Campus Biodiesel Plant Design

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Overview

- Objectives
- Background Information
- Alkali Catalyst Research
- Reactor Mass Balance
- Economic Considerations
- Methanol Recovery
- Uses of Glycerol

Objectives

- Produce 100 gal/week of biodiesel
  - Used to run campus shuttle buses
- Motivation for Plant
  - Combat rising prices of petroleum fuel
  - Reduce waste produced on campus by recycling
- Educational Tool

Background Information

- Transesterification of a vegetable oil was conducted as early as 1853
- Rudolf Diesel's prime model in 1900 was powered by peanut oil
- 1990s biodiesel production begins in Europe

Background Information

- Most plants are batch operation

$$Triglyceride + 6Methanol \xrightarrow[(Catalyst)]{} 3Biodiesel + Glycerol + 3Methanol$$

- 3 Types of Catalysts
  - Alkali
  - Acid
  - Enzyme

Alkali Catalyst

- Most common catalyst type
- NaOH or KOH
- Shortest reaction time

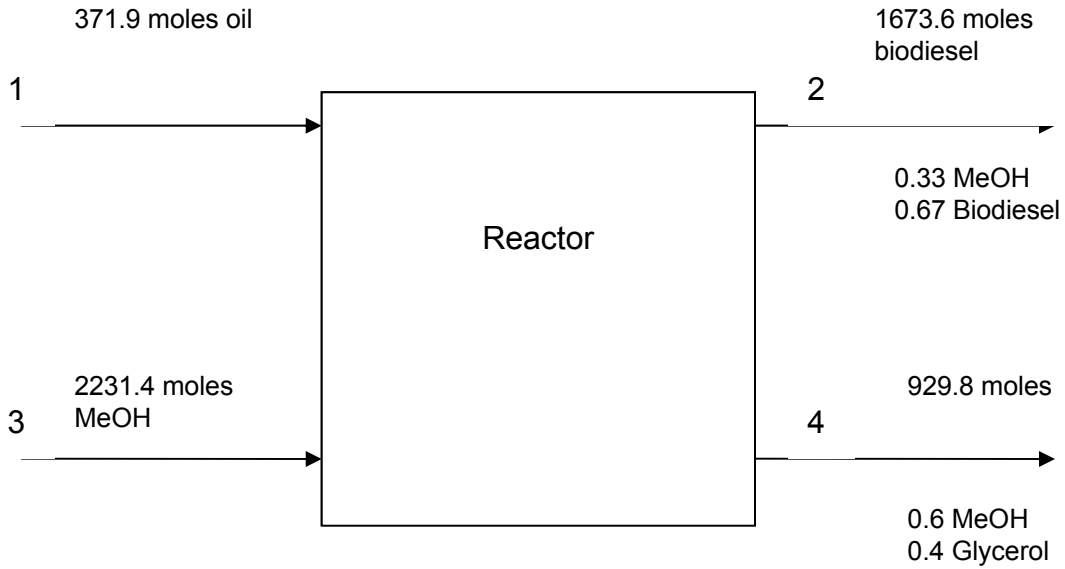
Disadvantages of Alkali Catalysts

- Highly hygroscopic
- Less effective with a high concentration of free fatty acids

Advantages of Alkali Catalysts

- The benefits of an alkali catalyst are:
  - Low temperature and pressure reaction
  - High conversion (up to 98%)
  - Quicker reaction time
  - No intermediate compounds
  - Relatively low materials and equipment costs

Reactor Mass Balance



Economic Considerations

- Cost of feedstock
  - Can effect biodiesel cost by up to 60%-75%
- Want to produce a high-value co-product
- Methanol recovery system

Methanol Recovery

- Vacuum distillation
- Assumed glycerol to be non-boiling
- Important equations:

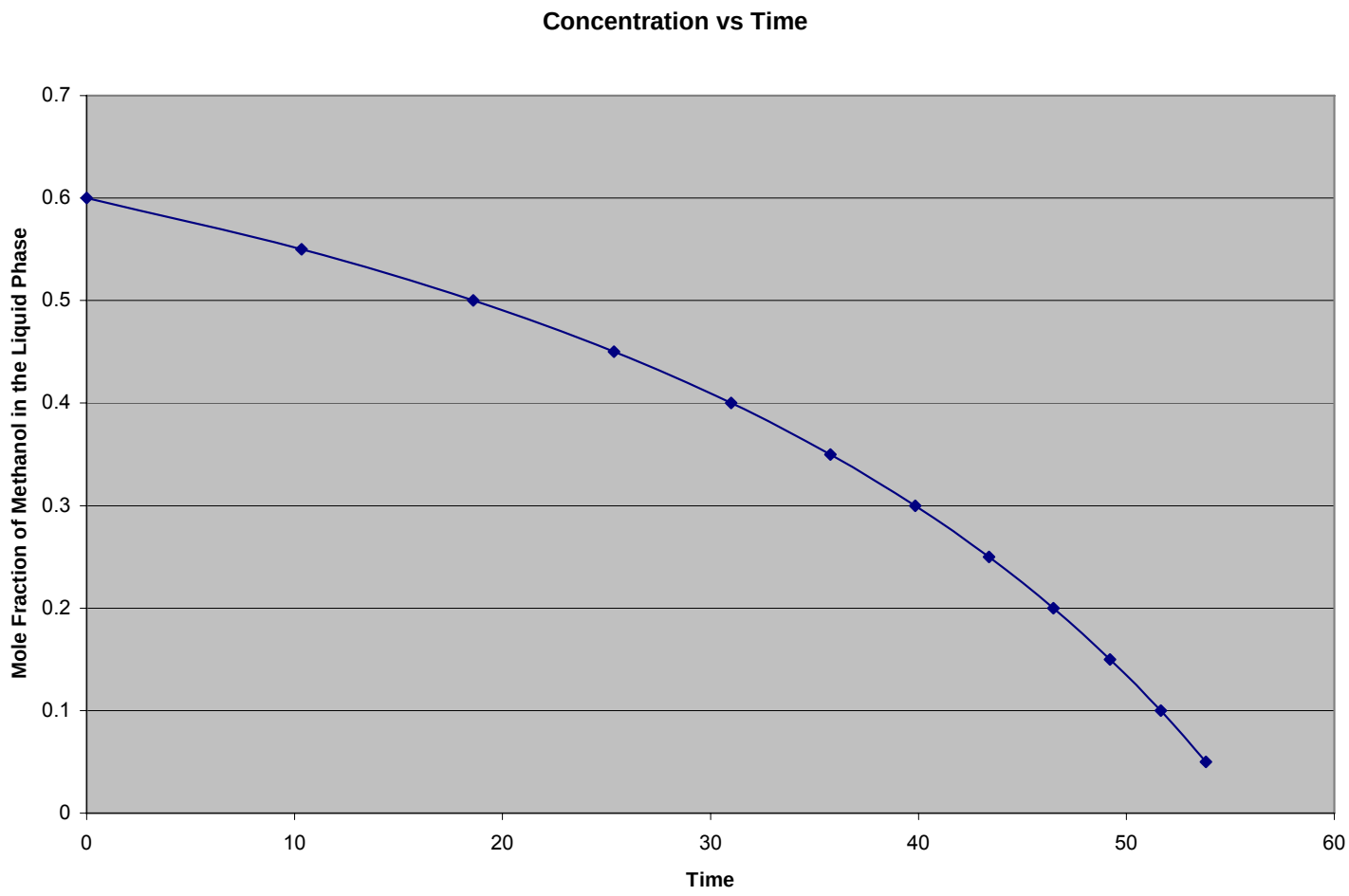
$$Antoine's \equiv \log(P^*) = 8.08097 - \frac{1582.271}{T + 239.726}$$

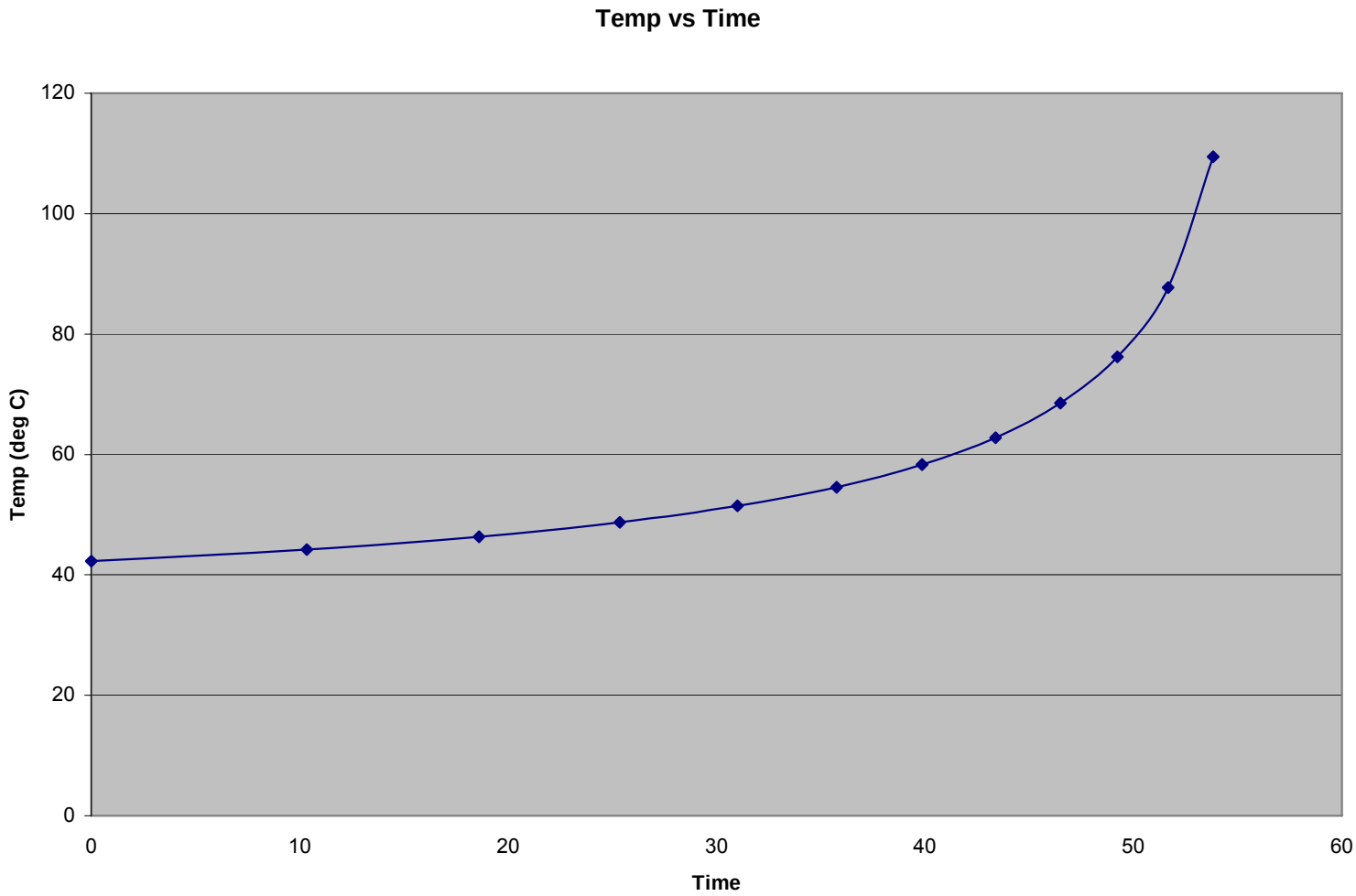
$$Raoult's \equiv P * y_i = P_i^* * x_i$$

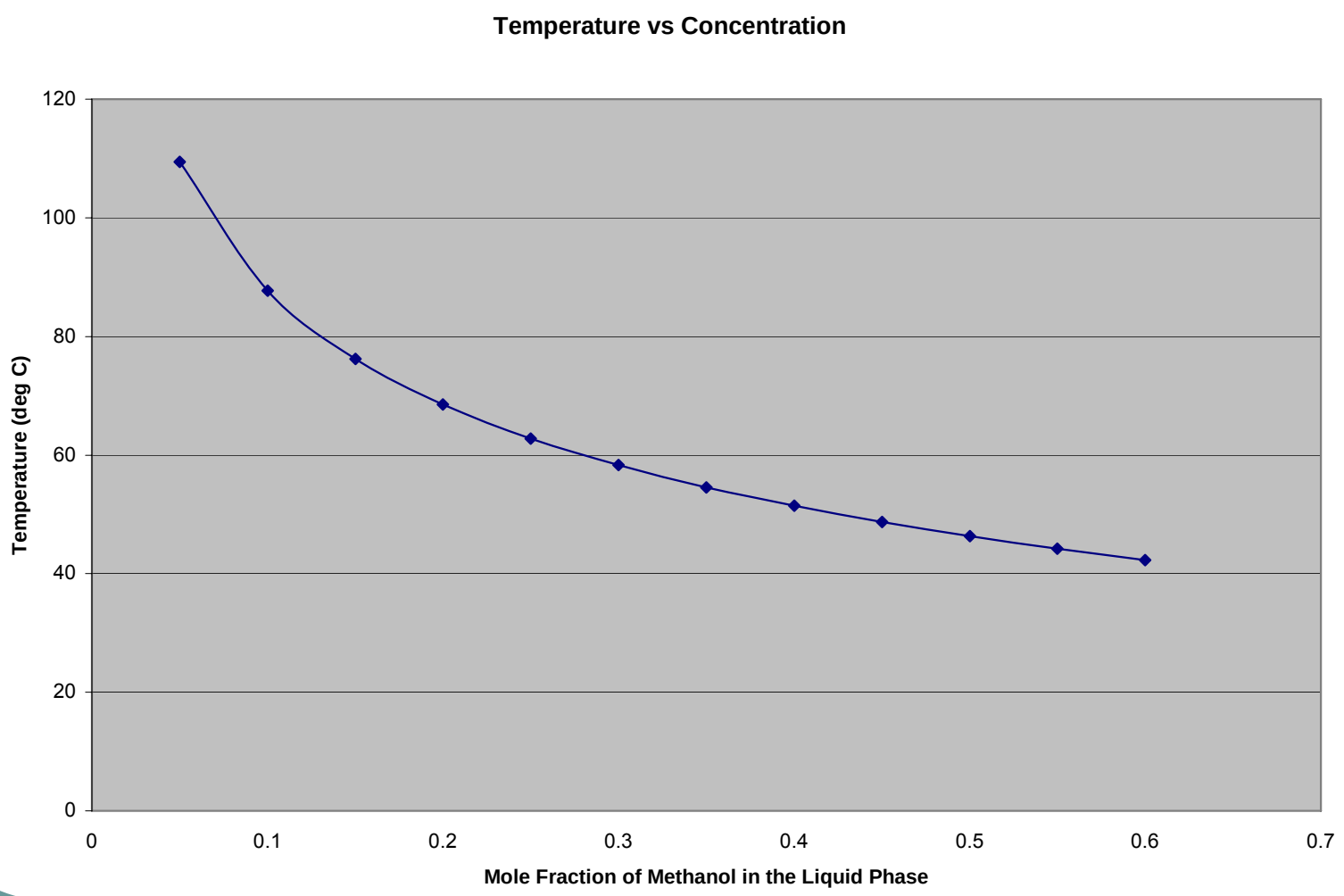
$$\int_{x_0}^{x} \frac{dx}{y - x} = \ln\left(\frac{W}{W_0}\right) \qquad \dot{Q} = n_v \Delta \dot{H}^{vap}$$

Distillation Results

- P^{*}=295.5 mmHg
- P^{Total}=177.3 mmHg
- Boiling Point of MeOH=43.3°C
- Boiling Point Elevation=43.3°C – 109.5°C
- Boiling Point of Glycerol= 252.34°C
- Heat Duty=16208.22 BTU/hr


Concentration vs Time
Mole Fraction of Methanol in the Liquid Phase
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
Time


Temp vs Time
Temp (deg C)
120
100
80
60
40
20
0
0
10
20
30
40
50
60
Time


Temperature vs Concentration
120
100
80
60
40
20
0
Temperature (deg C)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Mole Fraction of Methanol in the Liquid Phase

Uses of Glycerol

- De-icing agent
- Pharmaceuticals
- Cosmetics
- Industrial Lubricant


Any
Questions