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APPENDIX A: THEORY OF CAVITATION BUBBLES

Appendix A: Theory of cavitation bubbles [6]

Whenever the acoustic field is applied to a liquid, the pressure waves of the sonic vibrations create an acoustic pressure, P_a, which is time (t) dependent and can be represented by

$$P_a = P_A \sin 2\pi ft \quad \text{(A-1)}$$

where f is the frequency of the wave and P_A is the maximum pressure amplitude of the wave.

The progression of ultrasonic waves through a liquid medium in a series of compression and rarefaction caused the molecules oscillate about their mean position. If a sufficiently rarefaction ($P_c = P_h - P_a$) is applied to the liquid, the distance between the molecule exceeds the critical molecular distance (R) to hold the liquid intact, the liquid will break down and voids will be created, i.e., cavitation bubbles will formed.

Appendix A-1: Critical pressure (P_K) and bubble radius relationship

If a bubble radius R_e, present in a liquid is to remain in equilibrium, (i.e. neither contracting nor expanding), then the pressure acting on the bubble walls attempting to collapse the bubble must equal the pressure responsible for attempting to expand the bubble. In the case of expansion this pressure, P_{bub}, will be due to the trapped gas and vapour in the bubble, so that

$$P_{bub} = P_v + P_g \quad \text{(A-2)}$$

whilst for contraction the pressure, P_L, it is the combined effect of the hydrostatic pressure, P_h, within the liquid and the surface tension effect, $2\sigma / R_e$, i.e.

$$P_L = P_h + 2\sigma / R_e \quad \text{(A-3)}$$

At equilibrium, when neither expansion nor contraction occurs then $P_L = P_{bub}$, i.e.

$$P_h + 2\sigma / R_e = P_v + P_g \qquad \text{(A-4)}$$

Suppose the bubble now changes size to some new radius, R, as a result of a change in the hydrostatic pressure to a new value P'_h. Then, assuming ideal gas behaviour, the new gas pressure (P'_g) inside the bubble will become $P_g(R_e/R)^3$ and the new pressure in the bubble (P'_{bub}) will be given by

$$P'_{bub} = P_v + P'_g = P_v + P_g(R_e/R)^3 \qquad \text{(A-5)}$$

Since expansion of the bubble to R will decrease the surface tension effects, the new liquid pressure P'_L will be given by:

$$P'_L = P'_h + 2\sigma / R_e \qquad \text{(A-6)}$$

and if the bubble is still to be in equilibrium (i.e. $P'_L = P'_{bub}$) then

$$P'_h + 2\sigma / R_e = P_v + P_g(R_e/R)^3 \qquad \text{(A-7)}$$

or

$$P'_h = P_v + P_g(R_e/R)^3 - 2\sigma / R_e \qquad \text{(A-8)}$$

In other words the dependence of the radius, R, on the hydrostatic pressure of the liquid, P'_h., is not linear but has an inverse cubic dependence, such that for small but constant reduction in P'_h the radius increases quite rapidly. This is especially so when the hydrostatic is quite small. In fact there is a minimum critical hydrostatic pressure, a very small reduction of which causes a dramatic increase in R, i.e. the bubble becomes unstable and grows explosively. The radius at which this occurs may be termed the critical radius, R_K, and occurs when dP'_h/dR is effectively zero (i.e. small change in P'_h, large change in R).

An estimate may be made of this critical bubble radius, R_K, by differentiating the RHS of Equation (A-8), with respect to R, and equating to zero. That is

$$0 = -3P_g(R_e^3/R^4) - 0 + (2\sigma/R) \qquad \text{(A-9)}$$

Replacement of R by R_K yields

$$R_K^2 = \frac{3}{2\sigma}P_gR_e^3 \qquad \text{(A-10)}$$

If the critical pressure at which the bubble attains its critical radius, R_K, is denoted as P_K, then from (A-6) and (A-10)

$$P_K = P_v - \frac{2}{3}[(2\sigma/R)^3/P_g]^{1/2} \qquad \text{(A-11)}$$

Substitution of P_g (=$P_h - P_v + 2\sigma / R_e$) from (A-4) gives

$$P_K = P_v - \frac{2}{3}[(2\sigma/R)^3/3(P_h - P_v + 2\sigma / R_e)]^{1/2} \qquad \text{(A-12)}$$

If the presence of vapour in the bubble is neglected (i.e. $P_v \approx 0$) then the critical pressure may be given by

$$P_K = -\frac{2}{3}[(2\sigma/R)^3/3(P_h - P_v + 2\sigma / R_e)]^{1/2} \qquad \text{(A-13)}$$

The fact that the pressure is negative implies that a negative pressure must be applied to overcome the cohesive forces of a liquid and produce a bubble of radius R_e.

Appendix A-2: Time of bubble collapse

Consider an empty bubble collapsing under the influence of a constant external pressure P_h from an initial radius R_m to a final radius R in Figure A-1.

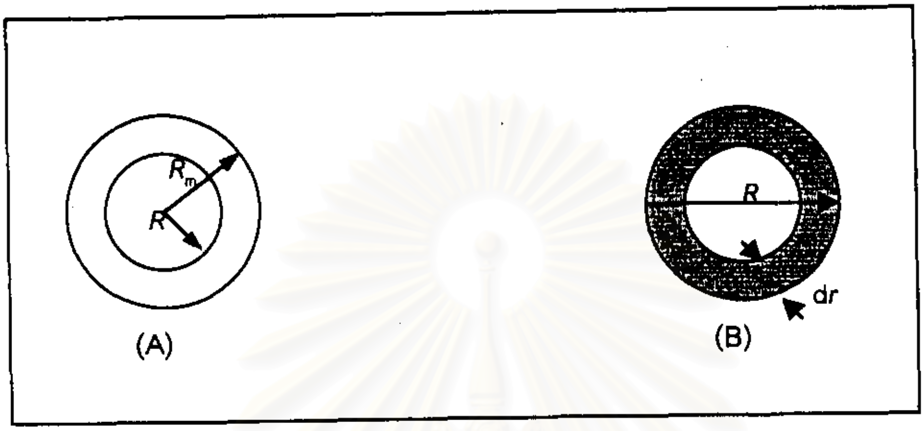


Figure A-1

The work done by the hydrostatic pressure, P_h, neglecting surface tension effects, is the product of the pressure and the change in volume and is given by

$$\int_{R}^{R_m} P_h 4\pi R^2 dR = P_h \frac{4\pi}{3}[R_m^{\ 3} - R^3] \qquad \text{(A-14)}$$

This work will be equal to the kinetic energy ($mv^2/2$) of the liquid as it moves to fill the space vacated by the collapse of the bubble and is given by $1/2\,\rho\, 4\pi r^2 dr(dr/dt)^2$, Figure A-1(B), where $4\pi r^2 dr$ = the volume of liquid moving and (dr/dt) is the velocity.

Thus

$$P_h \frac{4\pi}{3}[R_m^{\ 3} - R^3] = 2\pi\rho \int_{R}^{\infty} r^2 dr(dr/dt)^2 \qquad \text{(A-15)}$$

With the assumption of incompressible liquid, the volume lost by the cavity ($4\pi R^2 dR$) is equal to that filled by the liquid ($4\pi r^2 dr$), i.e.

$$R^2 dR = r^2 dr \tag{A-16}$$

Dividing both sides of Equation (A-16) by d*t* and rearranging yields

$$(dr/dt) = (R^2/r^2)(dR/dt) \tag{A-17}$$

Substitution into (A-15) gives

$$\frac{4\pi}{3}P_h[R_m^{\ 3} - R^3] = 2\pi\rho\int_R^\infty r^2 dr\frac{R^4}{r^4}\left(\frac{dR}{dt}\right)^2 = 2\pi\rho R^4\left(\frac{dR}{dt}\right)^2\int_R^\infty dr/r^2 \tag{A-18}$$

which on integration gives

$$\frac{4\pi}{3}P_h[R_m^{\ 3} - R^3] = 2\pi\rho R^4\left(\frac{dR}{dt}\right)^2\left[\frac{-1}{r}\right]_R^\infty$$

or more precisely

$$\frac{4\pi}{3}P_h[R_m^{\ 3} - R^3] = 2\pi\rho R^3\left(\frac{dR}{dt}\right)^2 \tag{A-19}$$

where RHS is equivalent to the kinetic energy of the liquid.

Rearranging gives

$$\left(\frac{dR}{dt}\right) = \left(\frac{2P_h}{3\rho}\right)^{1/2}\left(\frac{R_m^3}{R^3} - 1\right)^{1/2} \tag{A-20}$$

such that

$$dt = \frac{dR}{\left[\left(\frac{2P_h}{3\rho}\right)\left(\frac{R_m^3}{R^3} - 1\right)\right]^{1/2}} \tag{A-21}$$

The time to collapse the bubble can now be obtained by integrating RHS of (A-21) from R_m to zero to give

$$\tau \approx 0.915 R_m (\rho / P_h)^{1/2} \qquad \text{(A-22)}$$

In the presence of an acoustic field the pressure in the liquid (P_m) will be greater than the atmospheric pressure by an amount of P_a, i.e. $P_m = (P_h + P_a)$ where $P_a = P_A \sin 2\pi ft$, and Equation (3-36) may be modified to yield

$$\tau \approx 0.915 R_m (\rho / P_m)^{1/2} \qquad \text{(A-23)}$$

where P_m is the pressure in the fluid at the start of collapse of a bubble of radius R_m.

Appendix A-3: Motion of the bubble in the applied acoustic field

Consider the movement of a cavity containing gas and vapour, originally at a radius, R_e, due to and increase in the ambient hydrostatic pressure (P_h) by the application of an acoustic pressure wave (P_a).

At any instant in the compression cycle the new hydrostatic pressure, P'_h ($=P_h + P_a$) will cause the cavity radius to decrease from R_e to R (Figure A-2).

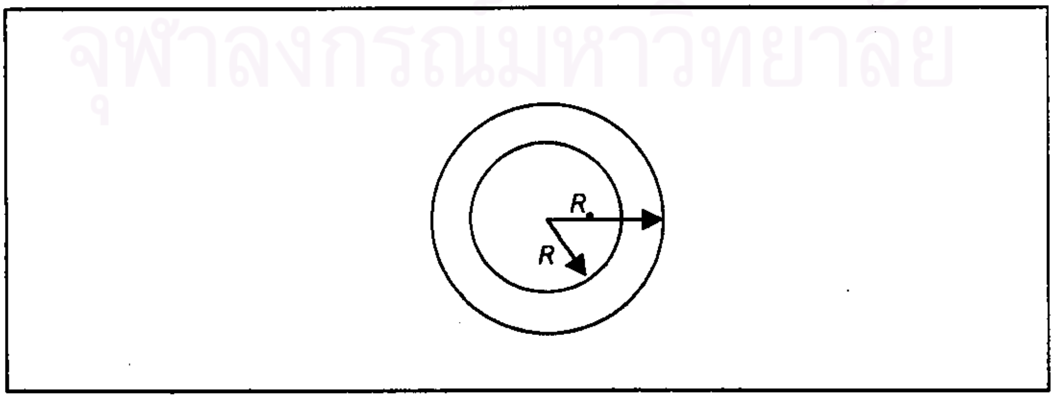


Figure A-2

This collapse will be augmented by an increase in the surface tension effect ($2\sigma/R$) as the cavity becomes smaller, i.e. the total collapse pressure is ($P'_h + 2\sigma/R$), but will be opposed by the increase in the pressure within the bubble due to the compression of gas, i.e. the expanding pressure, P'_{bub}.

By analogy with the empty cavity, the work done by the new hydrostatic pressure (P'_h), minus that of the layer adjacent to the bubble, is equal to the kinetic energy of the liquid.

$$-\int_{R_0}^{R} (P'_h + (2\sigma/R) - P'_{bub})\, 4\pi R^2 dR = 2\pi \rho R^3 \dot{R}^2 \tag{A-24}$$

Differentiation of (A-24) yields

$$(P'_{bub} - P'_h - (2\sigma/R))\, 4\pi R^2 dR = 2\pi\rho\,[3R^2\dot{R}^2 dR + R^3 2\ddot{R} dR] \tag{A-25}$$

Dividing by $2\pi R^2 dR$ and rearranging gives

$$R\ddot{R} + \frac{3}{2}\dot{R}^2 = \frac{1}{\rho}(P'_{bub} - P'_h - (2\sigma/R)) \tag{A-26}$$

Substitution of Equation (A-4) and Equation (A-5) into Equation (A-26) and replacement P_g gives, on neglecting vapour pressure (P_v=0), yields

$$R\ddot{R} + \frac{3}{2}\dot{R}^2 = \frac{1}{\rho}(\, P_h + (2\sigma/R))(R_0/R)^3 - (2\sigma/R) - P_h - P_a) \tag{A-27}$$

If the acoustic pressure, P_a, is replaced with $-P_A \sin\omega_A t$ (the form of appropriate for a sinusoidal wave of pressure amplitude P_A and circular frequency ω_A ($=2\pi f$).

$$R\ddot{R} + \frac{3}{2}\dot{R}^2 = \frac{1}{\rho}(\, P_h + (2\sigma/R))(R_0/R)^3 - (2\sigma/R) - P_h + P_A \sin\omega_A t) \tag{A-28}$$

Appendix A-4: Maximum bubble temperature (T_{max}) and pressure (P_{max})

From Equation (A-28), as it collapsed due to an external pressure P'_h,

$$R\ddot{R} + \frac{3}{2}\dot{R}^2 = \frac{1}{\rho}[P'_{bub} - P'_h - (2\sigma/R)] \tag{A-29}$$

where P'_{bub}, the pressure inside the bubble at a radius of R, was given by

$$P'_{bub} = P_v + P_g(R_e/R)^3 \tag{A-5}$$

(P_g = gas pressure in a bubble of initial radius R_e).

It has been argued from Equation (A-23): Appendix A-2 that the collapse time for a bubble, initially of radius R_e, is considerably shorter than the time period of the compression cycle. Thus the external pressure P'_h (= P_h + P_a), in the presence of an acoustic field, may be assumed to remain effectively constant (P_m) during the collapse period. Neglecting surface tension and vapour pressure effects, assuming adiabatic compression (i.e. very short compression time) and replacing R_e by R_m the size of the bubble at the start of collapse, the motion of the bubble wall becomes

$$R\ddot{R} + \frac{3}{2}\dot{R}^2 = \frac{1}{\rho}[P_g(R_m/R)^{3\gamma} - P_m] \tag{A-30}$$

With Z = $(R_m/R)^3$, the intregration of Equation (A-29) yields

$$\rho\dot{R}^2/2 = P_m(Z-1) - [\{P_g(Z-Z^{\gamma})\}/(1-\gamma)] \tag{A-31}$$

which on setting $R^2 = 0$ and rearranging yields

$$P_m(Z-1)(\gamma-1) = Pg\,(Z^{\gamma} - Z) \tag{A-32}$$

For very small values of R, (i.e. R_{min}), Z will be extremely large and (Z-1) approximates to Z, such that Equation (A-31) may be written as

$$P_m(\gamma - 1) \approx P_g Z^{\gamma - 1} \qquad \text{(A-33)}$$

which on rearrangement gives

$$Z = [P_m(\gamma - 1) / P_g]^{1/(\gamma - 1)} \qquad \text{(A-34)}$$

At the minimum cavity volume (V_{min}) the gas will have its maximum pressure value, P_{max}, such that

$$P_{max} V_{min}^{\gamma} = P_g V_{max}^{\gamma} \qquad \text{(A-36)}$$

And, as the volume of the cavity (V) is related to its radius (R) by $V = \frac{4}{3} \pi R^3$ then

$$(V_{max}/V_{min}) = (R_m/R_{min})^3 = Z \qquad \text{(A-37)}$$

and

$$(V_{max}/V_{min})^{\gamma} = P_{max}/P_g = Z^{\gamma} \qquad \text{(A-38)}$$

Replacement of Z from (A-24) and rearranging gives

$$P_{max} = P_g [P_m(\gamma - 1)/P_g]^{\gamma /(\gamma - 1)} \qquad \text{(A-39)}$$

At the instant of bubble collapse, this pressure will be released into the liquid. It is these very high liquid pressures which give rise to certain of well known effects of ultrasonic irradiation, such as cleaning and dispersion.

To find the maximum gas temperature attained at V_{min}, we apply

$$T_{max} V_{min}^{\gamma - 1} = T_{min} V_{max}^{\gamma - 1} \qquad \text{(A-40)}$$

i.e.

$$T_{max} = T_{min} [P_m(\gamma - 1)/P_g] \tag{A-41}$$

In most sonochemical applications T_{min} is taken to be the ambient (experimental) temperatures, and P_g as the vapour pressure of the liquid at that temperature.

APPENDIX B: EXAMPLES OF CALCULATION

Appendix B: Examples of calculation

1. Calculation of permeate flux, J

Permeate flux was calculated by dividing the permeate flow rate with filtration area (223.2 cm^2).

Example Data from Table C-9

Without ultrasound (sound intensity = 0), at 2nd minute the volume of permeate = 320 cm^3.

Since permeate was measured every 2 minutes or 120 seconds, then the permeate flow rate = 320 cm^3/ 120 s = 2.6667 cm^3/s.

Consequently, permeate flux, J = (2.6667 cm^3/s) / (223.2 cm^2) = 0.011947 $cm^3/cm^2.s$

2. Calculation of permeation resistance

As previously mentioned in cross-flow microfiltration principle, total permeation resistance, R_t can be calculated as follows,

$$J = \Delta P_{TM} / \mu R_t \qquad (3\text{-}10)$$

or

$$R_t = \Delta P_{TM} / \mu J \qquad (3\text{-}10\ a)$$

$$R_m = \Delta P_{TM} / \mu_w J_w \qquad (3\text{-}10\ b)$$

$$R_m + R_c + R_p = \Delta P_{TM} / \mu_w J'_w \qquad (3\text{-}10\ c)$$

$$R_m + R_p = \Delta P_{TM} / \mu_w J''_w \qquad (3\text{-}10\ d)$$

$$R_t = R_m + R_c + R_p \qquad (3\text{-}11)$$

where

J = permeate flux ($cm^3/cm^2.s$),

J_w = water flux before starting the filtration ($cm^3/cm^2.s$),

$\dot{J}_w$ = water flux measured after the flux reached the steady value ($cm^3/cm^2.s$),

$\dot{J}'_w$ = water flux measured after cake formation at the surface of membrane was removed ($cm^3/cm^2.s$),

μ = viscosity of the solution (kPa.s),

μ_w = viscosity of water = 8.5×10^{-7} kPa.s at 30 degree celsius [13],

R_t = total permeation resistance (1/cm),

R_m = membrane resistance (1/cm),

R_c = cake layer resistance (1/cm),

R_p = plugging resistance (1/cm).

Before starting the filtration, water flux, J, was measured to calculate the membrane resistance, R_m, by using Equation (3-10 b). After the permeate flux reached the steady value demineralized water was employed in filtration to be the feed instead of yeast suspension. Filtration at the same condition was taken and the water flux, $\dot{J}_w$, was measured to calculate the total permeation resistance, R_t, by using Equation (3-10 c). The last stage was to calculate the plugging resistance, R_p. Cake formation at the surface of the membrane was removed, and then the filtration of demineralized water was carried out at the same condition. Water flux, $\dot{J}'_w$, was measured to calculate R_p by using Equation (3-10 d).

3. Calculation of the pressure amplitude decrease along the distance

The pressure amplitude on the axis of the piston is the magnitude of the above expression,

$$P(r,0) = 2\rho_0 c U_0 \left| \sin\{\frac{1}{2}kr[\sqrt{1+\left[\frac{a}{r}\right]^2} - 1]\} \right| \quad (3\text{-}24)$$

where $k = \omega / c = 2\pi / \lambda$.

Rearrangement of (3-24) yields

$$P(r,0) / 2\rho_0 c U_0 = \left| \sin\{\frac{1}{2}kx[\sqrt{1+\left[\frac{1}{x}\right]^2} - 1]\} \right| \quad (B\text{-}1)$$

where $x = \dfrac{r}{a}$.

The value of a is constant at any frequencies as the same irradiation area was used, i.e. 1.9 cm.

<u>Data from Table C-11</u>: f = 19.8 kHz, λ = 7.6 cm.

a/λ = 1.9 cm./7.6 cm. = 0.25; $\lambda = 4a$

As $k = \omega / c = 2\pi / \lambda$, substitution of $\lambda = 4a$ yields $k = 1.57/a$.

Substitution of k into (B-1) gives

$$P(r,0) / 2\rho_0 c U_0 = \left| \sin\{\frac{1}{2} 0.79 x [\sqrt{1+\left[\frac{1}{x}\right]^2} - 1]\} \right| \qquad \text{(B-2)}$$

A sketch between the RHS and x was then performed in order to investigate the propagation of an acoustic wave along the distance. And the results (at various frequencies are shown in Table C-11.

APPENDIX C: EXPERIMENTAL DATA

Table C-1: Permeate flux of demineralized water at various applied pressures

applied pressure, ΔP_{TM} (kPa)	permeate flow rate (cm^3/s)	permeate flux ($cm^3/cm^2.s$)
16.66	10.121	0.0453
26.46	15.408	0.0690
36.26	19.685	0.0882
46.06	24.876	0.1114
55.86	29.412	0.1318

Data observed from microfiltration through membrane No. 1

Table C-2: Permeate flux of demineralized water at various applied pressures

applied pressure, ΔP_{TM} (kPa)	permeate flow rate (cm^3/s)	permeate flux ($cm^3/cm^2.s$)
16.66	6.596	0.0296
26.46	9.390	0.0421
36.26	11.848	0.0531
46.06	14.239	0.0638
55.86	16.543	0.0741

Data observed from microfiltration through membrane No. 2

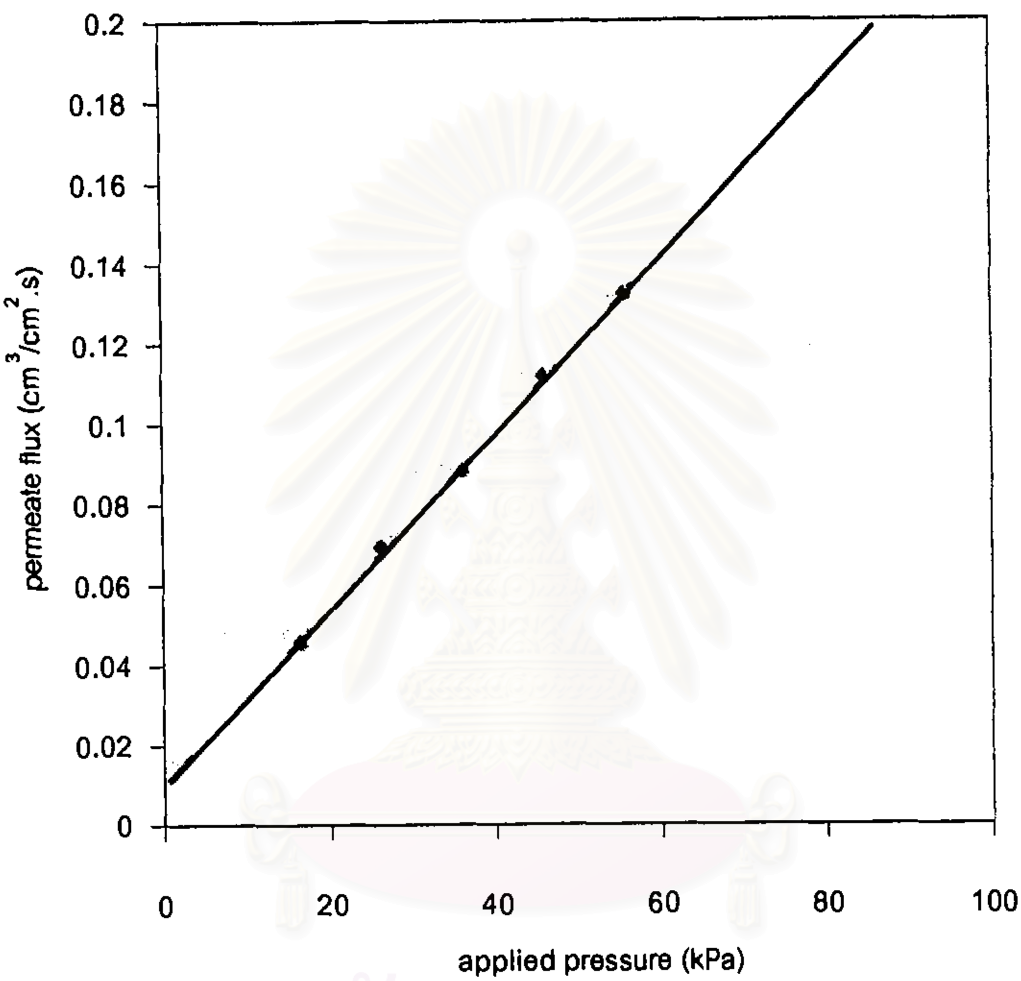


Figure C-1: Permeate flux of demineralized water (Membrane No.1)

- Operating temperature of 30°C
- Feed flow velocity of 0.48 m/s

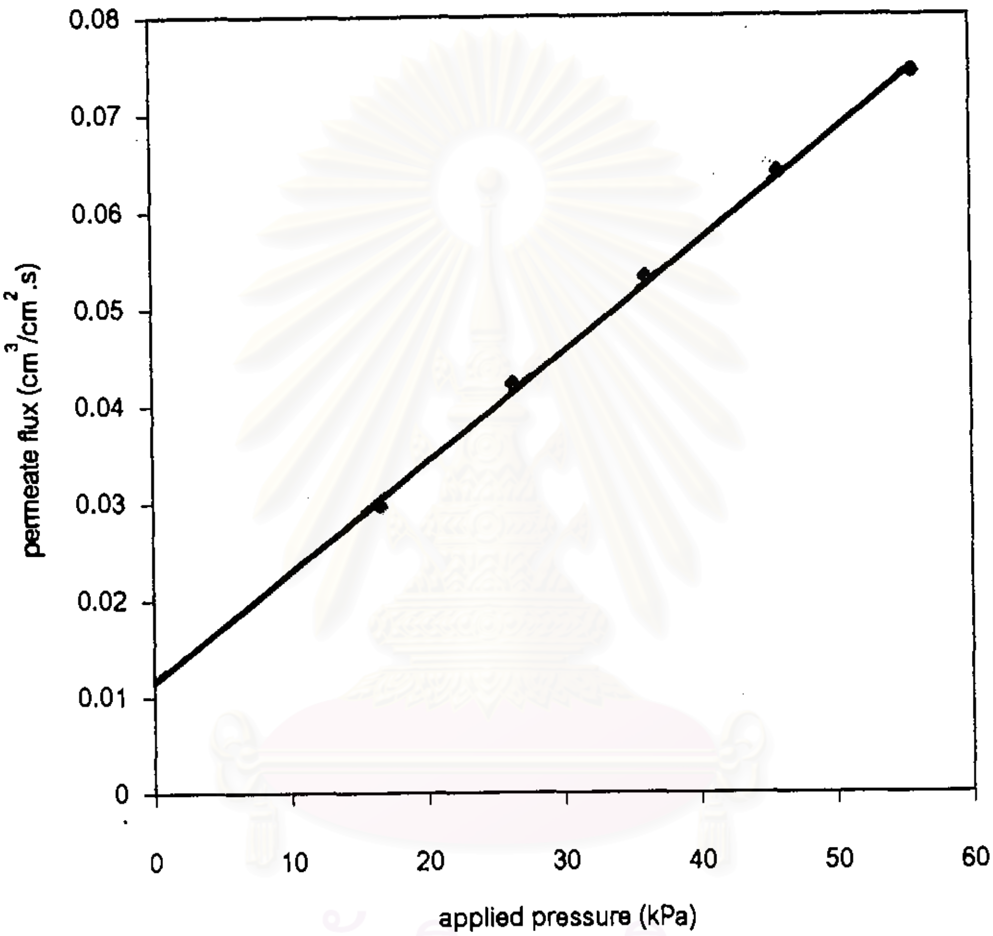


Figure C-2: Permeate flux of demineralized water

(membrane No. 2)

- Operating temperature of 30°C
- Feed flow velocity of 0.48 m/s

Table C-3: Experimental data of effect of the applied pressure, without ultrasound

time (min)	permeate volume (cm^3) at applied pressure of					permeate flux ($cm^3/cm^2.s$) at applied pressure of				
	11.27 (kPa)	16.66 (kPa)	26.46 (kPa)	36.26 (kPa)	46.06 (kPa)	11.27 (kPa)	16.66 (kPa)	26.46 (kPa)	36.26 (kPa)	46.06 (kPa)
2	215	300	310	375	320	0.00603	0.01120	0.01157	0.01400	0.01195
4	130	170	160	245	203	0.00465	0.00635	0.00672	0.00915	0.00756
6	110	135	150	200	175	0.00411	0.00504	0.00560	0.00747	0.00653
8	98	110	135	185	160	0.00366	0.00411	0.00504	0.00691	0.00597
10	90	100	122	150	140	0.00336	0.00373	0.00455	0.00560	0.00523
12	62	90	112	135	130	0.00306	0.00336	0.00416	0.00504	0.00485
14	76	81	106	125	115	0.00284	0.00302	0.00396	0.00467	0.00429
16	71	73	98	110	110	0.00265	0.00273	0.00366	0.00411	0.00411
18	66	71	97	100	105	0.00246	0.00265	0.00362	0.00373	0.00392
20	63	62	90	98	99	0.00235	0.00231	0.00336	0.00366	0.00370
22	80	57	86	92	90	0.00224	0.00213	0.00321	0.00343	0.00336
24	57	54	83	89	87	0.00213	0.00202	0.00310	0.00332	0.00325
26	55	51	80	84	83	0.00205	0.00190	0.00299	0.00314	0.00310
28	51	48	77	79	79	0.00190	0.00179	0.00287	0.00295	0.00295
30	49	45	75	75	76	0.00183	0.00168	0.00280	0.00280	0.00284
32	46	42	72	72	72	0.00172	0.00157	0.00269	0.00269	0.00269
34	44	40	69	69	69	0.00164	0.00149	0.00258	0.00258	0.00258
36	42	37	87	66	67	0.00157	0.00138	0.00250	0.00246	0.00250
38	41	36	65	63	65	0.00153	0.00134	0.00243	0.00235	0.00243
40	39	35	63	61	62	0.00146	0.00131	0.00235	0.00228	0.00231
42	38	33	60	59	54	0.00142	0.00123	0.00224	0.00220	0.00202
44	37	32.5	59	57	53	0.00138	0.00121	0.00220	0.00213	0.00198
46	35	31	57	55	52	0.00131	0.00116	0.00213	0.00205	0.00194
48	34	30	56	53	50	0.00127	0.00112	0.00209	0.00198	0.00187
50	33	29	53	51	46	0.00123	0.00108	0.00198	0.00190	0.00179
52	32	28	53	49	45	0.00119	0.00105	0.00198	0.00183	0.00168
54	32	28	51	48	44	0.00119	0.00105	0.00190	0.00179	0.00164
56	30	27	50	48	43	0.00112	0.00101	0.00187	0.00172	0.00161
58	30	26	49	45	42	0.00112	0.00097	0.00183	0.00168	0.00157

Table C-3 (continue): Experimental data of effect of the applied pressure, without ultrasound

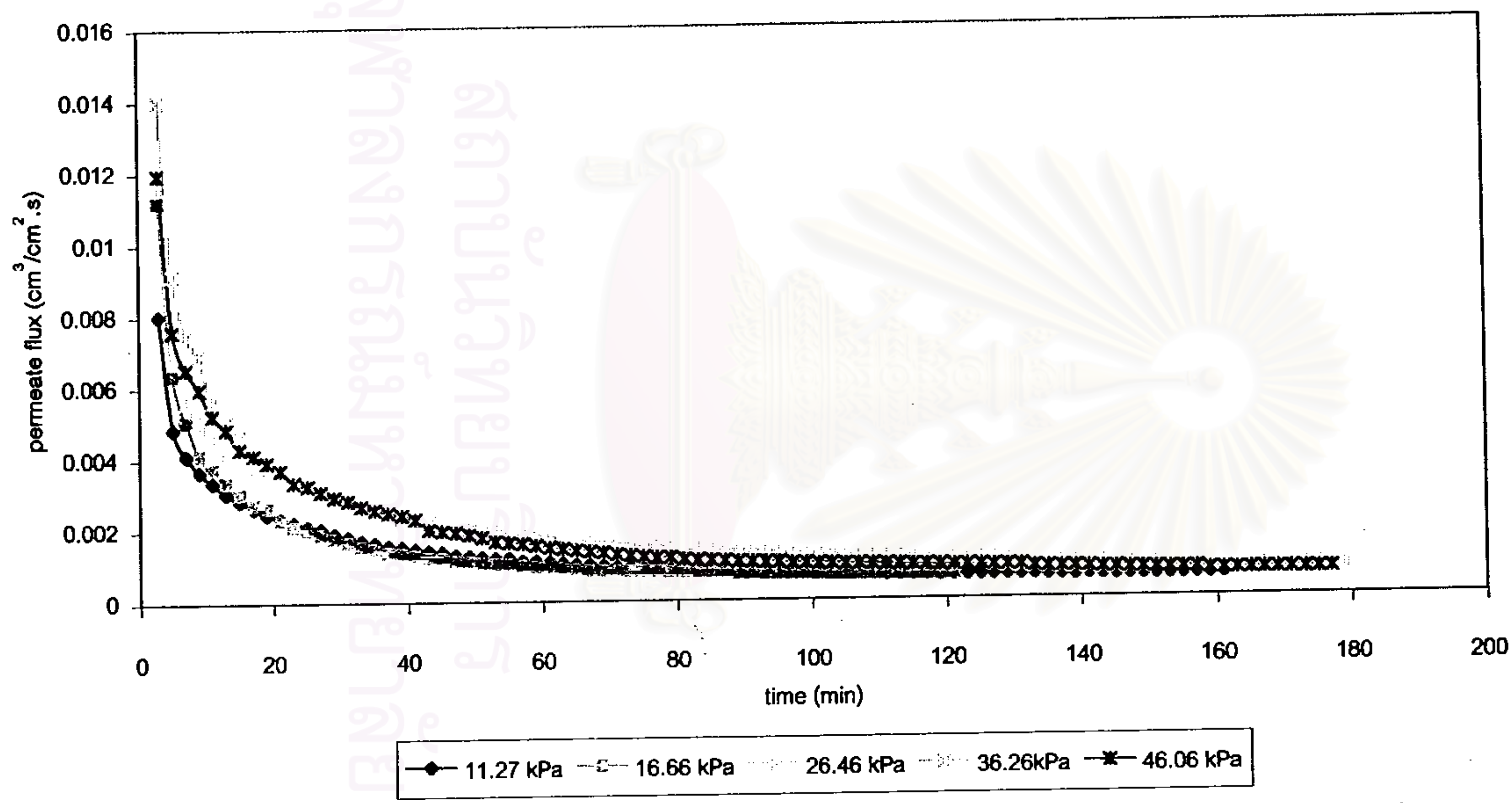
time (min)	permeate volume (cm^3) at applied pressure of					permeate flux ($cm^3/cm^2.s$) at applied pressure of				
	11.27 (kPa)	16.88 (kPa)	26.46 (kPa)	36.26 (kPa)	46.06 (kPa)	11.27 (kPa)	16.88 (kPa)	26.46 (kPa)	36.26 (kPa)	46.06 (kPa)
60	29	26	48	43	40	0.00108	0.00097	0.00179	0.00161	0.00149
62	28	25	46	42	39	0.00105	0.00093	0.00172	0.00157	0.00146
64	27	24	46	41	38	0.00101	0.00090	0.00172	0.00153	0.00142
66	27	23	44	40	37	0.00101	0.00086	0.00164	0.00149	0.00138
68	26	23	44	39	36	0.00097	0.00086	0.00164	0.00146	0.00134
70	25	22.5	43	39	35	0.00093	0.00084	0.00161	0.00146	0.00131
72	25	22	42	38	34	0.00093	0.00082	0.00157	0.00142	0.00127
74	24	22	41	37	33	0.00090	0.00082	0.00153	0.00138	0.00123
76	24	22	40	36	32	0.00090	0.00082	0.00149	0.00134	0.00119
78	23	21	39.5	35	32	0.00086	0.00078	0.00147	0.00131	0.00119
80	23	21	39	35	31	0.00086	0.00078	0.00146	0.00131	0.00116
82	22.5	21	38	34	30	0.00084	0.00078	0.00142	0.00127	0.00112
84	22	21	37.5	33	30	0.00082	0.00078	0.00140	0.00123	0.00112
86	21.5	21	37	33	29.5	0.00080	0.00078	0.00138	0.00123	0.00110
88	21	20	36	33	29	0.00078	0.00075	0.00134	0.00123	0.00108
90	21	20	35.5	32	28.5	0.00078	0.00075	0.00133	0.00119	0.00108
92	20.5	19.5	35	32	28	0.00077	0.00073	0.00131	0.00119	0.00105
94	20.5	19.5	35	31	28	0.00077	0.00073	0.00131	0.00116	0.00105
96	20	19.5	34	30	27.5	0.00075	0.00073	0.00127	0.00112	0.00103
98	20	19.5	34	30	27.5	0.00075	0.00073	0.00127	0.00112	0.00103
100	19.5	19	34	30	27	0.00073	0.00071	0.00127	0.00112	0.00101
102	19.5	18.5	33.5	29	27	0.00073	0.00069	0.00125	0.00108	0.00101
104	19	18.5	33	29	26.5	0.00071	0.00069	0.00123	0.00108	0.00099
106	19	18.5	32	28	26.5	0.00071	0.00069	0.00119	0.00105	0.00099
108	19	18.5	32	27	26.5	0.00071	0.00069	0.00119	0.00101	0.00099
110	18.5	18.5	32	27	26	0.00069	0.00069	0.00119	0.00101	0.00097
112	18.5	18.5	31	27	26	0.00069	0.00069	0.00116	0.00101	0.00097
114	18.5	18.5	31	26	25.5	0.00069	0.00069	0.00116	0.00097	0.00095
116	18.5	18.5	31	26	25.5	0.00069	0.00069	0.00116	0.00097	0.00095

Table C-3 (continue): Experimental data of effect of the applied pressure, without ultrasound

time (min)	permeate volume (cm^3) at applied pressure of					permeate flux ($cm^3/cm^2.s$) at applied pressure of				
	11.27 (kPa)	16.66 (kPa)	26.46 (kPa)	36.26 (kPa)	46.06 (kPa)	11.27 (kPa)	16.66 (kPa)	26.46 (kPa)	36.26 (kPa)	46.06 (kPa)
118	18	18.5	30.5	26	25	0.00067	0.00069	0.00114	0.00097	0.00093
120	18	18.5	30.5	25	25	0.00067	0.00069	0.00114	0.00093	0.00093
122	18		30	24.5	25	0.00067		0.00112	0.00091	0.00093
124	18		30	24.5	25	0.00067		0.00112	0.00091	0.00093
126	18		29	24	24.5	0.00067		0.00108	0.00090	0.00091
128	18		29	23	24.5	0.00067		0.00108	0.00086	0.00091
130	18		28	22.5	24.5	0.00067		0.00105	0.00084	0.00091
132	18		27.5	22.5	23.5	0.00067		0.00103	0.00084	0.00088
134	17.5		27	22	23	0.00065		0.00101	0.00082	0.00086
136	17.5		27	21.5	23	0.00065		0.00101	0.00080	0.00086
138	17		26	21.5	23	0.00063		0.00097	0.00080	0.00086
140	17.5		26	21	22.5	0.00065		0.00097	0.00078	0.00084
142	17		26	20.5	22	0.00063		0.00097	0.00077	0.00082
144	17		25	20.5	22	0.00063		0.00093	0.00077	0.00082
146	17		25	20.5	21.5	0.00063		0.00093	0.00077	0.00080
148	17		25	20.5	21.5	0.00063		0.00093	0.00077	0.00080
150	17		25	20.5	21	0.00063		0.00093	0.00077	0.00078
152	17		24	20.5	21	0.00063		0.00090	0.00077	0.00078
154	17		23.5	20.5	21	0.00063		0.00088	0.00077	0.00078
156	17		23.5	20.5	21	0.00063		0.00088	0.00077	0.00078
158	17		23	20.5	20	0.00063		0.00066	0.00077	0.00075
160	17		22.5	20.5	20	0.00063		0.00084	0.00077	0.00075

Conditions:

- Operating temperature of 30 °C
- Feed flow velocity of 0.29 m/s
- Feed concentration of 0.005 g/cm^3



Conditions: Operating temperature of 30℃, feed flow velocity of 0.29 m/s, feed concentration of 0.005 g/cm^3

Figure C-3: Effect of applied pressure on permeate flux, without ultrasound

Table C-4: Experimental data of effect of the applied pressure, with ultrasound

time (min)	permeate volume (cm^3) at applied pressure of					permeate flux ($cm^3/cm^2.s$) at applied pressure of				
	11.27 (kPa)	16.66 (kPa)	26.46 (kPa)	36.26 (kPa)	46.06 (kPa)	11.27 (kPa)	16.66 (kPa)	26.46 (kPa)	36.26 (kPa)	46.06 (kPa)
2	315	520	500	500	510	0.01176	0.01941	0.01867	0.01867	0.01904
4	250	300	250	260	260	0.00933	0.01120	0.00933	0.00971	0.00971
6	200	230	200	170	210	0.00747	0.00859	0.00747	0.00635	0.00784
8	180	185	189	145	200	0.00672	0.00691	0.00706	0.00541	0.00747
10	190	170	160	115	180	0.00709	0.00635	0.00597	0.00429	0.00672
12	165	150	143	103	170	0.00616	0.00560	0.00534	0.00385	0.00635
14	150	135	120	92	135	0.00560	0.00504	0.00448	0.00343	0.00504
16	140	132	105	84	130	0.00523	0.00493	0.00392	0.00314	0.00485
18	130	121	93	78	108	0.00485	0.00452	0.00347	0.00291	0.00403
20	105	113	86	73	100	0.00392	0.00422	0.00321	0.00273	0.00373
22	110	107	82	68	96	0.00411	0.00399	0.00306	0.00254	0.00358
24	105	94	77	66	90	0.00392	0.00351	0.00287	0.00246	0.00336
26	103	88	75	63	84	0.00385	0.00329	0.00280	0.00235	0.00314
28	100	89	72	60	79	0.00373	0.00332	0.00269	0.00224	0.00295
30	98	93	70	58	74	0.00366	0.00347	0.00261	0.00217	0.00276
32	95	84	69	56	71	0.00355	0.00314	0.00258	0.00209	0.00265
34	93	78	66	54	68	0.00347	0.00291	0.00246	0.00202	0.00254
36	90	74	64	51	65	0.00336	0.00276	0.00239	0.00190	0.00243
38	89	74	63	50	63	0.00332	0.00276	0.00235	0.00187	0.00235
40	86	70	65	49	59	0.00321	0.00261	0.00243	0.00183	0.00220
42	84	80	64	48	58	0.00314	0.00299	0.00239	0.00179	0.00217
44	83	70	62	47	56	0.00310	0.00261	0.00231	0.00175	0.00209
46	81	66	63	46	55	0.00302	0.00246	0.00235	0.00172	0.00205
48	80	67	62	45	53	0.00299	0.00250	0.00231	0.00168	0.00198
50	78	63	61	44	50	0.00291	0.00235	0.00228	0.00164	0.00187
52	77	62	61	43	49	0.00287	0.00231	0.00228	0.00161	0.00183
54	77	60	61	42	49	0.00287	0.00224	0.00228	0.00157	0.00183
56	75	60	60	42	46	0.00280	0.00224	0.00224	0.00157	0.00179
58	74	60	60	42	47	0.00276	0.00224	0.00224	0.00157	0.00175

Table C-4 (continue): Experimental data of effect of the applied pressure, with ultrasound

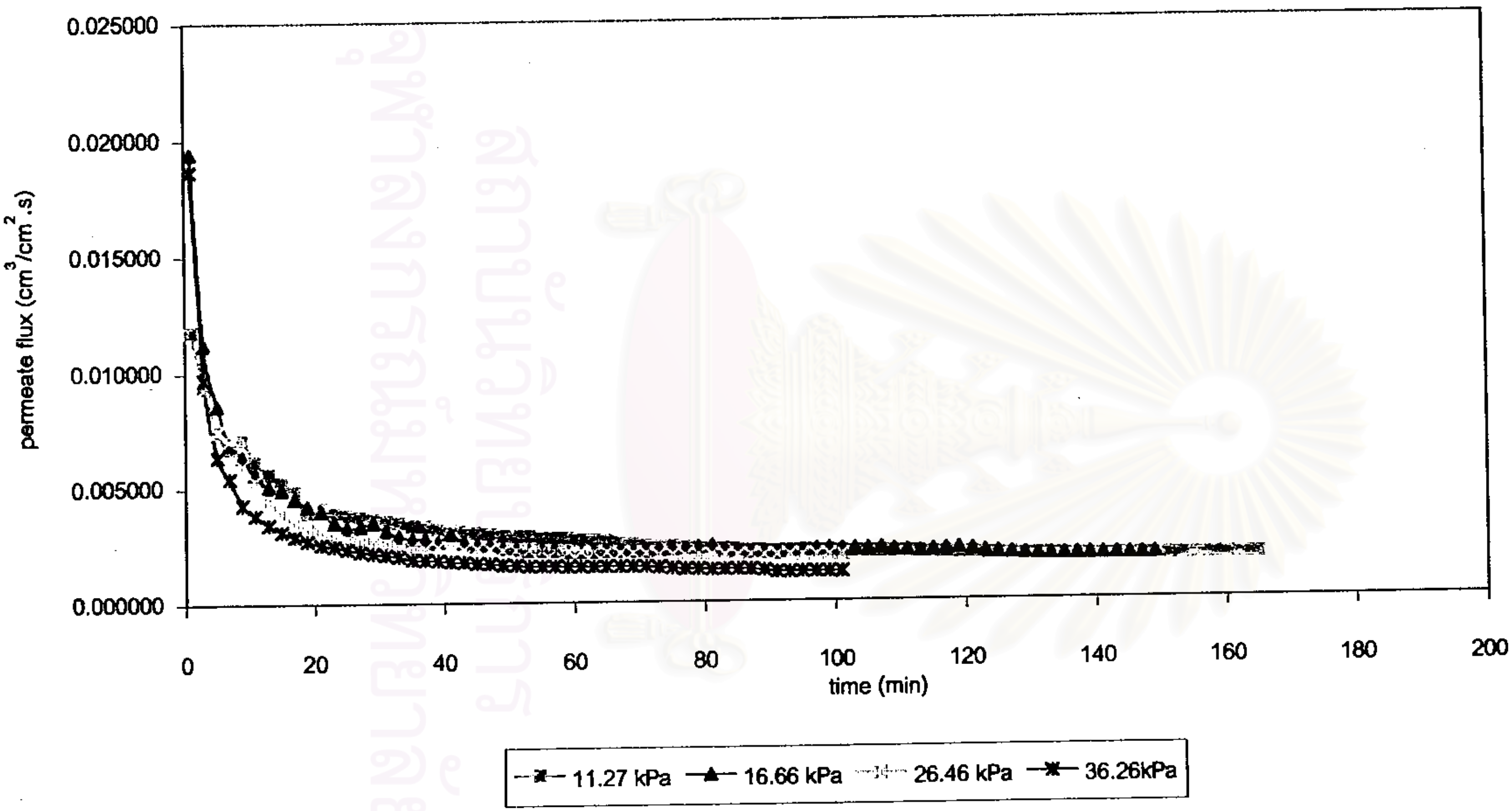
time (min)	permeate volume (cm^3) at applied pressure of					permeate flux ($cm^3/cm^2.s$) at applied pressure of				
	11.27 (kPa)	16.66 (kPa)	26.46 (kPa)	36.26 (kPa)	46.06 (kPa)	11.27 (kPa)	16.66 (kPa)	26.46 (kPa)	36.26 (kPa)	46.06 (kPa)
80	74	58	59	41	46	0.00276	0.00217	0.00220	0.00153	0.00172
62	72	58	59	41	46	0.00269	0.00217	0.00220	0.00153	0.00172
64	72	58	58	41	45	0.00269	0.00217	0.00217	0.00153	0.00166
66	71	59	58	41	44	0.00265	0.00220	0.00217	0.00153	0.00164
66	68	59	57	41	43	0.00254	0.00220	0.00213	0.00153	0.00161
70	67	59	57	41	42	0.00250	0.00220	0.00213	0.00153	0.00157
72	65	59	57	41	42	0.00243	0.00220	0.00213	0.00153	0.00157
74	64	60	55	40	41	0.00239	0.00224	0.00205	0.00149	0.00153
76	64	61	55	39	41	0.00239	0.00228	0.00205	0.00146	0.00153
78	63	82	54	36	40	0.00235	0.00231	0.00202	0.00142	0.00149
80	62	83	55	38	40	0.00231	0.00235	0.00205	0.00142	0.00149
82	61	65	55	37	39	0.00228	0.00243	0.00205	0.00136	0.00146
84	61	58	54	37	39	0.00228	0.00217	0.00202	0.00136	0.00146
88	60	59	54	37	39	0.00224	0.00220	0.00202	0.00138	0.00146
88	59	57	54	37	36	0.00220	0.00213	0.00202	0.00136	0.00142
90	59	56	54	36	37.5	0.00220	0.00209	0.00202	0.00134	0.00140
92	58	55	54	34	37	0.00217	0.00205	0.00202	0.00127	0.00136
94	58	58	54	34	37	0.00217	0.00217	0.00202	0.00127	0.00138
96	58	59	54	34	36	0.00217	0.00220	0.00202	0.00127	0.00134
98	58	60	54	34	36	0.00217	0.00224	0.00202	0.00127	0.00134
100	58	61	54	34	35	0.00217	0.00228	0.00202	0.00127	0.00131
102	57	60	54	34	35	0.00213	0.00224	0.00202	0.00127	0.00131
104	57	60		34	34	0.00213	0.00224		0.00127	0.00127
106	57	60		34	34	0.00213	0.00224		0.00127	0.00127
108	57	61		34	34	0.00213	0.00228		0.00127	0.00127
110	56	59		34	34	0.00209	0.00220		0.00127	0.00127
112	56	56			33.5	0.00209	0.00217			0.00125
114	58	57			33	0.00209	0.00213			0.00123
116	55	58			33	0.00205	0.00217			0.00123

Table C-4 (continue): Experimental data of effect of the applied pressure, with ultrasound

time (min)	permeate volume (cm^3) at applied pressure of					permeate flux ($cm^3/cm^2.s$) at applied pressure of				
	11.27 (kPa)	16.66 (kPa)	26.46 (kPa)	36.26 (kPa)	46.06 (kPa)	11.27 (kPa)	16.66 (kPa)	26.46 (kPa)	36.26 (kPa)	46.06 (kPa)
118	55	59			33	0.00205	0.00220			0.00123
120	54	60			33	0.00202	0.00224			0.00123
122	54	58			33	0.00202	0.00217			0.00123
124	53	56			33	0.00198	0.00209			0.00123
126	53	55			33	0.00198	0.00205			0.00123
128	53	54			33	0.00198	0.00202			0.00123
130	52	53			33	0.00194	0.00198			0.00123
132	52	52			33	0.00194	0.00194			0.00123
134	52	52				0.00194	0.00194			
136	52	52				0.00194	0.00194			
138	51	52				0.00190	0.00194			
140	51	52				0.00190	0.00194			
142	51	52				0.00190	0.00194			
144	51	52				0.00190	0.00194			
146	50	52				0.00187	0.00194			
148	50	52				0.00187	0.00194			
150	50	52				0.00187	0.00194			
152	50					0.00187				
154	50					0.00187				
156	50					0.00187				
158	50					0.00187				
160	50					0.00187				

Conditions:

- Operating temperature of 30 °C
- Feed flow velocity of 0.29 m/s
- Feed concentration of 0.005 g/cm^3
- Input power of 25 W



Conditions: Operating temperature of 30°C, feed flow velocity of 0.29 m/s, feed concentration of 0.005 g/cm^3, input power of 25 W

FigureC-4: Effect of applied pressure on permeate flux, with ultrasound

Table C-5: Experimental data of effect of the feed flow velocity, without ultrasound

time (min)	permeate volume (cm^3) at feed flow velocity of				permeate flux ($cm^3/cm^2.s$) at feed flow velocity of			
	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.46 (m/s)	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.46 (m/s)
2	280	310	300	375	0.01045	0.01157	0.01120	0.01400
4	170	170	220	200	0.00635	0.00635	0.00821	0.00747
6	140	135	140	150	0.00523	0.00504	0.00523	0.00560
8	120	120	130	125	0.00448	0.00448	0.00485	0.00467
10	110	105	110	105	0.00411	0.00392	0.00411	0.00392
12	105	93	96	90	0.00392	0.00347	0.00358	0.00336
14	94	88	85	84	0.00351	0.00329	0.00317	0.00314
16	90	82	75	74	0.00336	0.00306	0.00280	0.00276
18	84	76	68	66	0.00314	0.00284	0.00254	0.00246
20	80	72	64	63	0.00299	0.00269	0.00239	0.00235
22	75	69	54	60	0.00280	0.00258	0.00202	0.00224
24	73	66	52	54	0.00273	0.00246	0.00194	0.00202
26	68	63	50	53	0.00254	0.00235	0.00187	0.00198
28	68	58	45	50	0.00254	0.00217	0.00168	0.00187
30	65	57	42.5	48	0.00243	0.00213	0.00159	0.00179
32	63	56	41	46	0.00235	0.00209	0.00153	0.00172
34	62	55	36	43	0.00231	0.00205	0.00134	0.00161
36	59	52	35	42	0.00220	0.00194	0.00131	0.00157
38	58	50	33	40.5	0.00217	0.00187	0.00123	0.00151
40	57	49	31	39	0.00213	0.00183	0.00116	0.00146
42	55	47	30.5	38	0.00205	0.00175	0.00114	0.00142
44	54	45	29	37	0.00202	0.00168	0.00108	0.00138
46	53	43	28	36	0.00198	0.00161	0.00105	0.00134
48	52	42	27	35	0.00194	0.00157	0.00101	0.00131
50	51	40	26	34	0.00190	0.00149	0.00097	0.00127
52	50	39	25	33.5	0.00187	0.00146	0.00093	0.00125
54	49	38	24	33	0.00183	0.00142	0.00090	0.00123
56	48	36	23.5	32	0.00179	0.00134	0.00088	0.00119
58	47	35	23	32	0.00175	0.00131	0.00086	0.00119

Table C-5 (continue): Experimental data of effect of the feed flow velocity, without ultrasound

time (min)	permeate volume (cm^3) at feed flow velocity of				permeate flux ($cm^3/cm^2.s$) at feed flow velocity of			
	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)
80	45	34	22.5	30.5	0.00168	0.00127	0.00084	0.00114
62	44	33	22	30.5	0.00164	0.00123	0.00082	0.00114
64	43	32	21.5	30.5	0.00161	0.00119	0.00080	0.00114
66	43	31	21	30	0.00161	0.00118	0.00078	0.00112
68	42	30.5	20.5	30	0.00157	0.00114	0.00077	0.00112
70	41	30	20.5	29	0.00153	0.00112	0.00077	0.00108
72	41	29	20	29	0.00153	0.00108	0.00075	0.00108
74	41	29	20	28	0.00153	0.00108	0.00075	0.00105
76	40	28	20	28	0.00149	0.00105	0.00075	0.00105
78	40	27	19	28	0.00149	0.00101	0.00071	0.00105
80	40	27	19	27.5	0.00149	0.00101	0.00071	0.00103
82	39	28	19	27.5	0.00146	0.00097	0.00071	0.00103
84	39	25	19	27	0.00148	0.00093	0.00071	0.00101
88	39	24	19	26	0.00146	0.00090	0.00071	0.00097
88	39	24	18.5	26	0.00146	0.00090	0.00089	0.00097
90	38	23	18.5	26	0.00142	0.00086	0.00069	0.00097
92	38	23	18.5	26	0.00142	0.00086	0.00089	0.00097
94	37	22.5	18.5	26	0.00138	0.00084	0.00069	0.00097
96	37	22.5	18.5	26	0.00138	0.00084	0.00089	0.00097
98	36	22.5	18.5	26	0.00134	0.00084	0.00069	0.00097
100	36	22.5	18.5	26	0.00134	0.00084	0.00069	0.00097
102	35	22	18.5	26	0.00131	0.00082	0.00069	0.00097
104	35	22	18.5		0.00131	0.00082	0.00069	
106	34	21			0.00127	0.00078		
108	34	21			0.00127	0.00078		
110	33	21			0.00123	0.00078		
112	33	20			0.00123	0.00075		
114	33	19.5			0.00123	0.00073		
116	33	19			0.00123	0.00071		

Table C-5 (continue): Experimental data of effect of the feed flow velocity, without ultrasound

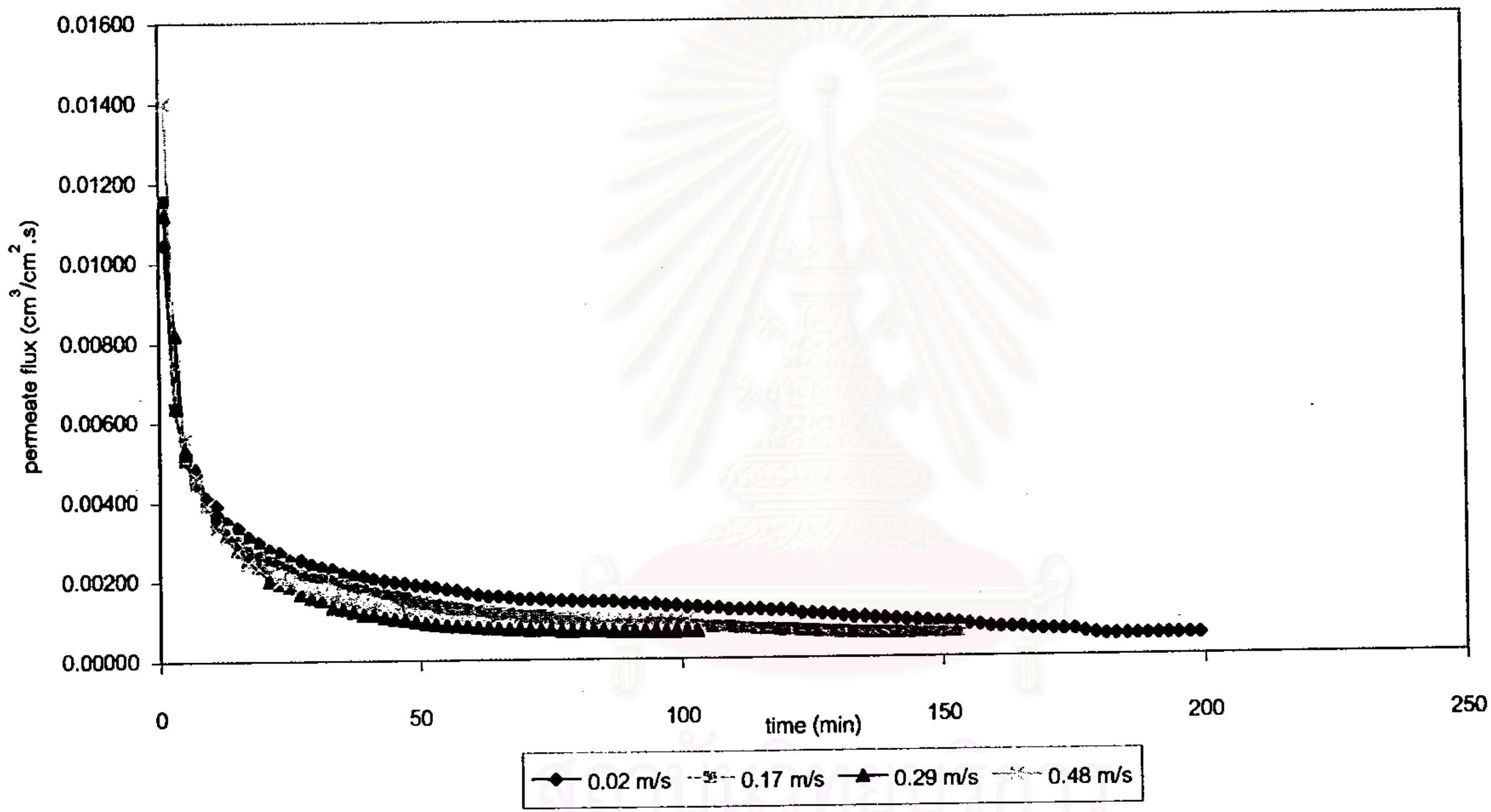
time (min)	permeate volume (cm^3) at feed flow velocity of				permeate flux ($cm^3/cm^2.s$) at feed flow velocity of			
	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)
118	32	19			0.00119	0.00071		
120	32	18.5			0.00119	0.00069		
122	32	18.5			0.00119	0.00089		
124	30	18			0.00112	0.00067		
126	30	17.5			0.00112	0.00065		
128	29.5	17.5			0.00110	0.00065		
130	29	17			0.00108	0.00083		
132	28	17			0.00105	0.00083		
134	27	16.5			0.00101	0.00062		
136	27	16			0.00101	0.00060		
138	26.5	16			0.00099	0.00060		
140	26	16			0.00097	0.00060		
142	25.5	16			0.00095	0.00060		
144	25	16			0.00093	0.00060		
146	24.5	16			0.00091	0.00060		
148	24	16			0.00090	0.00080		
150	23.5	16			0.00086	0.00060		
152	23.5	16			0.00066	0.00060		
154	22.5	16			0.00064	0.00060		
156	22				0.00082			
158	21				0.00078			
160	20				0.00075			
162	19.5				0.00073			
164	19.5				0.00073			
166	19.5				0.00073			
168	18.5				0.00069			
170	16				0.00067			
172	18				0.00067			
174	17.5				0.00065			

Table C-5 (continue): Experimental data of effect of the feed flow velocity, without ultrasound

time (min)	permeate volume (cm^3) at feed flow velocity of				permeate flux ($cm^3/cm^2.s$) at feed flow velocity of			
	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)
176	17.5				0.00085			
178	16				0.00060			
180	15				0.00056			
182	14				0.00052			
184	14				0.00052			
186	14				0.00052			
188	14				0.00052			
190	14				0.00052			
192	14				0.00052			
194	14				0.00052			
196	14				0.00052			
198	14				0.00052			
200	14				0.00052			

Conditions:

- Operating temperature of 30 °C
- Applied pressure of 16.66 kPa
- Feed concentration of 0.005 g/cm^3



Conditions: Operating temperature of 30°C, applied pressure of 16.66 kPa, feed concentration of 0.005 g/cm^3

FigureC-5: Effect of feed flow velocity on permeate flux, without ultrasound

Table C-6: Experimental data of effect of the feed flow velocity, with ultrasound

time (min)	permeate volume (cm^3) at feed flow velocity of				permeate flux ($cm^3/cm^2.s$) at feed flow velocity of			
	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)
2	500	500	520	560	0.01887	0.01867	0.01941	0.02091
4	370	300	475	500	0.01381	0.01120	0.01773	0.01867
6	140	200	465	450	0.00523	0.00747	0.01736	0.01680
8	120	175	425	380	0.00448	0.00653	0.01587	0.01419
10	110	135	380	275	0.00411	0.00504	0.01419	0.01027
12	100	108	350	245	0.00373	0.00403	0.01307	0.00915
14	92	103	330	280	0.00343	0.00385	0.01232	0.01045
16	87	89	315	220	0.00325	0.00332	0.01176	0.00821
18	82	80	305	160	0.00308	0.00299	0.01139	0.00597
20	84	74	270	170	0.00314	0.00278	0.01008	0.00635
22	74	68	255	175	0.00276	0.00254	0.00952	0.00653
24	70	65	235	135	0.00261	0.00243	0.00877	0.00504
26	68	61	225	125	0.00254	0.00228	0.00840	0.00487
28	65	58	220	110	0.00243	0.00217	0.00821	0.00411
30	60	57	215	100	0.00224	0.00213	0.00803	0.00373
32	56	57	210	99	0.00209	0.00213	0.00784	0.00370
34	61	57	202	102	0.00228	0.00213	0.00754	0.00381
36	60	53	198	94	0.00224	0.00198	0.00739	0.00351
38	60	50	190	88	0.00224	0.00187	0.00709	0.00329
40	58	47	180	86	0.00217	0.00175	0.00672	0.00321
42	56	50	175	82	0.00209	0.00187	0.00653	0.00306
44	56	48	175	76	0.00209	0.00179	0.00653	0.00284
46	54	46	170	78	0.00202	0.00172	0.00635	0.00291
48	54	45	170	66	0.00202	0.00168	0.00635	0.00246
50	54	48	165	70	0.00202	0.00179	0.00616	0.00261
52	53	43	160	81	0.00198	0.00161	0.00597	0.00302
54	52	43	160	72	0.00194	0.00161	0.00597	0.00269
56	51	43	155	69	0.00190	0.00161	0.00579	0.00258
58	50	45	152	68	0.00187	0.00168	0.00568	0.00254

Table C-6 (continue): Experimental data of effect of the feed flow velocity, with ultrasound

time (min)	permeate volume (cm^3) at feed flow velocity of				permeate flux ($cm^3/cm^2.s$) at feed flow velocity of			
	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)
60	49	45	150	86	0.00183	0.00168	0.00560	0.00246
62	47	47	145	85	0.00175	0.00175	0.00541	0.00243
64	48	47	145	74	0.00179	0.00175	0.00541	0.00276
66	47	47	140	75	0.00175	0.00175	0.00523	0.00280
68	47	47	140	86	0.00175	0.00175	0.00523	0.00246
70	46	48	140	66	0.00172	0.00179	0.00523	0.00246
72	46	49	135	63	0.00172	0.00183	0.00504	0.00235
74	46	50	160	61	0.00172	0.00187	0.00597	0.00228
76	45	50	150	58	0.00168	0.00187	0.00560	0.00217
78	48	53	150	55	0.00179	0.00198	0.00560	0.00205
80	46	53	150	72	0.00172	0.00198	0.00560	0.00269
82	45	60	145	95	0.00168	0.00224	0.00541	0.00355
84	43	60	140	75	0.00161	0.00224	0.00523	0.00280
86	43	60	140	83	0.00161	0.00224	0.00523	0.00310
88	43	60	135	83	0.00161	0.00224	0.00504	0.00310
90	43	60	130	103	0.00161	0.00224	0.00485	0.00385
92	43	86	130	79	0.00161	0.00321	0.00485	0.00295
94	42	80	125	91	0.00157	0.00299	0.00467	0.00340
96	41	70	125	72	0.00153	0.00261	0.00467	0.00269
98	41	66	120	105	0.00153	0.00246	0.00448	0.00392
100	40	62	120	105	0.00149	0.00231	0.00448	0.00392
102	40	59	115	80	0.00149	0.00220	0.00429	0.00299
104	37	57	110	80	0.00138	0.00213	0.00411	0.00299
106	39	56	110	83	0.00146	0.00209	0.00411	0.00310
108	39	55	105	73	0.00146	0.00205	0.00392	0.00273
110	39	51	105	72	0.00146	0.00190	0.00392	0.00269
112	39	48	100	70	0.00146	0.00179	0.00373	0.00261
114	39	47	100	80	0.00146	0.00175	0.00373	0.00299
116	39	47	96	80	0.00146	0.00175	0.00358	0.00299

Table C-6 (continue): Experimental data of effect of the feed flow velocity, with ultrasound

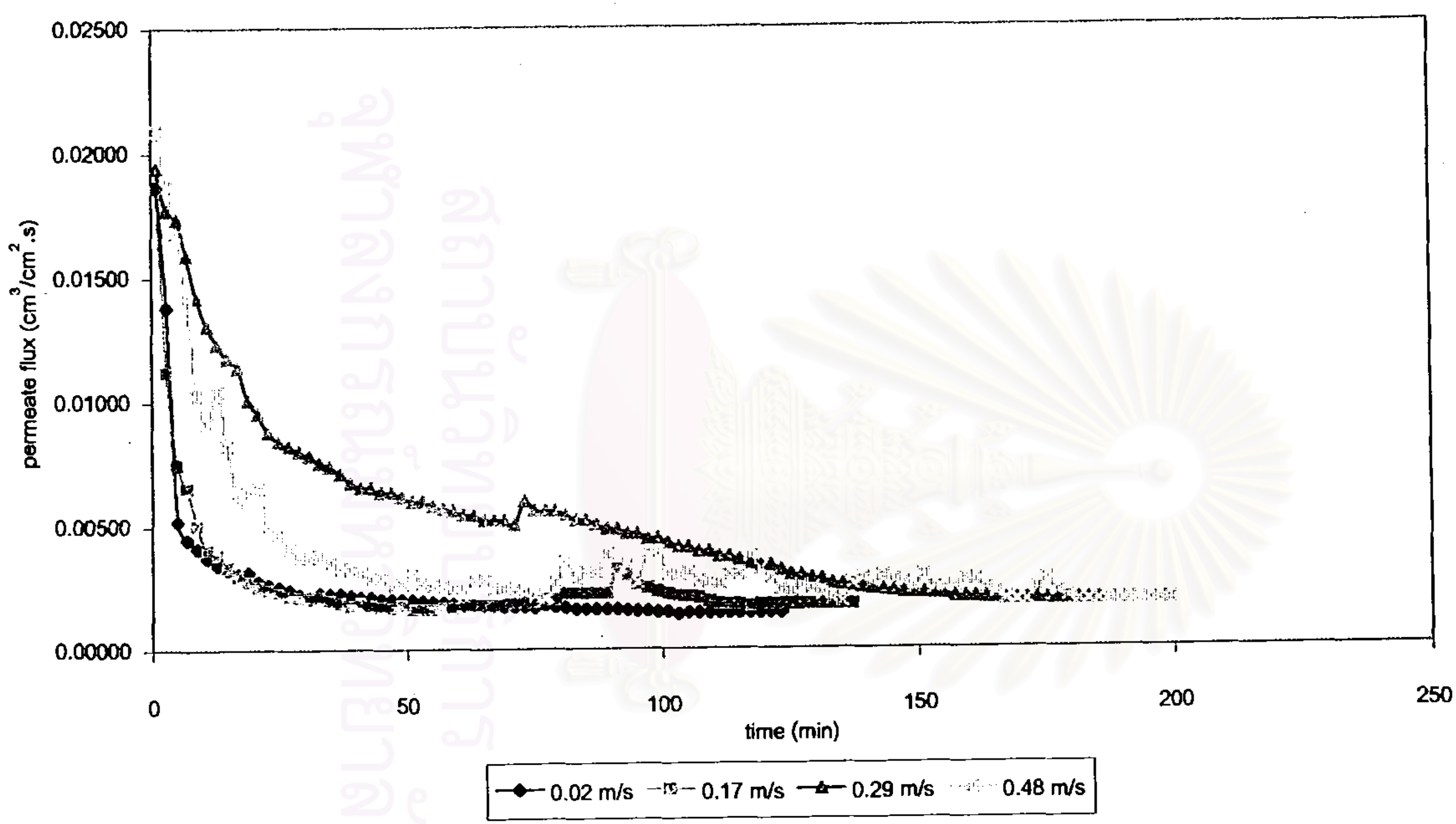
time (min)	permeate volume (cm^3) at feed flow velocity of				permeate flux ($cm^3/cm^2.s$) at feed flow velocity of			
	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)
118	39	45	92	100	0.00146	0.00168	0.00343	0.00373
120	39	47	90	86	0.00146	0.00175	0.00336	0.00321
122	39	47	90	76	0.00146	0.00175	0.00336	0.00284
124	39	47	85	64	0.00146	0.00175	0.00317	0.00239
126		47	80	62		0.00175	0.00299	0.00231
128		47	79	68		0.00175	0.00295	0.00254
130		47	78	65		0.00175	0.00264	0.00243
132		47	75	58		0.00175	0.00280	0.00217
134		47	70	53		0.00175	0.00261	0.00198
136		47	69	50		0.00175	0.00258	0.00187
138		47	68	70		0.00175	0.00254	0.00261
140			66	75			0.00246	0.00280
142			64	71			0.00239	0.00265
144			63	78			0.00235	0.00291
146			62	73			0.00231	0.00273
148			80	70			0.00224	0.00261
150			60	65			0.00224	0.00243
152			59	79			0.00220	0.00295
154			58.5	64			0.00218	0.00239
156			58	64			0.00217	0.00239
158			55	66			0.00205	0.00246
160			55	74			0.00205	0.00276
162			55	73			0.00205	0.00273
164			54	64			0.00202	0.00239
166			53	59			0.00198	0.00220
168			52	53			0.00194	0.00198
170			52	51			0.00194	0.00190
172			52	51			0.00194	0.00190
174			52	63			0.00194	0.00235

Table C-6 (continue): Experimental data of effect of the feed flow velocity, with ultrasound

time (min)	permeate volume (cm^3) at feed flow velocity of				permeate flux ($cm^3/cm^2.s$) at feed flow velocity of			
	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)	0.02 (m/s)	0.17 (m/s)	0.29 (m/s)	0.48 (m/s)
176			52	74			0.00194	0.00276
178			52	60			0.00194	0.00224
180			52	55			0.00194	0.00205
182			52	51			0.00194	0.00190
184			52	51			0.00194	0.00190
186			52	51			0.00194	0.00190
188				51				0.00190
190				51				0.00190
192				51				0.00190
194				51				0.00190
196				51				0.00190
198				51				0.00190
200				51				0.00190

Conditions:

- Operating temperature of 30 °C
- Applied pressure of 16.66 kPa
- Feed concentration of 0.005 g/cm^3
- Input power of 25 W



Conditions: Operating temperature of 30°C, applied pressure of 16.66 kPa, feed concentration of 0.005 g/cm^3, input power of 25 W

Figure C-6: Effect of feed flow velocity on permeate flux, with ultrasound

Table C-7: Experimental data of effect of the feed concentration, without ultrasound

time (min)	permeate volume (cm^3) at feed concentration of			permeate flux ($cm^3/cm^2.s$) at feed concentration of		
	0.005 g/cm^3	0.010 g/cm^3	0.020 g/cm^3	0.005 g/cm^3	0.010 g/cm^3	0.020 g/cm^3
2	320	263	175	0.01195	0.00982	0.00653
4	210	142	100	0.00784	0.00530	0.00373
6	161	120	80	0.00601	0.00448	0.00299
8	140	100	65	0.00523	0.00373	0.00243
10	125	80	56	0.00467	0.00299	0.00209
12	114	70	50	0.00426	0.00261	0.00187
14	107	63	46	0.00399	0.00235	0.00172
16	99	58	39	0.00370	0.00217	0.00146
18	93	55	38	0.00347	0.00205	0.00142
20	88	51	35	0.00329	0.00190	0.00131
22	84	48	31	0.00314	0.00179	0.00116
24	78	47	30	0.00291	0.00175	0.00112
26	73	45	27	0.00273	0.00168	0.00101
28	69	42	23	0.00258	0.00157	0.00086
30	66	40	22.5	0.00246	0.00149	0.00084
32	63	38	22.5	0.00235	0.00142	0.00084
34	60	36	21	0.00224	0.00134	0.00078
36	57	34	19	0.00213	0.00127	0.00071
38	55	32	18	0.00205	0.00119	0.00067
40	53	31	16.5	0.00198	0.00116	0.00062
42	51	30	15.5	0.00190	0.00112	0.00058
44	49	28	14	0.00183	0.00105	0.00052
46	47	27	13	0.00175	0.00101	0.00049
48	46	26	13	0.00172	0.00097	0.00049
50	44	25	13	0.00164	0.00093	0.00049
52	43	24	12	0.00161	0.00090	0.00045
54	41	24	11.5	0.00153	0.00090	0.00043
56	40	23	11	0.00149	0.00086	0.00041
58	39	22	10.5	0.00146	0.00082	0.00039
60	38	21.5	10	0.00142	0.00080	0.00037

Table C-7 (continue): Experimental data of effect of the feed concentration, without ultrasound

time (min)	permeate volume (cm^3) at feed concentration of			permeate flux ($cm^3/cm^2.s$) at feed concentration of		
	0.005 g/cm^3	0.010 g/cm^3	0.020 g/cm^3	0.005 g/cm^3	0.010 g/cm^3	0.020 g/cm^3
62	37	21.5	10	0.00138	0.00080	0.00037
64	36	20.5	9.5	0.00134	0.00077	0.00035
86	35	20	9.5	0.00131	0.00075	0.00035
68	35	20	9.5	0.00131	0.00075	0.00035
70	34	19.5	9.5	0.00127	0.00073	0.00035
72	33	19.5	9	0.00123	0.00073	0.00034
74	33	19.5	9	0.00123	0.00073	0.00034
76	32	19	9	0.00119	0.00071	0.00034
78	32	19	9	0.00119	0.00071	0.00034
80	31	18.5	9	0.00116	0.00069	0.00034
82	30	18.5	9	0.00112	0.00069	0.00034
64	30	18	9	0.00112	0.00067	0.00034
86	30	18	9	0.00112	0.00067	0.00034
86	29	17.5	9	0.00108	0.00065	0.00034
90	29	17.5	9	0.00108	0.00065	0.00034
92	28	17.5		0.00105	0.00065	
94	28	17.5		0.00105	0.00065	
96	28	17.5		0.00105	0.00065	
98	27	17.5		0.00101	0.00065	
100	27	17.5		0.00101	0.00065	
102	27	17.5		0.00101	0.00065	
104	26	17.5		0.00097	0.00065	
106	26	17.5		0.00097	0.00065	
108	26	17.5		0.00097	0.00065	
110	25			0.00093		
112	25			0.00093		
114	24			0.00090		
116	24			0.00090		
118	23.5			0.00088		
120	23.5			0.00088		

Table C-7 (continue): Experimental data of effect of the feed concentration, without ultrasound

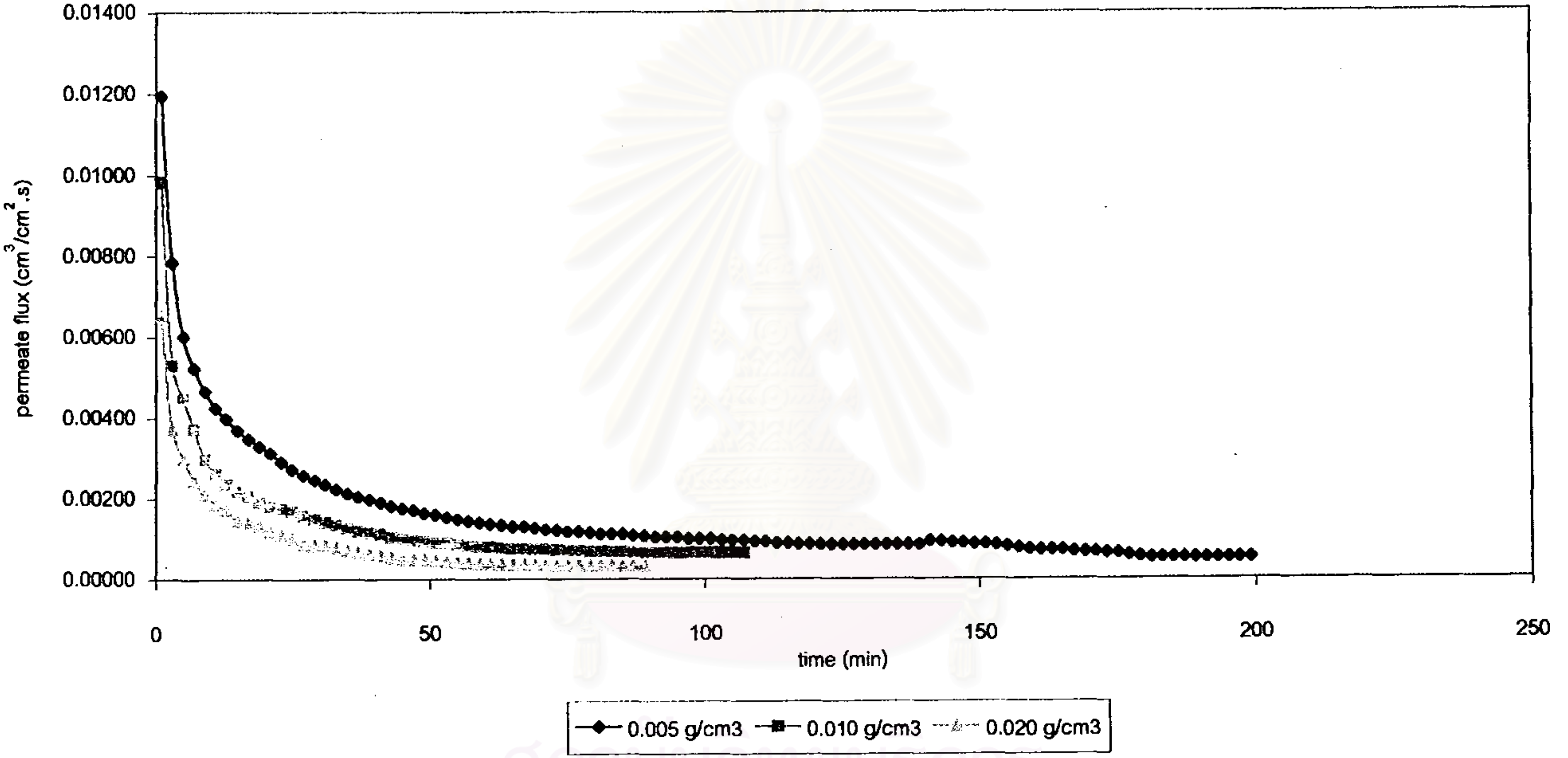
time (min)	permeate volume (cm^3) at feed concentration of			permeate flux ($cm^3/cm^2.s$) at feed concentration of		
	0.005 g/cm^3	0.010 g/cm^3	0.020 g/cm^3	0.005 g/cm^3	0.010 g/cm^3	0.020 g/cm^3
122	23			0.00086		
124	23			0.00086		
126	23			0.00086		
128	23			0.00086		
130	23			0.00086		
132	23			0.00086		
134	23			0.00086		
136	23			0.00086		
136	23			0.00086		
140	23			0.00086		
142	25.5			0.00095		
144	25			0.00093		
146	24.5			0.00091		
148	24			0.00090		
150	23.5			0.00086		
152	23.5			0.00086		
154	22.5			0.00084		
156	22			0.00082		
158	21			0.00078		
160	20			0.00075		
162	19.5			0.00073		
164	19.5			0.00073		
166	19.5			0.00073		
168	18.5			0.00069		
170	18			0.00067		
172	18			0.00067		
174	17.5			0.00065		
176	17.5			0.00065		
178	16			0.00060		
180	15			0.00056		

Table C-7 (continue): Experimental data of effect of the feed concentration, without ultrasound

time (min)	permeate volume (cm^3) at feed concentration of			permeate flux ($cm^3/cm^2.s$) at feed concentration of		
	0.005 g/cm^3	0.010 g/cm^3	0.020 g/cm^3	0.005 g/cm^3	0.010 g/cm^3	0.020 g/cm^3
182	14			0.00052		
184	14			0.00052		
186	14			0.00052		
188	14			0.00052		
190	14			0.00052		
192	14			0.00052		
194	14			0.00052		
196	14			0.00052		
198	14			0.00052		
200	14			0.00052		

Conditions:

- Operating temperature of 30 °C
- Applied pressure of 26.46 kPa
- Feed flow velocity of 0.29 m/s



Conditions: Operating temperature of 30°C, applied pressure of 26.46 kPa, feed flow velocity of 0.29 m/s

Figure C-7: Effect of feed concentration on permeate flux, without ultrasound

Table C-8: Experimental data of effect of the feed concentration, with ultrasound

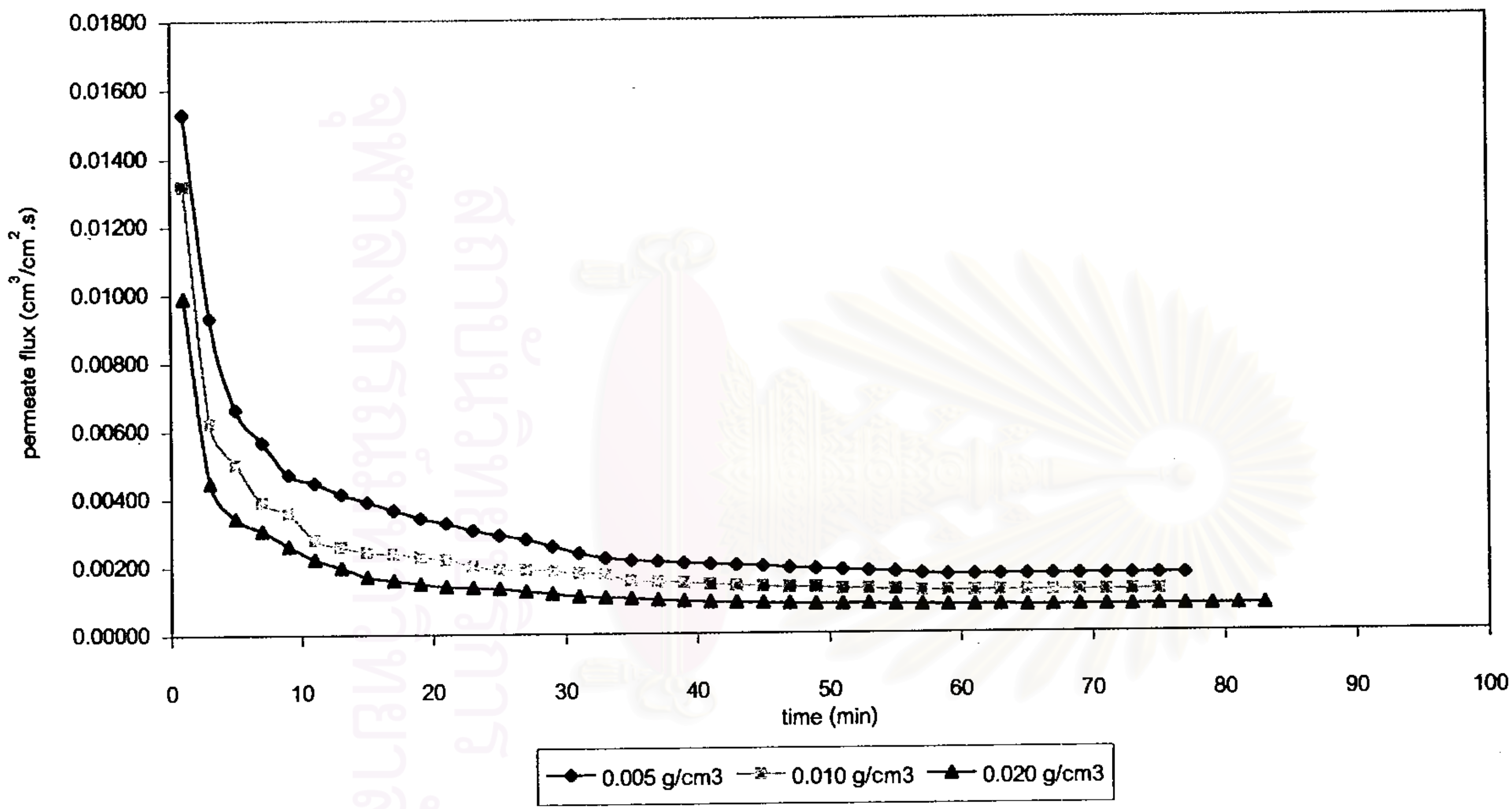
time (min)	permeate volume (cm^3) at feed concentration of			permeate flux ($cm^3/cm^2.s$) at feed concentration of		
	0.005 g/cm^3	0.010 g/cm^3	0.020 g/cm^3	0.005 g/cm^3	0.010 g/cm^3	0.020 g/cm^3
2	410	353	285	0.01531	0.01318	0.00989
4	250	187	120	0.00933	0.00824	0.00448
6	178	135	92	0.00665	0.00504	0.00343
8	152	105	82	0.00568	0.00392	0.00306
10	127	96	70	0.00474	0.00358	0.00261
12	120	75	80	0.00448	0.00280	0.00224
14	111	69	53	0.00414	0.00258	0.00198
18	105	65	46	0.00392	0.00243	0.00172
18	98	64	43	0.00366	0.00239	0.00161
20	92	61	40	0.00343	0.00228	0.00149
22	88	59	38	0.00329	0.00220	0.00142
24	82	54	37	0.00306	0.00202	0.00138
28	78	51	36	0.00291	0.00190	0.00134
28	75	51	34	0.00280	0.00190	0.00127
30	69	50	32	0.00258	0.00187	0.00119
32	64	48	30	0.00239	0.00179	0.00112
34	60	47	29	0.00224	0.00175	0.00108
36	58	42	28	0.00217	0.00157	0.00105
38	57	41	27	0.00213	0.00153	0.00101
40	56	40	26	0.00209	0.00149	0.00097
42	55	39	25	0.00205	0.00146	0.00093
44	54	38	24.5	0.00202	0.00142	0.00091
46	53	37	24	0.00198	0.00138	0.00090
48	52	36	23.5	0.00194	0.00134	0.00086
50	51	36	23	0.00190	0.00134	0.00086
52	50	35	23	0.00187	0.00131	0.00088
54	49	35	23	0.00183	0.00131	0.00086
56	48	34	22.5	0.00179	0.00127	0.00084
58	47	33	22.5	0.00175	0.00123	0.00084
60	46	33	22	0.00172	0.00123	0.00082

Table C-8 (continue): Experimental data of effect of the feed concentration, with ultrasound

time (min)	permeate volume (cm^3) at feed concentration of			permeate flux ($cm^3/cm^2.s$) at feed concentration of		
	0.005 g/cm^3	0.010 g/cm^3	0.020 g/cm^3	0.005 g/cm^3	0.010 g/cm^3	0.020 g/cm^3
62	48	33	22	0.00172	0.00123	0.00082
64	48	33	22	0.00172	0.00123	0.00082
66	46	33	21.5	0.00172	0.00123	0.00080
68	46	33	21.5	0.00172	0.00123	0.00080
70	48	33	21.5	0.00172	0.00123	0.00080
72	46	33	21.5	0.00172	0.00123	0.00080
74	46	33	21.5	0.00172	0.00123	0.00080
76	46	33	21.5	0.00172	0.00123	0.00080
78	46		21.5	0.00172		0.00080
80			21.5			0.00080
82			21.5			0.00080
84			21.5			0.00080

Conditions:

- Operating temperature of 30 °C
- Applied pressure of 26.46 kPa
- Feed flow velocity of 0.29 m/s
- Input power of 25 W



Conditions: Operating temperature of 30°C, applied pressure of 26.46 kPa, feed flow velocity of 0.29 m/s, input power of 25 W

Figure C-8: Effect of feed concentration on permeate flux, with ultrasound

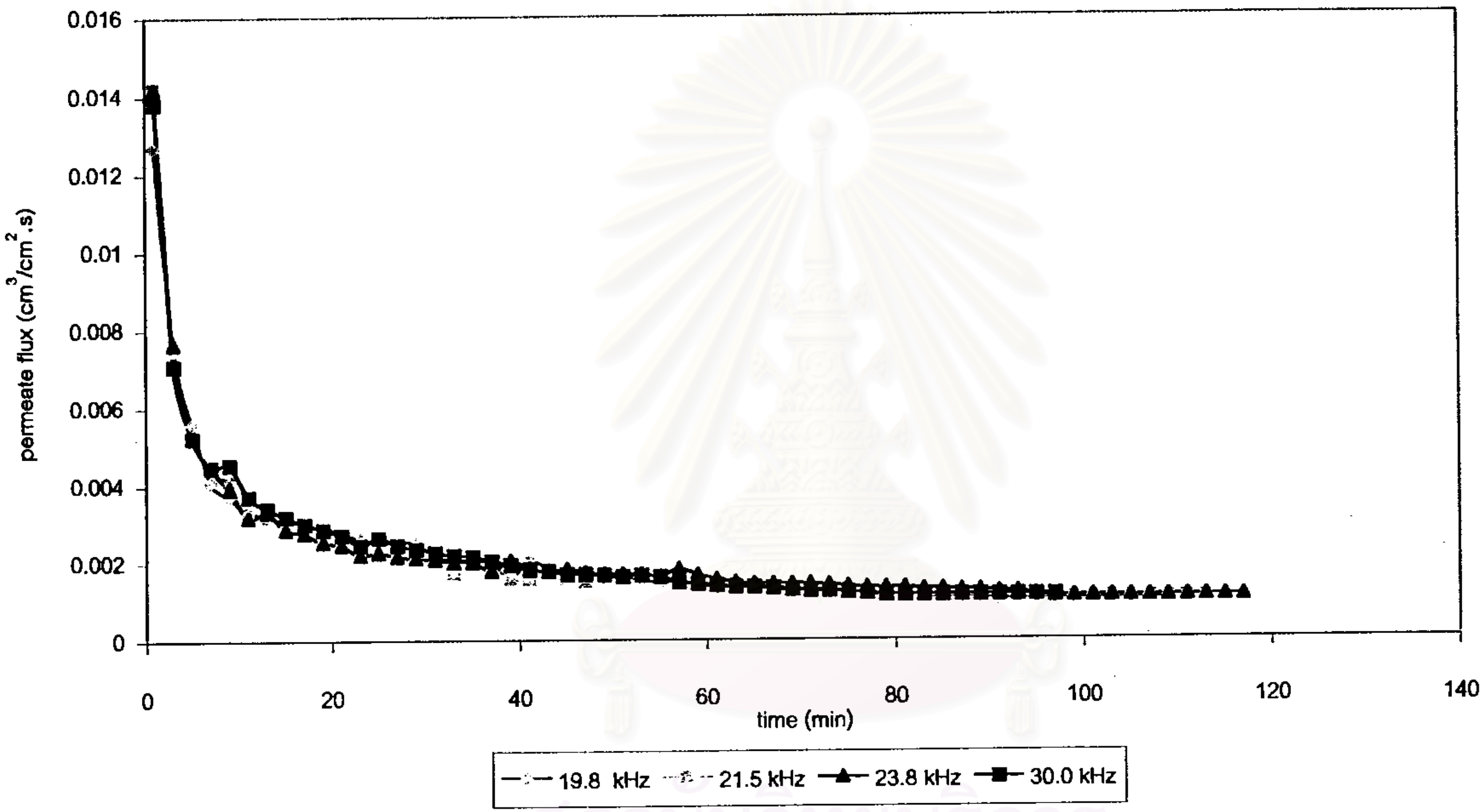
Table C-9: Experimental data of effect of the sound frequency

time (min)	permeate volume (cm^3) at sound frequency of				permeate flux ($cm^3/cm^2.s$) at sound frequency of			
	19.8 kHz	21.5 kHz	23.8 kHz	30.0 kHz	19.8 kHz	21.5 kHz	23.8 kHz	30.0 kHz
2	340	380	380	370	0.012694	0.014188	0.014188	0.013814
4	200	190	205	190	0.007467	0.007094	0.007654	0.007094
6	150	140	140	140	0.005600	0.005227	0.005227	0.005227
8	110	120	120	120	0.004107	0.004480	0.004480	0.004480
10	100	110	105	122	0.003734	0.004107	0.003920	0.004555
12	90	88	85	100	0.003360	0.003286	0.003174	0.003734
14	86	65	89	92	0.003211	0.003174	0.003323	0.003435
16	83	82	77	86	0.003099	0.003062	0.002875	0.003211
18	80	80	74	81	0.002987	0.002987	0.002763	0.003024
20	78	71	68	77	0.002912	0.002651	0.002539	0.002875
22	75	64	66	73	0.002800	0.002389	0.002464	0.002726
24	70	62	59	66	0.002614	0.002315	0.002203	0.002464
26	67	58	61	71	0.002501	0.002165	0.002277	0.002651
28	68	57	58	66	0.002539	0.002128	0.002165	0.002464
30	67	56	57	63	0.002501	0.002091	0.002128	0.002352
32	59	54	56	61	0.002203	0.002016	0.002091	0.002277
34	55	46	54	59	0.002053	0.001717	0.002016	0.002203
36	56	52	54	58	0.002091	0.001941	0.002016	0.002165
38	52	50	48	55	0.001941	0.001867	0.001792	0.002053
40	43	42	55	52	0.001605	0.001568	0.002053	0.001941
42	55	42	50	49	0.002053	0.001568	0.001867	0.001829
44	50	48	46	48	0.001867	0.001792	0.001792	0.001792
46	48	42	49	46	0.001792	0.001568	0.001829	0.001717
48	44	40	47	46	0.001643	0.001493	0.001755	0.001717
50	44	46	46	45	0.001643	0.001717	0.001717	0.001680
52	43	45	46	44	0.001605	0.001660	0.001717	0.001643
54	42	43	46	45	0.001568	0.001605	0.001717	0.001680
56	40	44	44	44	0.001493	0.001643	0.001643	0.001643
58	40	42	49	40	0.001493	0.001568	0.001829	0.001493

Table C-9 (continue): Experimental data of effect of the sound frequency

time (min)	permeate volume (cm^3) at sound frequency of				permeate flux (cm^3/cm^2.s) at sound frequency of			
	19.8 kHz	21.5 kHz	23.8 kHz	30.0 kHz	19.8 kHz	21.5 kHz	23.8 kHz	30.0 kHz
60	39	40	45	39	0.001456	0.001493	0.001680	0.001456
62	36	38	42	38	0.001344	0.001419	0.001568	0.001419
64	36	38	40	37	0.001344	0.001419	0.001493	0.001381
66	36	37	39	37	0.001344	0.001381	0.001456	0.001381
68	35	36	39	36	0.001307	0.001344	0.001456	0.001344
70	34	35	39	35	0.001289	0.001307	0.001456	0.001307
72	34	35	39	34	0.001269	0.001307	0.001458	0.001289
74	33	34	38	34	0.001232	0.001269	0.001419	0.001269
76	33	34	37	33	0.001232	0.001269	0.001381	0.001232
78	33	32	36	32	0.001232	0.001195	0.001344	0.001195
80	32	32	36	31	0.001195	0.001195	0.001344	0.001157
82	30	30	36	31	0.001120	0.001120	0.001344	0.001157
84	30	30	35	31	0.001120	0.001120	0.001307	0.001157
86	29	30	35	31	0.001083	0.001120	0.001307	0.001157
88	29	30	34	31	0.001083	0.001120	0.001289	0.001157
90	29	30	34	31	0.001083	0.001120	0.001289	0.001157
92	28	30	33	31	0.001045	0.001120	0.001232	0.001157
94	28	30	33	31	0.001045	0.001120	0.001232	0.001157
96	28	29	31	31	0.001045	0.001083	0.001157	0.001157
98	28	29	30	31	0.001045	0.001083	0.001120	0.001157
100	28	29	30		0.001045	0.001083	0.001120	
102	28	29	30		0.001045	0.001083	0.001120	
104	28	29	30		0.001045	0.001083	0.001120	
106	28	29	30		0.001045	0.001083	0.001120	
108	28	29	30		0.001045	0.001083	0.001120	
110	28	29	30		0.001045	0.001083	0.001120	
112		29	30			0.001083	0.001120	
114		29	30			0.001083	0.001120	
118			30				0.001120	

Conditions: Applied pressure of 26.46 kPa, Feed flow velocity of 0.29 m/s, Input Power of 25 W



Conditions: Operating temperature of 30 C, applied pressure of 26.46 kPa, feed flow velocity of 0.29 m/s, feed concentration of 0.005 g/cm3, input power of 25 W

Figure C-9: Effect of sound frequency on permeate flux

Table C-10: Pressure amplitude decreases along the distance

r/a	$P(r,0) / 2\rho_0 cU_0$			
	f = 19.8 kHz	f = 21.5 kHz	f = 23.8 kHz	f = 30.0 kHz
0.0000005	0.70682490	0.75128012	0.81341523	0.93021543
0.1	0.65214861	0.69558901	0.75767172	0.88264507
0.2	0.60003596	0.64179245	0.70243557	0.83031109
0.3	0.55141884	0.59110334	0.64942582	0.77651544
0.4	0.50680188	0.54423588	0.59974413	0.72363485
0.5	0.46634697	0.50149757	0.55397584	0.67321688
0.6	0.42998991	0.46289804	0.51231723	0.62614370
0.7	0.39743015	0.42825173	0.47469968	0.58281079
0.8	0.36840290	0.39726176	0.44089323	0.54328642
0.9	0.34253094	0.36958099	0.41058385	0.50743725
1	0.31945818	0.34485239	0.38342593	0.47501863
1.1	0.29884909	0.32273325	0.35907493	0.44573504
1.2	0.28039846	0.30290792	0.33720595	0.41927780
1.3	0.26383481	0.28509319	0.31752270	0.39534712
1.4	0.24892007	0.26903919	0.29976069	0.37366374
1.5	0.23544739	0.25452770	0.28368696	0.35397407
1.6	0.22323799	0.24136946	0.26909805	0.33605155
1.7	0.21213778	0.22940083	0.25581714	0.31969579
1.8	0.20201405	0.21848054	0.24369095	0.30473064
1.9	0.19275250	0.20848669	0.23258672	0.29100182
2	0.18425454	0.19931396	0.22238942	0.27837444
2.1	0.17643498	0.19087118	0.21299926	0.26673057
2.2	0.16922002	0.18307933	0.20432953	0.25596709
2.3	0.16254557	0.17586969	0.19630472	0.24599369
2.4	0.15635581	0.16918235	0.18885889	0.23673117
2.5	0.15060200	0.16296496	0.18193436	0.22810991
2.6	0.14524140	0.15717161	0.17548045	0.22006860
2.7	0.14023650	0.15176193	0.16945260	0.21255311
2.8	0.13555419	0.14670034	0.16381145	0.20551551
2.9	0.13116524	0.14195534	0.15852217	0.19891330
3	0.12704371	0.13749902	0.15355385	0.19270866

Table C-11: Experimental data of effect of the sound intensity

time (min)	permeate volume (cm^3) at the intensity (W/cm^2) of						permeate flux ($cm^3/cm^2.s$) at the intensity (W/cm^2) of					
	0	0.91	1.77	2.19	2.68	3.53	0	0.91	1.77	2.19	2.68	3.53
2	320	270	320	300	510	360	0.011947	0.010081	0.011947	0.011201	0.019041	0.013441
4	210	125	170	170	310	185	0.007841	0.004667	0.006347	0.006347	0.011574	0.006907
6	161	110	150	150	230	170	0.006011	0.004107	0.005600	0.005600	0.008587	0.006347
8	140	100	125	125	200	150	0.005227	0.003734	0.004667	0.004667	0.007467	0.005600
10	125	91	110	115	195	120	0.004667	0.003398	0.004107	0.004294	0.007280	0.004480
12	114	80	100	110	190	110	0.004256	0.002987	0.003734	0.004107	0.007094	0.004107
14	107	74	95	108	175	96	0.003995	0.002763	0.003547	0.004032	0.006534	0.003584
16	99	70	85	100	140	85	0.003696	0.002614	0.003174	0.003734	0.005227	0.003174
18	93	67	81	91	110	84	0.003472	0.002501	0.003024	0.003398	0.004107	0.003136
20	88	64	77	83	91	84	0.003286	0.002389	0.002875	0.003099	0.003398	0.003136
22	84	62	72	77	83	78	0.003136	0.002315	0.002688	0.002875	0.003099	0.002912
24	78	59	68	73	85	75	0.002912	0.002203	0.002539	0.002726	0.003174	0.002800
26	73	57	66	70	72	73	0.002726	0.002128	0.002464	0.002614	0.002688	0.002726
28	69	55	64	67	68	68	0.002576	0.002053	0.002389	0.002501	0.002539	0.002539
30	66	54	62	64	64	67	0.002464	0.002016	0.002315	0.002389	0.002389	0.002501

Table C-11 (continue): Experimental data of effect of the sound intensity

time (min)	permeate volume (cm^3) at the intensity (W/cm^2) of						permeate flux ($cm^3/cm^2.s$) at the intensity (W/cm^2) of					
	0	0.91	1.77	2.19	2.68	3.53	0	0.91	1.77	2.19	2.68	3.53
32	63	52	60	62	63	66	0.002352	0.001941	0.002240	0.002315	0.002352	0.002464
34	60	51	59	60	62	65	0.002240	0.001904	0.002203	0.002240	0.002315	0.002427
36	57	50	58	59	60	64	0.002128	0.001867	0.002165	0.002203	0.002240	0.002389
38	55	50	56	58	59	63	0.002053	0.001867	0.002091	0.002165	0.002203	0.002352
40	53	50	55	56	59	62	0.001979	0.001867	0.002053	0.002091	0.002203	0.002315
42	51	50	54	55	58	61	0.001904	0.001867	0.002016	0.002053	0.002165	0.002277
44	49	49	53	54	57	60	0.001829	0.001829	0.001979	0.002016	0.002128	0.002240
46	47	47	53	53	56	59	0.001755	0.001755	0.001979	0.001979	0.002091	0.002203
48	46	46	52	52	55	58	0.001717	0.001717	0.001941	0.001941	0.002053	0.002165
50	44	45	51	53	54	57	0.001643	0.001680	0.001904	0.001979	0.002016	0.002128
52	43	44	50	52	54	56	0.001605	0.001643	0.001867	0.001941	0.002016	0.002091
54	41	43	49	52	54	56	0.001531	0.001605	0.001829	0.001941	0.002016	0.002091
56	40	42	49	52	54	56	0.001493	0.001568	0.001829	0.001941	0.002016	0.002091
58	39	42	48	52	54	56	0.001456	0.001568	0.001792	0.001941	0.002016	0.002091

Table C-11 (continue): Experimental data of effect of the sound intensity

time (min)	permeate volume (cm^3) at the intensity (W/cm^2) of						permeate flux ($cm^3/cm^2.s$) at the intensity (W/cm^2) of					
	0	0.91	1.77	2.19	2.68	3.53	0	0.91	1.77	2.19	2.68	3.53
60	38	42	47	52	54	56	0.001419	0.001568	0.001755	0.001941	0.002016	0.002091
62	37	42	46	52	54	56	0.001381	0.001568	0.001717	0.001941	0.002016	0.002091
64	36	42	46	52	54	56	0.001344	0.001568	0.001717	0.001941	0.002016	0.002091
66	35	42	46	52	54	56	0.001307	0.001568	0.001717	0.001941	0.002016	0.002091
68	35	42	46	52	54	56	0.001307	0.001568	0.001717	0.001941	0.002016	0.002091
70	34	42	46	52	54	56	0.001269	0.001568	0.001717	0.001941	0.002016	0.002091
72	33	42	46				0.001232	0.001568	0.001717			
74	33	42	46				0.001232	0.001568	0.001717			
76	32		46				0.001195		0.001717			
78	32		46				0.001195		0.001717			
80	31		46				0.001157		0.001717			
82	30						0.001120					
84	30						0.001120					
86	30						0.001120					

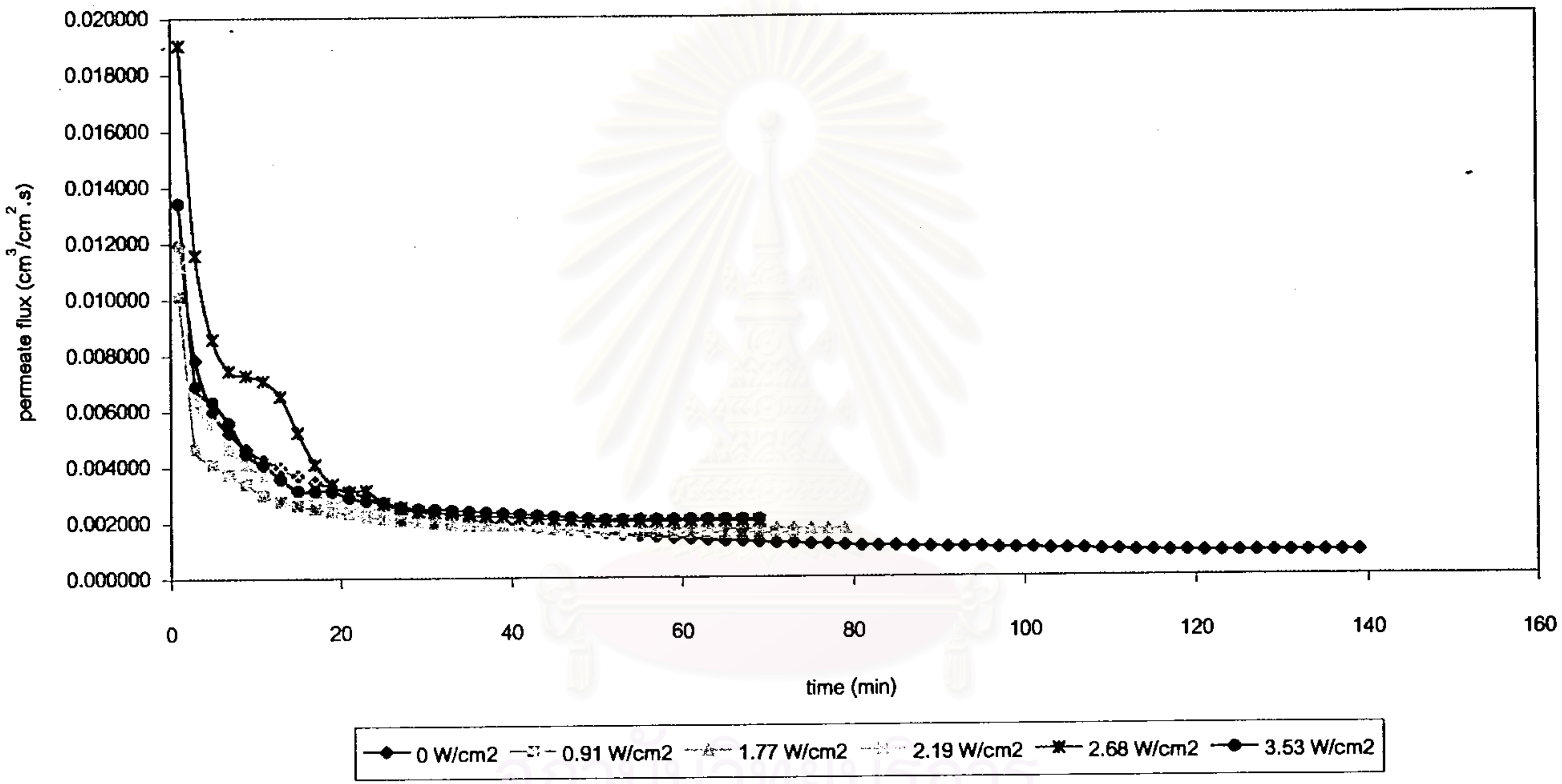
Table C-11 (continue): Experimental data of effect of the sound intensity

time (min)	permeate volume (cm^3) at the intensity (W/cm^2) of						permeate flux ($cm^3/cm^2.s$) at the intensity (W/cm^2) of					
	0	0.91	1.77	2.19	2.68	3.53	0	0.91	1.77	2.19	2.68	3.53
88	29						0.001083					
90	29						0.001083					
92	28						0.001045					
94	28						0.001045					
96	28						0.001045					
98	27						0.001008					
100	27						0.001008					
102	27						0.001008					
104	26						0.000971					
106	26						0.000971					
108	26						0.000971					
110	25						0.000933					
112	25						0.000933					
114	24						0.000896					

Table C-11 (continue): Experimental data of effect of the sound intensity

time (min)	permeate volume (cm^3) at the intensity (W/cm^2) of						permeate flux ($cm^3/cm^2.s$) at the intensity (W/cm^2) of					
	0	0.91	1.77	2.19	2.68	3.53	0	0.91	1.77	2.19	2.68	3.53
116	24						0.000896					
118	23.5						0.000877					
120	23.5						0.000877					
122	23						0.000859					
124	23						0.000859					
126	23						0.000859					
128	23						0.000859					
130	23						0.000859					
132	23						0.000859					
134	23						0.000859					
136	23						0.000859					
138	23						0.000859					
140	23						0.000859					

Conditions: Operating temperature of 30 °C, Applied pressure of 26.46 kPa, Feed flow velocity of 0.29 m/s, Feed concentration of 0.005 g/cm^3



Conditions: Operating temperature of 30°C, applied pressure of 26.46 kPa, feed flow velocity of 0.29 m/s, feed concentration of 0.005 g/cm^3

Figure C-11: Effect of sound intensity on permeate flux

Table C-12: Experimental data of effect of irradiation time, ultrasonic irradiated at 2nd minute for 4 minutes

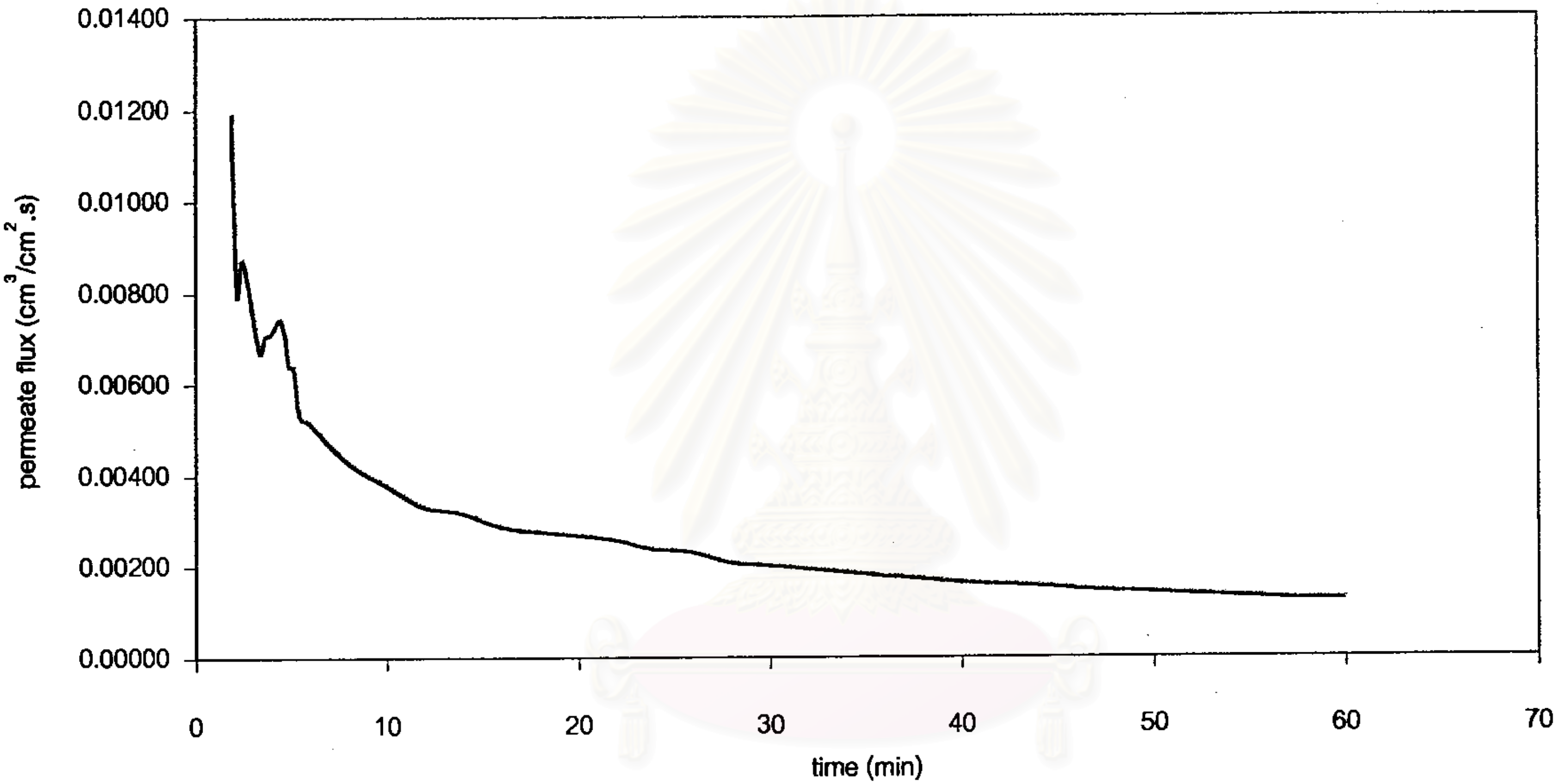
time (min)	permeate volume (cm^3)	permeate flux (cm^3/cm^2.s)
2:00	320	0.01195
2:15	26.86	0.00802
2:30	29.29	0.00875
2:45	28.21	0.00843
3:00	26.15	0.00781
3:15	23.93	0.00715
3:30	22.5	0.00672
3:45	23.78	0.00710
4:00	23.86	0.00713
4:15	24.47	0.00731
4:30	24.97	0.00746
4:45	24.05	0.00718
5:00	21.56	0.00644
5:15	21.5	0.00642
5:30	18.13	0.00542
5:45	17.55	0.00524
6:00	17.46	0.00522
8:00	117	0.00437
10:00	103	0.00385
12:00	90	0.00336
14:00	86	0.00321
16:00	78	0.00291
18:00	75	0.00280
20:00	73	0.00273
22:00	70	0.00261
24:00	65	0.00243
26:00	63	0.00235
28:00	57	0.00213
30:00	55	0.00205

Table C-12 (continue): Experimental data of effect of irradiation time, ultrasonic irradiated at 2nd minute for 4 minutes

time (min)	permeate volume (cm^3)	permeate flux ($cm^3/cm^2.s$)
32:00	53	0.00198
34:00	51	0.00190
36:00	49	0.00183
38:00	47	0.00175
40:00	45	0.00168
42:00	44	0.00164
44:00	43	0.00161
46:00	41	0.00153
48:00	40	0.00149
50:00	39	0.00146
52:00	38	0.00142
54:00	37	0.00138
56:00	36	0.00134
58:00	35	0.00131
60:00	35	0.00131

Conditions:

- Operating temperature of 30 °C
- Applied pressure of 26.46 kPa
- Feed flow velocity of 0.29 m/s
- Feed concentration of 0.005 g/cm^3



Conditions: Operating temperature of 30°C, applied pressure of 26.46 kPa, feed flow velocity of 0.29 m/s, feed concentration of 0.005 g/cm^3, input power of 25 W

Figure C-12: Effect of irradiation time, ultrasound was irradiated in 2nd min for 4 minutes

Table C-13: Experimental data of effect of irradiation time, ultrasonic irradiated at 6^{th} minute for 4 minutes

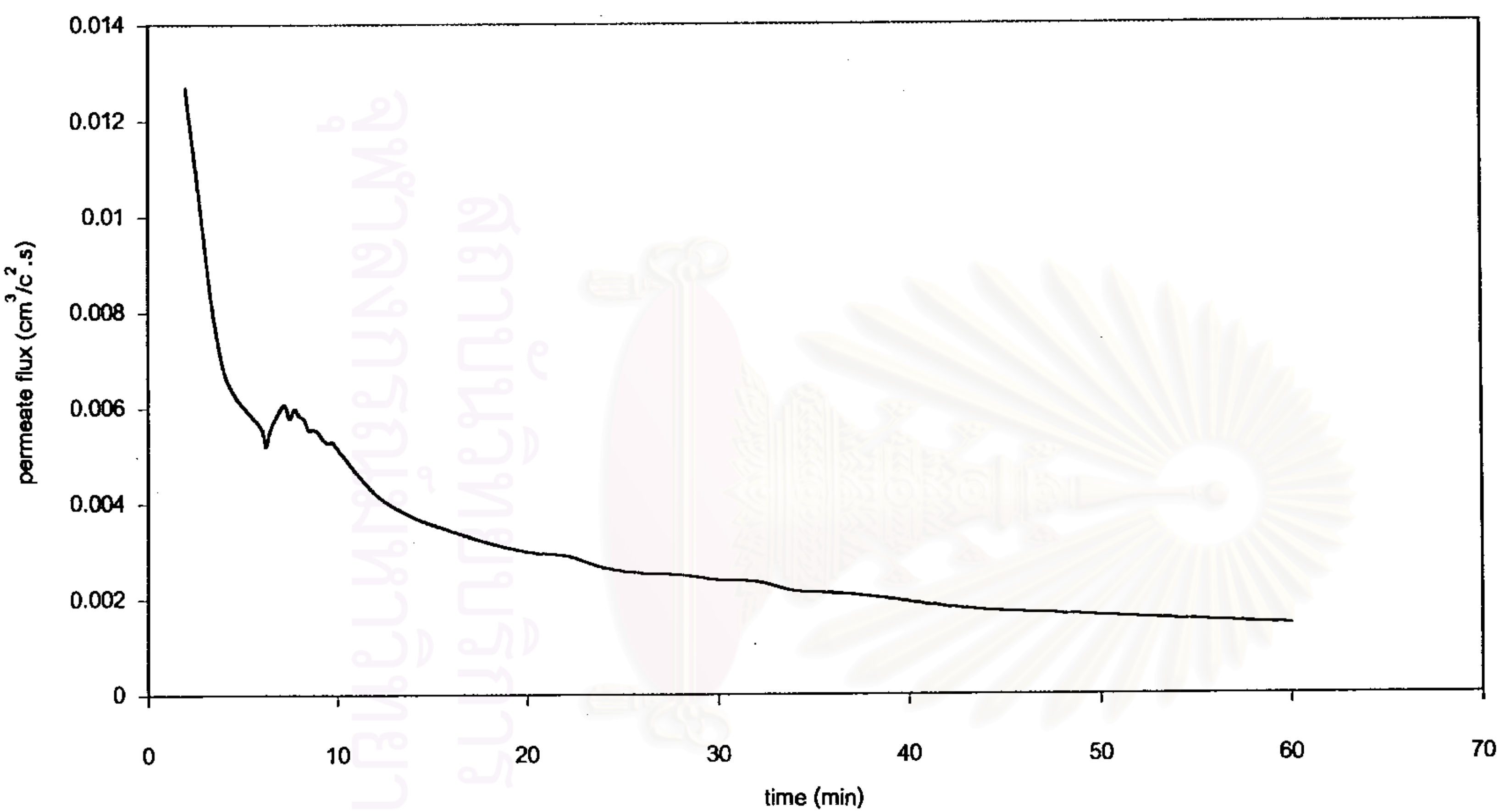
time (min)	permeate volume (cm^3)	permeate flux ($cm^3/cm^2.s$)
2:00	340	0.01269
4:00	185	0.00691
6:00	150	0.00560
6:15	17.41	0.00520
6:30	18.57	0.00555
6:45	19.37	0.00579
7:00	19.99	0.00597
7:15	20.31	0.00607
7:30	19.37	0.00579
7:45	20.06	0.00599
8:00	19.56	0.00584
8:15	19.4	0.00579
8:30	18.55	0.00554
8:45	18.62	0.00556
9:00	16.43	0.00550
9:15	17.95	0.00536
9:30	17.65	0.00527
9:45	17.75	0.00530
10:00	17.26	0.00516
12:00	113	0.00422
14:00	100	0.00373
16:00	92	0.00343
18:00	85	0.00317
20:00	80	0.00299
22:00	78	0.00291
24:00	71	0.00265
26:00	68	0.00254
26:00	67	0.00250
30:00	64	0.00239

Table C-13 (continue): Experimental data of effect of irradiation time, ultrasonic irradiated at 6[th] minute for 4 minutes

time (min)	permeate volume (cm^3)	permeate flux ($cm^3/cm^2.s$)
32:00	63	0.00235
34:00	58	0.00217
36:00	57	0.00213
38:00	55	0.00205
40:00	52	0.00194
42:00	49	0.00183
44:00	47	0.00175
46:00	46	0.00172
48:00	45	0.00168
50:00	44	0.00164
52:00	43	0.00161
54:00	42	0.00157
56:00	41	0.00153
58:00	40	0.00149
60:00	39	0.00146

Conditions:

- Operating temperature of 30 °C
- Applied pressure of 26.46 kPa
- Feed flow velocity of 0.29 m/s
- Feed concentration of 0.005 g/cm^3



Conditions: Operating temperature of 30°C, applied pressure of 26.46 kPa, feed flow velocity of 0.29 m/s, feed concentration of 0.005 g/cm^3, input power of 25 W

Figure C-13: Effect of irradiation time, ultrasound was irradiated in 6th min for 4 minutes

Table C-14: Experimental data of effect of irradiation time, ultrasonic irradiated at 10th minute for 4 minutes

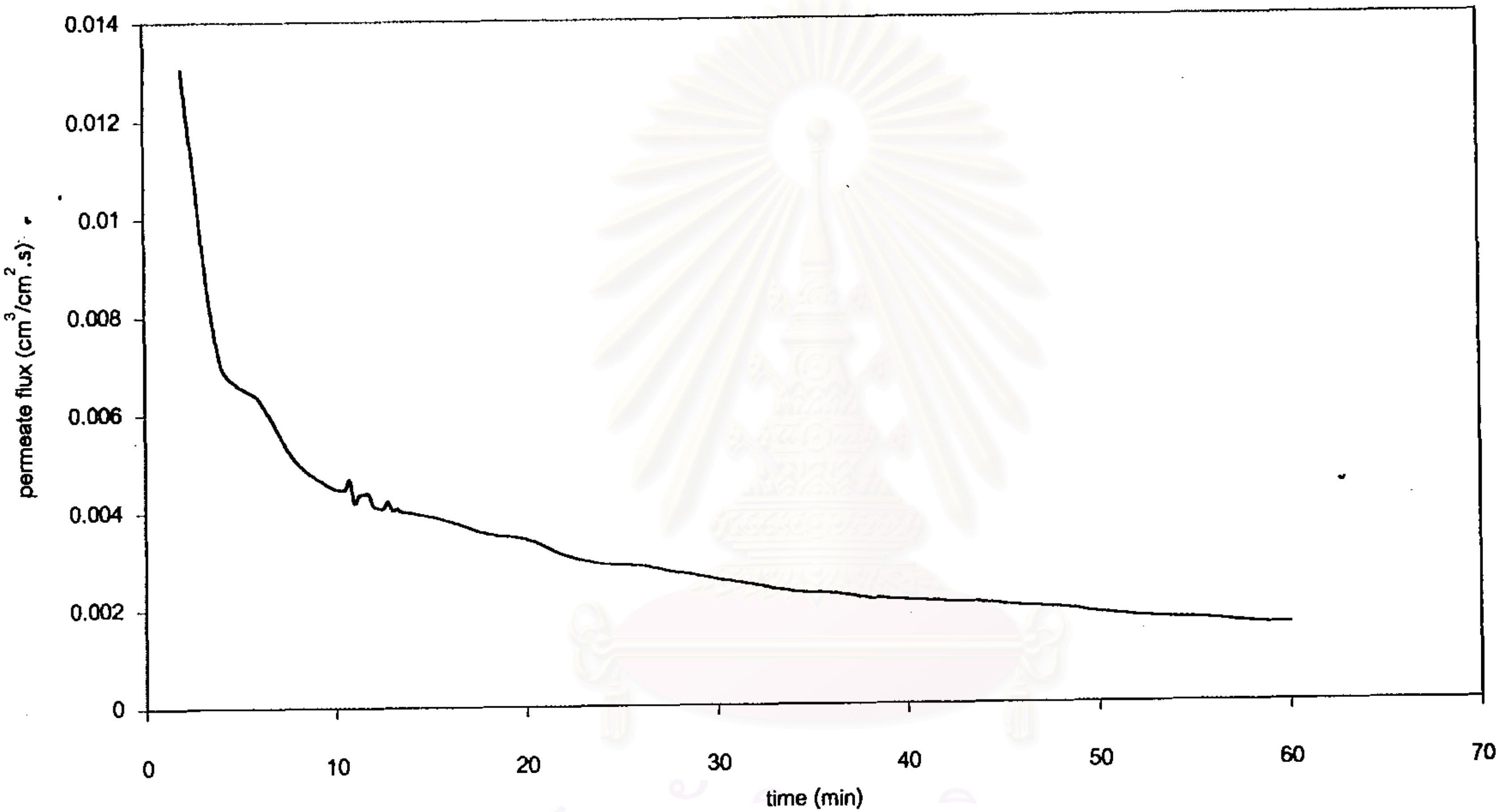
time (min)	permeate volume (cm^3)	permeate flux ($cm^3/cm^2.s$)
2:00	350	0.01307
4:00	190	0.00709
6:00	170	0.00635
8:00	135	0.00504
10:00	120	0.00448
10:15	14.97	0.00447
10:30	14.99	0.00448
10:45	15.63	0.00467
11:00	14.06	0.00420
11:15	14.58	0.00435
11:30	14.65	0.00438
11:45	14.68	0.00438
12:00	13.86	0.00414
12:15	13.69	0.00409
12:30	13.68	0.00409
12:45	14.15	0.00423
13:00	13.52	0.00404
13:15	13.68	0.00409
13:30	13.41	0.00401
13:45	13.39	0.00400
14:00	13.35	0.00399
16:00	102	0.00381
18:00	95	0.00355
20:00	92	0.00343
22:00	83	0.00310
24:00	78	0.00291
26:00	77	0.00287
28:00	73	0.00273
30:00	69	0.00258

Table C-14 (continue): Experimental data of effect of irradiation time, ultrasonic irradiated at 10th minute for 4 minutes

time (min)	permeate volume (cm^3)	permeate flux ($cm^3/cm^2.s$)
32:00	66	0.00246
34:00	62	0.00231
36:00	61	0.00228
38:00	58	0.00217
40:00	57	0.00213
42:00	56	0.00209
44:00	55	0.00205
46:00	53	0.00198
48:00	52	0.00194
50:00	49	0.00183
52:00	47	0.00175
54:00	46	0.00172
56:00	45	0.00168
58:00	43	0.00161
60:00	42	0.00157

Conditions:

- Operating temperature of 30 °C
- Applied pressure of 26.46 kPa
- Feed flow velocity of 0.29 m/s
- Feed concentration of 0.005 g/cm^3



Conditions: Operating temperature of 30℃, applied pressure of 26.46 kPa, feed flow velocity of 0.29 m/s, feed concentration of 0.005 g/cm^3, input power of 25 W

Figure C-14: Effect of irradiation time, ultrasound was irradiated in 10^{th} min for 4 minutes

Table C-15: Experimental data of effect of irradiation time, ultrasonic irradiated at 20th minute for 4 minutes

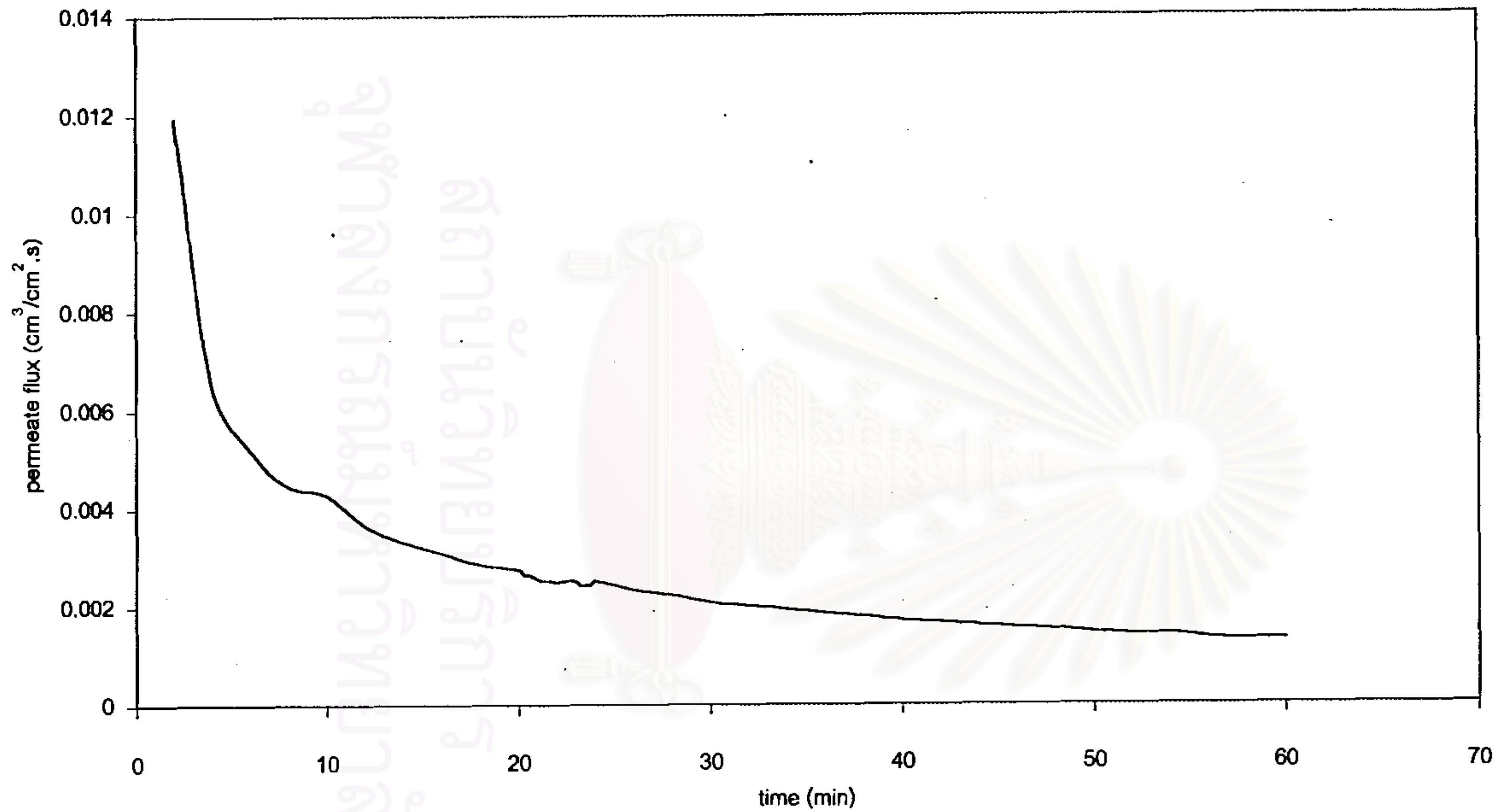
time (min)	permeate volume (cm^3)	permeate flux ($cm^3/cm^2.s$)
2:00	320	0.01195
4:00	175	0.00653
6:00	140	0.00523
8:00	120	0.00448
10:00	115	0.00429
12:00	98	0.00366
14:00	89	0.00332
16:00	83	0.00310
18:00	77	0.00287
20:00	74	0.00276
20:15	8.87	0.00265
20:30	8.92	0.00266
20:45	8.79	0.00263
21:00	8.6	0.00257
21:15	8.48	0.00253
21:30	8.46	0.00253
21:45	8.47	0.00253
22:00	8.38	0.00250
22:15	8.47	0.00253
22:30	8.5	0.00254
22:45	8.53	0.00255
23:00	8.44	0.00252
23:15	8.16	0.00244
23:30	8.19	0.00245
23:45	8.18	0.00244
24:00	8.46	0.00253
26:00	63	0.00235
28:00	60	0.00224
30:00	56	0.00209

Table C-15 (continue): Experimental data of effect of irradiation time, ultrasonic irradiated at 20[th] minute for 4 minutes

time (min)	permeate volume (cm^3)	permeate flux ($cm^3/cm^2.s$)
32:00	54	0.00202
34:00	52	0.00194
36:00	50	0.00187
38:00	48	0.00179
40:00	46	0.00172
42:00	45	0.00168
44:00	43	0.00161
46:00	42	0.00157
48:00	41	0.00153
50:00	39	0.00146
52:00	38	0.00142
54:00	38	0.00142
56:00	36	0.00134
58:00	35	0.00131
60:00	35	0.00131

Conditions:

- Operating temperature of 30 °C
- Applied pressure of 26.46 kPa
- Feed flow velocity of 0.29 m/s
- Feed concentration of 0.005 g/cm^3



Conditions: Operating temperature of 30°C, applied pressure of 26.46 kPa, feed flow velocity of 0.29 m/s, feed concentration of 0.005 g/cm^3, input power of 25 W

Figure C-15: Effect of irradiation time, ultrasound was irradiated in 20^{th} min for 4 minutes

Table C-16: Experimental data of effect of irradiation time, ultrasound was applied after steady state flux reached

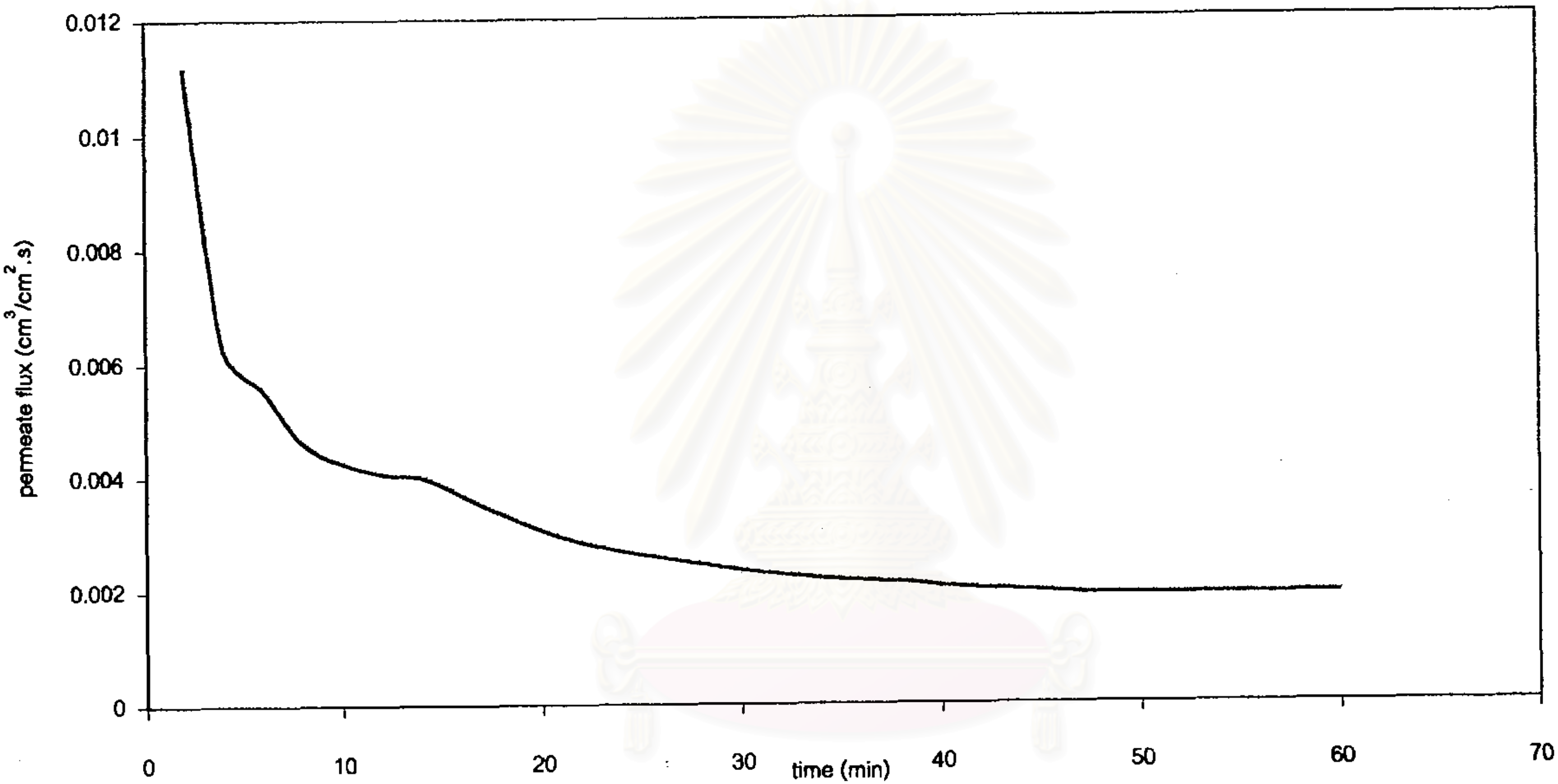
time (min)	permeate volume (cm^3)	permeate flux (cm^3/cm^2.s)
2	325	0.01213
4	165	0.00616
6	120	0.00448
8	98	0.00366
10	80	0.00299
12	66	0.00254
14	58	0.00217
16	51	0.00190
18	46	0.00172
20	42	0.00157
22	38	0.00142
24	36	0.00134
26	34	0.00127
28	31	0.00116
30	30	0.00112
32	29	0.00108
34	27	0.00101
36	27	0.00101
38	27	0.00101
40	26	0.00097
42	26	0.00097
44	25	0.00093
46	25	0.00093
48	25	0.00093
50	25	0.00093
52	24	0.00090
54	24	0.00090
56	23	0.00086
58	23	0.00086
60	23	0.00086

Table C-16 (continue): : Experimental data of effect of irradiation time, ultrasound was applied after steady state flux reached

time (min)	permeate volume (cm^3)	permeate flux ($cm^3/cm^2.s$)
62	23	0.00086
64	23	0.00086
66	23	0.00088
68	23	0.00086
70	23	0.00086
72	23	0.00086
74	23	0.00088
76	62	0.00231
78	67	0.00250
80	63	0.00235
82	58	0.00217
84	58	0.00217
86	53	0.00198
88	60	0.00224
90	51	0.00190
92	50	0.00187
94	50	0.00187
96	50	0.00187
98	50	0.00187

Conditions:

- Operating temperature of 30 °C
- Applied pressure of 26.46 kPa
- Feed flow velocity of 0.29 m/s
- Feed concentration of 0.005 g/cm^3



Conditions: Operating temperature of 30°C, applied pressure of 26.46 kPa, feed flow velocity of 0.29 m/s, feed concentration of 0.005 g/cm^3, input power of 25 W

Figure D-16: Effect of irradiation time , ultrasound was irradiated from the beginning of filtration

PORESIZER 9320 V2.02 PAGE 1

SAMPLE DIRECTORY/NUMBER: DATA1 /35
OPERATOR: oor LP 10:01:46 04/07/99
SAMPLE ID: ceramic before being sonicated HP 11:02:28 04/07/99
SUBMITTER: REP 11:02:51 04/07/99

PENETROMETER NUMBER: 07-0865	ADVANCING CONTACT ANGLE: 130.0 deg
PENETROMETER CONSTANT: 10.79 fL/pF	RECEDING CONTACT ANGLE: 130.0 deg
PENETROMETER WEIGHT: 63.0527 g	MERCURY SURFACE TENSION: 485.0 dyn/cm
STEM VOLUME: 0.3920 mL	MERCURY DENSITY: 13.5335 g/mL
MAXIMUM HEAD PRESSURE: 4.4500 psi	SAMPLE WEIGHT: 64.3894 g
PENETROMETER VOLUME: 1.0000 mL	SAMPLE+PEN+Hg WEIGHT: 125.5545 g

LOW PRESSURE:
MERCURY FILLING PRESSURE: 9.7897 psia
LAST LOW PRESSURE POINT: 30.5582 psia

HIGH PRESSURE:
RUN TYPE: AUTOMATIC
RUN METHOD: EQUILIBRATED
EQUILIBRATION TIME: 10 seconds

INTRUSION DATA SUMMARY

TOTAL INTRUSION VOLUME =	0.0060 mL/g
TOTAL PORE AREA =	0.114 sq-m/g
MEDIAN PORE DIAMETER (VOLUME) =	1.8147 fm
MEDIAN PORE DIAMETER (AREA) =	0.0099 fm
AVERAGE PORE DIAMETER (4V/A) =	0.2103 fm
BULK DENSITY =	56.5079 g/mL
APPARENT (SKELETAL) DENSITY =	85.4242 g/mL
POROSITY =	33.85 %
STEM VOLUME USED =	98 % ####

PORESIZER 9320 V2.02 PAGE 1

SAMPLE DIRECTORY/NUMBER: DATA1 /41
OPERATOR: por LP 14:39:29 04/07/99
SAMPLE ID: ceramic after being sonicated HP 15:42:09 04/07/99
SUBMITTER: REP 15:42:09 04/07/99

PENETROMETER NUMBER: 07-0865
PENETROMETER CONSTANT: 10.79 fL/pF
PENETROMETER WEIGHT: 63.0484 g
STEM VOLUME: 0.3920 mL
MAXIMUM HEAD PRESSURE: 4.4500 psi
PENETROMETER VOLUME: 1.0000 mL

ADVANCING CONTACT ANGLE: 130.0 deg
RECEDING CONTACT ANGLE: 130.0 deg
MERCURY SURFACE TENSION: 485.0 dyn/cm
MERCURY DENSITY: 13.5335 g/mL
SAMPLE WEIGHT: 1.0892 g
SAMPLE+PEN+Hg WEIGHT: 128.5964 g

LOW PRESSURE:
MERCURY FILLING PRESSURE: 1.0467 psia
LAST LOW PRESSURE POINT: 30.3134 psia

HIGH PRESSURE:
RUN TYPE: AUTOMATIC
RUN METHOD: EQUILIBRATED
EQUILIBRATION TIME: 10 seconds

INTRUSION DATA SUMMARY

TOTAL INTRUSION VOLUME = 0.3569 mL/g
TOTAL PORE AREA = 6.172 sq-m/g
MEDIAN PORE DIAMETER (VOLUME) = 2.2522 fm
MEDIAN PORE DIAMETER (AREA) = 0.0100 fm
AVERAGE PORE DIAMETER (4V/A) = 0.2313 fm
STEM VOLUME USED = 99 % ****

ศูนย์เครื่องมือวิจัยวิทยาศาสตร์และเทคโนโลยี จุฬาลงกรณ์มหาวิทยาลัย
อาคารสถาบัน 2 จุฬาลงกรณ์ ซอย 62 ถ.พญาไท ปทุมวัน กรุงเทพฯ 10330 โทร 2188029-32, 2188101
Scinetific and Technological Research Equiment Centre Chulalongkorn University
Buliding 2-3 Chula Soi 62 Phaya-Thai Rd. Phatumwan Bangkok 10330 Tel. 2188029-32, 2188101 Fax. 2540211

Result: Analysis Report

Sample Details

Sample ID: sample11
Sample File: JITTIWUT
Sample Path: A:\
Sample Notes: Test by Pranee : Scientific and Technological Research Equipment Centre Chulalongkorn University.
Liquid medium : WATER

Run Number: 2
Record Number: 38

Measurement Date: Thu, Mar 18, 1999 1:06PM
Analysis Date: Thu, Mar 18, 1999 1:06PM
Result Source: Analysed

System Details

Range Lens: 300RF mm
Presentation: 3OHD
Analysis Model: Polydisperse
Modifications: Active --

Beam Length: 2.40 mm
[Particle R.I. = (1.5295, 0.1000); Dispersant R.I. = 1.3300]
Killed Data Channels: Low 0; High 2

Sampler: MS17

Obscuration: 28.6 %
Residual: 0.964 %

Result Statistics

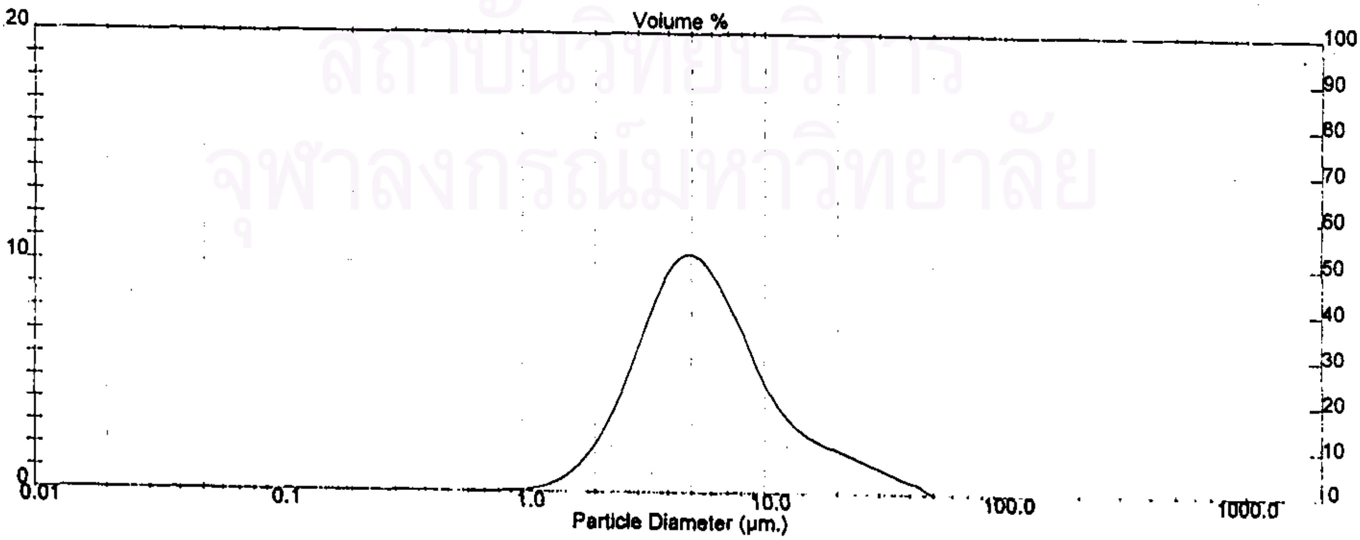
Distribution Type: Volume
Mean Diameters:
D [4, 3] = 7.57 um

Concentration = 0.0203 %Vol
D (v, 0.1) = 2.70 um
D [3, 2] = 4.80 um

Density = 1.000 g / cub. cm
D (v, 0.5) = 5.47 um
Span = 2.263E+00

Specific S.A. = 1.2492 sq. m / g
D (v, 0.9) = 15.07 um
Uniformity = 7.118E-01

Size_Low (um)	In %	Size_High (um)	Under%	Size_Low (um)	In %	Size_High (um)	Under%
0.05	0.00	0.06	0.00	6.63	8.20	7.72	70.34
0.06	0.00	0.07	0.00	7.72	6.74	9.00	77.09
0.07	0.00	0.08	0.00	9.00	5.10	10.48	82.19
0.08	0.00	0.09	0.00	10.48	3.84	12.21	86.03
0.09	0.00	0.11	0.00	12.21	2.99	14.22	89.02
0.11	0.00	0.13	0.00	14.22	2.48	16.57	91.49
0.13	0.00	0.15	0.00	16.57	2.11	19.31	93.60
0.15	0.00	0.17	0.00	19.31	1.82	22.49	95.41
0.17	0.00	0.20	0.00	22.49	1.52	26.20	96.93
0.20	0.00	0.23	0.00	26.20	1.22	30.53	98.15
0.23	0.00	0.27	0.00	30.53	0.92	35.56	99.06
0.27	0.00	0.31	0.00	35.56	0.62	41.43	99.68
0.31	0.00	0.36	0.00	41.43	0.32	48.27	100.00
0.36	0.00	0.42	0.00	48.27	0.00	56.23	100.00
0.42	0.00	0.49	0.00	56.23	0.00	65.51	100.00
0.49	0.01	0.58	0.01	65.51	0.00	76.32	100.00
0.58	0.03	0.67	0.04	76.32	0.00	88.91	100.00
0.67	0.04	0.78	0.08	88.91	0.00	103.58	100.00
0.78	0.05	0.91	0.13	103.58	0.00	120.67	100.00
0.91	0.08	1.06	0.21	120.67	0.00	140.56	100.00
1.06	0.16	1.24	0.36	140.56	0.00	163.77	100.00
1.24	0.39	1.44	0.77	163.77	0.00	190.80	100.00
1.44	0.79	1.68	1.57	190.80	0.00	222.28	100.00
1.68	1.48	1.95	3.05	222.28	0.00	258.95	100.00
1.95	2.48	2.28	5.53	258.95	0.00	301.68	100.00
2.28	3.89	2.65	9.42	301.68	0.00	351.46	100.00
2.65	5.70	3.09	15.11	351.46	0.00	409.45	100.00
3.09	7.66	3.60	22.77	409.45	0.00	477.01	100.00
3.60	9.33	4.19	32.10	477.01	0.00	555.71	100.00
4.19	10.26	4.88	42.36	555.71	0.00	647.41	100.00
4.88	10.29	5.69	52.65	647.41	0.00	754.23	100.00
5.69	9.49	6.63	62.14	754.23	0.00	878.67	100.00



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Scinetific and Technological Research Equipment Centre Chulalongkorn University
Buliding 2-3 Chula Soi 62 Phaya-Thai Rd. Phatumwan Bangkok 10330 Tel. 2188029-32, 2188101 Fax. 2540211

Result: Analysis Report

Sample Details

Sample ID: sample11
Sample File: JITTIWUT
Sample Path: A:\
Sample Notes: Test by Pranee : Scientific and Technological Research Equipment Centre Chulalongkorn University.
Liquid medium : WATER

Run Number: 3
Record Number: 39

Measurement Date: Thu, Mar 18, 1999 1:06PM
Analysis Date: Thu, Mar 18, 1999 1:06PM
Result Source: Analysed

System Details

Range Lens: 300RF mm
Presentation: 3OHD
Analysis Model: Polydisperse
Modifications: Active --

Beam Length: 2.40 mm
[Particle R.I. = (1.5295, 0.1000); Dispersant R.I. = 1.3300]
Killed Data Channels: Low 0; High 2

Sampler: MS17

Obscuration: 29.0 %
Residual: 0.944 %

Result Statistics

Distribution Type: Volume
Mean Diameters:
D [4, 3] = 6.93 um

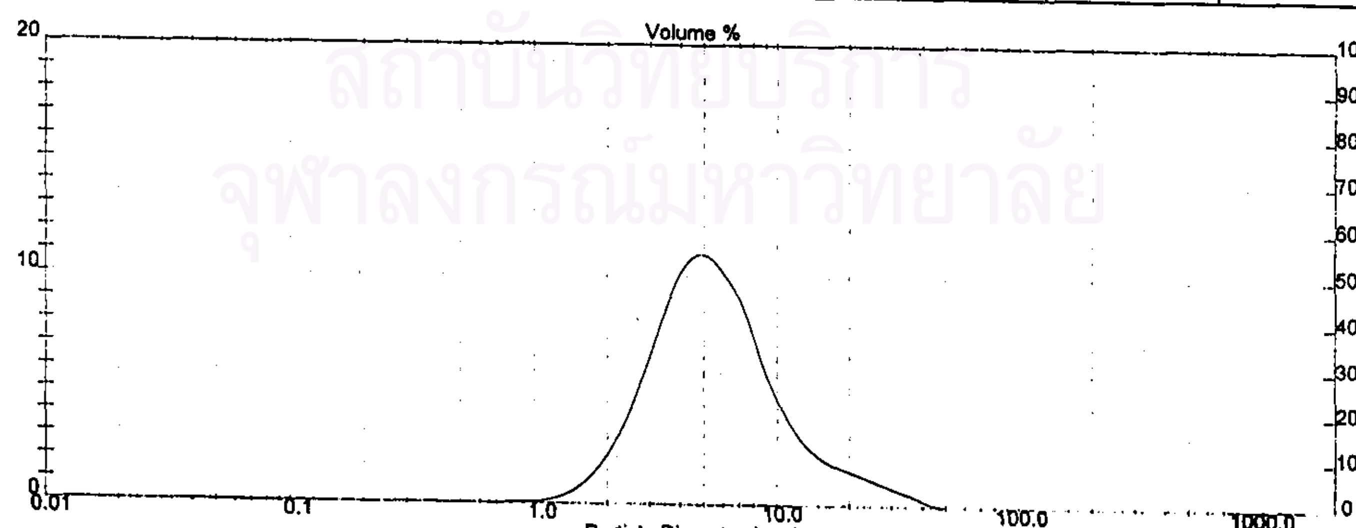
Concentration = 0.0201 %Vol
D (v, 0.1) = 2.68 um
D [3, 2] = 4.67 um

Density = 1.000 g / cub. cm
D (v, 0.5) = 5.30 um
Span = 1.894E+00

Specific S.A. = 1.2843 sq. m / g
D (v, 0.9) = 12.72 um
Uniformity = 6.235E-01

Size_Low (um)	In %	Size_High (um)	Under%
0.05	0.00	0.06	0.00
0.06	0.00	0.07	0.00
0.07	0.00	0.08	0.00
0.08	0.00	0.09	0.00
0.09	0.00	0.11	0.00
0.11	0.00	0.13	0.00
0.13	0.00	0.15	0.00
0.15	0.00	0.17	0.00
0.17	0.00	0.20	0.00
0.20	0.00	0.23	0.00
0.23	0.00	0.27	0.00
0.27	0.00	0.31	0.00
0.31	0.00	0.36	0.00
0.36	0.00	0.42	0.00
0.42	0.00	0.49	0.00
0.49	0.01	0.58	0.01
0.58	0.02	0.67	0.03
0.67	0.04	0.78	0.07
0.78	0.04	0.91	0.11
0.91	0.07	1.06	0.18
1.06	0.17	1.24	0.35
1.24	0.39	1.44	0.74
1.44	0.80	1.68	1.53
1.68	1.51	1.95	3.04
1.95	2.53	2.28	5.57
2.28	4.01	2.65	9.58
2.65	5.92	3.09	15.50
3.09	8.02	3.60	23.53
3.60	9.82	4.19	33.35
4.19	10.81	4.88	44.16
4.88	10.83	5.69	54.99
5.69	10.03	6.63	65.02

Size_Low (um)	In %	Size_High (um)	Under%
6.63	8.86	7.72	73.89
7.72	6.80	9.00	80.68
9.00	4.98	10.48	85.66
10.48	3.57	12.21	89.23
12.21	2.61	14.22	91.84
14.22	2.02	16.57	93.86
16.57	1.66	19.31	95.52
19.31	1.40	22.49	96.92
22.49	1.14	26.20	98.06
26.20	0.88	30.53	98.93
30.53	0.62	35.56	99.55
35.56	0.36	41.43	99.91
41.43	0.09	48.27	100.00
48.27	0.00	56.23	100.00
56.23	0.00	65.51	100.00
65.51	0.00	76.32	100.00
76.32	0.00	88.91	100.00
88.91	0.00	103.58	100.00
103.58	0.00	120.67	100.00
120.67	0.00	140.58	100.00
140.58	0.00	163.77	100.00
163.77	0.00	190.80	100.00
190.80	0.00	222.28	100.00
222.28	0.00	258.95	100.00
258.95	0.00	301.68	100.00
301.68	0.00	351.46	100.00
351.46	0.00	409.45	100.00
409.45	0.00	477.01	100.00
477.01	0.00	555.71	100.00
555.71	0.00	647.41	100.00
647.41	0.00	754.23	100.00
754.23	0.00	878.67	100.00



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Scinetific and Technological Research Equiment Centre Chulalongkorn University
Buliding 2-3 Chula Soi 62 Phaya-Thai Rd. Phatumwan Bangkok 10330 Tel. 2188029-32, 2188101 Fax. 2540211

Result: Analysis Report

Sample Details

Sample ID: sample11
Sample File: JITTIWUT
Sample Path: A:\
Sample Notes: Test by Pranee : Scientific and Technological Research Equipment Centre Chulalongkorn University. Liquid medium : WATER

Run Number: 4
Record Number: 40

Measurement Date: Thu, Mar 18, 1999 1:07PM
Analysis Date: Thu, Mar 18, 1999 1:07PM
Result Source: Analysed

System Details

Range Lens: 300RF mm
Presentation: 3OHD
Analysis Model: Polydisperse
Modifications: Active --

Beam Length: 2.40 mm
[Particle R.I. = (1.5295, 0.1000); Dispersant R.I. = 1.3300]
Killed Data Channels: Low 0; High 2

Sampler: MS17

Obscuration: 29.3 %
Residual: 0.922 %

Result Statistics

Distribution Type: Volume
Mean Diameters:
D [4, 3] = 6.67 um

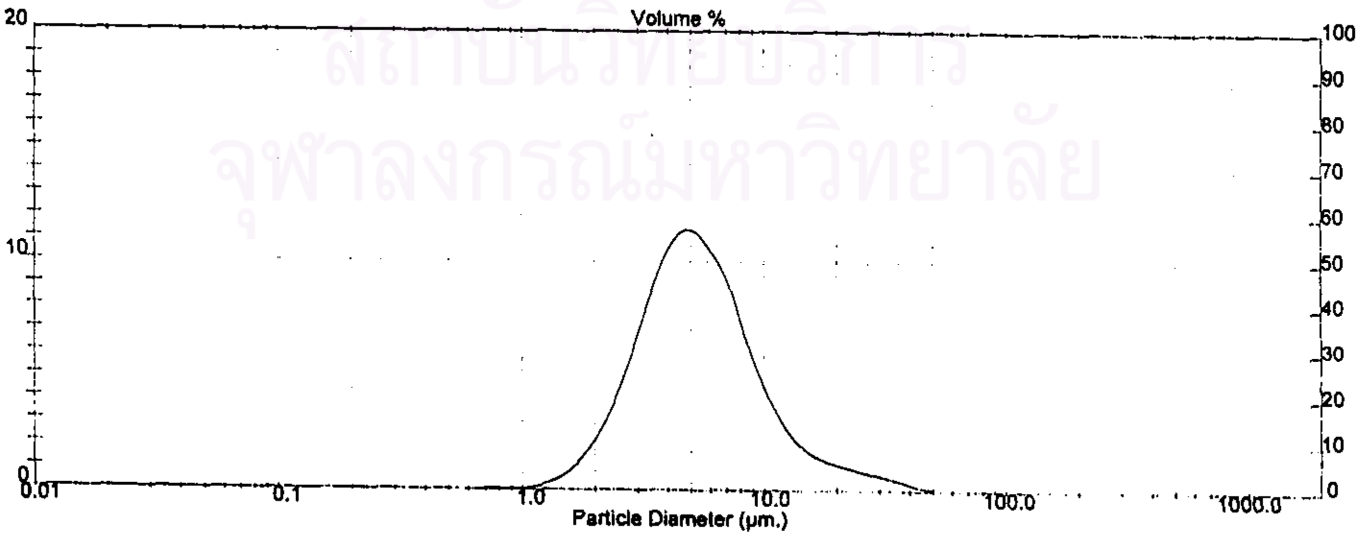
Concentration = 0.0200 %Vol
D (v, 0.1) = 2.68 um
D [3, 2] = 4.60 um

Density = 1.000 g / cub. cm
D (v, 0.5) = 5.20 um
Span = 1.713E+00

Specific S.A. = 1.3038 sq. m / g
D (v, 0.9) = 11.58 um
Uniformity = 5.922E-01

Size_Low (um)	In %	Size_High (um)	Under%
0.05	0.00	0.06	0.00
0.06	0.00	0.07	0.00
0.07	0.00	0.08	0.00
0.08	0.00	0.09	0.00
0.09	0.00	0.11	0.00
0.11	0.00	0.13	0.00
0.13	0.00	0.15	0.00
0.15	0.00	0.17	0.00
0.17	0.00	0.20	0.00
0.20	0.00	0.23	0.00
0.23	0.00	0.27	0.00
0.27	0.00	0.31	0.00
0.31	0.00	0.36	0.00
0.36	0.00	0.42	0.00
0.42	0.00	0.49	0.00
0.49	0.01	0.58	0.01
0.58	0.02	0.67	0.03
0.67	0.03	0.78	0.06
0.78	0.04	0.91	0.10
0.91	0.07	1.06	0.16
1.06	0.16	1.24	0.32
1.24	0.38	1.44	0.70
1.44	0.79	1.68	1.49
1.68	1.51	1.95	3.00
1.95	2.55	2.28	5.55
2.28	4.06	2.65	9.61
2.65	6.06	3.09	15.67
3.09	8.28	3.60	23.95
3.60	10.19	4.19	34.14
4.19	11.24	4.88	45.38
4.88	11.23	5.69	56.62
5.69	10.34	6.63	66.96

Size_Low (um)	In %	Size_High (um)	Under%
6.63	9.05	7.72	76.01
7.72	6.82	9.00	82.83
9.00	4.85	10.48	87.68
10.48	3.32	12.21	91.00
12.21	2.28	14.22	93.28
14.22	1.65	16.57	94.94
16.57	1.30	19.31	96.24
19.31	1.06	22.49	97.32
22.49	0.90	26.20	98.23
26.20	0.72	30.53	98.95
30.53	0.54	35.56	99.48
35.56	0.35	41.43	99.83
41.43	0.17	48.27	100.00
48.27	0.00	56.23	100.00
56.23	0.00	65.51	100.00
65.51	0.00	76.32	100.00
76.32	0.00	88.91	100.00
88.91	0.00	103.58	100.00
103.58	0.00	120.67	100.00
120.67	0.00	140.58	100.00
140.58	0.00	163.77	100.00
163.77	0.00	190.80	100.00
190.80	0.00	222.28	100.00
222.28	0.00	258.95	100.00
258.95	0.00	301.68	100.00
301.68	0.00	351.48	100.00
351.48	0.00	409.45	100.00
409.45	0.00	477.01	100.00
477.01	0.00	555.71	100.00
555.71	0.00	647.41	100.00
647.41	0.00	754.23	100.00
754.23	0.00	878.67	100.00



ศูนย์เครื่องมือวิจัยวิทยาศาสตร์และเทคโนโลยี จุฬาลงกรณ์มหาวิทยาลัย
อาคารสถาบัน 2 จุฬาลงกรณ์ ซอย 62 ถ.พญาไท ปทุมวัน กรุงเทพฯ 10330 โทร 2188029-32, 2188101
Scinetific and Technological Research Equiment Centre Chulalongkorn University
Buliding 2-3 Chula Soi 62 Phaya-Thai Rd. Phatumwan Bangkok 10330 Tel. 2188029-32, 2188101 Fax. 2540211

Result: Analysis Report

Sample Details

Sample ID: sample8
Sample File: JITTIWUT
Sample Path: A:\
Sample Notes: Test by Pranee : Scientific and Technological Research
Equipment Centre Chulalongkorn University.
Liquid medium : WATER

Run Number: 1
Record Number: 28

Measurement Date: Thu, Mar 18, 1999 11:02AM
Analysis Date: Thu, Mar 18, 1999 11:03AM
Result Source: Analysed

System Details

Range Lens: 300RF mm
Presentation: 3OHD
Analysis Model: Polydisperse
Modifications: Active --

Beam Length: 2.40 mm
[Particle R.I. = (1.5295, 0.1000); Dispersant R.I. = 1.3300]
Killed Data Channels: Low 0; High 2

Sampler: MS17

Obscuration: 29.1 %
Residual: 0.751 %

Result Statistics

Distribution Type: Volume
Mean Diameters:
D [4, 3] = 4.69 um

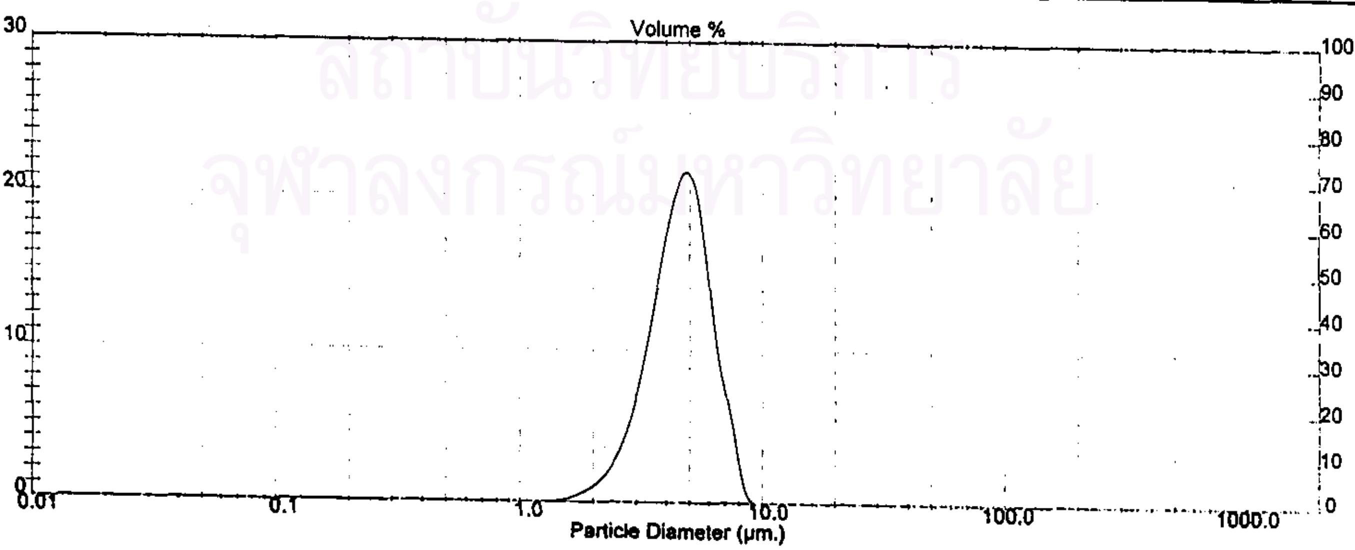
Concentration = 0.0185 %Vol
D (v, 0.1) = 3.05 um
D [3, 2] = 4.29 um

Density = 1.000 g / cub. cm
D (v, 0.5) = 4.61 um
Span = 7.341E-01

Specific S.A. = 1.3990 sq. m / g
D (v, 0.9) = 6.43 um
Uniformity = 2.269E-01

Size_Low (um)	In %	Size_High (um)	Under%
0.05	0.00	0.06	0.00
0.06	0.00	0.07	0.00
0.07	0.00	0.08	0.00
0.08	0.00	0.09	0.00
0.09	0.00	0.11	0.00
0.11	0.00	0.13	0.00
0.13	0.00	0.15	0.00
0.15	0.00	0.17	0.00
0.17	0.00	0.20	0.00
0.20	0.00	0.23	0.00
0.23	0.00	0.27	0.00
0.27	0.00	0.31	0.00
0.31	0.00	0.36	0.00
0.36	0.00	0.42	0.00
0.42	0.00	0.49	0.00
0.49	0.00	0.56	0.00
0.58	0.00	0.67	0.00
0.67	0.00	0.78	0.00
0.78	0.00	0.91	0.00
0.91	0.00	1.08	0.00
1.06	0.01	1.24	0.01
1.24	0.05	1.44	0.06
1.44	0.20	1.68	0.26
1.68	0.62	1.95	0.88
1.95	1.35	2.28	2.23
2.28	2.80	2.65	5.04
2.65	5.62	3.09	10.66
3.09	10.30	3.60	20.96
3.60	16.25	4.19	37.21
4.19	20.88	4.88	58.09
4.88	20.52	5.69	78.61
5.69	13.26	6.63	91.87

Size_Low (um)	In %	Size_High (um)	Under%
6.63	6.80	7.72	98.67
7.72	1.33	9.00	100.00
9.00	0.00	10.48	100.00
10.48	0.00	12.21	100.00
12.21	0.00	14.22	100.00
14.22	0.00	16.57	100.00
16.57	0.00	19.31	100.00
19.31	0.00	22.49	100.00
22.49	0.00	26.20	100.00
26.20	0.00	30.53	100.00
30.53	0.00	35.56	100.00
35.56	0.00	41.43	100.00
41.43	0.00	48.27	100.00
48.27	0.00	56.23	100.00
56.23	0.00	65.51	100.00
65.51	0.00	76.32	100.00
76.32	0.00	88.91	100.00
88.91	0.00	103.58	100.00
103.58	0.00	120.67	100.00
120.67	0.00	140.58	100.00
140.56	0.00	163.77	100.00
163.77	0.00	190.80	100.00
190.80	0.00	222.28	100.00
222.28	0.00	258.95	100.00
258.95	0.00	301.68	100.00
301.68	0.00	351.46	100.00
351.46	0.00	409.45	100.00
409.45	0.00	477.01	100.00
477.01	0.00	555.71	100.00
555.71	0.00	647.41	100.00
647.41	0.00	754.23	100.00
754.23	0.00	878.67	100.00



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อาคารสถาบัน 2 จุฬาลงกรณ์ ซอย 62 ถ.พญาไท ปทุมวัน กรุงเทพฯ 10330 โทร 2188029-32, 2188101
Scinetific and Technological Research Equiment Centre Chulalongkorn University
Building 2-3 Chula Soi 62 Phaya-Thai Rd. Phatumwan Bangkok 10330 Tel. 2188029-32, 2188101 Fax. 2540211

Result: Analysis Report

Sample Details

Sample ID: sample8
Sample File: JITTIWUT
Sample Path: A:\
Sample Notes: Test by Pranee : Scientific and Technological Research Equipment Centre Chulalongkorn University.
Liquid medium : WATER

Run Number: 2
Record Number: 29

Measurement Date: Thu, Mar 18, 1999 11:03AM
Analysis Date: Thu, Mar 18, 1999 11:03AM
Result Source: Analysed

System Details

Range Lens: 300RF mm
Presentation: 3OHD
Analysis Model: Polydisperse
Modifications: Active --

Beam Length: 2.40 mm
[Particle R.I. = (1.5295, 0.1000); Dispersant R.I. = 1.3300]
Killed Data Channels: Low 0; High 2

Sampler: MS17

Obscuration: 29.0 %
Residual: 0.740 %

Result Statistics

Distribution Type: Volume
Mean Diameters:
D [4, 3] = 4.67 um

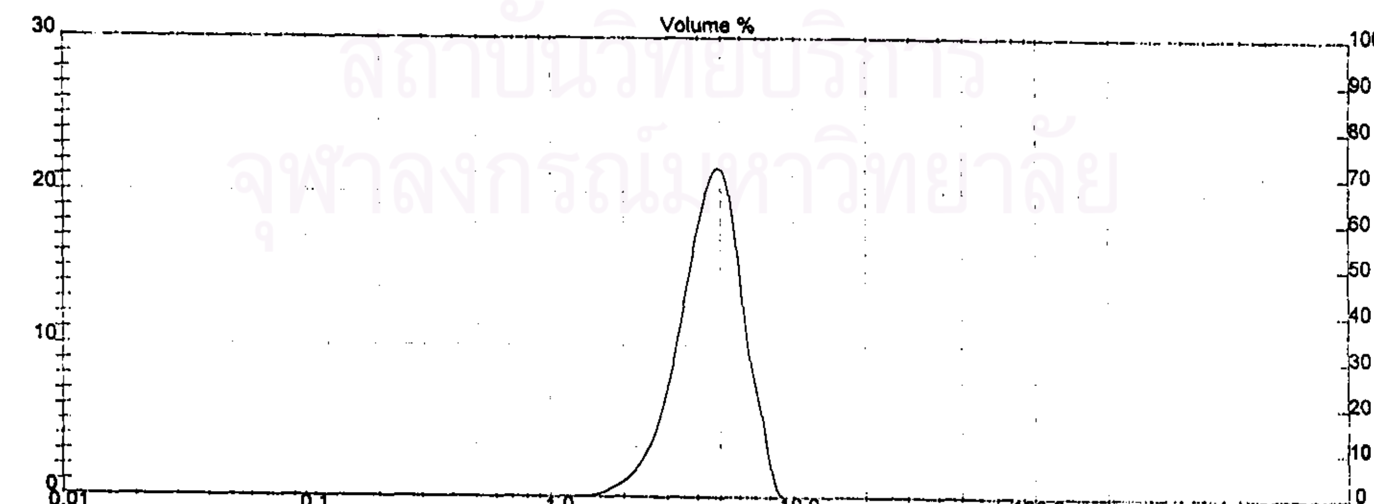
Concentration = 0.0185 %Vol
D (v, 0.1) = 3.04 um
D [3, 2] = 4.28 um

Density = 1.000 g / cub. cm
D (v, 0.5) = 4.60 um
Span = 7.274E-01

Specific S.A. = 1.4033 sq. m / g
D (v, 0.9) = 6.39 um
Uniformity = 2.262E-01

Size_Low (um)	In %	Size_High (um)	Under%
0.05	0.00	0.06	0.00
0.06	0.00	0.07	0.00
0.07	0.00	0.08	0.00
0.08	0.00	0.09	0.00
0.09	0.00	0.11	0.00
0.11	0.00	0.13	0.00
0.13	0.00	0.15	0.00
0.15	0.00	0.17	0.00
0.17	0.00	0.20	0.00
0.20	0.00	0.23	0.00
0.23	0.00	0.27	0.00
0.27	0.00	0.31	0.00
0.31	0.00	0.36	0.00
0.36	0.00	0.42	0.00
0.42	0.00	0.49	0.00
0.49	0.00	0.58	0.00
0.58	0.00	0.67	0.00
0.67	0.00	0.78	0.00
0.78	0.00	0.91	0.00
0.91	0.00	1.06	0.00
1.06	0.01	1.24	0.01
1.24	0.05	1.44	0.06
1.44	0.21	1.68	0.27
1.68	0.63	1.95	0.90
1.95	1.37	2.28	2.26
2.28	2.84	2.65	5.10
2.65	5.68	3.09	10.78
3.09	10.43	3.60	21.21
3.60	16.34	4.19	37.55
4.19	20.77	4.88	58.31
4.88	20.70	5.69	79.01
5.69	13.34	6.63	92.35

Size_Low (um)	In %	Size_High (um)	Under%
6.63	6.63	7.72	98.99
7.72	1.01	9.00	100.00
9.00	0.00	10.48	100.00
10.48	0.00	12.21	100.00
12.21	0.00	14.22	100.00
14.22	0.00	16.57	100.00
16.57	0.00	19.31	100.00
19.31	0.00	22.49	100.00
22.49	0.00	26.20	100.00
26.20	0.00	30.53	100.00
30.53	0.00	35.56	100.00
35.56	0.00	41.43	100.00
41.43	0.00	48.27	100.00
48.27	0.00	56.23	100.00
56.23	0.00	65.51	100.00
65.51	0.00	76.32	100.00
76.32	0.00	88.91	100.00
88.91	0.00	103.58	100.00
103.58	0.00	120.67	100.00
120.67	0.00	140.58	100.00
140.58	0.00	163.77	100.00
163.77	0.00	190.80	100.00
190.80	0.00	222.28	100.00
222.28	0.00	258.95	100.00
258.95	0.00	301.68	100.00
301.68	0.00	351.48	100.00
351.48	0.00	409.45	100.00
409.45	0.00	477.01	100.00
477.01	0.00	555.71	100.00
555.71	0.00	647.41	100.00
647.41	0.00	754.23	100.00
754.23	0.00	878.67	100.00



ศูนย์เครื่องมือวิจัยวิทยาศาสตร์และเทคโนโลยี จุฬาลงกรณ์มหาวิทยาลัย
อาคารสถาบัน 2 จุฬาลงกรณ์ ซอย 62 ถ.พญาไท ปทุมวัน กรุงเทพฯ 10330 โทร 2188029-32, 2188101
Scinetific and Technological Research Equiment Centre Chulalongkorn University
Buliding 2-3 Chula Soi 62 Phaya-Thai Rd. Phatumwan Bangkok 10330 Tel. 2188029-32, 2188101 Fax. 2540211

Result: Analysis Report

Sample Details

Sample ID: sample8
Sample File: JITTIWUT
Sample Path: A:\
Sample Notes: Test by Pranee : Scientific and Technological Research Equipment Centre Chulalongkorn University.
Liquid medium : WATER

Run Number: 3
Record Number: 30

Measurement Date: Thu, Mar 18, 1999 11:03AM
Analysis Date: Thu, Mar 18, 1999 11:03AM
Result Source: Analysed

System Details

Range Lens: 300RF mm
Presentation: 3OHD
Analysis Model: Polydisperse
Modifications: Active --

Beam Length: 2.40 mm
[Particle R.I. = (1.5295, 0.1000); Dispersant R.I. = 1.3300]
Killed Data Channels: Low 0; High 2

Sampler: MS17

Obscuration: 29.1 %
Residual: 0.750 %

Result Statistics

Distribution Type: Volume
Mean Diameters:
D [4, 3] = 4.67 um

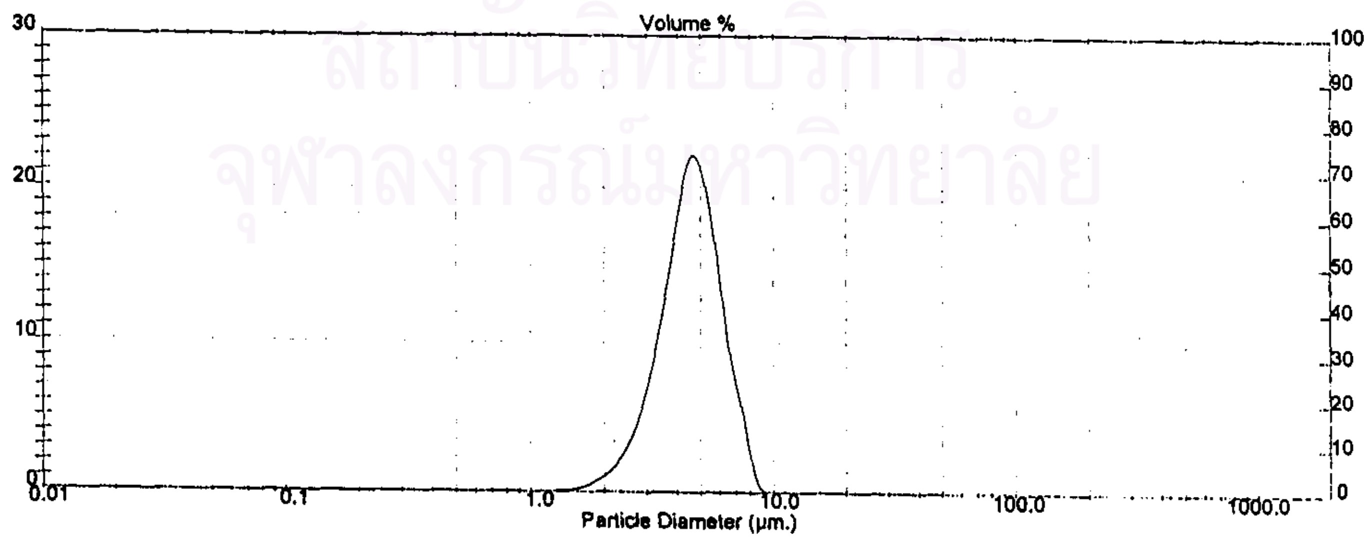
Concentration = 0.0185 %Vol
D (v, 0.1) = 3.05 um
D [3, 2] = 4.28 um

Density = 1.000 g / cub. cm
D (v, 0.5) = 4.58 um
Span = 7.349E-01

Specific S.A. = 1.4031 sq. m / g
D (v, 0.9) = 6.41 um
Uniformity = 2.246E-01

Size_Low (um)	In %	Size_High (um)	Under%
0.05	0.00	0.06	0.00
0.06	0.00	0.07	0.00
0.07	0.00	0.08	0.00
0.08	0.00	0.09	0.00
0.09	0.00	0.11	0.00
0.11	0.00	0.13	0.00
0.13	0.00	0.15	0.00
0.15	0.00	0.17	0.00
0.17	0.00	0.20	0.00
0.20	0.00	0.23	0.00
0.23	0.00	0.27	0.00
0.27	0.00	0.31	0.00
0.31	0.00	0.36	0.00
0.36	0.00	0.42	0.00
0.42	0.00	0.49	0.00
0.49	0.00	0.58	0.00
0.58	0.00	0.67	0.00
0.67	0.00	0.78	0.00
0.78	0.00	0.91	0.00
0.91	0.00	1.06	0.00
1.06	0.01	1.24	0.01
1.24	0.05	1.44	0.06
1.44	0.21	1.68	0.27
1.68	0.64	1.95	0.91
1.95	1.37	2.28	2.28
2.28	2.81	2.65	5.09
2.65	5.58	3.09	10.66
3.09	10.24	3.60	20.91
3.60	16.47	4.19	37.37
4.19	21.92	4.88	59.29
4.88	19.81	5.69	79.10
5.69	12.94	6.63	92.04

Size_Low (um)	In %	Size_High (um)	Under%
6.63	6.65	7.72	98.69
7.72	1.31	9.00	100.00
9.00	0.00	10.48	100.00
10.48	0.00	12.21	100.00
12.21	0.00	14.22	100.00
14.22	0.00	16.57	100.00
16.57	0.00	19.31	100.00
19.31	0.00	22.49	100.00
22.49	0.00	26.20	100.00
26.20	0.00	30.53	100.00
30.53	0.00	35.56	100.00
35.56	0.00	41.43	100.00
41.43	0.00	48.27	100.00
48.27	0.00	56.23	100.00
56.23	0.00	65.51	100.00
65.51	0.00	76.32	100.00
76.32	0.00	88.91	100.00
88.91	0.00	103.58	100.00
103.58	0.00	120.67	100.00
120.67	0.00	140.58	100.00
140.58	0.00	163.77	100.00
163.77	0.00	190.80	100.00
190.80	0.00	222.28	100.00
222.28	0.00	258.95	100.00
258.95	0.00	301.68	100.00
301.68	0.00	351.46	100.00
351.46	0.00	409.45	100.00
409.45	0.00	477.01	100.00
477.01	0.00	555.71	100.00
555.71	0.00	647.41	100.00
647.41	0.00	754.23	100.00
754.23	0.00	878.67	100.00



ศูนย์เครื่องมือวิจัยวิทยาศาสตร์และเทคโนโลยี จุฬาลงกรณ์มหาวิทยาลัย
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Scinetific and Technological Research Equiment Centre Chulalongkorn University
Buliding 2-3 Chula Soi 62 Phaya-Thai Rd. Phatumwan Bangkok 10330 Tel. 2188029-32, 2188101 Fax. 2540211

Result: Analysis Report

Sample Details

Sample ID: sample4
Sample File: JITTIWUT
Sample Path: A:\
Sample Notes: Test by Pranee ; Scientific and Technological Research Equipment Centre Chulalongkorn University.
Liquid medium : WATER

Run Number: 1
Record Number: 10

Measurement Date: Thu, Mar 18, 1999 10:36AM
Analysis Date: Thu, Mar 18, 1999 10:36AM
Result Source: Analysed

System Details

Range Lens: 300RF mm
Presentation: 3OHD
Analysis Model: Polydisperse
Modifications: Active --

Beam Length: 2.40 mm
[Particle R.I. = (1.5295, 0.1000); Dispersant R.I. = 1.3300]
Killed Data Channels: Low 0; High 2

Sampler: MS17

Obscuration: 30.9 %
Residual: 0.719 %

Result Statistics

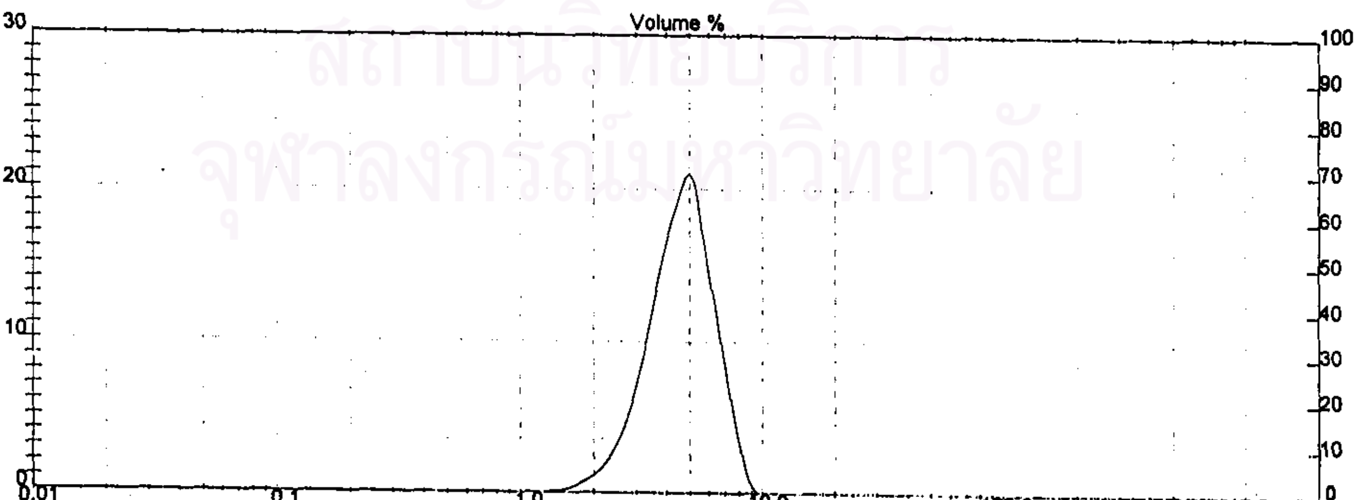
Distribution Type: Volume
Mean Diameters:
D [4, 3] = 4.73 um

Concentration = 0.0200 %Vol
D (v, 0.1) = 3.01 um
D [3, 2] = 4.30 um

Density = 1.000 g / cub. cm
D (v, 0.5) = 4.65 um
Span = 7.710E-01

Specific S.A. = 1.3969 sq. m / g
D (v, 0.9) = 6.60 um
Uniformity = 2.388E-01

Size_Low (um)	In %	Size_High (um)	Under%	Size_Low (um)	In %	Size_High (um)	Under%
0.05	0.00	0.06	0.00	6.63	7.50	7.72	97.85
0.06	0.00	0.07	0.00	7.72	2.15	9.00	100.00
0.07	0.00	0.08	0.00	9.00	0.00	10.48	100.00
0.08	0.00	0.09	0.00	10.48	0.00	12.21	100.00
0.09	0.00	0.11	0.00	12.21	0.00	14.22	100.00
0.11	0.00	0.13	0.00	14.22	0.00	16.57	100.00
0.13	0.00	0.15	0.00	16.57	0.00	19.31	100.00
0.15	0.00	0.17	0.00	19.31	0.00	22.49	100.00
0.17	0.00	0.20	0.00	22.49	0.00	26.20	100.00
0.20	0.00	0.23	0.00	26.20	0.00	30.53	100.00
0.23	0.00	0.27	0.00	30.53	0.00	35.56	100.00
0.27	0.00	0.31	0.00	35.56	0.00	41.43	100.00
0.31	0.00	0.36	0.00	41.43	0.00	48.27	100.00
0.36	0.00	0.42	0.00	48.27	0.00	56.23	100.00
0.42	0.00	0.49	0.00	56.23	0.00	65.51	100.00
0.49	0.00	0.58	0.00	65.51	0.00	76.32	100.00
0.58	0.00	0.67	0.00	76.32	0.00	88.91	100.00
0.67	0.00	0.78	0.00	88.91	0.00	103.58	100.00
0.78	0.00	0.91	0.00	103.58	0.00	120.67	100.00
0.91	0.00	1.06	0.00	120.67	0.00	140.58	100.00
1.06	0.01	1.24	0.02	140.58	0.00	163.77	100.00
1.24	0.07	1.44	0.09	163.77	0.00	190.80	100.00
1.44	0.25	1.68	0.34	190.80	0.00	222.28	100.00
1.68	0.71	1.95	1.05	222.28	0.00	258.95	100.00
1.95	1.47	2.28	2.52	258.95	0.00	301.68	100.00
2.28	2.96	2.65	5.48	301.68	0.00	351.46	100.00
2.65	5.75	3.09	11.23	351.46	0.00	409.45	100.00
3.09	10.24	3.60	21.47	409.45	0.00	477.01	100.00
3.60	15.63	4.19	37.09	477.01	0.00	555.71	100.00
4.19	19.50	4.88	56.59	555.71	0.00	647.41	100.00
4.88	20.10	5.69	76.70	647.41	0.00	754.23	100.00
5.69	13.66	6.63	90.35	754.23	0.00	878.67	100.00



ศูนย์เครื่องมือวิจัยวิทยาศาสตร์และเทคโนโลยี จุฬาลงกรณ์มหาวิทยาลัย
อาคารสถาบัน 2 จุฬาลงกรณ์ ซอย 62 ถ.พญาไท ปทุมวัน กรุงเทพฯ 10330 โทร 2188029-32, 2188101
Scinetific and Technological Research Equiment Centre Chulalongkorn University
Buliding 2-3 Chula Soi 62 Phaya-Thai Rd. Phatumwan Bangkok 10330 Tel. 2188029-32, 2188101 Fax. 2540211

Result: Analysis Report

Sample Details

Sample ID: sample4
Sample File: JITTIWUT
Sample Path: A:\
Sample Notes: Test by Pranee : Scientific and Technological Research Equipment Centre Chulalongkorn University.
Liquid medium : WATER

Run Number: 2
Record Number: 11

Measurement Date: Thu, Mar 18, 1999 10:36AM
Analysis Date: Thu, Mar 18, 1999 10:36AM
Result Source: Analysed

System Details

Range Lens: 300RF mm
Presentation: 3OHD
Analysis Model: Polydisperse
Modifications: Active --

Beam Length: 2.40 mm
[Particle R.I. = (1.5295, 0.1000); Dispersant R.I. = 1.3300]
Killed Data Channels: Low 0; High 2

Sampler: MS17

Obscuration: 30.9 %
Residual: 0.732 %

Result Statistics

Distribution Type: Volume
Mean Diameters:
D [4, 3] = 4.71 um

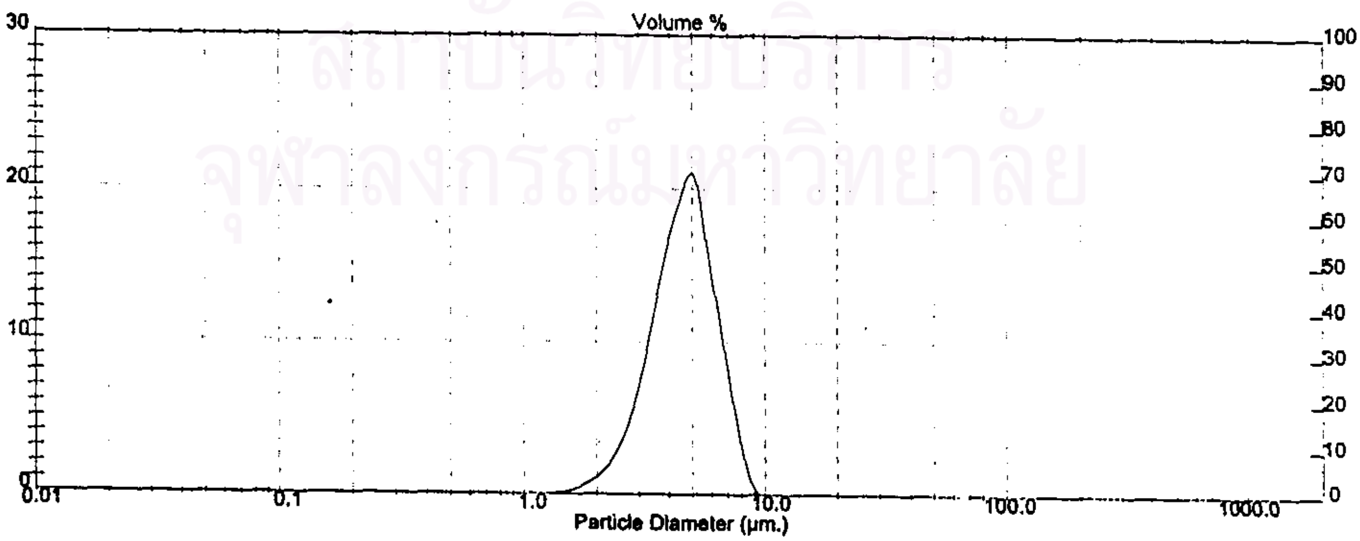
Concentration = 0.0199 %Vol
D (v, 0.1) = 3.00 um
D [3, 2] = 4.28 um

Density = 1.000 g / cub. cm
D (v, 0.5) = 4.64 um
Span = 7.685E-01

Specific S.A. = 1.4011 sq. m / g
D (v, 0.9) = 6.57 um
Uniformity = 2.375E-01

Size_Low (um)	In %	Size_High (um)	Under%
0.05	0.00	0.06	0.00
0.06	0.00	0.07	0.00
0.07	0.00	0.08	0.00
0.08	0.00	0.09	0.00
0.09	0.00	0.11	0.00
0.11	0.00	0.13	0.00
0.13	0.00	0.15	0.00
0.15	0.00	0.17	0.00
0.17	0.00	0.20	0.00
0.20	0.00	0.23	0.00
0.23	0.00	0.27	0.00
0.27	0.00	0.31	0.00
0.31	0.00	0.36	0.00
0.36	0.00	0.42	0.00
0.42	0.00	0.49	0.00
0.49	0.00	0.58	0.00
0.58	0.00	0.67	0.00
0.67	0.00	0.78	0.00
0.78	0.00	0.91	0.00
0.91	0.00	1.06	0.00
1.06	0.01	1.24	0.02
1.24	0.07	1.44	0.09
1.44	0.25	1.66	0.34
1.66	0.71	1.95	1.05
1.95	1.48	2.26	2.53
2.26	2.99	2.65	5.52
2.65	5.81	3.09	11.33
3.09	10.35	3.60	21.68
3.60	15.77	4.19	37.45
4.19	19.61	4.88	57.06
4.88	20.10	5.69	77.16
5.69	13.53	6.63	90.68

Size_Low (um)	In %	Size_High (um)	Under%
6.63	7.34	7.72	98.02
7.72	1.98	9.00	100.00
9.00	0.00	10.48	100.00
10.48	0.00	12.21	100.00
12.21	0.00	14.22	100.00
14.22	0.00	16.57	100.00
16.57	0.00	19.31	100.00
19.31	0.00	22.49	100.00
22.49	0.00	26.20	100.00
26.20	0.00	30.53	100.00
30.53	0.00	35.56	100.00
35.56	0.00	41.43	100.00
41.43	0.00	48.27	100.00
48.27	0.00	56.23	100.00
56.23	0.00	65.51	100.00
65.51	0.00	76.32	100.00
76.32	0.00	88.91	100.00
88.91	0.00	103.58	100.00
103.58	0.00	120.67	100.00
120.67	0.00	140.58	100.00
140.58	0.00	163.77	100.00
163.77	0.00	190.80	100.00
190.80	0.00	222.28	100.00
222.28	0.00	258.95	100.00
258.95	0.00	301.66	100.00
301.66	0.00	351.46	100.00
351.46	0.00	409.45	100.00
409.45	0.00	477.01	100.00
477.01	0.00	555.71	100.00
555.71	0.00	647.41	100.00
647.41	0.00	754.23	100.00
754.23	0.00	878.67	100.00



Result: Analysis Report

Sample Details

Sample ID: sample4
Sample File: JITTIWUT
Sample Path: A:\
Sample Notes: Test by Pranee : Scientific and Technological Research
Equipment Centre Chulalongkorn University.
Liquid medium : WATER

Run Number: 3
Record Number: 12

Measurement Date: Thu, Mar 18, 1999 10:37AM
Analysis Date: Thu, Mar 18, 1999 10:37AM
Result Source: Analysed

System Details

Range Lens: 300RF mm
Presentation: 3OHD
Analysis Model: Polydisperse
Modifications: Active --

Beam Length: 2.40 mm
[Particle R.I. = (1.5295, 0.1000); Dispersant R.I. = 1.3300]
Killed Data Channels: Low 0; High 2

Sampler: MS17

Obscuration: 30.9 %
Residual: 0.736 %

Result Statistics

Distribution Type: Volume
Mean Diameters:
D [4, 3] = 4.70 um

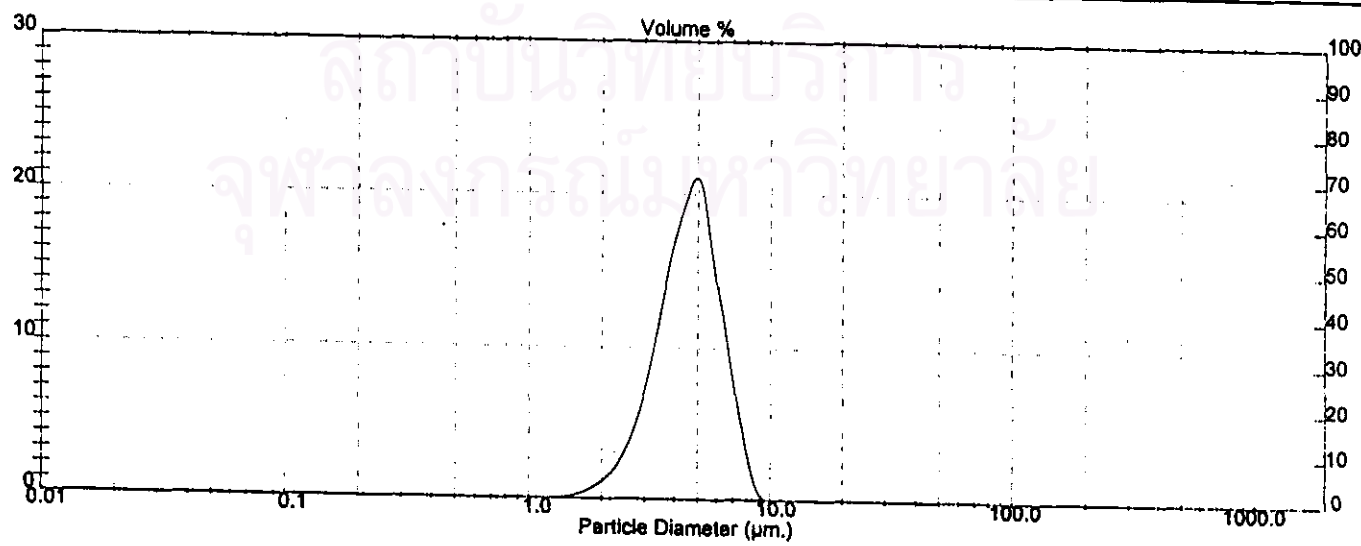
Concentration = 0.0198 %Vol
D (v, 0.1) = 3.00 um
D [3, 2] = 4.27 um

Density = 1.000 g / cub. cm
D (v, 0.5) = 4.82 um
Span = 7.663E-01

Specific S.A. = 1.4047 sq. m / g
D (v, 0.9) = 6.54 um
Uniformity = 2.363E-01

Size_Low (um)	In %	Size_High (um)	Under%
0.05	0.00	0.06	0.00
0.06	0.00	0.07	0.00
0.07	0.00	0.08	0.00
0.08	0.00	0.09	0.00
0.09	0.00	0.11	0.00
0.11	0.00	0.13	0.00
0.13	0.00	0.15	0.00
0.15	0.00	0.17	0.00
0.17	0.00	0.20	0.00
0.20	0.00	0.23	0.00
0.23	0.00	0.27	0.00
0.27	0.00	0.31	0.00
0.31	0.00	0.36	0.00
0.36	0.00	0.42	0.00
0.42	0.00	0.49	0.00
0.49	0.00	0.58	0.00
0.58	0.00	0.67	0.00
0.67	0.00	0.78	0.00
0.78	0.00	0.91	0.00
0.91	0.00	1.06	0.00
1.06	0.01	1.24	0.02
1.24	0.07	1.44	0.09
1.44	0.25	1.68	0.34
1.68	0.72	1.95	1.06
1.95	1.49	2.28	2.55
2.28	3.01	2.65	5.56
2.65	5.86	3.09	11.43
3.09	10.44	3.60	21.87
3.60	15.89	4.19	37.75
4.19	19.70	4.88	57.45
4.88	20.10	5.69	77.55
5.69	13.42	6.63	90.97

Size_Low (um)	In %	Size_High (um)	Under%
6.63	7.20	7.72	98.17
7.72	1.83	9.00	100.00
9.00	0.00	10.48	100.00
10.48	0.00	12.21	100.00
12.21	0.00	14.22	100.00
14.22	0.00	16.57	100.00
16.57	0.00	19.31	100.00
19.31	0.00	22.49	100.00
22.49	0.00	26.20	100.00
26.20	0.00	30.53	100.00
30.53	0.00	35.56	100.00
35.56	0.00	41.43	100.00
41.43	0.00	48.27	100.00
48.27	0.00	56.23	100.00
56.23	0.00	65.51	100.00
65.51	0.00	76.32	100.00
76.32	0.00	88.91	100.00
88.91	0.00	103.58	100.00
103.58	0.00	120.67	100.00
120.67	0.00	140.58	100.00
140.58	0.00	163.77	100.00
163.77	0.00	190.80	100.00
190.80	0.00	222.28	100.00
222.28	0.00	258.95	100.00
258.95	0.00	301.68	100.00
301.68	0.00	351.46	100.00
351.46	0.00	409.45	100.00
409.45	0.00	477.01	100.00
477.01	0.00	555.71	100.00
555.71	0.00	647.41	100.00
647.41	0.00	754.23	100.00
754.23	0.00	878.67	100.00



BIOGRAPHY

Miss Bongkot Ngamsom was born on 20th December, 1974 in Rayong province, Thailand. She finished her secondary school from Ramhamhaeng University Demonstration school in 1992. After that, she studied in the major of Chemical Engineering in Faculty of Engineering at Srinakharinwirot University. She continued her further study for Master's degree in Chemical Engineering at Chulalongkorn University. She proudly participated in the Biochemical Engineering research group and achieved her Master's degree in April, 1999.