10.1071/CH20153_AC



Australian Journal of Chemistry 2021, 74(3), 165-172

# Supplementary Material

# Synthesis, Characterization, and Determination of Physical Properties of New Two-Protonic Acid Ionic Liquid and its Catalytic Application in the Esterification

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**Figure S1**. The product image of $[TMDPH_2][SO_4]$ after reaction (left) and crystallization from methanol (right).

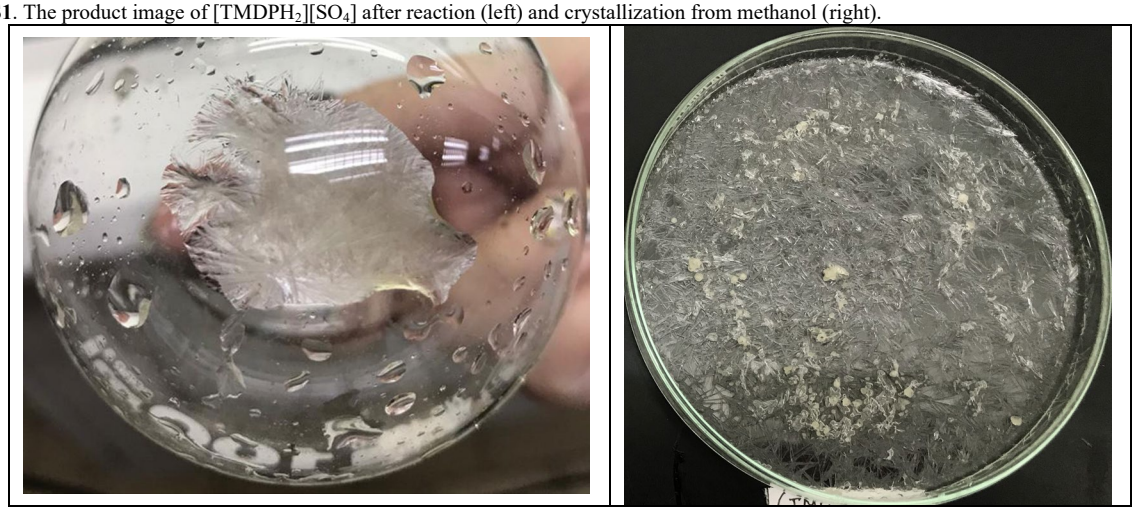


**Figure S2**. $^{1}$H NMR of new ionic liquid in DMSO-$d_6$.

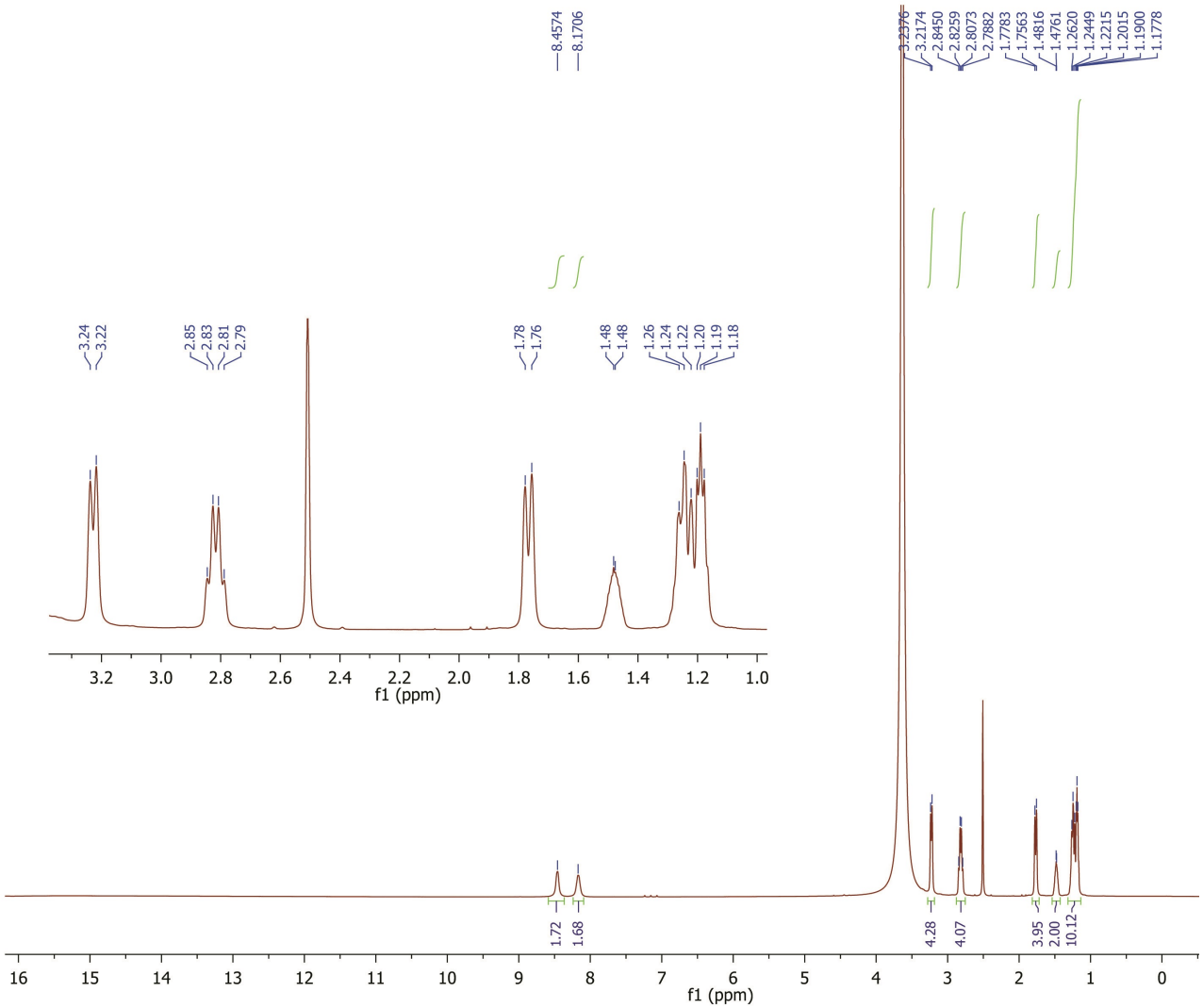


**Figure S3**. $^{1}H$ NMR of new ionic liquid in $D_2O$.

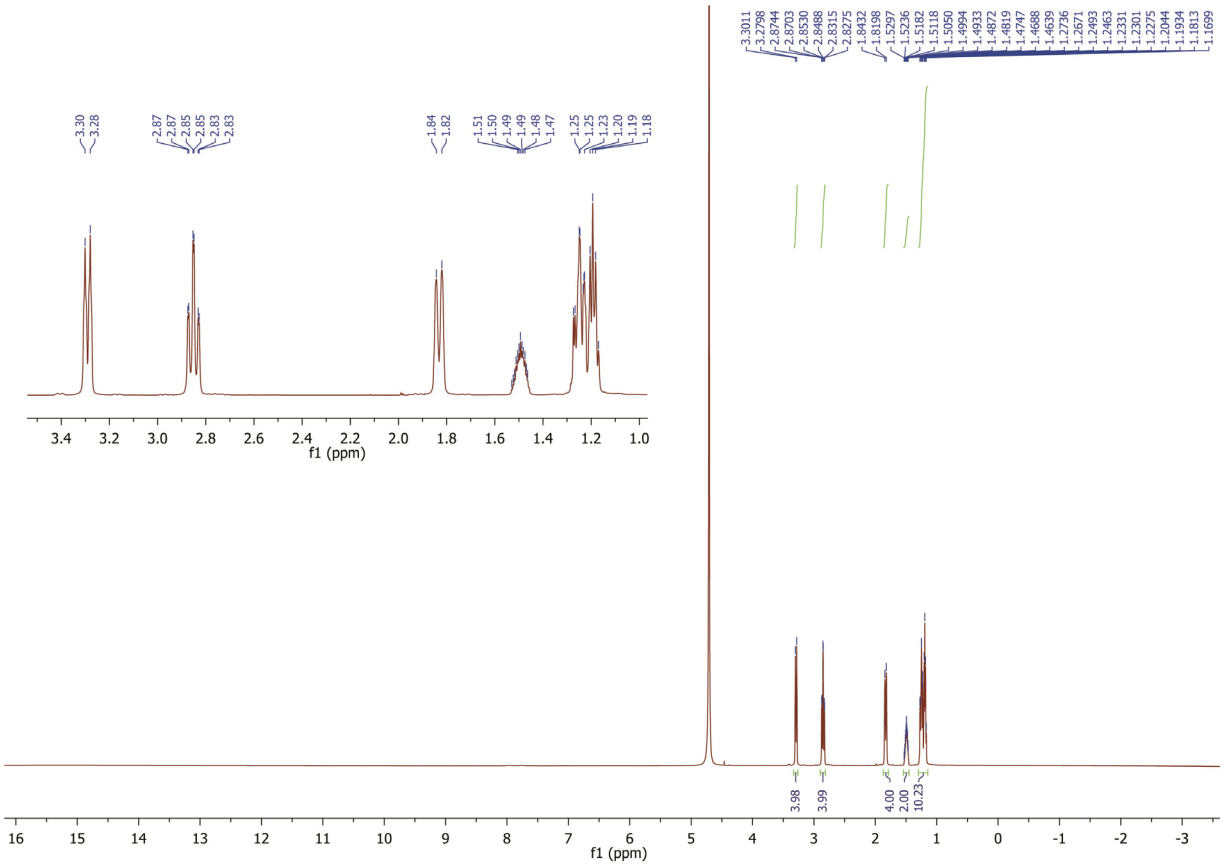


**Figure S4**. $^{13}C$ NMR of new ionic liquid in DMSO-$d_6$.

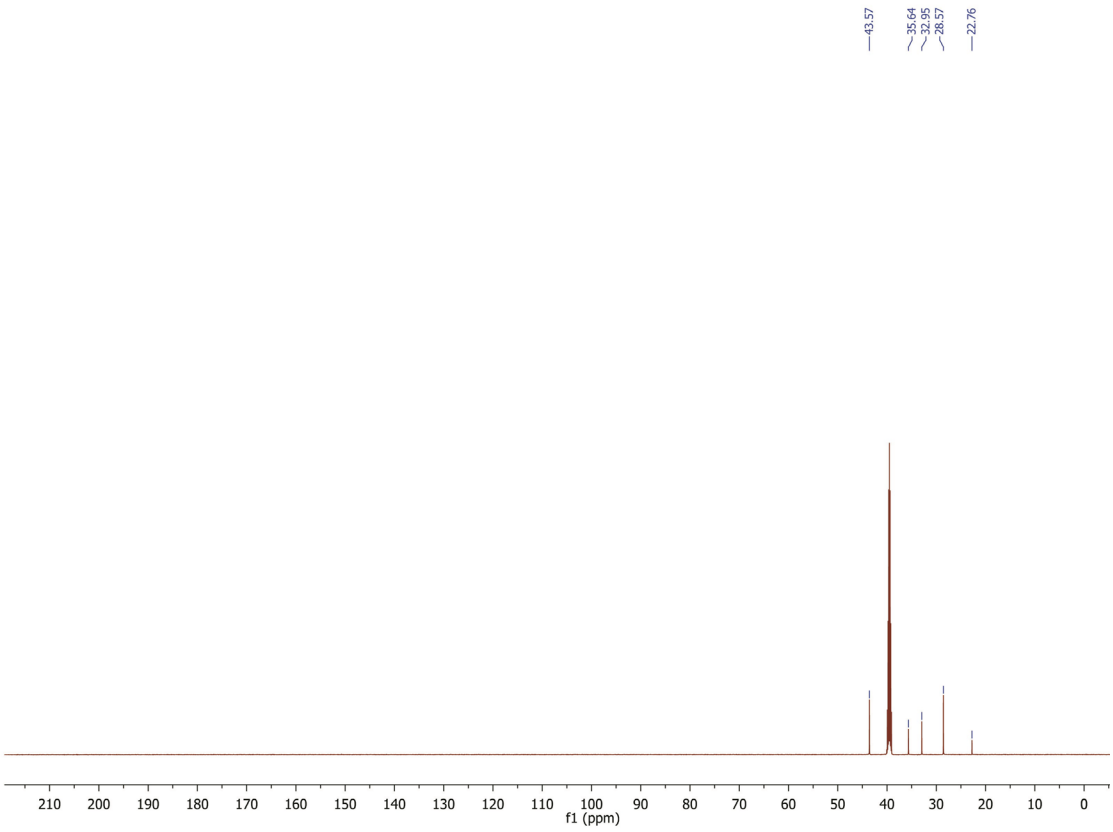



**Figure S5**. $^{13}C$ NMR of new ionic liquid in $D_2O$.

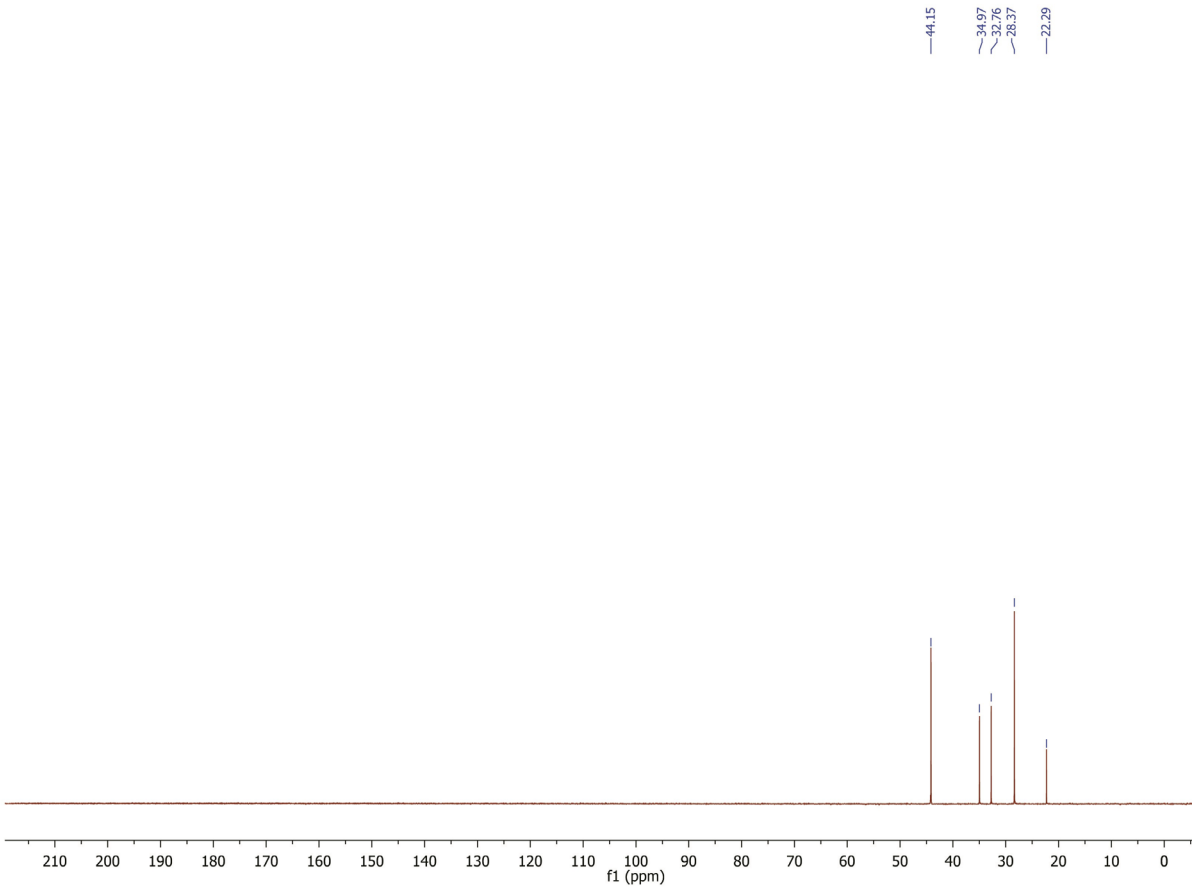



**Figure S6**. $^{1}$H,$^{1}$H-COSY spectrum of new ionic liquid.

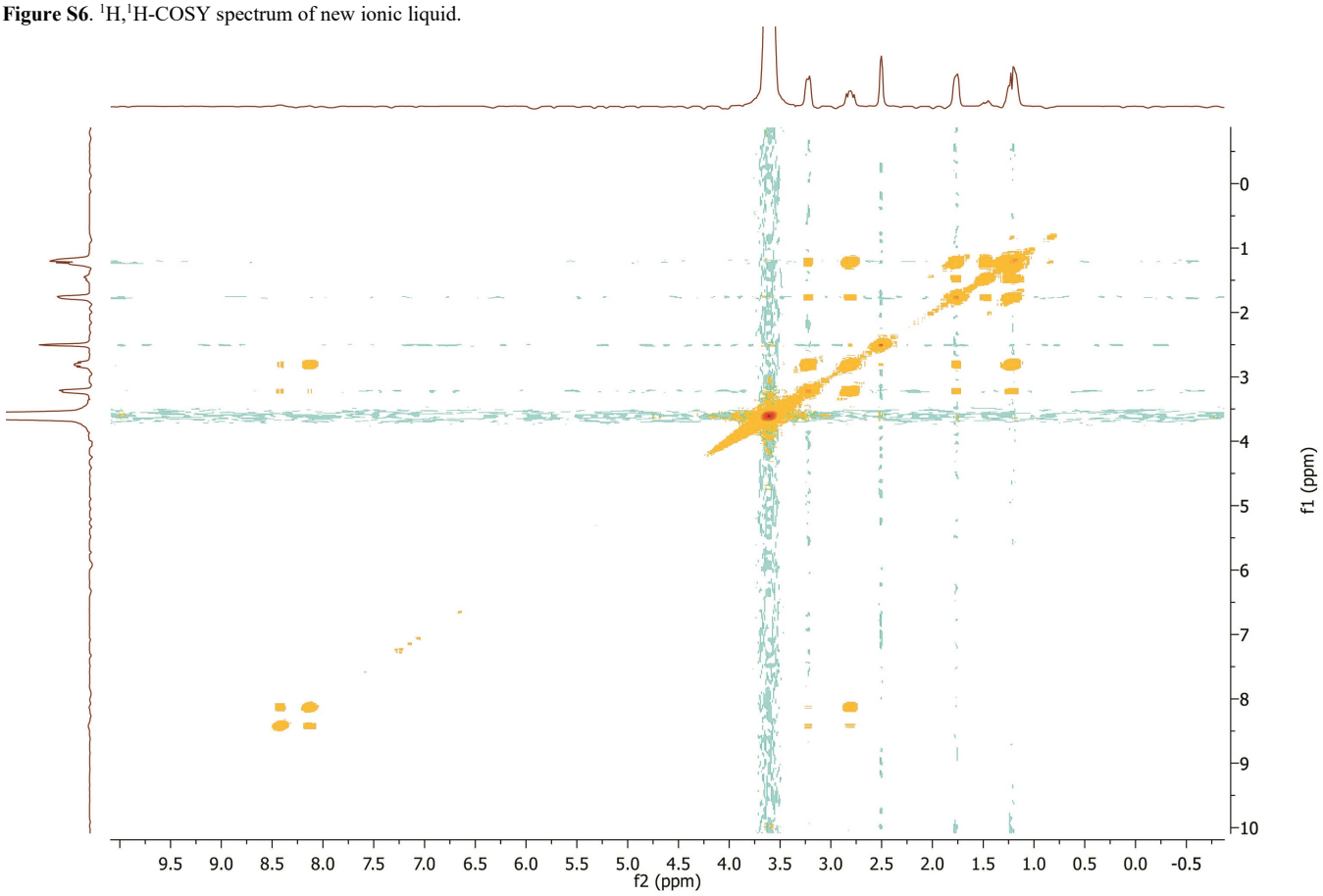
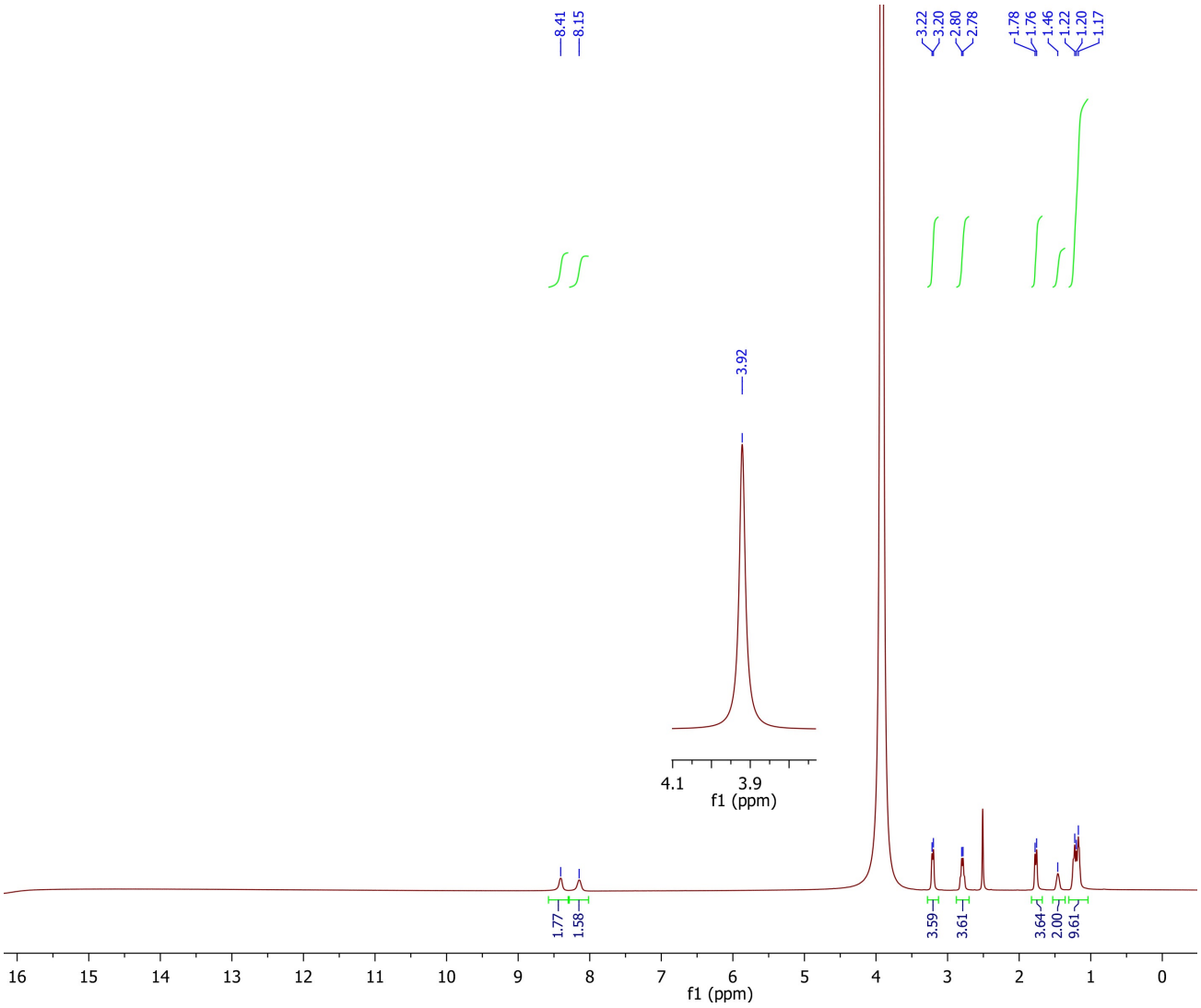


**Figure S7**. $^{1}H$ and $^{13}C$ NMR of TMDP+SA at a ratio of 1:1 in DMSO-$d_6$.

**a**


8.41
8.15
3.22
3.20
2.80
2.78
1.78
1.76
1.46
1.22
1.20
1.17
3.92
4.1
3.9
f1 (ppm)
1.77
1.58
3.59
3.61
3.64
2.00
9.61
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

**b**

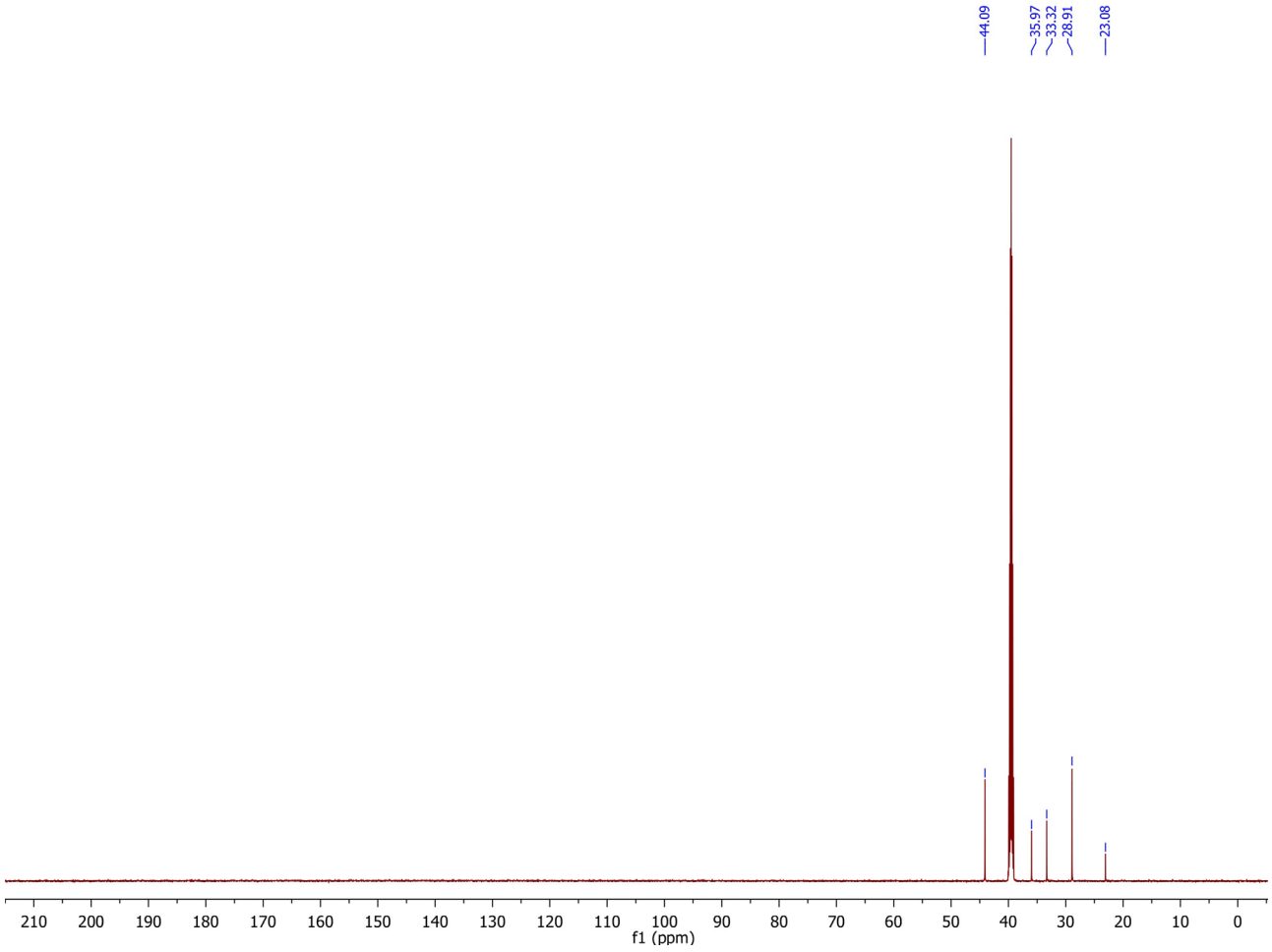
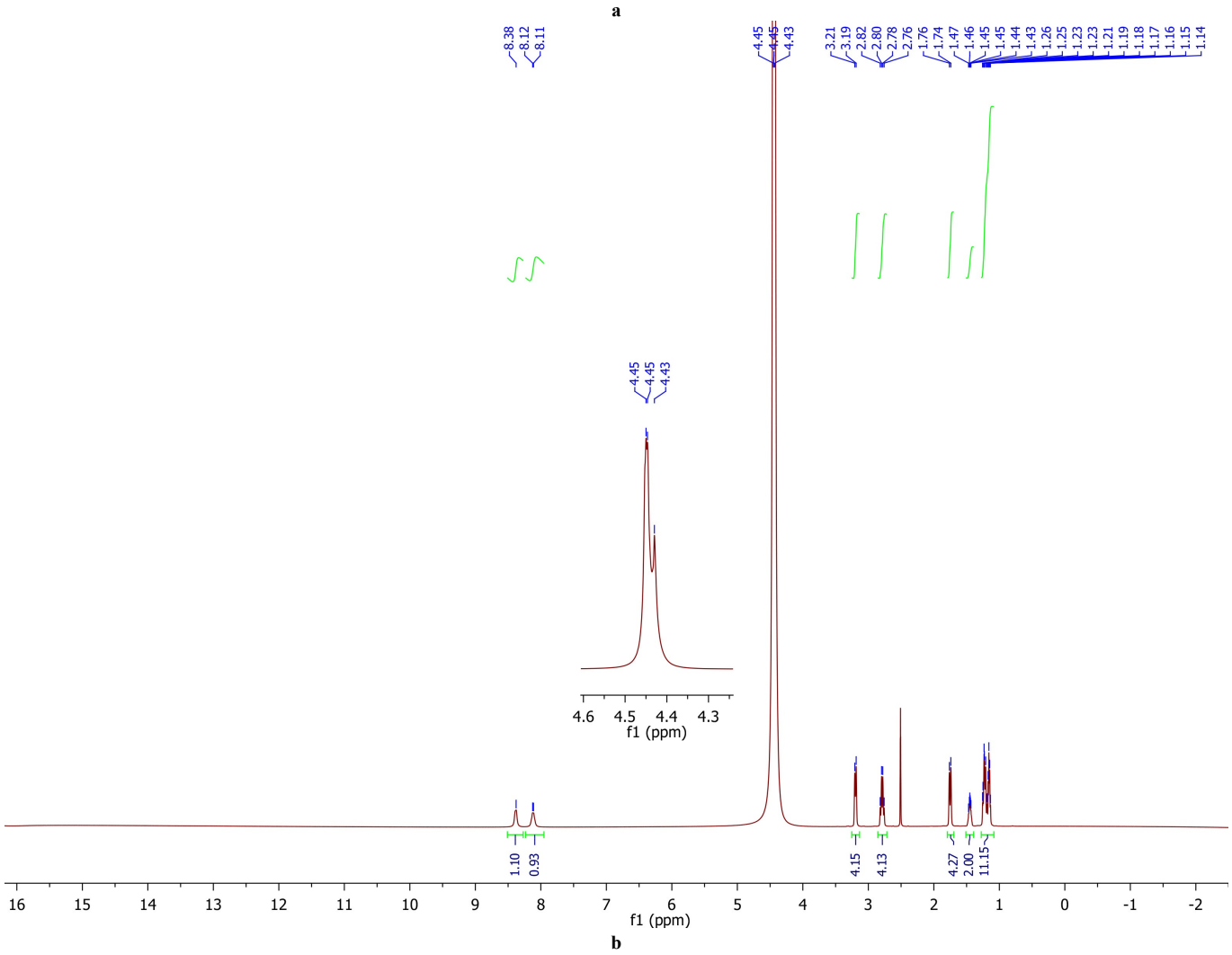

44.09
35.97
33.32
28.91
23.08
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

**Figure S8**. $^{1}$H NMR of TMDP+SA at a ratio of 1:1 in DMSO-$d_6$ after adding 1.0 equivalent (**a**) and 2.0 equivalents (**b**) of sulfuric acid (98%) to the NMR tube.



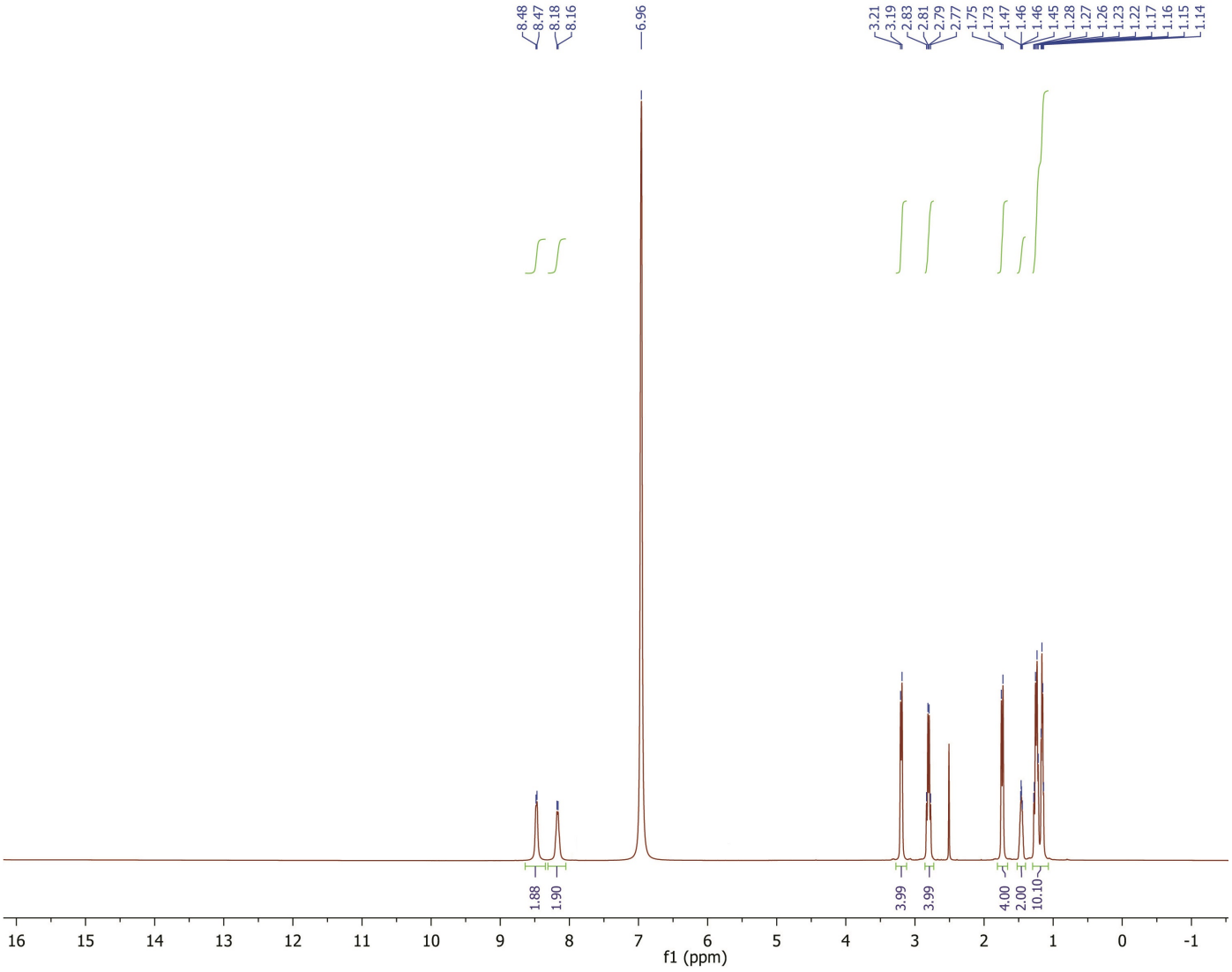

8.48
8.47
8.18
8.16
6.96
3.21
3.19
2.83
2.81
2.79
2.77
1.75
1.73
1.47
1.46
1.46
1.45
1.28
1.27
1.26
1.23
1.22
1.17
1.16
1.15
1.14
1.88
1.90
3.99
3.99
4.00
2.00
10.10
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
f1 (ppm)

**Figure S9**. $^{1}$H NMR of sulfuric acid (98%) in DMSO-$d_6$.

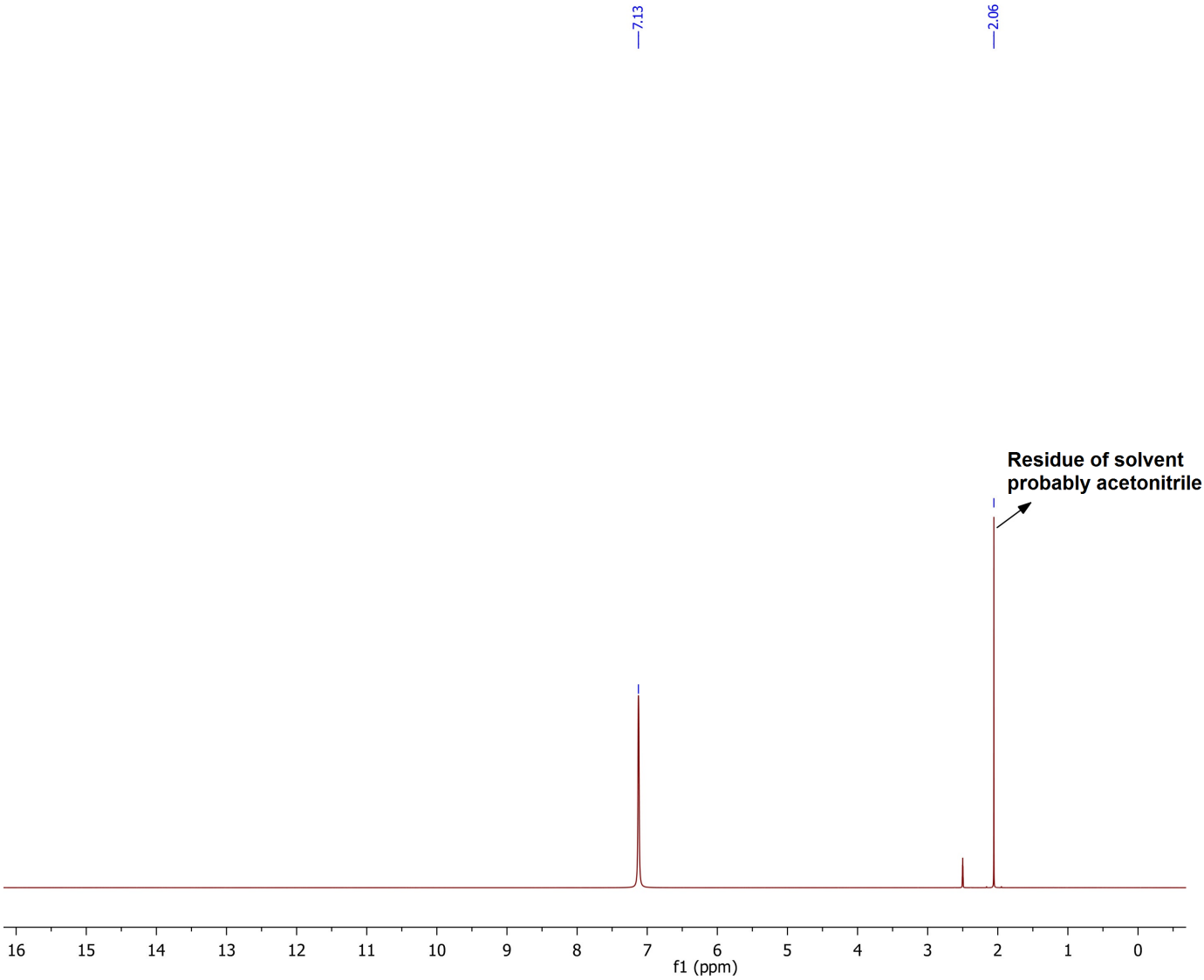


**Figure S10**. FTIR of new ionic liquid (neat).

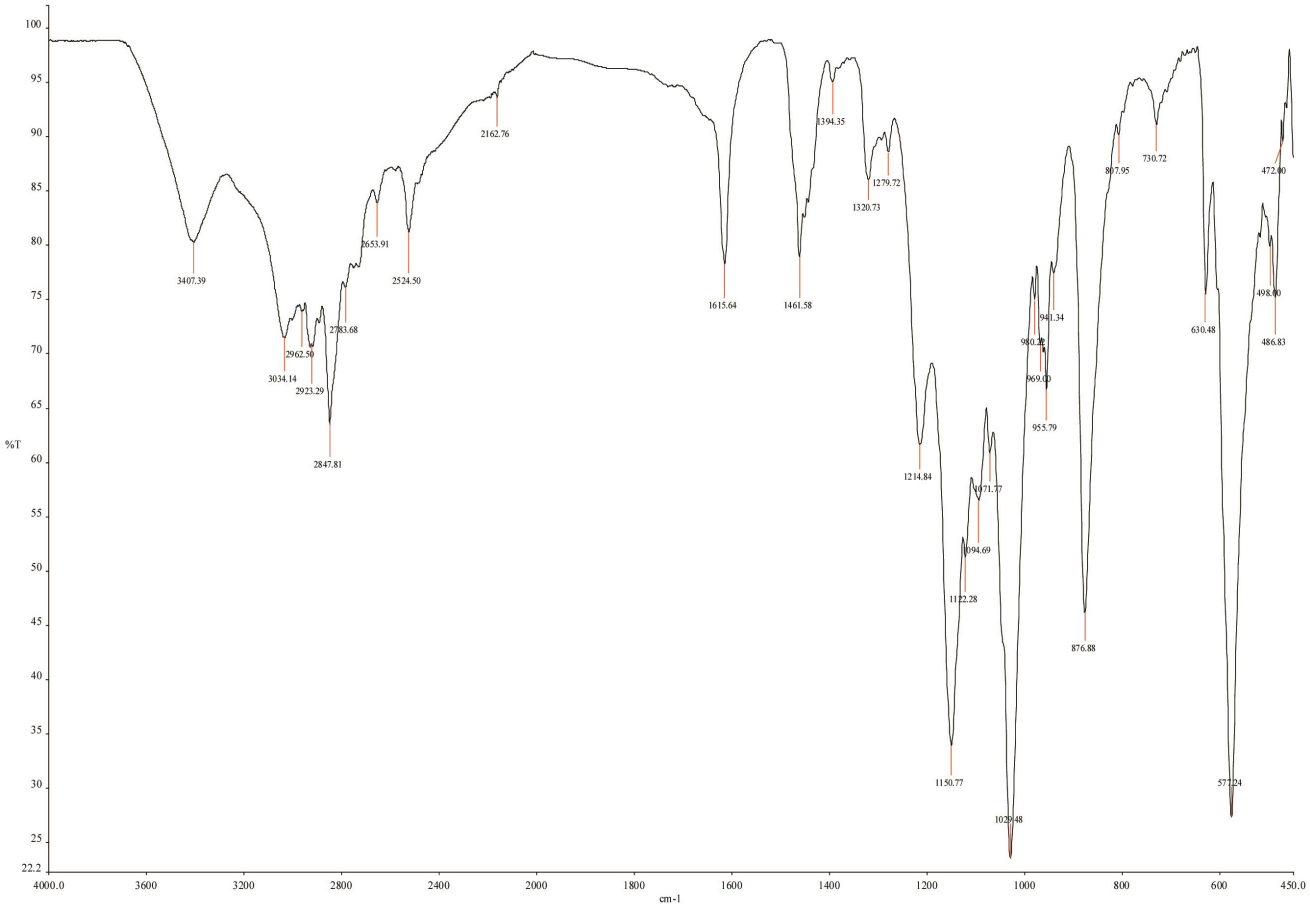
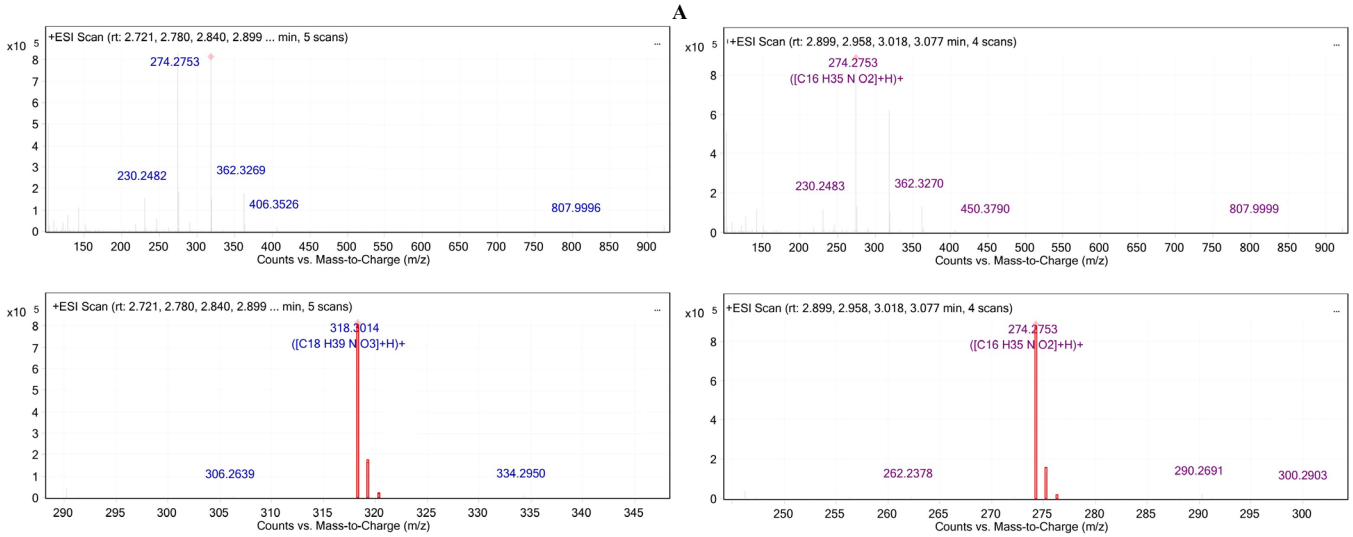


**Figure S11**. ESI mass spectra of $[TMDPH_2][SO_4]$ in positive ion (A) and negative ion (B) modes.



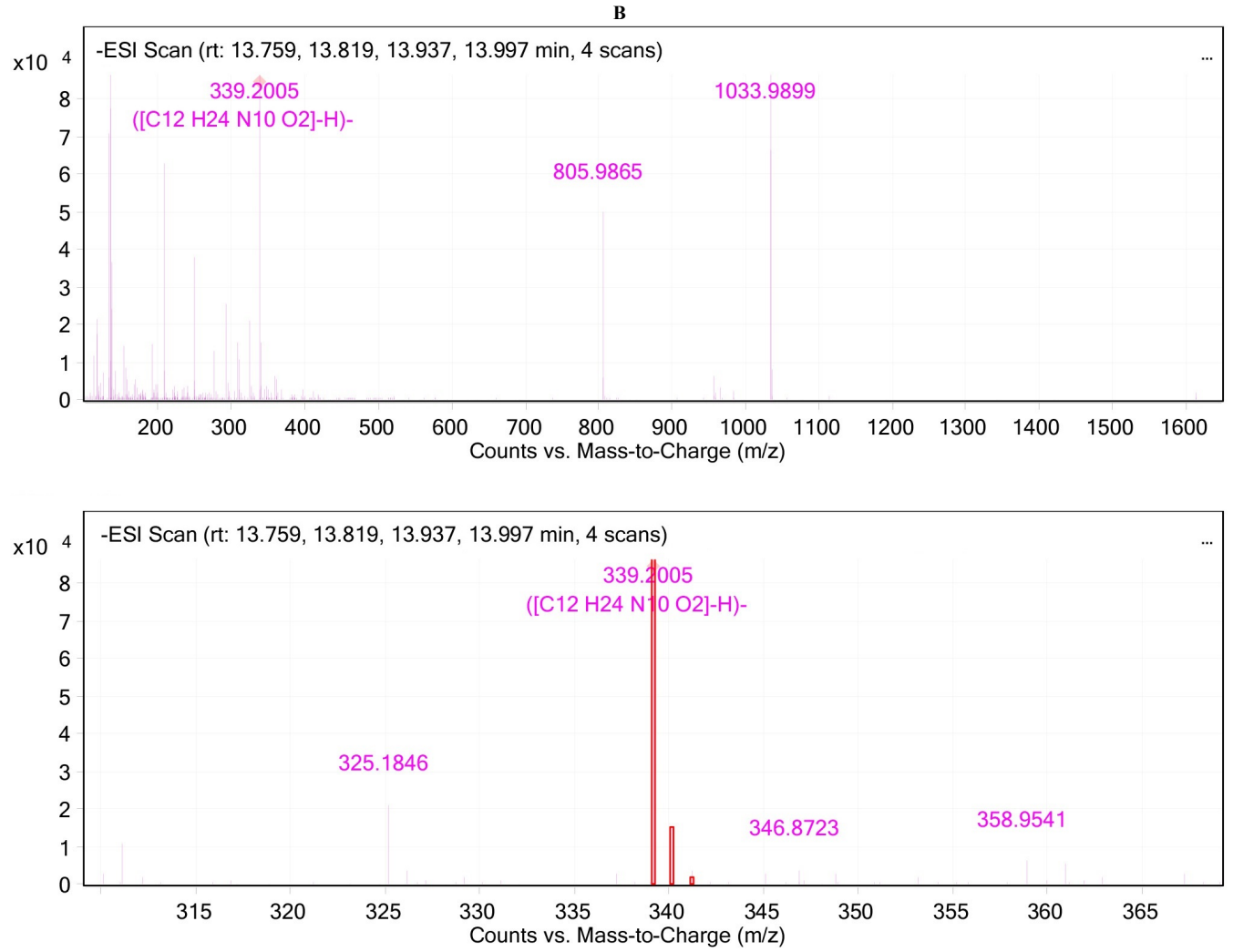



**Figure S12**. DSC of the new ionic liquid at nitrogen atmosphere.

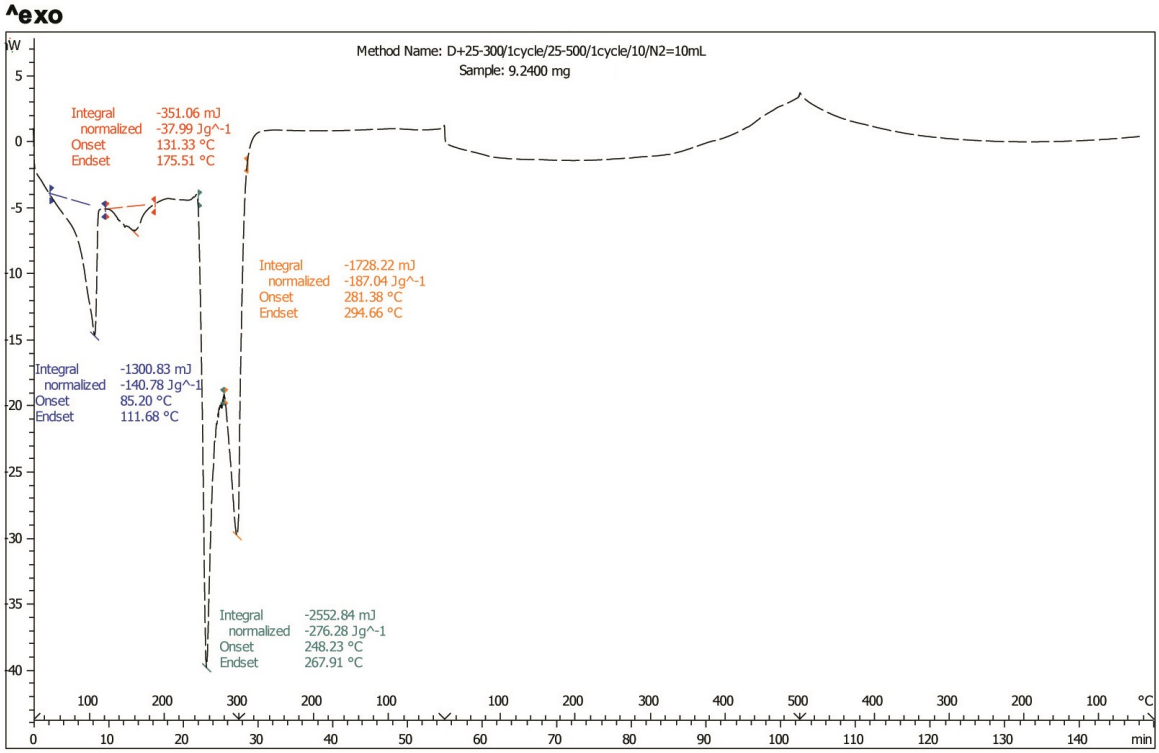



**Figure S13**. TGA/DTA of the new ionic liquid at nitrogen atmosphere.