecosystems.
Human Impact: Agriculture and urban development contribute to nutrient runoff.
Prevention Strategies: Methods to prevent or mitigate HABs, such as reducing fertilizer use and improving wastewater treatment.

EXPLORATION

Brief Description: This two-part inquiry lab introduces students to the real-world applications of graphene through hands-on experiments in heat transfer and water filtration. In the first lab, students investigate how different thicknesses of graphene coatings affect the speed of heat conduction along polyethylene strips under a heat lamp. In the second lab, students compare the effectiveness of graphene-coated versus uncoated plastic beads in filtering food dye from water. Both activities promote data collection, graphing, and analysis while connecting material science to environmental and

engineering challenges.

Graphene_Heat_Transfer_Student_Lab.docx Graphene_Heat_Transfer_Teacher_Guide.docx
Graphene Column Filtration Inquiry Lab: Student Handout
Graphene Column Filtration Inquiry Lab: Teacher Notes

Procedures:

Background information: Graphene is a single-layer sheet of carbon atoms arranged in a hexagonal lattice. It is known for exceptional strength, electrical conductivity, and particularly thermal conductivity. These labs explore two real-world applications of graphene coatings:

- Heat Transfer: Understanding how graphene thickness influences heat conduction along polyethylene strips.
- Water Filtration: Investigating how graphene-coated beads affect filtering efficiency and water clarity compared to plain beads.

Lab setup: This inquiry lab can be divided into 2 parts in the classroom, such as 2 stations, or you can have students conduct these labs separately. The first lab is the heat transfer portion.

Objective of Heat Transfer Lab:
Explore how varying graphene thickness affects heat transfer rate along black polyethylene strips under a heat lamp.

Procedure Overview & Time Frame
Experiment (25–30 min):
Students place the 0.2 mm coated strip on the bench, marking 1-inch intervals. Heat lamp positioned 5 cm above one end. Students start the lamp and stopwatch simultaneously, recording time for each interval to reach the target temperature (e.g., 35°C) using infrared thermometers or temperature stickers.
Repeat for 0.4 mm and 0.7 mm coated strips. Record data in tables, graph their data, and answer the analysis and inquiry questions provided on the student lab handout.

Objective of Column Filtration Lab:
Determine if graphene-coated plastic beads improve the filtration of food dye from water compared to uncoated beads.

Procedure Overview & Time Frame
Experiment (30–35 min):
Students prepare two columns: one with plain beads, one with graphene-coated beads.
Pour identical volumes of dyed water into each column simultaneously, starting the stopwatch.
Record filtration times. Use Secchi disks/turbidity tubes to measure the water clarity of the filtrate by

observing the depth at which the disk disappears. Students will record data in tables, create two bar graphs, and answer the analysis questions as described and provided on the student lab handout.

Virtual Lab Simulations(if needed)

Use interactive simulations like the PhET Heat Transfer Simulation for modeling conduction and assign a simple web-based simulation (e.g., MyNASAData Water Filtration Activity).

Adaptations for Individual Learners Suggestions:

- Visual Instructions: Provide step-by-step visual guide.
- Modified Data Tables: Use partially filled tables to reduce cognitive load.
- Peer Collaboration: Pair with a lab partner or small group for support during hands-on activities.
- Chunked Timing: Break procedures into smaller timed tasks with check-ins.
- Flexible Output Formats: Allow students to present findings through drawings, recorded audio explanations, or oral responses instead of written conclusions.

EXPLANATION

Brief Description: Following the two-part graphene lab, students will engage in structured reflection, data interpretation, and class discussion to explain the science behind their observations. Students will connect coatings such as graphene and the physical properties of carbon to their practical uses and analyze how these applications relate to the physical properties of adsorption, surface area, and thermal conductivity.

Procedures:

Time Frame: 30–45 minutes

1. **Class Discussion – Interpreting Results (15–20 minutes):**
   Begin by guiding students in comparing their results from both the heat transfer and filtration labs:
   - Which graphene thickness conducted heat the fastest? Why?
   - Which bead column filtered water more clearly or quickly?
   - How do the results demonstrate the unique properties of graphene?
2. **Direct Instruction – Science Behind the Phenomena (15-20 minutes):**

   Presentation Slides_ Conductivity, Adsorption, and Surface Area in Carbon Materials .pptx

Student Note Sheet: Exploring Conductivity, Absorption, and Surface Area.docx

Students will receive a notes sheet about thermal conductivity, adsorption, and surface area. This will be a teacher-led instruction about each of those three topics. I have added a video as well in the notes to help explain if needed. There are a few guided questions as well.

3. **Exit Ticket(10–15 minutes)**: Exit Ticket Worksheet

   Students will complete and submit the exit ticket as a formative assessment.
   Adaptations for individual learners:

   - Offer a read-along version of the note sheet, with simplified definitions or diagrams for key terms.
   - Highlight or bold key vocabulary and key points in the presentation slides.
   - Allow students to pair up to complete notes and answer guided questions together.
   - Provide color-coded visuals or hands-on manipulatives (such as models or felt surface area squares) for tactile learners.

Virtual Options:

Publish the notes Sheet, Presentation, and Exit Ticket to your school's LMS like Canvas or Google Classroom.

ELABORATE

Brief Description: Students will apply their understanding of graphene's properties by designing shade ball prototypes. Working in teams, each group will choose between activated charcoal or carbon black paint and determine the number of coating layers (1, 2, or 3) that will most effectively reduce water temperature and limit algae growth. They will test their shade balls over several days.

Elaborate: Shade Ball Prototype.docx

Procedures:

Day 1 - Design and Set Up:

1. The teacher introduces the challenge of designing and building a prototype shade ball
2. Students form groups of four and decide on the material and the number of layers
3. Each team creates a design plan, predicts outcomes, and coats their plastic balls.
4. Shade balls are labeled by team, material, and number of layers.

Day 2 - 6 :

1. Teams place their shade balls in identical water containers under grow lamps to simulate sunlight.
2. Students collect the following data once per day, for five consecutive days:
    - **Water temperature**
    - **Algae growth**, using a Secchi plate.

Day 6 - Data Analysis:

1. Teams create graphs and data tables to show changes in temperature and algae presence across the 5-day period.
2. Students analyze how material choice and coating thickness affected performance.
3. Each team reflects on the success of their prototype and prepares to share findings in the Evaluation phase.

Once data collection is complete, carefully clean up using these steps:

1. Making sure you are wearing protective gloves and googles, carefully lift the shade balls from the aquarium using tongs. Rinse them with warm, soapy water tray or sink to remove algae residue and then place on a paper towel to dry. Set aside for reuse.
2. Dispose of algae culture. Pour the algae water from the aquarium slowly down the sink with running water, flushing continuously to prevent buildup. Avoid pouring large clumps or solid algae down the drain. Place those pieces in the trash.
3. Clean the aquarium by rinsing it thoroughly with warm, soapy water and allowing it to air dry.
4. Wash Secchi disks, thermometers, and any other supplies used with soapy water as well. All to air dry.
5. Wipe down tables and sink with disinfectant or wipes.

EVALUATION

Brief Description: Students will communicate their findings and explain their prototype by choosing one option from the choice board: a Shark Tank-style pitch or an advertisement (flyer, commercial, or Product Review). Each student must describe their prototype and explain the materials used and the effectiveness of the chosen design using evidence from their tests. A rubric will be used by both the students and teacher.

Shade Ball Choice Board | Evaluation: Shade Ball Advertisement Rubric

Procedures:
Time Frame: 2 class periods

1. Students will choose one of four product formats:
   Shark Tank Pitch, Flyer, Product Review, Commercial

2. Research and Design:
   Students need to apply understanding of shade ball functions from their lab findings: thermal insulation, sunlight blockage, environmental safety, cost-effectiveness.
   Students need to use vocabulary they learned in the unit in their product: "evaporation," "thermal conductivity," and "adsorption"

3. Create and Revise: Draft and revise their product
   For visual/audio products, plan with storyboards or scripts before recording/designing.

4. Present or Submit once they have reviewed the rubric that will be used by the teachers for grading.

Adaptations for Individual Learners:

- Visual Supports: Sentence frames, graphic organizers.
- Flexible Formats: Allow audio recordings for students who struggle with writing.
- Checklists: Provide step-by-step checklists for each product type.
- Extra Time: Extend deadlines or break the project into daily chunks with clear goals.
- Model Examples: Show exemplars of each project type (from previous students or teacher-created samples).

REFERENCES

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