Sweet rocks WIP

Keywords: dissolve, solution, sugar

Meta Description

An edible sweet science experiment! The idea is to grow your own sugar crystals by dissolving sugar in warm water and leaving it to cool.

Learning Objectives

To produce and understand the meaning of a supersaturated solution.
To determine the influence of temperature on the solubility of the liquid.
To produce crystals from a supersaturated solution.

Key Terms

Crystallisation
It is the process through which a highly organised solid is formed to result into a crystal.

Dissolve
A visible solid substance is dispersed within a liquid as the molecules interact and attract each other so as to result into a solution.

Saturated solution

The point at which no further solid can be incorporated into the liquid under normal conditions.

Solute
A substance that is dissolved in another substance.

Solution

The resulting mixture when the solute, which is the minor component, is distributed evenly throughout the solvent, which is the major component.

Solvent

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A substance that is able to dissolve the solute.

Sucrose

A type of sugar.

Supersaturated solution

A solution that is not able to dissolve further solute in the solvent. At normal conditions, the amount of dissolved solute exceeds its amount that can be dissolved.

Nucleation
The initial process where a small number of atoms or ions are arranged in a particular pattern to form a crystal.

Seed-crystals

A tiny single crystal that aids for large crystal formation of the same material.

Method

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Step 1
Boil 250 mL of water in a pan.
Step 2
Add about 300 g of sugar to the boiling water.
Step 3
Mix well with a wooden spoon until no more sugar is visible in the water.
Step 4
Continue to add more sugar (~ 300 g) whilst stirring until the sugar added is no longer dissolving in water.
Step 5
Allow the solution to cool for 10 minutes and then transfer the water into a glass cup.
Step 6
Dip the wooden stick into the water and roll it in some sugar.
Step 7
Submerge the skewer in the sugar solution and hold it by a peg. Make sure that the skewer is not touching the sides or the bottom of the cup.
Step 8
Leave this setup to cool without disturbing the solution.
Step 9
Wait a few days for the sugar crystals to start to appear.
Step 10
Once the crystals stop growing, use a butter knife to break the surface of the solution.
Step 11
Remove the crystals from the solution, hang them in an empty glass cup, and allow them to drip.
Step 12
Once this is all done, crystalline sugar is obtained.

Alternative Method

To create candy with different colours, add food colour or flavourings to the sugar solution to have a greater variety of candy.

Instead of wooden sticks, make use of a piece of string or thread. Tape the string to a pencil and place the pencil across the lid of the jar.

Precautions

Use caution when handling the warm water. Do this step with the help of an adult.

Narrative

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As one can easily observe when preparing tea, adding a tablespoon of sugar to the tea when it is cold causes only a portion of the sugar to dissolve as the rest ends up sinking to the bottom. Adding the same amount of sugar to a hot cup of tea, then the same amount of sugar dissolves in water fairly rapidly. This is due to the fact that the higher the temperature of a solvent, the greater the amount of solute that can be dissolved. However, after substantial addition of sugar to the hot tea, there comes a point where that particular volume of water is not able to dissolve any more sugar. This is referred to as a supersaturated solution.

Questions

Why is it important for the water to be heated?

Warmer water can dissolve more sugar.

Why is sugar added until no further sugar can be dissolved?

The resultant supersaturated solution is more likely to form sugar crystals.

Why is it important that the wooden stick should not touch the sides of the cup?
In order to give more space for the crystals to grow.

Why do we need to cover the stick with sugar?

To aid for the sugar to crystallise out of solution.

Does it make a difference if another solvent is used instead of water?
Yes. Different solvents have different solubilities which influence crystal formation.

Is it correct that the crystalline structure is the same for all solutes?
No, crystal structure depends on the solute

Brief Explanation

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In this experiment, the chemical used to form crystals is sugar which is made up of a repetitive arrangement of the carbohydrate molecules, referred to as sucrose. Once you mix sugar and water, the sucrose molecules separate as they are attracted to the water molecules. A solution is formed when molecules of the solvent collide with molecules of the solution, if this is done with enough energy the solute molecules will be picked up by the solvent molecules, these are they known as being a solution

The solubility of a substance depends on the physical and chemical properties of both the solute (sugar) and the solvent (water). For example the larger the solute, the more difficult it is for the solvent molecules to surround them (a low surface area to volume ratio). Polarity of both the solute and the solvent also plays a role in solubility. Keeping in mind that ‘Like dissolves Like’, polar (where a molecule has a positively charged end and a negatively charged end) solutes will dissolve in polar solvents. However, if one substance is polar and the other non polar, the solute will not dissolve.

In a set volume of solvent, only a certain amount of solute can be dissolved at a particular temperature, this is when a solution becomes saturated. Any further addition of the solid will remain at the bottom of the solution.
http://www.solubilityofthings.com/basics/factors_affecting_solubility.php

Generally, an increase in the temperature of a liquid will increase its solubility. This is because as the liquid gets hotter the greater the energy the molecules that it is made of, resulting in more high energy impacts between the solvent and solute molecules and a greater likelihood of the solute molecules being removed. The resulting solution is referred to as an unstable supersaturated solution. This simply means that there is a greater amount of solute dissolved in the solvent at this higher temperature than the solvent can actually hold at room temperature.
https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/archive-2014-2015/candymaking.html

If you allow this solution to cool, the amount of sugar that can be dissolved in the water decreases, resulting in some of the sugar molecules coming out of solution and becoming visible. As the temperature continues to drop, more of the sugar will crystallise. Eventually, these crystals will start to cluster together and will attach to the wooden stick, leaving you with some delicious rock candy.

Detailed Explanation

Sucrose has the chemical formula $C_{12}H_{22}O_{11}$, and the sugar molecules are held together by relatively weak intermolecular forces.

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Energy is required to disrupt the relatively weak intermolecular forces between sugar molecules, as well as the weak hydrogen bonds between the water molecules; both of these bonds need to be broken for a mixture to become a solution. This energy comes from random collisions between the solute and solvent molecules. Once these bonds are broken, the disassociated sugar molecules form in intermolecular bonds between the slightly polar sucrose molecules and the polar water molecules.
Upon cooling, the solubility of the water decreases, with less thermal energy, the system tries to compensate by forming chemical bonds to generate energy. Such bonds are formed by joining sucrose molecules together in an ordered and repetitive pattern, causing the sugar molecules to start to become visible as crystals. When these molecules start forming crystals around each other is referred to as nucleation. The greater the drop in temperature, the more sugar forming crystals form.
https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/archive-2014-2015/candymaking.html

Dissolved sugar molecules need to interact with other sugar molecules to start crystalising, and as this movement is random this can be unpredictable. However, the use of a seed crystals (the sugar coating on the stick), can provide a surface for the nucleation process, speeding up crystallisation. This is because, when dissolved sugar comes in contact with a pre-formed crystal, the sugar molecules has a surface to form around.

https://www.sciencebuddies.org/science-fair-projects/project-ideas/FoodSci_p005/cooking-food-science/growing-rock-candy-crystals#background

The more sugar molecules that attach together, the greater the size of the crystals. The size of the final crystals depends on the substance used. For example, sugar crystals are a different size compared tp salt crystals.
http://chemguide.co.uk/atoms/structures/ionicstruct.html

Applications and Research

Applications

A supersaturated solution leads to crystallisation and precipitation. Crystallisation is a common process that occurs in nature, however, such a process is also used in industry. Its main use is for purification, isolation, and recovery of solid materials from a solution. Another important use is for the production of crystals. Crystallisation remains one of the most cost-effective techniques for the production of salt.
https://en.wikipedia.org/wiki/Supersaturation#Application

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Research

A major drawback encountered with pharmaceuticals is the difficulty in creating drugs which are soluble in the body's fluids, but where the body needs the drugs. Pharmaceutical researchers use supersaturating drug delivery systems (SDDS), where a drug will be maintained for a longer period of time using precipitation inhibitors which stop the molecules from dissolving and to allow for more efficient oral bioavailability where the drug is needed.

The research is based on assessing methods in easing drug intestinal absorption of poorly soluble drugs. http://www.sciencedirect.com/science/article/pii/S0378517312010332
https://www.ncbi.nlm.nih.gov/pubmed/19373886
https://www.ncbi.nlm.nih.gov/pubmed/27518171

Investigation

Does this experiment work only with sugar? Try the same method but replace sugar with salt and see if you manage to get salt crystals. [It is expected that the same outcome will be achieved.]

Make a comparison by following the same procedure but in this second set do not coat the wooden sticks with sugar prior to dipping into the solution. Is there a difference between the size of the crystals obtained in the two sets prepared? [This should make it more difficult for the crystals to form and smaller crystals should be obtained.]

Carry out the experiment again but without heating the water. Observe what happens. [The lack of heating prevents the water from becoming supersaturated, therefore, no crystals are expected to form.]

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Subject

Chemistry

Education

Preschool
Primary
Secondary

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Time Required

1 day or more
Preparation: 15 mins
Conducting: 5 mins
Clean Up: 3-5 days

Cost

0 – 10 €

Recommended Age

3 – 6
6 – 9
10 – 12

Number of People

1 participant

Supervision

Required

Location

Indoors
Laboratory

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Materials

Butter knife
2 glass cups
Measuring jug
Pan
Peg
Stove-top oven or microwave
Weighing balance
Wooden spoon
Wooden stick
Sugar
Water

Contributors

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Sources

The Sweet Science of Candymaking

Rock Candy Recipe – Crystallization of Sugar – The Sci Guys: Science at Home

Hard candies – How its made

HHard Candy Chemistry!

Crystal Growing – Cool Science Experiment

Additional Content

How to Make a Supersaturated Solution
(Beginner)

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Appliance Science: The compressed chemistry of carbonation
(Intermediate)

Sugar Chemistry of Hard Candies
(Advanced)

Cite this Experiment

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