Unlocking Lithium:
A Chemical Process Journey

This STEM activity was designed for the LiTHIUMLEARNS HIRED Grant program.

Unlocking Lithium: A Chemical Process Journey (Middle School)

Students will explore **mixtures and separation techniques** (adsorption, ion exchange, solvent extraction) through a hands-on activity using a **homemade separating funnel**. They'll simulate how chemical plants extract lithium from brines—connecting real-world engineering with fundamental science.

Arkansas Science Standards Alignment (Middle School):

- 5-PS1-3: Make observations and measurements to identify materials based on their properties.
- 5-PS1-4: Conduct an investigation to determine whether the mixing of two or more substances results in new substances.
- 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.
- 6-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
- 6-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
- 7-PS1-2: Analyze and interpret data on the properties of substances before and after substances interact to determine if a chemical reaction has occurred.
- 8-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
- MS-ETS1-2: Evaluate competing design solutions using a systematic process.
- MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process.

Intro:

- Vocabulary:
    - Adsorption – When molecules stick to the surface of a solid or liquid.
    - Ion Exchange – A process where ions are swapped between a solution and a solid material.
    - Solvent Extraction – Separation technique using immiscible liquids to selectively dissolve compounds.
    - Immiscible – Liquids that don't mix (e.g., oil and water).
    - Partitioning – Distributing a solute between two immiscible solvents.

- Begin with a short video or image-based explanation of how **lithium is extracted from salt brine** using **Direct Lithium Extraction** in places like Arkansas' Smackover Formation.
- Ask: *Why do we need lithium?* (Phones, cars, batteries)
- Introduce the three separation techniques: **adsorption, ion exchange, solvent extraction.**

Materials:

- 1 homemade separating funnel (can be made from a 2-liter plastic soda bottle with a hole/cap at the bottom or a stopcock-style spigot)
- Alternate separating funnel
- Water (dyed blue with food coloring)
- Vegetable oil
- Isopropyl alcohol (90% or higher)
- Table salt (colored with food dye)
- Beakers or clear plastic cups
- Funnels & filter paper (optional)
- Plastic spoons
- Goggles and gloves (for alcohol safety)

Procedure:

- Setup:
  - Pour ~100 mL dyed saltwater and 100 mL oil into the funnel. Let students observe the two layers form.
  - Add ~50 mL alcohol. Mix and allow to separate.
- Drain & Separate:
  - Slowly open the bottom cap to release water layer. Collect layers and examine where the salt and dye ended up.
- Use visual aids to explain:
  - Solvent Extraction: Alcohol dissolves the dye, mimicking lithium's selective solubility in a solvent.
  - Adsorption: Surface binding (colored salt residue on plastic).
- Connect to real-world DLE:
  - Brine flows through columns with materials that adsorb lithium, or lithium is selectively pulled out with solvents.

Data Collection:

- Students will observe and record which liquids form layers and how the colored salt behaves.
- Lab Notebook Prompts:
  - *Where does the color go?* (alcohol extracts dye – **solvent extraction**)
  - *Does anything stick to the plastic or sides?* (residues mimic **adsorption**)
  - *Can we filter or separate salt crystals?* (use filter paper – discuss **ion exchange**)

Discussion

- What is one method scientists separate mixtures?
- What happened to the salt in your experiment?
- How is this like a real chemical plant?

- Ask students how they'd design a better separation system. Give them constraints: speed, purity, environment.
- For advanced learners, introduce **polar vs. nonpolar solvents** concept.

Unlocking Lithium: A Chemical Process Journey (High School)

Students will explore **mixtures and separation techniques** (adsorption, ion exchange, solvent extraction) through a hands-on activity using a **homemade separating funnel**. They'll simulate how chemical plants extract lithium from brines—connecting real-world engineering with fundamental science.

Arkansas Academic Standards for Science

- **HS-PS1-2:** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and properties of elements.
- **HS-PS1-3:** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
- **HS-PS1-5:** Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
- **HS-ETS1-2:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems.

Materials:

- 1 homemade separating funnel (can be made from a 2-liter plastic soda bottle with a hole/cap at the bottom or a stopcock-style spigot)
- Alternate separating funnel
- Colored saline solution (NaCl in water + dye)
- Vegetable oil
- Isopropyl alcohol (90% or higher)
- water softener resin (ion exchange resin beads) (optional found in aquarium supplies))
- Graduated cylinders, pipettes, and beakers
- Conductivity meter or multimeter with a DIY probe (optional)
- Goggles and gloves (for alcohol safety)

Intro:

- Brief presentation or video on:
    - The demand for lithium in **EV batteries**
    - Comparison between **hard rock mining** and **brine-based DLE**
    - The **Smackover Formation** in Arkansas
    - Introduce key question:
      How do we extract lithium efficiently and cleanly from brine?

- Vocabulary:
    - **Polarity** and solubility ("like dissolves like")
    - **Ion exchange** using charged resins
    - **Adsorption** at the molecular level (surface interactions)
    - **Solvent extraction** and partitioning coefficients

Procedure:

- Lab Introduction & Hypothesis Writing
    - Students write a hypothesis predicting:
    - Where salt and dye will migrate (water, alcohol, oil)
    - Which phase will extract the dye
    - How ion exchange or adsorption will alter salt levels
- Partitioning and Simulated Extraction
    - Part A: Solvent Extraction & Partitioning
        - Mix ~100 mL **colored saline solution** with ~100 mL **oil** in the separating funnel.
        - Add 50 mL **isopropyl alcohol**.
        - Shake gently. Allow layers to settle.
        - Drain each layer and record:
        - Color intensity
        - Electrical conductivity (if available)
        - Salt presence via evaporation (optional)
- Part B: Adsorption/Ion Exchange Column (Optional)
        - Prepare a mini column (syringe with ion exchange resin)
        - Pass the water layer through it.
        - Measure **color change**, **conductivity drop**, or **pH change**.

Data Collection:

Students record **color change**, **conductivity drop**, or **pH change**.
Students compare:

- Color intensities: Which layer extracted dye best?
- Conductivity/pH (if available): Where did ions go?

Discussion:

- How polarity affected solvent partitioning
- Adsorption surface effects
- Effectiveness of ion exchange materials
- Encourage students to **map their lab stations** to each part of the real DLE process.