Simple cloud chambers using a freezing mixture of ice and cooking salt

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Simple cloud chambers using a freezing mixture of ice and cooking salt

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Abstract
We have developed much simpler cloud chambers that use only ice and cooking salt instead of the dry ice or ice gel pack needed for the cloud chambers produced in our previous work. The observed alpha-ray particle tracks are as clear as those observed using our previous cloud chambers. The tracks can be observed continuously for about 20 min, and the preparation and operation are simple.

1. Introduction

Cloud chambers are useful tools for visualizing ionizing radiations such as alpha-ray particles, and are often used in junior/senior high-school science in Japan [1, 2]. However, it is not easy for teachers to arrange and conduct cloud chamber experiments using dry ice because it cannot be kept for many days at school, and therefore must be prepared shortly before the experiment. In order to improve this situation, we have developed a diffusion cloud chamber that uses an ice gel pack instead of dry ice [3]. Although our cloud chamber was good enough for educational purposes, preparing the cold plate using coolant taken from the ice gel pack is rather complicated.

On the other hand, the temperature of ice mixed with salt (sodium chloride) can reach as low as −21 °C, which is lower than the temperature of the ice gel pack used in our previous work. This means that it is possible to make a simpler cloud chamber by using a mixture of ice and salt. In this paper, we will explain how to build a cloud

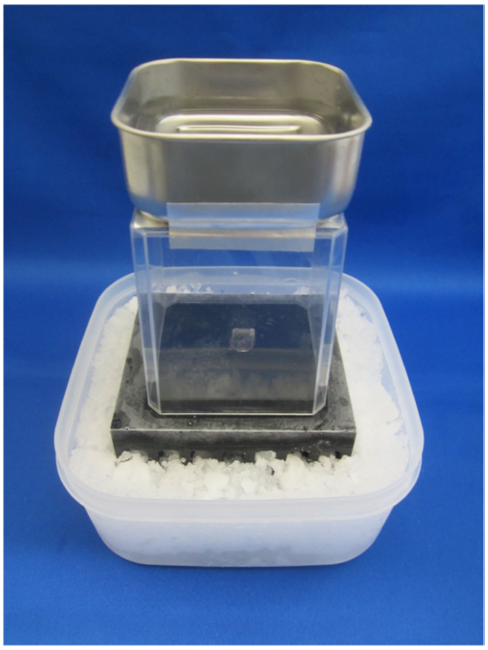

Figure 1. The external appearance of the cloud chamber.

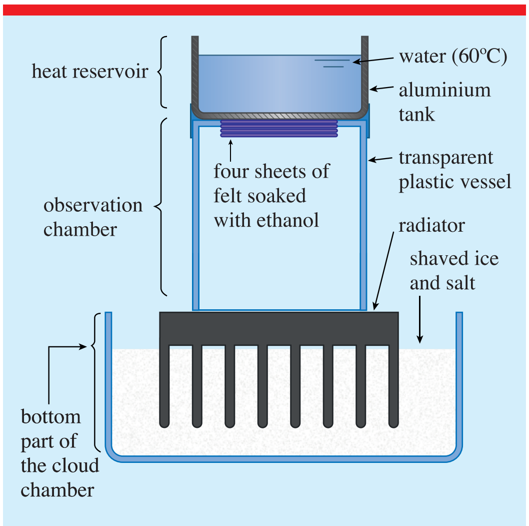

Figure 2. The structure of the cloud chamber.

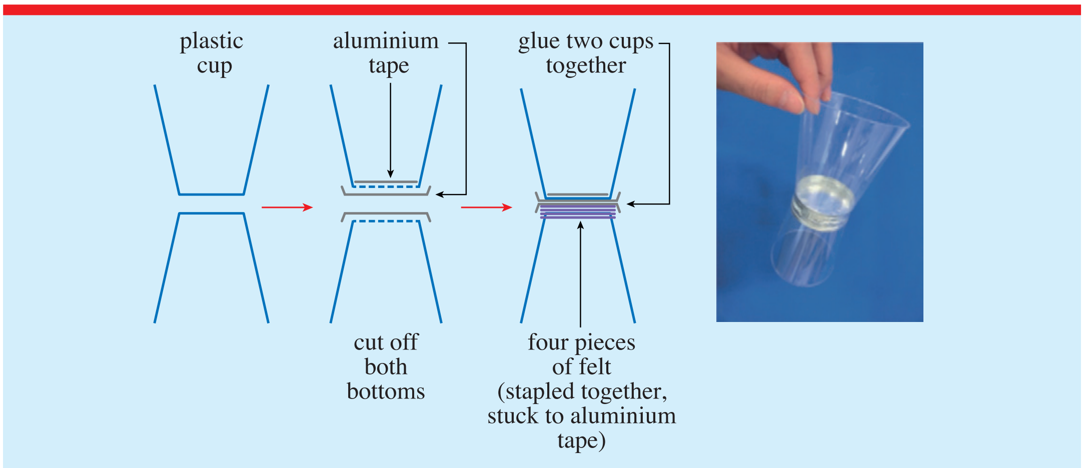

Figure 3. The observation chamber used in our previous work [2].

chamber using a freezing mixture of ice and salt, and show some of the cloud-like tracks observed with this cloud chamber.

2. Structure of the cloud chamber

The external appearance of the cloud chamber and its structure are presented in figures 1 and 2, respectively. The cloud chamber is composed of an upper part (a transparent observation chamber with a hot-water tank) and a bottom part (a finned radiator and a freezing mixture).

The hot-water tank is an aluminium tank with a capacity of 200 mL, and the observation chamber is a plastic vessel (80 × 80 × 95 mm) whose

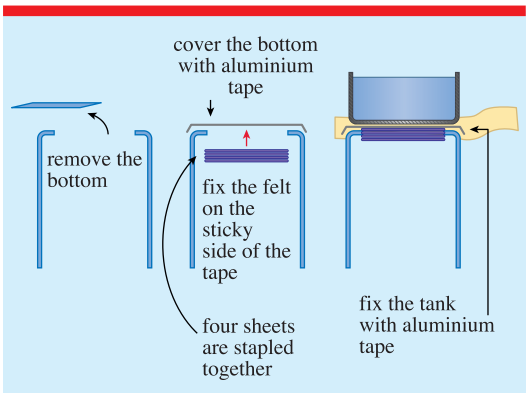

Figure 4. How to assemble the upper part of the chamber.

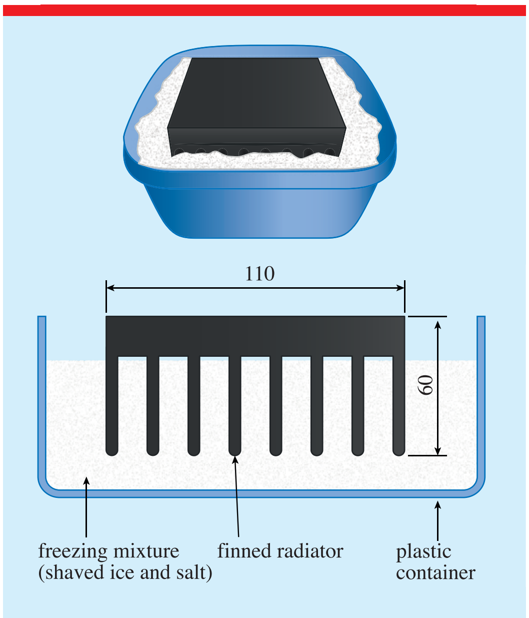

Figure 5. The bottom part of the cloud chamber.

bottom is removed so that four sheets of felt stapled together are in contact with the bottom of the aluminium tank. Since this chamber has a larger volume than the chamber made of plastic cups in our previous work (figure 3), more tracks can be easily observed.

The bottom of the cloud chamber is an aluminium radiator (110 × 100 × 60 mm) with eight fins, which are larger than the fins used in our previous work. The radiator fins are inserted into a freezing mixture of shaved ice and sodium chloride packed into a plastic container.

Figure 6. The observed alpha-ray tracks (source: the mantle of a camping gas lantern).

3. How to prepare and use the cloud chamber

(a) Remove the bottom of the plastic vessel and cover the removed area with aluminium tape. Next, cut the four sheets of felt to the same shape as the removed bottom, staple them together, and fix them to the sticky side of the aluminium tape. Then fix the aluminium tank onto the plastic vessel with aluminium tape as shown in figure 4.

(b) Prepare 700 g of shaved ice and mix it with 300 g of sodium chloride. Then put the mixture into the plastic container and insert the radiator fins into the mixture, as shown in figure 5.

(c) Wet the felt with 10 mL of ethanol heated to 50 °C and put 100 mL of hot water in the upper tank that is fixed on the top of the chamber. The hot water should be about 60 °C. This will help the ethanol soaked in the felt to continue to vaporize.

(d) Shine a light on the bottom of the chamber at a low angle, and look at the bottom of the chamber. The tracks are more visible when the room is dark.

At first, a light ethanol mist can be seen falling near the bottom, like rain. After about 1–2 min, white linear tracks will appear, as shown in figure 6. When a PVC rod that is electrically charged or

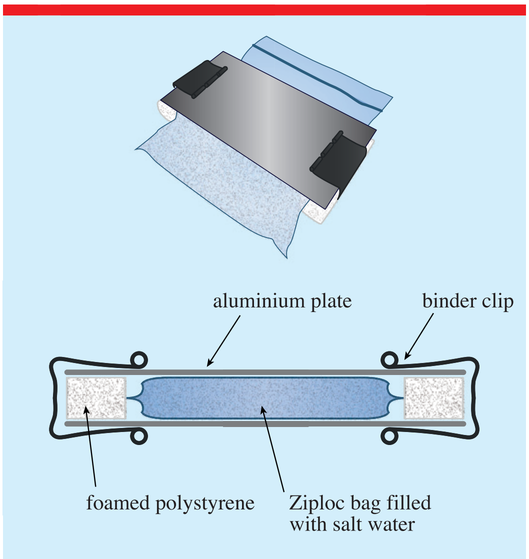

Figure 7. The cold plate produced using a Ziploc bag.

rubbed with paper is held close to the chamber, extra ions that can disturb the appearance of the tracks are removed and the tracks become clearer.

4. Simpler type using ice/salt sealed in a Ziplock bag

The temperature of a domestic freezer is usually set between −18 and −20 °C. However, the temperature of modern freezers can reach lower than −21 °C when the controller is set to a high level. If you put a cup of water saturated with sodium chloride in your freezer and find it frozen in one night, the freezing power of your freezer is sufficient to carry out the following experiment.

First, dissolve 200 g of sodium chloride in 400 mL of water to make the saturated salt water. Then pour the saturated salt water into a Ziploc bag (196 × 177 mm) and zip it up after expelling the air. Sandwich the Ziploc bag and the two spacers (foamed polystyrene) between two aluminium sheets with black surfaces, as shown in figure 7, and fix them with two large binder clips. This forms a plate. After removing the handles of the clips, store the Ziploc bag in the freezer until the salt water in it has completely frozen.

When removed from the freezer, the plate can be used as a substitute for the cold plate reported in our previous work. When you place the observing chamber mentioned above (or the previous type made of plastic cups) on this plate, as shown in figure 8, a clear image of alpha tracks, which is almost the same as that shown in figure 6, can be observed.

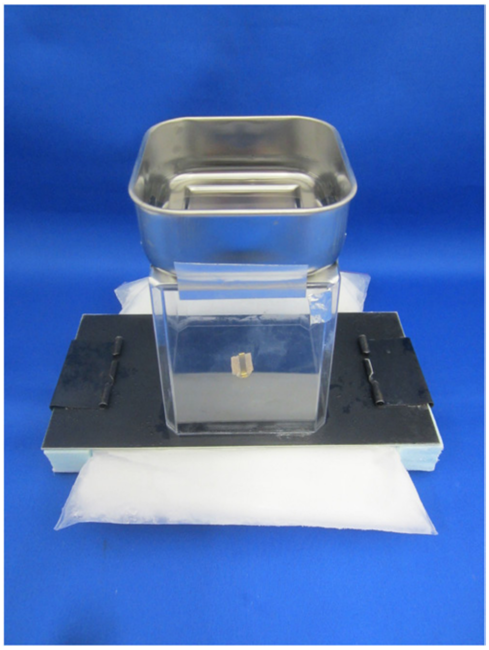

Figure 8. The cloud chamber produced using a cold plate with a frozen Ziploc bag.

5. Conclusion

The two types of cloud chamber presented in this paper are easy and inexpensive enough to be used in school science. When shaved ice (or snow) is available, the first type of chamber may be more useful because it eliminates the need for a powerful freezer. On the other hand, if a powerful freezer is available, the second type may be more convenient because you can use the same cold plate repeatedly. In both cases, cloud-like tracks can be observed for about 20 min at room temperature.

It should be noted here that all the chemicals used in this work are harmless and special treatment is not needed when you dispose of them.

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