



## The Science Behind

### Hot Ice

#### **What is the liquid that we start with?**

Hot Ice is not ice made from water. The liquid for this experiment is made by adding baking soda to vinegar and boiling the solution to concentrate it. The resulting liquid is called sodium acetate. Sodium acetate is usually found in its solid crystal-like form, but this experiment begins with its liquid form.

#### **Why does it freeze when you play with it, and then get hot?**

All liquids have a freezing point- the temperature at which they turn from a liquid into a solid. Water's freezing point is 0°C (32°F). The freezing point of sodium acetate is much higher, 58°C (136.4°F). However, by creating the liquid solution and cooling it slowly, we are able to supercool the sodium acetate- to bring it down to a temperature below its freezing point without it freezing. In a super cooled state, the liquid will not begin to crystalize and turn into a solid without being given a starting point to crystalize around. By pouring the liquid onto another surface, or by introducing a seed crystal, we are disturbing the super cooled state and providing a starting site for crystallization. Since the solution is at a much cooler temperature than its freezing point, it must heat up in order to freeze.

#### **Fun Facts!**

The solid form of sodium acetate, which looks like crystals, is used in heating pads and hand warmers, as well as in food seasonings. You've probably eaten it on 'salt and vinegar' chips!

#### **How can I do this at home?**

Ingredients: 1 liter of clear vinegar and 3 tablespoons of baking soda

Pour the liter of vinegar into a pot. Slowly add the baking soda and stir to dissolve. Boil the liquid until you see a film start to form on the surface of the liquid. If a crust begins to form on the walls of the pot, stir it back into the solution. You may want to save some of the crystals in this crust to help make your hot ice freeze later. Continue boiling the liquid until the surface film forms. You will need to boil off a considerable amount of the solution before this occurs. As soon as it forms, remove the solution from heat and carefully pour it into another clean container that can withstand the heat of the solution. Make sure this container is clean and dust-free so that your solution doesn't start crystallizing there. Stir the liquid in the container to dissolve any crust that remains. You may need to add tiny amounts of vinegar if the crust is not dissolving. Make sure to dissolve all of the crust, then cover the container with a lid and refrigerate.

To begin crystallization you can drop some crystals from the crust into your liquid. You may be able to initiate freezing just by touching the liquid or pouring it onto another surface. You can reuse hot ice by re-melting it the solids.



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### Elephant's Toothpaste

#### **What makes all of the bubbles?**

Hydrogen peroxide is made up of two hydrogen atoms and two oxygen atoms ( $H_2O_2$ ). Hydrogen peroxide molecules are very unstable and decompose on their own into water ( $H_2O$ ) and oxygen gas ( $O_2$ ). This is why hydrogen peroxide that you buy in the store has an expiration date. Adding yeast accelerates the natural decomposition, and the addition of the dish soap helps the bubbles form.

Our bodies, and the bodies of most living things, produce hydrogen peroxide as a by-product of the chemical reactions that keep us alive (our metabolism). To deal with this hydrogen peroxide, we produce an enzyme called catalase to promote the decomposition of hydrogen peroxide into harmless water and oxygen gas. Yeast is a living thing, a fungus, which produces catalase. Adding yeast to the hydrogen peroxide accelerates the decomposition of the hydrogen peroxide into water and oxygen gas. The dish soap gathers the oxygen gas into the thousands of bubbles that you see flowing from the container. In the end, you're left with soap bubbles full of pure oxygen, and water. You'll notice that the foam feels warm, because the decomposition also produces a small amount of heat. This means that this is an exothermic reaction- a reaction that produces heat.

#### **How can I do this at home?**

Ingredients:

- Half a cup of 6% hydrogen peroxide
- 1 packet of yeast
- 4 tablespoons of warm water
- Safety goggles
- Food coloring
- Dish soap
- Funnel
- Dishwashing gloves
- Empty bottle
- Plastic tray or tub

Empty the packet of yeast into a cup and add 4 tablespoons of warm water. Stir until the yeast has dissolved. Using a funnel if necessary, and we recommend wearing goggles and gloves, pour half a cup of hydrogen peroxide into the empty bottle. Add a big squirt or two of dish soap and swirl the bottle to mix the soap throughout. Add food coloring to the solution in the bottle (about 10 drops). Pour the yeast solution into the bottle. Watch as the foam forms and rises, spilling out of the bottle and giving the toothpaste effect. What you are left with are soap bubbles filled with oxygen gas, and water, which so the foam is safe to play with and can be washed down the drain.

Using half a cup of 6% hydrogen peroxide will give you about 2 liters of foam. You can create stronger reactions and more foam using higher concentrations of hydrogen peroxides. However, higher concentrations are harder to find, and are increasingly more harmful to the skin and eyes. Be sure to wear safety goggles and gloves if experimenting with higher concentrations and have an adult handle the hydrogen peroxide.