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APPENDICES

Appendix A Adsorption Isotherm

Table A.1 Adsorption isotherm of 1:0 molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Equilibrium concentration (μM)	Amount of surfactant adsorbed (μmol/g of silica)
100	77.35	3.09
200	82.22	4.71
300	120.59	7.18
400	195.29	8.19
500	189.49	12.42
1000	428.79	22.85
2000	841.92	46.32
3000	1197.34	72.11
4000	1432.00	95.84
5000	1984.90	120.60
6000	2320.61	147.18
7000	2743.70	170.25
8000	3149.20	194.03
9000	3542.99	218.28
10000	3952.22	241.91
11000	4340.14	266.39
12000	4733.93	290.64
15000	5669.63	373.21
16000	6985.79	360.57
20000	8925.41	442.98
30000	18935.00	442.60
40000	28676.66	452.93

Table A.2 Adsorption isotherm of 3:1 molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Equilibrium concentration (μM)	Amount of surfactant adsorbed (μmol/g of silica)
30	18.20	0.47
50	22.73	1.09
70	26.40	1.74
100	33.18	2.67
150	51.63	3.93
200	70.00	5.20
300	95.30	8.19
400	109.65	11.61
500	120.00	15.20
600	135.00	18.60
700	148.00	22.08
800	155.00	25.80
1000	176.00	32.96
2000	230.00	70.80
3000	265.00	109.40
4000	280.90	148.76
5000	321.10	187.16
6000	355.70	225.77
7000	433.40	262.66
8000	500.50	299.98
9000	557.30	337.71
10000	622.40	375.10
12000	653.00	453.88
14000	700.00	532.00
16000	1003.61	599.86
18000	1500.23	659.99
20000	1919.00	723.24
21000	2893.00	724.28
23000	4700.00	732.00

Table A.3 Adsorption isotherm of 1:1 molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Equilibrium concentration (μM)	Amount of surfactant adsorbed (μmol/g of silica)
200	23.63	7.05
400	31.32	14.75
600	32.88	22.68
800	35.04	30.60
1000	51.70	37.93
1300	72.60	49.10
1500	84.45	56.62
2000	112.23	75.51
3000	142.691	114.29
4000	193.81	152.25
5000	230.97	190.76
6000	274.06	229.04
6500	295.00	248.20
7000	320.56	267.18
7500	348.10	286.08
8000	361.02	305.56
9000	445.43	342.18
10000	461.27	381.55
12000	556.00	457.76
14000	1231.10	510.76
16000	1565.47	577.38
18000	3898.40	564.06
20000	5784.12	568.64

Table A.4 Adsorption isotherm of 1:3 molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Equilibrium concentration (μM)	Amount of surfactant adsorbed (μmol/g of silica)
50	47.06	0.12
200	62.70	5.49
400	114.06	11.44
600	126.59	18.94
800	148.94	26.04
1000	167.53	33.30
1300	196.46	44.14
1500	213.32	51.47
2000	257.37	69.71
3000	299.74	108.01
4000	372.20	145.11
5000	462.84	181.49
6000	561.47	217.54
6500	590.12	236.40
7000	641.36	254.35
7500	716.85	271.33
8000	712.44	291.50
9000	890.14	324.39
10000	997.03	360.12
12000	1265.33	429.39
14000	2056.00	477.76
16000	4500.00	460.00
18000	6012.00	479.52
20000	7986.75	480.53

Table A.5 Adsorption isotherm of 0:1 molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Equilibrium concentration (μM)	Amount of surfactant adsorbed (μmol/g of silica)
100	41.47	2.34
150	55.21	3.79
200	75.64	4.97
250	90.79	6.37
300	91.45	8.34
350	93.82	10.25
400	106.63	11.73
500	120.71	15.17
600	134.02	18.64
700	142.80	22.29
800	146.60	26.14
900	151.40	29.94
1000	161.15	33.55
1500	165.60	53.38
2000	167.17	73.31
3000	192.60	112.30
4000	209.00	151.64
6000	230.72	230.77
8000	402.65	303.89
10000	638.22	374.47
11000	1514.32	369.12
12000	2865.34	365.39
14000	4900.32	363.99
18000	9002.45	359.90
22000	13451.48	341.94
25000	15906.99	363.72

Table A.6 Molar ratio of cationic: nonionic adsorbed at 3:1 molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Total amount of surfactants adsorbed (μmol/g of silica)	Nonionic surfactant adsorbed (μmol/g of silica)	Cationic surfactant adsorbed (μmol/g of silica)	Ratio Cationic:Nonionic adsorbed
800	25.80	4.78	21.02	4.39
1000	32.96	6.65	26.31	3.96
2000	70.80	16.73	54.07	3.23
3000	109.40	26.78	82.62	3.09
4000	148.76	35.20	113.56	3.23
5000	187.16	42.94	144.21	3.36
6000	225.77	54.40	171.37	3.15
7000	262.66	63.98	198.69	3.11
8000	299.98	73.80	226.18	3.06
9000	337.71	81.55	256.15	3.14
10000	375.10	85.63	289.47	3.38

Table A.7 Molar ratio of cationic: nonionic adsorbed at 1:1 molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Total amount of surfactants adsorbed (μmol/g of silica)	Nonionic surfactant adsorbed (μmol/g of silica)	Cationic surfactant adsorbed (μmol/g of silica)	Ratio Cationic:Nonionic adsorbed
400	14.75	6.62	8.13	1.23
600	22.68	10.10	12.58	1.25
800	30.60	14.98	15.62	1.04
1000	37.93	17.57	20.36	1.16
1300	49.10	23.30	25.80	1.11
1500	56.62	27.66	28.96	1.05
2000	75.51	36.76	38.75	1.05
3000	114.29	56.91	57.38	1.01
4000	152.25	76.60	75.65	0.99
5000	190.76	95.93	94.83	0.99
6000	229.04	115.69	113.35	0.98
6500	248.20	125.25	122.95	0.98
7000	267.18	134.46	132.72	0.99
7500	286.08	144.30	141.78	0.98
8000	305.56	153.89	151.67	0.99
9000	342.18	169.78	172.40	1.02
10000	381.55	191.53	190.02	0.99

Table A.8 Molar ratio of cationic: nonionic adsorbed at 1:3 molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Total amount of surfactants adsorbed (μmol/g of silica)	Nonionic surfactant adsorbed (μmol/g of silica)	Cationic surfactant adsorbed (μmol/g of silica)	Ratio Cationic:Nonionic adsorbed
600	18.94	12.51	6.42	0.51
1000	33.30	23.45	9.85	0.42
1300	44.14	32.26	11.88	0.37
1500	51.47	38.44	13.02	0.34
2000	69.71	52.23	17.47	0.33
3000	108.01	81.65	26.36	0.32
4000	145.11	111.06	34.06	0.31
5000	181.49	139.22	42.27	0.30
6000	217.54	168.32	49.23	0.29
6500	236.40	183.56	52.84	0.29
7000	254.35	198.24	56.10	0.28
7500	271.33	211.36	59.97	0.28
8000	291.50	227.12	64.38	0.28
9000	324.39	254.69	69.71	0.27
10000	360.12	283.21	76.91	0.27

Table A.9 Zeta potential of 1:0 molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Total amount of surfactant adsorbed (μmol/g of silica)	Zeta Potential (mV)
100	3.09	-44.52
500	12.42	-38.45
1000	22.85	-35.83
4000	95.84	-12.46
6000	147.18	-4.90
9000	218.28	0.98
10000	241.91	11.64
12000	290.64	10.87
15000	373.21	11.98
20000	442.98	12.65

Table A.10 Zeta potential of 3:1 molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Total amount of surfactant adsorbed (μmol/g of silica)	Zeta Potential (mV)
200	5.20	-38.18
600	18.60	-29.49
1000	32.96	-27.88
2000	70.80	-26.61
4000	148.76	-21.87
5000	187.16	-3.64
6000	225.77	2.80
7000	262.66	12.23
8000	299.98	18.04
9000	337.71	22.75

Table A.11 Zeta potential of 1:1 molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Total amount of surfactant adsorbed (μmol/g of silica)	Zeta Potential (mV)
200	7.05	-42.2
1000	37.93	-35.83
2000	75.51	-33.72
6000	229.04	-12.46
9000	342.18	-4.9
10000	381.55	0.93
12000	376.00	11.64
14000	436.00	10.87
16000	465.40	11.02
18000	470.00	11.98

Table A.12 Zeta potential of 1:3 molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Total amount of surfactant adsorbed (μmol/g of silica)	Zeta Potential (mV)
200	5.49	-51.76
800	26.04	-41.12
1000	33.30	-26.32
5000	181.49	-24.58
6000	217.54	-20.21
7000	254.34	-15.69
8000	291.51	-8.57
9000	324.39	5.01
10000	360.12	7.97
20000	480.53	20.86

Table A.13 Zeta potential of 0:1molar ratio of Arquard®T-50:Teric®X-10

Initial concentration (μM)	Total amount of surfactant adsorbed (μmol/g of silica)	Zeta Potential (mV)
100	1.65	-48.99
200	4.97	-40.56
500	15.17	-31.85
1000	34.81	-23.52
2000	73.31	-17.70
3000	113.87	-17.55
4000	153.85	-15.17
6000	230.77	-14.77
8000	303.89	-14.50
10000	374.47	-14.81

Appendix B Adsolubilizaiton Isotherm

Table B.1 Adsolubilization of styrene of Arquard®T-50: Teric®X-10 ratio 3:1 at surfactant adsorbed 500 μmol/ g of silica

Volume of styrene initial (μl)	Initial styrene concentration (μM)	Equilibrium styrene concentration (μM)	Styrene adsolubilization (μmol/ g of silica)	Xadmicelle	Styrene (mole)	Volume of styrene	Xbulk	K
5	543.69	250.47	11.73	2.29E-02	2.00E-05	2.30E-03	4.51E-06	5.08E+03
10	1087.37	473.10	24.57	4.68E-02	3.78E-05	4.35E-03	8.52E-06	5.50E+03
15	1631.06	712.19	36.75	6.85E-02	5.70E-05	6.55E-03	1.28E-05	5.34E+03
20	2174.75	1020.22	46.18	8.46E-02	8.16E-05	9.38E-03	1.84E-05	4.60E+03
25	2718.43	1196.78	60.87	1.09E-01	9.57E-05	1.10E-02	2.15E-05	5.04E+03

Table B.2 Adsolubilization of styrene of Arquard®T-50: Teric®X-10 ratio 3:1 at surfactant adsorbed 350 μmol/ g of silica

Volume of styrene initial (μl)	Initial styrene concentration (μM)	Equilibrium styrene concentration (μM)	Styrene adsolubilization (μmol/ g of silica)	Xadmicelle	Styrene (mole)	Volume of styrene	Xbulk	K
5	543.69	304.95	9.55	2.66E-02	2.44E-05	2.80E-03	5.49E-06	4.84E+03
10	1087.37	594.58	19.71	5.33E-02	4.76E-05	5.47E-03	1.07E-05	4.98E+03
15	1631.06	893.90	29.49	7.77E-02	7.15E-05	8.22E-03	1.61E-05	4.83E+03
20	2174.75	1203.06	38.87	1.00E-01	9.62E-05	1.11E-02	2.17E-05	4.62E+03
25	2718.43	1441.71	51.07	1.27E-01	1.15E-04	1.33E-02	2.60E-05	4.91E+03

Table B.3 Adsolubilization of styrene of Arquard®T-50: Teric®X-10 ratio 3:1 at surfactant adsorbed 200 µmol/ g of silica

Volume of styrene initial (µl)	Initial styrene concentration (µM)	Equilibrium styrene concentration (µM)	Styrene adsolubilization (µmol/ g of silica)	Xadmicelle	Styrene (mole)	Volume of styrene	Xbulk	K
5	543.69	316.89	9.07	4.34E-02	2.54E-05	2.91E-03	5.70E-06	7.61E+03
10	1087.37	616.33	18.84	8.61E-02	4.93E-05	5.67E-03	1.11E-05	7.76E+03
15	1631.06	950.11	27.24	1.20E-01	7.60E-05	8.74E-03	1.71E-05	7.01E+03
20	2174.75	1227.28	37.90	1.59E-01	9.82E-05	1.13E-02	2.21E-05	7.21E+03
25	2718.43	1480.69	49.51	1.98E-01	1.18E-04	1.36E-02	2.67E-05	7.44E+03

Table B.4 Adsolubilization of isoprene of Arquard®T-50: Teric®X-10 ratio 3:1 at surfactant adsorbed 500 µmol/ g of silica

Volume of isoprene initial (µl)	Initial isoprene concentration (µM)	Equilibrium isoprene concentration (µM)	Isoprene adsolubilization (µmol/ g of silica)	Xadmicelle	Isoprene (mole)	Volume of isoprene	Xbulk	K
5	1249.63	254.94	39.79	7.37E-02	2.04E-05	2.04E-03	4.59E-06	1.61E+04
10	2499.27	826.56	66.91	1.18E-01	6.61E-05	6.61E-03	1.49E-05	7.93E+03
15	3748.90	1341.94	96.28	1.61E-01	1.07E-04	1.07E-02	2.42E-05	6.68E+03
20	4998.53	1922.57	123.04	1.97E-01	1.54E-04	1.54E-02	3.46E-05	5.71E+03
25	7497.80	2693.01	192.19	2.78E-01	2.15E-04	2.16E-02	4.85E-05	5.73E+03

Table B.5 Adsolubilization of isoprene of Arquard®T-50: Teric®X-10 ratio 3:1 at surfactant adsorbed 350 µmol/ g of silica

Volume of isoprene initial (µl)	Initial isoprene concentration (µM)	Equilibrium isoprene concentration (µM)	Isoprene adsolubilization (µmol/ g of silica)	Xadmicelle	Isoprene (mole)	Volume of isoprene	Xbulk	K
5	1249.63	435.79	32.55	8.51E-02	3.49E-05	3.49E-03	7.84E-06	1.08E+04
10	2499.27	1147.03	54.09	1.34E-01	9.18E-05	9.18E-03	2.06E-05	6.48E+03
15	3748.90	1914.85	73.36	1.73E-01	1.53E-04	1.53E-02	3.45E-05	5.03E+03
20	4998.53	2634.11	94.58	2.13E-01	2.11E-04	2.11E-02	4.74E-05	4.49E+03
25	7497.80	4010.53	139.49	2.85E-01	3.21E-04	3.21E-02	7.22E-05	3.95E+03

Table B.6 Adsolubilization of isoprene of Arquard®T-50: Teric®X-10 ratio 3:1 at surfactant adsorbed 200 µmol/ g of silica

Volume of isoprene initial (µl)	Initial isoprene concentration (µM)	Equilibrium isoprene concentration (µM)	Isoprene adsolubilization (µmol/ g of silica)	Xadmicelle	Isoprene (mole)	Volume of isoprene	Xbulk	K
5	1249.63	703.29	21.85	9.85E-02	5.63E-05	5.63E-03	1.27E-05	7.78E+03
10	2499.27	1492.09	40.29	1.68E-01	1.19E-04	1.19E-02	2.69E-05	6.24E+03
15	3748.90	2338.77	56.41	2.20E-01	1.87E-04	1.87E-02	4.21E-05	5.22E+03
20	4998.53	3284.96	68.54	2.55E-01	2.63E-04	2.63E-02	5.91E-05	4.32E+03
25	7497.80	5095.28	96.10	3.25E-01	4.08E-04	4.08E-02	9.18E-05	3.54E+03

Table B.7 Adsolubilization of co-monomer of Arquard®T-50: Teric®X-10 ratio 3:1 at surfactant adsorbed 500 μmol/ g of silica

Initial styrene concentration (μM)	Initial isoprene concentration (μM)	Equilibrium styrene concentration (μM)	Equilibrium isoprene concentration (μM)	Equilibrium co-monomer concentration (μM)	Styrene adsolubilization (μmol/ g of silica)	Isoprene adsolubilization (μmol/ g of silica)	Co-monomer adsolubilization (μmol/ g of silica)
161.94	486.4	123.63	47.88	171.51	1.53	17.54	19.07
404.86	1216	171.45	122.39	293.84	9.34	43.74	53.08
809.72	2432	292.23	221.83	514.06	20.70	88.41	109.11
1214.57	3648	362.60	538.82	901.42	34.08	124.37	158.45
1619.43	4864	477.28	731.77	1209.04	45.69	165.29	210.98
2429.15	7296	492.70	1672.21	2164.91	77.46	224.95	302.41

Table B.8 Adsolubilization of co-monomer of Arquard®T-50: Teric®X-10 ratio 3:1 at surfactant adsorbed 350 μmol/ g of silica

Initial styrene concentration (μM)	Initial isoprene concentration (μM)	Equilibrium styrene concentration (μM)	Equilibrium isoprene concentration (μM)	Equilibrium co-monomer concentration (μM)	Styrene adsolubilization (μmol/ g of silica)	Isoprene adsolubilization (μmol/ g of silica)	Co-monomer adsolubilization (μmol/ g of silica)
161.94	486.4	109.64	76.74	186.38	2.09	16.39	18.48
404.86	1216	145.03	326.80	471.83	10.39	35.57	45.96
809.72	2432	320.07	546.22	866.29	19.59	75.43	95.02
1214.57	3648	416.76	919.99	1336.75	31.91	109.12	141.03
1619.43	4864	514.84	1674.42	2189.26	44.18	127.58	171.77
2429.15	7296	883.56	2993.75	3877.31	61.82	172.09	233.91

Table B.9 Adsolubilization of co-monomer of Arquard®T-50: Teric®X-10 ratio 3:1 at surfactant adsorbed 200 μmol/ g of silica

Initial styrene concentration (μM)	Initial isoprene concentration (μM)	Equilibrium styrene concentration (μM)	Equilibrium isoprene concentration (μM)	Equilibrium co-monomer concentration (μM)	Styrene adsolubilization (μmol/ g of silica)	Isoprene adsolubilization (μmol/ g of silica)	Co-monomer adsolubilization (μmol/ g of silica)
161.94	486.4	124.64	86.91	211.55	1.49	15.98	17.47
404.86	1216	218.48	231.96	450.44	7.46	39.36	46.82
809.72	2432	743.16	335.73	1078.88	2.66	83.85	86.51
1214.57	3648	909.89	858.39	1768.28	12.19	111.58	123.77
1619.43	4864	1265.66	1339.54	2605.20	14.15	140.98	155.13
2429.15	7296	1454.34	3562.94	5017.28	38.99	149.32	188.31

Appendix C Sample Calculation for surfactant adsorption isotherm and partition coefficient

C.1 Surfactant Adsorption Isotherms

Adsorption of mixed surfactants (Arquard®T-50 to Teric®X-10) at 1:0 ratio

$$Surfactant_{adsorp} = \frac{(([Surfactant]_I - [Surfactant]_E)/1000) \times V_{sol}]}{W_{silica}}$$

where

$Surfactant_{adsorp}$ = Adsorption of surfactant, (μmol/g)

$[Surfactant]_I$ = Initial concentration of surfactant solution, (μM)

$[Surfactant]_E$ = Equilibrium concentration of surfactant, (μM)

V_{sol} = Volume of solution, (ml)

W_{silica} = Weight of silica, (g)

The adsorption isotherm was a plot between adsorption of surfactant on silica (μmol/g) and concentration of surfactant solution (μM).

$[Surfactant]_I$ = 10,000 μM

Equilibrium concentration of surfactant was converted from TOC (ppm) to μM

Equation from TOC $Y = 5.3286 X$

where

X = the amount of carbon from TOC (ppm) = 741.7 ppm

Y = $[Surfactant]_E$ (μM) = 5.3286 (741.7)

= 3,952.22 μM

V_{sol} = 20 ml

W_{silica} = 0.5 g

$$Surfactant_{adsorp} = \frac{[(10,000 - 3,952.22)/1000) \times 20]}{0.5}$$

= 241.91 μmol/g

C.2 Partition Coefficient

$$K = \frac{X_{admicell}}{X_{bulk}}$$

where

$X_{admicelle}$ = mole fraction of solute in the surfactant coverage.

X_{bulk} = mole fraction of solute in the bulk.

Adsolubilization of isoprene (in Arquard®T-50 to Teric®X-10 , 3:1 ratio)

$$Isoprene_{adsolub} = \frac{(([Isoprene]_I - [Isoprene]_E)/1000) \times V_{sol}]}{W_{silica}}$$

where

$Isoprene_{adsolub}$ = Adsolubilization of isoprene, (μmol/g)

$[Isoprene]_I$ = Initial concentration of surfactant solution, (μM)

$[Isoprene]_E$ = Equilibrium concentration of surfactant, (μM)

V_{sol} = Volume of solution, (ml)

W_{silica} = Weight of silica, (g)

$[Isoprene]_I$ = 1,249.63 μM

Equation from GC-Head space $Y = 754.23 X$

where

Y = Area of benzene from head space gas chromatography
= 192,282.34

X = $[Isoprene]_E$ (μM)
= (192,282.34)/ 754.23 = 254.94 μM

V_{sol} = 80 ml

W_{silica} = 2 g

$$\text{Isoprene}_{adsclu} = \frac{[((1{,}249.63 - 254.94)/\ 1{,}000) \times 80]}{2}$$

$$= 39.97\ \mu mol/g$$

Adsorption of surfactant adsorbed = 500 μmol/g silica

$$X_{admicelle} = \frac{\text{Mole of isoprene}}{\text{(Mole of adsorbed CTAB + Mole of isoprene)}}$$

$$X_{admicelle} = \frac{39.97}{(500+39.97)} = 7.37E\text{-}02$$

<u>At the supernatant</u>

Isoprene concentration at equilibrium is converted to mol

Molecular weight of isoprene = 68.12 g/mol

$\rho_{isoprene}$ = 0.681 g/ml

$$\text{Mole of isoprene} = \frac{[\text{Isoprene}]_E \times V_{sol}}{1E+09}$$

$$= \frac{254.94 \times 80}{1E+09}$$

$$= 2.0395E\text{-}05$$

Total volume = Volume of isoprene + Volume of H_2O

$$\text{Volume of isoprene (ml)} = \frac{\text{mol of isoprene} \times MW}{\text{Density}}$$

$$= \frac{2.0395E\text{-}05 \times 68.12}{0.681}$$

$$= 2.04E\text{-}03\ ml$$

Volume of H_2O = Total volume – Volume of benzene

= 80 ml – 2.04E-03 ml

= 79.99 ml

Assume density of water = 1 g/ml

Mass of H_2O = Volume of H_2O

= 79.99 g

$$\text{Mol of } H_2O = \frac{\text{Mass of } H_2O}{18} = \frac{79.99}{18} = 4.44$$

$$X_{bulk} = \frac{\text{Mol of isoprene}}{\text{Mol of } H_2O + \text{Mol of isoprene}}$$

$$= \frac{2.0395E\text{-}05}{(4.44+2.0395E\text{-}05)}$$

$$= 4.59E\text{-}06$$

$$K = \frac{X_{admicelle}}{X_{bulk}} = \frac{7.37E\text{-}02}{4.59E\text{-}06} = 1.61E+04$$

Appendix D Continuous Stirred Tank Reactor

D.1 Co-monomer loading calculation

Table D.1 Sample calculation of the amount of co-monomer loading for the surface modification

Monomer	**Styrene**	**Isoprene**
Mole ratio	1	3
Molecular weight (Mw)	104.15	68.12
Density	0.906	0.681

Mole factor	Weight (g)		Total weight	Volume (ml)	
	Styrene	Isoprene		Styrene	Isoprene
0.0053	0.5527	1.0859	1.6386	0.61	1.59

Mole factor was calculated from following equation;

$$(\text{Mole factor})(\text{Mw})_{\text{styrene}}(\text{Mole ratio})_{\text{styrene}} + (\text{Mole factor})(\text{Mw})_{\text{isoprene}}(\text{Mole ratio})_{\text{isoprene}} = \text{Total weight}$$

D.2 Pump flow rate determination

Table D.2 Calculation of pump flow rate for 30 min reaction times of the surface modification

Reactor size 1 l (V)

Total run volume 12.5 l

τ	($v = V/\tau$)		($t = \tau/v$)		
Mean resident time (min)	Flow rate		Total run time		
	ml/sec	ml/min	min	h	h:min
30	0.556	33.33	375	6.25	6:15

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