

Tetrabutylammonium Chloride Based Ionic Liquid Analogues and Their Physical Properties

Farouq S. Mjalli*, Jamil Naser, Bab^a Jibril, Vahid Alizadeh and Zaharaddeen Gano

Department of Petroleum and Chemical Engineering, Sultan Qaboos University, Sultanate of Oman, 123

*Correspondence to: Farouq S. Mjalli, email: farouqsm@yahoo.com

Table S1-1: Density of glycerol- based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	Density (kg.cm ⁻³)		
	1:3	1:4	1:5
293.15	1.014	1.029	1.04
303.15	1.008	1.023	1.034
313.15	1.001	1.017	1.027
323.15	0.995	1.01	1.02
333.15	0.988	1.004	1.014
343.15	0.982	0.997	1.007
353.15	0.976	0.991	1.000

^a Standard uncertainty u= 0.0001 g. cm⁻³

Table S1-2: Viscosity of glycerol- based DESs at Pressure p = 0.1 MPa^a

T(K)	Viscosity (mPa.s)		
	1:3	1:4	1:5
293.15	1170.0	950.0	1100.0
303.15	580.0	476.1	541.3
313.15	293.3	225.0	261.0
323.15	157.0	115.7	137.3
333.15	90.7	64.7	78.4
343.15	56.7	41.9	47.6
353.15	36.7	25.0	32.0

^a Standard uncertainty 5% of measured value

Table S1-3: Conductivity of glycerol- based DESs at Pressure p = 0.1 MPa^a

T(K)	Conductivity (μS.cm ⁻¹)		
	1:3	1:4	1:5
293.15	169.6	192.1	161.8
303.15	309	358	307
313.15	485	525	492
323.15	781	863	788
333.15	1172	1310	1135
343.15	1510	1820	1410
353.15	2400	2640	2220

^a Standard uncertainty u= 5 μS.cm⁻¹

Table S1-4: Surface tension of glycerol- based DESs at Pressure p = 0.1 MPa^a

T(K)	Surface Tension (mN.m ⁻¹)		
	1:3	1:4	1:5
293.15			
303.15	46	46.7	47.1
313.15	44.9	45.9	46.2
323.15	44.1	44.9	45.5
333.15	43.4	44.1	45
343.15	42.7	43.5	44.2
353.15	41.9	42.9	43.5

^a Standard uncertainty u= 0.1 mN.m⁻¹

Table S1-5: Refractive index of glycerol- based DESs at Pressure p = 0.1 MPa^a

T(K)	Refractive Index		
	1:3	1:4	1:5
293.15	1.4802	1.4776	1.4781
303.15	1.4774	1.4747	1.4754
313.15	1.4745	1.4718	1.4726
323.15	1.4716	1.4687	1.4697
333.15	1.4685	1.4658	1.4668
343.15	1.4652	1.4626	1.4638
353.15	1.4620	1.4603	1.4607

^a Standard uncertainty u= 0.001

Table S1-5: pH of glycerol- based DESs at Pressure p = 0.1 MPa^a

T(K)	pH		
	1:3	1:4	1:5
293.15	6.511	8.945	6.806
303.15	6.445	8.704	6.741
313.15	6.38	8.427	6.673
323.15	6.313	8.19	6.6
333.15	6.245	7.936	6.525
343.15	6.188	7.708	6.46
353.15	6.114	7.501	6.417

^a Standard uncertainty u= 0.05

Table S2-1: Density of ethylene glycol- based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	Density (kg.cm^{-3})		
	1:2	1:3	1:4
293.15	1.1050	1.1300	1.1450
303.15	1.0990	1.1230	1.1380
313.15	1.0920	1.1170	1.1320
323.15	1.0860	1.1100	1.1250
333.15	1.0790	1.1040	1.1190
343.15	1.0730	1.0970	1.1120
353.15	1.0670	1.0910	1.1060

^a Standard uncertainty $u = 0.0001 \text{ g. cm}^{-3}$

Table S2-2: Viscosity of ethylene glycol - based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	Viscosity (mPa.s)		
	1:2	1:3	1:4
293.15	212.00	105.00	85.33
303.15	127.00	71.90	56.90
313.15	76.43	45.17	37.16
323.15	49.30	29.37	26.27
333.15	33.60	20.23	19.70
343.15	23.53	14.53	14.85
353.15	16.00	10.70	10.50

^a Standard uncertainty 5% of measured value

Table S2-3: Conductivity of ethylene glycol - based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	Conductivity ($\mu\text{S.cm}^{-1}$)		
	1:2	1:3	1:4
293.15	0.991	1.538	2.02
303.15	1.39	2.14	2.72
313.15	2.2	2.93	3.54
323.15	2.6	3.87	4.5
333.15	3.75	4.57	5.21
343.15	3.85	5.67	6.15
353.15	4.68	6.2	7.22

^a Standard uncertainty $u = 5 \mu\text{S.cm}^{-1}$

Table S2-4: Surface tension of ethylene glycol - based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	Surface Tension (mN.m^{-1})		
	1:2	1:3	1:4
293.15			
303.15	39.3	40.1	40.7
313.15	38.3	39.4	39.9
323.15	37.2	38.3	39.1
333.15	36.6	37.5	38.3
343.15	35.7	36.8	37.5
353.15	34.9	36.1	36.8

^a Standard uncertainty $u = 0.1 \text{ mN.m}^{-1}$

Table S2-5: Refractive index of ethylene glycol - based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	Refractive Index		
	1:2	1:3	1:4
293.15	1.4703	1.4653	1.4615
303.15	1.4672	1.4619	1.4585
313.15	1.4641	1.4587	1.4554
323.15	1.4609	1.4556	1.4523
333.15	1.4578	1.4525	1.4491
343.15	1.4545	1.4495	1.445
353.15	1.4509	1.4469	1.4427

^a Standard uncertainty $u = 0.001$

Table S2-5: pH of ethylene glycol - based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	pH		
	1:2	1:3	1:4
293.15	9.1	9.2	9.35
303.15	8.93	8.96	9.2
313.15	8.72	8.74	9.04
323.15	8.39	8.54	8.86
333.15	8.03	8.21	8.6
343.15	7.79	7.99	8.37
353.15	7.51	7.76	8.19

^a Standard uncertainty $u = 0.05$

Table S3-1: Density of triethylene glycol- based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	Density (kg.cm^{-3})			
	1:1	2:1	3:1	4:1
293.15	1.027	1.007	0.996	0.99
303.15	1.021	1.001	0.99	0.985
313.15	1.015	0.995	0.984	0.98
323.15	1.009	0.989	0.978	0.973
333.15	1.003	0.983	0.972	0.968
343.15	0.997	0.976	0.966	0.961
353.15	0.991	0.97	0.96	0.955

^a Standard uncertainty $u = 0.0001 \text{ g. cm}^{-3}$

Table S3-2: Viscosity of triethylene glycol - based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	Viscosity (mPa.s)			
	1:1	2:1	3:1	4:1
293.15	870.0			
303.15	543.8	1399.0		3265.3
313.15	289.4	952.2	7031.7	1900.4
323.15	166.4	493.0	909.1	862.9
333.15	100.8	264.1	452.1	411.2
343.15	68.1	154.0	244.7	204.5
353.15	44.7	91.3	155.6	99.9

^a Standard uncertainty 5% of measured value

Table S3-3: Conductivity of triethylene glycol - based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	Conductivity ($\mu\text{S.cm}^{-1}$)			
	1:1	2:1	3:1	4:1
293.15	138.9	68.1	22.08	17.82
303.15	228	149.3	50	47
313.15	376	284	97	108
323.15	550	458	154	214
333.15	805	676	217	252
343.15	1100	842	282	262
353.15	1474	920	319	273

^a Standard uncertainty $u = 5 \mu\text{S.cm}^{-1}$

Table S3-4: Surface tension of triethylene glycol - based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	Surface Tension (mN.m^{-1})			
	1:1	2:1	3:1	4:1
293.15				
303.15	40.6	40.1	39.3	40
313.15	39.5	38.6	38.3	38.4
323.15	38.8	38	37.2	37.3
333.15	38.2	37.4	36.6	36.5
343.15	37.6	36.4	35.7	35.6
353.15	37	35.6	34.9	34.6

^a Standard uncertainty $u = 0.1 \text{ mN.m}^{-1}$

Table S3-5: Refractive index of triethylene glycol - based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	Refractive Index			
	1:1	2:1	3:1	4:1
293.15	1.48	1.4851	1.4858	1.4871
303.15	1.4772	1.4821	1.4836	1.4841
313.15	1.4742	1.479	1.4806	1.4811
323.15	1.4711	1.476	1.4777	1.4781
333.15	1.4678	1.4731	1.4747	1.4752
343.15	1.4646	1.4701	1.4717	1.4722
353.15	1.4614	1.4673	1.4686	1.4692

^a Standard uncertainty $u = 0.001$

Table S3-5: pH of triethylene glycol - based DESs at Pressure $p = 0.1 \text{ MPa}^a$

T(K)	pH			
	1:1	2:1	3:1	4:1
293.15	6.404	6.970	7.698	8.064
303.15	6.323	6.844	7.537	7.892
313.15	6.219	6.721	7.371	7.709
323.15	6.159	6.578	7.181	7.535
333.15	6.074	6.449	7.016	7.348
343.15	6.005	6.326	6.87	7.184
353.15	5.919	6.212	6.732	7.033

^a Standard uncertainty $u = 0.05$