Following in the Footsteps of Edison, Part 3

It's a Blast!

Content area: Science, Technology

Grade level(s): 5 to 12

Objective: Students will learn that the consistency of a solid material, whether as a fine powder or large chunks, greatly affects its utility. In this activity students will practice *agglomeration*, the process of binding powders into larger masses more conducive to their intended use, and will learn how this process, as perfected by Thomas Edison, is still a mainstay of materials processing today.

NGSS/NJ SLS: Students develop proficiency towards the following performance expectations:
3-*5-ETS1-1* Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-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 problem.
MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Background Information for the Teacher:
In Part 2 of this activity set, students learned how Thomas Edison was able to utilize low-grade iron ore to produce an ore concentrate that contained as much iron as any ore in the country. His decade-long quest to develop massive rock crushers and electromagnetic separators was ultimately successful, and, by the late 1890s, Edison was poised to mine many millions of tons of iron ore. In practice, however, his ore concentrate didn't work. The reason was its powdery consistency – it wasn't in big chunks like the magnetite mined from the vein deposits. This created several problems:

● The ore concentrate was transported by rail in open hopper cars to the smelter. On dry days, some of the powdered concentrate simply blew away.
● On rainy days the powdered concentrate soaked up water, so the hopper cars became heavier. Inasmuch as transportation costs are based on weight, Edison was losing money by paying freight charges for transporting water.
● The water-soaked concentrate, just like wet beach sand, refused to pour out of the hopper cars.
● When added to a blast furnace some of the powdery concentrate was blown right out again and clogged the works. [They are not called *blast* furnaces for nothing.]

Now what? That is the subject of this activity. Edison set out to *agglomerate* the ore – to form the powder into larger pieces. It took a lot of experimentation to find an appropriate binding agent and invent a process to compress the powder into briquettes, but Edison succeeded. His briquettes greatly resemble hockey pucks in size, shape, and color but are much heavier. In this activity, students will make their own "Edison hockey pucks" to better understand the agglomeration process and develop a greater appreciation for how Edison refused to let obstacles stand in his way, but repeatedly found a way around them through dogged persistence.

Materials Needed:
Cardboard cores from rolls of toilet paper, cut into 1" lengths
Aluminum foil
Paper towels
Short (8") length of ¼" wooden dowel to use as a stirring rod. A screwdriver will do as well.
Cooking oil
A candle (black ones are best, but any candle will do)
Small saucepan
Teaspoon
Laboratory hot plate

Class Management: Because this lesson involves hot and potentially messy materials, teachers may prefer to perform this activity as a classroom demonstration without direct student participation. If instead you prefer a hands-on activity (recommended for responsible students), you will need enough materials for each group of 3-4 students.

Time: One class period or part thereof.

Teaching the Lesson:
1. Introduce students to the various problems caused by Edison's powdered ore concentrates as outlined above. Ask what they would do to overcome these problems. There are two general approaches: either modify the smelting technique to accept powdered ore concentrates, or somehow form the powdered concentrate into larger pieces that wouldn't clog the furnace. The latter, for various reasons, was the only practical course.

2. Explain that the process of forming small particles into larger pieces is called *agglomeration* and that students are going to agglomerate the powdered ore concentrate that they prepared in Part 2 of this activity.

3. Break off a portion of the black candle, add it to the saucepan, and gently heat it so the paraffin will melt. How much paraffin to use depends on how much magnetite concentrate is available, but the objective is to end up with a thick magnetite slurry with a consistency like that of stiff cookie dough.

4. When the paraffin is melted and hot enough to be a thin liquid, gradually add the magnetite concentrate and stir it into the paraffin. As noted above, the resultant product should be fairly stiff, not so thin that it pours.

5. Arrange one or more circular sections of cardboard toilet-paper roll on a sheet of aluminum foil. Coat both the foil and the inside of the sections of toilet-paper roll with cooking oil. Spoon

enough of the paraffin-soaked magnetite concentrate into each to fill it nearly to the top and allow to cool until the paraffin is once more at room temperature. When cool, peel the cardboard wrapper and aluminum foil from the magnetite to complete the magnetite "hockey pucks."

6. Explain to students that many types of ore being mined today require first that the ore be crushed so the valuable minerals can be separated from the others, resulting in a powdered concentrate much like the ones the students prepared, and that agglomeration of the powder is a necessary step before shipping the concentrate to a smelter. Variations on Thomas Edison's agglomeration process are still a mainstay of ore processing today. In addition, many other materials must be agglomerated before they are used, so Edison's process is widely used outside of the mining industry as well.

Assessment:

● Students demonstrated understanding that the physical properties of solid materials greatly affect the potential uses of those materials.
● Students demonstrated understanding of the historical context of Edison's attempts to mine iron ore and process it into a material suitable for smelting to recover iron metal.
● Students demonstrated understanding that recovering metals from various types of ore requires multiple processing steps including crushing, concentration of the valuable components, and tending to various requirements for shipping and smelting.

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Author: Earl R. Verbeek, Ph.D.

Dr. Verbeek worked for 20 years as a research geologist with the U.S. Geological Survey in Denver, Colorado and is now Resident Geologist and Curator at the Sterling Hill Mining Museum.