A Simple, Inexpensive Chamber for Growing Snow Crystals in the Classroom

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The creation of artificial snow crystals for scientific study usually requires patience, hard work, and fairly elaborate and expensive equipment that almost always includes a cold room. Here we describe an inexpensive and easy-to-build apparatus that can produce artificial snow crystals in the classroom. The apparatus, which can operate as both a diffusion and cloud chamber, was developed in Japan in 1996 and has been in use in schools there for several years, where it has also been reported on in scientific journals, the newspapers, and television.[1,2] The apparatus allows students and teachers to actually watch snow crystals grow. While it has been demonstrated in the United States,[3] we are not aware that it has seen much use here.

It is no surprise the apparatus was developed in Japan, since that nation has had a long history of fascination with snow crystals. The Japanese scientist Ukichiro Nakaya was the first to perform truly systematic studies on how snow crystals form. His career began in 1932 when he was appointed to a professorship at Hokkaido University. Trained as a nuclear physicist, but lacking facilities for physics at the university, he turned his attention instead to snow. He began by observing natural snowflakes and crystals, but eventually found he had to grow artificial snowflakes if he was going to understand how so many different types could form in nature. Perhaps his most endearing scientific contribution was the idea that a snowflake was a "letter from the sky," its form, shape, and texture determined by the temperature and moisture regime of the clouds and sky that it fell through. His goal was to be able to read these letters, a goal he largely achieved by the end of his life. When he published his landmark book *Snow Crystals: Natural and Artificial*[4] in 1954, he produced that rarest of things: a great work of science as well as a beautiful work of art. Today Ukichiro Nakaya is widely known and honored in Japan. He is not so well known in the United States, but he should be. Information about his work and some of his snow crystal photographs can be found at http://www.lowtem.hokudai.ac.jp/~frkw/english/ss1.html and http://www.its.caltech.edu/~atomic/snowcrystals/photos/Nakaya/nakaya.htm.

Materials
- 500-ml clear polyethylene (PET) soda bottle
- Styrofoam cooler box with a lid
- 1.5 kg dry ice
- thin fishing monofilament
- rubber cork
- eraser

Tools
- hammer (to crush dry ice)
- razor cutter (to cut hole in cooler for bottle)
- stapler (to attach line to eraser "weight")

The Apparatus

The apparatus [Figs. 1(a) and (b)] consists of 1) a chamber made from a clear plastic soda bottle, of which the bottom three-quarters is embedded in dry ice in a Styrofoam cooler, and 2) a thin vertical string or pair of strings, usually made from monofilament fishing line that runs down the middle of the bottle and on which the snow crystals nucleate and grow.

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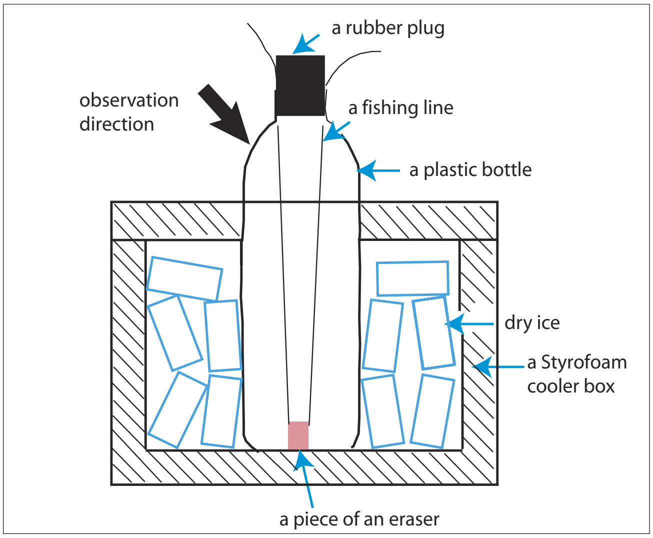

Fig. 1(a). A schematic of the snow crystal growth chamber.

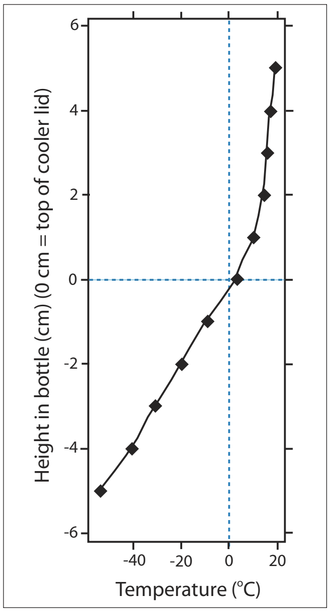

Fig. 2. Temperature profile in the snow crystal growth chamber. Temperatures range from –53° near the bottom, through the freezing point (0°C) where the bottle projects out of the lid of the cooler, to above-freezing temperatures at the top of the bottle.

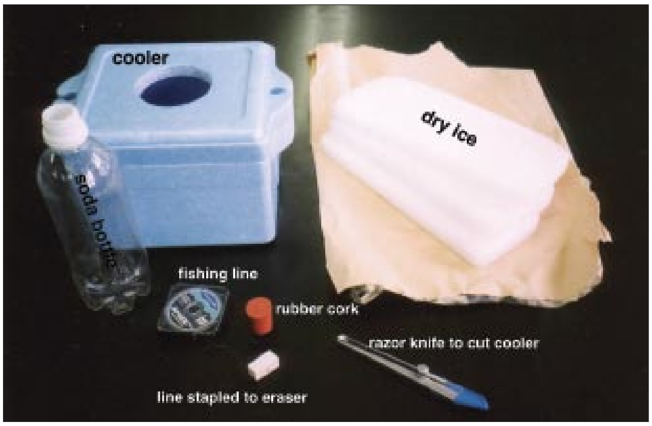

Fig. 1(b). Equipment needed to make and operate the snow crystal growth chamber.

The line needs to be as thin as possible (~0.1mm) in order to imitate natural dust and other condensation nuclei. The top of the bottle extends out from the top of the cooler and is therefore exposed to the air at room temperature. This achieves two things: 1) the upper part of the bottle remains free of frost, making it easier to see the snow crystals as they grow, and 2) a strong vertical temperature profile (Fig. 2) is created within the bottle that mimics stratospheric conditions where natural snow crystals form.

It takes about two hours to build the apparatus and run an experiment. See materials list on previous page.

Snow Crystal Experiment

In nature, snowflakes grow from water vapor molecules, initially nucleating around tiny fragments of ice, dust, or other foreign material. Three things are required: below-freezing temperatures, an environment supersaturated with water vapor, and a nucleus. In the snow crystal growth chamber, the fishing line is the nucleus, the supersaturation is achieved by blowing into the bottle, and the below-freezing temperatures are created by the dry ice surrounding the base of the bottle.

The experiment proceeds like this. First, the student or teacher pours a little warm water into the bottle, seals it and shakes it, then pours out the water. Next, he or she breathes into the bottle seven to 10 times to ensure it is filled with warm, moist air. Then the weighted string is dropped into the bottle, which is sealed with the cork in a way that catches the fishing line and holds it in place. Adjust the line so it is taut. The bottle is then inserted into the cooler and embedded in the dry ice. It is critical that enough dry ice be used (at least 1.5 kg), and that the ice ends up tightly packed against the bottle when it is in place. Visual observations are made through the top of the bottle, so it is best if this is smooth and clear. Small needle crystals grow in about five minutes. This is followed by the growth of larger, dendritic crystals after about 45 minutes [Fig. 3(a)]. These form several centimeters below the level of the cooler lid and are rarely symmetrical but often grow to a diameter of 1 cm or more [Fig. 3(b)]. The temperature in the bottle a few centi-

Fig. 3(a). Left, a dendritic snow crystal grown on the fishing line in the bottle.

Fig. 3(b). Below, two dendritic snow crystals, each about 1 cm in diameter, on the monofilament line in the bottle.

meters below the level of the cooler lid is -15°C (Fig. 2), about optimum for the growth of dendritic snow crystals.

Diamond Dust Experiment

Diamond dust, tiny airborne ice crystals that sparkle in the sun, is common in the Arctic and Antarctic where it gives rise to halos, sun dogs, and other beautiful atmospheric optical phenomena (see http://www.sundog.clara.co.uk/halo/halosim.htm). The dust can be formed in the chamber in the following manner. Cut off the top of a PET bottle so that it is level with the top of the Styrofoam cooler. Take a piece of black construction paper and roll it so it fits into the bottle. Blow into the bottle several times to provide moisture. Then shine a flashlight into the bottle. The diamond dust, floating in the air, will glitter in the light. A similar experiment was described in 1949 by V.J. Schaefer,[5] father of cloud-seeding for making rain. These tiny ice crystals nucleate spontaneously at low temperatures,[6] but in the chamber the process can be aided by popping some bubble foam near the bottle to produce an adiabatic expansion.

Conclusions

While textbooks can teach students how snow crystals are formed, creating snow crystals in the classroom is far more exciting and graphic. We have seen that even students who have become accustomed to the fast pace of computer games and DVD movies are fascinated when they can actually watch a natural and beautiful process like the formation of a snowflake take place before their eyes.

References

1. K. Hiramatsu, "Making snow crystals in the cozy living room," *Hokkaido Shinbun Daily Newspaper* (Japanese, Nov. 18, 1996).
2. K. Hiramatsu, "Making snow crystals in the PET bottle," *Kodomo–No- Kagaku* **61** (Japanese, Aug. 1, 1998).
3. S. Ryen, "Visiting scientists get frosty with kids," *The Davis (Calif.) Enterprise* **102** (107), 1 (May 6, 1998).
4. U. Nakaya, *Snow Crystals: Natural and Artificial* (Harvard Univ. Press, Cambridge, MA, 1954).
5. V.J. Schaefer, "The formation of ice crystals in the laboratory and the atmosphere," *Chem. Rev.* **44**(2), 291–320 (1949).
6. J. Hallett and B.J. Mason, "The influence of temperature and supersaturation on the habit of ice crystals grown from the vapour," *Proc. Roy. Soc.* **247**, 440–453 (1958).

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