APPENDICES

Appendix A

Appendix B

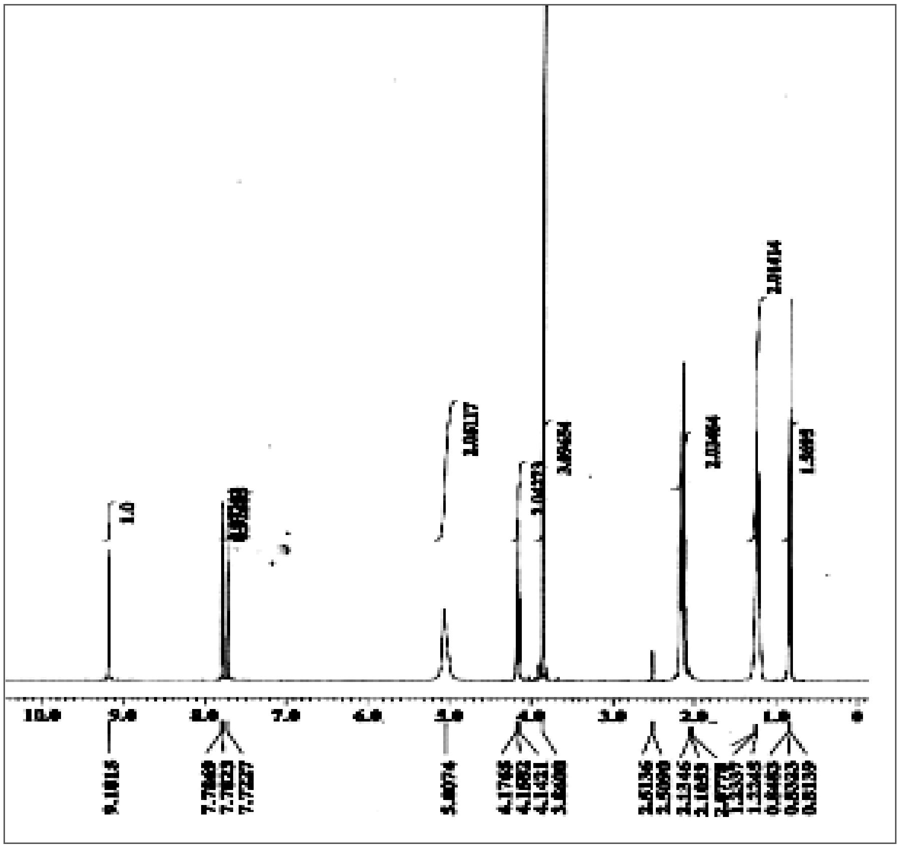


Figure B.1 Proton NMR spectrum for $MSBIMHSO_4$. The peaks 1-9 indicated, -N-C-C$\underline{H}_2$-C-C-S-, -N-C-C-C$\underline{H}_2$-C-S-, -N-C-C-C-C$\underline{H}_2$-S-, C$\underline{H}_3$-N-, -N-C$\underline{H}_2$-C-C-C-S-, O$\underline{H}$, -N-C$\underline{H}$-C-N-,-N-C-C$\underline{H}$-N-, and -N-C$\underline{H}$-N-, respectively.

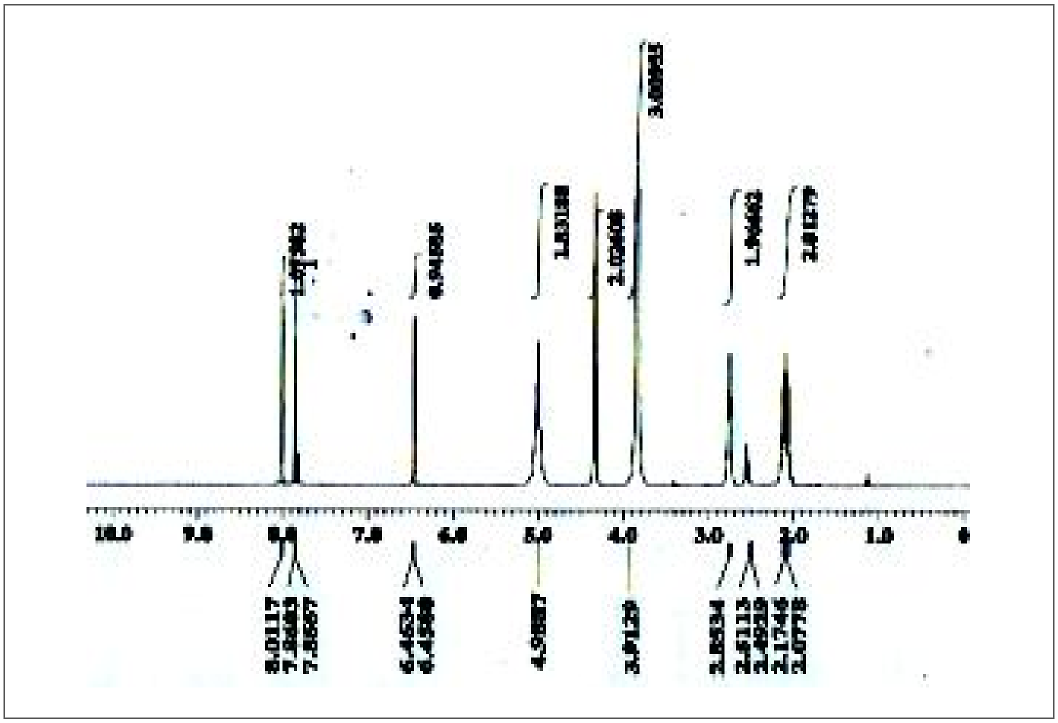


Figure B.2 Proton NMR spectrum for $MSPPHSO_4$. The peaks 1-8 indicated, -N-C-C$\underline{H_2}$-C-S-, -N- C$\underline{H_2}$-C-C-S-, C$\underline{H_3}$-C-, -N-C-C-C$\underline{H_2}$-S-, -O$\underline{H}$, -N-C-C$\underline{H}$-C-N-, -N-C$\underline{H}$-C-N-,-and -N-C-C$\underline{H}$-N-, respectively.

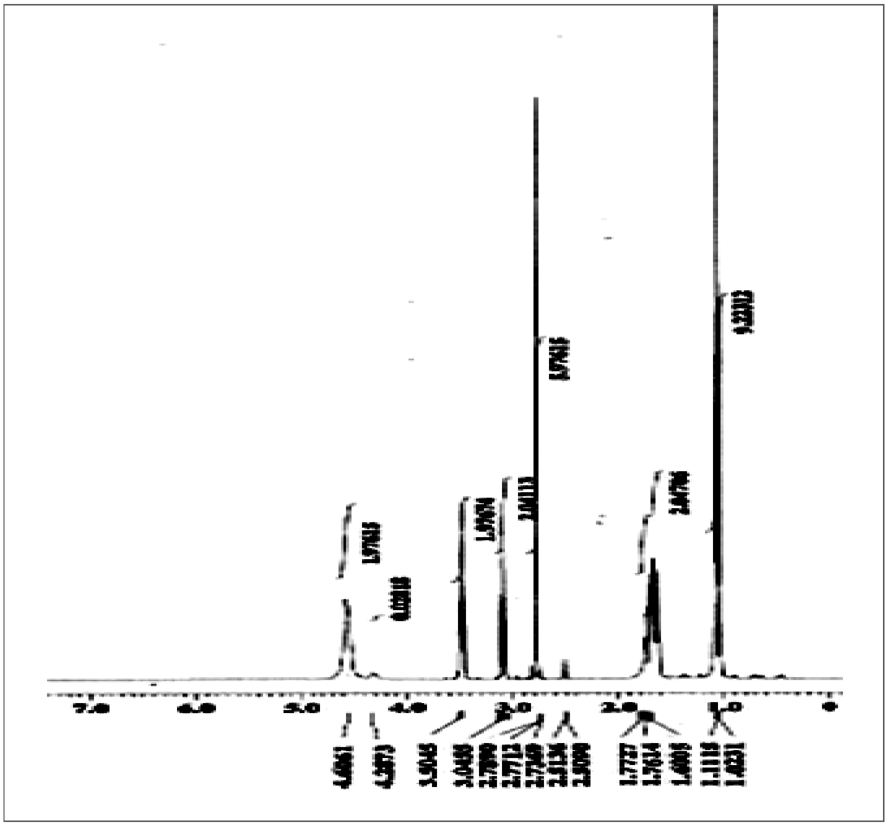


Figure B.3 Proton NMR spectrum for $TESPAMHSO_4$. The peaks 1-6 indicated, C$\underline{H}_3$-C-, -N-C-C$\underline{H}_2$-C-S-, -N-C-C-C$\underline{H}_2$-S-, C-C$\underline{H}_2$-N-, -N-C$\underline{H}_2$-C-C-S-, and -S-O$\underline{H}$, respectively.

Appendix C

Table C.1 Carbon (C, 12.0107 g/mol), Hydrogen (H, 1.0079 g/mol), Nitrogen (N, 14.0067 g/mol) and Sulfur (S, 32.066 g/mol) percentages in the investigated ILs

IL	C	H	N	S	Predicted

	(%)	(%)	(%)	(%)	formula
MPSIM	43.23 ± 0.02	6.07 ± 0.018	13.37 ± 0.044	16.58 ± 0.015	$C_7H_{12}N_2O_3S$
$MSPIMHSO_4$	27.85 ± 0.047	4.58 ± 0.053	9.29 ± 0.081	21.26 ± 0.046	$C_7H_{14}N_2O_7S_2$
MBSIM	45.03 ± 0.026	6.556 ± 0.031	12.23 ± 0.029	15.44 ± 0.030	$C_8H_{14}N_2O_3S$
$MSBIMHSO_4$	30.32 ± 0.095	5.094 ± 0.024	8.99 ± 0.0164	20.26 ± 0.073	$C_8H_{16}N_2O_7S_2$
BPSIM	49.05 ± 0.03	7.551 ± 0.005	11.38 ± 0.045	13.34 ± 0.038	$C_{10}H_{18}N_2O_3S$
BBSIM	50.93 ± 0.038	7.772 ± 0.010	10.80 ± 0.075	12.47 ± 0.045	$C_{11}H_{20}N_2O_3S$
$BSBIMHSO_4$	36.82 ± 0.01	6.17 ± 0.058	7.91 ± 0.086	18.11 ± 0.03	$C_{11}H_{22}N_2O_7S_2$
PSP	48.71 ± 0.049	9.66 ± 0.058	5.92 ± 0.053	14.73 ± 0.026	$C_6H_{10}N_2O_3S$
$SPPHSO_4$	24.78 ± 0.015	4.31 ± 0.004	10.03 ± 0.011	22.95 ± 0.02	$C_6H_{12}N_2O_7S_2$
$SBPHSO_4$	27.77 ± 0.032	4.599 ± 0.016	9.29 ± 0.033	21.24 ± 0.020	$C_7H_{14}N_2O_7S_2$
$MSPPHSO_4$	27.77 ± 0.064	4.62 ± 0.008	9.28 ± 0.010	21.25 ± 0.06	$C_7H_{14}N_2O_7S_2$
$MSBPHSO_4$	30.23 ± 0.040	5.095 ± 0.025	8.985 ± 0.022	20.26 ± 0.035	$C_8H_{16}N_2O_7S_2$
DEMSPAM	48.93 ± 0.035	9.57 ± 0.020	6.24 ± 0.01	14.51 ± 0.015	$C_9H_{21}NO_3S$
$DEMSBAMHSO_4$	33.90 ± 0.020	7.312 ± 0.010	4.42 ± 0.004	20.24 ± 0.072	$C_9H_{23}NO_7S_2$
TEPSAM	49.26 ± 0.036	9.64 ± 0.020	6.30 ± 0.006	14.62 ± 0.035	$C_9H_{21}NO_3S$
$TESPAMHSO_4$	33.73 ± 0.038	7.31 ± 0.005	4.42 ± 0.003	20.24 ± 0.059	$C_9H_{23}NO_7S_2$
TEBSAM	50.97 ± 0.011	9.96 ± 0.025	6.004 ± 0.034	13.98 ± 0.086	$C_{10}H_{23}NO_3S$
$TESBAMHSO_4$	36.05 ± 0.026	7.58 ± 0.005	4.24 ± 0.009	19.07 ± 0.050	$C_{10}H_{25}NO_7S_2$

Appendix D

Table D.1 The thermal decomposition of investigated zwitterionic ILs and RTILs

IL	T_{dec} ± 2.5 (°C)
MPSIM	370
$MSPIMHSO_4$	315

MBSIM	367.9
$MSBIMHSO_4$	306
BPSIM	372.8
$BSPIMHSO_4$	323
BBSIM	360.2
$BSBIMHSO_4$	311.5
PSP	347.4
$SPPHSO_4$	300.4
BSP	352.7
$SBPHSO_4$	308.3
MPSP	359.8
$MSPPHSO_4$	320
MBSP	350.8
$MSBPHSO_4$	308
DEMPSAM	328
$DEMSPAMHSO_4$	332.7
DEMBSAM	318
$DEMSBAMHSO_4$	330
TEPSAM	296.8
$TESPAMHSO_4$	295.4
TEBSAM	288.8
$TESBAMHSO_4$	280

Appendix E

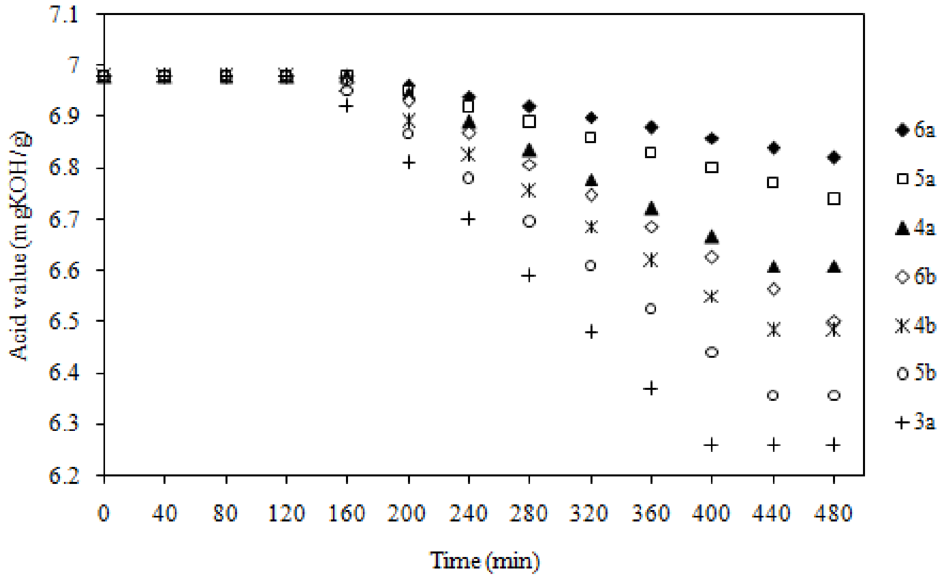


Figure E.1 The effect of different catalysts on the CPO acidity reduction during the transesterification reactions. 3a = $SPPHSO_4$; 4a = $MSPPHSO_4$; 4b = $MSBPHSO_4$, 5a = $DEMSPAMHSO_4$, 5b = $DEMSBAMHSO_4$, 6a = $TESPAMHSO_4$, 6b = $TESBAMHSO_4$.

Appendix F

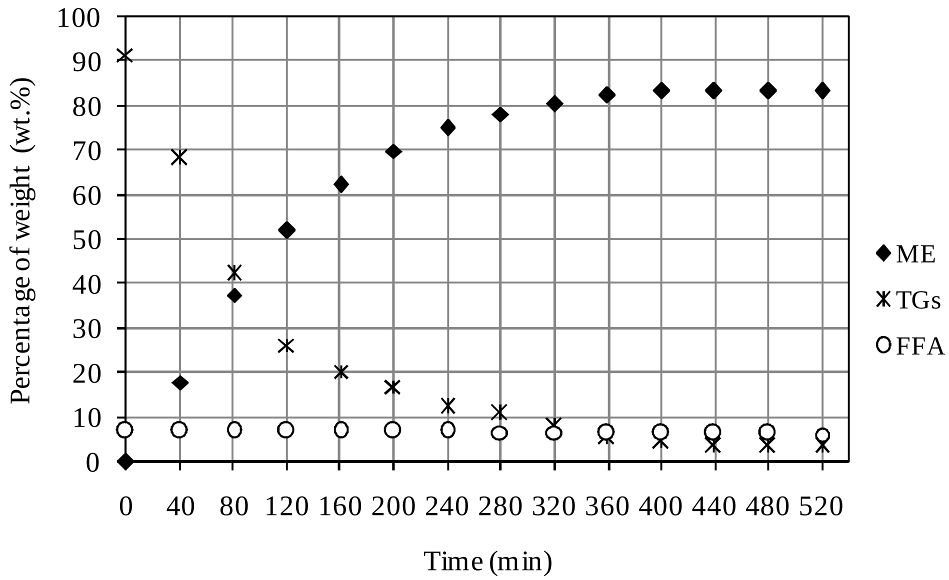


Figure F.1 The effect of $MSPIMHSO_4$ catalyst on the TGs and FFA conversion to ME.

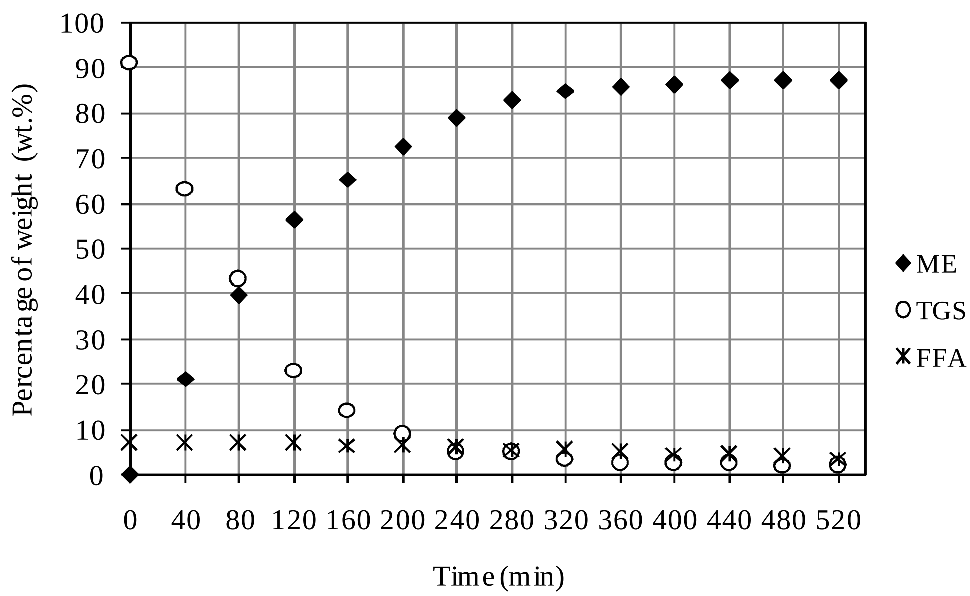


Figure F.2 The effect of $MSBIMHSO_4$ catalyst on the TGs and FFA conversion to ME.

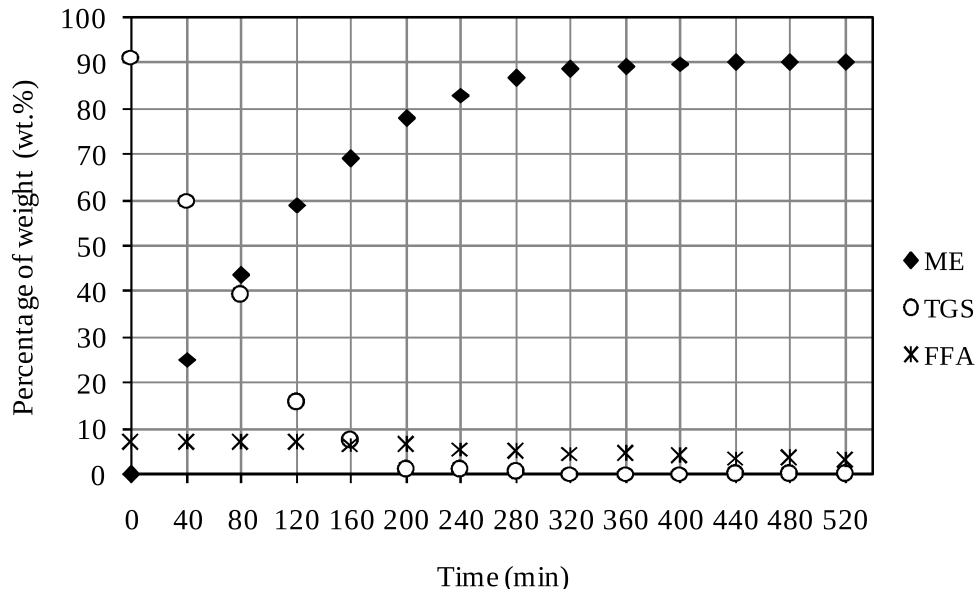


Figure F.3 The effect of $BSPIMHSO_4$ catalyst on the TGs and FFA conversion to ME.

Appendix G

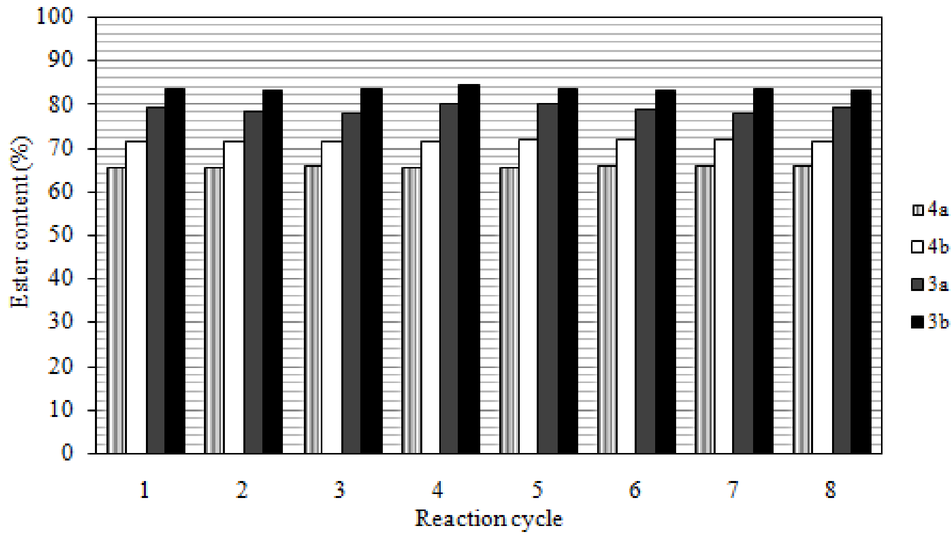


Figure G.1 Functionalized pyrazolium acidic ILs recyclability for catalyzing the transesterification of CPO with methanol under their optimal conditions. 3a = $SPPHSO_4$; 4a = $MSPPHSO_4$; 3b = $SBPHSO_4$; 4b = $MSBPHSO_4$.

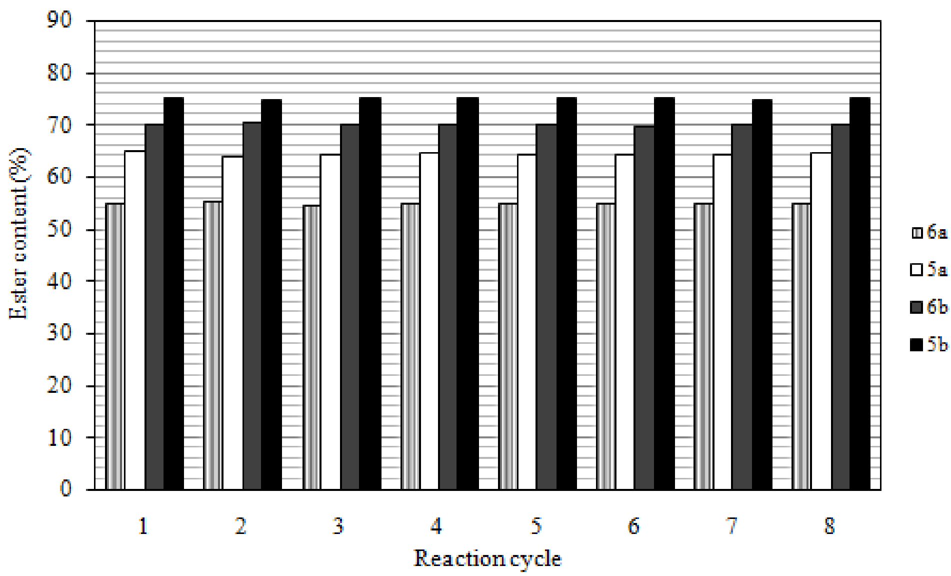
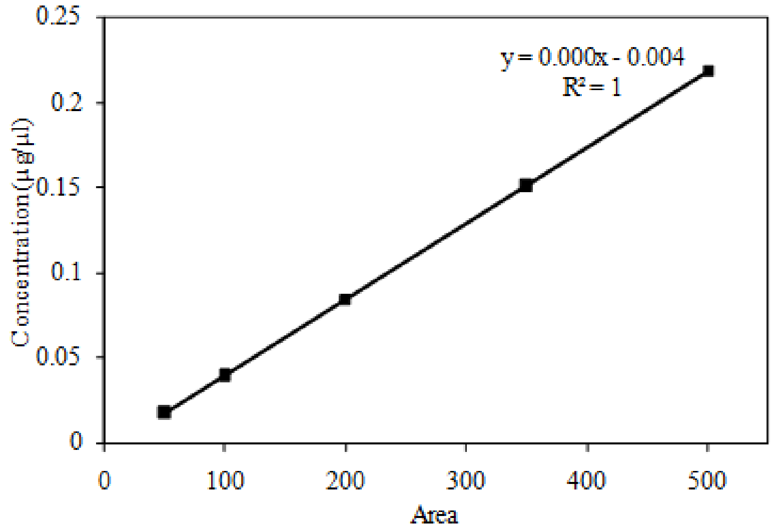
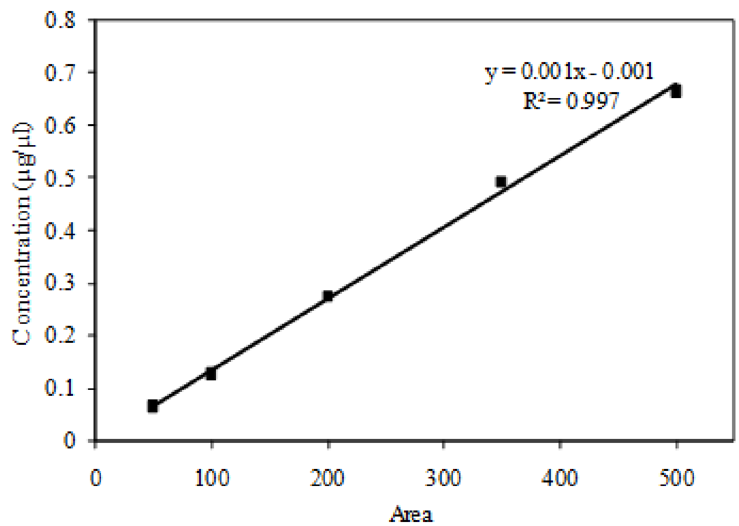


Figure G.2 Functionalized ammonium acidic ILs recyclability for catalyzing the transesterification of CPO with methanol under their optimal conditions. 3a = SPPHSO4; 4a = MSPPHSO4; 3b = SBPHSO4; 4b = MSBPHSO4.

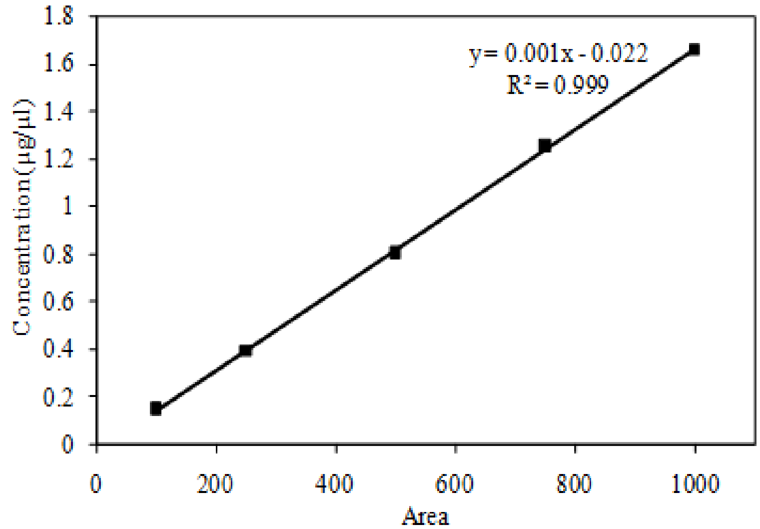
Appendix H


y = 0.000x - 0.004
R² = 1
Concentration (µg/µl)
0.25
0.2
0.15
0.1
0.05
0
0
100
200
300
400
500
Area

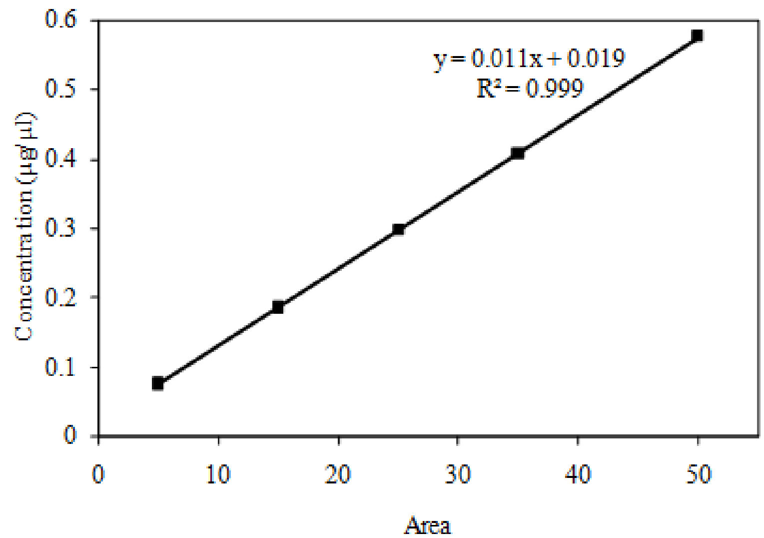
(a)


y = 0.001x - 0.001
R² = 0.997
Concentration (µg/µl)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
100
200
300
400
500
Area

(b)



(c)



(d)

Figure I.1 GC standard curves for: (a) TG; (b) DG; (c) MG; (d) Gl.