CHEG 3128 – Chemical Engineering Junior Laboratory
Heat & Mass Transfer Experiment

In this laboratory, groups will perform two experiments. First, heat transfer in a potato cube, and second, mass transfer in a button mushroom. The transfer of heat and mass in a system is a fundamental concept in chemical engineering. Groups should focus on efficient design of experiments and accurate data collection.

Objectives

Potato Heat Transfer:

The three fundamental methods of heat transfer are convection, conduction, and radiation. Heat transfer changes the internal energy of the systems involved in the transfer. In this experiment, the amount of heat transfer via conduction will be quantified by measuring the extent of cooking in a potato cube. Groups may change the side length/surface area of cube, pH of solution, cooking time, etc.

The extent of cooking can be measured either by measuring the cooking line distance, or by calculating the ratio of cooking line distance to cube radius.

Mushroom Osmosis:

Mass transfer occurs in various methods, such as absorption, evaporation, and distillation. In this experiment, mass transfer occurs through osmosis; the water moves through the semi-permeable mushroom membrane to the salt solution in which the mushroom sample is immersed. Groups may study the effect of changing the salt concentration and/or the surface area of the mushroom.

A one-dimensional simplification of Fick's first law of diffusion is as follows:

$$J = D\frac{dC}{dx}$$

With the data collected in the mass transfer experiment, groups can calculate D, the diffusivity constant of water. To determine the value for D, groups must calculate:

a. Flux of water (J)
b. Concentration of salt solutions (mol/L)
c. Smallest dimension of each mushroom piece (dx, length scale)

How does your experimental value compare with the literature value? Is it expected? What may be a cause of this difference?

Deliverables:

1. A technical memo detailing the heat transfer experiment, submitted via HuskyCT. A template for this assignment can be found on HuskyCT.
    - The memo should be NO LONGER than 6 pages, including figures. For each page over the limit, your team will be penalized 10 points.
2. A poster detailing the mass transfer experiment, submitted electronically via HuskyCT. Guidelines and a rubric for this assignment can be found on HuskyCT.

Groups' memos and e-Posters are due at 11:59PM, on the date according to the due date schedule in the syllabus.

Groups must bring to lab:

1. Detailed procedures
2. 4-5 white/russet potatoes
3. 10 white button mushroom samples
4. Distilled white vinegar, if desired

A basic procedure for both experiments can be found below; groups should use these to develop their detailed procedures in the prelab.

Heat Transfer Experiment

Available variables: Side length, time, pH (bring vinegar if changing pH)

1. Cut potatoes into cubes of desired side lengths. Mark one side of each cube with a permanent marker.
    - Recommended maximum side length is 2.5cm
2. Fill beakers with specified amount of water, then heat to the desired temperature.
3. Using tongs, place potato cubes into water beakers with the marked side facing up.
4. After the specified sample time, remove the cube. Cut the cube down the middle and measure the cooking line length.
5. When testing is complete, discard all samples in the trash and clean all used glassware.

Mass Transfer Experiment

1. Prepare salt solution(s) of desired concentration(s).
    - Groups will be provided with NaCl solutions of the following concentrations, per 100g water: 0g, 5g, 10g, 15g
2. De-stem the mushrooms and peel the caps; make sure the skin as well as the brown fins are removed. Groups may choose to cut the caps into pieces that are roughly 3x1x1 cm.
3. Record the initial mass of the mushroom samples.
4. Place mushroom samples in the salt water solutions.
    - Due to the buoyancy of the mushrooms, plastic forks will be provided to keep the samples submerged
5. Remove the samples at 5-min intervals. Pat dry, then record the mass. Measure the dimensions of the samples.
    - Dimensions can be measured with a ruler, or by taking an image with the sample next to an object of known size (ruler, coin, etc). Groups can analyze images later using ImageJ or a similar imaging analysis software
6. Repeat this process over a 45-50 minute span.
7. When testing is complete, discard all samples in the trash and clean all used glassware.

Useful Links:

- https://www.ars.usda.gov/ARSUserFiles/80400525/Articles/ift2006_mushroom.pdf
- http://www.wolframalpha.com/input/?i=mushroom+density
- https://www.researchgate.net/publication/245089510_Transient_heat_transfer_in_a_boiled_pot

ato_a_study_related_to_food_process_engineering