

13.2 Boiling Point Elevation – Maple Syrup

Subjects: Solutions, Boiling point elevation, colligative properties

Description: Demonstrate that maple syrup has a higher boiling point than water. As maple syrup continues to boil, the solution becomes more and more concentrated as water is lost. The increasing concentration of sugar in the water increases the boiling point of the solution.

Materials:

100g grade A maple syrup[Ⓞ] (or 67% w/w sugar solution)

400 ml beaker

Stir bar

Hot plate*

Thermometer

*Shared item: located in the top drawer of the center bench opposite the chemical storage shelves.

[Ⓞ]Provided by instructor

Procedure:

1. Heat the syrup in the beaker until boiling. Record the temperature.
2. Continue to stir and boil syrup.
3. Measure the temperature again over time. The temperature will increase as the water evaporates.

Discussion:

Maple sap has approximately 2% sugar. To produce maple syrup, the sap is boiled until enough water has evaporated to produce a syrup with approximately 67% sugar content with a boiling point of 219 degrees Fahrenheit (103.8° C)^{1,2}.

Maple sap contains other solutes besides sugar, but assuming these concentrations are negligible, we can calculate the boiling point elevation of maple syrup compared with water.

$$\text{Elevation in boiling point} = \Delta T_{\text{bp}} = K_{\text{bp}} * m_{\text{solute}}$$

Maple sugar is primarily sucrose (C₁₂H₂₂O₁₁) with a molecular weight of 342.30g/mol.

Assume we have 100 grams of Grade A light maple syrup containing 67% sugar. The solution is composed of 67 grams sucrose and 33 grams water. The K_{bp} for water is 0.5121°C /m.

$$\text{Moles of sucrose} = 67\text{g} (1 \text{ mol} / 342.30 \text{ g}) = 0.1957 \text{ mol sucrose}$$

Molality (c_{sucrose}) = $0.1957 \text{ mol}/0.033\text{kg water} = 5.93 \text{ m}$

Elevation of BP = $K_{\text{bp}} * m_{\text{sucrose}} = (0.5121 \text{ }^\circ\text{C /m})(5.93\text{m}) = 3.03 \text{ }^\circ\text{C}$

Boiling point of maple syrup is $100.0 + 3.03 = 103.03^\circ\text{C}$

The boiling point stated above (taken from the producer's websites) is 0.77°C higher than what we calculated. Ask the students to answer this question. Is this because, in reality, syrup also contains a small amount of other solutes that contribute to the increase in boiling point?

After boiling for some time we lose approximately 5 grams of water. There are still 67 grams of sucrose in the solution. What is the boiling point now?

Molality (c_{sucrose}) = $0.19 \text{ mol}/ 0.028 \text{ kg water} = 6.99 \text{ m}$

Elevation of BP = $K_{\text{bp}} * m_{\text{sucrose}} = (0.5121 \text{ }^\circ\text{C /m})(6.99\text{m}) = 3.57^\circ\text{C}$

Boiling point of maple syrup is $100.0 + 3.57 = 103.57^\circ\text{C}$

What is the percentage of maple sugar in the syrup now?

$$67\text{g} / 67\text{g} + 28\text{g} * 100 = 70\%$$

Safety: Use caution working with boiling materials to avoid burns.

Disposal: Syrup can be washed down the drain

References:

1. J. Kotz, P. Treichel, J. Townsend; *Chemistry & Chemical Reactivity* 7th ed. Instructors Edition; Brooks/Cole; 2009
2. Vermont Maple Syrup website:
<http://vermontmaple.org/make-maple-syrup.php>
3. Massachusetts Maple Producers Association website:
<http://www.massmaple.org/how.php>