Designing Foods with Sugar

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Abstract

A chef 'imagines' a new food to make, and spends the time to create a recipe. They do this to create new flavors and textures. They know what they want, as a finished item, but they have to figure out how to make it in a kitchen. So, they have to think of pots and pans and ingredients and what order to do things to get it right.

An engineer does something similar! They get their requirements from an engineering design process, but both chefs and engineers have to know their materials and how to process them to get the desired result. This activity is an introduction to processing a material to display certain properties.

Sugar is a basic food item and wonderfully suited to exemplify this task. It is possible to 'process' sugar to meet the requirements of that chef's imagination. Sugar can be processed to exhibit a wide variety of properties from syrups to hard candy. In this module students use sugar to make a variety of liquids (syrups), and then hard solids (candy) by suitable material processing (e.g. cooking!).

Rock candy growth (part 2 of this module) takes a few days, so the prepared jars of solution can be set aside in an undisturbed location and checked daily for candy creation.

A PowerPoint presentation is included for use with the students. This module is also published as Materials Science Educational Handbook module 6.1.2.

Student learning objectives: Students will be able

- Process a material (e.g. cook sugar) to exhibit ranges of hardness.
- Qualitatively compare the mechanical properties (e.g. hardness, stiffness or viscosity) of the sugar products, ranging from liquid to solid.
- Predict trends in properties of the resulting materials.

Module data

Key Words: Sugar, Candy, Syrup, Rock Candy

Type: This activity describes in-class, demo and hands-on sugar cooking activities. The accompanying PowerPoint presentation may be used to help student comprehension.

Target Grade Level: Secondary education

Time Requirements: Part one (syrup) takes one hour to make and evaluate. Part two (rock candy) takes an hour to prep, and five days to grow results

Pre-requisite Knowledge: None

Equipment and supplies needed (per participant or team at 2+):

Environment: Each student or team will need:

- Table-top space (about four square feet)

A list of materials at a 'common space' (to be used by all groups) follows:

- Sugar accessible
- Water accessible
- Wax paper
- Cotton string
- Paper towels
- Plastic spoons
- Hot pads

A list of materials for each group (making candy) follows:

- Hot plate or stove top
- Sauce Pan, spoon, coffee cups

Curriculum overview and instructor notes:

Many students never participate in creating or making anything at all. Since everyone eats, it is appropriate for students to investigate 'material processing' in this venue. 'Cooking' is just another example of 'material processing'.

Safety: Please use normal personal protection equipment (PPE) during this lab. This includes using gloves for handling hot items, as is normally done in a kitchen. Eye protection is appropriate. Other items may be considered such as aprons for protecting clothing.

This activity is separated into three parts. In the first part, sugar and water are combined to make a liquid syrup. In the second part, sugar is cooked into a taffy that is a soft solid. In the last part, sugar is processed over a period of time to make a hard candy.

Each activity is described and defined so that it can be planned with regard to resources and timing. There is also a list of outcomes for each activity, as well as a list of questions that can be used during and after the activity.

Part One: Syrup

Activity Description:

In preparation, the instructor should review this activity before using it. The scenario is to prepare the space, run the activity, and then debrief. In addition to the above space and material requirements, there are specific tasks to define. A basic recipe is shown below:

1/2 cup water + ½ cup sugar + any flavoring (e.g. Maple, Vanilla)

Variations: Change the amount of sugar from very little (i.e. like putting a teaspoon of sugar in your coffee) to a very large amount (twice the amount of sugar to water). The resulting liquids will vary in both viscosity and flavor. This can be evaluated as a group after all the syrups are made.

Preparation:

Preparation for the activity:

- Determine the workspace (tables for teams)
- Pre-measure the water and sugar quantities, if desired
- Plan the location of common tools (e.g. utensils, towels) as needed

Introduction:

Includes a discussion of cooking in general. It is appropriate to use local experiences as examples. Students should plan ahead before they turn on the hot plate. For example, review how many cooks pre-measure their ingredients (e.g. the ½ cup of water and sugar). Then go over a 'plan' of what they are going to do in what order. Even thinking about where to place items during their task is appropriate.

Syrup processing:

Students first heat the water to a boil. Then add the sugar and mix until dissolved. Then add, if desired, any flavoring. This is a simple but effective way to make syrup to accompany breakfast pancakes. It will be appropriate to cool the liquid, so there should be a hot pad to set the pan on. There will be some discussion about the results of their efforts, so consider how much time it will take to cool the liquid before they can taste it (e.g. 10 minutes +).

Debriefing:

Debriefing is an important aspect of the activity. There are questions concerning both the cooking process and the resulting liquid (reflecting the module objectives).

- Did the heating of the water and dissolving of the sugar take the time you expected?
- Did the resulting liquid have a consistency you expected? Is it 'runny' (less viscous) or really 'stiff' (will not pour or stir easily)?
- Does the liquid taste as sweet as you expected?

Further, after the activity can student describe the interesting parts of their cooking process. For example, were the tools easy to clean up, or were they able to flavor the syrup like they desired.

Part two: Rock Candy

Activity Description:

In preparation, the instructor should run through this activity before using it. The scenario is to prep the space, run the activity, and then debrief. In addition to the above

space and material requirements, there are specific tasks to define. A basic recipe (the same as for syrup!) is shown: below:

1/2 cup water + 1 cup sugar + any flavoring (e.g. Maple, Vanilla, Peppermint) or color dyes.

Note: to make 'rock candy', we simply need a super-saturated sugar solution and a place for nucleation (the string). A better product is made if you use 'pure' water (e.g. distilled), because impurities in tap water can attract the sugar (instead of to the string).

Preparation:

Preparation for the activity:

- Determine the workspace (tables for teams)
- Pre-measure the water and sugar quantities, if desired
- Get glass jars (clean) with paper towels to cover them
- Cut appropriate lengths of string and tie to pencils (add paper clip for weight)
- Plan the location of common tools (e.g. utensils, towels) as needed

Introduction:

Should include a discussion of cooking in general. It is appropriate to use local experiences as examples. Students should plan ahead before they turn on the hot plate. For example, review how many cooks pre-measure their ingredients (e.g. the cup of water and sugar). Then go over a 'plan' of what they are going to do in what order. Even thinking about where to place items during their task is appropriate, such as now to hang the string. A 'string' is used to attract the sugar from solution. Over time, the sugar molecules will orient onto the string in straight lines. This creates a very hard structure that looks like 'crystals' encasing the string.

Rock Candy Processing:

Students first heat the water to a boil. Then they add sugar in increments and mix until dissolved. Then add, if desired, any flavoring or colorants. Since a super-saturated solution is desired, a lot of sugar is added until at least a 2:1 ratio is met (twice as much sugar as water).

A glass jar is typically used to allow the candy to crystallize. The string should be hung down the center of the jar, so it doesn't touch the sides or bottom. Typically, a pencil is place across the top of the jar, with the string tied, and a paper clip used as a weight to make the string hang straight.

After the jar and string are situated, pour the sugar liquid into the jar and cover with a towel. It is best to place the jar in a cool/dark/quiet (little vibration) area for a few days to let the sugar crystallize onto the string.

When a reasonable amount of time has passes (3-5 days), there should be a string of rock candy about a half inch across. The string will probably be 'stuck' on some inner part of the jar, so simply run some hot water into the jar until the candy can be pulled out. Then lay it aside to dry (and later, eat!).

Debriefing:

There are questions concerning both the cooking process and even the jar/string assembly that allows crystallization to occur (reflecting the module objectives).

- Did the heating of the water and dissolving of the sugar take the time and work as you expected? Was there excess sugar in the pan (why or why not)?
- Is the resulting candy 'hard'? Does it break easily, or stay in its shape?
- Does the candy taste as sweet as you expected? If flavored, does it have the taste you desired?

Further, after the activity can student describe the interesting parts of their cooking process. For example, were the tools easy to clean up, or were they able to flavor the syrup like they desired.

Variations of the activity (the joys of sugar!):

Other aspects of sugar products may be of interest. For example, most sugar candies (e.g. taffy, brittle) use 'modifiers' and other ingredients in the cooking process. These ingredients serve purposes of modifying the viscosity or allowing certain reactions to occur that result in desired properties. Confectionary techniques may be quite involved, and whole industries are based on the simple material of sugar.

Reflection questions:

The following is a list of questions that might be used in a Socratic scenario:

- What aspects of the syrup or rock candy are good (vs. poor) and which are really important?
- What aspects of making the syrup or rock candy were difficult or easy, and which could be improved?
- Is there a way to speed up the process (and what are the related issues)?

Comments this activity:
The 'processing' (or cooking) of the syrup and rock candy is readily achievable during this activity. Humans generally like sugar.

- Through making syrup and rock candy, students experience processing a simple material to obtain different products. Liquid syrups can be very runny or quite viscous. And that same combination of sugar and water can be processed to make very hard candy! It is amazing how a single material can be processed to result in such extremely different products.
- It can be interesting to discuss what other types of sugar products exist, and how they may have been processed. This is a great investigation into engineering a material to meet desired properties.

Reference

Please see accompanying Power Point presentation and refer to the additional references from the following Internet sites.

- Wikihow, 'How to Make Sugar Syrup', https://www.wikihow.com/Make-Sugar-Syrup
- Wikihow, 'How to Make Rock Candy', https://www.wikihow.com/Make-Rock-Candy

Author biography

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Evaluation packet

Student Evaluation Questions (discussion or quiz):

1. Explain the difference in syrup viscosity and why different viscosities may be desired. Explain why toughness in rock candy may be desired.
2. Compare your sugar properties. Syrup may display low or high viscosity. Rock candy can be tough or brittle.
3. Describe how you tested your material for properties (e.g. stirring to determine viscosity, or crushing to determine toughness). How could you improve the testing procedure?

Course Evaluation Questions (for students):

1. Did the activity help you better understand the processing/cooking of sugar?
2. Did the instructor explain and facilitate the activity well?
3. Were you able to get your questions answered easily?
4. Did you have what you needed to make the syrup and rock candy?
5. Were you able to test your syrup and rock candy for properties?
6. Were you able to assess the quality of your sugar products?
7. What was the most interesting thing that you learned?

Instructor Evaluation Questions (for teachers):

1. At what grade level was this activity used?
2. Did the activity succeed in facilitating the outcomes of interest?
3. Did the references and content suffice for your needs?

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