WMRC Greening School's Green Chemistry Lesson GS005-008

Glue From Milk

Objectives
1. Examine how a chemical reaction can change into a new product,
2. Understand how renewable resources can be used in our everyday lives

Green Chemistry Principles
- Safety first and last
- Use renewable resources

IL State Standards (Science)
11.A, 12.B, 12.C, 12.E, 13.B

Materials
- 2 one-ounce medicine cups
- Safety goggles
- Plastic spoon (reuse)
- Basket-type coffee filter
- 2 9-once clear (reusable) plastic cups
- 3-quart package of powdered non-fat milk
- 1 ½ cups vinegar
- 8 ounce box of baking soda
- set of measuring spoons
- Measuring cup
- Hot water (1/3 – ½ cup)
- Plastic or newspaper (to cover table if necessary)
- Paper for gluing
- Towels for cleanup

Levels
Middle School (Use as a demonstration for elementary school)

Vocabulary
Curd, Whey, Casein, Rennin

Time
One class period

Overview
Utilizing renewable resources in the classroom visually illustrates the principles of Green Chemistry. The Milk and Glue activity demonstrates to the students that you can take a renewable resource-milk in this case, and through a chemical reaction, turn it into a usable product such as glue. The activity also shows the students that chemistry can be fun. One batch of glue will be made, although this glue does not have a long shelf life.

Procedure
1. Measure ¼ cup of hot water
2. Pout into a clear 9-ounce cup
3. Add 2 tablespoons of powdered mil to the water and stir until dissolved.
4. Add one tablespoon of vinegar to the mixture and stir. You should see the milk begin to separate into solid chunks of curd and a watery liquid called whey.
5. Stir until the milk is well separated. [*This separation works best when the milk is very warm or hot. That is why powdered milk and hot water are used. If your*

milk does not separate well, try a little more vinegar or try heating it. If it still does not separate after a few minutes, try it again with warmer water.]

6. Separate the curd from the whey. To do this, line the clean, empty second cup with the coffee filter and pour the curd/whey mixture into the filter.
7. Lift the filter slowly. The liquid whey should drain through the filter, leaving only the curd. The curd is what you want to keep.
8. Squeeze the filter containing the curd to remove as much of the whey (liquid) as possible. Drop the lump of curd back into the plastic cup that you first used. [*Dispose of the whey by pouring it down the sink.*]
9. Use the spoon to break the curd into small pieces. [*Breaking up the curd is important for making good glue.*]
10. Add one teaspoon of hot water and 1/8-1/4 teaspoon of baking soda to the chopped curd and mix thoroughly. You should see some slight foaming, a chemical reaction. Continue mixing until the curd becomes smoother and more liquid. The curd has now become glue. [*If the mixture is too thick, add a few drops of water. If it is too lumpy, add another pinch of baking soda, and stir. You should see some foaming. Don't be afraid to experiment by adding more water or baking soda to improve the consistency of your glue. The finished product can vary from a thick liquid to a thick paste. This depends on how much curd there is, and how much water and baking soda are used.*]
11. Use glue to paste together pieces of paper. It may take 15-30 minutes to dry depending on how much you use, but it should work as well as traditional white school paste.
12. Cover cup of glue with plastic wrap and let sit for a few hours, or even overnight. The consistency should become smoother and clearer. Dispose of the wet glue in the trash within 24-48 hours or it will start to spoil and smell like spoiled milk—or worse.

Teacher Background

Milk contains a special type of protein called casein (pronounced kay-seen). When milk sours, or has an acid such as vinegar added to it, the casein clumps together to form curds. The watery liquid that remains is called whey.

These curds of casein protein are used to make cheese. In cheese making, an enzyme called rennin is used to separate the curd from the whey, instead of using an acid such as vinegar. The curd is then washed, salted, and active cultures are added. This mixture is then aged until it turns into cheese. The type of cheese it becomes depends upon the specific cultures added, and how it is stored during the aging process.

The baking soda neutralizes the acid in the vinegar. When the curd no longer has acid in it, it returns to a more liquid form. The foaming you see when the baking soda is added to the curd is the carbon dioxide gas, which is made when the baking soda reacts with the acid in the vinegar. (*Is there a way to demonstrate the presence of the CO_2 gas?*)

The liquefied casein protein is a natural glue. Casein is used in food products such as non-dairy creamers and as a raw material for some commercial glues and other products.

The Twelve Principles of Green Chemistry

1. It is better to prevent waste than treat or clean up waste after it is formed.
2. Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product. (Preventing waste)
3. Wherever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. Chemical products should be designed to preserve efficacy of function while reducing toxicity.
5. The use of auxiliary substances (e.g. solvents, separation agents) should be made unnecessary whenever possible and, innocuous when used.
6. Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
7. A raw material feedstock should be renewable rather than depleting whenever technically and economically practical.
8. Unnecessary derivatization (blocking group, protection/deprotection, temporary modification of physical/chemical processes) should be avoided whenever possible.
9. Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products.
11. Analytical methodologies need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances.
12. Substances and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosion and fires.

Real World Applications

A variety of web resources provide instruction for making cheese. Two are provided, but there are many others, depending upon your time and interests.
http://www.glue.umd.edu/~nsw/ench485/lab1.htm
http://biology.clc.uc.edu/fankhauser/Cheese/Cheese98.htm

On the Web

Make Milk Glue, http://www.strausmilk.com/pages/kids/glue.html