Adiabatic flash drum with binary liquid feed

Name(s) ____

A two-component, pressurized liquid is fed to an adiabatic flash drum and mass balances are used to determine the vapor composition and flow rate. A T-x-y diagram is generated from measurements at constant drum pressure and different feed conditions. The T-x-y diagram is compared to Raoult's law.

Student learning objectives

1. Be able to explain the principles of flash distillation,
2. Be able to create a T-x-y diagram for a binary mixture at constant pressure.
3. Be able to apply Raoult's law.
4. Be able to do mass balances on a flash drum.
5. Be able to explain how changes in feed temperature and drum pressure affect the relative amounts of liquid and vapor, the compositions of the phases leaving the drum, and the separation ability of the drum.

Equipment

- A lab-scale, insulated flash drum with liquid feed and vapor and liquid outlets. The drum contains pressure and temperature sensors and a pressure relief valve.
- A system (with a temperature controller and temperature sensor) to preheat the feed mixture using steam.
- A pressure controller to maintain a constant pressure within the drum.
- Mass flow meters to measure the flow rates of the feed and the liquid outlet.
- A gas chromatograph to analyze the composition of the liquid outlet.

Before starting

Select the binary mixture (A, B, C, or D) to study from the dropdown menu.

Mixture ____________

Record the molecular weights of the two components: MW_1 _______ MW_2 _______

Record the Antoine constants for the two components.

A_1 __________ B_1 _________ C_1 __________

A_2 __________ B_2 _________ C_2 __________

Select one pressure of the flash drum for your measurements by clicking on the arrows on the pressure gauge. The selected pressure will display red, and the drum will be at this pressure only after the feed flows into the tank and reaches steady state.

Pressure ___________

Procedure for measurements at one condition

In the menu, select a feed mole fraction using the slider. The slider displays the mole fraction of the first chemical in the mixture. Record in the Table below.

Select a feed temperature by clicking on the arrows on the temperature sensor. The set temperature will display red; record it in the Table below. The display will indicate “steam off” until the feed pump is turned on. It will then approach the set temperature.

Fill the tank with the feed liquid.

Turn on the feed pump. The feed flow rate is 1.0 mol/s, and the feed pressure is high enough that the feed is liquid.

Allow the system to reach steady state.

Measure drum temperature and record in the Table below.

Measure outlet liquid mass flow rate and record in the Table.

Take a sample of the liquid outlet stream and inject into a GC to measure its mole fraction. Record in the Table.

Use molecular weights to calculate outlet liquid molar flow rate.

Use mass balances to determine vapor molar flow rate and composition and record in the Table.

Feed temp °C	Feed mole fraction z_1	Drum temp °C	Outlet liquid mass flow rate (g/h)	Outlet liquid mole fraction x_1	Outlet liquid molar flow rate (mol/h)	Outlet vapor molar flow rate (mol/h)	Outlet vapor mole fraction y_1

Repeat these measurements for a range of feed compositions and temperatures and record the results in the Table.

Create a T-x-y diagram

Use the data in the Table to create a spreadsheet and generate a T-x-y diagram at constant pressure.

Does the system obey Raoult's law? Explain.

Questions to answer

1. Where might these measurements have errors?

2. In an adiabatic flash drum, why is the drum temperature lower than the feed temperature?

3. How does changing the feed temperature affect the outlet compositions and flow rates?

4. Suppose you repeated measurements at a lower pressure. What would be different in the outlet flow rates and compositions?

5. What safety precautions would you take to conduct this experiment in the laboratory?