Water Salinity And Specific Heat Capacity

Name

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Water Salinity And Specific Heat Capacity Of Water

Research question

How does salt concentration in water affect the specific heat capacity of the solution?

Introduction

The knowledge behind specific heat capacity has been applied in various food industries, such as the ice cream-making and baking. In ice cream making, salt is often added as it helps to lower the freezing temperature of the water and thus faster freezing. Adding salt reduces the specific heat capacity and thus increases its freezing point. Salt is also added in the baking and bringing industry to lower the specific heat capacity of the solution. Through this discovery, I decided to conduct a scientific investigation to determine how salt concentration affects the specific heat capacity of a given solution.

Background Information

Specific heat capacity, otherwise known as specific heat (SH), is a physical property that normally quantifies the total amount of energy required to increase the temperature of a given body by a unit mass (Adun et al., 2021). Specific heat capacity is defined as the total amount of heat energy (Q) required to raise the temperature (ΔT) of a given body with unit mass (m) by one degree Celsius. Mathematically, specific heat capacity is given as shown by the formula below;

$$c = \frac{Q}{m \, \Delta \, t}$$

Where;

C=specific heat capacitance

Q= energy supplied

M=mass of the salt solution

Δt= change in temperature

The specific heat capacity changes from one substance to the other. The specific heat capacity of pure water is 4184J/g (AreeJ, 2022). Various factors affect the specific heat capacity of water. Some factors that affect water's specific heat capacity include salinity and temperature. The presence of a dissolved substance in water (salinity) affects the specific heat capacity of water. Increasing the salinity of water will reduce the specific heat capacity of water. The dissolved salt in the water does affect the hydrogen bonding between water molecules and thus reducing the ability of water to store heat energy (Hutchinson, 2019).

Increasing the amount of salt in the water will thus reduce the ability of water to store heat energy and thus reduce the specific heat capacity of water. The objective of this investigation is to investigate how salt concentration affects the specific heat capacity of water. In this exploration, varying salt solutions will be used (0.00%, 10.0%, 20.0%, 30.0%, and 50.0%).

Hypothesis

As the amount of salt in water increases, the hydrogen bonds between water molecules will be affected, and as a result, the ability of water to store heat energy will reduce. As a result, increasing salt concentration will reduce the specific heat capacity of water. In this exploration, therefore, I predict that as the concentration of salt in the solution increases, the specific heat capacitance of the solution reduces, and thus there is a negative relationship between salinity and specific heat capacitance. In this exploration, it is also predicted that a graph of salt concentration against specific heat capacitance will have a negative gradient confirming a negative link between the variables.

Aim

The main objective of this exploration is to investigate how salt concentration in water affects the heat capacity of the solution. In this exploration, various concentrations of salt will be used ((0.00%, 10.0%, 20.0%, 30.0%, and 50.0%). The temperature change of the solution will be recorded, and thus the specific heat capacity of the solution will be computed using the following formula;

$$c = \frac{Q}{m \Delta t}$$

Variables

Dependent

The salt concentration in the water will be used as a dependent variable in this exploration. Varying concentrations of salt (0.00%, 10.0%, 20.0%, 30.0%, and 50.0%) will be used in this investigation.

Independent variable

The specific heat capacitance of different salt solutions will be used as an independent variable in this exploration. The fooling equation will be used to compute the specific heat capacitance of the solution;

$$c = \frac{Q}{m \Delta t}$$

Where;

C=specific heat capacitance

Q= energy supplied

M=mass of the salt solution

Δt= change in temperature

Control variable

The table below summarises some of the variables which will be controlled in this experiment;

Table 1: Control variable table

Control variable	**how the variable will affect the variable**	**How the variable will be manipulated**
Initial temperature	The initial temperature of a solution will impact the specific heat capacitance, and thus there is a need to control the initial temperature of the solution.	-To have accurate data, the initial temperature will be kept constant as the experiment will be conducted in the same room.

Time	The time used to heat a given solution will impact the specific heat capacity of the solution. As the time (s) increase, the total specific heat capacity of the solution also increases.	In this exploration, the time for the experiment will be kept constant (5 minutes) as this will increase the accuracy and consistency of data.
Energy supplied	The amount of heat energy supplied will affect the specific heat capacity of the solution.	An aluminum calorimeter will be used to ensure a uniform energy supply in the solution.
The volume of the solution	As the volume of the solution increases, the temperature change will reduce and thus affecting the specific heat capacitance. As the temperature of the solution reduces, the temperature change will be high and thus affecting the specific heat capacitance of the solution.	-The volume of the solution will be kept constant (100ml). A graduated cylinder will be used to measure the volume of water.

Materials

-1 aluminum calorimeter

-1 glass beaker

-1 stopwatch

-1 mercury thermometer

-Distilled water 500ml

-100ml graduated cylinder

-copper stirrer

-500g salt (sodium chloride)

Method 1 (Salt Concentration Preparation)

1. Measure 100 ml of distilled water using a graduated cylinder.
2. Transfer the water to a glass beaker and label the beaker as 0.00%.
3. Measure 100 ml of distilled water using a graduated cylinder. Using a measuring scale, add 1 gram of sodium chloride and stir the solution.
4. Repeat step (3) above using different amounts of salt as indicated by the table below;

Mass of salt	Sodium concentration (%)
0.00 g	0%
10.0 g	10%
20.0 g	20%
30.0 g	30%
50.0 g	50%

Method 2:

1. Arrange all the materials listed above (this will ensure easier access to the materials during the exploration).
2. Measure the initial temperature of the solution ladled (0.00%) and record the temperature.
3. Pour the water into a copper container and transfer the container to a calorimeter.
4. Put on the calorimeter and heat the solution for 5 minutes.
5. Remove the lid and measure the final temperature of the solution.
6. Find the difference between the initial temperature and final temperature and record the temperature change.
7. Repeat steps 2-6 two more times to ensure the accuracy and consistency of data.
8. Repeat steps 2-7 using other salt solutions (10%, 20%, 30%, and 50%).
9. Find the specific heat capacity of each solution and record the data in a processed data table.

10. Plot a graph of specific heat capacitance against sodium chloride (salt) concentration.

Raw data

Table 2: Raw data table

Salt concentration (%)	**Temperature change (^{0}C)**		
	Trial 1	**Trial 1**	**Trial 1**
0.0	1.50	1.51	1.52
10.0	1.55	1.57	1.58
20.0	1.70	1.68	1.72
30.0	1.85	1.83	1.87
50.0	2.00	1.98	2.10

Sample Calculation

Uncertainty

In order to compute the uncertainty of the above data, the following formula will be used;

$$uncertainity = \frac{\max value - \min value}{2}$$

$$uncertainty\ (0.00\%) = \frac{1.52 - 1.50}{2} = 0.01$$

The same method was used to compute the uncertainty for other experiment;

Average temperature change

To compute the average temperature change, the following formula will be used;

$$Average\ temperature\ = \frac{Trial\ 1 + Trial\ 2 + Trial\ 3}{3}$$

$$Average\ temperature\ (0.00\%) = \frac{1.50 + 1.51 + 1.52}{3} = 1.52$$

The same method was applied to find the average temperature, as shown in the table below;

Table 3: Average temperature change

Salt concentration (%)	**Temperature change (^0C)**
0.0	1.51
10.0	1.57
20.0	1.70
30.0	1.85
50.0	2.03

Specific heat capacitance

To compute the specific heat capacitance, the following formula will be applied;

$$Q = CM\Delta t$$

Where;

C=specific heat capacitance

Q= energy supplied

M=mass of the salt solution

Δt= change in temperature

$Q = 4184*100*1.51$

$Q = 631784\ J$

The heat energy is constant throughout the experiment, and the $\boldsymbol{Q} = 631784\ \boldsymbol{J}$

To find the specific heat capacitance of the solution, the following formula will be used;

$$c = \frac{Q}{m\,\Delta\,t}$$

When the concentration of salt is (10%);

$$c = \frac{631784}{110*1.57} = 3658.27\ j/g$$

The same method was used to compute the specific heat capacitance of the solution, as shown in the table below;

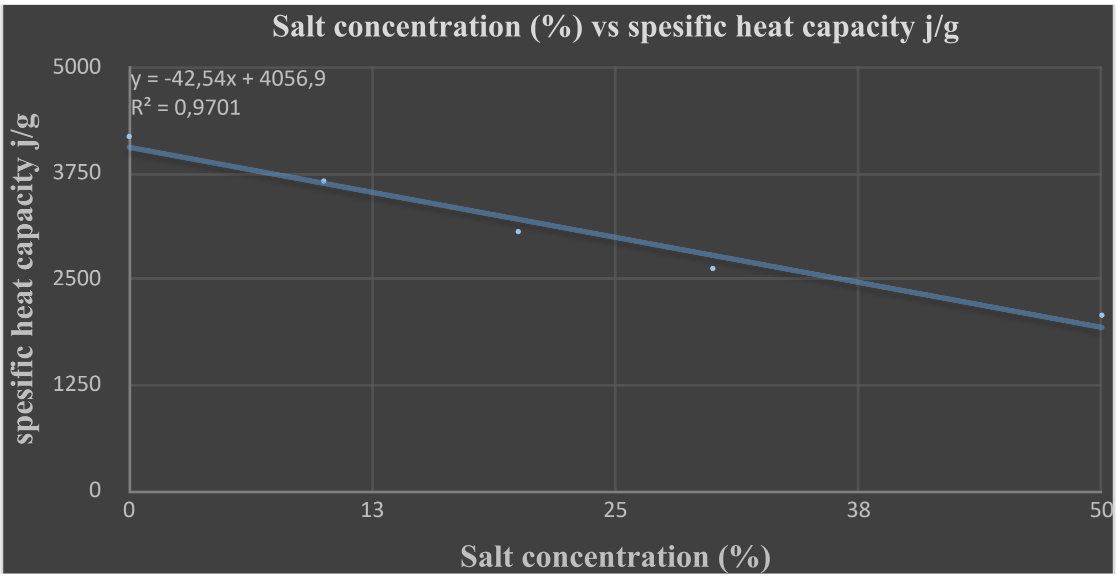
Table 4: Processed data table

Salt concentration (%)	**Temperature change (^{0}C)**	**Specific heat capacitance (j/g^{0}C)**	**Uncertainty**
0.0	1.51	4184.00	0.01
10.0	1.57	3658.27	0.02
20.0	1.70	3060.97	0.02
30.0	1.85	2626.96	0.02
50.0	2.03	2074.82	0.06

Analysis

Based on the data from Table 4 above, it can be noted as the concentration of salt increases, the temperature change also increases. When the concentration of the salt was 0.0%, the temperature change was 1.51⁰C. At the same time, as the concentration of salt increases to 50%, the temperature change also increases to 2.03⁰C. At the same time, as the concentration of the salt increases, the specific heat capacitance of the solution reduces. When the concentration of salt was 0.0%, the specific capacitance of the solution was 4184.0 j/g. As the concentration increases to 10.0%, the specific heat capacitance of the solution reduces to 2074.82 j/g, indicating a decline.

The data from the table above can be used to develop the following graph;



Based on the graph above, it can be noted that as the concentration of salt increases, the specific heat capacitance of the solution also increases. The gradient from the above indicates a decline direction indicating that there is a negative association between salt concentration and the specific heat capacitance of a solution. The coefficient correlation from the above graph can be computed as follows;

$R^2 = 0.9701$

$R = \sqrt{0.9701}$

$R = 0.98$

The coefficient correlation from the above graph is 0,98confirming that there is a negative link between salt concentration and specific heat capacitance and thus confirming my hypothesis, which stated that "as the concentration of salt in the solution increases, the specific heat capacitance of the solution reduces."

Conclusion

The main objective of this exploration was to investigate how salt concentration affects the specific heat capacitance of the solution. Before this exploration, it was hypothesized that "as the concentration of salt in the solution increases, the specific heat capacitance of the solution reduces." Based on the data collected in this exploration, it was evident that as the concentration of the slat increases, the specific heat capacitance of the solution reduces. A graph of salt concentration against specific heat capacitance indicates a negative gradient confirming a negative link between the variables. The uncertainty value was very small, suggesting that the exploration was a huge success.

Evaluation

The exploration was a huge success as the aim of the exploration was achieved, and the hypothesis was confirmed. The high number of trials was the main strength of this exploration. A high number of trials ensured there was high data accuracy, and the random errors were minimized. Although the exploration was a huge success, some errors might have impacted the final results. Some of the errors incurred in this exploration are; the usage of liquid in the thermometer might have impacted the final results of this exploration. The exploration is not very sensitive to temperature change, which might have impacted the final results. In order to eliminate this error in the future, a digital thermometer should be used, as this would reduce systematic error. The room temperature kept changing, which might have impacted the final results. To ensure data accuracy, the experiment needs to be conducted in a controlled environment.

Extension

Various factors affect the specific heat capacity of a solution. In this exploration, however, only concentration was investigated. In future exploration, it is important to investigate other factors such as mass and change in temperature. The research question will be, "How do the temperature change, concentration, and mass affect the heat capacitance of salt solution?

References

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