

INVESTIGATION OF THE COLLIGATIVE PROPERTIES OF FATTY ACIDS

INTRODUCTION

FATTY ACIDS

Fatty acids play a relevant role in our daily life. Fatty acids are long chain hydrocarbons with a terminal carboxyl (COOH) group. Organic compounds with the COOH group are called carboxylic acids (Figure 1(a)). Fatty acids are not manufactured by the body and therefore must be included in the diet. They are required to ensure cell membrane formation, hormone synthesis and vitamin absorption among other things. It is now widely accepted that omega-3 fatty acids are essential to heart health (Figure 1 (b)). Some common natural fatty acids include, butter and lard. Have you ever noticed that if butter is left too long at too high a temperature it becomes rancid? This happens because the fatty acid (butter) has undergone auto-oxidation. Vitamins A and E are absorbed in the body using fatty acids. Fatty acids are also useful in various industrial processes, including soap manufacture. You will learn more about the reactions of fatty acids in organic chemistry.

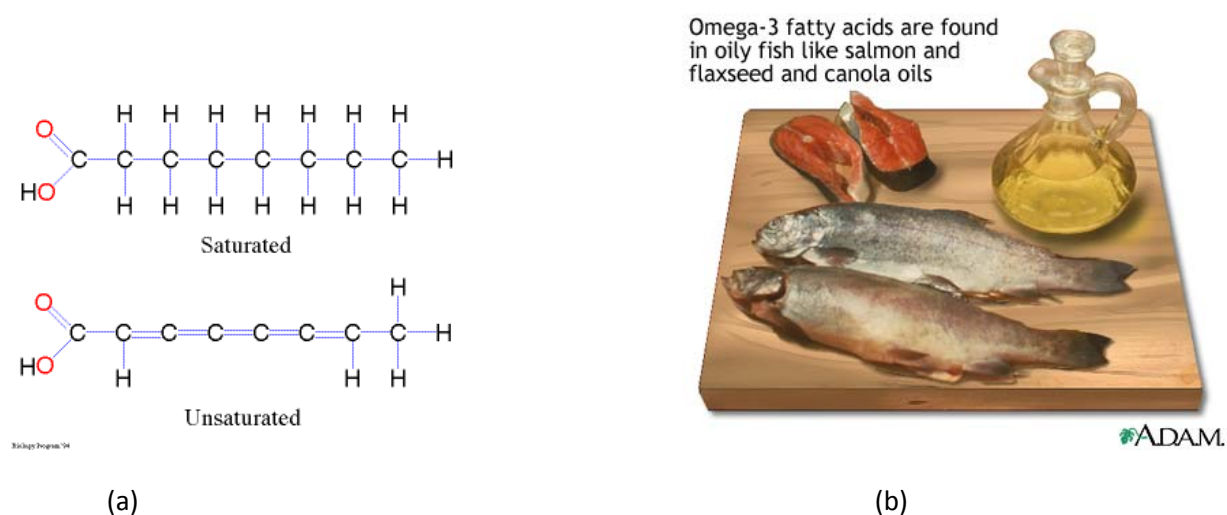


Figure 1 (a) Molecular structure of fatty acid (b) Some sources of omega-3 fatty acids

COLLIGATIVE PROPERTIES

Colligative properties are those properties of solutions which are not affected by the nature of the solute present in the solution, but only by the amount of the solute that is present. More specifically, colligative properties change with the number of particles present in solution. The four colligative

properties presented in this course are vapor pressure lowering, boiling point elevation, freezing point depression and osmotic pressure.

Since colligative properties do not depend on the nature of the solute, they may be used to determine the molecular weight of a substance. In this experiment you will determine the molecular mass of an unidentified fatty acid and use this value to identify the fatty acid. You will do this by measuring the freezing point of stearic acid before and after the addition of different amounts of the unidentified fatty acid. The difference between the freezing points of pure stearic acid and the mixture (stearic acid containing unidentified fatty acid) is the freezing point depression, ΔT_f . Given that the freezing point depression constant (K_f) for stearic acid is $4.5\text{ }^\circ\text{C}/\text{kg}/\text{mole}$ and the following equation:

$$\Delta T_f = K_f m, \text{ where } m = \text{molality of solvent}$$

you will be able to determine the number of moles of solute (unidentified fatty acid) present in the solution. The molecular weight of the unidentified fatty acid can then be calculated.

REFERENCES:

McCarthy, S. and Gordon-Whyllie, S. *A greener approach for measuring colligative properties* Journal of Chemical Education **2005** Vol (82) Iss. 1 pp.116.

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EXPERIMENTAL

Apparatus:

1 18 x 150 mm test tube

1 25 x 150 mm test tube

Paper towels

Thermometer

Clamp stand and clamps

Hot plate or Bunsen burner

Procedure:

- 1) Determine the mass of the 18 x 150 mm test tube (it may be necessary to place the test tube in a beaker to prevent rolling-if you do this please don't forget to account for the mass of the beaker!).
- (2) For the taking of temperature measurements an insulating jacket will be used. The insulating jacket will be prepared by wrapping a piece of paper towel around the 18 x 150 mm test tube, A, and fitting it in a 25 x 150 mm test tube, B. (Figure 3). The insulating jacket prevents premature cooling due to contact with the skin or other surfaces.

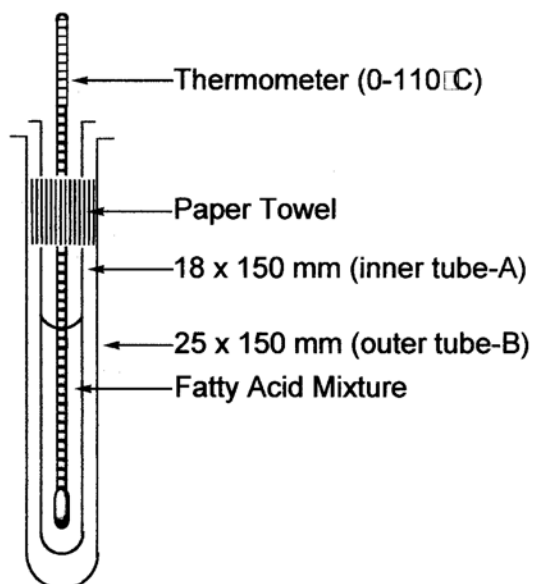


Figure 3. Apparatus Arrangement for insulating jacket.

- (3) Place 9 grams of stearic acid in test tube A (the smaller test tube). Determine the exact mass of stearic acid added by difference.
- (4) Prepare a hot water bath by filling a 600 ml beaker 3/4 full with tap water and heating with either a Bunsen burner or a hot plate.
- (5) Melt the stearic acid by immersing the test tube (A) containing the fatty acid sample in the hot water. (A clamp would be helpful for this step).
- (6) After the stearic acid has completely melted, place the thermometer in test tube A and heat until the sample reaches 85 °C. The thermometer should remain in this test tube for the remainder of the experiment. Remove the test tube from the water and dry the outside.
- (7) Place the test tube A containing the stearic acid in the insulating jacket (wrap test tube A with paper towel and place it in test tube B). Stirring constantly with the thermometer, record the temperature of the stearic acid sample every 30 seconds for about 8-10 minutes. Temperatures are collected until the temperature of the sample remains constant, changing by less than 0.2 °C per reading, for 3 minutes, (6 readings). **Perform a second trial using the same sample to determine the freezing point of the stearic acid (how will you do this?)**
- (8) To the *same* stearic acid sample above, add approximately 1 g of an unidentified fatty acid sample which will be provided by your instructor.

NOTE: Considering that you will need to determine the molecular mass of this unidentified fatty acid, decide whether you need to know the exact mass of the unidentified fatty acid sample that is added.

- (9) Repeat steps 5 through 7.
- (10) To the *same* stearic acid mixture you just measured, add an *additional* 1 g of the same unidentified fatty acid as in step 8.
- (11) Repeat steps 5 through 7 again.

DATA TREATMENT AND CALCULATIONS

In order to determine the value of ΔT_f you will need to determine the freezing point of the pure stearic acid and the stearic acid solutions. In order to do this accurately, you will plot a graph of temperature (y-axis) versus time (x-axis). You will tabulate and graph two sets of data for each experiment, one in which the temperature changes by more than 0.5 °C in a 30 second period and another in which the temperature changes by less than 0.5 °C in a 30 second period . The temperature at the point of intersection of the two lines is the freezing point of the solution. (Figure 4)

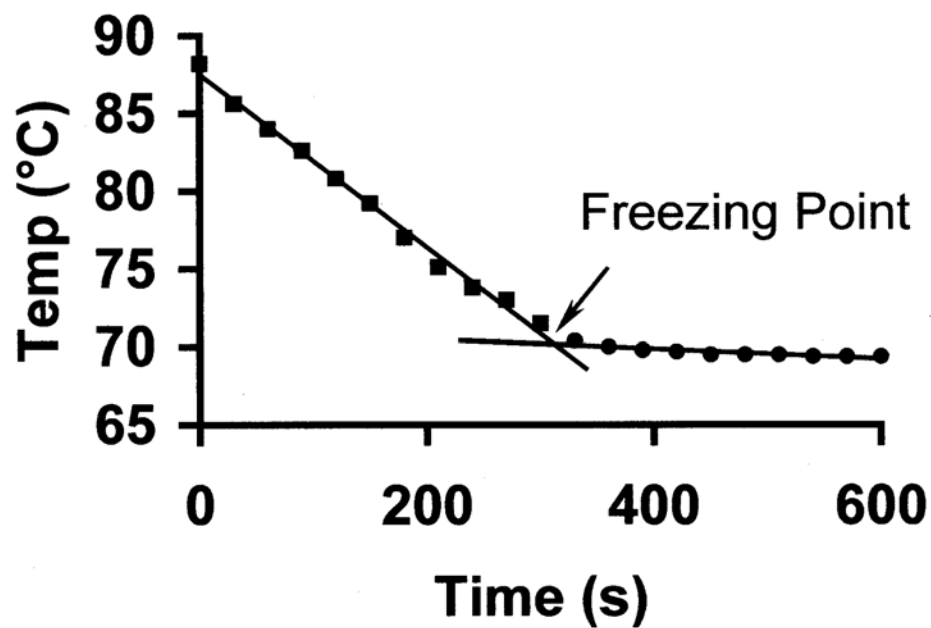


Figure 4. Example of graph used to determine freezing point of stearic acid (stearic acid mixture).

Determine the molecular mass of the unknown fatty acid using the data you have collected and Report an average value.

Given that the possible unknown fatty acids are:

palmitic acid ($\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$)

lauric acid ($\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$)

myristic acid $\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$

Identify your unknown based on the molecular weight you have calculated.