APPENDICES

APPENDIX A Amine Concentration Data Before and After CO_2 Absorption

Table A.1: Amine concentration before and after CO_2 absorption for 1.0 M MAE at 30, 40 and 60 ^oC

Temperature (^oC)	CO_2 Partial Pressure (kPa)	Amine Concentration before Test ($mol.dm^{-3}$)	Amine Concentration after Test ($mol.dm^{-3}$)	Deviation (%)
30	99.08	1	1.028	2.8
	49.37	1	1.031	3.1
	24.69	1	1.044	4.4
	9.84	1	1.052	5.2
	4.95	1	1.038	3.8
	0.98	1	1.013	1.3
40	98.91	1	1.049	4.9
	49.37	1	1.007	0.7
	24.64	1	1.031	3.1
60	98.41	1	1.040	4.0
	49.37	1	1.063	6.3
	24.64	1	1.106	10.6

Table A.2: Amine concentration before and after CO_2 absorption test for 2.0 M MAE at 30, 40 and 60 ^oC and 4.0 M MAE at 30 ^oC

Temperature (^oC)	CO_2 Partial Pressure (kPa)	Amine Concentration before Test ($mol.dm^{-3}$)	Amine Concentration after Test ($mol.dm^{-3}$)	Deviation (%)
30	98.75	2	2.011	0.6
	49.04	2	1.966	1.7
	24.64	2	2.052	2.6
	9.87	2	2.067	3.4
	4.95	2	2.029	1.5
	0.99	2	2.059	3.0
40	98.58	2	2.033	1.7
	49.12	2	2.032	1.6
	24.64	2	2.004	0.2
60	98.58	2	2.060	3.0
	49.29	2	2.149	7.5
	24.81	2	1.809	9.6
30	98.41	4	3.898	2.6
	49.37	4	3.778	5.6
	24.64	4	3.930	1.8
	9.89	4	3.947	1.3
	4.95	4	3.942	1.5
	0.99	4	4.071	1.8

APPENDIX B pH Data and Time to Reach Equilibrium

Table B.1: Amine pH data before and after CO_2 absorption and time to reach equilibrium for 1.0 M MAE at 30, 40 and 60 ^oC

Temperature (^oC)	Amine Concentration ($mol.dm^{-3}$)	CO_2 Partial Pressure (kPa)	pH before Test	pH after Test	Time to Reach Equilibrium (min)
30	1	99.08	11.62	7.34	32
	1	49.37	10.5	6.65	38
	1	24.69	10.51	7.87	45
	1	9.84	11.93	8.5	70
	1	4.95	10.5	7.45	85
	1	0.98	11.38	8.87	150
40	1	98.91	10.1	6.37	25
	1	49.37	10.02	7.51	35
	1	24.64	11.41	7.83	65
60	1	98.41	10.74	7.34	20
	1	49.37	11.1	7.76	32
	1	24.64	10.73	7.76	50

Table B.2: Amine pH data before and after CO_2 absorption and time to reach equilibrium for 2.0 M MAE at 30, 40 and 60 ^oC and 4.0 M at 30 ^oC

Temperature (^oC)	Amine Concentration ($mol.dm^{-3}$)	CO_2 Partial Pressure (kPa)	pH before Test	pH after Test	Time to Reach Equilibrium (min)
30	2	98.75	11.89	7.49	35
	2	49.04	11.48	7.86	45
	2	24.64	11.66	7.98	75
	2	9.87	12.28	8.68	80
	2	4.95	12.25	8.88	100
	2	0.99	11.56	8.18	170
40	2	98.58	11.76	7.51	30
	2	49.12	10.22	7.86	40
	2	24.64	11.8	8.2	65
60	2	98.58	10.51	7.68	25
	2	49.29	11.36	7.86	35
	2	24.81	10.82	7.79	55
30	4	98.41	12.36	8.25	60
	4	49.37	12.09	8.47	72
	4	24.64	11.97	8.67	85
	4	9.89	12.17	8.94	92
	4	4.95	12.5	9.03	150
	4	0.99	12.3	9.18	200

APPENDIX C Non-Linear Regression Program Results for Estimating the Parameters for K_2 Correlation

NLREG version 6.5
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Non-Linear Regression to fit experimental $\ln K_2$, T, M, and P to Model
Number of observations = 17
Maximum allowed number of iterations = 500
Convergence tolerance factor = 1.000000E-010
Stopped due to: Relative function convergence.
Number of iterations performed = 5
Final sum of squared deviations = 2.6814277E+001
Final sum of deviations = -3.3801547E-009
Standard error of estimate = 1.49483
Average deviation = 0.973436
Maximum deviation for any observation = 2.67345
Proportion of variance explained (R^2) = 0.5284 (52.84%)
Adjusted coefficient of multiple determination (Ra^2) = 0.3712 (37.12%)
Durbin-Watson test for autocorrelation = 2.204
Analysis completed 24-Apr-2010 01:44. Runtime = 0.05 seconds.

---- Descriptive Statistics for Variables ----

Variable	Minimum value	Maximum value	Mean value	Standard dev.
lnK2	-3.905	3.1041	-1.357082	1.885126
P	303	333	312.4118	12.48529
M	0.9841	98.913	30.93721	34.6903
T	0.9605	4.0416	1.708041	0.9986274

---- Calculated Parameter Values ----

Parameter	Initial guess	Final estimate	Standard error	t	Prob(t)
a	1	1.30081964	11.46776	0.11	0.91156
b	1	-4.23040899	1.32262	-3.20	0.00765
c	1	0.002474157	0.037044	0.07	0.94785
d	1	-0.0334237468	0.050418	-0.66	0.51990
e	1	0.00035097811	0.0004516	0.78	0.45207

---- Analysis of Variance ----

Source	DF	Sum of Squares	Mean Square	F value	Prob(F)
Regression	4	30.04493	7.511233	3.36	0.04587
Error	12	26.81428	2.234523		
Total	16	56.85921			

---- 90.000% Confidence Intervals ----

Parameter	Lower limit	Best estimate	Upper limit
a	-19.1376722	1.30081964	21.7393115
b	-6.58765765	-4.23040899	-1.87316033
c	-0.063548557	0.00247415668	0.0684968704
d	-0.123281526	-0.0334237468	0.0564340326
e	-0.000453831	0.0003509781	0.00115578725

APPENDIX D Equilibrium Constant Data for Hydrolysis of Carbamate

Table D.1: Equilibrium constant data for hydrolysis of carbamate for 1.0 M MAE at 30, 40 and 60 ^{o}C

Temperature (^{o}C)	Amine Concentration (mol.dm^{-3})	CO_2 Partial Pressure (kPa)	Equilibrium Constant (K_2)
30	1	99.08	2.73
	1	49.37	3.18
	1	24.69	3.37
	1	9.84	3.49
	1	4.95	3.52
	1	0.98	3.55
40	1	98.91	16.27
	1	49.37	18.31
	1	24.64	19.42
60	1	98.41	92.17
	1	49.37	103.58
	1	24.64	109.59

Table D.2: Equilibrium constant data for hydrolysis of carbamate ion for 2.0 M MAE at 30, 40 and 60 ^{o}C and 4.0 M at 30 ^{o}C

Temperature (^{o}C)	Amine Concentration (mol.dm^{-3})	CO_2 Partial Pressure (kPa)	Equilibrium Constant (K_2)
30	2	98.75	2.44
	2	49.04	2.66
	2	24.64	2.91
	2	9.87	2.93
	2	4.95	2.96
	2	0.99	2.98
40	2	98.58	14.08
	2	49.12	15.85
	2	24.64	16.80
60	2	98.58	79.76
	2	49.29	89.65
	2	24.81	95.03
30	4	98.41	105.07
	4	49.37	117.69
	4	24.64	120.89
	4	9.89	125.21
	4	4.95	130.81
	4	0.99	138.05

APPENDIX E List of Publications

Haider, H., Yusoff, R., Aroua, M. K. (2009), Solubility of carbon dioxide in 2(methylamino) ethanol, Techpos2009, 14-15th December 2009, Kuala Lumpur, Malaysia.

Haider, H., Yusoff, R., Aroua, M. K. (2011), Equilibrium solubility of carbon dioxide in 2(methylamino) ethanol. Accepted for publication, Fluid Phase Equilibria.