

Experimental raw data -1

Date: 27-2-2001

Membrane: FP110 [(Mem -01-00); 1<sup>st</sup> new membrane after 1<sup>st</sup> chemical cleaning]

1<sup>st</sup> Water Flux Test

TMP (barg)	Calculated Permeate Flux $J_v$ ( $m^3/s. m^2$ )
1	1.73161E-05
2	2.64798E-05
3	5.41268E-05
4	6.74428E-05
5	7.32219E-05
6	8.72983E-05

Date: 27-2-2001

Experiment UF1

Sample reference: UF/DV/04

Sample type: NR Latex Sample with Preservation System PS1 [Ammonia (1%); Ammonium Laurate (0.1%); ZnO (0.025); TMTD(0.025)]

Membrane: FP110 [(Mem-01-00); 1<sup>st</sup> new Membrane after 1<sup>st</sup> chemical cleaning and completing 1<sup>st</sup> water flux test)]

Table A-1

TMP (barg)	Calculated Permeate Flux $J_v$ ( $m^3/s. m^2$ )	Cross flow Rate (mL/s)	Protein Content ( $\mu g/g$ )	
			BSA Method	OVBM Method
2.50	2.93552E-06	253	858	2787
3.00	2.89733E-06	251	1143	2186
4.00	2.86762E-06	197	1730	3360
5.00	1.55618E-06	179	1622	3138
5.50	1.29446E-06	131	1352	2285
Testing Parameters	DRC (% mass)	TSC (%mass)	pH	Viscosity (cPs)
Before UF run	31.73	34.26	10.73	3.73
After UF run	29.57	32.00	10.59	3.65

Experimental raw data - 2

Date: 28 -2-2001

Membrane: FP110 [(Mem-01-01); 1<sup>st</sup> membrane after 1<sup>st</sup> water flux test; 1<sup>st</sup> run with NRL and completing 2<sup>nd</sup> chemical cleaning cycle]

2<sup>nd</sup> Water Flux Test

TMP (barg)	Calculated Permeate flux $J_v$ ( $m^3/s \cdot m^2$ )
1	1.82710E-05
2	3.44906E-05
3	4.77571E-05
4	5.87777E-05
5	6.68309E-05
5.5	7.27798E-05

Date: 28-2-2001

Experiment UF1

Sample reference: UF/DV/05

Sample type: NR Latex sample with preservation system PS2 [Ammonia (0.6%); Teric (3phr)]

Membrane: FP110 [(Mem-01-01); 1<sup>st</sup> membrane after 1<sup>st</sup> run with NRL and completing 2<sup>nd</sup> water flux test and 2<sup>nd</sup> chemical cleaning cycle]

Table A-2

TMP (barg)	Calculated permeate flux, $J_v$ ( $m^3/s \cdot m^2$ )	Cross flow rate (mL/s)	Protein content ( $\mu g/g$ )	
			BSA method	OVBM method
1.00	4.76616E-06	320	1036	1506
1.50	4.73079E-06	288	965	1438
2.00	4.52142E-06	270	568	921
2.50	3.71927E-06	266	412	658
3.00	3.66834E-06	250	297	579
3.50	3.18310E-06	200	290	493
4.00	2.23524E-06	158	256	434

Testing Parameters	DRC (%mass)	TSC (%mass)	pH	Viscosity (cPs)
Before UF run	23.67	25.30	6.54	3.4
After UF run	23.11	24.59	6.13	3.2

Experimental raw data - 3

Date: 2-3-2001

Membrane: FP110 [(Mem-01-02); 1<sup>st</sup> membrane after 2<sup>nd</sup> water flux test, 2<sup>nd</sup> run with  
NRL and 3<sup>rd</sup> chemical cleaning cycle completed]

3<sup>rd</sup> Water Flux Test

TMP (barg)	Calculated Permeate Flux, $J_v$ ( $m^3/s \cdot m^2$ )
1.25	3.74898E-05
1.75	4.88075E-05
2.25	6.22473E-05
3.00	8.06385E-05
3.60	8.70047E-05
4.00	9.01878E-05
4.50	9.19562E-05

Date: 2-3-2001

Experiment UF1

Sample reference: UF/DV/06

Sample type: NR Latex Sample with Preservation SystemPS1 [Ammonia (1%);  
Ammonium Laurate (0.1%); ZnO (0.025); TMTD(0.025)]

Membrane: FP110 [(Mem-01-02); 1<sup>st</sup> membrane after 2<sup>nd</sup> run with NRL;  
3<sup>rd</sup> chemical cleaning cycle and completing 3<sup>rd</sup> Water Flux Test and  
completed)]

Table A-3

TMP (barg)	Calculated permeate flux, $J_v$ ( $m^3/s \cdot m^2$ )	Cross flow rate (ml/s)	Protein content ( $\mu g/g$ )	
			BSA method	OVB method
1.75	4.78172E-06	313	1681	3403
2.25	5.23443E-06	327	1486	2975
2.50	5.54850E-06	341	1637	3176
3.00	5.43673E-06	336	1338	2789
3.50	5.07315E-06	307	1359	2575
4.00	4.37429E-06	295	1267	3052
4.50	2.68088E-06	222	1056	2586

Testing parameters	DRC (% mass)	TSC (%mass)	pH	Viscosity (cPs)
Before UF run	31.88	34.52	10.69	3.7
After UF run	29.62	32.06	10.59	3.3

Experimenta raw data -4

Date: 15-3-2001

Membrane: FP110 [(Mem-01-03); 1<sup>st</sup> membrane after 3<sup>rd</sup> run with NRL, 3<sup>rd</sup> water flux test and 4<sup>th</sup> chemical cleaning cycle completed]

4<sup>th</sup> Water Flux Test

TMP (barg)	Calculated Permeate Flux $J_v$ ( $m^3/s \cdot m^2$ )
2.00	6.89671E-05
2.25	8.34679E-05
3.00	1.14945E-04
3.60	1.24495E-04
4.00	1.28739E-04
4.50	1.38642E-04
5.00	1.40056E-04

Date: 15-3-2001

Experiment UF1

Sample reference: UF/DV/07

Sample type: NR latex sample with preservation system PS2 [Ammonia (0.6%); Terric (3phr)]

Membrane: FP110 [(Mem-01-03); 1<sup>st</sup> membrane after 3<sup>rd</sup> run with NRL, 4<sup>th</sup> chemical cleaning cycle and completing 4<sup>th</sup> Water Flux Test]

Table A-4

TMP (barg)	Calculated Permeate Flux $J_v$ ( $m^3/s \cdot m^2$ )	Cross flow Rate (mL/s)	Protein Content ( $\mu g/g$ )	
			BSA Method	OVB Method
1.75	4.54122E-06	308	1008	1883
2.20	4.15925E-06	322	1049	1685
3.00	4.34033E-06	312	888	1379
3.50	4.06022E-06	310	541	751
4.00	3.45189E-06	290	448	798
4.50	2.91430E-06	251	429	626
5.00	2.34842E-06	218	344	728

Testing Parameters	DRC (% mass)	TSC (%mass)	pH	Viscosity (cPs)
Before UF run	28.44	30.89	6.95	3.79
After UF run	28.66	30.86	6.49	3.45

Experimental raw data - 5

Date: 6-4-2001

Membrane: FP110 [(Mem-01-04); 1<sup>st</sup> membrane after 4<sup>th</sup> UF run with NRL,  
4<sup>th</sup> water flux test and completing 5<sup>th</sup> chemical cleaning cycles]

Sample reference: UF/DV/07

Sample type: NR latex sample with preservation system PS 2: [Ammonia  
(0.6%); Terric(3phr)]

Concentration Process – Experiment UF4  
TMP: Maintained at 2.75 barg

Time (Sec)	Cumulative time	Volume of Permeate (mL)	Cumulative Volume of Permeate	Permeate Flow rate (mL/s)	Calculated Permeate Flux $J_v$ ( $m^3/s \cdot m^2$ )
2511	2511	320	320	0.127439	5.40867E-06
233	2744	40	360	0.117994	7.28606E-06
339	3083	60	420	0.176991	7.51174E-06
328	3411	60	480	0.182927	7.76366E-06
229	3640	46	526	0.200873	8.52531E-06
180	3820	50	576	0.277777	1.17892E-05
1020	4840	112	688	0.109804	4.66022E-06
960	5800	200	888	0.208333	8.25247E-06
360	6160	70	958	0.194444	8.84194E-06
600	6760	100	1058	0.166667	8.25247E-06
720	7480	130	1188	0.180556	7.66301E-06
600	8080	100	1288	0.166667	7.07355E-06
1140	9220	200	1488	0.175439	7.44584E-06

Experimental raw data – 6

Date: 22-3-2001

Membrane: FP110 [(Mem-02-00) 2<sup>nd</sup> new membrane after 1<sup>st</sup> chemical cleaning cycle]

1<sup>st</sup> Water Flux Test

TMP (barg)	Calculated Permeate Flux $J_v$ (m <sup>3</sup> /s. m <sup>2</sup> )
1.80	2.97089E-05
2.75	5.09295E-05
3.50	9.75000E-05
4.00	1.05300E-04
4.50	1.11000E-04
5.00	1.18000E-04
5.50	1.27600E-04

Sample Analysis Results:

Testing Parameters	DRC (% mass)	TSC (%mass)	pH	Viscosity (cPs)
Before UF run	31.54	33.71	10.59	3.90

Date: 22-3-2001

Experiment UF2

Sample reference: UF/DV/09

Sample type: NR latex sample with preservation system PS 1 [Ammonia (1%);  
Ammonium Laurate(0.1%); ZnO (0.025); TMTD(0.025)]Membrane: FP110 [(Mem-02-00); 2<sup>nd</sup> membrane after 1<sup>st</sup> chemical cleaning and  
completing 1<sup>st</sup> water flux test])

Table A-6

TMP (barg)	Mass of Permeate Collected every 5 min (gm)	Calculated Permeate Flux $J_v$ ( $m^3/s \cdot m^2$ )	Cross flow rate (mL/s)
2.00	37.40	5.29102E-06	421
	23.60	3.33872E-06	333
	12.70	1.79668E-06	196
3.00	8.73	1.23504E-06	98
	42.50	6.01252E-06	353
	25.70	3.63581E-06	309
	13.12	1.85609E-06	179
4.00	8.70	1.15582E-06	112
	42.40	5.99837E-06	318
	28.30	4.00363E-06	184
	13.10	1.85327E-06	142
5.00	5.60	7.92238E-07	29
	26.60	3.76313E-06	211
	13.10	1.85327E-06	144
	5.71	8.07799E-07	47
	4.00	5.65884E-07	20

Experimental raw data - 7

Date: 16/5/2001

Membrane: FP110 [(Mem-03-00); 3<sup>rd</sup> new membrane after 1<sup>st</sup> chemical cleaning cycle]

1<sup>st</sup> Water Flux Test

TMP (barg)	Calculated Permeate Flux $J_v$ ( $m^3/s \cdot m^2$ )
1	2.88601E-05
2	4.51292E-05
3	5.98422E-05
4	6.99574E-05
5	8.29727E-05

Date: 16-5-2001

Experiment UF3

Sample reference: UF/DV/10

Sample type: NR latex sample with preservation system PS 1: [Ammonia (1%); Ammonium Laurate(0.1%); ZnO (0.025); TMTD(0.025)]

Membrane: FP110 [(Mem-03-00); 3<sup>rd</sup> new membrane after 1<sup>st</sup> chemical cleaning and completing 1<sup>st</sup> Water Flux Test]

Sample Analysis Results:

Testing Parameters	DRC (% mass)	TSC (%mass)	pH	Viscosity (cPs)
Before UF run	30.93	33.23	10.58	5.0

Table A-7

TMP (barg)	Calculated Permeate Flux $J_v$ ( $m^3/s \cdot m^2$ )	Cross flow Rate (mL/s)
1.00	5.51736E-06	359
2.00	5.89934E-06	335
3.00	5.44663E-06	304
4.00	4.75343E-06	268
5.00	3.09821E-06	230

Experimental raw data - 8

Date: 11-6 -2001

Membrane: FP110 [(Mem-03-01); 3<sup>rd</sup> membrane after 1<sup>st</sup> water flux test and with 1<sup>st</sup> run with NRL with 2<sup>nd</sup> chemical cleaning cycle]

### 2<sup>nd</sup> Water Flux Test

TMP (barg)	Calculated Permeate Flux $J_v$ ( $m^3/s \cdot m^2$ )
1	2.76575E-05
2	4.35023E-05
3	5.67298E-05
4	6.58547E-05
5	7.80212E-05

Date: 11-6-2001

### Experiment UF3

Sample reference: UF/DV/11

Sample type: NR latex sample with preservation system PS1 [ Ammonia(1%); Ammonium Laurate(0.1%); ZnO (0.025); TMTD(0.025)]

Membrane: FP110 [(Mem-03-01); 3<sup>rd</sup> membrane after 1<sup>st</sup> UF run with NRL and completing 2<sup>nd</sup> water flux test and 2<sup>nd</sup> chemical cleaning cycle]

### Sample Analysis:

Testing Parameters	DRC (% mass)	TSC (%mass)	pH	Viscosity (cPs)
Before UF run	28.77	31.29	10.60	4.7

Table A-8

TMP (barg)	Calculated Permeate Flux $J_v$ ( $m^3/s \cdot m^2$ )	Cross flow Rate (mL/s)
1.00	7.39893E-06	365
2.00	7.63943E-06	349
3.00	6.86134E-06	330
4.00	4.85245E-06	270
5.00	2.63136E-06	174

Experimental raw data – 9

Date: 12-6-2001

Membrane: FP 110 [(Mem -04-00); 4<sup>th</sup> new membrane after 1<sup>st</sup> chemical cleaning cycle]

1<sup>st</sup> Water Flux Test

TMP (barg)	Calculated Permeate Flux $J_v$ ( $m^3/s \cdot m^2$ )
1.00	2.93189E-05
2.00	4.70195E-05
3.00	6.03121E-05
4.00	7.14900E-05
5.00	9.09300E-05

Sample reference: UF/DV/12

Sample type: NR latex sample with preservation system PS1 [Ammonia (1%); Ammonium Laurate (0.1%); ZnO (0.025); TMTD (0.025)]

Sample Analysis:

Testing Parameters	DRC (% mass)	TSC (%mass)	pH	Viscosity (cPs)
Before UF run	28.69	31.09	10.41	5.10

Concentration Process – Experiment UF4  
TMP: Maintained at 3.0barg

Time/hrs	Temperature °C	Volume of Permeate (mL)	Cumulative Volume of Permeate	Permeate Flow rate (ml/s)	Calculated Permeate Flux $J_v$ ( $m^3/s. m^2$ )
9.00am/0	28	-	-		
10.00am/1	33	569	569	0.158055	6.708059311E-06
11.00am/2	37	560	1129	0.155556	6.601998508E-06
12.00pm/3	40	544	1673	0.151111	6.413346940E-06
1.00pm/4	41	523	2196	0.145278	6.165786850E-06
2.00pm/5	42	504	2700	0.140000	5.941781681E-06
3.00pm/6	43	461	3161	0.128056	5.434862821E-06
4.00pm/7	44	450	3611	0.125000	5.305162215E-06
4.30pm/7.5	44	198	3809	0.110000	4.668542749E-06

Date: 13-6-2001 (Day 2)

Membrane: FP110 [(Mem-04-00); membrane unchanged]

Sample type: NR latex sample with preservation system: [Ammonia(1%);  
Ammonium Laurate(0.1%); ZnO (0.025); TMTD(0.025)]

Sample reference: UF/DV/12 (Continued from Day 1)

Time/hrs	Temperature °C	Volume of Permeate (mL)	Cumulative Volume of Permeate	Permeate Flow rate (mL/s)	Calculated Permeate Flux $J_v$ ( $m^3/s. m^2$ )
9.00am/7.5	27	-	-		
10.00am/8.5	34	390	4199	0.108333	4.597793106E-06
11.00am/9.5	38	364	4563	0.101111	4.291236298E-06
12.00pm/10.5	40	359	4922	0.099722	4.232331091E-06
1.00pm/11.5	45	336	5258	0.093333	3.961186372E-06
2.00pm/12.5	41	295	5553	0.081944	3.477809700E-06
3.00pm/13.5	42	263	5816	0.073056	3.100591446E-06
4.00pm/14.5	42	182	5998	0.050556	2.145662248E-06
4.30pm/15	43	67	6065	0.037222	1.579749984E-06

Date: 14-6-2001 (Day 3)  
 Membrane: FP110 [(Mem-04-00); Membrane unchanged]  
 Sample Type: NR Latex Sample with Preservation System PS 1 [Ammonia (1%);  
 Ammonium Laurate (0.1%); ZnO (0.025); TMTD (0.025)]

Concentration Process – Experiment UF4  
 TMP: Maintained at 2.75barg

Time/hrs	Temperature °C	Volume of Permeate (mL)	Cumulative Volume of Permeate	Permeate Flow rate (mL/s)	Calculated Permeate Flux $J_v$ ( $m^3/s. m^2$ )
9.00am/15	27	-	-		
10.00am/16	33	105	6170	0.029166	1.237842889E-06
11.00am/17	36	82	6252	0.022778	0.966727879E-06
12.00pm/18	37	78	6330	0.021667	0.919575597E-06
1.00pm/19	37	74	6404	0.020556	0.872423315E-06
2.00pm/20	37	73	6477	0.020277	0.860582193E-06

Testing Parameters	DRC (% mass)	TSC (%mass)	pH	Viscosity (cPs)
After UF run (20hrs)	46.09	48.52	10.04	8.30

Date: 14-6-2001  
 Membrane: FP110 [(Mem-04-01); 4<sup>th</sup> membrane after 20 hours UF run, after 2<sup>nd</sup> chemical cleaning cycle and after 1<sup>st</sup> water flux test]

2<sup>nd</sup> Water Flux Test

TMP (barg)	Calculated Permeate Flux $J_v$ ( $m^3/s. m^2$ )
1.00	2.33551E-05
2.00	3.77708E-05
3.00	4.84487E-05
4.00	5.74279E-05
5.00	7.30441E-05

## LIST OF PUBLICATIONS

### a. Papers

1. Devaraj Veerasamy and Nik Meriam Sulaiman.. *Concentration of Natural Rubber Latex by Ultrafiltration*. Proceeding of the 1<sup>st</sup> Technical Postgraduate Symposium, TechPos'02, Malaysia, 16-17 October 2002. pp 42-48.
2. Devaraj Veerasamy and Nik Meriam Sulaiman.. Nambiar. J. and Yusof. A.. *Concentration of Natural Rubber Latex by Ultrafiltration*. Proceedings of the Malaysian Science and Technology Conference 2002 (MSTC 2002), Genting Highlands, Malaysia, 17-19 October 2002.
3. Devaraj Veerasamy and Nik Meriam Sulaiman.. *Environment Friendly Latex Concentration by Membrane Separation Technology*. Proceeding of the Regional Symposium on Chemical Engineering 2002 (RSCE 2002), Malaysia, 28-30 October 2002. pp 1159-1165.
4. Devaraj Veerasamy, Nik Meriam Sulaiman, Nambiar.J and Yusof. A. *Environmentally Friendly Natural Rubber Latex Concentration by Membrane Separation Technology*, Proceeding of the International Membrane Science and Technology Conference (IMSTEC 03), University of New South Wales, Sydney Australia, 10-14 November, 2003.

### b. Refereed Journal

1. Devaraj Veerasamy, Nik Meriam Sulaiman, Nambiar. J. and Yusof. A., (2003). *Concentration of Natural Rubber Field Latex Using Tubular Cross Flow Ultrafiltration System*. J. Rubb. Res., 2003, 6(1), pp.12-35.