Adiabatic flash drum with binary liquid feed

Name(s)____

A two-component, heated, pressurized liquid is fed to an adiabatic flash drum, and mass balances determine vapor compositions and flow rates. 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 do mass balances on a flash drum.
3. Be able to create a T-x-y diagram for a binary mixture at constant pressure.
4. Be able to apply Raoult's law.
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.
- A system (with a temperature controller and temperature sensor) that preheats the feed mixture using steam.
- A pressure controller maintains constant pressure within the drum.
- Mass flow meters measure the flow rates of the feed and the liquid outlet.
- A gas chromatograph to analyze the composition of the liquid outlet.

Procedure for measurements at one condition

1. In the hamburger menu, select a feed mole fraction of chemical 1 in the binary mixture using the slider. Record in the Table below.
2. Select a binary mixture (A, B, C, or D) from the dropdown menu. Mixture ________
3. Record the Antoine constants for the two compounds. Note that these constants are for an Antoine equation whose pressure is in mm Hg and temperature in ^{o}C. Convert the pressure to bar by multiplying it by 0.001333.

   A_1 _________ B_1__________ C_1 ___________

   A_2 _________ B_2__________ C_2 ___________

4. Record the molecular weights of the two c: MW_1 ___________ MW_2 ___________
5. Close the hamburger menu and click "fill tank."
6. Click "on" to turn on the feed pump.

7. Turn on the feed pump. The feed flow rate is 60. mol/min, and the feed pressure is high enough that the feed is liquid.
8. Increase the feed temperature by clicking on the red box with the triangle pointing up on the temperature sensor. The set temperature will display red until the feed temperature reaches the set temperature. It will then display white. The feed temperature needs to be high enough that vapor forms in the flash drum (also, the liquid flow rate will be less than the feed rate). Record the feed temperature in the Table. You may want to start a spreadsheet and record the values there.
9. Select the flash drum pressure by clicking on the red boxes on the pressure gauge. The pressure displays red until the selected pressure is reached. Pressure ___________
10. Allow the system to reach steady state.
11. Record the drum temperature in the Table.
12. Record the outlet liquid mass flow rate in the Table.
13. Click "take sample" of the liquid outlet stream and "inject sample" into the GC to measure its mole fraction. Record the mole fraction of component 1 in the Table.
14. Use molecular weights to calculate outlet liquid molar flow rate and record in Table.
15. Use mass balances to determine vapor molar flow rate and mole fraction (y_1) and record in the Table.

Feed temp ^oC	Feed mole fraction z_1	Drum temp ^oC	Outlet liquid mass flow rate (kg/min)	Outlet liquid mole fraction x_1	Outlet liquid molar flow rate (mol/min)	Outlet vapor molar flow rate (mol/min)	Outlet vapor mole fraction y_1

Repeat these measurements: click “empty tank,” select a new feed mole fraction, and start a new experiment at the same tank pressure by repeating steps 5 to 15. Make measurements over a wide enough composition and temperature range to generate a T-x-y diagram.

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 repeat 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?