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APPENDIX A

DENSITY OF STYRENE-BUTADIENE

In this work the density of styrene-butadiene is measured at room temperature (25°C) using water displacement principle as follows: the dry empty pyconometer is weighed. Ten pellets of styrene-butadiene of known weight are carefully dropped into the filled pyconometer and the water displacement of styrene-butadiene pellets which over flowed from the pyconometer is wiped off-using a clean towel. the final weight of the pyconometer with styrene-butadiene pellets and water is determined. The density value can then be easily calculated as follows

Determintion of density of solid particles :

1. Weight of empty empty pycnometer, m_1 = 62.1362 g.
2. Weight of pycnometer + Water, m_2 = 73.3245 g.
3. Weight of twenty styrene-butadiene pellets, m_3 = 1.0197 g.
4. Weight of pynometer+Water + Styrene-butadiene pellets, m_4 = 72.9340 g.
5. Density of Water =1.00000 g/cc.
6. Volume of solid particles by water displacement, m_2 - (m_4-m_3) /Density of water at 30 °C, V = 1.4102 g/cc.
7. Density of solid particles, ρ_s = m_3 /V

$$= \frac{1.0197}{1.4102} \text{ g/cc.}$$

$$\rho_s = 0.7231 \text{ g/cc.}$$

APPENDIX B

SOLUBILITY vs TEMPERATURE

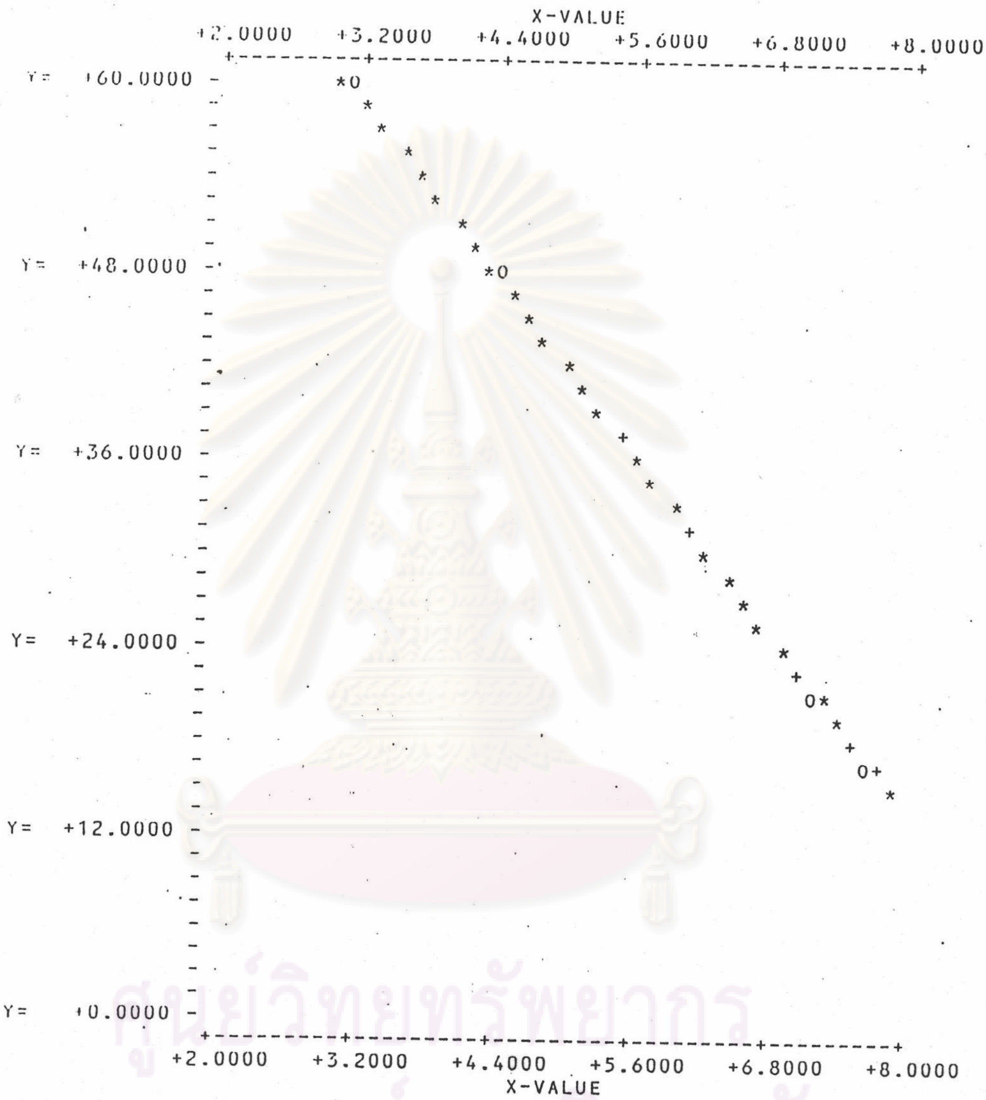
FT-IRspectrometer model 2000 is used to detect Styrene-Butadiene concentraton at a wave length 700cm^{-1}. The mass needed to saturate the liquid*(Ws)* at a specific temperature is measured as %transmitance and converted to %wt by calibration curve (Figure B1)

Accurate value of saturation concentration (solubility) are essential for a proper calculation of mass diffusion solubility of styrene-butadiene vs temperature

Temperature (°C)	Solubility (g of solute/1000 cm^3 of mineral oil)		
	% T	% wt	Solute,Ws (g)
95	59.52	3.07	231.5087
100	47.39	4.38	330.2958
105	37.31	5.46	411.7386
110	31.44	6.09	459.2469
115	22.99	7.01	528.6200
120	21.23	7.20	542.9520
125	18.45	7.50	565.5750
130	17.24	7.63	575.3783
135	17.21	7.63	575.3783
140	16.23	7.73	582.9193

Figure B1 : Calibration curve of % transmitance and converted to %wt of solid

CURVE	EQUATION-FORM	A	B	R-SQUARED	ADJ. R^2
1	Y = A+B*X	+87.992561	-9.276540	0.999996	0.999996



CURVE	EQUATION-FORM	A	B	R-SQUARED	ADJ. R^2
1	Y = A+B*X	+87.992561	-9.276540	0.999996	0.999996

OBSN	X	Y	FITTED-Y	RESID.ERROR	%ERROR
1	3.0700	59.5200	59.5136	0.0064	0.01
2	4.3800	47.3900	47.3613	0.0287	0.06
3	5.4600	37.3100	37.3427	-0.0327	0.09
4	6.0900	31.4400	31.4984	-0.0584	0.19
5	7.0100	22.9900	22.9640	0.0260	0.11
6	7.2000	21.2300	21.2015	0.0285	0.13
7	7.5000	18.4500	18.4185	0.0315	0.17
8	7.6300	17.2400	17.2126	0.0274	0.16
9	7.6300	17.2100	17.2126	-0.0026	0.01
10	7.7300	16.2300	16.2849	-0.0549	0.34

MEAN ABSOLUTE % ERROR .1275128
MEAN SQUARE ERROR 1.159968E-03

APPENDIX C

VISCOSITY OF MINERAL OIL vs TEMPERATURE

Temperature (°C)	Viscosity (Poise) x10^2
60	11.5838
70	7.2864
80	5.5640
90	4.4357
100	3.4722
110	3.2009
120	3.1070
130	2.9970
140	2.9765

APPENDIX D

DENSITY OF MINERAL OIL vs TEMPERATURE

Temperature (°C)	Density x10^3 (g/cm^3)
26	0.8632
90	0.6591
100	0.6478
110	0.6315
115	0.6215
120	0.6205
125	0.6205
130	0.6198
135	0.6145

APPENDIX E

VISCOSITY OF STYRENE - BUTADIENE vs TEMPERATURE

E.1 Viscosity of 2wt% Styrene-Butadiene in Mineral Oil vs Temperature

Temperature (°C)	Viscosity (Poise)x10^2
60	28.4105
70	18.4795
80	11.8033
90	8.1951
110	6.6801
115	6.2819
120	6.1382
125	6.0749
130	6.0402
135	6.0206
140	6.0076

APPENDIX E

VISCOSITY OF STYRENE - BUTADIENE vs TEMPERATURE

E.2 Viscosity of 3wt% Styrene-Butadiene in Mineral Oil vs Temperature

Temperature (°C)	Viscosity (Poise)x10^2
70	52.5201
80	31.8203
90	18.7933
100	12.7466
105	10.0105
110	9.3706
115	8.9004
120	8.6131
125	8.4956
130	8.3911
135	8.2474
140	8.1625

APPENDIX E

VISCOSITY OF STYRENE - BUTADIENE vs TEMPERATURE

E.3 Viscosity of 4wt% Styrene-Butadiene in Mineral Oil vs Temperature

Temperature (°C)	Viscosity (Poise)
60	83.7192
70	50.8971
80	29.3542
90	18.4995
100	16.4360
110	11.0161
115	10.5459
120	10.2978
125	10.0170
130	9.8276
135	9.6840
140	9.5338

APPENDIX F

DENSITY OF STYRENE - BUTADIENE vs TEMPERATURE

F.1 Density of 2wt% Styrene-Butadiene in Mineral Oil vs Temperature

Temperature (°C)	Density (g/cm^3)
26	0.8582
40	0.8356
50	0.8334
60	0.8012
70	0.7611
80	0.7030
90	0.6530
100	0.6530
110	0.6530
120	0.6530
130	0.6530
140	0.6530

APPENDIX F

DENSITY OF STYRENE - BUTADIENE vs TEMPERATURE

F.2 Density of 3wt% Styrene-Butadiene in Mineral Oil vs Temperature

Temperature (°C)	Density (g/cm^3)
26	0.8656
50	0.8412
60	0.8010
70	0.7605
80	0.7029
90	0.6530
100	0.6530
110	0.6530
120	0.6530
130	0.6530
140	0.6530

APPENDIX F

DENSITY OF STYRENE - BUTADIENE vs TEMPERATURE

F.3 Density of 4wt% Styrene-Butadiene in Mineral Oil vs Temperature

Temperature (°C)	Density (g/cm^3)
26	0.8623
50	0.8378
60	0.8060
70	0.7656
80	0.7075
90	0.6530
100	0.6530
110	0.6530
120	0.6530
130	0.6530
140	0.6530

APPENDIX G

Diffusion coefficient vs Temperature.

G1 : Diffusivity Coefficient of Styrene - Butadiene of 2 wt % in Mineral Oil vs Temperature

Temp (C°)	D_v (cm^2/s)
115	1.5149×10^{-12}
120	1.4629×10^{-12}
125	1.4057×10^{-12}
130	1.3559×10^{-12}
135	1.3380×10^{-12}

G2 : Diffusivity Coefficient of Styrene - Butadiene of 3 wt % in Mineral Oil vs Temperature.

Temp (C°)	D_v (cm^2/s)
115	1.5149×10^{-12}
120	1.4629×10^{-12}
125	1.4057×10^{-12}
130	1.3559×10^{-12}
135	1.3380×10^{-12}

APPENDIX G

G3 : Diffusion Coefficient of Styrene - Butadiene of 4 wt % in Mineral Oil vs Temperature

Temperature (C°)	D_v (cm^2/s)
115	1.3922×10^{-12}
120	1.4015×10^{-12}
125	1.4041×10^{-12}
130	1.4037×10^{-12}
135	1.4022×10^{-12}

APPENDIX H

Dissolution Rate Coefficient of Styrene-Butadiene
In Mineral Oil vs Temperature.

H1 : Dissolution Rate Coefficient of 2wt%of Styrene - Butadiene of in Mineral Oil vs Temperature (120°C)

Speed of standard 6-blade turbine (rpm)	*K* (cm/s) $\times 10^2$
350	4.1910
400	4.7430
450	4.8420
500	7.6624
550	9.1176

H2 : Dissolution Rate Coefficient of 3wt%of Styrene - Butadiene of in Mineral Oil vs Temperature (120°C)

Speed of standard 6-blade turbine (rpm)	*K* (cm/s) $\times 10^2$
350	2.2163
400	2.5896
450	2.7389
500	2.8327
550	3.2497

APPENDIX H

Dissolution Rate Coefficient of Styrene-Butadiene in Mineral Oil vs Temperature.

H3 : Dissolution Rate Coefficient of 4wt%of Styrene - Butadiene of in Mineral Oil vs Temperature (120°C)

Speed of standard 6-blade turbine (rpm)	K (cm/s) $\times 10^2$
350	2.2940
400	2.2592
450	2.5349
500	2.9771
550	3.0787

H4 : Dissolution Rate Coefficient of 2wt%of Styrene - Butadiene of in Mineral Oil vs Temperature (120°C)

Speed of paddle (rpm)	K (cm/s) $\times 10^2$
350	3.1162
400	3.1648
450	3.6237
500	4.3856
550	5.8371

APPENDIX H

Dissolution Rate Coefficient of Styrene-Butadiene
In Mineral Oil vs Temperature.

H5 : Dissolution Rate Coefficient of 3wt%of Styrene - Butadiene of in Mineral Oil vs Temperature (120°C)

Speed of paddle (rpm)	*K* (cm/s) x10^2
350	2.1397
400	2.1888
450	2.4864
500	2.5509
550	2.7316

H6 : Dissolution Rate Coefficient of 4wt%of Styrene - Butadiene of in Mineral Oil vs Temperature (120°C)

Speed of Paddle (rpm)	*K* (cm/s) x10^2
350	2.1846
400	2.3706
450	2.4627
500	2.5329
550	2.7951

APPENDIX H

Dissolution Rate Coefficient of Styrene-Butadiene in Mineral Oil vs Temperature.

H7 : Dissolution Rate Coefficient of 2wt%of Styrene - Butadiene of in Mineral Oil vs Temperature for Standard 6-Blade Turbine (550rpm)

Temperature (°C)	K (cm/s) x10^2
350	2.3901
400	2.6908
450	2.8284
500	3.1970
550	3.4783

H8 : Dissolution Rate Coefficient of 3wt%of Styrene - Butadiene of in Mineral Oil vs Temperature for Standard 6-Blade turbine (550rpm)

Temperature (°C)	K (cm/s) x10^2
135	2.5971
130	2.8175
125	3.2638
120	3.3861
115	3.8369

APPENDIX H

Dissolution Rate Coefficient of Styrene-Butadiene

In Mineral Oil vs Temperature.

H9 : Dissolution Rate Coefficient of 4wt%of Styrene - Butadiene of in Mineral Oil vs Temperature for Standard 6-Blade Turbine (550rpm)

Temperature (°C)	*K* (cm/s) $x10^2$
135	2.7293
130	3.2551
125	3.5906
120	3.7565
115	4.1695

H10 : Dissolution Rate Coefficient of 2wt%of Styrene - Butadiene of in Mineral Oil vs Temperature for Paddle (550rpm)

Temperature (°C)	*K* (cm/s) $x10^2$
350	1.7446
400	2.0221
450	2.2513
500	2.2900
550	2.7443

APPENDIX H

Dissolution Rate Coefficient of Styrene-Butadiene in Mineral Oil vs Temperature.

H11 : Dissolution Rate Coefficient of 3wt%of Styrene - Butadiene of in Mineral Oil vs Temperature for Paddle (550rpm)

Temperature (°C)	K (cm/s) $\times 10^2$
135	2.6173
130	2.9545
125	3.1172
120	3.2632
115	3.63818

H12 : Dissolution Rate Coefficient of 4wt%of Styrene - Butadiene of in Mineral Oil vs Temperature for Paddle (550rpm)

Temperature (°C)	K (cm/s) $\times 10^2$
135	2.9622
130	3.1442
125	3.4677
120	3.4902
115	4.0948

APPENDIX I

SOLID CONCENTRATION DISSOLVED IN MINERAL OIL MEASURED BY FT-IR spectrophotometer

FT-IRspectrometer model 2000 is used to detect %transmitance of Styrene-Butadiene at a wave length 700cm^{-1}.The calibration curve is shown in Figure I1 . The Styrene-Butadiene transmitance (%) is converted to mass of solid particles dissolved(*W*) by calibration curve data (Figure I2) of each experiment. At the and of each experiment, the calibration data of various can.

For example,to find the mass of solid particles dissolved (*W*) of the experiment data at the temperature of 120°C, the rotation speed of 350,400 and 450 rpm and the experimental period 30 mins,they are shown in table I1 and Figure I3

Table I1: Calibration data of 0-4%wt & 50-88%T of Styrene-Butadiene is measured by FT-IR spectrophotometer

OBSN	X	Y	FITTED-Y	RESID.ERROR	%ERROR
1	0.0000	88.0000	87.9992	0.0008	0.00
2	0.2000	86.1400	86.1436	-0.0036	0.00
3	0.4000	84.2900	84.2879	0.0021	0.00
4	0.6000	82.4300	82.4323	-0.0023	0.00
5	0.8000	80.5800	80.5767	0.0033	0.00
6	1.0000	78.7200	78.7210	-0.0010	0.00
7	1.2000	76.8700	76.8654	0.0046	0.01
8	1.4000	75.0100	75.0098	0.0002	0.00
9	1.6000	73.1500	73.1541	-0.0041	0.01
10	1.8000	71.3000	71.2985	0.0015	0.00
11	2.0000	69.4400	69.4429	-0.0029	0.00
12	2.2000	67.5900	67.5872	0.0028	0.00
13	2.4000	65.7300	65.7316	-0.0016	0.00
14	2.6000	63.8800	63.8760	0.0040	0.01
15	2.8000	62.0200	62.0203	-0.0003	0.00
16	3.0000	60.1600	60.1647	-0.0047	0.01
17	3.2000	58.3100	58.3090	0.0010	0.00
18	3.4000	56.4500	56.4534	-0.0034	0.01
19	3.6000	54.6000	54.5978	0.0022	0.00
20	3.8000	52.7400	52.7421	-0.0021	0.00
21	4.0000	50.8900	50.8865	0.0035	0.01

MEAN ABSOLUTE % ERROR 3.702068E-03
MEAN SQUARE ERROR 7.940325E-06

Figure I1: Calibration Curve of 0-4wt% of Styrene-Butadiene vs % transmitance are measured by FT-IR

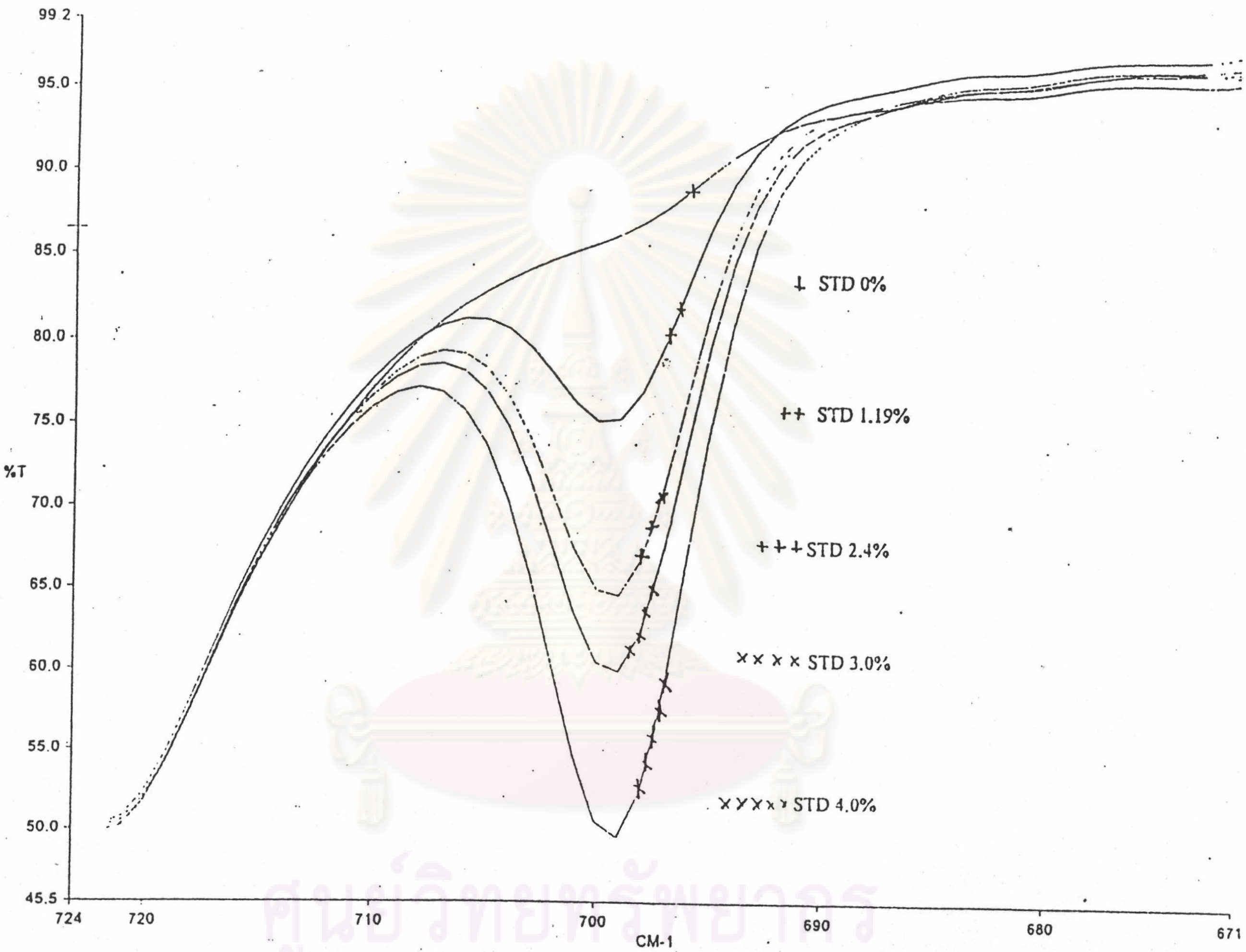


Figure I2 : Calibration Curve of 0-4wt% of Styrene-Butadiene are Calculated by Least-Square Method

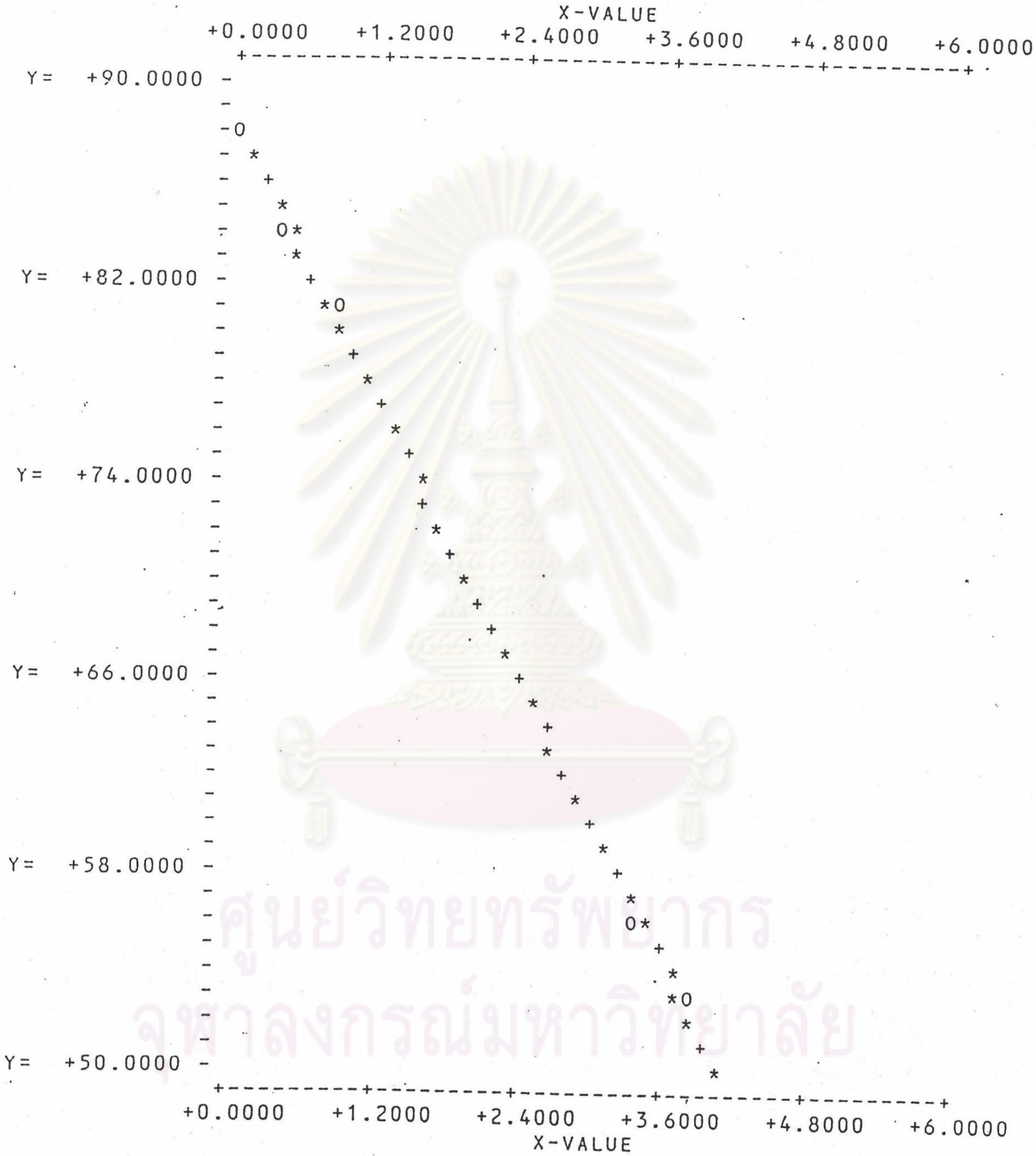
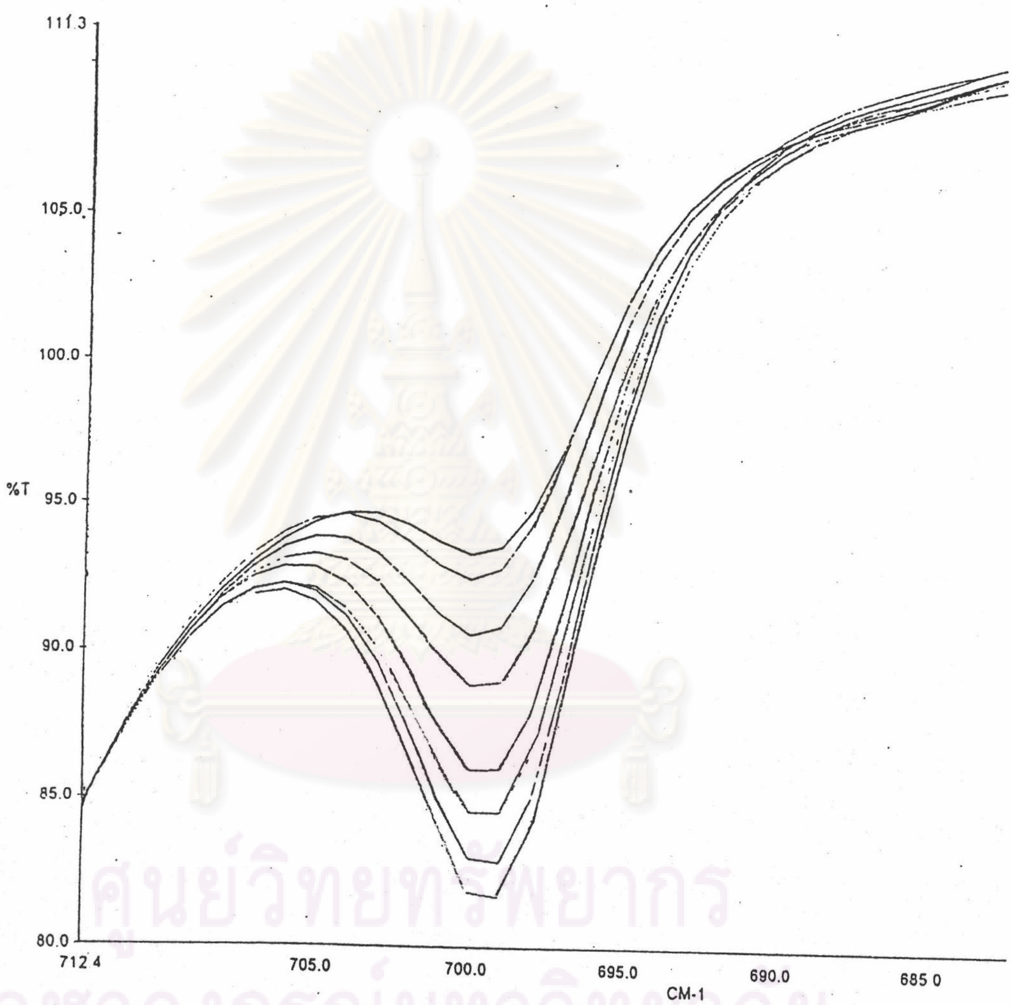


Table I2: Example data of 2wt% of Styrene-Butadiene in mineral oil at 350,400 and 450 rpm,120°C are measured by FT-IR spectrophometer and converted by calibration curve (Figure I2)

TIME	350rpm			400rpm			450rpm		
(min)	%T	%wt	W(g)	%T	%wt	W(g)	%T	%wt	W(g)
5	88	0.015	1.1312	87.3	0.0176	1.3272	82.8	0.0214	1.6164
10	86.6	0.152	11.4621	86.1	0.210	15.8361	75.2	0.530	39.9673
15	84.6	0.335	25.2600	84.5	0.380	28.6558	72.1	0.780	58.8198
20	83.1	0.565	42.6067	81.3	0.720	54.2952	71.9	0.950	71.6395
25	82.2	0.650	49.0165	80.2	0.840	63.3444	71.3	1.150	86.7215
30	81.0	0.750	56.5575	79.8	0.880	66.3608	70.8	1.340	101.049
35	78.1	1.000	75.4100	76.3	1.120	84.4592	70.4	1.580	119.147
40	73.5	1.500	113.869	71.2	1.550	116.885	70.1	1.880	141.770
45	71.3	1.800	135.738	69.2	1.852	139.058	69.7	1.900	143.279
50	68.8	1.850	139.508	68.8	1.860	140.262	69.5	1.910	144.033
55	68.7	1.851	139.509	68.9	1.871	141.016	-	-	-

Figure I3 : Example Data of 2wt% of Styrene-Butadiene in mineral oil of the experiment are measured by FT-IR spectrophotometer at 120°C, 350, 400 and 450 rpm.



APPENDIX J

DIMENSIONAL ANALYSIS OF SOLID DISSOLUTION CORRELATION

In solid - liquid agitation the entire solid dissolution relation can be expressed by five independent variables as follows :

$$K = f(T, D_i, \mu, \rho, D_v, w)$$

Where D_v is the diffusion coefficient of a solid in liquid

w is the rotation speed of the agitator.

Let $K = C \; T^a \mu^6 \; \rho^c \; Dv^d \; w^e$

Where C is constant. the dimensions of each term may be expressed in term of Mass M, Length L, and time T units.

Equate the exponents for men., length and time, respectively to give.

$$(LT^{-1}) = (L)^a (ML^{-1} T^{-1})^b (ML^{-3})^c (L^2T^{-1})^d (T^{-1})^c$$

therefore,

$$M : O = b + c$$

$$L : 1 = a - b - 3c + 2d$$

$$T : -1 = -b - d - c$$

therefore,

$$b = -c$$

$$d = 1 - b - e$$

$$a = -1 + 2e.$$

Express the K in term of the exponents derived above to give.

$$K = C \; T^{(-1+2e)} \; \mu^{-c} \; \rho^c \; D_v^{(1+c-e)} \; w^e$$

therefore,

$$K = C \; T^{-1} D_v^{+1} \; (T^2 w\rho/\mu)^e \; (\mu/D_v)^e \; (\rho D_v)^c$$

Rearrange the term to give

$$KT/D_v = C \; (T^2 w\rho/\mu)^e \; (\mu/\rho D_v)^{e-c}$$

Let $p = c$, $q = e-c$ and rewrite equation as

$$KT/D_v = C(T^2 w\rho/\mu)^p \; (\mu/\rho D_v)^q$$

$$\text{or } KT/D_v = C(D_i^2 w\rho/\mu)^p \; (\mu/\rho D_v)^q$$

therefore, $Sh_T = f(Re_T, Sc)$ or $Sh_T = f(Re_a, Sc)$

APPENDIX K

SAMPLE CALCULATION FOR Sh_T, Re_a, Sc

2wt% styrene-butadiene dissolution in mineral oil on speed 350 rpm at temperature 120°C

1. Sherwood number , $Sh_T = KT/D_v$

1.1 Calculation of dissolution rate coefficient *(K)*

The dissolution rate coefficient are calculated from the equation (2.2) sample of dissolution rate coefficient calculation:

$$K = (V/\alpha_w t m^{2/3}) \left\{ 3^{0.5} \tan^{-1} \frac{(2\sqrt{3}m^{1/3}(W_o^{1/3}-W^{1/3})}{3m^{2/3}+(2W_o^{1/3}-m^{1/3})(2W^{1/3}-m^{1/3})} + \right.$$

$$\left. 1.1513\log \frac{(m^{1/3}+W_o^{1/3})^2}{(m^{1/3}+W^{1/3})^2} \right\} x \frac{\{m^{2/3}-m^{1/3} W^{1/3}+W^{2/3}\}}{\{m^{2/3}-m^{1/3} W_o^{1/3}+W_o^{2/3}\}} \quad ....(2.2)$$

where	α_w	=	Shape factor relating the surface area with mass
	W_s	=	Mass needed to saturate the liquid [g]
	W_o	=	Total mass charged [g]
	K	=	Dissolution rate coefficient [cm/sec]
	t	=	Time [sec]
	W	=	Mass of solid particles [g]
	V	=	Volume of liquid (cm^3)
	A	=	Contact surface area of solid and liquid
	m	=	$Ws-Wo$

$$K = \left[\frac{12271.85}{\pi(300)\,(424.5583)^{2/3}} \right] \frac{3^{0.5}\tan^{-1} (2\sqrt{3}(424.5583)^{1/3}(150.82^{1/3}-1.1312^{1/3})}{3(424.5583)^{2/3}+(2(150.82)^{1/3}-(424.5583)^{1/3}} +$$

$$1.1513\log\frac{[(424.5583)^{1/3}+(150.82)^{1/3}]}{(424.5583)^{1/3}+(1.1312)^{1/3}}]2x\frac{[(424.5583)^{2/3}-(424.5583)^{1/3}}{(424.5583)^{2/3}-(424.5583)^{2/3}}$$

$$\frac{x\,(1.1312)^{1/3}+(1.1312)^{2/3}\ ]}{x\,(150.82)^{1/3}+(150.82)^{2/3}}$$

$K = 3.1162x10^{-2}$ cm/sec

(Appendix H)

1.2 Calculation of diffusion coefficient (D_v)

The diffusion coefficients are calculated from the equation (4.8)

$$D_{AB} = \frac{(\kappa T/\mu_B)}{3\pi \sqrt[3]{6/\pi(W/n\rho_s)}} \quad \text{.....................................(4.8)}$$

where :

κ	=	Boltzmamn constant = 1.38×10^{-16} ergs/K.
r_A	=	Solute particle radius [cm]
μ_B	=	Solvent viscosity [cSt]
T	=	Temperature [K]
W	=	Mans of solid particles [g]
n	=	Total number of solid particles
ρ_s	=	Density of solid particless [g/cm^3]

Sample of diffusion coefficients calculation :

$$Dv = \left[\frac{(1.38\text{x}10^{-16})(393)/2.9970\text{x}10^{-2}}{(3\pi(6/\pi(17.240)/(728)(0.7231))} \right]$$

$$= 4.5588\text{x}10^{-12} \text{ cm}^2\text{/s}$$

$$Sh_T = KT/D_v$$

$$= (0.03116)(25) / (4.5588\text{x}10^{-12})$$

$$= 1.7089\text{x}10^{11} \quad \text{(Appendix G)}$$

2. Schmidt number , $Sc = \mu / \rho D_v$

μ = $6.1382\text{x}10^{-2}$ P (Appendix....E1....)

ρ = 0.6145 g/cm^3 (Appendix....F1....)

Sc = $(6.1382\text{x}10^{-2}) / (0.6205)(4.5588\text{x}10^{-12})$

= $1.0595\text{x}10^{10}$

3. Reynolds number , $Re_a = Di^2 \rho N / \mu$

$Di^2 = (8.333)^2$ cm^2

$\mu = (2.9970 \times 10^{-2})$ P (Appendix....E1.....)

$\rho = (0.6205\ g/cm^3)$ (Appendix....F1....)

$N = 350$ rpm

$$Re_a = \frac{(8.333)^2 (0.6205)(350)}{(2.9970 \times 10^{-2})(60)} = 8.3864 \times 10^3 \text{ (Table 5.1)}$$

APPENDIX L

REPEATABILITY OF DATA

To find the repeatability of the experiment data are collected at the same condition i.e. at constant speed, temperature,solid-liquid system and time. The maximum relative error is calculated. Data of the system of styrene-butadiene - mineral oil are collected at the temperature of 120°C ,the rotation speed of 550 rpm and the experimental period 30 mins, They are shown below

Run no.	%Transmittance	%wt	Weight of dissolved Styrene-Butadiene (g)
1	69.7	1.97	148.44
2	69.8	1.96	147.69
3	69.4	2.00	150.71
4	69.7	1.97	148.44
5	69.8	1.96	147.69
6	69.5	1.99	149.95
Average	69.65	1.975	148.82

The maximum relative error of repeatability in this experiment is

$$[(150.71-147.69)/(147.69)]x100 = 2.05\ \%$$

APPENDIX M

CURVE FITTING

To draw the curve in order to correlate two variables the Least-Square methed is used. The logarithmic functions of Sherwood number and Reynolds number or Schmidt number are obtained as straight lines. The slope of each line indicates whether the variable has influence on the Sherwood number or not

1. The Influene of Reynolds Number

Figures 5.1-5.4 and 5.9-5.12 demonstrate the influence of Reynolds number on for Standard 6-blade turbine and Paddle respectively. The curves are drawn by least-square method. Data from table 5.1-5.3 and 5.7-5.9 are plotted. Each set of data gaves one straight line. Table M1 is a summary of the slopes and intercepts of each straight line. The average slope is 1.35 This is the exponent (p) of the Reynolds number in the correlation. This average slope is used to draw all curves again as shown in Figures 5.1-5.4 and 5.9-5.12

Table M1: Slopes and intercepts for relation between the Reynolds number and Sherwood number

For standard 6-blade turbine

Data from tables	Slope	Intercept
5.1	1.151	6.8438×10^{10}
5.2	1.238	6.7552×10^{10}
5.3	1.647	5.4699×10^{10}
	Average=1.35	

Table M2: Slopes and intercepts for relation between the Reynolds number and Sherwood number

For paddle

Data From Tables	Slope	Intercept
5.7	0.625	8.7707×10^{10}
5.8	0.581	9.0406×10^{10}
5.9	0.490	9.4091×10^{10}
	Average=0.57	

All Least-Square lines of table 5.1-5.3,5.4-5.6 and5.7-5.9,5.10-5.12 have the average slopes1.35,3.20,0.57 and 2.22 respectively.

2. The Influence of Schmidt Number on Sherwood Number

Figures 5.5-5.8 and 5.13-5.16 demonstrate the influence of the Schmidt number. The curves are drawn by Least-Square method. Data from Tables5.4-5.6 and 5.10-5.12 are plotted the same as above. The fitted curves of the data have the average slope is 3.20 and2.22 . This is the exponent of the Schmidt number in the Correlation for standard 6-blade disc turbine and paddle respectively.

Table M3 : Slope and intercepts method for the relation between the Schmidt number and Sherwood number

For standard 6-blade disc turbine

Data from tables	Slope	Intercept
5.4	2.938	-18.2419×10^{11}
5.5	1.713	-22.9581×10^{9}
5.6	2.323	-17.6784×10^{9}
	Average = 3.20	

The calculation of lines by using the averge slope,are not shown here

Table M4 : Slope and intercepts method for the relation between the Schmidt number and Sherwood number

For paddle

Data from tables	Slope	Intercept
5.10	2.587	-14.7466×10^{11}
5.11	1.442	-3.8633×10^{9}
5.12	2.632	-3.723×10^{9}
	Average = 2.22	

APPENDIX N

DETERMINATION OF THE CONSTANT, *r* IN THE CORRELATIONS

From the results the correlations are expressed in the from

$Sh_T = r\ Re_a^p\ Sc^q$ for Standard 6-Blade Turbine

$Sh_T = r\ Re_a^p\ Sc^q$ for Paddle

The value of r depends on the solid-liquid systems. To determine the constant, r the terms $Sh_T\ /Sc^q$ and Re_a are plotted on log-log scales,see Figure: N1 The relations give straight line having same slope 1.35 The constants, r are obtained by calculating the values of anti-logarithmic of the intercepts. Table :N1 show the results by least-squares method as described in Apendix M. The average value of Ao_{cal} are the intercepts of least-square lines. From Tables: N1-N6 the constant, r obtained as follows:

System	Constant, *r*
Standard 6-Blade Turbine	
I. 2wt% of Styrene-Butadiene	$9.0769\text{x}10^{-22}$
II. 3wt% of Styrene-Butadiene	$3.6008\text{x}10^{-23}$
III.4wt% of Styrene-Butadiene	$1.1397\text{x}10^{-23}$
Paddle	
IV. 2wt% of Styrene-Butadiene	$4.1153\text{x}10^{-12}$
V. 3wt% of Styrene-Butadiene	$2.8897\text{x}10^{-13}$
VI. 4wt% of styrene-Butadiene	$2.0053\text{x}10^{-13}$

Table N1 Calculation of Least-Square Line to Evaluate the Constant, *r*

Data from Table 5.1

STANDARD 6-BLADE TURBINE

The constant, *r* is Anti-Log A = 9.0769×10^{-22}

RPM	Sc	Re	Sh	cRe = $Sh/Sc^{3.20}$	X Log(Re)	Y Log(cRe)
	$\times 10^{10}$		$\times 10^{11}$	$\times 10^{-21}$		
350	1.0595	8.386.4	2.2983	1.9102	3.9236	-20.7189
400	1.0595	9584.4	2.6010	2.1618	3.9816	-20.6652
450	1.0595	10782.5	3.2020	2.6613	4.0327	-20.5749
500	1.0595	11980.5	3.3090	2.7503	4.0327	-20.5606
550	1.0595	13178.6	3.8970	3.2390	4.1199	-20.4896

Least-Squares Method are obtained by calculating the value of anti-logarithmic of intercept as below:


```
CURVE  EQUATION-FORM          A            B   R-SQUARED  ADJ. R^2
  1    Y = A+B*X         -21.042065   +0.173009  0.994638   0.992851

OBSN         X          Y      FITTED-Y   RESID.ERROR    %ERROR
  1       1.9102   -20.7189   -20.7116     -0.0073        0.04
  2       2.1618   -20.6652   -20.6681      0.0029        0.01
  3       2.6613   -20.5749   -20.5816      0.0067        0.03
  4       2.7503   -20.5606   -20.5662      0.0056        0.03
  5       3.2390   -20.4896   -20.4817     -0.0079        0.04

MEAN ABSOLUTE % ERROR     2.957979E-02
MEAN SQUARE ERROR         4.028441E-05
```

Table N2: Calculation of Least-Square Line to Evaluate the Constant, *r*

Data from Table 5.2

STANDARD 6-BLADE TURBINE

The constant, *r* is Anti-Log A = 3.6008×10^{-23}

RPM	Sc	Re	Sh	cRe = $Sh/Sc^{3.20}$	X Log(Re)	Y Log(cRe)
	$\times 10^{10}$	$\times 10^{3}$	$\times 10^{11}$	$\times 10^{-23}$		
350	2.8933	3.0710	2.2983	7.6727	3.4873	-22.1151
400	2.8933	3.5097	2.6010	8.6832	3.9816	-22.0600
450	2.8933	3.9483	3.2020	10.6896	4.0327	-21.9790
500	2.8933	4.3817	3.3090	11.0468	4.0785	-21.9567
550	2.8933	4.858	3.8970	13.0098	4.1199	-21.8857

Least-Squares Method are obtained by calculating the value of anti-logarithmic of intercept as below:

```
CURVE  EQUATION-FORM          A              B       R-SQUARED  ADJ. R^2
  1     Y = A+B*X       -22.443604     +0.043531   0.993585   0.991447

OBSN        X          Y       FITTED-Y   RESID.ERROR    %ERROR
  1      7.6727    -22.1151    -22.1096     -0.0055       0.02
  2      8.6832    -22.0660    -22.0656     -0.0004       0.00
  3     10.6896    -21.9700    -21.9783      0.0083       0.04
  4     11.0468    -21.9567    -21.9627      0.0060       0.03
  5     13.0098    -21.8857    -21.8773     -0.0084       0.04

MEAN ABSOLUTE % ERROR     2.604159E-02
MEAN SQUARE ERROR         4.123193E-05
```

Table N3: Calculation of Least-Square Line to Evaluate the Constant, *r*

Data from Table 5.3

STANDARD 6-BLADE TURBINE

The constant, *r* is Anti-Log A = 1.1397×10^{-23}

RPM	Sc	Re	Sh	cRe = $Sh/Sc^{3.20}$	X Log(Re)	Y Log(cRe)
	$\times 10^{10}$	$\times 10^{3}$	$\times 10^{11}$	$\times 10^{-23}$		
350	3.4592	2.5685	1.2580	2.3712	3.4097	-22.6250
400	3.4592	2.9355	1.3870	2.6143	3.4677	-22.5826
450	3.4592	3.3025	1.7010	3.2061	3.5188	-22.4947
500	3.4592	3.6693	1.9326	3.6427	3.5646	-22.4386
550	3.4592	4.0463	2.1883	4.1246	3.6071	-22.3846

Least-Squares Method are obtained by calculating the value of anti-logarithmic of intercept as below:

```
CURVE  EQUATION-FORM              A              B    R-SQUARED  ADJ. R^2
  1     Y  =  A+B*X          -22.943220     +0.137309   0.991785   0.989047

OBSN          X          Y        FITTED-Y   RESID.ERROR    %ERROR
  1       2.3712    -22.6250    -22.6176      -0.0074       0.03
  2       2.6143    -22.5826    -22.5843       0.0017       0.01
  3       3.2061    -22.4940    -22.5030       0.0090       0.04
  4       3.6427    -22.4386    -22.4430       0.0044       0.02
  5       4.1246    -22.3846    -22.3769      -0.0077       0.03

MEAN ABSOLUTE % ERROR      2.683513E-02
MEAN SQUARE ERROR          4.346569E-05
```

Table N4 :Calculation of Least-Square Line to Evaluate the Constant, *r*

Data from Table 5.7

PADDLE ,The constant,*r* is Anti-Log A =4.1153x10^{-12}

RPM	Sc	Re	Sh	cRe = Sh/Sc$^{2.22}$	X Log(Re)	Y Log(cRe)
	x1010	x103	x1011	x10-12		
350	1.0485	8.3864	1.7089	9.7063	3.9236	-11.0129
400	1.0485	9.5844	1.7520	9.9511	3.9815	-11.0021
450	1.0485	10.7825	1.9872	11.2870	4.0327	-10.9474
500	1.0485	11.9805	1.9890	11.2973	4.0785	-10.9470
550	1.0485	13.1786	2.2890	13.0012	4.1189	-10.8860

Least-Squares Method are obtained by calculating the value of anti-logarithmic of intercept as below:


```
CURVE  EQUATION-FORM              A              B    R-SQUARED  ADJ. R^2
  1     Y = A+B*X        -11.385598      +0.038604    0.990610   0.987480

OBSN          X           Y      FITTED-Y   RESID.ERROR    %ERROR
  1       9.7063    -11.0129    -11.0109      -0.0020       0.02
  2       9.9511    -11.0021    -11.0014      -0.0007       0.01
  3      11.2870    -10.9474    -10.9499       0.0025       0.02
  4      11.2973    -10.9470    -10.9495       0.0025       0.02
  5      13.0012    -10.8860    -10.8837      -0.0023       0.02

MEAN ABSOLUTE % ERROR     1.810022E-02
MEAN SQUARE ERROR         4.398562E-06
```

Table N5 :Calculation of Least-Square Line to Evaluate the Constant, *r*

Data from Table 5.8

PADDLE ,The constant,*r* is Anti-Log A =2.8897×10^{-13}

RPM	Sc	Re	Sh	cRe = $Sh/Sc^{2.22}$	X Log(Re)	Y Log(cRe)
	$\times 10^{10}$		$\times 10^{11}$	$\times 10^{-13}$		
350	2.8933	3071.0	1.1734	7.0009	3.4873	-12.1548
400	2.8933	3509.6	1.2090	7.2133	3.5453	-12.1419
450	2.8933	3948.3	1.3635	8.1351	3.5964	-12.0896
500	2.8933	4381.7	1.4208	8.4769	3.6416	-12.0718
550	2.8933	4825.8	1.4980	8.9375	3.6836	-12.0488

Least-Squares Method are obtained by calculating the value of anti-logarithmic of intercept as below:

```
CURVE EQUATION-FORM              A              B   R-SQUARED  ADJ. R^2
  1    Y = A+B*X           -12.539141     +0.055045   0.996682   0.995575

OBSN        X          Y       FITTED-Y   RESID.ERROR    %ERROR
   1     7.0009   -12.1548   -12.1538     -0.0010        0.01
   2     7.2133   -12.1419   -12.1421      0.0002        0.00
   3     8.1351   -12.0896   -12.0913      0.0017        0.01
   4     8.4769   -12.0718   -12.0725      0.0007        0.01
   5     8.9375   -12.0488   -12.0472     -0.0016        0.01

MEAN ABSOLUTE % ERROR     8.778679E-03
MEAN SQUARE ERROR         1.459701E-06
```

Table N6 :Calculation of Least-Square Line to Evaluate the Constant, *r*

Data from Table 5.9

PADDLE ,The constant,*r* is Anti-Log A =2.0053×10^{-13}

RPM	Sc	Re	Sh	cRe = $Sh/Sc^{2.22}$	X Log(Re)	Y Log(cRe)
	$\times 10^{10}$	$\times 10^{3}$	$\times 10^{11}$	$\times 10^{-13}$		
350	3.4592	2.5685	1.1980	4.8076	3.4097	-12.3181
400	3.4592	2.9355	1.3055	5.2390	3.4678	-12.2807
450	3.4592	3.3025	1.3508	5.4208	3.5188	-12.2659
500	3.4592	3.6693	1.3890	5.5741	3.5646	-12.2538
550	3.4592	4.0363	1.5328	6.1512	3.6059	-12.2110

Least-Squares Method are obtained by calculating the value of anti-logarithmic of intercept as below:

```
CURVE EQUATION-FORM              A               B    R-SQUARED  ADJ. R^2
  1    Y = A+B*X           -12.697830      +0.079420   0.996725   0.995634

OBSN        X          Y       FITTED-Y   RESID.ERROR   %ERROR
  1      4.8076   -12.3181   -12.3160     -0.0021       0.02
  2      5.2390   -12.2807   -12.2817      0.0010       0.01
  3      5.4208   -12.2659   -12.2673      0.0014       0.01
  4      5.5741   -12.2538   -12.2551      0.0013       0.01
  5      6.1512   -12.2110   -12.2093     -0.0017       0.01

MEAN ABSOLUTE % ERROR     1.235881E-02
MEAN SQUARE ERROR         2.42469E-06
```

BIOGRAPHY

Mr. Samarn Poboonchuin was born on July 10, 1965. He received his Bachelor of Engineering in Chemical Engineering from The Department of Chemical and Process Engineering, Faculty of Engineering, King Mongkut's Institute of Technology North Bangkok in 1990. He is at present work at The Shell Co., of Thailand Ltd. in a position of ISO 9000 Verifier at the Lubricating Oil Blending and Grease Plant in Chong Nonsri Installation Bangkok 10110.