



Driving Question:

How does the temperature change during the cooling of stearic acid?

Applied Technology: Data-logging

Student Level: Middle School Level (11-14)

Duration: 1 lesson period

Recommended Settings: Student Investigations

Learning Objectives

- To observe temperature changes in a sample of stearic acid as it cools from the liquid to the solid state
- To associate each region of the graph with the liquid, solid and the transition between them
- To associate the flat region on the graph with the change of state at the melting point temperature

Didactical Approach

In this activity, the cooling of stearic acid (changing from liquid to solid) is studied. Students record the temperature of stearic acid as it cools. The method makes it possible to observe the whole process, to explore the rate of temperature changes and compare the measured values with theoretical predictions.

This experiment takes quite a long time to carry out. The experiment can be performed as a teacher demonstration and then students can do another activity alongside the experiment. The data analysis can be done as student investigations.

Stearic acid, $\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$ can act as an eye, skin and respiratory irritant so the laboratory should be well ventilated.

Concepts learnt in this activity:

- Liquid state, solid state, change of state, melting temperature.

Materials

In your investigations you will use:

- Data-logger e.g. CMA €Lab,
- Temperature sensor,
- A stand and clamp,

- Boiling tube containing about 10 g stearic acid,
- 250 mL beaker containing water,
- Electrical heater or Bunsen heater, tripod and gauze for heating water bath.

Procedure

- Connect the temperature sensor to input 1 of your data-logger.
- Open Coach Activity 'Cooling curve'.
- Let the students perform the experiment. As the measurement time is long let the students do another activity alongside the experiment.
- Let the students analyse the measurement data.

Questions and Assignments

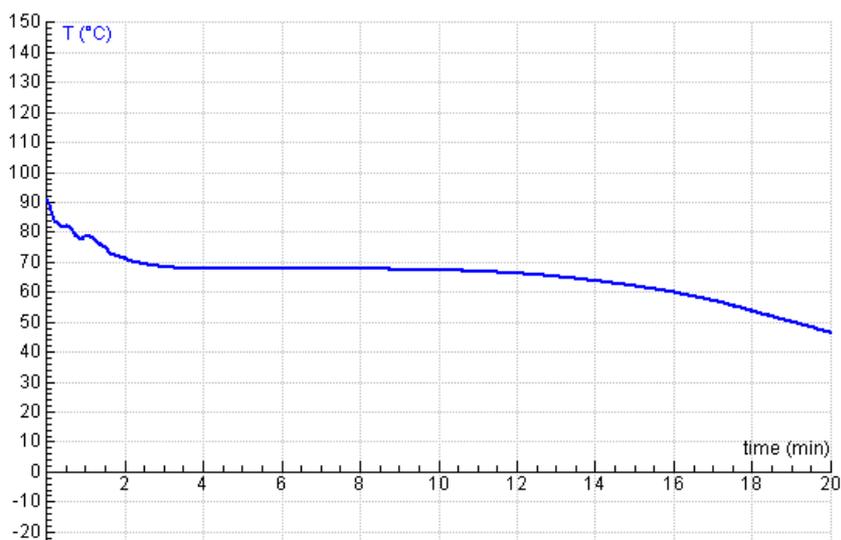
- How can you tell from the recorded temperature vs. time graph which part shows the liquid state?
- Which part shows the solid state?
- At what temperature did the liquid start solidifying?
- How long did it take for the liquid to solidify?
- The temperature of the stearic acid does not change as it solidifies. What evidence is there that it is actually losing heat?
- The temperature continues to fall after it has solidified. Why?
- What does the shape of the graph show you about the loss of heat by the substance?
- What do you think would happen to the graphs if you had kept taking results for another 10 minutes?

Data Analysis

During the experiment it is advisable:

- to continue heating to raise the temperature as high as possible near the boiling point of water; this will ensure that a good range of cooling may be observed during the liquid state.
- to stir continuously the liquid with the probe. This ensures that all the substance maintains a homogeneous temperature. This becomes more difficult when solid begins to form, but stirring should be continued as long as possible. The reasons for this may be discussed with pupils. If the experiment is repeated without stirring, the resulting graph may be compared and discussed

Before you start the experiment ask students to make predictions. Many students will anticipate that the stearic acid will continue to cool to zero.



Exemplary data: cooling of stearic acid.

After the measurement is finished students analyse the resulting graph. They can annotate each section of the graph to show where the substance was liquid, where it was solid and where the change from liquid to solid took place. They can take temperature readings and find:

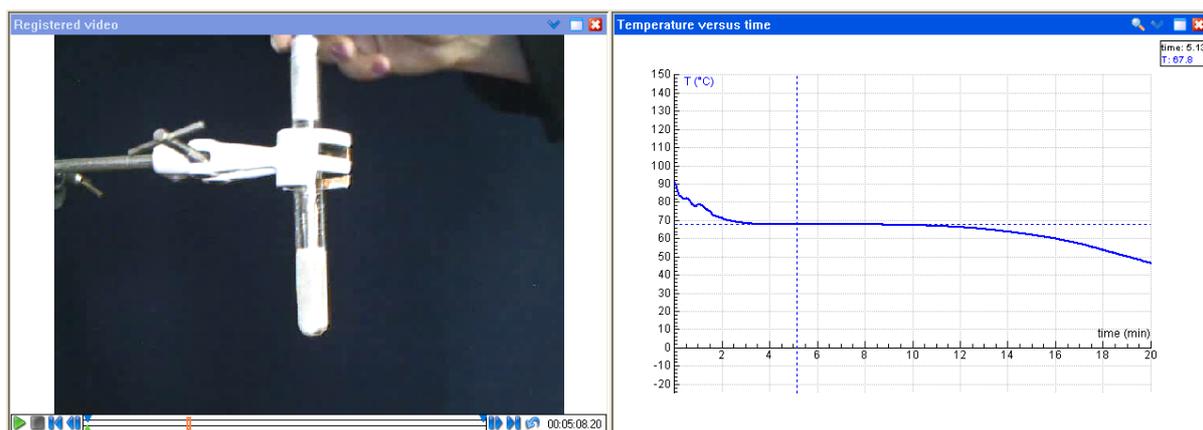
- the highest and lowest temperatures,
- the melting point temperature from the flat region on the graph,
- the range of temperature for the substance in the liquid state,
- the range of temperature for the substance in the solid state,
- the time needed to change from liquid to solid.

It is useful to discuss why the stearic acid stops cooling when it reaches room temperature.

The exact melting and freezing points of the stearic acid may not be exactly the same and will depend on the purity of the product and where it was purchased from, but are usually around 55-70 °C.

A slight modification of the experiment can yield an intriguing result when the test-tube is placed in an insulated cup containing a few cm³ of water. Use a second temperature sensor to monitor the temperature of the water. The water temperature should rise as the stearic acid cools and it should continue to rise even as it changes state.

In the Coach program the temperature recording can be synchronized with video capture taken during the course of a measurement. In this way the temperature measurement results can be illustrated by video images in real-time. By comparing the video frame-by-frame with the graph of temperature against time, it is possible to verify the appearance as liquid or solid for each portion of the graph. The flat region is most interesting in that this is where the transition between liquid and solid is in progress.



When scanning in the diagram the corresponding video frame is shown.

Resources

Coach 6 Activity: Cooling curve.cma

Coach 6 Result: Cooling curve.cmr

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