

MULTI-COMPONENTDISTILLATIONOBJECTIVES :

- To perform multi-component distillation of methanol - ethanol - butanol in a laboratory - scale distillation column.
- To calculate minimum no. of trays (stages) via Fenske's Equation.

THEORY :

DISTILLATION - method of separating components from a liquid mixture based on the difference in boiling points of the individual components and the distribution of the components between a liquid and a gas phase in the mixture.

The vaporisation process changes liquid to gaseous state. At equilibrium, the rates of the two processes are the same. Pressure exerted by the vapor at the equilibrium state is called the VAPOR PRESSURE of the liquid.

The following methods can be used to calculate vapor pressure :

a) CLAUSIS - CLAPERYRON EQ.N.

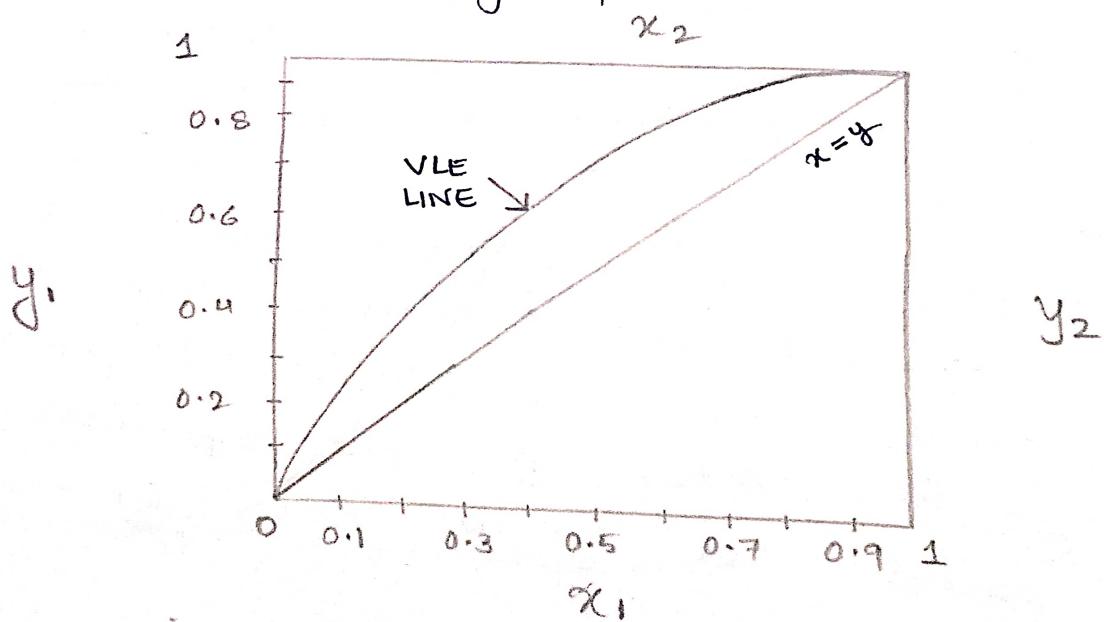
$$\ln\left(\frac{P^v}{P_1^v}\right) = \frac{\lambda}{R} \left(\frac{1}{T_1} - \frac{1}{T} \right)$$

λ = molar latent heat of vaporization

b) ANTOINE EQ.N.

$$\ln(P^v) = A - \frac{B}{T+C}$$

RELATIVE VOLATILITY is the measure of difference in volatility between components, & hence, their boiling points.



VAPOR - LIQUID EQUILIBRIUM PLOT

$$\text{Reflex Ratio} = \left(\frac{\text{Flow returned on reflux}}{\text{Flow of stop product removed}} \right)$$

For Quantitative Analysis, Gas chromatography is performed. It analyses different components in a sample. Gas chromatography (GC) is an analytical method utilising a gas chromatograph.

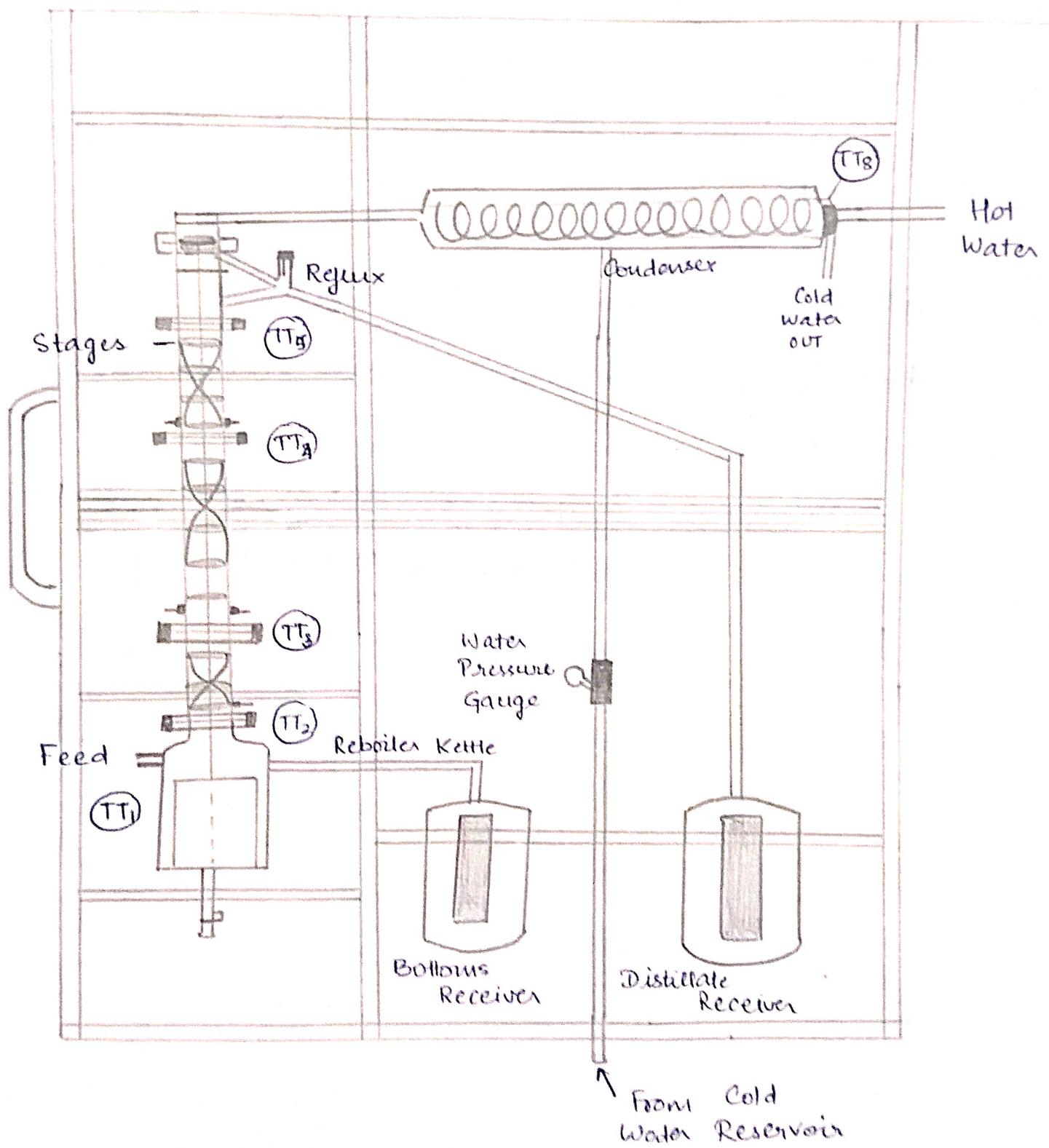
Two major relevant constituents include :

- a) Thermal Conductivity Detector (TCD)
- b) Flame Ionization Detector (FID) -

FID is a scientific instrument that measures analytes in a gas stream, and is used as a detector for GC.

EXPERIMENTAL

SETUP



OBSERVATIONS :

Area : $mV^* \text{ min}$
(under curve)

Observation Tables.1. TOTAL REFLUX :

Temp. at top of column (T_{1t}) = 63.3°C

Temp. at bottom (T_{1b}) = 76.6°C

	wt. of CH	Area CH_4	Area C_2H_6	Area C_4H_{10}	Area CH
Distillate	5.008	10.54	15.73	0.15	75.95
Bottoms	4.997	9.00	10.25	16.71	62.77

2. $R = 1.9$:

Temp. at top of column (T_{2t}) = 64.8°C

Temp. at bottom (T_{2b}) = 79.4°C

	wt. of CH	Area CH_4	Area C_2H_6	Area C_4H_{10}	Area CH
Distillate	5.038	36.90	2.31	0.18	42.34
Bottoms	5.025	7.37	25.72	16.65	64.11

3. $R=1$:

Temp. at top of column (T_{3t}) = 65.7°C
 Temp. at bottom (T_{3b}) = 82.3°C

• Distillate = 250 ml

	wt. of CH	area CH ₄	area C ₂ H ₆	area C ₄ H ₁₀	area CH
Distillate	4.996	22.15	11.54	0.29	63.58
Bottoms	5.023	5.15	11.28	18.44	65.41

• Distillate = 500 ml

	wt. of CH	area CH ₄	area C ₂ H ₆	area C ₄ H ₁₀	area CH
Distillate	5.001	23.43	25.58	0.12	61.85
Bottoms	5.000	2.42	13.65	20.13	72.33

Initial (Feed) Composition:

	CH ₄	C ₂ H ₆	C ₄ H ₁₀
weights fed (kg)	1.5	0.75	0.75

$$\text{Moles } (n) = \frac{\text{Mass}}{\text{Molar Mass}}$$

$$n_{\text{CH}_4} = \frac{1.5}{34.04} \text{ mol}$$

$$n_{\text{C}_2\text{H}_6} = \frac{0.75}{46.07} \text{ mol}$$

$$n_{\text{C}_4\text{H}_{10}} = \frac{0.75}{74.13} \text{ mol}$$

	CH ₄	C ₂ H ₆	C ₄ H ₁₀
Moles (mol)	46.82	16.28	10.12

$$\begin{aligned} \text{Total Moles} &= n_{\text{CH}_4} + n_{\text{C}_2\text{H}_6} + n_{\text{C}_4\text{H}_{10}} \\ &= \underline{73.22} \text{ mol (approx.)} \end{aligned}$$

$$\text{Mol. fraction } (x) = \frac{\text{moles of component } (n_i)}{\text{total moles } (n)}$$

	CH ₄	C ₂ H ₆	C ₄ H ₁₀
mol. fraction (x)	0.639	0.222	0.139

$$\text{Area Ratio} = \frac{\text{Area of component}}{\text{Area of cyclohexanone (CH)}}$$

Weight Ratio = (via calibration curves)

$$y = m \left(\frac{\text{Area}}{\text{Ratio}} \right) + b$$

M E B

where $m = 1.293, 1.4527, 1.0115$
 $b = 0.1829, 0.0604, 0.016$

$$\text{weight of component} = [\text{weight ratio} \times \text{wt. of CH}]$$

CALCULATIONS -

o TOTAL REFLUX : DISTILLATE

	Area Ratio	Weight Ratio	Weight	Mol. fraction
Methanol	0.14	0.36	1.81	0.61
Ethanol	0.18	0.32	1.58	0.37
Butanol	0.06	0.02	0.09	0.01

BOTTOMS

	Area Ratio	Wt. Ratio	Weight	Mole fraction
Methanol	0.14	0.37	1.84	0.51
Ethanol	0.18	0.33	1.63	0.32
Butanol	0.27	0.29	1.43	0.17

• $R = 1.9$:

DISTILLATE

	Area Ratio	Weight Ratio	Weight	Mole fraction
Methanol	0.87	1.31	6.60	0.71
Ethanol	0.49	0.77	3.86	0.29
Butanol	0.00	0.02	0.10	0.005

BOTTOMS

	Area Ratio	Weight Ratio	Weight	Mole fraction
Methanol	0.11	0.33	1.67	0.49
Ethanol	0.19	0.33	1.66	0.34
Butanol	0.26	0.28	1.40	0.18

• $R = 1$:

250 ml

DISTILLATE

	Area Ratio	Wt. Ratio	Weight	Mole fraction
Methanol	0.35	0.63	3.16	0.70
Ethanol	0.22	0.38	1.90	0.29
Butanol	0.00	0.02	0.10	0.01

BOTTOMS

Methanol	0.08	0.28	1.43	0.45
Ethanol	0.17	0.30	1.53	0.34
Butanol	0.28	0.30	1.51	0.21

500ml

DISTILLATE

	Area Ratio	wt. Ratio	Weight	Mole fraction
Methanol	0.38	0.67	3.36	0.70
Ethanol	0.24	0.40	2.02	0.29
Butanol	0.00	0.02	0.09	0.01

BOTTOMS

	Area Ratio	WT. Ratio	Weight	Mole fractions
Methanol	0.03	0.23	1.13	0.48
Ethanol	0.07	0.16	0.82	0.24
Butanol	0.28	0.30	1.49	0.27

Initial Composition of feed:

Weight of methanol = 1.5 kg

Weight of ethanol = 0.25 kg

Weight of Butanol = 0.25 kg

$$\text{moles of methanol} = \frac{1.5}{32.04} = 46.816 \text{ mol}$$

$$\text{moles of ethanol} = \frac{0.25}{46.07} = 16.273 \text{ mol}$$

$$\text{moles of Butanol} = \frac{0.25}{70.121} = 10.118 \text{ mol}$$

$$\text{Total moles} = 73.213 \text{ mol}$$

$$\text{mole fraction of methanol} = 0.639$$

$$\text{mole fraction of ethanol} = 0.222$$

$$\text{mole fraction of Butanol} = 0.139$$

Mole fractions:

1) Total Reflux

1.1) methanol →

Distillate

Area ratio = Area of methanol / Area of cyclohexane

$$(AR) = 10.54 / 75.95$$

$$= 0.14$$

Calibration curve $\Rightarrow y = 1.293n + 0.1829$

$$\text{Weight ratio} = 1.293 \times 0.14 + 0.1829 \\ = 0.36$$

$$\begin{aligned}\text{Weight of methanol} &= \text{Weight ratio} \times \text{Weight of cyclohexane} \\ &= 0.36 \times 5.008 \\ &= 1.81\end{aligned}$$

1.2) Ethanol

	Area ratio ethanol	weight ratio ethanol	weight of ethanol	mole fraction ethanol
Distillate	0.176	0.316	1.58 0.372	0.6372
Bottom	0.183	0.327	1.63 0.378	0.6316

1.3) Butanol

	Area ratio Butanol	weight ratio Butanol	weight of Butanol	mole fraction Butanol
Distillate	0.00197	0.018	0.09	0.013
Bottom	0.266	0.285	1.42	0.17

~~1.4)~~ Sample Calculation for Distillate \rightarrow

$$\begin{aligned}\text{mole fraction of methanol} &= \frac{1.81}{32.04} \\ &= 0.056 \\ &\quad \frac{1.81}{32.04} + \frac{1.58}{46.07} + \frac{0.09}{79.121}\end{aligned}$$

~~2) Top~~

Total Reflux

R = 19

R = 1

Part-methanol-top	0.9509 atm	1.0089 atm	1.0452 atm
Part-methanol-bottom	1.5768 atm	1.7443 atm	1.9332 atm
Part-ethanol-top	0.5342 atm	0.5703 atm	0.5930 atm
Part-ethanol-bottom	0.9335 atm	1.0437 atm	1.1689 atm
Part-butanol-top	0.0948 atm	0.1025 atm	0.1074 atm
Part-butanol-bottom	0.1841 atm	0.2100 atm	0.2901 atm

Relative Volatility :-

X _{methanol-ethanol-top}	1.7802	1.7691	1.725
X _{methanol-ethanol-bottom}	1.6887	1.6712	1.6538
X _{methanol-butanol-top}	10.0329	9.8447	9.7548
X _{methanol-butanol-bottom}	8.5644	8.3053	8.0522
X _{ethanol-butanol-top}	5.6359	5.5649	5.5233
X _{ethanol-butanol-bottom}	5.0717	4.9095	4.8689

Minimum Number of Trays:

Fenske Eqⁿ:

$$N = P \log \left[\frac{x_a}{(1-x_a)} \left(\frac{1-x_b}{x_b} \right) \right]$$

$\log(d_{avg})$

x_a = mole fraction of light key in distillate

x_b = mole fraction of heavy key component at bottom

d_{avg} = mean of relative volatilities at top and bottom of the column

$$\text{At } 0^\circ \text{C: } d_{avg} = \sqrt{d_t d_b}, \quad P = 0.0329 \times 8.5644$$

$$= 9.27$$

$$238.0 \text{ to } 111.1 = 0$$

$$\begin{cases} d_t = d_{MB} = 10.0329 \\ d_b = d_{MB}_{\text{bottom}} = 8.5644 \end{cases}$$

$$N = \log \left[\frac{\frac{0.61}{1-0.61} \times \frac{0.17}{0.17-0.017}}{0.912} \right] = 0.912$$

$1 \times 200.0 + 0.5 \times 0.0 \times P_{H_2} \cdot 2 + 15.0 \times P_{H_2} \cdot P_1 = n_{min} + 1$

$P_1 = 0.0 \text{ We need Minimum tray.}$

$$n_{min} = 0.912$$

$$\frac{n_{min}}{2} = 0.456 = 0.46$$

$$n_{min} = 0.912$$

$$n_{min} = 0.912$$

Minimum Beflum Ratios : maximum superheat

by Underwood eqn :

$$\sum \left(\frac{d_i z_i + f}{d_i - \theta} \right) = 1 \quad q = 1$$

(parts) per

$$\sum \left(\frac{d_i z_i + f}{d_i - \theta} \right) = 1.14 \quad R_{\min}, \text{ when } \theta = 0.36$$

maximum for minimum R_{\min} , when $\theta = 0.36$

Saturated + light $\Rightarrow q = 1$ for saturation factor = zero
saturation sub

\therefore Substituting values,

$$\frac{9.8447 \times 0.639}{q.8447 - \theta} + \frac{5.649 \times 0.222}{5.649 - \theta} + \frac{0.005 \times 0.139}{1 - \theta} = 0$$

This gives $\theta = 1.14$ or 6.36

$\theta = 1.14$ gives R_{\min} as negative

$$\theta = 6.36 \text{ given } \frac{120-1}{120} + \frac{120-1}{120-1} = 6$$

(PS-P) part

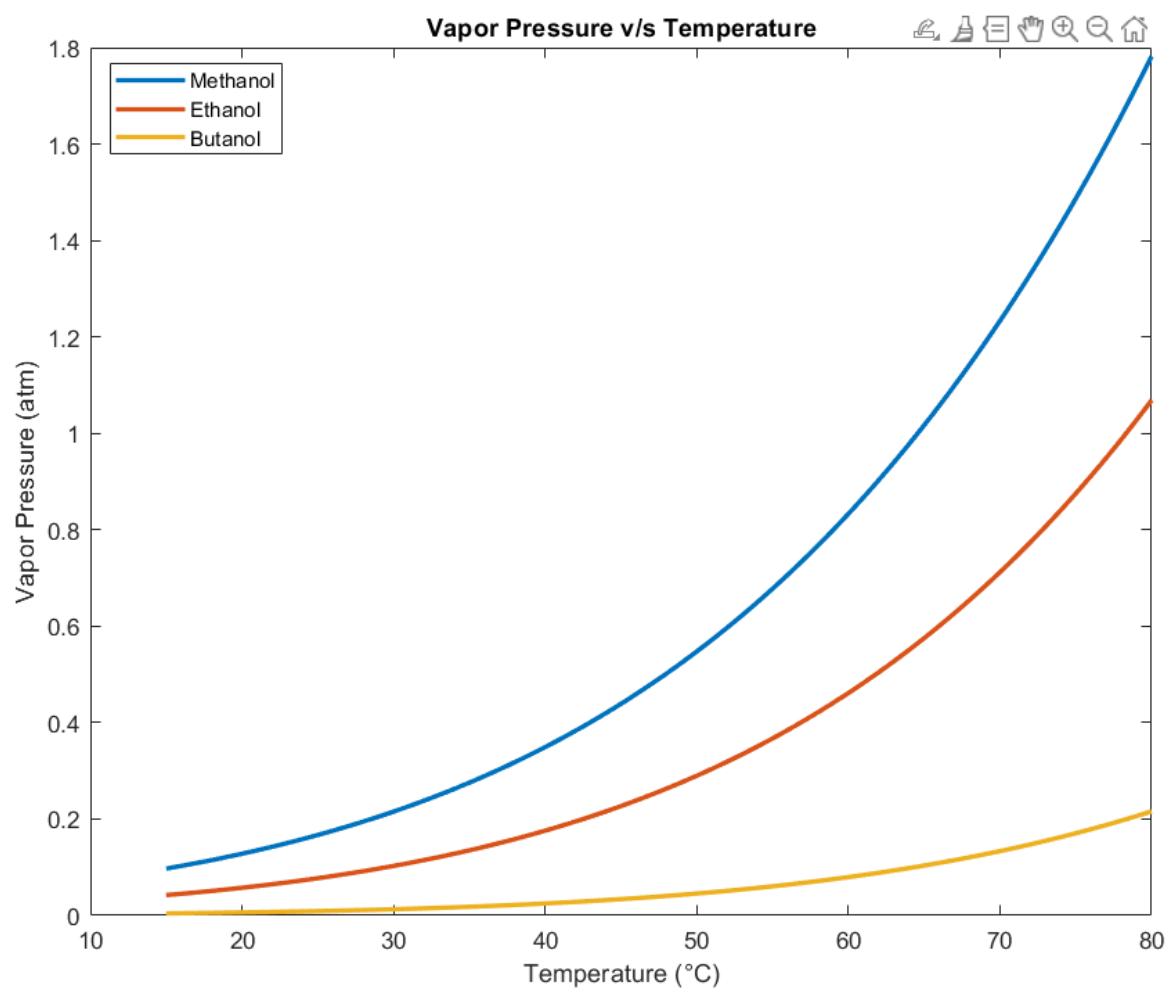
$$1 + R_{\min} = \frac{9.8447 \times 0.71}{9.8447 - 1.14} + \frac{5.649 \times 0.29}{5.649 - 1.14} + \frac{0.005 \times 1}{1 - 1.14}$$

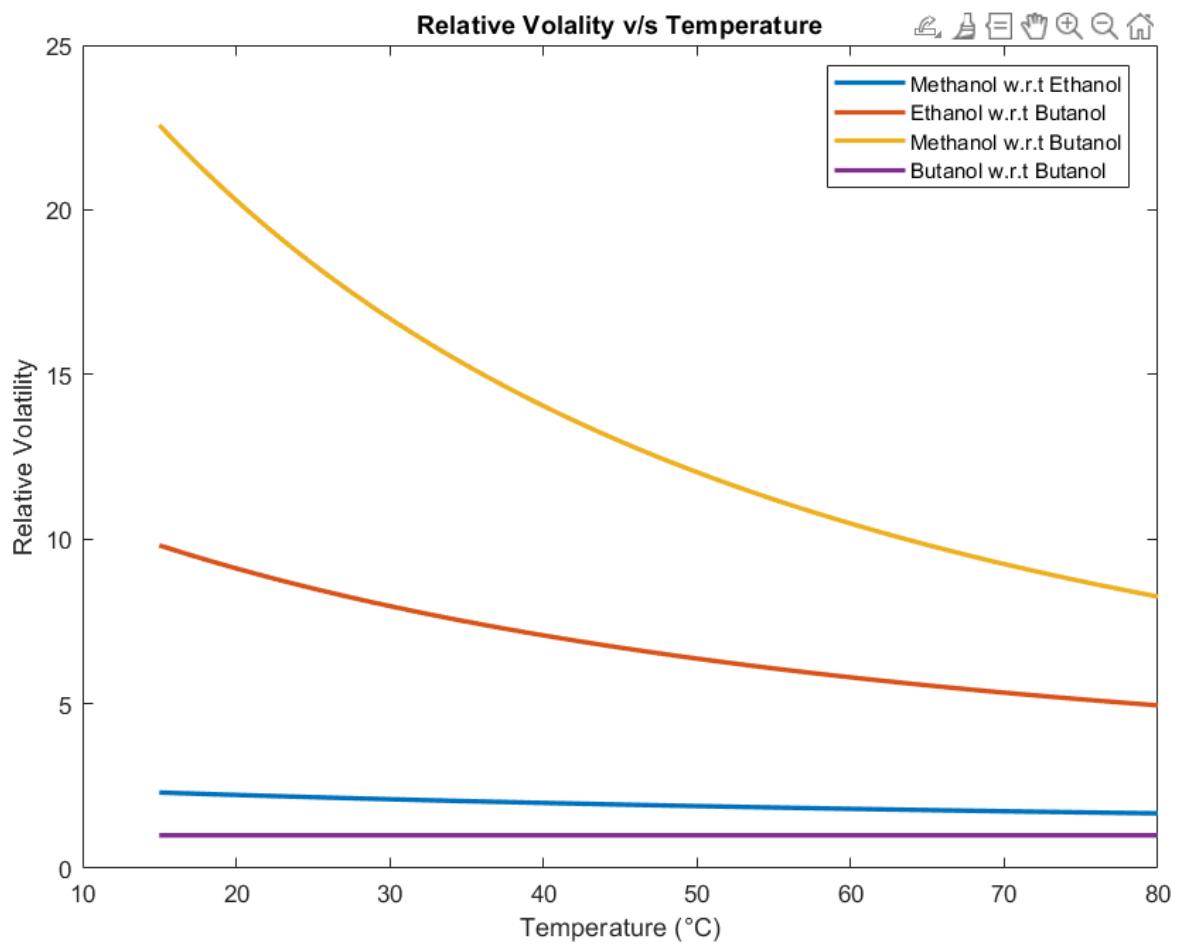
$$R_{\min} = 0.12$$

$\theta = 6.36$ gives

$$R_{\min} = -ve$$

$$\therefore R_{\min} = 0.12$$





Observations :

→ Right height

- 1) * Mole fraction of methanol increases from 0.61 (at total reflux) to 0.71 (at $R=1.9$) then decreased to 0.70 (at $R=1$) in the distillate
* For $R=1$, the mole fraction increases slightly with time in the distillate and bottom in next 10 min (at $R=1$)
P.I. at last 10 min
- 2) * Mole fraction of ethanol increases with decrease in reflux ratio at bottoms while decreases for decrease in reflux ratio at top in the distillate. Thus, the ratio of mole fraction of methanol to ethanol decreases for ethanol at the bottom, with time.
- 3) * Mole fraction of butanol obtained at the bottom increases with decrease in reflux ratio.
* Mole fraction of butanol at bottoms increases with time.

Conclusion :

- Minimum number of tray required is 1
- Minimum reflux ratio $R_{min} = 0.2$

Sources of Error :

- Miscommunication between the 8 people performing the experiment in noting the readings.
- Error in weighing cyclohexane
- Presence of impurities in sample put in GC

Hypothesis :-

Increasing reflux ratio should increase mole fraction of methanol

In first distillation of benzene + H₂O (P₁:1) 18% H₂O
Methanol 82% H₂O

We however observe a strange trend of first increase in methanol mole fraction as we reduce the reflux ratio from total to 1.9

also, major error after normal reflux (noting) John & (s
too others). This error could have been possibly due to, caused by
→ discrepancy in the reported and used value for cyclohexanone
with others as this area obtained is relatively huge, intergral.

→ Overlapped reading of Methanol & Ethanol by the GC (s
also note in sample
with after 24.05 ml added to formed nonsolvent NOM &

in beginning work to minor maximum ←
S.O = next other values working ←

at primed 8 ml resulted maximum ←
relative to today is theory (s)
maximum position of 10 ml ←
in last 2nd in 2nd → 10 ml ←

```
clc  
T = linspace(15,80,100)
```

```
T = 1x100  
15.0000 15.6566 16.3131 16.9697 17.6263 18.2828 18.9394 19.5960 ...
```

```
% Source for data  
% http://ddbonline.ddbst.com/AntoineCalculation/AntoineCalculationCGI.exe  
% Vapor Pressure for Methanol  
A_m = 8.08097;  
B_m = 1582.27;  
C_m = 239.7;  
P_methanol = 10.^(A_m - (B_m./(C_m+T))) ;  
P_methanol = P_methanol./760 % converting from mmHg to atm
```

```
P_methanol = 1x100  
0.0972 0.1009 0.1046 0.1085 0.1125 0.1167 0.1209 0.1253 ...
```

```
% Vapor Pressure for Ethanol  
A_e = 8.20417;  
B_e = 1642.89;  
C_e = 230.3;  
P_ethanol = 10.^(A_e - B_e./(C_e+T)) ;  
P_ethanol = P_ethanol./760 % converting from mmHg to atm
```

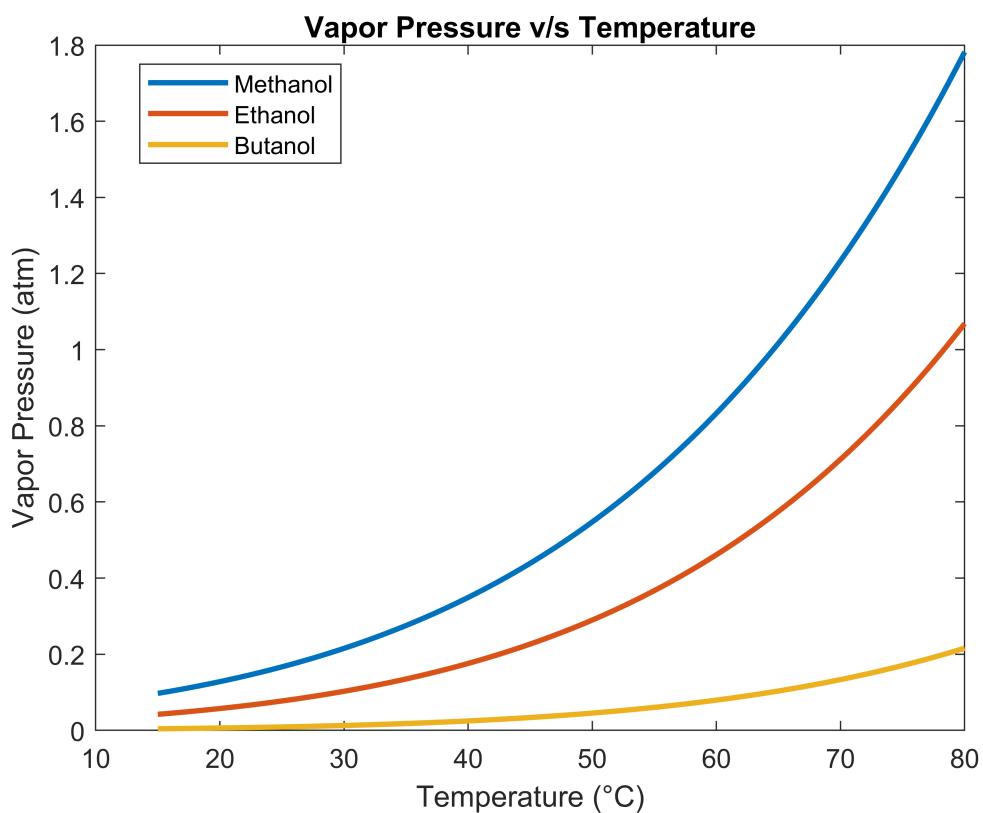
```
P_ethanol = 1x100  
0.0423 0.0440 0.0459 0.0478 0.0498 0.0518 0.0539 0.0561 ...
```

```
% Vapor Pressure for 1-Butanol  
A_b = 7.92484;  
B_b = 1617.52;  
C_b = 203.296;  
P_butanol = 10.^(A_b - B_b./(C_b+T)) ;  
P_butanol = P_butanol./760 % converting from mmHg to atm
```

```
P_butanol = 1x100  
0.0043 0.0045 0.0048 0.0050 0.0053 0.0055 0.0058 0.0061 ...
```

```
% Vapor Pressure Plot  
plot(T,P_methanol,LineWidth=2);  
hold on;  
plot(T,P_ethanol,LineWidth=2);  
plot(T,P_butanol,LineWidth=2);  
title("Vapor Pressure v/s Temperature");  
xlabel("Temperature (°C)");  
ylabel("Vapor Pressure (atm)");  
legend("Methanol","Ethanol","Butanol", Location = 'best');
```

hold off



% Relative Volatility Calculation

α ME = P methanol./ P ethanol % Methanol and Ethanol

`alpha_ME = 1x100`
2.3014 2.2913 2.2813 2.2715 2.2617 2.2521 2.2426 2.2332 ...

alpha EB = P ethanol./ P butanol % Ethanol and Butanol

```
alpha_EB = 1x100
    9.8087    9.7112    9.6154    9.5214    9.4292    9.3386    9.2496    9.1623 ...
```

alpha MB = P methanol./ P butanol % Methanol and Butanol

```
alpha_MB = 1x100
    22.5734   22.2510   21.9359   21.6276   21.3262   21.0314   20.7429   20.4607 ...
```

alpha BB = P butanol./P butanol

```
alpha_BB = 1×100
```

```

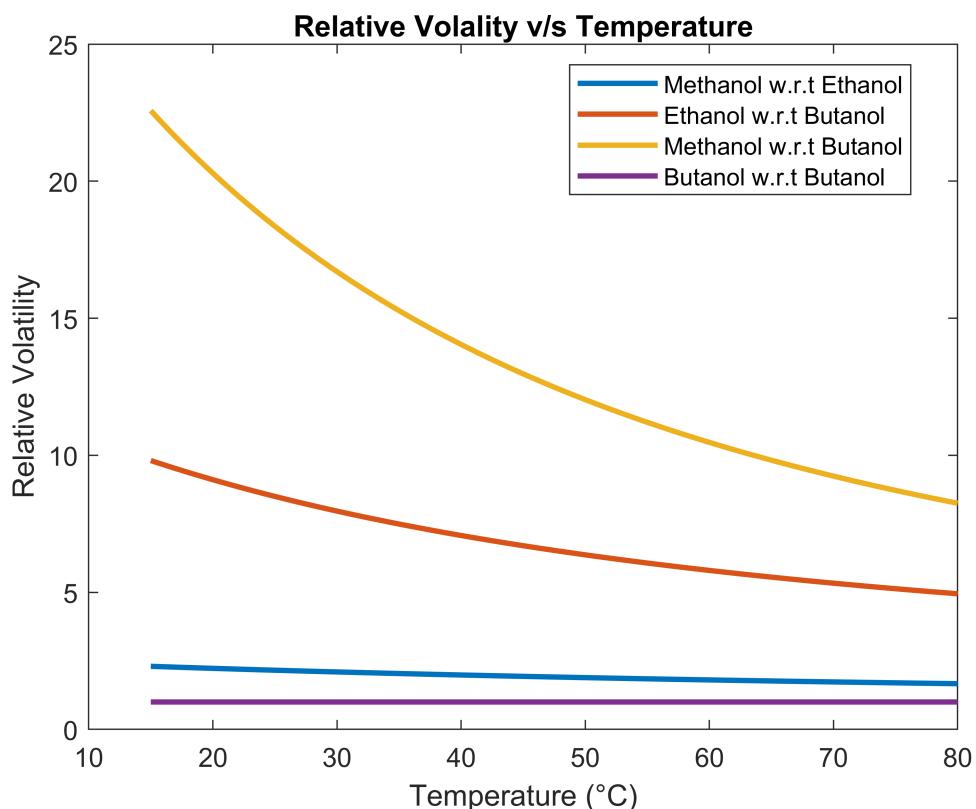
plot(T,alpha_ME,LineWidth=2);
hold on;
plot(T,alpha_EB,LineWidth=2);
plot(T,alpha_MB,LineWidth=2);
plot(T,alpha_BB,LineWidth=2);
title("Relative Volatility v/s Temperature");
xlabel("Temperature (°C)");

```

```

ylabel("Relative Volatility");
legend("Methanol w.r.t Ethanol","Ethanol w.r.t Butanol","Methanol w.r.t Butanol","Butanol w.r.t Ethanol");
hold off

```



%Total Reflux Vapor Pressures

```
T_bottom_tr = 76.6;
```

```
T_top_tr= 63.3;
```

```
P_methanol_top_tr = 10.^ (A_m - B_m./(C_m+T_top_tr));
```

```
P_methanol_top_tr = P_methanol_top_tr./760
```

```
P_methanol_top_tr = 0.9509
```

```
P_methanol_bottom_tr = 10.^ (A_m - B_m./(C_m+T_bottom_tr));
```

```
P_methanol_bottom_tr = P_methanol_bottom_tr./760
```

```
P_methanol_bottom_tr = 1.5766
```

```
P_ethanol_top_tr = 10.^ (A_e - B_e./(C_e+T_top_tr));
```

```
P_ethanol_top_tr = P_ethanol_top_tr./760
```

```
P_ethanol_top_tr = 0.5342
```

```
P_ethanol_bottom_tr = 10.^ (A_e - B_e./(C_e+T_bottom_tr));
```

```
P_ethanol_bottom_tr = P_ethanol_bottom_tr./760
```

```
P_ethanol_bottom_tr = 0.9336
```

```
P_butanol_top_tr = 10.^ (A_b - B_b ./ (C_b + T_top_tr));  
P_butanol_top_tr = P_butanol_top_tr./760
```

```
P_butanol_top_tr = 0.0948
```

```
P_butanol_bottom_tr = 10.^ (A_b - B_b ./ (C_b + T_bottom_tr));  
P_butanol_bottom_tr = P_butanol_bottom_tr./760
```

```
P_butanol_bottom_tr = 0.1841
```

```
% Relative Volatility Calculation
```

```
% Methanol and Ethanol
```

```
alpha_ME_top_tr = P_methanol_top_tr./ P_ethanol_top_tr
```

```
alpha_ME_top_tr = 1.7802
```

```
alpha_ME_bottom_tr = P_methanol_bottom_tr./ P_ethanol_bottom_tr
```

```
alpha_ME_bottom_tr = 1.6887
```

```
% Ethanol and Butanol
```

```
alpha_EB_top_tr = P_ethanol_top_tr./ P_butanol_top_tr
```

```
alpha_EB_top_tr = 5.6359
```

```
alpha_EB_bottom_tr = P_ethanol_bottom_tr./ P_butanol_bottom_tr
```

```
alpha_EB_bottom_tr = 5.0717
```

```
% Methanol and Butanol
```

```
alpha_MB_top_tr = P_methanol_top_tr./ P_butanol_top_tr
```

```
alpha_MB_top_tr = 10.0329
```

```
alpha_MB_bottom_tr = P_methanol_bottom_tr./ P_butanol_bottom_tr
```

```
alpha_MB_bottom_tr = 8.5644
```

```
%R = 1.9
```

```
T_bottom = 79.4
```

```
T_bottom = 79.4000
```

```
T_top= 64.8
```

```
T_top = 64.8000
```

```
P_methanol_top = 10.^ (A_m - B_m./(C_m+T_top));  
P_methanol_top = P_methanol_top./760
```

```
P_methanol_top = 1.0089
```

```
P_methanol_bottom = 10.^ (A_m - B_m./(C_m+T_bottom));  
P_methanol_bottom = P_methanol_bottom./760
```

```
P_methanol_bottom = 1.7443
```

```
P_ethanol_top = 10.^ (A_e - B_e./(C_e+T_top));  
P_ethanol_top = P_ethanol_top./760
```

```
P_ethanol_top = 0.5703
```

```
P_ethanol_bottom = 10.^ (A_e - B_e./(C_e+T_bottom));  
P_ethanol_bottom = P_ethanol_bottom./760
```

```
P_ethanol_bottom = 1.0437
```

```
P_butanol_top = 10.^ (A_b - B_b./(C_b+T_top));  
P_butanol_top = P_butanol_top./760
```

```
P_butanol_top = 0.1025
```

```
P_butanol_bottom = 10.^ (A_b - B_b./(C_b+T_bottom));  
P_butanol_bottom = P_butanol_bottom./760
```

```
P_butanol_bottom = 0.2100
```

```
% Relative Volatility Calculation  
% Methanol and Ethanol  
alpha_ME_top = P_methanol_top./ P_ethanol_top
```

```
alpha_ME_top = 1.7691
```

```
alpha_ME_bottom = P_methanol_bottom./ P_ethanol_bottom
```

```
alpha_ME_bottom = 1.6712
```

```
% Ethanol and Butanol  
alpha_EB_top = P_ethanol_top./ P_butanol_top
```

```
alpha_EB_top = 5.5649
```

```
alpha_EB_bottom = P_ethanol_bottom./ P_butanol_bottom
```

```
alpha_EB_bottom = 4.9695
```

```
% Methanol and Butanol
```

```
alpha_MB_top = P_methanol_top./ P_butanol_top
```

```
alpha_MB_top = 9.8447
```

```
alpha_MB_bottom = P_methanol_bottom./ P_butanol_bottom
```

```
alpha_MB_bottom = 8.3053
```

```
%R=1
```

```
T_bottom = 82.3
```

```
T_bottom = 82.3000
```

```
T_top= 65.7
```

```
T_top = 65.7000
```

```
P_methanol_top = 10.^ (A_m - B_m./(C_m+T_top));
```

```
P_methanol_top = P_methanol_top./760
```

```
P_methanol_top = 1.0452
```

```
P_methanol_bottom = 10.^ (A_m - B_m./(C_m+T_bottom));
```

```
P_methanol_bottom = P_methanol_bottom./760
```

```
P_methanol_bottom = 1.9332
```

```
P_ethanol_top = 10.^ (A_e - B_e./(C_e+T_top));
```

```
P_ethanol_top = P_ethanol_top./760
```

```
P_ethanol_top = 0.5930
```

```
P_ethanol_bottom = 10.^ (A_e - B_e./(C_e+T_bottom));
```

```
P_ethanol_bottom = P_ethanol_bottom./760
```

```
P_ethanol_bottom = 1.1689
```

```
P_butanol_top = 10.^ (A_b - B_b./(C_b+T_top));
```

```
P_butanol_top = P_butanol_top./760
```

```
P_butanol_top = 0.1074
```

```
P_butanol_bottom = 10.^ (A_b - B_b./(C_b+T_bottom));
```

```
P_butanol_bottom = P_butanol_bottom./760
```

```
P_butanol_bottom = 0.2401
```

```
% Relative Volatility Calculation
```

```
% Methanol and Ethanol
```

```
alpha_ME_top = P_methanol_top./ P_ethanol_top
```

```
alpha_ME_top = 1.7625
```

```
alpha_ME_bottom = P_methanol_bottom./ P_ethanol_bottom
```

```
alpha_ME_bottom = 1.6538
```

```
% Ethanol and Butanol
```

```
alpha_EB_top = P_ethanol_top./ P_butanol_top
```

```
alpha_EB_top = 5.5233
```

```
alpha_EB_bottom = P_ethanol_bottom./ P_butanol_bottom
```

```
alpha_EB_bottom = 4.8689
```

```
% Methanol and Butanol
```

```
alpha_MB_top = P_methanol_top./ P_butanol_top
```

```
alpha_MB_top = 9.7348
```

```
alpha_MB_bottom = P_methanol_bottom./ P_butanol_bottom
```

```
alpha_MB_bottom = 8.0522
```

Calculations:

<https://docs.google.com/spreadsheets/d/12g8-Yh2Qh2XQK6XGBpmZK13OCQcWEC40umOc51WMxzU/edit#gid=0>