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An Inexpensive Replacement for Dry Ice in the Laboratory

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Abstract

A reusable, inexpensive replacement for dry ice in laboratory use is presented. Commercially available, small pellets of stone or metal can be stored in a -80°C freezer and used for quickly freezing small samples with a freeing rate that is actually somewhat faster than with dry ice itself. Following use, the material is returned to the freezer to re-chill until the next useage.

Dry ice is often useful in the laboratory for rapidly and reproducibly freezing small samples, destined for longer term storage in a -80°C freezer or in liquid nitrogen, as well as for other uses. In order to have regular access to dry ice, it is necessary to have regular deliveries and onsite storage. This means obtaining and dedicating space for a storage chest. It often also means that a significant quantity of the dry ice delivered is simply waiting to be used, and frequently sublimates away before it actually does get used. Hence this can be wasteful in terms of space and money. But dry ice is sufficiently useful that many labs accept the cost.

However for some laboratories, the infrequency of usage means that the cost in money and space of obtaining and storing dry ice is hard to justify. An alternative could be very useful. Since we were in this situation, we sought another way to obtain the same reliable freezing that we had obtained with dry ice (previously obtained from colleagues in another building). It is this alternative that we describe here.

Our main use for dry ice in the laboratory is to quickly freeze samples for storage at -80°C or in liquid nitrogen. Since sublimating dry ice has a temperature of -78.5°C , it occurred to us that our -80°C freezer provided an alternative and reliable environment of this temperature. We tested several substances that can be cooled and stored in the -80°C freezer and used as substitutes for dry ice. We found two suitable materials. Both are quasi-spherical pellets of 5-8 mm diameter, similar in size to the dry ice we use. Material A consists of metallic beads, marketed as Bath Armor (e.g. Fisher Scientific # 10-876-001, (0.75 L \$100-120) or many other suppliers) and intended as a replacement for water in

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References

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heated water baths. Material B consists of aquarium pebble gravel (e.g. Petco #142892, (5lb \$3.20), or many other suppliers, available in multiple colors).

In order to compare the suitability of the materials, we measured the rate at which an aqueous sample in a microcentrifuge tube cooled when plunged into a container of dry ice, or materials (A) or (B) precooled to -80°C . The rate of cooling / freezing afforded by the three materials was very similar, although materials (A) and (B) consistently gave slightly faster cooling than did dry ice.

In each case, as with dry ice, we placed the material to be tested in a small Styrofoam shipping box, $10 \times 7 \times 7$ cm (see Figure 1). A 4 ml sample of 50% ethanol / water was pushed into the pre-cooled material up to the lip of the tube. A digital metal thermoprobe (VWR 77776-730 probe thermometer) was positioned into the center of the tube using a positioning hole in the cap of the tube. The temperature of the alcohol/water solution was recorded as a function of time. Alcohol/water was used in order to allow the temperature to smoothly pass through 0°C . The results are shown in Figure 2. Materials A and B were consistently very similar to each other, and allowed cooling that was actually somewhat faster than that observed with dry ice. We assume that the slower cooling with dry ice is due to the layer of sublimed CO_2 that surrounds each pellet of dry ice, but not the other two materials.

After use, the styrofoam container was simply returned to the -80°C freezer and left until required again. A difference between Materials A and B was observed during storage at -80°C in between uses. While the beads of Material A remained separate and 'granular', the pellets of Material B tended to clump together somewhat, requiring a step to break them apart before using again. This step required only a few pick strokes with a screwdriver or equivalent (large spatula, ice pick, etc).

A couple of other observations about these materials may be useful. We tested a number of other materials of differing composition and differing granule size (e.g. glass beads of different diameters). We found that materials with granule size much larger than the 5-8 mm reported here did not cool tubes as well as these materials, presumably due to reduced surface contact with the sample tubes. On the other hand, materials with much smaller granule size (e.g. sand), which had even greater contact surface, tended to stick to the tubes when they were lifted out, requiring a cleaning step.

The other observation relates to the processes by which these materials warm up. Starting at -80°C , materials A and B will simply slowly warm up but lose no mass. Dry ice, on the other hand, will remain at -80°C but sublime away until nothing is left. So a container of dry ice will remain a source of -80°C until it is gone, while materials A and B will warm up. We have found that this is not a problem if the material is left in the -80°C freezer until shortly before use, and if the box (such as shown in Figure 1) is kept closed with its Styrofoam lid until use. Because dry ice undergoes a phase transition upon warming and therefore holds -80°C longer, it is much more suitable for shipping.

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Figure 1. Small styrofoam box for freezing

The small styrofoam insulated box that we use routinely, and which was used in the experiment shown in Figure 2, is shown with a 6 inch / 15 cm ruler and a 15 ml conical tube for scale. The material in the box is Material A, the metal beads.

- ◆ Beads = Material A
- ▲ Rocks = Material B
- Dry Ice

Figure 2. Cooling rate of sample in dry ice, beads, or rocks

The rate of temperature decrease is shown for a 4 ml sample of 1:1 water : ethanol. The results shown are typical of multiple repeats performed for each material. Filled circles (●) are dry ice. Filled diamonds (◆) are metallic beads. Filled triangles (▲) are rocks.