

Solid “Water”

Kitchen Table Demonstration

The Rundown

Time: 15-20 minutes

Content: Solutions, Solubility, Saturation, Super-Saturation, Enthalpy of Solution

Safety Concerns: Minimal

Materials Availability: Chemical Supplier

If you’ve ever added sugar to your iced tea, you know that if you overdo it you’ll not only get pucker-faced over the sweetness, you’ll also notice that some of the sugar crystals remain solid at the bottom of the glass no matter how much stirring you do. But if you forget about the drink for a while and give it a chance to warm up, the crystals may “disappear” – they have, in fact, dissolved into the beverage.

The concept of solubility is a simple and important one in all sorts of everyday applications. This demonstration shows the effects of temperature on solubility, and how “overdoing” it can lead to a round of “oohs” and “aaahs” from the class!



Chemistry

Solubility is a measure of the amount of solute that can dissolve in a given mass of solvent at a given temperature. Solubility is typically reported as grams of solute per 100 grams of solvent. The solubility of sodium acetate at 25 °C is 76.0 g/100g H₂O.

A **solution** is a homogenous mixture of a solute dissolved in a solvent (in the case of this demonstration, sodium acetate, NaC₂H₃O₂ is dissolved in water, H₂O).

A solution is **saturated** when a mass of solvent contains the maximum amount of solute dissolved for that temperature. For example, a 100 gram mass of water containing 76 grams of sodium acetate is a saturated solution.

A solution is **supersaturated** when it contains a greater mass of solute than the maximum amount indicated by its solubility. For example, a 100 gram mass of water containing more than 76 grams of sodium acetate is a supersaturated solution.

Crystallization is the process of molecules coming together to form a cohesive crystal structure.

A **seed crystal** is a small sample of the crystalline form of a dissolved substance that is used to promote the formation of new crystals. The surfaces of the seed crystal serve as the starting point for new crystals to cohere to and propagate.

Enthalpy of solution is the net energy consumed or released as the result of dissolving the substance in a solvent. The dissolving of sodium acetate is endothermic; therefore, its crystallization is exothermic.



Content Application

- Solubility
- Solutions
- Saturation and Supersaturation
- Seed Crystals and Crystallization
- Enthalpy of Solution



Enduring Understandings

- All solute-solvent combinations are subject to the concept of solubility, a measure of how much of the solute will dissolve in a given mass of solvent.
- Solubility is a function of temperature.
- A solution is a homogenous mixture of solute and solvent.
- Seed crystals are often used to initiate crystallization.
- The process of dissolving a solute in a given solvent requires or derives energy.



Materials

- Sodium acetate, solid crystals
- Distilled water
- Electric hot plate or equivalent (preferably one with a digital temperature control, but any type will do)
- 250 mL Erlenmeyer flask or equivalent glass container
- Parafilm or plastic wrap
- Thermometer (optional)



Safety

- Goggles – sodium acetate is an eye irritant and contact with the eyes must be avoided.
- Hot mitt – the Erlenmeyer flask (or other glass container) will be hot after heating. Use a silicone or Nomex mitt or flask tongs to handle the flask until it is safe to touch with bare skin.
- **WARNING!** Do not use a microwave oven to heat water for this demonstration. Adding dry sodium acetate to superheated water may result in explosive boiling and lead to severe burns.



Procedure

This procedure is divided into two parts – the pre-demonstration setup and the actual performance.

SETUP

1. Add approximately 100 mL of distilled water to the Erlenmeyer flask.
2. Set the flask on the hot plate and set it to about 90 °C (if you cannot control the temperature so precisely, use a thermometer to monitor the temperature and adjust the hot plate until it is stable around 90 degrees).
3. If you used a thermometer for step two, remove it from the flask the when the water is stable at the desired temperature.
4. To the heated water, slowly add 500 g of sodium acetate, stirring to ensure that it is completely dissolved.
5. Allow the supersaturated solution to cool to room temperature. Cover the top of the flask to prevent any contaminants from causing premature crystallization.

DEMONSTRATION

The demonstration portion of this procedure can be done on a variety of ways. The procedures below are three of the most common approaches. Use of an overhead projector or camera wired to a television screen is useful (but not required) to improve the students' view of the demonstration.

Approach 1

1. Place a small, dry crystal of sodium acetate on the lab bench or in a metal pan (to protect a normal table top).
2. Optionally, rest the thermometer on the lab table adjacent to the crystal with the graduations facing upward for readability.
3. **VERY SLOWLY** pour the saturated solution over the seed crystal. You will quickly begin to form a “lump” of sodium acetate crystals. Keep on pouring! The lump will get bigger as you go.
4. Point out to the students any change in the temperature as indicated by the thermometer (it's pretty dramatic!).

NOTE: You will have to reheat the solution to get your thermometer back without breaking it.

Approach 2

1. Place the thermometer, if you have one, into the solution.
2. Drop a small crystal of sodium acetate into the flask and look at it go!

NOTE: You will have to reheat the solution to get your thermometer back without breaking it.

Approach 3

1. Make enough solution to fill a clean, shallow metal pan (a pie tin works well) to a depth of about a 1 cm.
2. Place a small toy car or action figure in the liquid.
3. Sprinkle a few seed crystals over the pan and watch as the toy gets trapped!

NOTE: You may have to reheat the solution to get your toy back.



Disposal

- It is not recommended that these solutions be discarded – they can be reheated (and re-dissolved) for an indefinite number of uses.
- If it is necessary to discard the solution, supersaturated solution should be made to crystallize and all “solid” solution discarded in the trash.



Follow-Up and Student Participation

1. Ask students to brainstorm or research applications where the solubility of a substance might be important, such as in a consumer product.
2. Have students use solubility values for different common lab chemicals to determine the maximum molarity of room temperature solutions.
3. Discuss with the students the mechanics of why the crystallization of sodium acetate is exothermic.