

Activities Guide

Workshop 5. Chemical Design

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Comment

1. All activities have been peer-reviewed but not tested.
2. Some safety considerations are suggested in the activities. For full safety information, consult the MSDS sheets (go to <http://msds.pdc.cornell.edu/>) before doing the experiment.
3. A concise source book for further assignments, activities, and background information is *ChemSource*, version 2.1 (Orna, Mary Virginia, O.S.U.; Schreck, James O. & Heikkinen, Henry, eds.), 1998. Visit the Web site at <http://intro.chem.okstate.edu/ChemSource/chemsource.html>.

The Stoichiometry of Cooking:

Lisa Morine

Teacher's Guide

Goals

- To understand the meaning of stoichiometry
- To relate chemistry to the everyday phenomena of cooking so that new concepts are assimilated

The Activity

In this activity, the importance of stoichiometry is emphasized by teaching the effect of changes in ingredients on a final product. Baking is fun, and when kids are having fun, they're more open to learning new ideas. The analogy to stoichiometry deals with relative amounts of ingredients, with measurement of weights and volumes, and with the analysis of the chemistry which is involved in baking.

Materials for Each Group

- Plastic ware for weighing, measuring, and mixing
- Tray with six muffin tins
- 6 small cake trays
- 240 g (1 cup) sifted flour
- 180 g (3/4 cup) sugar
- 10 g (2 teaspoons) baking powder
- 60 ml (1/4 cup) shortening
- 1.25 g (1/4 teaspoon) salt
- 120 ml (1/2 cup) milk
- 2.5 ml (1/2 teaspoon) vanilla
- 2 eggs
- Favorite frosting

Note: if you have a big oven, you can double the amount of batter being made.

In Addition

- Baking oven
- A new (chemical free) semi-analytical balance
- 10 g (2 teaspoons) baking soda (for one group)
- 180 ml (3/4 cup) shortening (for one group)
- 60 ml (1/4 cup) butter (for one group)

The Stoichiometry of Cooking: Teacher's Guide, page 2

SAFETY

Never eat in the laboratory! If you want to eat the cakes, make them in the kitchen (out of the lab), in chemical-free vessels.

Use a new balance or a kitchen balance instead.

Lecture Notes

What is the definition of stoichiometry? Stoichiometry is using molar mass to calculate the gram amount of reactants needed in order for a product to form.

How important is it to add the correct amount of reactant in order for a reaction to occur? In today's class we are going to bake cupcakes and you're going to see the chemical reactions. More than one chemical reaction is going on when you're baking a cake.

Try to predict what may happen if you vary the amount of reactants that you put in the cake.

This relates to chemistry, because if you don't add the correct amount of chemical reactants before the reaction, the product might come out different, or the reaction might not occur.

Look at the different cake batters and how they are different. The "mole" of the reactant, in the batter of one group, will be different than the "mole" of a reactant in another.

Easy Cupcakes

The ingredients and instructions for baking cupcakes are listed below, taken from:

<http://www.funology.com/inthekitchen/kit062.cfm>

What you will need:

- 240 g (1 cup) sifted flour
- 180 g (3/4 cup) sugar
- 10 g (2 teaspoons) baking powder
- 60 ml (1/4 cup) shortening
- 5 g (1/4 teaspoon) salt
- 120 ml (1/2 cup) milk
- 2.5 ml (1/2 teaspoon) vanilla
- 2 eggs
- Favorite frosting

Recipe:

1. Preheat the oven to 350 degrees Fahrenheit.
2. Sift all dry ingredients and set aside.
3. Measure all liquid ingredients, and combine in a separate container.
4. Combine dry and wet ingredients in a large mixing bowl.
5. Blend for 1/2 minute on low speed, scraping the sides of the bowl constantly.
6. Beat an additional three minutes on high speed, again scraping the bowl occasionally.
7. Place cupcake papers in muffin tins, and pour the batter into the cups, filling them halfway up to the top.

The Stoichiometry of Cooking: Teacher's Guide, page 3

- Bake for 20-25 minutes.
- Cover with favorite frosting after it cools.

Instructions

Divide class into groups of no more than five students.

Assign the variations in the recipe such that every group will have a different recipe (see table below). When finished mixing, put one of each groups' batter in a muffin tray and bake them (you can bake the rest of the batter in the other cake trays).

Group	Variation
I	none
II	use 5 g (1 teaspoon) baking powder instead of two
III	use 10 g (2 teaspoons) baking soda instead of baking powder
IV	use no leavening agent
V	use no eggs
VI	use 180 ml (3/4 cup) shortening instead of 60 ml (1/4 cup)
VII	replace 60 ml (1/4 cup) shortening with 60 ml (1/4 cup) butter

Observe your cupcakes, taste them and conduct a class discussion.

Comment

A useful site for unit conversion in the kitchen is <http://www.hungrymonster.com/calculators.cfm>.

Teaching Tips From Ms. Morine

You have to be familiar with their prior knowledge and practical experience in the past, and find a way to connect it to the chemistry. It's a leap: it's a reasoning that they have to go through.

They have to realize that they are weighing a mass. It's flour, but they are weighing a mass. They are adding it to the batter and a chemical reaction occur while baking.

When you are doing an activity like this, you can't forget that it's fun. And whenever something is fun, they tend to be more open to new information. They are just having a good time.

When you mention moles they do not get freaked out or stressed. You can't overestimate how important it is to have fun while you are learning.

Song

*"A mole is a unit, or have you heard
Containing six times ten to the twenty-third
It's the six with 23 zeroes at the end
Much too big a number to comprehend"*

The Stoichiometry of Cooking: Teacher's Guide, page 4

It's a leap of thought, to get down to the molecular level and say, well, if I had varied the gram amount or if I had varied the chemical substance then my outcome would have been different. I like starting the process in reasoning, and the subject with an activity like this, and not as a worksheet with lots of calculations.

They had to look at moisture, texture, consistency and height, because leavening agents produce the CO_2 bubbles which cause the cake to rise. This was one of the reactions that they could qualitatively observe more closely.

I included pH in this exercise because I wanted them to think about the chemical composition of the food, not only that it is cake or batter but that it has a lot of chemistry in it. It has atoms, it has molecules, it's a mixture... when you get to pH, you consider the acidity or basicity of the substance; you consider the molecules in its basicity.

I am happy with the results. I love that students have fun. It might look like things are going crazy in here, when we are doing those hands-on experiments. But in reality I can tell they are learning and tonight they will go out, and it's going to be a thing that they remember, about the time they were talking about moles and baking a cake.

References: Links

http://www.uen.org/utahlink/lp_res/nutri375.html

An extensive site from the University of Utah on food science.

<http://www.hungrymonster.com/calculators.cfm>

A unit converter for the kitchen. Will convert SI and English units. Convenient for anyone adapting a recipe for class use.

References: Readings

JCE Editorial Staff (2000) "Flat as a Pancake? Exploring Rising in Baked Goods," *Journal of Chemical Education*, Vol. 77, No. 10, pp: 1264A-1264B and supplements1-3.

McCamish, M. (1987) "The Rise of Self-Rising Flour: A Recipe for Success," *Journal of Chemical Education*, Vol. 64, p: 710.

The Stoichiometry of Cooking:

Lisa Morine

Students' Guide

Goals

- To understand the meaning of stoichiometry
- To relate to chemistry via everyday phenomena so that new concepts are better internalized

The Activity

In this activity, the importance of stoichiometry is emphasized by showing the effect of changes in ingredients on a final product. The analogy to stoichiometry deals with relative amounts of ingredients, with measurement of weights and volumes, and with the analysis of the chemistry that is involved in baking.

Materials for Each Group

- Plastic ware for weighing, measuring, and mixing
- A tray with six muffin tins
- 6 cake trays
- 240 g (1 cup) sifted flour
- 180 g (3/4 cup) sugar
- 10 g (2 teaspoons) baking powder
- 60 ml (1/4 cup) shortening
- 1.25 g (1/4 teaspoon) salt
- 120 ml (1/2 cup) milk
- 2.5 ml (1/2 teaspoon) vanilla
- 2 eggs
- Favorite frosting

SAFETY

Never eat in the laboratory! If you want to eat the cakes, make them in the kitchen (out of the lab), in chemical-free vessels.

Use a new balance or a kitchen balance instead.

The Stoichiometry of Cooking: Students' Guide, page 2

Instructions

Follow the instructions and make your own cupcakes. Make sure that you know the variation in your recipe.

Before You Bake

When you bake at home you use measuring cups. Here, you weigh the ingredients in grams. Why? What can you learn from the gram weight of the ingredients? _____

Pour a little batter into a plastic cup and measure its pH: _____

Is the batter acidic or basic? Why? _____

Easy Cupcakes

What You will Need:

- 240 g (1 cup) sifted flour
- 180 g (3/4 cup) sugar
- 10 g (2 teaspoons) baking powder
- 60 ml (1/4 cup) shortening
- 5 g (1/4 teaspoon) salt
- 120 ml (1/2 cup) milk
- 2.5 ml (1/2 teaspoon) vanilla
- 2 eggs
- Favorite frosting

Recipe:

1. Preheat the oven to 350 degrees Fahrenheit.
2. Sift all dry ingredients and set aside.
3. Measure all liquid ingredients, and combine in a separate container.
4. Combine dry and wet ingredients in a large mixing bowl.
5. Blend for 1/2 minute on low speed, scraping the sides of the bowl constantly.
6. Beat an additional three minutes on high speed, again scraping the bowl occasionally.
7. Place cupcake papers in muffin tins, and pour the batter into the cups, filling them halfway up to the top.
8. Bake for 20-25 minutes.
9. Cover with favorite frosting after it cools.

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After You Bake

Fill in the following table about properties of the cake:

Property	Description
Moisture	
Texture	
Consistency	
Height	
Taste	

Explain your results: _____

Summary

Define stoichiometry: _____

How does baking stoichiometry affect your cake product? _____

Cherry Coke Distillation Laboratory:

Al DeGennaro

Teacher's Guide

Goals

- To use a new technique for separating mixtures
- To relate chemical principles to everyday life

The Laboratory

In this laboratory, Cherry Coke is distilled in order to learn about separation methods and food content. At least three components are identified: CO₂, food flavorings, and distilled water. The reaction of CO₂ with lime water is demonstrated before the experiment. This experiment should give the students the feeling of the chemistry of food.

Lecture Notes

Lime water is a chemical which is actually called Ca(OH)₂. The reason that it is called lime water is because the stuff that you put in your garden, which is called lime, is also Ca(OH)₂.

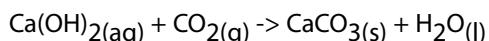
When you are distilling, you will have the tubing going into some lime water. Why are we doing it? Allow me to demonstrate.

Instructions

Put some lime water in a test tube. Immerse a drinking straw in it. Blow into the straw and watch the lime water become cloudy.

Discussion

In this demonstration, the teacher exhales air into a test tube which contains lime water, Ca(OH)₂. The following reaction takes place:



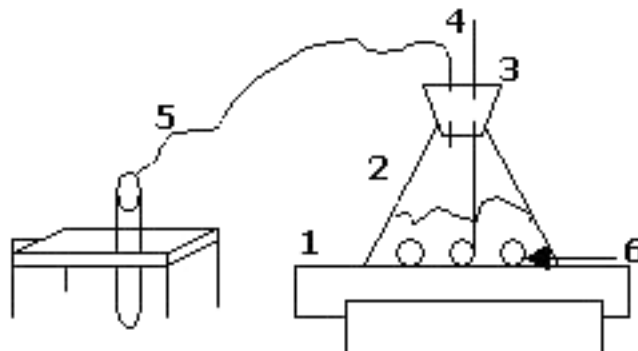
The solution turns cloudy due to the solid particles of CaCO₃ that are formed. This is a simulation of the same process of distilling CO₂ from soda pop.

Materials for Each Group

- Cherry Coke or grape soda
- Test tube rack
- Two 50 ml test tubes, one empty and one with lime water
- Ice bath
- Stopwatch
- Graduated cylinders: 100 ml and 5 ml

Cherry Coke Distillation Laboratory: Teacher's Guide, page 2

- Apparatus for distillation:
 1. Hot plate,
 2. 500 ml Erlenmeyer flask,
 3. A suitable rubber stopper for the flask with two holes,
 4. Thermometer in one hole,
 5. A tygon/plastic tubing connected to a short glass tube in the other hole,
 6. Boiling chips.



Note: professional distillation equipment can be used, if available.

SAFETY

Wear safety goggles at all times during the demonstration and laboratory.

Do not touch hot plate or hot vessels with bare hands.

Before heating, have your students show you their distillation apparatus: be sure they tighten all connections and open the tubing.

Lecture Notes

Lime water gets cloudy if you shake it, so don't shake it.

It's cloudy because little chunks of solid form in the water.

What is it in the exhaled air that reacted with $\text{Ca}(\text{OH})_2$? CO_2 , which forms CaCO_3 .

What does this have to do with the soda pop lab? It is the same CO_2 that is in soda pop. It is one of the ingredients that we have to remove from the soda. And the way that we're going to test it is by bubbling it through lime water.

Lime water is not very dangerous and getting it on your fingers is no big deal. But try not to get it on your skin, if you can help it. You will collect it in the test tube during the experiment.

We're expecting to get flavorings out of the drinks. There should be at least one flavor, and there should be even two flavorings in the grape. So, what you are going to do while carrying out the experiment, is to waft the odors towards you from time to time and, if you smell something, record that.

You know that many of the food flavorings are artificial. The companies mix a chemical or two which only taste like it. These chemicals come out at different times (in distillation).

Instructions

You didn't check your apparatus before you started. The only reason I'm doing this is to make sure that nothing is wrong with your apparatus.

Keep the stopper in real tight.

Keep an eye on the thermometer. When it gets to about 30°C , you should keep it there for about 20 mins. You should see some action in your lime water.

If you don't get cloudy lime water, you should do the distillation over again.

Other groups have found that if the stopper is not really tight, the carbon dioxide squirts out of the tube. If you see bubbles coming through that's a good sign.

Did you smell the cherry? At what temperature was it noticeable, do you remember?

When the odor starts to fade and the temperature drops, heat it some more.

Cherry Coke Distillation Laboratory: Teacher's Guide, page 3

There's no way that you have so much grape flavor in it. If there were so much then it would probably have driven us all out of the room. There are probably about two drops of grape flavor in it.

You can unplug the heater and take off your goggles, and I will give you the closing questions.

Discussion Questions

Did you smell the flavoring? Did it come before or after the water?

How many people smelled the flavoring? Did you smell one or two?

Did the flavoring come out before or after the carbon dioxide or sort of in the middle?

What's the last thing you saw? There's still water in the test tube.

What would be left in the flask? Anything else in the soda (read the label).

Comment

Another fun lab to do without a formal write-up is to distill Cherry Coke. This is a simulation of the distillation of crude oil in the petroleum unit. The sweet smelling ester and carbon dioxide are similar to the more volatile fractions, which come off in the distillation of crude oil. The water fraction is a good contrast to the dark liquid left in the flask and points out distillation as a means of separating components with different boiling points in a mixture. This lab is simple but gives students a known mixture to work with in the lab. (By John R. Kirkau, taken from <http://chem.lapeer.org/Chem1Docs/cherrycoke.html>.)

Teaching Tips From Mr. DeGennaro

Separating mixtures is a very often misunderstood topic in chemistry. The idea of element, mixture and compound is very confusing to beginners. So, we will address that and we will have fun, too.

We are really at a disadvantage of a large class in a fairly small room. That's pretty much the trend...large classes. It puts a cramp on the kids. The tables are designed for four kids max and they're working five on each table.

You don't need a lot of equipment. The flasks and Erlenmeyers are everywhere, the tubing and thermometers are also pretty easy to get. This is very low tech, and this is the beauty of it.

They always show distillations on Frankenstein movies. That's expensive glassware. It's not practical to do seven stations on this, especially with kids who are pretty young and are likely to break things. So this is easy stuff.

The thing I like about it is the ingredients. These are things that they see all the time. So, instead of pulling chemicals off the shelf, deliberately mixing it and saying "now separate the 2-propanol from the 1-propanol," we can get their attention with something they are familiar with.

Except for the loose connections, everybody got successful results. There's always something you forget to tell the kids and that's to keep the stopper in, really tight.

I think the concept was driven across very well. I think they all understand it. And I'm going to drop in on some of the kids and see how they worked.

I would hope that they come out of this with a feeling that the products that they are using are understandable things. There is no such thing as a grape soda spring...that somebody blended this together with ingredients, which everybody knows about.

It's not just the food. I think that they should think the same about their medicine. If the doctor is telling them to take it they should ask: what is it doing to me?

I've seen chemicals that fizz violently when they touch water. I've seen chemicals, which burn up other chemicals. I've seen chemicals that do nothing. What exactly is this stuff doing to me?

That's a mindset that people should have all the time, that things are made from understandable things, and that they can do it.

Students' Comments

We want to see what makes the bubbles in Cherry Coke. By boiling it to evaporate, and putting it on ice, we get back whatever liquid there was in it.

I actually enjoy doing experiments, so I'm having a good time doing this stuff. In normal life I don't really care, I just like having things to drink and I don't really care what's in it. But knowing what's in it makes you actually aware of what sorts of chemicals are in objects these days.

I'm learning to do all kinds of things with heat that I didn't think that you could do before.

References: Links

http://www.pafko.com/history/h_distill.html

This site applies distillation to petroleum refining.

<http://www.schoolscience.co.uk/content/3/chemistry/materials/index.html>

A series of interactive pages that explain the composition of matter. Distillation and chromatography are highlighted.

References: Readings

Stanitski, C. (1999) "Molecules at an Exhibition: Portraits of Intriguing Molecules in Everyday Life (by John Emsley)," *Journal of Chemical Education*, Vol. 76, No. 8, pp: 1065-1066.

Rohrig, B. (2000) "Fizzy Drinks: Stoichiometry You Can Taste," *Journal of Chemical Education*, Vol. 77, No. 12, pp: 1608A-1608B.

Cherry Coke Distillation Laboratory:

Al DeGennaro

Students' Guide

Goals

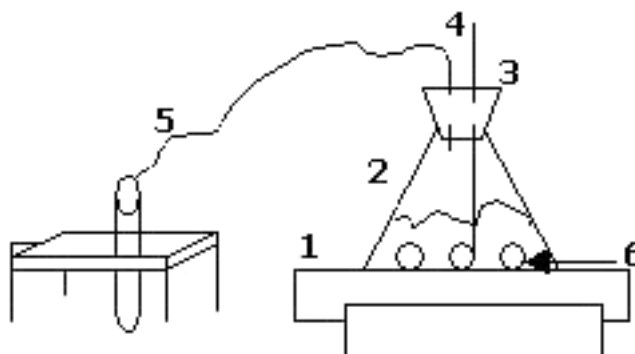
- To use a new technique for separating mixtures
- To relate chemical principles to everyday life

The Laboratory

In this laboratory, you will distill Cherry Coke in order to learn about separation methods and food content. You should be able to identify at least three components: CO_2 , food flavorings, and distilled water. The reaction of CO_2 with lime water is demonstrated before the experiment.

Materials for Each Group

- Cherry Coke or grape soda
- Test tube rack
- Two 50 ml test tubes, one empty and one with lime water
- Ice bath
- Stopwatch
- Graduated cylinders: 100 ml and 5 ml
- Apparatus for distillation:
 1. Hot plate,
 2. 500 ml Erlenmeyer flask,
 3. A suitable rubber stopper for the flask with two holes,
 4. Thermometer in one hole,
 5. A tygon/plastic tubing connected to a short glass tube in the other hole,
 6. Boiling chips.



Note: professional distillation equipment can be used, if available.

SAFETY

Wear safety goggles at all times during the demonstration and laboratory.

Do not touch hot plate or hot vessels with bare hands.

Before heating, show the teacher your distillation apparatus: tighten all connections and open the tubings.

Cherry Coke Distillation Laboratory: Students' Guide, page 2

Instructions

1. Put a boiling chip or glass bead into the Erlenmeyer flask.
2. Add 100 ml Cherry Coke or grape soda.
3. Close the stopper tightly, when both the thermometer and the tubing are connected to it.
Make sure tubing is tightly connected, otherwise the CO₂ gas escapes!
4. Put the tubing into the test tube with lime water. Have the empty test tube ready on ice.
5. Put the flask on the hot plate and start the stopwatch going
6. Heat the Cherry Coke/soda pop gently, to about 30°C, for about 20 minutes.
- 7a. Notice the bubbles in the lime water and their cloudy appearance. Record the time of appearance:

- 7b. Smell the odors coming out of the distillation apparatus. Record the smell(s) that you recognize and time of appearance: _____

8. When the temperature starts to drop, remove the tubing from the lime water. Wash end of tubing with distilled water and insert it into the test tube which is on the ice.
10. Stop the distillation.
11. Note the clear fraction and measure its density: _____

Measure an empty 5 ml graduated cylinder. Put in exactly 2 ml of the distilled fraction. Weigh the sample on a semi-analytical balance. Record the weight: _____

Density is calculated as gr/ ml. What is the measured density? _____

What substance is this? _____

Discussion

Which flavorings did you smell? _____

Did the flavoring come out before or after the carbon dioxide? _____

Where are the flavorings at the end of the experiment? _____

What is left in the flask? Read the label on the bottle and write down the other components which you haven't identified: _____

Summary

Define chemicals. Are there chemicals in your Cherry Coke? _____

Personal Chemistry Topic: Lisa Morine

Teacher's Guide

Goals

- To research a personal chemistry topic, in which all steps, from design to synthesis of molecules, are followed
- To start out from students' points of interest in order to make learning more effective

The Personal Chemistry Topic

In the personal chemistry topic, the students are asked to choose some subject about the chemistry of the human body, for example, the chemical structure and synthesis of different medications. The students start from their own interest and go on to learn chemistry, enjoying both.

Lecture Notes

You have got to pick a personal topic related to chemistry.

You need to have a presentation ready. It has to have a visual. You may have slides or pictures, you may have filmed something, and you might have done a puppet show or a rap.

It is up to you how you want to do your project.

Are you ready to do some research on the Internet? I pulled out a whole card of books and encyclopedias from the chemistry section.

Instructions

Research—this includes:

- Introduction to the substance research
- Three paragraphs of facts
- Your feelings about what you learned
- Concluding paragraph

Presentation—this includes:

- 5-10 minutes in length
- A visual component

Lesson plan—this includes:

- Learning objectives
- Lesson procedure
- Any materials needed

Experiment—this includes:

- Getting prepared for the experiment
- Showing what you did in class work

Teaching Tips From Ms. Morine

This exercise is an individual project in which the students are given tasks. The first task is to write a research paper about a chemical, and the chemical is a personal chemistry topic. Personal chemistry is the chemistry that deals with the human body. There is a very broad range of topics, for example, illegal drugs, cosmetics, cleansers. Anything that goes in their body can be a personal chemistry topic.

They get to pick the topic, they do a research paper on it. The second part is a presentation/lesson. They present the information they learned. That way it is not one person learning only one subject, but they share what they learned with everybody.

What I like about online research or an independent research project is that, it is very open-ended to what the students' interests are. For example, if they are interested in lipstick, drugs, or medication. For example, one student has asthma, so she is taking medication, and she's doing the personal project about her medication.

Whatever their interest is, then they can focus on that, they can learn from it, they can do a lot online, and because the interest is high, they learn a lot of chemistry that way. Any student-directed activity can help them learn chemistry better, I think.

I might give them five minutes totally free to find out, to see what it's like. And what happens is frustration, because there's so much out there, and they find out that it is much more difficult than they had anticipated. They get the five minutes of frustration, then I'm there to narrow it down.

I teach them two skills: chemistry skills and research skills.

Example for Personal Topic: Making Aspirin

Teacher's Notes

You can demonstrate making aspirin and I have information for you on how to do so.

Comment

See for example:

Olmsted, J. A., III. (1998) "Synthesis of Aspirin: A General Chemistry Experiment," *Journal of Chemical Education*, Vol. 75, No. 10, pp:1261-1263.

Pandita, S., Goyal, S. (1998) "An Efficient Microscale Procedure for the Synthesis of Aspirin," *Journal of Chemical Education*, Vol. 75, No. 6 p: 770.

You probably have to come here one day after school so we can practice.

You might even want to do the demo on video first, because you will be using concentrated nitric acid so we want to be careful.

Search the Internet using the keywords aspirin synthesis or go to:

<http://www.chemheritage.org/EducationalServices/pharm/tg/asp/asp31.htm>
A complete lab activity for making aspirin, including student and teacher guides.

Here is aspirin, right there: it has carbons, hydrogens, and oxygens. That's all it has. You will start out with salicylic acid, which is a white powder, add different chemicals to it, and get aspirin.

Salicylic acid—it comes from the bark of trees. They use phosphoric acid, but I will have you use nitric acid. Any acid can make it do this.

SAFETY

Use safety goggles at all times. Wear aprons and gloves. Open and use all strong acids and organic materials only in the fume hood!

Laboratory Discussion

The next chemical [nitric acid] is very dangerous and you really have to use it in the hood. These are truly unsafe chemicals and you need to order such chemicals through a company. You need proper storage and usage and you should use them in a fume hood. So there's no way you could find them around the house. You can buy aspirin over the counter but chemicals used to prepare aspirin you can only buy from a chemical company.

After we take it out and add distilled water, and we put it on ice, will it freeze? No, it will not. It will cool down to make crystals.

It's like making rock candy from sugar: first you have to heat the sugar and dissolve it. Then you let it cool down.

You made aspirin from salicylic acid, so you let it crystallize, to acylsalicylic acid. Acylsalicylic acid has another double-bond oxygen, a set of three hydrogens and a whole other carbon. So acylsalicylic acid has this extra carbon double-bond oxygen, carbon tri-hydrogen, it's almost an Acetate so they call it acyl.

Why will it not be good to try your aspirin now? Because it's not made in the factory, and you don't know how pure it is. In the factory they have quality control and its done on a commercial level. But, it is still aspirin that comes out.

Concluding Remarks—Ms. Morine

I think that they are doing really well. I'm so impressed with how thorough they are and how they read the directions and followed them, they had questions, they weren't afraid to ask. So, I'm very impressed.

I am glad they did it, because I think it helps the students that don't get the opportunity to use chemicals like this, to feel the dangers, and they learn to see how it appears.

In the past, all students used to make aspirin, but now there are safety regulations against it, so at least they got to see how you actually design a chemical.

One wonderful thing that I found on the Internet was a bunch of rubrics from the Harvard Division of Education: http://artsedge.kennedy-center.org/professional_resources/howto/rubrics.html.

They had all kinds of rubrics regarding PP presentations and rubrics for oral presentation. I kind of modified it for this project, there's a lot of cut and paste in it, but it's a rubric and it's made grading easy and fair. I have done it so many times now, that it's all in my head so as they are presenting, in my head I am clicking: yes, they had good projection, yes, they were clear on their topic, yes, they had faced the audience. Then I can grade it in my head and give them their grade right away.

Concluding Remarks—The Students

Aspirin is a drug. Some people think that it's a safe drug. But when you think about it, there's a lot of dangers that it poses: if you don't know how to take it, when to take it, what to take it for. That's why we decided to pursue aspirin. I mean, I learned a lot. I didn't know before. Sometimes I had a head ache, and I used to take about three or four aspirins, it's not really good.

To me, I was very nervous [about the presentation].

The video really helped me. I watched the video once before and I knew where I was going to fast forward and where to go slowly. I had the lab report in my hand and I actually knew the stuff, I knew what I was talking about: why I used phosphoric acid, and distilled water, and that really helped.

I think that it really helped me doing this project.

Separating Mixtures Laboratory:

Veatta Berry

Teacher's Guide

Goals

- To bring the students to a certain level of knowledge regarding chemistry concepts
- To teach the ways of scientific investigation: asking questions, discovering, and concluding

The Laboratory

In this laboratory, chemical concepts in mixture separation are brought about in an easy activity with water-based chromatography of colorful markers. The students get a chance to experiment and investigate various conditions and trials, and thus they learn the chemistry of markers, an everyday product which they constantly use.

Materials for Each Group

- Vis-a-Vis black marker
- Different markers in different colors and different brands
- Test tubes in well plate or test tube rack
- Chromatography papers
- Pencils and rulers

Lecture Notes

There are many types of chromatography, which are used to separate all kinds of mixtures and solutions.

We are doing paper chromatography. What happens to paper when it touches water? It absorbs it by capillary action.

As the water moves up we hope it will pull some of the colors of the marker with it. Some of your markers are mixtures of colors, and we may be able to see those mixtures of colors.

We need the pencil mark at the bottom so we know where we started. Sometimes the marker will move totally, and you will not know where you started unless you mark it.

If the ink mark is not moving much, the water may not be the best solvent to use.

Discussion Questions

Why don't a couple of the dots move at all? They are formed by permanent markers.

When we look for permanent markers why do we use them? Because they don't come off in rain, and if they get on our clothes, it is very hard to get rid of them.

Did you use the same brand with different colors, or the same color with different brands? What did you see?

What happened when the paper touched the side of the test tube? It gave a swirly line, because of the water drops.

Separating Mixtures Laboratory: Teacher's Guide, page 2

Teaching Tips From Ms. Berry

Today we are looking at separating mixtures again, except that this time they are markers, which most of the time students are not aware that they can separate.

We are going to talk about "like-dissolves-like," how polar substances dissolve other substances. We will use this to identify different markers and to show that quantitative data can be obtained from separation, through identifying the different markers.

We will also look at different solvents, so that students will come with their own research questions.

We sometimes start out the investigation more open than that: Here are some markers and water, here is some paper. Put them together and see what happens. That's it.

Or give them some guidelines: You must have ten qualitative observations and ten quantitative observations, so they are willing to try more and more things to get these observations. And from that we have enough different observations and trials to make discussions, and they can make some conclusions regarding they have seen and lead us to the next step in where we are going.

We also grade their lab book, and their observations must be significant. Don't tell me that the test tube is made of glass. That's not an important observation when you do paper chromatography. And it helps them focus on what they are doing, and look for observations that they didn't look for.

We often lead to new research questions.

There are two things that we are trying to teach them. One, is that there are certain concepts in chemistry that they must learn in order to pass the standards of their state test, and those are the things that they are supposed to show that they understand by the end of the course in order to get credit.

We also think that it is important that they learn how to do science. Why is it important to ask questions about the world around you. And that's what the investigation is supposed to teach them. It is a process of thinking, deduction, and we help them through this process, and get them to a point where by the end of the semester they can do their own research project.

I try to find as many possibilities as I can because they feel empowered, and that it's their project, and they feel more involved that way.

References: Links

<http://chemscape.santafe.cc.fl.us/chemscape/catofp/chromato/paper/paper.htm#description>
Paper chromatography explained, with illustrations and video.

http://www.yesmag.bc.ca/projects/paper_chroma.html
Directions for using paper chromatography in the classroom.

References: Readings

JCE Editorial Staff (2000) "The Write Stuff: Using Paper Chromatography To Separate an Ink Mixture," *Journal of Chemical Education*, Vol. 77, No. 2, pp: 176A-176B.

Separating Mixtures Laboratory: Veatta Berry

Students' Guide

Goals

- To achieve a certain level of knowledge regarding chemistry concepts
- To learn the ways of scientific investigation: asking questions, discovering, and concluding

The Laboratory

In this laboratory, you will experiment with paper chromatography of colorful markers. You will investigate various conditions and trials.

Materials for Each Group

- Vis-a-Vis black marker
- Different markers in different colors and different brands
- Test tubes in well plate or test tube rack
- Chromatography papers
- Pencils and rulers

Instructions

Cut a piece of chromatography paper an inch longer than the test tube that you are going to use.

Stand the test tube in the well plate.

Put about 2 cm of water in the test tube. This is going to be your solvent.

Measure the water level with a ruler.

Draw a line with a pencil on the chromatography paper, just a little above the water level (pencil doesn't run when it touches water).

Right at your pencil line, put a small dot of your marker.

Insert your chromatography paper into the test tube.

Pull out the paper from the test tube when the water line reaches half an inch from the top.

Put it on a paper towel to dry out.

Do at least one Vis-a-Vis black marker, and more test tubes with other markers that you choose.

Make and register about ten observations in the following table.

Investigate: different types of the same colored markers, different colored markers from the same company, etc.

