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greenTEG

gSKIN® Application Note: Molar Enthalpy of Salt Dissolution in Water

Tutorial about how to measure the molar enthalpy of salt dissolution in water

Aim

The aim is to measure the molar enthalpy of dissolution of a salt in water. As an example, we will dissolve 2 g of NaOH in 100 ml Water and derive its molar enthalpy of dissolution at room temperature.

Experimental setup

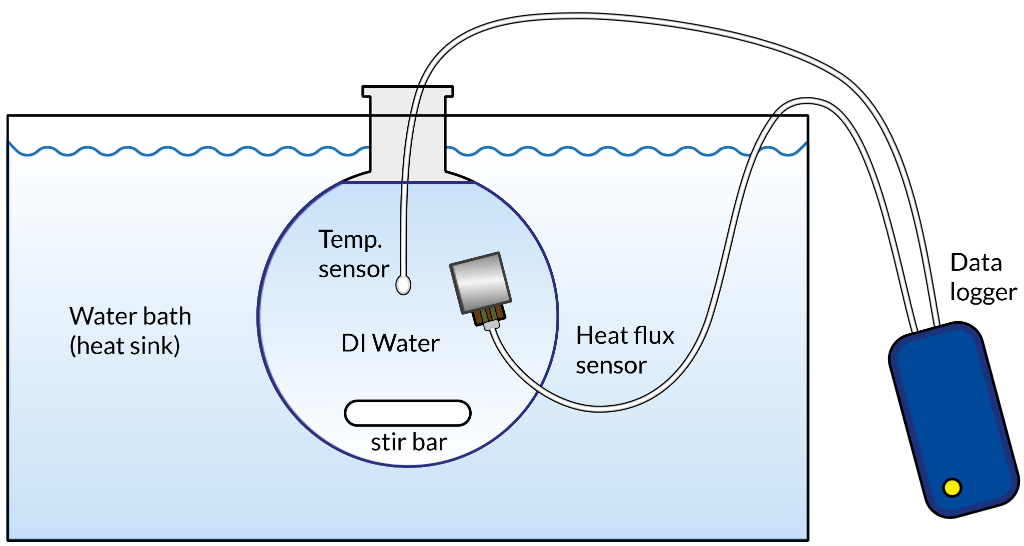

Figure 1: A possible configuration of an experimental setup for measuring the solution enthalpy of a water-soluble salt.

Figure 1 shows a possible experimental setup. To conduct the measurement, the following equipment is needed:

- 1 Heat flux sensor: greenTEG recommends gSKIN®-XE 24 9C, and gSKIN®-XO 64 9C
- 1 Datalogger: greenTEG recommends gSKIN® DLOG-4228 (includes 1 temperature sensor)
- (Optional) 1 Temperature sensor: any sensor with a 0.5°C accuracy. greenTEG recommends to use a datalogger which includes a temperature sensor (e.g. gSKIN® DLOG-4228)
- 1 Reaction vessel, e.g. a 100 ml round flask of Pyrex, filled with DI water
- 1 Stir bar and stirring device
- 1 Water bath
- The salt to be analyzed, in this case 2g of NaOH.

Make sure that all components involved in the measurement are at room temperature. The ambient temperature must not fluctuate during the measurement. Isolate your setup from direct air currents. Make sure to cover the water bath in order to prevent evaporation.

Tutorial

1. Set up your system as shown in Figure 1. See the "gSKIN® Application Note: Calorimetry" for recommendations on equipment and mounting.
2. For most accurate results, calibrate your system as described in "gSKIN® Application Note: Calorimetry".
3. Connect the datalogger to the sensor. Set the measurement rate of the datalogger to 1Hz (i.e. 1 data point per second). Faster rates are possible but rarely necessary.
4. Before starting the reaction, check the output value of the sensor. The output signal should be very close to zero. If this is not the case, wait for the system to equilibrate.
5. Start the datalogger.
6. Put the salt into the reaction vessel and begin stirring until the salt is completely dissolved.
7. Wait for the system to reach thermal equilibrium (heat flux close to zero). Depending on the thermal conductivity of your vessel, this may take up to 30 minutes.
8. Load the measurement data into a spreadsheet. Figure 2 shows an example of a measurement over 20 minutes (1200 data points) using the gSKIN® DLOG-4228 datalogger.

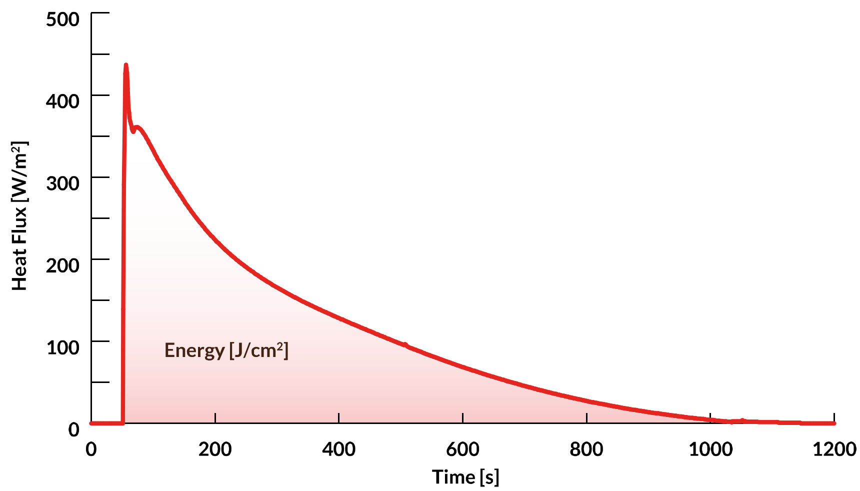

Figure 2: Typical measurement curve as recorded with the gSKIN® DLOG-4228 datalogger. The shaded area included by the curve is proportional to the reaction energy.

9. Convert all measurement values (q_1, q_2, ... q_n) into W/m^2. If you are using the gSKIN® DLOG-4228 datalogger, the output is already available in W/m^2. If you are using a voltmeter, convert the values using the following equation:

$$\varphi = U / So \qquad [W/m^2]$$

where φ is the heat flux in W/m2,
U is the output signal from the sensor in μV,
So is the sensitivity of the gSKIN® Sensor in $\mu V/(W/m^2)$.

10. Calculate the total energy released ΔE. You need to sum up all measurement points (q_1, q_2, ... q_n), correct for the measurement rate f (usually f = 1 Hz) and multiply by the outer vessel surface A (in our case 120 cm^2 = 0.0120 m^2) according to the formula below.
Note: Depending on the mounting of your sensor, you may need to adjust the sign. For exothermic reactions, like in our case, the sign of ΔE must be negative.

$$\Delta E = -(q_1+q_2+...+q_n) \cdot 1/f \cdot A \qquad [J]$$

where ΔE is the energy change in J,
$q_1+q_2+...+q_n$ are the measurement points in W/m^2,
f is the measurement rate in Hz,
A is the vessel surface in m^2.

11. The molar enthalpy of the dissolution can be derived from the molar mass M and the mass of the dissolved salt (in our case M = 40.0 g/mol and m = 2.0 g).

$$\Delta H_S = \Delta E \cdot M/m \qquad [J/mol]$$

where ΔH_S is the molar enthalpy of the dissolution in J/mol,
M is the molar mass of the salt in g/mol,
m is the mass of the salt in g.
A is the vessel surface in m^2.

12. Following this tutorial step by step, the following results were obtained for NaOH:

	Result
Total energy release	ΔE = -2131 J
Molar enthalpy of the dissolution at room temperature	ΔH_S = -42.6 kJ/mol

This short Youtube video (http://www.youtube.com/watch?v=UWksEiJAaLk) shows an example of a calorimetric measurement. It shows a latent heat storage material, Sodium Acetate, at crystallization.

Document information

Pictures and figures by greenTEG AG
Video: http://www.youtube.com/watch?v=UWksEiJAaLk

Revision History

Date	Revision	Changes
11. February 2014	1.02 (preliminary)	Initial revision