



Power Crystals: The Science Behind Lithium Extraction

This STEM activity was designed for the LITHIUMLEARN.S HIRED Grant.

Power Crystals: The Science Behind Lithium Extraction (4th and 5th grades)

Students will grow crystals using common materials (alum, sugar, and Epsom salt) to explore crystal formation and understand how certain materials—like lithium—are extracted and used in clean energy. This hands-on investigation introduces the concept of **Direct Lithium Extraction (DLE)** by drawing a comparison to how scientists separate lithium from brines in a sustainable way.

Arkansas Science Standards Alignment (4th and 5th grades)

- **4-PS3-4:** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. (*Contextual tie-in: batteries/lithium power storage*)
- **4-ESS3-1:** Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
- **4-ETS1-2:** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the design solution.
- **5-PS1-3:** Make observations and measurements to identify materials based on their properties. (*Crystal shape, texture, growth rate*)
- **5-PS1-4:** Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

Materials:

- 3 shallow dishes per group (labeled: Alum, Sugar, Epsom Salt)
- Alum (found in spice section or pharmacy)
- Granulated sugar
- Epsom salt
- Hot water (teacher prepared)
- Measuring spoons
- Stirring sticks
- Labels & observation sheets
- Magnifying glasses (optional)
- Images or samples of lithium crystals and lithium-ion batteries

Introduction:

- Introduce students to how lithium powers things like smartphones and electric cars.
- Relate lithium to the experiment: “We’re going to see how different materials form crystals, just like how scientists extract useful crystals from liquids.”

Procedure:

- Day 1: Setup
 - In small groups, mix hot water with alum, sugar, and Epsom salt in three separate dishes (ratios: 1 tablespoon solute to ½ cup hot water; mix until mostly dissolved).
 - Label each dish and set them in a safe place to crystallize over several days.



- Students complete Day 1 observations: describe appearance, texture, and clarity of solutions.
- Days 2–5: Observations & Analysis
 - Students observe crystal growth daily using magnifying glasses.

Data Collection

- Record observations in a **crystal journal**, noting:
 - **Crystal size**
 - **Shape and texture**
 - **Rate of growth**

Discussion:

- Compare how each type of crystal formed.
- Which solution made the largest crystals? Which formed fastest?
- Discuss how this relates to lithium: scientists look for **efficient and clean** ways to extract valuable crystals from solutions, like DLE.
- Reinforce: Not all materials crystallize the same way—understanding this helps scientists decide **how to get resources like lithium** from nature in a better way.



Power Crystals: The Science Behind Lithium Extraction (Middle School)

Students will investigate crystal growth using **alum**, **sugar**, and **Epsom salt**, analyze solubility and molecular structure, and apply this knowledge to understand **direct lithium extraction (DLE)** as a modern method for sourcing lithium in an environmentally responsible way. Students will explore the environmental trade-offs between traditional and modern extraction techniques.

Arkansas Academic Standards Alignment:

- **PS1.A: Structure and Properties of Matter**
- *MS-PS1-1:* Develop models to describe the atomic composition of simple molecules and extended structures.
- *MS-PS1-2:* Analyze and interpret data on the properties of substances before and after interactions.
- **ESS3.A: Natural Resources**
- *MS-ESS3-1:* Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral resources are the result of geoscience processes.
- Evaluate competing design solutions using a systematic process.

Materials (per group):

- 3 labeled shallow dishes or petri dishes
- Measuring cups/spoons
- Distilled hot water
- Stirring sticks or spoons
- **Alum (aluminum potassium sulfate)**
- **Epsom salt (magnesium sulfate)**
- **Sugar (sucrose)**
- Thermometer (optional for measuring water temp)
- Observation journal or worksheet
- Magnifying lenses or microscope

Intro:

- Begin with a real-world hook: "How does your phone store energy?" Lead into lithium-ion batteries.
- Show a short video or infographic comparing **traditional lithium mining** (open-pit/brine evaporation) to **Direct Lithium Extraction (DLE)**.
- Discuss environmental concerns: land disruption, water use, carbon emissions.
- Define **crystallization** and how it plays a role in lithium separation in both traditional and modern methods.

Procedure:

- DAY 1: Setup
 - Students form hypotheses: *Which compound will grow the fastest? Which will make the most defined crystals?*
 - Each group prepares 3 saturated solutions using alum, Epsom salt, and sugar (1 tbsp solute to ½ cup near-boiling water).
 - Pour into dishes and label.



- Record starting observations (appearance, temperature, how fast solutes dissolve).
- DAYS 2–5: Observation & Analysis
 - Students observe and measure crystal development daily. Use **magnifying tools** for close-up observations.

Data Collection:

- Record observations in a **lab notebook**, noting:
 - Changes in appearance, texture
 - Crystal size (estimates or using rulers)
 - Rate of growth (how quickly crystals appear)

Discussion:

- Compare how each type of crystal formed.
- Which solution made the largest crystals? Which formed fastest?
- Discuss how this relates to lithium: scientists look for **efficient and clean** ways to extract valuable crystals from solutions, like DLE.
- Reinforce: Not all materials crystallize the same way—understanding this helps scientists decide **how to get resources like lithium** from nature in a better way.



Power Crystals: The Science Behind Lithium Extraction (High School)

Students will investigate crystal formation using alum, Epsom salt, and sugar, analyze differences based on chemical bonding and solubility, and connect findings to **direct lithium extraction (DLE)** as a cleaner, more sustainable mining practice, particularly relevant to **Arkansas' lithium-rich brines**.

Arkansas Academic Standards Alignment:

- **C.1.PS1.1:** Use the periodic table as a model to predict the relative properties of elements.
- **C.1.PS1.3:** Plan and conduct an investigation to compare the properties of ionic and covalent compounds.
- **C.1.PS1.6:** Design a procedure for separating the components of a mixture based on physical and chemical properties.
- **EVS.6.ESS3.3:** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- **EVS.2.ESS3.1:** Analyze geoscience data and technologies to explain the uneven distribution of Earth's resources (e.g., lithium deposits).

Materials (per lab group):

- Beakers (250–500 mL), hot plate, thermometer
- Stirring rods
- Distilled water
- **Alum** ($\text{AlK}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$) – ionic compound
- **Epsom salt** ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) – ionic compound
- **Sucrose** ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$) – covalent compound
- Watch glasses or crystallization dishes
- Rulers, magnifying lenses or digital microscope
- Lab notebooks or data sheets

Intro:

- **Engage:**
 - Start with a prompt: *"How do we extract the lithium that powers your phone?"*
- Present an interactive map of global lithium resources, highlighting **Arkansas' Smackover Formation**.
 - Introduce DLE vs. traditional methods using short videos or infographics.
- **Content Review:**
 - Ionic vs. covalent bonding
 - Solubility rules and crystal lattice structures
 - Phase changes and precipitation

Procedure:

- DAY 1: Background & Pre-Lab
- **Pre-lab Questions:**
 - Predict which compound will form the most defined or fastest crystals, and why (based on structure and bonding).
- DAY 2–4: Crystal Growth Lab



- **Prepare Saturated Solutions:**
- Students heat 200 mL water to near boiling (~80–90°C).
- Stir in solute until saturation is reached (record mass used).
- Pour into labeled shallow dishes and observe over 3–5 days.
- Optional: Place one sample in refrigerator or under fan to test cooling rate effects.

Data Collection:

- **Daily Observations:**
 - Crystal growth rate (mm/day)
 - Shape and morphology (cubic, needle-like, amorphous)
 - Qualitative observations (clarity, color, sediment)
- **Data Analysis:**
 - Compare ionic (alum, Epsom) vs. covalent (sugar) crystals
 - Use solubility data to construct simple solubility curves
 - Discuss how bonding type influences crystal lattice and solubility

Discussion:

- How do different types of chemical compounds form crystals under various conditions?
- What are the physical and chemical properties that enable lithium extraction from brine?
- How can crystal formation help us understand sustainable resource extraction?
- Discuss why DLE uses **ion-exchange membranes**, **adsorption materials**, and **solvent extraction** to isolate lithium. Compare to student methods: What principles overlap?