Another Method for Determining the Pressure inside an Intact Carbonated Beverage Can (or Bottle)

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Methods for quantitative determination of CO_2 inside carbonated beverages have been discussed in this *Journal (1, 2)*. Glasser describes an interesting method for determining P_{CO_2} in a soda pop can without even opening the can. Following Glasser, we have spent some time devising and testing a method for estimating P_{CO_2} inside unopened carbonated drinks using a combination of Henry's law and freezing point depression measurements.

The molality of CO_2 in carbonated water is given by the freezing point depression equation,[1]

$$\Delta T_{fp} \equiv T_c - T_w = k_{fp} m \tag{1}$$

where ΔT_{fp} is the difference in freezing point between pure (T_w) and carbonated (T_c) water, k_{fp} is the freezing point depression constant for water (-1.86 °C kg mol^{-1}) and m is the molality of CO_2 in the carbonated drink. The high concentration of CO_2 in carbonated drinks is maintained by high P_{CO_2} as described by Henry's law:

$$m = k_H P_{CO_2} \tag{2}$$

where k_H is Henry's law constant at the freezing temperature of the carbonated drink (0.0726 kg mol^{-1} bar $^{-1}$ at 273 K *(3, 4)*). Substitution of eq 2 into eq 1 yields

$$P_{CO_2} = \frac{\Delta T_{fp}}{k_H k_{fp}} \tag{3}$$

Thus, by simply measuring ΔT_{fp}, one may estimate P_{CO_2} in the carbonated water.

To estimate ΔT_{fp}, we used black electric tape to attach MicroLab thermistor sensors to the outside of unopened cans of LaCroix brand sparkling water[2] and to opened beverage cans that were rinsed and filled with deionized water. The containers were placed in a freezer at -15 °C. The temperature of each fluid was measured over time (Figure 1). Upon freezing, the supercooled liquids warmed and leveled off at their freezing temperatures. ΔT_{fp} was found from T_c and T_w. Results of several measurements yielded 2.0 ± 0.9 bar, consistent with cited values *(5)*. We have also estimated the pressure inside plastic bottles of sparkling water (4.0 ± 2.7 bar) and unopened cans of various diet carbonated beverages (2.0 ± 1.0 bar). The former is fairly consistent with values previously reported *(6)*, whereas the latter indicates that additives in diet carbonated drinks (other than CO_2) contribute negligibly to the overall solute molality.

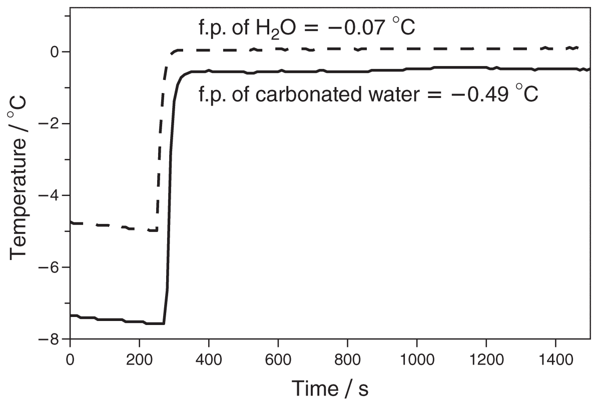

Figure 1. One set of student data for an unopened can of LaCroix sparkling water and an opened soda can containing deionized water that had been placed in a freezer at -15 °C. The initial temperature data are not shown.

Notes

1. Assumes all dissolved CO_2 is CO_2(aq); a good approximation at the low pH in soft drinks *(6)*. We also assume ideal gas conditions.
2. The ingredients of LaCroix brand sparkling water are essentially carbon dioxide and water *(7)*.

Literature Cited

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